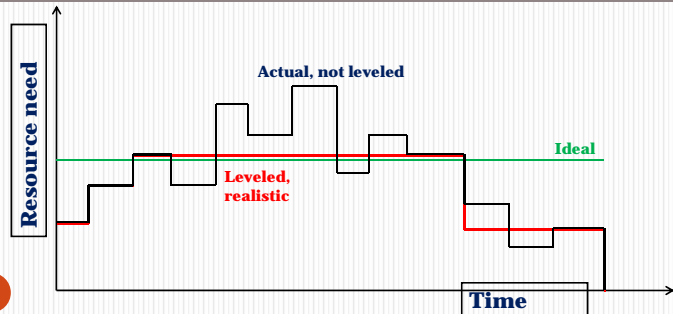


Resources Leveling



The Resource Allocation Problem

- CPM/PERT ignore resource utilization and availability
 - Schedules need to be evaluated in terms of both time and resources
 - Time and resource use:
 - Time limited: A project must be finished by a certain time
 - Resource limited: A project must be finished without exceeding some specific level of resource usage
 - System-constrained: A project has fixed amount of time and resources
- 2

Categories of resources

- **Labor**
 - Salaried staff
 - Hourly workers
 - **Materials**
 - **Equipment**
 - Construction machinery
- 3

What is resource allocation?

Is the assignment of the required resources to each activity, in the required amount and timing. (Resource loading)

What Is Resource Leveling?

Is minimizing the fluctuations in day-to-day resource use throughout the project.

It is usually done by shifting noncritical activities within their available float. It attempts to make the daily use of a certain resource as uniform as possible.

4

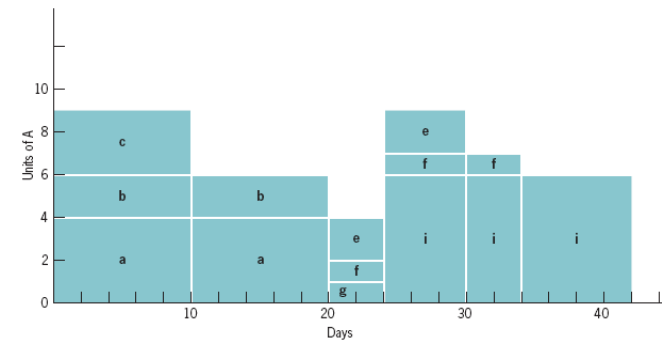
Why level Resources?

1. When the contractor adds the daily total demand for a specific resource for all activities he must provide the required amount, or work will be delayed.
2. Leveling may also be necessary for an expensive piece of equipment.
3. The main idea of resource leveling is to *improve work efficiency* and *minimize cost* during the life of the project.

Note: In general, materials do not need to be leveled

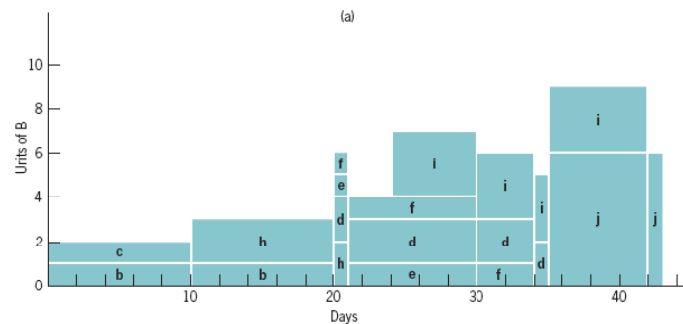
5

Resource A



6

Resource B



7

Resource Leveling

- When an activity has slack, we can move that activity to shift its resource usage
- May also be possible to alter the sequence of activities to levelize resources
- Small projects can be leveled by hand
- Software can levelize resources for larger projects
- Large projects with multiple resources are complex to levelize

8

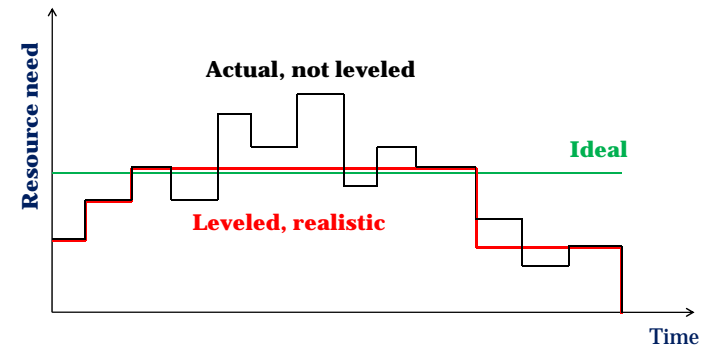
Constrained Resource Scheduling

Heuristic Approach: An approach, such as a rule of thumb, that yields a good solution that may or may not be optimal

Optimization Approach: An approach, such as linear programming, that yields the *one best* solution. (Not all projects can be optimized)

9

Resource Profiles



10

Heuristic Methods

- They are the only feasible methods used for large projects
- While not optimal, the schedules are very good
- Take the CPM/PERT schedule as a baseline
- They sequentially step through the schedule trying to move resource requirements around to levelize them
- Resources are moved around based on one or more priority rules
- Sort : the process of arranging activities in a list to certain specific order/priority.

11

Common Priority Rules

- As soon as possible
- As late as possible
- Shortest task first
- Most resources first
- Minimum slack first
- Most critical followers
- Most successors
- Arbitrary, etc...
- The heuristic can either start at the beginning and work forwards
- Or it can start at the end and work backwards

12

Activities Sort

Activity	Duration	ES	TF	Resource unit
A	1	1	0	8H
B	9	2	0	9H
C	5	2	3	7H
D	5	11	0	5H
E	4	7	3	4H
F	4	16	0	8H
G	6	11	3	2H
H	1	20	0	4H

Activity sort reflects the logic sequence of the network.

13

Major Sort

Activity	Duration	ES	TF	Resource unit
A	1	1	0	8H
B	9	2	0	9H
C	5	2	3	7H
E	4	7	3	4H
G	6	11	3	2H
D	5	11	0	5H
F	4	16	0	8H
H	1	20	0	4H

Activity sort with ES time as Major sort

14

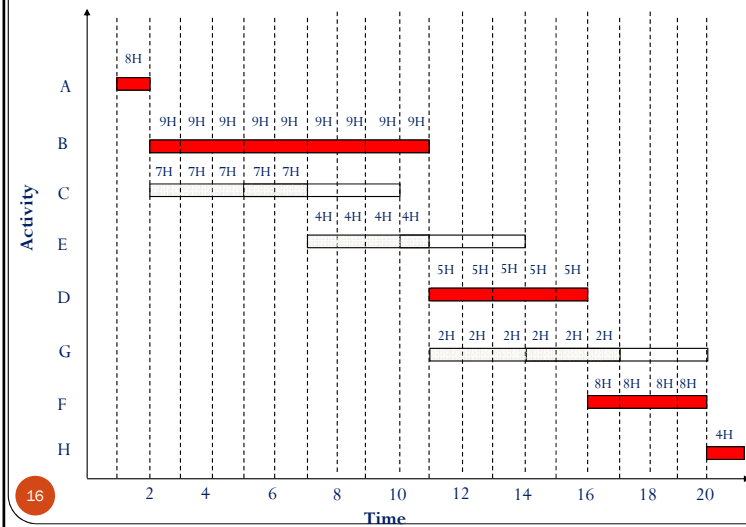
Major and Minor Sorts

Activity	Duration	ES	TF	Resource unit
A	1	1	0	8H
B	9	2	0	9H
C	5	2	3	7H
E	4	7	3	4H
D	5	11	0	5H
G	6	11	3	2H
F	4	16	0	8H
H	1	20	0	4H

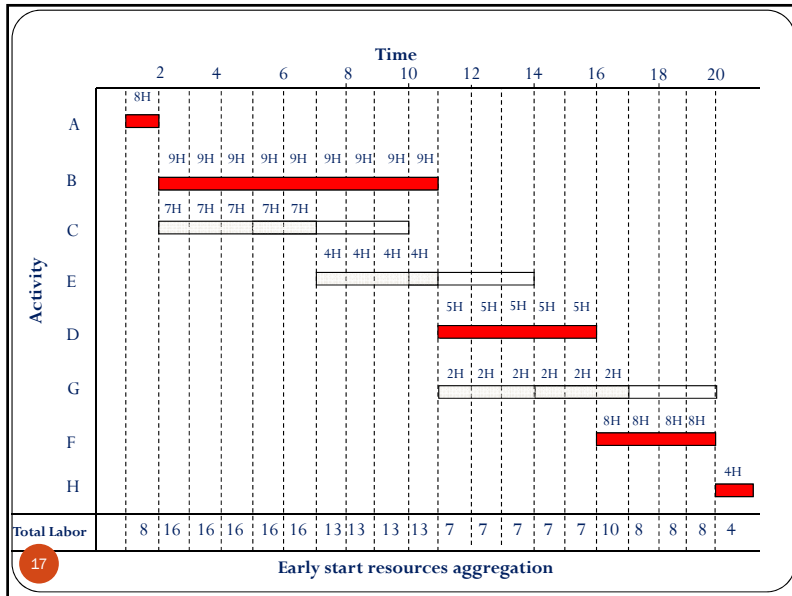
Activity sort with ES time as Major sort & TF as Minor Sort

15

Allocated resources



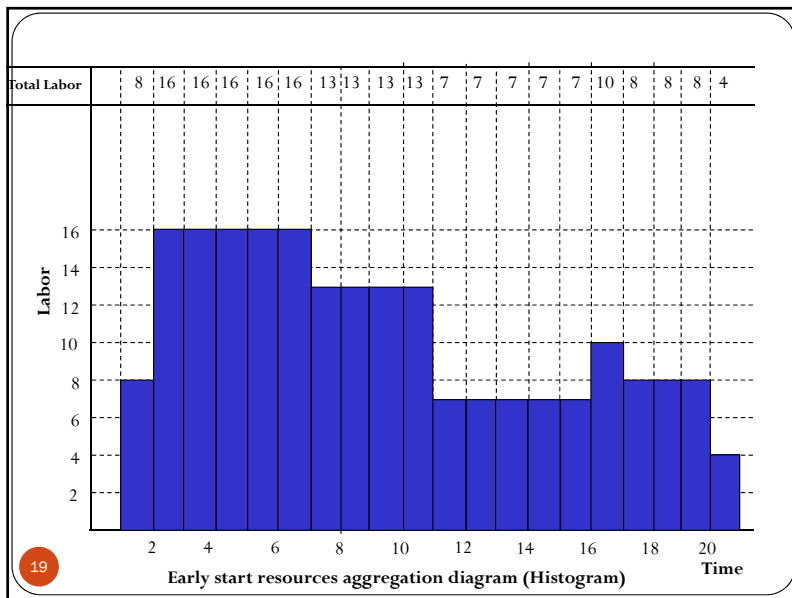
16



Resource Aggregation

Resources aggregation: is a summation of the resources that are used to carry out the program on a *time period basis*. For example, day to day, or week to week.

18



Late start

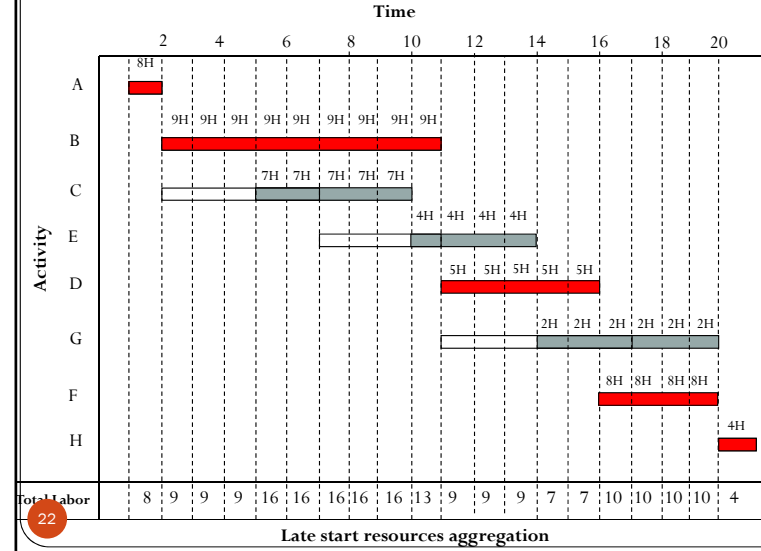
- Another histogram can be obtained if Late start considered. Shows different resources demand.
- And many histograms can be obtained considering a different time in the network.
- Each histogram shows different resources demand.

20

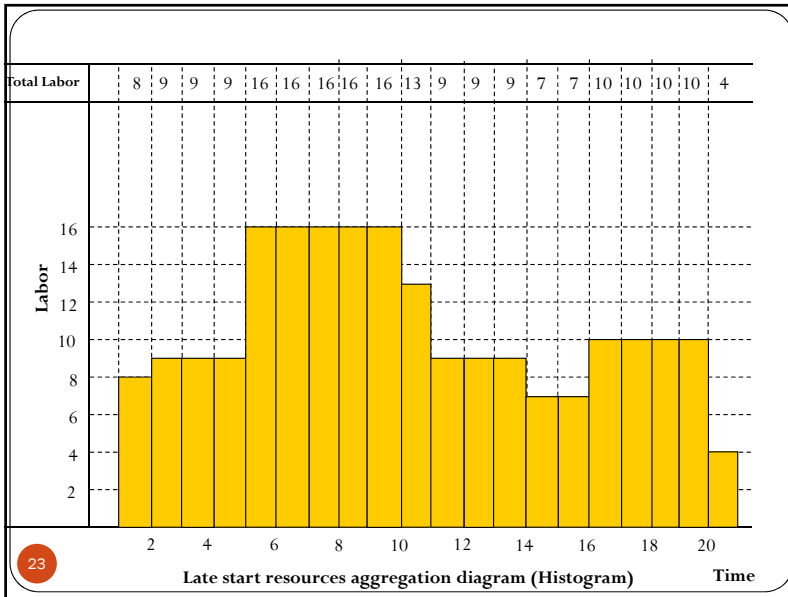
Late Start Sorts

Activity	Duration	LS	TF	Resource unit
A	1	1	0	8H
B	9	2	0	9H
C	5	5	3	7H
E	4	10	3	4H
D	5	11	0	5H
G	6	14	3	2H
F	4	16	0	8H
H	1	20	0	4H

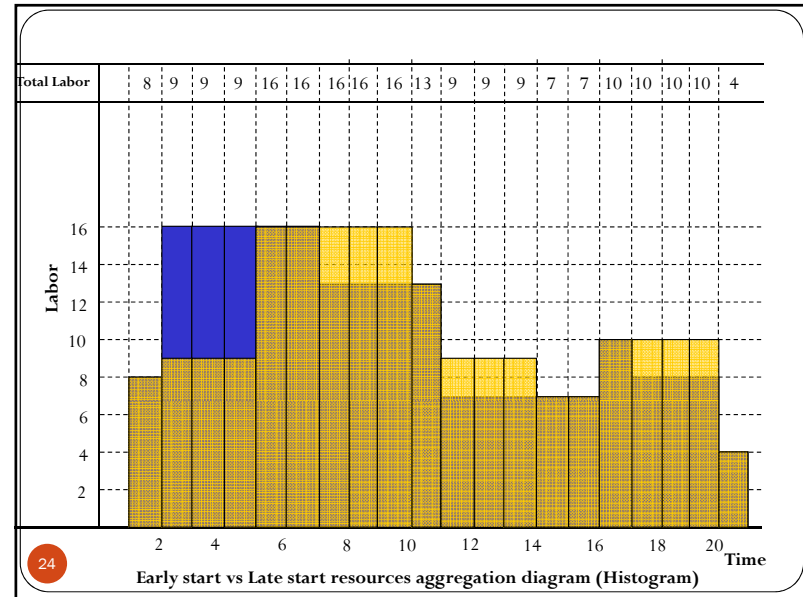
21. Activity sort with LS time as Major sort & TF as Minor Sort



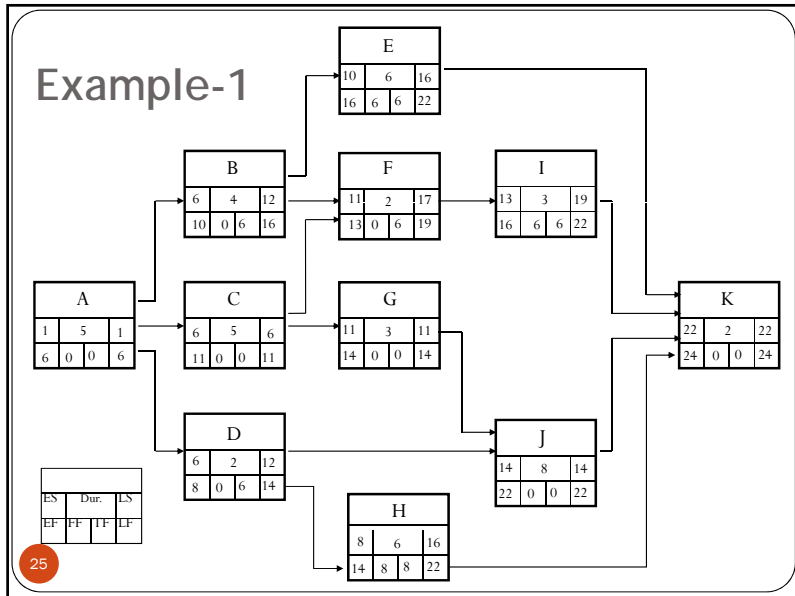
22



23



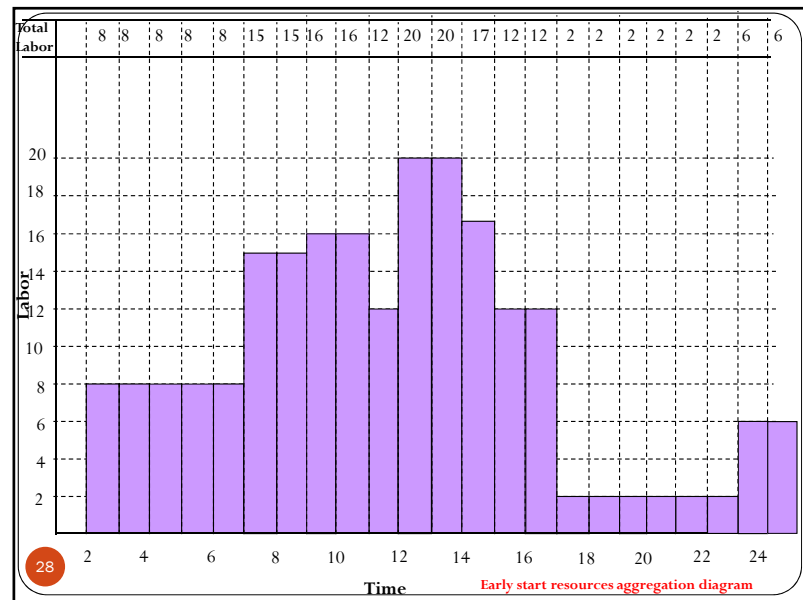
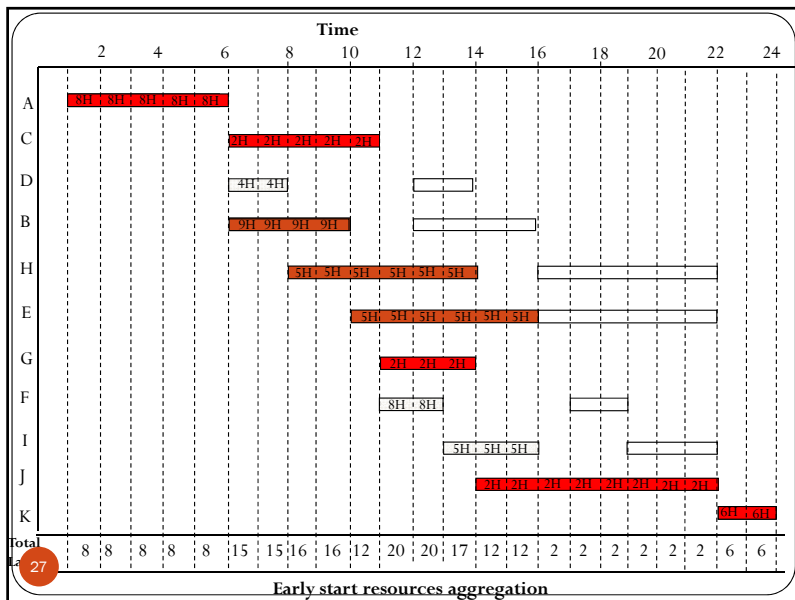
24



Activities Sort

Activity	Duration	ES	TF	Resource unit
A	5	1	0	8H
C	5	6	0	2H
D	2	6	6	4H
B	4	6	6	9H
H	6	8	8	5H
E	6	10	6	5H
G	3	11	0	2H
F	2	11	6	8H
I	3	13	6	5H
J	8	14	0	2H
K	2	22	0	6H

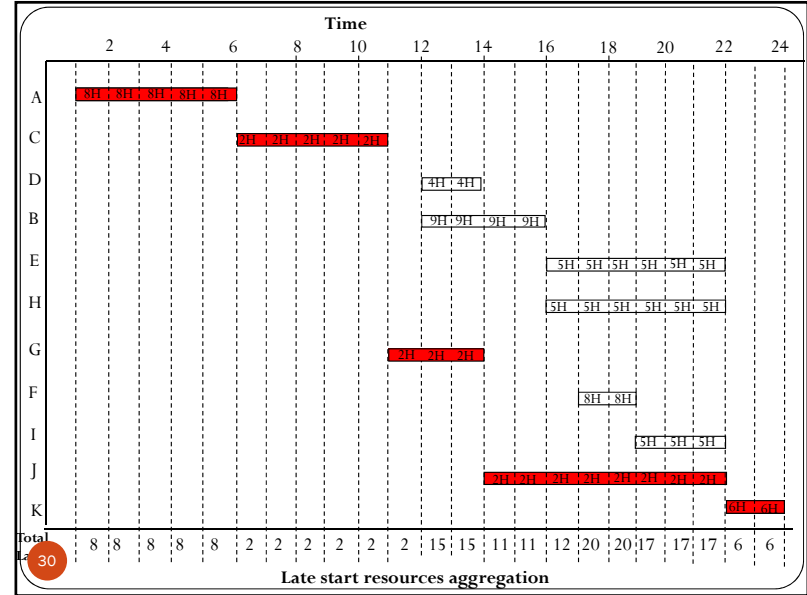
26 Activity sort with ES time as Major sort & TF and duration as Minor Sorts



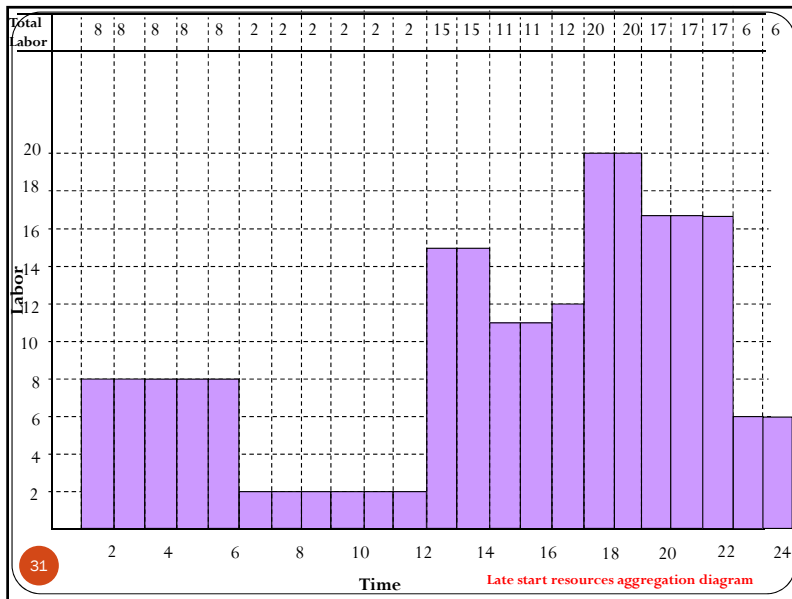
Activities Sort

Activity	Duration	LS	TF	Resource unit
A	5	1	0	8H
C	5	6	0	2H
D	2	12	6	4H
B	4	12	6	9H
E	6	16	6	5H
H	6	16	8	5H
G	3	11	0	2H
F	2	17	6	8H
I	3	19	6	5H
J	8	14	0	2H
K	2	22	0	6H

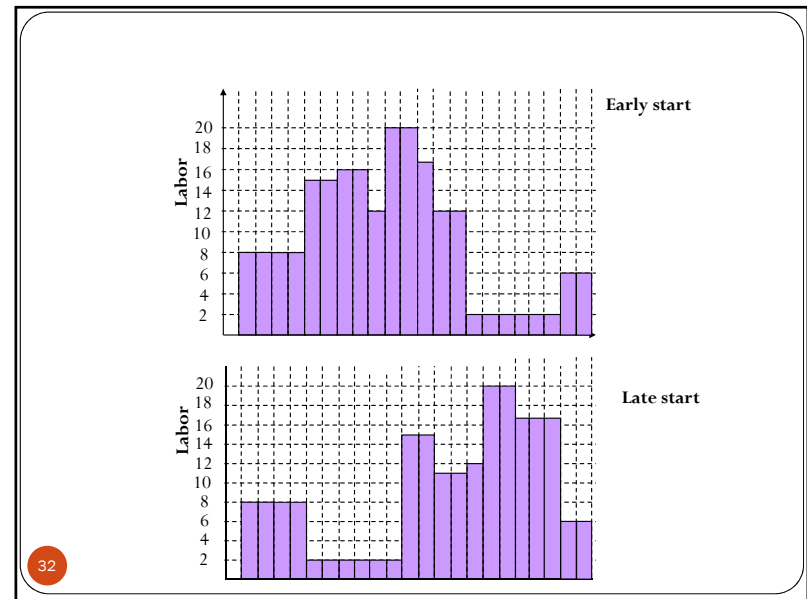
29 Activity sort with LS time as Major sort & TF and duration as Minor Sorts



30



31

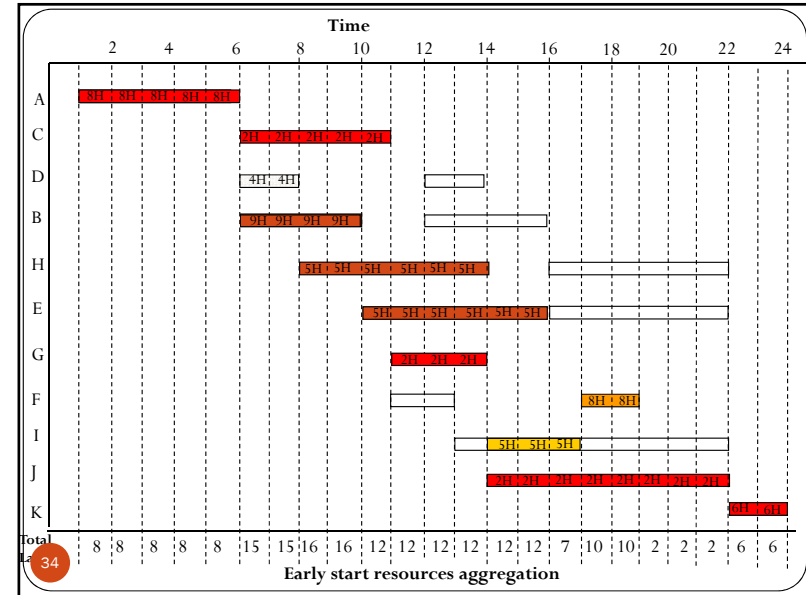


32

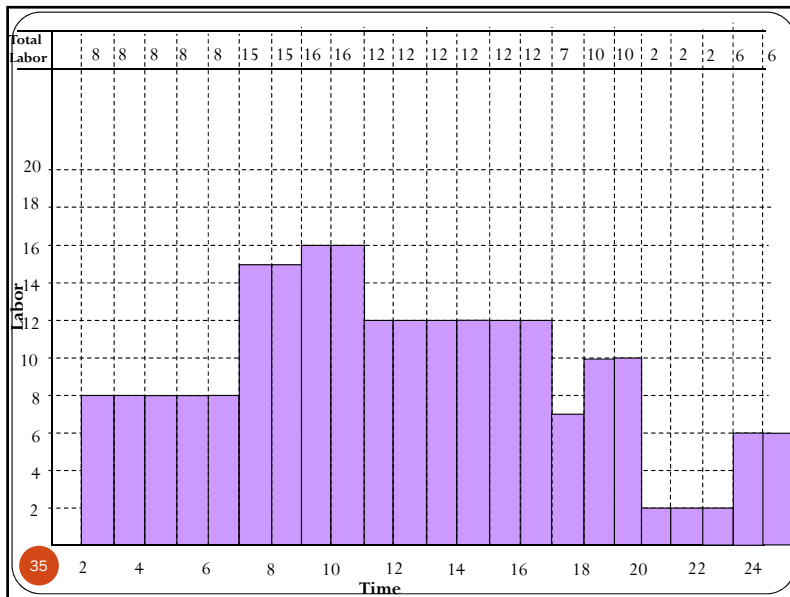
Smoothing/Leveling

- Let us program activity **F** to start by its late start day which is day 17.
- And activity **I** to start by day 14.
- The resulting resources aggregation histogram will be as follows:

33



34

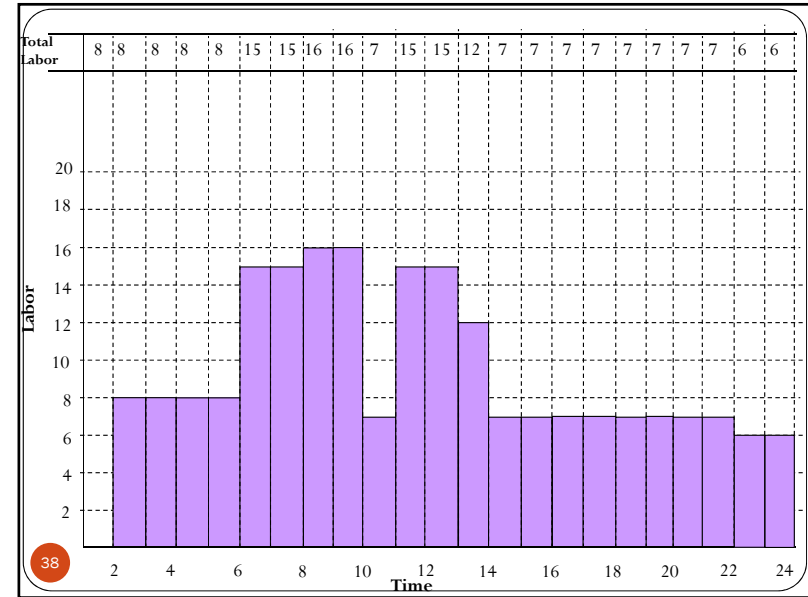
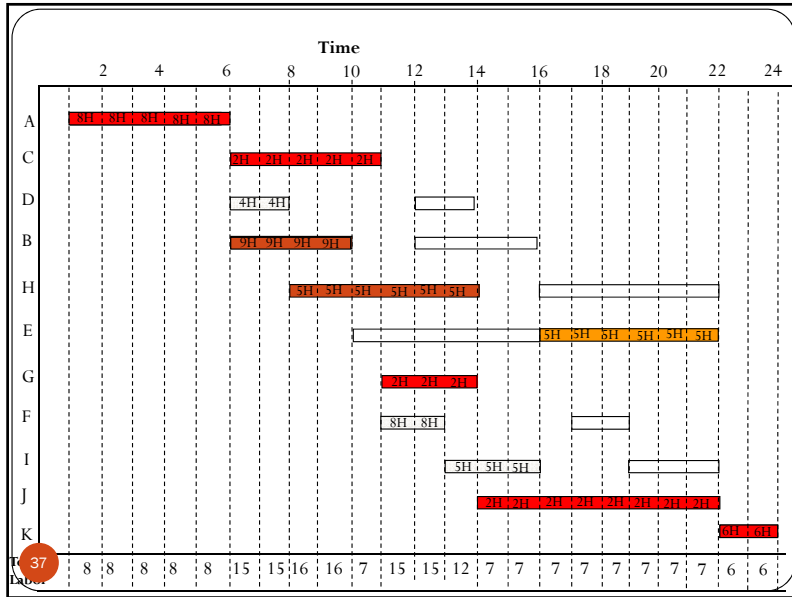


35

Smoothing/Leveling

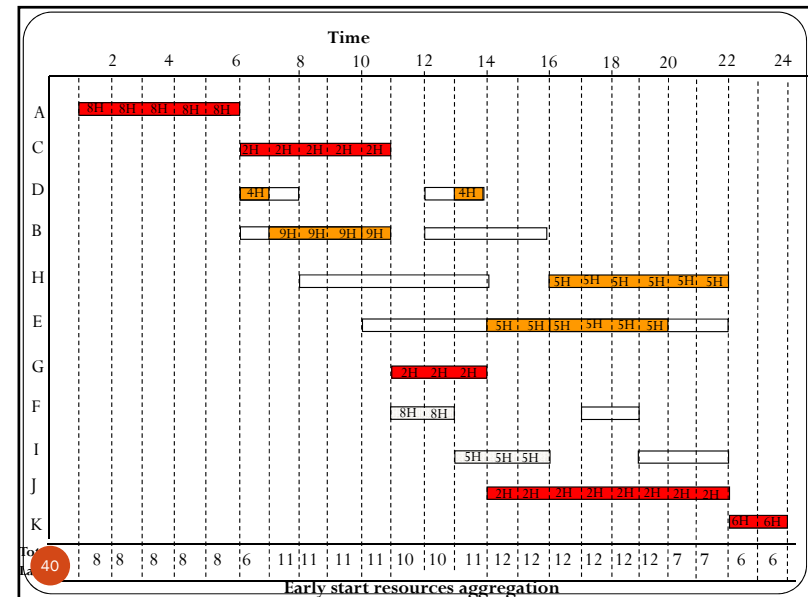
- Let us program activity **E** to start by its late start time.
- So its resources demand starts with its Late start date.
- The resulting resource aggregation and histogram will be as follows:

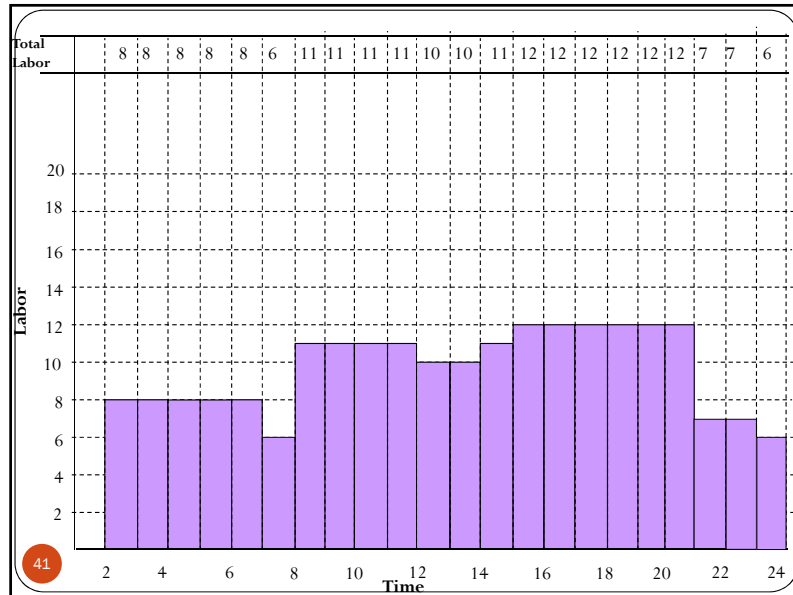
36



Smoothing/Leveling

- In case activity **D** is split able activity. It could be interrupted to be carried out in tow parts.
- Let us program activity **B** to start by 7th day .
- And activity **H** to starts by its Late start date.
- And activity **E** to start by day 14.
- The resulting resource aggregation and histogram will be as follows:





Early Start or Late Start or..

- The optimal solution is zero fluctuation histogram. Which is hard to be achieved.
- It is preferred to solve the problem toward the Early start resources aggregation diagram.
- If there are labor availability problems to be overcome, they will occur in the early beginning of the project.
- If the program based on the Late Start date, it means that all the activities are Critical, and any labor problem will affect the project completion.

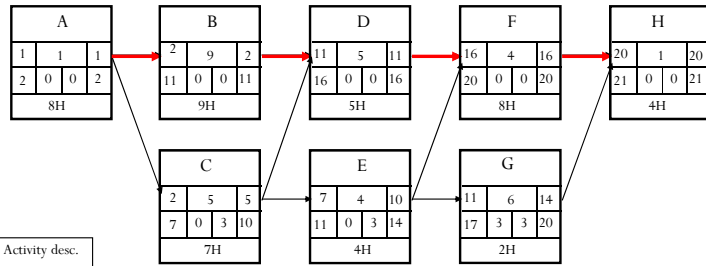
Allocation within resources restraints

- Another situation which you may face in practice is the restricted resources availability.
- Where you have to carry out the job with the available resources only.
- In this case the project duration may be **prolonged** to suit the availability of the restricted resources.

Rules for scheduling activities with limited resources

1. schedule activities to start as soon as their predecessors have been completed.
2. If more than one activity using a specific limited resources can be scheduled, priority is given to the activity with early Late Start. (LS as Major Sort)
3. If two or more activities have the same Late start, give priority to the activity with least Total Float. (TF as Minor Sort)
4. If the activities have the same Total Float in the minor sort, give the priority to the activity with the Largest Number of Resources.
5. If the activities are tied in the number of resources, give priority to the activity that has already started.

Example-2



Activity desc.			
ES	Dur.	LS	
EF	FF	TF	LF
Resources			

45

Solution

Activity	Duration	ES	TF	Resource unit
A	1	1	0	8H
B	9	2	0	9H
C	5	2	3	7H
E	4	7	3	4H
D	5	11	0	5H
G	6	11	3	2H
F	4	16	0	8H
H	1	20	0	4H

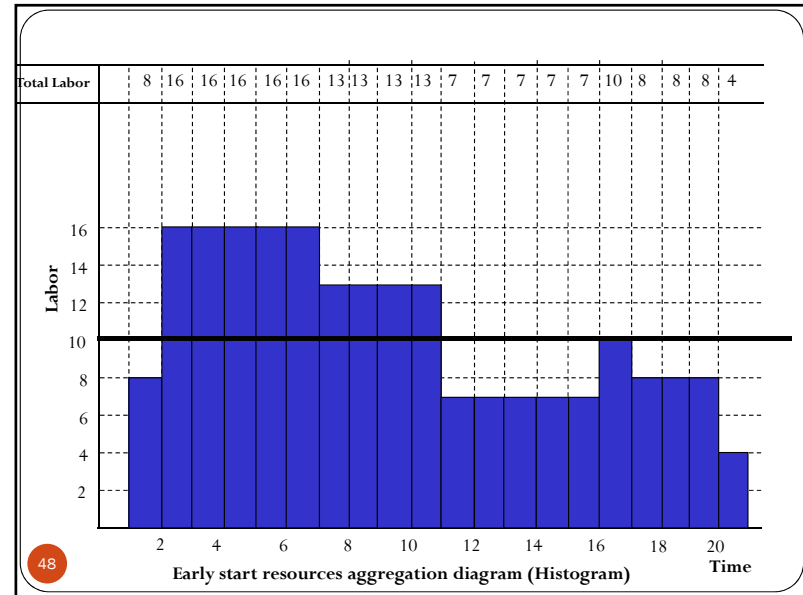
Activity sort with ES time as Major sort & TF as Minor Sort

46

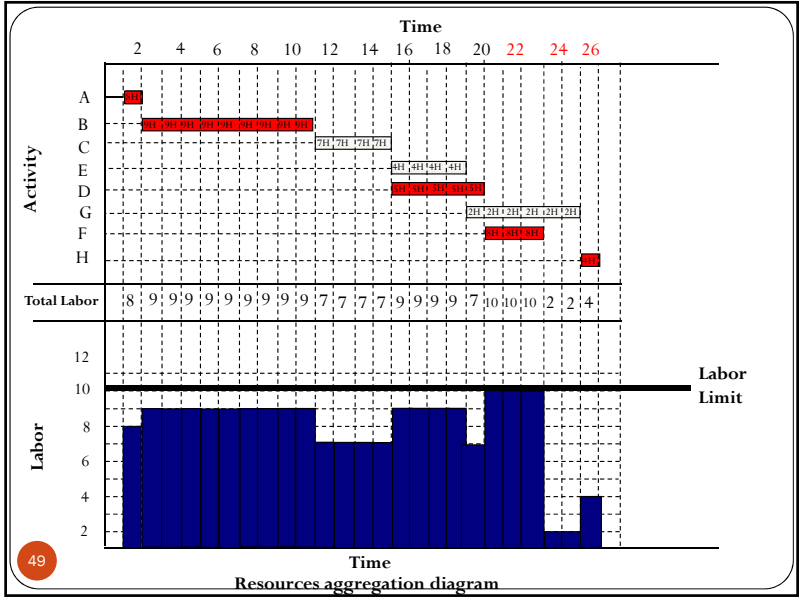
Solution

- Assume that the available labors in the company restricted to **10**, and the company decided to carry out the job without resorting to hire more labor.
- The resulting program will exceed the Early finish date based on the network.

47



48



49