Lecture #23

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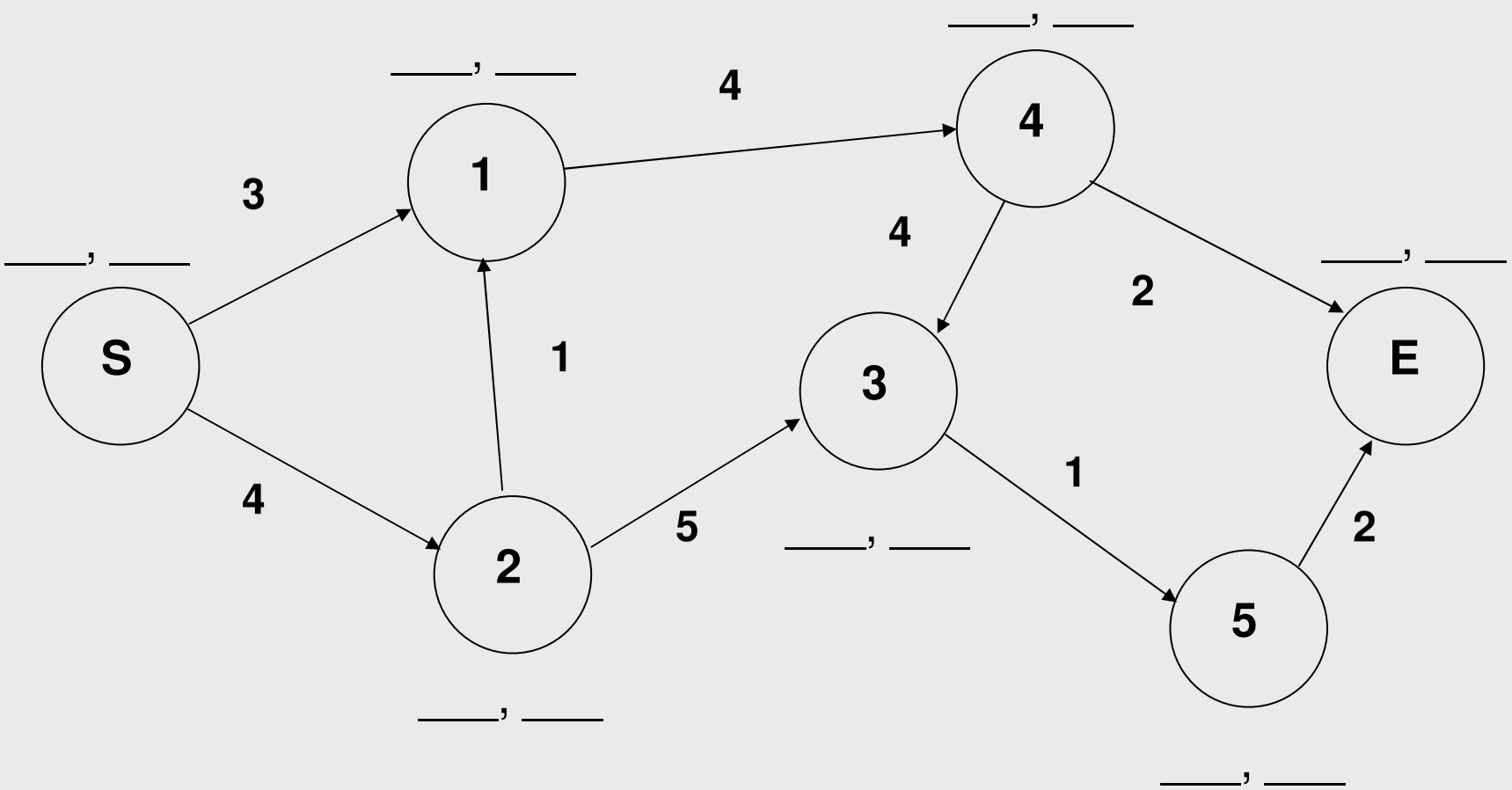
Michigan Technological University

CPM



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Critical Path Method

Item	Symbol	Definition
Activity duration	*t*	The expected duration of an activity
Early start	*ES*	The earliest time an activity can begin if all previous activities are begun at their earliest times
Early finish	*EF*	The earliest time an activity can be completed if it is started at its early start time
Late start	*LS*	The latest time an activity can begin without delaying the completion of the project
Late finish	*LF*	The latest time an activity can be completed if it is started at its latest start time
Total slack	*TS*	The amount of time an activity can be delayed without delaying the completion of the project

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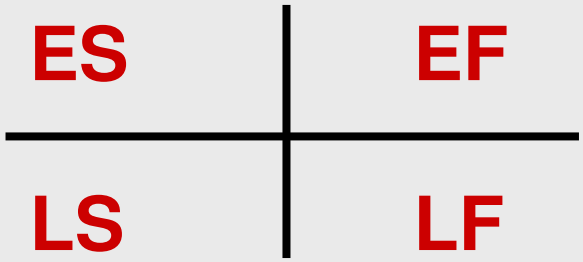
Critical Path Method

	$ES = EF_{predecessor}$	(max)	(1)
	$EF = ES + t$		(2)
	$LF = LS_{successor}$	(min)	(3)
	$LS = LF - t$		(4)
	$TS = LF - EF$		(5)
or	$TS = LS - ES$		(6)

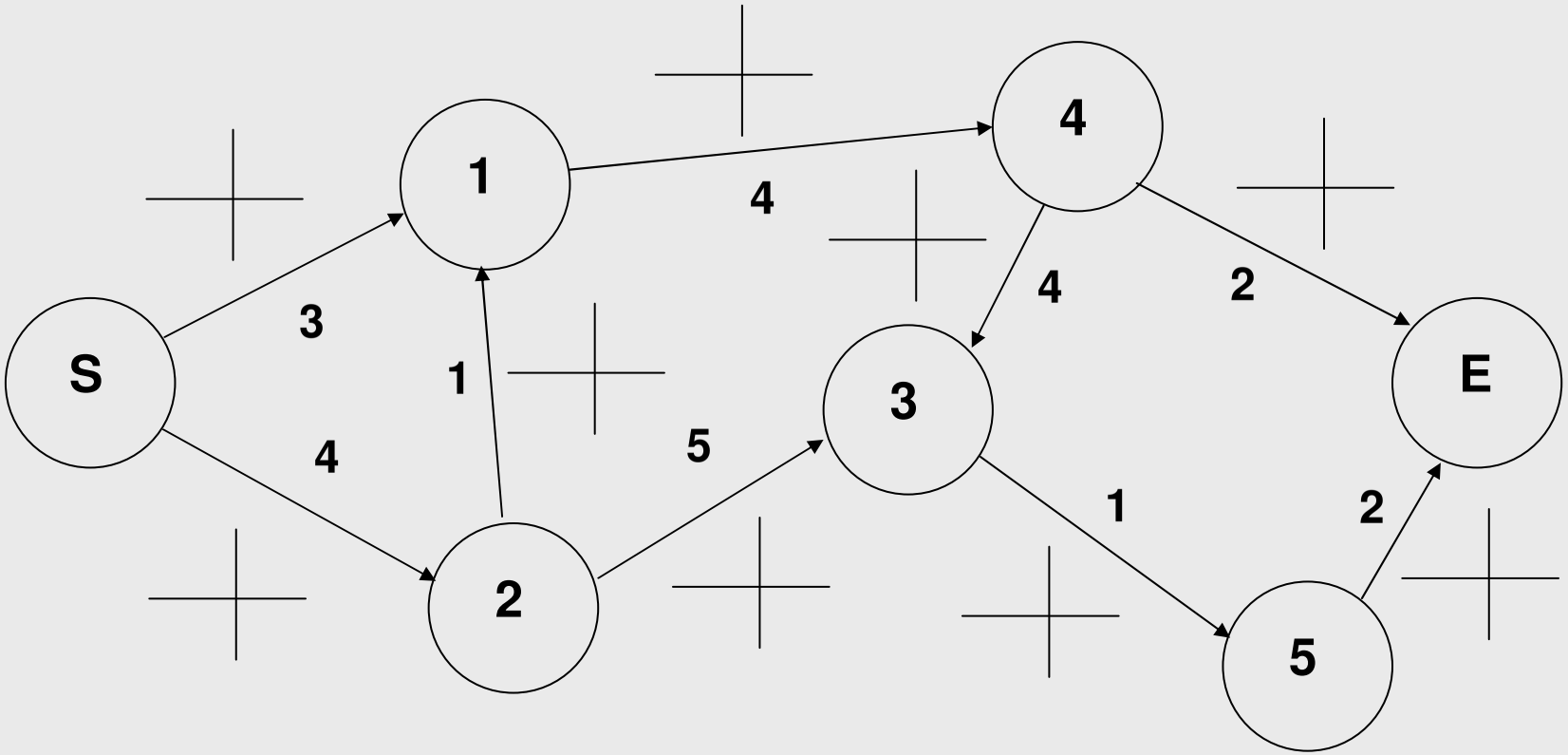
More on CPM

- Associated with each activity is a cross to be filled in with the activity schedule times, which are calculated as follows:

$$TS = LS - ES$$



More CPM



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More on Activity Networks

- In many cases t values are assumed to be deterministic (i.e., constant)
- In other cases, expected duration is mean of known probability distributions
- PERT Approach – Beta Dist.
  - 3 time estimates
  - Most likely time (M), optimistic time (O), and pessimistic time (P)
  - For each activity: Mean = (O + 4M + P) / 6
  - For each activity: Std Dev = (P – O) / 6
  - Add variances along path
  - End up with Mean and S.D. of Completion Time

Routing Problems

- Shortest path problem (SPP)
- Minimum Spanning Tree (MST)
- Traveling salesman problem (TSP)
- Vehicle routing problem (VRP)
- Chinese postman problem (CPP)

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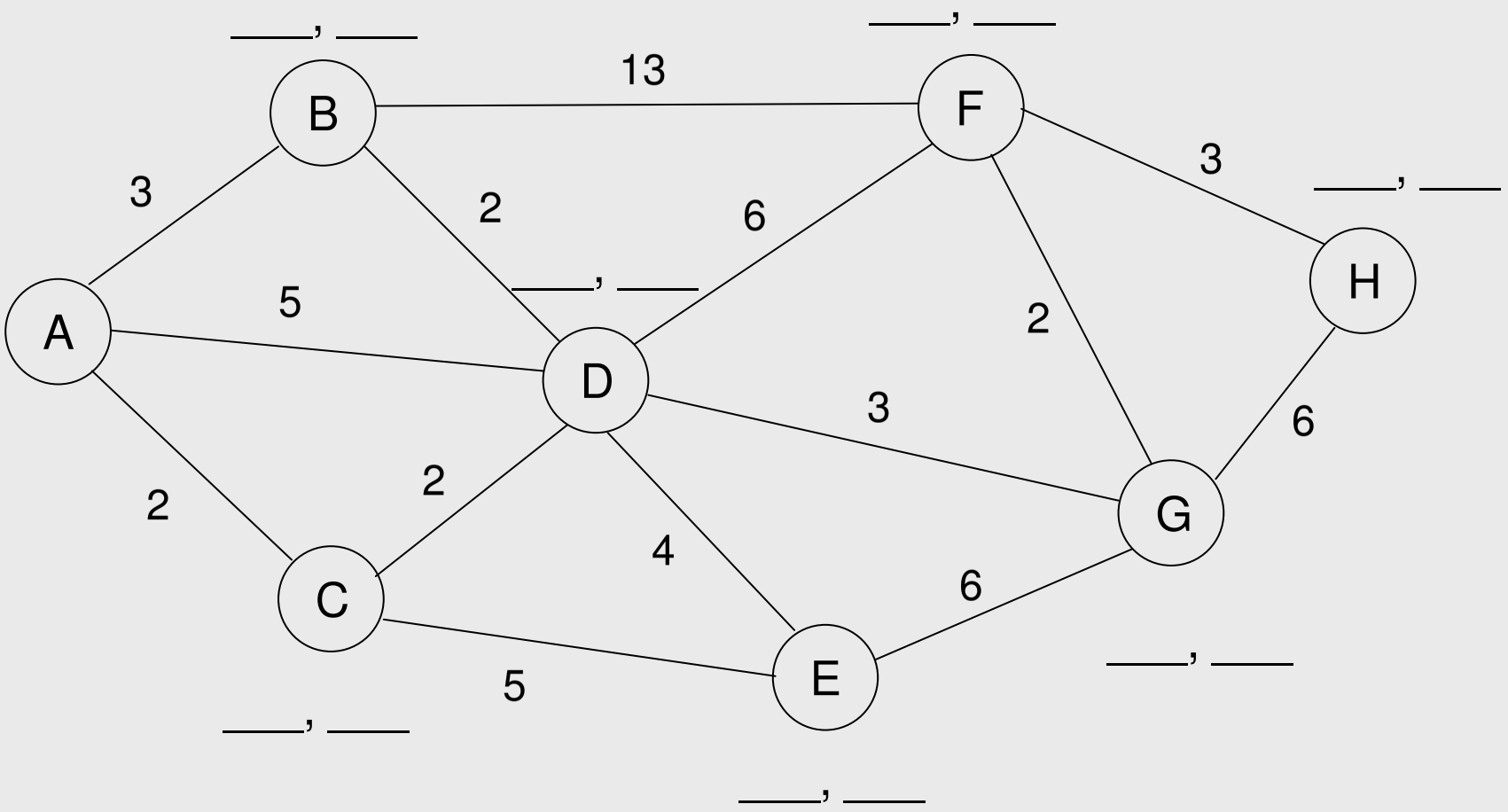
Classifying Routing and Scheduling

- If the customers being serviced have no time restrictions and no precedence relationships exist, then the problem is a pure routing problem.
- If there is a specified time for the service to take place, then a scheduling problem exists.
- Otherwise, we are dealing with a combined routing and scheduling problem.

Shortest Route Problem



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Dijkstra's Algorithm

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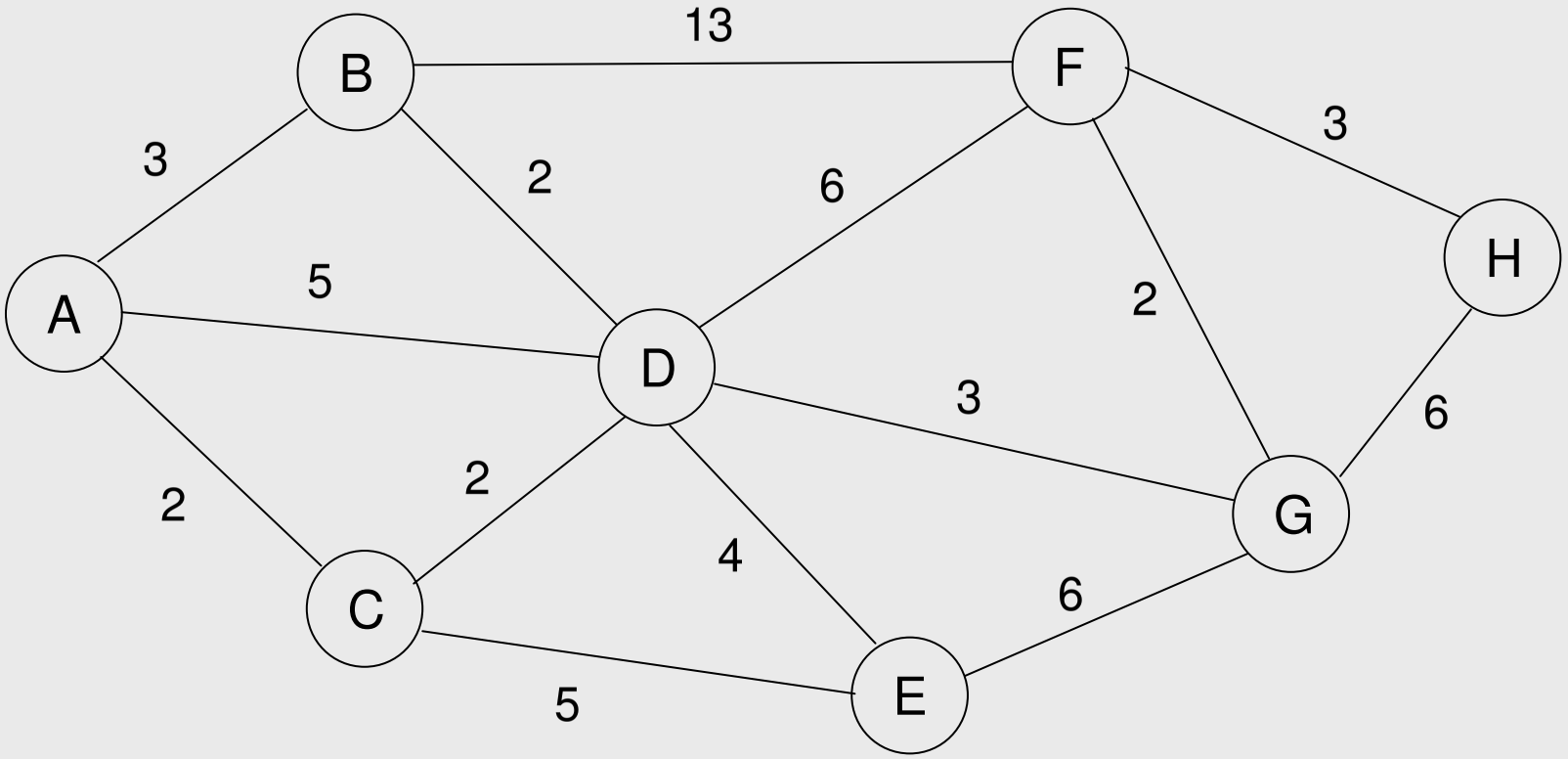
Minimum Spanning Tree



Traveling Salesman Problem

- No simple way to obtain solution
- Nearest neighbor procedure (NNP)
  - NNP builds tour based only on cost/ distance of traveling from the last-visited node in network to other nodes
  - Has disadvantage of being rather shortsighted
    1. Start with node at the beginning of the tour
    2. Find node closest to last node & add to tour
    3. Go to step 2 until all nodes added
    4. Connect first & last nodes to close tour
- Can use as upper bound for Branch and Bound Soln.

Example of the NNP

- In this case where the arcs are undirected, the distance from i to j will be the same as the distance from j to i
- Such a network with undirected arcs is said to be symmetrical

	To Node (distances in miles)					
From Node	1	2	3	4	5	6
1	—	5.4	2.8	10.5	8.2	4.1
2	5.4	—	5.0	9.5	5.0	8.5
3	2.8	5.0	—	7.8	6.0	3.6
4	10.5	9.5	7.8	—	5.0	9.5
5	8.2	5.0	6.0	5.0	—	9.2
6	4.1	8.5	3.6	9.5	9.2	—

Symmetric Distance Matrix