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Computer Networks II
IPv4 routing

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A.A. 2009/2010

NEXT WEEK...

- 2 exercise classes on topics covered so far
- Please review
  - Basics
  - IP/TCP/UDP
  - Addressing, ARP etc.

Routing

- The path traversed by an IP datagram consists of subnetworks interconnected by routers
- An IP datagram is interpreted by a subnet as a Service Data Unit (SDU)
- A subnet delivers each SDU to the next router on the path towards destination or to the destination itself **using its own protocol mechanisms**

Routing/cont.

- Two types
  - direct
  - indirect
- Direct routing
  - Destination host belongs to same subnetwork as sender (be it a host or a router)
- Indirect routing
  - Destination host belongs to different subnetwork than that to which sender belongs (be it a host or a router)

Direct routing

- No intermediate routers involved
- Need IP -> physical address translation (e.g., MAC address)
- IP datagram encapsulated into subnet-dependent layer 2 data unit, which is relayed directly to destination host
- Forwarding within subnet uses subnet specific mechanisms

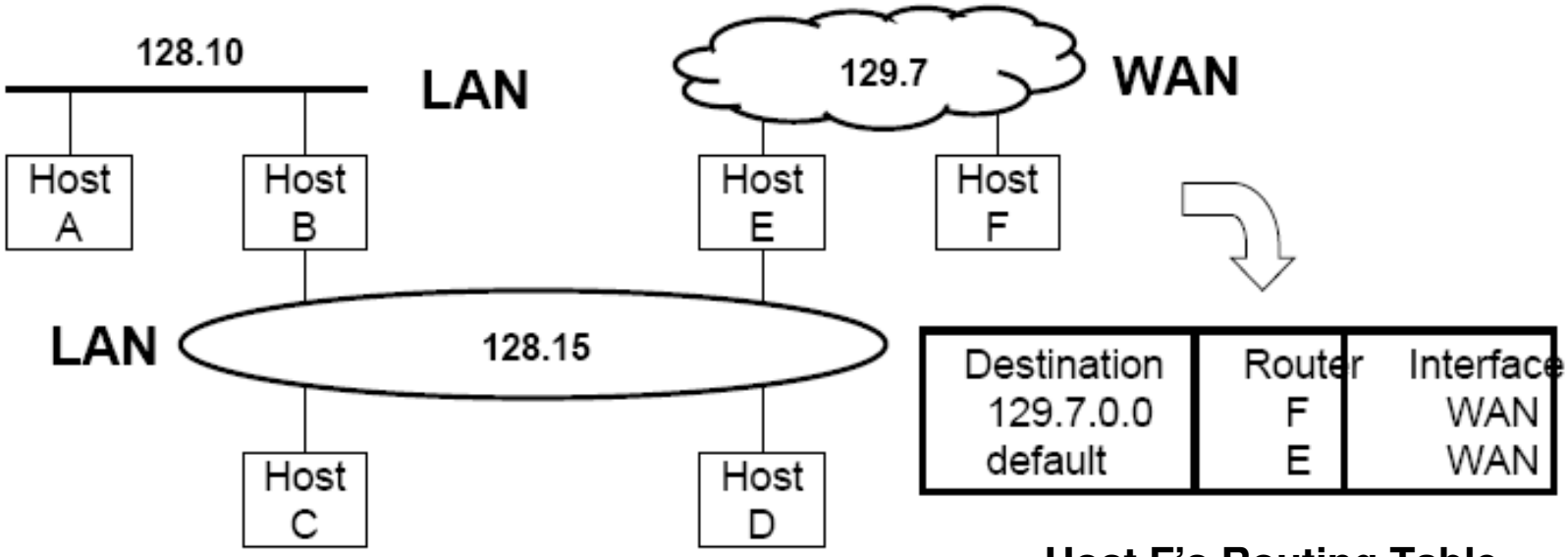
Indirect routing

- Host identifies next router on path to destination
  - Physical address of router's interface required (ARP protocol)
- Router analyzes received IP datagram and identifies next router on path towards destination
  - Datagram forwarding to next hop router occurs according to specific mechanisms of traversed subnet
- Process iterated until destination subnet is reached
  - Direct routing used in destination subnet

Routing table

- Next hop router chosen according to Routing Table (RT) - Every host/router contains an RT
- Every RT entry contains
  - Destination IP address/prefix (host address or network address)
  - Address of next hop router on path towards destination network
  - Identifier of physical output interface to next hop
- A router does not know full path towards destination

Routing table/cont.



Destination	Router	Interface
129.7.0.0	F	WAN
default	E	WAN

Host F's Routing Table

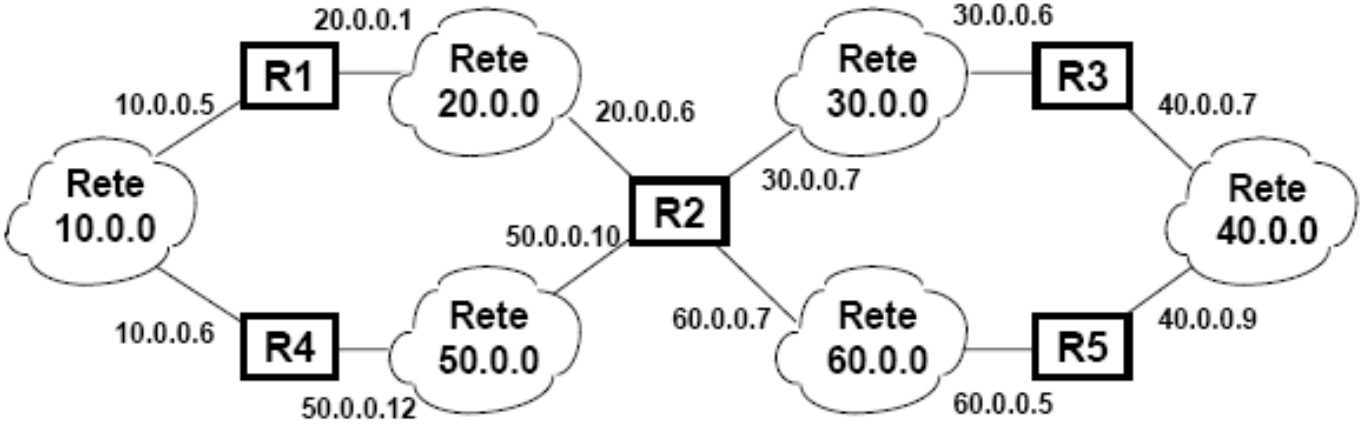
Destination	Router	Interface
129.7.0.0	E	LAN
128.15.0.0	D	LAN
128.10.0.0	B	LAN
default	B	LAN

Host D's Routing Table

Routing table/cont.

- When forwarding a datagram, a router performs the following steps:
  - Look for an entry corresponding to complete IP destination address in datagram header
  - Look for entry corresponding to network address - apply “longest prefix matching” rule
  - Look for “default router” (default next hop)
- If none of steps above succeeds “undeliverable datagram”
  - Datagram dropped
  - ICMP “host unreachable” message to sender
- Default router used
  - By small hosts, which may not possess a full-fledged RT - they send to default router any packets whose destination does not belong to local network [e.g., Home LAN with ADSL router]
  - By routers/hosts with RT not covering all possible destinations

Routing table/cont.



Routing Table di R2	
Net_Id	Router_Id
10.0.0	20.0.0.1
20.0.0	Instradamento diretto
30.0.0	Instradamento diretto
40.0.0	30.0.0.6
50.0.0	Instradamento diretto
60.0.0	Instradamento diretto

Routing Table di R3	
Net_Id	Router_Id
10.0.0	30.0.0.7
20.0.0	30.0.0.7
30.0.0	Instradamento diretto
40.0.0	Instradamento diretto
50.0.0	30.0.0.7
60.0.0	40.0.0.9

Routing function

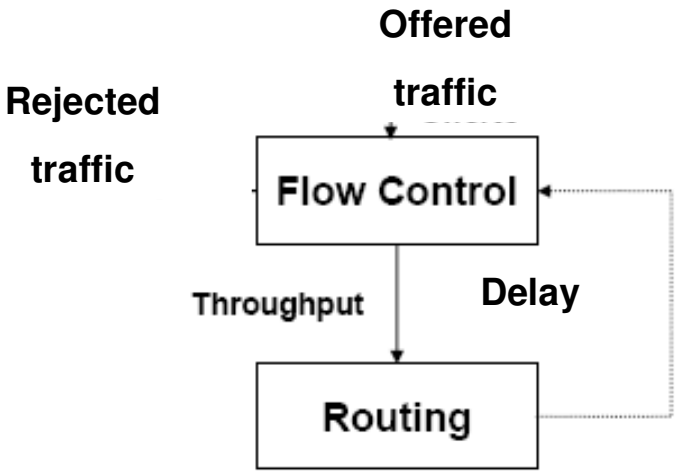
- It is the function of forwarding IP datagrams towards destination network
- Every link in the network has an associated cost *(metric)*. Metric can be:
  - Same for all links
  - Inversely proportional to link's bandwidth
  - Proportional to current link's congestion
  - Proportional to cost (however defined) of using link
  - Infinite if link broken
- **Source destination route chosen as shortest source-destination path**

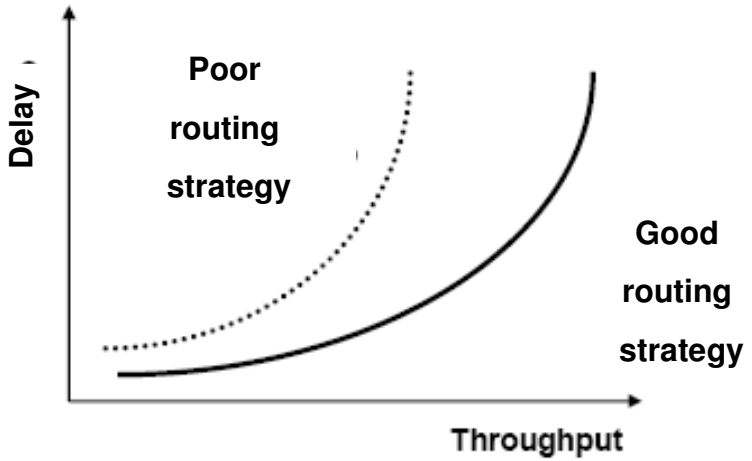
Routing function/cont.

- Choice of shortest route dynamic
  - Internet topology changes over time
  - Some routes can become unavailable due to link failures
- Dynamic routing strategy
  - More complex than static routing
  - More information exchange among network nodes required - further overhead for network
    - Control traffic increases with routing algorithm's adaptivity
    - Risks of routing oscillations (highly rapid adaptation) or ineffectivity (slow response to changes)
    - Possible side effects (e.g., loops, flooding)

Routing function/cont.

- Routing strategy has impact on network performance
  - Throughput
  - Average transit delay





Routing function/cont.

- Routing Tables updated dynamically
  - Every router/host maintains updated routing information over time
- RTs updated periodically
  - Every few seconds
- RTs' update performed by routing protocols for router information exchange
  - Routing Protocol [e.g., RIP, OSPF,…]

Autonomous Systems

- Autonomous System - AS: set of hosts and routers under a single, specific administrative authority
  - AS is called “Core AS” if it belongs to Internet’s backbone
  - Core Router: a router belonging to a Core AS
  - All other ASes are “Stub AS”
- Every AS has own routing protocol for interior use
- A Stub AS must possess at least one router connected to a Core router; such routers are said Exterior Gateway routers
- A router internal to an AS is said Interior Gateway router

Interior and Exterior Gateway Protocols

- Routing protocols used within an AS are said Interior Gateway Protocols (IGP)
  - Routing Information Protocol (RIP)
  - Open Shotest Path First (OSPF)
- Routing information involving more than one AS is is exchanged using Exterior Gateway Protocols (EGP)
  - Border Gateway Protocol (BGP)
- IGP and EGP have, in general, different purposes

Interior and Exterior Gateway Protocols

- An IGP protocol runnig on a router
  - Discovers adjacent routers *within the same AS*
  - Collects and redistributes to every other router data about the topology of the local AS and the costs of its links
  - Promptly spreads information about possible changes in cost of one or more links of the AS
- An EGP running on a (border) router
  - Discovers adjacent routers belonging to different AS in order to exchange routing information with them
  - Continuously tests the correct operation of adjacent routers
  - Periodically exchanges routing information with adjacent routers belonging to different ASes

Interior and Exterior Gateway Protocols