P. A. DARGAN

OPEN SYSTEMS AND STANDARDS

FOR SOFTWARE PRODUCT DEVELOPMENT

Open Systems and Standards for Software Product Development

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Open Systems and Standards for Software Product Development

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Dedicated to the visionaries who created the technological innovations and standards described in this book, and the One who created them.

Contents

Preface

Open systems offer a building block approach to development through standards that provide a foundation for reuse, interoperability, and evolution. Today, vendors are offering standards-based products that implement new, powerful capabilities for enterprise infrastructures and applications. But, what becomes immediately apparent after a brief review of the marketplace is that there are so many standards to choose from that the sheer number is simply overwhelming (e.g., XML, OpenGIS, MIDI, SQL, PKI, PNG, SMI-S, iFSCP, Java™, J2EE, WebNFS, CIM, UDDI, SOAP, LDAP, X3D, TCP/IP, WAP, and the list goes on). Sorting through the host of standards developments to select suitable commercial products that enable an enterprise system to evolve with improved, more powerful capabilities over time is a real challenge. The book *Open Systems and Standards for Software Product Development* provides the means for facing this challenge.

If you have questions or comments, the author welcomes feedback and can be reached via e-mail at pdargan@erols.com.

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Acknowledgments

It is with heartfelt appreciation that I convey my thanks to Tricia Oberndorf for her many insightful review comments to improve the material in this book. I also thank her for co-authoring *Managing Software Acquisition: Open Systems and COTS Products* with Craig Meyers, which inspired me to write this one as a complementary book.

I want to express my appreciation to Mr. Matt Hosey, for his encouragement and vision for standards as a foundation for modernization. Special thanks go to Jim Coates, my Division Manager at SAIC, who never tired of providing encouragement and support whenever I needed it. In addition, I am grateful to Lee Akridge, the SAIC Deputy Operations Manager, who periodically received informal progress updates which served as motivation for me to continue on, and who personally reviewed the book and facilitated its corporate release. My thanks can also go to Barbara Lovenvirth, the developmental editor at Artech House, who spurred me on when my pace lagged near the end, and to Tiina Ruonamaa, the assistant editor at Artech House who saw me through the beginning months.

Last but not least, thanks to my husband Scott who provided encouragement that I would "get there" and finally complete the book.

CHAPTER 1

Introduction

1.1 Promise of Open Systems

Imagine sitting at a computer and logging onto a server thousands of miles away needing only a single user ID and password. Now, imagine executing a software application where you do not need to know the location of the application and data; whether the computer is the right platform with the current operating system; or whether there is sufficient memory capacity, disk space, and bandwidth to run the application in a time-responsive manner. This is the open systems vision, where a computer system takes care of these concerns automatically and transparently.

Just a few years ago, critics claimed that the open system vision could never be achieved: vendors would be unwilling to implement software products based on standards because they would inhibit competition. Critics predicted that in the future only one computer company would dominate the industry.

Reality today is quite different than what the critics predicted. The number of companies developing software and hardware has grown exponentially as the market has expanded to include computer applications for home appliances, automobiles, mobile phones, televisions, ATM machines, laptops, personal data assistants (PDA), and the list goes on. Even the microwave oven uses software to pop a bag of popcorn, heat up a TV dinner, and cook a hamburger.

The ability to network diverse systems is leading to a host of new and innovative technologies that make it imperative that systems be able to work together. For instance, consider how some automobiles are equipped with automated navigation systems that communicate with a Global Positioning System (GPS) to obtain their geographic location and display to the driver the location of their automobile on a map of the area. This is an essential capability for drivers navigating new territory and it is made possible by standards that enable a map-based system to operate in an automobile and communicate with a GPS satellite.

As another example, consider how mobile phones are used to communicate with the Internet to receive and send e-mail, attachments, and voicemail-capabilities critical to employees working outside an office. Mobile communications, user interface, and data interchange standards make this possible. As another example, think about how interactive television enables a viewer to dynamically select a video from a broadcaster and have it displayed on their television *on demand*, allowing them to schedule viewing when it is convenient. Broadcast communication standards are making this possible. It should then come as no surprise that companies now clamor for standards that will enable their systems to be *open* and interoperate with other systems in novel ways.

Open systems offer a building block approach to development that makes effective use of commercial products, and open systems are based on standards that define basic system building blocks and provide a foundation for reuse, interoperability, and evolution. The importance of standards has been recognized as the means for building *plug-and-play* hardware components from elements such as standard chips, standard computer circuit boards, and peripheral component interconnect (PCI) slots based on standards for interfaces, services, sizes, materials, and shapes.

Today's standards emphasize software because software components require standards for the same reasons as hardware—compatibility, modularity, and integrated plug-in/plug-out functionality. You are probably aware of software standards such as the HyperText Markup Language (HTML) used to implement Internet Web browsers, the Extensible Markup Language (XML) used to implement more sophisticated Web browsers, and the unix standard used for implementing unix operating systems. But these are only a few of the standards being defined for open systems.

A brief search through recent press releases and articles for the phrase "open standard" revealed literally hundreds of matches. A few of the titles included:

- "ASPs [Application Service Providers] Look Toward Open Standards," *Electronics Engineering Times* [1];
- "We Need Blade Standards, but Not Yet: Companies Need Time to Innovate, but Down the Road, Blade Specs Are a Must," *InfoWorld* [2];
- "Wi-Fi Alliance Certifies 802.11g Standard: Puts Stamp of Approval on First Batch of Products," *IDG News Service* [3];
- "XMPP vs. SIMPLE: The Race for Messaging Standards: As IM Bounds Ahead in the Enterprise, a Behind-the-Scenes Battle Is Taking Place Between Competing IETF Standards," *InfoWorld* [4];
- "Oracle, IBM Team on XQuery Java Specification: Arch Rivals Cooperate on Spec to Further the Use of XML, Java," *IDG News Service* [5];
- "2002 Technology of the Year: 10 Gigabit Ethernet: 10GbE Streamlines Connections, Provides a Single Protocol for All Networks," InfoWorld [6];
- "Mobile World Readies for IP-Based Future," *Network World Fusion* [9];
- "Migration Toward Open Standards Energizes PBX and Key Systems," *Cambridge Telecom Report* [10];
- "Open World: Intel's Barret Champions Standards for the Enterprise," *Network World Fusion* [11];
- "The Road to Open SANs [Storage Area Networks] – How Much Longer Until We Arrive at Some Agreement on Standards?" *VARbusiness* [12];
- "Open Market's New Mantra: Standards," *InternetWeek* [13];
- "MEDIA MOVERS – Vendors Push for Open Media Standards," *Computer Reseller News* [14];
- "IBM Chief: Open Standards Are 'Net's Future,'" *TechWeb* [15];
- "SpeechWorks Launches OpenSpeech Recognizer 1.0, Industry's First Speech Recognition Software Optimized for the VoiceXML Standard," *EDGE: Work-Group Computing Report* [16].

While the list of titles referring to open standards developments may seem numerous, they are only a subset of the many areas where standards developments are occurring:

- Application service providers (ASP);
- Mobile networking;
- Business-to-business (B2B);
- Storage area networks (SAN);
- World Wide Web.

Vendors recognize the need to develop commercial products based on open standards; they are even clamoring for them. Consider some of their responses, which explain the importance of standards for development:

- *Open standards facilitate development of third-party products.* A group of leading technology companies launched the Internet Streaming-Media Alliance to accelerate the adoption of open standards for streaming media, saying, "open standards will make it easier for content developers to format streaming media and for end users to play it" [14].
- *Open standards define an interoperable infrastructure that can reduce costs and shorten development schedules.* Barrett, Intel Corporation President and CEO, claimed, "Interoperable architectures and common standards … [span] all facets of the network, from silicon to systems and services, [and] can reduce development costs, because new hardware and software won't have to be custom-made each time a new feature or function is created" [11].
- *Open standards keep users from being locked into one vendor's solution.* "Open Standards Unlock Opportunity…Proprietary standards often lock solution providers and their customers into one vendor's technology. Open standards allow for the use of technology from many different vendors" [17].

Open systems have become a reality: vendors are implementing standards-based products that companies are using in computer systems. Open systems enable completely new, powerful capabilities to be built on mature, stable, *standard* capabilities. Open systems are the future for system development.

1.2 Challenges of Open Systems

What becomes immediately apparent after a brief review of open system standards is that today's marketplace offers so many to choose from that it is easy to become overwhelmed by their sheer number. This book was written to equip software product managers and developers, enterprise managers, system and communications engineers, software engineers, and product vendors with relevant information on standards.

Open system solutions should be considered when equipment and/or software is, or will become, obsolete; when maintenance costs are becoming unaffordable; when system capabilities are inadequate; or when the system is locked-in to a particular vendor solution, and a more price-competitive solution is required.

The greatest challenge in designing an open system is *selecting which standards to use for an enterprise*. The key to selecting a suitable mix of standards lies in an understanding of the enterprise infrastructure functions they are defined to support, whether communications, data management, security, system management, or another category. This book provides a solid foundation for understanding the standards by providing a framework that distinguishes between standards by infrastructure categories. It discusses their history, the specific functions that they support, and the standards organizations that defined them.

Another challenge is *finding suitable standards-compliant commercial products*. Employing standards-based products for development enables heterogeneous platforms to be used in an enterprise and simplifies the migration of applications from one platform to another. Where applicable, the book identifies vendors that offer standards-based products, along with names and Web sites of standards organizations responsible for branding products for conformance to standards. For instance, The Open Group brands operating systems for conformance to the Unix standards, and major Unix vendors include Hewlett-Packard and Sun Microsystems.

Another challenge is *choosing standards that keep pace with technology innovations*. Many of you may recall how consumer video recorders and players were once based on competing Beta and VHS standards, but even though Beta products provided high quality video, they became obsolete because the majority of manufacturers supported VHS. For the same reason, it is important to know which enterprise standards the vendors are basing their products on; and even more importantly, which standards organizations they are members of. As members of standards organizations, vendors become stakeholders that influence the future of standards, and improve the vendors' ability to keep pace with standards developments. The book provides insight by identifying which vendors offer standards-based products and providing Web links (in Chapter 15) that enable you to find out which vendors are currently members of the standards organizations.

1.3 Who Should Read This Book

Open Systems and Standards for Software Product Development is an essential resource for open systems. It equips chief information officers, program and project managers, enterprise architects, system engineers, and developers with valuable insights for building and evolving open systems for the enterprise. The book covers 12 categories of significant open standards: the World Wide Web, data management, data interchange, distributed computing, communications, security, operating systems, system management, software engineering, applications, user interfaces, and graphics. It provides a framework for understanding how the standards relate to the enterprise and to other standards. It also provides a status of the standards, identifies vendors and standards-based products, offers Web sites to consult for technical questions or product development, lists Web sites for downloading specifications, and provides links to the respective standards bodies. There is no other book like it on the market today.

1.4 How to Get the Most out of This Book

This book addresses three aspects of open systems: its past, its present, and its future. Chapter 2, on foundational concepts, provides the novice with fundamental information on what an open system is, and what it is not.

The middle chapters survey prevailing open standards (Chapters 3 through 14) and standards organizations (Chapter 15). Each standard is discussed in detail using the following categories:

- *Name:* current name of the standard;
- *Purpose:* intended function of the standard;
- *History:* background information on how the standard was developed;
- *Standards Organization:* organization(s) responsible for defining the standard;
- *Status:* current state of the standard;
- *Obtaining the Specifications:* how a copy of the specification can be obtained;
- *URL:* World Wide Web link for the standard;
- *Vendors:* where applicable, lists vendors and products;
- *Other Sources of Information:* URLs and other sources are provided, as applicable.

Similar information is provided for each of the standards organizations listed in Chapter 15:

- *Organization Name:* current name of the organization;
- *Inception Date:* date that the standards organization was established;
- *Purpose:* mission of the standards body;
- *History:* background information about the organization;
- *Membership:* lists some of the major companies and organizations involved;
- *Collaboration Efforts:* indicates if there is any collaboration with other organizations;
- *Standards:* families of open standards that the organization has defined;
- *URL:* World Wide Web link for the organization;
- *Other Sources of Information:* other sources are provided, as applicable.

Finally, Chapter 16 discusses five enterprise trends that are moving open standards toward achieving the open systems vision. These are:

1. High speed, ubiquitous communications;
2. Better security mechanisms;
3. Intelligent push/pull from families of petabyte data stores;
4. Worldwide electronic collaboration;
5. Seamless interfaces to networked applications, data, and computers.

The future for open systems and standards for software product development is promising because standards offer an achievable mechanism for implementing a set of complex system functions from a foundation of standard services to move us toward achieving the open systems vision.

1.5 Organization of This Book

The book is organized into the following chapters:

- Chapter 1: Introduction;
- Chapter 2: Foundational Concepts;
- Chapter 3: Application Standards;
- Chapter 4: Communication Standards;
- Chapter 5: Data Interchange Standards;
- Chapter 6: Data Management Standards;
- Chapter 7: Distributed Computing Standards;
- Chapter 8: Graphics Standards;
- Chapter 9: Operating System Standards;
- Chapter 10: Security Standards;
- Chapter 11: Software Engineering Standards;
- Chapter 12: System Management Standards;
- Chapter 13: User Interface Standards;
- Chapter 14: World Wide Web Standards;
- Chapter 15: Open Standards Organizations and Vendor Consortia;
- Chapter 16: Trends;
- Chapter 17: Conclusion.

References

[1] Mooney, T., "ASPs [Application Service Providers] Look Toward Open Standards," Elecronics Engineering (EE) Times, http://www.eetimes.com/story/OEG20001114S0040, November 13, 2000.

[2] Zeichick, A., "We Need Blade Standards, but Not Yet: Companies Need Time to Innovate, but Down the Road, Blade Specs Are a Must," http://www.infoworld.com/article/03/07/03/26FEbladesstand_1.html, *InfoWorld*, July 3, 2003.

[3] Blau, J., "Wi-Fi Alliance Certifies 802.11g Standard: Puts Stamp of Approval on First Batch of Products," http://www.infoworld.com/article/03/07/09/HNwificertifies_1.html, *IDG News Service*, July 9, 2003.

[4] Moore C., "XMPP vs. SIMPLE: The Race for Messaging Standards: As IM Bounds Ahead in the Enterprise, a Behind-the-Scenes Battle Is Taking Place Between Competing IETF Standards," http://www.infoworld.com/article/03/05/23/21FExmpp_1.html, *InfoWorld*, May 23, 2003.

[5] Niccolai, J., "Oracle, IBM Team on XQuery Java Specification: Arch Rivals Cooperate on Spec to Further the Use of XML, Java," http://www.infoworld.com/article/03/06/10/HNxqueryspec_1.html?standards, *IDG News Service*, June 10, 2003.

[6] Rash, W., "2002 Technology of the Year: 10 Gigabit Ethernet: 10GbE Streamlines Connections, Provides a Single Protocol for All Networks," http://www.infoworld.com/article/03/01/24/2002TOYgbe_1.html, *InfoWorld*, January 24, 2003.

[7] Weiss, T. R., "Adoption of New ebXML Standards Inching Forward," http://www.computerworld.com/managementtopics/ebusiness/story/0,10801,62694,00.html, *Computer World*, July 31, 2001.

[8] Meehan, M., "Users Seek Web Service Standards," http://www.computerworld.com/managementtopics/ebusiness/story/0,10801,66886,00.html, *ComputerWorld*, December 21, 2001.

[9] Uimonen, T., "Mobile World Readies for IP-Based Future," http://www.nwfusion.com/news/2000/0203mobileip.html, *IDG News Service*, February 7, 2000.

[10] "Migration Toward Open Standards Energizes PBX and Key Systems," *Cambridge Telecom Report*, December 20, 1999.

[11] Vance, A., "Open World: Intel's Barret Champions Standards for the Enterprise," http://www.nwfusion.com/news/2000/1003barrett.html, *Network World Fusion*, October 9, 2000.

[12] Cook, R., "The Road to Open SANs [Storage Area Networks] – How Much Longer Until We Arrive at Some Agreement on Standards?" http://vb.channelsupersearch.com/news/var/16145.asp, *VARbusiness*, April 27, 2000.

[13] Booker, E., "Open Market's New Mantra: Standards," *InternetWeek*, http://internetweek.com/story/showArticle.jhtml?articleID=6403181, March 27, 2000.

[14] Hooper, L., "MEDIA MOVERS–Vendors Push for Open Media Standards," http://crn.channelsupersearch.com/news/crn/22457.asp, *Computer Reseller News*, December 18, 2000.

[15] Anderson, K. R., "IBM Chief: Open Standards Are 'Net's Future," http://www.techweb.com/wire/story/TWB20001212S0004, *TechWeb*, December 13, 2000.

[16] "SpeechWorks Launches OpenSpeech Recognizer 1.0, Industry's First Speech Recognition Software Optimized for the VoiceXML Standard," http://www.findarticles.com/cf_dls/m0EIN/2001_July_16/76543670/p1/artile.jhtml?term=%22SpeechWorks+Launches+Open Speech+Recognizer+1.0%22, *EDGE: Work-Group Computing Report*, July 23, 2001.

[17] Montalbano, E., "Open Standards Unlock Opportunity," http://crn.channelsupersearch.com/news/crn/24063.asp, *Computer Reseller News*, February 26, 2001.

CHAPTER 2

Foundational Concepts

2.1 What Is an Open System? Key Concepts and Terminology

Historically, computer vendors promulgated a view of hardware and software product lines that locked the customer into a proprietary solution. Product lines were anything but portable, interoperable, and adhering to standards. Systems were *closed*, meaning that to use a vendor's software, customers were required to use compatible support products (e.g., computer platform, operating system, and software applications). In short, customers were forced to purchase a proprietary product line, resulting in dependence on a single vendor.

Today, open systems offer an interoperable, seamless, scalable, and reusable approach to system development. Potential benefits include:

- Vendor independence;
- Reduced development costs;
- Standard user interface;
- Reduced development time;
- Reduced training costs;
- Enterprise networking.

Open systems represent a paradigm shift from reliance on proprietary products and interfaces to the use of standard services (functions) with well-defined application program interfaces (APIs). Different computer circuit boards, each performing different functions, fit easily into PCI slots designed using PCI standards for interfaces, services, size, materials, and shapes. Software components need standards for the same reason: unless software components are designed to work together, then the components—even if they are commercial-off-the-shelf (COTS)—will require extra effort to resolve incompatibilities, leading to mounting system integration costs. Custom *glue* software or bridge products can be used as an attempt to resolve incompatibilities, but architectural mismatches—conflicts between underlying architectures, such as contention for the same address space—are hard to overcome and can result in serious system errors [1]. Figure 2.1 illustrates the potential for problems when a system is built from a variety of components not designed to work together, as illustrated by the incompatible interfaces shown in the diagram.

Using standards-based products for system development is a step toward reducing problems with portability and compatibility. Another step is using standards-based products developed by vendors that recognize the importance of interoperability with other software products and that are able to demonstrate that their products are interoperable with other products. As applicable, subsequent chapters

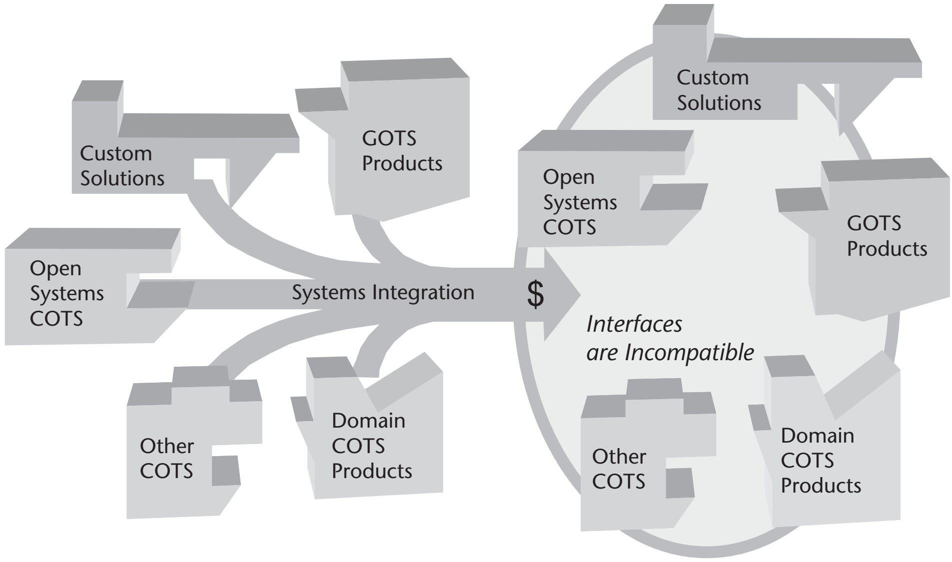

Figure 2.1 Incompatible interfaces drive system integration costs. (*Note:* Domain COTS products are those developed for specialized domains, such as accounting.)

list organizations currently providing independent interoperability evaluations and testing for vendor products.

The list is growing for large organizations that attribute the open system development paradigm with lower risk and more economical information system development. Over time, as the open system paradigm matures, more and more business and government organizations are moving to open systems. A partial list of organizations that have migrated to open systems includes:

- Boeing (http://www.opengroup.org/comm/case-studies/boeing.htm);
- The U.S. government:
  - U.S. Department of Defense (DoD) (http://www.opengroup.org/comm/case studies/usaf.htm);
  - National Aeronautics and Space Administration (NASA) [2];
  - Internal Revenue Service (http://www.opengroup.org/comm/case-studies/irs.htm);
- Hyatt Corporation [3];
- Home Depot [3];
- Merck [3].

There is sometimes confusion about what makes a system open, what open standards are, how open standards are defined, and what the process is for building an open systems. Vendors claim that their products are open and adhere to standards, but how do you substantiate their claims? This section defines key terms to provide an understanding of what open systems are.

Open System. A system is considered *open* if it contains components that conform to specifications that are defined and maintained by group consensus (typically a standards body or consortia); those specifications are available to the public; and the interfaces are fully defined. When these conditions are satisfied, then public specifications become open system standards. At the heart of an open system is a computing environment that supports *interoperable*, *portable*, and *scalable* applications through standard services, interfaces, data formats, and protocols.

As systems grow more complex and expand to incorporate numerous components that implement different services, it becomes absolutely critical for the components to be interoperable. *Interoperability* refers to the ability of system components to readily exchange data and interoperate. *Portability* is important because as computer platforms rapidly become outdated and obsolete, it becomes necessary to move (or port) system software to newer computer platforms. *Scalability* addresses the need for systems to expand without degraded performance, providing more complex capabilities and access to larger amounts of data.

Open systems provide a foundation to achieve these three features—interoperability, portability, and scalability—through the use of components that conform to open standards.

Open Standard. An open standard is a public specification developed and maintained by consensus of a recognized standards body that defines interfaces and services for a computer system to perform, and that is made available to review and implement. A public specification may be defined by a formal standards body such as the U.S. Institute for Electrical and Electronics Engineers (IEEE) or a vendor consortium such as the World Wide Web Consortium (W3C). In some cases, a company or group of companies may provide a specification to a standards body for them to approve, own, manage, and refine as a standard.

As an example, when Tim Berners-Lee was at CERN, the European Particle Physics Laboratory in Switzerland, he proposed a project to develop software that would link a distributed *web* of files [4]. CERN approved the project, and it led to the foundational World Wide Web (WWW or the Web) technologies for the Internet [4].[1] The popularity of the Web led Berners-Lee to found the W3C to produce specifications that would standardize the technologies used for the World Wide Web. The W3C has more than 350 national and international member organizations (http://www.w3.org/Consortium/#membership).

Profile. A profile identifies a set of standards and specifications used (or that will be used) to implement an open system architecture. In developing a standards profile, it is best to identify interdependent, compatible standards. Figure 2.2 shows a set of standards defined to work together.

Open standards emphasize the need for standard interfaces and services. When interoperable COTS products are selected that implement standards designed to work together, system integration activities become less challenging to accomplish.

Services. In discussing open systems, the term "services" is frequently used. This term refers to a set of system functions provided by the system or its component(s).

Technical Reference Model. A technical reference model (TRM) is an abstract description that provides a framework for system concepts and a lexicon of terms to be used in defining a system architecture or its components. A TRM can be viewed as a simplifying mechanism that enables its users to describe and visualize the major services that an architecture is (or will be) designed to support. A TRM is a tool that

1. Refer to Chapter 14, specifically the introduction to Section 14.1, for a history of the Web.

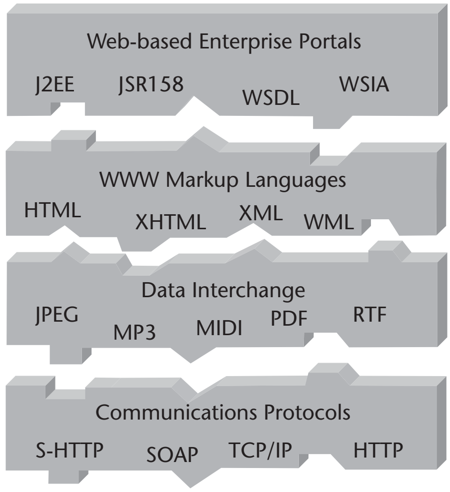

Figure 2.2 Standards designed to work together.

aids in the development of a system architecture of many applications or a system of systems that may cross organizational boundaries.

Technical Reference Models for Open Systems. As part of their portable operating system interface (POSIX) development, the IEEE POSIX Working Group defined a reference model for an Open Systems Environment (OSE) (see Figure 2.3). This model has been used by different organizations as the basis for their open systems architecture development efforts [5]. A detailed guide for the model is available from International Organization for Standardization (ISO) (http://www.iso.org/) [5].

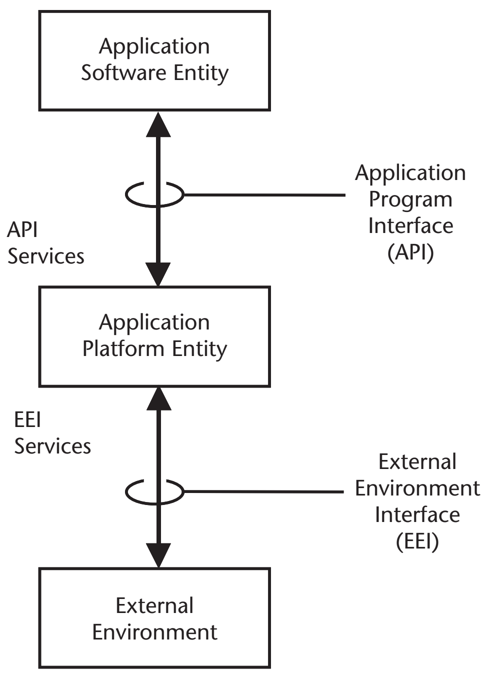

Figure 2.3 POSIX OSE Reference Model. By the IEEE POSIX Working Group [5].

The POSIX OSE Reference Model entities and interfaces are briefly described below [6]:

- *Application software entity:* collection of computer programs, data, and documentation that enable a user to perform some functions;
- *Application platform entity:* collection of hardware and software components that provide basic system infrastructure services used by application software;
- *External environment (EE) entity:* system elements outside of the application software and the application platform;
- *Application program interfaces:* provide the connection between application software and application platform services;
- *External environment interfaces (EEIs):* provide the connection between application platform and external environment components.

The U.S. DoD is an example of a major organization that has used the POSIX OSE Reference Model to develop the DoD TRM (Figure 2.4). The DoD views the TRM as a means to "minimize continued proliferation of domain models in support of open systems and interoperability across domains…and across a wide range of

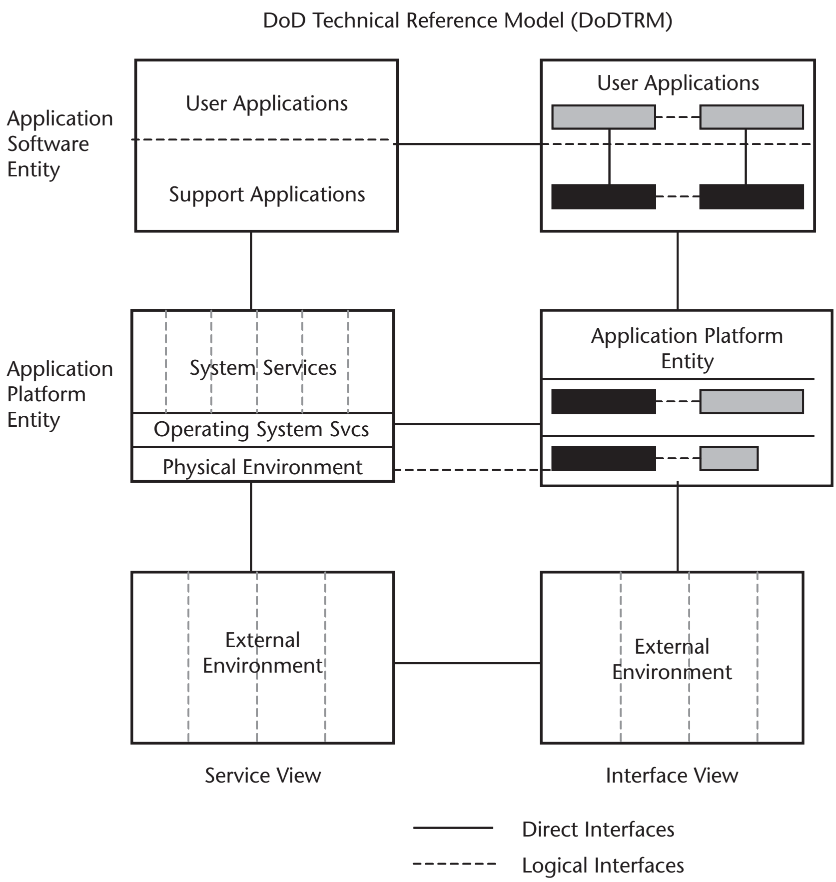

Figure 2.4 High-level representation of the DoD TRM. (2001 U.S. Department of Defense. [7])

application." The DoD has mandated its use for all DoD information systems and applications to provide a common conceptual framework and vocabulary [7].

Originally, the DoD had developed a Technical Architecture Framework for Information Management (TAFIM). The TAFIM (Figure 2.5) is shown here to illustrate the kinds of services that could be included in an open system such as data management and data interchange services. The current version of the DoD TRM is shown in Figure 2.6.

The DoD TRM includes a *services view* and an *interface view* so that the model can be used to "enable communications from one DoD community and their model to another" [7]. *Logical interfaces* shown in Figure 2.6 "define what information is exchanged…and define peer-to-peer relationships between similar entities," while the *direct interfaces* define the relationships between the application platform entities in terms of transmission, receipt, and routing of data [7].

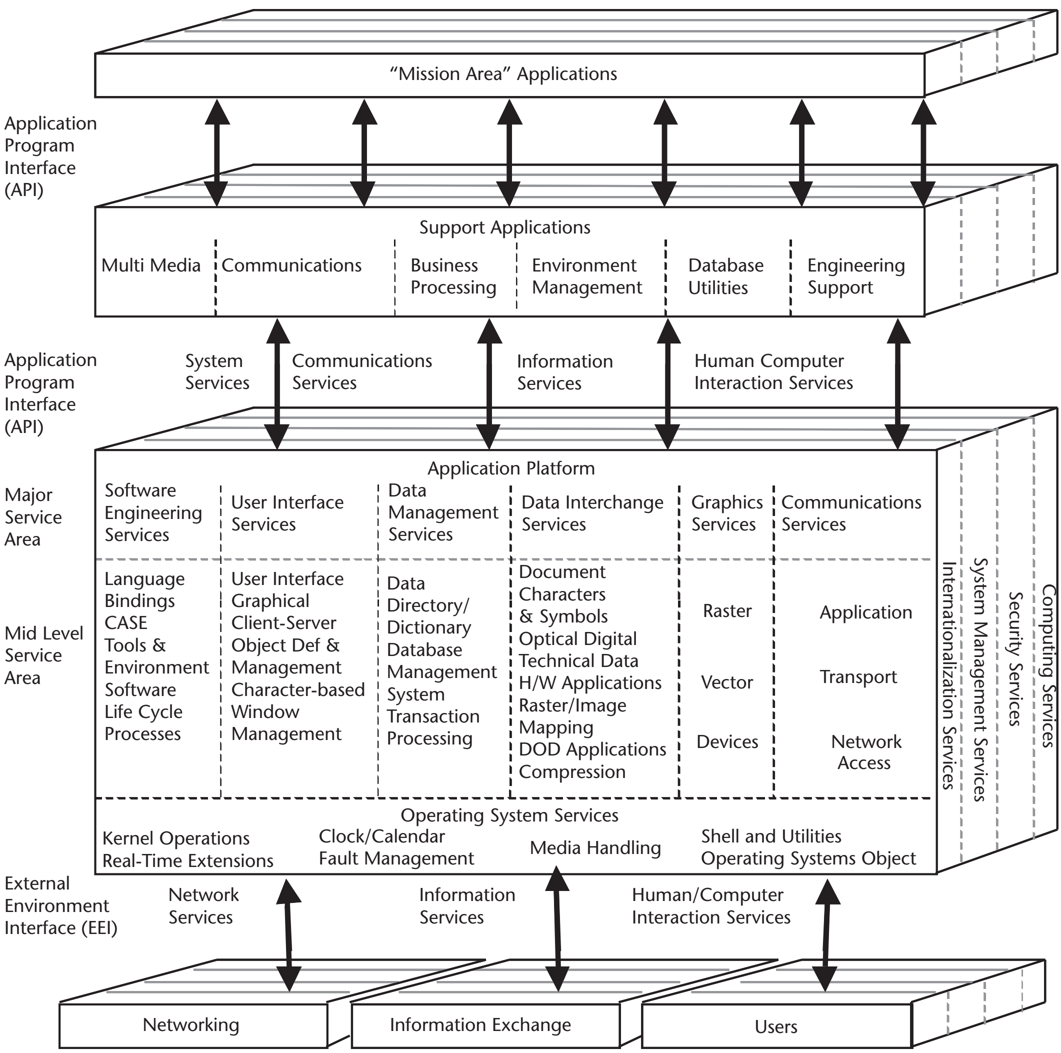

Figure 2.5 DoD TAFIM. (*From:* 1996 U.S. Department of Defense [8].)

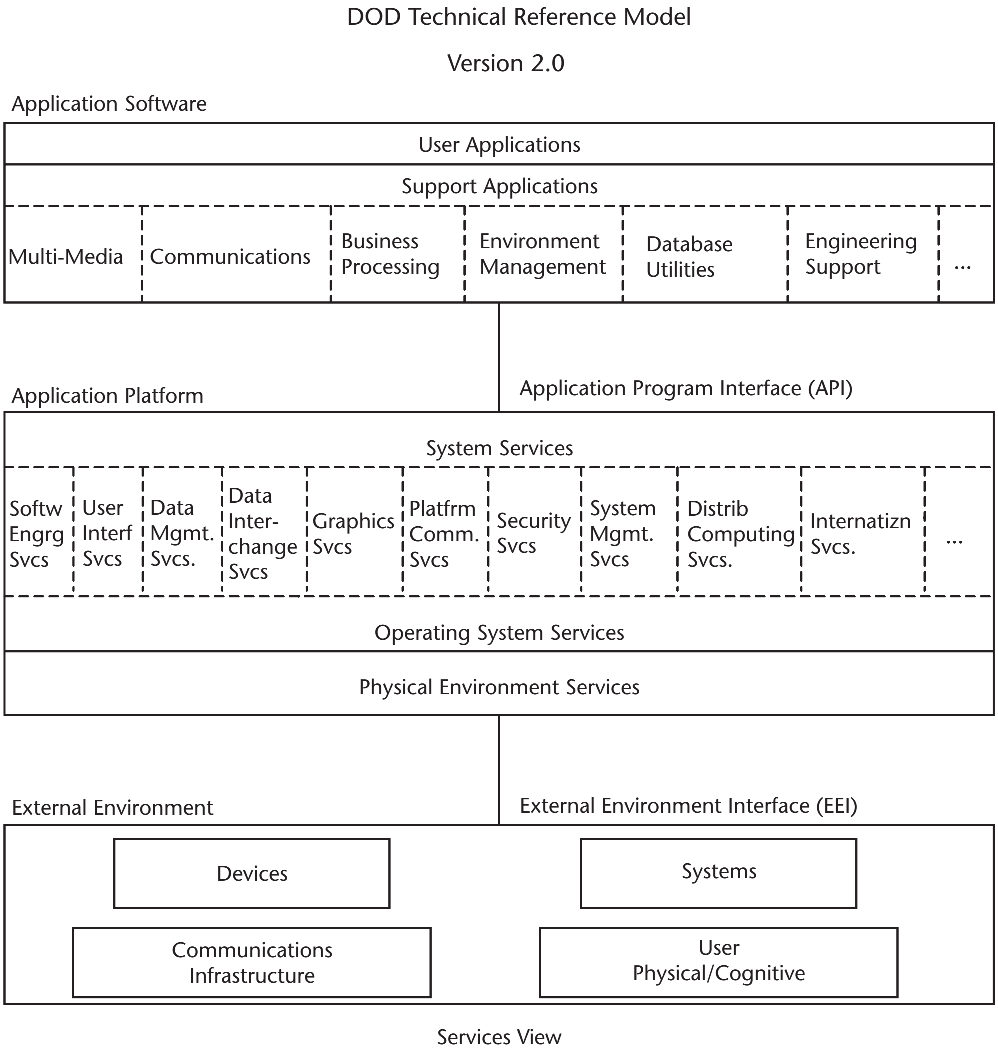

Figure 2.6 DoD TRM Version 2.0. (*From:* 2001 U.S. Department of Defense [7].)

Another example of a major organization that used the POSIX OSE Reference Model for its initial development of a TRM is The Open Group. The Open Group named their reference model The Open Group Architecture Framework (TOGAF). There is a TOGAF version 7 Technical Edition and a TOGAF version 8 Enterprise Edition.[2] TOGAF version 7 provides a framework that organizations use to develop their information technology (IT) architecture, and TOGAF version 8 is used to develop a business architecture, data architecture, technical architecture, and application architecture for the enterprise [9]. The Open Group provides training and certification programs to ensure consistent application and usage of the TOGAF. Documentation is available to members or those who wish to consider a corporate license [9].

2. For more information about TOGAF, refer to Chapter 11, Section 11.1.5.

Open System Infrastructure. The essence of an open system is the open system infrastructure, which implements the application platform entity services shown in Figure 2.6 and provides the basic system building blocks for application development and execution. An open system infrastructure is based on an architecture where application software builds on infrastructure services that provide low-level, foundational computing capabilities. The open system infrastructure consists of the hardware and software necessary to implement the standards identified in a system profile.

Figure 2.7 depicts an open system infrastructure that implements the application platform services based on open standards. Open system infrastructure services are described below [10]:

- *System services:*
- *Software engineering:* tools to support software development (e.g., language compilers);
- *User interface:* support human interaction with applications (e.g., window manager, menus);
- *Data management:* structure, access, store, recover, and modify data [e.g., database management system (DBMS) services];
- *Data interchange:* identify standard formats and semantics to facilitate exchange of information between applications;
- *Graphics:* generate and manipulate two- and three-dimensional images;
- *Network communications:* support distributed applications (e.g., data communications);

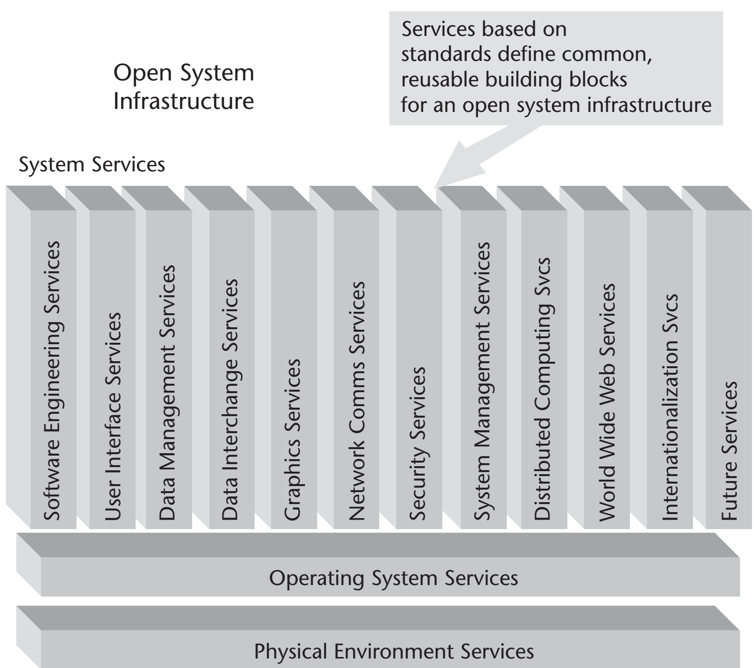

Figure 2.7 Open system infrastructure.

- *Security:* protect electronic aspects of the system and data;
- *System management:* control and monitor system resources;
- *Distributed computing:* support cooperative processing across logically dispersed computer systems in a network;
- *Internationalization:* provide services and interfaces that allows a user to select a culturally related application;
- *World Wide Web:* provide the ability to interface with WWW applications and protocols (e.g., communications protocols, Web programming languages, and Web browsers);
- *Operating system:* provides core services to interface between the computer and software applications (e.g., system commands);
- *Physical environment*: hardware-based services that include interface software (e.g., device drivers).

Within the context of defining an open system, a technical architecture is a view of a system architecture that defines “a collection of the technical standards, conventions, rules, and criteria that govern system implementation and system operation” [7].

Consortia such as the W3C and OASIS are using the term “technical architecture” to refer to their development of architecture principles, components, and services that support interoperability with complementary standards and architectures defined by their consortium and other consortia and standards bodies [11, 12]. However, the author agrees with the definition for a technical architecture provided in the preceding paragraph, where a technical architecture provides a profile that identifies which standards are to be implemented by the system along with the conventions, rules, and criteria that will govern system implementation and operation. Overarching architecture principles, components, and services belong in the system architecture.

2.2 Process of Defining Standards

If an individual, company, or group of companies defines a specification and provides it to the public for review and comment, these actions do not go far enough to turn the capabilities into a standard. Vendors may claim that a product is a de facto standard because of its widespread popularity, but having a specification that is provided to the public is no guarantee that the resulting vendor products will be portable to other platforms, compatible with other vendor products, and stable. In reviewing the histories of the standards in Chapters 3 to 14, take special note of just how many times a technology began as the offering of an individual or company but was later submitted to a standards group. Also note how many vendor consortia have formed to take responsibility for these technologies (e.g., the W3C, the Free Standards Group, the Open Mobile Alliance,[3] and the list goes on). Hence, open system standards are defined by formal standards bodies and vendor consortia.

3. See Chapter 15, Section 15.2.16.

Formal Standards Bodies. If a U.S. standards organization is endorsed by ISO, then it is an official (formal) standards body [13]. The IEEE, the American National Standards Institute (ANSI), and the Internet Engineering Task Force (IETF) have been designated as official U.S. organizations to define formal, or de jure standards that can become legal requirements. In Europe, "the Commission of the European Communities (CEC) set up ETSI (European Telecommunications Standards Institute) on behalf of European governments; [and the European] governments appointed the national standards institutions that make up ISO…. Everything else is a consortium…" [13].

Vendor Consortia. Vendor consortia are organizations primarily composed of companies from the industry that have a vested interest in defining standards for their own commercial products and who work together to achieve consensus on standard services and interfaces. "For example, industry consortia like the ATM [Asynchronous Transfer Mode] Forum and the Frame Relay Forum work up specs [specifications] and then pass them along for…ratification by official organizations like the IETF and IEEE (Institute of Electrical and Electronics Engineers)…. Vendor participation helps guarantee that standards are based on commercial demand rather than elegant engineering…" [13].

2.2.1 Formal Standards Bodies Standards Process

De jure standards are often defined *prior* to prototyping in order to enable the standards body to define a comprehensive set of standards. The Open System Interconnection (OSI) communications protocol is an example of a de jure standard.

The IEEE Standards Association (IEEE-SA) is responsible for developing IEEE standards, and their standards process is shown in Figure 2.8 [14]. Other formal standards bodies use similar processes for their standards development.

The first step in the process is developing an idea for a standard, where the group of people interested in the standard obtains a sponsor such as an existing standards committee, which takes responsibility for the idea (Idea). A project authorization request (PAR) form is completed and submitted to the New Standards Committee (Project Approval Process). If approved, a working group is given the task of developing and revising the standard (Develop Draft Standard). When the standard has been defined, the sponsor has a group ballot for the standard (Sponsor Ballot). If the standard achieves a consensus of the ballot, then it is submitted to a review committee or a standards board—in the case of IEEE, this would

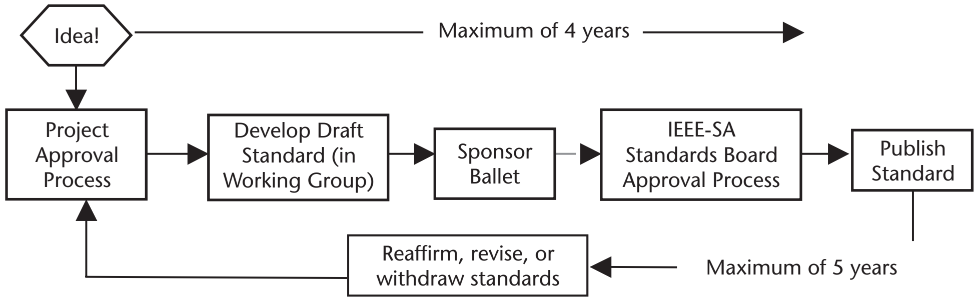

Figure 2.8 IEEE-SA standards process. (*From:* © 2003 IEEE. Reprinted with permission [14].)

be the IEEE-SA, where it can take up to 4 years for approval (Standards Board Approval process) [14].

Once the standards board approves the standard, then it is published by an IEEE Project Editor (Publish Standard). The standard remains valid for 5 years (Reaffirm, revise, or withdraw standards) [14].

2.2.2 Vendor Consortia Standards Definition Process

Vendor consortia define specifications that often become de facto standards, public specifications proposed by one or several vendors and adopted by a broad segment of the market. De facto standards are typically defined after a product has been accepted by a large community of users. Well-known examples of de facto standards are HTTP and HTML. Vendor Consortia have processes for defining and publishing standards. As an example standards process, the W3C develops a *W3C Recommendation* as its equivalent to a Web standard: (see URL: http://www.w3.org/2004/02/Process-2004 0205/cover.html#toc for details) [15].

The process begins with submission of a technical report containing a proposed specification to the appropriate Working Group or Activity [15]. A technical report can move from the entry level as a *Working Draft* to a *Candidate Recommendation*, and then a *Proposed Recommendation*, and finally, a *W3C Recommendation* after endorsement by the W3C [15]. Typically, a Working Group is responsible for refining the technical report and moving it through the standards process [15]. If the Working Group wishes to support it, the Working Group makes any changes necessary and submits it to the W3C Director [15]. If approved, it is published as a *Working Draft* for review by other W3C groups and the public [15].

The Working Group must formally address any substantive review comments and communicate significant issues to the Director[4] [15]. After several reviews, if the Working Group feels the technical report is ready for implementation, the Director puts out a *Call for Implementation* and the report becomes a *Candidate Recommendation* [15]. After at least two independent and interoperable implementations, the Working Group revises the technical report as needed, and it becomes a *Proposed Recommendation* [15]. Then it is submitted to the W3C Director for review [15]. If the W3C Director announces a *Call for Review* by the W3C Advisory Committee, W3C members are also asked for their endorsement [15]. If the W3C Director and Advisory Committee approve the technical report, then it is published as a *W3C Recommendation* [15].

2.3 Example Standard Specification

What exactly does a standard (public specification) look like? A specification is essentially a white paper that provides sufficient detail to clearly describe the standard's detailed behavior, features, functions, appearance, language, and interfaces

4. This is usually accomplished through the W3C Team established to oversee the development of standards. The W3C Team is composed of paid staff, unpaid interns, and W3C Fellows led by the Chief Operating Officer, W3C Chair, and the W3C Director [15].

(API) to enable it to be successfully implemented. For example, the HTML 4.0.1 specification includes the following [16]:

- Links to previous or related HTML specifications;
- Abstract description of the specification;
- Available languages (e.g., English version);
- Errata;
- Table of contents (quick version and full version);
- Description of HTML behavior, appearance, interfaces, language, and functions. For example, Section 5 "HTML Document Representation," describes the HTML document character set, character encodings, character reference set, and undisplayable characters.
- References.

The following extracts provide two examples that show how white space and structured text phrase elements were defined in the HTML 4.0.1 Specification [16].

9.1 White space

The document character set includes a wide variety of white space characters. Many of these are typographic elements used in some applications to produce particular visual spacing effects. In HTML, only the following characters are defined as white space characters:

* ASCII space ( )
* ASCII tab (	)
* ASCII form feed ()
* Zero-width space ()

Line breaks are also white space characters. Note that although   and   are defined in [ISO10646] to unambiguously separate lines and paragraphs, respectively, these do not constitute line breaks in HTML, nor does this specification include them in the more general category of white space characters.

This specification does not indicate the behavior, rendering or otherwise, of space characters other than those explicitly identified here as white space characters. For this reason, authors should use appropriate elements and styles to achieve visual formatting effects that involve white space, rather than space characters.

9.2 Structured text

9.2.1 Phrase elements: EM, STRONG, DFN, CODE, SAMP, KBD, VAR, CITE, ABBR, and ACRONYM

```
<!ENTITY % phrase "EM | STRONG | DFN | CODE |
      SAMP | KBD | VAR | CITE | ABBR | ACRONYM">
<!ELEMENT (%fontstyle;|%phrase;) - - (%inline;)*>
<!ATTLIST (%fontstyle;|%phrase;)
 %attrs;            — %coreattrs, %i18n, %events —
Start tag: required, End tag: required
```

2.4 Standards-Based COTS Products

COTS products are available that implement many of the standards, such as HTML. But here the buyer must beware: vendors may claim that their product *complies* with open system standards, but their product may not fully *conform*.

Keep in mind that *conformance* measures the *degree* of adherence to the standards, while *compliance* indicates adherence to only a subset of standards. When selecting COTS products, using fully-conformant products greatly reduces the risk of encountering incompatibilities with other standards-based products during system integration.

Who determines if a product fully conforms? There are a number of organizations that employ conformance test suites to brand for product conformance to standards. In addition, some companies have begun adding interoperability testing to their test conformance suites for standards-based products. For example, the Free Standards Group (http:/www.freestandards.com) has developed a series of tests to assess the level of conformance of Linux operating systems to the Linux Standards Base (LSB) (http://www.linuxbase.org/test/).[5]

In the past, large system procurements could take from 5 to 10 years to accomplish, an unacceptable life cycle duration to keep pace with today's technologies. COTS products need to be procured directly from vendors in a timely and efficient manner. In their book *Managing Software Acquisition: Open Systems and COTS Products*, Craig Meyers and Patricia Oberndorf discuss practices for facilitating the procurement process for standards-based COTS products [17].

2.5 Degrees of Openness

When designing an open system, keep in mind that system openness is relative and depends on the number of standards in the profile, which services and interfaces they implement, and the degree of standards compliance in the products used. Using COTS products that *conform* to the open standards increases the openness of a system. Development needs to emphasize implementing an infrastructure based on open standards to improve system interoperability, portability, and scalability. For this reason, it is especially important to consider using standards-based products to implement basic services for the infrastructure, such as operating systems, software engineering tools, and distributed computing.

2.6 Open Source Versus Open System

Recently, there has been a lot of confusion about what *open source* really is. Many are told that if they use *open source* then their system is automatically open. This, however, is not the case. So how does *open source* relate to open systems?

5. For more information about LSB, refer to Chapter 9, Section 9.1.

A clear definition for "open source" was published by *Communications of the ACM* (Association for Computing Machinery): "[open source] is source [code] that is available for redistribution without restriction and without charge and the license must…allow derivatives to be redistributed under the same terms as the original work" [18].

Examples of open source include Emacs (a word processor that can be used in a Unix environment) and PERL (a scripting language).

Open source is not the same as source code that adheres to open standards, where all of the vendors implement the same specifications for services and APIs. With open source, an end-user can make modifications to source code and devise completely new features, thereby providing the potential for future incompatibilities. This approach has had mixed success.

For example, Linux began as open source software, but to insure that there was a standard version of source code, an organization named the Free Standards Group took over its evolution and standardization. Why? Because at one point in time, there were so many variants of Linux with different services and interfaces that porting it from one platform to another had become a virtual nightmare.

Open source software relies on the interest of the community of programmers developing it. There is risk of "buggy" code if the community is too small or not skilled enough to maintain it [19]. To address this problem, the Open Source Initiative (OSI) (http://www.opensource.org/), a nonprofit corporation, is dedicated to managing and promoting the definition of what constitutes open source for the good of the community. They provide a certification mark to indicate what they consider to be open source: "the term 'open source' itself is subject to misuse, and…can't be protected as a trademark…. Since the community needs a reliable way of knowing whether a piece of software really is open source, OSI…[registers]…a [text] certification mark, OSI Certified, for this purpose. OSI has also created a graphic certification mark that can be used instead of the text certification mark. If you see either of these marks on a piece of software, the software is being distributed under a license that conforms to the Open Source Definition" (http://opensource.org/index.php).

2.7 Why Standards Are Important for Software Development

Throughout Chapters 3 to 14, you will see examples of why standardization is so critical for software technologies. A recent example serves to make this point clear: a free Linux operating system was developed by Linus Torvalds, a computer science student at the University of Helsinki in Finland, and distributed over the Internet in 1991 [20, 21]. One of its most important features was that it provided Unix-like functionality and it worked on PCs [20]. The use of Linux exploded, and numerous companies sprang up to distribute it. But despite all of this attention, there were so many variants of Linux that its portability, compatibility, and stability suffered. Several groups began competing standardization efforts for Linux, but it was finally the establishment of the Free Standards Group that enabled the Linux community to have a definitive specification for Linux: the LSB [21].

The story was no different for the Internet, which led to the establishment of the IETF.[6] Chapter 15 provides a list of numerous standards organizations that have arisen to take responsibility for particular technologies. For the software community at large to be able to develop large complex systems that rely on stable, portable, and interoperable components, standards are an absolute necessity. This book was written to discuss standards developments and provide readers with a framework for understanding where the standards fit in the system and in what direction they are moving.

References

[1] Garlan, D., R. Allen, and J. Ockerboom, "Architectural Mismatch: Why Reuse Is So Hard," *IEEE Software*, IEEE Computer Society, November 1995, Vol. 12, No. 6, pp. 17–26.

[2] NASA, *Pioneering Innovation: NASA's Open System Investment*, The Open Group, Reading, U.K., 1995.

[3] Senn, A., *Open Systems for Better Business*, New York: Van Nostrand Reinhold, New York, N.Y., 1995.

[4] Quittner, J., "Tim Berners-Lee: Scientists and Thinkers," http://www.time.com/time/ time 100/scientist/profile/bernerslee.html, *Time*, 2003.

[5] Guide to the POSIX Open System Environment (OSE) (ISO/IEC TR 14252:1996), International Organization for Standardization (ISO), 1996.

[6] Dargan, P., "Best Practices for Open System Challenges," http://www.stsc.hill.af.mil/crosstalk/1997/11/practices.asp, *CrossTalk*: *The Journal of Defense Software Engineering*, November 1997.

[7] *Department of Defense Technical Reference Model (TRM) Version 2.0,* http://www-trm.itsi.disa.mil/entirever2.pdf, DoD, April 9, 2001, pp. 5–50.

[8] *Department of Defense Technical Architecture Framework for Information Management (TAFIM) Version 3.0*, http://www-library.itsi.disa.mil/tafim/tafim3.0/pages/tafim_2.htm, Department of Defense (DoD) Defense Information Systems Agency (DISA), Vol. 2, 1996.

[9] *The Open Group Architecture Framework (TOGAF) version 8.0*, http://www.opengroup.org/architecture/togaf7/index7.htm, The Open Group, August 1, 2003.

[10] Dargan, P., "Open System Developments and Technology Trends," *Proceedings of the Software Technology Conference (STC 2000)*, May 2, 2000.

[11] "Technical Architecture Group (TAG) Charter," http://www.w3.org/2001/07/19-tag, World Wide Web Consortium (W3C), July 19, 2001.

[12] *ebXML Technical Architecture Specification v1.0.4*, http://www.ebxml.org/specs/ebTA_print.pdf, Technical Architecture Team, OASIS, February 16, 2001.

[13] Heywood, P., M. Jander, and S. Saunders, "Standards: The Inside Story – Do Vendors Have Too Much Influence on the Way Industry Specs Are Written and Ratified?" http://www. eng.nene.ac.uk/~amir/01-home/standards.htm, Data Communications Tutorial, March 1997.

[14] "Overview of the Standards Process," http://standards.ieee.org/faqs/train-list.html, IEEE, August 1, 2003.

[15] Bassetti, A., Bell. J., Cargill, C., et. al., "W3C Process Document," http://www.w3.org/2004/02/Process-20040205/cover.html#toc, W3C, February 5, 2004.

6. See Chapter 15, Section 15.2.8.

[16] Raggett, D., L. H. Arnaud, and I. Jacobs, "HTML 4.01 Specification," http://www.w3.org/TR/html401/, W3C, December 24, 1999.

[17] Meyers, C. B., and P. Oberndorf, *Managing Software Acquisition: Open Systems and COTS Products*, Reading, MA: Addison-Wesley Publishing Company, July 12, 2001.

[18] O'Reilly, T., "Lessons from Open-Source Software Development," *Communications of the ACM*, Vol. 42, Issue 4, April 1999, pp. 32–37.

[19] Kenwood, C. A., "A Business Case Study of Open Source Software," http://www.mitre.org/support/papers/tech_papers_01/kenwood_software/index.shtml, MITRE, Report No. MP01B0000048, July 2001.

[20] Newitz, A., "Abridged History of Linux," http://archives.cnn.com/2000/TECH/computing/02/11/mini.linux.history.idg/, CNN.com, February 11, 2000.

[21] Myser, M., "Linux and Open Source: Linux Standard Base Takes On Industry Fragmentation," http://www.eweek.com/article2/0,1759,1646006,00.asp, *eWeek*, September 14, 2004.

CHAPTER 3

Application Standards

3.1 E-Business (Electronic-Business)

Electronic-business, or e-business as it is more commonly called, has caused a paradigm shift that is driving companies to conduct their business on the Internet rather than meeting face-to-face. E-business includes buying, selling, and providing a variety of services on the Internet. Business-to-business (B2B) is an important aspect of e-business, as it provides the impetus for improving and expanding the Internet to support complex business transactions. B2B involves business processes between two or more business partners using digital technology, and it comprises collaboration, data exchanges, planning activities, trades, and execution of orders [1].

How does B2B work? As a simple example, suppose that company A distributes widgets manufactured by company B, and has just received an order for 100 more widgets. Company A would complete an electronic purchase order on-line via a business application (its own or company B's), and would send it via the Internet to company B. The purchase order would be sent automatically to company B's business process application for receiving and processing purchase orders. Suppose that company B's business process application determines from the purchase order that company A needs 100 more widgets within the next 7 days to meet their projected demand. Company B's business process application would then execute a series of internal business processes to determine if there are 100 more widgets available in the warehouse, or whether it needs to manufacture some number at their manufacturing site and ship from there.

Based on computed time estimates, company B's business application would determine the best method (or combination of methods) for shipping widgets to company A so that they can be received within the 7-day window. After company B's business application has finished executing its internal business processes and has calculated the solution, it would notify company A's business application that the order has been processed, and that 100 more widgets can be delivered in 6 days, and would request a corporate credit card number to charge the services. Company A may have decided *not* to automate the authorization process, inserting a human-in-the-loop at this point to review the computed solution before permitting the corporate credit card to be charged. Of course, if the 7-day window cannot be met, company B's business process application might alert a designated company A employee and request consideration of an alternate solution: 75 widgets to be delivered in 5 days, and the remaining 25 widgets to be delivered in 14 days.

The point of automating business processes is not to eliminate the human-in-the-loop, but rather, to enable employees to focus on handling exceptions, conduct monitoring functions, perform restocking, and conduct marketplace and business trends analyses. So understanding, depicting, and streamlining business processes has become paramount for developing automation for the Internet, and competing standards to automate business processes are emerging. Furthermore, since the Internet is still maturing and does not yet provide the level of security, robustness, and level of sophistication necessary to fully automate complex business processes, the W3C has begun defining a framework of Web Services. This framework is often referred to as the *Web Stack*, and it defines a set of layered services that companies are beginning to build upon to implement Internet-based, automated business processes (see Section 14.3 for a detailed discussion of the Web Services Architecture Stack).

The vision for the Web Stack has only been partially implemented, and since there are significant gaps in services, companies are buying tools that build on Web standards such as XML, the Simple Object Access Protocol (SOAP), and the Universal Description, Discovery and Integration (UDDI) protocol, and that include their own unique tool services so that companies can fully implement their business processes [2]. XML is used as the basis for defining how a company's data can be exchanged on the Internet with another company's application; SOAP defines the protocol for packaging the XML-based business process data and sending it to another company's business application on the Internet; and UDDI enables a company's automated business processes to be discovered and executed on the Internet by other companies' business applications [2].

Frustrated by nonstandard tools that lack the necessary interoperability with other business applications and lead to unique, stovepiped Internet applications, companies are clamoring for more Web Service standards to fill in the gaps. This section discusses six major standards efforts that offer varying levels of functionality, maturity, and support in the marketplace:

1. Business Process Execution Language (BPEL) formerly known as Business Process Execution Language for Web Services (BPEL4WS) under the auspices of Organization for the Advancement of Structured Information Standards (OASIS);
2. Business Process Modeling Language (BPML), Business Process Modeling Notation (BPMN), and Business Process Query Language (BPQL) by the Business Management Process Initiative (BPMI) organization;
3. eXtensible Markup Language (ebXML);
4. RosettaNet standards;
5. XML Process Definition Language (XPDL) by the Workflow Management Consortium (WfMC);
6. Web Services Choreography Interface (WSCI) under the auspices of the W3C.

3.1.1 Business Process Execution Language for Web Services

Name. Business Process Execution Language for Web Services (BPEL4WS).

Purpose. Extend Web Services by defining a language to specify business process models, interaction, and protocols.

History. IBM had originally defined a Web Services Flow Language (WSFL) and Microsoft had implemented a XLANG grammar for business processes, and the two companies combined their efforts and collaborated with BEA Systems, Inc., SAP AG, and Seibel to coauthor a specification [3]. The companies named the resulting specification BPEL4WS. At the heart of the language is the ability to model peer-to-peer interactions, or what some refer to as a *choreography* of synchronized interactions between applications to implement B2B processes that emulate real-world interactions [4].

In April 2003, they turned their specification over to OASIS [3, 4]. Sun Microsystems had led the development of a competing specification in its WSCI, which was provided to the W3C to refine and publish as a W3C standard (see Section 3.1.6) [3, 4].

Standards Organization. The OASIS Web Services Business Process Execution Language (WS-BPEL) Technical Committee (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel) is responsible for this standard.

Status. OASIS is continuing the work on BPEL4WS but has renamed it the Web Services Business Process Execution Language, which it refers to as WS-BPEL and BPEL. In addition, IBM and Seibel have developed BPELJ products that enable BPEL to be developed in Java.

Obtaining the Specification. An early version of the specification can be downloaded at URL: http://www-106.ibm.com/developerworks/webservices/library/ws-bpel/or URL: http://www-106.ibm.com/developerworks/webservices/library/ws-bpel/. Refer to the WS-BPEL OASIS Technical Committee Web site (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel) for an updated version, once it has been released to the public.

URL. http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel.

Vendors. IBM (http://www.ibm.com/), Microsoft (http://www.microsoft.com/), BEA Systems, Inc., (http://www.bea.com/), and Siebel (http://www.siebel.com) have implemented the original specification for BPEL4WS.

Other Sources of Information.

- Jean-Jacques Dupray provides a critique of this language and compares it with BPML at URL: http://www.ebpml.org/bpel4ws.htm. Note that these are Dupray's opinions and are not endorsed by OASIS or any other organization.
- IBM provides a series of articles on BPEL4WS at URL: http://www-106.ibm.com/developerworks/webservices/library/ws-bpelcol.html.

3.1.2 Business Process Modeling, Notation, and Language

Name. Business Process Modeling Language (BPML), Business Process Modeling Notation (BPMN) and, Business Process Query Language (BPQL).

Purpose. To define standards based on XML that provide a common notation and language for modeling business processes.

History. BPMI unified Microsoft's XLANG specification based on the Pi-Calculus model and IBM's WSFL based on Petri Nets into BPML version 1.0 that BPMI published as a first draft in 2000, and revised in 2001. At nearly the same time that BPMI was working on BPML, IBM and Microsoft were working with other companies to define BPEL4WS, which BPMI considers a subset of BPML [5].

Next, BPMI began working on a notation for business modeling in 2002, the BPMN, to enable business analysts to model their own business processes—rather than have a software developer do this—and use this as the foundation for working with the software developers to ensure that their business processes are correctly implemented on the Internet [6]. The BPMN specification was released to the public in May 2004. The BPMN diagram techniques are a form of *swim lane* diagrams (see Steve White's "Introduction to BMPN" at URL: http://www.bpmi.org/bpmi-downloads/Introduction_to_BPMN.pdf for details).

Standards Organization. The Business Process Management Initiative (http://www.bpmi.org) is responsible for defining these standards.

Status. BPMI expects to submit its developed specifications to a standards organization such as the Object Management Group to continue their evolution [6]. BPMI's standards efforts include:

- *BPML:* provides a meta-language to use for modeling business processes;
- *BPMN:* provides a notation for graphically depicting business processes and converting the notation to either BPML or BPEL4WS;
- *BPQL:* BPMI is defining BPQL as a standard management interface for deploying and executing business processes as Web Services on the Internet, and a first draft specification is forthcoming.

Obtaining the Specifications. The specifications can be downloaded from URL: http://www.bpmi.org/specifications.esp after personal information is provided.

URL. http://www.bpmi.org/specifications.esp.

- *BPML:* http://www.bpmi.org/bpml.esp;
- *BPMN:* http://www.bpmi.org/bpmn-spec.esp;
- *BPQL:* http://www.bpmi.org/bpql.esp.

Vendors. At URL: http://www.bpmn.org/BPMN_Supporters.htm, BPMI provides a list of BPMN users, current and planned implementations of BPMN, and service providers. A partial list of vendors includes:

- Intalio (http://www.intalio.com/) offers its n3 product suite.
- IDS Scheer (http://www.ids-scheer.com/) provides the ARIS product suite.
- Vision Software (http://www.visionsoftware.biz/) supports BizAgi®.
- Popkin Software's (http://www.popkin.com/) System Architect V9.1 and higher supports BPMN.

3.1.3 Electronic Business Using eXtensible Markup Language

Name. Electronic Business Using eXtensible Markup Language (ebXML).

Purpose. To define a framework in which to develop and execute e-business process applications around the world [7].

History. In September 1999, the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) kicked off a global initiative to define a standards-based framework based on XML that would facilitate the development and use of secure, international, and interoperable e-business applications [7]. UN/CEFACT worked with OASIS to develop ebXML, which was completed in May 2001 as part of a formal, international standardization process [7]. At that time, ebXML defined a framework of services to support the following [7]:

- Part 1. Technical Architecture (TA);
- Part 2. Business Process Specification Schema (BPSS);
- Part 3. Registry Information Model (RIM);
- Part 4. Registry services specification (RS);
- Part 5. ebXML requirements (REQ);
- Part 6. Collaboration Protocol Profile and Agreement specification (CPPA);
- Part 7. Message Service Specification (MS);
- Related specification: Core Component Technical Specification (CCTS).

Standards Organization. The ebXML standard was developed by UN/CEFACT (http://www.unece.org/cefact/) working with OASIS, and OASIS is responsible for maintaining and evolving ebXML (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ebxml-bp).

Status. OASIS is actively engaged in expanding ebXML for greater usability and has initiated a number of Technical Committees dedicated to that end:

- ebXML Collaboration Protocol Profiles at URL: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ebxml-cppa;
- ebXML Implementation, Interoperability, and Conformance at URL: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ebxml-iic;
- ebXML Messaging Services at URL: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ebxml-msg;
- ebXML Registry at URL: http://www.oasis-open.org/committees/ tc_home.php?wg_abbrev=regrep;
- ebXML Business Process Specification Schema at URL: http://www.ebxml.org/specs/ebBPSS.pdf.

Obtaining the Specifications. OASIS provides a number of specifications for ebXML at URL: http://www.ebxml.org/specs/index.htm. In addition, UN/CEFACT provides specifications for ebXML that can be downloaded by going to URL: http://www.unece.org/cefact/ and selecting the link for "ebXML specifications" from the leftmost frame on the window.

URL. http://www.ebxml.org/.

Vendors. A list of implementations of ebXML can be found at URL: http://www.ebxml.org/implementations/index.htm. In addition, a January 2004 press release at URL: http://www.ebusinessready.org/pdfs/eBusinessReady%20ebXML%203Q%20Release%2001.12.04%20Final.pdf indicates that the following products are certified for ebXML messaging:

- B2Binternet, Inc., (http://www.b2binternet.co.kr/): Xico ebXML Connector V1.0;
- BTrade, Inc., (http://www.btrade.com/): ebXML Connector v3.0;
- Cyclone Commerce (http://www.cyclonecommerce.com): Cyclone Interchange/Activator/Central v4.2 and v5.0;
- IPNet Solutions (http://www.inovis.com/): IPNet BizManager 2.5;
- SeeBeyond (http://www.seebeyond.com/): SeeBeyond ICAN Suite 5.0;
- Sterling Commerce (http://www.stercomm.com/): Gentran Integration Suite/Sterling Integrator v3.0;
- Sybase, Inc., (http://www.sybase.com/): Web Services Integrator Suite v2.6.

Other Sources of Information.

- OASIS provides articles and news releases on ebXML at URL: http://www.ebxml.org/news/ebXMLclippings.htm. In addition, OASIS provides its vision for a "Business Centric Methodology (BCM): Creating Practical Tools for Business Integration" at URL: http://www.oasis-open.org/ committees/download.php/5931/BCM%20Executive%20Brochure.pdf.
- WebServices.org provides an ebXML forum at URL: http://www.ebxmlforum.org/ that provides a number of current articles on ebXML.

3.1.4 RosettaNet

Name. RosettaNet.

Purpose. To define a suite of standards to support e-business exchanges [8].

History. The RosettaNet Consortium began an initiative in the fall of 2000 to produce XML-based B2B protocol standards that would support e-business collaboration between manufacturers and suppliers for the electronics industry [8]. Supply chain companies wanted standards to implement their e-business processes and did not feel that the Electronic Data Interchange (EDI) standards had gone far enough [9]. The RosettaNet Consortium used the complex supply chain business processes as a starting point for developing a set of generic processes that could serve as the basis for B2B applications [9]. The efforts were successful, and by May 2002 Intel Corporation had implemented an Intel Architecture Software Development Kit (IA SDK) based on RosettaNet standards, which it began using to conduct business transactions with its partners [10].

Standards Organization. RosettaNet Consortium.

Status. RosettaNet provides a suite of standards to support different e-business services:

- Partner Interface Processes (PIPs) define business processes that exchange messages between business applications via XML.
- Product and Partner Codes are used to provide identifiers for the trading partner companies and their products that are used in the PIPs.
- RosettaNet Dictionaries are used to define business properties for the trading partner transactions.
- RosettaNet Implementation Framework Core Specification (RNIF) provides the exchange protocols between trading partner servers using XML.

Obtaining the Specifications. RosettaNet specifications can be downloaded by making selections from the main URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?container=com.webridge.entity.Entity[OID[5F6606C8AD2BD411841F00C04F689339]]. Individual specifications comprise:

- PIPs at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity%5BOID%5B279B86B8022CD411841F00C04F689339%5D%5D;
- PIP directory specifications at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity%5BOID%5B9A6EEA233C5CD411843C00C04F689339%5D%5D;
- RosettaNet dictionaries at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity%5BOID%5B969B86B8022CD411841F00C04F689339%5D%5D;
- RNIF at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity%5BOID%5BAE9C86B8022CD411841F00C04F689339%5D%5D is used to transport the business messages;
- Product and partner codes at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity%5BOID%5BB19A86B8022CD411841F00C04F689339%5D%5D.

URL. http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?container=com.webridge.entity.Entity[OID[5F6606C8AD2BD411841F00C04F689339]].

Vendors. Intel Corporation (https://supplier2.intel.com/static/B2Bi/Rosettanet_Benefits.htm), Microsoft Corporation (http://www.computerworld.com/managementtopics/ebusiness/story/0,10801,71511,00.html), and IBM (http://www-306.ibm.com/software/websphere/crossworlds/library/doc/410/solutions/rosettanet/RN et.pdf).

Other Sources of Information. IBM provides a helpful article on using RosettaNet services at URL: http://www-106.ibm.com/developerworks/library/ws-rose1/?ca= dnt-428. This site also provides links to other interesting articles.

3.1.5 XML Process Definition Language

Name. XML Process Definition Language (XPDL).

Purpose. To define XML-based standards to provide a framework for implementing business process management [11].

History. The WfMC defined a detailed Workflow Reference Model more than 10 years ago that enabled business analysts and software developers to work together to understand and reengineer business models. It was considered a mature model, and its implementations employed a client-server architecture. As e-business and XML have risen to the forefront in business process management, WfMC saw a need in 2001 to revitalize the workflow reference model as a model based on XML that supports e-business processes [11]. The result of this effort was XPDL, which was developed in 15 months by a number of vendors and users and was completed in December 2002 [11].

Standards Organization. The WfMC is responsible for this standard.

Status. WfMC is establishing a Conformance Test Center in the United States to independently verify vendor product conformance to WfMC specifications for XPDL. Its Workflow Reference Model is available at URL: http://www.wfmc.org/standards/model.htm. WfMC offers a *Workflow Handbook* that describes the WfMC Reference Model and approach to workflows at URL: http://www.wfmc.org/information/info.htm (note that there is a fee to download the handbook). XPDL has been implemented by a number of vendors in their business process modeling tool suites.

To support XPDL, WfMC has defined a workflow process protocol known as WfMC-XML, which has evolved to maintain currency with evolving protocols, transitioning from the early IETF Simple Workflow Access Protocol (SWAP) in 1997 (before XML had been defined) to SOAP after the W3C defined it to support XML and Web Services [12]. More recently, WfMC-XML was updated to leverage a protocol defined by OASIS, the Asynchronous Service Access Protocol (ASAP). ASAP was defined by OASIS as a Web Services protocol that is based on XML and SOAP, to provide asynchronous interfaces between processes on remote computers [12]. WfMC-XML employs ASAP to support workflow activities between users and applications on remote computers [12].

Obtaining the Specifications. A link to the specifications for this standard can be found at URL: http://www.wfmc.org/standards/docs.htm and at URL: http://www.wfmc.org/standards/docs/xpdl_010522..pdf.

URL. http://www.wfmc.org/standards/XPDL.htm.

Vendors. WfMC provides a list of vendors that support XPDL at URL: http://www.wfmc.org/standards/XPDL.htm, which includes Fujitsu, Oracle9i Warehouse Builder, WfMOpen OpenSource workflow engine, and Zaplet 3 Process Builder.

Other Sources of Information. WfMC has linked white papers on various subjects at URL: http://www.wfmc.org/standards/docs.htm, which can be reviewed for additional information. In addition, it sells the *Workflow Handbook 2003* (http://www.wfmc.org/information/handbook03.htm), which describes the WfMC workflow standards in detail.

3.1.6 Web Services Choreography Interface

Name. Web Services Choreography Interface (WSCI).

Purpose. To provide a foundation for XML-based interaction between business partners by prescribing an order for the messages to be sent and received between them (choreography) to accomplish the business processes [13].

History. While IBM and Microsoft were leading efforts to define BPEL4WS, Sun Microsystems, BEA Systems, Intalio, and SAP developed the WSCI specification [13]. These companies perceived limitations in Web Services (see http://xml.coverpages.org/wsci.html for a detailed description) and defined WSCI to provide synchronized message interaction (collaboration) between business partner applications as a means for emulating more complex, real-world business processes [13]. The specification, which was completed in June 2002, was submitted in August 2002 to the W3C for their oversight.

Standards Organization. The W3C Choreography Working Group (http://www.w3c.org/2002/ws/chor/) is responsible for this standard.

Status. At the time that this book was written, the W3C was developing three specifications: Web Services Choreography Requirements, Web Services Choreography Model Overview, and the Web Services Choreography Description Language.

Obtaining the Specifications. The specifications for WSCI can be downloaded at URL: http://www.w3c.org/2002/ws/chor/. The original specification submitted to the W3C can be viewed at URL: http://www.w3.org/TR/wsci/.

URL. http://www.w3c.org/2002/ws/chor/.

Vendors. Vendors are awaiting the release of the specifications from W3C.

3.2 Ontologies

With the emergence of e-business processes as a component of Web Services, it is becoming imperative that business processes be automated as models of the real world that business people can recognize, relate to, and even define. For decades, business people have tolerated stovepiped software applications that were difficult to use because user interfaces were anything but intuitive. For some time, there was a push toward *natural language* interfaces that would eliminate this concern, but the technologies were not mature enough to overcome it.

Today, the software community is beginning to emphasize the importance of understanding the *ontology* that business people use in their business processes, and also to recognize that it is a necessary aspect of defining business process applications that business people can quickly understand and use.

An ontology is defined as a vocabulary of basic terms and a precise definition of what the terms mean *within the context of the domain that uses them* [14]. This is an important distinction for semantics, where a term may have a particular definition in one domain, but an entirely different definition in another domain.

Ontology.org was formed in 1998 under the sponsorship of Computer Sciences Corporation to focus on ontology issues that arise in the application of commerce on the Internet, and to consider how ontologies might be incorporated in XML-based architectures [14]. Ontology.org believes that the primary obstacle to electronic commerce is the difficulty applications have in sharing meaningful information [15]. Hence, Ontology.org is collaborating with CommerceNet (http://www.commerce.net/), a not-for-profit international community, on these issues. For more information, refer to Ontology.org's article "The Need for Shared Ontology" at URL: http://www.ontology.org/main/page1.html.

The W3C is also actively engaged in defining ontologies as part of their Semantic Web effort for the future World Wide Web (refer to Chapter 14, Section 14.3.1 for more information about the Semantic Web).

Recognizing the need to build domain ontologies is only a first step in starting to define standards for them. This area will continue to grow in importance as organizations define and populate metadata for repositories using standard ontologies, and then work on expanding ontologies to define and implement common business processes for Web Services. Currently, the efforts show potential for yielding promising technologies, but they are not yet mature enough to provide a history, list of vendors and products, and set of applications. So stay tuned.

References

[1] "What is B2B?" http://www.it-director.com/article.php?id=1463, IT-Director.com, Bloor Research, January 31, 2001.

[2] Howarth, F., "Web Services: Coming to an Organisation Near You," http://www.it-director.com/article.php?articleid=11601, IT-Director.com, Bloor Research, January 23, 2004.

[3] Sliwa, C., "Division over Web Services Standards Work Stirs Debate: IBM, Microsoft Choose OASIS over W3C," http://www.computerworld.com/developmenttopics/development/webservices/story/0,10801,80941,00.html, *ComputerWorld*, May 5, 2003.

[4] Krill, P., "OASIS to Get BPEL4WS Jurisdiction: Web Services Spec Finally Goes to Standards Body," http://www.infoworld.com/article/03/04/15/HNbpel_1.html, *InfoWorld*, April 15, 2003.

[5] "BPML/BPEL4WS: A Convergence Path Toward a Standard BPM Stack," http://www.bpmi.org/downloads/BPML-BPEL4WS.pdf, Position Paper, BPMI, August 15, 2002.

[6] White, S., "Introduction to BPMN," http://www.bpmi.org/bpmn-spec.esp, BPMI, May 2004.

[7] "Electronic Business eXtensible Mark-up Language (ebXML)," http://www.unece.org/cefact/, United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), 2003.

[8] Songini, M. L., "Lack of Standards Blocks Supply-Chain Automation," http://www.computerworld.com/softwaretopics/erp/story/0,10801,59259,00.html, *ComputerWorld*, April 5, 2001.

[9] Kay, R., "RosettaNet," http://www.computerworld.com/managementtopics/ebusiness/story/0,10801,83809,00.html, *ComputerWorld*, August 11, 2003.

[10] Neel, D., "Intel Ships RosettaNet Tools," http://www.computerworld.com/management-topics/ebusiness/story/0,10801,71511,00.html, *InfoWorld*, May 24, 2002.

[11] "WfMC Announces Release of Workflow Standard XML Process Definition Language," http://www.wfmc.org/pr/XPDL_10_Release.pdf, News Release, WfMC, December 5, 2002.

[12] DeJean, D., "WfMC Brings Standard Protocols to BPM," http://www.enterpriseappspipe-line.com/showArticle.jhtml?articleID=22100906, *enterpriseappspipeline*, June 18, 2004.

[13] "BEA, Intalio, SAP, Sun Publish Web Services Choreography Interface, Take Web Services Collaboration to New Level: New XML-Based Specification Helps Developers Build Web Services for Open Application to Application Collaboration," http://www.sun.com/smi/Press/sunflash/2002-06/sunflash.20020626.3.html, News Release, Sun Microsystems, June 26, 2002.

[14] "Ontology.Org: Frequently Asked Questions," http://www.ontology.org/main/papers/faq.html, Ontology.Org, May 31, 2004.

[15] "The Need for Shared Ontology," at URL: http://www.ontology.org/main/page1.html, Ontology.Org, May 2004.

CHAPTER 4

Communications Standards

Why include a chapter on communications? There are already a number of books devoted to the subject—dictionaries, encyclopedias, books on particular communications topics, books that describe specific communications technologies in detail, and so on. This chapter is not a substitute for these books nor is its intent to cover every single communications standard in existence. This chapter is intended to provide the software professional with a basic understanding of what are considered major communications standards and those that represent new and important developments.

Communications address the transmission of data (e.g., alphanumeric text, voice, and video) from one object to another, and involve a sender, recipient, a protocol, and a medium for exchanging data. To communicate with other computers and share resources, computers need networks—the collection of computer equipment and devices connected by some means to exchange data. There are literally hundreds of standards for communications. This chapter covers prominent families of standards for computer networking such as the Internet, as well as emerging standards that are growing in popularity. In order to appreciate just why there are so many standards, it is important to provide some background.

In the 1970s, networking systems were chiefly proprietary and closed; they supported communications only between a vendor's own product lines. If a vendor added interfaces to another vendor's product lines, the software and hardware modifications required could become both costly and time consuming to accomplish, not to mention the extra expense for continued revisions to accommodate the other vendor's upgrades. Unaware of the potential for problems, industry and government organizations procured heterogeneous computers and peripheral devices from multiple vendors to widen the variety of enterprise functions available on their networks, only to discover that many had never been designed to connect to other networks. The heterogeneous computers and devices worked only with their vendor's product lines.

The demand grew for multivendor product compatibility and the ability to internetwork. By 1977, organizations from countries around the world had approached the ISO and asked for a solution. At the ISO's first meeting to address this growing concern, members of the ISO Technical Committee 97/Subcommittee 16 decided that a reference model that provided a generic architecture for communications would provide a starting point for a general solution [1]. This model would describe a layered network architecture that supported "the concept of 'open-ness'…[using] a set of commonly agreed [upon] standards that…[would make] possible meaningful [sic] interactions between any combination of computing systems, data processing systems, or human operators which are connected together in some way" [1]. ISO's intent was to provide a family of standards that vendors would use to interconnect heterogeneous computers and devices.

The ISO Reference Model (Figure 4.1), published in 1984, is the result of these efforts. It is shown here to provide a general framework for describing the communications standards in this chapter [2].

There are seven layers in this model[1]:

- *Application—Layer 7:* The application layer provides application programs (e.g., services to transfer files, manage e-mail, and manage the network) with access to a network [2]. This layer includes the protocols to interface with application programs, the presentation layer, and other networks' application layer services [2].
- *Presentation—Layer 6:* This layer includes the services and protocols necessary to convert data from the session layer into a format and data type (such as packets[2]) that can be readily used by application programs or users [2]. The presentation layer sends the packets to the application layer.

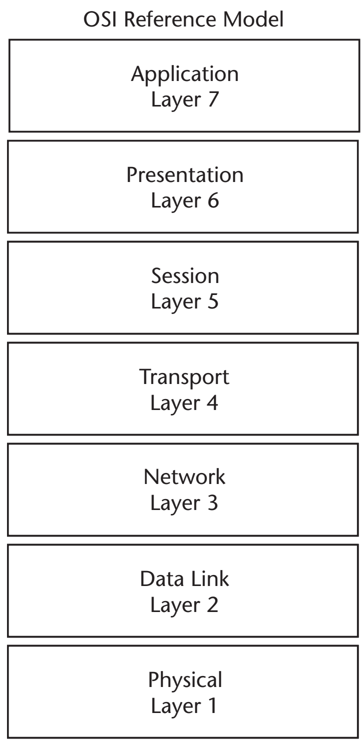

Figure 4.1 OSI Reference Model.

1. For a more detailed treatment of the seven layers, refer to the "OSI Layers" section of Werner Feibel's *Novell's Complete Encyclopedia of Networking* (pages 727–735), published by Novell Press. Even though it is outdated, this book remains an excellent resource for networking concepts [2].
2. A packet is a variable or fixed block of bytes that includes a header, the data, and a trailer.

- *Session—Layer 5:* The session layer synchronizes and sequences the data packets and the communications to transmit/receive the packets in a network transmission [2]. The services in this layer ensure that the connection is maintained from beginning to completion, and that the connection is reliable [2].
- *Transport—Layer 4:* The transport layer ensures that the data transfer achieves the required quality, such as transmission speed and error rate, and it guarantees delivery [2]. Transport services number the packets that are to be transmitted by the lower layers, ensure that all packets are delivered, and, if necessary, put the packets into the correct order before the recipient receives them [2].

The network, data link, and physical layers are called the *subnet* layers, meaning that they are responsible for actually moving the packets from the sender's physical location to the recipient's physical destination [2].

- *Network—Layer 3:* The network layer services determine a path to transmit the packets between either the source and destination or intermediate locations; translate network addresses to physical locations to communicate across networks as needed; and establish and maintain a connection between the two locations (either the sender and receiver, or their intermediate locations) [2]. Layer 3 protocols include address resolution and routing [2]. Address resolution protocols determine the physical network addresses, and routing protocols address moving packets from one network to another local network [2].
- *Data Link—Layer 2:* This layer creates the data as packets to be sent and transmitted [2]. It also labels, packages, transmits, and receives them from the physical layer [2].
- *Physical—Layer 1:* The physical layer converts the data packets from the data link layer into the digital signals that it sends to a destination location, and it also converts digital signals received into packets that it passes to the data link layer [2]. This layer includes the physical devices such as cable (e.g., coaxial, twisted pair, fiber optic), connectors, pin assignments, and digital signals [2].

The sections below cover standards that address different aspects of computer communications using twisted pair and coaxial cable, fiber optics, and radio waves (wireless).

4.1 Asynchronous Transfer Mode

Name. Asynchronous Transfer Mode (ATM).

Purpose. To define a physical network structure, a *switching fabric*, with "the ability to switch all forms of traffic [asynchronously] at extremely high speeds, while maximizing the use of bandwidth," and over long distances [3].

To understand the purpose of ATM, a few definitions are in order. A *switch* is a device that joins multiple computers together at a low-level network protocol layer, at the data link layer of the OSI model. It determines the destination address for incoming data and sets up a transmission path on the network to move the data between the incoming and outgoing physical communications *ports* and *links* [4]. A switch operates primarily at the data link (layer 2) and physical (layer 1) layers of the OSI Reference Model.

A *port* is the "physical interface between a device [such as switch, a computer, or a printer] and [a] circuit," and a link joins a "point of connection in a network," also called a node of one subnet to a node in another subnet [4].

Asynchronous refers to the manner in which the data is transmitted. One way to understand this is to discuss the opposite form of transmission, *synchronous*, where the data is separated into a subset of data such as packets, and then transmitted from the first to the last packet in sequential order in a timed sequence. Asynchronous transmission also separates the data into packets, but does not send them in a timed sequence but at irregular intervals as the need to transmit arises. To enable the recipient to distinguish where a packet begins and ends, this mode of transmission includes a start bit at the beginning and a stop bit at the end of the packet.

History. Prior to the 1980's, telephone companies built international wide area networks (WANs) using copper cables for voice communications, but they began to encounter significant bandwidth limitations as the number of customers increased [3]. So the telephone companies began upgrading their systems to use fiber optics as a means for increasing the bandwidth and performance for voice; they did not consider support for computer communications [3]. Concurrently, industry began linking their computer networks over long distances using these telephone fiber optic systems, but since telephone networks were optimized for analog rather than digital data communications there were problems connecting computers (e.g., noisy lines, delays in data transmissions, and loss of data) [3]. What was needed were networks that could support voice, video, and data communications on high-performance networks over long distances, with standards for interconnecting [3].

In the 1980s, the International Telephone and Telegraph Consultative Committee (CCITT)—now the International Telecommunication Union (ITU) Telecommunications Standardization Sector[3]—began working on defining standards for an intelligent, high-performance network based on fiber optics [3]. They defined a Broadband[4] Integrated Services Digital Network (B-ISDN) standard in 1986 and then began working on defining the lower-level, complementary standards [3]. ATM was one of those standards, and it was required to provide an intelligent switching fabric for broadband [3]. To focus on its development, the ATM Forum was established, and it published the first ATM specification in July 1991 [3].

Standards Organization. The ATM Forum is responsible for maintaining this standard (http://www.atmforum.org/).

Status. ATM is a widely used broadband standard for high bandwidth transmission over fiber-based networks. It is used as a *network backbone*, the collection of wires or cables that connect a set of networks [WANs, local area networks (LANs),

3. For information on this sector, refer to Chapter 15, Section 15.1.6 on ITU.

4. *Broadband* is a type of transmission that can carry multiple signals at different frequencies on a single medium. Cable television is an example of a technology that uses this form of transmission.

and metropolitan area networks (MANs)], enabling them to communicate and share data without interfering with their routine operations. Today, ATM interconnects networks based on the Internet, Gigabit Ethernet, Digital Subscriber Line (DSL), wireless technologies, and the Synchronous Optical Network (SONET).

ATM relies on the *packet-switching* transmission method, where the transfer of a packet uses any available path to travel to the destination, leaving that path available once the transfer is complete [2]. Hence, packets for the same transmission may take different paths and arrive at the destination in a different order than sent [2]. This mode of transmission is used to speed the delivery of packets. ATM packets use a fixed length and are referred to as *cells* [2].

The ATM architecture consists of a set of standards that comprise three layers[5]:

1. *ATM adaptation layer:* performs protocol translation for voice, video, and/or data traffic between user/node applications and ATM (i.e., translates voice, video, and data traffic into ATM packets known as "cells") [2];
2. *ATM layer:* supports the kinds of services described in the OSI Reference Model Data Link layer (e.g., establishing virtual connections, creating and transmitting packets) [2];
3. *Physical layer:* similar to the physical layer in the OSI Reference Model [2];

The ATM Forum continues to expand the ATM specifications to address new and emerging communications technologies.

Obtaining the Specifications. There are a number of ATM specifications, as the development of this standard continues. These are available at URL: http://www.atmforum.com/standards/approved.html.

URL. http://www.atmforum.com/news/releases.html.

Vendors. A partial list of vendors includes:

- Cisco (http://www.cisco.com/en/US/products/hw/switches/ps1893/index.html);
- Ciena (http://www.ciena.com/solutions/atmfr.htm);
- Nortel (http://www.nortelnetworks.com/index.html);
- Qwest Communications (http://www.qwest.com/).

Other Sources of Information.

- The nonprofit International Engineering Consortium provides free Web-based tutorials for the communications and information industries, including ATM, after registering, at URL: http://www.iec.org/online/tutorials/. One of the tutorials is entitled "Asynchronous Transfer Mode (ATM) Fundamentals," and it can be downloaded at URL: http://www.iec.org/online/tutorials/acrobat/atm_fund.pdf. Another is entitled "Accelerating the Deployment of Voice over IP (VoIP) and Voice over ATM (VoATM)," found at URL: http://www.iec.org/online/tutorials/voip_voatm/.

5. Refer to the "ATM User Network Interface (UNI) Specification Version 4.1" document prepared by the ATM Forum at URL: ftp://ftp.atmforum.com/pub/approved-specs/af-arch-0193.000.pdf for a detailed description of the architecture.

- For general material on telecommunications and networking concepts as well as older communications standards refer to *Novell's Complete Encyclopedia of Networking* by Werner Feibel published by Novell Press in 2000.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies on their Web site. They also provide a "Network Design Manual" at URL: http://www.networkcomputing.com/netdesign/series.htm that covers a number of topics under the "Infrastructure" heading, including "Building an ATM Wide Area Network."
- Alcatel has written a paper entitled "ATM in the Next Generation Network," http://www.alcatel.com/industry_analysts/pdf/mpls_atm_a4.pdf, from August 2001, that discusses "ATM - MPLS Mediation," mediating ATM traffic using multiprotocol label switching (MPLS). MPLS is covered in Section 4.7 of this chapter.

4.2 Ethernet (IEEE 802.3)

Name. Ethernet (IEEE 802.3).

Purpose. Originally intended only to connect Xerox *ALTO* personal computers, its purpose expanded to provide an industry-wide standard for LANs [5].

History. The history of Ethernet begins with Norm Abramson (http://www.hicss.hawaii.edu/hicss_31/specpl3.html), a professor at the University of Electrical Engineering and Computer Science at the University of Hawaii who led the design and implementation of the ALOHA System network in the 1960s [5]. The ALOHA System was a two-way packet-based radio broadcast system that enabled terminals and card readers on ships at sea and on the Hawaiian islands to connect to the university's IBM 360 mainframe [6]. Abramson published a number of papers on ALOHA System concepts in the 1970s, and his work provided a foundation for today's packet-based local area networks, including Ethernet [6].

Robert (Bob) Metcalfe had begun working as a network specialist at the Xerox Palo Alto Research Center (PARC) in 1972, and his first task was to connect Xerox's *ALTO* computer, a personal computer, to the ARPANET [6].[6] Metcalfe read one of the papers that Abramson had published on the Aloha System, and began working with his colleague David Boggs to employ some of those concepts as the basis for designing the *ALTO ALOHA* Network, considered the first LAN for personal computers [6]. The *ALTO ALOHA* Network connected a number of *ALTO* computers on coaxial cable and enabled them to share a laser printer [6]. The date that the *ALTO ALOHA* Network first ran was on May 22, 1973, and on that same day Metcalfe changed its name to *Ethernet* because it was through "ether" that the "electromagnetic radiation was thought to propagate" [6].

6. The Internet evolved from the ARPANET, which was a communications network sponsored by the Department of Defense's Advanced Research Projects Agency (ARPA, now named DARPA) and constructed by BBN in 1969 that connected university researchers and engineers. See Section 4.5 for a more detailed description.

In the ALOHA Network, the mainframe station would broadcast transmissions to the stations ships at sea and on the Hawaiian Islands [6]. A remote station would transmit a message back to the mainframe station using the same frequency and wait for an acknowledgment from the mainframe within a particular period of time [6]. If no acknowledgment was received, then the remote station would assume that a *collision* had occurred with another remote station's message, corrupting its message, and that station would retransmit within a random period of time [6].

Metcalfe had refined the ALOHA Network algorithm for the Ethernet LAN, inventing a concept known as *carrier-sense* in which a node in a network first checks to ensure that no other transmissions are being sent before transmitting its own [6]. Metcalfe and three colleagues refined the concept and received a patent for it in 1977, using it for Ethernet, and naming it Carrier-Sense Multiple Access with Collision Detection (CSMA/CD) [6]. CSMA/CD is a technique for transmission where a device on a network waits until the network is free of signals from other devices before it transmits its message [6]. If a collision occurs with another device's message, then each of the devices waits for a specified time period (an algorithm is used to determine a suitable time period for each device) and then transmits again.

Beginning in 1979, the Digital Equipment Corporation (DEC), Intel Corporation, and Xerox began working together to define a standard for Ethernet [6]. They worked out an arrangement: DEC would provide system engineering and supply the hardware, Intel would provide Ethernet integrated circuit *building blocks*, and Xerox would develop the Ethernet products [6]. Together, they published the DEC, Intel, and Xerox (DIX) Ethernet Version 1.0 specification in 1979; they refined it and published the Version 2.0 specification in 1982 [6].

In 1981, Project 802 of the IEEE established the 802.3 subcommittee to develop and publish an international standard for LANs based on the DIX specification [6]. Xerox gave IEEE the rights to license Ethernet and gave its patents to the IEEE [6]. In 1983, this subcommittee published the IEEE 10BASE5 (10 Mbps for 500m distances between nodes) standard for Ethernet, which the ISO approved as an international standard in 1989 as ISO 8802 [6].

Standards Organization. The IEEE 802.3 Subcommittee (http://ieee802.org/3/) is responsible for maintaining this standard.

Status. Ethernet is widely used for implementing LANs. Its architecture provides a network backbone that supports services in the data-link and physical layers of the OSI Reference Model [2]. The IEEE 802.3 subcommittee provides URL: http://standards.ieee.org/cgi-bin/status?802 and http://ieee802.org/3/ for a current status of the specifications. Over the years, this subcommittee has developed numerous specifications to improve Ethernet performance. The following partial list of standards marks major performance milestones:

- *10BASE5:* the original IEEE 802.3 standard for LAN transmissions at 10 Mbps for 500m distances between nodes;
- *10Base-T:* the IEEE 802.3i standard for LAN transmissions at 10 Mbps performance over unshielded, twisted pair (UTP) telephone cables [6];

- *100Base-T (Fast Ethernet):* the standard for 100-Mbps Ethernet transmissions. The 100Base-T specification was developed in 1993 by the Fast Ethernet Alliance, composed of such companies as Intel, Grand Junction, Sun Microsystems, and 3Com [6]. The Fast Ethernet Alliance formed because its members had been frustrated by the slow pace at which the IEEE 802.3 subcommittee was defining the fast Ethernet standard [6]. After the Fast Ethernet Alliance defined a specification, members began shipping products for it in late 1994 [6]. In March 1995, the IEEE approved their specification as IEEE 802.3u, and the Fast Ethernet Alliance disbanded [6];
- *1000BASE-T, 1000BASE-SX, and 1000BASE-CX (Gigabit Ethernet):* standards that support 1,000-Mbps or 1-Gbps Ethernet transmissions. In May 1996, many of the same member companies that had belonged to the Fast Ethernet Alliance formed a Gigabit Ethernet Alliance (GEA) to work on an even higher speed Ethernet [6]. Their first products were demonstrated in the fall of September 1996, and the specification was turned over to the IEEE 802.3z Working Group which refined the specification to include three standards for cabling and published the specifications as IEEE 802.3z in 1998:
    - *1000BASE-X:* media-independent interfaces based on fiber channel technology [2];
    - *1000BASE-SX and LX:* fiber optics (short wave laser optics are denoted by SX and long wave laser optics with LX);
    - *1000BASE-CX:* high-quality copper cables.
- *10GbE (10 Gigabit Ethernet):* In 1999, the 10 Gigabit Alliance (http://www.10gea.org/) formed and included many of the same companies that had supported the GEA (http://www.10gea.org/about_classifications.htm) [7]. They completed the specification in 2002 and turned it over to the IEEE 802.3ae subcommittee, which refined and published it in June 2002 (http://standards.ieee.org/announcements/8023aeapp.html). They then dissolved the 10 Gigabit Alliance in 2003 [7]. The 10 Gigabit Alliance maintains a copy of the white papers they have written for reference at URL: http://www.10gea.org/Tech-whitepapers.htm#10%20Gigabit%20Ethernet %20Technology%20Timeline.

Obtaining the Specifications. The IEEE 802.3 standards can be purchased from the IEEE store by going to URL: http://shop.ieee.org/ieeestore/ and entering “802.3” in the search for products and “standards” for the product type. Some of the standards may be available for free from *Get IEEE 802* at URL: http://standards.ieee.org/getieee802/. In addition, the ISO provides the specifications for ISO 8802 for a fee by going to URL: http://www.iso.org/iso/en/CatalogueListPage.CatalogueList and entering “8802” for the ISO number:

- ISO/IEC TR 8802-1:2001: Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 1: Overview of local area network standards;
- ISO/IEC 8802-2:1998: Information technology – Telecommunications and information exchange between systems – Local and metropolitan area

networks – Specific requirements – Part 2: Logical link control, with the Corrigendum (update) provided by ISO/IEC 8802-2:1998/Cor 1:2000;

- ISO/IEC 8802-3:2000: Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

URL. http://standards.ieee.org/cgi-bin/status?802 and http://ieee802.org/3/.

Vendors. The *Online Industrial Ethernet Book* (http://ethernet.industrial-networking.com/products/intro.asp) allows users to search for products and manufacturers on their Web site. As a partial list, Intel continues to provide Ethernet components (http://www.intel.com/), and Sun Microsystems supports Ethernet for its computer products (htttp://www.sun.com/).

Other Sources of Information.

- Robert Metcalfe and David Boggs coauthored "Ethernet: Distributed Packet Switching for Local Computer Networks," in the *Communications of the ACM*, Vol. 19, No. 7, July 1976, pp. 395–404, which describes the Ethernet concepts they had invented.
- Matt Hamblin interviewed Robert Metcalfe, the inventor of Ethernet, in a *ComputerWorld* article published in 2003 at URL: http://www.computerworld.com/networkingtopics/networking/story/0,10801,81274,00.html.
- Robert Breyer and Sean Riley coauthored a comprehensive book on Ethernet entitled *Switched, Fast, and Gigabit Ethernet, Third Edition: Understanding, Building, and Managing High-Performance Ethernet Networks*, which was published by the Macmillan Network Architecture and Development Series in 2002.
- O'Reilly Media sponsors a Web site where Charles E. Spurgeon provides information about Ethernet at URL: http://www.ethermanage.com/. Spurgeon also wrote the book *Ethernet: The Definitive Guide*, published by O'Reilly and Associates.
- For more information on the ALOHA System, refer to Dr. Abramson's paper, "Development of the ALOHANET," published in *IEEE Transactions*, Vol. 31, No. 2, March 1985, pp. 119–123.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies on their Web site.

4.3 Fiber Distributed Data Interface

Name. Fiber distributed data interface (FDDI).

Purpose. To define an architecture that specifies a 100-Mbps fiber-based network backbone [2].

History. In the 1980s, the ANSI X3T9.5 Committee began developing a specification for the FDDI architecture and services based on the IBM token ring architecture [2]. So while DEC, Intel Corporation, and Xerox were involved in defining and refining Ethernet LANs, IBM had engaged in developing token ring LANs as a competing architecture [8].

When the token ring architecture was first introduced, the computing devices were physically connected to a closed ring of cables (Figure 4.2) [8]. However, there were difficulties with this approach. When any of the devices was turned off, disconnected, or not working for some reason, the network would no longer operate because the ring connection was broken. To counteract this, IBM changed the *physical* architecture so that the devices would be connected in a *star* formation to a multistation access unit in the center, and this multistation access unit would manage the connections [8]. Hence, if a device were turned off but the multistation access unit was still on, then the multistation access unit would close that device's connection to the network, and the network would remain operational. As token ring technologies improved, the services treated the network devices as if they belonged to a ring formation (the logical architecture), but the physical topology that connected the devices used a star formation.

A *token* is passed from one device to another in the ring until it reaches its intended destination. A token is a signal that contains a fixed number of bits that indicate whether a device owns the token or it is available for use, the type of data the token contains, the data itself, and the device to which the token is being sent. The recipient device updates the token to indicate that the token was received, passes the updated token to the next device on the ring, and the next device passes the token along, and so on, until the token reaches the *monitor* [8]. The monitor is a device on the network that acts as a traffic cop: sets priorities for devices, ensures that tokens arrive at their proper destinations, resets tokens so that they

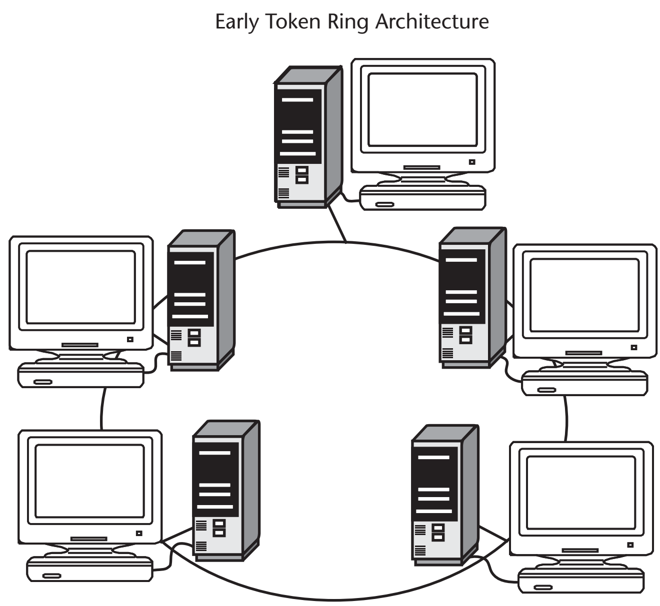

Figure 4.2 Early token ring architecture.

are free, and sends free tokens along the ring so that new messages can be transmitted on the network [8].

If a device wants to send a message to another device, it waits until a token is free, updates that token with the appropriate information, and then transmits it to the next device in the ring. The token continues to be transmitted from one device to another until it reaches its destination. Then the system updates the token to indicate the token was received, and passes the updated token along the ring back to the monitor.

The token ring approach for sending data is inherently different than that of CSMA/CD. With CSMA/CD, a device in a network listens to determine if any other device is sending a signal, and if it is, it waits until a specified period of time has elapsed before sending a message, to avoid a collision with another message.

At the time that development of FDDI began, industry demanded high-speed network backbones that exceeded the limitations of the prevailing twisted pair and coaxial cables: 10 Mbps for throughput and 1,500m maximum cable lengths [2, 9]. Many vendors believed that a fiber-based network backbone would exceed the speeds of twisted pair and coaxial cables [2]. ANSI defined a fiber backbone architecture for FDDI that supported the data-link and physical layers of the OSI Reference Model, and operated at 100 Mbps with a distance of up to 124 miles for a single ring and 100 miles for a dual token ring, where a second ring was used to support redundancy [2].

ANSI submitted its FDDI specification to ISO, and ISO published it as ISO 9314-1 and ISO 9314-2 in 1989. After that, ISO combined its efforts with the International Electrotechnical Commission (IEC) and published the following ANSI specifications as ISO/IEC 9314.

Standards Organization. ISO/IEC (http://www.iso.org/) is responsible for maintaining the FDDI family of specifications.

Status. ANSI developed an extension to FDDI called FDDI II, which enabled voice, video, and data to be carried on a network. FDDI products for MANs and LANs flourished in the late 1980s through the mid-1990s because there were relatively few products that could compete with their high performance, reliability and maturity [10]. However, with the advent of ATM and Gigabit Ethernet in the late 1990s, where newer technologies offered higher performance at a lower cost, the market for FDDI products declined [9].

Obtaining the Specifications. The specifications can be obtained from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html, and entering either "FDDI", "9314", or "10608". Note that the ISO/IEC ISP 10608 series defines FDDI standards for LANs. They can also be purchased from the ANSI Standards Store at URL: http://webstore.ansi.org/ansidocstore/find.asp? by entering "FDDI" for the search string.

URL. No official Web site is provided for a status of FDDI standards.

Vendors. Many of the vendors that used to support FDDI products, such as Nortel, no longer do so. However, Cisco Systems (http://www.cisco.com/) and IBM (http://www.ibm.com/) do offer support for products.

4.4 Frame Relay

Name. Frame relay.

Purpose. To provide a high-performance, packet switching protocol to transfer data packets between LANs, MANs, and WANs [8].

History. In the 1980s, industry was demanding higher performance and faster networks than was available from telephone network systems [8]. Several companies developed products for *frame relay* technologies that supported packet switching using *frames* (a form of data packets) that were transmitted between LANs and WANs [8]. When first introduced, frame relay product transmission speeds could range from 64 Kbps up to 2 Mbps [8]. Using the products as a basis, several specifications for frame relay were submitted to CCITT (now ITU-T) for standards as early as 1984, but the lack of interoperability between the products delayed marketplace acceptance and standardization [9].

It was not until 1990 that Cisco, DEC, Northern Telecom, and Stratacom established a consortium to focus on the development of frame relay technologies and developed a specification that extended the frame relay protocol that CCITT was considering at that time [9]. ANSI and CCITT refined and standardized this specification [9].

Standards Organization. ITU-T (http://www.itu.int/) is responsible for maintaining this standard.

Status. The original frame relay products were designed to support the Integrated Services Digital Network (ISDN) standard for transmitting data over WANs, but over time, the capabilities were extended to connect LANs and WANs [2]. Frame relay technologies support the first two layers of the OSI reference Model (physical and data link) [9]. ANSI and CCITT both published frame relay specifications in the 1990s: ANSI published the primary specifications as T1.606, T1.617, and T1.618, and ITU-T published similar specifications for frame relay as I.233, I.370, Q.920, and Q.922 [2].

A number of vendors established the Frame Relay Forum in May 1991 as a non-profit organization to speed the deployment of frame relay products [11]. By 1996, frame relay networks were very popular and widely used for long haul services on T1 and T3 leased lines [12]. Today, frame relay technologies remain widely used for *convergent networks* that support both voice and data communications over the networks. It is important to note that in April 2003, the Frame Relay Forum merged with the Multiprotocol Label Switching Forum to become the MPLS and Frame Relay Alliance (see URL: http://www.mplsforum.org/about/index.shtml), to ensure that MPLS technologies integrate with frame relay and eventually replace it [11].

Obtaining the Specifications. The family of specifications for frame relay can be obtained from ITU at URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC and searching for "frame relay". General specifications for frame relay can be found in the specifications for I.233 and Q.920 through Q.922 [2]. They can also be purchased from the ANSI Standards Store at URL: http://webstore.ansi.org/ansidocstore/find.asp? and entering "Frame Relay" for the search string.

URL. No official Web site is provided for a status of frame relay standards.

Vendors. A partial list of vendors for frame relay products is shown below. Note that a number of the members of the MPLS and Frame Relay Alliance (http://www.mplsforum.org/about/members.shtml) are also vendors.

- Cisco Systems (http://www.cisco.com/);
- Nortel Networks (http://www.nortelnetworks.com/index.html);
- Lucent Technologies (http://www.lucent.com/);

Other Sources of Information.

- Cisco provides a Web site that provides detailed information about frame relay at URL: http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/frame.htm.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies on their Web site. Their "Network Design Manual" at URL: http://www.networkcomputing.com/netdesign/series.htm covers a number of topics under the "Infrastructure" heading, including "Building a Frame Relay Network."

4.5 Internet

Name. Internet.

Purpose. To define a distributed network that enables remote computers to communicate using packet switching.

History. It was the era of the Cold War, and the U.S. DoD strategic forces command, control, and communications depended on shortwave radio and the domestic telephone system (analog communications), but both were vulnerable to a major disruption if there was a nuclear attack [13]. What was needed was a communications system that would survive such an attack [13]. When Paul Baran joined the RAND Corporation in 1959, he began researching potential solutions [13] Baran proposed concepts that involved major changes to existing systems: a distributed network topology that relied on digital signal communications instead of analog, so that if one or more nodes were destroyed, messages could be rerouted and transmitted on existing nodes to achieve their final destinations [13]. In addition, Baran developed the concept of packet switching—decomposing messages into digital signal blocks (renamed later as packets[7]) that are transmitted on separate, but optimal, paths on a distributed network and assembled when they reach their destination [14].

7. After Paul Baran published his concepts for a distributed network topology, Donald W. Davies, a British physicist, published similar concepts, naming the approach *packet switching*, a term that caught on and that now refers to Baran's original concepts. Although Davies had pursued the concepts independently, Baran is credited with their invention because he published them first (for more information about Davies, refer to [17]). However, Davies was the first to implement an experimental packet switching system.

These were groundbreaking concepts, and understandably Baran encountered resistance—the magnitude of cost and changes necessary to rebuild systems to use this approach would be significant [13]. Nevertheless, Baran continued his seminal work and published a series of RAND reports from 1960 on that culminated in a comprehensive description of his concepts in an August 1964 report [13].[8] Around the same time period, in July 1961, Leonard Kleinrock, a professor at the Massachusetts Institute of Technology (MIT), published a paper on packet switching theory that influenced Lawrence (Larry) Roberts, a researcher at MIT [15].

In 1964, at the Second Congress on the Information System Sciences, Larry Roberts engaged in discussions with other researchers, one of whom was J. C. R. Licklider, a researcher from the Advanced Research Projects Agency (ARPA, now named the Defense Advanced Research Projects Agency [DARPA]) [16]. From that conversation, Roberts recognized that enabling computers to network in an economical manner and share resources was of paramount importance for the computer field [16]. As an experiment, Roberts worked with Thomas Merrill to connect a computer in Massachusetts to one in California over an analog, dial-up telephone line in 1966; the limitations of analog communications (slow speed and lack of reliability) convinced him that packet switching would prove a more efficient approach [16]. He and Merrill documented their lessons learned at a conference in the fall of that year [16].

In 1966, Larry Roberts was asked to join ARPA to manage the Information Processing Techniques Office (IPTO) and lead its programs [16]. In 1967, Roberts wrote a paper describing his plans for building the ARPANET, which he published in the *Proceedings of the First ACM Symposium on Operating System Principles*, entitled "Multiple Computer Networks and Intercomputer Communication" [17]. In this paper, Roberts explained why a computer network was necessary, not only to support load sharing and exchanging user messages, but to share data between remotely located computers, use a remote computer with specialized capabilities to execute certain programs, and access remote programs and data [17]. Today, these are foundational capabilities that users take for granted on the Internet.

Roberts was provided a complete copy of Baran's reports on the packet switching and distributed networking concepts, and he used them as a starting point for specifying the ARPANET [16]. In 1968, ARPA published a Request for Proposal (RFP) for ARPANET and awarded it in January 1969 to Bolt, Baranek and Newman, Inc. (BBN) [16]. The RFP specified packet switching concepts to be implemented in ARPANET [16].

In 1969, BBN connected four host computers at four universities: the University of California at Los Angeles (UCLA) (http://la.ucla.edu/), the University of California at Santa Barbara (http://www.ucsb.edu/), the University of Utah (http://www.utah.edu/), and Stanford University (http://www.stanford.edu/) [18]. The objective of the network was to enable computers to connect with each other on a distributed network, and these four nodes supported the mainframe computers that hosted the communications between them [18]. Robert Kahn, then at BBN, was responsible for the ARPANET system design [15]. When Kahn joined DARPA in

8. The RAND Corporation has posted a copy of the original report at URL: http://www.rand.org/publications/RM/RM3420/.

1972, he initiated the Internetting[9] Program to implement internetworking: distribted communications between diverse network implementations that did not require modifications to networks, gateways, and routers [15]. Kahn recognized that the ARPANET needed a more sophisticated protocol than its Network Control Protocol (NCP) if it was going to realize his vision, to connect hundreds of thousands of nodes rather than a few hundred [15, 18].

In 1973, Kahn asked Vinton G. Cerf, one of the developers of NCP, to assist in developing this protocol [15]. From 1973 until 1978, Cerf and Kahn worked on defining the Transport Control Interface/Internet Protocol (TCP/IP) [15]. Early development efforts focused on defining and implementing TCP[10], and lessons learned from those efforts resulted in a reorganization of the original TCP into two protocols—one for TCP, which would control the flow and recovery of packets, and the other for IP, which would address and forward individual packets [15]. By 1978, TCP/IP had been implemented and demonstrated on three independent networks that connected nodes at San Francisco, London, and UCLA [18–20]. By January 1, 1983, all of the ARPANET networks had moved from NCP to TCP/IP, and the Internet was born [19]. From then on, the Internet expanded to host literally thousands of nodes [21].

Standards Organization. The IETF (http://www.ietf.org) is responsible for defining and maintaining Internet standards.

Status. As the nodes connected to the Internet have increased from hundreds to thousands, so has the community that provides ideas and refinements for Internet services. Today, there are hundreds of Internet standards, and their number continues to rise. Furthermore, maintaining these standards is no small task. In discussing the status of Internet standards, it is necessary to provide some background information on how they are defined.

Before the Internet was introduced, ARPANET project engineers made changes through a process that involved development and approval of a Request for Changes (RFC) [20]. After the ARPANET evolved into the Internet, and individuals from around the world were submitting refinements and ideas for new Internet services, it became apparent that there was a need for a more structured organization with specialization accompanied by a more a rigorous, formal process for developing and approving RFCs [20]. Hence, the following Internet groups are now in place:

- The IETF is composed of working groups focused on developing Internet specifications for different areas of interest; area directors are appointed to oversee each area [20]. Working groups include the applications area, operations and maintenance area, transport area, and router area (see URL: http://www.ietf.org/html.charters/wg-dir.html) and remain active as long as they are needed to develop and refine specifications for their particular area.

9. Over time, the Internetting Program became the Internet Program.

10. Vinton Cerf and Robert Kahn wrote "A Protocol for Packet Network Interconnection," which described their design for TCP. It was published in *IEEE Transactions on Communications*, Vol. 22, No. 5, May 1974, pp. 637–648.

- The Internet Architecture Board (IAB) (http://www.iab.org/) oversees Internet activities and architecture developments [20].
- The Internet Engineering Steering Group (IESG) (http://www.ietf.org/iesg .html) is the major review body for Internet standards. It is composed of area directors [20].
- The Internet Assigned Numbers Authority (IANA) (http://www.iana.org/) coordinates registration of domain names and assigns IP addresses.
- The Internet Society (ISOC) (http://www.isoc.org/) facilitates the efforts of the IETF, raises funds, develops policies, and coordinates with international communities [20].

Today, the IETF is an international community of members with networking expertise, and membership is open to the public. The IETF has published its formal process for defining Internet standards (see URL: http://www.ietf.org/rfc/rfc2026 .txt for the standards process). A specification that a working group develops is referred to as an Internet-Draft; these are available for review in the Internet-Draft directory (URL: http://www.ietf.org/ID.html) for no more than 6 months unless the IESG recommends it for publication as an RFC; otherwise, it is removed from the directory [21]. If an Internet-Draft is replaced by a newer version, then the new version has up to 6 months to be considered [21]. If an Internet-Draft is expected to be published, then it becomes a Work in Progress [21]. When the IESG approves an Internet-Draft or a Work in Progress, then it becomes an official Internet standard, an RFC [21]. However, RFCs undergo an evaluation process in three stages:

- *Proposed standard*: sufficiently detailed to be implemented, and ready to be tested [2];
- *Draft standard*: at least two implementations of the proposed standard have passed the tests, and the standard has been in a proposed standard for at least 6 months [2];
- *Internet standard*: standard has been a draft standard for at least 4 months and achieved general approval of its readiness for implementation [2].

The Internet architecture is composed of four layers, and the Internet standards support these layers:

1. *Application layer:* The application layer consists of the interfaces and protocols that enable users to interact with the network [22]. There are numerous protocols that operate on this layer, and only a few are listed below:
    - *File Transfer Protocol (FTP):* enables users to download files from remote computers on the Internet (RFC 959);
    - *HTTP:* enables users to display Web pages located on servers and computers on the Internet on their local browsers (RFC 2817);
    - *Post Office Protocol (POP):* an Internet protocol for retrieving e-mail messages from e-mail servers (RFC 1939 is the primary specification);
    - *Simple Mail Transfer Protocol (SMTP):* transmits e-mail to their destinations on the Internet (RFC 2821 is the primary specification);

- *Remote Procedure Call (RPC):* enables a client application on the Internet to execute a service on a server application (RFC 1831 is the primary specification);
- *Telnet:* runs on a user's computer and enables a connection to a server on the Internet and runs operating system commands (RFC 854 is the primary specification).

2. *Transport layer:* The transport layer controls the flow and recovery of packets [20]. TCP and the User Datagram Protocol (UDP) belong to this layer [20]. UDP is an alternative to TCP, operates with IP (UDP/IP), and is used principally to broadcast messages.
3. *Network layer:* The network layer determines the path to route packets to their destinations [20]. Since IP addresses individual packets and forwards them, it belongs to the network layer, as do the Internet Control Message Protocol (ICMP) and the Internet Group Management Protocol (IGMP). ICMP extends IP to provide packets for error, control, and information messages. ICMP is defined by RFC 792. IGMP extends IP with a multicast capability that enables servers to broadcast messages to multiple destinations on a distributed network; it is defined by RFC 1112.
4. *Link layer:* The link layer communicates with the physical hardware of the network and includes device drivers and network interface cards [20].

Figure 4.3 demonstrates how the Internet architecture layers map to the OSI Reference Model layers. Note that the gray shaded boxes in the diagram represent layers of services in the OSI Reference Model that are not supported by the Internet architecture.

Additional Internet research is being conducted by 207 universities working with government organizations and vendors to research advanced applications for the Internet [21]. These universities have formed the Internet2 consortium, which hosts a set of working groups for particular research areas, and have implemented an Internet2 backbone that it uses for testing prototype implementations [23]. Intenet2 maintains a Web site of its activities at URL: http://www.internet2.edu/.

Obtaining the Specifications. The IETF provides the URL: http://www.ietf.org/iesg/1rfc_index.txt as a means for listing RFCs. To find a desired RFC, refer to URL: http://www.rfc-editor.org/cgi-bin/rfcsearch.pl. In some cases, however, it may be necessary to refer to a particular IETF working group's Web page to find specifications under development. Refer to URL: http://www.ietf.org/html.charters/wg-dir.html for a list of current IETF working groups.

URL. http://www.rfc-editor.org/rfcxx00.html.

Vendors. Many vendors, including Microsoft (http://www.microsoft.com/), Sun Microsystems (http://www.ibm.com/), IBM (http://www.ibm.com/)—and the list could go on—support Internet products.

Other Sources of Information.

- For further details on the history of the Internet, refer to URL: http://www.isoc.org/internet/history/brief.shtml, which is supported by the

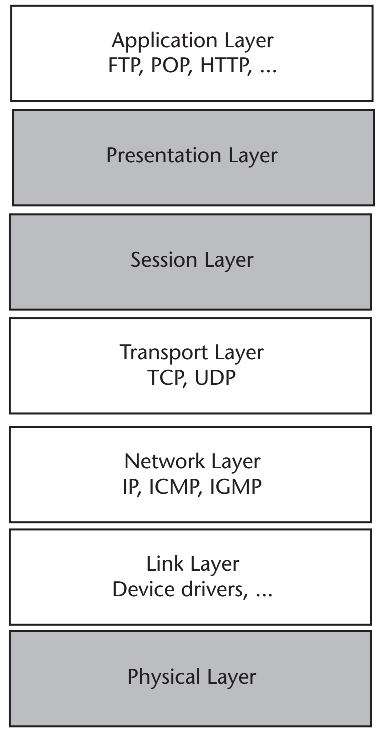

Figure 4.3 Internet layers mapped to OSI.

ISOC. The ISOC also supports other informational Web pages at URL: http://www.isoc.org/internet/history/index.shtml.

- The RAND Corporation provides information about Paul Baran and some of his RAND reports, most notably a copy of his August 1964 report, "On Distributed Communications," at URL: http://www.rand.org/about/history/baran.html.
- Stephen Hartley from Orange Peel, a Canadian Web design and hosting company, provides a detailed account of researchers involved in the "History of the Internet" at URL: http://www.orangepeel.com/newOP/en/internet/short History.php.
- The *IEEE Communications Magazine* published in July 2002 (Vol. 40, No. 7) describes "The Internet: Past, Present, and Future," and provides more information on the origin of packet switching.
- The first paper describing ARPANet, authored by Larry Roberts and entitled "Multiple Computer Networks and Intercomputer Communication," can be found in the *Proceedings of the First ACM Symposium on Operating System Principles* (1967, pp. 3.1–3.6).
- Jason Yanowitz wrote "Under the Hood of the Internet: An Overview of the TCP/IP Protocol Suite" in *CrossRoads* magazine published by the Association for Computing Machinery (ACM) that provides an overview of the Internet. A copy of this article is available at URL: http://info.acm.org/crossroads/xrds 1-1/tcpjmy.html.

4.6 Integrated Services Digital Network

Name. Integrated Services Digital Network (ISDN).

Purpose. To transmit data, audio, and video as digital signals over public telephone networks as an end-to-end service.

History. For decades, the national and international telephone networks supported analog communications and were not well suited to supporting digital transmissions. What was needed was an interface that would enable homes and businesses to use local telephone carrier systems to transmit facsimile, voice, and data over local lines [24]. CCITT (now ITU-T) began working on an ISDN standard in the 1970s, and in 1984 published the first version to integrate voice and data over analog telephone lines [24, 25]. ISDN products relied on transport services that operated using twisted pair cable telephone lines. In 1986, ITU-T extended the ISDN standard to define Broadband (B-ISDN), which provides standards for radio wave and fiber optic telephone lines [3].

Standards Organization. ITU-T (http://www.itu.int/) is responsible for maintaining this standard.

Status. ISDN operates at the network and data link layers of the OSI model and was defined for compatibility with OSI standards that operated at the presentation, session, and transport layers [25]. ISDN supports features such as call waiting, conference calls, caller identity, and video teleconferencing [25]. ISDN relies on the *bearer services* (transport services) provided by X.25, frame relay, or circuit switching [2]. Two ISDN network interface devices are used to connect the devices at the endpoints; they are known as the Basic Rate Interface (BRI) and the Primary Rate Interface (PRI) [25]. ISDN BRI supports two bearer channels (B channels) and a signals channel (D channel); and PRI supports 23 B channels and one D channel [2, 24]. The bearer channels are used for transmitting digital data, audio, and video, and the D channel can be used to control the number of devices (e.g., computers, telephones, facsimile equipment) using the channels [25]. The cost and speed of ISDN equipment has discouraged widespread use for home and business networking and telephony, but ISDN equipment is widely used for video teleconferencing. B-ISDN has not been widely implemented.

Obtaining the Specifications. The family of specifications for ISDN can be obtained from ITU at URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC by searching for "ISDN". Note that the majority of ISDN specifications can be found in the ITU I-series, and Q.931 and Q.932 [25].

URL. No official Web site is provided for a status of ISDN standards.

Vendors. The Global ISDN & Future Access Technologies Industry Forum (GIIF) (http://www.giif.com/) is a nonprofit organization established in 1998 to expand the market for ISDN products and develop concepts to improve vendor ISDN offerings. Refer to the GIIF membership list for a list of ISDN product vendors. In addition, ISDN Zone (http://www.isdnzone.com/) provides information about ISDN and supports ISDN products.

Other Sources of Information. James Y. Bryce wrote *Special Edition, Using ISDN*, Second Edition, published by Que Corporation, which provides detailed information about ISDN.

4.7 Multiprotocol Label Switching

Name. Multiprotocol Label Switching (MPLS).

Purpose. To define standards for a foundational technology that supports *label switching* over switching technologies implemented at the Internet link layer, such as Frame Relay, ATM, Ethernet, and so on, for IP packets [26]. The term *label switching* refers to tagging packets with a label to aid in the process of determining how to forward a packet to its destination [26].

History. Industry is moving toward what is referred to as *convergent networks* that support both voice and data packet traffic. The issues involved in combining the two relate to the need for providing real-time receipt of voice packets to support interactive conversations: network delays in sending voice packets pose a concern for voice, while loss of information can be overcome by a user repeating a word or phrase; whereas for data, delays are not the issue, but losing information in the packets poses a problem for data integrity [27]. Adding labels to packets provides information for managing priorities, satisfying metrics, and providing special services for packets, depending on their type [27]. For instance, voice packets are accorded higher priorities for forwarding to their destinations, to minimize latency and improve the timeliness of delivery [26]. In addition, services are provided to minimize information loss [26].

MCI Worldcom submitted requirements for MPLS to the IETF in RFC 2702 dated September 1999, and the IETF MPLS Working Group became responsible for the development of MPLS for IP packets [27]. The working group has defined an architecture for MPLS (RFC 3031), in addition to a number of other RFCs [26].

Standards Organization. The IETF MPLS Working Group (http://www.ietf.org/html.charters/mpls-charter.html) is responsible for defining this family of standards.

Status. The IETF MPLS Working Group has a number of Internet-Draft specifications under development and a number of objectives for MPLS that they are working to achieve [26].

Some of the major networking vendors support products that integrate Ethernet LANs with frame relay and ATM IP backbones using MPLS [26]. In 2000, the MPLS Forum was established to promote the deployment of MPLS products. Then in April 2003, the Frame Relay Forum merged with the MPLS Forum and become the MPLS and Frame Relay Alliance (see URL: http://www.mplsforum.org/about/index.shtml) [11]. Both fora have foreseen the potential for MPLS to be integrated with frame relay, and eventually to replace it [28]. In addition, Gartner has predicted that MPLS will replace frame relay by 2006 [29].

Obtaining the Specifications. The MPLS specifications, both the Internet-Drafts and the RFCs, are listed on the MPLS Working Group Web page, URL: http://www.ietf.org/html.charters/mpls-charter.html.

URL. http://www.ietf.org/html.charters/mpls-charter.html.

Vendors. A partial list of major vendors for MPLS products are listed below:

- Agilent (http://www.agilent.com/);
- Alcatel (http://www.alcatel.com/);
- Cisco Systems (http://www.cisco.com/);
- Nortel (http://www.nortel.com/).

Other Sources of Information.

- The book *Broadband Telecommunications Handbook*, written by Regis J. “Bud” Bates, provides an excellent technical discussion of how MPLS works.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies on their Web site.
- The nonprofit International Engineering Consortium provides free (after registering) Web-based tutorials for the communications and information industries, including MPLS, at URL: http://www.iec.org/online/tutorials/.

4.8 Open Systems Interconnection

Name. Open Systems Interconnection (OSI).

Purpose. To define a reference model and a family of standards that enable multivendor computer equipment to interconnect and communicate

History. The year was 1978. There were a number of networks in use, but the stiffest competition was between IBM’s Systems Network Architecture (SNA) and the Digital Network Architecture (DNA) developed by former IBM employees who had founded DEC [8]. SNA was based on a seven-layer architecture, and DNA used a five-layer architecture [8]. When ISO began to develop its OSI Reference Model, both IBM and DEC were members of the committee and submitted SNA and DEC to be considered [8]. The resulting OSI Reference Model drew from the SNA seven-layer architecture and was approved by ISO in 1984 as ISO 7498 [8]. Note that CCITT (now ITU-T) had independently developed a specification for OSI but combined their efforts with OSI in 1983 and dropped their version to focus on refining OSI’s Reference Model and developing standards for the services [30].

In the mid-1980s, ISO combined their efforts with the IEC in the Joint Technical Committee 1 (JTC1), which reported to both ISO and IEC [30]. Standards were defined for every layer of the OSI model.

Standards Organization. The ISO (http://www.iso.org/) and ITU-T (http://www.itu.int/) are responsible for maintaining these standards.

Status. The OSI Reference Model continues to be used for an understanding of the basic concepts of networking. With the wild popularity of the Internet in the 1990s, however, interest in OSI declined. There are a few OSI standards-based products still being offered however.

Obtaining the Specifications. Specifications can be purchased from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/CatalogueListPage.CatalogueList and entering either the ISO number or text. A partial list of the numerous ISO/IEC specifications for OSI include:

- ISO/IEC 2382-26:1993, OSI Vocabulary, Part 26;
- ISO 7498-1:1994, ISO/IEC 7498-2:1989 through ISO/IEC 7498-4, OSI Basic Reference Model;
- ISO/IEC 8072:1996, ISO/IEC 8073:1997, Transport Service and Protocol;
- ISO/IEC 8326:1996 and ISO/IEC 8327-1:1996 through ISO/IEC 8327-2:1996: Session Service and Protocol;
- ISO/IEC 8348:202: Network Service;
- ISO/IEC 8648:1988: Internal Organization of the Network Layer;
- ISO/IEC 8571-1:1988 through ISO/IEC 8571-5:1990: File Transfer, Access, and Management;
- ISO/IEC 8822:1994, ISO/IEC 8823-1:1994 through ISO/IEC 8823-2:1997: Presentation Service and Protocol;
- ISO/IEC 8886:1996: Data Link Service;
- ISO/IEC 9594-1:2001 through ISO/IEC 9594-8:1998, The Directory.

At the ITU URL: http://www.itu.int/publications/online/index.html in the "Standardization Sector," selecting "ITU-T Recommendations" will bring up a Web site that shows all of the standards series for ITU-T. The ITU-T X-Series provides a number of ISO standards that can be purchased from ITU by selecting the links to the specifications and following the information provided on how to purchase them.

URL. No official Web site is provided for OSI standards.

Vendors. Because the market for OSI products has declined, there are only a few vendors that still support them. Some products are available for OSI standards such as X.25 (defines protocols for establishing and maintaining connections between packet switch networks and user devices used for packet switching), X.400 (standards for electronic messaging handling services), and X.500 (standards for directory services). Sample vendors include:

- Cisco Systems (http://www.cisco.com/) provides products for X.25, X.400, and X.500;
- Sangoma Technologies supports X.25 products (http://www.sangoma.com/x25.htm);
- Isode provides products for X.400 and X.500 (http://www.isode.com/).

Other Sources of Information.

- The ACM published the results of the first meeting of the ISO Technical Committee 97/Subcommittee 16 where the OSI Reference Model was discussed in "Provisional Model of Open-Systems Architecture," in the *ACM SIGCOMM Communications Review* (Vol. 8, No. 3, July 1978, pp. 49–61). This paper is available to nonmembers for a fee from the ACM via their digital portal (refer to URL: http://www.acm.org/ for details).
- Dr. John Larmouth, who received his doctorate from Cambridge University and was the founding Director of the Information Technology Institute, wrote *Understanding OSI*, which he has made available at URL: http://www.csse.monash.edu.au/~jwb/osi/osi2.htm. In addition, Salford University in the United Kingdom—where Dr. Larmouth was the Director for Computing Systems Research and Development—also hosts a copy of his book at URL: http://www.isi.salford.ac.uk//books/osi/osi.html.

4.9 Synchronous Optical Network/Synchronous Digital Hierarchy

Name. Synchronous Optical Network (SONET)/Synchronous Digital Hierarchy (SDH).

Purpose. To provide standards for packaging and transmitting signals (voice, data, and video) on fiber optic networks, and ensuring interoperability between different vendor services and products [3].

History. Users of telephone communications based on copper cable had grown to the extent that carriers were having difficulty supporting the enormous number of phone calls being placed nationwide [31]. In addition, copper cables were (and are) vulnerable to electrical spikes from storms or other kinds of interference [31]. Many carriers saw fiber optics as the means for overcoming these problems and developed highly complex, proprietary, closed systems to support their users [31]. They had failed to consider, however, the need for interoperability between their systemsand other carriers' systems to transmit the calls nationwide, so they ran into problems [31].

In 1984, the Exchange Carriers Standards Association (ECSA) proposed a concept for interconnecting the carriers' fiber optic systems. Bell Communications Research, known as Bellcore and which has since become Telecordia Technologies (http://www.telcordia.com/), developed requirements and specifications for the concepts in 1984 that formed the basis for the SONET specifications published by ANSI in 1988 [31, 32]. CCITT (now ITU-T) published the international version of SONET as Synchronous Digital Hierarchy [32].

Standards Organization. ANSI (http://www.ansi.org) is responsible for maintaining SONET standards, and the ITU-T (http://www.itu.int/) is responsible for SDH.

Status. SONET is implemented at the physical layer of the OSI reference model. It is widely used in the United States and is supported in Japan; SDH is used in Europe [33]. ANSI and ITU continue to refine and expand the specifications for SONET and SDH, respectively [33].

Obtaining the Specifications.

- ANSI provides copies of the SONET specifications for a fee at their Standards Store by linking to URL: http://webstore.ansi.org/ansidocstore/default.asp and entering “SONET”.
- SONET specifications can be purchased from Telecordia Technologies at URL: http://www.telcordia.com.
- The family of specifications for SDH can be obtained from ITU at URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC by searching for “SDH”. General specifications for SDH can be found in the F.750 series, G.743 series, and G.783 series.

URL. No official Web site is provided for a status of SONET standards.

Vendors. A partial list of vendors is provided below.

- Alcatel (http://www.alcatel.com/) supports both SONET and SDH.
- Cisco Systems (http://www.cisco.com/) supports both SONET and SDH.
- Lucent Technologies (http://www.lucent.com/) supports both SONET and SDH.
- Nortel Networks (http://www.nortel.com/) supports both SONET and SDH.

Other Sources of Information.

- ANSI compares the SONET and SDH specifications in their T1.TR.36-1994 report available for a fee by linking to their Standards Store at URL: http://webstore.ansi.org/ansidocstore/find.asp? and entering the report number.
- The nonprofit IEC provides free Web-based tutorials for the communications and information industries, after registering, at URL: http://www.iec.org/online/tutorials/. One of their tutorials covers SONET at URL: http://www.iec.org/online/tutorials/sonet/.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies such as SONET on their Web site. Darrin Woods wrote “Shedding Light on SONET,” published by *Network Computing* on March 20, 2000 and available at URL: http://www.networkcomputing.com/1105/110 5f1.html. It discusses technical aspects of building a SONET frame.
- A Network and Services Integration Forum (NSIF) was established in 1991 to assist in resolving SONET implementation issues; it lasted until November 2001, when it was determined that it had achieved its mission and concluded its activities. Some of its historical SONET documents are posted at URL: http://www.atis.org/atis/sif/sifhom.htm.

4.10 Voice over IP (H.323)

Name. Voice over IP (VoIP) (H.323).

Purpose. To provide real-time, multimedia communications (voice, video, and data) over the Internet.

History. Before discussing VoIP, it is important to cover the term *telephony*. For a long time, telephony referred to the business of the worldwide, public networked telephone systems, and it was a separate domain from the one where computer networks and digital data communications belonged [4]. This recalls Paul Baran's revolutionary concepts that digital communications were better suited for computers than those provided for telephony in the 1960s. But since that time, public telephone systems have migrated to digital communications, leading to new possibilities for converging data and voice communications.

In the early 1990s, Sun Microsystems described multimedia capabilities that ran "simultaneous voice, image, data, and video applications on a computer" [4]. Suddenly, telephony was redefined to integrate the telephone system with the computer [4]. By February 1995, voice communications over the Internet became a reality when Vocaltec, Inc., offered the first Internet Phone software [34]. The Vocaltec interface card ran on a 486 personal computer with a sound card, speakers, microphone, and modem, and the software compressed voice into digital IP packets, and, if another Vocaltec user was equipped similarly, the users could converse on the Internet through their workstations [35]. Using this approach, users experienced delays in hearing some of the other user's conversation, clipped speech, echoes on the line, and jitters caused by receiving different parts of a conversation at different times than it was said. But it was a step toward the vision for IP telephony [35].

The vision for IP telephony is to enable users to converse by phone, computer-to-computer or computer-to-phone in real time, with the highest quality of reliable transmission. Whether users decide to use a phone, a workstation, or some other computer device to call another user is unimportant, because the communications system will be ubiquitous, integrating voice, data, and video signals simultaneously over IP, with exceptional performance.

In May 1996, the ITU approved the H.323 umbrella standard, which specifies how voice, data, and video signals are to be transmitted over IP-based networks [35].

Standards Organization. ITU-T (http://www.itu.int/) is responsible for maintaining and developing the specifications for H.323.

Status. There is a great deal of interest in pursuing standards to achieve the VoIP objective. The reason is because it could significantly reduce the cost of long-distance phone calls since Internet service providers (ISPs) would charge only a fixed monthly fee for IP telephony, rather than the multiple connection fees that the long distance carriers charge today [35].

One of the features of IP telephony is that it builds on existing standard protocols. Figure 4.4 depicts a sample stack of VoIP protocols as they map to the OSI Reference Model; they demonstrate how they might be integrated to support H.323 applications at the application layer [35]:

- From the application layer through the session Layer (layers 5 through 7 of the OSI Reference Model), a set of control protocols such as the SIP protocol that creates, modifies, and terminates conferencing sessions with several users.
- The transport layer would use UDP.
- The network layer would be based on IP.

- The link layer could be supported by either ATM or frame relay.
- The physical layer would rely on SONET.

Obtaining the Specifications. Links to the H.323 specifications can be found at the following URLs:

- The H.323 Forum provides links to the core H.323 specifications and information about revisions at URL: http://www.packetizer.com/cgi-bin/redirect?http://www.h323forum.org/.
- A Web site is supported for H.323 at URL: http://www.packetizer.com/voip/h323/ that provides links to the specifications at the ITU site, along with information about revisions.
- To order the standards directly from ITU, refer to URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC and search for "H.323". General specifications for H.323 can be found in the H.323 series, H.225 series, and H.245 series.

URL. http://www.packetizer.com/voip/h323/.

Vendors.

- The H.323 Forum provides a list of vendors who support H.323 products at URL: http://www.packetizer.com/cgi-bin/redirect?http://www.h323forum.org/. H.323 products are supported by major vendors such as Microsoft Corporation, Cisco Systems, and Nortel Networks.
- There is also an OpenH323 Project that is developing open source to implement H.323 protocols. For more information, see their URL: http://www.openh323.org/.

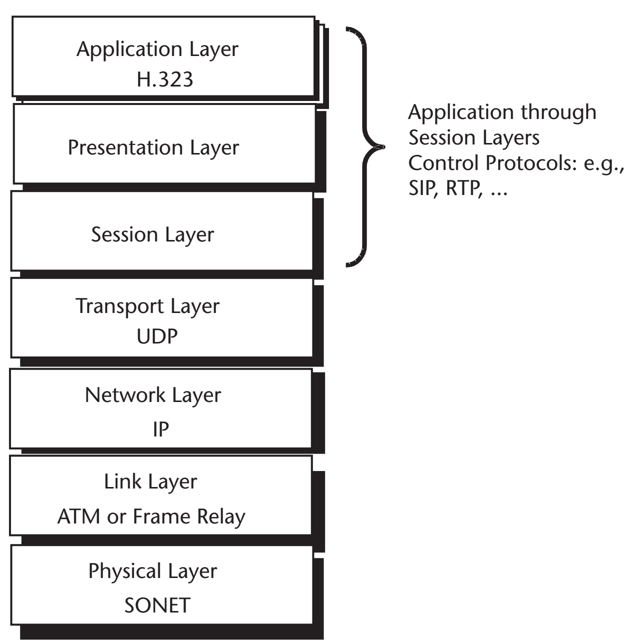

Figure 4.4 VoIP protocol stack mapped to OSI [35].

Other Sources of Information.

- The book *Broadband Telecommunications Handbook* by Regis J. "Bud" Bates provides an excellent technical discussion of how VoIP works.
- The nonprofit IEC provides free Web-based tutorials for the communications and information industries, after registering, at URL: http://www.iec.org/online/tutorials/. Several tutorials relate to VoIP:
  - "Voice Over Internet Protocols" at URL: http://www.iec.org/online/tutorials/acrobat/int_tele.pdf;
  - "Including VoIP over WLAN in a Seamless Next-Generation Wireless Environment" at URL: http://www.iec.org/online/tutorials/acrobat/ti_ voip_wlan.pdf;
  - "Accelerating the Deployment of Voice over IP (VoIP) and Voice over ATM (VoATM)" at URL: http://www.iec.org/online/tutorials/acrobat/voip_ voatm.pdf.
- *Network Computing* (http://www.networkcomputing.com/docs/start.html) provides technical articles and product reviews for a variety of networking technologies on their Web site.

4.11 Wireless

The trend today is toward hybrid networks that support a variety of network technologies. Wireless networks are growing in popularity because they enable organizational personnel who are on the move to easily connect to corporate networks using wireless phones, laptops, and other devices to pick up e-mail, check calendars, download data, and a variety of other functions. This section identifies seven wireless standards, some that are widely used, such as Code Division Multiple Access (CDMA) and Global Systems for Mobile Communications (GSM), and some that are emerging, such as Bluetooth, the Universal Mobile Telecommunications System (UMTS), the Wireless Application Protocol (WAP), Wi-Fi, and WiMax.

4.11.1 Bluetooth (IEEE 802.15)

Name. Bluetooth (IEEE 802.15).

Purpose. To define standards for wireless personal area networks (WPAN), digital communications among personal digital devices such as PDAs, cell phones, pagers, and computer notebooks.

History. In May 1998, Intel Corporation, Ericsson, and other major vendors formed the Bluetooth Special Interest Group (SIG) (http://www.bluetooth.com) to define standard protocols that would enable cell phones, laptops, and handheld computers to transmit voice and data wirelessly over short distances using a radio system [36, 37]. The IEEE 802.15 WPAN Task Group based their specification of IEEE 802.15.1a on the Bluetooth v1.1 specification, and the IEEE Standards Association approved it as a standard in June 2002 [38].

Standards Organization. The IEEE 802.15 WPAN Task Group (http://grouper.ieee.org/groups/802/15/) is responsible for maintaining this standard. Bluetooth

SIG provides a copy of the Bluetooth specifications at URL: https://www.bluetooth.org/spec/.

Status. The IEEE 802.15 WPAN Task Group has continued to refine the specifications. The WiMedia Alliance (http://www.wimedia.org/about/) formed to develop a specification based on IEEE 802.15.3 and promote products from multiple vendors for interoperability between multivendor products, based on the IEEE 802.15.3 draft standard [39].

Obtaining the Specifications. The specifications can be downloaded through the Get IEEE 802 pilot program at URL: http://standards.ieee.org/getieee802/ and by following the instructions for selecting from the list of available standards. They can also be purchased from the IEEE "Shop IEEE" Web site at URL: http://shop.ieee.org/ieeestore/, entering the text "IEEE 802.15" for *Keywords*, selecting "Standards" for the *Product Type*, and clicking on the button labeled "Go".

URL. http://grouper.ieee.org/groups/802/15.

Vendors. The Bluetooth SIG provides a list of promoter members who are also Bluetooth vendors at URL: https://www.bluetooth.org/foundry/sitecontent/document/member_directory.

Other Sources of Information.

- The Bluetooth SIG (https://www.bluetooth.org/) provides information for development efforts and news at their site.
- The Wi-Fi Forum (http://www.wifi-forum.com/wf/) provides technical information and ideas about Bluetooth, Wi-Fi, and other wireless technologies.

4.11.2 Code Division Multiple Access (IS-95)

Name. Code Division Multiple Access (CDMA) (IS-95).

Purpose. To define standards to support multiple cellular, digital transmissions on the same channel of the frequency spectrum.

History. In 1985, seven men met to discuss ideas for a company that would research and develop wireless telecommunications products [40]. The company that they formed became Qualcomm, and it introduced technologies using CDMA, which it had defined [40]. CDMA assigns a code to the speech bits, transmits them to their destination, and then re-assembles them at their destination in the proper order [4].

Qualcomm introduced CDMA only 3 months after Time Division Multiple Access (TDMA) technologies had been endorsed by the Cellular Telecommunications Industry Association in 1989 [40]. TDMA uses a different access method than CDMA: it allocates a small frequency bandwidth for multiple cellular, digital transmissions, and a digital cellular telephone carrier is able to support a fixed number (usually from 3 to 10) simultaneous phone calls on a particular frequency band; the voice bits are transmitted in bursts during the time slot allocated to the call and are reassembled at the destination [4].

The U.S. Telecommunications Industry Association (TIA) (http://www.tiaonline.org/) adopted a cellular standard based on CDMA, naming it Interim Standard (IS)-95 [40]. The first commercial CDMA products were released in 1995 [40].

Standards Organization. TIA (http://www.tiaonline.org/) is responsible for maintaining the CDMA family of standards.

Status. CDMA products are used extensively in the United States and Japan, and in more than 30 other countries as well [41]. CDMA products are seen as the primary competitor to GSM, which relies on TDMA for its access method. The CDMA standards continue to progress to support third generation systems (3G), the future for high-speed, seamless, broadband, digital, cellular communication systems for audio, video, and data around the world. 3G CDMA2000 was introduced and endorsed by TIA in 1998, and it continues to evolve, improving both speed and performance [41]. More recently, ITU defined the Wideband CDMA (W-CDMA) standards which are based on CDMA, so that CDMA is now an international standard.

Obtaining the Specifications. ITU-T (http://www.itu.int/) is responsible for maintaining W-CDMA. The family of specifications for W-CDMA can be obtained from ITU at URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC by searching for "W-CDMA". The specifications are currently in the Q-Series and include Q.1742.1 (12/02), Q.1742.2 (07/03), and Q.1742.3 (01/04). TIA provides specifications of CDMA standards via its Web site at URL: http://www.tiaonline.org/standards/search_n_order.cfm and searching for "CDMA".

URL. http://www.consortiuminfo.org/links/cdma2.shtml.

Vendors. The CDA Development Group (CDA) (http://www.consortiuminfo.org/links/cdma2.shtml) is an international consortium of companies that work together to develop interoperable products. Refer to the membership page of CDG at URL: http://www.consortiuminfo.org/links/cdma2.shtml for vendors. A partial list of vendors includes:

- Qualcomm (http://www.qualcomm.com/);
- Ericsson (http://www.ericsson.com/);
- Verizon Wireless (http://www.verizonwireless.com/).

Other Sources of Information. The nonprofit International Engineering Consortium provides free Web-based tutorials for the communications and information industries after registering, at URL: http://www.iec.org/online/tutorials/. One of their tutorials covers W-CDMA at URL: http://www.iec.org/online/tutorials/wcdma/.

4.11.3 Global Systems for Mobile Communications

Name. Global Systems for Mobile Communications (GSM).

Purpose. To define standards for mobile, cellular telephones.

History. In the early 1970s, Bell Laboratories (Bell Labs) developed a concept for cellular, mobile, radio services, but it was not until 1983 that the Advanced Mobile

Phone Service (AMPS) system, a cellular mobile system, was introduced to the United States [40]. From there its use spread to Asia, Latin America, and other regions [40]. However, around the same time period, the United Kingdom was using the Total Access Communications System (TACS), and Nordic countries were using Nordic Mobile Telephone (NMT), which had been around since 1981 [35, 40]. All of the systems supported analog mobile communications, but were different systems, not interoperable, and worked only within the countries that used it [40]. The Europeans wanted a unified system [40]. Furthermore, as the use of analog, cellular telephone communications increased, it became apparent that analog communications had difficulty accommodating the demand [35]. The solution was to move to digital communications.

In Europe, the Groupe Special Mobile (GSM[11]) was established in 1982 to develop European standards for a mobile, cellular telephone system [41]. In 1989, the responsibility for the development of GSM passed to the European Telecommunications Standards Institute (ETSI) (http://www.etsi.org/), a new organization established to continue the work on GSM [41]. In 1991, ETSI defined a family of standards for Global Systems for Mobile Communications, and by mid-1991, GSM products were available [35].

Standards Organization. ETSI has designated the 3GPP (http://www.3gpp.org/) organization with responsibility for maintaining the GSM family of standards.

Status. Today, GSM is used in many countries around the world for mobile cellular telephones [4]. It is the predominant system in more than 85 countries [4]. General Packet Radio System (GPRS) standards have been defined to provide a transition point from GSM to 3G standards in development, referred to as UMTS. The GPRS standards support packet switching and access to packet switching networks.

The 3rd Generation Partnership Project (3GPP) (http://www.3gpp.org/) was established in December 1998 as a collaboration of different telecommunications standards bodies to maintain and develop GSM specifications and reports, including GPRS and Enhanced Data Rates for GSM Evolution (EDGE).

Obtaining the Specifications. ETSI standards can be accessed at URL: http://www.etsi.org/services_products/freestandard/home.htm, and by selecting the link for "Download Now" and entering a keyword for the specifications after registering. 3GPP specifications are available at URL: http://www.3gpp.org/specs/ specs.htm.

URL. http://www.gsmworld.com/about/index.shtml. The GSM Association (GSMA), a global trade association formed to promote GSM worldwide, provides information about GSM.

Vendors. Vendors include Ericsson (www.ericsson.com), Nortel Networks (http://www.nortel.com/), and Cisco Systems (http://www.cisco.com/).
Other Sources of Information.

- The book *Broadband Telecommunications Handbook* by Regis J. Bates provides a detailed technical description of GSM.

11. For a more detailed history of GSM, refer to the history page hosted by the GSM Association, a trade association, at URL: http://www.gsmworld.com/about/history/index.shtml.

- The nonprofit International Engineering Consortium provides free Web-based tutorials for the communications and information industries, after registering, at URL: http://www.iec.org/online/tutorials/. There is an excellent tutorial on GSM at URL: http://www.iec.org/online/tutorials/acrobat/gsm.pdf.
- Cisco Systems provides a technical overview entitled "Overview of GSM, GPRS, and UMTS" at URL: http://www.cisco.com/en/US/netsol/ns341/ns396/ns177/ns278/networking_solutions_design_guide_chapter09186a00801219ac.html.

4.11.4 Universal Mobile Telecommunications System

Name. Universal Mobile Telecommunications System (UMTS).

Purpose. To define standards that support seamless broadband, digital, mobile communications for audio, video, and data around the world.

History. As mentioned in the CDMA section (Section 4.11.2), GSM standards are used in more than 85 countries worldwide for mobile cellular telephony, and it is the predominant system in the world [4]. However, its major competitor has been CDMA, which is used in North America and 29 other countries [41].

3G defines the future for high-performance, broadband, digital, mobile communications for audio, video, and data that operate seamlessly around the world. UMTS is the name of the family of 3G standards that defines it. ETSI is responsible for coordinating the UMTS developments to achieve a unified family of standards for UMTS [4].

Standards Organization. ETSI (http://www.etsi.org/) is responsible for maintaining the UMTS family of standards.

Status. Work has been progressing on products that support UMTS. The vision is for UMTS services to be supported worldwide by 2005 [42]. In October 2002, Nortel Networks and Qualcomm claimed to have demonstrated the first live demonstration of mobile phones on the 1,900-MHz radio spectrum [42]. Efforts are continuing to implement UMTS. For more information, refer to the history of events at URL: http://www.umtsworld.com/umts/history.htm.

Obtaining the Specifications. ETSI standards can be accessed at URL: http://www.etsi.org/services_products/freestandard/home.htm, selecting the link for "Download Now" and entering a keyword for the specifications after registering. ITU has defined W-CDMS for UMTS, and these specifications can be obtained from ITU at URL: http://www.itu.int/rec/recommendation.asp?lang=e&type=series&parent=T-REC and searching for "UMTS". ITU-T specifications for UMTS include Q.1741.1 (04/02) through Q.1741.3 (09/03).

URL. http://www.umtsworld.com/default.htm. UMTS World provides this Web site to provide free information about 3G products and news.

Vendors. UMTS World provides a list of 3G devices at URL: http://www.umtsworld.com/industry/3gphones.htm.

Other Sources of Information.

- The UMTS Forum (http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/About_index) is an international body that promotes 3G devices.
- The nonprofit International Engineering Consortium provides free Web-based tutorials for the communications and information industries, after registering, at URL: http://www.iec.org/online/tutorials/. A tutorial on UMTS is entitled "UMTS Network and Service Assurance" and is located at URL: http://www.iec.org/online/tutorials/acrobat/agilent_umts_network.pdf.
- The book *Broadband Telecommunications Handbook* by Regis J. Bates provides a detailed technical description of UMTS.
- Cisco Systems provides a technical overview entitled "Overview of GSM, GPRS, and UMTS" at URL: http://www.cisco.com/en/US/netsol/ns341/ns396/ns177/ns278/networking_solutions_design_guide_chapter09186a008 01219 ac.html.

4.11.5 Wireless Application Protocol

See Chapter 14, Section 14.2.4 for more information on the Wireless Application Protocol.

4.11.6 Wi-Fi (IEEE 802.11)

Name. Wi-Fi (IEEE 802.11).

Purpose. To define radio standards for wireless LANs.

History. The IEEE has been defining 802 standards for local area networks, and they have formed a Wireless LAN Working Group to define WLAN standards. The original WLAN standard is IEEE 802.11. All of the IEEE 802.11 versions are based on Ethernet [43].

Standards Organization. The IEEE 802.11 Wireless LAN Working Group (http://grouper.ieee.org/groups/802/11/) of the IEEE LAN/MAN Standards Committee is responsible for maintaining this standard.

Status. There have been a number of refinements of IEEE 802.11, as follows:

- *IEEE 802.11:* This is the original specifications that provides for 1- to 2-Mbps transmission in the 2.4-GHz band [43].
- *IEEE 802.11a:* This extends 802.11 to provide up to 54 Mbps in the 5-GHz band; but most communications will occur at 6, 12, or 24 Mbps. This specification applies to wireless ATM systems [43].
- *IEEE 802.11b:* This is referred to as Wi-Fi. It changes the modulation method from phase-shift keying (PSK) to complementary code keying (CCK) to support higher data speeds [43].
- *IEEE 802.11e:* This extends the wireless standard to provide for home and business environments, with quality-of-service (QoS) features and support for multimedia [43].[12]

12. Service providers see support for multimedia as critical for enabling residential customers to have on-demand video.

- *IEEE 802.11g:* This provides 20+ Mbps in the 2.4-GHz band [43].
- *IEEE 802.11i:* This provides the Advanced Encryption Standard (AES) security protocol [43].

Products are available for Wi-Fi, and they can work with two computers if they each contain a Wi-Fi card [44]. If more than two computers are in use, a wireless access point is required—an antenna and radio transmitter/receiver that is connected to a network, router, or hub that is not wireless [44].

Obtaining the Specifications. The specifications can be downloaded through the Get IEEE 802 pilot program at URL: http://standards.ieee.org/getieee802/, and following the instructions for selecting from the list of available standards. The specifications can be purchased from the IEEE "Shop IEEE" Web site at URL: http://shop.ieee.org/ieeestore/, entering the text "IEEE 802.11" for *Keywords*, selecting "Standards" for the *Product Type*, and clicking on the button labeled "Go".

URL. http://grouper.ieee.org/groups/802/11/. IEEE also provides information about the status by linking to their site at URL: http://www.ieee.org/portal/site/mainsite/, clicking on the *Standards* menu item on the left-hand side of the page, and selecting *802 Std. Info* from the menu.

Vendors. The Wi-Fi Alliance (http://www.wi-fi.org/OpenSection/index.asp) certifies WLAN products based on IEEE 802.11. Use its *Certified Product Listing* at URL: http://www.wi-fi.org/OpenSection/certified_products.asp?TID=2 to select from the numerous vendors.

Other Sources of Information.

- The Wi-Fi Forum (http://www.wifi-forum.com/wf/) provides technical information and ideas about Bluetooth, Wi-Fi, and other wireless technologies.
- Bob Brewin describes "Wireless LANs," at URL: http://www.computerworld.com/mobiletopics/mobile/story/0,10801,69442,00.html, published in C*omputerWorld* (March 25, 2002).

4.11.7 WiMax (IEEE 802.16)

Name. WiMax (IEEE 802.16).

Purpose. To define broadband wireless access.

History. IEEE 802.16 is a family of broadband wireless communications specifications that extend access over longer distances and to new areas [45]. IEEE 802.16 was first published in December 2001 for fixed point-to-multipoint broadband wireless systems running in the 10- to 66-GHz spectrum [43]. The 802.16 specifications require wireless access to be supported for a distance of up to 31 miles [45].

Intel Corporation, Proxim, Nokia, and other companies combined their efforts in 2003 to form WiMAX (http://www.wimaxforum.org/home/), a nonprofit corporation that will certify products for compliance with the IEEE 802.16 specifications and for computability and interoperability with other products [46].

Standards Organization. The IEEE 802.16 Working Group on Broadband Wireless Access (http://grouper.ieee.org/groups/802/16/) is responsible for maintaining this standard.

Status. The IEEE 802.16 Working Group on Broadband Wireless Access plans for the WiMax standards to begin with *fixed* wireless access and then expand to allow *mobile* wireless access in the specifications for 802.16e [45]. In addition, future versions of the standards will address QoS and protocol interoperability [46].

Obtaining the Specifications. The specifications can be downloaded through the Get IEEE 802 pilot program at URL: http://standards.ieee.org/getieee802/, and following the instructions for selecting from the list of available standards. The specifications can be purchased from the IEEE "ShopIEEE" Web site at URL: http://shop.ieee.org/ieeestore/, entering the text "IEEE 802.16" for *Keywords*, selecting "Standards" for the *Product Type*, and clicking on the button labeled "Go".

URL. http://grouper.ieee.org/groups/802/16/. In addition, a Web site called WiMax Trends located at URL: http://www.wimaxtrends.com/, provides news, resources, and events related to WiMax.

Vendors. Many of the member companies of the WiMax Forum listed at URL: http://www.wimaxforum.org/about/roster/ may also become product vendors. Products are planned for the 2005 time frame.

References

[1] "Provisional Model of Open-Systems Architecture," *ACM SIGCOMM Communications Review*, Association for Computing Machinery (ACM) Press, Vol. 8, No. 3, July 1978, pp. 49–61.

[2] Feibel, W., *Novell's Complete Encyclopedia of Networking*, Novell Press, 1995.

[3] "History: Learn About ATM," http://www.atmforum.com/aboutatm/history.html, The ATM Forum, October 3, 2004.

[4] Newton, H., *Newton's Telecom Dictionary: The Official Dictionary of Telecommunications Networking and the Internet*, 16th Expanded & Updated Edition, Telecom Books, 2000.

[5] "HICSS Distinguished Lecture: ALOHA TO THE WEB – Norman Abramson, ALOHA Networks, Inc.," http://www.hicss.hawaii.edu/hicss_31/specpl3.html (main page: http://www.hicss.hawaii.edu/hicss_31/tocmain.htm), *Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS)*, University of Hawaii at Mãnoa, January 6–9, 1998.

[6] Breyer, R., and S. Riley, *Switched, Fast, and Gigabit Ethernet, Third Edition: Understanding, Building, and Managing High-Performance Ethernet Networks*, Macmillan Network Architecture and Development Series, 2002.

[7] "10 Gigabit Ethernet Alliance: Site Highlights," http://www.10gea.org/, October 11, 2004.

[8] Bates, R. J., and D. W. Gregory, *Voice & Data Communications Handbook*, Fourth Edition, New York: Osborne/McGraw-Hill, 2001.

[9] "Frame Relay," http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/frame.htm, Cisco Systems, June 14, 2004.

[10] Duffy, J., "FDDI Nears the End of the Line," http://www.nwfusion.com/archive/1999/83033_12-13-1999.html, *NetworkWorldFusion*, December 13, 1999.

[11] "About the MFA: Overview," http://www.mplsforum.org/about/index.shtml, MPLS (Multiprotocol Label Switching) and Frame Relay Alliance, October 14, 2004.

[12] Willis, D., "State of the WAN," http://www.networkcomputing.com/706/706f1.html, *Network Computing*, April 15, 1996.

[13] Baran, P., "The Beginnings of Packet Switching: Some Underlying Concepts," *IEEE Communications Magazine*, Vol. 40, No. 7, July 2002, pp. 42–48.

[14] "Paul Baran and the Origins of the Internet," http://www.rand.org/about/history/baran.html, RAND, October 18, 2004.

[15] Leiner, B. M., et al., "The Past and Future of the Internet," *Communications of the ACM*, Vol. 40, No. 2, February 1997, pp. 102–108.

[16] Roberts, L., "The Arpanet and Computer Networks," *Proceedings of the ACM Conference on The History of Personal Workstations*, Palo Alto, CA, 1986, pp. 51–58.

[17] Roberts, L. G., "Multiple Computer Networks and Intercomputer Communication," *Proceedings of the First ACM Symposium on Operating System Principles*, ACM, 1967, pp. 3.1–3.6.

[18] Ruthfield, S., "The Internet's History and Development: From Wartime Tool to Fish-Cam," *Crossroads*, ACM Press New York, Vol. 2, No. 1, September 1995, pp. 2–4.

[19] Jaffe, J., "Happy Birthday, Dear Internet," http://www.wired.com/news/infostructure/0,1377,57013,00.html, *Wired News*, December 31, 2002.

[20] Leiner, B. M., et al., "The History of the Internet," http://www.isoc.org/internet/history/brief.shtml#Origins, ISOC, December 10, 2003.

[21] Bradner, S., "The Internet Standards Process – Revision 3," RFC: 2026, http://www.ietf.org/rfc/rfc2026.txt, IETF, October 1996.

[22] Yanowitz, J., "Under the Hood of the Internet: An Overview of the TCP/IP Protocol Suite," http://info.acm.org/crossroads/xrds1-1/tcpjmy.html, *Crossroads*, ACM Press New York, Vol. 1, No. 1, September 11, 1994, pp. 8–10.

[23] "About Internet2," http://www.internet2.edu/about/, Internet2, October 21, 2004.

[24] Davies, M., "Why Is ISDN so Popular: Real Applications – Real Solutions," http://www.isdnzone.com/ISDN_Popular.pdf, Eicon Networks, February 2001.

[25] Bryce, J. Y., *Special Edition, Using ISDN*, Second Edition, Indianapolis: Que Corporation, 1996.

[26] "Multiprotocol Label Switching (MPLS)," http://www.ietf.org/html.charters/mpls-charter.html, MPLS Working Group, IETF, September 20, 2004.

[27] Awduche, D., et al., "Requirements for Traffic Engineering over MPLS: Request for Comments 2702," http://www.ietf.org/rfc/rfc2702.txt, IETF, September 1999.

[28] "MPLS and Frame Relay Forums Announce Intent to Merge," Press Release, MPLS, January 29, 2003.

[29] Costanza, M., "What Protocols Work Best for VoIP?" http://www.computerworld.com/networkingtopics/networking/story/0,10801,92921,00.html, *ComputerWorld*, May 5, 2004.

[30] Larmouth, J., "Understanding OSI," http://www.csse.monash.edu.au/~jwb/osi/osi2.htm, 1997. (Update to *Understanding OSI*, published by Prentice Hall in 1995)

[31] Woods, D., "Shedding Light on Sonet," http://www.networkcomputing.com/1105/1105f1.html, *Network Computing*, March 20, 2000.

[32] "Synchronous Optical Network (SONET)," http://www.iec.org/online/tutorials/acrobat/sonet.pdf, The International Engineering Consortium, October 22, 2004.

[33] Woods, D., "Shedding Light on Sonet: Europe's Synchronous Digital Hierarchy," http://www.networkcomputing.com/1105/1105f1side2.html?ls=NCJS_1105bt, Network Computing, March 20, 2000.

[34] "Voice over Internet Protocols," http://www.iec.org/online/tutorials/acrobat/int_tele.pdf, Internet Engineering Consortium, October 23, 2004.

[35] Bates, R. J., *Broadband Telecommunications Handbook*, Second Edition, New York: McGraw-Hill Companies, Inc., 2002.

[36] Hamblen, M., “Microsoft Joins Bluetooth Push for Bluetooth Wireless Standard,” http://www.computerworld.com/news/1999/story/0,11280,29560,00.html, *ComputerWorld*, December 2, 1999.

[37] Hamblen, M., “Bluetooth Wireless Links Draw Interest, but Sharing Files, Security a Worry for Some,” *ComputerWorld*, June 28, 1999.

[38] “IEEE 802.15 WPAN Task Group 1 (TG1),” http://www.ieee802.org/15/pub/TG1.html, IEEE 802.15 WPAN Task Group, October 24, 2004.

[39] “WiMedia FAQs,” http://www.wimedia.org/about/default.asp?content=faq.asp&style=1#7, WiMedia Alliance, October 24, 2004.

[40] “Qualcomm History,” http://www.qualcomm.com/about/history.html, Qualcomm, October 24, 2004.

[41] “Global System for Mobile Communication,” http://www.iec.org/online/tutorials/acrobat/gsm.pdf, Internet Engineering Consortium, October 23, 2004.

[42] “UMTS History,’ http://www.umtsworld.com/umts/history.htm, *UMTS World*, October 24, 2004.

[43] “IEEE 802 General Information,” http://www.ieee.org/portal/site/mainsite/menuitem.818c0c39e85ef176fb2275875bac26c8/index.jsp?&pName=corp_level1&path=about/802std&file=index.xml&xsl=generic.xsl, IEEE, October 24, 2004.

[44] Brewin, B., “Wireless LANS,” http://www.computerworld.com/mobiletopics/mobile/story/0,10801,69442,00.html, *ComputerWorld*, March 25, 2002.

[45] Kay, R., “QuickStudy: WiMax,” http://www.computerworld.com/mobiletopics/mobile/story/0,10801,87555,00.html, *ComputerWorld*, December 1, 2003.

[46] “WiMax Forum: About,” http://www.wimaxforum.org/about, WiMax, October 25, 2004.

CHAPTER 5

Data Interchange Standards

Data Interchange Services define common formats and semantics to facilitate the exchange of information and data between applications independent of the computer platforms, programming languages, and operating systems. This section discusses standards in widespread use according to their respective category:

- *Graphics data interchange standards* are used to compress raster and vector graphics formats. The raster format uses pixel encoding to store an image, and vector format uses a set of commands that an application employs to display an image [1]. Graphics data interchange standards covered in this chapter include Computer Graphics Metafile (CMG), Joint Photographic Experts Group (JPEG) File Interchange Format (JFIF), Portable Network Graphics (PNG), and Tagged Image File Format (TIFF). Unlike the other graphics data interchange standards discussed in this chapter, the Graphics Interchange Format (GIF) is *not* an open standard; however, its widespread use on the Internet makes it worthwhile to cover here.
- *Digital audio and video standards* are used to define interfaces to control electronic music devices or compress audio and video data. This section discusses the Musical Instrument Data Interface (MIDI) and Motion Picture Experts Group (MPEG) standards.
- *Spatial data interchange standards* such as those provided by OpenGIS and discussed below are defined to support application display, manipulation, and other geographically oriented functions.
- The *word processing data interchange standard* covered is the Standard Generalized Markup Language (SGML). However, Rich Text Format (RTF) and Portable Document Format (PDF) are also covered because they are so widely supported, even though they are not open standards. RTF is used in many word processing systems, and numerous word processing files are converted to PDF for display on the Web.

5.1 Computer Graphics Metafile

Name. Computer Graphics Metafile (CGM).

Purpose. To generate compressed high-quality digital vector, raster, or hybrid (vector and raster) graphics pictures.

History. ANSI published an early CGM specification in 1986 (ANSI X3.122-1986). In 1999, ISO/IEC JTC I/SC 24 published an updated CGM international standard (ISO/IEC 8632:1999). CGM is a proven format for technical illustrations used in electronic technical documents, geographic visualization, and two-dimensional drawings [2]. While ISO/IEC JTC I/SC 24 published the CGM standard, ISO/IEC JTC I/SC 24 worked in conjunction with W3C and CGM Open Consortium to develop the WebCGM Profile, which was based on the CGM ISO/IEC 8632:1999 Version 1, 2, 3, and 4 specifications. WebCGM was released as a WC3 recommendation to support CGM for scalable two-dimensional Web-based document applications [3, 4].

Standards Organizations. ISO/IEC JTC I/SC 24 is responsible for the CGM international standard ISO/IEC 8632:1999. W3C has been releasing updates to WebCGM as W3C recommendations.

Status. W3C and CGM Open Consortium are jointly developing the WebCGM specification.

Obtaining the Specifications. The CGM specifications can be purchased from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html for:

- ISO/IEC 8632-1:1999 – Part 1: Functional specification;
- ISO/IEC 8632-3:1992 – Part 2: Character encoding;
- ISO/IEC 8632-3:1999 – Part 3: Binary encoding;
- ISO/IEC 8632-4:1999 – Part 4: Clear text encoding.

The WebCGM specification can be downloaded from the W3C Web site at http://www.w3.org/TR/REC-WebCGM/.

URL. For more information about WebCGM, refer to http://www.cgmopen.org/webcgm/index.html.

Vendors. The CGM Open Consortium maintains a list of vendor products at http://www.cgmopen.org/webcgm/products.html.

Other Sources of Information.

- "CGM – Computer Graphics Metafile," http://www.itl.nist.gov/fipspubs/fip128-2.htm, *Graphics File Formats*, October 4, 2003;
- "Computer Graphics Metafile (CGM)," FIPS PUB 128-2, NIST, September 1, 2003.

5.2 Graphics Interchange Format

As mentioned in the introduction, GIF is not an open standard, but because its use is so pervasive, a discussion of GIF is provided.

Name. Graphics Interchange Format (GIF).

Purpose. To support color raster images that would support high-resolution graphics on a variety of graphics hardware and provide the format for an exchange mechanism [5]. GIF employs a *lossless* method of compression, which means that it does not lose any data when the compression algorithm is applied [6].

History. CompuServe developed the first GIF specification which was released in 1987, and has made subsequent updates to the specification [1]. However, since GIF implementations employ a version of the Lempel Ziv Welch (LZW) data compression and decompression algorithm that Unisys developed and patented, the software is not free. Unisys has held the licensing for GIF software that implements the LZW algorithm since 1985 in the United States and in many other countries as well (see the URL provided in the status section to determine whether the Unisys LZW patent still applies). GIF files are distinguished by the suffix ".GIF." At the time this book was written, Unisys continued to hold the patent for GIF.

Licensing Organization. As mentioned in the history section, Unisys holds the patent for the LZW algorithm used for the GIF compression encoders and decoders.

Status. Although GIF is limited to a maximum of 256 colors, it is extremely popular and used extensively. At the time this book was written, the Unisys patent had expired in the United States (see the following Unisys URL for details: http://www.unisys.com/about__unisys/lzw/). The gnu.org Web page monitors the GIF developments at URL http://www.gnu.org/philosophy/gif.html.

Obtaining the Specifications. The GIF 89a specification can be downloaded at http://www.w3.org/Graphics/GIF/spec-gif89a.txt.

URL. Refer to URL: http://www.unisys.com/about__unisys/lzw/ for current details on GIF.

Vendors. Numerous vendors support this specification, including word processing packages such as Microsoft Word.

Other Sources of Information.

- Moan, C., "The GIF Controversy: A Software Developer's Perspective," http://www.cloanto.com/users/mcb/19950127giflzw.html, June 20, 2004.
- "What's a GIF or JPEG?" http://www.radix.net/~tpa/index.html, October 4, 2003.

5.3 Joint Photographic Experts Group File Interchange Format

Name. Joint Photographic Experts Group (JPEG) File Interchange Format. It is officially listed as a joint ITU and ISO standard as: ITU-T T.81 | ISO/IEC 10918-1 [7].

Purpose. To generate a 16-bit and 24-bit compressed high-quality image file for display purposes [8]. JPEG uses a *lossy* compression algorithm, meaning that to achieve the high compression rate, it degrades the image to a certain extent [8]. JPEG is used extensively for high-resolution photographic images.

History. JPEG defined the JPEG compression algorithm. The de facto file format for JPEG compressed images was originally called the JPEG File Interchange Format (JFIF), but over time the name became JPEG. JPEG submitted the JPEG draft specification to ISO and it was approved as an ISO standard by ISO/IEC. JPEG submitted the draft JPEG 2000 specification later and this was approved by ISO/IEC and ITU [7].

Standards Organization. The JPEG compression algorithm was developed by JPEG (http://www.jpeg.org/).

Status. JPEG 2000 addresses all parts of the JPEG standard, including Part 1 – The Core, which was published by the ISO SC29/WG1 Committee as an international standard; nine more parts are under development [7]. JPEG 2000 employs state-of-the-art compression techniques based on wavelet technology, and its architecture provides the flexibility for a wide range of applications, from digital cameras to medical imaging and other sectors [7].

Obtaining the Specifications. The draft JPEG 2000 can be downloaded at http://www.jpeg.org/public/fcd14495p.pdf. The published version of JPEG 2000 can be purchased from the ISO IEC Web Store by selecting their "Search and Buy" option at URL: https://domino.iec.ch/webstore/webstore.nsf.

URL. http://www.jpeg.org/jpeg_about.html.

Vendors. Vendors that provide JPEG software and listed by the JPEG Standards Group are listed below [9]:

- AutoGraph International, Inc.;
- Aware, Inc.;
- Cloanto;
- Imagepower;
- Integrated Silicon Systems—silicon cores for JPEG VLSI;
- Lead Technologies—imaging toolkits;
- Luratech – Lurawave, soon with JPEG 2000;
- Pegasus Imaging Corporation;
- ZORAN compression software.

5.4 Musical Instrument Digital Interface

Name. Musical Instrument Digital Interface (MIDI).

Purpose. To define a family of digital interfaces for controlling electronic music devices such as synthesizers.

History. The MIDI Manufacturers Association (MMA) has published a number of MIDI specifications in keeping with its primary focus of producing standards for the companies that manufacture MIDI hardware and/or software products.

Standards Organization. The MMA is composed of a number of companies that work together to define standards for compatible MIDI products. Since 1985, MMA has developed 11 major specifications for MIDI standards, which, when implemented, created new products and markets [10]. In addition, the IEEE Standards Association (IEEE-SA) has begun working on a standard to enable MIDI transmission over the Internet or a LAN environment named IEEE P1639 [11].

Status. MMA has defined an Extensible Music Format (XMF) as part of the MIDI formats (http://www.midi.org/xmf/index.shtml).

Obtaining the Specifications. The specifications can be downloaded at http://www.midi.org/about-midi/specshome.shtml.

URL. http://www.midi.org/about-midi/aboutmidi3.shtml.

Vendors. MMA identifies the following MIDI product vendors (http://www.midi.org/about-midi/aboutmidi3.shtml):

- Yamaha Corporation, U.S. (http://www.yamaha.com/);
- Korg USA;
- Cakewalk;
- Edirol;
- Evolution;
- Bitheadz;
- Madwaves;
- Steinberg.

5.5 Motion Picture Experts Group Layer 3

Name. Motion Picture Experts Group-1 (MPEG-1) Layer 3 (MP3).

Purpose. To compress audio data to a much smaller size while still maintaining the sound quality. MPEG can shrink the original audio data by a factor of 12 [12].

History. Fraunhofer Institut Integrierte Schaltungen (IIS) is considered a leading international research laboratory for audio and multimedia high-quality, low bit rate audio coding [13]. Fraunhofer IIS has been the main developer of MP3. In 1987, in conjunction with the University of Erlangen, scientists under Karlheinz Brandenburg at Fraunhofer IIS along with Dr. Dieter Seitzer and his team from the University of Erlangen, developed a powerful algorithm that became the ISO-MPEG Audio Layer-3 (IS 11172-3 and IS 13818-3) standards [12, 14]. The research on MP3 was carried out as part of the ISO/IEC MPEG Working Group charter [14]. Fraunhofer IIS has also contributed to many other standardization efforts such as MPEG-4, MPEG-7, and MPEG-21 [13].

Standards Organization. The MPEG organization is responsible for defining MPEG standards. Their Web site is at http://www.chiariglione.org/mpeg/index.htm. MPEG is a working group of ISO/IEC (ISO/IEC JTC1/SC29 Working Group 11) and is chartered to define digital standards for audio and video.

Status. MP3 is very popular and used internationally. The MP3 encoder is licensed by Thomson and Fraunhofer.

Obtaining the Specifications. The specifications can be purchased from ISO/IEC at http://www.iec.ch/ and searching for the applicable ISO/IEC specification by name. MPEG-1 has five parts:

- ISO/IEC 11172-1: 1993, ISO/IEC 11172-1:1993/Cor 1:1996, and ISO/IEC 11172-1:1993/Cor 2:1999, Part 1: Systems;
- ISO/IEC 11172-2: 1993, ISO/IEC 11172-2:1993/Cor 1:1996, and ISO/IEC 11172-2:1993/Cor 2:1999, Part 2: Video;
- ISO/IEC 11172-3: 1993 and ISO/IEC 11172-3:1993/Cor 1:1996, Part 3: Audio;
- ISO/IEC 11172-4:1995, Part 4: Compliance Testing;
- ISO/IEC TR 11172-5:1998, Part 5: Software Simulation.

URL. For detailed information on MPEG-1, refer to the MPEG home page at http://www.chiariglione.org/mpeg/index.htm.

Vendor. Thomson MP3Pro (http://www.mp3licensing.com/mp3/mp3pro2.html).

Other Sources of Information. "From ISO to a Global Standard," http://www.mp3licensing.com/mp3/iso.html, Thomson MP3 Licensing, October 4, 2003.

5.6 Motion Pictures Experts Group

Name. Motion Pictures Experts Group (MPEG).

Purpose. To define coded representation of digital audio and video [15].

History. Established in 1988 as an ISO/IEC Working Group (ISO/IEC JTC1/SC29 Working Group 11), MPEG is chartered to define international compression, decompression, processing, and coded representation standards for moving pictures and audio for a variety of applications [16].

Standards Organization. The MPEG Working Group of ISO/IEC is responsible for defining MPEG standards. Their Web site is at http://www.chiariglione.org/mpeg/index.htm.

Status. The MPEG Working Group is continuing to define and refine MPEG standards.

Obtaining the Specifications. The specifications can be purchased from ISO/IEC at http://www.iec.ch/ and searching for the applicable ISO/IEC specification by name. Detailed documentation of the standards can be found at URL: http://

www.chiariglione.org/mpeg/standards.htm. The MPEG Terms of Reference identifies a list of MPEG standards that it is involved in defining:

- 11172: MPEG-1: “Coding of Moving Pictures and Associated Audio” [16];
- 13818 MPEG-2: “Generic Coding of Moving Pictures and Associated Audio” [16];
- 14496 MPEG-4: “Coding of Audio-Visual Objects” [16];
- 15938 MPEG-7: “Multimedia Content Description Interface” [16];
- 21000 MPEG-21: “Multimedia Framework” [16].

URL. For detailed information on MPEG standards, refer to the ISO/IEC JTC1/SC29 Working Group 11 MPEG home page: http://www.chiariglione.org/mpeg/index.htm.

5.7 OpenGIS Specifications

Name. Open Geographic Information Systems (OpenGIS).

Purpose. To provide rules for programming and implementing interfaces and protocols for geographically oriented, spatial processing systems, to support interoperability [17]. The specifications provide a single spatial reference system for all mapping and geographical queries, algorithms, and displays [17].

History. The OpenGIS specifications are being defined by the Open GIS Consortium, Inc. (OGC), and OpenGIS is the registered trademark for their specifications and documents.

Standards Organization. OGC is responsible for developing and maintaining OpenGIS (http://www.opengis.org/).

Status. OGC provides a family of specifications identified by service categories, such as those listed below. OGC also administers an OpenGIS conformance testing program to determine if a vendor’s product satisfactorily implements the APIs and, if so, allows the vendor to use the OpenGIS trademark (http://www.opengis.org/datasheets/20010414.TS.ProdImpl.htm, http://www.opengis.org/testing/about.html).

Obtaining the Specifications. OpenGIS specifications can be downloaded at http://www.opengis.org/techno/implementation.htm and include the following services:

- *OpenGIS Web Mapping Services:* enables dynamic queries, accesses, processing of spatial information on the Web [17];
- *OpenGIS Web Map Server (WMS) Interface:* provides Web clients with a standard access to maps on the Internet [17];
- *OpenGIS Geospatial Fusion Services:* integrates non-map information such as text, video, audio, and photographs, with a geographic location [17];

- *OpenGIS Catalog Service Interface:* defines a common interface for queries [17];
- *OpenGIS Coordinate Transformation:* converts coordinates to a standard spatial reference system [17];
- *OpenGIS Geography Markup Language (GML 2.0 and GML 3.0):* provides an XML interface to support Web-based functions for the exchange of information [17];
- *OpenGIS Simple Features:* associates two-dimensional features with the spatial reference system [17].

URL. http://www.opengis.org/ogcSpecsPrg.htm.

Vendors.

- OpenGIS survey of vendors: http://www.opengis.org/testing/product/index.php.
- Open Systems International supports OpenGIS APIs (http://www.osii.com/PD_OpenGIS.pdf);
- ESRI (http://www.esri.com/software/opengis/interopdownload.html, http://www.esri.com/news/releases/03_1qtr/opengisgita.html).

5.8 Portable Document Format

As mentioned in the introduction, PDF is not an open standard, but because it is used so widely to display documents on the Web, this section is provided.

Name. Portable Document Format (PDF).

Purpose. To provide a standard format that would allow files produced by desktop publishing and word processing systems to be displayed and printed independent of the specific computer platforms, printers, operating systems, and applications.

History. PDF grew from an internal project at Adobe Systems and was publicly released in 1992 as PDF Version 1.0 [18]. Adobe Systems had developed PostScript as a means for printing word processing files and graphics objects independent of the computing platforms, and the original PDF specification was based on PostScript [18]. PDF files are distinguished by the suffix ".PDF."

Configuration Management. Adobe Systems is responsible for defining and enhancing the Portable Document Format, and manages the software that generates it.

Status. Adobe Systems develops and maintains the Adobe Acrobat® software products that generate, display, print, and modify PDF files (http://www.adobe.com/products/acrobat/adobepdf.html).

Obtaining the Software. Adobe Acrobat Reader software is provided by Adobe Systems for free to display and print PDF files, and it can be obtained by downloading it at http://www.adobe.com/products/acrobat/readermain.html.

Other Sources of Information. PDF information by Laurens Leurs, found at URL: http://www.prepressure.com/pdf/overview.htm.

5.9 Portable Network Graphics

Name. Portable Network Graphics (PNG).

Purpose. To replace the GIF image compression format with one that would support "indexed-color, grayscale, and truecolor images," and "sample depths [that would] range from 1 to 16 bits per component" for grayscale images and "up to 48-bit images for RGB [Red Green and Blue]" [1, 19].

History. In the 1980s, developers using the GIF compression algorithm were chagrined that they would need to purchase a GIF license from Unisys because they had used it previously for free [20]. Hence, they began working within the auspices of the W3C to develop a specification for a free image compression algorithm [20]. Eventually, the draft specification was referred to as PNG, for Portable Network Graphics. On October 1, 1996, the PNG specification was issued as a W3C Recommendation [19].

Standards Organization. W3C. (http://www.w3.org/) is responsible for maintaining this specification.

Status. It is expected that PNG will replace GIF in time for Web-based applications as users perceive a greater need for 24-bit color images; however, until PNG supports animated images as GIF does, GIF will probably not disappear altogether [21].

Obtaining the Specifications. The specification for PNG can be downloaded from the W3C graphics Web site at: http://www.w3.org/Graphics/PNG/.

URL. The Web site for PNG is located at http://www.libpng.org/pub/png/.

Vendors. PNG is supported by the Internet Explorer browsers and the following URL provides information about PNG viewer availability: http://www.libpng.org/pub/png/pngapbr.html.

Other Sources of Information. Greg Roelofs maintains Web pages that discuss the history of PNG: http://www.libpng.org/pub/png/pnghist.html, October 5, 2003.

5.10 Rich Text Format

As mentioned in the introduction, RTF is not an open standard. However, because it is supported by Microsoft Word and other word processing applications, this section is provided to describe RTF.

Name. Rich Text Format (RTF).

Purpose. To provide a format that supports the interchange of text and graphics to enable its use with different output devices, operating environments, and operating systems [22].

History. The Microsoft Word (since version 6.0) application is able to save, read, and modify RTF files. RTF files are distinguished by the suffix ".RTF." Microsoft developed RTF as a means for exchanging text files between applications, especially those that support Microsoft Word but use other than Microsoft's operating systems.

Configuration Management. RTF is a de facto standard since the Microsoft Word application that supports it enjoys widespread use and popularity on a variety of operating systems. Microsoft is responsible for developing and refining the RTF specification.

Status. Microsoft Corporation is continuing to mature the specification for RTF, and it is currently at version 1.7.

Obtaining the Specifications. The RTF Version 1.7 specification is available from Microsoft at http://www.microsoft.com/downloads/details.aspx?displaylang=en&familyid=e5b8ebc2-6ad6-49f0-8c90-e4f763e3f04f.

Vendors. Microsoft Word supports the RTF format. Microsoft Word is available on the Microsoft Operating Systems (e.g., 95/98/2000/NT/XP) and Apple Macintosh Operating Systems.

5.11 Standard Generalized Markup Language

Name. Standard Generalized Markup Language (SGML).

Purpose. To define a common format for word processing applications independent of computer platforms. SGML is a *markup language*, which WC3 describes as a language where designations (markings or tags) are embedded in a document to represent semantic information for text content [23].

History. In 1969, Charles Goldfarb, E. Mosher, and R. Lorie invented the Generalized Markup Language (GML) to enable information retrieval subsystems to support textual editing, formatting, and document sharing. Because major portions of GML were used in mainframe publishing systems by IBM and other companies, it achieved general acceptance within industry [24]. In 1978, ANSI asked Goldfarb to join their committee, where they developed his design for a GML language into the SGML standard and published a draft of the standard in 1980 [24]. In 1986, ISO published SGML as a standard (ISO 8879:1986).

Standards Organization. ISO is responsible for maintaining the SGML specification.

Status. SGML is considered a mature standard and was used as the basis for HTML [23].

Obtaining the Specifications. The ISO 8879:1986 specification for SGML can be purchased from ISO at http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=16387.

URL. ISO is responsible for maintaining the SGML specification.

Vendors. SGML is widely supported by vendors.

Other Sources of Information.

- Charles Goldfarb, "The Roots of SGML—A Personal Recollection," http://www.sgmlsource.com/history/roots.htm, 1996.
- Price, L. A., "Practical SGML as an Introduction to SGML," *ACM SIGDOC Asterisk Journal of Computer Documentation*, Vol. 20, No. 2, May 1996, pp. 36–38.
- The OASIS Web page for SGML at URL: http://www.oasis-open.org/cover/general.html provides general information.
- There is an SGML FAQ at URL: http://lamp.man.deakin.edu.au/sgml/sgml faq.txt.

5.12 Tag(ged) Image File Format

Name. Tag(ged) Image File Format (TIFF).

Purpose. To define a platform-independent tag-based file format that supports the ability to store and interchange raster images [25].

History. Aldus Corporation published the first version of the TIFF specification in 1986 after having already released two draft versions. Since Adobe Systems acquired Aldus Corporation in 1994, the TIFF specification belongs to Adobe Systems [25].

Standards Organization. Adobe Systems is responsible for maintaining the specification.

Status. TIFF defines several classes of image data: monochrome, 4- to 8-bit grayscale, 4- to 8-bit color palette, and 24-bit RGB [25]. In addition, TIFF supports Huffman, LZW, and JPEG compression [25]. It supports video, fax, and medical and scientific images [25]. However, because it is fairly complex, it is not commonly used for home applications [25].

Obtaining the Specifications. TIFF Version 6 can be downloaded at http://partners.adobe.com/asn/developer/pdfs/tn/TIFF6.pdf.

Vendors. TIFF is widely supported by vendors for fax, video, and document storage.

References

[1] Graef, G., "Graphics Formats for Linux," *Linux Journal*, Vol. 1996, No. 23es, Article 3, March 1996.

[2] "WebCGM at a Glance," http://www.cgmopen.org/webcgm/overview.html, CGM Open Consortium, October 6, 2003.

[3] Gebhardt, J., and L. Henderson, "BIIF, VRML, and CGM: CGM Open and the WebCGM Profile," *ACM Siggraph Computer Graphics*, Vol. 33, No. 2, May 1999, pp. 56–60.

[4] "WebCGM Profile," http://www.w3.org/Graphics/WebCGM/, W3C, October 6, 2003.

[5] "Graphics Interchange Format Specification," http://www.nist.ru/hr/doc/spec/gif87.htm, CompuServe Incorporated, June 15, 1987 (October 6, 2003).

[6] "Creating Graphics for the Web: Compression Basics," http://www.widearea.co.uk/designer/compress.html, Wide Area Communications, 1996 (October 4, 2003).

[7] "New – JPEG 2000 Coverage from Two of Our Key Members," http://www.jpeg.org/JPEG2000.html, JPEG, October 4, 2003.

[8] Schroeder, M. D., "JPEG Compression Algorithm and Associated Data Structures," http://people.cs.und.edu/~mschroed/jpeg.html, University of North Dakota, October 4, 2003.

[9] "Some Links to JPEG Related Sites and Documents," http://www.jpeg.org/public/jpeglinks.html, JPEG, October 4, 2003.

[10] "MIDI Manufacturers Association," http://www.midi.org/, MIDI Manufacturers Association, October 4, 2003.

[11] "Start of Distributed MIDI Standard to Open Creative Possibilities for Musical Composition and Performance," http://www.plus24.com/ieee1639/index.php, IEEE, October 4, 2003.

[12] "Audio & Multimedia MPEG Audio Layer-3 History," http://www.iis.fraunhofer.de/amm/techinf/layer3/index.html, Fraunhofer Institut Integrierte Schaltungen (IIS), October 4, 2003.

[13] "Audio & Multimedia: Home of MP3," http://www.iis.fraunhofer.de/amm/index.html, Fraunhofer Institut Integrierte Schaltungen (IIS), October 5, 2003.

[14] "Audio Revolution: The Story of MP3," http://www.mp3licensing.com/mp3/index.html, Thompson MP3 Licensing, October 5, 2003.

[15] "The MPEG Home Page," http://www.chiariglione.org/mpeg/index.htm, MPEG, October 5, 2003.

[16] "@Ref # = [MPEG] Terms of Reference," http://www.chiariglione.org/mpeg/terms_of_reference.htm, MPEG, October 5, 2003.

[17] "About OpenGIS®," http://www.opengis.org/ogcAbout.htm, OpenGIS Consortium, October 4, 2003.

[18] Leurs, L., "The History of PDF," http://www.prepressure.com/pdf/history/history01.htm, prepressure page, October 5, 2003.

[19] "PNG (Portable Network Graphics)," http://www.w3.org/Graphics/PNG/, W3C, October 5, 2003.

[20] Roelofs, G., "History of the Portable Network Graphics (PNG) Format," http://www.libpng.org/pub/png/pnghist.html, January 1977.

[21] Mickiewicz, M., and N. Danino, "GIF, JPG, and PNG – What's the Difference?" http://www.sitepoint.com/article/44?SID=e21bfd5fe8115289ded6b6f89500f93c, sitepoint, December 26, 1999.

[22] "Rich Text Format (RTF) Version 1.7 Specification," http://www.microsoft.com/downloads/details.aspx?displaylang=en&familyid=e5b8ebc2-6ad6-49f0-8c90-e4f763e3f04f, Microsoft, October 5, 2003.

[23] "On SGML and HTML," http://www.w3.org/TR/REC-html40/intro/sgmltut.html#h-3.1, W3C, October 6, 2003.

[24] "A Brief History of the Development of SGML," http://www.sgmlsource.com/history/sgmlhist.htm, 1990 SGML Users' Group, June 11, 1990.

[25] "TIFF™: Revision 6.0 Final," http://partners.adobe.com/asn/developer/pdfs/tn/TIFF6.pdf, Adobe Developers Association, June 3, 1992.

CHAPTER 6

Data Management Standards

6.1 Database Query Languages

Two and three decades ago, stand-alone applications managed their own data in what were referred to as *flat files*—American Standard Code for Information Interchange (ASCII) or IBM's Extended Binary-Coded Decimal Interchange Code (EBCDIC) text files that contained alphanumeric data. These stand-alone applications managed the access, manipulation, updates, and storage of their own unique application data. For other programmers to use the data, they typically developed their own stand-alone applications to access, manipulate (parse), and save the updated data. This cumbersome approach to sharing data changed in the 1980s as programmers were introduced to database management systems (DBMS) and a common query language for accessing and manipulating data in relational databases.

This section discusses four standards used to query DBMS: Java Database Connectivity (JDBC), Java Data Objects (JDO), the Object Data Management Group (ODMG) specification, and the Standard Query Language (SQL).

6.1.1 Java Database Connectivity

Name. Java Database Connectivity (JDBC).

Purpose. To provide an API to relational databases, spreadsheets, and files for Java applications on Java 2 platforms (see Java 2 Platform specifications discussed in Chapter 11: J2EE, J2SE, and J2ME).

History. Java programmers needed database connectivity to store and retrieve Java objects, but the SQL for relational DBMS did not support a Java interface. Consequently, Sun Microsystems developed and introduced a JDBC software package in 1996 that provided a driver enabling Java client applications to retrieve and store Java objects using an interface to SQL [1]. In addition, JDBC provided a bridge to the ODBC technology (referred to as the JDBC/ODBC bridge), which Microsoft had developed as a standard method for allowing applications written in object-based programming languages other than Java (e.g., C++) to access and store data in ODBC-compliant databases [1]. The JDBC specification is now under the purview of the Java Community Process (JCP) organization and was expanded to provide Java APIs for spreadsheets and other files.

Standards Organization. The JCP organization (http://www.jcp.org/en/home/index) maintains Java-related technology specifications, including JDBC, for technologies originally created by Sun Microsystems.

Status. The JCP organization has developed a JDBC 3.0 Specification [Java Specification Request (JSR) #54] update that will accommodate changes in the SQL specifications for Java for the Java 2 Platform Standard Edition (J2SE) and Java 2 Platform Enterprise Edition (J2EE). See http://www.jcp.org/en/jsr/detail?id=54 for details. JSR 169 is being developed for the Java 2 Platform Micro Edition (J2ME).

Obtaining the Specifications. The specifications for JDBC can be downloaded via URL: http://java.sun.com/products/jdbc/download.html.

URL. http://java.sun.com/products/jdbc/download.html.

Vendors. Numerous vendors support JDBC, including Sun Microsystems (http://www.sun.com), IBM (http://www.ibm.com), Postgres (http://www.postgres.com), and Oracle (http://www.oracle.com).

Other Sources of Information.

- JDBC Forum provides information about JDBC at URL: http://forum.java.sun.com/forum.jsp?forum=48.
- A JDBC tutorial can be found at URL: http://java.sun.com/docs/books/tutorial/jdbc/http://java.sun.com/docs/books/tutorial/jdbc/.
- For development, refer to TheServerSide.com Web site dedicated to discussing Java technologies such as JDBC and answering technical questions at URL: http://www.theserverside.com/discussion/index.jsp.

6.1.2 Java Data Objects

Name. Java Data Objects (JDO) Specification.

Purpose. To define an API for Java objects using the Java programming language for persistent data storage and transactions.

History. To further Java developers' ability to create and use persistent data storage for Java objects without needing to learn a database language like SQL, the JCP oversaw the development of a Java API that supports queries, transactions, and storage for Java objects [2]. The JDO specification is based on the ODMG 3.0 specification, which the ODMG organization gave the JCP the rights to use [3].

Standards Organization. The JCP organization (http://www.jcp.org/en/home/index) is responsible for maintaining the JDO specifications.

Status. The JCP organization developed the Java Specification Request 12 (JSR 12) that defines JDO.

Obtaining the Specifications. The JDO specification can be downloaded at URL: http://jcp.org/aboutJava/communityprocess/final/jsr012/index2.html.

URL. http://java.sun.com/products/jdo/.

Vendors. A list of vendors that have implemented JDO-compatible products can be viewed at URL: http://www.jdocentral.com/ by selecting the "JDO Vendor Directory" on the left-hand frame.

Other Sources of Information. The JDO Central Web site was designed to allow the developer community to share insights and news. It is located at URL: http://www.jdocentral.com/. In addition, refer to TheServerSide.com Web site for information about Java technologies such as JDO and answers to technical questions at URL: http://www.theserverside.com/discussion/index.jsp.

6.1.3 Object Data Management Group Specification

Name. Object Data Management Group (ODMG) Specification.

Purpose. To define standards to extend object-oriented languages such as C++ or Smalltalk to create, manipulate, and store persistent objects in a database management system.

History. In the fall of 1991, five object DBMS vendors met at Sun Microsystem to begin development of a specification for an object-oriented DBMS, thereby establishing an ODMG Group [4]. Representatives from each company (five in all) worked 1 week per month for more than 2 years to develop a specification they referred to as ODMG [4]. The first version of the specification was published as ODMG-93, and the final version was named ODMG 3.0 [4].

Standards Organization. ODMG was responsible for developing the ODMG specifications, but it disbanded in 2001 after completing the ODMG 3.0 specification [5].

Status. The Java Community Process incorporated the ODMG 3.0 Java Binding into its JDO specification [5].

Obtaining the Specifications. The ODMG 3.0 specification was published in a book that is available for purchase (see URL: http://www.odmg.org/ordering-book.html for details).

6.1.4 Standard Query Language

Name. Standard Query Language (SQL).

Purpose. To provide a standard means of accessing, storing, manipulating, and displaying data used for software applications.

History. In the early 1970s, While working at the IBM San Jose Research Lab, IBM programmer Dr. E. F. Codd developed a query language that organized data into relations consisting of two dimensions, rows and columns that were based on set theory [6]. By 1974, IBM had developed a relational database known as System/R that used Structured English Query Language (SEQUEL) to access data tables. The name SEQUEL was shortened over time to SQL (also known as SQL-92) [7]. A company formerly known as Relational Software, Inc. (now named

Oracle) produced Oracle, the first relational database management system to be commercially available. Oracle used SQL for its query language [7].

IBM followed up System/R with a commercial relational database product known initially as the SQL/Data System (SQL/DS), and then as Database 2 (DB2) in 1981 [7]. IBM's version of SQL became the de facto standard [6, 7]. ANSI defined the first SQL standard based on IBM's product (1986), developed a revised version named SQL2 in 1992, and submitted it to the ISO, where it was revised and approved as a joint ISO/IEC standard, ISO/IEC 9075, in the mid-1990s.

Standards Organization. The ISO/IEC Joint Technical Committee 1 (JTC 1) Subcommittee 32 (http://www.jtc1sc32.org/) is responsible for maintaining and extending the SQL specifications.

Status. SQL is supported by a number of major vendors and continues to expand to accommodate new technologies.

Obtaining the Specifications. The SQL specifications can be purchased from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html for ISO/IEC 9075 and ISO/IEC 13249. Current SQL specifications include:

- ISO/IEC 9075-1:2003[1] – SQL Part 1, Framework;
- ISO/IEC 9075-2:2003 – SQL Part 2, Foundation. In addition, there is an amendment and technical Corrigenda (corrections) for this specification:
  - ISO/IEC 9075-2 1999/Amd 1:2001/Cor 1:2003;
  - ISO/IEC 9075-2:1999/Cor 2:2003.
- ISO/IEC 9075-3:2003 – SQL Part 3, SQL/CLI (Call-Level Interface);
- ISO/IEC 9075-4:2003 – SQL Part 4, SQL/PSM (Persistent Stored Modules);
- ISO/IEC 9075-5:2003 – SQL Part 5, SQL/Bindings:
  - ISO/IEC 9075-5:1999/Amd 1:2001/Cor 1:2003;
  - ISO/IEC 9075-5:1999/Amd 1:2001/Cor 1:2003, SQL/OLAP (On-Line Analytical Processing).
- ISO/IEC 9075-9:2003 – SQL Part 9, SQL/MED (Management of External Data)
- ISO/IEC 9075-10:2003 – SQL Part 10, SQL/OLB (Object Language Bindings). This specification was originally known as SQLJ and was originally developed by such companies as IBM, Informix, Microsoft, Oracle, Sun Microsystems, and Sybase, Inc., with the purpose of integrating SQL with Java [8];
- ISO/IEC 9075-11:2003 – SQL Part 11, SQL/Schemata (Information and Definition Schemas);
- ISO/IEC 9075-13:2003 – SQL Part 13, SQL/JRT (SQL Routines and Types Using the Java Programming Language);
- ISO/IEC 9075-14:2003 – SQL Part 14, SQL/XML (XML-Related Specifications);

1. ISO/IEC 9075:2003 replaced ISO/IEC 9075:1999 for SQL:1999.

- Standards that support SQL manipulation of multimedia and application data;
  - ISO/IEC 13249-1:2002 – Part 1, SQL Framework for Multimedia and Application Packages;
  - ISO/IEC 13249-2:2002 – Part 2, Full Text;
  - ISO/IEC 13249-3:2002 – Part 3, Spatial[2];
  - ISO/IEC 13249-5:2002 – Part 5, Still image;
  - ISO/IEC 13249-6: 2002 – Part 6, Data mining.

Vendors. Vendor products that support SQL standards include:

- Oracle supports the Oracle database management system (http://www.oracle.com).
- Sybase, Inc., provides Sybase database products (http://www.sybase.com/products/databaseservers).
- Microsoft provides the SQL Server (http://www.microsoft/sql/).
- IBM supports Informix database products (http://www-306.ibm.com/software/data/informix/) and DB2 database products (http://www-306.ibm.com/software/data/db2/).
- Open source database products include PostgresSQL (http://www.postgres.org/) supported by PostgresSQL, Inc. (http://www.pgsql.com/), which was originally developed at the University of California at Berkeley and is associated with Linux; and MySQL (http://www.mysql.com/).

Other Sources of Information.

- SQL.org provides a portal dedicated to providing information about some SQL products and links to SQL experts who can answer questions (http://www.sql.org/).
- For a history of the Oracle Relational Database Management System, refer to URL: http://www.oracle.com/corporate/index.html?history.html.

6.2 File Systems for Networks

File systems were developed as a means to enable users, applications, peripherals and other devices to access and share files on a network. Vendors used to develop custom file systems and networks that could be used only with their own platforms, but over time, file systems evolved to connect multivendor, heterogeneous platforms and devices that supported a variety of functions—printing, faxing, complex graphics, number crunching, databases, and applications.

File systems require standard protocols to share files, since a protocol defines the format and procedure for sending and receiving data between devices, for example, provides details on how the transmission must begin and end; outlines how to

2. Mark Ashworth wrote a paper entitled "SQL and Beyond" in *StandardView* (Vol. 2, No. 3, ACM Press, 1994, pp. 175–178) that provides details about the spatial standard.

send the data (e.g., data partitioning, encryption, and encapsulation); and describes how to provide error checking to insure data integrity. Each of the standards listed in this section are actually protocols for file systems.

6.2.1 Common Internet File System

Name. Common Internet File System (CIFS).

Purpose. To define a remote file-system access protocol for the Internet that enables multiple applications (clients) to access and update (share) the same file without conflicts [9].

History. In the mid-1980s, Microsoft developed the CIFS protocol to support multiuser read and write operations, file locking, file sharing, and file caching over TCP/IP for Microsoft operating system applications and users, and this was considered a vast improvement to the simpler File Transfer Protocol (FTP) or manual mode of copying files from floppy disks to a Microsoft operating system directory [9].

Microsoft developed CIFS as an enhancement to their Server Message Block (SMB) protocol, which was implemented based on the SMB specification defined by The Open Group (formerly X/Open) in 1992 (http://www.opengroup.org/products/publications/catalog/c209.htm) and was "tuned to run efficiently over slow dial-up lines" [9]. Because "CIFS servers support both anonymous transfers and secure, authenticated access to named files," [9] with easy-to-implement file and directory security policies, CIFS has become "an integral part of workstation and server operating systems as well as embedded and appliance systems" [9]. CIFS was extended to address Network Attached Storage (NAS) as well as Storage Area Networks (SAN) [10]. Microsoft wrote the CIFS 1.0 protocol specification to accomplish this, and provided it to numerous companies for their feedback prior to submitting it to the IETF in 1996. IETF did not publish the CIFS draft specification as a standard, and since that time, the Storage Networking Industry Association (SNIA) has developed a final CIFS technical proposal dated March 2002 that could potentially lead to a formal specification [10].

Standards Organization. The CIFS Sub-Group of the SNIA NAS Technical Working Group (TWG) is responsible for the current CIFS technical proposal.

Status. The CIFS specification is currently an SNIA technical proposal.

Obtaining the Specifications. The CIFS technical proposal can be downloaded at URL: http://www.snia.org/tech_activities/CIFS/CIFS-TR-1p00_FINAL.pdf.

URL. http://www.snia.org/tech_activities/CIFS.

Vendors. The majority of platform vendors support CIFS products, such as Microsoft Corporation (http://www.microsoft.com), IBM (http://www.ibm.com/), Sun Microsystems (http://www.sun.com/), and Hewlett-Packard (http://www.hp. com/).

Other Sources of Information.

- Christopher Hertel's *Implementing CIFS: The Common Internet File System*, published by Prentice Hall Professional Technical Reference (PTR), can be viewed on-line at URL: http://www.ubiqx.org/cifs/.

- For a detailed discussion of CIFS, refer to the article by Paul Leach and Dan Perry, "CIFS: A Common Internet File System," published in the November 1996 issue of *Microsoft Internet Developer* at URL: http://www.microsoft.com/mind/1196/cifs.asp.

6.2.2 Direct Access File System

Name. Direct Access File System (DAFS).

Purpose. To define a protocol for storing and accessing files on a network, with an emphasis on high performance and direct, memory-to-memory access [11].

History. Network Appliance, Inc., was responsible for beginning the development of DAFS [12]. Network Appliance defined DAFS to leverage the speed of the 10 Gigabit Ethernet and InfiniBand protocols and enable applications on heterogenous networked platforms and storage device clusters to read and write directly to memory addresses to exchange file data and information, rather than rely on handshaking and buffering between software applications [12]. In June 2000, a group of vendors that included Network Appliance, Intel, and Seagate Technology formed an association that they named the DAFS Collaborative in order to define a protocol for DAFS [11, 12]. The association grew to 85 members and completed a DAFS 1.0 specification that incorporated portions of the NFS protocol. In September 2001, the DAFS Collaborative submitted the specification to the IETF and the Storage Networking Industry Association to consider its publication as a standard [12].

Standards Organization. The DAFS Collaborative association merged with SNIA in 2001 and formed a DAFS Implementers Forum (http://www.snia.org/tech_activities/dafs/Intro_DAFS_pres.pdf, slide 13).

Status. SNIA has published several versions of the specification for DAFS.

Obtaining the Specifications. The specification can be downloaded at URL: http://www.snia.org/tech_activities/dafs/DAFS_Spec_v10.pdf.

URL. Information about DAFS can be viewed at the following URLs:

- "Introduction to DAFS," which discusses the use of the Virtual Interface architecture: http://www.snia.org/tech_activities/dafs/Introduction_to_DAFS_wp.pdf;
- DAFS' Implementers Forum: http://www.snia.org/tech_activities/dafs##top;
- DAFS' Implementers Forum Charter: http://www.snia.org/tech_activities/dafs##top.

Vendors. As would be expected, Network Appliance, Inc., implemented the first DAFS product (http://searchstorage.techtarget.com/originalContent/0,289142,sid5_gci813369,00.html) to operate on a number of storage vendor platforms. As the use of storage device clusters such as NAS and SAN grows, the implementation of DAFS as part of an integrated vendor solution is also expected to increase. A NAS is a dedicated file server with one or more hard disks (the number is scalable), where the server attaches directly to the network and has its own network address [12]. A

NAS is considered an economical solution for expanding storage, especially since it allows multiple users to simultaneously access the same data [12]. NAS appliances are frequently used to augment corporate Web servers by storing popular Web pages and enabling simultaneous user access. For a description of a SAN, see the introduction to Section 6.5.

6.2.3 Network File System

Name. Network File System (NFS).

Purpose. To define a protocol for storing and access files on a distributed network.

History. Sun Microsystems Corporation developed NFS in the mid-1980s as a means for sharing files between its Unix operating system platforms and peripheral devices. Whereas Microsoft developed CIFS predominantly for Microsoft operating systems (see Section 6.2.1) and its use spread to other PC platforms, NFS was Sun's solution for distributed file sharing among its Unix platforms that became widely used on other vendor platforms [11]. In 1998, Sun Microsystems gave control of NFS to the IETF, which assumed responsibility to create a version of NFS for the Internet [13]. The IETF defined NFS Version 4 to support file sharing for any operating system using the Internet [13].

Standards Organization. The IETF NFS Version 4 Working Group (http://www.ietf.org/html.charters/nfsv4-charter.html) maintains the NFS specifications and publishes them as standards.

Status. The IETF has proposed the RFC 3530 Network File System version 4 Protocol standard as a replacement to RFC 3010. NFS version 4 is based on RFC 1094, NFS version 2, and RFC 1813, NFS version 3.

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.ietf.org/rfc/rfc3530.txt?number=3530.

URL. http://www.nfsv4.org/.

Vendors. For Unix platforms, vendors that provide NFS products include: Sun Microsystems (http://wwws.sun.com/software/solstice/netclient/) and Novell (http://www.wais.com/products/nc/nfs/index.html?cks=y).

For PCs on a NFS network (e.g., Windows-based NFS platforms), refer to Xlink Technology (http://www.xlink.com/product_link.htm) and Hummingbird Limited (http://www.wais.com/products/nc/nfs/index.html?cks=y).

Other Sources of Information. For NFS as implemented on Linux, see URL: http://nfs.sourceforge.net/.

6.3 Metadata and Data Models

Section 6.1 discussed how data files evolved into databases that required a standard query language for persistent data storage, access and manipulation; and Section 6.2

covered how file systems evolved to enable users and systems to access data in files residing on a network. Today, there are hosts of organizational databases, data repositories, and data files around the world, and large organizations need to access, mine, and use that data in unique ways. Metadata and data models are used to provide a structured, integrated, conceptual view of the data.

Metadata can be described as "data about data." Metadata provides an overview of the kinds of data stored in one or more repositories by delineating key categories and providing specific data for each category as applicable to the repository. For instance, a repository might be a set of image files delineated by country, with pictures of landmarks for major cities. The metadata might have a category of image files with the attributes of country, cities, and landmarks, where each image file would be catalogued in the metadata by its country, city, and landmark, to be used to find and retrieve relevant images. In this manner, metadata can facilitate data mining.

Data models describe the relationships between the categories of data and identify all of the attributes, and may include a data dictionary. Implementations of metadata may include a data model. Today's data warehouse applications rely on metadata as the basis for searching, discovering, and retrieving data in an enterprise. However, as a means for keeping the size of metadata manageable (there is a danger of it growing exponentially as new data repositories are added), *domain* metadata are being defined that distinguish between repositories developed for particular kinds of data, such as images, documents, purchase orders, or personnel records. *Master metadata* are also being defined, and they contain a superset of the domain metadata, and are used to focus queries to the most applicable domain metadata.

Numerous organizations and consortia are forming to define domain metadata for many kinds of repositories—financial applications, e-business applications, documents, scientific applications, and so on—but the three standards described in this section are important because they apply to the enterprise and are important for software product development.

6.3.1 Common Information Model

Name. Common Information Model (CIM).

Purpose. To define object-oriented schema that model a distributed enterprise environment, where the schema describe objects in the environment, their relationships and topology, and provide management information about the objects (e.g., status). Enterprise objects include networks, servers, applications, platforms, and devices in the enterprise.

History. In the 1990s, each vendor developed unique schema to provide information about their product (e.g., status of internal processes, configuration, performance, application version and/or serial numbers) once it had been installed on a platform, server, or device in the enterprise. This approach became unwieldy as enterprise managers attempted to inventory their enterprise products but had to learn the individual manufacturer's application and functions to query each device in the enterprise [14, 15]. Although the Simple Network Management Protocol (SNMP) and Desktop Management Information (DMI) alleviated this problem for network devices and desktop systems, a standard was needed for all objects in the enterprise (e.g., servers, printers, etc.) [14]. In July 1996, Cisco Systems, Inc., Compaq Computer Corporation, Intel Corporation, Microsoft Corporation, and BMC Software, Inc., sponsored a Web-Based Enterprise Management (WBEM) Initiative to provide system managers with standard information about enterprise configurations so that they could determine and diagnose problems [14]. The CIM was a major part of the WBEM initiative, and the companies turned over what they had defined to the Distributed Management Task Force (DMTF) in 1998, which became responsible for it thereafter [14].

Standards Organization. The DMTF is responsible for defining and maintaining this standard.

Status. With the introduction of storage management technologies such as SAN and NAS, major vendors such as EMC, IBM, and Hitachi Data Systems are providing support for storage products that support the CIM standard.

Obtaining the Specifications. The specification can be found at URL: http://www.dmtf.org/standards/cim.

URL. http://www.dmtf.org/standards/cim/.

Vendors. EMC's WideSky storage management middleware supports CIM (http://www.emc.com/technology/abstracts/esg_0202.jsp), and Sun Microsystems (http://www.sun.com) is offering a StorEdge Enterprise Storage Manager that supports CIM. In addition, IBM (http://www.ibm.com/), Hitachi Data Systems Corporation (http://www.hds.com), and Veritas (http://www.veritas.com) are working together to support CIM-based products (http://www.veritas.com/news/press/PressReleaseDetail.jhtml?NewsId=9600).

6.3.2 Common Warehouse Metamodel

Name. Common Warehouse Metamodel (CWM).

Purpose. To define a metadata model for enterprise data that would integrate data repositories at a conceptual level, regardless of whether the repositories had been implemented by different vendor products, and would provide a means for an interface that would enable data mining and the exchange of metadata.

History. There was a Meta Data Coalition (MDC) not-for-profit consortium that formed in 1995 to develop a solution for metadata exchange [16]. The MDC formed out of a recognized need for data warehouse standards that would prevent data from becoming lost as the enterprise repository grew exponentially. The MDC defined the Open Information Model (OIM) based on a specification provided by Microsoft, but its model competed with what the Object Management Group (OMG) was developing. Hence, in September 2000, the MDC merged with the OMG so that there would be only one metadata standard for data warehouses [16]. The CWM is the result of their combined efforts.

Standards Organization. The OMG (http://www.omg.org) is responsible for maintaining the CWM standard.

Status. The CWM version 1.0 specification was defined using the Unified Modeling Language and was published in February 2001. For current information about the CWM specification, refer to URL: http://www.omg.org/cwm/.

Obtaining the Specifications. A softcopy of the specification can be found at URL: http://www.omg.org/cwm/ and clicking on the Part 1, Part 2, and Part 3 links of the specification.

URL. http://www.omg.org/cwm/.

Vendors.

- Informatica Corp. provides a Web-based metadata management tool called SuperGlue. For more information, refer to URL: http://www.informatica.com/news/press%2breleases/2003/08182003.htm.
- The SAS Institute, Inc., provides SAS System 9 to support CWM (see their press release at URL: http://www.sas.com/news/preleases/110402/news2.html).

6.3.3 Open Information Model

Name. Open Information Model (OIM).

Purpose. To define a foundational set of metadata types such as database schema, business processes, or business objects [17].

History. The MDC defined the OIM specification based on a proposal by the Microsoft Corporation. Because the OIM specification competed with the OMG metadata standard, MDC merged its efforts with OMG's in September 2000 (see Section 6.3.2). Since then, the OMG completed the CWM, which provides standards for metadata [17].

Standards Organization. Although the MDC defined the OIM specification, it has since merged with the OMG.

Status. The OIM specification was combined with the CWM (http://xml.coverpages.org/OMG-MDC-20000925.html).

6.4 Information Management

6.4.1 Desktop Management Interface

Name. Desktop Management Interface (DMI).

Purpose. To define a standard framework for managing and tracking components in a desktop PC, notebook, or server [18].

History. The DMTF defined DMI in 1995 to automate software and hardware inventory and metering, and software distribution [19]. Windows 95 was one of the first operating systems to support it [19]. Enterprise managers appreciated the DMI capabilities that enabled them to list applications loaded on PCs, notebooks, and servers, especially when platforms had been manufactured by different vendors [19]. DMI was designed to provide vendors with a single approach for inventorying heterogeneous platforms. However, the CIM standard also defined by the DMTF is supposed to provide broader specifications that cover a number of other features (see Section 6.3.1) [18].

Standards Organization. The DMTF (http://www.dmtf.org) is responsible for defining the DMI.

Status. DMTF provides a tool for vendors to use to insure that their products comply with the DMI 2.0 specification, and if so they can be certified using the tool provided at URL: http://www.dmtf.org/standards/dmi/selfcertification/#compchk. However, since DMTF's CMI and WBEM[3] specifications include the capabilities defined by the DMI standard, DMTF does not plan to support DMI after March 31, 2005 (http://www.dmtf.org/newsroom/newsletter/2003/06/page5) and recommends that developers migrate to the CIM and WBEM.

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.dmtf.org/standards/dmi/spec.

URL. http://www.dmtf.org/standards/dmi/spec.

Vendors. Microsoft Corporation (http://www.microsoft.com/) and other vendors support this standard.

6.5 Storage Areas and Connectivity

Where business units and elements of major organizations once created and maintained their own unique application data, today's dynamic environment is forcing executives to make decisions rapidly based on current, relevant organizational *intelligence*—information that they can act on. Hence, organizations are being forced to rethink how they structure, store, and access organizational information and are migrating to storage resources that provide rapid access to data and can store volumes up to the petabyte range. SANs have emerged as a means for supporting both of these requirements.

A SAN is a dedicated, high-performance network infrastructure deployed between storage resources and servers. The storage resources usually include a Redundant Array of Independent Disks (RAID) system[4] to protect the data, speed data access to large data blocks, and support fault tolerance. A SAN provides extremely high interconnection data rates (at the gigabits per second level) between the network infrastructure and storage resources, with centralized data storage. Servers interact with the SAN to access and store data. "Connections to a SAN are

3. See Section 12.2.5 for a detailed description of WBEM.

4. RAID utilizes a collection of disks that use a *striping* technique to store redundant copies of the data on different disks to prevent data loss. RAID also speeds data access. For more information, refer to: Hibner, D., "Raid Levels and Striping," http://www.nwfusion.com/archive/1995/95-02-13raid.html, *Network World Fusion*, February 13, 1995.

made over a high-speed protocol such as Fibre Channel or iSCSI. SAN storage is accessible from all servers, so users can access any storage device on the SAN, regardless of the physical location of the storage or users. SANs were designed to help manage and speed storage by simplifying the data path and taking hard-wired servers out of the loop…" [12].[5]

This section discusses three storage interconnect protocols that have been published by the IETF and are being used for SANs: Fiber Channel over IP (FCIP), Internet Fiber Channel Protocol (iFCP), and the Internet Small Computer Interface (iSCI) protocol. Fiber Channel is a high-speed, high-performance transport technology that moves SCSI traffic from servers to disk arrays and tape drives, and requires dedicated fiber lines, but has a distance limitation of 10 km [20]. The three protocols mentioned—FCIP, iFCP,[6] and iSCI[7]—extend the network transport over IP so that network distances can exceed 10 km. Each of these protocols had their beginnings from storage vendors that developed them as a means for lowering the high cost of Fiber Channel networks that connect to SANs, and that provided the draft specification to the IETF, so the "History" section is excluded from their descriptions [20].

The fourth standard covered in this section relates the Storage Management Initiative Specification (SMI-S) defined by the SNIA as a management interface for SANs, and formerly known as the "Bluefin Specification."

6.5.1 Fiber Channel over IP

Name. Fiber Channel over IP (FCIP), also known as fiber channel tunneling or storage tunneling.

Purpose. To define a specification for a high-speed network (gigabit and higher) that implements Fiber Channel SANs over IP networks to provide a unified SAN in a single Fiber Channel fabric using a tunneling protocol [21].

Standards Organization. The IETF IP Storage Working Group (http://www.ietf.org/html.charters/ips-charter.html) is responsible for defining and maintaining the FCIP specification.

Status. The FCIP IETF draft specification was approved in late January 2003 [22].

Obtaining the Specifications. A draft of the Internet specification can be viewed at URL: http://www.ietf.org/internet-drafts/draft-ietf-ips-fcovertcpip-12.txt. The final specification is not yet available.

URL. For FCIP information, refer to URL: http://www.snia.org/ipstorage/about/fcip.

5. For more information, consult *Designing Storage Area Networks, A Practical Reference for Implementing Fibre Channel SANs and IP SANs,* written by Tom Clark, a member of the SNIA board and published by Addison-Wesley Professional in 2003.

6. Nishan Systems, which was acquired by McData, wrote the specification for iFCP (http://www.ietf.org/proceedings/01mar/slides/ips-19.pdf) that was submitted to IETF.

7. Cisco and IBM introduced iSCI in 2000 [20].

Vendors. Major vendors such as Cisco, EMC, and Hitachi Data Systems (HDS) (using McData components) support both FCIP and iCSCI.

Other Sources of Information.

- An article by S. Gordon discusses the competing iCSCI and FCIP standards: "Choosing Your Storage Networking Protocol," http://searchstorage.techtarget.com/tip/1,289483,sid5_gci878647,00.html, SearchStorage.com, February 5, 2003.
- SNIA, "The Emerging FCIP Standard for Storage Area Network Connectivity Across TCP/IP Networks," http://www.snia.org/ipstorage/about/fcip/FCIP_whitepaper.pdf, June 2001.

6.5.2 Internet Fiber Channel Protocol

Name. Internet Fiber Channel Protocol (iFCP).

Purpose. To define a protocol for operating Fiber Channel traffic over a TCP/IP network where iFCP acts as a gateway protocol to connect Fiber Channel RAID arrays, switches and servers to IP storage networks by mapping IP addresses to Fiber Channel devices [23].

Standards Organization. The IETF IP Storage Working Group (http://www.ietf.org/html.charters/ips-charter.html) is responsible for defining and maintaining the iFCP specification.

Status. The iFCP IETF draft specification was approved in late January 2003 [22].

Obtaining the Specifications. A technical overview of the protocol can be downloaded at URL: http://www.snia.org/tech_activities/ip_storage/iFCP_tech_overview.pdf, and a copy of the IETF draft can found at URL: http://quimby.gnus.org/internet-drafts/draft-ietf-ips-ifcp-01.txt. The final specification is not yet available.

URL. For information about iFCP, refer to URL: http://www.snia.org/ipstorage/about/ifcp.

Vendors. Vendors that support iFCP products include McData (http://www.mcdata.com/downloads/mkt/ink/byteandswitch_091903.pdf) and Equallogic (http://www.equallogic.com/).

6.5.3 Internet Small Computer System Interface

Name. Internet SCSI (iSCSI).

Purpose. To define an IP-based storage networking standard that connects to storage areas (e.g., SANs) and carries SCSI commands over IP networks that can cover long distances.

Standards Organization. The IETF IP Storage Working Group (http://www.ietf.org/html.charters/ips-charter.html) is responsible for defining and maintaining the iSCSI specification.

Status. The iSCSI IETF draft specification was approved in late February 2003 [22].

Obtaining the Specifications. A technical white paper describing iSCSI can be downloaded at URL: http://www.snia.org/ipstorage/about/iscsi/iSCSI_Technical_whitepaper.PDF, and the IETF draft can be found at URL: http://www.haifa.il.ibm.com/satran/ips/draft-ietf-ips-iscsi-17.txt. The final specification is not yet available.

URL. For more information about iSCI, refer to URL: http://www.snia.org/ipstorage/about/iscsi.

Vendors. Major vendors such as Cisco, EMC, and Hitachi Data Systems (using McData components) support both FCIP and iSCSI. Microsoft Corporation plans to provide Windows clients and server environments that support iSCSI. (Refer to: Earls, A., "iSCSI and Microsoft Make a Potent Combination," http://searchstorage.techtarget.com/tip/1%2C289483%2Csid5_gci899453%2C00.html, SearchStorage.com, May 7, 2003.)

Other Sources of Information. "ICSCI Technical White Paper," http://www.snia.org/tech_activities/ip_storage/iSCSI_Technical_whitepaper.PDF, SNIA IP Storage Forum White Paper, SNIA, May 30, 2002.

6.5.4 Storage Management Initiative Specification

Name. Storage Management Initiative Specification (SMI-S), formerly known as the Bluefin Specification.

Purpose. To define a SAN management API "for discovering, monitoring and managing [heterogenous] devices on a SAN" [24].

History. A group of 16 vendors defined the Bluefin Specification as an object-oriented messaging API specification to interface distributed SAN management applications with heterogeneous devices [24]. Bluefin provided for a storage management environment that made logical and physical storage components accessible to the management applications through their interfaces [24]. Bluefin was the first industry standard for a SAN management interface, and also the first to build on the CIM and WBEM technologies for a common storage management interface [25]. The vendors turned their Bluefin specification over to the SNIA, which launched a Storage Management Initiative based on Bluefin. During the week of October 28, 2003 and after 5 years in development, SNIA demonstrated a prototype that showed how the interfaces would work [26].

Standards Organization. SNIA is responsible for defining this standard.

Status. HP, Veritas, EMC, and IBM plan to "implement SMI-S interfaces in hardware and software" [24].

Obtaining the Specifications. The SMI-S specification for SMI-S version 1.0.1 can be downloaded at URL: http://www.snia.org/smi/tech_activities/smi_spec_pr/spec/SMIS_v101.pdf.

URL. For SMI-S developments, refer to URL: http://www.snia.org/smi/home.

Vendors. HP, Veritas, EMC, and IBM plan to build hardware/software products based on SMI-S [26]. HP has a HP SMI-S Developers Program (SMI-S DP) to enable product vendors to develop SMI-S software for their storage products (http://h21007.www2.hp.com/dspp/pp/pp_FAQ_IDX/1,,74,00.html).

References

[1] Konchady, M., "An Introduction to JDBC," http://www.linuxjournal.com/article/2846, *Linux Journal*, Vol. 1988, No. 2, Specialized Systems Consultants, Inc., November 1998, pp. 1–5.

[2] "JSR 12: Java™ Data Objects (JDO) Specification," http://www.jcp.org/en/jsr/detail?id=12, Java Community Process, January 5, 2004.

[3] "Technical Articles and Tips: Related Technologies @Ref # = [JDO and JDBC]," http://java.sun.com/products/jdbc/related.html, Sun Microsystems, January 5, 2004.

[4] Cattell, R., "Experience with the ODMG Standard," *StandardView*, Vol. 3, No. 3, ACM Press, September 1995, pp. 90–95.

[5] "Object Data Management Group: The Standard for Storing Objects," http://www.odmg.org/, ODMG, January 4, 2004.

[6] "E. F. Codd," http://searchdatabase.techtarget.com/sDefinition/0%2C%2Csid13_gci895554%2C00.html, SearchDatabase.com, December 29, 2003.

[7] "Data Management Strategies: SQL History/Overview," http://www.itworld.com/nl/db_mgr/05142001/pf_index.html, *ITworld.com*, May 14, 2001.

[8] Eisenberg, A., and J. Melton, "SQLJ Part 0, now known as SQL/OLB (Object-Language Bindings)," *ACM SIGMOD*, Vol. 27, No. 4, December 1996, pp. 94–100.

[9] Leach, P., and D. Perry, "CIFS: A Common Internet File System," http://www.microsoft.com/mind/1196/cifs.asp, *Microsoft Internet Developer*, November 1996.

[10] "Common Internet File System Technical Reference," http://www.snia.org/tech_activities/CIFS, Storage Network Industry Association (SNIA), January 7, 2004.

[11] Skamarock, A., "The DAFS Collaborative Moves Ahead," http://www.nwfusion.com/newsletters/stor/2001/01047664.html, *NetworkWorldFusion*, October 8, 2001.

[12] Kay, R., "Direct Access File System," http://www.computerworld.com/hardwaretopics/storage/story/0,10801,75191,00.html, *ComputerWorld*, October 21, 2002, p. 42.

[13] Pawlowski, B., et al., "The NFS Version 4 Protocol," http://www.nluug.nl/events/sane2000/papers/pawlowski.pdf, IETF NFS version 4 Working Group, January 8, 2004.

[14] Horwitt, E., "WBEM Just Might Make Systems Management Real. Finally!" http://www.computerworld.com/printthis/1999/0,4814,33738,00.html, *ComputerWorld*, February 1, 1999.

[15] Horwitt, E., "Common Information Model," http://www.computerworld.com/printthis/1999/0,4814,43442,00.html, *ComputerWorld*, February 1, 1999.

[16] Cover, R., "Competing Data Warehousing Standard to Merge in the OMG," http://xml.coverpages.org/OMG-MDC-20000925.html, *OASIS*, September 25, 2000.

[17] 'MDC Open Information Model (OIM)," http://xml.coverpages.org/mdc-oim.html, *OASIS*, September 25, 2000.

[18] "Desktop Management Interface Standards," http://www.dmtf.org/standards/dmi, DMTF, January 11, 2004.

[19] DiDio, L., "Windows 95 Will Get DMI by Fall," http://www.computerworld.com/news/1995/story/0,11280,13780,00.html, *ComputerWorld*, February 13, 1995.

[20] Mears, J., "The Ins and Outs of Interconnects," http://www.nwfusion.com/sup/storage 2002/iconnect.html, *Network World Fusion*, September 9, 2002.

[21] "Fibre Channel over TCP/IP (FCIP)," http://www.ietf.org/internet-drafts/draft-ietf-ipsf covertcpip-12.txt, Internet-Draft Specification, IETF, August 2002.

[22] Dale, D., "IP Storage: The Year in Review; IP Storage (Including iSCSI, iFCP, and FCIP) Has Moved from Emerging Technology to End-User Deployments," http://is.pennnet.com/Articles/Article_Display.cfm?Section=Articles&ARTICLE_ID=186314&VERSION_NUM=1, *InfoStor*, September 2003.

[23] Pammidimukkala, P., "IFCP Melds Fibre Channel and IP," http://www.nwfusion.com/news/tech/2003/0217techupdate.html, *Network World Fusion*, February 17, 2003.

[24] Peterson, T., "Bluefin," http://www.computerworld.com/hardwaretopics/storage/story/0%2C10801%2C76083%2C00.html, *ComputerWorld*, November 25, 2002.

[25] "Storage Management Initiative," http://www.snia.org/join/forum_membership#SMI, SNIA, December 27, 2003.

[26] Shafer, S., "SNIA Unveils Storage Management Spec," http://www.computerworld.com/printthis/2003/0,4814,86589,00.html, *ComputerWorld*, October 28, 2003.

CHAPTER 7

Distributed Computing Standards

Each of the distributed computing standards below defines an environment that enables applications to run in a distributed, networked, multivendor platform environment. Three basic approaches are covered in this chapter:

- Distributed, object-oriented environments as defined by the Active-X/Component Object Model (COM)/Distributed COM (DCOM), the Common Object Request Broker Architecture (CORBA), Enterprise JavaBeans (EJB), and the Java 2 Platforms
- The Distributed Computing Environment (DCE) approach supports client-server applications implemented using procedural languages.
- The grid computing approach distributes parts of a computer job across available, networked, heterogeneous computers and devices the same way a supercomputer would allocate parts of its processing job to parallel processors to speed processing performance.

7.1 Active-X/COM/DCOM

Name. Active-X/Component Object Model (COM)/Distributed COM (DCOM).

Purpose. To define an architecture and object model that supports distributed, networked objects.

History. In the 1990s, Microsoft Corporation developed a specification and product known as Object Linking and Embedding (OLE) that implemented Microsoft's object model for Microsoft Windows desktop systems [1]. What developers needed, however, was a model that enabled objects to operate on the desktop as well as on other vendor's platforms as part of an enterprise solution [1]. OLE simply did not offer sufficient capabilities to achieve this objective [1]. By mid-1994, OMG had defined a distributed object standard named the Common Object Request Broker Architecture (CORBA), and industry indicated that it expected Microsoft to provide a CORBA-compatible distributed object solution [1]. But instead of developing a specification to support interoperable OLE and CORBA objects, Microsoft Corporation worked with Digital Equipment Corporation to define a COM specification that supported multiplatform OLE applications [2, 3]. So industry responded by increasing its pressure on Microsoft to develop a specification compatible with CORBA.

Microsoft responded by releasing the DCOM in 1995 for Windows NT [4]. DCOM specified a distributed computing environment that supported communication between COM objects on client-server computers on a network [4]. Pressure on Microsoft mounted: industry wanted a solution compatible with CORBA. In 1996, Microsoft introduced ActiveX Core Technology, which included COM, DCOM, and ActiveX Controls (ActiveX Controls incorporated OLE). Then in the fall of 1996, Microsoft made a startling move: it turned the ActiveX Core Technology specification over to The Open Group and asked The Open Group to maintain the specification [5].

Standards Organization. The Open Group controls the ActiveX Core Technology specification [5]. The Open Group also has Microsoft's permission to brand, certify, and test other vendor implementations of ActiveX/COM/DCOM technologies [6].

Status. The current version of the ActiveX Specification is dated 1999 and shows Microsoft, Hewlett Packard Corporation, and Compaq Computer Corporation as the original holders of the copyright, with The Open Group as the current copyright holder. Note that The Open Group implemented COMSource as an open system COM/DCOM product for Unix platforms, although COMSource does not support ActiveX Controls (see http://www.opengroup.org/comsource/cs_faq.htm#q19 and two press releases: http://www.opengroup.org/press/10jan01.htm and http://www.opengroup.org/press/30sep99.htm for details). Since then, Microsoft developed COM+ as an extension to COM (http://www.microsoft.com/com/tech/complus.asp) to enable COM objects to be developed in different programming languages. COM+ is not a part of the ActiveX Core Technology Specification.

Figure 7.1 shows a conceptual view of how ActiveX Controls, COM, and DCOM relate. ActiveX supports *software application services* with its ActiveX Controls, which enable development of reusable binary COM objects for use in software applications. COM is shown under *cross-platform services*, because it provides a binary standard for objects that enables them to communicate across multivendor platforms and operating systems. DCOM supports *distributed network services* by

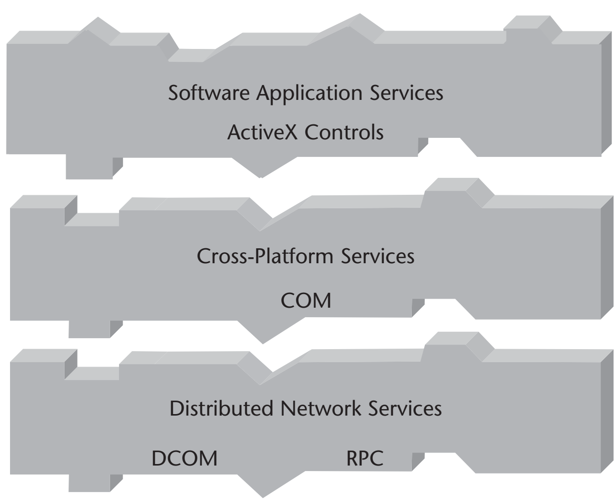

Figure 7.1 Conceptual view of ActiveX Core Technology.

supporting low-level interprocess communications between objects. DCOM uses the DCE Remote Procedure Call (RPC) standard (via Microsoft's DCE implementation) to enable COM objects to communicate across networked clients and server systems.

After COM++, Microsoft employed another approach for distributed computing and released a nonstandard product named ".NET." Microsoft implemented .NET as a framework for Microsoft Web-based services that allows developers to build Microsoft Windows applications on heterogeneous platforms (e.g., desktops, laptops, mobile phones) and exchange information over the Internet (http://www. microsoft.com/net/basics/framework.asp). .NET application programming languages include C, C++, Visual Basic, FORTRAN, and Microsoft's own object-oriented language C# that *ComputerWorld* likens to Java [7]. Currently, .NET competes with the Java2 Enterprise Edition (J2EE) products (see Section 7.5 for a discussion of J2EE) [7].

Obtaining the Specifications. The specification for Active-X Core Technology can be downloaded at URL: http://www.opengroup.org/onlinepubs/009899899/.

URL. http://www.microsoft.com/com/default.asp.

Vendors. For information about Microsoft's COM technologies, refer to Microsoft's Web site URL: http://www.microsoft.com/com/default.asp and http://www.microsoft.com/com/resources/specs.asp.

Other Sources of Information.

- For additional information on COM and DCOM, refer to S. Comella-Dorda's article entitled "Component Object Model (COM), DCOM, and Related Capabilities," available at URL: http://www.sei.cmu.edu/str/descriptions/ com.html. This article is included in the Software Engineering Institute (SEI) Software Technology Roadmap (http://www.sei.cmu.edu/str/descriptions/ com.html) dated March 13, 2001 that provides information about different software technologies.
- Byron Taylor and Oriel Maxime compare "J2EE vs. .Net: The Choice Depends on Your Needs" in an article in *ComputerWorld* dated August 19, 2003 at URL: http://www.computerworld.com/developmenttopics/development/story/0,10801,84155,00.html.
- For general information on .NET, refer to URL: http://www.microsoft.com/net/basics/framework.asp, and for development questions refer to the Developer Center at URL: http://msdn.microsoft.com/netframework/.

7.2 CORBA

Name. Common Object Request Broker Architecture (CORBA).

Purpose. To define a distributed object environment that enables objects to interoperate across heterogeneous, networked, multivendor client/server platforms.

History. The first version of the OMG's architecture for distributed objects was released in the fall of 1991 as CORBA. CORBA was envisioned as an environment of networked, multivendor client and server platforms with seamless interoperation of objects implemented by different programming languages [8]. At that time, there were more Lisp (List processing) and Smalltalk object-oriented (OO) programmers than ever, and C++[1] was rapidly growing in popularity. The OMG perceived the next step for object-oriented applications was an environment that supported objects in a distributed environment.

However, when a committee defines a specification for a technology before it has ever been implemented, it can take a long time—years even—for vendors to build a successful product. This was the case with CORBA. To achieve CORBA's primary objective of enabling different vendor Object Request Broker (ORB)[2] implementations to interoperate, it took years of implementations before the CORBA specification provided sufficient detail [9]. Hence, it was not until after CORBA version 2.0 had been introduced in August 1996 that vendors began producing interoperable, CORBA-conformant ORB products.

Standards Organization. The (http://www.omg.org/) is responsible for defining and maintaining this standard.

Status. A list of current versions of OMG specifications, including those for CORBA, can be found at URL: http://www.omg.org/technology/documents/spec_summary.htm. For a chronology of the versions of CORBA specifications, refer to http://www.omg.org/gettingstarted/history_of_corba.htm. The OMG has worked with ISO/IEC to have their specifications published as international standards, and those related to CORBA include CORBA Interoperability platform (ISO/IEC 19500-2) and Interface Design Language (IDL) (ISO/IEC 14750| ITU-T Rec. X.920) [10].

Figure 7.2 provides a conceptual view of the compatibility of CORBA standards with programming languages and the TCP/IP. Objects can be written in a number of different programming languages: C, C++, Java, COBOL, Smalltalk, Ada, Lisp, Python, and IDLscript (see URL: http://www.omg.org/gettingstarted/corba faq.htm#HowWork for details). CORBA's IDL is not a programming language per se, but instead defines an external interface for each object so that a client can access the object and invoke its methods (functions) through CORBA's ORB. Vendor implementations of ORBs include an IDL compiler with a language binding for each programming language supported. The OMG's General Internet Inter-ORB Protocol (GIIOP) is a protocol for ORBs to communicate with each other, and the OMG's Internet Inter-ORB Protocol (IIOP) provides a transport mapping from GIIOP to TCP/IP, enabling ORBs to communicate over TCP/IP.

The CORBA specification was expanded to support cross-platform interoperability with the Java 2 Platforms and Enterprise JavaBeans client and server

1. C++ was introduced in 1986 by Bjarne Stroustrup (http://www.research.att.com/~bs/C++.html).
2. A CORBA ORB is considered middleware that runs on a network to enable a client application, server application, or object to communicate with CORBA objects. The ORB finds the object an application needs to communicate with, routes the application's request to the object (which can include invoking the object's methods (functions), and returns the result to the application.

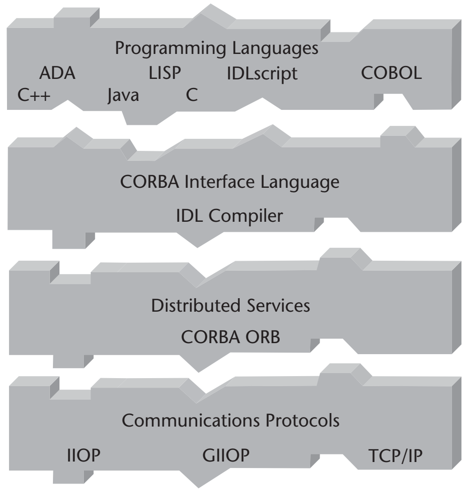

Figure 7.2 Conceptual View of CORBA standards with TCP/IP and programming standards.

platforms [11]. To support interoperability with CORBA, Sun Microsystems provides a remote method invocation (RMI) capability over IIOP as its distributed object model [11]. Sun also provides the Java Transaction Service to send messages between distributed Java Platform objects and CORBA ORB objects, and the Java IDL to interface Java objects with CORBA objects implemented in other programming languages [11].

Obtaining the Specifications. The CORBA specifications can be downloaded at URL: http://www.omg.org/technology/documents/formal/corba_iiop.htm, and individual parts of the CORBA specifications can be downloaded at URL: http://www.omg.org/cgi-bin/apps/doclist.pl.

URL. http://www.corba.org/.

Vendors.

- OMG provides a list of CORBA vendors and products at URL: http://www.corba.org/vc.htm.
- Sun Microsystems offers Java RMI technology that operates over IIOP (i.e., RMI-IIOP) to deliver CORBA distributed computing capabilities to Java 2 platforms (http://java.sun.com/products/rmi-iiop/). Refer to URL: http://java.sun.com/j2se/1.3/docs/guide/rmi-iiop/ for more information on this capability.
- The OMG provides information about its test suite for CORBA implementations and interoperability testing at URL: http://www.omg.org/interoperability_testing.

Other Sources of Information.

- OMG provides a fact sheet on CORBA at URL: http://www.omg.org/gettingstarted/corbafaq.htm.

- David Curtis' article "Java, RMI and CORBA," at URL: http://www.omg.org/library/wpjava.html (dated 1997), discusses details on Java Platform compatibility with CORBA.
- Netscape provides detailed information discussing aspects of CORBA in its *DevEdge Archive*: entitled "CORBA: Catching the Next Wave" at URL: http://developer.netscape.com/docs/wpapers/corba/index.html#what (dated June 5, 1997). Another article offered on CORBA by the *DevEdge Archive* is "CORBA: Theory and Practice" at URL http://developer.netscape.com/docs/wpapers/.
- Geoffrey R. Lewis wrote an article that provides an overview of the CORBA 2.0 specification entitled "CORBA 2.0: Universal Networked Objects" (*StandardView*, Vol. 3, No. 3, 1995, pp. 102–106). It is available electronically from the ACM Digital Library (http://portal.acm.org/) for a fee (free to members with an ACM digital library subscription).
- The Software Engineering Institute covers features of CORBA in its Software Technology Roadmap at URL: http://www.sei.cmu.edu/str/descriptions/corba.html.

7.3 Distributed Computing Environment

Name. Distributed Computing Environment (DCE).

Purpose. To provide a distributed, enterprise client/server environment for multivendor operating systems and platforms, and applications developed using procedural programming languages (e.g., C).

History. In 1989, the Open Software Foundation (OSF)[3] put out a Request for Technology and invited companies to develop components for a distributed computing technology and promised them royalties in exchange for the development [12]. Hewlett-Packard, Sun Microsystems, Digital Equipment Corporation, the Massachusetts Institute of Technology, and other organizations (primarily Unix vendors) responded by providing their source code [12].

OSF evaluated the submissions over the period of a year and selected several "best of breed technologies" that formed the basis for a distributed computing specification [12]. The resulting DCE specification was based on technologies that included RPC developed by a vendor team composed of Hewlett-Packard, Apollo, and DEC; DEC's Concert Multithread Architecture for threads; MIT's Kerberos version 5 to support security services; DEC's directory and time synchronization services; and the Distributed File System from Carnegie Mellon and Transarc's Andrew File System [12]. The first version of the DCE specification was released in 1992, and vendor products became available in 1993.

Standards Organization. Since the OSF merged with The Open Group in 1996, The Open Group is responsible for maintaining the DCE specification.

3. Refer to Chapter 15, Section 15.2.20 for the history of the Open Software Foundation.

Status. Although products that incorporate DCE components (such as RPC) are still in use and supported by major vendors, The Open Group does not have any plans to expand the standard. The final version of DCE was DCE 1.2.2 (http://www.opengroup.org/dce/info/papers/tog-dce-pd-1296.htm#intro).

Obtaining the Specifications. The specification for DCE can be downloaded at URL: http://www.opengroup.org/dce/ by selecting the "Introduction" button, and then the "download" button on the *Introduction* page. Vendors can purchase a license for the source code from The Open Group; for details, select the button for "Order" on the URL link mentioned above.

URL. http://www.opengroup.org/dce/. For technical information about DCE, refer to URL: http://www.opengroup.org/dce/info/papers/tog-dce-pd-1296.htm and URL: http://www.opengroup.org/tech/dce/info/faq-mauney.html#tier1.

Vendors. The DCE technology can be purchased from Compaq Computer Corporation (http://h30097.www3.hp.com/dce/), Entegrity Solutions (http://www2.entegrity.com/products/dce/dce.shtml), Hewlett-Packard (http://h71033.www7.hp.com/page/NS_DCE_SW.html), IBM (http://www-306.ibm.com/software/network/dce/library/), and Finally Software (http://www.finallysoftware.com/finally/products.htm?referrer=GoogleDCE).

Other Sources of Information. C. Vondrak wrote an article entitled "Distributed Computing Environment," (http://www.sei.cmu.edu/str/descriptions/dce.html) as part of the Software Technology Roadmap for the Software Engineering Institute.

7.4 Enterprise Javabeans

Name. Enterprise JavaBeans (EJB).

Purpose. To define a standard, distributed, vendor-independent component architecture for Java that is portable across platforms and improves productivity by transparently handling state management, multithreading, network connections and protocols, and resource and pooling [13]. In addition, the standard architecture would support compatibility with other programming languages and CORBA [13].

History. Sun Microsystems developed JavaBeans to provide a software component technology for the Java programming language. A software component is a Java class that conforms to a Java software component specification that specifies what a Java class must accomplish in order to be considered a Bean [14]. To become a Bean, a Java class needs to implement the Java serializable interface (java.io.Serializable), which contains information for the class to transmit the resulting JavaBean over the network or store it [14]. JavaBeans are used to build client applications.

In March of 1998, Sun Microsystems published the EJB 1.0 specifications [13]. Whereas JavaBeans was developed to build client applications, Enterprise JavaBeans supports a distributed architecture for interoperable, multivendor, server applications [13]. Sun turned over the EJB specifications to the Java Community Process (JCP) organization, which is now responsible for maintaining and extending it.

Standards Organization. The JCP organization (http://www.jcp.org/) is responsible for defining and maintaining this specification.

Status. The EJB specification is continuing to undergo expansion. At the time this book was written, the JCP had defined an EJB 2.0 specification to address persistent JavaBean aspects of the Java 2 Platform, Enterprise Edition (http://www.jcp.org/en/jsr/detail?id=19). Sun provides a home page for EJB updates at URL: http://java.sun.com/products/ejb/.

Obtaining the Specifications. EJB specifications can be downloaded via URL: http://www.jcp.org/en/jsr/detail?id=19 by selecting the link for the current specification version.

URL. http://java.sun.com/products/ejb/docs.html.

Vendors. Vendors that provide products that implement the EJB specifications include:

- Sun Microsystems (http://wwws.sun.com/software/);
- BEA Systems' Weblogic (http://edocs.bea.com/platform/docs70/index.html);
- IBM CICS Application Server (http://www.research.ibm.com/journal/sj/401/bainbridge.html);
- Apache.org (http://www.apache.org/) provides an open source product known as XMLBeans (http://xmlbeans.apache.org/);
- Jonas Open Source Server (http://www.evidian.com/jonas/).

Other Sources of Information. *Java World* provides informative articles and Java product news at URL: http://www.javaworld.com/. Refer to Section 7.5 for additional sources of information.

7.5 Java 2 Platform Specifications (J2EE, J2SE, and J2ME)

Name. Java 2 Platform (J2) Micro Edition (J2ME), J2 Standard Edition (J2SE), and J2 Enterprise Edition (J2EE).

Purpose. To define APIs and tools for running and developing Java applications in a Web-based environment [15].

History. Sun Microsystems designed the Java Platform to provide a computing environment that would run Java applications that could operate on any heterogeneous platform and support Web services, whether on the Internet or a company intranet [16]. Sun introduced the Java Platform in the mid-1990s equipped with a Java virtual machine component to support Java applications independent of the computer they ran on—from a powerful, high-end computer server down to a device like a mobile phone or PDA. But even though Sun Microsystems invented the Java technologies (e.g., Java programming language, Java 2 Platform, Java core components) and holds the licensing, the shift of the market toward standards affected Sun. Major platform vendors and product developers who used Java technologies began clamoring for Java standards [17]. A news report from January 2000 indicated that

Java's "biggest backers" such as IBM were planning to "break ranks" with Sun unless Sun created a Java standard to ensure interoperability and cross-platform portability [17].

Although Sun Microsystems had already attempted to pursue standardization of Java by submitting a request to ISO the previous year, it was not successful. The ISO process does not provide for individual companies submitting their own proposals directly to ISO, but requires them to work with organizations approved by ISO to develop standards [18]. Consequently, Sun submitted the J2SE Version 1.2.2 to Ecma International so that Ecma International could refine and formally submit it to ISO [17]. Since ISO had already approved an Ecma International standard that was similar to Java—ECMAScript (ISO 16262)—the Java proposal stalled.[4]

Prior to this, Sun had established a Java Community Process (JCP) organization in 1998 to work with the software community to achieve consensus on the direction of Java specifications. The vendors, however, did not feel it went far enough, and thought that Sun was retaining too much control over Java licenses [17]. Hence, Sun established a blue-ribbon advisory group who would become the final arbiters for changes to the core Java specification and would seek the consensus of the largest licensees before changes were made to the specifications [17, 19]. Sun still holds the licensing for Java technologies, but the JCP now manages Java technology developments, including the J2 specifications which were introduced in late 1999 and are continually expanding to include new services.

Standards Organization. The JCP Program (http://www.jcp.org/en/home/index) maintains Java-related technology specifications, including the Java 2 Platform specifications.

Status. There are three editions of the Java 2 Platform technology specifications (see Figure 7.3 for an illustration of the differences):

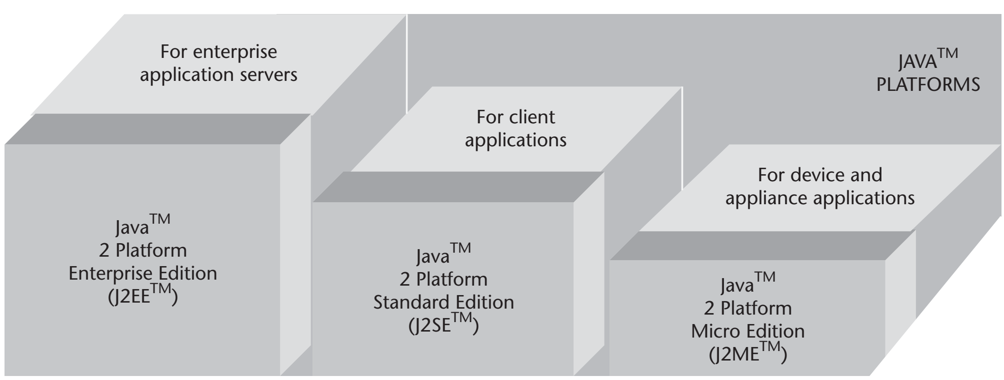

Figure 7.3 Relationship of Java 2 Platform specifications.

4. See Chapter 11, Section 11.2.5 on ECMAScript and Section 11.2.7 on the Java Programming Language.

- *Java 2 Platform, Enterprise Edition:* defines services designed to implement and deploy application servers in the enterprise and includes EJB, process monitoring, distributed Java object transactions, and Java object messaging;
- *Java 2 Platform, Standard Edition:* defines services designed to implement and deploy client applications that access Web services;
- *Java 2 Platform, Micro Edition:* defines services designed to implement and deploy applications on devices such as mobile phones, PDAs, and network appliances.

JavaSoft, Sun Microsystems' division for Java, developed the Remote Method Invocation (RMI) protocol (http://java.sun.com/products/jdk/rmi/) that enables Java objects written in the Java programming language to communicate across Java virtual machines. JCP is considering using the RMI specification that Sun wrote for J2ME (see the RMI specification at URL: http://java.sun.com/products/jdk/rmi/reference/docs/index.html. In addition, JCP is working on an RMI specification for J2SE that would allow the protocol to be customized (http://jcp.org/en/jsr/detail?id=78), depending on what the objects would require.

Obtaining the Specifications. J2 API specifications can be downloaded at http://java.sun.com/reference/api/index.html.

URL. Link to URL: http://java.sun.com/ and select the J2 Platform that applies (e.g., J2EE, J2ME, or J2SE).

Vendors. Major vendors support J2, including Sun Microsystems (http://search.sun.com/), Hewlett-Packard (http://www.hp.com/), IBM (http://www.ibm.com/), BEA Systems (http://www.bea.com/), Oracle (http://www.oracle.com/), and Macromedia (http://www.macromedia.com).

Other Sources of Information.

- A tutorial for using J2EE can be found at URL: http://java.sun.com/j2ee/tutorial/1_3-fcs/index.html.
- For development, refer to TheServerSide.com Web site dedicated to discussing Java technologies such as J2EE and answering questions at URL: http://www.theserverside.com/discussion/index.jsp. For more information about TheServerSide.com Web site hosted by the Middleware Company (http://www.middleware-company.com/), refer to URL: http://java.sun.com/features/2001/09/serverside.html, which provides an article by S. Meloan entitled "*TheServerSide*.com: Bringing the J2EE Community Together," which provides the history of TheServerSide Web site.
- For an opinion on J2EE versus Microsoft's .NET, refer to "J2EE vs. Microsoft .NET: A Comparison of Building XML-Based Web Services," at URL: http://www.theserverside.com/resources/article.jsp?l=J2EE-vs-DOTNET; this is a discussion from TheServerSide.com Discussion Forums dated December 30, 2003.

7.6 Open Grid Services Architecture

Name. Open Grid Services Architecture (OGSA).

Purpose. To define a foundational set of interfaces, behaviors, resource models, and binding for distributed, standard grid services [20].

History. The first Grid Forum Workshop was held in June 1999 at the National Aeronautics and Space Administration (NASA) Ames Research Center (http://www.arc.nasa.gov/) to assess the interest in grid computing technologies [21]. More than 150 attendees from more than 50 organizations and four countries attended [21]. Attendees were interested in establishing a more permanent group, and they organized an initial working group for the Grid Forum [21].

The Grid Forum workshops continued to be held periodically in different locations in the United States until after November 2000, when the Forum became the international Global Grid Forum (GGF) and consolidated three grid computing groups: the Grid Forum of North America, the European eGrid, and the Asia-Pacific grid community [21].

A number of GGF members had been involved in super computer efforts and were investigating how to support network-intensive applications such as high-performance computing and distributed collaboration [22]. They agreed that an infrastructure was needed that would support such advanced network capabilities as resource discovery, caching, and other services [22]. They named this infrastructure a *grid*, and likened it to the contemporary electrical power grid infrastructure that provides ubiquitous electricity to anyone, anywhere, anytime, transparently [22]. Over time, these grid infrastructure concepts became known as *grid computing*.

Grid computing involves splitting a single large job into smaller pieces so that it can be run on several—or even several thousand—computers simultaneously, resulting in supercomputer speed [23]. Grid computing harnesses the processing power of computing devices such as servers and workstations on a distributed network and simultaneously manages the execution of the smaller jobs to accomplish the larger job [23].

The Globus Alliance[5] (http://www.globus.org/) and IBM (http://www.ibm.com/) are major players in developing grid computing technologies [24]. Together, they led the definition of the Open Grid Services Infrastructure (OGSI) specification 1.0 that was released in 2003 to provide lower level services for the OGSA (http://www.globus.org/wsrf/#motivation) [25]. However, since OGSI was based on the existing Web Services Definition Language (WSDL) and members believed that the Web Services Resource Framework (WSRF) defined by OASIS (http://www.oasis-open.org/) had greater potential for vendor implementation, the GGF changed its direction and revised the OGSA to build on the WSRF [25].

5. Globus Alliance is an organization that sponsors collaboration between Argonne National Laboratory, the University of Southern California's Information Sciences Institute, the University of Chicago, the University of Edinburgh, and the Swedish Center for Parallel Computers to produce open source software for grid computing.

The WSRF specification defines a framework for modeling and accessing the state of resources on a distributed network [26]. OGSA describes required grid computing services that include features such as:

- Quality of Service [27];
- Management, monitoring, and optimization of job execution [27];
- Seamless use and management of all distributed, multivendor resources [27];
- Efficient movement of and access to large volumes of data [27];
- Robust security protocols and implementation of security policies to control access to multiple security infrastructures to authenticated, authorized users [27];
- Cross-organizational sharing of resources [27];
- Resource discovery and consistent management and administration for all resources [27].

Standards Organization. The OGSA Working Group (http://forge.gridforum. org/ projects/ogsa-wg) of GGF (http://www.ggf.org) is working on the specification for OGSA.

Status. As the director of the GGF's Architecture developments and a co-chair of the OASIS WSRF Technical Committee, Dave Snelling is in a key place to promote collaboration between the two organizations as they work together to revise their specifications (http://www.ggf.org/L_News/ggf-oasis.pdf) [25]. Nevertheless, it is critical for GGF to collaborate with the W3C on the OGSA grid computing developments. The W3C leads the international community in the development of Web Services standards. Efforts at collaboration between GGF and W3C are beginning. On September 4, 2004, members of the OGSA presented a "Grid-Centered Position Paper for the W3C Workshop on Constraints and Capabilities for Web Services," which described grid computing applications and use cases for Web Services [28]. But it will be years before a grid computing architecture is implemented that supports the probably seamless, dynamic services described by the OGSA [29].

Obtaining the Specification. The draft specification can be downloaded at URL: http://forge.gridforum.org/projects/ogsa-wg/document/draft-ggf-ogsa-spec/en/1.

URL. http://forge.gridforum.org/projects/ogsa-wg.

Vendors. There are numerous efforts by commercial vendors as well as researchers to develop grid technologies. See URL: http://www.gridforum.org/L_News/ press_ 2004_b.htm for GGF press releases that tout new capabilities. In addition, Grid Strategies, Inc., (http://www.gridstrategies.com/) plans an on-line *Computing Resource Guide* with vendor listings for grid computing hardware, middleware, and application/tools products (see URL: http://www.gridtoday.com/breaking/ 1580.html for the *Grid Today* article).

- GGF highlighted the DataSynapse, Inc., (http://www.datasynapse.com/) GridServer product in its spring 2004 *Connection* newsletter (http:// www.gridforum.org/L_News/Newsletter/Grid%20Connections/ggfnews springforpdf04.pdf).

- Globus Alliance has developed an open source toolkit (http://www-unix.globus.org/toolkit/) for grid computing that implements an OGSI.
- The Gridbus Project has developed GridSim Toolkit for grid simulation software (refer to URL: http://www.gridtoday.com/breaking/1318.html for details).

Other Sources of Information.

- GGF provides a description of grid computing and the need for standards at URL: http://www.gridforum.org/L_WG/News/OGSA%20Flyer_v31 .pdf.
- GGF provides periodic newsletters at URL: http://www.gridforum.org/L_News/gridconnect.htm.
- See D. Robb's article, "Plugging into Computing Power Grids," http://www.computerworld.com/networkingtopics/networking/story/0,10801,70328,00.html, *ComputerWorld*, April 22, 2002.
- *Enter the Grid – Primeur Monthly* (http://www.hoise.com/primeur/04/articles/index.html) is an on-line magazine that provides free news on grid computing and supercomputers.
- *Grid Today* provides an on-line source for daily grid news (http://www.gridtoday.com/gridtoday.html).
- *GridComputingPlanet.com* (http://www.gridcomputingplanet.com/) provides yet another source for grid computing news.
- Julie Bort describes a grid application in "Grid on the Job" at URL: http://www.nwfusion.com/supp/2004/ndc6/1025hewitt.html, published in *NetworkWorldFusion* on October 24, 2004.

References

[1] Ballou, M. C., "Through Cooperation Come Standards," http://www.computerworld.com/news/1994/story/0,11280,4608,00.html, *ComputerWorld*, May 16, 1994.

[2] Ballou, M. C., "Microsoft Due for Shift on CORBA," http://www.computerworld.com/news/1994/story/0,11280,6024,00.html, *ComputerWorld*, July 11, 1994.

[3] Ballou, M. C., "COM Spec Falls Short of CORBA Compliance," http://www.computerworld.com/news/1994/story/0,11280,6792,00.html, *ComputerWorld*, July 18, 1994.

[4] "DCOM," http://www.webopedia.com/TERM/D/DCOM.html, January 31, 2004.

[5] Hibbard, J., "The Open Group Takes on the ActiveX Initiative," http://www.computerworld.com/news/1996/story/0,11280,23657,00.html, *ComputerWorld*, October 4, 1996.

[6] Stedman, C., and F. Hayes, "Microsoft to Hand Off Certification of ActiveX Implementations," http://www.computerworld.com/news/1996/story/0,11280,23568,00.html, *ComputerWorld*, September 25, 1996.

[7] Taylor, B., and P. Maxime, "J2EE vs. .Net: The Choice Depends on Your Needs," http://www.computerworld.com/developmenttopics/development/story/0,10801,84155,00.html, *ComputerWorld*, August 19, 2003.

[8] Linthicum, D. S., "Are We There Yet? Microsoft's Recently Released DCOM Stirs Up the Distributed Object Marketplace," http://www.dbmsmag.com/9611d07.html, *DBMS*, November 1996.

[9] Orenstein, D., "CORBA," http://www.computerworld.com/softwaretopics/os/story/0,10801,43435,00.html, *ComputerWorld*, October 5, 1998.

[10] Gilman, J., "CORBA Interoperability Approved as ISO Standard: OMG's Interoperability Specifications Achieve International Standard Status," http://www.omg.org/news/releases/pr2000/2000-10-25.htm, Press Release, OMG, October 25, 2000.

[11] "CORBA Technology and the Java Platform," http://java.sun.com/j2ee/corba/, Sun Microsystems, November 21, 2004.

[12] "DCE and DFS Anthropology," http://www.dsps.net/History.html, DSPS, September 1997.

[13] Hemrajani, A., "The State of Java Middleware, Part 2: Enterprise JavaBeans," http://www.javaworld.com/javaworld/jw-04-1999/jw-04-middleware.html, *JavaWorld*, April 1999.

[14] Johnson, M., "A Walking Tour of JavaBeans," http://www.javaworld.com/javaworld/jw-08-1997/jw-08-beans.html, *JavaWorld*, August 1997.

[15] "List by Technology – JSRs: Java Specification Requests," http://www.jcp.org/en/jsr/tech, Java Community Process (JCP), December 29, 2003.

[16] Hardee, M., et al., "Java@Ref # = [tm] 2 Platform," http://java.sun.com/java2/whatis/index.html, Sun Microsystems, December 30, 2003.

[17] "Sun Must Give Up Some Java Control," http://www.internetweek.com/columns00/pers011700.htm, *InternetWeek*, January 17, 2000.

[18] Booker, E., "Sun End-Runs ISO," http://www.internetweek.com/shared/printableArticle.jhtml?articleID=6404525, *InternetWeek*, May 6, 1999.

[19] Booker, E., "Sun Inches Closer to Open Java Spec," http://www.internetweek.com/story/showArticle.jhtml?articleID=6403008, *InternetWeek*, February 29, 2000.

[20] Foster, I., et al., "The Open Grid Services Architecture, Version 1.0," http://www.ggf.org/documents/Drafts/draft-ggf-ogsa-spec.pdf, GGF, July 12, 2004

[21] "Global Grid Forum Overview: History & Background," http://www.ggf.org/L_About/hist&back.htm, GGF, 2003.

[22] Catlett, C., and I. Foster, "Grid Forum: An Overview," http://www-fp.mcs.anl.gov/~catlett/GF/GridForum-Overview.pdf, IEEE Technical Committee on Distributed Processing, March 2000.

[23] "What Is Grid Computing?" http://www.computerworld.com/industrytopics/financial/story/0,10801,70326,00.html, *ComputerWorld*, April 22, 2002.

[24] Anthes, G. H., "Sidebar: Building Grid Standards," http://www.computerworld.com/industrytopics/defense/story/0,10801,85894,00.html, *ComputerWorld*, October 13, 2003.

[25] Snelling, D., "Web Services Resource Framework: Impact on OGSA and the Grid Computing Roadmap," *GridConnections*, Vol. 2, No. 1, Spring 2004, pp. 1, 7.

[26] "OASIS Web Services Resource Framework (WSRF) TC," http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsrf, OASIS, November 21, 2004.

[27] Foster, I., et al., "The [Draft] Open Grid Services Architecture, Version 1.0," http://www.ggf.org/documents/Drafts/draft-ggf-ogsa-spec.pdf, GGF, July 12, 2004.

[28] Siebenlist, F., and T. Mori, "Grid-Centered Position Paper for the W3C on Constraints and Capabilities for Web Services," http://www.w3.org/2004/08/ws-cc/grid-20040904, W3C Workshop on Constraints and Capabilities for Web Services, W3C, September 4, 2004.

[29] Kobielus, "Grid not Ready for Prime Time," http://www.nwfusion.com/columnists/2004/0524kobielus.html, *Network World Fusion*, May 24, 2004.

CHAPTER 8

Graphics Standards

In the late 1960s and early 1970s, programming computer graphics required special computer hardware and software to achieve such functions as: high-speed coordinate transformations to rotate objects; displaying different shades of color; and rendering objects (adding qualities like shading to surfaces to make them appear three-dimensional) [1].

As computer graphics capabilities matured over the years, software graphics library routines were developed that could generate and manipulate two-and three-dimensional graphics objects. These graphics library functions provided basic drawing services that created, erased, edited, moved, scaled, and transformed graphics objects; graphics object management services that stored and retrieved graphics data for two- and three-dimensional graphics objects; and imaging services that scanned, compressed, and decompressed graphics objects. The problem with these functions was that they were highly hardware dependent and not easily ported to other computer platforms, even if the change was simply a hardware upgrade [1, 2].

By the 1970s, what software developers needed most were *device independent* graphics that would enable them to concentrate on building more advanced functionality rather than having to reinvent the graphics libraries each time they migrated to a new computer platform or operating system. In "The History of Computer Graphics Standards Development," Dr. Andries Van Dam recounted how he and several others had organized a workshop at the National Institute of Standards and Technology (NIST) to discuss the potential for graphics standards [3]. The year was 1974, and attendees of the workshop fiercely debated whether the field had advanced sufficiently to produce a standard for graphics, and what features should be included since there were competing algorithms [3].

There emerged not one standard, but several competing standards later in the 1970s, but it was the Graphical Kernel System (GKS) that became an ANSI graphics standard. Later on, GKS became the precursor to the Programmer's Hierarchical Interactive Graphics System (PHIGS) [3]. Then in the 1990s, Silicon Graphics (SGI), a leading vendor for high-resolution, high-performance graphics software and computer platforms, developed the OpenGL API specification, which was widely used and later incorporated portions of the PHIGS specification [3].

The increased emphasis on World Wide Web applications has led some to turn to Web-based graphics languages that define graphics environments that can be distributed across a Web-based network. Web languages include Scalable Vector Graphics (SVG), Virtual Reality Modeling Language (VRML), and X3D.

This chapter covers each of these standards: GKS, PHIGS, OpenGL, SVG, VRML, and X3D.

8.1 Graphical Kernel System

Name. Graphical Kernel System (GKS).

Purpose. To define a wide range of graphics functions to create, manipulate, and display two- and three-dimensional graphical objects.

History. The 1974 NIST workshop led attendees to form the Association for Computing Machinery (ACM) SIGGRAPH Graphics Standard Planning Committee (GSPC) at its conclusion [3]. The purpose of the GSPC was to develop a GSPC standard for graphics [1, 3]. By 1977, the GSPC had produced the 3D Core Graphics System [3].

Jose Encarnacao, who had also attended the NIST workshop, worked in parallel [3]. Based on an early version of the Core specification that he received from the GSPC and German graphics software packages, he defined GKS, which defined two-dimensional graphics, and submitted it to the ISO [3]. GKS was accepted by ISO in 1981 as a working draft [3]. By 1985, ISO had published GKS as its first graphics standard, and later extended it to support GKS 3-D [3]. Also in 1985, ANSI approved GKS as a standard (http://www.itl.nist.gov/fipspubs/withdraw.htm), ANSI X3.124-1985, and it became Federal Information Processing Standard (FIPS) 120-1, meaning that it was a standard for use on U.S. federal government computer systems.

Standards Organization. The GKS specification was published by both the ANSI X3H3 Technical Committee and by the ISO Technical Committee JTC 1/SC 24. The specification for the standard is still listed by ISO.

Status. GKS was popular in the 1980s and 1990s, and it was used extensively for scientific programming, especially with FORTRAN. On November 18, 1998, it was withdrawn as from the FIPS list of standards [4].

Obtaining the Specifications. All of the specifications listed can be obtained from the ISO Web site. Specifications developed by IEC can be obtained from the IEC Web Store by selecting their "Search and Buy" option at https://domino.iec.ch/webstore/webstore.nsf, and doing a word search for the specification; or from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html.

- ISO/IEC 7942-1:1994 – GKS Part 1: Functional Description;
- ISO/IEC 7942-2:1997 – GKS Part 2: NDC Metafile;
- ISO/IEC 7942-3:1999 – GKS Part 3: Audit Trail;
- ISO/IEC 7942-4:1998 – GKS Part 4: Picture Part Archive;
- GKS language bindings:
  - ISO 8651-1:1988 – Part 1: FORTRAN;
  - ISO 8651-2:1988 – Part 2: Pascal;

  - ISO 8651-3:1988 – Part 3: Ada;
  - ISO/IEC 8651-4:1995 – Part 4: C Language.
- GKS-3D:
  - ISO 8805:1988 – Functional Description;
  - ISO/IEC 8806-4:1991 – Language Bindings – Part 4: C Language.
- GKS standards withdrawn as of November 18, 1998 [4]:
  - ANSI X3.124-1985(R1991);
  - ANSI X3.124.1-1985(R1991);
  - ANSI X3.124.2-1988(R1994);
  - ANSI X3.124.3-1989;
  - ISO/IEC 8651-4:1991.

URL. Refer to the ISO Web site http://www.iso.ch/iso/en/ISOOnline.openerpage.

Vendors. Galaxy Advanced Engineering, Inc., provides a FORTRAN graphics library language called UGL that is compatible with GKS on HP/UNIX, SUN/SOLARIS, Alpha/OpenVMS, VAX/VMS, LINUX, SGI/IRIX and Window95/98/2000 and NT or DOS. For more information, refer to http://www.gae-inc.com/gks.htm.

Other Sources of Information.

- ISO/IEC 7942:1994 Information technology – Computer graphics and image processing – Graphical Kernel System (GKS) – Part 1: Functional description, Part 2: NDC metafile (updated in 1997), Part 3: Audit, and Part 4: Archive, ISO/IEC, 1985.
- Dr. Van Dam's bio is provided at URL: http://www.cs.brown.edu/people/avd/.

8.2 Open Graphics Language

Name. Open Graphics Language (OpenGL).

Purpose. To create a single, vendor-independent API for to develop two- and three-dimensional graphics [5].

History. SGI developed the OpenGL API based on its IRIS GL software library [5]. SGI provided the specification to hardware vendors in June 1992, enabling them to develop drivers, and it became widely used. At that time, there was an OpenGL Architectural Review Board (ARB) that included Digital Equipment Corporation, Evans & Sutherland, Hewlett-Packard, IBM, Intel Corporation, Intergraph, Microsoft, Sun Microsystems, and of course, SGI [6]. The ARB approved version 1.1 of the specification as a graphics standard [6].

OpenGL became extremely popular, and its success may be attributed to a more mature graphics standard and more comprehensive implementation of two- and three-dimensional capabilities than the formal standards bodies had achieved [6].

Standards Organization. The OpenGL ARB continues to maintain the OpenGL specification [6].

Status. SGI provides OpenGL for Linux and is continuing its development under the auspices of the OpenGL ARB.

Obtaining the Specifications. The source code is available as open source and the documentation can be downloaded at http://oss.sgi.com/ (hardware vendors need a license to download it).

URL. http://www.opengl.org//.

Vendors. Most major vendors offer OpenGL on their computer platforms (e.g., Sun Microsystems, Silicon Graphics, Hewlett-Packard, and IBM). For more information, refer to http://www.opengl.org/users/about/index.html.

Other Sources of Information.

- Segal, M. and K. Akeley, *The OpenGL Graphics System: A Specification (Version 1.1)*, Silicon Graphics, Inc., 1995.
- Carson, G. S., "Standards Pipeline: The OpenGL Specification," *ACM SIGGRAPH Computer Graphics*, Vol. 31, No. 2, May 1997, pp. 17–18.
- OpenGL licensing information: http://www.sgi.com/software/opengl/license.html.

8.3 Programmer's Hierarchical Interactive Graphics System

Name. Programmer's Hierarchical Interactive Graphics System (PHIGS).

Purpose. Developed to extend GKS to support three-dimensional graphics and to hierarchically structure graphics data for interactive applications [3, 7].

History. Work began on a specification for a Basic PHIGS in 1984 [3]. PHIGS was based on the two-dimensional GKS standard, and was extended to support a three-dimensional specification [3]. PHIGS supported basic features such as editable graphics data, multiple simultaneous input/output devices, and three-dimensional graphics primitives [3]. It became an ISO standard in 1989 [3].

Although the original PHIGS was supported by major computer platform vendors, it was incomplete [2]. A PHIGS PLUS project was initiated to specify additional features, such as three-dimensional surface primitives, support for direct color, enhanced rendering, and hidden line and surface removal [3]. ISO/IEC 9592-4 1992, which was approved in 1992, is known as PHIGS Plus [3].

By 1997, amendments to PHIGS PLUS were published by ISO that provided such features as support for texture mapping and transparence, rendering to targets, and programmer-definable logical input devices [3]. This specification became known as Full PHIGS [3].

Standards Organizations. PHIGS was initially approved by ANSI as ANSI X3.144-1988 and then published as ISO 9592-1:1989. PHIGS is an ANSI/ISO standard.

Status. Full PHIGS specifications were published in 1997: ISO/IEC 9592-3 (1997-12) and ISO/IEC 9592-2 (1997-12). In 1995, NIST published PHIGS as FIPS

153-1 as a U.S. federal government standard, and then on November 18, 1998, withdrew it [4].

Obtaining the Specifications. The specifications can be obtained from the IEC Web Store by selecting their "Search and Buy" option at URL: https://domino.iec.ch/webstore/webstore.nsf:

- Full PHIGS:
  - ISO/IEC 9592-3 (1997-12) and ISO/IEC 9592-2 (1997-12) define Part 2 and Part 3 archive file format.
- ISO/IEC 9592-1 (1997-12) defines Part 1 functional description of PHIGS and replaces ISO/IEC 9592-4 (1992), which was known as PHIGS Plus.
- PHIGS Plus:
  - ISO/IEC 9592-4 (1992).
- PHIGS amendments:
  - ISO/IEC 9593-4 (1991-12), ISO/IEC 9593-4-am1 (1994-05) and ISO/IEC 9593-4-am2 (1998-12) (Part 4 and Amendments 1 and 2 to Part 4) define Part 4 C programming language bindings.
  - ISO/IEC 9593-3 (1990-12) and ISO/IEC 9593-3-am1 (1991-12) (Part 3 and Amendment 1) define Part 3 ADA programming language bindings.
  - ISO/IEC 9593-1 (1990-12) and ISO/IEC 9593-1-AM1 (1995-04) (Part 1 and Amendment 1) define Part 1 FORTRAN language bindings.
- Basic PHIGS:
  - ISO/IEC 9592:1989 Information technology – Computer graphics and image processing – Programmer's Hierarchical Interactive Graphics System (PHIGS) – Part 1: Functional description, Part 2: Archive file format and Part 3: Specification for clear-text encoding of archive file [3].

URL. The specifications can only be obtained from the IEC Web Store.

Vendors. Some vendors may support PHIGS for legacy platforms.

8.4 Scalable Vector Graphics

Name. Scalable Vector Graphics (SVG).

Purpose. To define an XML-based graphics format and an API for two-dimensional interactive graphics on the Web that supports shapes, text with raster graphics, painting, rendering, and animation [8, 9].

History. The W3C Scalable Vector Graphics Working Group began working on a specification for SVG and released a working draft in 1999 [8]. Members of the Working Group included Adobe Systems, Inc., Apple, Corel, Hewlett-Packard, IBM, Microsoft Corporation, Nokia Corporation, Sun Microsystems, Netscape Communications, Xerox, and Visio [8, 10]. Their objective was to develop it as an open standard for the Web that would build on XML, JPEG, and PNG for image data interchange standards, and other W3C standards [11].

Standards Organization. The W3C SVG Working Group (http://www.w3. org/Graphics/SVG) is responsible for developing and maintaining SVG specifications.

Status. The W3C SVG Working Group is continuing development of SVG, and SVG has strong industry support. In addition, three vendors, Nokia, Ericsson, and Motorola are developing a mobile SVG specification (refer to URL: http://www.w3.org/TR/SVGMobile/ for the specification).

Obtaining the Specifications. The SVG 1.1 specification is a W3C Recommendation, and at the time this book was written, SVG 1.2 was under development [11]. The URL at http://www.w3.org/Graphics/SVG/ provides links for both specifications.

URL. http://www.w3.org/Graphics/SVG/. A Web site dedicated to providing SVG news is located at URL: http://svg.org/.

Vendors. The SVG home site lists vendors that offer SVG. Some of the vendors listed include:

- Adobe Systems supports SVG tools and a viewer (http://www.adobe.com/ svg/).
- The Sketsa vector drawing application (http://www.kiyut.com/products/sketsa/index.html) by the Indonesian company Kiyut (http://www.kiyut.com/about_us.html) supports SVG and runs on Java platforms.
- Inkscape (http://www.inkscape.org/) is an open source SVG editor developed by the Inkscape organization.
- Evolgrafix (http://www.evolgrafix.com/) offers Xstudio 6 (http://www.evolgrafix.de/htDocs/html/products/xstudio6x/index.shtml).

Other Sources of Information.

- Adobe Systems provides a tutorial of SVG and other information at URL: http://www.adobe.com/svg/.
- "About SVG: 2d Graphics in XML," http://www.w3.org/Graphics/SVG/About.html, SVG Working Group, November 19, 2004.

8.5 Virtual Reality Modeling Language

Name. Virtual Reality Modeling Language (VRML).

Purpose. To define three-dimensional, interactive, graphical worlds that can be created and viewed on the Internet [12].

History. In the 1990s, a VRML Architecture Group (VAG) was established under the auspices of W3C by 10 three-dimensional software technologists from the graphics industry: Virtus Corporation, Silicon Graphics, Inc., Intervista Software, Visible Decisions, Sun Microsystems, IBM, and others [12]. VRML had its beginnings in the OpenInventor product from Silicon Graphics and expanded over time to include a browser to view and interact with the three-dimensional worlds, along with software to create them [12].

Standards Organization. At one time, the W3C VRML Architecture Group was responsible for defining the VRML specification, but now that X3D has been defined, VRML is no longer being maintained.

Status. VRML is no longer maintained, but it became the basis for defining X3D. See section 8.6 for details.

Obtaining the Specification. The specifications for VRML97(ISO/IEE 14772) can be downloaded at URL: http://www.web3d.org/x3d/specifications/Vrml/ISO-IEC-14772-IS-XRML97withAmendement11.

URL. http://www.w3.org/MarkUp/VRML.

8.6 X3D

Name. X3D.

Purpose. To enable interactive, three-dimensional graphics to be created, deployed, and broadcast on the Web [13].

History. The same community that led the development of the VRML specification moved from the W3C to establish the Web3D Consortium [13]. They used the VRML 2.0 specifications as the basis for defining a more powerful, interactive, three-dimensional graphical environment that could operate on a distributed environment: X3D [13].

Standards Organization. The Web3D Consortium (http://www.web3d.org/x3d) is responsible for defining this specification.

Status. The final draft version of the X3D was released in July 2002 and submitted to ISO for consideration as an international standard [14]. ISO is considering adopting X3D as three standards: ISO 19775:200x, ISO 19776:200x, and ISO 19777:200x [14].

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.web3d.org/x3d/.

URL. http://www.web3d.org/x3d/.

Vendors. Refer to the X3D FAQ located at URL: http://www.web3d.org/x3d/faq/#general-1 for information on the software support available.

References

[1] Machover, C., "Computer Graphics Pioneers: The Giloi's School of Computer Graphics," *ACM SIGGRAPH*, Vol. 35, No. 4, November 2001, pp. 12–16.

[2] Herman, I., et al., "PREMO: An ISO Standard for Presentation Environment for Multimedia Objects," *Proceedings of the Second ACM International Conference on Multimedia*, ACM Press, 1994, pp. 11–118.

[3] Carson, S., et al., "The History of Computer Graphics Standards Development," *ACM SIGGRAPH Computer Graphics*, ACM Press, Vol. 32, No. 1, February 1998, pp. 34–38.

[4] "Federal Information Processing Standards Publications (FIPS) Pubs: Withdrawn FIPS Listed by Number," http://www.itl.nist.gov/fipspubs/withdraw.htm, NIST, November 19, 2004.

[5] "OpenGL Developed by Silicon Graphics," http://www.sgi.com/software/opengl, SGI, November 17, 2004.

[6] Carson, G. S., "Standards Pipeline: The OpenGL Specification," *ACM SIGGRAPH Computer Graphics*, Vol. 31, No. 2, May 1997, pp. 17–18.

[7] Straayer, D., et al., "Technical Implications of Proposed Graphics Standards," *Proceedings of the 10th Annual Conference on Computer Graphics and Interactive Techniques*, ACM Press, 1983, p. 103.

[8] Walsh, J., "Groups Push Ahead with Vector Graphics Advances," http://www.infoworld.com/cgi-bin/displayStory.pl?990212.eivector.htm, *InfoWorld*, February 12, 1999.

[9] Froumentin, M., "Advances in W3C Web Graphics Standards," International Conference on Computer Graphics and Interactive Techniques, *Proceedings of the SIGGRAPH 2003 Conference on Web Graphics: In Conjunction with the 30th Annual Conference on Computer Graphics and Interactive Techniques*, San Diego, CA, 2003, p. 1.

[10] Perera, R., "W3C Issues Scalable Vector Graphics Specs," http://www.computerworld.com/softwaretopics/software/appdev/story/0,10801,63663,00.html, *ComputerWorld*, September 6, 2001.

[11] "About SVG: 2d Graphics in XML," http://www.w3.org/Graphics/SVG/About.html, W3C, November 19, 2004.

[12] Vacca, J. R., *VRML: Bringing Virtual Reality to the Internet*, Chestnut Hill, MA: Academic Press, Inc., 1996, pp. 31–39.

[13] "About the Web3D Consortium," http://www.web3d.org/contact/about.html, W3C, September 13, 2004.

[14] "X3D Frequently Asked Questions," http://www.web3d.org/x3d/faq/#general-1, Web3D Consortium, September 6, 2004.

CHAPTER 9

Operating System Standards

Many of today's operating system standards are based on Unix. Unix has been in use since 1969—more than three decades—and continues to be used. Originally developed by Ken Thompson and Dennis Ritchie of Bell Labs for the PDP-7 and named Unics as a variation of the Honeywell operating system name MULTICS, Unics eventually became known as Unix [1].

In 1973, Brian Kernighan and Dennis Ritchie invented the C programming language at Bell Labs and rewrote Unix in C [1]. So many employees at Bell Labs were using Unix that Bell Labs formed the AT&T Unix Systems Group [1]. Universities were provided free copies of Unix source code to use for educational purposes, and its popularity grew. Some universities organized their own Unix development user groups, one of which was at Berkeley, where they developed Berkeley Software Distribution (BSD) Unix [1].

By the 1980s there were so many Unix variants that the need for standardization was apparent. This chapter discusses how Linux grew from a Unix clone to become the Linux Standard Base (LSB) and the two Unix families of operating system standards, the Portable Operating System Interface (POSIX) and the Single UNIX Specification.

9.1 Linux Standard Base

Name. Linux Standards Base (LSB).

Purpose. To standardize the Linux operating system to promote application portability across heterogeneous computer platforms.

History. The Linux story begins in 1987 with Dr. Tanenbaum, a university professor who developed Minix, an open source operating system that was a Unix clone [2].[1] A few years later, Linus Torvalds, a computer science student at the University of Helsinki in Finland, wanted to be able to run Unix on his home computer but found the cost prohibitive [3]. Torvalds became familiar with Minix, and it gave him the idea for developing a free Unix [2]. By October 1991, Torvalds had released a Linux as a free operating system on the Internet that could run on

1. Refer to Dr. Tanenbaum's Web pages hosted by the vriji Universitat in Amsterdam at URL: http://www.cs.vu.nl/~ast/minix.html for more information on Minix.

PCs [2, 3]. Other developers worked with Torvalds to refine Linux, and companies like Red Hat begin to appear and offer Linux bundled with applications for a fee [2]. Linux became extremely popular because it was free and could execute on PCs. Businesses moved to it because it was low cost and considered fairly reliable.

To ensure that Linux would remain free, Torvalds patented Linux under the Free Software Foundation's General Public License [3]. Nevertheless, more was needed to prevent the host of companies and developers from creating so many versions of Linux that interoperability and portability became a significant concern [4]. To combat this problem, different groups emerged on the scene to develop standards for Linux. Two Linux experts involved with different standards efforts—Daniel Quinlan, who had led Linux developments at Transmeta in 1994,[2] and Hideki Hiura—teamed to cofound the Free Standards Group in 2000 [5]. Note that Quinlan had been chair of the LSB effort since August 1998, and The Free Standards Group continued those efforts, which recently culminated in approval from the ISO and IEC Joint Technical Committee 1 (ISO/IEC JTC 1) for LSB to be submitted for consideration as an international standard [5, 6].

Standards Organization. The Free Standards Group (http:/www.freestandards.com//) is a nonprofit organization responsible for maintaining this standard.

Status. The LSB is extremely popular and supported by the major vendors. Development of standards for Linux is continuing, especially now that it is being considered as an international standard.

Obtaining the Specifications. The LSB specification is available at URL: http://www.linuxbase.org.

URL. http://www.linuxbase.org/.

Vendors. Major vendors such as IBM, Sun Microsystems, HP, and others are members of the Free Standards Group and provide Linux products (see URL: http://www.freestandards.com/modules.php?name=Content2&pa=showpage&pid=7 for a more complete list).

Other Sources of Information.

- Michael Learmonth interviews Linus Torvalds in "Giving it All Away," a 1997 article published by MetroActive that can be found at URL: http://www.metroactive.com/papers/metro/05.08.97/cover/linus-9719.html.
- *Linux Today* provides news about Linux at URL: http://linuxtoday.com/.

9.2 Portable Operating System Interface

Name. Portable Operating System Interface (POSIX).

Purpose. To standardize the Unix operating system interfaces to support application portability across heterogeneous computer platforms.

2. Transmeta (http://www.transmeta.com) is the same company where the inventor of Linux, Linus Torvalds, was employed after inventing Linux.

History. In 1980, AT&T Unix operating system minicomputer and microcomputer users from different companies formed a user group they named the /usr/group [7]. Membership was limited to 40 people, and to make decisions, a two-thirds majority was required [7]. At the time, there were numerous Unix variants: the AT&T Unix System 3, the University of California Berkeley BSD version 4, and other versions such as Idris (by Whitesmith), Coherent (by Mark Williams), and Unos (by Charles River Data Systems) [7]. Employees from Whitesmith, Mark Williams, and Charles River Data Systems companies were members of this user group [7]. The user group's primary concern was the need for portability across computers and operating systems, so they began focusing on defining standard program interfaces [7]. This led to the development of a document of standard interfaces [7]. In 1984, the user group completed the document and published it as the 1984 /usr/group Standard [7].

Independent of the /usr/group, IEEE had initiated a project in 1983 to standardize the Unix operating system kernel [7]. In January 1985, the /usr/group provided the document to the IEEE, and /usr/group members began participating in the IEEE project [7].

In 1985, the IEEE Unix project became the Portable Open System Interface for Computer Environments Working Group 1003 (P1003), and its mission was to specify standard interfaces for the UNIX operating system. The group worked with AT&T to define the standards, and as the group membership expanded (the IEEE P1003 did not limit the number of members), the U.S. National Bureau of Standards (now the National Institute of Standards and Technology), also began to participate [7]. The standards defined by the IEEE P1003 became known as the POSIX standards.

In 1987, the IEEE P1003 approached the ISO for consideration of POSIX as an international standard [7]. ISO assigned the POSIX development to the JTC1 SC22 of ISO and the IEC in May 1987 [7]. ISO and the IEC approved POSIX and published the POSIX standards from 1993 on (http://www.pasc.org/standing/sd11.html).

Standards Organizations. The IEEE Computer Society's Portable Application Standards Committee (PASC) is the group now responsible for continuing development of the POSIX family of standards [8]. In addition, the Austin Common Standards Revision Group (CSRG) is a joint technical working group that develops and maintains the latest version of the IEEE 1003.1 [8].

Status. POSIX was defined by the IEEE as a family of P1003.X standards (refer to URL: http://www.pasc.org/standing/sd11.html for a complete list). Of these standards, however, the IEEE 1003.1 standard (referred to as POSIX.1) defined the basic operating system and environment to support application portability, and the IEEE 1003.2 standard (referred to as POSIX.2) defined the shell and common utilities [9]. The most recent version of the IEEE 1003.1 standard was published in April 2004 as the IEEE Std 1003.1, 2004 Edition, and combined [8]:

- ISO/IEC 9945-1, 1996;
- ISO/IEC 9945-2, 1993;
- IEEE Std 1003.1,1996;

- IEEE Std 1003.2, 1992;
- Parts of the Single UNIX Specification.

Obtaining the Specifications. The POSIX specifications can be obtained from the IEC Web Store by selecting their "Search and Buy" option at https://domino.iec.ch/webstore/webstore.nsf and doing a word search for the specification; or from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html. The ISO/IEC 9945: 2003, IEEE Std 1003.1, 2003 Edition, Single UNIX Specification Version 3 can be downloaded from http://www.unix-systems.org/version3/.

- 2003 POSIX:
  - ISO/IEC 9945-1:2003 – Part 1: Base Definitions;
  - ISO/IEC 9945-2:2003 – Part 2: System Interfaces;
  - ISO/IEC 9945-3:2003 – Part 3: Shell and Utilities;
  - ISO/IEC 9945-4:2003 – Part 4: Rationale;
- ISO/IEC 14519:2001 POSIX Ada Language Interfaces – Binding for System Application Program Interface (API);
- ISO/IEC 14515-1:2000 Test Methods for Measuring Conformance to POSIX – Part 1: System Interfaces;
- ISO/IEC ISP 15287-2:2000 Standardized Application Environment Profile – Part 2: POSIX Realtime Application Support (AEP);
- ISO/IEC 15068-2:1999 Portable Operating System Interface (POSIX) System Administration – Part 2: Software Administration;
- ISO/IEC 13210:1999 Requirements and Guidelines for Test Methods Specifications and Test Method Implementations for Measuring Conformance to POSIX Standards;
- ISO/IEC TR 14252:1996 Information technology – Guide to the POSIX Open System Environment (OSE).

URL. The IEEE Std 1003.1, 2003 Edition, Single UNIX Specification Version 3 can be found at http://www.unix-systems.org/version3/. Refer to URL: http://std.dkuug.dk/JTC1/SC22/WG15/ for status.

Vendors. The products in the following IEEE URL have been tested by an Accredited POSIX Testing Laboratory (APTL): http://standards.ieee.org/regauth/posix/posix2.html. For more information, e-mail IEEE at: posix@ieee.org.

Other Sources of Information.

- The IEEE and The Open Group provide "A Backgrounder on IEEE Std 1003.1, 2003 Edition" at URL: http://www.opengroup.org/austin/papers/backgrounder.html, dated September 1, 2003.
- James Isaak provides "The History of POSIX: A Study in the Standards Process" in *IEEE Computer Magazine* published in July 1990, pp. 89–92.
- The Open Group provides "POSIX® 1003.1 Frequently Asked Questions" at URL: http://www.opengroup.org/austin/papers/posix_faq.html.

9.3 Single UNIX Specification

Name. Single UNIX Specification.

Purpose. To standardize the Unix operating system interfaces to support application portability across heterogeneous computer platforms.

History. The company Novell (http://www.novell.com/) acquired AT&T's Unix and transferred the rights, Unix trademark, and specification to the X/Open Company (now known as The Open Group) in 1994 [10]. Novell also sold the Unix source code and implementation of the product (Unixware) to the SCO Group (SCO) http://www.sco.com [10]. SCO transferred the Unixware trademark to The Open Group [10]. Hence, The Open Group owns both the Unix and Unixware trademarks [10]. The Open Group introduced the Unix specification as the Single UNIX Specification for which it also developed a branding program to ensure vendor product conformance to the Single UNIX Specification [10].

Standards Organization. The Open Group (http://www.opengroup.org/) is responsible for maintaining the Single UNIX Specification.

Status. The latest version is the Single UNIX Specification Version 3 (UNIX 03).

Obtaining the Specifications. The Single UNIX Specification and other documents are available at URL: http://www.opengroup.org/pubs/catalog/un.htm for a fee.

URL. http: //www.unix.org/.

Vendors. Major computer platform vendors (e.g., Sun, HP, IBM) offer older products that implement the Single UNIX Specification.

Other Sources of Information.

- "POSIX" definition, *search390.com Definitions*, http://search390.techtarget.com/sDefinition/0%2C%2Csid10_gci214309%2C00.html, August 1, 2003.
- A FAQ for the Single UNIX Specification is provided at URL: http://www.opengroup.org/austin/papers/single_unix_faq.html.

References

[1] Martin, V., "There Can Be Only One: A Summary of the Unix Standardization Movement," Special issue on operating systems, *Crossroads*, ACM Press, Vol. 1, No. 3, February 1995, pp. 9–11.

[2] Newitz, A., "Abridged History of Linux," http://archives.cnn.com/2000/TECH/computing/02/11/mini.linux.history.idg/, CNN.com, February 11, 2000.

[3] Learmonth, M., "Giving It All Away," http://www.metroactive.com/papers/metro/05.08.97/cover/linus-9719.html, MetroActive, May 8–14, 1997.

[4] Myser, M., "Linux and Open Source: Linux Standard Base Takes On Industry Fragmentation," http://www.eweek.com/article2/0,1759,1646006,00.asp, eWeek, September 14, 2004.

[5] "Staff," http://www.freestandards.com/modules.php?name=Content&pa=showpage&pid=17, Free Standards Group, November 17, 2004.

[6] "Free Standards Group Recognized by ISO/IEC JTC 1 as PAS Submitter: Achieves Major Milestone in Advancing Internationally Recognized Standards for Linux," http://www.freestandards.com/modules.php?name=News&file=article&sid=65, Press Release, Free Standards Group, January 27, 2004.

[7] Isaak, J., "The History of POSIX: A Study in the Standards Process," *IEEE Computer Magazine*, July 1990, pp. 89–92.

[8] "POSIX® 1003.1 Frequently Asked Questions," http://www.opengroup.org/austin/papers/posix_faq.html, The Open Group, October 28, 2004.

[9] Walli, S. R., "The POSIX Family of Standards," *StandardView*, ACM Press, Vol. 3, No. 1, March 1995, pp. 11–17.

[10] "Who Owns UNIX®?" http://www.opengroup.org/comm/press/who-owns-unix.htm, The Open Group, June 17, 2003.

CHAPTER 10

Security Standards

10.1 Strategies for Securing Systems

Computer security standards and technologies are seriously challenged to keep pace with new and evolving threats. Every aspect of an information technology (IT) enterprise relies on some form of security to protect the hardware, networks, communications, operating systems, applications, system management, system performance, and data. Nevertheless, nearly every day users are bombarded with warnings about new viruses and worms and the damage they can do. While many viruses and worms are designed to exploit vulnerabilities in operating and e-mail systems, a new class of them has emerged that is even more threatening, since it targets holes in the security technologies themselves. Consider how the Witty Worm targeted the Internet Security System's BlackICE and RealSecure products, and within 45 minutes of being released had managed to destroy 12,000 computer systems that hosted particular versions of the products [1]. For this reason and because the use of standards and security technologies is not enough to address the rapid growth in security threats, this chapter also discusses strategies for securing systems.

Security threats vary so widely and affect different computing elements, the best strategy today is to provide layers of security. Consider the physical layers of security that a corporation employs to protect itself. Security guards man the entrance of the building to ensure that only authorized individuals enter. An employee swipes his or her picture badge against a badge reader for identification and authorization, or holds up the badge for the security guard to examine the picture and permit entrance. If the person does not have a badge, the security guard calls his or her point of contact for confirmation that the person is allowed entry. If the individual is carrying any large items into the building, the security guard might check them by running them through a scanner, and looking inside them for potentially dangerous objects. Once authorized, a person walks toward an office, and if security is especially tight, enters a cipher combination to get into the office. Security guards rove the outside perimeter of the building 24 hours a day, 7 days a week, looking for suspicious activity and protect the occupants and building from harm.

An IT enterprise needs analogous layers of security. Section 10.1.1 opens the discussion of strategies by describing national security monitoring capabilities established to provide alerts about security incidents and offer guidance. Section 10.1.2 discusses the kinds of security threats that are targeting the enterprise. Sections 10.1.3 through 10.1.5 describe the recommended security layers: access controls, identification and authentication services, and finally, perimeter controls.

10.1.1 National Security Monitoring

In his testimony on cyber terrorism to a Congressional Subcommittee on Terrorism, Unconventional Threats and Capabilities (July 24, 2003), Dr. Spafford[1] indicated that since 1986, the number of known viruses that affect the Intel/Microsoft platforms alone is around 90,000, with anywhere from 50 to 100 "in the wild" (released and infecting numerous platforms) at any point in time [2]. With the advent of millions of personal computers, desktop systems, server systems, and mobile devices connected to the Internet, the magnitude of security threats has been raised to a national level. To address this, national focal points have been established that monitor security incidents and provide information on how to counteract them. National security monitoring organizations include:

- *U.S.-Computer Emergency Readiness Team (US-CERT):* The U.S. Defense Homeland Security operates a US-CERT (http://www.us-cert.gov/) that acts as the "nation's focal point for preventing, protecting against, and responding to cyber security and vulnerabilities…[;] interacts with all federal agencies, private industry, the research community, state and local governments, and others on a 24×7 basis to disseminate reasoned and actionable cyber security information…[; and] is the operational arm of the National Cyber Security Division (NCSD) at the Department of Homeland Security (DHS). The NCSD was established by DHS to serve as the federal government's cornerstone for cyber security coordination and preparedness, including implementation of the *National Strategy to Secure Cyberspace*" [3].
- *U.S. National Security Agency (NSA) Central Security Services:* The NSA operates a Central Security Services organization that provides computer security configuration guidance for Microsoft operating systems and applications, Sun- and Unix-based applications, Oracle databases, particular collaboration systems, and Web browsers (see URL: http://www.nsa.gov/snac/downloads_all.cfm?MenuID=scg10.3.1).
- *Software Engineering Institute CERT Coordination Center*[2]: The CERT Coordination Center (CERT®CC) (URL: http://www.cert.org/) at the Software Engineering Institute (SEI) provides another source for security resources. The SEI CERT®CC was originally established after a graduate student at Cornell University brought down most of the Internet with the Morris Worm in 1988 (see URL: http://www.cert.org/faq/cert_faq.html#A1 for details). A group of government and academic experts was organized to contain it, and their efforts were successful. Shortly thereafter, the Defense Advanced Research Projects Agency (DARPA) established the SEI CERT®CC to address future Internet security incidents, and this organization has

1. Dr. Eugene Spafford is the director of the Purdue University Center for Education and Research in Information Assurance and Security (CERIAS), which conducts research in information assurance and computer, network, and communications security (see URL: http://www.cerias.purdue.edu/ for details).
2. "CERT" and "CERT Coordination Center" are registered with the U.S. Patent and Trademark office as service marks of Carnegie Mellon University. When referring to the CERT/CC in writing, please use "the CERT® Coordination Center" or "the CERT®/CC". Although "CERT" should not be expanded beyond its acronym, it is appropriate to note in text that the CERT/CC was originally the Computer Emergency Response Team.

expanded its services over time to include numerous education and training publications.

10.1.2 Security Threats

No discussion of security threats is complete without first covering what constitute essential attributes for a computer system, including its hardware, information, applications, communications, operating system, utilities, and the network systems it uses for communications:

- *Confidentiality:* The privacy of information is maintained, and only authorized users are permitted disclosure.
- *Integrity:* Systems, applications, information, and data are not corrupted or tampered with in any way.
- *Authentication:* Only authorized individuals, systems, and applications are allowed to conduct transactions, and their identity has been confirmed.
- *Nonrepudiation:* A user who undertook a transaction cannot subsequently deny it.
- *Availability:* All systems, applications, and data are ready for use in a timely and uninterrupted manner whenever required by authorized users.

Information assurance is the branch of computer security that addresses techniques and services for ensuring these attributes. Security threats intend to affect or disrupt the smooth operation of a computer system by altering one or more of these attributes. The designers of the security threat artifacts generally seek to exploit weaknesses and vulnerabilities in a system. They may be trusted employees of an organization, outsourced programmers, or outsiders hacking into the systems. Either way, the artifacts that they develop become the security threats discussed in the following sections. The following list is not exhaustive, but rather highlights a number of security threats that pose a significant risk.

10.1.2.1 Security Threats from Macros and Programs

This section describes five forms of macros and programs that pose threats to security: virus, worm, back door/trapdoor, trojan horse, and spyware.

Virus. This is a program or macro designed to intentionally perform benign or malicious functions by attaching itself to an application and executing each time the application runs. It enters the computer system without the user's knowledge or permission. Acts that a virus may perform include changing a screensaver, erasing application files, or destroying an operating system. A virus can replicate itself upon entering and can spread to other applications on the computer, infecting them as well. It can also send itself to other computers on a network to infect their applications as well. For example, the Melissa virus began as a macro attached to a Microsoft Word 8/9 document in Office 97/2000 that would e-mail a message using the user's name as the sender to 50 addressees identified in the user's Outlook system with a pornographic attachment, every time the infected document was opened [4]. Variants of Melissa continue to appear, along with variations of other viruses.

The lesson here is not to open attachments from senders you do not know, attachments you are not expecting from senders you do know, and attachments that use suffixes you are not familiar with. A mitigation strategy for this threat is to keep all antivirus software current and for system administrators to monitor national virus alerts every day.

Worm. A worm is a complete program that is able to self-replicate on a computer system or travel across networks from computer to computer to spread multiple copies of itself, clogging a computer system or network with multiple copies of itself until system performance degrades and eventually stops. Dr. Shoch and Dr. Hupp, employees at the Palo Alto Research Center in 1982, coined the term "worm" (after tapeworms) while working on one of the first LANs to describe applications they had created to perform useful tasks by replicating themselves across computer systems on the network to accomplish such activities as reclaim unused disk space, turn off computer systems not in use, and deliver e-mail [2]. However, it was not long before others had altered their benevolent concept to create malicious worms, and one actually managed to shut down the Internet. Known as the Internet Worm of 1988,[3] the worm attacked a weakness in particular versions of Unix, cloned itself multiple times on the Unix systems, and propagated itself across networks until so many copies were running that they effectively shut down the Internet. Rebooting computers had no effect on the worm, nor did killing the processes it created. In many cases, when information describing system or product vulnerabilities is published in a public setting and patches are made available, the worm writers immediately engage in exploiting vulnerabilities on systems whose users fail to apply the requisite patches. A mitigation strategy for this threat is to ensure that all weaknesses and vulnerabilities of systems and applications are patched as soon as they are available. This strategy also requires keeping up with product newsletters and updates.[4]

Back Doors and Trapdoors. Applications and system utilities that contain entry points invisible to the majority of users are known as back doors and trapdoors. These entry points typically eliminate the need for normal authentication and can potentially provide system administrator level access not only to the application's functions, but potentially the computer system and data. Application and system programmers build these features into the software ostensibly to use for debugging purposes, but sometimes forget to remove them once the software has been completed [2]. For organizations involved in outsourcing software development, the risk of this threat occurring may be high. A mitigation activity would be for the procuring organization to require the outsourcing organization to provide source code and for the procuring organization to review the source for back doors and compile and link it in-house.

3. Francis Litterio provides an article authored by Donn Seeley entitled "A Tour of the [Internet] Worm," which lists a chronology of events and describes exactly how the worm operated, at URL: http://world.std.com/~franl/worm.html.

4. P. Roberts noted in *ComputerWorld* that "Companies Warn of Mass Trojan Distribution: The Program Is Being Distributed on the Web Through Spam" at URL: http://www.computerworld.com/securitytopics/security/story/0,10801,94515,00.html, July 13, 2004.

Trojan Horse. The term "trojan horse" comes from the Trojan horse in Homer's *The Iliad*, where the Greeks, enemies of the Trojans, left a very large wooden horse outside the city of Troy apparently as a tribute and offering to the Trojan goddess Athena. The Trojans moved the horse into their city, only to discover too late that Greek soldiers had hidden in it and came out to rob, pillage, and destroy Troy. Likewise, a trojan horse appears to be a useful program, such as a game, but when the user executes it, it does something entirely different than what was expected. It may appear to be a logon script, while in actuality it sends the user's id and password to someone else on the network. A trojan horse does not replicate itself, but has been known to delete applications and data files, or reformat disks. A recent trojan horse released on the Internet was called Backdoor-CGT [5]. It would be activated by unknowing users of Microsoft Outlook who would link to a Web site provided with a spam e-mail [5]. After the Web link had been made, the Backdoor-CGT trojan horse would be downloaded to the user's system and would link to a series of Web sites to download malicious code [5]. The recommended strategy is never to link to unknown Web sites provided by e-mail senders who are mitigation unknown, and especially if the e-mails are spam.

Spyware. Spyware is a complete program that operates on a computer without the user's permission or knowledge and may be inadvertently downloaded when a user links to a particular company's Web site and downloads freeware. Unlike the malicious programs already mentioned, its purpose is to monitor a user's activity, read cookies, and otherwise gather information about a user to transmit back to its mother company over the Internet. The mitigation strategy is to be wary of linking to company Web sites and downloading freeware and use firewall software that blocks applications from sending messages to the Internet without your permission.

10.1.2.2 Network Traffic Attacks

This section discusses two prevalent attacks on networks through network traffic intended to overwhelm and crash network servers: denial of service, and distributed denial of service. These attacks are intended to degrade or halt system availability.

Denial of Service (DoS) Attack. A denial of service attack floods a network with traffic in an attempt to bring it down. Basically, it overwhelms the network servers, which become unable to keep up with the volume of requests, and they become unavailable for processing legitimate requests. One example of this was the Ping of Death DoS that exploited vulnerabilities in network servers by sending them numerous packets that exceeded the size threshold [6]. A mitigation strategy for DoS is to use network blockers and to ensure that all network server and router patches are current.

Distributed Denial of Service (DDoS) Attack. Multiple compromised computer systems are used to target networks, Web sites, and servers with DoS attacks. One examination of attacks discovered that organized groups—in some cases, from foreign countries—were targeting military, government, e-commerce, and ISP Web sites with DDoS attacks to bring them down [7]. The best mitigation strategy is to ensure that network blockers are in use, and all computer system and product security patches are kept current so that computer systems are not compromised and able to host attacks.

10.1.2.3 Direct User Attacks

This section describes attacks from individuals who gain direct access to a system: imposters, intruders, and disloyal but trusted users.

Imposter. An imposter is an individual who masquerades as, or impersonates, an actual authorized user and who, upon authentication and identification, achieves access to information and applications which he or she would not otherwise be entitled to. An imposter can inject malicious code, send spurious e-mails that might damage the reputation of the true user, alter data, destroy or delete files and applications. This case is frequently extremely difficult to detect. One mitigation strategy is to provide each authorized user with a token, a device that generates a password dynamically and must be used as part of the authentication process.

Intruder. An intruder is an individual who has gained access to a computer system without authorization, usually by exploiting system weaknesses and vulnerabilities. An intruder can potentially do more damage than an imposter, because he or she is frequently able to operate at the system programmer level. Intruders are very difficult to detect. One mitigation strategy is to use intrusion detection systems that monitor the system in real-time and send automatic alerts to system operators of suspicious activity. Another mitigation strategy is to ensure that all system utilities and applications that have publicized or known weaknesses are updated with corrective software updates as soon as they become available.

Disloyal, Trusted User. What many consider by far the most serious of all threats is the user with special privileges who acts with malicious intent against the system that he or she was entrusted to care for. This individual has inside knowledge that could cause the most damage. Trusted users include system programmers, system administrators, and applications programmers who introduce worms, viruses, or other malicious code into the system to effect damage, alter data, delete files, gain privileged information about the company, or otherwise act outside the trust accorded. Trusted users may turn on their organization if bribed by competitors or foreign companies, as revenge for poor treatment by management, out of curiosity to see if they can get away with it, and for other reasons. These are the hardest to detect because they are able to purge their trails from the system. There is no simple remedy; one strategy might be to audit all activities, store the audit trails in a manner that does not permit compromise or destruction [e.g., write once, read many (WORM) storage], automate the review of audit trails for suspicious activities,[5] and send flagged activities to senior managers of several different organizations. Keep in mind that auditing user activities can degrade system performance; trade-offs have to be made.

5. Of course, someone would need to ensure that the audit trail review software was not compromised and correctly identified cases considered by corporate management to violate the privileges accorded, such as altering salary data without permission.

10.1.2.4 Passive Attacks

There are several forms of attacks intended to gain knowledge about an organization, its system, or its users by operating in a passive mode that is frequently difficult to detect and prevent.

Eavesdropping. Eavesdropping occurs when a user collects network traffic for the purpose of analyzing it at some later time to extract, for example, user ids and passwords from logon packets, information about employees and organizations in messages, and business intelligence in documents transmitted from senders to receivers. Eavesdropping is usually accomplished by attaching some physical device directly to a network through some means such as a network port or spliced cable to establish a communications connection at that point, and then storing network traffic packets in a device such as a laptop. Mitigation strategies include turning off ports not in use, periodically checking physical port connections for unauthorized connections, and encrypting critical transmissions of information.

Unauthorized, Remotely Accessed/Controlled Computing Resources.
Many times, system administrators fail to disable other users from being able to access and/or control system resources. For example, a user might remotely access another user's desktop microphone to eavesdrop on that person's conversations without that person's permission or knowledge. Or a user might remotely access a user's desktop file system to copy files that contain proprietary or personal information. As another example, a user might intercept a shared facsimile (fax) server and either eavesdrop or divert faxed materials to his/her own fax machine. There are other such examples of unauthorized resource access and control. A mitigation strategy is to disable remote control of desktop devices.

10.1.3 Access Controls

Access controls provide mechanisms to authorize valid users and enable them to conduct transactions on a system. Access controls define who the users are and establish their permissions for using the system. Users can be applications, individuals, groups of individuals, system resources (e.g., printers), or other systems. Access controls validate whether a user is authorized to use the system and govern what he or she is allowed to do while using the system. This section discusses a variety of access controls available today.

10.1.3.1 Account Administration

Account administration provides services that create, edit, delete, and manage user accounts for a system. Each account includes personal information that can be used to establish the identity of a user and authorize access. In addition, each user account establishes the permissions a user has been granted to govern what a user can and cannot do while using the system.

10.1.3.2 Permissions

A user is assigned privileges, or a set of permissions, that enable the user to conduct transactions with objects on the system (e.g., files, applications, printers).

Permissions include the ability to execute certain applications; print to shared or private resources; change a password; and read, write, and/or delete files on other users' directories. Most systems have a system administrator or super-user account to provide at least one individual with access to all system objects for the purpose of maintaining the system.

10.1.3.3 Authentication

Authentication establishes the identity of a user and allows that individual or resource to logon to the system. In most cases, entering a particular user id establishes a claim to hold a certain identity on the system, but the system will not authenticate a user until the user has presented one or more credentials, such as a correct password. However, because compromise of passwords is such a frequent occurrence, many systems require additional forms of identification to establish a user's identity. This subject is covered in Section 10.1.4.

10.1.3.4 Authorization

Authorization services are executed after the user provides identifying information and is authenticated to verify that this is a valid user before logging them onto the system. Authorization services also come into play when a user attempts to conduct a transaction such as run an application, delete a set of files, and open and read files. Authorization services review the user's account information to verify that the user has the necessary permissions before allowing the user to continue.

10.1.3.5 Monitoring

Most systems provide a capability to log user actions and store them into a log, commonly referred to as an audit trail. The most limited form of monitoring captures only successful logons and failed logon attempts. More sophisticated capabilities log every action, or only particular actions, that a user performs on the system. When monitoring captures every user's actions, the overhead can be tremendous and seriously degrade system performance; so many organizations rarely use this capability or turn it on only for specific users who are considered to be acting suspiciously. Audit trails can be reviewed manually for patterns of suspicious behavior, or they can be automated to find user-defined patterns of behavior considered suspicious (e.g., numerous failed login attempts, deleting another user's files, attempting to execute applications or access files that the user is not permitted to access).

10.1.3.6 User Profiling

User profiling services, if supported by the system, rely on the audit trails for input. They examine the audit trails using statistical analysis to develop a profile of what would constitute normal behavior for a user. For instance, if a user works for several months from 9 am to 6 pm from Monday through Friday in a particular office, then this pattern would be considered normal behavior, and would become part of the profile. Now if the user suddenly shows up at a completely different office on a Saturday, and starts working at 10 pm, then this activity would be flagged as suspicious. Most systems run the user profiling function after working hours, so that personnel can review flagged behavior patterns the following day.

Where mission-critical systems are involved, and where there are serious concerns about the possibility of hackers, an organization might require the system to provide the information in real-time to security personnel so that a security officer can be dispatched immediately to physically verify that the user really is who they claim to be. In some cases, security personnel might also contact the user's manager at home, to verify that the manager was aware that his or her employee would be working over the weekend.

10.1.4 Identification and Authentication

There are a number of techniques for identifying and authenticating users that can be combined to increase the accuracy of a system's authentication services. A system that requires only a password is considered the easiest to break into.

10.1.4.1 User id, Password, and Personal Identification Number

User ids are entered into the system in concert with a password and/or a personal identification number (PIN). The user id, password, and/or PIN are assigned to the user when the account is opened. Passwords are typically 6 to 12 alphanumeric and special characters (e.g., @), where the shift or control keys have to be used for part of the password, along with numbers. Some systems require the user to reset the passwords every 3 to 6 months. PINs are frequently five digits that are provided to the user when his/her account is opened, and they are rarely changed unless the number has been forgotten.

10.1.4.2 Token

A token is a physical device that displays a new combination of digits (usually eight) every few seconds. The user enters the number displayed as part of a password during the logon process. The system is able to determine what the token password should be in real-time for that user, and validate the user. Sometimes the token and system become out of synch and the token has to be reprogrammed. The user generally keeps the token with him or her all of the time he or she is at work.

10.1.4.3 Biometric Identification

Biometric identification equipment is being used by some organizations that use a fingerprint, scan a retina, use a voice pattern, or examine a biological body part or behavior of a user as a means for authentication.

10.1.4.4 Personal Questions

When a user account is created, a user is asked one or more personal questions and the answers provided become part of the authentication process and are included with the account information. A more sophisticated technique is to allow the user to enter his or her own questions and supply the answers. Some systems ask these questions of a user who has forgotten their password as a means for authenticating them and allowing them to create a new password. Other systems might use a subset of these questions to verify a user identity only when he or she is acting suspiciously by operating outside his or her user profile.

10.1.4.5 User Profile Verification

Systems that establish a user profile often compare the logon activity with the user profile as part of the authentication process. For instance, if a user is operating outside of his or her profile, the system might use personal questions to establish his or her identity, dispatch a security guard to validate the user in person in order to complete the authentication process, or simply deny the user's logon request.

10.1.4.6 Third Party Confirmation

Third party confirmation builds on user profiling. Suppose that a user is operating out of profile: it is a normal workday, the time is between 9 and 5, but he or she is not using his or her own office to login—he or she is logging in from another city. Although this behavior may be perfectly legitimate, the system may flag the behavior to a security officer, so that the security officer can call someone else near that office to confirm the user's identity. The objective here is to ensure that the user's authentication information has not been compromised. In this case, the security officer would complete the authentication process.

10.1.5 Perimeter and Interface Controls

This section describes the logical controls that relate to system boundaries and interfaces with other systems. These are the software controls reminiscent of the physical security guards, alarm systems, and locks. This section covers encryption, digital certificates, digital signatures, firewalls, demilitarized zones (DMZ), antivirus software, and intrusion detection systems.

10.1.5.1 Encryption, Digital Certificates, and Digital Signatures

Encryption is used to protect the confidentiality of data during communications transmission from sender to receiver. Encryption is a process where a mathematical algorithm is applied to convert ordinary, alphanumeric data referred to as *plain text* to *ciphertext*, an obscure or meaningless form, to keep the information from being understood until the intended recipient receives it. The encryption algorithm relies on a key to encode and decode (decrypt) the text. The key provides an initial value for the algorithm. Francis Litterio provides a bibliography of papers on aspects of cryptography—the principles, mechanisms, and methods for encryption and decryption—at URL: http://world.std.com/~franl/crypto/.[6]

As companies and customers move to the Web to conduct financial transactions, it becomes absolutely critical to provide mechanisms that increase the confidence in authentication—that a user is exactly who he or she claims to be. Companies want proof that a particular customer conducted a Web transaction, rather than have the customer deny it later on after the companies' goods and/or services have been provided. Likewise, customers need a guarantee that they are dealing with a reputable firm that will honor their financial transactions and provide the goods and/or services purchased.

With this as background, cryptography is important because it involves the principles, mechanisms, and methods for encrypted and decrypted communications. Public and private keys are integral to the encryption/decryption process, essential for creating a digital certificate, and are generated by a cryptographic key algorithm. Signed digital certificates strengthen the assurance that a user actually is who he or she claims to be.

The user first needs to consult a certificate authority (CA). A CA is the trusted middleman selected to oversee the identity certification process and manage the certificates. For the Public Key Infrastructure (PKI), authorized CAs are listed at URL: http://www.pkiforum.org/resources.html#ca. The user usually needs to meet with the CA in person to prove his or her identity as part of the digital certificate enrollment process.

After the CA has established the user's identity, then most frequently it is the CA who assigns a public key and a private key to the user. The user needs to keep the private key confidential and treat it the same as a password. The CA also assigns the user a serial number and a signature algorithm. X.509 (see Section 10.3.2) provides standards governing what information must be present in a digital certificate. Using the user's public key, the CA digitally signs the certificate to verify the identity of the user and authorize the user to use that digital certificate for conducting transactions. The CA provides the user with a file that contains the signed digital certificate, and most often, the user either provides this file to an application for authentication or imports it into his or her Internet browser and the browser presents it to the application.

Note that the CA also maintains a revocation list that identifies users whose certificates have been revoked, possibly because their certificates have expired, they have terminated their employment at the company, or for some other reason. When a system authenticates a user's digital certificate, it typically reviews the CA's revocation list to ensure that the certificate is still valid.

Digital signatures also require encryption. Digital signatures are used to send business contracts and other documents electronically using some form of communication such as e-mail along with other data used to determine whether or not the document has been altered. A digital signature supports nonrepudiation; namely, it validates the identity of a sender and verifies that the document was sent by the sender without alteration. To use this approach, a sender must have a public and private key and the receiver must have the sender's public key.

6. This bibliography is part of the World Wide Web Virtual Library begun by Tim Berners-Lee, inventor of the World Wide Web (see URL: http://www.vlib.org/).

First, the sender applies a hashing algorithm such as RSA (see the RSA discussion in Section 10.4.2) to the document. As an example, suppose the document is a plain text message. The result of applying the hashing algorithm is a file containing what is referred to as a message digest. Next, the sender encrypts the message digest with his or her private key, and the result of this computation becomes the digital signature for that plain text message. The sender sends this digital signature with the plain text message.

When the receiver receives the plain text message and the digital signature, he or she first applies the sender's private key to the digital signature to decrypt it, resulting in the sender's message digest. The receiver also applies the same hashing algorithm to the plain text message, resulting in the receiver's message digest. The user compares the two message digests. If they match, the message sent from the sender has not been altered.

10.1.5.2 Firewalls

A firewall is a software and/or hardware mechanism used to filter traffic. Generally, it filters traffic from the Internet to a link on a private network, but it is also used to protect a computer system from unauthorized Internet access to that computer, or links between different private networks. Depending on the particular firewall system and user preferences, it may support one or more of the following capabilities:

- Protect the identity of the host computer system from Internet queries (pings) or by changing the packet header information before allowing transmission to protect private network information;
- Block unauthorized traffic to and from a network or host computer, such as vendor applications that attempt to transmit private user or system information to the vendor via the Internet;
- Automate security policies defined by the system administrator, such as preventing users from accessing particular Web sites;
- Limit the use of particular ports to particular users.

10.1.5.3 Demilitarized Zone

A DMZ is a computer or a network that acts as a buffer between a public network, such as the Internet, and a private network. For instance, an organization might implement a DMZ to share a subset of organizational data with other organizations over a public network. However, concerned about the possibility of compromise if direct access was allowed, the organization provides users on the public network with access to a *middleman* server and/or a subnetwork that provides them with access to an approved copy of the organizational database (or a subset of it). The organizational database is not accessible to the public network, but its host server is connected to the middleman's server or network to periodically transmit database updates. Depending upon the configuration, the server hosting the organizational database might only have a one-way interface to the middleman server and/or network, to ensure that it is completely inaccessible to outside users.

10.1.5.4 Antivirus Software

Most viruses have what is considered a signature *pattern* that antivirus software is programmed to detect by periodically scanning the disk drives and applications for the known patterns. Depending on the software, it might delete, quarantine, or repair infected files. Because new viruses are being introduced almost daily, it behooves users to regularly update their antivirus software. Some vendor products are programmed to access the vendor's Web site to periodically download updates at the user's discretion.

10.1.5.5 Intrusion Detection System

An intrusion detection system (IDS) is a software application that is used to identify and sometimes prevent unauthorized attempts to access computers, networks, applications, resources, and/or data; and possibly to evaluate degradations in performance that might be caused by intruders or unauthorized applications (e.g., viruses, worms). An IDS might be programmed to review audit trails for suspicious activity either in an off-line mode or dynamically, as the audit trail is collected (if the auditing capability is turned on). An IDS alerts system administrators as soon as suspicious activity is detected, and it may have some limited ability to prevent intrusions. An IDS may monitor activity on a particular computer, or it may monitor an enterprise consisting of a network and the computers on that network.

10.1.6 Security Policies

Although the subject of security policies is discussed last in this section, it is foremost on the list of security requirements. Installing security products to counteract threats does not go far enough to reduce security risks. Policies must be established and enforced. Personnel must be educated on what the security policies are. Actions must be taken if security policies are violated or ignored.

The previous sections provide a basis for considering what kinds of system security capabilities might be needed, but it is absolutely essential for an organization to administer security policies. Some thoughts on what security policies should cover are as follows:

- Definition for what constitutes authorized access to a system, for example:
  - What combination of characters can be used for passwords (e.g., passwords should not be easily guessed, such as names of children, but contain a series of at least eight alphanumeric characters that include numbers and capital letters)?
  - What combination of identification and authentication controls will be supported?
  - How often should these be changed to reduce the opportunity for compromise?
- How authorized access to the system is to be administered;
- What permissions need to be set to limit user access to private organizational and employee files;

- Identification of which activities will be monitored, how they will be monitored, and who will monitor them;
- Identification of which layers of security will be supported, a standard set of tools to be used across the organization, and a means for periodically updating them;[7]
- How the system will be periodically tested to determine how well the system prevents intrusions (penetration testing);
- Identification of personnel responsible for monitoring and protecting the system and a means for contacting them (7×24, if necessary);
- What Web sites personnel are allowed to visit;
- How to ensure that only authorized computers are connected to the enterprise. This is especially critical as wireless laptops become popular and personnel connect them to the enterprise on their own: hackers can pick up signals from unsecured Wi-Fi laptops or devices from miles away, or they can be used to collect message traffic that can be analyzed later [8]. When not authorized and properly secured, Wi-Fi laptops are considered rogue access points in a network and cause breaches in security [8];
- What are allowable e-mail attachments, messages, and files to have at the workplace;[8]
- How training will be conducted to educate personnel on the organizational security policies (e.g., requirement for a security training program and for personnel to take it);
- What would be considered a violation of security policies, and what actions would be taken if it occurs.

10.2 Authentication and identity Management Standards

As services to identify and authenticate users mature and move to the Web to automate business processes, the importance of identity management becomes paramount. Identity management covers the creation, access, update, and storage of private user information, along with security services to protect its confidentiality. Once completely within the purview of system administrators who created and updated user accounts, now, with the advances on the Web, self-service capabilities exist that enable users to create and manage their own accounts. This section discusses the Kerberos standard, Liberty Version 1.0 Specification, and Security Assertion Markup Language (SAML).

7. Note that the more widely used and inexpensive a security software product is, the greater the opportunity for hackers to find and exploit weaknesses and vulnerabilities. Depending on the level of system protection desired, a more expensive product, or even a custom product might be more desirable.
8. Businesses are addressing concerns about pornographic materials in security policies as a means for preventing employees from downloading them from the Internet and inadvertently introducing viruses and worms, or sending e-mail attachments containing pornographic materials that will offend other employees and customers. In one instance, an employee used a pornographic screensaver at a customer site because his company did not have a policy barring this, but it led to his immediate removal from the project after his customer had seen it.

10.2.1 Kerberos

Name. Kerberos.

Purpose. To serve as a network authentication protocol for client/server applications [9].

History. In the early 1980s, members of Project Athena at MIT were concerned about the security of their network and wanted to prevent passing passwords *in the clear*, or unencrypted, where they might be *sniffed* and then compromised [9, 10]. They based the initial design of Kerberos on the Needham-Schroeder authentication protocol, which provided for the use of keys to encrypt and decrypt authentication information [10]. Kerberos software versions 1 through 4 were designed and implemented by members of Project Athena and the MIT campus network manager [9]. Kerberos was considered a groundbreaking development in security.

Standards Organization. The IETF Kerberos Working Group (http://www.ietf.org/html.charters/krbwg-charter.html) is responsible for maintaining this standard.

Status. The original proposed standard, RFC 1510, "The Kerberos Network Authentication Service (V5)," by J. Kohl and C. Neuman was replaced by the Internet Draft by C. Neuman , T. Yu, S. Hartman, and K. Raeburn dated June 29, 2004.[9]

Obtaining the Specifications. The Draft Internet standard can be downloaded at URL: http://www.ietf.org/internet-drafts/draft-ietf-krb-wg-kerberos-clarifications-06.txt.

URL. http://www.ietf.org/html.charters/krbwg-charter.html.

Vendors. MIT provides source code and binaries for Kerberos that can be downloaded at URL: http://web.mit.edu/kerberos/www/. Vendors for Kerberos implementations include:

- Microsoft Corporation (http://www.microsoft.com) for its 2000 and XP products;
- Finally Software (http://www.finallysoftware.com/finally/products.htm?referrer=GoogleDCE);
- Sun Microsystems (http://wwws.sun.com/software/security/kerberos/).

Other Sources of Information. John T. Kohl, B. Clifford Neuman, and Theodore Y. Ts'o wrote an article describing Kerberos entitled "The Evolution of the Kerberos Authentication System," published in *Distributed Open Systems*, pages 78–94, by IEEE Computer Society Press in 1994.

10.2.2 Liberty Version 1.0 Specifications

Name. Liberty Version 1.0 Specifications.

Purpose. To define standards for a secure, single sign-on through identity services and identity management.

9. At the time that this book was written, the expiration date for the standard was December 29, 2004.

History. As more companies automate their business services on the Internet, there is a greater need to provide better authentication and identification services. To use a company's Internet services, an individual must create a user id, password, and/or PIN, and provide identifying information such as a credit card number, social security number, and home address to become an authorized user. This process rapidly becomes laborious when that same individual has to provide similar kinds of information to conduct related transactions with other businesses and is forced to remember all of the user ids and passwords assigned (or that he or she created).

This is why businesses have pushed for a single sign-on. The Liberty Alliance Project, led by Sun Microsystems and United Air Lines, Inc., developed a technical specification as an open standard and an alternative to Microsoft Corporation's Passport system [11]. The specification is based on SAML, which provides for the exchange of authentication information [11].

Standards Organization. The Liberty Alliance Project (http://www.projectliberty.org/) is responsible for defining the standard.

Status. The technical specification describes a federated network identity, where a group of companies agree to work together as trusted parties (a federation), and after a user logs on, an identity provider identifies and authenticates the user so that now, all of these companies' Internet services are available to that user on what becomes a unified (federated) network, and only one sign-on activity is required [11]. Implicit in this concept is the individual's agreement to have his or her information available to the other companies in the federation; he or she can terminate this arrangement at any time [12]. This capability is extremely useful for conducting transactions such as planning a business trip, purchasing tickets from an airline, and then renting a car and reserving a room in a hotel—all transactions with different companies but needing only one sign-on. Vendors are in the process of implementing the specification, but at the time that this book was written, were still in the early stages of development.

Obtaining the Specifications. The specifications are provided at URL: http://www.projectliberty.org/specs/index.html and include an architecture overview, implementation guidelines, and personal and employee profiles.

URL. http://xml.coverpages.org/libertyAlliance.html. OASIS (http://www.oasis-open.org/home/index.php) hosts a Web page that provides the status of the Liberty Alliance specifications.

Vendors. Sun Microsystems already supports identity management products (http://www.sun.com/2004-0608/feature/), but Sun and other vendors are in the process of implementing the Liberty Alliance specification.

10.2.3 Security Assertion Markup Language

Name. Security Assertion Markup Language (SAML).

Purpose. To define an XML-based protocol for exchanging information for authentication and authorization on the Internet.

History. IBM, the Microsoft Corporation, and VeriSign, Inc., developed the SAML specification and submitted it to OASIS in June 2002 [13]. The motivation in defining SAML was to provide standards for secure identification and authentication capabilities on the World Wide Web, to enable companies to automate their business processes, and to allow customers to make purchases on-line in a secure manner, with only a single logon.

Standards Organization. The OASIS Security Services Technical Committee (SSTC) (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security) is responsible for maintaining this standard.

Status. OASIS approved SAML 1.1 as an OASIS standard on September 22, 2003 (http://www.oasis-open.org/news/oasis_news_09_22_03.php), and a number of vendor products are available to support it. In addition, the Liberty Version 1.0 Specification is based on SAML.

Obtaining the Specifications. The specifications are linked to the Web page at URL: http://www.oasis-open.org/specs/index.php and can be downloaded from the "SAML" link on that page.

URL. http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security.

Vendors. Refer to URL: http://www.oasis-open.org/news/oasis_news_09_22_03.php for the list of vendors that support SAML. A partial list is shown below:

- Sun Microsystems (http://www.sun.com/);
- Novell Incorporated (http://www.novell.com/);
- RSA Security (http://www.rsasecurity.com/) in its RSA Cleartrust product;
- Entrust (http://www.entrust.com/).

10.3 Digital Certificate Standards

This section discusses the PKI and X.509 standards.

10.3.1 Public-Key Infrastructure X.509

Name. Public-Key Infrastructure X.509 (PKIX).

Purpose. To provide a foundation for Internet certificate technology based on the ITU-T X.509 Recommendation (refer to Section 10.3.2 for details) [14].

History. In 1976, Whitfield Diffie and Martin Hellman introduced the concept of using a pair of keys (one private and one public) for cryptography in a landmark paper entitled "New Directions in Cryptography" [14].[10] Until then, only a secret or private key was used, and any party who needed to communicate in a secure manner had to know the private key to encrypt or decrypt text [14]. In 1995, the PKIX Working Group was formed to develop Internet standards to support PKI technology based on the X.509 Recommendation [15]. Since that time, the PKIX Working Group has developed a family of PKI standards for X.509 [15].

10. See "Other Sources of Information" in this section for information about the article by Diffie and Hellman.

Standards Organization. The IETF PKIX Working Group (http://www.ietf.org/html.charters/pkix-charter.html) is responsible for maintaining this standard.

Status. Industry, the U.S. DoD, and other federal government organizations are moving to PKI to accomplish what is commonly referred to as PKI-enabling their applications and requiring that personnel obtain digitally signed certificates to use the applications. PKIX is seen as a means for improving confidence in user identities and securely conducting business and exchanging e-mail on the Internet. The PKIX Working Group continues to update and refine the family of standards, which includes an architecture framework to guide their implementation. The most recent version of the primary PKI specification is RFC 3280.

In addition, the ISO Bulletin published in May 2000 entitled "An Important Milestone for the Financial Services Security – Public Key Infrastructure (PKI) Certificate Extensions," at URL: http://www.iso.ch/iso/en/commcentre/isobulletin/articles/2002/pdf/pki02-05.pdf, discusses ISO's international standard for PKI-based certificate management to support the banking industry (ISO 15782).

Obtaining the Specifications. The PKIX family of specifications can be downloaded from URL: http://www.ietf.org/html.charters/pkix-charter.html.

URL. http://www.ietf.org/html.charters/pkix-charter.html.

Vendors. The OASIS PKI Forum, which advocates the use of PKI for business transactions on the Internet, lists PKI product vendors on their Web page at URL: http://www.pkiforum.org/resources.html.

Other Sources of Information.

- Whitfield Diffie and Martin Hellman wrote "New Directions in Cryptography," published in *IEEE Transactions on Information Theory 22*, 1976, pages 644–654.
- PKI certificate authorities are listed at URL: http://www.pkiforum.org/resources.html#ca.
- The PKI Forum Business Working Group provides a basic understanding of PKI in "PKI Basics – A Technical Perspective," at URL: http://www.pkiforum.org/pdfs/PKI_Basics-A_technical_perspective.pdf.
- S. Kelm supports a Web page that links to a variety of PKI white papers and projects at URL: http://www.pki-page.org/.

10.3.2 X.509

Name. X.509.

Purpose. To define digital certificates.

History. The International Telecommunication Union (ITU) (http://www.itu.int/home/index.html) defined X.509 recommendations as part of the X.500 directory services to support ISO's OSI standards. The ITU-T X.509 recommendations were adopted by the ISO and IEC as ISO/IEC 9594 in 1997 [16].

Standards Organization. The ITU Telecommunication Standardization (ITU-T) Study Group 7 defined X.509 as a recommended standard, and the ISO and IEC organizations published it as an international standard.

Status. Development on X.509 continues and it is widely used. The most recent update was in 2000 and was coordinated with ISO/IEC and ISOC/IETF [16].

Obtaining the Specifications. The X.509 specifications can be purchased from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html for ISO/IEC 9594. In addition, ITU-T provides the following specifications:

- Recommendation X.509 (03/00) Open Systems Interconnection (OSI) – Directory: Public-Key and Attribute Certificate Frameworks at URL: http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-X.509-200003-I;
- Recommendation X.509 (2000) Technical Corrigendum 1 (10/01) at URL: http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-X.509-200110-I!Cor1;
- Recommendation X.509 (2000) Technical Corrigendum 2 (04/02) at URL: http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-X.509-200204-I!Cor2;
- Recommendation X.509 (2000) Corrigendum 3 (04/04) at URL: http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-X.509-200404-P!Cor3.

URL. http://www.itu.int/rec/recommendation.asp?type=folders&lang=e&parent=T-REC-X.509.

Vendors. Microsoft implemented X.509 certificates for Microsoft .NET to sign SOAP messages (URL: http://msdn.microsoft.com/library/default.asp?url=/library/en-us/wse/html/gxaconx509certificate.asp). IBM (http://www.ibm.com/), Netscape (http://www.netscape.com), and Oracle (http://www.oracle.com/) also support X.509 certificates in some of their server products. Vendors listed at URL: http://www.pkiforum.org/resources.html have implemented X.509 within their PKI products as defined by PKIX.

10.4 Digital Signature Standards

This section discusses the Digital Signature Standard (DSS) and the widely used Rivest-Shamir-Adelman (RSA) algorithm.

10.4.1 Digital Signature Standard/Federal Information Processing Standard 186-2

Name. Digital Signature Standard (DSS)/Federal Information Processing Standard (FIPS) 186-2.

Purpose. To identify which hashing algorithms can be used by U.S. federal government organizations to generate digital signatures using public key signature systems to protect sensitive, unclassified information [17].[11]

History. NIST began developing DSS for use by the U.S. government in 1991 through 1994 as a means for protecting official, unclassified, electronic communications between organizations. The first DSS was published as a Federal Information Processing Standard in May 1994 [17].

Standards Organization. NIST (http://www.nist.gov/) is responsible for maintaining this standard.

Status. The 1994 version of DSS was updated by FIPS 186-2 and released in January 2000 [17]. It became effective on July 27, 2000. FIPS 186-2 mandates the use of the Secure Hash Standard (SHS) FIPS 180-1 for the hashing algorithm. However, FIPS 180-1 has since been replaced by FIPS 180-2 [17].

Three digital signature techniques that use the Secure Hash Standard (SHS) were approved for application of FIPS 186-2: the Digital Signature Algorithm (DSA), which is provided with the DSS specifications; RSA as specified in ANSI X9.31; and the Elliptic Curve DSA (ECDSA) by ANSI X.9.62 [18].

SHS/FIPS 180-2 specifies the hashing algorithms that can be used by U.S. government organizations. NIST (http://www.nist.gov/) is also responsible for maintaining this standard, and the specification can be downloaded at URL: http://csrc.nist.gov/publications/fips/fips180-2/fips180-2.pdf.

Obtaining the Specifications. The specifications for DSS can be found at URL: http://csrc.nist.gov/publications/fips/fips186-2/fips186-2-change1.pdf.

- The specifications for ECDSA can be purchased from ANSI at URL: http://webstore.ansi.org/ansidocstore/product.asp?sku=ANSI+X9%2E62%2D1998.
- DSA is included in the DSS specifications [17].
- Algorithms for ECDSA are provided in the DSS specifications Appendix 6 (see "Other Information" in URL: http://csrc.nist.gov/cryptval/dss.htm for additional information) [18].
- RSA is covered in the next section.

URL. http://csrc.nist.gov/cryptval/dss.htm. The status of DSS is provided at URL: http://www.itl.nist.gov/fipspubs/by-num.htm.

Vendors. Validated implementations of DSA are listed by NIST at URL: http://csrc.nist.gov/cryptval/dss/dsaval.htm.

10.4.2 Rivest-Shamir-Adelman

Name. Rivest-Shamir-Adelman (RSA).

Purpose. To define a public key encryption algorithm [19].

11. The sensitive, unclassified data that FIPS 186-2 applies to must not be subject to Title 10, section 2315 or Title 44, section 3502(2) of the United States Code.

History. In 1976, the same year that NIST released the symmetric Data Encryption Standard (DES) for the U.S. government, Ronald Rivest, Adi Shamir, and Leonard Adelman developed the asymmetric RSA algorithm and named it after their last names [19]. The RSA algorithm was developed by these three individuals using U.S. government funds (grants from the National Science Foundation and Office of Naval Research) while they were working at MIT [20]. Hence, the government had the right to use the algorithm without charge [20]. In 1983, MIT was issued a patent for RSA and gave RSA Security, Inc., exclusive rights to the license [20]. Hundreds of companies licensed the algorithm to develop products including Microsoft, Lotus, and Cisco [20].

Standards Organization. The X9 Standards Committee (http://www.x9.org/) accredited by ANSI/X9 is responsible for maintaining the government standard.

Status. The RSA algorithm has been widely implemented by industry. On September 18, 2000, RSA Security, Inc., released the algorithm into the public domain [21].

Obtaining the Specifications. The specifications for ANSI X9.31 are entitled "Digital Signatures Using Reversible Public Key Cryptography for the Financial Services Industry (rDSA)." They can be purchased from the ANSI Store at URL: http://webstore.ansi.org/ansidocstore/product.asp?sku=ANSI+X9%2E31%2D1998.

URL. No official Web site currently provides the status of RSA.

Vendors. Validated implementations of RSA are listed by NIST at URL: http://csrc.nist.gov/cryptval/dss/rsaval.html. RSA Security supports a number of RSA products (http://www.rsasecurity.com/node.asp?id=1155).

Other Sources of Information.

- The IETF RFC 3447 at URL: http://www.ietf.org/rfc/rfc3447.txt?number=3447 provides "Public-Key Cryptography Standards (PKCS) #1: RSA Cryptography Specifications Version 2.1" as information.
- "A Method for Obtaining Digital Signatures and Public-Key Cryptosystems," the paper published by the three inventors in 1977 can be viewed at URL: http://theory.lcs.mit.edu/~rivest/rsapaper.pdf.
- Francis Litterio provides additional information about RSA at URL: http://world.std.com/~franl/crypto/rsa-guts.html.

10.5 Encryption Standards

Encryption converts e-mail messages, text documents, passwords, and other forms of text communications to an unreadable form (ciphertext) to protect the contents from unauthorized review. Encryption algorithms include a decryption algorithm to restore the contents of the ciphertext to its original form. There are two types of encryption algorithms: symmetric and asymmetric. Symmetric encryption uses the same key for encryption and decryption, and the key needs to be kept secret and must be known by the sender and receiver of the ciphertext. Asymmetric encryption, on the other hand, requires a pair of keys: one to encrypt and another to decrypt.

This section covers the Advanced Encryption Standard (AES) and the Escrowed Encryption Standard (EES).

10.5.1 Advanced Encryption Standard/FIPS 197

Name. Advanced Encryption Standard (AES).

Purpose. To replace the government-approved symmetric DES (FIPS 46-3) with more secure, symmetric encryption keys.

History. In June 1997, the government-approved 20-year-old DES had been cracked [19]. An authorized DES Challenge (Deschall) project was initiated to crack DES [19]. There had been a concern that since DES relies on a 56-bit key it was more vulnerable to compromise. The first success at cracking the algorithm took 96 days and harnessed thousands of computers on the Internet to try different keys to match the DES key; the second success was a year later in 1998 and required only one very powerful computer to crack the algorithm in 56 hours [19]. Clearly, a new encryption standard was needed.

Earlier in 1997, NIST had put out a call for proposed encryption algorithms that could replace DES with a key size of 128, 192, and 256 bits [22]. By August 1999, NIST had selected five algorithms and announced the winner in October 2000: the Rijndael algorithm created by Joan Daemen and Vincent Rijmen [22]. AES was officially released in May 2002 and is considered a stronger encryption scheme than DES [19]. It provides for keys with lengths ranging from 128 to 256 bits.

Standards Organization. NIST (http://www.nist.gov/) is responsible for maintaining this standard.

Status. There are few industry implementations of AES.

Obtaining the Specifications. The specifications can be downloaded at URL: http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf.

URL. http://csrc.nist.gov/CryptoToolkit/aes/.

Vendors. Vocal Technologies, Inc., (http://www.vocal.com/index.html) supports products for AES.

Other Sources of Information.

- Carnegie Mellon University participated in the Deschall project to crack DES. See URL: http://www-2.cs.cmu.edu/Unofficial/deschall/, which provides a Deschall FAQ.
- NIST lists its standards at URL: http://www.itl.nist.gov/fipspubs/by-num. htm.
- M. Benantar provides background information on encryption schemes for DES and PKI in “The Internet Public Key Infrastructure,” at URL: http://www.research.ibm.com/journal/sj/403/benantar.html, published by IBM and dated May 4, 2001.

10.5.2 Escrowed Encryption Standard/FIPS 185

Name. Escrowed Encryption Standard (EES)/FIPS 185.

Purpose. To define a government standard for a symmetric-key encryption algorithm [23].

History. EES was introduced as a standard in 1994 by NIST as a standard for the government and industry. It is popularly known as the Clipper chip, because the Clipper chip was designed to implement an encryption scheme for personal and business communications (e.g., voice communications, facsimile, and computer communications) [24]. The encryption keys are based on the Skipjack algorithm, which uses an 80-bit key [24]. The encryption keys are supposed to be escrowed and made available for law enforcement officials to decrypt communications and eavesdrop if they obtain a court order to permit this [24].

Although industry's use of the standard was to be voluntary, they voiced strong objections to the standard principally because they feared that it would be misused and violate their privacy [25]. They also believed that Skipjack was not a strong enough algorithm and could be compromised just as DES had been [24].

Standards Organization. The NIST (http://www.nist.gov/) is responsible for maintaining this standard.

Status. EES is not supported by industry.

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.itl.nist.gov/fipspubs/fip185.htm.

URL. http://www.itl.nist.gov/fipspubs/by-num.htm provides a general status of the NIST standards.

Vendors. EES is not supported by industry.

Other Sources of Information.

- The Computer Professionals for Social Responsibility (CSPR) host a Web site that provides a number of historical links about the Clipper chip at URL: http://www.cpsr.org/program/clipper/clipper.html.
- MIT and Harvard University support Web pages for course #.805/STS085, "Ethics and Law on the Electronic Frontier," which provides a history of Clipper chip events up to 1998 at URL: http://www-swiss.ai.mit.edu/6805/articles/crypto/clipper-to-key-recovery.html.

10.5.3 Secure Socket Layer

The Secure Socket Layer (SSL) was introduced as an Internet Draft by the Transport Layer Security (TLS) Working Group of IETF in November 1996 (see URL: http://wp.netscape.com/eng/ssl3/draft302.txt), but the draft expired and the IETF did not recommend it as a standard.[12] Instead, the IETF defined the TLS standard based on SSL 3.0. SSL was designed to allow two applications (ostensibly a client

12. Note that the TLS Working Group's purpose in forming was to define a standard based on SSL.

and server) to exchange encryption information and to communicate using a secure protocol over the TCP/IP (Internet). As the originator of SSL and provider of browsers that implement SSL, Netscape provides developers with an introduction to SSL at URL: http://developer.netscape.com/docs/manuals/security/sslin/contents.htm. In addition, *ComputerWorld* interviewed one of the inventors of SSL in its June 1, 1999 issue at URL: http://www.computerworld.com/developmenttopics/website mgmt/story/0,10801,43518,00.html. SSL is briefly discussed in this section because it is widely used by industry and many vendors support SSL products (e.g., Entrust, Nortel Networks, and VeriSign).

10.5.4 Transport Layer Security

Name. Transport Layer Security.

Purpose. To define a security protocol for the transport layer of TCP/IP [26].

History. When the IETF TLS Working Group was formed in 1996, it was chartered to define a security protocol for the transport layer of TCP/IP [26]. Using SSL 3.0 as a basis, the TLS Working Group defined RFC 2246 in 1999 as a proposed standard for TLS [26]. Since then, the TLS Working Group has defined other standards for TLS [26].

Standards Organization. The IETF TLS Working Group (http://www.ietf.org/html.charters/tls-charter.html) is responsible for advancing this standard.

Status. The IETF TLS Working Group submitted TLS Protocol Version 1.0 (RFC 2246) as a proposed standard in 1999.

Obtaining the Specifications. The specification can be downloaded at URL: http://www.ietf.org/rfc/rfc2246.txt.

URL. http://www.ietf.org/ids.by.wg/tls.html. The TLS Working Group Web page at URL: http://www.ietf.org/html.charters/tls-charter.html also provides information on the TLS standards.

Vendors. Major vendors like Sun Microsystems (http://java.sun.com/products/jsse/), IBM Corporation (http://www.ibm.com), Microsoft Corporation (http://www.microsoft.com/), and Fujitsu (http://www.fujitsu.com/) support TLS.

Other Sources of Information.

- *ComputerWorld* interviewed one of the inventors of SSL in its June 1, 1999 issue. He discussed the relationship of SSL to TLS in the article at URL: http://www.computerworld.com/developmenttopics/websitemgmt/story/0,10801,43518,00.html.
- The Netscape URL: http://developer.netscape.com/docs/manuals/security/sslin/contents.htm provides a brief discussion on how SSL relates to TLS.

10.5.5 Wireless Transport Layer Security

Name. Wireless Transport Layer Security (WTLS).

Purpose. To support TLS for wireless applications.

History. The WAP Forum of the Open Mobile Alliance defined a set of WTLS specifications using the TLS 1.0 specification as its basis for wireless mobile technologies.

Standards Organization. The WAP Forum of the Open Mobile Alliance (http://www.wapforum.org/what/technical.htm) is defining wireless standards for mobile users. WTLS is one of the standards they are developing.

Status. WTLS is part of the WAP Wireless Security Specification Suite that has been approved. WTLS includes a reference mode. It defines a set of wireless TLS services and is based on TLS. However, since SSL is still so widely used, implementations will need to address incompatibilities between WTLS and SSL that cause WTLS messages to become temporarily unencrypted at SSL gateways before being converted to SSL [27]. One solution is to support WTLS tunneling so that the encrypted material is not decrypted until it reaches the receiver's destination [27].

Obtaining the Specifications. The WTLS family of specifications are listed at URL: http://www.wapforum.org/what/technical.htm, but they can only be downloaded after agreeing to the Open Mobile Alliance conditions such as those listed at URL: http://www.openmobilealliance.org/tech/affiliates/LicenseAgreement.asp?DocName=/wap/wap-261-wtls-20010406-a.pdf for the WTLS 1.0 specification.

URL. http://www.wapforum.org/what/technical.htm is the official URL but it does not provide a detailed status.

Vendors. Some companies in the banking and mobile phone industries are building their own implementations of WTLS since the specifications are still maturing [27]. Cisco supports WTLS (http://www.cisco.com/en/US/products/sw/iosswrel/ps5012/products_feature_guide09186a008007fd5e.html).

References

[1] Schneier, B., "The Witty Worm: A New Chapter in Malware," http://www.computerworld.com/networkingtopics/networking/story/0,10801,93584,00.html, *ComputerWorld*, June 2, 2004.

[2] Spafford, E. H., "Testimony Before the House Armed Services Committee Subcommittee on Terrorism, Unconventional Threats and Capabilities: Cyberterrorism, the New Asymmetric Threat," http://www.acm.org/usacm/PDF/03-07-24spafford.pdf, ACM, July 24, 2003.

[3] "Frequently Asked Questions About the United States Computer Emergency Readiness Team (US-CERT)," http://www.us-cert.gov/aboutus.html, US-CERT, June 23, 2004.

[4] Harrison, A., "FAQ: The Melissa Virus," http://www.computerworld.com/news/1999/story/0,11280,27617,00.html, *ComputerWorld*, March 31, 1999.

[5] Roberts, P., "Companies Warn of Mass Trojan Distribution: The Program Is Being Distributed on the Web Through Spam," http://www.computerworld.com/securitytopics/security/story/0,10801,94515,00.html, *ComputerWorld*, July 13, 2004.

[6] "Patching over the Ping of Death," http://www.pcmag.co.uk/News/13157, *PC Magazine*, December 13, 1996.

[7] Harrison, A., "University Researcher Traces Response to DDOS Attacks," http://www.computerworld.com/securitytopics/security/story/0,10801,48738,00.html, *Computer World*, August 18, 2000.

[8] Brewin., B., "Watch Out for Wireless Rogues," http://www.computerworld.com/mobile-topics/mobile/story/0,10801,72664,00.html, *ComputerWorld*, July 15, 2002.

[9] "Kerberos: The Network Authentication Protocol," http://web.mit.edu/kerberos/www/, MIT, July 14, 2004.

[10] Fonseca, B., "Clifford Neuman: For Kerberos Co-author, Security Hasn't Lost its Allure," http://www.infoworld.com/awards/awd_iwi_2002_7.html, InfoWorld Awards, *InfoWorld*, 2002.

[11] Sliwa, C., "Liberty Alliance to Unveil Single Sign-on Technical Spec," *ComputerWorld*, July 15, 2002, p. 7.

[12] "Liberty Alliance Specifications for Federated Network Identification and Authorization," http://xml.coverpages.org/libertyAlliance.html, OASIS, July 31, 2004.

[13] Fontana, J., "XML-Based Security Protocol Wins Approval from OASIS," http://www.computerworld.com/developmenttopics/development/xml/story/0,10801,757 54,00.html, Network World, reprinted by *ComputerWorld*, November 11, 2002.

[14] PKI Forum Business Working Group, "PKI Basics – Technical Perspective," http://www.pki forum.org/pdfs/PKI_Basics-A_technical_perspective.pdf, PKI Note, November 2002.

[15] "Public Key Infrastructure, (X.509) (PKIX)," http://www.ietf.org/html.Charters/PKIX-char ter.html, IETF PKIX, July 2, 2004.

[16] "ITU Announces New Edition of X.509 Recommendation Which Accelerates Global E-commerce Through Enhancements to Authentication and Authorization Specifications," http://www.itu.int/ITU-T/news/sg7-x509.html, ITU-T News, ITU, March 31, 2000.

[17] "Digital Signature Standard (DSS): Federal Information Processing Standard 186-2," http://csrc.nist.gov/publications/fips/fips186-2/fips186-2-change1.pdf, NIST, January 27, 2000.

[18] "Digital Signature Standard (DSS) (DSA, RSA, and ECDSA Algorithms)," http://csrc.nist.gov/cryptval/dss.htm, NIST, June 14, 2004.

[19] Hayes, F., "The Story So Far: IT Copes with Trapdoors, Worms, Russian Hackers, and Hurricane Hugo," http://www.computerworld.com/securitytopics/security/story/0,10801, 72646,00.html, *ComputerWorld*, July 15, 2002.

[20] Rivest, R. L., A. Shamir, and L. Adleman, "A Method for Obtaining Digital Signatures and Public-Key Cryptosystems," http://theory.lcs.mit.edu/~rivest/rsapaper.pdf, *Communications of the ACM*, February 1978.

[21] Harrison, A., "RSA Encryption Patent Released," http://www.computerworld.com/securitytopics/security/story/0,10801,50546,00.html, *ComputerWorld*, September 18, 2000.

[22] "Advanced Encryption Standard," http://searchsecurity.techtarget.com/gDefinition/ 0,294 236,sid14_gci344759,00.html, *Information Security Magazine*, April 10, 2003.

[23] "Escrowed Encryption Standard (EES)," http://www.itl.nist.gov/fipspubs/fip185.htm, NIST, February 9, 1994

[24] "Escrowed Encryption Standard," http://searchsecurity.techtarget.com/gDefinition/0,,sid 14_gci837181,00.html, *Information Security Magazine*, July 4, 2002.

[25] "Clipper Chip: October 1994," http://www.cpsr.org/program/clipper/clipper.html, Computer Professionals for Social Responsibility (CSPR), October 14, 1998.

[26] "Transport Layer Security," http://www.ietf.org/html.charters/tls-charter.html, IETF TLS Working Group, November 14, 2003.

[27] Radding, A., "Crossing the Wireless Gap," http://www.computerworld.com/securitytopics/security/story/0,10801,55583,00.html, *ComputerWorld*, January 1, 2001.

CHAPTER 11

Software Engineering Standards

11.1 Architecture Frameworks

Since the early 1990s, technical reference models (TRMs) have been used to describe system concepts and provide a lexicon of terms for defining system architectures and architecture components. A TRM is a simplifying mechanism to describe major services that an architecture would support, and it is often accompanied by diagrams for more effective communication and visualization.

Large, U.S. government organizations such as the DoD have used TRMs as the basis for creating an overarching Architecture Framework that describes the kinds of products and architecture views that their organizations must define before their system acquisition programs are funded. Architecture Frameworks are seen as a means for reducing the risks and cost of system acquisition by providing architecture artifacts that employ common terminology and representation schemes to describe system services to be supported, and identify standards to be used for implementation.

This section covers five Architecture Frameworks: the Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework that led to the DoD Architecture Framework (DoDAF)—the DODAF mandated for the U.S. DoD—the Federal Enterprise Architecture (FEA) mandated for federal government organizations, the Object Management Architecture (OMA), and The Open Group Architecture Framework (TOGAF).

11.1.1 C4ISR Architecture Framework

Name. Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework.

Purpose. To provide an architecture framework to be used for defining more effective C4ISR system capabilities and processes.

History. In the early 1990s, the Defense Information Systems Agency (DISA) defined a TRM that could be used by the U.S. Services as the basis for defining architectures for open systems (see Figure 11.1).

In 1995, the U.S. DoD established a C4ISR Integration Task Force (ITF) to "define and develop better means and processes to ensure C4ISR capabilities most effectively" meet "warfighter needs" [2]. The C4ISR ITF believed that use of a consistent architecture framework for all C4ISR systems would improve DoD's

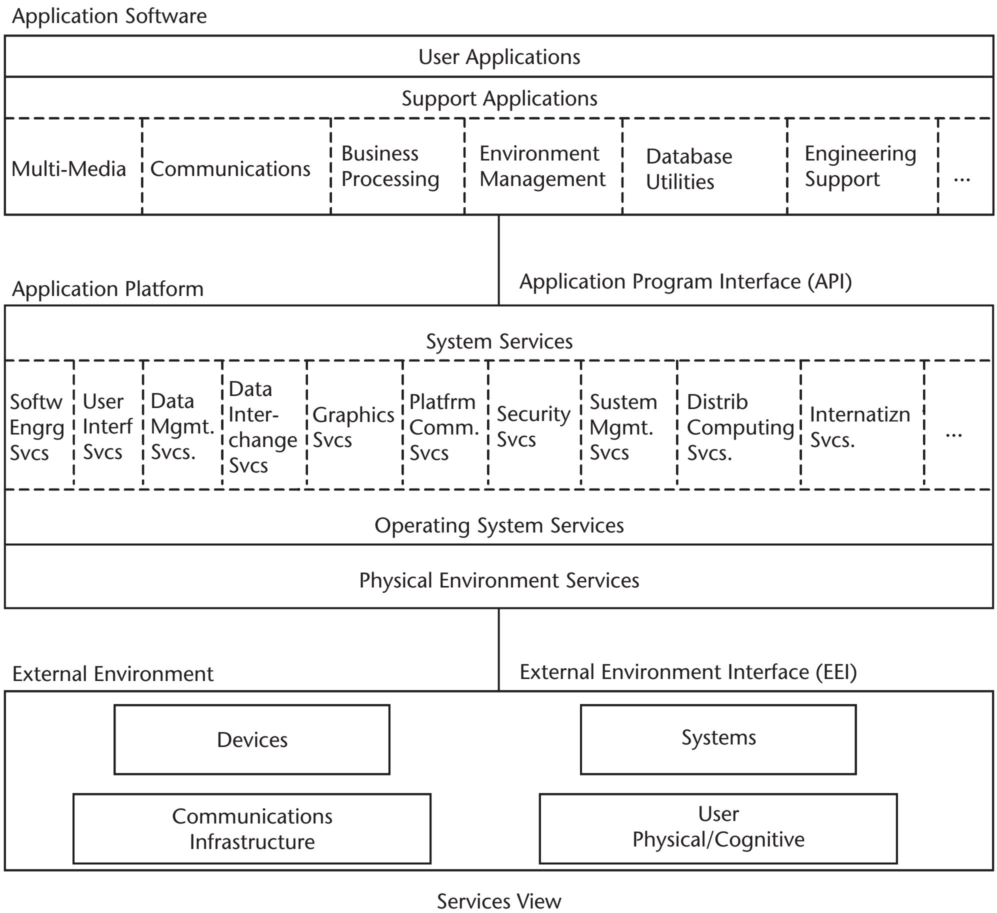

Figure 11.1 DoD TRM Version 2.0. (*From:* [1], 2001 U.S. DoD.)

development and acquisition processes [2]. On October 18, 1996, the U.S. Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD/C^{3}I) and the Joint Staff created a C4ISR Architecture Working Group (AWG) to refine and expand that architecture to support interoperable C4ISR systems [2].

The C4ISR AWG developed a C4ISR Framework that was based on the DoD TRM and describes a set of products (architecture views) that when combined, define an architecture [3]. The architecture products describe three views:

- *Operational architecture views:* describe tasks and activities, operational elements, and information flows similar to a Concept of Operations for the system [3];
- *Systems architecture views:* describe systems and interconnections (includes graphics as needed); diagrams to depict these views include data flows and data dictionaries [3];
- *Technical architecture views:* provide the "minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements…to ensure that a conformant system satisfies a specified set of requirements" [3]. In practice, a standards profile is defined [3].

Status. The C4ISR AWG produced the C4ISR Architecture Framework Version 2.0 in 1998, but it was replaced on August 30, 2003 by the DoDAF.

Obtaining the Specifications. The document can be downloaded at URL: http://www.tricare.osd.mil/imtr/ppm/documents/c4isr.pdf (if this URL does not work, try searching for "C4ISR Architecture Framework" at URL: http://www.defenselink.mil/search). The Federation of American Scientists (FAS) (http://www.fas.org/index.html) is maintaining a copy of the C4ISR Architecture Framework documentation at URL: http://www.fas.org/irp/program/core/c4isr.htm, which can be found by selecting the "C4ISR Architecture Framework Version 2.0" document dated December 18, 1997.

URL. http://www.fas.org/irp/program/core/c4isr.htm.

Vendors.

- Vitech Corporation provides a CORE product to support the DoDAF and C4ISR architecture frameworks (http://www.vitechcorp.com/index.html).
- Popkin Software supports a System Architect DODAF (C4ISR) Option. See http://www.popkin.com/products/system_architect/c4isr.htm for details.

11.1.2 DoD Architecture Framework

Name. DoD Architecture Framework (DoDAF).

Purpose. To define "a common approach for DoD architecture description development, presentation, and integration" [4].

History. The relative success of the C4ISR Architecture Framework demonstrated the importance of providing standard architecture views that could apply not only for C4ISR systems, but to all U.S. Department of Defense systems. Architecture views provide a means for understanding how current systems are implemented and a foundation for planning migration efforts that support system interoperability and seamless operations. Using the C4ISR Architecture Framework as a basis, a DoDAF Working Group was established to evolve the C4ISR Architecture Framework into one that could be used across the Department of Defense. Numerous DoD organizations supported this effort, and the resulting DoD Architecture Framework was published in August 2003. In a memorandum distributed on February 9, 2004, the Office of the Secretary of Defense (OSD) Chief Information Officer (CIO) mandated its use across DoD.

Organization. The DoDAF Architecture Working Group defined the DoDAF, and it is now the responsibility of the U.S. OSD CIO to maintain it as a standard.

Status. The DoDAF has been mandated as a standard approach for describing system architecture views (architecture products) and is mandated for all of DoD. Numerous U.S. companies and non DoD government organizations also use this approach. Note that Chapter 2 of the DoDAF document clearly demonstrates how it maps to the FEA, which has been mandated for all federal government organizations to use and is covered in the next section [4].

In addition to the DoDAF, DoD provides a Joint Technical Architecture (JTA) based on the DoD TRM. The JTA identifies industry and government standards to be used for DoD systems for the categories of services shown in the DoD TRM. JTA documentation can be obtained at URL: http://www.amc.army.mil/amc/ci/matrix/documents/dod/jta31e.pdf (if this URL does not work, try searching for "JTA" at URL: http://www.defenselink.mil/search).

Obtaining the Specifications. The documentation for the DoDAF can be downloaded at URL: http://www.defenselink.mil/nii/org/cio/i3/AWG_Digital_Library/pdfdocs/fw.pdf/. If you experience difficulty with this site, refer to Volume 1 URL: http://www.defenselink.mil/nii/doc/DoDAF_v1_Volume_I.pdf and Volume 2 URL: http://www.defenselink.mil/nii/doc/DoDAF_v1_Volume_II.pdf. If these URLs do not work, go to URL: http://www.defenselink.mil/search/ and do a search for "DoDAF".

URL. http://www.defenselink.mil/nii/doc/ and look for information on DoDAF.

Vendors.

- Vitech Corporation provides a CORE product to support the DoDAF and C4ISR architecture frameworks (http://www.vitechcorp.com/index.html).
- Popkin Software supports a System Architect DoDAF (C4ISR) Option. See URL: http://www.popkin.com/products/system_architect/c4isr.htm for details.

Other Sources of Information. The Software Productivity Consortium provides additional information about the DoDAF at URL: http://www.software.org/pub/architecture/dodaf.asp.

11.1.3 Federal Enterprise Architecture

Name. Federal Enterprise Architecture (FEA).

Purpose. To provide a standard framework for government agencies to use in defining enterprise architectures.

History. In November 2000, the U.S. Office of Management and Budget (OMB) provided guidance related to the Clinger Cohen Act of 1996 and directed that every U.S. federal "agency's capital planning and investment control process must build from the agency's current Enterprise Architecture (EA) and its transition from [a] current architecture to [a] target architecture.... The Enterprise Architecture must be documented and provided to OMB as significant changes are incorporated" [5]. The Clinger Cohen Act requires federal agencies to appoint a CIO who, in addition to other duties, "promotes a coordinated, interoperable, secure, and shared government wide infrastructure that is provided and supported by a diversity of private sector suppliers" [5] (from URL: http://www.whitehouse.gov/omb/circulars/a130/a130trans4.html#1).

On February 6, 2002, the OMB began developing a FEA to "identify opportunities to simplify processes and unify work across the agencies and within the lines of business of the Federal Government" [6]. Also in February 2002, the U.S. General Accounting Office published a report that stated: "Enterprise architectures (EA) provide a clear and comprehensive picture of an entity, whether an organization or a functional or mission area that cuts across more than one organization (e.g., financial management).... Our work in the early 1990s identified architectures as a critical success factor for organizations that effectively leveraged IT in meeting their mission goals, and it [our work] advocated federal agency use of architectures.... Nevertheless, our reviews of agency IT management practices and major systems modernization programs continue to identify the lack of architectures as a major IT management weakness..." [7].

Federal agencies are mandated to use the FEA framework as the basis for developing their EAs and IT investments. The FEA describes five reference models that provide the framework for a comprehensive IT architecture:

- *Business Reference Model:* describes a government agency's line[s] of business and services to its customers [8];
- *Performance Reference Model:* provides a framework for measuring the performance of the enterprise—effectiveness of the IT systems (e.g., services, applications, and infrastructure), satisfaction of customers with services, and measurement of results as compared to the goals for the IT systems [8];
- *Service Component Reference Model:* describes services designed to support customers, management of the businesses, intelligence capital and electronic media, decision support functions, enterprise planning, and domain support [8];
- *Data and Information Reference Model:* describes data and information that support information exchanges for business and program management operations [8];
- *Technical Reference Model:* provides the standards profile, specifying the services and technologies to be used for service access and delivery; platforms, infrastructure, and system applications; and interfaces [8].

Organization. The U.S. OMB maintains the FEA. The OMB defined the FEA as a means for reducing the cost and risk of IT acquisition and evolution efforts. Hence, OMB requires that all federal government organizations, including the U.S. OSD, demonstrate to the OMB how their architectures adhere to the FEA.

Status. All U.S. federal government organizations are mandated to use the FEA for development of their architectures.

Obtaining the Specifications. The descriptions of the five models that comprise the FEA can be downloaded at URL: http://www.feapmo.gov/fea.asp.

URL. http://www.feapmo.gov/fea.asp.

Vendors.

- The Federal Enterprise Architecture Program Management Office currently supports the Federal Enterprise Architecture Management System (FEAMS), a Web-based tool that supports development of FEA models (see URL: http://www.feapmo.gov/feams.asp for details).
- Popkin Software supports the System Architect tool to support FEA development (http://government.popkin.com/frameworks/feaf.htm).

- The Institute for Enterprise Architecture Developments lists Enterprise Architecture Tools available at URL: http://www.enterprise-architecture.info/EA_Tools.htm.

Other Sources of Information.

- The Chief Information Officer Council published a document entitled "A Practical Guide to Federal Enterprise Architecture," at URL: http://www.gao.gov/special.pubs/eaguide.pdf, dated February 2001, that describes aspects of defining an enterprise architecture and includes sample architecture products in its Appendix D.
- Federal Computer Week (http://www.fcw.com/) provides the latest information on events and trends for federal government enterprise architectures, IT, CIO meetings, and other items of interest.
- The Federal Enterprise Architecture Certification (FEAC) Institute (http://www.feacinstitute.org/certification_education/dodaf/index.htm) provides certification for enterprise architects.
- The Software Productivity Consortium provides additional information about the FEA (they refer to it as the FEAF, or FEA Framework) at URL: http://www.software.org/pub/architecture/feaf.asp.

11.1.4 Object Management Architecture

Name. Object Management Architecture (OMA).

Purpose. To define an architectural framework for a distributed object environment.

History. The Object Management Group formed in 1989 to address the pervasive problem of software applications that exceeded their budget, lacked quality, and lacked interoperability with other software applications. They envisioned a distributed environment based on the object-oriented paradigm that would reduce the complexity of software development and enable developers to focus on building software applications [9].

By 1990, the OMG had defined the Object Management Architecture, which provided a reference model and the basis for the CORBA specification that they would define several years later. Figure 11.2 depicts the OMA Reference Model, where an object request broker brokers messages between objects that contain requests and responses [9]. CORBA services support functions and interfaces to create, maintain, and save objects, including low-level services for modeling object classes and physically storing objects [9]. CORBA facilities provide objects and classes to support applications with basic capabilities, such as transaction services and system management [9]. Application objects that belong to user-defined applications interact with other objects and services via the ORB [9].

Standards Organization. The Object Management Group (http://www.omg. org/) maintains the specification for OMA.

Status. The OMG is using OMA as an architectural framework to provide a foundation for advanced object-oriented concepts such as CORBA, which specifies

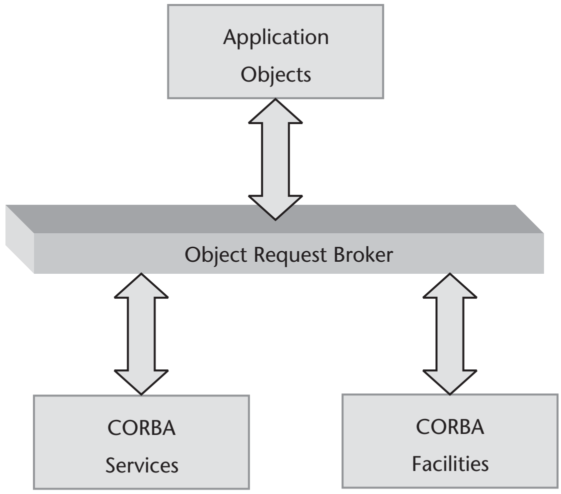

Figure 11.2 OMA Reference Model.

an architecture for a distributed object environment where objects interoperate across heterogeneous, networked, multivendor client/server platforms (see Section 7.2 for details) [9].

Obtaining the Specifications. The OMA documentation is included in the "Object Management Architecture Guide" and can be downloaded at URL: http://www.omg.org/docs/ab/97-05-05.pdf.

URL. http://www.omg.org/oma/.

Vendors. The OMG provides tools that support implementation of applications for the OMG's Model-Driven Architecture (MDA), which is based on the OMA.

Other Sources of Information. The Software Engineering Institute discusses features of CORBA and how it relates to OMA at URL: http://www.sei.cmu.edu/str/descriptions/corba.html.

11.1.5 The Open Group Architecture Framework

Name. The Open Group Architecture Framework (TOGAF).

Purpose. To define a framework for developing an IT architecture [10].

History. Some members of The Open Group had a strong interest in providing a TRM to guide the development of open system architectures, and they formed an Architecture Forum. DISA personnel were members of that Forum, and they presented the TAFIM for consideration. After gaining the U.S. DoD's permission, the Architecture Forum used the TAFIM as the basis for Version 1 of TOGAF, which they completed in 1995 [11]. TOGAF has undergone a number of revisions since then to maintain currency with technology developments.

Standards Organization. The Open Group (http://www.opengroup.org/) maintains the documentation for TOGAF.

Status. The Open Group has two versions of TOGAF that they maintain: versions 7 and 8. Version 7 is described as the Technical Edition, and it emphasizes services for a technical architecture. TOGAF Version 7 was published in 2001 [10]. TOGAF version 8 is described as the Enterprise Edition, and builds on TOGAF version 7 to describe other elements of an Enterprise Architecture—a business architecture, application architecture, and data architecture [10]. The last update to TOGAF version 8 was in December of 2003 [10]. In addition, The Open Group offers a certification program for TOGAF, which can be employed to verify that the framework has been applied correctly (http://www.opengroup.org/architecture/togaf/ and http://www.opengroup.org/certification/idx/togaf.html).

Obtaining the Specifications. TOGAF documentation is free to members of The Open Group. Nonmembers may obtain a free license for 90 days for evaluation purposes. If TOGAF documentation is to be used only internally within a company or an academic environment, The Open Group may grant a free license for long-term use.

- The TOGAF version 7 framework can be downloaded at URL: http://www.opengroup.org/architecture/togaf7-doc/arch/.
- The TOGAF version 8 framework can be downloaded at URL: http://www.opengroup.org/architecture/togaf8/index8.htm.

URL. http://www.omg.org/oma/.

Vendors. Popkin Software's System Architect supports TOGAF (http://www. popkin.com/products/system_architect/togaf.htm).

Other Sources of Information. The Software Productivity Consortium provides additional information about TOGAF at URL: http://www.software.org/pub/architecture/togaf.asp.

11.2 Programming Languages

Since 1944 when the world's first digital computer, the Electronic Numerical Integrator and Computer (ENIAC), was put into operation to prepare firing and bombing tables for the Army's use in World War II, programmers have been looking for ways to simplify the job of programming [12].[1] In the beginning, ENIAC programming required such a high degree of engineering and mathematical expertise that it required highly skilled mathematicians to run it. Maintaining the ENIAC was no easy job, either, since it was composed of 30 individual units, 19,000 vacuum tubes, hundreds of thousands of resistors, and weighed over 30 tons [12]. Programming the ENIAC was initially accomplished by manually changing switches and cable connections, and setting the sequence for repetitive calculations by hand, but this evolved into the use of punched cards for input [12].

1. Refer to URL: http://ftp.arl.mil/~mike/comphist/eniac-story.html for "The ENIAC Story" by M. H. Weik, published in *ORDNANCE*, The Journal of the American Ordnance Association, 1961.

Over time, machine code was used to program computers either manually, by entering a sequence of codes (a series of 1s and 0s) into memory, or onto tapes that computers would read and then execute. Programmers needed in-depth knowledge of how computers were built to program them properly.

Assembler languages were an innovation developed to provide a higher level of abstraction for programming, but programmers still required engineering knowledge on how computers were built to insure instructions were properly programmed and executed. Debugging was labor-intensive and error-prone. What was needed was a higher order language (HOL) that would ease the burden of developing, debugging, and testing software, along with the high cost of development and maintenance. Along came FORTRAN in the 1950s, COBOL in the early 1960s, C in the early 1970s, Ada in the early 1980s, and in the 1990s came C++, Java, and the Real-Time Specification for Java. This section discusses each of these higher order languages.

11.2.1 Ada

Name. Ada programming language.

Purpose. To provide a standard higher order programming language for U.S. DoD applications that supported strong typing and exception handling [13].

History. In 1973–1974, a review of all DoD software costs determined that about $3 billion dollars were expended annually [13]. This was considered an extraordinarily large amount to expend for software, and efforts were engaged immediately to find ways to reduce it. One means was for DoD to develop all software in a standard manner using a common programming language. In January 1975, the DoD established a Higher Order Language Working Group (HOLWG) to develop requirements for such a language [13]. From January 1975 through January 1977, the HOLWG developed three successive versions of requirements (Strawman, Woodenman, and Tinman) and achieved a final language specification named Ironman in 1977 [13]. During this time, the HOLWG examined 23 programming languages (e.g., FORTRAN, COBOL, PL/I) for a language that could provide a starting point for a programming language [13]. Although the HOLWG identified several that could be used as a starting point, they concluded that none were suitable for use as currently defined [13].

In April 1977, DoD issued a RFP, and four contractors (Cii Honeywell Bull, Intermetrics, SoftTech, and SRI International) were each selected to develop a prototype language that would satisfy the DoD specification [13]. In the meantime, the Ironman language specification was revised several times and eventually resulted in Steelman in 1979 [13]. DoD selected Cii Honeywell Bull's prototype language as the winner, and work on a DoD programming language ensued with a Cii Honeywell Bull design team in May 1979 [13].

Also in May 1979, the DoD programming language became known as Ada after Augusta Ada Byron, daughter of the famed poet Lord Byron and who was also known as the Countess of Lovelace [14]. Her peers considered her a noted mathematician, and she was the world's first published programmer according to the

ACM [14]. Having completed its function, the HOLWG ended and DoD established an Ada Joint Program Office (AJPO) in December 1980 to oversee the use and development of Ada for all of DoD [13]. The Ada specification was submitted in 1981 to ANSI to consider for a national standard, and after several revisions, it became an ANSI standard in February 1983. The Ada specification was later approved in 1987 by the ISO and published as ISO 8562.

In July 1988, the AJPO established an Ada 9X Project to revise the language, and Ada95 was approved as a standard by ISO and ANSI in February 1995 [13]. For a time, DoD mandated the use of the Ada programming language for all software developments, unless an organization could substantiate the need for a waiver to use another programming language. Over time, Ada was overtaken by the popularity of other programming languages, most notably, the C programming language, C++, and then Java. The AJPO closed in October 1998 [13].

Standards Organization. The ISO and the IEC Joint Technical Committee 1 (http://www.jtc1.org/) Subcommittee 22 Working Group 9 (SC22/W9) maintain this standard.

Status. An Ada Resource Association (http://www.adaresource.org/) was formed to promote the use of Ada for software development. Ada is currently being reviewed to determine whether it will remain an ISO standard.

Obtaining the Specifications. The Ada95 Reference Manual can be downloaded at URL: http://www.adaic.org/standards/95lrm/html/RM-TOC.html. It can also be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html, and by searching for "8652" to obtain the following two specifications:

- ANSI/ISO/IEC 8652-1995 Programming Languages – Ada;
- ISO/IEC 8652/Cor1:2001.

URL. http://std.dkuug.dk/JTC1/SC22/WG9/ (maintained by ISO/IEC/JTC1/SC 22/WG9). Ada users maintain a site at http://www.adahome.com/.

Vendors. The Ada Resource Association maintains a list of current Ada vendors (http://www.adaic.org/compilers/comp-tool.html), and there are a number of vendors that support development tools such as McCabe and Associates (http://www.mccabe.com/). A partial list is shown below:

- AdaCore Technologies (http://www.gnat.com/);
- Aonix (http://www.aonix.com/);
- Sofcheck (http://www.sofport.com:8088/);
- IBM (http://www-306.ibm.com/software/awdtools/developer/ada/).

Other Sources of Information.

- The ACM Special Interest Group for Ada (SIGAda) maintains information about Ada at URL: http://www.acm.org/sigada/.
- Information about the AJPO is being maintained at URL: http://sw-eng.falls-church.va.us/AdaIC/ by Irvine Compiler Corporation.

11.2.2 C

Name. C programming language.

Purpose. To define a higher order programming language to implement the Unix operating system [15].

History. Until the late 1960s, operating systems were implemented in machine code or assembler language. Bell Telephone Laboratories initiated a joint venture with MIT, General Electric, and Bell Laboratories in the late 1960s to develop the Multics Operating System using PL/I, a higher order language [15]. However, the difficulties of using PL/I to implement Multics led Ken Thompson to investigate alternatives [15]. What was needed was a higher order language that would facilitate the job of building and maintaining an operating system, but would also provide some of the advantages of assembler languages, such as direct access to memory [15]. PL/I did not provide direct access to memory.

Even though Ken Thompson built the ancestor of the Unix operating system using an assembler language (GEMAP Assembler), he later decided that it was important to define a system programming language that could be used with the predecessor to Unix [15]. Thus, he created the B language, a precursor to C and a derivative of the BCPL language created by Martin Richards and used for some of the Multics development before the Multics project was terminated [15].

In 1971, Dennis Richie began working on extending B to include typing that would support character and byte addressing (B addressed only word addresses), in preparation for floating-point hardware, special operators, and a number of other changes [15]. By early 1973, the name of the programming language had changed to the C programming language, and it was used to implement the Unix operating system [15]. The research community was delighted that they were able to use C to extend the Unix operating system to satisfy special purpose applications, and C became extremely popular. By the 1980s, the use of C had spread to industry, and there were so many variants of the language that a standard was critically needed.

In 1983, ANSI established the X3J11 committee to produce a standard C programming language [15]. The standard developed by X3J11 was submitted to ISO in 1989 and was approved as ISO/IEC 9899-1990 [15].

Standards Organization. The ISO/IEC/JTC1 (http://www.jtc1.org/) Subcommittee 22 Working Group 14 (SC22/WG14) (http://std.dkuug.dk/jtc1/sc22/wg14/) is responsible for maintaining the C programming language specification.

Status. The C programming language is still actively used.

Obtaining the Specifications. The standard can be purchased from ISO at the URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html, and by searching for "C programming" to obtain the following:

- ISO/IEC 9899:1999, C – Programming Languages;
- ISO/IEC 13719-2:1998, Information technology, Part 2: C Programming Language Binding (Portable Common Tool Environment [PCTE]).

URL. http://std.dkuug.dk/jtc1/sc22/wg14/ (ISO/IEC/JTC1/SC22/WG14).

Vendors. There are numerous C compilers available; a partial list is shown below:

- Portland Group Compilers (http://www.pgroup.com/) for Linux
- Microsoft (http://www.microsoft.com/)
- IBM (http://www.ibm.com/)
- Silicon Graphics (http://www.sgi.com/)
- The Free Software Foundation (http://www.free-soft.org/) supports open source compilers for C and C++ (for a fee).

Other Sources of Information.

- Dennis Ritchie wrote a history of C in an article entitled "The Development of the C Language," published by ACM Press, and he has made a copy available at URL: http://cm.bell-labs.com/cm/cs/who/dmr/chist.html through Lucent Technologies.
- The classic C book is the *C Programming Language* by Brian W. Kernighan and Dennis Ritchie, but there are numerous books discussing this language.

11.2.3 C++

Name. C++ programming language.

Purpose. To define an efficient programming language written in the style of Simula67, an object-oriented programming language [16].

History. While working on his Ph.D. at Cambridge University, Bjarne Stroustrup wrote software using the Simula67 language for some of his projects [17]. After receiving his Ph.D. in 1979, he was employed by AT&T Bell Labs, where he designed and implemented "C with Classes," a language that emulated Simula67 and was used by Bell Labs internally beginning in August 1983 to conduct research for distributed computing projects [15, 16]. Over time, the language became known as C++, but it was not released commercially until October 1985 [16].

In 1989, the ISO began an effort to publish a standard for C++ [18]. A number of major companies contributed to this effort, including AT&T, and ISO approved the ISO/IEC 14882 standard for C++ in 1997 [18].

Standards Organization. ISO/IEC/JTC1 (http://www.jtc1.org/) Subcommittee 22 Working Group 21 (SC22/WG21) is responsible for maintaining the C++ programming language specification.

Status. The C++ language is still actively used.

Obtaining the Specifications. The standard can be purchased from ISO at the URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html, and by searching for "14882" to obtain the specification for ISO/IEC 14882:2003, C++ – Programming Language. Bjarne Stroustrup provides an early version of the standard at his site located at URL: http://www.research.att.com/~bs/C++.html. Related standards include:

- ISO/IEC TR 18015: C++ Performance;
- ISO/IEC TR 19768: C++ Library Extensions.

URL. http://std.dkuug.dk/jtc1/sc22/wg21/ (maintained by ISO/IEC/JTC1/SC22/WG21). Bjarne Stroustrup also maintains his own site at URL: http://www.research.att.com/~bs/C++.html.

Vendors. There are numerous C++ compilers available; a partial list is shown below:

- Portland Group Compilers (http://www.pgroup.com/) for Linux;
- Microsoft (http://www.microsoft.com/);
- IBM (http://www.ibm.com/);
- Silicon Graphics (http://www.sgi.com/);
- The Free Software Foundation (http://www.free-soft.org/) supports open source compilers for C and C++ (for a fee).

Other Sources of Information.

- There are numerous books on C++, most notably the ones written by its inventor, Bjarne Stroustrup: *The C++ Programming Language*, Third Edition and Special Edition, published by Addison Wesley Professional in 1997 (http://www.awprofessional.com/titles/0-201-88954-4), and *The Design and Evolution of C++*, published by Addison Wesley Professional in 1994. (http://www.research.att.com/~bs/dne.html).
- A. Dolya wrote "Conversations: Interview with Bjarne Stroustrup," which was published by *Linux Journal* on August 28, 2003 (see URL: http://www.linuxjournal.com/article.php?sid=7099).
- Bjarne Stroustrup maintains a Web site at URL: http://www.research.att.com/~bs/homepage.html, which provides links for information about C++.

11.2.4 Common Business Oriented Language

Name. Common Business Oriented Language (COBOL).

Purpose. Designed as a higher order programming language to support business applications

History. In April 1959, a group of computer vendors, academicians, and computer users met at the University of Pennsylvania to discuss the need for a higher order language for implementing business applications [19]. At that time, FORTRAN was under development as a higher order language to support scientific applications, and the belief was that business applications should also have a specialized programming language [19]. The group that met at the University of Pennsylvania requested that the U.S. DoD lead such an effort [19]. DoD agreed to undertake this [19].

In May 1959, Charlie Phillips, the DoD lead, conducted the first meeting of the Conference of Data Systems Languages (Codasyl), which included eight major computer vendors and a few users [19]. A specification was completed for COBOL by

December 1959, and commercial compilers were ready by January 1960 [19]. However, vendors began implementing different versions of the COBOL compiler, and a standard was needed. ANSI developed a standard for COBOL in 1968, and it underwent several more ANSI standard versions until it became an ISO/IEC standard in 1989.

Standards Organization. The ISO/IEC/JTC1 (http://www.jtc1.org/) Subcommittee 22 Working Group 4 (SC22/WG4) (http://www.cobolstandard.info/wg4/ wg4. html) is responsible for maintaining the COBOL programming language specification.

Status. ISO/IEC TR 19755:2003 defines a standard for COBOL that includes object-oriented features.

Obtaining the Specifications. The standard can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html, and by searching for "COBOL" to obtain the specifications for:

- ISO/IEC 1989:2002 – COBOL Programming Language;
- ISO/IEC TR 19755:2003 – Information Technology – Programming languages, their environments and software interfaces – Object finalization for COBOL programming language.

URL. http://www.cobolstandard.info/wg4/wg4.html (maintained by ISO/IEC/JTC1/SC22/WG4).

Vendors. Major vendors support COBOL. A partial list of vendors includes:

- IBM (http://www.ibm.com/);
- Hewlett-Packard (http://h71000.www7.hp.com/commercial/cobol/);
- Futjitsu (http://www.fujitsu.com/);

Other Sources of Information. There is an ongoing project to develop an open source compiler for COBOL. Refer to URLs: http://cobolforgcc.sourceforge.net/cobolforgcc.html and http://cobolforgcc.sourceforge.net/ for more information.

11.2.5 ECMAScript

Name. ECMAScript programming language.

Purpose. To define an international scripting language for the World Wide Web.

History. Microsoft's Jscript and the JavaScript developed by Brendan Eich at Netscape were submitted to Ecma International (formerly known as the European Manufacturers Association) in 1996 and became the basis for ECMAScript, which was adopted in 1997 [20]. It has been through several versions since then, and was approved by ISO/IEC as an international standard in 2002 [20].

Standards Organization. The Ecma International TC39 Task Group (http://www.ecma-international.org/) maintains the standard.

Status. TC39 is enhancing the ECMAScript specification to support XML (http://www.ecma-international.org/memento/TC39.htm).

Obtaining the Specifications. The standard can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html, and by searching for "ISO/IEC 16262" to obtain the specifications for ISO/IEC 16262:2002. In addition, Ecma International provides the following ECMA specifications that can be downloaded:

- ECMA-262, which was used as the basis for the ISO/IEC 16262 standard, can be downloaded at URL: http://www.ecma-international.org/publications/files/ECMA-ST/Ecma-262.pdf.
- ECMA-290, ECMAScript Components Specification, can be downloaded at URL: http://www.ecma-international.org/publications/standards/Ecma-290.htm.
- ECMA-327, ECMAScript 3rd Edition Compact Profile, can be downloaded at URL: http://www.ecma-international.org/publications/standards/Ecma-327.htm.

URL. http://www.ecma-international.org/publications/standards/Ecma-262.htm.

Vendors. Most Web browsers support a version of ECMAScript.

11.2.6 Formula Translation

Name. Formula Translation (FORTRAN).

Purpose. To define a higher order language that would simplify programming [21].

History. John Backus, an employee at IBM, made a proposal to his boss to develop a programming language that would be more cost effective than those that were available at that time [21]. The date was December 1953, and John Backus noted that 25% to 50% of computer use at that time was spent in debugging programs, and the combined salaries of programmers assigned to a computer center at least equaled the purchase price of the mainframe computer being used [21]. As an illustration: if a programmer in 1954 received $8,000 annually, and the mainframe computer cost about a quarter of a million dollars, then at least 31 programmers were needed to support it [21]. However, if 25% to 50% of the programmers' time was spent in debugging, this could be considered a loss of productivity of up to $125,000 per year. Clearly, something had to be done.

Considering that programmers at the time used machine code or assembler, programmers required an in-depth understanding of how the computer translated their instructions to get their programs to work correctly, and so it is no wonder that John Backus' proposal was approved. His prime objective was to create a programming language that would operate as efficiently as its machine code or assembler equivalent; this feature was essential if the programming language were to be successful [21].

John Backus' team grew to include others, and they worked on designing a language that would operate on the IBM 704 [21]. By November 1954, the team had developed a preliminary report that provided initial specifications for the Formula Translating System they called FORTRAN [21]. The team briefed customers on their ideas and encountered great skepticism that such a language could be developed and still be efficient (no one had ever done this successfully before) [21]. Following an intense development process to build a FORTRAN I compiler (they had originally estimated that it would take only 6 months to complete), it was not until April 1957 that they had a working compiler for IBM 704 that was released to the public, along with a detailed Reference Manual for Programmers [21]. As calls, letters, and telegrams poured in requesting help for programming problems, Backus and his team began developing a Primer for FORTRAN that provided instructions for using FORTRAN I [21]. The Primer was available by fall/winter of 1957, and after that, updates were made to release a revised FORTRAN II compiler by spring of 1958, and then an enhanced version of FORTRAN III by winter of 1958 [21].

FORTRAN is considered the first successful higher order language, and was widely used by industry for numerous applications.

Standards Organization. ISO/IEC/JTC1 (http://www.jtc1.org/) Subcommittee 22 Working Group 5 (SC22/WG5) (http://www.nag.co.uk/sc22wg5/overview.html) is responsible for maintaining the FORTRAN standard.

Status. The ISO/IED/JTC1/SC22 Working Group 5 continues to extend FORTRAN and plans to update it with object-oriented capabilities.

Obtaining the Specifications. The standard can be purchased from ISO at URL: http://www.iso.org/iso/en/CatalogueListPage.CatalogueList.

URL. http://www.nag.co.uk/sc22wg5/ (maintained by ISO/IED/JTC1/SC22/WG5).

Vendors. Major vendors support FORTRAN compilers and other products:

- IBM (http://www-306.ibm.com/software/awdtools/fortran/support/);
- Hewlett-Packard (http://h18009.www1.hp.com/fortran/);
- Fujitsu (http://www.fujitsu-siemens.com/products/software/compiler/languages/fortran.html).

11.2.7 Java

Name. Java programming language.

Purpose. To develop and demonstrate future capabilities for digital devices.

History. In 1991, Sun Microsystems kicked off a project to explore potential capabilities for the next generation of systems [22]. The project was called Green Door, and it began with 13 employees sequestered in an office in Menlo Park, cut off from Sun Microsystems and working secretly on developing a new technology [22]. By the summer of 1992, the team had developed a remote, hand-held digital device controller (StarSeven.) to support a capability like video on-demand and featured an animated user interface [22]. They attempted to market it to cable television manufacturers, but without success [22].

The project members regrouped and considered expanding the technology to transmit and receive media content over the Internet [22]. Instead, they decided to rename it Java technology and develop it as a programming language for the Web [22]. James Gosling, a lead for the Sun Microsystems' Green Door project, is considered the key architect for the Java technology [22]. Using this new Java technology, the team rewrote and debugged the Mosaic Web browser, named it WebRunner (later called HotJava), and released the code for free downloads over the Internet in March 1995 [22].

Then executives from Sun Microsystems met with Marc Andreesen, cofounder and an executive vice-president of Netscape, and Marc Andreesen agreed to integrate Java technology into Netscape, allowing Web developers to build Java applets (Java programs) that would support a host of functions on Netscape browsers [22]. Later on, Microsoft said that it would also support Java on its Internet Explorer.

Status. Sun Microsystems founded the Java Community Process (http://www.jcp.org) as a standards body in 1998 and gave it responsibility for managing a formalized process to create, maintain, and revise Java technology specifications. As the Java technology continues to grow in popularity, it expands to support new standards for system capabilities such as J2ME, J2SE, and J2EE, covered in Section 7.5. Other standards bodies have followed suit, enhancing their specifications to include Java language bindings.

Obtaining the Specifications. The JDO Specification and other Java-related specifications can be downloaded at URL: http://www.jcp.org/en/jsr/stage?list By=final.

URL. http://www.jcp.org/en/jsr/overview.

Vendors. Sun Microsystems supports Java products (http://wwws.sun.com/software/learnabout/java/), *JavaWorld* provides product news and other information about Java (http://www.javaworld.com/), and a partial list of vendors includes:

- IBM (http://www.ibm.com/);
- Hewlett Packard (http://h18012.www1.hp.com/java/);
- Fujitsu (http://www.fujitsu.com/services/microelectronics/product/micom/java/webpage_pdt-mic-java.html).

Other Sources of Information.

- For an overview of Java, refer to URL: http://research.sun.com/features/tenyears/volcd/papers/7Gosling.pdf.
- For development, refer to TheServerSide.com Web site dedicated to discussing Java technologies and answering developer questions at URL: http://www.theserverside.com/discussion/index.jsp.
- *JavaWorld* provides informative articles and Java product news at URL: http://www.javaworld.com/.
- The Java Tools Community (http://www.javatools.org/) hosts a forum for vendors to collaborate on Java tools.
- Shahrooz Feizabadi provides a more detailed "History of Java," published in *World Wide Web Beyond the Basics*, published by Prentice-Hall, Inc., and available at URL: http://www.prenhall.com/abrams/demo/chap1/java_hist. html.
- James Gosling discusses the development of Java in "James Gosling Discusses Java," at URL: http://www.sun.com/951201/feature1/report4.html.

11.2.8 Real-Time Specification for Java

Name. Real-Time Specification for Java (RTSJ).

Purpose. To develop real-time core extensions to Java for embedded applications.

History. Early in 1998, the U.S. NIST kicked off a real-time requirements working group that transitioned into a Real-Time Java Working Group (RTJWG) and was formalized with the establishment of the J Consortium (http://www.j-consortium.org/purpose.shtml). The J Consortium wanted to have a free hand in developing a real-time specification as a collaborative effort among companies with a vested interest in real-time applications, so that it would satisfy the majority of needs. They developed a Real-Time Core Extensions to Java (see http://www.j-consortium.org/rtjwg/index.shtm) in 2000 and submitted it to ISO for consideration.

The RTJWG provided their specification (http://www.jcp.org/en/jsr/detail?id=1) to the Java Community Process as input to the Real-Time for Java Expert Group and they finalized the specification.

Standards Organization. The JCP (http://www.jcp.org) is responsible for maintaining this specification.

Status. The Java-consortium has combined its efforts with The Open Group to continue development of RT Java as part of the real-time Java Forum for submission to teh JCP (see http://www.opengroup/rt.forum/rt-java/).

Obtaining the Specifications: The specification can be downloaded at URL: http://jcp.org/aboutJava/communityprocess/final/jsr001/index.html.

URL. http://jcp.org/aboutJava/communityprocess/final/jsr001/index.html.

Vendors. Sun Microsystems supports Real-Time Java products (http://java.sun.com/products/embeddedjava/real-time.html).

11.3 Software Engineering Tools

As HOLs such as the C language became commonly used, tools were developed to facilitate the job of compiling, debugging, integrating, and testing source code. While developers found these tools useful, what they needed was a software engineering environment—an integrated environment and suite of tools—that supported the entire software development lifecycle, from requirements to testing. This section covers several standards that were defined to support software engineering environments, principally the ECMA Framework for Software Engineering Environments and the Portable Common Tool Environment (PCTE).

Since the advent of HOLs, developers have envisioned automatic code generators that operate on languages akin to spoken languages and convert them automatically to executable code. While this vision has not yet been attained, the OMG's Model Driven Architecture (MDA) defines code generators that operate on the OMG's Unified Modeling Language (UML), an object-oriented diagramming language for application objects that MDA tools can convert to code. This section describes the ECMA Framework, MDA, PCTE, and UML.

11.3.1 ECMA Framework for Software Engineering Environments

Name. ECMA Framework for Software Engineering Environments (SEEs).

Purpose. To define a reference model that could be used as the basis for defining and developing services for SEE using common concepts.

History. In the 1980s and early 1990s, there was a great deal of interest in SEEs that would facilitate the software development life cycle. At that time, SEEs were designed for specific manufacturer platforms and programming languages and were not portable across multiple, heterogeneous environments. Providing standard services for SEEs was considered a means for achieving portability and easing the transition from one computer platform to another [23].

In 1988, the European Manufacturers Association (now known as Ecma International) spearheaded Task 33, the Task Group on the Reference Model (TGRM) for a standard SEE framework [23]. The first version of the reference model was completed in 1990.

Standards Organization. The Ecma International TC33 Task Group (http://www.ecma-international.org/) defined the standard, but it is no longer active.

Status. Ecma International continues to make the specifications available for viewing, but it is not actively maintaining them.

Obtaining the Specifications. The third edition of the Reference Model for Frameworks of Software Engineering Environments, Technical Report TR/55, can be downloaded at URL: http://www.ecma-international.org/publications/techreports/E-TR-055.htm.

URL. http://www.ecma-international.org/publications/techreports/E-TR-055.htm.

11.3.2 Model Driven Architecture

Name. Model Driven Architecture (MDA).

Purpose. To allow developers to define a platform-independent application business model using UML and convert it to source code using MDA automated code generators [24].

History. OMG members had been considering a means for generating application source code from an object-oriented model to facilitate the software development process. The OMG had designed the IDL to enable application objects to communicate in a CORBA environment, and now they were interested in designing a more powerful capability that could automatically convert an application model into source code. OMG's UML provided an object-oriented modeling language that would become the basis for code generation of what OMG calls the application's business model, and XML Metadata Interchange (XMI)[2] and Meta-Object Facility

2. XMI is used to facilitate the exchange of metadata between modeling tools (http://www.omg.org/technology/documents/formal/xmi.htm).

(MOF™)[3] would provide the foundation for defining aspects of that model [24]. Work on MDA began in 1996, and the first version of the specification was completed in 2001 [24].

Standards Organization. The Object Management Group (http://www.omg.org/) maintains MDA.

Status. MDA supports OMG's UML, MOF and XMI standards. Developers use MDA to build a platform-independent model in UML—OMG calls this a platform independent model (PIM) and considers it the business model. Next, developers use a code generator tool to convert the PIM to an artifact that one or more MDA code converters customize for a platform environment (e.g., J2EE). At this stage, OMG refers to the artifact as a platform specific model (PSM). Developers can refine the PSM, or immediately run another MDA code generator to convert the PSM to source code, which can be compiled and executed or further refined before compilation. MDA is becoming widely used among CORBA developers.

Obtaining the Specifications. The following URL: http://www.omg.org/mda/specs.htm provides an overview of the components of MDA.

URL. http://www.omg.org/mda/.

Vendors. The OMG lists a number of vendors and their products at URL: http://www.omg.org/mda/committed-products.htm and relates MDA success stories at URL: http://www.omg.org/mda/products_success.htm. Vendors include IBM (http://www.ibm.com/), Hewlett-Packard (http://www.hp.com/), Iona (http://www.iona.com/), and Borland (http://www.borland.com/).

Other Sources of Information.

- The OMG recommends MDA reading materials at URL: http://www.omg.org/mda/reading-room.htm.
- The Server Side (http://www.theserverside.com/) provides development information about MDA as well as sources for open source products and tips for programming.
- C. Sliwa documents challenges and successes in "Blueprint for Code Automation: Early Adopters of Model Driven Architecture Face Cultural Barriers, but the Payoff Promises Savings in Time and Money and Better Code Quality" at URL: http://www.computerworld.com/softwaretopics/software/story/0,10801,91383,00.html in the March 22, 2004 issue of *ComputerWorld*.
- Pathfinder Solutions (http://www.pathfindersol.com/) provides a set of white papers on MDA at URL: http://www.pathfindersol.com/web/pages/MDA-UML_resources/WhatsMDA.html.

3. MOF defines an abstract model for defining, building, and managing vendor-independent metamodels (http://www.omg.org/docs/formal/02-04-03.pdf).

11.3.3 Portable Common Tool Environment

Name. Portable Common Tool Environment (PCTE).

Purpose. To define the set of software tool facilities that provide an integrated collection of environment services for data management, process control, security, network management, auditing, and accounting with the overall objective of promoting software tool portability.

History. In the 1980s, the European Strategic Programme for Research and Development in Information Technology (ESPRIT) had formed a project 32 to investigate a basis for a common tool environment [25]. It produced a specification in the C programming language for tools defined in C, an implementation, and a preliminary set of tools for a PCTE [25]. The Commission of the European Communities (CEC) furthered PCTE by defining a version for the Ada programming language [25]. In 1988, ECMA was assigned the task of continuing development of PCTE, now ECMA International. By June 1991, Ecma International had defined a C language binding and shortly thereafter defined an Ada language binding [25].

In June 1993, ECMA International released a second edition of a PCTE specification that incorporated review comments from international experts, and this version was submitted to the ISO/IEC JTC1 for fast-track ISO/IEC processing [25]. After making revisions, ISO/IEC published it as ISO/IEC 13719-2 in 1994 [25].

Standards Organization. Ecma International developed this standard and submitted it to the ISO and IEC JTC1 (http://www.jtc1.org/) for approval. The ISO/IEC/JTC1 Subcommittee 22 Working Group 22 (ISO/IEC/JTC1/SC22/W22) published a set of specifications in 1995. Working Group 22 has since disbanded.

Status. Ecma International continues to make the specifications available for access, viewing, but neither ISO/IEC nor Ecma International is updating them.

Obtaining the Specifications. PCTE specifications can be downloaded from URL: http://www.ecma-international.org/publications/standards/Stnindex.htm and can also be purchased from ISO/IEC. Specific standards include:

- ISO/IEC 13719-1:1995, Information technology – Portable Common Tool Environment (PCTE) – Part 1: Abstract specification can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html.
- This specification is based on ECMA-149, Portable Common Tool Environment (PCTE) – Abstract Specification, URL: http://www.ecma-international.org/publications/standards/Ecma-149.htm.
- ISO/IEC 13719-2:1995, Information technology – Portable Common Tool Environment (PCTE) – Part 2: C programming language binding can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html.
- This specification is based on ECMA-158, Portable Common Tool Environment (PCTE) – C Programming Language Binding, URL: http://www.ecma-international.org/publications/standards/Ecma-158.htm.

- ISO/IEC 13719-3:1995, Information technology – Portable Common Tool Environment (PCTE) — Part 3: Ada programming language binding can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html.
- This specification is based on ECMA-162, Portable Common Tool Environment (PCTE) – Ada Programming Language Binding, URL: http://www.ecma-international.org/publications/standards/Ecma-162.htm.
- ECMA-230, Portable Common Tool Environment (PCTE) – IDL Binding (Interface Definition Language), URL: http://www.ecma-international.org/publications/standards/Ecma-230.htm.
- ECMA-270, Portable Common Tool Environment (PCTE) – Mapping from CASE Data Interchange Format (CDIF) to PCTE, URL: http://www.ecma-international.org/publications/standards/Ecma-270.htm.
- Mapping of PCTE to the Ecma/NIST Frameworks Reference Model, Technical Report TR/66, URL: http://www.ecma-international.org/publications/techreports/E-TR-066.htm.

URL. http://std.dkuug.dk/JTC1/SC22/WG22/.

11.3.4 Unified Modeling Language

Name. Unified Modeling Language (UML).

Purpose. To define a standard language for designing object-oriented models.

History. In the early 1990s, James Rumbaugh, Grady Booch, and Ivar Jacobson had each developed different approaches and notations for object-oriented analysis and design. James Rumbaugh had co-authored *Object-Oriented Modeling and Design*[4] published by Prentice-Hall in 1990; Booch's book was entitled *Object-Oriented Analysis and Design with Applications* and was published by Addison-Wesley in 1993; and Ivar Jacobson had co-authored a book entitled *Object-Oriented Software Engineering: A Use Case Driven Approach* that was published by Addison-Wesley in 1995.[5]

In 1995, James Rumbaugh and Grady Booch began collaborating on the Unified Method, and Ivar Jacobson joined them in 1996 to work on unifying their three different modeling approaches in UML [26]. Also in 1996, various vendors and system integrators began working with these three men to define UML so that UML could become a standard for the OMG. They completed the first version in January 1997 [26]. The OMG accepted their second version submitted in September 1997 and published it in November 1997 [26].

The OMG formed a Revision Task Force for UML in 1997 to refine the specification, and UML has continued to evolve [26]. Note that Grady Booch had been the

4. James R. Rumbaugh co-authored *Object-Oriented Modeling and Design* with Michael R. Blaha, William Lorensen, Frederick Eddy, and William Premerlani.
5. Ivar Jacobson co-authored *Object-Oriented Analysis and Design with Applications* with Magnus Christerson, Patrik Jonsson, and Gunnar Overgaard.

Chief Technology Officer for Rational Software, Inc., which supported tools for object-oriented analysis and design, and IBM acquired Rational Software in 2002.

Standards Organization. The Object Management Group (http:///www.omg.org/) maintains the specification for UML.

Status. The OMG is refining UML in a version 2.0 that provides a better foundation for more powerful MDA code generators [27].

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.uml.org/.

URL. http://www.uml.org/.

Vendors. The UML URL (http://www.uml.org/) provides links that list numerous vendors that support UML (look for the "UML Tools" title on the Web page, and the Web links are listed below). A few of the vendors are listed here:

- IBM (http://www.ibm.com/) offers Rational Rose (http://www-306.ibm.com/software/rational/uml/resources/uml2/contributions.html) and provides information about customizing the Rational Rose framework at URL: http://www-106.ibm.com/developerworks/rational/library/693.html.
- Gentleware (http://www.gentleware.com/) supports a Poseidon for UML collaborative modeling tool.
- Microgold Software, Inc., (http://www.microgold.com/) supports UML design tools.
- Borland (http://info.borland.com/03/together.htm) provides Together Solo (http://www.borland.com/together/solo/index.html).

Other Sources of Information. There are numerous books published on UML, and Microgold Software, Inc., provides a UML FAQ page at URL: http://microgold.com/Stage/UML_FAQ.html.

11.4 Software Engineering Models

Along with the introduction of HOLs and tools to support development, the software engineering processes used by numerous organizations matured to the extent that particular activities and artifacts turned into common practices and products for developing successful software systems. This led SEI to define a Capability Maturity Model for Software (SW-CMM®) and a Capability Maturity Model-Integrated for Systems Engineering/Software Engineering (CMMI®-SE/SW), that are used by numerous software development companies to define software processes for their organization. The ISO/IEC/JTC1 Subcommittee 7 developed a family of standards for quality management of system processes, and these were published as the ISO 9000 series.

11.4.1 Capability Maturity Model for Software

Name. Capability Maturity Model for Software (SW-CMM).

Purpose. To provide a process improvement model for Software Engineering.

History. The U.S. DoD was concerned about the escalating costs of software development and maintenance, and so established SEI at Carnegie Mellon University in the early 1980s to address this problem [28]. In 1988, SEI began developing a Capability Maturity Model for software development best practices that it published in 1991 [28]. This CMM described five levels of maturity that an organization should achieve to attain an optimized software development life cycle with an established process improvement process [28]:

- *Level 1 – Initial.* The software process is ad hoc, and success depends on individual team member heroes [28].
- *Level 2 – Repeatable:* Some project management processes have been established, such as project cost tracking, schedule management, and system functionality, and these processes are repeatable [28].
- *Level 3 – Defined:* The project management and engineering software processes are documented, standardized, and integrated into a standard software process that the entire organization uses for all projects [28].
- *Level 4 – Managed:* Metrics are collected for the software process across the organization, and the quality of the process and products is controlled [28].
- *Level 5 – Optimizing:* The organization as a whole is continuously improving the software process based on feedback and innovations [28].

Organization. SEI at Carnegie Mellon University (http://www.sei.cmu.edu/) developed and published the CMM.

Status. The U.S. Office of the Secretary of Defense directed SEI to replace the CMM-SW with the Capability Maturity Model-Integrated (CMMI) for Systems Engineering/Software Engineering before the review of version 2 of the SW-CMM had been completed [28]. Hence, the SW-CMM has been integrated into the CMMI.

Obtaining the Specifications. The documentation can be downloaded at URL: http://www.sei.cmu.edu/cmm/obtain.cmm.html.

URL. http://www.sei.cmu.edu/cmm/.

11.4.2 Capability Maturity Model-Integrated for Systems Engineering/ Software Engineering

Name. Capability Maturity Model-Integrated for Systems Engineering/Software Engineering (CMMI-SE/SW).

Purpose. To provide a framework and models to achieve product and process improvement for system engineering, software development, and system acquisition [28].

History. The SW-CMM that SEI published in 1991 was used by numerous government agencies to qualify companies to work on government software acquisition projects. Soon after this, SEI developed methodologies for evaluating an organization's maturity level such as a Software Capability Evaluation (SCE) (see

URL: http://www.sei.cmu.edu/publications/documents/96.reports/96.tr.002.html for details), and then trained government and contractor personnel in its use. Now, the SCE is an established method for certifying that an organization has achieved a particular CMM level, and for achieving the higher levels.

In the mid-1990s, the success of the SW-CMM and SCE led a group of industry and government personnel to form the Enterprise Process Improvement Collaboration (EPIC) effort to develop a System Engineering CMM (SE-CMM) [28]. In addition, the International Council on Systems Engineering (INCOSE) developed a Systems Engineering Capability Assessment Model (SECAM) for the SE-CMM, analogous to the SCEs for the SW-CMM [28]. Rather than have disparate CMMs, SEI collaborated with industry and the government to integrate the SW-CMM and SE-CMM into a CMMI [28].

A CMMI was developed that provides a framework that includes models and components shared by each of the CMMs, an assessment methodology, and training materials [28]. The CMMI models include the combined CMMI-SW, CMMI-SE, and Integrated Product and Process Development [28].

Organization. SEI at Carnegie Mellon University (http://www.sei.cmu.edu/) developed and published the CMMI in collaboration with other organizations.

Status. SEI is in the process of developing an acquisition CMM to include in the CMMI. The CMMI is widely used across government organizations and industry and is treated as a standard.

Obtaining the Specifications. The documentation can be downloaded at URL: http://www.sei.cmu.edu/cmmi/models/models.html. Note that SEI continues to update the CMMI to insure that it is consistent and compatible with ISO/IEC/JTC1 Subcommittee 7 standards for assessing a software development process, and these can be purchased from ISO at URL: http://www.iso.org/iso/en/prods-services/ISO store/store.html [28]:

- ISO/IEC TR 15504-1:1998, Information technology – Software process assessment – Part 1: Concepts and introductory guide;
- ISO/IEC 15504-2:2003, Information technology – Process assessment – Part 2: Performing an assessment;
- ISO/IEC 15504-2:2003/Cor 1:2004;
- ISO/IEC 15504-3:2004, Information technology – Process assessment – Part 3: Guidance on performing an assessment;
- ISO/IEC TR 15504-5:1999, Information technology – Software Process Assessment – Part 5: An assessment model and indicator guidance;
- ISO/IEC TR 15504-7:1998, Information technology – Software process assessment – Part 7: Guide for use in process improvement;
- ISO/IEC TR 15504-8:1998, Information technology – Software process assessment – Part 8: Guide for use in determining supplier process capability;
- ISO/IEC TR 15504-9:1998, Information technology – Software process assessment – Part 9: Vocabulary.

URL. http://www.sei.cmu.edu/cmmi/.

Vendors. SEI licenses organizations to certify that they are qualified to conduct process appraisals (http://www.sei.cmu.edu/cmmi/appraisals/appraisals.html). While there are a number of companies that are licensed, the Software Productivity Consortium (http://www.software.org/) is a nonprofit organization that companies have used to conduct their SCEs.

11.4.3 ISO 9000

Name. ISO 9000 Series on Quality Management Systems.

Purpose. To provide a family of generic system standards that addresses the efficient quality management of processes for activities such as satisfying customer quality requirements [29].

History. The ISO first defined ISO 9000 series in 1987 and has continued to update them [30].

Standards Organization. The ISO/IEC/JTC1 (http://www.jtc1.org/) Subcommittee 7 (SC7) is responsible for defining and maintaining this family of standards.

Obtaining the Specifications. ISO/IEC specification for the ISO 9000 series on quality management systems can be purchased at URL: http://www.iso.org/iso/en/prods-services/ISOstore/store.html. Specific standards include:

- ISO 9000:2000 – Selection and use;
- ISO 9000:2000 series – Implementation and transition;
- ISO 9001:2000 interpretations service;
- ISO 9001:2000 "auditing kit";
- ISO/IEC 90003:2004, Software engineering – Guidelines for the application of ISO 9001:2000 to computer software.

URL. http://www.iso.ch/iso/en/iso9000-14000/iso9000/iso9000index.html.

Vendors. SPICE (http://www.sqi.gu.edu.au/spice/) is an international initiative that has been developing standards for process assessment in conjunction with the ISO/IEC/JTC1/SC7. They provide documentation at their site for earlier versions of the ISO 9000 standards (see list below), and provide information about products available to support process assessments.

- ISO 9001 - 1994, Model for Quality Assurance in Design, Development, Production, Installation and Servicing;
- ISO 9000-3 - 1991, Quality Management and Quality Assurance Standards – Part 3: Guidelines for the Application of ISO 9001 to the development, supply and maintenance of software;
- ISO 9004-4 - 1993, Quality Management and Quality System Elements – Part 4: Guidelines for quality improvement;
- ISO DIS 12207-1 - 1994, Software Life Cycle Process;
- ISO DIS 12119-1995, Software products – evaluation and test.

Other Sources of Information. The ISO/IEC/JTC1/SC7 has developed certification, registration, and accreditation of the ISO 9000 family of standards, and continues to actively manage them [31]. In addition, an ISO 9000 FAQ is provided at URL: http://www.isoeasy.org/.

References

[1] Department of Defense Technical Reference Model (TRM) Version 2.0, http://www-trm.itsi.disa.mil/entirever2.pdf, U.S. DoD, April 9, 2001, pp. 5–50.

[2] C4ISR Architectures Working Group (AWG), C4ISR Architecture Working Group Final Report, http://www.defenselink.mil/nii/org/cio/i3/AWG_Digital_Library/pdfdocs/fnl rprt.pdf, U.S. DoD, April 14, 1998, pp. 4–6. (Refer to URL: http://www.fas.org/irp/program/core/fnlrprt.pdf if the other URL does not work.)

[3] C4ISR Architectures Working Group, C4ISR Architecture Framework Version 2.0, http://www.defenselink.mil/nii/org/cio/i3/AWG_Digital_Library/pdfdocs/fw.pdf, U.S. DoD, December 18, 1997. (Refer to URL: http://www.fas.org/irp/program/core/fw.pdf if the other URL does not work.)

[4] DoD Architecture Framework Working Group, *DoD Architecture Framework Version 1.0: Volume I: Definitions and Guidelines*, U.S. DoD, August 15, 2003, pp. ES-1–ES-2, 2-1–2-4.

[5] "OMB Circular No. A-130 (Revised, Transmittal Memorandum No. 4)," http://www.whitehouse.gov/omb/circulars/a130/a130trans4.html#1, OMB, November 2000.

[6] "Federal Enterprise Architecture (FEA): History and Background," http://www.feapmo.gov/feaHistory.asp, Federal Enterprise Architecture Program Management Office (FEAPMO), OMB, April 4, 2004.

[7] *Information Technology: Enterprise Architecture Use Across the Federal Government can be Improved: GAO Report to Congressional Committees*, http://www.gao.gov/new.items/d026.pdf, U.S. General Accounting Office (GAO), February 19, 2002.

[8] "What Is the Federal Enterprise Architecture?" http://www.feapmo.gov/fea.asp, Federal Enterprise Architecture Program Management Office (FEAPMO), OMB, April 4, 2004.

[9] Soley, R. M., et al., *Object Management Architecture Guide (Revision 3.0)*, http://www.omg.org/cgi-bin/doc?ab/97-05-05, John Wiley & Sons, Inc., Object Management Group, June 13, 1995.

[10] "Welcome to TOGAF 7: Technical Edition," http://www.opengroup.org/architecture/togaf7/index7.htm, The Open Group, May 1, 2004.

[11] "The Open Group Architectural Framework Version 7," http://www.opengroup.org/architecture/togaf7-doc/arch/, The Open Group, May 1, 2004.

[12] Weik, M. H., "The ENIAC Story," http://ftp.arl.mil/~mike/comphist/eniac-story.html, *ORDNANCE*, The Journal of the American Ordnance Association, 1961.

[13] Stansifer, R., "History of the Ada Programming Language," http://www.cs.fit.edu/~ryan/ada/ada-hist.html, Department of Computer Sciences, Florida Institute of Technology, January 25, 2002.

[14] "Ada 95: The Language for a Complex World," http://www.acm.org/sigada/ada_95/what_is_ada.html, ACM SIGAda, Association for Computing Machinery (ACM), May 1, 2004.

[15] Ritchie, D. M., "The Development of the C Language," http://cm.bell-labs.com/cm/cs/who/dmr/chist.html, *Proceedings of the Second ACM SIGPLAN Conference on History of Programming Languages*, ACM Press, Cambridge, Massachusetts, April 1993, pp. 201–208.

[16] Stroustrup, B., "Bjarne Stroustrup's FAQ," http://www.research.att.com/~bs/bs_faq.html# why, May 9, 2004.

[17] Dolya, A., "Conversations: Interview with Bjarne Stroustrup," http://www.linuxjournal.com/ article.php?sid=7099, *Linux Journal*, August 28, 2003.

[18] "International Standard for the C++ Programming Language Approved!" http://www.research.att.com/~bs/iso_release.html, Press Release, Morristown, NJ, November 14, 1997.

[19] Brandel, M., "1959: The Creation of Cobol," http://www.cnn.com/TECH/computing/9906/09/1959.idg/, *ComputerWorld*, June 9, 1999.

[20] Virdel, M., "What Is ECMAScript?" http://www-106.ibm.com/developerworks/web/library/wa-emca.html, *e-business Architect*, IBM, February 1, 2001.

[21] Backus, J., "The history of FORTRAN I, II, and III," *The First ACM SIGPLAN Conference on History of Programming Languages*, ACM Press, New York, 1982, pp. 165–180.

[22] Byous, J., "Java Technology: The Early Years," http://java.sun.com/features/1998/05/birthday.html, Sun Microcomputers, 1998.

[23] *Reference Model for Frameworks of Software Engineering Environments*, Third Edition, http://www.ecma-international.org/publications/techreports/E-TR-055.htm, European Computer Manufacturers Association (ECMA), June 1993.

[24] Siegel, J., "Making the Case: OMG's Model Driven Architecture," http://www.sdtimes.com/news/064/special1.htm, *SD Times*, October 15, 2002.

[25] *Portable Common Tool Environment (PCTE) – Abstract Specification*, http://www.ecma-international.org/publications/files/ECMA-ST/Ecma-149.pdf, ECMA, December 1997.

[26] Kobryn, C., "UML 2001: A Standardization Odyssey," *Communications of the ACM*, ACM Press, Vol. 42, No. 10, pp. 29–37.

[27] Sliwa, C., "Sidebar: Waiting for UML 2.0," http://www.computerworld.com/development topics/development/story/0,10801,91325,00.html, *ComputerWorld*, March 22, 2004.

[28] "Concept of Operations for the CMMI," http://www.sei.cmu.edu/cmmi/background/conops.html, Software Engineering Institute, January 15, 2001.

[29] "Generic Management System Standards," http://www.iso.org/iso/en/iso9000-14000/basics/general/basics_3.html, ISO, May 15, 2004.

[30] "In the Beginning," http://www.iso.org/iso/en/iso9000-14000/basics/general/basics_2. html, ISO, May 16, 2004.

[31] "Certification, Registration, and Accreditation," http://www.iso.org/iso/en/iso9000-14000/basics/general/basics_2.html, ISO, May 15, 2004.

CHAPTER 12

System Management Standards

12.1 Directory Services

As stand-alone software applications evolved into multiuser applications that operated across networks, it became increasingly important to know who was using the applications. Software applications implemented unique user access/authentication controls and electronic *white pages* that authenticated users by user id and/or password, stored access permissions in a custom directory that included personal information such as user name, organizational affiliation, office location, and social security number. Some applications provided electronic white pages for enterprise resources such as servers, printers, faxes, routers, and client platforms. For example, e-mail messaging systems stored user information that included physical addresses for delivering e-mail to its proper destinations.

These kinds of capabilities led to what are referred to now as *directory services*. However, the standards for directory services are evolving. As companies grow larger through acquisitions and mergers, they seek to share directory information across organizational boundaries. Businesses need to share directory information about their customers (e-business users) as they provide federated e-business services. But security concerns immediately arise: how should this information be protected? Who should have access to a user's private information? How do Web-based applications that need this private information become "trusted" applications to receive it? What protocols are needed for these information exchanges?

These are the questions that the directory services standards efforts are trying to resolve, and none of the standards described in this section fully addresses these concerns. Nevertheless, the expectation is that directory services standards will continue to evolve and ultimately be integrated into a mature set of Web Services. In the meantime, this section identifies four directory services standards supported by vendor products: Directory Enabled Networks (DEN), Directory Services Markup Language (DSML), the Lightweight Directory Access Protocol (LDAP), and X.500 Directory Services.

12.1.1 Directory Enabled Networks

Name. Directory Enabled Networks (DEN).

Purpose. To define a centralized repository with management services that create, edit, store, and retrieve information about users and enterprise resources such as printers, faxes, servers, platforms, and software applications, and the relationships between them [1].

History. Microsoft Corporation and Cisco Systems spearheaded development of a draft specification for a DEN Initiative and then turned their draft specification over to the DEN Ad Hoc Working Group (AHWG) (refer to https://murchison.org/den/ for details) [1]. The primary objective of the DEN AHWG was to continue development of the draft specification in preparation for submission to a standards body that would refine it and publish it as a formal standard. The DEN AHWG included an advisory board to moderate development of the specification, and members constituted both customers and vendors who were interested in a standard that supported interoperable vendor products for directory services.

The DEN AHWG saw DEN as a means to provide a single, centralized point to administer all network resources and a standard means for integrating the management of servers, networking devices, applications, and access control settings across multivendor directory databases (e.g., vendor directory databases would include Microsoft's Windows Active Directory, Novell, Inc.'s Novell Directory Services and Unix directory databases) [1]. The DEN specification was highly supported—300 networking vendors stood behind it [1]. DEN could simplify directory services by integrating vendor enterprise solutions into a single, centralized repository with management services.

The DEN AHWG continued developing the DEN specification and after discussing its transfer with the IETF and the DMTF, decided that the DMTF was the most logical choice (DEN builds on the DMTF CIM specification). In September of 1998, the DEN AHWG transitioned ownership of the DEN specification to the DMTF and then the AHWG disbanded [2].

Standards Organization. The DMTF (http://www.dmtf.org) is responsible for maintaining the DEN specification.

Status. The DEN standard builds on the DMTF CIM and includes a mapping from the DMTF's CIM schema to the LDAP. The DMTF continues to actively manage development of DEN.

Obtaining the Specifications. The specifications can be found at URL: http://www.dmtf.org/standards/den and selecting a version to download.

URL. http://www.dmtf.org/standards/den.

Vendors.

- The Open Group has established a Directory Interoperability Forum (http://www.opengroup.org/dif/spdna/charter.htm) to work with vendors to ensure their product implementations based on DEN, X.500, and LDAP are interoperable.
- Microsoft has incorporated DEN in its Windows-based operating systems from Windows NT and later.
- Cisco Systems developed Cisco Networking Services (CNS), which is based on DEN and CIM (http://newsroom.cisco.com/dlls/fspnisapi74a5.html).
- Novell's ZENWorks incorporates DEN capabilities. For more information, refer to URL: http://www.novell.com/documentation/lg/zen4nw/zfncfg_enu/data/a2wfen8.html and http://www.novell.com/coolsolutions/zenworks/features/a_zfn_faq_zw.html.

Other Sources of Information.

- The original specifications submitted by the DEN AHWG to the DMTF can be downloaded at https://murchison.org/den/. There is also a "Design Specification Development Process" on that Web page that discusses the role of the DEN AHWG in preparing the DEN specification for the DMTF.
- DMTF provides a Fact Sheet on DEN at URL: http://www.dmtf.org/about/faq/den.
- Microsoft provides an overview of DEN at URL: http://www.microsoft.com/technet/prodtechnol/winntas/plan/dirennet.mspx.

12.1.2 Directory Services Markup Language

See Chapter 14, Section 14.2.1 for details on the DSML standard.

12.1.3 Lightweight Directory Access Protocol

Name. Lightweight Directory Access Protocol (LDAP).

Purpose. To define a directory protocol for the Internet that incorporated a subset of X.500 standards (a "light" version) and was easier to implement.

History. In the mid to late 1980s, the ISO, the IEC, and the CCITT (now known as ITU-T) defined a comprehensive set of directory services in their X.500 standard. X.500 defined protocols to exchange directory data and a client-server architecture to manage the directory. In the early 1990s, the University of Michigan needed to access data in a X.500 directory server over the IP on its desktop clients [3]. However, the X.500 Directory Access Protocol (DAP) that enabled clients to interact with the X.500 directory server required a large amount of computer memory (overhead) to operate, and degraded the performance of the university's desktops. Hence, three men at the University of Michigan—Tim Howes, William Yeong, and Steve Kille— solved this problem by defining LDAP, a light version that implemented a subset of the X.500 DAP services [3]. Their solution was to design desktop clients that used TCP/IP to interact with an LDAP directory server, and the LDAP directory server would interact with the X.500 directory server to fulfill client requests, like a front-end server to the X.500 directory server [4]. The result was a success, and it was not long afterward that the three men submitted the "X.500 Lightweight Directory Access Protocol" specification to the IETF as RFC 1487, and it was published in 1993.

Over time, the IETF has extended LDAP to support services for an LDAP directory server, eliminating the need for an X.500 directory server. LDAP directory services can be used to support users, applications, desktop clients, servers, and other enterprise resources [5]. It has been implemented extensively to support company e-mail systems, authenticate users, control user access, and provide personnel information about users [3].

Standards Organization. The IETF LDAP (v3) Revision Working Group (http://www.ietf.org/html.charters/ldapbis-charter.html/) is responsible for maintaining the standard.

Status. The IETF LDAP (v3) Revision Working Group is continuing to extend the LDAP specification to include policies, connection level security, a readable string representation for string filters, and LDAP search operations. LDAP is widely used and supported by numerous vendors.

Obtaining the Specifications.

- RFC-1777, LDAP can be found at URL: http://www.ietf.org/rfc/rfc1777.txt?number=1777;
- RFC-1778, The String Representation of Standard Attribute Syntaxes can be found at URL: http://www.ietf.org/rfc/rfc1778.txt?number=1778;
- RFC-1779, The String Representation of Standard Attribute Syntaxes can be found at URL: http://www.ietf.org/rfc/rfc1778.txt?number=1779;
- RFC-1798, Connection-less Lightweight X.500 Directory Access Protocol can be found at URL: http://www.ietf.org/rfc/rfc1798.txt?number=1798;
- RFC-1823, The LDAP Application Program Interface can be found at URL: http://www.ietf.org/rfc/rfc1823.txt?number=1823;
- RFC-1959, An LDAP URL Format can be found at URL: http://www.ietf.org/rfc/rfc1959.txt?number=1959.

URL. http://www.ietf.org/html.charters/ldapbis-charter.html.

Vendors.

- The Open Group has established a Directory Interoperability Forum (http://www.opengroup.org/dif/spdna/charter.htm) to work with vendors to ensure their product implementations based on DEN, X.500, and LDAP are interoperable.
- Many vendors have implemented versions of LDAP: Netscape, Microsoft (http://www.microsoft.com/technet/prodtechnol/winntas/plan/ldapcmr.mspx), Cisco (http://www.cisco.com/en/US/products/sw/voicesw/ps556/products_administration_guide_chapter09186a00800c4cb2.html), and Novell.
- Nexor (http://www.nexor.com/) offers products that support both X.500 and LDAP, and provides a gateway between X.500 and LDAP applications (http://www.nexor.com/media/datasheets/x500_ldap_gateway_ds.pdf)
- The *ComputerWorld* URL: http://www.computerworld.com/networkingtopics/networking/story/0,10801,68075,00.html/ provides a link to other LDAP vendors and products (e.g., CP Directory Server and eTrust Directory).
- The OpenLDAP Foundation established the OpenLDAP Project (http://www.openldap.org/) in 1998 as a community effort to implement an open source version of LDAP. Refer to their URL to download source code and documentation.

Other Sources of Information.

- The Open Group has established a Directory Interoperability Forum (http://www.opengroup.org/dif/spdna/charter.htm) to work with vendors that are developing interoperable directory applications based on DEN, X.500, and LDAP.

- The University of Michigan provides URL: http://www.umich.edu/~dirsvcs/ldap/doc/index.html for a list of LDAP specifications that were published as RFCs. Note that some of the HTML links may no longer be active.
- Naveen Mohammed, who was an instructor at Marquette University in Milwaukee, Wisconsin, developed Web pages that provide information about LDAP: http://studsys.mscs.mu.edu/~nmohamme/MSCS210/final/ldap.html.
- LDAP Resources and early specifications can be viewed at URL: http://olymp.wu-wien.ac.at/manuals/rfc-ldap.html.
- Greg Retowski provides information about early versions of LDAP at URL: http://www.rage.net/ldap/ldapns-howto/LdapNS-howto.html#toc1.

12.1.4 X.500 Directory Services

Name. X.500 Directory Services.

Purpose. To define a comprehensive architecture concept, model, and capabilities for directory services.

History. By the 1980s, the number of multiuser applications that extended across networks had grown to such an extent that the job of maintaining custom directory services for each application had become labor-intensive and time-consuming. Even each DBMS had its own directory to be maintained, likewise the e-mail system, along with special-purpose applications, and application directories needed to be interconnected to enable access by users across networks.

To address this need, the ITU-T kicked off the X.500 standardization effort to provide a white pages service that would integrate application directories by providing a standard set of services [6]. Directory services were critical for e-mail messaging, since directory services map a user id into a physical address so that a message can be delivered on a network. CCITT began working on a specification as early as 1984 [6]. At the same time, ISO and the IEC were working on a complementary effort—an OSI name server service.[1] Consequently, the two efforts merged in 1986 to combine their efforts and define comprehensive directory services for OSI [6]. The first X.500 specification was published in 1988.

X.500 defines a client-server architecture based on the following concepts [7]:

- *Directory User Agent (DUA):* standard services provided for client systems that allow them to access and retrieve directory information from X.500 directory servers;
- *Directory System Agent (DSA):* standard services provided for directory servers, such as a detailed definition of the directory database content and structure, and the search and retrieval capabilities;
- *Directory Access Protocol:* protocol for controlling the communication between the client (DUA) and server system (DSA);
- *Directory System Protocol (DSP):* protocol for controlling the communication between two or more DSAs (servers)

1. Refer to Chapter 4, Section 4.8 for more information about OSI.

Standards Organization. ITU-T defined the original X.500 specifications and worked with the ISO and IEC to publish them as ISO/IEC standards. The ISO/IEC is responsible for maintaining the standard.

Status. X.500 defines a series of X.5nn services, such as X.501 for directory models, X.509 for public-key and attribute certificate frameworks, X.511 for abstract directory service definitions, and X.518 for procedures for distributed directory operations. In addition, there are a number of vendor implementations of X.500.

Obtaining the Specifications. The X.500 specifications can be obtained from the ISO Store by selecting their "Search and Buy Standards" option at http://www.iso.ch/iso/en/prods-services/ISOstore/store.html. Specifications available include:

- ISO/IEC 9594-1:2001, Information technology–OSI–The Directory: Overview of concepts, models, and services;
  - Earlier version: ISO/IEC 9594-1:1998;
- ISO/IEC 9594-2:2001, Information technology–OSI–The Directory: Models
  - ISO/IEC 9594-2:1998, ISO/IEC 9594-2:1998/Cor 1:2002, and ISO/IEC 9594-2:1998/Cor 2:2002;
- ISO/IEC 9594-3:2001, Information technology–OSI–The Directory: Abstract service definition;
  - ISO/IEC 9594-3:1998, ISO/IEC 9594-3:1998/Cor 1:2002, and ISO/IEC 9594-3:1998/Cor 2:2002;
- ISO/IEC 9594-4:2001, Information technology–OSI–The Directory: Procedures for distributed operation;
  - ISO/IEC 9594-4:1998, ISO/IEC 9594-4:1998/Cor 1:2002, and ISO/IEC 9594-4:1998/Cor 2:2002;
- ISO/IEC 9594-5:2001, Information technology–OSI–The Directory: Protocol specifications;
  - ISO/IEC 9594-5:1998, ISO/IEC 9594-5:1998/Cor 1:2002, and ISO/IEC 9594-5:1998/Cor 2:2002;
- ISO/IEC 9594-6:2001 and ISO/IEC 9594-6:2001/Cor 1:2003, Information technology–OSI–The Directory: Selected attribute types;
  - ISO/IEC 9594-6:1998, ISO/IEC 9594-6:1998/Cor 1:2001, ISO/IEC 9594-6:1998/Cor 2:2002, and ISO/IEC 9594-6:1998/Cor 3:2003;
- ISO/IEC 9594-7:2001, Information technology–OSI–The Directory: Selected object classes;
  - ISO/IEC 9594-7:1998 and ISO/IEC 9594-7:1998/Cor 1:2002;
- ISO/IEC 9594-8:2001, ISO/IEC 9594-8:2001/Cor 1:2002, and ISO/IEC 9594-8:2001/Cor 2:2002, Information technology–OSI–The Directory: Authentication Framework;
  - ISO/IEC 9594-8:1998, ISO/IEC 9594-8:1998/Cor 1:2000, ISO/IEC 9594-8:1998/Cor 2:2002, and ISO/IEC 9594-8:1998/Cor 3:2003 and ISO/ IEC 9594-8:1998/Cor 4:2003;
- ISO/IEC 9594-9:2001, Information technology–OSI–The Directory: Replication;

- ISO/IEC 9594-9:1998, ISO/IEC 9594-9:1998/Cor 1:2002, and ISO/IEC 9594-9:1998/Cor 2:2002;
- ISO/IEC 9594-10:2001, Information technology–OSI–The Directory: Use of systems management for administration of the Directory;
  - ISO/IEC 9594-10:1998, and ISO/IEC 9594-10:1998/Cor 1:2002;
- Related specifications:
  - ISO/IEC 13235-3:1998, Information technology–Open Distributed Processing–Trading Function–Part 3: Provision of Trading Function Using OSI Directory Service;
  - ISO/IEC ISP 15125-4:1998 Information technology–International Standardized Profiles ADYnn–OSI Directory Part 4: ADY22-DSA Support of Distributed Operations;
  - ISO/IEC ISP 15125-7:1998, Information technology–International Standardized Profiles ADYnn–OSI Directory Part 7: ADY43-DSA to DSA Authentication;
  - ISO/IEC ISP 10615-3:1996, Information technology – International Standardized Profiles ADInn–OSI Directory–Part 3: ADI21–DSA Performer Role;
  - ISO/IEC ISP 10615-4:1996, Information technology–International Standardized Profiles ADInn–OSI Directory–Part 4: ADI22–DSA Invoker Role;
  - ISO/IEC ISP 10615-5:1996, Information technology–International Standardized Profiles ADInn–OSI Directory–Part 5: ADI31–DUA Support for Distributed Operations;
  - ISO/IEC ISP 10615-6:1996, Information technology–International Standardized Profiles ADInn–OSI Directory–Part 6: ADI32–DSA Support for Distributed Operations.

URL. There is no official URL to provide updates on revisions to X.500.

Vendors.

- The Open Group has established a Directory Interoperability Forum (http://www.opengroup.org/dif/spdna/charter.htm) to work with vendors to ensure their product implementations based on DEN, X.500, and LDAP are interoperable.
- Siemens AG (http://www.siemens.com/) provides DirX products that support X.500.
- Nexor (http://www.nexor.com/) offers products that support both X.500 and LDAP, and provides a gateway between X.500 and LDAP applications (http://www.nexor.com/media/datasheets/x500_ldap_gateway_ds.pdf).
- Isode (http://www.isode.com/) supports both X.500 and X.400 (messaging services).
- Sun Microsystems supports X.500 Solstice products (http://wwws.sun.com/software/x500/index.html).

Other Sources of Information.

- Many books are available that describe X.500 in detail. Other X.500 resources and early specifications can be viewed at URL: http://olymp.wu-wien.ac.at/manuals/rfc-ldap.html.
- Delivery of Advanced Network Technology to Europe (DANTE) (http://www.dante.net/), a European not-for-profit organization, is involved in planning, building, and operating European research networks. DANTE provides X.500 information and specifications at URL: http://archive.dante.net/np/ds/osi.html.

12.2 System Management Data and Capabilities

Managing an enterprise effectively requires that system and network managers maintain an inventory of every application on each computer system and network device, including its manufacturer, model, version, and serial number. In addition, more detailed information needs to be maintained for every computer system and network device in an enterprise: for example, its configuration (manufacturer; model; purchase date; serial number; make, manufacturer, and serial number of peripheral devices such as a monitor), its office location, and its points of contact. This kind of information is typically referred to as system management data or management information.

Historically, network and system managers had to manually catalogue every piece of information about the servers, desktops, networks, and other devices in their domain. Recognizing the need for more automation, vendors began providing application information data with their applications, along with a custom query capability, so that it would be easier for network and system managers to inventory. But this approach still required a lot of legwork to accomplish the inventory, since the applications had to be queried from the device that they were located on. What network and system managers needed was a step beyond directory services—network-centered, automated capabilities that could query individual enterprise servers, routers, and other devices remotely to gather pertinent system management data and then store it in a centralized repository. Standards were needed to enable computer systems and network devices to self-publish their system management data using a common format and protocol, and for system and network management tools that would collect this information and store it in a centralized repository.

This section describes the Common Information Model, Desktop Management Interface (DMI), System Management BIOS (SMBIOS), and WBEM standards.

12.2.1 Common Information Model

CIM provides a common structural organization and schema that define system management information for networks, applications, servers, desktops, network devices, and other resources [8]. See Chapter 6, Section 6.3.1 for details on the CIM standard.

12.2.2 Desktop Management Interface

Name. Desktop Management Interface (DMI).

Purpose. To define a standard way for allowing desktops and servers to publish system management information about themselves on a network so that it can be stored in a centralized repository [9].

History. The Desktop Management Task Force (now called the Distributed Management Task Force) started development of the DMI specification in 1993 [10]. The specification described an architecture that included an information broker between the desktop and server components and a system management application, a structure for the management data, a procedure for providing and extracting system management data, an event model, and an interface that could access, manage, and control desktops, servers, and their peripheral components [10]. DMTF provided a revised and more comprehensive version for DMI (version 2) in 1996 [10].

Standards Organization. The DMTF (http://www.dmtf.org/) is responsible for maintaining this standard.

Status. The DMTF ended development of the DMI specification after December 31, 2003, and will no longer provide support after March 31, 2005 [11]. DMI has been replaced by the CIM standard.

Obtaining the Specification. The DMI specification can be downloaded from URL: http://www.dmtf.org/standards/dmi.

URL. http://www.dmtf.org/standards/dmi.

12.2.3 System Management BIOS

Name. System Management BIOS (SMBIOS).

Purpose. To define a standard format for publishing system management information for motherboards and other system products [12].

History. The DMTF defined the SMBIOS specification and has continued to update it since 1999.

Standards Organization. The DMTF (http://www.dmtf.org/) is responsible for maintaining this standard.

Status. SMBIOS is considered complementary to CIM and DMI, and its format can be easily converted so that it can be used by CIM and DMI applications.

Obtaining the Specifications. Different versions of specifications can be found at URL: http://www.dmtf.org/standards/smbios and downloaded by selecting a specific version.

URL. http://www.dmtf.org/standards/smbios.

Vendors. SMBIOS has been implemented by a number of manufacturers.

- PCPitstop is an example tool that relies on implementations of the SMBIOS standard for system data (http://www.pcpitstop.com/faq/smbios.asp).
- A tool used for Linux systems is dmidecode (http://www.nongnu.org/dmideode/).
- DMIScope (http://www.drivertools.net/html_apsoft/dmiscope.htm) is available for Microsoft Windows–based systems.

12.2.4 Web-Based Enterprise Management

Name. Web-Based Enterprise Management (WBEM).

Purpose. To provide an integrated set of management tools that leverage Web-based technologies to consolidate the management of enterprise computing environments [13] by providing a consistent format and reporting mechanism for system management data and status; and to detect system anomalies and problems "before they become serious" [14].

History. At the same time that Microsoft proposed a specification for WBEM, five companies (Microsoft, BMC Software, Cisco Systems, Compaq, and Intel Corporation) began a WBEM Initiative in July 1996 to build Web-based browsers that would allow developers to build interactive interfaces to system management tools using Java [15, 16]. This effort was eventually transitioned to DMTF in 1998, which began by incorporating CIM into WBEM, which is why WBEM is often referred to as CIM/WBEM [17].

Standards Organization. The DMTF (http://www.dmtf.org/) is responsible for maintaining the WBEM architecture, concepts, and standards.

Status. The WBEM Initiative does not define one standard, but instead, identifies a set of standards that include:

- CIM schema;
- DEN directory services;
- A WBEM Service Location Protocol (SLP) that enables clients to discover directory servers that manage the centralized system management repositories;
- WBEM Universal Resource Identifiers (URI) that define URIs (compact string representations for Internet resources) for WBEM CIM objects.

In addition, WBEM is defined to operate using the following standards:

- CIM operations over HTTP;
- CIM representation using XML.

In 2002, the vendors responsible for defining the Bluefin specification for SANs (e.g., Brocade Communications, Computer Associates International, Inc., Hewlett-Packard Company, McData Corporation, and Veritas) incorporated CIM/WBEM into Bluefin [17]. Bluefin's purpose was to allow users to manage any storage device from a common interface [17]. Since then, the vendors submitted the Bluefin Specification to the Storage Networking Association. SNIA has incorporated CIM/WBEM into its official SNIA standard for Bluefin, the SMI-S (see Chapter 6, Section 6.5.4 for details on SMI-S).

Obtaining the Specifications. The specifications for WBEM can be downloaded at URL: http://www.dmtf.org/standards/wbem.

URL. http://www.dmtf.org/standards/wbem.

Vendors.

- Microsoft provides a Windows Management Infrastructure (WMI) that supports WBEM for Windows 98 and Windows 2000 operating systems.
- Novadigm's Radia Software Manager, Radia Application Manager, and Radia Inventory Manager 3.0 are certified by HP for its Openview products and supports WBEM (http://www.openview.hp.com/sso/isv/detail?appid=A7 85).
- Sun Microsystems' (http://wwws.sun.com/software/solaris/wbem/) Solaris product supports WBEM.
- The Open Group is promoting open source implementations of WBEM. See URL: http://www.wbemsource.org/ for details on WBEM tools and vendors participating in this initiative.

Other Sources of Information.

- Paul Monday from Imation Corporation discusses implementing WBEM and CIM in his primer "Management Application Programming, Part 2: Introduction to WBEM and the CIM/A Primer on Web-Based Enterprise Management and the Common Information Model (Level: Intermediate)," at URL: http://www-106.ibm.com/developerworks/java/library/j-wbem/, dated June 19, 2001.
- DMTF provides details on WBEM in "New Preliminary WBEM Specs Released," published in the DMTF Newsletter (Vol. 9, No. 2, March 2004) and available at URL: http://www.dmtf.org/newsroom/newsletter/2004/03/ page4.
- DMTF provides "Web-Based Enterprise Management (WBEM) FAQs" at URL: http://www.dmtf.org/about/faq/wbem.

References

[1] DiDio, L., "Directory Spec Inches Forward: Standard Would Provide Central Administration," http://www.computerworld.com/news/1998/story/0,11280,30155,00.html, *Computer World*, March 16, 1998.

[2] "Directory Enabled Networks Initiative Formally Submitted to DMTF: DMTF Leverages DEN Specification to Further Define CIM Model," http://www.dmtf.org/newsroom/releases/old/1998_09_28, Press Release, DMTF, September 28, 1998.

[3] DiSabatino, J., "LDAP," http://www.computerworld.com/networkingtopics/networking/story/0,10801,68145,00.html, *ComputerWorld*, February 11, 2002.

[4] Cole-Gomolski, G., "LDAP Standard Seen Overtaking X.500," http://www.computerworld.com/news/1997/story/0,11280,4171,00.html, *ComputerWorld*, May 19, 1997.

[5] Mohammed, N., "Lightweight Directory Access Protocol (LDAP)," http://studsys.mscs.mu.edu/~nmohamme/MSCS210/final/ldap.html, Marquette University, Spring 1998.

[6] Chadwick, D. W., "Understanding X.500 – The Directory," http://www.isi.salford.ac.uk/staff/dwc/Version.Web/Contents.htm, University of Salford, U.K., 1994.

[7] Shuh, B., "Network Notes #45: Directories and X.500: An Introduction," http://www.nlc-bnc.ca/9/1/p1-244-e.html, Information Technology Services, National Library of Canada, March 14, 1997.

[8] "Common Information Model (CIM) Standards," http://www.dmtf.org/standards/cim, DMTF, March 10, 2004.

[9] Girard, K., "Desktop Management Interface," http://www.computerworld.com/hardware-topics/hardware/desktops/story/0,10801,43554,00.html, *ComputerWorld*, November 16, 1998.

[10] "DMI v.2.0 Update," http://www.dmtf.org/standards/dmi/dmiupdate.pdf, white paper, DMTF), July 1996.

[11] "DMTF Announces End of Life for DMI," http://www.dmtf.org/newsroom/newsletter/2003/06/page5, DMTF Newsletter, DMTF, June 2003.

[12] "System Management BIOS (SMBIOS) Specification," http://www.dmtf.org/standards/smbios, DMTF, March 10, 2004.

[13] "Web-Based Enterprise Management (WBEM) Initiative," http://www.dmtf.org/standards/wbem, DMTF, March 13, 2004

[14] Horwitt, E., "WBEM Just Might Make Systems Management Real. Finally!" http://www.computerworld.com/news/1999/story/0,11280,33738,00.html, *ComputerWorld*, February 1, 1999.

[15] Dryden, P., "Web Management Specs to Head-to-Head," http://www.computerworld.com/news/1996/story/0,11280,7678,00.html, *ComputerWorld*, July 29, 1996.

[16] "Web-Based Enterprise Management (WBEM) FAQs," http://www.dmtf.org/about/faq/wbem, DMTF, March 13, 2004.

[17] Connor, D., "Storage Vendors to Demonstrate Heterogeneous Management," http://www.computerworld.com/hardwaretopics/storage/story/0,10801,73153,00.html, *Network World* (reprinted by *ComputerWorld*), July 30, 2002.

CHAPTER 13

User Interface Standards

The traditional windowing system and graphical user interface standards discussed in this Chapter were developed for Unix platforms and include X Window System and Motif. With the recent popularity of the open source Linux, a Unix operating system, an open source version of Motif has also been developed that is referred to as Open Motif. These represent solid, mature standards that present sophisticated capabilities.

As industry and universities turn to the World Wide Web and Web-based capabilities become the norm for the desktop, it is anticipated that the Web-based standards will mature and either integrate Unix-compatible standards or provide capabilities like them. For user interface standards, this would mean that Web browser functionality would need to become more powerful to support capabilities similar to what X Window System and Motif provide today [1].

13.1 Motif

Name. Motif.

Purpose. To "provide a set of guidelines [for a graphical user interface] which define the way an X-Window user interface should look and feel" [2].

History. "The driving force behind Motif was to unify the graphical user interface look and feel of Unix-based software.... By having a standard look and feel which was common across many hardware platforms, users would benefit by not having to relearn how to interact with software as they moved around" [2]. Motif was originally developed in 1989 by the Open Software Foundation (OSF). OSF merged with the X/open company and became The Open Group, which currently maintains Motif.

Standards Organization. Motif is a standard graphical user interface defined by the IEEE 1295 specification that provides application developers with an "environment for standardizing application presentation" for the Unix system [3]. The Open Group maintains the Motif specification.

Status. The core components of Motif include "an extensible user interface toolkit; a stable application programming interface; a user interface language; and a window manager" [3]. Although The Open Group continues to maintain Motif, they recently developed an open source version called Open Motif that is being used by Linux vendors and developers (see Section 13.2 for details).

Obtaining the Specifications. The Open Group makes Motif available under standard Open Group software licenses and requires the payment of source code and royalty fees.

URL. The Open Group maintains information about Motif at URL: http://www.opengroup.org/desktop/motif.html.

Vendors. All major Unix platform vendors support Motif with X Window System.

Other Sources of Information.

- Fountain, A., et al., Volume 6B: Motif Reference Manual, 2nd edition O'Reilly & Associates, Cambridge, February 2000.
- Young, D. A., *The X Window System: Programming and Applications with XT, OSF/Motif*, Second Edition, Pearson Education POD, March 7, 1994.

13.2 Open Motif

Name. Open Motif.

Purpose. To provide an open source version of Motif.

History. With the rising popularity of the open source Linux operating system (a variant of Unix), The Open Group recognized a need to develop an open source version of Motif that could be used with Linux, and so they developed Open Motif.

Standards Organization. The Open Group is responsible for maintaining this standard.

Status. Open Motif source code and binaries are distributed by The Open Group royalty-free under their Public License, provided that the operating system Open Motif uses satisfies the Open Source Definition by the Open Source Initiative (see URL: http://www.opensource.org/) [4].

Obtaining the Specifications. The software for Open Motif can be downloaded at http://www.opengroup.org/openmotif/downloads.html. The Open Group requires that a license be obtained from them to use the software (http://www.opengroup.org/openmotif/license/).

URL. The Open Group maintains information about Open Motif at http://www.opengroup.org/openmotif/.

Vendors. Vendors are currently working with Open Motif to integrate it with the Linux environment.

13.3 X Window System

Name. X Window System.

Purpose. To provide high-performance, device-independent graphics user interface primitives and a display windowing environment in a distributed environment.

History. X Window System (X) was originally developed at MIT using C language and it became very popular among the Unix community [5]. The system grew out of a need to develop an application that could support window displays on multiple distributed, networked workstations for project Athena, which initially relied on Berkely Unix [5]. Work commenced on X Window System beginning in 1984 [5]. X Window System provided a device-independent basis for supporting different two-dimensional graphics applications, networked communications, a client-server model, and an interactive user interface. By 1986, X Window System source was being provided for a nominal fee to whoever requested it, and within a few years, the major Unix vendors had incorporated it into Unix and its use became widespread [5]. In 1993, MIT gave authority to enhance and distribute X to the X Consortium, a nonprofit company. Over time, the X Consortium merged with The Open Group and was renamed X.Org. X.Org left The Open Group to become an independent organization, and on January 24, 2004 became known as The X.Org Foundation.

Standards Organization. The X.Org Foundation develops and maintains the X Window System software and specifications.

Status. X Window System represents a very mature and stable windowing system for Unix platforms that is still in use. X Window System version 11 release 8 (X11R8) was available in November 2004. *ComputerWorld* indicates that "X remains the predominant thin-client standard for Linux and Unix applications" [6].

Obtaining the Specifications. The X Window System can be downloaded at http://www.x.org/Downloads.html.

URL. The X.Org Foundation maintains the information about X Window System at http://www.x.org/X11.html.

Vendors. All major Unix vendors support X Window System.

Other Sources of Information. Young, D. A., *The X Window System: Programming and Applications with XT, OSF/Motif*, Second Edition, Prentice Hall, Lebanon, Indiana POD, March 7, 1994.

References

[1] Rees, M. J., "Evolving the Browser Towards a Standard User Interface Architecture," *ACM International Conference Proceeding Series*, Third Australiasian Conference on User Interfaces – Volume 7, 2002, pp. 1–7.

[2] Lutz, D., "Motif 1.2.3 Runtime and Development System," *Linux Journal*, Vol. 1994, No. 6es, Article 16, October 1994.

[3] "Desktop Technologies – Motif," http://www.opengroup.org/desktop/motif.html, The Open Group, November 16, 2004.

[4] "Open Motif Frequently Asked Questions," The Open Group, http://www.opengroup.org/ openmotif/faq.html, November 16, 2004.

[5] Scheifler, R. W., and J. Gettys, "The X Window System," *ACM Transactions on Graphics (TOG)*, Vol. 5, No. 2, April 1986, pp. 79–109.

[6] Mitchell, R. L., "Q&A: The X Factor," http://www.computerworld.com/topics/search/results?qp=&qt=The+X+Factor&submit.x=5&submit.y=6, *ComputerWorld*, February 4, 2002.

CHAPTER 14

World Wide Web Standards

14.1 Web Markup Languages

The World Wide Web had its beginnings in ARPANET, a physical communications network sponsored by the Department of Defense's Advanced Research Projects Agency (ARPA, now named DARPA), and constructed by BBN in 1969 to connect four universities: the University of California at Los Angeles (UCLA) (http://la.ucla.edu/), the University of California at Santa Barbara (http://www.ucsb.edu/), the University of Utah (http://www.utah.edu/), and Stanford University (http://www.stanford.edu/) [1]. The objective of the network was to enable computers to connect with each other on a distributed network, and these four nodes supported the mainframe computers that hosted the communications between them [1].

In the 1970s, numerous corporate and government organizations were using different, proprietary networks, and very few were connected to each other [2]. By 1977, ARPANET had connected only 107 additional nodes, and the engineers recognized that they needed a sophisticated networking protocol if they were going to expand their network to include many more [1]. By late 1977, TCP[1] had been implemented and was demonstrated on three independent networks that connected nodes at San Francisco, London, and UCLA [1, 2]. By January 1983, all of the ARPANET networks had migrated to TCP/IP, and the Internet was born [1]. Internet users could exchange e-mail and transfer files, but there was no easy way to link to files on different nodes.

Tim Berners-Lee, a graduate from Oxford University and British consultant, worked for six months in 1980 at CERN, the Geneva, Switzerland European Particle Physics Laboratory [3, 4]. He wrote a program for his own use that he named Enquire-Within-Upon-Everything after a Victorian-era encyclopedia of that name [4]. Enquire-Within-Upon-Everything enabled him to link to different files on the system containing his notes [4]. Berners-Lee left CERN to work for another organization, and then returned to CERN in 1984 as a fellow [3]. It was not until 1989, however, that he proposed to develop a system that would build on what he had learned from his *Enquire* program, and provide CERN with a capability that would allow its international employees to link to files on geographically dispersed CERN computers and access technical details about past projects, software, organizational information, and documents [5]. In the system that Berners-Lee envisioned, there would be no centralized management or central database; the files would remain distributed and linked through a "web" of files [5].

1. Vinton Cerf (Stanford) and Bob Kahn (DARPA) are responsible for leading the development of the TCP/IP standard. More details are provided in Chapter 4.

Berners-Lee's proposal was approved. He began development in October 1990, and by August 1991 he had developed the foundational World Wide Web (WWW) technologies for the Internet: a Web browser, the HTML to build Web pages, the HTTP to exchange data, and URLs that provided links to files at their physical Web page locations [4].

In December 1991, the WWW was demonstrated at a U.S. conference and made available to the public at a FTP site [6]. While many Internet users downloaded the Web technologies, its use was limited to Unix computers and the academic and engineering research communities [7].

Marc Andreesen was a part-time employee at the National Center for Supercomputing Applications (NCSA) and an undergraduate student at the University of Illinois when the Web was introduced [7]. At the time, most of the Web browsers available were not user-friendly [7]. This motivated Marc Andreesen to extend HTML and develop a Web browser that was easier to use and could display graphics as well as text on the same page [7]. He and Eric Bina, a colleague at NCSA, worked long hours to create NCSA Mosaic, a Web browser that could display both graphics and text on the same Web page, and provide graphical buttons that could be clicked on to navigate through a set of Web pages [7]. NCSA Mosaic was introduced to the public in early 1993 and initially ran only on Unix computers [7]. Thousands of users downloaded NCSA Mosaic and began using it [7]. By spring 1993, Marc Andreesen, Eric Bina, and other NCSA employees had created NCSA Mosaic versions that ran on the PC and Macintosh [7]. Once the Web browser technologies were available on PCs and Macintoshes, users of Web technologies multiplied to hundreds of thousands.

After he graduated in 1993, Marc Andreesen formed the Mosaic Communications Corporation in 1994 with Jim Clark, who was also the founder of Silicon Graphics Inc., and together they created Netscape, which they made available to the public in 1994 [8]. They expanded the Web concepts to create Web servers that could support numerous Web pages and thousands of users [8]. The Microsoft Corporation, in turn, created Internet Explorer, and the browser wars between Netscape and Internet Explorer began. Both Netscape and Internet Explorer remain proprietary Products.[2]

In 1994, Tim Berners-Lee accepted a position at MIT where he founded the W3C at the MIT Laboratory for Computer Science (LCS) and became the Director of the W3C, a position he still holds [4]. In December 2003, Tim Berners-Lee was knighted for his invention of the Web (see the BBC URL: http://news.bbc.co.uk/1/hi/technology/3357073.stm for details).

The success of the Web continues to be phenomenal, as it extends to remote locations around the world to connect users of every nationality. The W3C continues to develop Web specifications and technologies to define more advanced capabilities.

2. Netscape browser technologies are still being developed. However, Netscape's company has undergone several acquisitions: it was purchased by AOL, and then acquired as part of the AOL acquisition by Time-Warner. For details refer to the *InfoWorld* article by J. Evers entitled "Netscape Renaissance: AOL to Release Browser Update," at URL: http://www.thestandard.com/article.php?story=20040419163612466, published April 19, 2004.

This section discusses notable markup languages provided for the Web: DSML, HTML, the eXtensible HTML (XHTML), XML, and the Wireless Markup Language (WML).

14.1.1 Directory Services Markup Language

Name. Directory Services Markup Language (DSML).

Purpose. To define data content and structure for an XML-based directory and maintain it with distributed directories [9].

History. Directory services provide electronic white pages for enterprise resources such as servers, printers, faxes, routers, and client platforms, as well as detailed information about users. For example, e-mail messaging systems typically maintain a directory of user information that includes users' physical addresses so that the systems can deliver e-mail to their proper destinations. As more and more commercial and government organizations conduct e-business services on the Internet, their need to share and exchange information stored in directories gains importance. Bowstreet Software, Inc., spearheaded development of the DSML standard in cooperation with IBM, Oracle Corporation, Sun Microsystems, and Novell [9]. On December 7, 1999, they turned over their draft DSML v1.0 specification to OASIS [9].

There were concerns about DSML v1.0 because many of the developers wanted the standard to support modification of directory entries (e.g., delete, edit) and a means for interacting with LDAP directories [10]. Hence, OASIS defined the DSML v2.0 specification to address these concerns [10].

Standards Organization. OASIS (http://www.oasis-open.org/) is responsible for maintaining this standard.

Status. The OASIS Technical Committee for DSML submitted the DSML v2.0 specifications to OASIS in November 2001, and OASIS approved it as a final version of the standard in April 2002 (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=dsml).

Obtaining the Specifications.

- The DSML v2.0 specifications can be downloaded at URL: http://xml.coverpages.org/DSMLv2-draft14.pdf.
- The DSML 2.0 XML Schema can be downloaded at URL: http://xml.coverpages.org/DSMLv2-xsd.txt.

URL. http://www.oasis-open.org/cover/dsml.html.

Vendors.

- The IBM Corporation (http://www.ibm.com) supports DSML in its Directory Server 5.1 product.
- The Microsoft Corporation offers DSML services for Windows (http://msdn.microsoft.com/library/default.asp?url=/library/en-us/dsml/dsml/about_dsml_ services_for_windows.asp).

- Novell, Inc. (http://www.novell.com/) provides DSML software using SOAP for its eDirectory software product at URL: http://developer.novell.com/dsml/. (Novell's general developer site is at URL: http://developer.novell.com/.)
- The dmsltools.org Web page provides the open source *DSML v1 Tools*, DSML Java utilities, at URL: http://www.dsmltools.org/index.html. The open source was released by Gerv Markham (http://www.xmlhack.com/read.php?item=1538). To contact him, refer to his Web page at URL: http://www.gerv.net/index.html.

Other Sources of Information.

- The OASIS URL for DSML at http://www.oasis-open.org/cover/dsml.html provides a chronology of DSML developments.
- Doug Allen discusses the features of DSML v1.0 that users considered shortfalls and which led to the development of DSML v2.0 in his article, "Emerging Technology: DSML and DEN: Signs of Things to Come," published in *Network World*, June 14, 2000, and available at URL: http://www.networkmagazine.com/shared/article/showArticle.jhtml?articleId=8702834.

14.1.2 HyperText Markup Language

Name. HyperText Markup Language (HTML).

Purpose. To develop software that could publish hypertext files on geographically dispersed computers on the Internet so that they could be accessed by users worldwide [5].

History. The term "hypertext" was coined by Ted Nelson in a presentation he gave at a national ACM conference in 1965 [12]. In the paper, Nelson described a computer system for retrieval of personal information that allowed a user to save related information in documents linked together and where an item could be retrieved by tapping a button below it [12]. Nelson described hypertext as a collection of written or pictorial material that was linked in such an elaborate manner that it was not easily presented/represented on paper, and could consist of maps, summary information, and annotations.[3] He also lamented that even though computer technologies existed to automate this kind of capability, no one had implemented it [12].[4]

It was not until Tim Berners-Lee was employed at CERN for the second time that he submitted a proposal to build a system that would implement a mechanism for connecting a web of hypertext files through links [5]. Berners-Lee patterned HTML after SGML,[5] which is an ISO standard for tags that mark plain text with functions such as bold text, underline, center, indent, and so on, and is used by word processing systems [13].

3. For those readers who obtain the paper to find the reference to "hypertext," the word does not appear until page 96, and is in the fifth paragraph.
4. Ted Nelson's paper, "Complex Information Processing: A File Structure for the Complex, the Changing and the Indeterminate," published in the *Proceedings of the 1965 20th ACM/CSC-ER National Conference*, inspired Tim Berners-Lee to invent the World Wide Web [13].
5. Refer to Chapter 5, Section 5.10 for more information on SGML.

In 1995, the IETF HTML Working Group published HTML 2.0 as an IETF RFC 1866 [14]. The RFC had been submitted by Tim Berners-Lee and D. Connolly (see URL: http://www.ietf.org/rfc/rfc1866.txt?number=1866) [14]. When the IETF HTML Working Group ended in September 1996, the W3C took responsibility for all revisions to HTML from then on [14].

Standards Organization. The W3C HTML Working Group is responsible for maintaining this specification.

Status. The HTML specifications have undergone a number of revisions. The last revision of HTML was HTML 4.0.1 [11]. Since then, HTML has been replaced by XHTML [11].

Obtaining the Specifications. The final version of HTML 4.0.1 can be downloaded at URL: http://www.w3.org/TR/html4/. Note that the HTML 4.0 specifications were approved by the ISO and the IEC as an international standard ISO/IEC 15445:2000(E), and can be downloaded at URL: http://www.cs.tcd.ie/15445/TC1.html.

URL. http://www.w3.org/MarkUp/.

Vendors. The most popular Web browsers for reading HTML Web pages are Internet Explorer from the Microsoft Corporation and Netscape, which is supported by AOL/Time Warner.

Other Sources of Information.

- The W3C hosts annual international conferences (see URL: http://www.w3.org/Conferences/Overview-WWW.html).
- Ted Nelson's paper on a hypertext system, "Complex Information Processing: A File Structure for the Complex, the Changing and the Indeterminate," can be found in the ACM's *Proceedings of the 1965 20th ACM/CSC-ER National Conference* and downloaded from the ACM Digital Library (URL: http://portal.acm.org/dl.cfm) to nonmembers for a fee.
- The original proposal that Tim Berners-Lee submitted in 1989 to CERN for the World Wide Web is entitled "Information Management: A Proposal," and can be viewed at URL: http://www.w3.org/History/1989/proposal. html.
- To contact Tim Berners-Lee for speaking engagements or for his e-mail address, he provides the URL: http://www.w3.org/People/Berners-Lee/. For his biography, refer to URL: http://www.w3.org/People/Berners-Lee/Longer. html.
- For a biography of Marc Andreesen, refer to URL: http://www.thoscp.net/biographics/andreesen_marc.htm (Web pages by Jones International and Jones Digital Century for *the History of Computing Project*). They also provide a biography of Tim Berners-Lee at URL: http://www.thocp.net/biographies/berners_lee.html.

14.1.3 Extensible HyperText Markup Language

Name. Extensible HyperText Markup Language (XHTML).

Purpose. To reformulate the HTML specifications in XML [11].

History. Web browser vendors such as Microsoft and Netscape Communications were using nonstandard tags for their HTML-based browsers, driving the browser products further and further away from the HTML standard [15]. However, at a workshop that W3C sponsored to discuss strategies for revising HTML, industry indicated that they wanted greater flexibility to create Web pages, but did not want to move away from HTML [15]. Hence, W3C decided to create a markup language that combined XML with HTML so that vendors could create style sheets that provided the ability to define special purpose tags [15]. The first version of XHTML v1.0 appeared in 2000 [11].

Standards Organization. The W3C HTML Working Group is responsible for maintaining this specification.

Status. XHTML 1.1 is considered by W3C to be the current version of XHTML. It defines a modularized form of XHTML that eliminates frames and sets the stage for extending the modules to support mobile and other kinds of computers [11].

Obtaining the Specifications.

- The XHTML 1.1 specification can be downloaded at URL: http://www.w3.org/TR/xhtml11/.
- The XHTML 1.0 specification can be downloaded at URL: http://www.w3.org/TR/xhtml1/.

URL. http://www.w3.org/MarkUp.

Vendors. While a small number of vendor products support XHTML, it has not yet captured the HTML market. A partial list of products include:

- The Microsoft Corporation provides a converter from HTML to XHTML that allows the end result to be edited by the InfoPath 2003 Software Development Kit (SDK) as an InfoPath form (see URL: http://msdn.microsoft.com/library/default.asp?url=/library/en-us/ipsdk/html/ipsdkusingthehtml toxhtmltool.asp).
- Sun Microsystems provides a listing of third-party products that lists Global Business Solutions as providing the *Webstation* product that supports XHTML, but makes no warranty about its capabilities. Refer to Sun's URL at: http://solutions.sun.com/NASApp/catalogs/en/US/adirect/sun?cmd=detai for details.
- Nokia supports XHTML for mobile computing (see URL: http://press.nokia.com/PR/200109/834257_5.html).
- Belus Technology, a Canadian firm, provides the XStandard Editor for XHTML 1.1 (see URL: http://belus.com/default.asp).

Other Sources of Information.

- The W3C hosts annual international conferences (see URL: http://www.w3.org/Conferences/Overview-WWW.html).

14.1.4 eXtensible Markup Language

Name. eXtensible Markup Language (XML).

Purpose. To define a markup language for the Web based on the ISO standard SGML [16].

History. Development of XML began in 1996 to provide greater flexibility in developing Web pages [16]. It began as a W3C SGML Working Group activity led by Jon Bosak of Sun Microsystems, and its intent was to create a markup language that would support "SGML on the Web," to enable the creation of SGML-like document types (stylesheets) that would operate as templates, facilitating their design and maintenance for the Web, and enabling the content to be maintained separately and easily updated [16]. The W3C SGML Working Group completed the first recommended XML 1.0 specification in December 1997, and it was approved in February 1998 [17].

Standards Organization. The W3C XML Core Working Group (http://www.w3.org/XML/Core/) is responsible for maintaining the XML specifications.

Status. The XML standard has become very popular, since it facilitates content management of Web pages. A number of standards consortia, such as the OMG, are developing XML-based standards to support their initiatives (e.g., OMG has defined the XMI for its metadata repositories—see URL: http://www.omg.org/technology/documents/formal/xmi.htm for details). There are now a number of W3C Working Groups devoted to developing and expanding XML:

- The XML Coordination Group coordinates the XML Working Groups and other groups of W3C [19].
- The XML Core Working Group maintains the XML specification [19].
- The XSL Working Group maintains the Extensible Stylesheet Language (XSL) [19].
- The XML Binary Characterization Working Group studies the need for a binary interchange format [19].
- The XML Query Working Group is developing a XML Query Language for Web documents [19].
- The XML Schema Working Group describes mechanisms for defining XML schemas [19].

Obtaining the Specifications. The XML specifications can be downloaded at URL: http://www.w3.org/XML/Core/#Publications.

URL. http://www.w3.org/XML/. In addition, the XML.Org organization formed by OASIS maintains information on XML at URL: http://www.xml.org/.

Vendors. Major vendors such as Sun Microsystems (http://www.sun.com/), IBM (http://www.ibm.com), Microsoft Corporation (http://www.microsoft.com), and Hewlett-Packard (http://www.hp.com/) support XML in their products.

Other Sources of Information.

- The initial Working Draft for XML is dated November 14, 1996 and can be found at URL: http://www.w3.org/TR/WD-xml-961114.html#sec1.1.
- W3C hosts a "Development History of XML" at URL: http://www.w3.org/XML/hist2002.
- W3C is sponsoring a XML Query project that is seeks to develop flexible query facilities that will extract and manipulate data from documents on the Web. Details can be found at URL: http://www.w3.org/XML/Query.
- Peter Flynn provides a XML FAQ Web page hosted at University College Cork, Ireland, at URL: http://www.ucc.ie/xml/ that he formerly maintained for the W3C XML Special Interest Group.
- O'Reilly Media (http://www.oreilly.com/oreilly/about.html/) is a company that provides technical books, conferences, and information about XML events and vendor products at URL: http://xml.oreilly.com/.

14.1.5 Wireless Markup Language Specification

Name. Wireless Markup Language (WML) Specification.

Purpose. To define a language based on XHTML that would support wireless applications for mobile devices [20].

History. The WAP Forum defined the WAP architecture and family of specifications for mobile devices such as PDAs in the late 1990s [21]. The WAP Forum developed WML for WAP beginning in the early 2000s [21]. The WAP Forum and Open Mobile Architecture Initiative merged as the Open Mobile Alliance in 2002, and the OMA continues to refine and develop the specifications.

Standards Organization. OMA (http://www.openmobilealliance.org/) is responsible for maintaining this specification.

Status. The OMA continues to refine WML. The current version is WML 2.0, and it supports the WAP 2.0 specification [21].

Obtaining the Specifications. The WML specifications can be found on the OMA Web page at URL: http://www.openmobilealliance.org/tech/affiliates/wap/ wapindex.html by selecting the archive link for technical WAP specifications, then searching for "WML" on the Web page that appears. Next, an OMA "Use Agreement" Web page will be displayed after selecting the WML specifications, and the specifications will be displayed if you indicate that you agree to their use requirements in the link at the bottom of the page.

URL. http://www.oasis-open.org/cover/wap-wml.html. The OMA does not support a Web page that provides the public with a status of WML. The URL shown here is supported by OASIS, and OASIS does not guarantee that the information is accurate, although useful links are provided.

Vendors. The founders of the WAP Forum, Ericsson Telephone Company (http://www.ericsson.com), Nokia (http://www.nokia.com), and Motorola (http://

www.motorola.com) support WAP and WML for mobile devices on what they refer to as the mobile Internet.

Other Sources of Information. The Roseindia Web site provides a tutorial on WAP and developing WAP applications in WML at URL: http://www.roseindia.net/wap/index.shtml.

14.2 Web Protocols

Each of the specifications described below define the rules for exchanging data and messages in a Web environment: HTTP, Secure HTTP (S-HTTP) for encrypted communications, SOAP for XML-based application messaging, and WAP for mobile devices.

14.2.1 HyperText Transfer Protocol

Name. HyperText Transfer Protocol (HTTP).

Purpose. To define the rules for exchanging data to enable a Web browser (client) to access HTML Web pages on the Internet and display them [4].

History. Tim Berners-Lee invented the first versions of a Web browser, HTML, and HTTP, which became the foundation for the World Wide Web technologies that he introduced on the Internet in 1991 [4]. Berners-Lee, R. Fielding, and H. Frystyk submitted a specification for the "Hypertext Transfer Protocol — HTTP/1.0" to the IETF, which approved it in 1996 (see RFC 1945, URL: http://www.ietf.org/rfc/rfc1954.txt?number=1954). The IETF formed an HTTP Working Group that worked with W3C for a number of years to continue to refine the HTTP specifications.

Standards Organization. The IETF HTTP Working Group (http://ftp.ics.uci.edu/pub/ietf/http/) was responsible for maintaining this standard, but it is no longer active.

Status. HTTP 1.1 (RFC 2616) is considered a stable standard (see "Press Release" at http://www.w3.org/1999/07/HTTP-PressRelease) [22].

Obtaining the Specifications. The family of HTTP specifications can be found on the W3C site at URL: http://www.w3.org/Protocols/.

URL. The IETF provides information about HTTP at URL: http://ftp.ics.uci.edu/pub/ietf/http/, and the W3C provides information at URL: http://www.w3.org/Protocols/.

Vendors. Vendors have implemented Web servers that communicate with Web clients using HTTP. There are many vendor products available today. Netscape (now AOL Time/Warner), Microsoft, Sun Microsystems, and IBM support Web servers and clients for HTTP, to name just a few.

Other Sources of Information.

- Tim Berners-Lee authored a book called *Weaving the Web*, published in 1999, that chronicles the beginnings of the World Wide Web. An overview of the book is provided at URL: http://www.w3.org/People/Berners-Lee/Weaving/Overview.html.
- The W3C hosts annual international conferences (see URL: http://www.w3.org/Conferences/Overview-WWW.html).

14.2.2 Simple Object Access Protocol

Name. Simple Object Access Protocol (SOAP).

Purpose. To define a protocol that enables XML-based messages that contain application instructions to be sent, executed, and received between systems (e.g., servers and clients) on the Internet.

History. Development of SOAP began in 1998 when XML 1.0 became a W3C Recommendation [23].[6] Microsoft and IBM played a key role in its development [23]. Progress was slow and difficult, especially since SOAP needed XML schema and a schema language as a foundational element, and enough of this had been developed by the XML Schema Working Group to enable the SOAP specification to be published in the fourth quarter of 1999, but it continued to evolve in 2000 [23]. In 2001, the XML Schema stabilized, and SOAP matured between 2001 and 2003 so that SOAP version 1.2 became a W3C Recommendation [24].

Standards Organization. The W3C XML Protocol Working Group (http://www.w3.org/2000/xp/Group/) is responsible for maintaining the specifications.

Status. SOAP v1.2 is the current version. SOAP is very popular and widely used for XML messaging.

Obtaining the Specifications. The specifications for SOAP can be downloaded at URL: http://www.w3.org/2000/xp/Group/. There is additional information on SOAP available at URL: http://www.w3.org/TR/soap/.

URL. http://www.w3.org/2000/xp/Group/.

Vendors. Vendors have implemented Web servers that communicate with Web clients using SOAP. There are many vendor products available today. Microsoft, Sun Microsystems, and IBM support SOAP, to name just a few.

Other Sources of Information. Uche Ogbuji, a consultant from Fourthought, Inc., authored "An Introduction to WSDL for SOAP programmers," dated November 1,

6. A W3C Recommendation has undergone a comprehensive process where a proposed specification has moved from the entry level as a Working Draft Recommendation through a consensus-based process to a Candidate Recommendation, and then a Proposed Recommendation, and finally a W3C Recommendation, once it has been endorsed by the W3C members and the Director. See Chapter 2 section 2.2.2 or URL: http://www.w3.org/2004/ 02/Process-20040205/tr.html#maturity-levels for details.

2000, which IBM hosts on their Web site at URL: http://www-106.ibm. com/developerworks/library/ws-soap/?dwzone=ws#soapfig1.

14.2.3 Wireless Application Protocol

Name. Wireless Application Protocol (WAP).

Purpose. To define rules for wireless applications to communicate with the Internet [20].

History. The WAP Forum defined the WAP architecture and family of specifications for mobile devices such as PDAs in the late 1990s [21]. The WAP Forum and the OMAOpen Mobile Architecture Initiative merged as the Open Mobile Alliance in 2002, and the OMA continues to refine and develop the standards.

Standards Organization. The OMA (http://www.openmobilealliance.org/) is responsible for maintaining the specifications.

Status. The OMA continues to refine the family of WAP specifications. The current version is WAP 2.0 [21].

Obtaining the Specifications. The WAP family of specifications can be found on the OMA Web page at URL: http://www.openmobilealliance.org/tech/affiliates/wap/wapindex.html by selecting the archive link for technical WAP specifications, then searching for "WAP" on the Web page that appears. Next, an OMA "Use Agreement" Web page will be displayed after selecting the WML specifications, and the specifications will be displayed if you indicate that you agree to their use requirements in the link at the bottom of the page.

URL. No official WAP site is provided for public use.

Vendors. The founders of the WAP Forum, Ericsson Telephone Company (http://www.ericsson.com), Nokia (http://www.nokia.com), and Motorola (http://www.motorola.com) support WAP and WML for mobile devices on what they refer to as the mobile Internet.

Other Sources of Information. The nonprofit IEC provides free Web-based tutorials after registering at URL: http://www.iec.org/online/tutorials/ for the communications and information industries, including WAP. One of the tutorials is entitled "Wireless Application Protocol" and is available at URL: http://www.iec.org/online/tutorials/acrobat/wap.pdf.

14.3 Web Services

Web Services are seen as the foundation for secure B2B and enterprise applications and transactions on the Internet, and they are being developed in tandem to support e-business [25]. While this chapter has discussed markup languages and protocols for the Web, the standards do not go far enough to provide a foundation for B2B applications. The W3C was concerned that unless the Web Services were defined to provide foundational, interoperable services for all platforms and languages, vendors would continue developing incompatible implementations of Web Services. Hence, W3C initiated a Web Services Activity with four Working Groups and one Interest Group to develop concepts and standards that will become the basic building blocks in a distributed, worldwide network of Web services [26]. These groups include the following [26]:

- A Web Services Architecture Group (http://www.w3.org/2002/ws/arch/) was established to define requirements and a reference model for Web Services [27]. It concluded in January 2004, when it accomplished its objective [27].
- The XML Protocol Working Group (http://www.w3.org/2000/xp/Group/) has as its objective to "create simple protocols that can be ubiquitously deployed and easily programmed through scripting languages, XML tools, interactive Web development tools, etc." [28]. It is responsible for defining and extending SOAP (see Section 14.2.3).
- The Web Services Description Working Group (http://www.w3.org/2002/ws/desc/) is defining the Web Services Description Language (WDSL) (http://www.w3.org/TR/2004/WD-wsdl20-20040803/).
- The Web Services Choreography Working Group (http://www.w3.org/2002/ws/chor/) is defining a Web Services Choreography Description Language (WS-CDL) that describes the relationships between lower level Web Services (http://www.w3.org/2003/01/wscwg-charter).
- The Semantic Web Services Interest Group (http://www.w3.org/2002/ws/swsig/) is exploring how to develop and implement the Semantic Web technologies that Tim Berners-Lee envisions as future Web Services [29].

The Web Services Architecture Group defined a Web Services Architecture Stack that describes the foundational Web Services building blocks (see Figure 14.1) [27]. Standards to implement these Web Services are still under development.

Each of the boxes in the Web Services Architecture Stack represents a category of Web Services. Central to supporting the processes, descriptions, and messages categories are the base technologies, which provide XML, Data Type Definitions (DTD), and schema as the basis for exchanging data using a standard format and structure [27].

The processes category includes discovery, aggregation, and choreography services [27]. Discovery finds other Web Services through a registry. Aggregation describes the resources (e.g., objects such as application functions), their relationships, and how they are represented. Choreography coordinates how transactions are to be conducted (i.e., choreographed) between the resources [27]. The UDDI specification (see Section 14.3.2) would belong to this category because it provides a universal registry that enables Web Service providers to publish the services that they have implemented on the Web [27]. UDDI supports three kinds of directories:

- *White pages:* contact information for a business (e.g., name, phone number, URLs) [30];
- *Yellow pages:* description of the Web Service a business provides [30];
- *Green pages:* technical details necessary to invoke a Web Service [30].

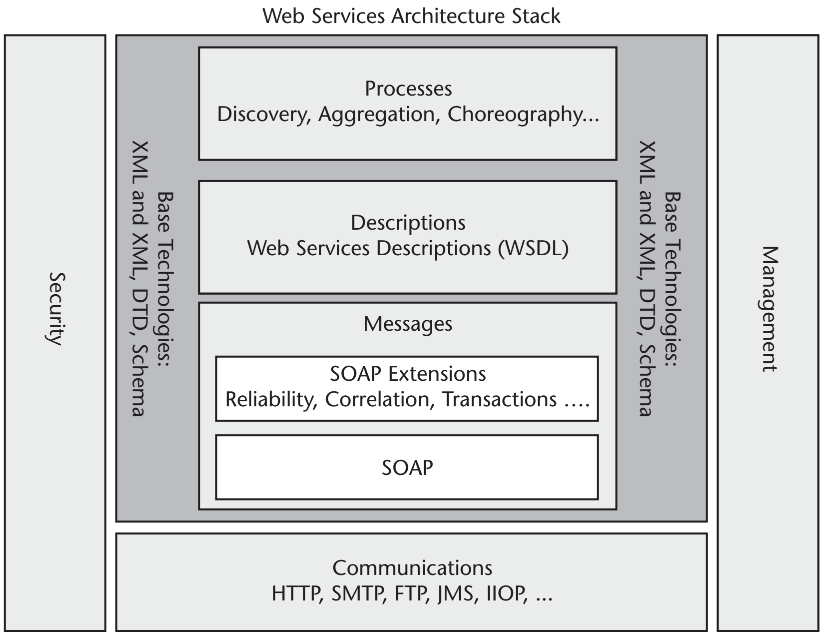

Figure 14.1 Web Services Architecture Stack. (*From:* [27]. Copyright © 2004 World Wide Web Consortium (Massachusetts Institute of Technology, European Research Consortium for Informatics and Mathematics, Keio University). All Rights Reserved. http://www.w3.org/Consortium/Legal/2002/copyright-documents-20021231.)

WS-CDL, a relatively new specification, would also belong to the processes category because it provides the "rules of engagement" for the required sequence of interactions (choreography) between different Web Services [31]. WS-CDL provides a means for defining how a Web Service will interact with other Web provider services and client (customer) services to conduct business transactions [31].

The descriptions category defines Web Service interfaces, and the WSDL shown for this category describes what a particular Web Service is designed to accomplish, where it is located, and how it is invoked [30]. WSDL provides a template that defines elements of a Web service, such as its data type definitions, messages, operations to be performed, bindings, ports (e.g., network address), and functions (services) [30].

The messages category defines how the Web Service messages are to be reliably exchanged between systems, with guaranteed delivery [27]. The SOAP standard shown for this category defines the protocol and remote procedure calls, and enables messages to be sent and received, relying on a protocol like HTTP for delivery [30].

The communications category represents transport services over TCP/IP, such as HTTP, SMTP, and the IIOP supported for applications of CORBA [27].

Finally, the security and management categories provide consistency, currency control, data integrity, and security for Web Services [27]. Standards for these categories are emerging: SAML would belong to the security category because it uses XML to define a framework for Web Services to exchange security information, and the XML Key Management Specification (XKMS) would as well, because it enables a client service to obtain a key from a Web Service.

Today, a number of products have been implemented that rely on UDDI yellow pages to find a Web Service and on UDDI green pages to bind to it; WSDL to define the Web Services; SOAP to encapsulate the WSDL templates and provide the handshaking protocol to send and execute the Web Service messages; and HTTP for delivery [32]. In addition, a Web Services Interoperability Organization (WS-I) has been established to promote interoperability of Web Services products across computing platforms (hardware and software), operating systems, and languages (see URL: http://www.ws-i.org/ for details).

This section covers the Semantic Web, UDDI, WSDL, WS-CDL, SAML, and XKMS in greater detail.

14.3.1 Semantic Web

Name. Semantic Web.

Purpose. To define future Web Services that use software agents to provide relevant information or accomplish appropriate actions using semantic reasoning [33].

History. Tim Berners-Lee, W3C Director and inventor of the World Wide Web, presented a vision and preliminary concepts for a Semantic Web as the next generation of Web Services as early as 2000 [34]. The means for searching Web content today is rudimentary at best: keywords, substrings, and predefined menus. The Semantic Web would provide a URI where an identifier would be used not only for Web sites, but for Web objects such as users, documents, files, relationships between information, and so on, and provide the basis for developing more sophisticated links [33]. Semantic Web languages and ontologies would be based on XML and XML artifacts (e.g., schema, namespaces) and would form the basis for automated reasoning using semantic structures that linked to URIs [33].

This next generation of Web Services will structure and relate Web information so that software agents will be able to provide more sophisticated and complex capabilities, which is especially important for improving Web-based B2B capabilities. As an example of how the Semantic Web might work, suppose you were going on a business trip to Chicago that required you to stay overnight. The Semantic Web would provide you with a software agent to help you work through the process of booking a flight. The software agent would first book a flight that attempted to satisfy your requirements, and would recognize—without being asked—that you might want to make a hotel reservation for the night and rent a car as well. The software agent would coordinate with you to make those additional reservations if you required them. You would no longer need to make three separate reservations yourself.

Standards Organization. The W3C Semantic Web Interest Group (http://www.w3.org/2002/ws/swsig) is responsible for defining the Semantic Web.

Status. The Resource Description Framework (RDF) and the OWL Web Ontology Language have been developed for the Semantic Web and approved as W3C Recommendations. The family of RDF specifications (http://www.w3.org/ RDF/) builds on XML and the concept of URI to define a vocabulary description language.

The OWL Web Ontology Language (http://www.w3.org/TR/2004/REC-owl-ref-20040210/) extends RDF so that ontologies can be published on the Web and shared with other users.

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.w3.org/2001/sw/.

URL. http://www.w3.org/2001/sw/.

Vendors. DARPA is funding the development of tools for the Semantic Web.

Other Sources of Information.

- The Charter for the Semantic Web Interest Group is at URL: http://www.w3.org/2003/10/swsig-charter.
- Tim Berners-Lee, James Hendler, and Ora Lassila coauthored "The Semantic Web," published in *Scientific American* on May 17, 2001, and available at URL: http://www.sciam.com/print_version.cfm?articleID=00048144-10D2-1C70-84A9809EC588EF21.
- Ayesha Malik wrote an article entitled "XML, Ontologies, and the Semantic Web," published by *XML Journal* in 2004. It elaborates on how the Semantic Web might work and can be viewed at URL: http://www.sys-con.com/xml/articleprint.cfm?id=577.

14.3.2 Universal Description, Discovery, and Integration

Name. Universal Description, Discovery, and Integration (UDDI).

Purpose. To provide a universal registry that enables Web Service providers to publish the services that they have implemented on the Web [27].

History. UDDI began as an industry effort in 2000 by Ariba, Inc., IBM, Microsoft Corporation, and more than 30 other companies [35]. UDDI is designed as a registry service to publish information about companies and their Web Services, is based on XML, and works with SOAP and HTTP [35]. On July 2002, the UDDI specification was submitted to OASIS [35].

Standards Organization. The OASIS UDDI Specification Technical Committee (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=uddi-spec) is responsible for this specification.

Status. OASIS has published UDDI specification version 3.

Obtaining the Specifications. The specifications for UDDI can be downloaded at URL: http://www.oasis-open.org/committees/uddi-spec/tcspecs.shtml#uddiv2 or URL: http://www.uddi.org/specification.html#specification.

URL. http://www.uddi.org/.

Vendors. In August 2003, the UDDI Universal Business Registry (UBR) Operators Council (http://www.oasis-open.org/cover/uddi.html) announced beta nodes for

UDDI: Microsoft Corporation (http://uddi.microsoft.com/), IBM (https://uddi.ibm.com/ubr/registry.html), NTT Communications, and SAP.

Other Sources of Information.

- OASIS provides a Web page with links to UDDI best practices and technical notes at URL: http://www.uddi.org/specification.html#specification.
- WebServices.org (http://www.webservices.org) provides a number of articles discussing Web Services standards and vendor products. It also provides information about industry events and a bulletin board so that software developers and others can post questions for experienced Web Services developers. WebServices.org is a privately owned, vendor-neutral organization. Access to its articles is free of charge after providing information (e.g., name, e-mail address, country of residence) to become a member.
- O'Reilly Media (http://www.oreilly.com/oreilly/about.html/) is a company that provides technical books, conferences, and information about Web Services events, vendor products, and developing Web Services at URL: http://webservices.xml.com.

14.3.3 Web Services Description Language

Name. Web Services Description Language (WSDL).

Purpose. To define a language based on XML that describes the interfaces, protocol bindings, and deployment details of Web Services [36].

History. In the late 1990s, a number of vendors wanted to develop middleware that would enable remote machines to execute XML-based service requests over the Internet [37]. Vendors included Allaire Corporation's Web Distributed Data eXchange (WDDX); UserLand, Inc.'s XML Remote Procedure Call (XML-RPC); and Microsoft's SOAP developed by IBM, Microsoft, and others [37]. IBM, Ariba, and Microsoft then combined their efforts to define the WSDL in September 2000 [37]. In March 2001, Microsoft and IBM submitted the specification to W3C (see http://www.w3.org/TR/wsdl), and W3C undertook its development from then on.

Standards Organization. The W3C Web Services Description Working Group (http://www.w3.org/2002/ws/desc/) has responsibility for maintaining this specification.

Status. The current version of the WSDL specification is version 2.0, Parts 1–3, which has been published as a Working Draft.

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.w3.org/2002/ws/desc/.

URL. The OASIS organization provides information about WSDL at URL: http://xml.coverpages.org/wsdl.html#urls.

Vendors. Vendors include IBM Corporation (http://www.ibm.com/), Microsoft Corporation (http://www.microsoft.com/), and Novell, Inc. (http://www.novell. com/).

Other Sources of Information.

- Uche Ogbuji, a consultant from Fourthought, Inc., authored "An Introduction to WSDL for SOAP Programmers," dated November 1, 2000, which IBM hosts on their Web site at URL: http://www-106.ibm.com/developerworks/library/ws-soap/?dwzone=ws#soapfig1.
- WebServices.org (http://www.webservices.org) provides a number of articles discussing Web Services standards and vendor products. It also provides information about industry events and a bulletin board so that software developers and others can post questions for experienced Web Services developers. WebServices.org is a privately owned, vendor-neutral organization. Access to its articles is free of charge after providing information (e.g., name, e-mail address, country of residence) to become a member.
- O'Reilly Media (http://www.oreilly.com/oreilly/about.html/) is a company that provides technical books, conferences, and information about Web Services events, vendor products, and developing Web Services at URL: http://webservices.xml.com.

14.3.4 Web Services Choreography Description Language

Name. Web Services Choreography Description Language (WS-CDL).

Purpose. To define the "rules of engagement" for the required sequence of interactions (choreography) between different Web Services [31].

History. In April 2001, W3C hosted a Workshop on Web Services where it became apparent that a number of vendors were developing languages that would support e-business transactions on the Web, but their approaches appeared to be leading to incompatible solutions (see URL: http://www.w3.org/2001/01/WSWS for details) [41]. Vendor products included:

- BPMI.org had developed BPML (URL: http://www.bpmi.org/bpml.esp) [38].
- OASIS had defined Business Process Specification Schema for ebXML (URL: http://www.ebxml.org/specs/ebBPSS.pdf) [38].
- IBM had defined the Web Services Flow Language (WFSL) (URL: http://www-4.ibm.com/software/solutions/webservices/pdf/WSFL.pdf) [38].
- Microsoft had defined XLANG Web Services for Business Processes (URL: http://www.gotdotnet.com/team/xml_wsspecs/xlang-c/default.htm) [38].
- IBM, Microsoft, and BEA had defined BPEL4WS (URL: http://www-106.ibm.com/developerworks/library/ws-bpel/) [38].

The number of different solutions demonstrated the industry need for a choreography language for business-based Web Services [38]. This need led the W3C to form a Web Services Choreography Working Group with the charter of defining a choreography language that the vendors could use to support lower level services [38]. The Group is now defining WS-CDL, which will support peer-to-peer collaborations between Web Services and define ordered message exchanges to accomplish a business objective [39]. A choreography language prevents deadlocks where Web Service processes wait for each other to act, remaining in a wait mode; livelocks where processes continue to try to interact, but the behaviors are not recognized, so the processes appear to hang; or leaks where an unauthorized process tries to interfere with the coordination of authorized processes [39].

Standards Organization. The W3 Web Services Choreography Working Group (http://www.w3.org/2002/ws/chor/) is responsible for defining WS-CDL.

Status. As of April 2004, WSDL Version 1.0 had been published as a W3C Initial Public Working Draft [39].

Obtaining the Specifications. The WS-CDL specifications can be downloaded at URL: http://www.w3.org/2002/ws/chor/.

Vendors. Since WS-CDL is still being defined, there are no known vendor products at this time.

Other Sources of Information.

- WebServices.org (http://www.webservices.org) provides a number of articles discussing Web Services standards and vendor products. It also provides information about industry events and a bulletin board so that software developers and others can post questions for experienced Web Services developers. WebServices.org is a privately owned, vendor-neutral organization. Access to its articles is free of charge after providing information (e.g., name, e-mail address, country of residence) to become a member.
- O'Reilly Media (http://www.oreilly.com/oreilly/about.html/) is a company that provides technical books, conferences, and information about webservices events, vendor products, and developing Web Services at URL: http://webservices.xml.com.

14.3.5 Security Assertion Markup Language

Name. Security Assertion Markup Language (SAML).

Purpose. To define an XML-based framework for user authentication, entitlements, and user attributes so that business entities can make assertions regarding the identity, attributes, and entitlements of a user [40].

History. In 2000, an OASIS Technical Committee for Security Services was formed to define security services for authentication and authorization for Web-based e-business services [41]. It began its efforts by reviewing the Security Services Markup Language (S2ML) specification that Netegrity and its partner had defined, and then determining what was necessary to support a SAML [41]. In November 2002, SAML version 1.0 was published as a standard [42]. The OASIS Security Services Technical Committee continues to evolve the specifications for SAML to support additional security services.

Standards Organization. The OASIS Security Services Technical Committee (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security) is responsible for maintaining the SAML specifications.

Status. As of September 2004, version 2 of the family of SAML specifications was published as a Committee Draft (http://xml.coverpages.org/ni2004-07-15-a.html).

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security.

URL. http://xml.coverpages.org/saml.html. Additional information is provided at URL: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security and URL: http://xml.coverpages.org/ni2004-08-19-a.html.

Vendors. A partial list of vendors includes:

- Sun Microsystems (http://www.sun.com/);
- RSA Security (http://www.rsasecurity.com/);
- OpenSAML (http://www.opensaml.org/) is a free toolkit but may require a license from RSA Security to use it.

14.3.6 XML Key Management Specification

Name. XML Key Management Specification (XKMS).

Purpose. To define an XML-based protocol that enables a client application to get public key information (e.g., certificate) [43].

History. In early 2000, VeriSign, Inc., proposed development of a XML-based standard that would support security services for digital signature handling and encryption on the Web so that these capabilities would not need to be supported independently by individual applications [44]. VeriSign, Inc., worked with the Microsoft Corporation and WebMethods, Inc., to define what they named the XKMS, and they released it in November 2000 [44]. They defined XKMS to work with SOAP and WSDL. On March 30, 2001, they submitted the XKMS specification to W3C (http://www.w3.org/TR/2001/NOTE-xkms-20010330/), and W3C undertook its development as a W3C specification.

Standards Organization. The W3C XML Key Management Working Group (http://www.w3.org/2001/XKMS/) is responsible for defining this specification.

Status. The WC3 XML Key Management Working Group is actively refining the specification. It is currently a W3C Candidate Recommendation [43].

Obtaining the Specifications. The specifications can be downloaded at URL: http://www.w3.org/TR/xkms/.

URL. http://www.w3.org/TR/xkms/.

14.4 Other Web Developments

This section covers the Web-based Distributed Authoring and Versioning (WebDAV) and provides references to other chapters that cover WBEM and the three-dimensional visualization languages (VRML and X3D).

14.4.1 Virtual Reality Modeling Language

VRML defines a language that is used to create three-dimensional environments on the WWW. Refer to Chapter 8, Section 8.5 for more information.

14.4.2 Web-Based Enterprise Management

DMTF (http://www.dmtf.org) is responsible for maintaining the WBEM architecture, concepts, and standards. See Section 12.2.5 for a detailed description.

14.4.3 Web-Based Distributed Authoring and Versioning

Name. Web-Based Distributed Authoring and Versioning (WebDAV).

Purpose. To extend the capabilities of HTTP to enable remote users to author, share, and update documents on the Web [45].

History. WebDAV was proposed as a standard in 1996 [45]. IETF published it in February 1999 as RFC 2518 [45]. In March 2002, RFC 3523 was published to support versioning [45].

Standards Organization. The IETF (http://www.ietf.org) is responsible for advancing this specification.

Status. WebDAV enables remote users to create and share a collection of documents on the Web; create and update metadata for the documents; lock/unlock documents while making changes; and edit, delete, copy, and move documents [45].

Obtaining the Specifications. The current proposed specification can be downloaded at URL: http://www.ietf.org/rfc/rfc3744.txt.

URL. http://www.webdav.org/.

Vendors. WebDAV is available on Microsoft Corporation Windows operating systems and Internet Information Server (http://www.microsoft.com), Novell's Netware (http://www.novell.com), Apple Computer's Macintosh Operating System X (http://www.apple.com), the Apache servers (http://www.apache.org), Documentum, Inc., (http://www.documentum.com/), Vignette Corporation (http://www.vignette.com/), and BroadVision, Inc. (http://www.broadvision.com/)[45].

Other Sources of Information.

- WebServices.org (http://www.webservices.org) provides a number of articles discussing Web Services standards and vendor products. It also provides information about industry events and a bulletin board so that software developers and others can post questions for experienced Web Services developers. WebServices.org is a privately owned, vendor-neutral organization. Access to its articles is free of charge after providing information (e.g., name, e-mail address, country of residence) to become a member.

14.4.4 X3D

X3D supersedes VRML and defines a language that enables interactive, three-dimensional graphics to be created, deployed, and broadcast on the Web. Refer to Chapter 8, Section 8.6 for more information.

References

[1] Ruthfield, S., "The Internet's History and Development: From Wartime Tool to Fish-Cam," *Crossroads*, New York: ACM Press, Vol. 2, No. 1, September 1995, pp. 2–4.

[2] Hartley, S., "History of the Internet: TCP/IP," http://www.orangepeel.com/newOP /en/internet/shortHistory.php?tcp, Orange Peel, Canada, May 2002.

[3] Berners-Lee, T., "Tim Berners-Lee: Longer Bio," http://www.w3.org/People/Berners-Lee/Longer.html, W3C, 2001

[4] Quittner, J., "Tim Berners-Lee: Scientists and Thinkers," http://www.time.com/time/time100/scientist/profile/bernerslee.html, *Time*, 2003.

[5] Berners-Lee, T., "Information Management: A Proposal," http://www.w3.org/History/1989/proposal.html, proposal to CERN, May 1989.

[6] Connelly, D., "A Little History of the World Wide Web from 1945 to 1995," http://www.w3.org/History.html, W3C, 2000.

[7] "Inventor of the Week Archive: Eric Bina and Marc Andreesen Internet Browser Technology," http://web.mit.edu/invent/iow/andreesen=bina.html, Massachusetts Institute of Technology (MIT) School of Engineering, MIT, January 2001.

[8] Griffin, S., "Internet Pioneers: Marc Andreesen," http://www.ibiblio.org/pioneers/andreesen.html, University of North Carolina, North Carolina, May 2000.

[9] McGeever, C., "Directory Services Markup Language," http://www.computerworld.com/news/2000/story/0,11280,44416,00.html, *ComputerWorld*, April 10, 2000.

[10] Allen, D., "Emerging Technology: DSML and DEN: Signs of Things to Come," http://www.networkmagazine.com/shared/article/showArticle.jhtml?articleId=8702834, *Network World*, June 14, 2000.

[11] "HyperText Markup Language (HTML) Home Page," http://www.w3.org/MarkUp/, W3C, MIT, July 22, 2004.

[12] Nelson, T. H., "Complex Information Processing: A File Structure for the Complex, the Changing and the Indeterminate," *Proceedings of the 1965 20th ACM/CSC-ER National Conference*, Association for Computing Machinery, ACM Press, New York, 1965 pp. 84–100.

[13] "What Is HyperText," http://www.w3.org/WhatIs.html, W3C, September 5, 2004.

[14] Connolly, D., and L. Masinter, "The 'text/html' Media Type," http://www.ietf.org/rfc/rfc2854.txt?number=2854, Internet Engineering Task Force (IETF), June 2000.

[15] Schwartz, M., "Spreading the Word on XHTML," http://www.computerworld.com/managementtopics/ebusiness/story/0,10801,45951,00.html, *ComputerWorld*, June 19, 2000.

[16] Bray, T., and C. M. Sperberg-McQueen, "Extensible Markup Language (XML): W3C Working Draft 14-Nov-96," http://www.w3.org/TR/WD-xml-961114.html#sec1.1, W3C, November 14, 1996.

[17] "W3C Issues XML1.0 as a Proposed Recommendation," http://www.w3.org/Press/XML-PR, Press Release, W3C, December 8, 1997.

[18] "XML Core Working Group Home Page," http://www.w3.org/XML/Core/, August 20, 2004.

[19] "Extensible Markup Language," http://www.w3.org/XML, W3C, August 27, 2004.

[20] *Wireless Markup Language Version 2.0: Wireless Application Protocol WAP-238-2ML-20010911-a*, WAP Forum, The Open Mobile Alliance, September 11, 2001.

[21] Seth, H., "Evolution of the Wireless Web – WAP 2.0," http://www.computerworld.com/news/2001/story/0,11280,63550,00.html, *ComputerWorld*, September 5, 2001.

[22] "HTTP – Hypertext Transfer Protocol," http://www.w3.org/Protocols/#Specs, W3C, September 6, 2004.

[23] Box, D., "A Brief History of Soap," http://webservices.xml.com/pub/a/ws/2001/04/04/soap.html, XML.com, O'Reilly Webservices, April 4, 2001.

[24] Silwa, C., "W3C Finalizes SOAP 1.2 Standard," http://www.computerworld.com/developmenttopics/websitemgmt/story/0,10801,82497,00.html, *ComputerWorld*, June 25, 2003.

[25] Kreger, H., "Fulfilling the Web Services Promise," *Communications of the ACM*, ACM, Vol. 46, No. 6, June 2003, pp. 29–34.

[26] "Web Services Activity," http://www.w3.org/2002/ws, W3C, September 6, 2004.

[27] "Web Services Architecture: W3C Group Note 11 February 2004," http://www.w3c.org/TR/ws- arch/#gwsasd, W3C, February 1, 2004.

[28] "XML Protocol Working Group Charter," http://www.w3.org/2004/02/XML-Protocol-Charter, W3C, September 12, 2004.

[29] Cowley, S., "Berners-Lee Extols Semantic Web at W3C Conference," http://www.computerworld.com/developmenttopics/websitemgmt/story/0,10801,93264,00.html, *Computer World*, May 19, 2004.

[30] Vasudevan, V., "A Web Services Primer," http://webservices.xml.com/pub/a/ws/2001/04/04/webservices/index.html, XML.com, O'Reilly Media, April 4, 2001.

[31] "W3C Publishes Web Services Choreography Description Language (WS-CDL)," http://xml.coverpages.org/ni2004-04-27-a.html, OASIS, September 13, 2004.

[32] Vasudevan, V., "A Web Services Primer," http://webservices.xml.com/pub/a/ws/2001/04/04/webservices/index.html, XML.com, O'Reilly Media, Inc., April 4, 2001.

[33] "Berners-Lee, T., J. Hendler, and O. Lassila, "The Semantic Web," http://www.sciam.com/print_version.cfm?articleID=00048144-10D2-1C70-84A9809EC 588EF21, *Scientific American*, May 17, 2001.

[34] Dumbill, E., "Berners-Lee and the Semantic Vision," http://www.xml.com/pub/a/2000/12/xml2000/timbl.html, XML.com, O'Reilly Media, December 6, 2000.

[35] Kay, R., "UDDI: Looking up Web Services," http://www.computerworld.com/news/2002/story/0,11280,73992,00.html, *ComputerWorld,* September 9, 2002.

[36] "OASIS UDDI Specifications TC–Comitteee Best Practices," http://www.oasis-open.org/committees/uddi-spec/doc/bps.htm, OASIS UDDI Specifications Technical Committee, OASIS, September 13, 2004.

[37] Ogbuji, U., "An Introduction to WSDL for SOAP Programmers," http://www-106.ibm.com/developerworks/library/ws-soap/?dwzone=ws#soapfig1, IBM, November 1, 2000.

[38] "Web Services Choreography Working Group Charter," http://www.w3.org/2003/01/wscwg-charter, W3C, September 12, 2004.

[39] "W3C Publishes Web Services Choreography Description Language (WS-CDL)," http://xml.coverpages.org/ni2004-04-27-a.html, OASIS, April 27, 2004.

[40] "OASIS Security Services TC Releases Approved SAML 2.0 Committee Drafts for Review," http://xml.coverpages.org/ni2004-08-19-a.html, OASIS, August 19, 2004.

[41] Chanliau, M., "Security Services Message," http://lists.oasis-open.org/archives/security-services/200012/msg00002.html, OASIS Security Services Technical Committee, OASIS, December 20, 2000.

[42] Roberts, P., "SAML 1.1 Ratified, Products Announced," http://ucsb.itworld.com/4812/030922saml/pfindex.html, IDG News Service, *Utility Computing*, September 22, 2003.

[43] "XML Key Management Working Group," http://www.w3.org/2001/XKMS/, W3C, September 3, 2004.

[44] Weiss, T. R., "VeriSign, Microsoft Unveil XML Net Security Protocol," http://www.computerworld.com/securitytopics/security/story/0,10801,54509,00.html, *ComputerWorld*, November 29, 2000.

[45] Kay, R., "WebDAV," http://www.computerworld.com/softwaretopics/software/groupware/story/0,10801,86688,00.html, *ComputerWorld*, November 3, 2003.

CHAPTER 15

Open Standards Organizations and Vendor Consortia

This chapter provides information about the formal standards bodies and vendor consortia responsible for developing the standards covered in the previous chapters of this book.

15.1 Formal Standards Bodies

Formal standards bodies are organizations recognized and endorsed by the ISO to define standards. Most of these organizations have been in existence for at least 50 years, and a number of them are more than a century old. The seven organizations discussed in this section are well known for their contributions to computer software and hardware, and most develop formal standards for many other disciplines.

15.1.1 American National Standards Institute

Inception Date. The American National Standards Institute (ANSI) was established as a private, nonprofit organization on October 19, 1918 [1].

Purpose. ANSI promotes and facilitates voluntary consensus standards that enhance "the global competitiveness of U.S. business and the American quality of life" and safeguards their integrity [1].

History. In 1916, the American Institute of Electrical Engineers (now IEEE), invited four other major engineering societies, the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society for Testing Materials, "to join in establishing a national body to coordinate standards development and to serve as a clearinghouse for the work of standards developing agencies" [2]. It was two years later on October 19, 1918 that the American Engineering Standards Committee (AESC) (now ANSI) was formed "to serve as the national coordinator in the standards development process as well as an impartial organization to approve national consensus standards…" [2].

Membership. ANSI membership numbers are up to 1,000 institutional and international members that include both commercial companies and government agencies. ANSI members include major companies and organizations such as General Motors Corporation, Dell Computer Corporation, Phillips Medical Systems, Emerson Electric Company, American Red Cross, Mayo Foundation, the Environmental Protection Agency, the U.S. Coast Guard, and the U.S. Department of Defense (URL: http://www.ansi.org/membership/membership_rosters/db_list.aspx?menuid=2).

Collaboration Efforts. ANSI represents the United States at ISO and IEC meetings [1].

Standards. "ANSI participates in almost the entire technical program of both the ISO and the IEC, and administers many key committees and subgroups.... In many instances, U.S. standards are taken forward to ISO and IEC, through ANSI or USNC [the United States National Committee of the International Electrotechnical Committee[1]], where they are adopted in whole or in part as international standards" [1]. A catalog of ANSI standards is available at URL: http://webstore.ansi.org/ansidocstore/product.asp?sku=ANSI+Catalog, along with instructions on how they may be purchased. Example ANSI standards include ANSI C, ANSI C++, ANSI Standard ADA, and ANSI X3 23-1985 (COBOL).

URL. http://www.ansi.org/.

15.1.2 International Electrotechnical Commission

Inception Date. June 27, 1906 is the Commission's official birthday [3].

Purpose. The purpose of the IEC is to define electric units and standards, related nomenclature (terminology), and the characteristics of electrical machines and apparatus [4].

History. At the International Electrical Congress in St. Louis, Missouri, in 1904, representatives strongly recommended that they "secure the co-operation of the technical societies of the world by the appointment of a representative Commission to consider the question of standardization of the Nomenclature and Ratings of Electrical Apparatus and Machinery" [4]. The IEC was subsequently established by 13 European countries, the United States, Canada, and Japan [4].

Membership. More than 51 countries are full members in the IEC, and there are a number of countries with associate membership.

Collaboration Efforts.

- IEC and ISO signed an agreement to establish the ISO/IEC JTC 1 to develop standards for information technology. Standards they have defined include MPEG, JPEG, FORTRAN, COBOL, and message handling. Refer to URL: http://www.jtc1.org/ for more information.
- The ISO/IEC JTC 1/SC 24 Working Group 8 on Environmental Representation addresses environmental data standards, which include geographical spatial standards (refer to URL: http://www.sedris.org/wg8home/).
- IEC also collaborates with the ITU on information technology standards.

1. The United States National Committee of the International Electrotechnical Committee (USNC) is an organization within ANSI [1].

Standards. IEC specifications can be obtained by purchasing them through URL: https://domino.iec.ch/webstore/webstore.nsf. To review a list of IEC standards categories such as networking, OSI Reference Model, and data storage, select “Publications by ICS codes” from the “Search” menu at http://www.iec.ch/, then select “Information Technology. Office Machines”. ISO/IEC JTC 1 standards are listed at http://www.iso.ch/iso/en/commcentre/pressreleases/pdf/markettrial.pdf, and there are ISO/IEC standards documents available to the public for free at URL: http://isotc.iso.ch/livelink/livelink/fetch/2000/2489/Ittf_Home/PubliclyAvailableStandards.htm.

URL. http://www.iec.ch/.

15.1.3 Institute of Electrical and Electronics Engineers

Inception Date. IEEE had its roots in an earlier organization, the American Institute of Electrical Engineers (AIEE), which was founded on May 13, 1884 [5].

Purpose. The IEEE is a nonprofit, technical professional association founded to promote “the engineering process of creating, developing, integrating, sharing, and applying knowledge about electro and information technologies and sciences for the benefit of humanity and the profession” [6].

History. IEEE had its beginnings more than a century ago, after national engineering societies had been established for the civil, mechanical, and mining engineering disciplines but none for electrical engineering [7]. In 1884, firms that manufactured electrical equipment and telephones participated in an International Electrical Exhibition held in Philadelphia. The Exhibition “proved to be the catalyst which resulted in the formation of the American Institute of Electrical Engineers [AIEE], an ancestor of today’s Institute of Electrical and Electronics Engineers” [7]. The Exhibition prompted electrical engineers such as Thomas A. Edison, Elihu Thomson, Edwin Houston, and Edward Weston to sign a “call” for an electrical national society in *The Operator*, the major American electrical engineering journal, and they met with other electrical engineers in New York on April 15 to organize the AIEE [7]. The first meeting of the AIEE was held on May 13, 1884, when Alexander Graham Bell and Thomas A. Edison were elected as two of its six vice-presidents [7]. “One of the important continuing activities of the AIEE was the development of standards for the engineering profession and the electrical industry. The Institute’s earliest efforts were directed toward standardizing units, definitions, and nomenclature relating to basic electrical science” [7]. On January 1, 1963, the AIEE combined with the rapidly growing Institute of Radio Engineers (IRE), and the merger of these two organizations became the Institute of Electrical and Electronics Engineers [7].

Membership. IEEE has more than 380,000 individual members in 150 countries [8].

Collaboration Efforts. IEEE has numerous working groups and committees developing a host of standards for different disciplines (e.g., aerospace engineering broadcast technologies and electromagnetics) (http://grouper.ieee.org/groups/index.html). IEEE and The Open Group launched a POSIX[2] Certification Program. A number of IEEE standards have been approved by ISO.

Standards. To access the standards, IEEE requires a prepaid annual subscription that will give a user access to the standards on the Web. Refer to URL: http://standards.ieee.org/catalog/olis/about.html for more information on a subscription. IEEE has developed a number of standards, including networking standards such as Ethernet (802.11), WiFi, WiMax, Bluetooth, and POSIX.[3]

URL. http://standards.ieee.org/.

15.1.4 International Committee for Information Technology Standards

Inception Date. The International Committee for Information Technology Standards (INCITS) was founded in 1961 as the Accredited Standards Committee X3 [9].

Purpose. INCITS creates and maintains formal de jure infrastructure, data interchange, and interoperability standards for disciplines such as multimedia (MPEG[4] and JPEG[5]), Small Computer System Interface (SCSI) interfaces, Geographic Information Systems, storage media, database management systems, security, and programming languages (C++) [9].

History. The Committee was established as the U.S. standards committee for information technology and was known as the Accredited Standards Committee X3, Information Technology from 1961 to 1996 [9]. Since 1961, it has been accredited by ANSI and sponsored by the Information Technology Industry Council (ITI) (http://www.itic.org/), a major U.S. trade association [9, 10].

In January 1997, the Accredited Standards Committee X3 changed its name to the National Committee for Information Technology Standards (NCITS) to reflect that it represented the U.S. as it participated in the ISO/IEC JTC 1 on Information Technology standards activities [11]. In January 2002, it changed its name to the International Committee for Information Technology Standards to reflect the global relevance of its standards developments [12].

Membership. INCITS has 1,700 organizations from 13 countries as members.

Collaboration Efforts. INCITS is working with SNIA (see Section 15.2.22) to standardize their SMI-S.

Standards. Information on draft standards can be reviewed via URL: http://www.ncits.org/stds_info.htm. To obtain a copy of a specification, it may be purchased at URL: http://www.ncits.org/ by clicking on the "Purchase Standards"

2. Refer to Chapter 9, Section 9.1, for more information on POSIX.
3. Refer to Chapter 4, Section 4.4.2 on Ethernet, Section 4.2.11 on Bluetooth (IEEE 803.15), Section 4.11.6 on Wi-Fi (IEEE 802.11), and Section 4.11.7 on WiMax (IEEE 802.16)
4. For more information about MPEG, refer to Chapter 5, Section 5.5.
5. For more information about JPEG, refer to Chapter 5, Section 5.3.

title that is listed under the "Standards Information" heading. Some of the specifications can be viewed at URL: http://www.service-architecture.com/web-services/articles/international_committee_for_information_technology_standards_incits.html.

URL. http://www.ncits.org/.

15.1.5 International Organization for Standardization

Inception Date. The ISO was established on February 23, 1947 [13].

Purpose. The ISO coordinates and unifies international standards for industry [13].

History. Delegates from 25 countries met in London, in 1946 and decided to establish a new international organization called the ISO to develop international standards [13]. The need for international standardization had become apparent when the International Federation of the National Standardizing Associations (ISA), which was formed in 1926, disbanded in 1942 during the Second World War. The ISO continued the work of ISA, essentially replacing it, when the ISO was established in 1947 in Geneva, Switzerland [13].

Membership. Refer to http://www.iso.ch/iso/en/aboutiso/isomembers/MemberCountryList.MemberCountryList for a current list of ISO members. The ISO is composed of members from the national institutes of 147 countries, where each member represents one country [13].

Collaboration Efforts. For international computer standards, ISO collaborates with the IEC and the ITU. The ISO/IEC JTC 1 has defined numerous Information Technology standards (see URL: http://www.jtc1.org/ for more information).

Standards.

- ISO standards are listed at URL: http://www.iso.ch/iso/en/prods-services/popstds/iso/en/prods%2Bservices/catalogue/CatalogueListPage.CatalogueList, and many of the software standards can be found by selecting #35 Information Technology.
- ISO/IEC JTC 1 standards are listed at URL: http://www.iso.ch/iso/en/commcentre/pressreleases/pdf/markettrial.pdf and also at URL: http://isotc.iso.ch/livelink/livelink/fetch/2000/2489/Ittf_Home/PubliclyAvailableStandards.htm.
- ISO/IEC JTC1 Subcommittee 7 (http://www.jtc1-sc7.org) is responsible for developing software engineering standards.
- ISO 9000 quality management at http://www.iso.ch/iso/en/iso9000-14000/iso9000/iso9000index.html.

URL. http://www.iso.org/.

Other Sources of Information.

- An introduction to ISO standards is provided by the ISO at URL: http://www.standardsinfo.net/isoiec/index.html.

- Jack Latimer provides the recollections of people who worked for the ISO over the last 50 years in "Friendship Among Equals," http://www.iso.org/iso/en/aboutiso/introduction/fifty/friendship.html, ISO, 1997.
- Borfitz, M. H., "About ISO," http://www.avquality.com/iso_history.htm, *Aviation Quality International*, November 16, 2003.
- Martincic, C. J., "IT Standards: II. A Brief History of ISO," http://www.sis.pitt.edu/~mbsclass/standards/martincic/isohistr.htm, University of Pittsburgh, February 20, 1997.

15.1.6 International Telecommunication Union

Inception Date. The ITU was founded on May 17, 1865 [14].

Purpose. As an international organization of the United Nations (http://www.unsystem.org/Default.htm), NIST defines standards for worldwide communications networks, developmental strategies, and reforms [15].

History. First known as the International Telegraph Union (ITU), the organization was established on May 17, 1865 to develop international legislation and standards for telegraph equipment that would promote connectivity across national boundaries, eliminating the numerous incompatible, custom telegraph network systems used by each country at that time [14]. Over time, ITU expanded its charter to cover standards for other communication inventions, such as telephony (the telephone) and radio communications. In 1932, ITU changed its name to the International Telecommunications Union, to cover a broader range of international communication standards [14].

On October 15, 1947, it became a United Nations specialized agency and moved its headquarters to Geneva, Switzerland [14]. In 1956, two ITU committees—the Consultative Committee for International Telephony (CCIF) and the Consultative Committee for International Telegraphy (CCIT)—merged and became the International Telephone and Telegraph Consultative Committee, a single ITU committee with responsibility for both telephony and telegraphy. In 1993, ITU reorganized into three sectors: ITU Telecommunication Standardization (ITU-T), ITU Radiocommunication (ITU-R), and ITU Telecommunication Development (ITU-D) [14]. CCITT was incorporated into ITU-T. (See http://www.itu.int/aboutitu/overview/history.html for details [14].)

Membership. ITU members are listed at http://www.itu.int/GlobalDirectory/index.html. The ITU has more than 900 members, which include national institutes, major international companies, and countries that participate in the United Nations.

Collaboration Efforts. ITU collaborates with the IEC, the ISO, and the IETF.

Standards. The list of ITU standards, regulations, and other documents can be viewed by selecting the "Catalogue of Publications" at URL: http://www.itu.int/publications/. The catalogue shows the fee required for purchasing a publication. In addition, ITU-T provides a list of their recommendations at URL: http://www.itu.int/rec/recommendation.asp?type=products&parent=T-REC-x. Example ITU standards include:

- International Mobile Telecommunications-2000 (IMT-2000) provides for global coverage and seamless roaming between networks (http://www.itu.int/itunews/issue/2000/09/the_dawn.html).
- ITU-T Recommendation G.695 (under development) applies to Coarse Wave Division Multiplexing (CWDM) and would increase the capacity of optical fiber (http://www.itu.int/newsroom/press_releases/2003/28.html).
- H.248 is the media gateway control protocol developed by the IETF MEGACO Working Group in close cooperation with ITU-T Study Group 16, http://www.ietf.org/html.charters/megaco-charter.html.
- H.32X includes a family of standards that support multimedia communication services (e.g., H.323).

URL. http://www.itu.int/home/index.html.

15.1.7 Internet Engineering Task Force

Inception Date. The IETF was formed in January of 1983 [42].

Purpose. The IETF mission is to accomplish the following:

- Identify and propose solutions to resolve Internet technical issues/problems [43];
- Recommend specifications for standard Internet protocols and their usage to the IESG [43];
- Provide a forum for the Internet community to exchange information [43];
- Facilitate technology transfer for the Internet [43].

History. In 1969, the U.S. DARPA funded the ARPANET, the ancestor of the Internet, to enable defense and university researchers to interactively communicate with each other via a national computer network [44]. When Bob Kahn joined DARPA in 1972, he initiated the Internetting[6] Program to implement an open architecture for networking that would support internetworking: distributed communications between diverse network implementations that did not require modifications to networks, gateways, and routers [45]. Kahn recognized that the ARPANET needed a more sophisticated protocol than its NCP if it was going to achieve his open architecture vision and connect hundreds of thousands of nodes rather than a few hundred [45].

In 1973, Kahn asked Vinton G. Cerf, one of the developers of NCP, to assist in developing this protocol [45]. From 1973 until 1978, Cerf and Kahn worked on defining the TCP/IP [44]. In the early 1980s, use of TCP/IP spread among the defense and research communities [45]. By January 1, 1983, all ARPANET networks had moved from NCP to TCP/IP, and the Internet was born [46].[7]

Also in 1983, the DARPA Internet Program moved away from selecting individuals as members of the Internet Configuration Control Board (ICCB) organization

6. Over time, the "Internetting" Program became the "Internet" Program.
7. Refer to Chapter 4, Section 4.5 for more information on the Internet.

to coordinate changes to the Internet, because the users attending the ICCB meetings had grown to such a large number [42]. Instead, DARPA assigned Task Forces to address specific Internet technology areas, and over time, the name of this group became the Internet Engineering Task Force [42]. Chairs of these Task Forces became members of the Internet Activities Board (IAB) [42].

Membership. IETF membership is open to the public, and being added to an IETF or Working Group mailing list constitutes membership [42].

Collaboration Efforts. The IETF collaborates with many standards bodies and vendor consortia, such as ITU-T, ISO, IEEE, and W3C (http://www.ietf.org/liaison Activities.html).

Standards. The IETF has developed numerous standards for the Internet and their specifications, and draft-specifications can be accessed by linking to the standards area listed on each of the IETF Working Group Web pages (see http://www.ietf.org/html.charters/wg-dir.html).

URL. http://www.ietf.org/.

Other Sources of Information.

- Hauben, M., "History of ARPANET: Behind the Net – The Untold History of the ARPANET," http://www.dei.isep.ipp.pt/docs/arpa.html, December 20, 1994.

15.1.8 National Institute of Standards and Technology

Inception Date. NIST was established on March 3, 1901 [16].

Purpose. NIST develops and promotes the development of measurements, standards, and technologies that enhance productivity and foster trade [17].

History. NIST was founded by charter of the U.S. Congress as the first U.S. federal government research laboratory [18, 19]. It was named the National Bureau of Standards until 1903, when it was renamed Bureau of Standards [18]. In 1934, was renamed again as the National Bureau of Standards (NBS) until 1988, when it was renamed the National Institute of Standards and Technology [20].

When it was chartered in 1901, the United States needed standards to promote commerce [19]. It was the Industrial Age, and there were few, if any, standards for product quality [19]. Standards were seen as necessary for product reliability and quality, and they were especially important for manufacturing and construction [19]. For example, the electrical industry was frequently subject to litigation because there were no standards to impose for quality [19]. Scientists and industry combined their efforts to promote the concept of a national standards laboratory, and the U.S. Congress agreed [19]. In keeping with the emphasis on research, the first director of NIST was a professor of physics at the University of Chicago [19]. Although originally established within the U.S. Treasury Department, NIST eventually became an institute within the Department of Commerce [19].

Membership. NIST partners with researchers from around the world.

Collaboration Efforts. NIST coordinates its development of standards with ANSI.[8]

Standards. As an organization within the purview of the Department of Commerce, the Secretary of Commerce needs to approve the standards and guidelines developed by NIST for federal computer systems. Subsequently, NIST issues the standards as FIPS for U.S. federal government use. Refer to the FIPS URL: http://www.itl.nist.gov/fipspubs/ for details.[9]

URL. http://www.nist.gov/.

15.2 Vendor Organizations and Consortia

Vendor organizations and consortia are composed primarily of companies from industry that work together to achieve consensus on standard services and interfaces. Most frequently, the vendor companies involved in a consortium have a vested interest, most likely because the consortium is defining specifications or standards applicable to their products, and participation provides an opportunity to influence the direction of standards.

15.2.1 Asynchronous Transfer Mode Forum

Inception Date. The ATM Forum was founded in 1991 [21].

Purpose. The ATM Forum was established to define standards for a high performance network based on fiber optics [21].

History. In the 1980s, CCITT (now the ITU-T sector) began working on defining standards for an intelligent, high-performance network based on fiber optics [21]. They defined a B-ISDN[10] standard in 1986, and then began working on defining the lower level, complementary standards [21]. ATM was one of those standards, and it was required to provide an intelligent switching fabric for broadband [21]. To focus on its development, the ATM Forum was established in 1991 and published the first ATM specification in July of that year [21].

Membership. The names of the member companies of the ATM Forum are kept private.

8. In 2000, NIST and ANSI signed a MOU that established their complementary roles and responsibilities in the development of national and international standards. Refer to the MOU at URL: http://ts.nist.gov/ts/htdocs/210/nttaa/ansimou.htm.

9. Refer to Chapter 10, Section 10.5.1 on FIPS 186-2 and Sections 10.6.1 through 10.6.2 on encryption standards.

10. "Broadband" is a type of transmission that can carry multiple signals at different frequencies on a single medium. Cable television is an example of a technology that uses this form of transmission.

Collaboration Efforts. The ATM Forum has collaborated with the IETF on protocol standards for ATM.

Standards. There are a number of ATM specifications as development continues. These are available at URL: http://www.atmforum.com/standards/approved.html.

URL. http://www.atmforum.com/. Refer to Chapter 4, Section 4.1 for more information about the ATM Forum's ATM standards.

15.2.2 Business Process Management Initiative

Inception Date. BPMI was founded in 2000 as a nonprofit organization [22].

Purpose. BPMI's mission is to establish standards for the design, deployment, operation and maintenance, and improvement of business processes [22].

History. Intalio (http://www.intalio.com), a business process modeling company about 5 years old, led the creation of BPMI.org along with 15 other companies that included Aventail, Black Pearl, and Bowstreet, in 2000 [23, 24]. It was not long afterward that IBM, Microsoft, and BEA systems joined forces to create BPELAWS, a competing standard, which they turned over to OASIS [25, 26].

Membership. Members are listed at URL: http://www.bpmi.org/members.htm and include Adobe Systems, BEA Systems, and IBM.

Collaboration Efforts. BPMI has collaborated with the OMG, the WfMC, and OASIS [27].

Standards. BPMI is responsible for defining BPML, BPMN, and BPQL, which support a common notation and language for modeling business processes. See Chapter 3, Section 3.1.2 for details.

URL. http://www.bpmi.org/.

15.2.3 Distributed Management Task Force, Inc.

Inception Date. The Distributed Management Task Force, Inc., was formed in April 1992 [28].

Purpose. DMTF directs the development of management standards for interoperable enterprise and Internet environments [28].

History. In 1992, five companies founded the Desktop Management Task Force as a not-for-profit association to promote the interoperability of enterprise/networked systems. Over time, its charter expanded to cover the enterprise, and its name changed to the Distributed Management Task Force. Today, the number of member companies has grown to include more than 200 [28].

Membership. DMTF membership includes a number of major companies such as Cisco, Dell Computer Corporation, EMC, Oracle, Sun Microsystems, and Intel Corporation.

Collaboration Efforts. SNIA (refer to Section 15.2.22 for information on SNIA) certifies products that conform to the DMTF specifications for the CIM and WBEM standards [29].

Standards. While there are other standards efforts that DMTF is involved in, it is best known for its CIM specification that addresses the exchange of management information of a network/enterprise environment [28].[11] Other standards include the DMI and WBEM. Refer to URL: http://www.dmtf.org/standards for details.

URL. http://www.dmtf.org/home.

15.2.4 Ecma International

Inception Date. Ecma International—the European Association for Standardizing Information and Communication Systems (formerly the European Computer Manufacturers Association)—was founded in 1961 [30].

Purpose. Ecma International works with the national, European, and international organizations to promote and standardize information technology and publishing standards [30].

History. The European Computer Manufacturers Association, now known as Ecma International, was founded in 1961 [30]. The European companies Compagnie des Machines Bull, IBM World Trade Europe Corporation and International Computers, and Tabulators Limited, sent a formal letter that invited all European computer manufacturers to send representatives to participate in a meeting that would address the need to develop standards for computing techniques such as programming, input, and output codes [31]. The outcome of the discussions was the founding of ECMA in May 1961, and the establishment of its headquarters in Geneva to be near ISO and IEC [31]. In 1987, ECMA became a member of the ISO/IEC JTC1 [31]. In 1994, it changed its name to Ecma International to reflect its involvement as a European association in international standards activities [31].

Membership. Ecma members (see http://www.ecma-international.org/memento/members.htm) include Alcatel, BEA Systems, Apple Computers, IBM, Intel Corporation, Toshiba, Hewlett-Packard, Fujitsu, and Ericsson.

Collaboration Efforts. Ecma participates in the ISO/IEC JTC 1 [31].

Standards. Ecma standards include the ECMAScript Language Specification (a standard for JavaScript).[12] A list of Ecma standards is provided at URL: http://www.ecma-international.org/publications/standards/Standard.htm.

URL. http://www.ecma-international.org/.

11. Refer to Chapter 6, Section 6.3.1 for CIM, Section 6.3.2 for DMI, and Section 6.3.5 for WBEM.
12. Refer to Chapter 11, Section 11.2.5 on ECMAScript, and Section 11.3.1 on the ECMA Framework.

15.2.5 European Telecommunications Standards Institute

Inception Date. ETSI was established as a standards organization in 1988 [32].

Purpose. ETSI was founded as a nonprofit organization to define standards for information and communications technologies in Europe [33].

History. In the 1980s, there were a number of analog mobile communications systems in use around the world, but each system was different, lacked interoperability, and worked only within the countries that used them. Europeans wanted a unified, standard mobile system [32]. The Conférence des Administrations Européenes des Postes et Télécommunications (CEPT), an organization of telecommunication administrations of 26 European countries, established the Groupe Special Mobile[13] in 1982 to develop European standards for a mobile, cellular telephone system [33]. These European standards became known as Global Systems for Mobile Communications (GSM).[14]

In 1989, the responsibility for the development of GSM passed to ETSI, a new organization tasked to continue the development of GSM [34]. In 1991, ETSI defined a family of standards for GSM, and by mid-1991, GSM products were available [34].[15] Since then, ETSI has expanded its development of standards to support other areas such as broadcasting, intelligent transportation, and medical electronics [35].

Membership. ETSI has 688 representatives from 55 countries, both inside and outside Europe, from a variety of disciplines, including manufacturing, networking, service providers, and researchers [32].

Collaboration Efforts. ETSI has a number of Memoranda of Understanding (MOU) with other organizations, such as ISO/IEC JTC1, ANSI, and ITU. The agreements can be viewed at URL: http://www.etsi.org/services_products/freestandard/home.htm.

Standards. ETSI standards can be downloaded at URL: http://www.etsi.org/services_products/freestandard/home.htm after registering.

URL. http://www.etsi.org/.

15.2.6 Free Standards Group

Inception Date. The Free Standards Group was founded in 2000 [36].

Purpose. The Free Standards Group develops standards for open source software and promotes the use of standards-based open source products [37].

13. For a more detailed history of GSM, refer to the history page hosted by the GSM Association, a trade association, at URL: http://www.gsmworld.com/about/history/index.shtml.
14. GSM standards are discuss in Chapter 4, Section 4.11.3.
15. For a detailed history of GSM, refer to *GSM World* hosted by the GSM Association at URL: http://www.gsmworld.com/about/history/index.shtml.

History. Daniel Quinlan was involved with several Linux distributions in 1994 and led the development of Linux at Transmeta.[16] Beginning in August 1998, he became chairman of the LSB [37]. He recognized a need for a nonprofit organization that would promote LSB [37]. In 2000, he and Hideki Hiura, another Linux expert who had participated in other Linux standardization efforts, teamed to cofound the Free Standards Group [37].

Membership. Major vendors such as IBM, Sun Microsystems, HP, and others, are members of the Free Standards Group and provide Linux products (see URL: http://www.freestandards.com/modules.php?name=Content2&pa=showpage&pid=7 for a more complete list).

Standards. The ISO/IEC JTC1 recognized the Free Standards Group development of Linux standards and officially approved their submission of LSB for consideration as international standards[17] [38].

URL. http://www.freestandards.com//.

15.2.7 Global Grid Forum

Inception Date. The Global Grid Forum (GGF) was founded in 2000 [39].

Purpose. The GGF was established to enable the members from industry and research communities to develop technical specifications and implementation guidelines for grid technologies to promote their development, deployment, and implementation [40].

History. Beginning in the late 1980s, university and government researchers began examining how to support network-intensive applications such as high performance computing and distributed collaboration [39]. They determined that to achieve this, an infrastructure was needed that would support advanced network capabilities, such as resource discovery, caching, and other services [39]. They named this infrastructure a Grid, and likened it to the contemporary electrical power grid infrastructure that provides ubiquitous electricity to anyone, anywhere, anytime, transparently [39]. Grid infrastructure concepts are now commonly referred to as grid computing.

In November 1998, a group of Grid researchers met to discuss their common efforts, and whether they should combine their efforts to work together to develop Grid technologies [39]. The researchers agreed that a community forum was needed to pursue their common goals, and founded the Grid Forum in 1999 [39]. The Grid Forum continued to host workshops, and the attendance continued to grow. In November 2000, the GGF was formed as a merger between Grid Forum, European Grid Forum (eGRID), and the Asia-Pacific Grid community (http://www.ggf.org/L_About/hist&back.htm).

16. Transmeta (http://www.transmeta.com) is the same company where the inventor of Linux, Linus Torvalds, was employed after inventing Linux.

17. Refer to Chapter 9, Section 9.3.1 on the Linux Standard Base for more information.

Membership. In 2004, GGF had more than 75 sponsor members that included Argonne National Laboratory, NASA, the U.K. e-Science Power Grid, the National Institute of Advanced Industrial Science and Technology, AIST (from Japan), Hewlett-Packard, IBM, Intel Corporation, Microsoft, Silicon Graphics, Inc., and Sun Microsystems (URL: http://www.gridforum.org/L_Involved_Sponsors/spons.htm).

Collaboration Efforts. A Utility Working Group was formed that is collaborating with GGF and other consortia to create a method for ensuring that multivendor products for utility computing environments are interoperable [41]. In addition, GGF has been collaborating with OASIS and the W3C on grid computing (URL: http://www.ggf.org/L_News/ggf-oasis.pdf and URL: http://www.w3.org/2004/08/ws-cc/grid-20040904).

Standards. GGF has defined the OGSA to support grid computing for WebSevrices.[18]

URL. http://www.ggf.org/ or http://www.gridforum.org/.

15.2.8 J Consortium (RT Java)

Inception Date. The J Consortium was formed in May 1999 [47].

Purpose. The Consortium was established to perform activities that included developing open standards for real-time, embedded, Java applications; providing tests and conformity assessments; and operating a branding program [48].

History. Early in 1998, NIST had kicked off a real-time requirements working group that transitioned into a Real-Time Java Working Group (RTJWG) composed of product vendors that wanted to accelerate the adoption of Java for real-time, embedded systems [49]. The RTJWG requested that ANSI form a technical committee to pursue RT Java Standards.[19] However, when ANSI did not approve this request, the Microsoft Corporation and Hewlett-Packard led a group of vendors to create the industry not-for-profit J Consortium in May 1999 to develop real-time Java technology independently from Sun [47]. Note that the RTJWG is now a technical committee of the J Consortium.

Membership. The J Consortium has more than 89 domestic and international members, including the Microsoft Corporation, Hewlett-Packard, The Open Group, OMG, Siemens A&D, Ericsson, and Aonix Europe. Refer to URL: http://www.j-consortium.org/members/corporate.shtml for a complete listing.

Collaboration Efforts. The RTJWG developed a RT Core Extensions Specification for Java that showed potential for ISO sponsorship (http://www.j-consortium.org/rtjwg/index.shtml) and which was submitted to the Java Community process.

18. Refer to Chapter 7, Section 7.7, for more information about GGF Standards.
19. For more information on Java standards, refer to Chapter 11, Section 11.2.6.

Standards. The technical committees of the J Consortium worked with the ISO/IEC JTC 1, Subcommittee 22 to pursue official standardization of their proposed Java specifications as ISO/IEC 20970. In addition, it is continuing the work on RT Java Specification with an Open Group.

URL. http://www.j-consortium.org/.

15.2.9 Java Community Process

Inception Date. JCP 1.0 was launched by Sun Microsystems on December 1998 [50].

Purpose. Sun founded the JCP to develop and maintain Java specifications in coordination with the Java community, and to foster the evolution of Java technologies on the Internet [50].

History. The JCP was initiated as a program by Sun Microsystems in 1998 to allow the Java software community to develop and revise standards for Java specifications [50].

Membership. JCP has hundreds of international members (http://www.jcp.org/en/participation/members) that include BEA Systems, Oracle, Hewlett-Packard, IBM, IONA Technologies PLC, Siemens AG, SONY International (Europe) GmbH, and Orange France SA.

Collaboration. Members of the JCP formed a Java Tools Community (JTC) (http://www.javatools.org/about.html) on January 6, 2004 to promote collaboration on developing interoperable Java tools using Java standards.

Standards. JCP is responsible for managing a formalized process to create, maintain, and revise Java-based specifications that include Enterprise JavaBeans, Java Platform 2 Enterprise Edition, and the Real-time Specification for Java.[20] A list of the standards is provided at URL: http://www.jcp.org/en/jsr/all.

URL. http://www.jcp.org/en/home/index.

15.2.10 Liberty Alliance Project

Inception Date. The Liberty Alliance Project was established as a consortium in September 2001 [51].

Purpose. The Liberty Alliance Project was formed to develop open standards for federated network identity [51].

History. A consortium of 33 companies that included Sun Microsystems, General Motors, Cisco Systems, Dun & Bradstreet, Bank of America, American Airlines, United Airlines, Nokia, and 25 others was established as the Liberty Alliance Project

20. For information about Enterprise JavaBeans and the Java Platform 2 Edition, refer to Chapter 7, Sections 7.4 and 7.5. For Java and the Real-Time Specification for Java, refer to Chapter 11, Sections 11.2.6 and 11.2.7.

in September 2001; it is commonly referred to as Liberty Alliance [52]. Liberty Alliance indicated that their objective is to develop standards for a single user logon where a user could be automatically authenticated for a variety of services, from banking to interactive TV, irrespective of how many companies were involved [52].

Membership. Liberty Alliance has 36 members and numerous affiliates and associates (see URL: http://www.projectliberty.org/membership/members.asp).

Standards. The specifications are listed under the Liberty Alliance Project Phase 2 Specifications at URL: http://www.projectliberty.org/specs/index.html, and include an architecture overview, implementation guidelines, personal and employee profiles, and so on.[21]

URL. http://www.project-liberty.org/ or http://www.projectliberty.org/.

15.2.11 Meta Data Coalition

The MDC was founded in 1995 as a consortium of 50 vendors and end-users to define a metadata standard for industry [53]. Although MDC had defined the OIM specification based on a proposal by the Microsoft Corporation, it competed with the OMG's metadata standard effort. Both organizations agreed that it was best that there should be only one standard for industry to use. Hence, on September 26, 2000, MDC and OMG agreed to combine their efforts, and MDC merged with OMG to unify their efforts on a set of specifications that would facilitate metadata interoperability between multivendor data warehouse products [53]. Since then, the OMG has completed the CWM, which defines their metadata standards. Refer to Section 15.2.14 for details.

15.2.12 Object Data Management Group

The ODMG was established in 1991 as a vendor consortium to work on standards for object-oriented DBMS. At that time, there was competition between the relational database vendors and object-oriented database vendors, and the consortium formed to develop concepts that would provide a foundation for object-oriented databases. The relational model was viewed as incompatible with object-oriented languages such C++ and Smalltalk, since objects could be created that went beyond the two-dimensional "rows and columns" of the relational model, having properties that could be associated with them as attributes, classes, inheritance, and methods (functions).

Relational database vendors responded by implementing object-based front-ends to their relational DBMS. With the onset and popularity of Java, relational DBMS vendors defined Java interfaces to their relational DBMS to enable Java objects to be created, manipulated, and stored in relational databases. ODMG disbanded in 2001 after completing the ODMG standard. The ODMG 3.0 standard was published as a book and can be obtained from the publishers (see URL: http://www.odmg.org/orderingbook.html for details).

21. Refer to Chapter 10, Section 10.2.2.

R. G. G. Cattell wrote an article entitled “The DBMS Wars: Pure Objects Versus Relational,” published in 1994 in *ComputerWorld*, that contrasts competing features of the relational versus object-oriented DBMS. The article can be found at URL: http://www.computerworld.com/news/1994/story/0,11280,15796,00.html.

URL. http://www.odmg.org/.

15.2.13 Object Management Group

Inception Date. The OMG was founded in April 1989 [54].

Purpose. The OMG develops guidelines and object management specifications to provide a framework for distributed, object-oriented applications [54].

History. OMG was established as a not-for-profit corporation by 11 companies in April 1989 to define a distributed object-oriented architecture that would operate on heterogeneous platforms [54].

Membership. OMG offers different kinds of memberships (e.g., Contributing Members with voting rights, Domain Members that develop products, University Members, and Government Members) and has hundreds of members that include numerous national and international universities (e.g., University of California, Irvine; University of College London, Universitat Innsbruck), not-for-profit and government organizations (e.g., The MITRE Corporation, NIST), product vendors (e.g., Oracle, Popkin Software, IONA), companies (e.g., Raytheon), and other consortia (e.g., the W3C and Open GIS Consortium). To view the list of OMG members, refer to URL: http://www.omg.org/cgi-bin/apps/membersearch.pl.

Collaboration Efforts. OMG collaborates with a number of vendor consortia. One of their collaborative efforts involves the Open GIS Consortium (OGC), the Simulation Interoperability Standards Organization (SISO),[22] and Web3D, on Web Enabled Modeling and Simulation capabilities [55].

Standards. Refer to URL: http://www.omg.org/technology/documents/spec_summary.htm for a list of OMG specifications. OMG specifications are available to OMG members and include:

- CORBA;
- UML profiles;
- CWM. A contractor team defined the CWM in response to an OMG RFP. For details on the CWM and to download a copy of the specifications, refer to http://www.cwmforum.org/.

URL. http://www.omg.org/.

Other Sources of Information. For more information on CORBA, UML and CWM, a number of books have been published that can be readily obtained from public book distributors.

22. SISO promotes the interoperability and reuse of modeling and simulation software for Modeling and Simulation Communities [52].

15.2.14 Open Geographic Information System Consortium

Inception Date. The Open Geographic Information System (GIS) Consortium was founded on September 25, 1994.

Purpose. The OGC involves a consensus process to develop OpenGIS Specifications that support location-based services for enterprise and Web environments [56].

History. In the early 1980s, the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory (CERL) developed a Unix-based GIS that they named the Geographic Resource and Analysis Support System (GRASS), which became widely used at many U.S. federal government agencies and universities around the world [57]. Over time, three GRASS organizations emerged—a steering committee, a user group [The User Forum (TURF), referred to as GRASS TURF], and a not-for-profit organization that would provide administrative support with a focus on the private sector [57]. In 1992, GRASS TURF and the not-for-profit organization merged to become the Open GRASS Foundation (OGF) with a focus on supporting and managing GRASS to enable its development in the private sector [57]. However, as GIS applications became commercially available and OGF began to collaborate with OMG on the need for open interfaces between geographic applications, it became apparent that what was needed was a not-for-profit trade association that would define network-centric standards for open GIS interfaces used worldwide [57]. On September 25, 1994, OGC was founded as a not-for-profit trade association with eight charter members and proceeded to define the OpenGIS specifications under its own trademark [57].

Membership. OGC has 260 international members (http://www.opengis.org/about/?page=members&view=Name), which include Intergraph Corporation, ESRI, Hitachi, Ltd., Spatial Knowledge Engineering, Inc. (from Canada), government agencies, and numerous universities.

Collaboration Efforts. The OGC has collaborated with ISO/TC 211 on open interfaces for GIS [56]. Currently, the OGC is collaborating with OMG, Web3D, and SISO on standards for Web modeling [55].

Standards. The OGC has defined OpenGIS specifications that can be downloaded via URL: http://www.opengis.org/specs/?page=specs.[23]

URL. http://www.opengis.org/.

15.2.15 Open Mobile Alliance

Inception Date. The OMA was founded in June 2002 [58].

Purpose. The OMA was established as a means for developing a family of specifications for mobile technologies. Their objectives include developing user-friendly mobile services; an open standards framework to use in building, deploying, and

23. Refer to Chapter 5, Section 5.7, for more information on OpenGIS.

managing multivendor devices and carriers; and a single, definitive industry mobile standards consortium that drives interoperability at the service level [55, 56].

History. Mobile devices such as laptops, pagers, personal digital assistants, and cellular phones had begun to provide the same information services available for years on desktop systems. Mobile devices were providing information about the weather, stocks, and news, and they could access the Internet and corporate intranets to display and respond to e-mail messages, provide instant messaging, send and receive e-mail attachments such as digital pictures, surf Web sites, and download or upload files. However, vendors were developing many proprietary and incompatible services. Two organizations emerged that were defining competing standards: the WAP Forum and the Wireless Village Initiative [60]. These two organizations consolidated their efforts in the Open Mobile Alliance, which was formed in June 2002 [60]. The OMA brought together more than 200 hundred companies at its inception, including Motorola, Nokia, L.M. Ericsson, Siemens AG, Sun, Open-Wave Systems, Microsoft, Oracle, Hewlett-Packard, BEA Systems, and Vodafone Group PLC [60].

Membership. To view the current members of OMA, refer to URL: http://www.openmobilealliance.org/currentmembers.html. OMA has more than 335 members. Different types of memberships are offered: full membership, associate memberships, and sponsorships.

Collaboration Efforts. OMA is collaborating on standards with the IETF and W3C. In addition, it is involved with several projects such as 3GPP (URL: http://www.3gpp.org/About/3gppagre.pdf) and 3GPP2 (URL: http://www.3gpp2.org/). 3GPP is a project that reports to ETSI and involves different standards organizations collaborating on the development of mobile specifications based on GSM standards, and 3GPP2 is a project for developing wireless communications standards based on CDMA 2000.

Standards. The OMA has developed specifications for a MultiMedia Message Service, and is continuing to develop WAP and WML based on XHTML [60].[24] Refer to URL: http://www.openmobilealliance.org/documents.html to view available OMA specifications and documents.

URL. http://www.openmobilealliance.org/.

15.2.16 Organization for the Advancement of Structured Information Standards

Inception Date. OASIS was established in 1993 [61].

Purpose. OASIS is a not-for-profit international consortium that leads the development of standards for e-business on Web and enterprise environments [61].

24. Refer to Chapter 14, Section 14.1.5 on WML, and 14.2.4 on WAP.

History In 1993, the SGML Open Consortium was founded to develop guidelines for the interoperability of SGML-based products. As the scope of their technical work expanded to include XML and other standards, it changed its name to the Organization for the Advancement of Structured Information Standards [61]. Currently, OASIS has been involved in promoting standards for interoperable markup languages [61].

Membership. Members of OASIS number more than 600 corporate and individual members in 100 countries worldwide, and comprise over 3,500 participants [61].

Collaboration Efforts. OASIS collaborates with a number of standards groups. For instance, OASIS and the United Nations jointly sponsor ebXML [61].[25] OASIS formed XML.org, which is now an independent organization, to reduce duplication in XML languages (http://www.xml.org/). OASIS has also collaborated with BPMI and the W3C [27].

Standards. OASIS has a number of technical committees that are defining specifications for e-business standards (http://www.oasis-open.org/committees/committees.php). Some of the specifications that are being developed include:

- UDDI of Web Services (http://uddi.org/) to advertise and find Web Services (http://www.sys-con.com/webservices/article.cfm?id=663);
- Framework for Web Services Implementation (FWSI) (http://www.oasis-open. org/committees/tc_home.php?wg_abbrev=fwsi) to define processes and elements that improve the quality of Web Services;
- User Interface Markup Language (UIML) (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=uiml) to specify a language for an XML-based user interface.

URL. http://www.oasis-open.org/home/index.php.

15.2.17 RosettaNet

Inception Date. RosettaNet was founded in February 1998 [62].

Purpose. RosettaNet was established to define, implement, and encourage open standards and services for e-business [62].

History. Forty IT companies formed RosettaNet as a nonprofit consortium to establish a global language for e-business [62]. They named it RosettaNet after the Rosetta Stone discovered in Egypt in 1799 that dated to 196 B.C. and provided symbols that enabled scientists to translate Egyptian hieroglyphics.

Membership. RosettaNet has grown to a membership of more than 500 organizations [62]. Members include Deutsche Telecom, Dell Asia Pacific, Ericsson, Fairchild Semiconductor, Hitachi Japan, Hitachi High Technologies, IBM, and Microsoft (refer to URL: http://www.rosettanet.org/RosettaNet/Rooms/Search/TPDSearch).

25. Refer to Chapter 3, Section 3.1.3 for information about ebXML.

Standards. RosettaNet lists its standards at URL: http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?container=com.webridge.entity.Entity[OID[5F6606C8AD2BD411841F00C04F689339]. RosettaNet standards are covered in Chapter 3, Section 3.1.4.

URL. http://www.rosettanet.org/.

15.2.18 Storage Networking Industry Association

Inception Date. SNIA was formed in December 1997 [63].

Purpose. The SNIA's mission is to define standards for storage networks that enable storage management applications to become efficient, reliable, and secure, and to aggressively promote these standards to users [63].

History. The SNIA formed as a registered nonprofit trade association in December 1997 to respond to increased demands for large storage applications (e.g., data warehouses), standardization, and product interoperability [64].

Membership. The SNIA membership list provided by URL: http://www.snia.org/about/member_list shows a large number of nonvoting members and more than 80 voting members, including a number of major storage vendors such as EMC Corporation, Hitachi Data Systems, ADIC, StorageTek, and McData.

Collaboration Efforts. INCITS and SNIA are working together to enable SMI-S to be taken through INCITS' Fast Track process so that it can become an ANSI accredited standard [65]. In addition, SNIA has collaborated with DMTF to develop a SAN management specification that would support WBEM (http://xml.coverpages.org/ni2002-05-23-a.html).[26]

Fora. The SNIA hosts technical fora that focus on specific technology areas:

- SNIA Supported Solutions Forum (SSF) focuses on the interoperability of vendor storage solutions (http://www.snia.org/tech_activities/supported_solutions).
- Data management Forum (DMF) addresses data management life cycle issues (http://www.snia.org/tech_activities/dmf/).
- Storage Security Industry Forum (SSIF) concentrates on the security aspects of storage networking solutions (http://www.snia.org/ssif/home).
- IP Storage Forum addresses IP-based storage solutions (http://www.snia.org/tech_activities/ip_storage).
- SMI Forum concentrates on promoting the use of the SMI specification (http://www.snia.org/smi/about/smf/).

Standards. SNIA has defined SMI-S, which was formerly known as Bluefin. It can be downloaded at URL: http://www.snia.org/smi/tech_activities/smi_spec_pr/spec.[27] In

26. Refer to Chapter 12, Section 12.2.5 on WBEM for more information.
27. Refer to Chapter 6, Section 6.5.4 on SMI-S.

addition, SNIA has defined a Shared Storage Model to describe common storage architectures (for details, refer to URL: http://www.snia.org/tech_activities/shared_ storage_model/).

URL. http://www.snia.org/home.

15.2.19 The Open Group

Inception Date. The Open Group was founded on February 14, 1996 as an international vendor consortium [66].

Purpose. The Open Group's mission is to drive the seamless flow of information by developing requirements; working with consortia, suppliers, and standards bodies to achieve consensus in defining, evolving, and integrating specifications and open source technologies; and both developing and operating certification services for standards-based products [67].

History. By the 1990s, Unix operating system vendors provided multiple proprietary versions of Unix with special hardware-dependent functions that could be invoked from application software. Consequently, porting software applications from one platform to another—even if these platforms were simply a newer, more advanced model by the same manufacturer—was difficult and time consuming since developers had to update their application software functions to be compatible with new platform's special features. To combat this problem, major Unix vendors formed a consortium called the X/Open Company to develop standards for Unix. Novell gave the X/Open Company rights to the Unix trademark and specification in 1994 [68]. X/Open expanded the Unix specification to include new functions, and named it the Single UNIX Specification. X/Open also began to test the conformance of vendor products with the Single UNIX Specification, and branded products as "UNIX" when they were fully conformant. On February 14, 1996, X/Open and the OSF consolidated their efforts and merged to form The Open Group [66]. Until that time, OSF had been responsible for defining the DCE specification, a set of functions that defined a cross-platform distributed operating system.

Membership. The list of members can be viewed at URL: http://www.opengroup.org/overview/members/membership_list.htm. Sponsors and members include Novell, the SCO Group, Fujitsu Limited, Hewlett-Packard Company, Hitachi Limited, IBM Corporation, Sun Microsystems, Inc., and Siemens.

Collaboration Efforts. The Open Group worked with IEEE to update its POSIX.1 specification. The Open Group also works with the OMG to brand vendor products for CORBA compliance.

Standards. The Open Group worked with IEEE to jointly revise POSIX and The Open Group's Single UNIX Specification Version (http://www.UNIX-systems.org/version3/) available at URL: at http://www.unix.org/version3/.[28] This specification

28. Refer to Chapter 9, Sections 9.2 and 9.3 for more information about POSIX and the Single UNIX Specification.

was also published as ISO/IEC 9945:2003 (http://www.unix.org/version3/iso_std.html). Refer to URL: http://www.opengroup.org/products/publications/catalog/mo.htm for more information.

URL. http://www.opengroup.org/.

15.2.20 Telecommunications Industry Association TIA

Inception Date. The U.S. TIA was established in April 1988 [69].

Purpose. TIA develops communications and information technology standards for worldwide use, for market development, performance improvements, and trade promotion programs [69].

History. In 1924, a small gathering of suppliers from the telephone industry planned an industry trade show, and afterward they decided to establish themselves as a committee within the U.S. Independent Telephone Association [69]. In 1979, that group left the association to form their own, the U.S. Telecommunications Suppliers Association (USTSA), which would organize telecommunications exhibitions and seminars [69]. In 1988, TIA was founded from a merger between USTSA and the Information and Telecommunications Technologies Group [69].

Membership. TIA has hundreds of members from many different disciplines, including carriers, software, distributors, and manufacturers (http://www.tiaonline.org/membership/members/).

Collaboration Efforts. TIA is accredited by ANSI [69].

Standards. TIA has developed numerous standards, including CDMA (IS-95). Refer to Chapter 4, Section 4.11.2 for more information.

URL. http://www.tiaonline.org.

15.2.21 Web3D Consortium

Inception Date. The VRML Consortium was formed in 1994 and changed its name to the Web3D Consortium in 1999 [70].

Purpose. The Web3D Consortium provides a forum for developing standards for Web3D applications, and to promote Web3D products through sponsorship of marketing and educational programs [70].

History. In the early 1990s, Silicon Graphics had developed prototype software that enabled technologists to define and display three-dimensional objects and environments within which those objects could move. A “Birds of a Feather” session was held at a W3C meeting where leading virtual reality technologists could discuss their ideas and collaborate on specifications for a language that would operate on the Web. This meeting led to a group known as the Virtual Reality Modeling Language Architecture Group (VAG), from which the VRML Consortium eventually emerged in 1994.

Membership. The Consortium currently has 37 organizational members, including Sun Microsystems, Hewlett-Packard, Intel Corporation, and France Telecom R&D (http://www.web3d.org/membership/company_members.html).

Collaboration Efforts. The Web3D Consortium worked with ISO and IEC to develop ISO/IEC standards for X3D graphics and VRML.

Standards. The specifications for X3D and VRML can be downloaded at URL: http://www.web3d.org/fs_specifications.htm. They are covered in Chapter 14, Sections 14.4.1 and 14.4.3. ISO specifications for these standards include:

- *X3D:* ISO/IEC FCD 19775, ISO/IEC FCD 19776 and ISO/IEC FCD 19777;
- *VRML:* ISO/IEC 14772-1:1997 and ISO/IEC 14772-2:2002.

URL. http://www.web3d.org/.

15.2.22 WiMedia Alliance

Inception Date. The WiMedia Alliance was formed as a not-for-profit industry consortium on September 3, 2002 [71].

Purpose. The WiMedia Alliance is developing a specification that promotes interoperable, IEEE 802.15.3 standards-based products with an emphasis on an ultra-wide band physical layer (802.15.3a). The Alliance also intends to brand products for conformance to WiMedia standards [72].

History. Nine leading international wireless network, consumer electronic, and semiconductor companies formed the WiMedia Alliance to both develop and employ standards for wireless imaging and multimedia products [71].

Membership. WiMedia Alliance's members include Eastman Kodak Company, Hewlett-Packard, Motorola, Inc., Royal Philips Electronics, Samsung Electronics Company, Ltd., Sharp Laboratories of America, Inc., Time Domain Corporation, and XtremeSpectrum, Inc. [72].

Standards. WiMedia Alliance is in the process of defining specifications for personal, wireless, multimedia devices based on the IEEE 802.15.3 draft standard [72]. See Chapter 4, Section 4.11.1 for more information about the IEEE 802.15 standard.

URL. http://www.wimedia.org/.

15.2.23 Wireless Application Protocol Forum

The WAP Forum was formed in the 1990s as a consortium to develop wireless telephony for mobile phones and other devices. It defined the WAP specifications (http://www.wapforum.org/what/technical.htm) that a number of telecommunications vendors adopted and used for their products. However, to promote a single standard, the WAP Forum consolidated their efforts with the Wireless Village Initiative and became the Open Mobile Alliance [60]. Refer to Section 15.2.16 for details.

URL. http://www.wapforum.org/. (Note that the WAP Forum Web page will automatically direct you to the Open Mobile Alliance page at URL: http://www.openmobilealliance.org/index.html.)

15.2.24 Workflow Management Coalition

Inception Date. The WfMC was established in August 1993 as a nonprofit, international organization in the United Kingdom [73].

Purpose. The WfMC defines standards for workflow software terminology, services, and interfaces to promote interoperability between multivendor workflow products [73].

History. In 1993, members of the workflow community—workflow vendors, analysts, and university/organizational research groups—united their efforts to define a standard workflow reference model, language, and protocol [74]. The WfMC Reference Model remains essentially the same as what the organization had defined years ago, but there have been changes in the workflow language and protocols to ensure interoperability with XML services and protocols. WfMC defined an XPDL based on XML, and its workflow process protocol, known as Wf-XML, has evolved to maintain currency with evolving protocols. Wf-XML evolved from its use of the early IETF protocol SWAP in 1997 (before XML had been defined), to SOAP after the W3C defined it to support XML and Web Services, and more recently has updated Wf-XML to use a protocol defined by OASIS (ASAP) that supports XML and SOAP with asynchronous/synchronous interfaces between workflow processes [74].

Membership. The WfMC has more than 300 international members composed of vendors, users, analysts, and research groups [73].

Collaboration Efforts. WfMC is collaborating with OASIS on interoperable standards-based products [75]. WfMC has also collaborated with BPMI on standards [27].

Standards. WfMC has developed: an XML XPDL and a Workflow Reference Model.[29] WfMC Specifications documents can be downloaded from URL: http://www.wfmc.org/standards/standards.htm and by selecting the links on the left-hand side of the window listed under "Standards". WfMC offers a *Workflow Handbook* that describes the WfMC Reference Model and approach to workflows at URL: http://www.wfmc.org/information/info.htm (note that there is a fee to download the handbook). For more information, refer to the Web page hosted by OASIS at URL: http://xml.coverpages.org/wf-xml.html.

URL. http://www.wfmc.org/.

15.2.25 World Wide Web Consortium

Inception Date. The W3C was created as a consortium in October 1994 [76].

29. Refer to Chapter 3, Section 3.1.5 for information about XPDL.

Purpose. The W3C produces specifications that are used to standardize the technologies used for the World Wide Web. The W3C intends for the Web to be accessible and provide secure services for any user, without respect to culture, language, education, ability, material resources, devices, and physical limitations [76].

History. Tim Berners-Lee, who was a graduate of Oxford University, invented the World Wide Web while he was working at CERN, the European Particle Physics Laboratory in Geneva, Switzerland [77]. He developed the first Web browser and first Web server, along with communications software, including HTTP and HTML [77].

However, it was not until Marc Andreesen, a developer at NCSA, created a user-friendly graphical Web browser (Mosaic) that it became relatively easy for users to develop their own Web pages on Unix computers, PCs, and Macintoshes [78]. Prior to this, the Web had been limited to researchers and engineers on Unix computers; the ability to access the Web from PCs and Macintoshes opened up its use to users worldwide [78]. Once the Web was accessible to PC and Macintosh users at business and home, its use exploded [78].

To promote free, global access to Web technologies, Tim Berners-Lee founded the W3C in October 1994 at the MIT/LCS in cooperation with CERN, where he had originated the Web [76]. DARPA and the European Commission also collaborate with the W3C [76]. Tim Berners-Lee has been its Director since its inception [76].

Membership. W3C has more than 400 international organizations as its members, including AOL, Adobe Systems, IEEE Computer Society, T-Mobile Deutschland GmbH, numerous universities, and worldwide government organizations (http://www.w3.org/Consortium/Member/List) [76].

Collaboration Efforts. The W3C collaborates with many standards bodies including IEEE, ISO, and ITU, along with numerous other consortia such as OASIS, The Open Group, DMTF, and OMG (http://www.w3.org/2001/11/StdLiaison).

Standards. W3C refers to their specifications as Recommendations.[30] Refer to URL: http://www.w3.org/TR/#Recommendations for a list. There are numerous W3C standards in use today. Refer to Chapter 14 for more information on Web standards.

URL. http://www.w3.org/.

Other Sources of Information.

- Tim Berners-Lee and Mark Fischetti wrote *Weaving the Web*, published by Harper San Francisco, and also produced an abridged audiocassette.

15.2.26 X.Org Foundation

Inception Date. The X.Org Foundation was founded on January 24, 2004 as a Delaware registered LLC, and acting as a scientific charity under the IRS 501(c)(3) [79].

30. See Chapter 2 Section 2.2.2 for details.

Purpose. The X.Org Foundation is the official steward of the X Window System technology, and is responsible for developing, maintaining, and promoting the X Window System (X) technology and standard [79].

History. In 1993, MIT gave authority to enhance and distribute X to the X Consortium, a nonprofit company [80]. Because the X Window System has been used principally on Unix-based systems, the X Consortium became an organization within The Open Group and was renamed X.Org on May 12, 1999 [81]. On January 24, 2004, the original members of X.Org and some new industry participants created the X.Org Foundation as a Delaware registered LLC and a scientific charity [79].

Membership. Members of the X.Org Foundation include Hewlett-Packard, Hummingbird, Sun, SGI, and IBM. Refer to URL http://www.x.org/XOrg_members.html for a list of current members.

Standards. The X.Org Foundation develops and maintains the X Window System, which can be downloaded at URL: http://www.x.org/Downloads.html. Refer to Chapter 13, Section 13.3 for information about the X Window System.

URL. http://www.x.org/.

References

[1] "Introduction [to ANSI]," http://www.ansi.org/about_ansi/introduction/introduction.aspx?menuid=1, ANSI, November 6, 2004.

[2] "ANSI – An Historical Overview," http://www.ansi.org/about_ansi/introduction/history.aspx?menuid=1, ANSI, November 7, 2004.

[3] "Founding of the IEC," http://www.iec.ch/zone/si/si_role.htm, IEC, November 6, 2004.

[4] "About the IEC: History," http://www.iec.ch/about/history/hentry-e.htm, IEC, November 6, 2004.

[5] "What Is the IEEE?" http://www.ieee.org/portal/site/mainsite/menuitem.818c0c39e85ef176fb2275875bac26c8/index.jsp?&pName=corp_level1&path=about/whatis&file=index. xml&xsl=generic.xsl, IEEE, November 7, 2004.

[6] "IEEE Vision and Mission," http://www.ieee.org/portal/site/mainsite/menuitem.818c0c39e85ef176fb2275875bac26c8/index.jsp?&pName=corp_level1&path=corporate&file=vision.xml&xsl=generic.xsl, IEEE, November 7, 2004.

[7] "History of the Institute of Electrical and Electronics Engineers (IEEE)," http://www.ieee.org/organizations/history_center/historical_articles/history_of_ieee.html, IEEE, November 7, 2003.

[8] "About the IEEE," http://www.ieee.org/portal/site/mainsite/menuitem.818c0c39e85ef176fb2275875bac26c8/index.jsp?&pName=corp_level1&path=about&file=index.xml&xsl=generic.xsl, IEEE, November 7, 2004.

[9] "What Is INCITS?" http://www.ncits.org/, INCITS, November 7, 2004.

[10] "How We Began," http://www.itic.org/whoweare/how.html, ITI, November 7, 2004.

[11] "X3 Changes Its Identity to NCITS," http://www.incits.org/press/1997/pr97001.htm, INCITS, January 24, 1997.

[12] "IT Standards Group Highlights International Agenda with Name Change," http://www.incits.org/press/2002/pr2002namechange.htm, Press Release, INCITS, Washington, D.C., January 15, 2002.

[13] "About ISO," http://www.iso.org/iso/en/aboutiso/introduction/index.html#four, ISO, November 17, 2004.

[14] "ITU Overview – History," http://www.itu.int/aboutitu/overview/history.html, ITU, November 7, 2004.

[15] "Welcome to the International Telecommunication Union," http://www.itu.int/home/index.html, ITU, November 7, 2004.

[16] "NIST: General Information," http://www.nist.gov/public_affairs/general2.htm, NIST, November 8, 2004.

[17] "NIST Mission, Vision, Values, and Practices," http://www.nist.gov/public_affairs/ nist_mission.htm, NIST, November 8, 2004.

[18] "NIST at 100: Foundations for Progress," http://www.100.nist.gov/, NIST, November 8, 2004.

[19] "NIST at 100: Foundations for Progress; The Founding," http://www.100.nist.gov/founding.htm, NIST, November 8, 2004.

[20] "From NBS to NIST," http://www.100.nist.gov/directors.htm, NIST, November 8, 2004.

[21] History: Learn About ATM," http://www.atmforum.com/aboutatm/history.html, The ATM Forum, October 3, 2004.

[22] "Frequently Asked Questions," http://www.bpmi.org/faq.htm, BPMI, November 9, 2004.

[23] "Intalio Leads XML Initiative for Business Process Management," http://www.bpmi.org/downloads/2000-08-07-BPMI%20Begins.pdf, BPMI, August 7, 2000.

[24] Farber, D., "A Revolution in Business Process Management?" http://www.techupdate.com/techupdate/stories/main/0%2C14179%2C2911035%2C00.html, *ZDNET*, February 17, 2003

[25] Sliwa, C., "Division over Web Services Standards Work Stirs Debate: IBM, Microsoft Choose OASIS over W3C," http://www.computerworld.com/developmenttopics/development/webservices/story/0,10801,80941,00.html, *ComputerWorld*, May 5, 2003.

[26] Krill, Pl., "OASIS to Get BPEL4WS Jurisdiction: Web Services Spec Finally Goes to Standards Body," http://www.infoworld.com/article/03/04/15/HNbpel_1.html, *InfoWorld*, April 15, 2003.

[27] "About BPMI.org: Our Mission," http://www.bpmi.org/aboutus.htm, BPMI, November 9, 2004.

[28] "Distributed Management Task Force," http://www.dmtf.org/home, Distributed Management Task Force, Inc., November 17, 2003.

[29] "Products Conformant to SMI-S – Storage Standard Based on DMTF's CIM and WBEM – Announced," http://www.dmtf.org/newsroom/releases/2004_04_06, Press Release, DMTF, April 6, 2004.

[30] "What Is Ecma International," http://www.ecma-international.org/memento/index.html, Ecma International, November 9, 2004.

[31] "History of Ecma," http://www.ecma-international.org/memento/history.htm, November 9, 2004.

[32] "Global System for Mobile Communication," http://www.iec.org/online/tutorials/acrobat/gsm.pdf, Internet Engineering Consortium, November 11, 2004.

[33] "Who Is ETSI?" http://www.etsi.org/about_etsi/5_minutes/5min_a.htm, ETSI, November 11, 2004.

[34] "History of GSM," http://www.gsmworld.com/about/history/history_page4.shtml, *GSM World*, November 11, 2004.

[35] "Want to Know About ETSI? You Have 30 Minutes," http://www.etsi.org/about_etsi/30_minutes/home.htm, ETSI, November 11, 2004.

[36] "Staff," http://www.freestandards.com/modules.php?name=Content&pa=showpage&pid=17, Free Standards Group, November 17, 2004.

[37] "About Us," http://www.freestandards.com/modules.php?name=Content2&pa=showpage&pid=4, Free Standards Group, November 17, 2004.

[38] "Free Standards Group Recognized by ISO/IEC JTC 1 as PAS Submitter: Achieves Major Milestone in Advancing Internationally Recognized Standards for Linux," http://www.freestandards.com/modules.php?name=News&file=article&sid=65, Press Release, Free Standards Group, January 27, 2004.

[39] Catlett, C., and I. Foster, "Grid Forum: An Overview," http://www-fp.mcs.anl.gov/~catlett/GF/GridForum-Overview.pdf, IEEE Technical Committee on Distributed Processing, March 2000.

[40] "Global Grid Forum Overview," http://www.gridforum.org/L_About/about.htm, Global Grid Forum (GGF), November 11, 2004.

[41] Boulton, C., "IBM, Veritas Lead New Utility Computing Standard," http://www.gridcomputingplanet.com/news/article.php/3311791, *Grid Computing Planet.com*, February 11, 2004.

[42] Leiner, B. M., et al., "The History of the Internet," http://www.isoc.org/internet/history/brief.shtml#Origins, ISOC, December 10, 2003.

[43] Kessler, G. C., "IETF—History, Background, and Role in Today's Internet," http://www.garykessler.net/library/ietf_hx.html, February 1, 1996.

[44] Ruthfield, S., "The Internet's History and Development: From Wartime Tool to Fish-Cam," *Crossroads*, ACM Press New York, Vol. 2, No. 1, September 1995, pp. 2–4.

[45] Leiner, B. M., et al., "The Past and Future of the Internet," *Communications of the ACM*, Vol. 40, No. 2, February 1997, pp. 102–108.

[46] Jaffe, J., "Happy Birthday, Dear Internet," http://www.wired.com/news/infostructure/0,1377,57013,00.html, Wired News, December 31, 2002.

[47] Bowe, T. S., "J Consortium Forms to Push for Independent Embedded Java," http://www.infoworld.com/cgi-bin/displayStory.pl?99058.ecjconsort.htm, *InfoWorld Electric*, May 8, 1999.

[48] "By-laws of J Consortium®, Inc.," http://www.j-consortium.org/bylaws.shtml, *J Consortium*, November 11, 2004.

[49] "Real-time JAVA™ Working Group Initiates New Open Standards Process for JAVA™ Programming Language," http://www.j-consortium.org/press.releases/pr110298.shtml, J Consortium Press Release, Silicon Valley, California, November 2, 1998.

[50] Heiss, J. H., "Java Community Process Program," http://java.sun.com/features/2001/06/jcp.program.html, Sun Microsystems, June 6, 2001.

[51] "Press Backgrounder," http://www.projectliberty.org/press/backgrounder.php, Liberty Alliance, November 11, 2004.

[52] Murray, C. J., "Liberty Alliance Takes Aim at Microsoft Passport," http://www.eetimes.com/story/OEG20010928S0131, *EE Times*, September 28, 2001.

[53] Verton, D., "Opposing Vendor Groups Merge to Develop Single Metadata Standard," http://www.computerworld.com/softwaretopics/software/story/0,10801,51254,00.html, *ComputerWorld*, September 26, 2000.

[54] "About the Object Management Group™ OMG™," http://www.omg.org/news/about/index.htm, *Object Management Group*, November 11, 2004.

[55] "OMG, OGC, Web3D and SISO Announce @Ref # = [the]First Annual Workshop on Web Enabled Modeling and Simulation," http://www.omg. org/news/releases/pr2003/09-26-03.htm, *OMG Press Release*, Needham, MA, September 26, 2003.

[56] Resources – Frequently Asked Questions," http://www.opengis.org/resources/?page= faq#16, *OGC*, November 11, 2004.

[57] "History of OGC," http://www.opengis.org/about/?page=history, OGC, November 11, 2004.

[58] "OMA Frequently Asked Questions," http://www.openmobilealliance.org/about_OMA/faq.html, OMA, November 13, 2004.

[59] "About OMA," http://www.openmobilealliance.org/about_OMA/index.html, OMA, November 13, 2004.

[60] Lemon, S., "Over 200 Vendors Join to Create Mobile Alliance," http://www.nwfusion.com/news/2002/0612moballiance.html, *Network World Fusion*, IDG News Service, June 12, 2002.

[61] "About OASIS," http://www.oasis-open.org/who/, OASIS, November 30, 2003.

[62] "RosettaNet," http://www.rosettanet.org/RosettaNet/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entit{yOID[F3B7FF807CE1C2429F6081C970993209], RosettaNet, May 31, 2004.

[63] "About SNIA," http://www.snia.org/about, SNIA, November 13, 2004.

[64] Kolesar, M., "SNIA Technology Mission," *Computer Technology Review*, September 1, 1999, page S-9.

[65] SNIA News Room, "SNIA Teams with INCITS to Fasttrack Storage Management Initiative Specification (SMI-S)," http://xml.coverpages.org/SNIA-INCITS.html, SNIA, Washington D.C., November 12, 2004.

[66] Lee K., "Motif FAQ: What Is The Open Group?" http://www.faqs.org/faqs/motif-faq/part2/section-14.html, X & Motif Consulting, February 1, 2002.

[67] "About the Open Group," http://www.opengroup.org/overview/index.htm, The Open Group, November 13, 2003.

[68] "Who Owns UNIX®?" The Open Group, http://www.opengroup.org/comm/press/who-owns-unix.htm, June 17, 2003.

[69] "TIA Facts at a Glance," http://www.tiaonline.org/about/overview.cfm, TIA, November 13, 2004.

[70] "About the Web3D Consortium," http://www.web3d.org/contact/about.html, Web3D Consortium, November 13, 2004.

[71] "Technology Leaders Establish WiMedia™ Alliance to Promote Personal Wireless Multimedia Connectivity," http://www.wimedia.org/news/press/default.asp?content=pr090302.htm&style=2, Press Release, WiMedia Alliance, San Ramon, CA, September 3, 2002.

[72] "WiMedia Alliance Overview," http://www.wimedia.org/about/WiMedia_One_Page_final_Connections03.pdf, WiMedia Alliance, November 13, 2004.

[73] "About WfMC: Introduction to the Workflow Management Coalition," http://www.wfmc.org/about.htm, WfMC, November 13, 2004.

[74] DeJean, D., "WfMC Brings Standard Protocols to BPM," http://www.enterpriseappspipeline.com/showArticle.jhtml?articleID=22100906, *enterpriseappspipeline*, June 18, 2004.

[75] "XML-Based Workflow and Process Management Standards: XPDL, Wf-XML," http://xml.coverpages.org/wf-xml.html, OASIS, November 14, 2004.

[76] Herman, I., "About the World Wide Web Consortium (W3C)," http://www.w3.org/Consortium/, W3C, November 14, 2004.

[77] "Who's Who at the World Wide Web Consortium," http://www.w3.org/People/all#timbl, November 14, 2004.

[78] "A Science Odyssey: People and Discoveries – The Internet Gives Rise to the World Wide Web in 1992," http://www.pbs.org/wgbh/aso/databank/entries/dt92ww.html, *PBS Online*, 1998.

[79] "X.org Foundation Background," http://www.x.org/XOrg_background.html, X.org, November 14, 2004.

[80] Scheifler, R. W., and J. Gettys, "The X Window System," *ACM Transactions on Graphics (TOG),* Vol. 5, No. 2, April 1986, pp. 79–109.

[81] "X.Org Becomes X Technology Steward: Industry Consortium to Guide the Future of the X Window System," http://www.x.org/News_press_release_5_99.html, X.Org, Menlo Park, CA, May 12, 1999.

CHAPTER 16

Trends

With the standards developments discussed in the previous chapters as background, this chapter highlights particular developments to identify five trends moving technologies closer to achieving the open systems vision.

16.1 Trend #1: High-Speed, Ubiquitous, Global Communications

Communications technologies are moving rapidly toward ubiquitous communications: *connectivity anywhere, anyplace, and anytime*. Long before and after the ARPANET, telephone carriers relied on analog communications. Looking back at the history of the Internet when Paul Baran proposed the groundbreaking concepts of packet switching and distributed digital communications, one can see the need for computer internetworking drove the development of digital communications [1].[1] Digital communications are superior to analog for transmitting digital data, and not riddled with problems like noise, jitter, and echoes.

Over the years, telephone carriers found themselves unable to keep up with the demand of a constantly growing population of users, and they began migrating analog capabilities to digital communications out of necessity. The techniques for digital communications were discovered to be better suited for addressing a growing population of users. This new direction for voice communications via digital transmission technologies led to new possibilities for computer capabilities, and enabled both data and voice to converge simultaneously on the same digital communications medium.

Voice over IP (VoIP) technologies,[2] also known as IP Telephony, enable users to talk to other users via their computers [2]. This is a feature of the trend toward ubiquitous communications where software compresses the voices into digital IP packets and transmits them over a digital communications system [2]. Although IP Telephony was introduced nearly 10 years ago in the mid-1990s, users still experience delays in hearing another user's conversation, as well as clipped speech, echoes on the line, and jitters from receiving different parts of a conversation at different times, but it marks a step toward achieving the vision for ubiquitous communications, and new techniques are being developed to improve it [2].

1. Refer to Chapter 4, Section 4.5, for a detailed discussion of the Internet.
2. Refer to Chapter 4, Section 4.10, for information on VoIP.

Video on demand (VoD) is another feature of the trend toward ubiquitous communications, allowing users to receive streaming video over the Internet to their computers from a server that hosts movies. SourceForge.net, an Open Source software development Web site, is sponsoring a VoD project (http://vod.sourceforge.net/) to implement open software based on open standards to support VoD. Another feature of ubiquitous communications is Interactive TV, where companies such as NDS (http://www.nds.com/) provide cable or local TV shows directly to TVs and computers via the Internet. Communications bandwidth must improve before streaming video over IP enables movies and television shows to run in real-time on your computer like it does on TVs, VCRs, and DVD players.

Advances in wireless technologies based on radio waves, such as Bluetooth (IEEE 802.15) and WiMax (IEEE 802.16), are enabling mobile devices such as PDAs and wireless laptops to remain connected to networks while the devices move with their users. Wi-Fi (IEEE 802.11) provides WLANs for home and business environments, with QoS features and support for multimedia [3]. In neighborhoods where ISPs are unable to connect users by cable, WiMax is considered a possible approach for connecting them to the Internet via radio waves [4]. WML provides mobile devices such as PDAs and cell phones with limited access to Web sites and services on the Internet [5]. Users can send and receive e-mail from their PDAs, pagers, and cell phones.

Now that data, video, and voice are supported to some degree by digital communications, there is a driving force for faster communications that transmit more data, video, and voice than ever before, simultaneously, with the highest quality, free of noise, jitter, echoes, and in real-time. Streaming video will be captured and displayed in real-time. And, in the not too distant future, the Internet will enable you to listen to international radio stations and watch movies as well as TV shows broadcast from anywhere in the world on your computer, your TV, your PDA, and other networked devices; send videomail, voicemail, and e-mail; and conduct conference calls where each person is connected to the Internet in a different way—by computer, mobile device, phone, PDA, and other devices. This is the direction and future for the Internet: ubiquitous communications.

16.2 Trend #2: Better Security Mechanisms

Identity theft is at an all-time high, as evidenced by the provision of an "ID Theft Home" page hosted by the Federal Trade Commission to provide advice on what to do if your identity is stolen (see URL: http://www.consumer.gov/idtheft/). Because the Internet was conceived as a means for facilitating open collaboration and communication across the DoD, research organizations, and universities, the same capabilities were extended to other users around the world. But by its very openness and lack of discrimination in who can use the system, the Internet has opened the door to cyber thieves who steal and sell identity data acquired via the Internet from hacking into credit card and other privately held databases.

When you provide a credit card at a brick-and-mortar store to charge an item, ownership of the card is sufficient to indicate your authorization of the transaction, and the credit card institution approves the transaction if the credit card number is valid. Unless you or the cashier inadvertently let someone else in line see your credit card when you provide the card to the cashier, you have physically protected it for that transaction. However, all bets are off if the store is an electronic one. If an electronic store receives your credit card number in the clear (unencrypted), or if its encryption scheme is considered easy to hack, there is always a chance that someone else might be able to get that number as well.

Credit card fraud is rampant on the Internet. As companies build e-business applications, they are re-examining how they protect their goods and services from unauthorized exploitation. So to entice you to purchase from their Internet stores, companies must guarantee that they will safeguard your transactions. Encrypted communications provides a layer of security. Standards under development to support encryption protocols include TLS from the IETF, and WTLS based on TLS for wireless communications by the OMA.[3]

The Public-Key Infrastructure X.509 (PKIX) introduces standards for public and private keys to validate a user's identity and encrypt messages, documents, e-mail attachments, and other files, so that only the intended recipient can decrypt and read them.[4] PKI is also used to limit the use of an application to a specific set of users who hold certain PKI certificates.

Identity management is another area where security standards are evolving. Identity management covers the creation, access, update, and storage of private user information, along with security services to protect its confidentiality. Once completely within the purview of system administrators who created and updated user accounts, now self-service capabilities exist that enable users to create and manage their own accounts. Identity management security standards include Kerberos, the Liberty Version 1.0 Specification, and SAML.[5]

The use of XML raises security concerns for data, depending on the nature of the data exchanged. For instance, as businesses implement XML in their Web applications to access data, stronger standards for XML security are being considered to handle concerns like XML denial of service (a host of user queries that overwhelm the server), or that enable access to sensitive database information for which the user is not entitled (e.g., providing a social security number for another individual) [6]. Vendors are also examining how to encrypt sensitive databases or particular fields in databases to secure them from hackers, but adding encryption/decryption processes for individual data elements can seriously degrade system responsiveness. Future security mechanisms will include standard approaches to protect databases and XML data exchanges at the data element level, and address performance issues as well.

Wireless devices, such as PDAs, laptops, cell phones, and WLANs are another area where security standards are under development to safeguard data, applications, and communications. As security standards evolve and mature, security mechanisms will improve and provide greater protection for applications, data, and communications exchanges, as well as the devices connected to the Internet.

3. Refer to Chapter 10, Sections 10.6.5 and 10.6.6.
4. Refer to Chapter 10, Section 10.4.1.
5. Refer to Chapter 10, Section 10.2.

16.3 Trend #3: Worldwide Electronic Collaboration

As major international companies acquire companies with a market niche for specialized services, virtual teams become the norm. A virtual team is a group of individuals who form and act as a team using electronic collaboration tools and information services, irrespective of their geographic location, for the purpose of accomplishing a mutual goal [7]. Virtual teams are seen as a means for reducing the expense of traveling to face-to-face meetings, and thinking outside the box as insights are offered from diverse specialty areas. A *Harvard Business Review* study found that virtual teams can actually be more productive and creative than face-to-face meetings if the teams leverage collaboration technologies, promote the diversity of ideas, and encourage frequent communications exchanges as a means for keeping the teams together [8].

Today, what immediately springs to mind when discussing electronic collaboration are capabilities like e-mail, bulletin boards, instant messaging, and virtual rooms [7]. These capabilities are only the beginning. As VoIP technologies become more mature, powerful, and robust, and connect individuals from around the world, video teleconferencing will become economical and commonplace to use for virtual teams. VoIP technologies will enable worldwide virtual teams to dynamically interact as they view presentations, documents, graphics, and other media with perfect audio and video over computers, laptops, IP phones, and other IP devices.

But language barriers among virtual team members pose a new obstacle for electronic collaboration that must be overcome. The solution requires a digital voice recognition and translation capability. NEC (http://www.nec.com/global/corp/index.html), an IT network technology company, has already spent years on this problem and has developed a digital voice recognition and translation technology or *speech-to-speech* technology that was introduced in a PDA at Tokyo's Narita Airport in 2004 [9]. The technology supports up to 50,000 Japanese words and 25,000 English words to translate conversations from English to Japanese [9]. It was developed as an aid for English-speaking tourists and travelers to Japan and is available in PDAs that can be rented at the airport [9]. This breakthrough technology is envisioned as a future telephone service, and could potentially evolve into a multilingual, electronic collaboration standard.

16.4 Trend #4: Intelligent Push/Pull from Petabyte Data Stores

How many times have you entered a keyword into a search engine on the Web, only for it to yield hundreds—maybe even thousands—of irrelevant matches? This problem is only exacerbated over time as more and more Web pages are posted. With an increased number of Web pages available to be searched, it may take even longer to get a complete response. Some search engines simply stop the search after a specified number of hits, but with that approach, you may never find the information you are looking for. *USA Today* indicated that in 2004, the Google search engine indexed a mind-boggling 4.2 billion Web pages [10].

Combined with the growth in the number of Web pages, the size of data storage is skyrocketing. Consider that some government and industry organizations are gearing up to house petabytes (PB) of data. A PB is equivalent to 1,024 terabytes. A terabyte is 1,024 gigabytes. A PB has been likened to 500 million pages of text that could fill the Library of Congress over eight times [11]. To handle this magnitude of data, vendors are manufacturing SANs[6] that utilize a high-speed network based on fiber channel to store and access data. But the ability to access meaningful data from PB stores is a daunting task, and developing suitable data structures remains a pioneering effort.

Organizations are investigating methods for accessing and storing PB of data, such as San Diego's Supercomputer Center (http://www.sdsc.edu/Press/2004/03/031604_HPSS.html), which in March 2004 passed its 1 PB mark for stored data [11]. The CCLRC e-Science Centre (http://www.e-science.clrc.ac.uk/web/) aims to store a petabyte of particle physics and data from other disciplines as part of its Atlas DataStore project (Atlas DataStore (http://www.e-science.clrc.ac.uk/web/projects/petabyte). CERN, the organization where Tim Berners-Lee was employed when he created the World Wide Web, will be collecting between 5 and 20 PB of raw particle accelerator data every year, beginning in 2006 [12].

Metadata, or data about data, is a data structuring approach in use for speeding access to large amounts of data.[7] Metadata is used to facilitate data queries and data mining. However, now that data stores are growing to PB, some organizations have begun to develop metadata "clusters" as a grouping mechanism with indexes to very large, complex, spatially oriented data files such as represented by seismic data. This approach is a simplifying mechanism to speed access to specific files stored somewhere in a specialized, vast data store of spatially oriented, temporal data such as maps, weather data, environmental data, and seismic data. The approach features a structuring mechanism akin to that of more advanced Geographic Information System (GIS) software. Advanced GIS software supports a tree structure to access geographically oriented map data stored as individual map files. The topmost node in the tree structure is an index to the entire map, and each successive level down the tree breaks the map into equivalent subsections of the parent node's map, where each node indexes a unique section of the map. GIS software relies on this tree structure to zoom down to the lowest level of map required in response to user selections. Metadata clusters that contain indexes to complex data files are implemented using similar concepts.

Combined with the use of metadata is a keen interest in developing ontologies as a mechanism for defining metadata categories. XML is widely used as a syntactical interface to facilitate data exchanges between Web applications and with users, but it does not address the content of the data in terms of its semantic meaning [13]. This limitation spurred W3C members to define a language, the OWL Web Ontology Language[8] (http://www.w3.org/TR/2004/REC-owl-features-20040210/#s1.2) as a first step toward developing Web interfaces that consider the semantic meaning of data to execute applications [13]. Ontology is defined as a vocabulary of basic terms and a precise definition of what the terms mean within the domain that uses them [14].

6. Refer to Chapter 6, Section 6.5, for a discussion of SANs and emerging standards.

7. Refer to Chapter 6, Section 6.3, for a discussion of metadata.

8. The OWL Web Ontology Language is being developed as part of the Semantic Web efforts. Refer to Chapter 14, Section 14.3.1, for information about the Semantic Web.

Organizations such as Ontology.org are forming to define ontologies for specific domain areas [14]. As domain ontologies mature and become approved by the communities for the domains they represent, they will form the foundation for more sophisticated Web-based searches for meaningful information from the PB stores of data on the Web. These sophisticated Web-based searches will support the intelligent *pull* of data. In addition, with the use of ontologies for defining metadata categories and content, organizing principles for how certain types of data should be stored will be standardized and form the basis for the intelligent *push* of data into integrated data stores that grow to PB and beyond.

16.5 Trend #5: Seamless Interfaces to Networked Applications and Data

The trend toward seamless interfaces to networked applications and data relies on the technologies and standards from the other trends. Seamless interfaces require the ubiquitous, networked communications to provide automatic connectivity to applications and data. The standards and technologies from better security mechanisms protect communications exchanges between applications, data, and users, and provide stronger user authentication.

There are three principal standards efforts propelling the move toward seamless interfaces. One is the standards push for a single user id and password, also referred to as a single logon, to applications and data. Another standards effort is spearheaded by the W3C to define Web interfaces that will provide a basis for seamless Web interfaces. A third standards effort will revolutionize the Web environment to support grid computing.

The first standards effort, a single logon, is driven by users' demand that they not have to remember a legion of user ids and passwords to logon to numerous networked applications and databases at work and on the Internet. They clamor for a single logon, where they can logon once and have immediate access to applications and data. Single logons are especially important for facilitating seamless interfaces between e-business applications. OASIS and Liberty Alliance are making strides in defining identity management standards that can significantly reduce the number of logons required for federated e-business applications: applications that belong to different companies and work together to provide complementary services.[9] Here is an example of how federated e-business applications might work to plan a trip for you: you would logon first to a "master" travel agent e-business application that would automatically interact with a set of different e-business applications to help you plan the trip. The travel agent application would book a flight with an electronic airline reservation application using the user profile it has on file for you with the information you provided: your leaving and return dates, the times you want to fly, and the maximum charge you are willing to pay for the trip. Next, the travel agent application would pass your travel information to a hotel application that would reserve a room for you at a nearby hotel. The travel agent application would then pass your travel and hotel information to a rental car application that would

9. Refer to Chapter 10, Section 10.2, for discussion of authentication and identity management standards.

reserve a rental car for you at the airport. These three applications would rely on the travel agent application to provide your personal information such as name, user profile, and preferences to enable them to make your reservations. The travel agent application would charge your credit card for these services, so you could limit access to your credit card. Identity management standards significantly reduce user logons. In addition, they can limit the number of trusted applications that could charge your credit card. The master application could work for a host of e-business applications, enabling you to order from companies around the world, purchase clothes from international stores, buy international movies and TV DVDs, and a host of other items using a single logon.

The second standards effort is driven by the W3C's efforts to define Web interfaces that achieve the vision of Tim Berners-Lee, director of the W3C and inventor of the World Wide Web, for a Semantic Web [15].[10] Semantic Web standards form the basis for the next generation of the World Wide Web. The Semantic Web provides a URI for all objects that interface with the Web, and this includes not only Web pages, but users, documents, files, applications, relationships, PDAs, phones, and so on, to provide the basis for developing sophisticated links [15]. Semantic Web markup languages and ontologies support XML and XML artifacts, and they are used to implement the functionality of Web applications, such as those described for planning a trip. For instance, the ontology for a trip might describe individual activities for booking an airline reservation, reserving a hotel room, and reserving a rental car, and the ontological terms for these activities would link to URIs for application functions that implemented the activities. These URIs would be executed when a user requested Web support to plan a trip.

The Semantic Web vision has led to the development of the OWL Web Ontology Language to define ontologies, but this is only the proverbial tip of the iceberg. The W3C is also defining markup languages for speech synthesis, speech recognition, and grammars, which VoiceXML (http://www.w3c.org/Voice) builds upon to create dialogs of synthesized speech [16]. The objective of these is to allow users to converse either audibly or by entering text on the Internet with devices such as laptops, PDAs, computers, and phones, which will respond by performing a predefined set of ontologically defined functions [16]. Boeing Company and Adobe Systems are already working on technologies to implement Semantic Web capabilities [17].

As the standards and their technologies matured, the Semantic Web markup languages would be used to define grammars for non-English languages and provide a foundation for Web-based automatic language translation.

One more standards effort is needed. In the ubiquitous, networked environment described in Trend #1, heterogeneous computing devices from diverse vendors connect to the network and offer differing levels of capabilities. To enable them to harness the power represented by the sum of devices connected to the Web, a different architecture than today's is needed.[11]

10. Refer to Chapter 14, Section 14.3.1, for more information about the Semantic Web.

11. Readers might recall the "thick net" versus "thin net" approach to supporting devices that were either minimally capable or fully capable of supporting applications on the devices or the network. Grid computing could be considered a more sophisticated form of this network capability.

The Global Grid Forum (http://www.ggf.org) has been defining an Open Grid Services Architecture that would support grid computing capabilities on the network.[12] How might they work? Suppose that a user with a wireless PDA logs on to the network. The system would automatically recognize the PDA—no matter what vendor had manufactured it—enable it to access the network, and accommodate its perceived limitations. If the PDA's user requested an application and the system determined that it would overburden the PDA, the system would be able to utilize the power of other devices on the entire network as needed to run applications on request and provide the results to the PDA. In this example, however, the system would determine which available computers or devices would be capable of running the application and would then assign the task of running the application to one of them. Subsequently, the application would be executed on the assigned computer or device, and when it completed, the system would return the results to the PDA. All of these activities would be transparent to the user. The same actions would apply to accessing data. In all cases, the user would never need to know where the applications and data resided because the system would automatically handle it.

Once all of the standards developments described in this section have been implemented on the Web, seamless interfaces to applications and data will be realized.

16.6 Challenges for Open Systems

The future is not entirely rosy. There are significant hurdles to be overcome in order to attain the open systems vision. While technologies and standards appear to be moving in the right direction, there are still numerous competing standards. One example of this is the number of organizations developing competing XML-based standards [18].

While one might expect that at least the W3C would be exempt from competition, one finds that this is not the case [19, 20]. An explanation for this might be that since the W3C's Web Services are still evolving and not mature enough to define comprehensive infrastructure services, some standards organizations have jumped into the fray to define Web Service standards that their other standards can build upon. So the real challenge is not actually defining standards that will enable technologies to achieve the vision, but for standards organizations to unify their efforts and forge relationships that will enable them to work together to define a single set of complementary, definitive standards instead of creating confusion by defining standards that compete [20].

Delving into the technical aspects of emerging standards, there are thorny problems to address. For grid computing, it becomes apparent that while the required services have been described, the mechanisms that will make them a reality have not been defined. Will the grid computing paradigm replace the client-server architecture with something else? Will the grid computing architecture provide for a centralized manager that monitors and manages the execution of jobs, or will a subset of computing devices on the network share this responsibility, or will every computing

12. See Chapter 7, Section 7.6, for more details.

device share this responsibility to some degree in a distributed fashion? Will it support peer-to-peer communications? Will users and applications be able to exchange private messages, or will all messages be subject to monitoring? What mechanisms will enable grid computing systems to seamlessly interoperate? These are the some of the basic questions to be answered, and why *Network World Fusion* claims "Grid [is] not ready for prime time" [21].

There is some skepticism that the Semantic Web will ever realize its vision for "semantic reasoning." Some view it as a repackaging of the artificial intelligence concepts that fell far below expectations a few years ago. Others argue that problems with semantics cause communication problems when only several individuals are involved, so how could computers be expected to perform any better? The real challenge will be providing users with a general set of commands that enable a computer to recognize what services, products, or answers the users really want from a universe of possibilities. This would be a difficult task for humans, but it is even more challenging for automation.

Finally, what mechanisms could ever possibly be invented that would make the Web secure enough that it cannot be compromised? Every day someone reports that a credit card database was accessed by a hacker, or a virus was downloaded that compromised thousand of system user ids and passwords, or a thief stole funds from a bank electronically. Just recently the Witty Worm targeted the Internet Security System's BlackICE and RealSecure products, and within 45 minutes of being released had managed to destroy 12,000 computer systems that hosted particular versions of the products [22]. When will it end?

While these challenges may seem insurmountable, consider that only a little over two decades ago, there was no Internet, and it was little more than a decade ago that the World Wide Web did not even exist, yet now they are pervasive element within cultures around the globe. They are used for shopping, dialoguing with friends, arranging and conducting meetings, planning travel, paying bills, training and education, and the list goes on. So it is not too farfetched to believe that within two or more decades the open systems vision will be a reality.

References

[1] Baran, P., "The Beginnings of Packet Switching: Some Underlying Concepts," *IEEE Communications Magazine*, Vol. 40, No. 7, July 2002, pp. 42–48.

[2] Bates, R. J., *Broadband Telecommunications Handbook*, Second Edition, New York: McGraw-Hill Companies, Inc., 2002.

[3] "IEEE 802 General Information," http://www.ieee.org/portal/site/mainsite/menuitem.818c0c39e85ef176fb2275875bac26c8/index.jsp?&pName=corp_level1&path=about/802std&file=index.xml&xsl=generic.xsl, IEEE, October 24, 2004.

[4] Sorid, D., "Wi-Fi Successor Called High-Speed Hype, for Now," http://www.computerworld.com/mobiletopics/mobile/story/0,10801,96624,00.html, *ComputerWorld*, October 14, 2004.

[5] Seth, H., "Evolution of the Wireless Web – WAP 2.0," http://www.computerworld.com/news/2001/story/0,11280,63550,00.html, *ComputerWorld*, September 5, 2001.

[6] Lilly, J., "Speed It Up: What It Really Takes to Accelerate Secure XML," http://www.computerworld.com/developmenttopics/development/story/0,10801,96151,00.html, *Computer World*, October 4, 2004

[7] P. A. Dargan, "The Ideal Collaborative Environment," http://www.stsc.hill.af.mil/crosstalk/2001/04/dargan.html, *CrossTalk*, *The Journal of Defense Software Engineering*, April 2001.

[8] Majchrzak, A., J. Stamps, and J. Lipnack, "Can Absence Make a Team Grow Stronger?" http://www.virtualteams.com/, *Harvard Business Review*, May 1, 2004.

[9] Twist, J., "Robo-Talk Helps Pocket Translator," http://news.bbc.co.uk/1/hi/technology/3513623.stm, BBC News, March 4, 2004.

[10] Maney, K., "What If the Web Could Anticipate Your Needs?" *USA Today*; October 1, 2004, p. A.1.

[11] "SDSC's High-Performance Storage System Achieves Petabyte Milestone," http://www.sdsc.edu/Press/2004/03/031604_HPSS.html, San Diego Supercomputer Center (SSDC) Press Release, March 17, 2004.

[12] Whiting, R., "CERN Project Will Collect Hundreds of Petabytes of Data," http://www.informationweek.com/story/IWK20020208S0007;jsessionid=O2IPDPWKTVXO4QSNDBGCKHSCJUMEKJVN, *InformationWeek*, February 11, 2002.

[13] "Owl Web Ontology Language Overview: W3C Recommendation 10 February 2004," http://www.w3.org/TR/2004/REC-owl-features-20040210/#s1.2, W3C, November 4, 2004.

[14] "Ontology.Org: Frequently Asked Questions," http://www.ontology.org/main/papers/faq.html, Ontology.Org, May 31, 2004.

[15] Berners-Lee, T., J. Hendler, and O. Lassila, "The Semantic Web," http://www.sciam.com/print_version.cfm?articleID=00048144-10D2-1C70-84A9809EC588EF21, *Scientific American.com*, May 17, 2001.

[16] "'Voice Browser' Activity—Voice enabling the Web!" http://www.w3c.org/Voice/, World Wide Web Consortium (W3C), November 3, 2004.

[17] Cowley, S., "Berners-Lee Extols Semantic Web at W3C Conference: The Inventor of the Web Wants to See It Made into a Giant Transactional Database," http://www.computerworld.com/developmenttopics/websitemgmt/story/0,10801,93264,00.html, *ComputerWorld*, May 19, 2004

[18] Stevens, R., "The Promise of Web Services Awaits Better Standards," http://www.computerworld.com/developmenttopics/development/webservices/story/0,10801,93739,00.html, ComputerWorld, June 14, 2004.

[19] Sliwa, C., "Berners-Lee: Standards groups Are 'Very Different Places': He Discussed How the W3C and OASIS Tackle Web Services Standards," http://www.computerworld.com/developmenttopics/developent/webservices/story/0,10801,81308,00.html, *ComputerWorld*, May 19, 2003.

[20] Sliwa, C., "Division over Web Services Standards Work Stirs Debate: IBM, Microsoft Choose OASIS over W3C," http://www.computerworld.com/developmenttopics/development/webservices/story/0,10801,80941,00.html?from=story_picks, *Computer World*, May 5, 2003.

[21] Kobielus, J., "Grid Not Ready for Prime Time," http://www.nwfusion.com/columnists/2004.0524kobielus.html, *Network World Fusion*, May 24, 2004.

[22] Schneier, B., "The Witty Worm: A New Chapter in Malware," http://www.computerworld.com/networkingtopics/networking/story/0,10801,93584,00.html, *ComputerWorld*, June 2, 2004.

CHAPTER 17

Conclusion

In the introductory chapter, you imagined sitting at a computer and logging onto a server thousands of miles away needing only a single user id and password. Next, you executed a software application without any idea where the application and data were located and without worrying about whether your computer was the right platform, if you had the right operating system, or even if there was sufficient memory capacity, disk space, and bandwidth to run the application in a time-responsive manner. This is the open systems vision, where the environment takes care of these concerns automatically, quickly, and transparently.

The book discussed 12 categories of significant open standards that are moving technologies toward the realization of this vision: applications, communications, data interchange, data management, distributed computing, graphics, operating systems, security, software engineering, system management, user interfaces, and the World Wide Web. Examples were provided where formal standards bodies and vendor consortia have merged competing efforts and are collaborating on compatible standards to promote interoperability, paving the way for more complex and powerful standards-based capabilities. The sheer number and types of standards serve to demonstrate that standards will continue to emerge over time, and are here for the long-term. Standards are the means for achieving open systems and developing advanced capabilities that build on standards.

Finally, the book identified five key trends that showcase Internet and Web-based standards that over time are expected to achieve the open systems vision: high speed, ubiquitous communications; better security mechanisms; intelligent push/pull from families of PB data stores; worldwide electronic collaboration; and seamless interfaces to networked applications, data, and computers. These five trends will move the vision for open systems from imagination to reality, but there are challenges to overcome before the vision can be achieved. It may take one or two decades to realize the vision for open systems, but the world is moving in that direction.

List of Acronyms

3G	Third Generation
3GPP	3rd Generation Partnership Project
ACM	Association for Computing Machinery
AJPO	Ada Joint Program Office
AES	Advanced Encryption Standard
AHWG	Ad Hoc Working Group
AMPS	Advanced Mobile Phone Service
ANSI	American National Standards Institute
API	Application Program Interface
ARB	Architectural Review Board
ARPA	Advanced Research Projects Agency
ARPANET	ARPA Network
ASD/C^{3}I	U.S. Assistant Secretary of Defense for Command, Control., Communications, and Intelligence
ATM	Asynchronous Transfer Mode
BBN	Bolt, Baranek and Newman, Inc.
B-ISDN	Broadband Integrated Services Digital Network
BPEL4WS	Business Process Execution Language for Web Services
BPMI	Business Process Management Initiative
BPML	Business Process Modeling Language
BPMN	Business Process Modeling Notation
BPQL	Business Process Query Language
C4ISR AWG	C4ISR ArchitectureWorking Group 4
C4ISR ITF	C4ISR IntegrationTask Force 4
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CA	Certificate Authority
CCIT	Consultative Committee for International Telegraphy

CCITT	International Telephone and Telegraph Consultative Committee
CDMA	Code Division MultipleAccess
CERT	Computer Emergency Response Team
CERT/CC	CERT CoordinationCenter
CGM	Computer GraphicsMetafile
CIFS	Common Internet File System
CIM	Common InformationModel
CIO	Chief Information Officer
CMM	Capability MaturityModel
CMMI-SE/SW	Capability MaturityModel-Integrated for Systems Engineering/Software Engineering
COBOL	Common Business Oriented Language
COM	Component Object Model
CORBA	Common Object Request Broker Architecture
COTS	Commercial-Off-The-Shelf
CSRG	Common Standards Revision Group
CWM	Common Warehouse Metamodel
DAFS	Direct Access File System
DAP	Directory Access Protocol
DARPA	Defense Advanced Research Projects Agency
DBMS	Database Management System
DCE	Distributed Computing Environment
DCOM	Distributed Component Object Model
DEC	Digital Equipment Corporation
DEN	Directory EnabledNetworks
DES	Data Encryption Standard
DHS	Department of Homeland Security
DMI	Desktop Management Interface
DMTF	Distributed Management Task Force, Inc.
DMZ	Demilitarized Zone
DNA	Digital Network Architecture
DoD	U.S. Department of Defense
DoDAF	DoD Architecture Framework
DSML	Directory Services Markup Language
DSA	Directory System Agent
DSS	Digital Signature Standard
DUA	Directory User Agent
ebXML	Electronic Business Using eXtensible Markup Language
ECDSA	Elliptic Curve DSA

EDGE	Enhanced Data Rates for GSM Evolution
EES	Escrowed Encryption Standard
EJB	Enterprise Javabeans
ENIAC	Electronic Numerical Integrator and Computer
ESPRIT	European Strategic Programme for Research and Development in Information Technology
ETSI	European Telecommunications Standards Institute
FAQ	Frequently Asked Questions
FCIP	Fiber Channel over IP
FDDI	Fiber Distributed Data Interface
FEA	Federal Enterprise Architecture
FIPS	Federal Information Processing Standard
FORTRAN	Formula Translation
FSG	Free Standards Group
FTP	File Transfer Protocol
GAO	U.S. General Accounting Office
GGF	Global Grid Forum
GIF	Graphics Interchange Format
GIIOP	General Internet Inter-ORB Protocol
GIS	Geographic Information System
GKS	Graphical Kernel System
GPS	Global Positioning System
GSM	Global Systems for Mobile Communications
GSPC	Graphics Standard Planning Committee
HOL	Higher Order Language
HOLWG	Higher Order Language Working Group
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IAB	Internet Architecture Board
IANA	Internet Assigned Numbers Authority
ICMP	Internet Control Message Protocol
IDL	Interface Design Language
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IEEE-SA	IEEE Standards Association
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IFCP	Internet Fiber Channel Protocol

IGMP	Internet Group Management Protocol
IIOP	Internet Inter-ORB Protocol
INCITS	International Committee for Information Technology Standards
INCOSE	International Councilon Systems Engineering
IP	Internet Protocol
IPCC	International Packet Communications Consortium
IPTO	Information Processing Techniques Office
ISCSI	Internet Small ComputerSystem Interface
ISDN	Integrated Services DigitalNetwork
ISO	International Organizationfor Standardization
ISO/IEC JTC1	ISO/IEC JointTechnical Committee 1
ISOC	Internet Society
IT	Information Technology
ITU	International Telecommunication Union
ITU-D	ITU TelecommunicationDevelopment
ITU-R	ITU Radiocommunication
ITU-T	ITU TelecommunicationStandardization
J2	Java 2 Platform
J2EE	Java 2 Platform EnterpriseEdition
J2ME	Java 2 Platform Micro Edition
J2SE	Java 2 Platform StandardEdition
JCP	Java Community Process
JDBC	Java Database Connectivity
JDO	Java Data Objects
JPEG	Joint Photographic ExpertsGroup File Interchange Format
Kbps	Kilobytes per second
LAN	Local Area Network
LDAP	Lightweight DirectoryAccess Protocol
LSB	Linux Standard Base
MAN	Metropolitan Area Network
Mbps	Megabits per second
MDA	Model Driven Architecture
MDC	Meta Data Coalition
MIDI	Musical Instrument DigitalInterface
MIT	Massachusetts Institute ofTechnology
MOF	Meta-Object Facility
MP3	Motion Picture ExpertsGroup Layer 3
MPEG	Motion Pictures ExpertsGroup

MPLS	Multiprotocol LabelSwitching
NASA	National Aeronautics andSpace Administration
NCP	Network Control Protocol
NCSD	National Cyber SecurityDivision
NFS	Network File System
NISO	National Information Standards Organization
NIST	National Institute of Standards and Technology
NMT	Nordic Mobile Telephone
NSA	U.S. National SecurityAgency
OASIS	Organization for the Advancement of Structured Information Standards
ODMG	Object Data Management Group
OGC	Open Geographic Information System Consortium
OGSA	Open Grid Services Architecture
OGSI	Open Grid Services Infrastructure
OIM	Open Information Model
OLE	Object Linking and Embedding
OMA	Object Management Architecture or Open Mobile Alliance
OMB	U.S. Office of Management and Budget
OMG	Object Management Group
OpenGL	Open Graphics Language
ORB	Object Request Broker
OSE	Open Systems Environment
OSF	Open Software Foundation
OSI	Open System Interconnection
OSI	Open Source Initiative
P1003	Portable Open System Interface for Computer Environments Working Group 1003
PARC	Palo Alto Research Center
PB	Petabyte
PC	Personal Computer
PCI	Peripheral Component Interconnect
PCTE	Portable Common ToolEnvironment
PDA	Personal Digital Assistant
PDF	Portable Document Format
PHIGS	Programmer's Hierarchical Interactive Graphics System

PIM	Platform-Independent Model
PIN	Personal Identification Number
PKCS	Public-Key CryptographyStandards
PKIX	Public-Key Infrastructure X.509
PNG	Portable Network Graphics
POP	Post Office Protocol
POSIX	Portable Operating System Interface
PSM	Platform Specific Model
QoS	Quality of Service
RFC	Request for Comments
RFP	Request for Proposal
RMI	Remote Method Invocation
RPC	Remote Procedure Call
RSA	Rivest-Shamir-Adelman
RTF	Rich Text Format
RTJWG	Real-Time Java Working Group
RTSJ	Real Time Specification for Java
SAML	Security Assertion Markup Language
SDH	Synchronous Digital Hierarchy
SEE	Software Engineering Environment
SEI	Software Engineering Institute
SGI	Silicon Graphics, Inc.
SGML	Standard Generalized Markup Language
SHS	Secure Hash Standard
SMBIOS	System Management BIOS
SMI-S	Storage Management Initiative Specification
SMTP	Simple Mail Transfer Protocol
SNA	Systems Network Architecture
SNIA	Storage Networking Industry Association
SOAP	Simple Object Access Protocol
SCE	Software Capability Evaluation
SONET	Synchronous Optical Network
SQL	Standard Query Language
SSL	Secure Socket Layer
SVG	Scalable Vector Graphics
SW-CMM	Capability Maturity Model for Software
TACS	Total Access Communications System
TAFIM	Technical Architecture Framework for Information Management

TAFIM Technical Architecture Framework for Information Management

TCP	Transport Control Interface
TCP/IP	Transport Control Interface/Internet Protocol
TDMA	Time Division Multiple Access
TIA	U.S. Telecommunications Industry Association
TIFF	Tag(ged) Image File Format
TLS	Transport Layer Security
TOG	The Open Group
TOGAF	The Open Group Architecture Framework
TRM	Technical Reference Model
UCLA	University of California at Los Angeles
UDDI	Universal Description, Discovery, and Integration
UDP	User Datagram Protocol
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunications System
URL	Universal Resource Locator
U.S. OSD CIO	U.S. Office of the Secretary of Defense Chief Information Officer
VAG	VRML Architecture Group
VoIP	Voice Over IP
VRML	Virtual Reality Modeling Language
W3C	World Wide Web Consortium
WAN	Wide Area Network
WAP Forum	Wireless Application Protocol Forum
WAP	Wireless Application Protocol
WBEM	Web-Based Enterprise Management
Web	World Wide Web
WebDAV	Web-Based Distributed Authoring and Versioning
WfMC	Workflow Management Coalition
WLAN	Wireless LAN
WS-BPEL	Web Services Business Process Execution Language
WML	Wireless Markup Language
WS-CDL	Web Services Choreography Description Language
WSCI	Web Services Choreography Interface
WSDL	Web Services Description Language
WSRF	Web Services Resource Framework

WTLS	Wireless Transport Layer Security
WWW	World Wide Web
XHTML	Extensible HyperText Markup Language
XKMS	XML Key Management Specification
XMI	XML Metadata Interchange
XML	eXtensible Markup Language
XPDL	XML Process Definition Language

About the Author

P. A. Dargan is a principal systems engineer at SAIC with more than 25 years of experience in all aspects of software system engineering, including software engineering education as a university faculty instructor. She specializes in developing open architectures and migration strategies based on open standards. She is currently involved in a standardization effort for a large federal government agency's modernization program. She has developed open systems migration strategies for the Federal Aviation Administration (FAA), U.S. Coast Guard, and other major federal government agencies.

P. A. Dargan is an international guest speaker and invited author and holds a B.S. in mathematics from Virginia Polytechnic and State University and an M.S. in computer science from George Mason University. She is listed in *Marquis Who's Who in America* and *Marquis Who's Who in the World*.

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