Introduction to Computer Networks

Equal-Cost Multi-Path Routing
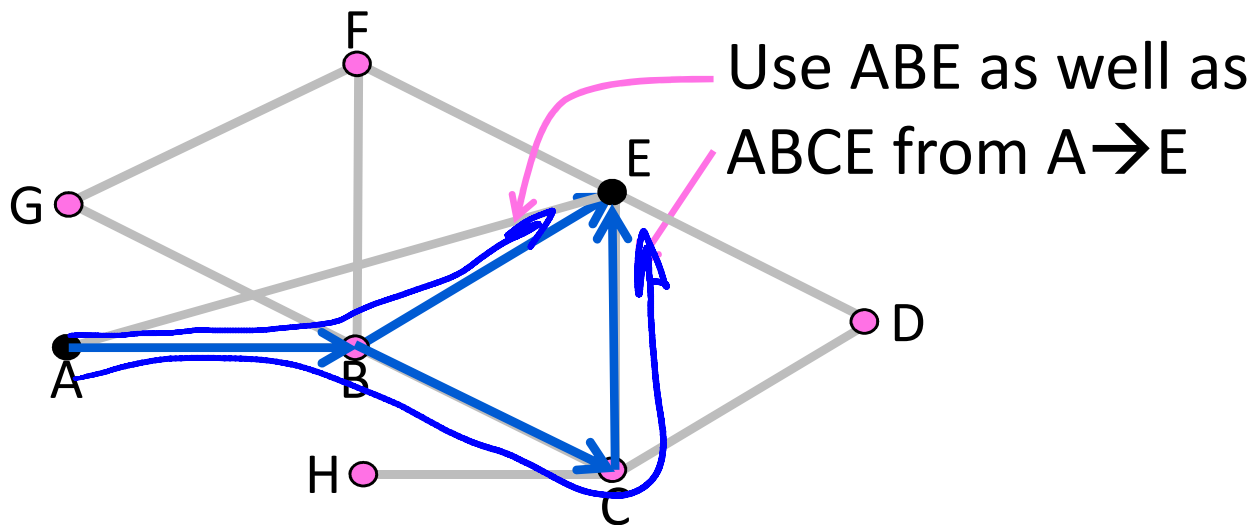## (§5.2.1, 5.6.6)

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Topic

- More on shortest path routes
  - Allow multiple shortest paths

Use ABE as well as ABCE from A→E

Multipath Routing

- Allow multiple routing paths from node to destination be used at once
  - Topology has them for redundancy
  - Using them can improve performance

- Questions:
  - How do we find multiple paths?
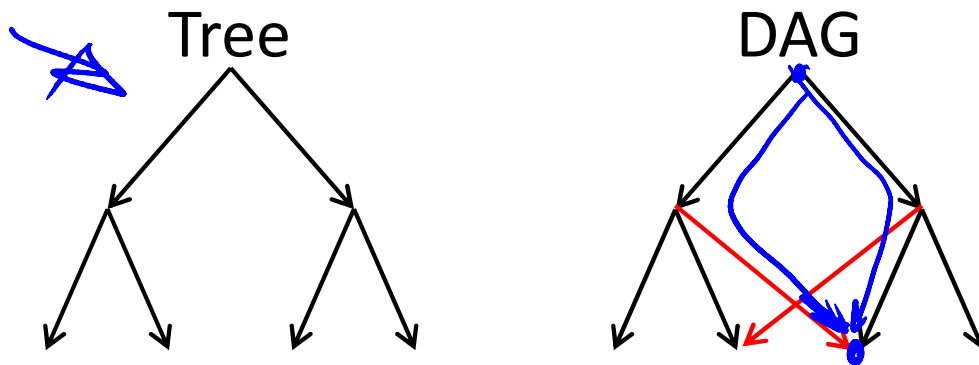 - How do we send traffic along them?

Equal-Cost Multipath Routes

- One form of multipath routing
  - Extends shortest path model by keeping set if there are ties

- Consider A→E
  - ABE = 4 + 4 = 8
  - ABCE = 4 + 2 + 2 = 8
 - ABCDE = 4 + 2 + 1 + 1 = 8
  - Use them all!
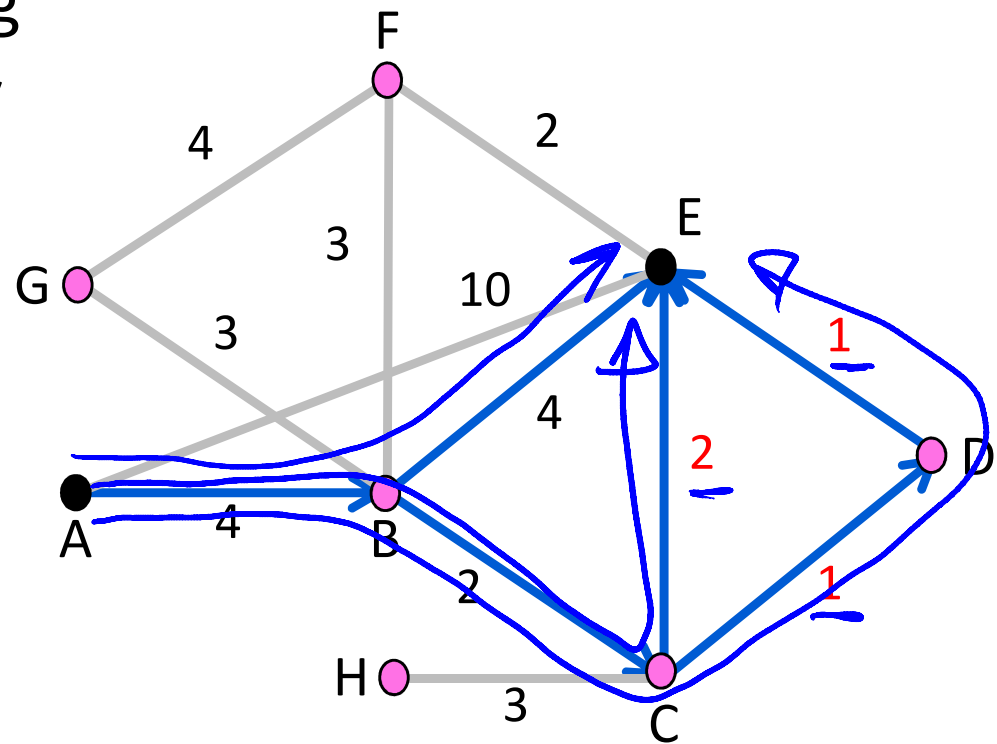
Source "Trees"

- With ECMP, source/sink "tree" is a directed acyclic graph (DAG)
  - Each node has set of next hops
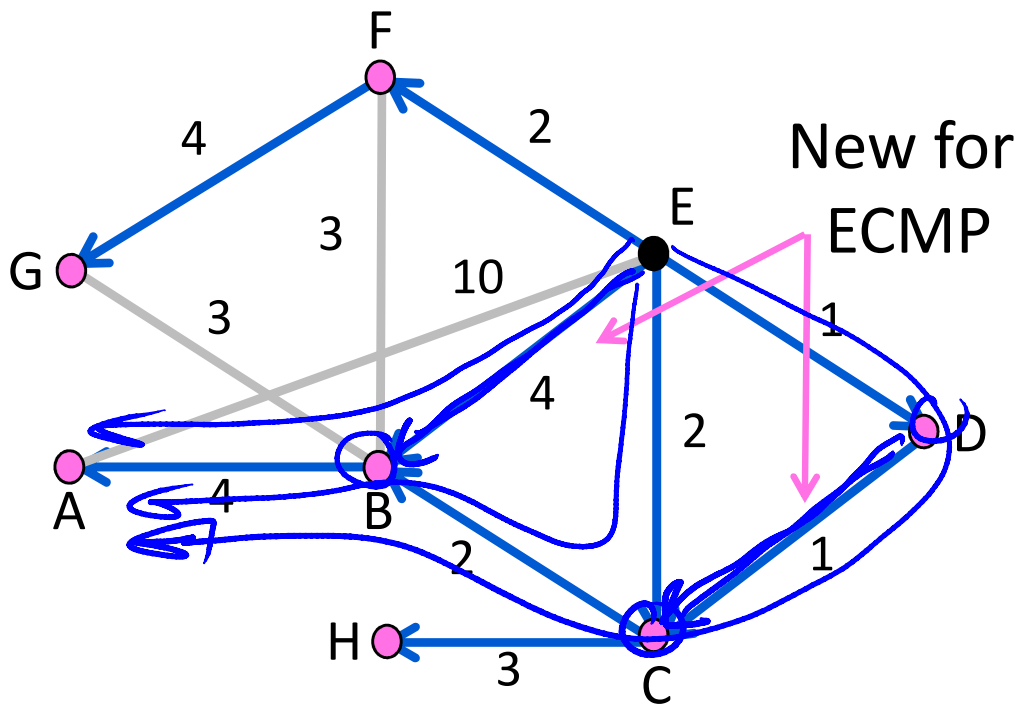 - Still a compact representation

Tree

DAG

Source "Trees" (2)

- Find the source "tree" for E
  - Procedure is Dijkstra, simply remember set of next hops
  - Compile forwarding table similarly, may have set of next hops

- Straightforward to extend DV too
  - Just remember set of neighbors
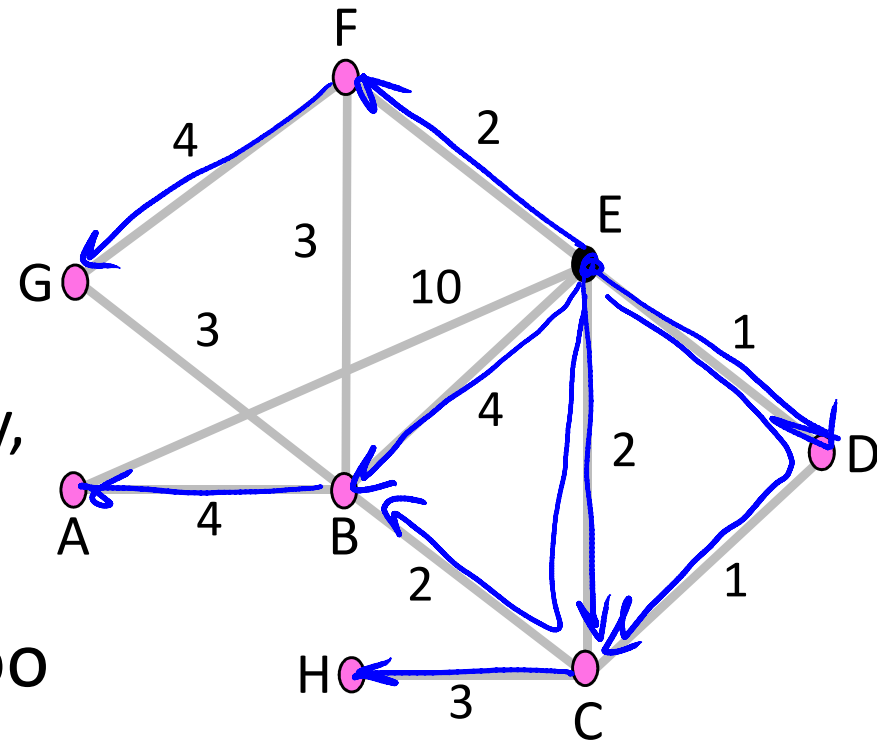
Source "Trees" (3)

Source Tree for E

E's Forwarding Table

New for ECMP

Node	Next hops
A	B, C, D
B	B, C, D
C	C, D
D	D
E	--
F	F
G	F
H	C, D

Forwarding with ECMP

- Could randomly pick a next hop for each packet based on destination
  - Balances load, but adds jitter

- Instead, try to send packets from a given source/destination pair on the same path
  - Source/destination pair is called a flow
  - Map flow identifier to single next hop
  - No jitter within flow, but less balanced

Forwarding with ECMP (2)
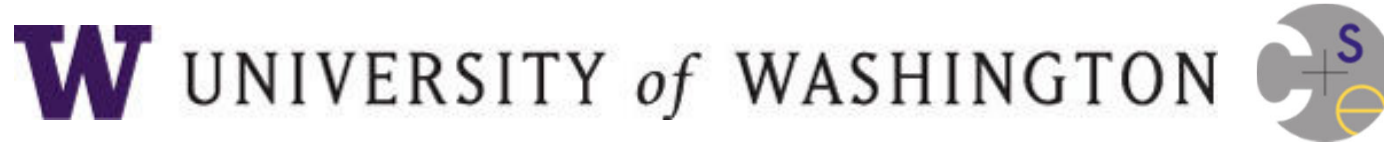
Multipath routes from F/E to C/H
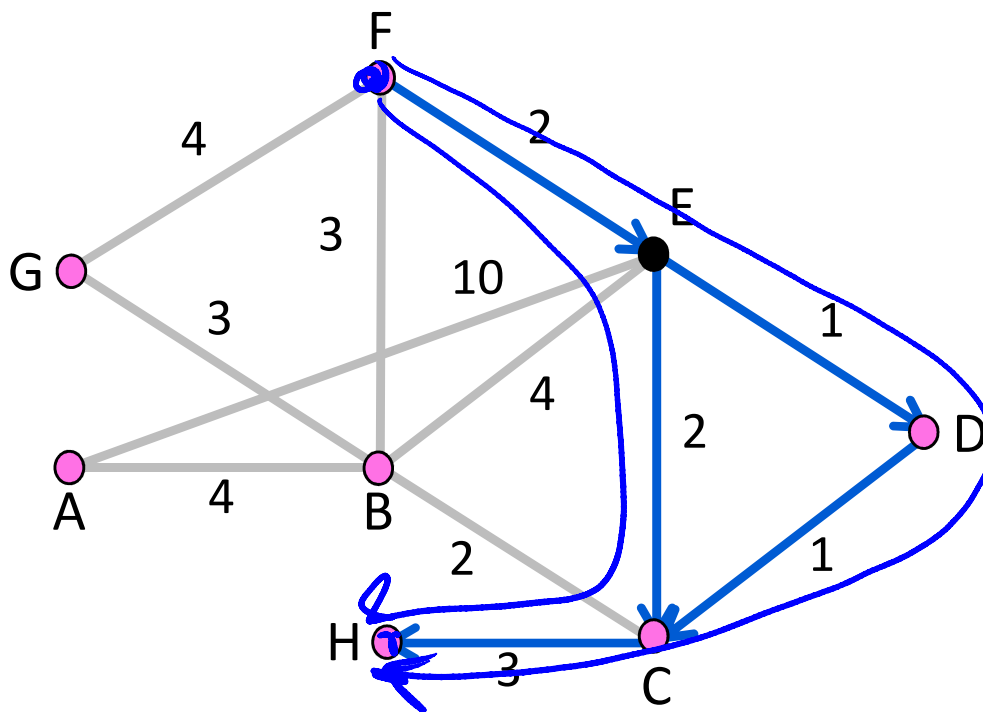
E's Forwarding Choices

Flow	Possible next hops	Example choice
F → H	C, D	D
F → C	C, D	D
E → H	C, D	C
E → C	C, D	C

Use both paths to get to one destination

END

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