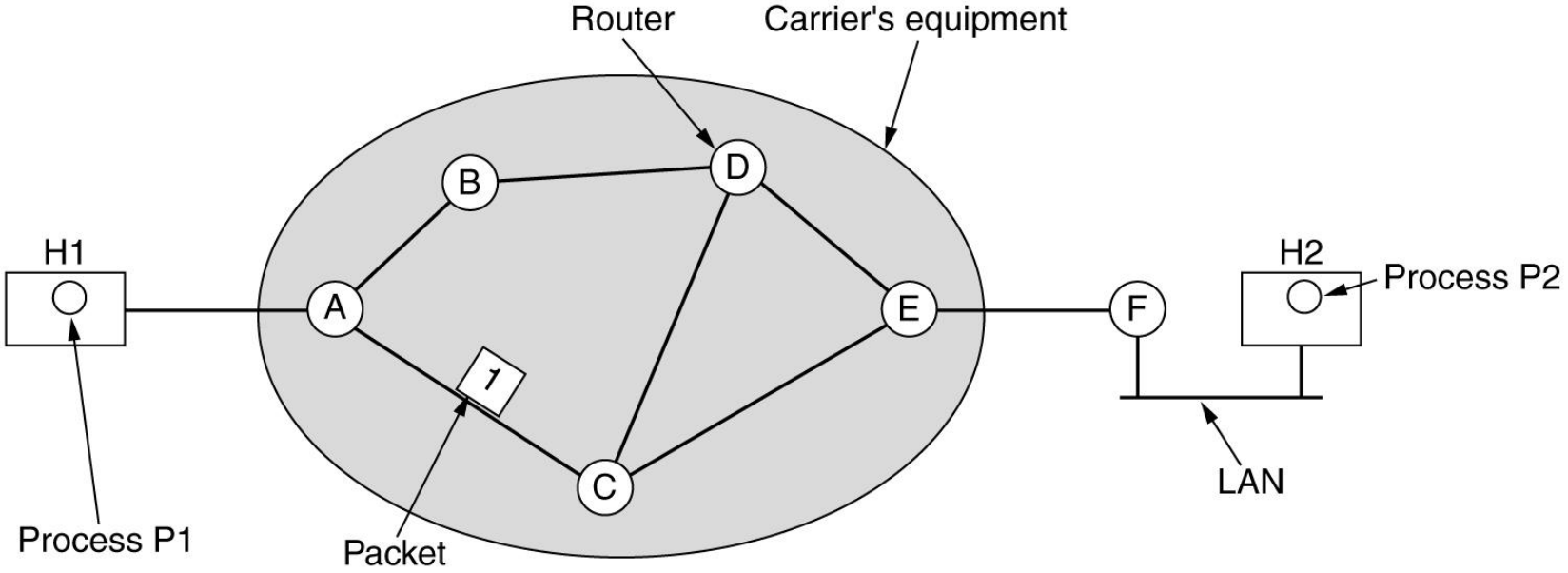
Network Layer Design Issues

- Store-and-Forward Packet Switching
- 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

The environment of the network layer protocols.



Services provided to Transport layer

The services need to be carefully designed with the following goals in mind:

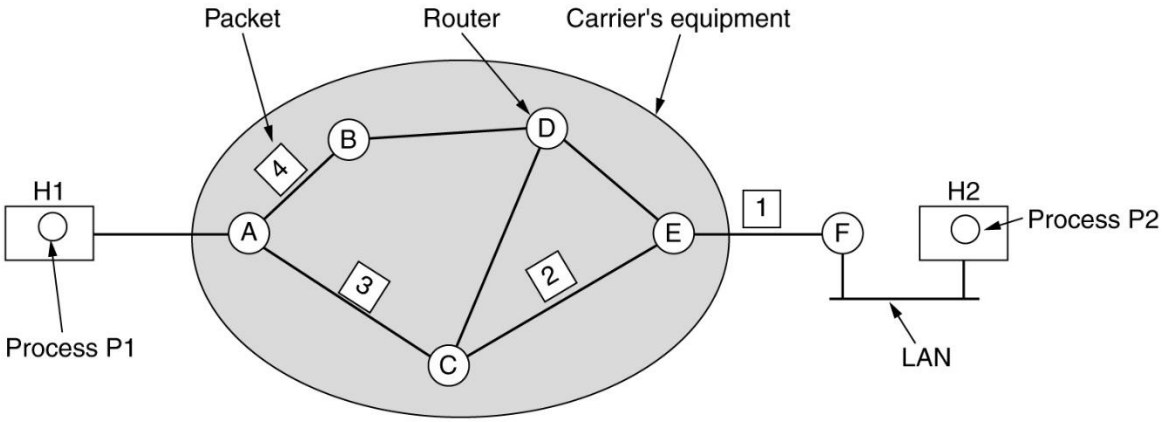
1. The services should be independent of the router technology.
2. The transport layer should be shielded from the number, type, and topology of the routers present.
3. The network addresses made available to the transport layer should use a uniform numbering plan, even across LANs and WANs.

Packet Switching

- Datagram Approach: Connectionless Service
- Virtual Circuit Approach: Connection Oriented Service

Implementation of Connectionless Service

Routing within a diagram subnet.



A's table

Dest.	Line (initially)
A	–
B	B
C	C
D	B
E	C
F	C

A's table later

Dest.	Line
A	–
B	B
C	C
D	B
E	B
F	B

C's table

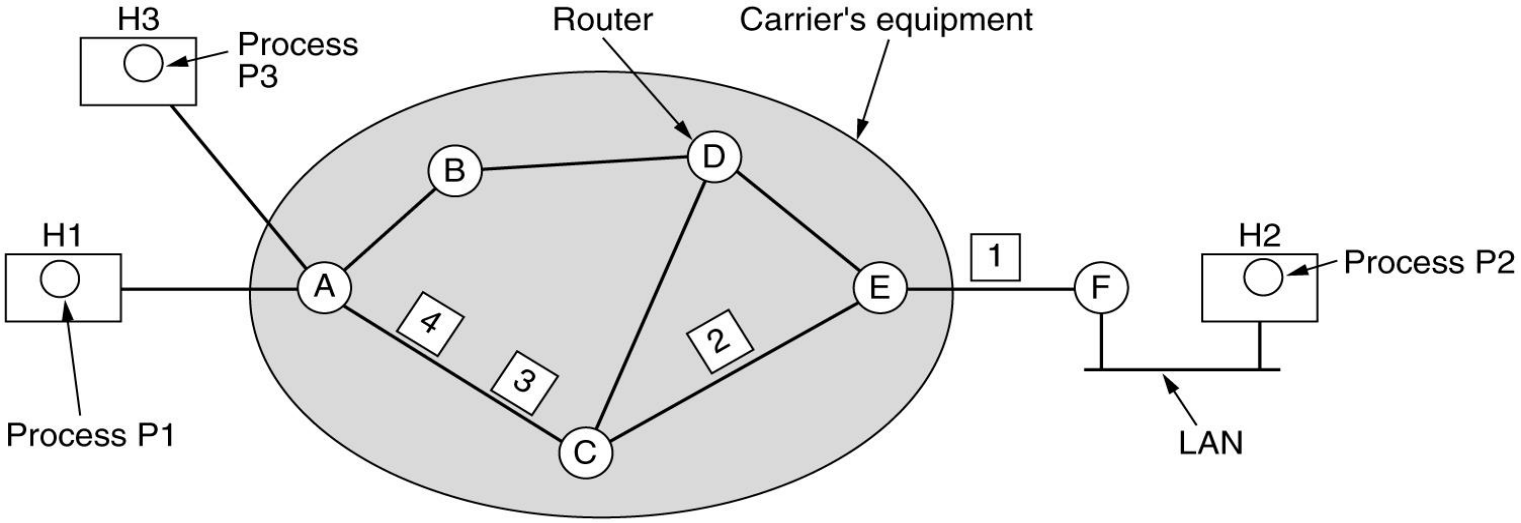
Dest.	Line
A	A
B	A
C	–
D	D
E	E
F	E

E's table

Dest.	Line
A	C
B	D
C	C
D	D
E	–
F	F

Implementation of Connection-Oriented Service

Routing within a virtual-circuit subnet.



A's table

In		Out	
H1	1	C	1
H3	1	C	2

C's table

A	1	E	1
A	2	E	2

E's table

C	1	F	1
C	2	F	2

Comparison of Virtual-Circuit and Datagram Subnets

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

Network Layer Services

- Packetizing: encapsulating the payload(data received from upper layer) at source and decapsulating at the destination.
- Routing: To find the best path from source to destination using routing protocols.
- Forwarding: Action applied by each router when packet arrives at one of its interface using routing or forwarding table.
- Routing and Forwarding are related to each other.

NETWORK-LAYER PERFORMANCE

The performance of a network can be measured in terms of:

- *Delay*
- *Throughput*
- *Packet loss*

Delay

The delays in a network can be divided into four types:

- Transmission delay
- Propagation delay
- Processing delay
- Queuing delay.

- *Transmission Delay*

  Delaytr = (Packet length) / (Transmission rate).

- *Propagation Delay*

  Delaypg = (Distance) / (Propagation speed).

- *Processing Delay*

  Delaypr = Time required to process a packet in a router or a destination host

- *Queuing Delay*

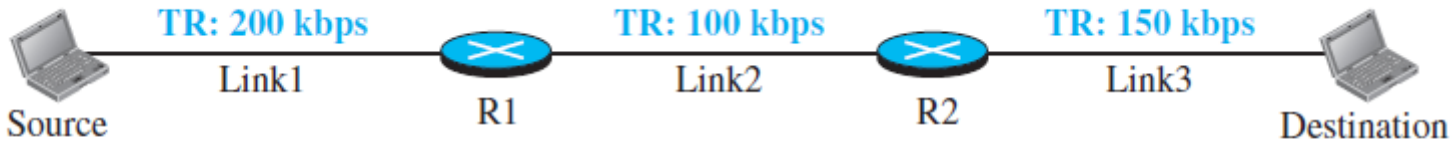
Delayqu = The time a packet waits in input and output queues in a router

- *Total Delay*

Total delay = (*n* + *1) (Delaytr* + *Delaypg* + *Delaypr)* + *(n) (Delayqu)*

Throughput

- **Throughput = minimum {TR1, TR2, . . . TRn}.**



a. A path through three links

TR: Transmission rate

Packet Loss

- When a router receives a packet while processing another packet, the received packet needs to be stored in the input buffer waiting for its turn.

- A router, however, has an input buffer with a limited size. A time may come when the buffer is full and the next packet needs to be dropped.

- The effect of packet loss on the Internet network layer is that the packet needs to be resent, which in turn may create overflow and cause more packet loss.