Lecture #21

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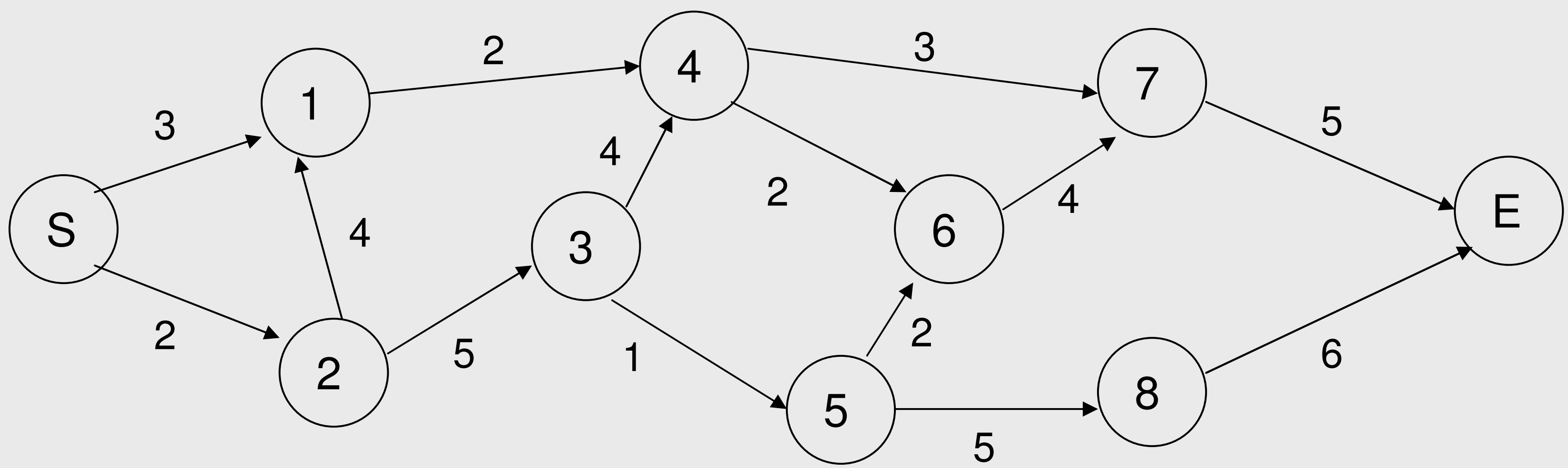
March 3, 2006

Applications of Graphs/Networks

- Konigsberg bridge problem
- Kirchhoff circuit laws
- Four color map problem
- Shortest Path Problem
- Routing and Scheduling
- Products – Assembly/Disassembly

Paths

- An arc – represents a path (with distance)
- Node – represents a location
- What is best way to get from S to E?



Routing and Scheduling

- Scheduling of customer service and routing of service vehicles critical to many service operations
- Some services (e.g., school buses and repair businesses) delivery is critical to the performance of the service
- Other services (e.g., mass transit and trucking firms) timely delivery is the service

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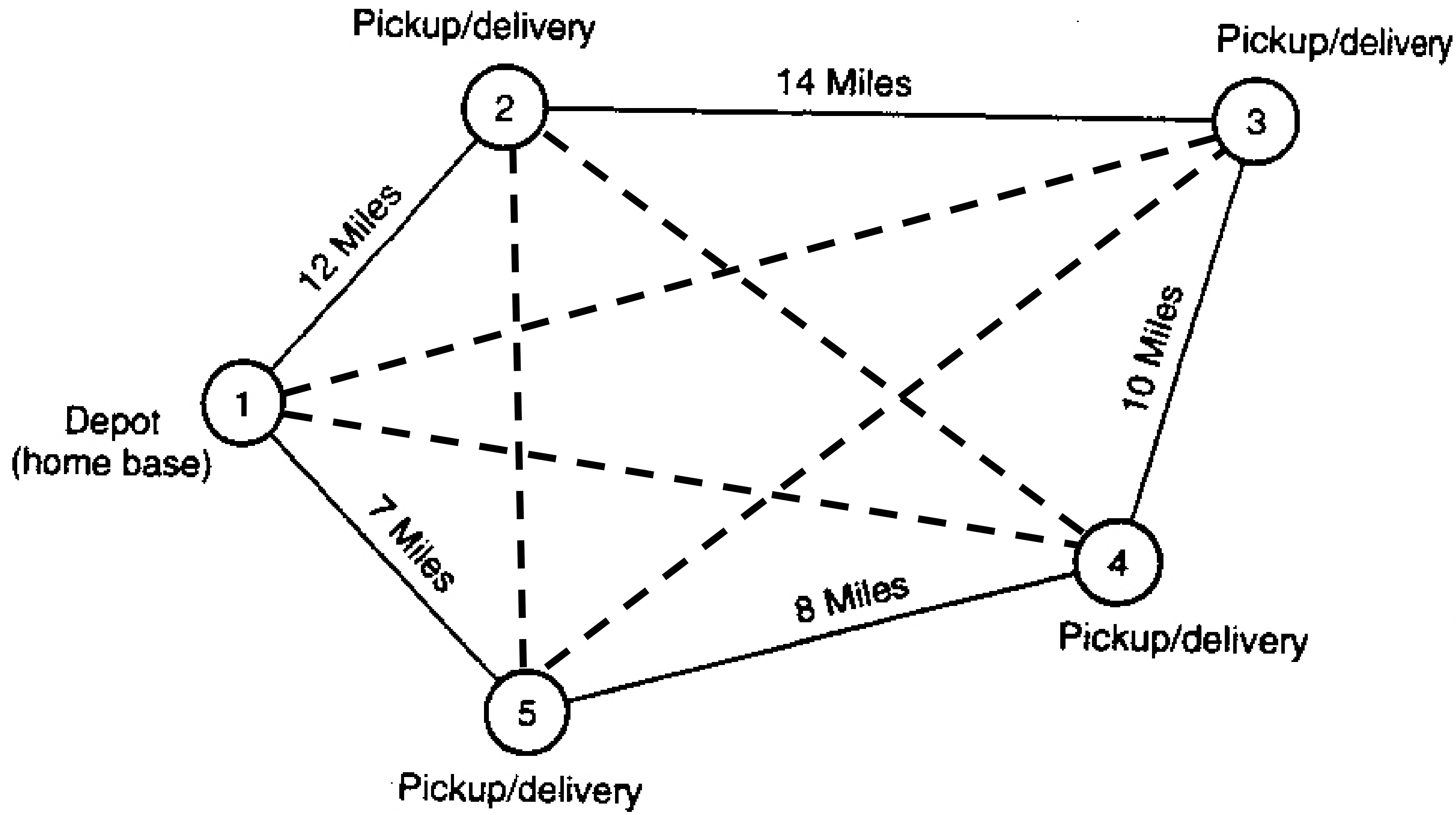
Service delivery example: Meals-for-ME

- Private, nonprofit meal delivery program for the elderly in Maine – Meals-for-ME – home delivery of hot meals
- For eligible individuals, program also supports a “congregate” program that provides daily transportation to group-meal sites
- Scheduling of volunteer delivery personnel and vehicles as well as construction of routes is done on a weekly to monthly basis.

Objectives

- Objective of most routing and scheduling problems – minimize service cost
  - Vehicle capital costs
  - Mileage
  - Personnel costs
- For public sector (e.g., schools) a typical objective is to minimize the total number of student-minutes on the bus
- For emergency services, minimizing response time is of primary importance

Routing Network Example



Characteristics

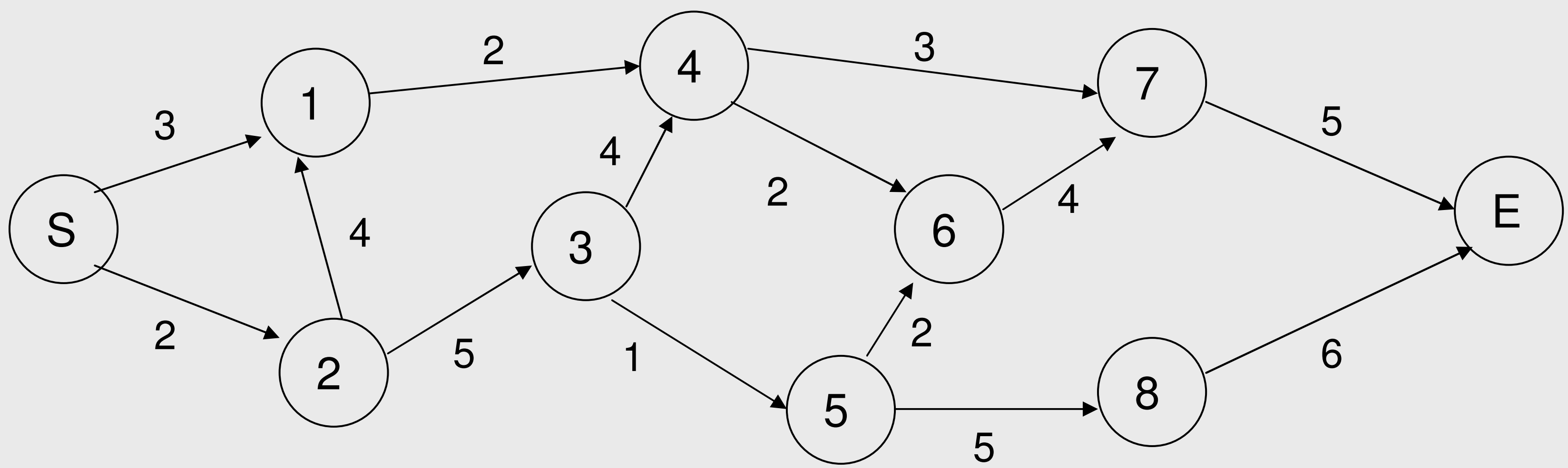
- Arcs describe time, cost, or distance of traveling from one node to another.
- Given an average speed of travel or a distribution of travel times, distance can be easily converted to time.
- The solid lines in previous figure can be viewed as a route for a vehicle
  - Also called a Tour
  - $1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 1$ or
  - $1 \rightarrow 5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$
  - Total distance = 51 miles

Characteristics

- The minimum-cost solution is subject to the tour being feasible:
  - A tour must include all nodes
  - A node must be visited only once
  - A tour must begin and end at a depot
- The route specifies the sequence in which the nodes (or arcs) are to be visited, and a schedule identifies when each node is to be visited.
- Traveling salesman problem

Activity Network

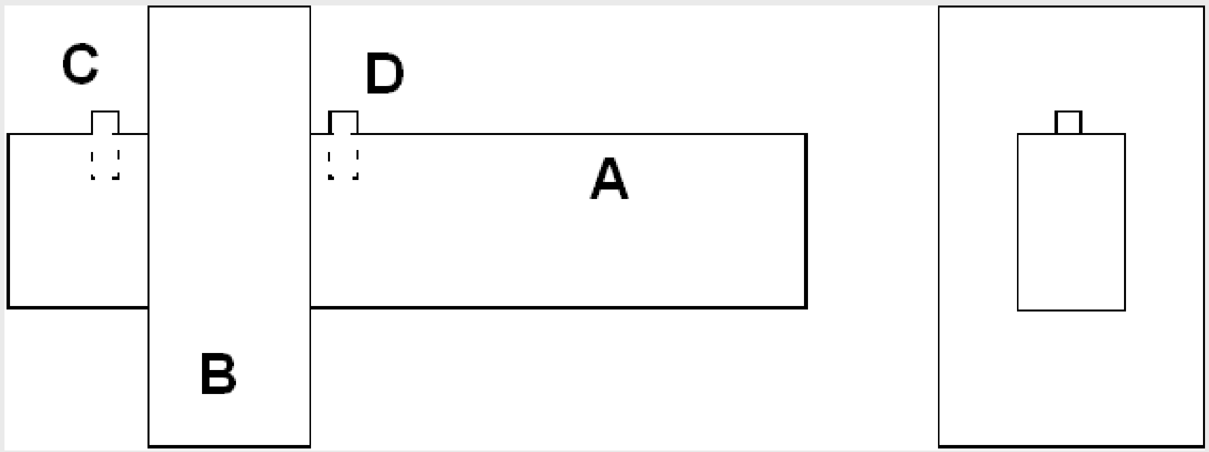
- An arc – represents an activity
- Node – represents an event – completing the activity
- When will E be reached?

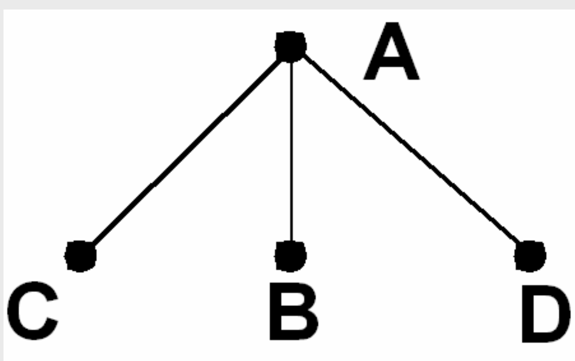


Products: Assembly/Disassembly

- Liaison diagram
- Product hierarchies
- And/Or Diagram – Alternatives
- Assembly/Disassembly process

Liaison Diagram

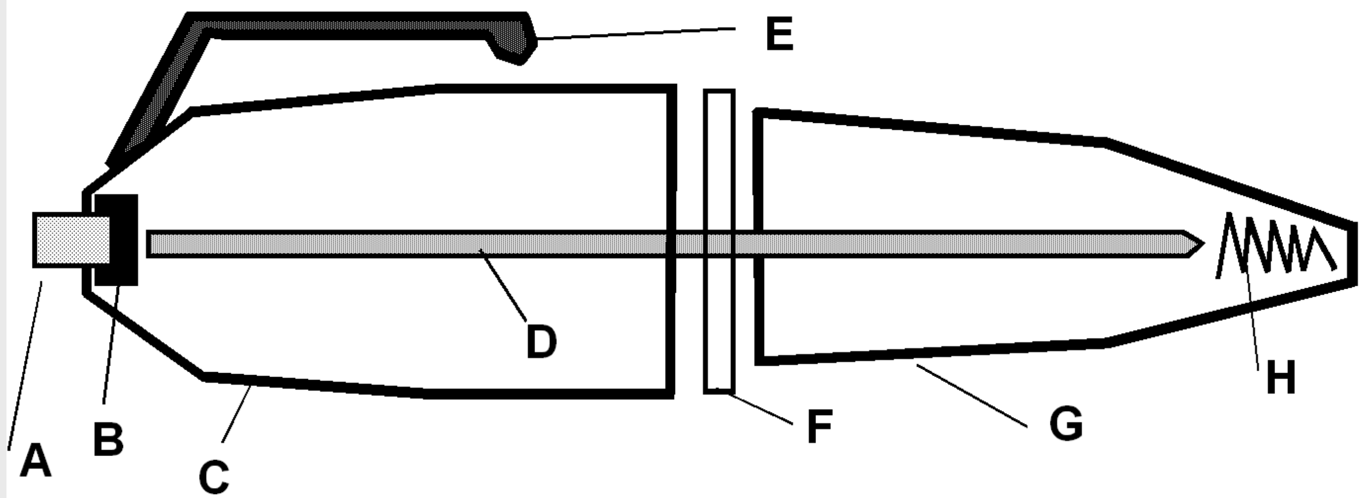


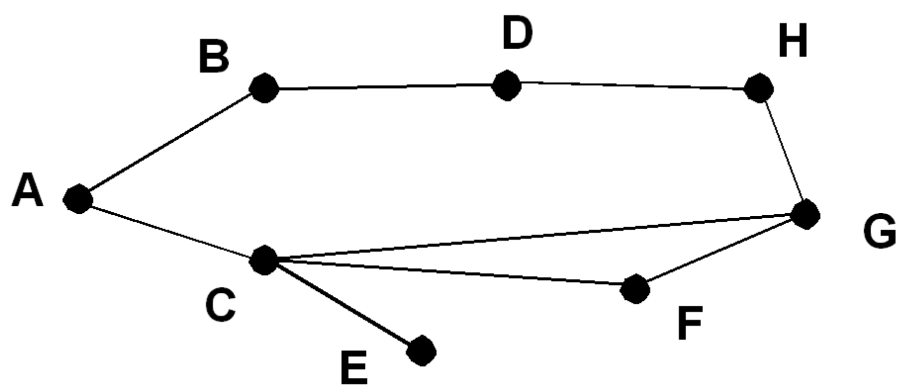


Which parts are touching?

Termed a product hierarchy

Another Liaison Diagram – Product Hierarchy

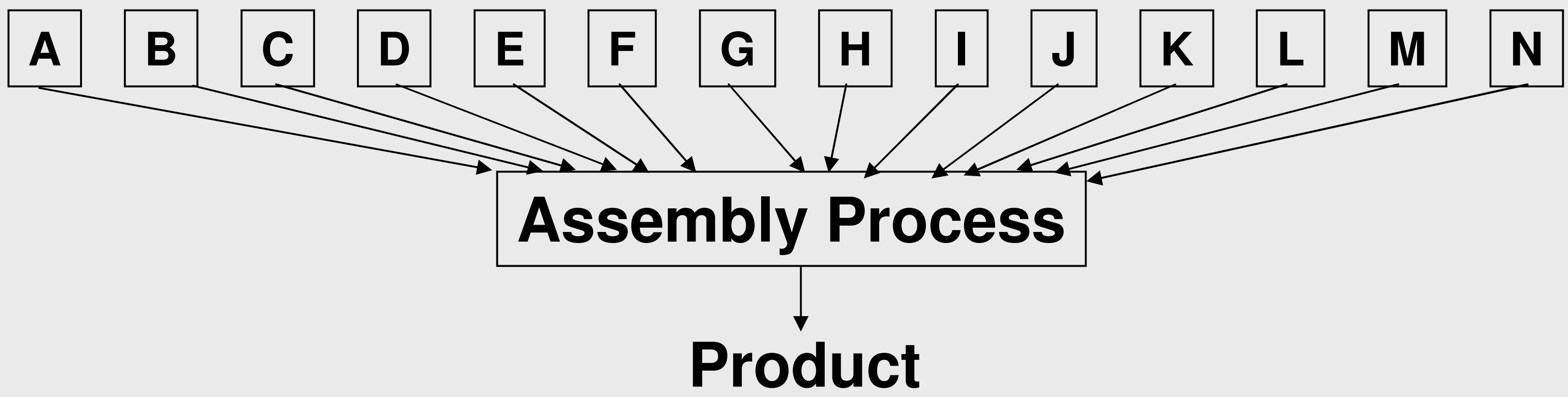




Product Hierarchy

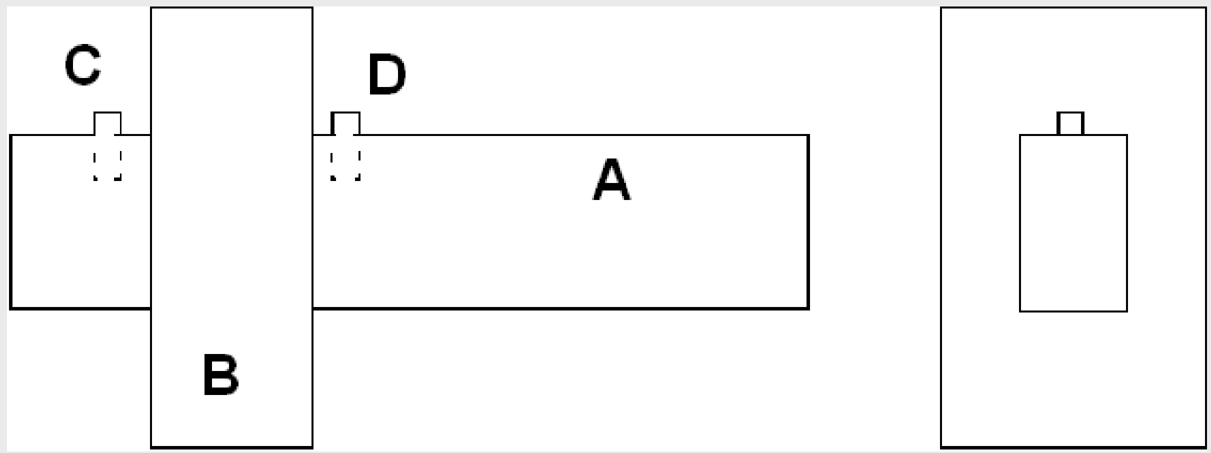
- Which type of hierarchy is preferred.
- Taller – more modularity
- Flatter – easier to replace individual components

Assembly



- How do we do the assembly?
- In what order to we handle the parts?

Disassembly Process

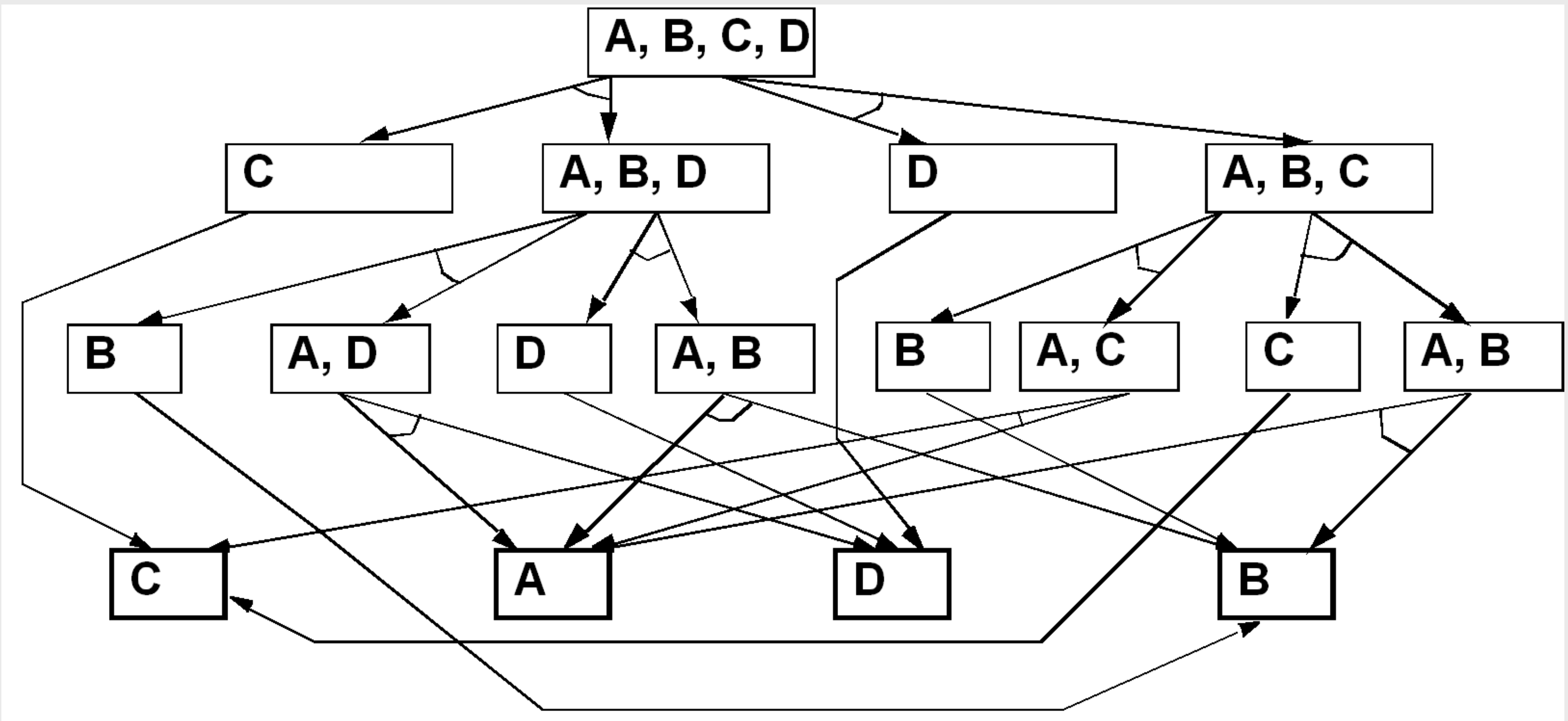


- Remove C from A
- Remove A from B
- Remove D from A

or

- Remove D from A
- Remove A from B
- Remove C from A

Disassembly Alternatives (“and or” diagram)



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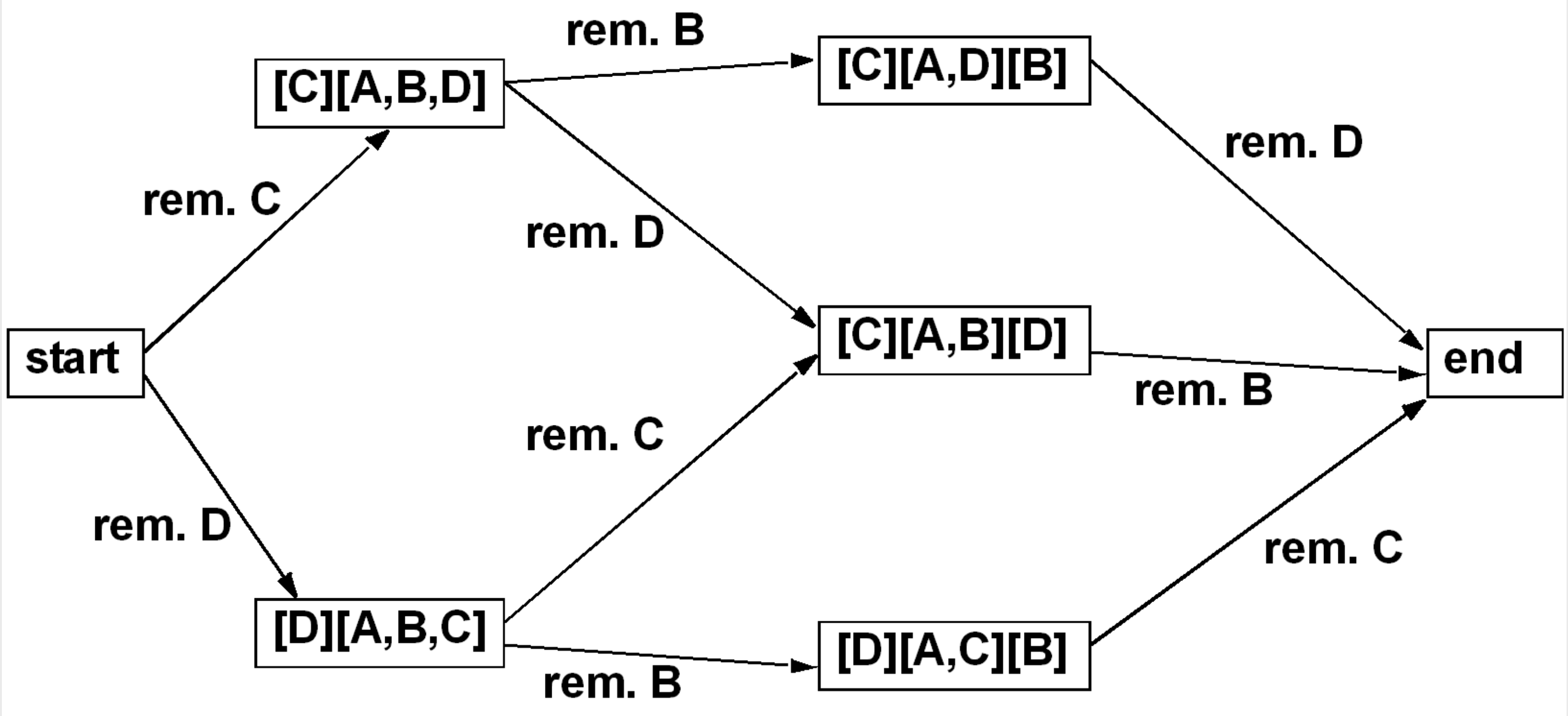
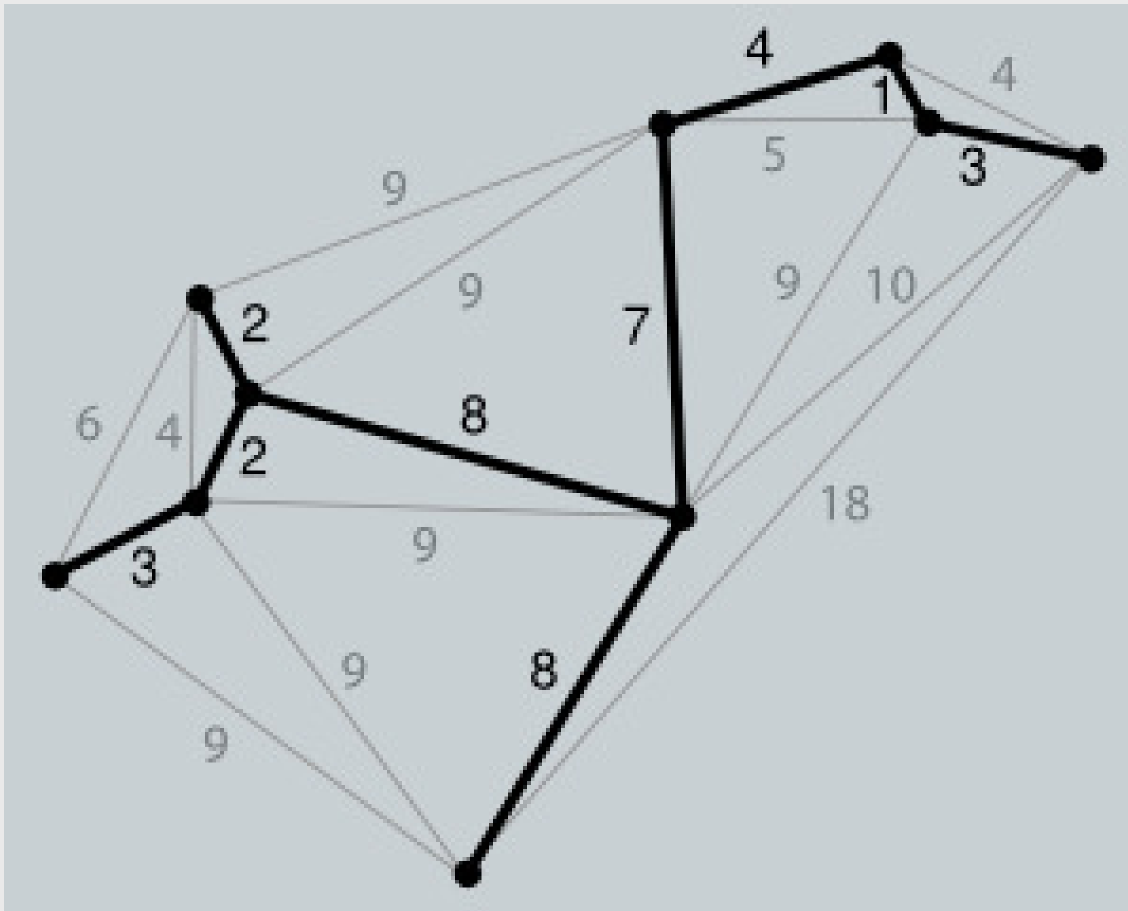
Disassembly Sequence (Network Model) – shortest path problem



Separate subassemblies in [ ]

Minimum Spanning Tree



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Flow Network

- **How many units can we pass from s to t? How much flow??**