CSE and EE 461
Lecture 18

Autumn Quarter 1997

The Network Layer

- Physical Layer handles a bit stream which may have errors.
- Data link layer handles the reliable delivery of a bit steam between two nodes by detecting errors, potentially resending lost data, and handling flow control.
- Medium access layer handles coordination of a broadcast channel to achieve point-to-point communication
- Network layer handles coordination among many nodes in a network to achieve point-to-point delivery of data.

  - routing of packets
  - congestion control
  - internetworking
  - provide services to the transport layer

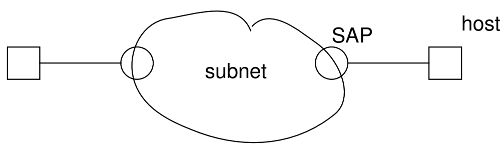
Services Provided to the Transport Layer

- Typically there is a strong separation between the network layer and the transport layer

  - the network layer controls the subnet which is typically owned by a "service provider" while the transport layer is owned by the "customer."
- Main goals of the service

  - The service provided is host-to-host so that the transport layer need not know what the underlying network looks like or what the technology is.

  - Service access points (SAPs) should be addressed uniformly over all hosts that may ever want to talk to each other.



Types of Services Provided

- Virtual Circuit - similar to telephone service

  - a connection is requested from one host to another
  - the connection is set up or refused
  - packets flow along the connection - FIFO order of delivery
  - connection is disconnected
- Datagram - similar to the postal system

  - connectionless service
  - each packet is individually addressed from one host to another
  - datagrams may not be FIFO
- The service provided can be negotiated between the transport layer and the network layer. This is "Quality of Service," QoS.

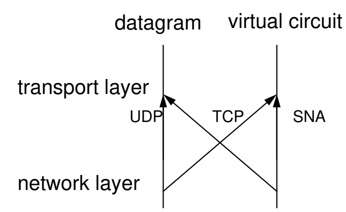
  - bandwidth and delay of virtual circuit
  - priority datagrams

Who Does What

- Error Control
  - virtual circuit may or may not provide an errorless channel
  - datagram does not provide error free delivery nor FIFO delivery
- Flow Control
  - virtual circuit may demand flow control from transport layer to avoid congestion
  - datagram - transport layer must provide its own flow control
- Connection Control
  - virtural circuit provides connection control
  - datagram - connection control must be done by the transport layer

Internal vs. External Virtual Circuit Service

	Datagram	Virtural Circuit
Network Layer	IP	ATM, SNA
Transport Layer	UDP	TCP

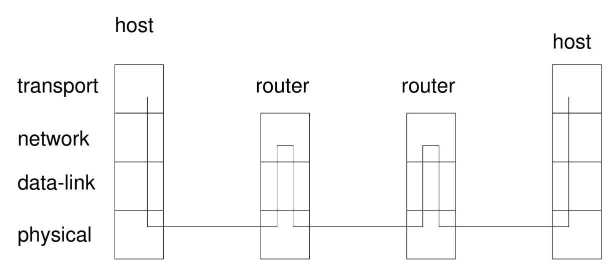


- IP = Internet Protocol
- ATM = Asynchronous Transfer Mode
- SNA = Systems Network Architecture
- UDP = User Datagram Protocol
- TCP = Transmission Control Protocol

Virtual Circuits - Internal vs. External

- Internal virtual circuit is implemented at the network layer
  - network layer provides a session service to transport layer
  - transport layer is asssured of a FIFO service and can negotiate quality of service guarantees with the network layer
  - typically uses fixed routes and can use preallocated buffer space
  - examples ATM, SNA
- External virtual circuit is implemented at the transport layer
  - transport layer must provide its own session service
  - transport layer must provide error control, flow control, and reorder out of order packets
  - quality of service guarantees difficult
  - example TCP

Relationship Between the Layers

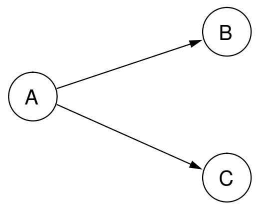


Structure of a Datagram Service

- Each switch has a routing table which allows the router to forward a packet to its eventual destination.
- Each packet has the final destination.

A’s Routing Table

Destination	Next Hop
E	B
F	C
G	B
K	B
M	C



Main Issues in Maintaining Routing Tables

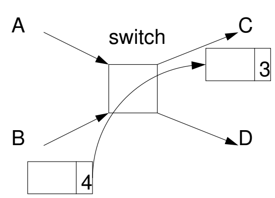
- Routing tables must be consistent - there can be no permanent cycles
- Routing tables should be dynamic - to route around congestion or failed switches.
- Routing tables should be small - hierarchical routing will be needed
- There are alternatives to using strict routing tables for accomplishing the task of packet delivery. Such alternatives are certainly needed to distribute data for maintaining routing tables. More later.

Network Layer Virtual Circuit

- When a virtual circuit is requested a specific route from source to destination must be found.
- Each switch has a number of available logical circuits to other adjacent switches. Virtural circuits are multiplexed by the switch.

Virtual Circuit Table

In	Circuit No.	Out	Circuit No
A	2	C	1
B	4	C	3
A	3	D	4
B	1	D	2
B	5	C	5



Available lists:
C: 2,4 D: 1,3,5

Tradeoffs

- Header size
  - Datagram - source and destination included
  - Virtual Circuit - circuit number only needs to be included
- Router/Switch Complexity
  - Datagram - routing table is concerned with all possible destinations
  - Virtual Circuit - circuit table is small
- Preallocation of resources to ensure QoS
  - Datagram - difficult
  - Virtual Circuit - easier
- The ATM "cell tax" - 5 bytes of header per 53 byte cell is about 10%. With IP the header is about 20 bytes for a usual 1500 byte packet is between 1% and 2%. Is the 10% too much to pay for Quality of Service?