Chapter 3

Solid waste collection

1. Solid waste collection

- Solid waste collection
  - Gathering solid wastes scattered together into one container.
- Collection of MSW
  - done by men and women who traverse a town in trucks and then ride with the truck to a site at which the truck is emptied.
- Thus, solid waste collection systems
  - person/truck systems

- There may be an intermediate stopover where the refuse is:
  - transferred from the small truck into
    - trailers, larger vans, barges, or railway cars
  - for long-distance transport or the final site
    - the landfill,
    - compost site, or
    - materials recovery facility.

2. Refuse collection systems

- The process of refuse collection is a multiphase process,
- There are at least five separate phases

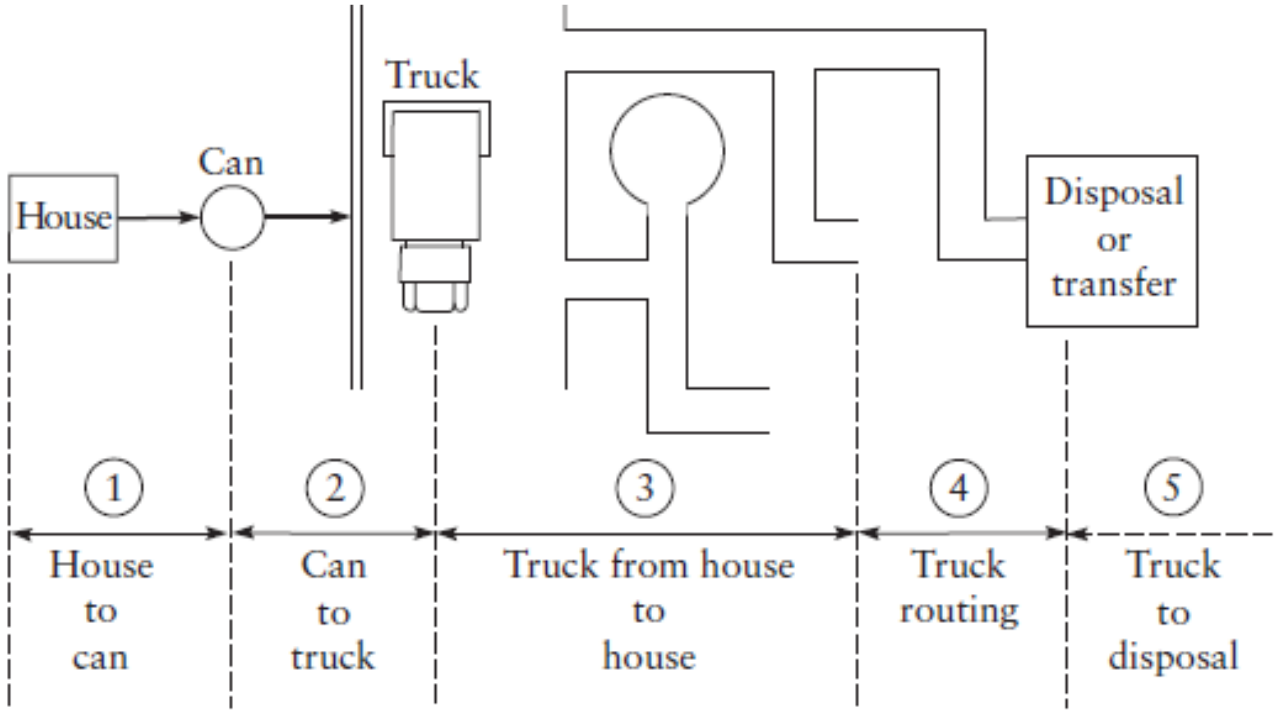


Figure 3-1 Five phases of municipal solid waste collection.

Refuse collection systems . . .

- Phase 1: The individual homeowner must transfer whatever is considered waste to the refuse can, which may be inside or outside the home.
- Phase 2: movement of the refuse can to the truck,
  - If the movement is made by the collection crew, it is called *backyard collection*.
  - If the can is moved to the street by the waste generator, the system is called *curbside collection*.
  - Note: if recyclable materials and yard wastes are separated at the source by generated, they will be collected separately, either in separate compartments of the same trucks as the mixed refuse or in separate vehicles.

- Phase 3: The truck must collect the refuse from many homes in the most efficient way possible,
- Phase 4: when the truck is full (or at the end of the day), it must travel to the materials recovery facility, the point of disposal, or the transfer site.
- Phase 5: the collection system involves the location of the final destination
  - materials recovery facility, disposal site, or transfer station).
  - This is a planning problem, often involving more than one community.

Phase 1: House to Can

- Received almost no attention or concern by researchers or government
- The efficiencies and conveniences gained are personal and not communal.
- Communities finance the solid waste collection and disposal system,
  - Using tax fund
  - By charging for the service just as they charge for water consumption and wastewater disposal
  - Some communities have adopted a *volume-based fee system* to pay for solid waste collection

- In a volume-based fee system,
  - Residents are offered cans in three sizes
    — 110, 230, and 340 liter cans
  - The fee for refuse service is based on the size of can used.
  - In the western countries, volume-based fee systems have generated renewed interest in the home compactor
- However,
  - there are communities which charge by actual weight, called the *weight-based fee system*.

Phase 2: Can to Truck

- In developing countries
  - the most common system of getting the solid waste into the truck was
  - the collectors going to the backyard,
  - emptying the garbage cans into large tote containers, carrying the containers to the waiting truck.

- In the western nations:
  - This system was expensive to the community,
  - but it was expensive in terms of the extremely high injury rate to the collectors
  - Even now, with all of the improvements in collection technology, solid waste collection is still one of the most hazardous jobs in America

- The traditional trucks used for residential and commercial refuse collection are:
  - rear-loaded and covered compactors called *packers*,
  - vary in size and design with 12- and 15 m^3 loads being common
  - The truck size is often limited not by its ability to store refuse but by its wheel weight.
  - Residential streets are not designed to carry large wheel loads, and refuse trucks can easily exceed these limits.

- Commonly,
  - the refuse is emptied from garbage cans into the back of the packers where it is scooped up by hydraulically operated compaction mechanisms that compress the refuse from a loose density of about 60 to 120 kg/m3 to about 360 to 420 kg/m3.
  - To reduce injuries and to speed up collection, some solid waste collection companies are changing from rear loaders to side loaders

Figure 3-2 A rear-loading packer truck for collecting residential solid waste. (Courtesy William A. Worrell)

Figure 3-4 Side-loading packer truck. (Courtesy William A. Worrell)

- Two revolutionary changes during the 1990s had a great impact on both:
  - the cost of collection
  - the injury rate of the collectors.
- *Can-on-wheels* idea, known as waste wheelers.
  - The resident fills a large plastic container on wheels and then pushes it to the curb for collection.
  - The containers can be used for mixed refuse, recyclables, and/or yard waste

- The collection vehicles are
  - equipped with hydraulic hoists that are used to empty the contents into the truck,
  - The collectors do not come into contact with the refuse, avoiding dangerous materials that can cut or bruise.
  - *semi-automated collection*,
    - typically requires a driver and one or more collectors.

- *fully automated collection*
  - *Requires can snatcher*
  - trucks equipped with long arms that reach out, grab a can, and lift it into the back of the truck
  - are especially useful where the street layout includes alleys behind the houses.
  - Western communities that have converted from the manual system to the fully automated system have saved at least 50% in collection costs, much of it in reduced medical costs

Figure 3-5 Recyclables, yard waste, and mixed refuse at the curb. (Courtesy William A

Figure 3-6 Green plastic containers used for solid waste collection. (Courtesy P. Aarne Vesilind)

Figure 3-7 Collection with vehicles equipped with "can snatchers." (Courtesy Peter Cron)

Phase 3: Truck from House to House

- Once the refuse is in the truck, it is compacted as the truck moves from house to house.
- The higher the compaction ratio, the more refuse the truck can carry
- The size of the truck crew can range from one to over five people.
  - backyard pickup requires a larger crew size
  - Curbside pickup requires a smaller crew,
  - fully automated systems require only one person.

- In USA,
  - a single truck is expected to service between 700 and 1000 customers per day if the truck does not have to travel to the landfill.
  - Realistically, most trucks can service only about 200 to 300 customers before the truck is full and a trip to the landfill is necessary

The total time in a workday can be calculated as

$$Y = a + c(b) + c(d) + e + f + g$$

where

Y = the total time in a workday

a = time from the garage to the route, including the time needed to get ready to get moving

b = actual time collecting a load of refuse

c = number of loads collected during the working day

d = time to drive the fully loaded truck to the disposal facility, deposit the refuse, and return to the collection route

e = time to take the final load to the disposal facility and return to the garage

f = official breaks

g = other lost time such as traffic jams, breakdowns, etc.

- If the number of customers that a single truck can service during the day is known, the number of collection vehicles needed for a community can be estimated by

$$N = \frac{SF}{XW}$$

where

N number of collection vehicles needed
S = total number of customers serviced
F = collection frequency, number of collections per week
X = number of customers a single truck can service per day
W = number of workdays per week

Example

A truck is found to be able to service customers at a rate of 1.25 customers per minute. Assume a truck spend on collection is 4 about hours. Calculate the number of collection vehicles a community would need if it has a total of 5000 services (customers) that are to be collected once per week.

Solution:

Costumers served by one truck per day:

$$\frac{1.25}{1} = \frac{X}{4 \times 60}$$

X= 300 customer day

Assume the town wants to collect for 4 days a week (on Mondays, Tuesdays, Thursdays, and Fridays), leaving Wednesdays for special projects and truck maintenance

$$N = \frac{SF}{XW} = \frac{5000 \times 1}{300 \times 4} = 4.2 \text{ trucks}$$

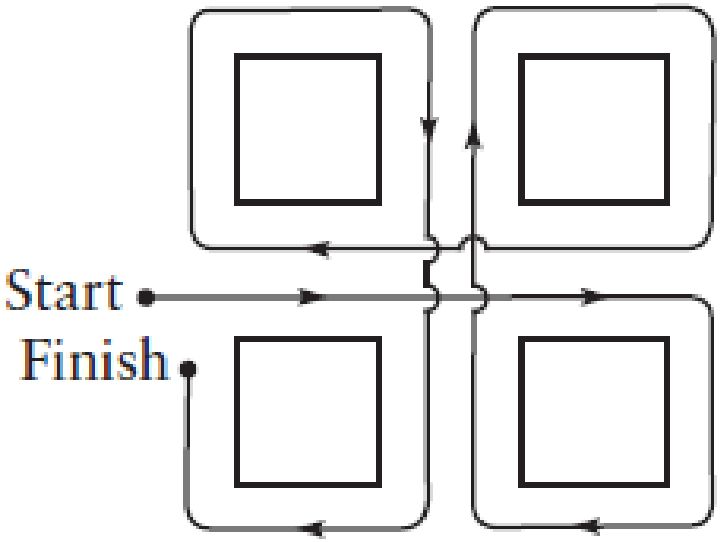
>>> The community will need **5 trucks**.

Phase 4: Truck Routing

- The routing of a vehicle within its assigned collection zone is often called micro-routing
- the establishment of the individual route boundaries.
- The larger-scale problems of routing to the disposal site known as macro-routing or districting
- How to route a truck through a series of one- or two way streets so that the total distance traveled is minimized?

- Minimizing deadheading, which is passing a collection point again after a previous pickup.
- the assumption is that if a route can be devised that has the least amount of deadheading possible, it is the most efficient collection route.
- Challenge: designing a route so as to eliminate all deadheading
- *Heuristic* (commonsensical) *routing methods*
- useful guidelines for determining overall strategy when planning a network
- Pure commonsensical judgment

- Eight rules:
  - Routes should not overlap, should be compact, and should not be fragmented.
  - The starting point should be as close to the truck garage as possible.
  - Heavily traveled streets should be avoided during rush hours.
  - One-way streets that cannot be traversed in one line should be looped from the upper end of the street.
  - Dead-end streets should be collected when on the right side of the street
  - On hills, collection should proceed downhill so that the truck can coast
  - Clockwise turns around blocks should be used whenever possible
  - Long, straight paths should be routed before looping clockwise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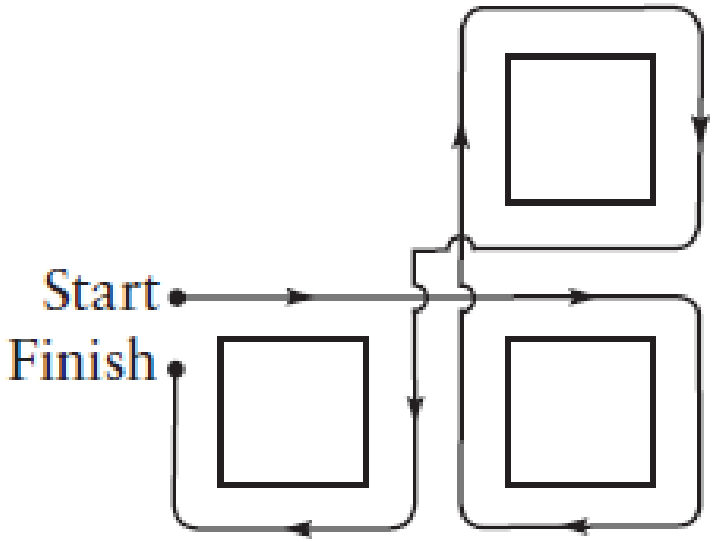
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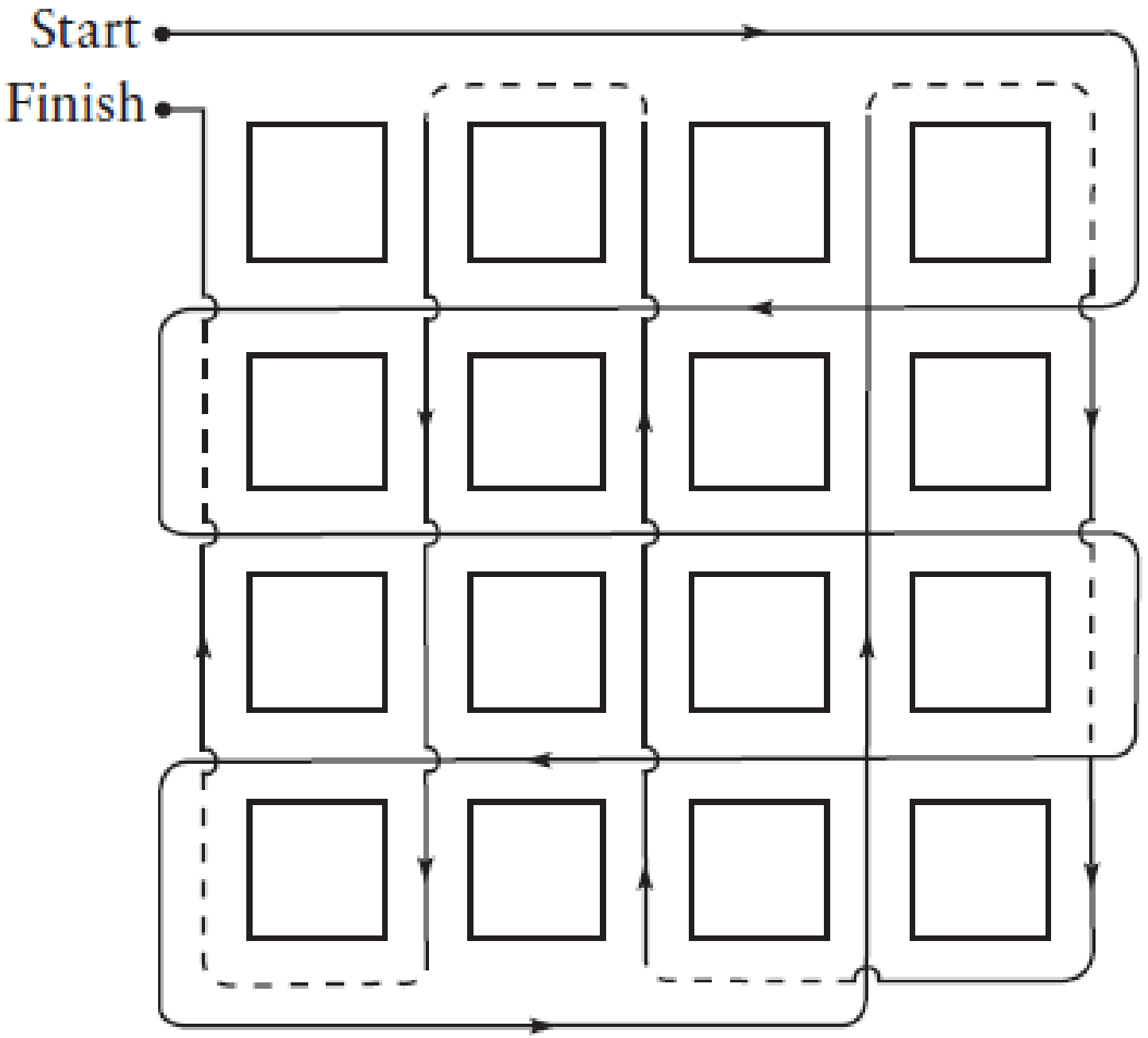
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Phase 5: Truck to Disposal

- For smaller isolated communities, the macro-routing problem reduces to one of finding the most direct road from the end of the route to the disposal site
- For regional systems or large metropolitan areas, however, macro-routing in terms of developing the optimum disposal and transport scheme can be used to great advantage
- *Allocation models* are all based on the concept of minimizing an objective function subject to constraints

- The simplest allocation problem is the assignment of solid waste disposal to more than one disposal site.
- Often the solution is obvious—the closest sources are allocated first, followed by the next closest, etc
- With more complex systems, however, it becomes necessary to use optimization techniques.