Routing -- Overview

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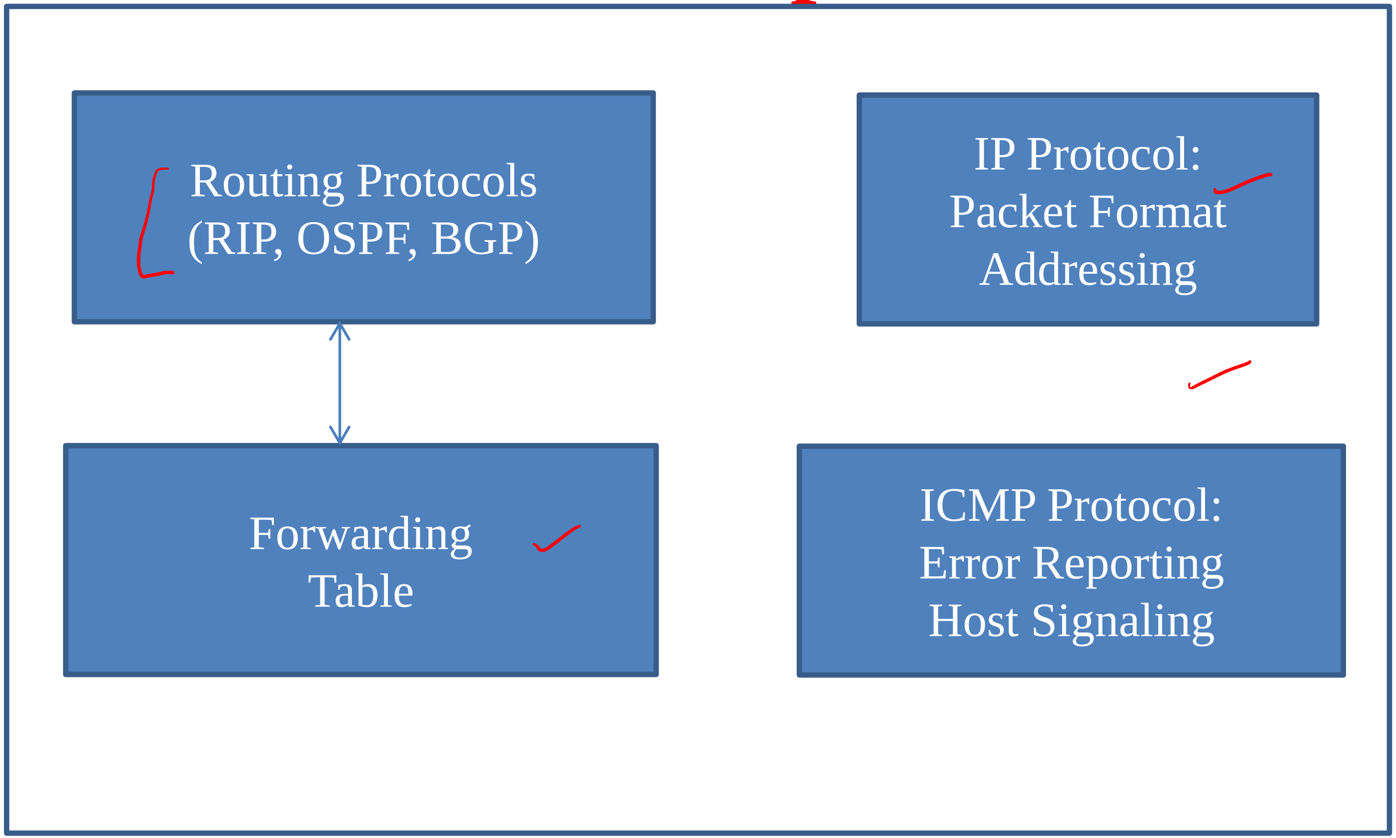
Service Model Implementation



Background

- Role of network layer is ‘end-host delivery’

  src dest

  - We looked at how packets are forwarded

- How are forwarding tables built? Via Routing Protocols

  dest

- Routing vs Forwarding

  process of building such tables

  process of looking in the table
  to see where to send based on dest

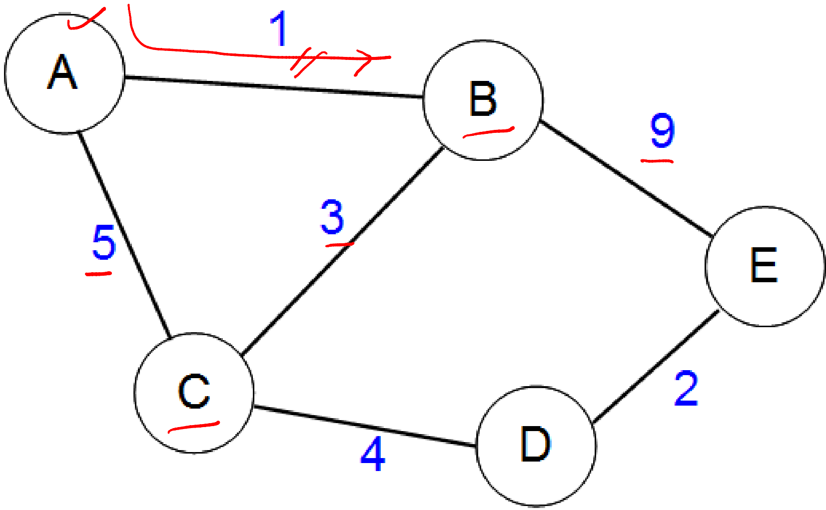
- Routing domain: All routers under same administrative control
  - E.g. University network, ISP network

Theory

- Based on Graph theory
- Nodes: Hosts, **Routers**, Networks

vertices

- Edges: Correspond to physical links
  - Edges associated with a cost
  - No edge → infinite cost



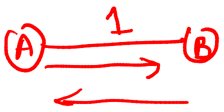
cost means time maybe

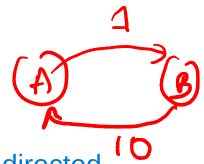
- Neighbor: Directly connected nodes

Goal of Routing

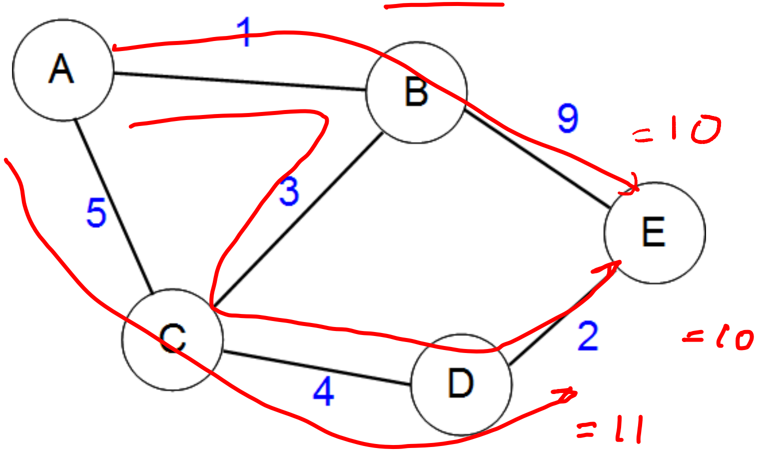
- Single Pair 'shortest' path problem: Find least cost path between two nodes
  - Path cost is sum of the costs of the individual edges
  - Assumption: Links are undirected

Nodes A, E



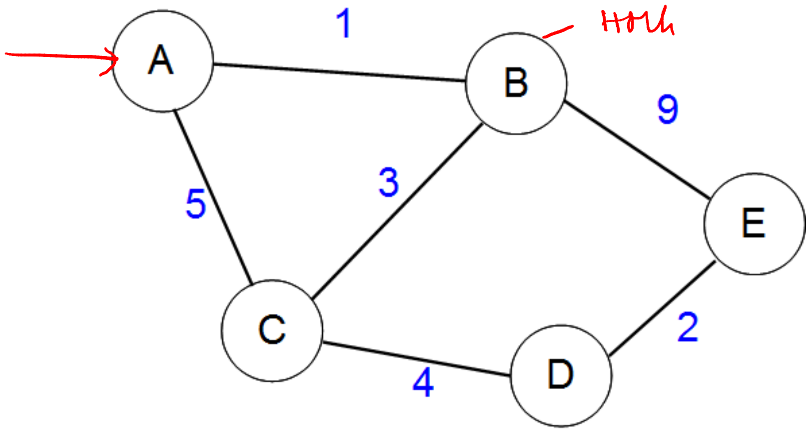


directed



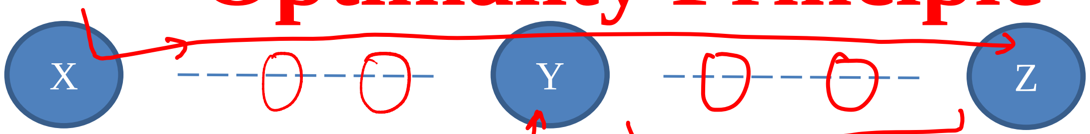
Goal of Routing

- Single-source ‘shortest’ path problem: Find least cost path from a source to all other nodes in the graph
- Refer to Dijkstra’s algorithm



Optimality Principle

least cost path

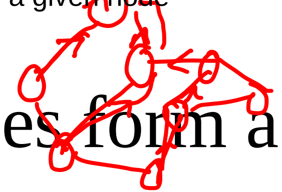


- Router Y is on the optimal path from X to Z → Y to Z is also an optimal path

other least cost path

destination source

For a given network topology, if one were to mark the optimal path from all nodes to a given node (destination), what would the resulting marked up paths form?
TREEE



- Set of optimal routes to a destination from all sources form a 'sink tree' routed at the destination
  - Sink tree need not be unique
  - No loops → each packet delivered within finite hops
  - For undirected links, a given source to all destinations also forms a tree
  - Routing algorithms helps find sink trees for all routers

Implementation Approach

- Static vs Dynamic
  - Static: Route computed in advance and downloaded in all routers
  - Dynamic: Handles changes in the topology
    - Nodes failure, addition of new nodes, variation in cost

Dynamic preferable over static

ImplementationApproach

- Central vs distributed processing

conjusted

congested

- Central: fault-tolerance, scalability issues

network topology

  - All nodes pass neighborhood information to a central node
  - Central node calculates routes and distributes to all
- Distributed: Each node determines routes by itself

complex,

in tgis case **Distributed preferable to Central**

Implementation Approach

- Global vs Local information
- Global: Node calculates routes based on full knowledge of entire topology this can still be distributed
- Local: Node does not have global information, determine routes based on local message exchange

Popular Approaches

- Dynamic, distributed algorithms
  - Global knowledge: Link State Algorithm
  - Local knowledge: Distance Vector Algorithm

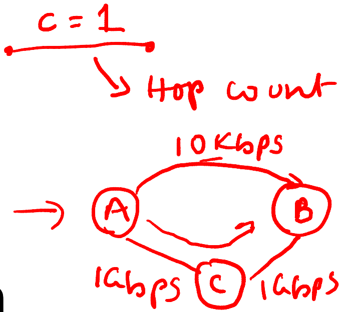
Desirable Features

- Optimality: Least cost paths
- Correctness: Path actually exists
- Simplistic: Easy to implement
- Robust: Handle router/link failures
- Stable: Fast convergence to equilibrium after state change
- Minimal overhead: No. and frequency of message exchange

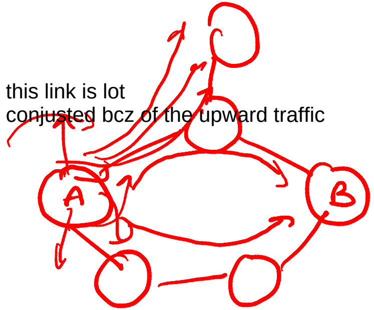
  reduce msg exchanges which are used to determine routes etc
- Scalable: Handle large number of nodes

Cost Metric

- Cost = 1 → Hop count
  - Doesn't distinguish between links based on bandwidth, delay, current load, losses etc



- Static: 1/link_bandwidth



- Dynamic: Queue Length, Delay
  - Not stable (ping-pong effect)

one line decrease, u go there, the other decrease ....

- Reality: Links assigned 'static' cost by administrators (e.g. Constant/link_bandwidth)

Summary

- Routing based on graph theory
- Goal of routing is to find 'optimal' path between nodes
- Many approaches to routing
  - Popular: dynamic, distributed based on global/local information
- Up ahead: Popular routing algorithms