CEN445 – Network Protocols and Algorithms

Chapter 5 – Network Layer

5.1 Network Layer Design Issues

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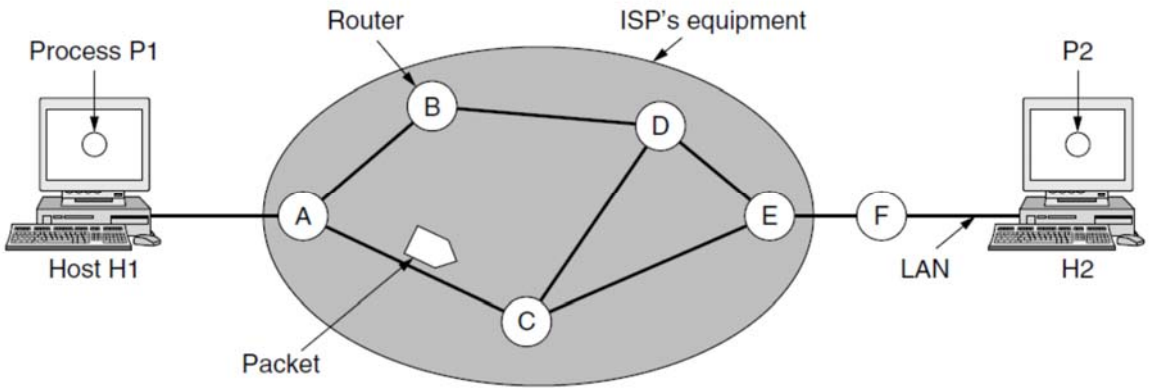
Network Layer Design Issues

- Store-and-Forward Packet Switching
  - restating the context of network layer protocols
- Services Provided to the Transport Layer
- Implementation of Connectionless Service
- Implementation of Connection-Oriented Service
- Comparison of Virtual-Circuit and Datagram Subnets

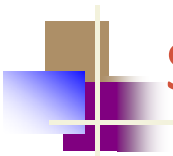
Store and Forward Packet Switching



- Customer equipment (outside the oval)
- Carrier's equipment: routers connected by transmission lines

Packet Switching

- Data is divided into small parts (packets)
- Packets are transmitted from node to node, processed and forwarded
- Also known as store-and-forward switching
- Two connection types
  - Connectionless: datagram
  - Connection-oriented: virtual circuit



Services Provided to Transport Layer

- Services should be independent of router technology
- Topology of network should be hidden
- Network addresses available to transport layer should use be uniform, even across LANs and WANs
- Network layer designers have freedom in writing specs of services to transport layer

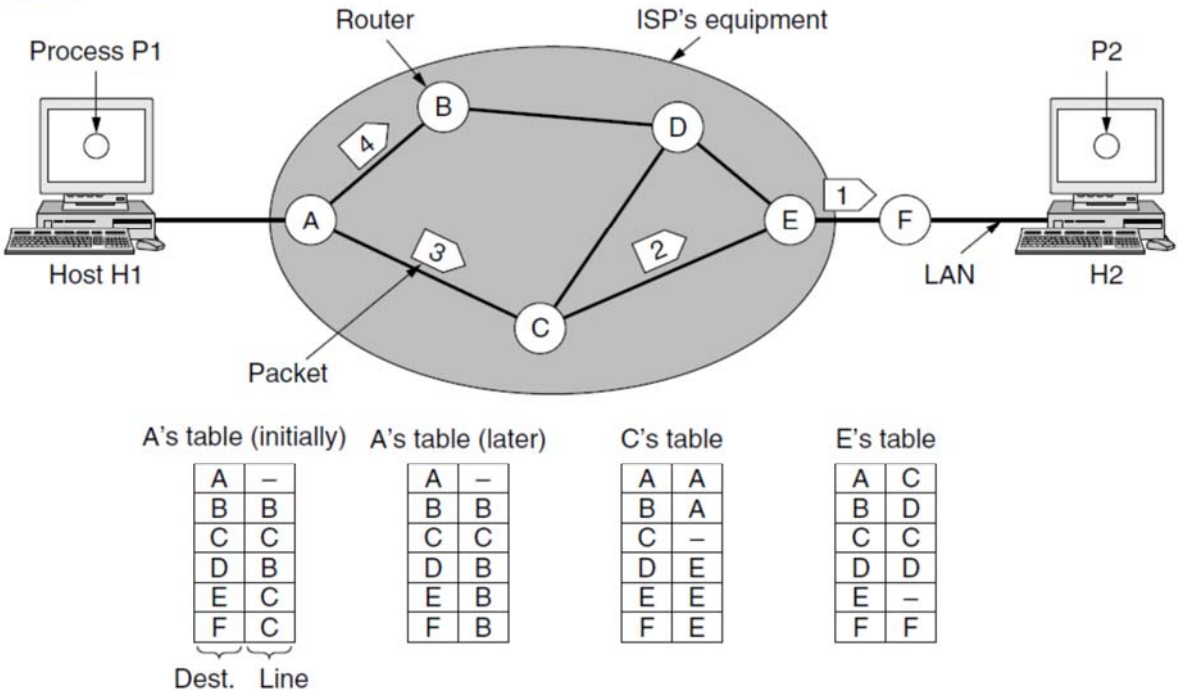
Connection-Oriented or Connectionless? Two competing camps

- Internet community: connectionless
  - routers job is moving packets and nothing else
  - subnet is inherently unreliable
  - *hosts* should provide error & flow control
- Telephone companies: connection-oriented
  - subnet should provide reliable service
  - successful experience with telephone system
  - without connections, QoS is hard to achieve

Example: the Internet

Example: ATM

Implementation of Connectionless Service



A's table (initially)

Dest.	Line
A	–
B	B
C	C
D	B
E	C
F	C

A's table (later)

A	–
B	B
C	C
D	B
E	B
F	B

C's table

A	A
B	A
C	–
D	E
E	E
F	E

E's table

A	C
B	D
C	C
D	D
E	–
F	F

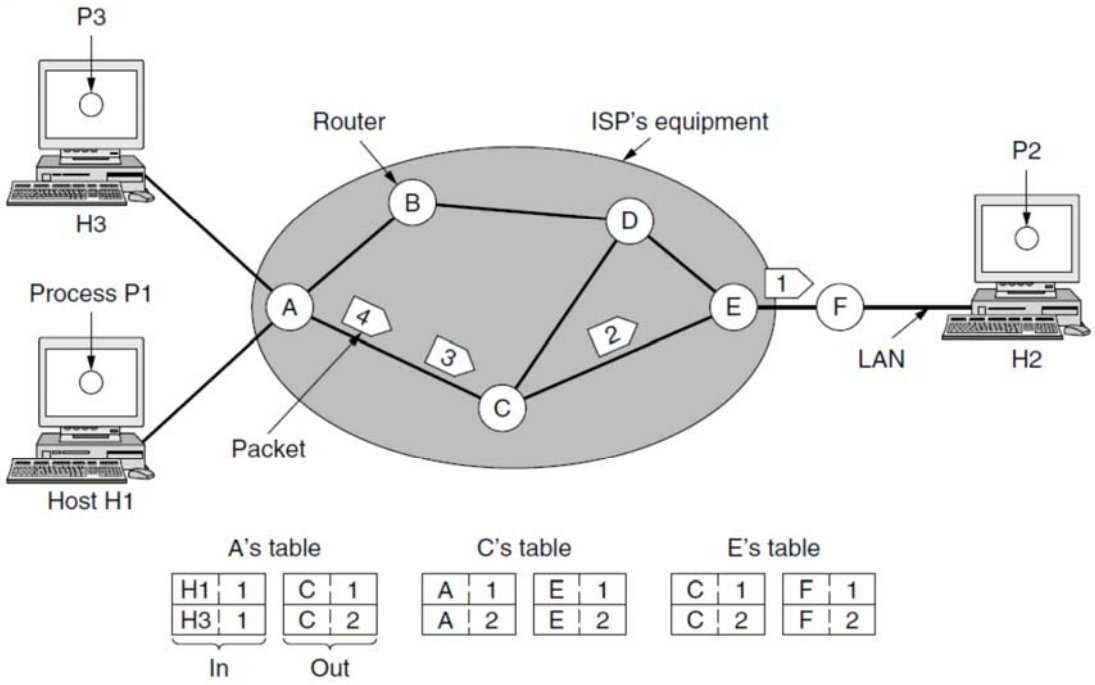
Implementation of Connectionless Service

- No connection setup
- Message is broken into packets
- Called datagram (in analogy with telegram)
- Each packet is individually routed
- Routers decides line based on routing table
- Packets may follow different paths
- Not guaranteed to arrive in order

Implementation of Connection-Oriented Service

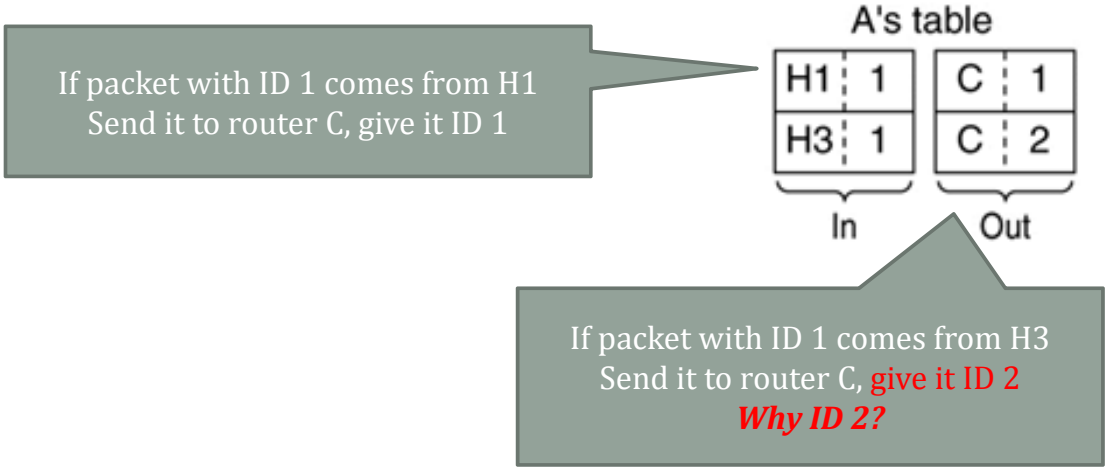
- Path from source to destination must be established before any data can be sent
- Connection is called a VC (virtual circuit)
  - analogy with physical circuit in phone system
  - why virtual?
- Avoid choosing new route for each packet
- Same route used for all packets in connection
- Each packet has ID for which VC it belongs to

Implementation of Connection-Oriented Service



Example: Connection-Oriented

- H1 has established connection 1 with H2
- First entry in each routing table
- H3 later establishes connection with H2



Example: Connection-Oriented

- A can easily know connection 1 packets of H1 from connection 1 packets of H3
- C cannot do this
- Thus, A assigns different connection ID to outgoing traffic for second connection
- To avoid conflicts, routers need ability to replace connection IDs in outgoing packets
- This is called label switching

Comparison of Virtual Circuit and Datagram

Issue	Datagram subnet	Virtual-circuit subnet
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Trade-Offs

- VC allow packets to contain short ID
  - datagram must contain full destination address
  - for short packets, significant overhead
  - OTOH, VC need table space in routers
- Datagram subnet needs entry for every possible destination
  - VC subnet just needs an entry for each VC
  - But!! VC setup packet have to be routed
  - same as datagram