Introduction to Network Layer

Reference:

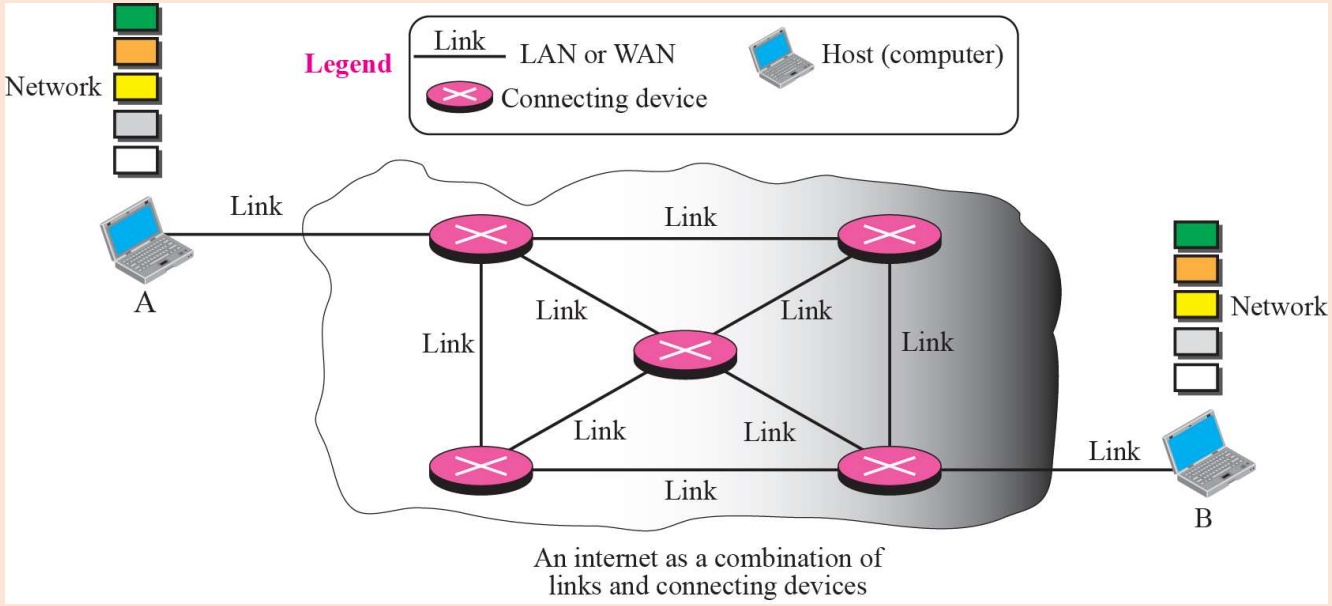
Behrouz A. Forouzan, TCP/IP Protocol Suite, 4th Edition, Tata McGraw Hill, 2010

The Internet

-Not one single network

-Made of many networks connected together through the connecting devices.

-So inter-network

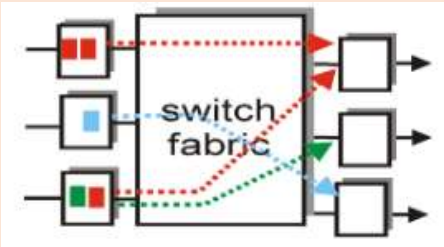


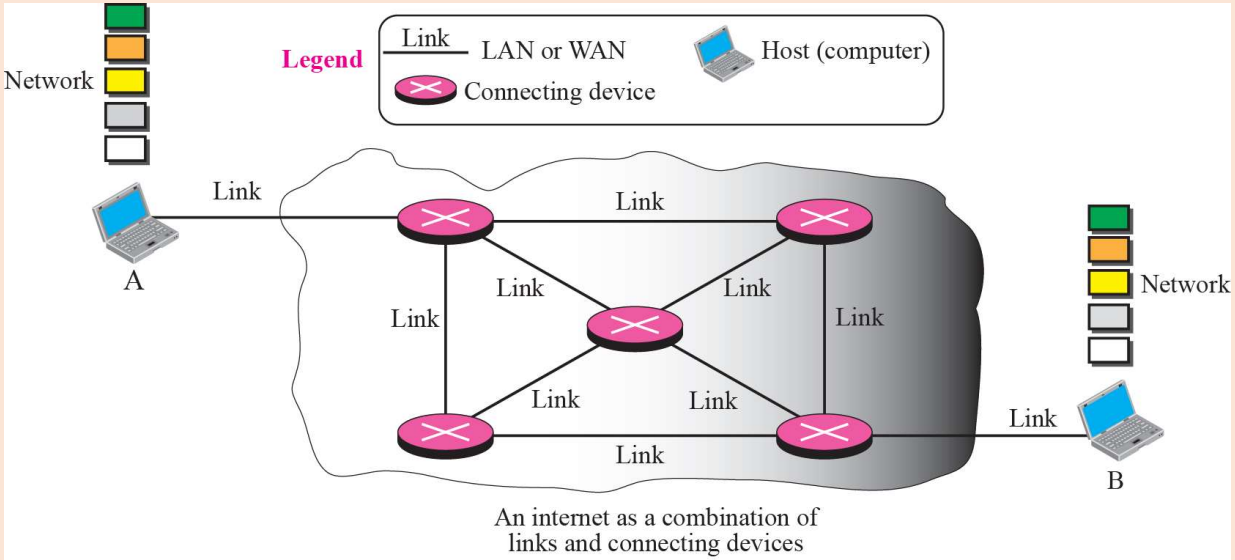
An imaginary small internet with a few networks and a few connecting devices

How data flows from A to B ? - Role of Routers. Switching Process

SWITCHING

When a message reaches a connecting device, a decision needs to be made to select one of the output ports through which the packet needs to be send out.





Connecting device acts as a switch that decides & connects one port to another port.

This process is known as - Switching

TYPES OF SWITCHING

Following are the two solutions to achieve Switching.

- ✓ Circuit Switching
- ✓ Packet Switching

Circuit Switching

A physical circuit (or channel) is established between the source and destination of the message before the delivery of the message.

-whole message is sent

-no need to divide into smaller chunks or packets

After transmission circuit (or channel) is established is removed.

Example-

A good example of a circuit-switched network is the **early telephone systems** in which the path was established between a Caller and a Callee when the telephone number of the Callee was dialed by the Caller.

Packet Switching

The network layer in the Internet today is a packet-switched network.

–The message is first divided into manageable chunks or packets at Source(upper layers) & transmitted.

- The Routers need to decide how to route the packets to the final destination.

- The packets are assembled at the destination.

Today, a packet-switched network can use two approaches-

- ✓ Datagram Approach -independent path (connectionless)
- ✓ Virtual Circuit Approach – a fixed path (Connection Oriented)

PACKET SWITCHING...

Datagram Approach

–The manageable chunks or packets are called as Datagrams

- - The packet-switched network layer of the Internet was designed as-

- Connectionless Service but tendency is towards Connection oriented

PACKET SWITCHING...

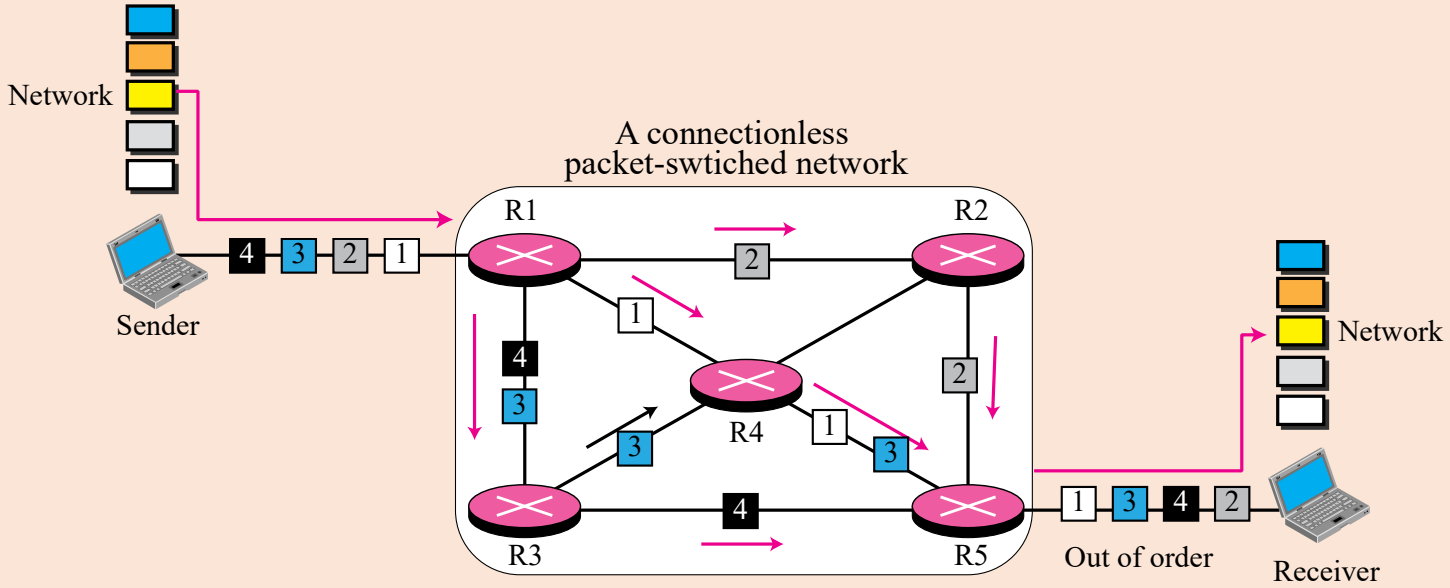
a. Connectionless Service

–The manageable chunks or packets are called as Datagrams

– The network layer protocol treats each packet independently.

– Each packet has no relationship to any other packet.

– Datagram of a message may or may not travel the same path.



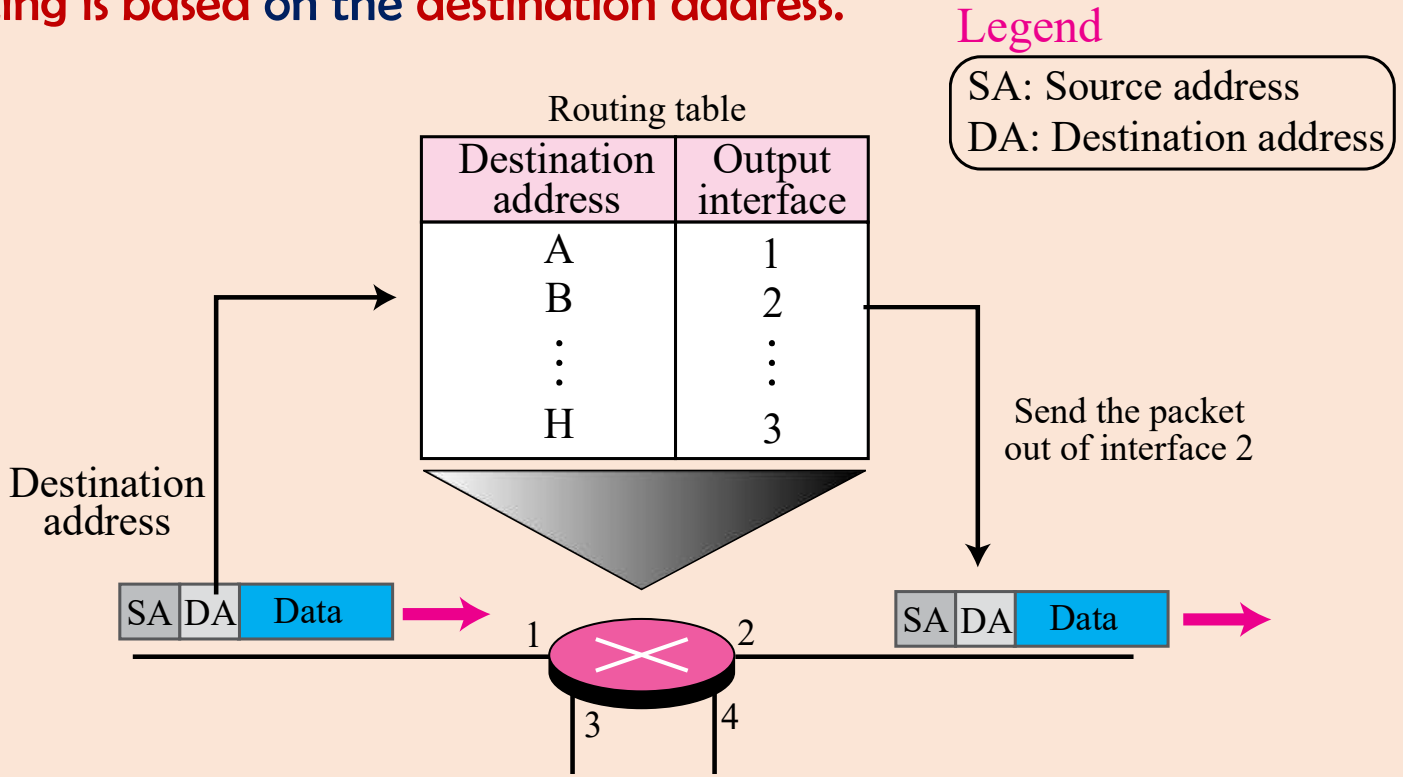
– Initially to keep design simple, Internet was decided to make Connectionless Service

PACKET SWITCHING...

Forwarding process in connectionless Service Network

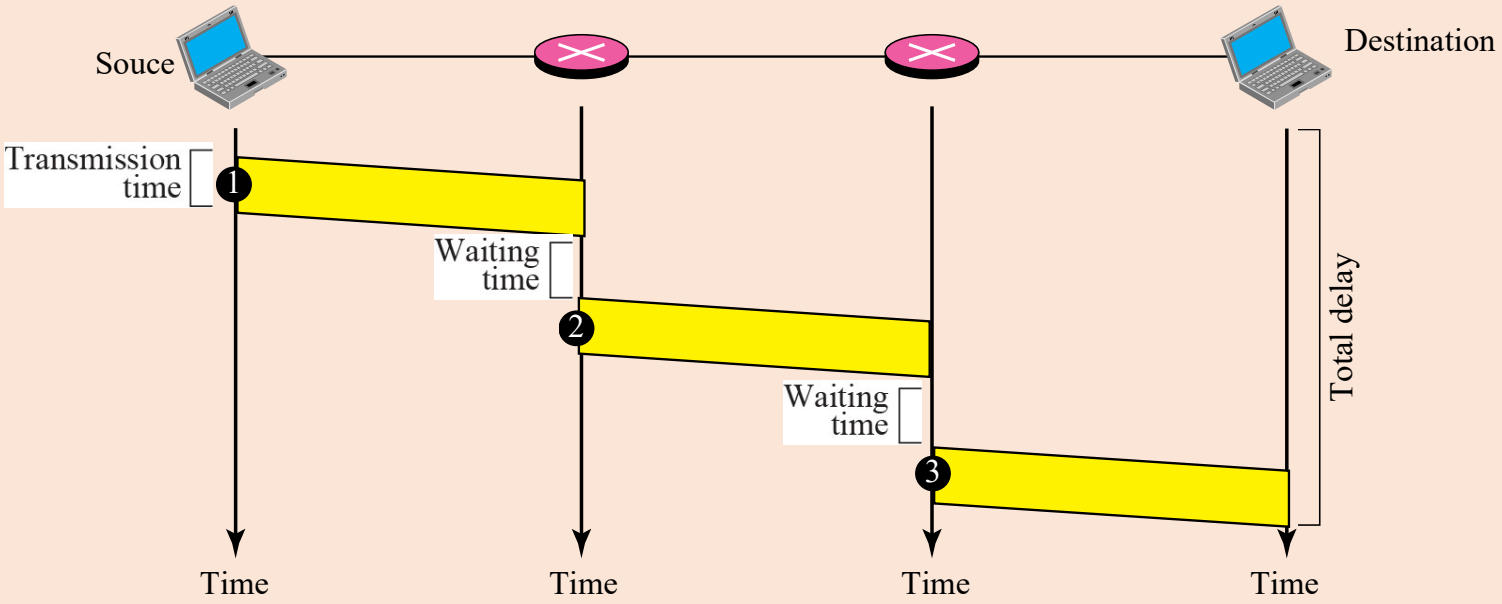
The packet contained in its header: source, destination address & other information.

Packet routing is based on the destination address.



PACKET SWITCHING...

Delay in Connection less Network



PACKET SWITCHING...

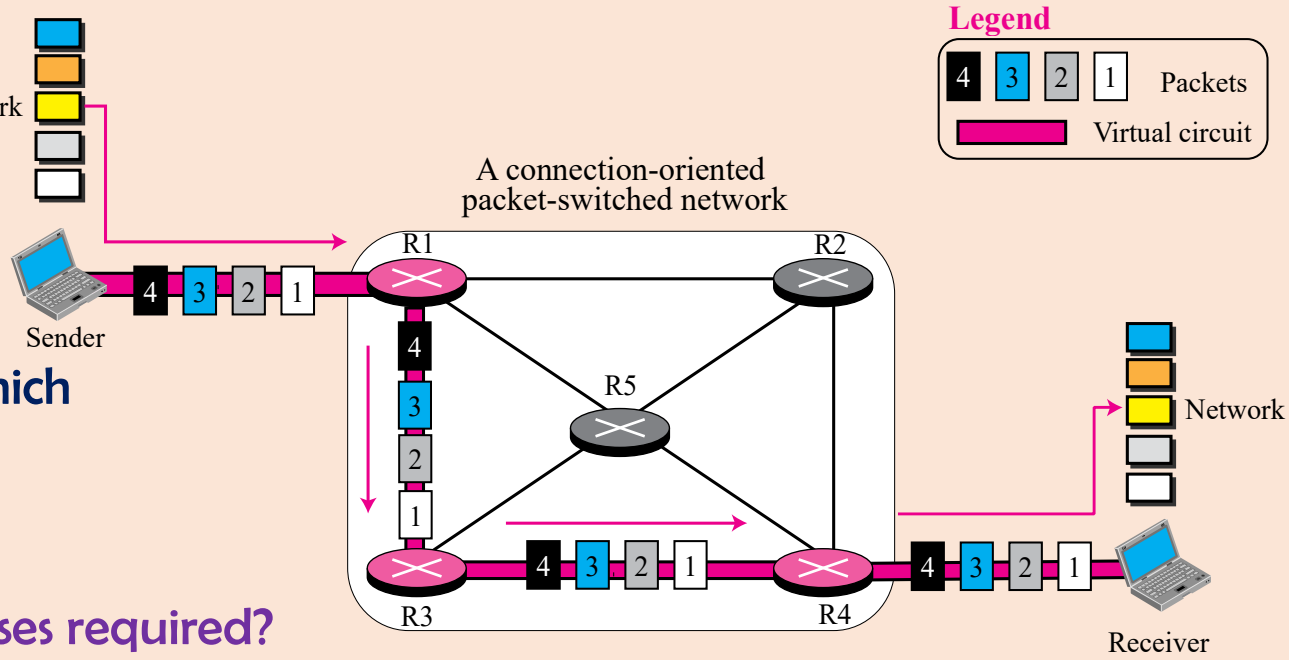
b. Connection Oriented Service

- –The manageable chunks or packets are called as Datagrams
- –There is a relation between all packets belonging to a message.
- –A virtual connection should be set up to define the path for the datagrams.

Packet contains-
Source , Destination Address also
flow label(Virtual Circuit identifier- VCI)

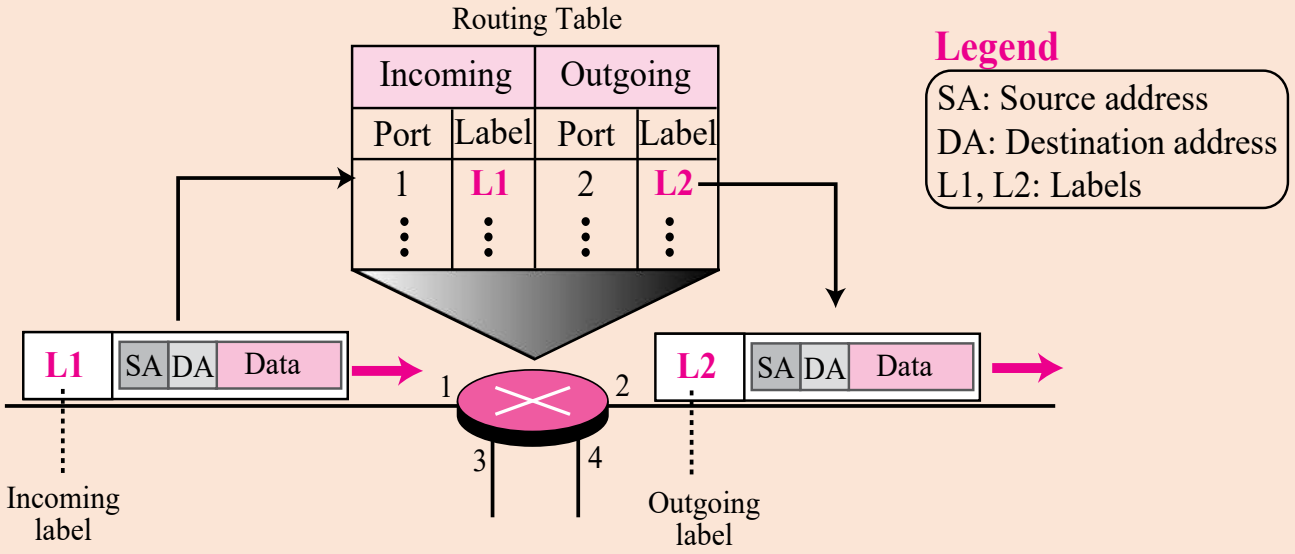
VCI determines path through which packet must pass through.

Is only VCI enough ?
Is still Source, Destination addresses required?



PACKET SWITCHING...

Forwarding process in a connection-oriented network



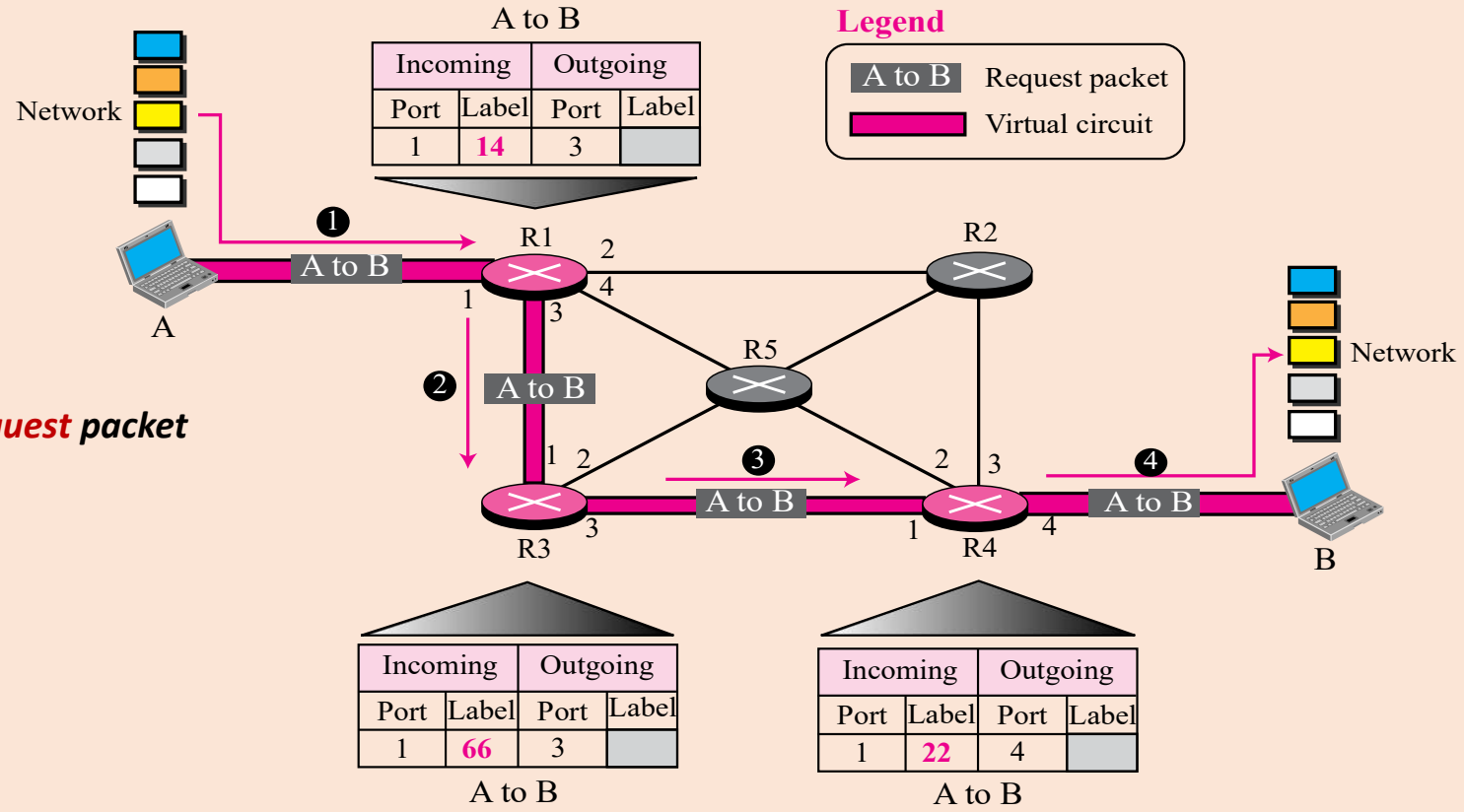
How Labels entries are made into the Routing table ?

PACKET SWITCHING...

Virtual Circuits -

A three-phase process is used: *setup*, *data transfer*, and *teardown*

Setup Phase uses two auxiliary packets named – **Request** & **Acknowledgement packets.**

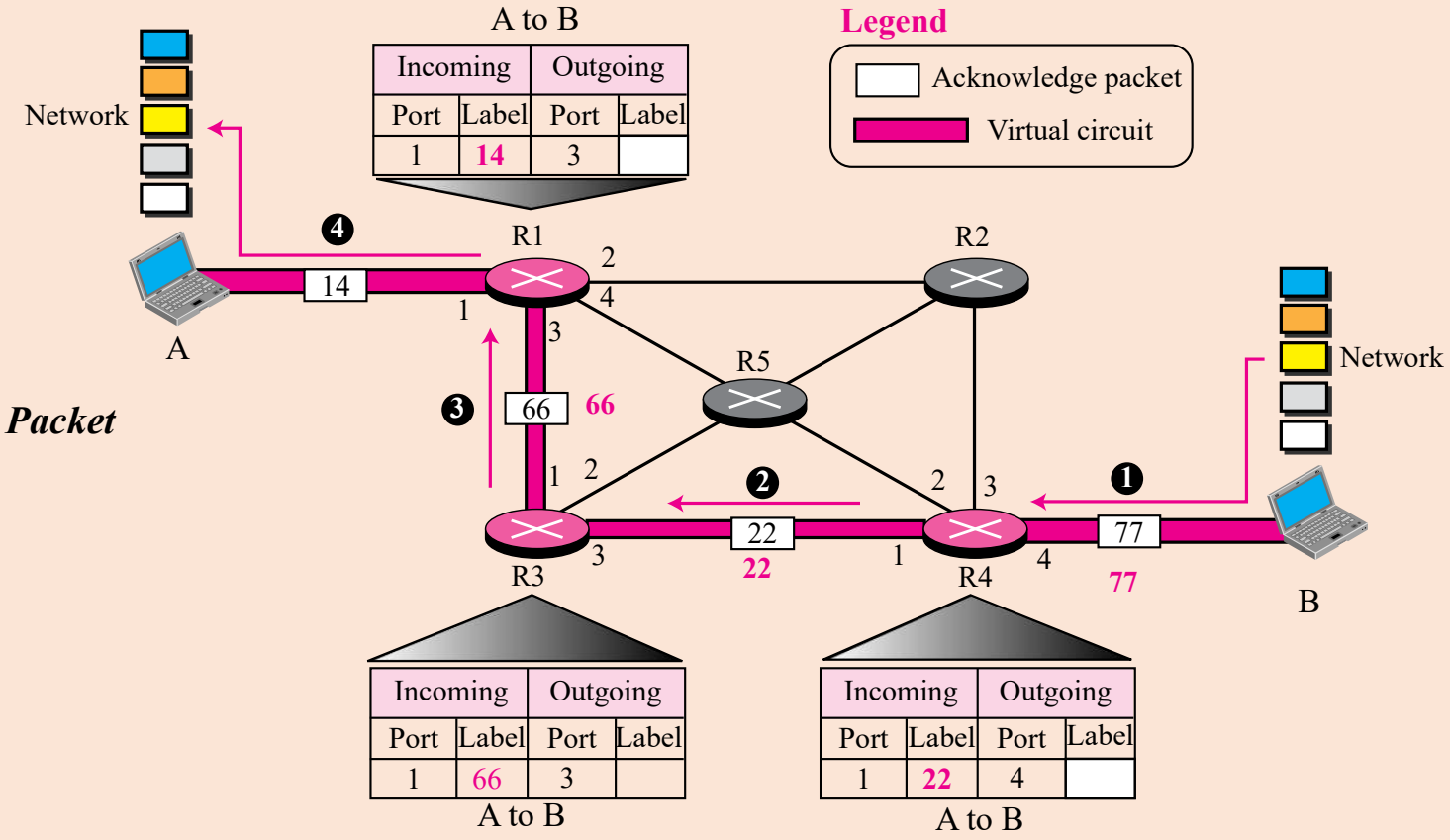


Sending Request packet

PACKET SWITCHING...

Virtual Circuits -

Setup Phase uses two auxiliary packets named – **Request** & **Acknowledgement packets.**

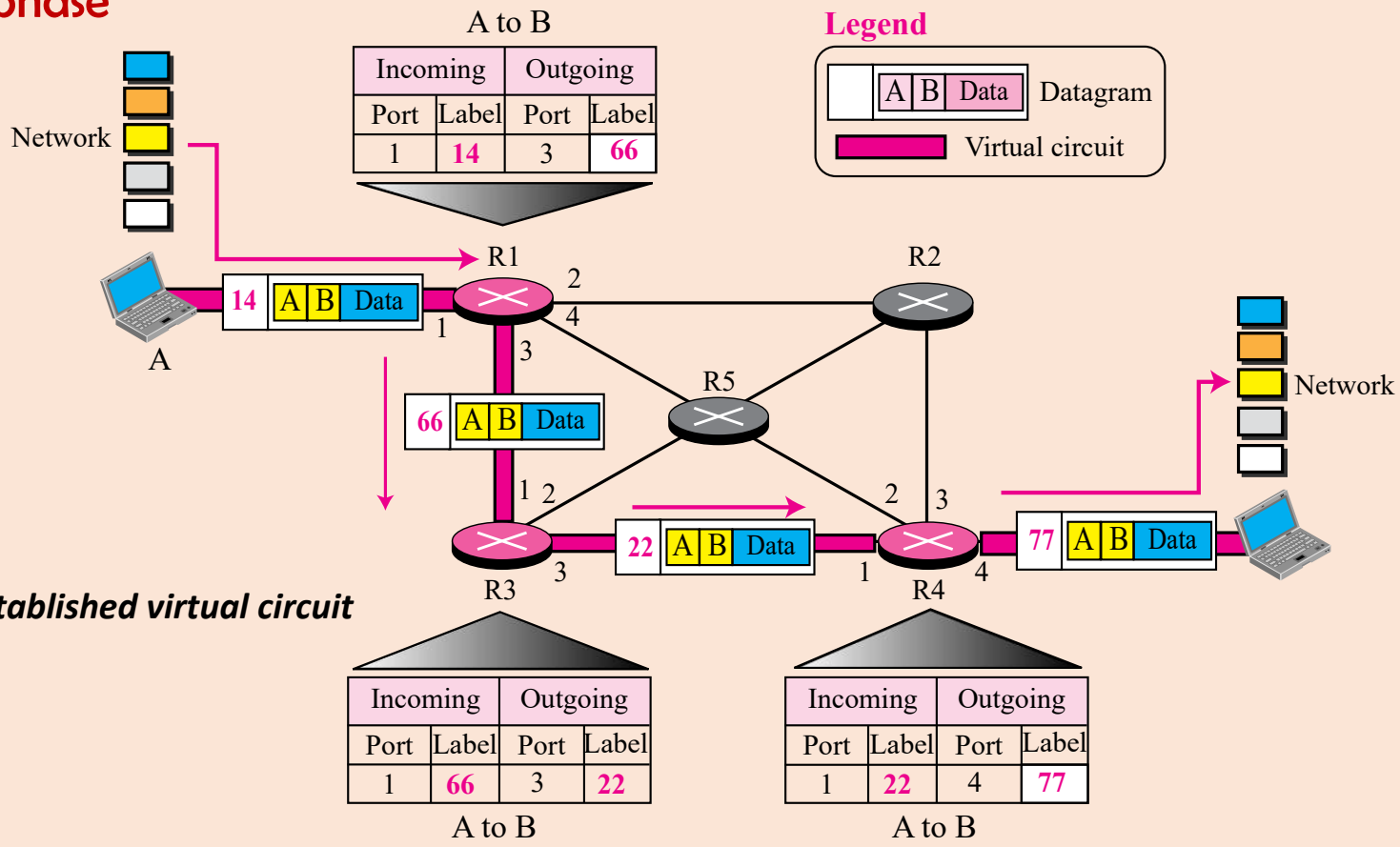


Setup Acknowledgment Packet

PACKET SWITCHING...

Virtual Circuits -

Data Transfer phase



Flow of one packet in an established virtual circuit

PACKET SWITCHING...

Virtual Circuits -

Teardown Phase

After sending all packets from A to B

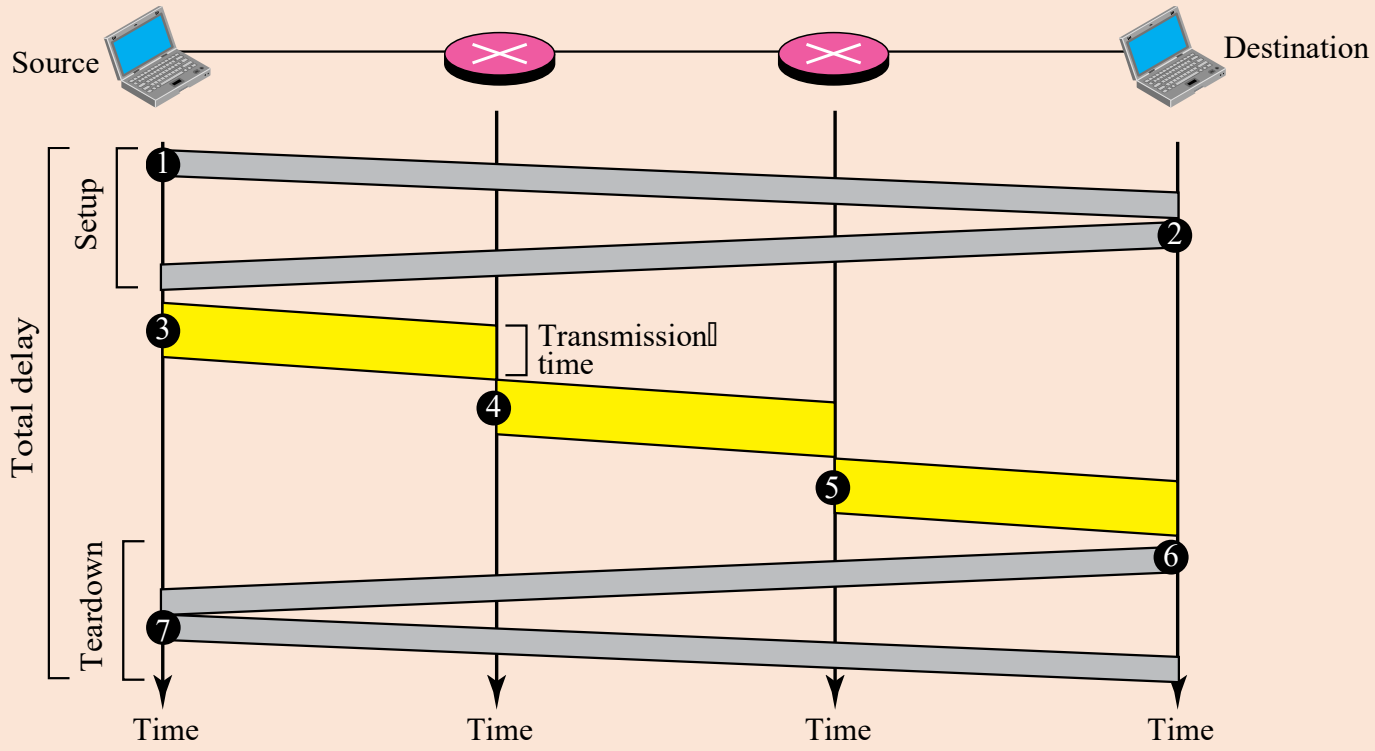
A sends a special packet called a teardown packet.

Destination B responds with a confirmation packet.

All routers delete the corresponding entry from their tables.

PACKET SWITCHING...

Delay in Connection Oriented Network



NETWORK LAYER SERVICES

What are the services provided by the network layer ?

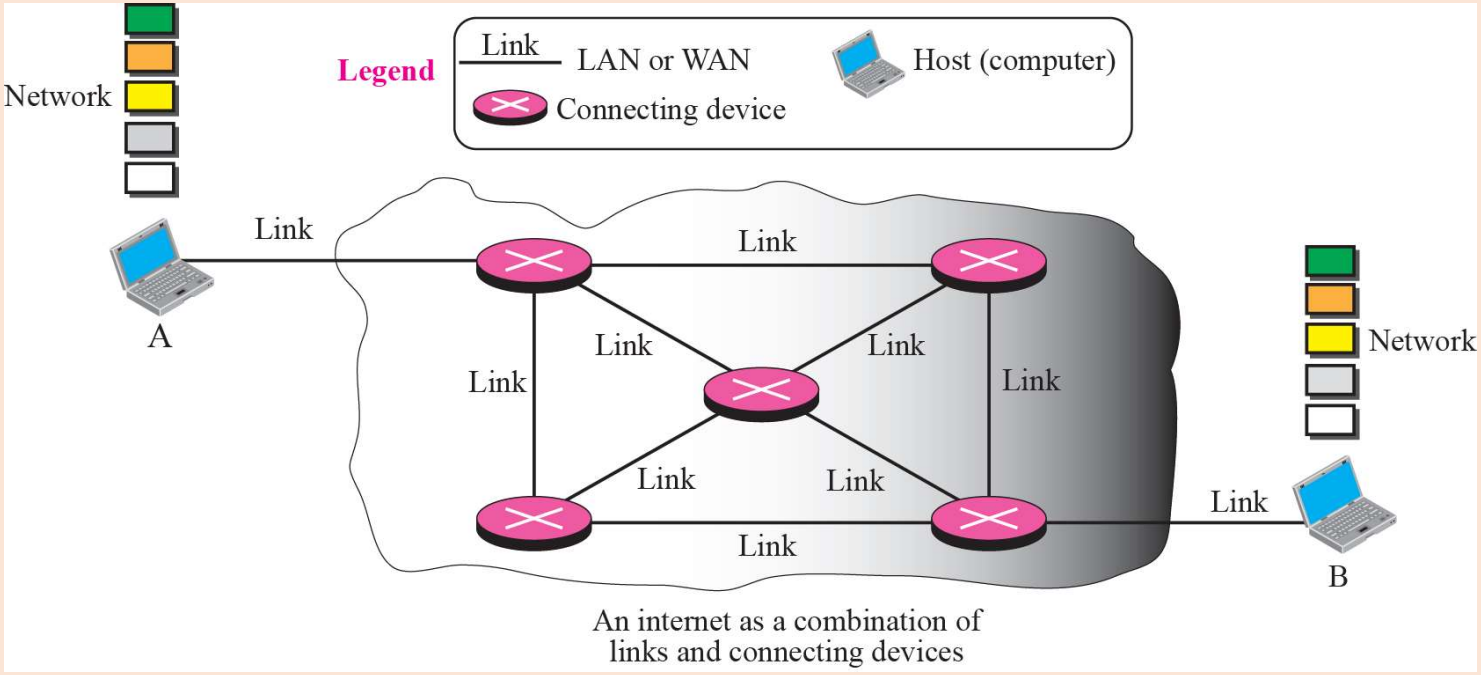
Our discussion will be based on the connectionless service, the dominant service in today's Internet.

Multiprotocol Label Switching (MPLS) is a routing technique in telecommunications networks that directs data from one node to the next based on short path labels rather than long network addresses(IP).

IPv6 is being introduced to overcome the address shortage of the current IPv4 protocol, but it also offers a new feature, i.e., the **Flow Label** field in the IPv6 packet header. However, it is used very little in practice

NETWORK LAYER SERVICES

Why Network Layer ?

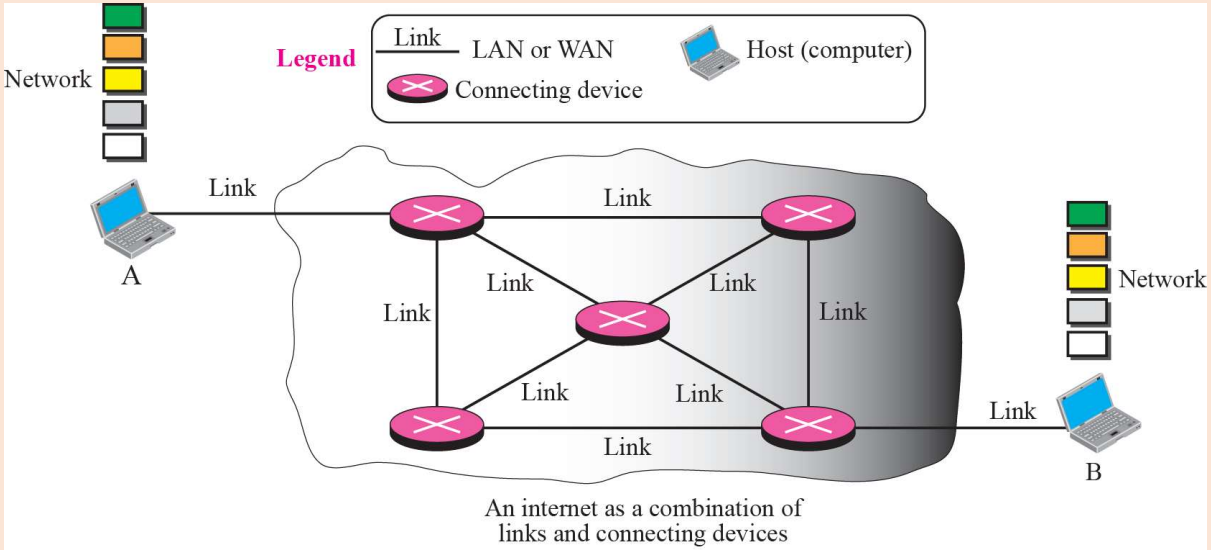


An internet as a combination of links and connecting devices

NETWORK LAYER SERVICES

Services provided.

a. Logical Addressing
b. Services Provided at the Source Computer
c. Services Provides at the Each Router
d. Services Provided at the Destination Computer



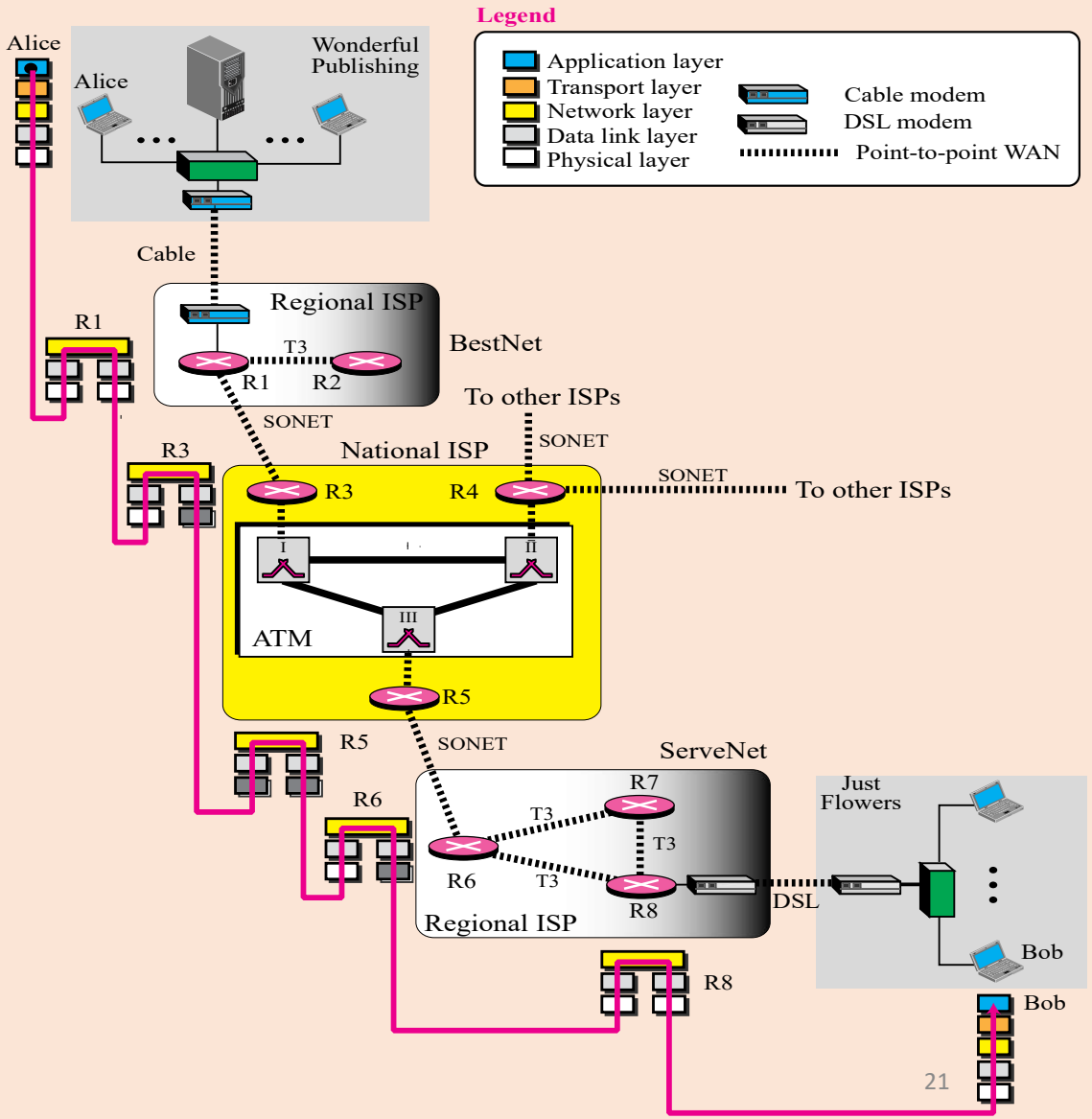
An internet as a combination of links and connecting devices

NETWORK LAYER SERVICES

Imaginary part of the Internet & TCP/IP Layers

The two computers are involved in five layers;

The routers are involved in three layers of the TCP/IP protocol suite.



NETWORK LAYER SERVICES

a. Logical Addressing

–The network layer provides end-to-end communication.

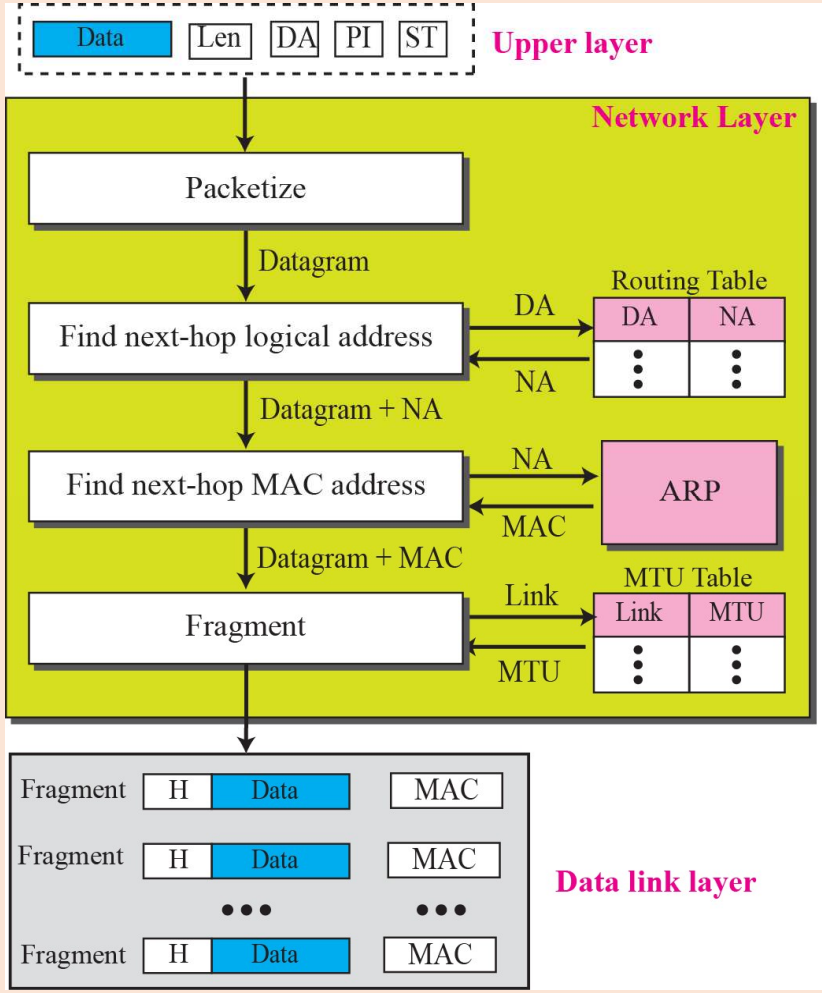
– Each system in the network needs universal identification system(Logical Address/ Network Layer Address).

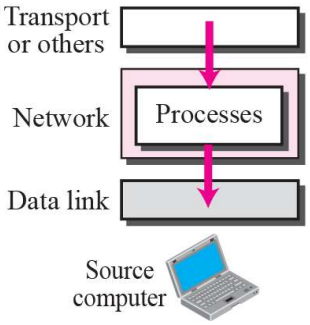
– IPv4 is the addressing scheme used(32 bit address)

– New one is IPv6 addressing scheme

NETWORK LAYER SERVICES

b. Services Provided at the Source Computer



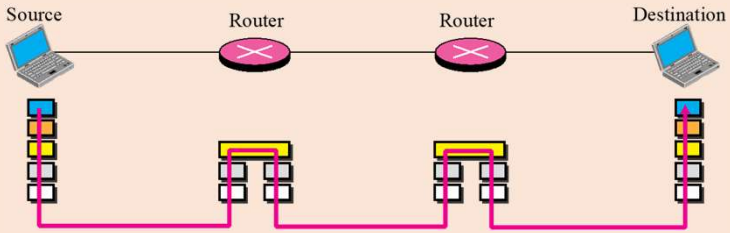


Legend

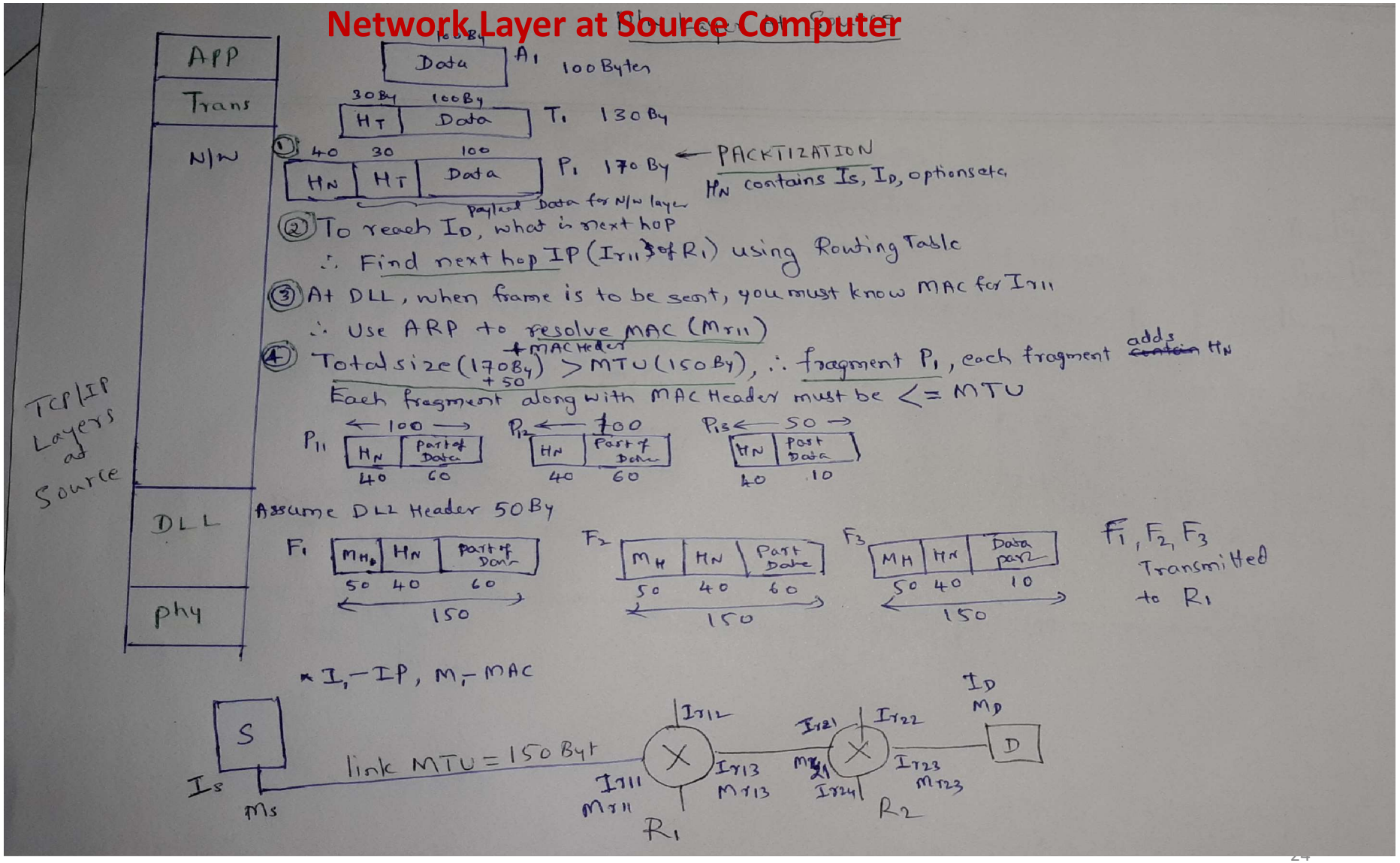
Data	Upper layer data
DA	Destination logical address
SA	Source logical address
PI	Protocol ID
ST	Service type
NA	Next-hop logical address
MAC	Next-hop MAC address
MTU	Maximum Transfer Unit
H	Datagram header
Len	Length of data

The network layer at the source computer provides 4 services:

- ✓ Packetizing
- ✓ Finding the logical address of the next hop
- ✓ Finding the physical (MAC) address of the next hop
- ✓ Fragmenting, the datagram if necessary.

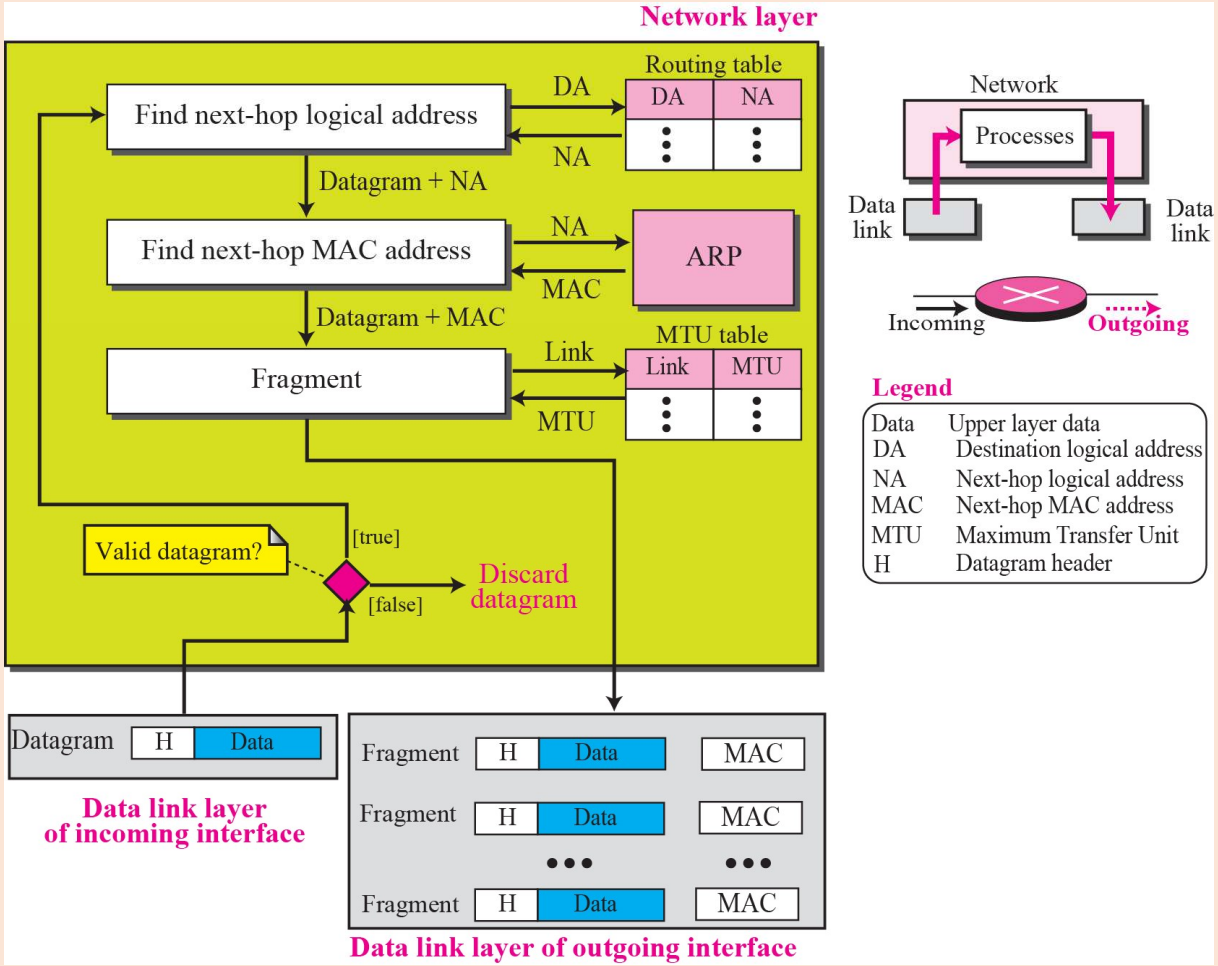


Network Layer at Source Computer



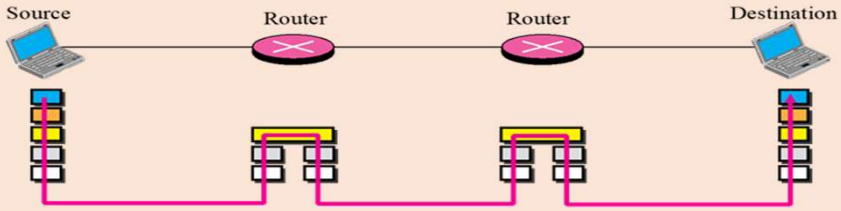
NETWORK LAYER SERVICES

c. Services Provides at the Each Router



Legend

Data	Upper layer data
DA	Destination logical address
NA	Next-hop logical address
MAC	Next-hop MAC address
MTU	Maximum Transfer Unit
H	Datagram header



Validates incoming Datagram.

The network layer at the Router provides 3 services:

- ✓ Finding the logical address of the next hop
- ✓ Finding the physical (MAC) address of the next hop
- ✓ Fragmenting, the datagram if necessary.

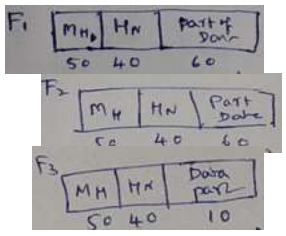
Recalculates Network Packet header checksum & adds to the header

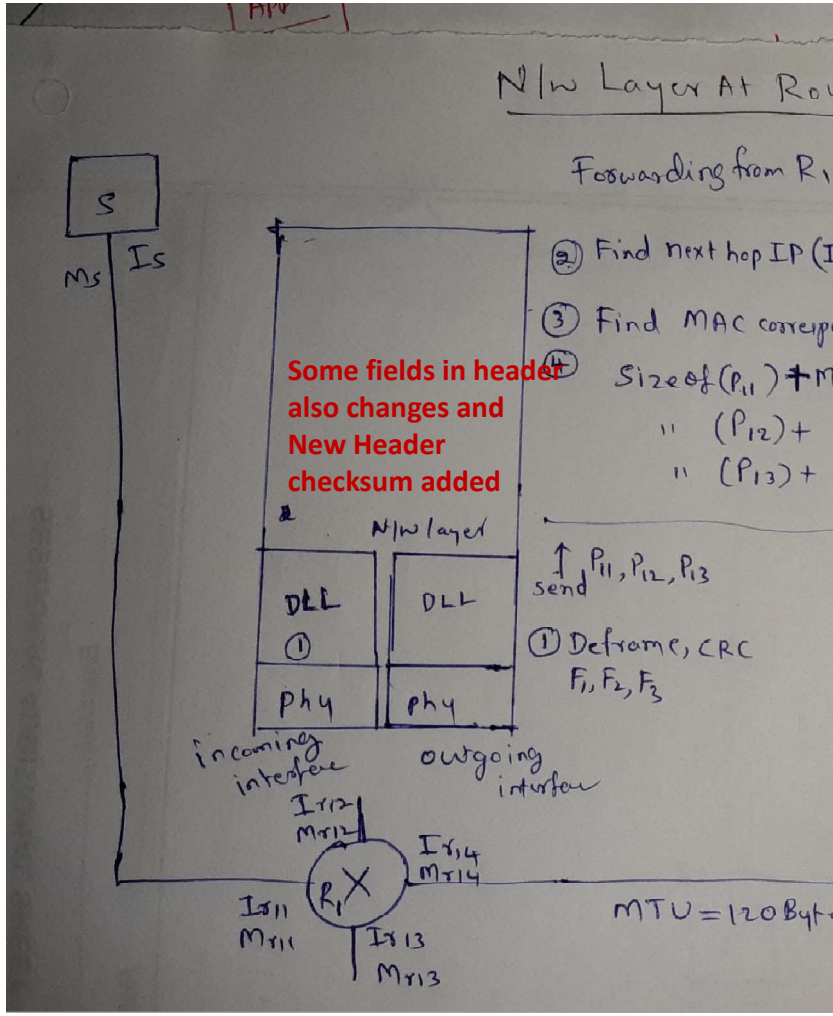
Router, therefore, needs to interact with two data link layers(DLL)

DLL of incoming interface

DLL of outgoing interface

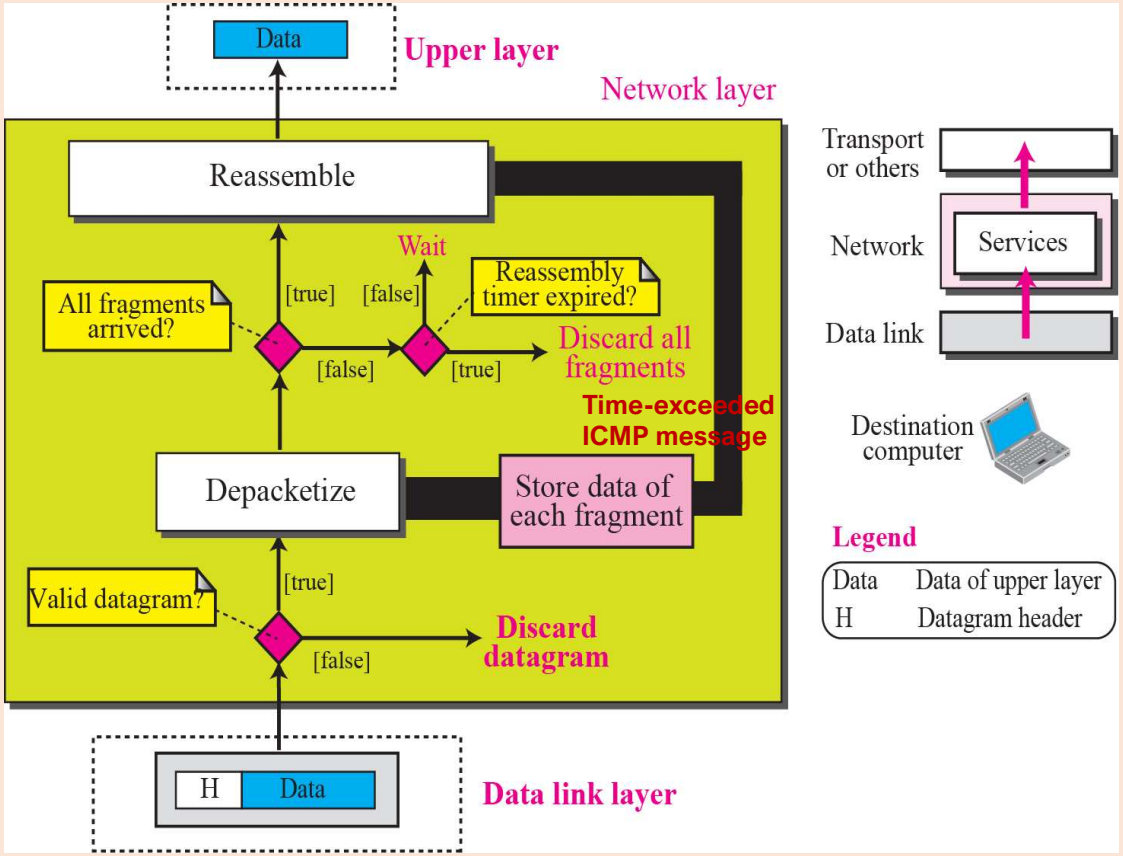
Network Layer at Router





NETWORK LAYER SERVICES

d. Services Provided at the Destination Computer



Validates incoming Datagram.

Depacketize.

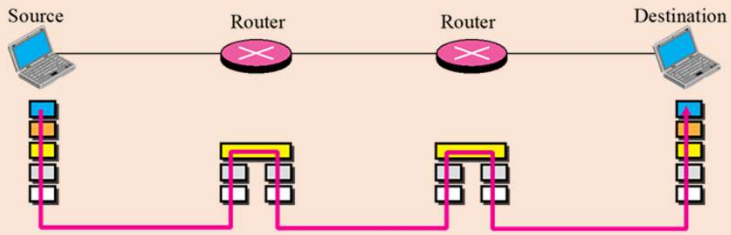
Store received fragment(**reassembly Timer** started)

If All Fragments not arrive before **timer expiry** then

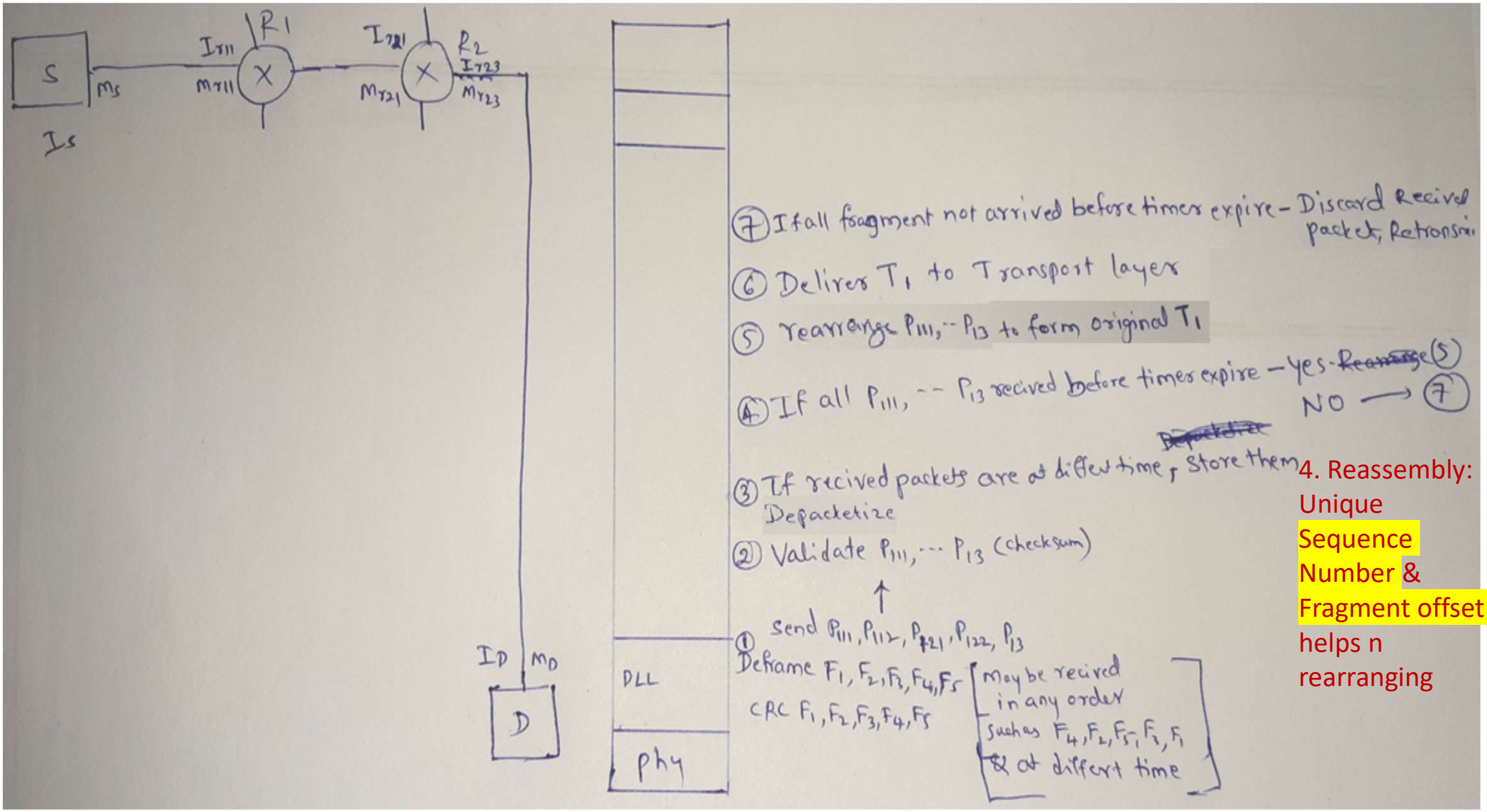
Destroy received fragment.

Else

Reassemble fragments in Order



Network Layer at Destination Computer



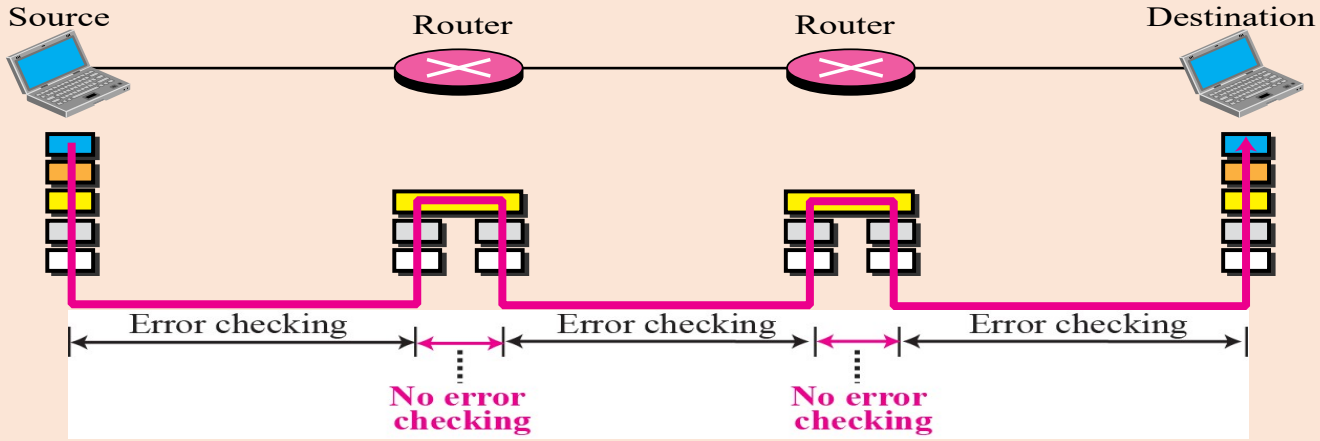
4. Reassembly: Unique Sequence Number & Fragment offset helps n rearranging

NETWORK LAYER SERVICES

OTHER SERVICES

–Error control : A mechanism for detecting corrupted, lost, or duplicate Datagrams.

Since a hop-to-hop error control (CRC)is already implemented at the data link layer, why do we need error control at the network layer?



The data link layer can miss any error that occurs when the datagram is being processed by the router. To keep Network layer processing fast, Network Layer do not implement rigorous error checking. However, N/W layer header checksum is used – to prevent packet being delivered to wrong destination The network layer at the Internet does not directly provide error control, the Internet uses another protocol- ICMP(Internet Message Control Protocol) to report error situation to Sender

Flow control

Regulates the amount of data a source can send without overwhelming the receiver.

–The network layer in the Internet, however, does not directly provide any flow control.

The datagrams are sent by the sender when they are ready without any attention to the readiness of the receiver.

– Flow control responsibility is given to the upper layer protocols (Transport layer) which use N/W layer protocol.

Congestion control

Congestion in the network layer is a situation in which too many datagrams are present in an area of the Internet.

–Congestion in a connectionless network can also be implemented using a choke Packet.

The network layer uses an auxiliary protocol, ICMP to inform Sender to slow down .

– Another way is to rank packets based on importance.

- In a connection-oriented network
  - One method simply creates an extra virtual circuit.
  - A better solution is advanced negotiation during the setup phase.

NETWORK LAYER SERVICES

Other services are – Routing , QoS (upper layer) and Security

END

NETWORK LAYER SERVICES

a. Logical Addressing

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