Introduction to Network Layer

Lecture Outline

1 Introduction

2 Switching

3 Packet Switching

4 Network Layer Services

5 Other Network Layer Issues

1 INTRODUCTION

At the conceptual level, we can think of the global Internet as a black box network that connects millions (if not billions) of computers in the world together. At this level, we are only concerned that a message from the application layer in one computer reaches the application layer in another computer.
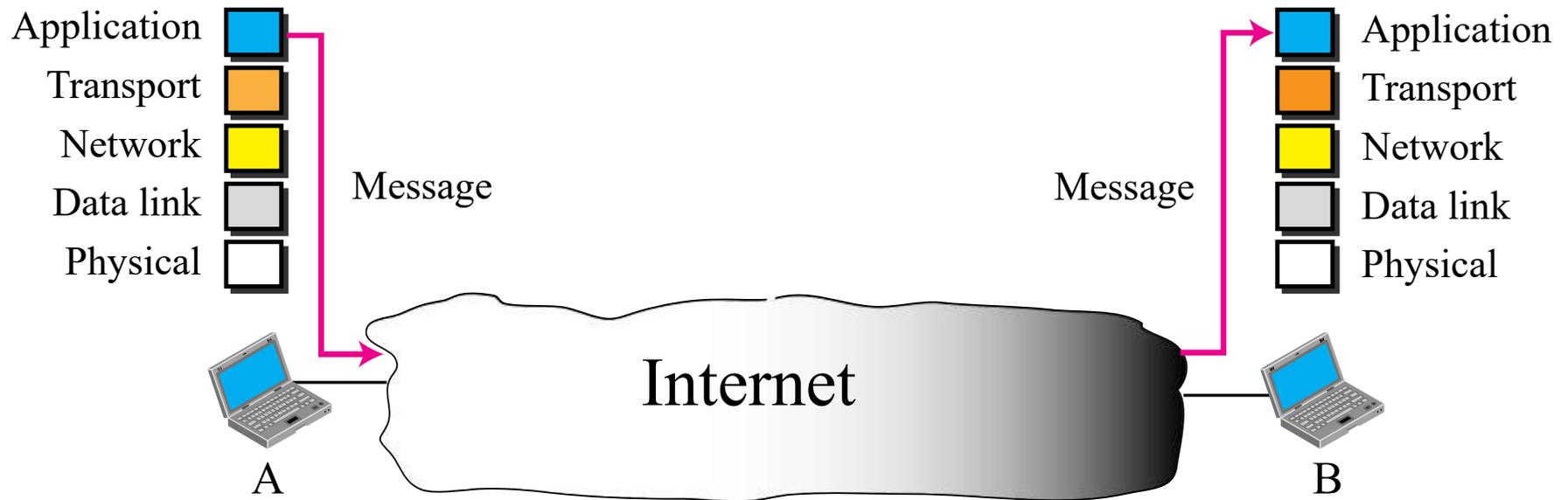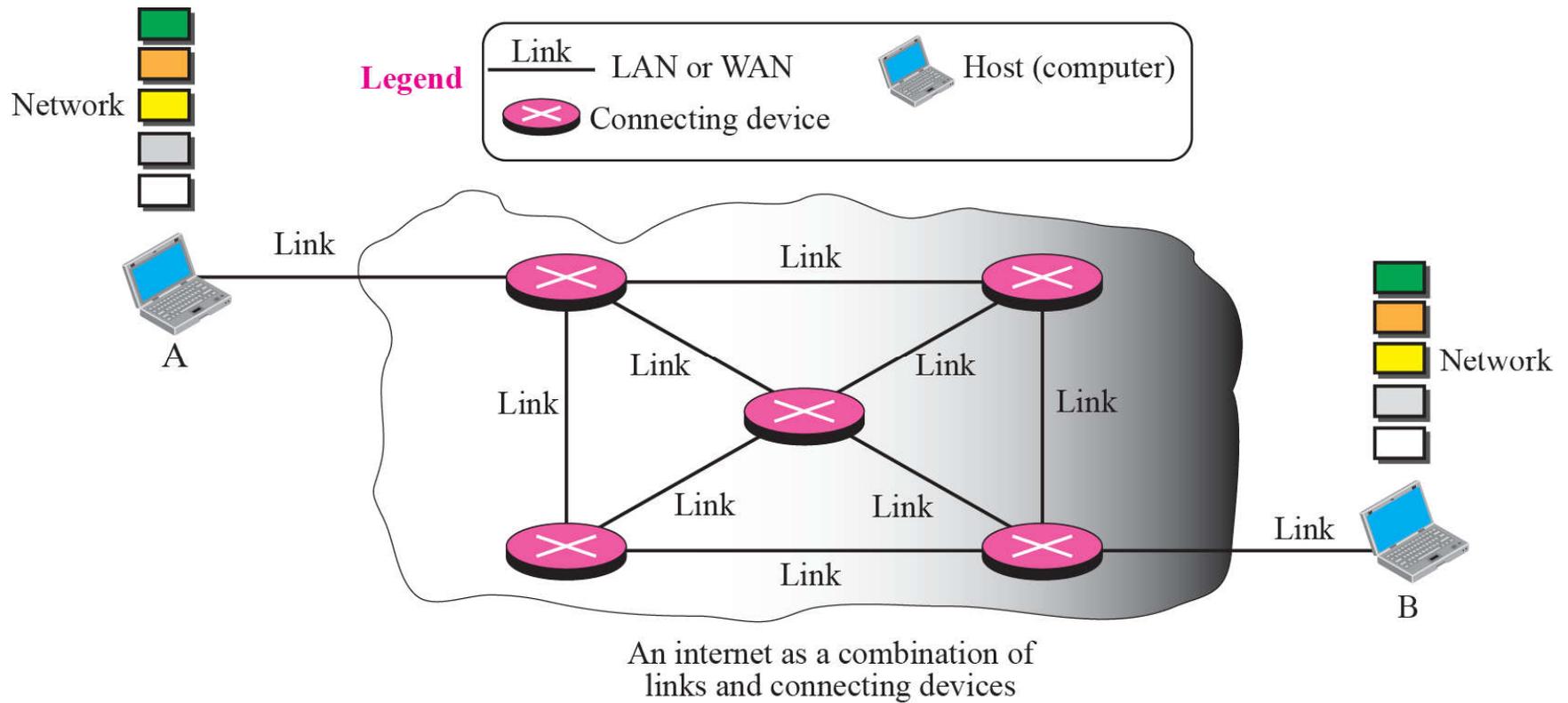
# Figure 1   Internet as a block box

Application   Transport   Network   Data link   Physical

Message

Message

Application   Transport   Network   Data link   Physical

Internet

A

B

An internet as a combination of
links and connecting devices

2 SWITCHING

•It is clear that the passage of a message from a source to a destination involves many decisions.

•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.

•In other words, the connecting device acts as a switch that connects one port to another port.
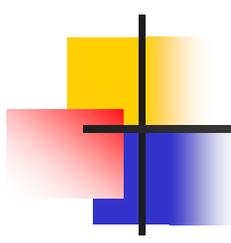
Note

In circuit switching, the whole message is sent from the source to the destination without being divided into packets.

Example1

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. When the callee responded to the call, the circuit was established. The voice message could now flow between the two parties, in both directions, while all of the connecting devices maintained the circuit. When the caller or callee hung up, the circuit was disconnected.
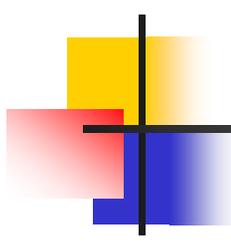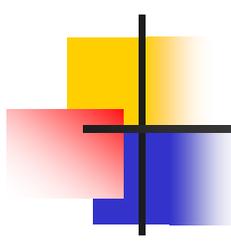
Note

In packet switching, the message is first divided into manageable packets at the source before being transmitted.
The packets are assembled at the destination.

3 PACKET SWITHING

- The network layer is designed as a packet-switched network.
- This means that the packet at the source is divided into manageable packets, normally called datagrams.
- *Individual datagrams* are then transferred from the source to the destination.
- The received datagrams are assembled at the destination before recreating the original message.
- *The packet-switched network layer* of the Internet was originally *designed as a connectionless service,*
- Recently there is a tendency to change this to a connection-oriented service.

Note

In a connectionless packet-switched network, the forwarding decision is based on the destination address of the packet.

Figure 3 *A connectionless packet-switched network*

Network

A connectionless
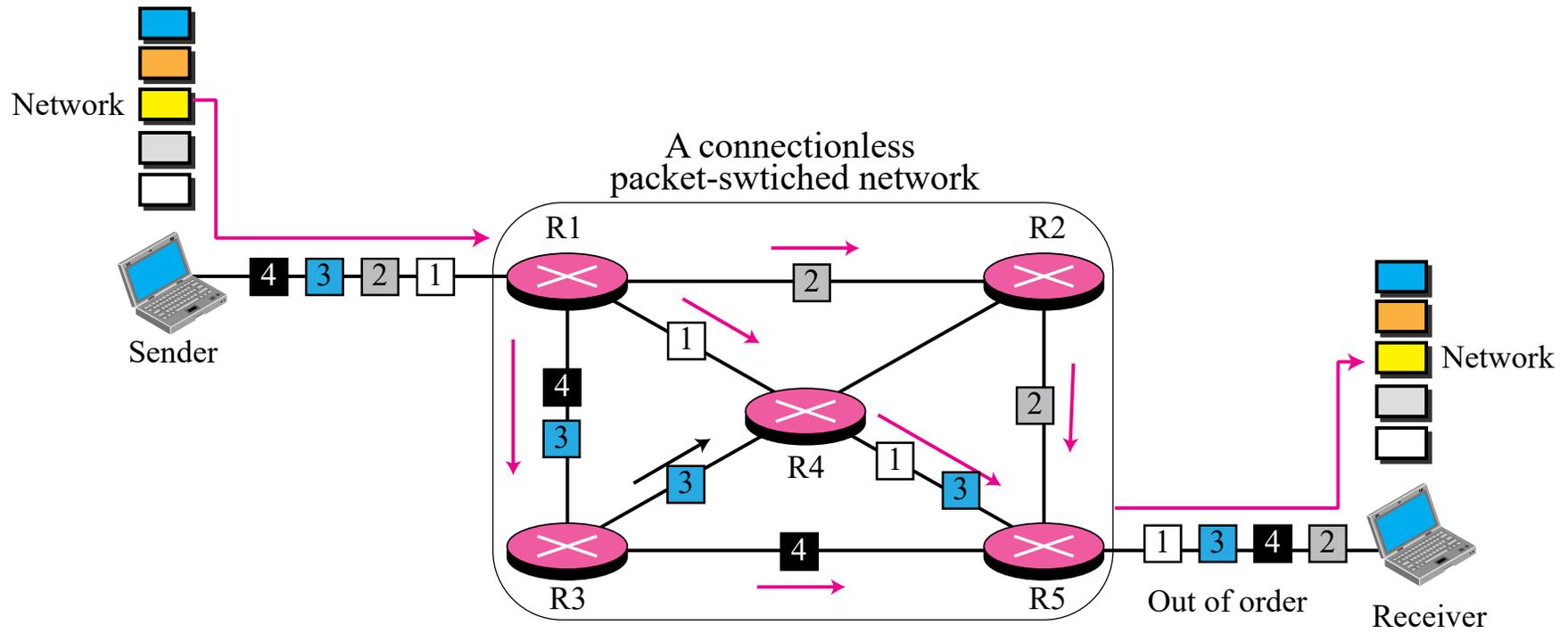packet-swtiched network

Sender

R1 R2 R3 R4 R5

Out of order

Network

Receiver

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Figure 4   Forwarding process in a connectionless network

Routing table

Destination address	Output interface
A	1
B	2
⋮	⋮
H	3

Legend
SA: Source address
DA: Destination address

Destination address

SA	DA	Data

1   2
3   4

Send the packet out of interface 2
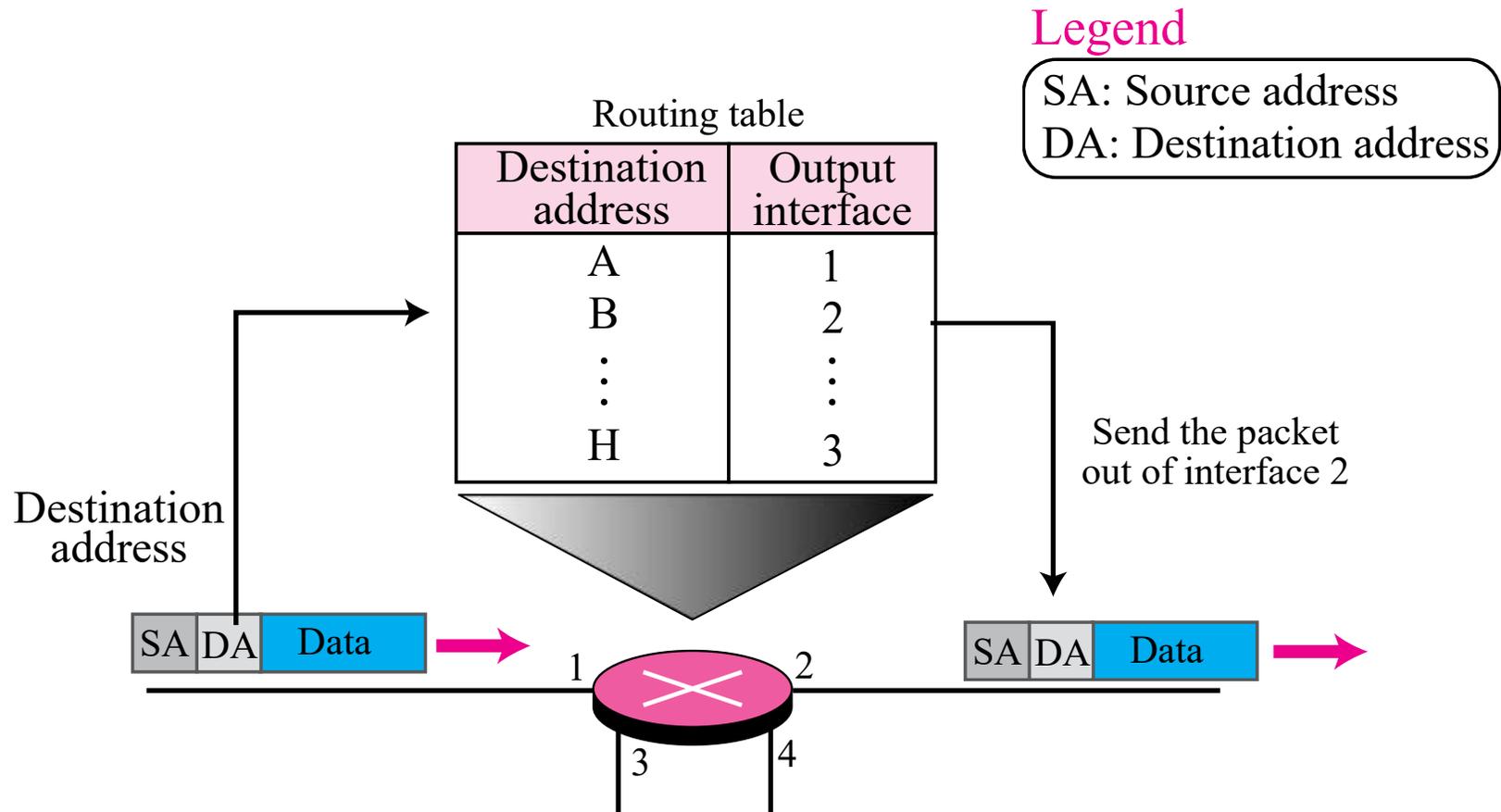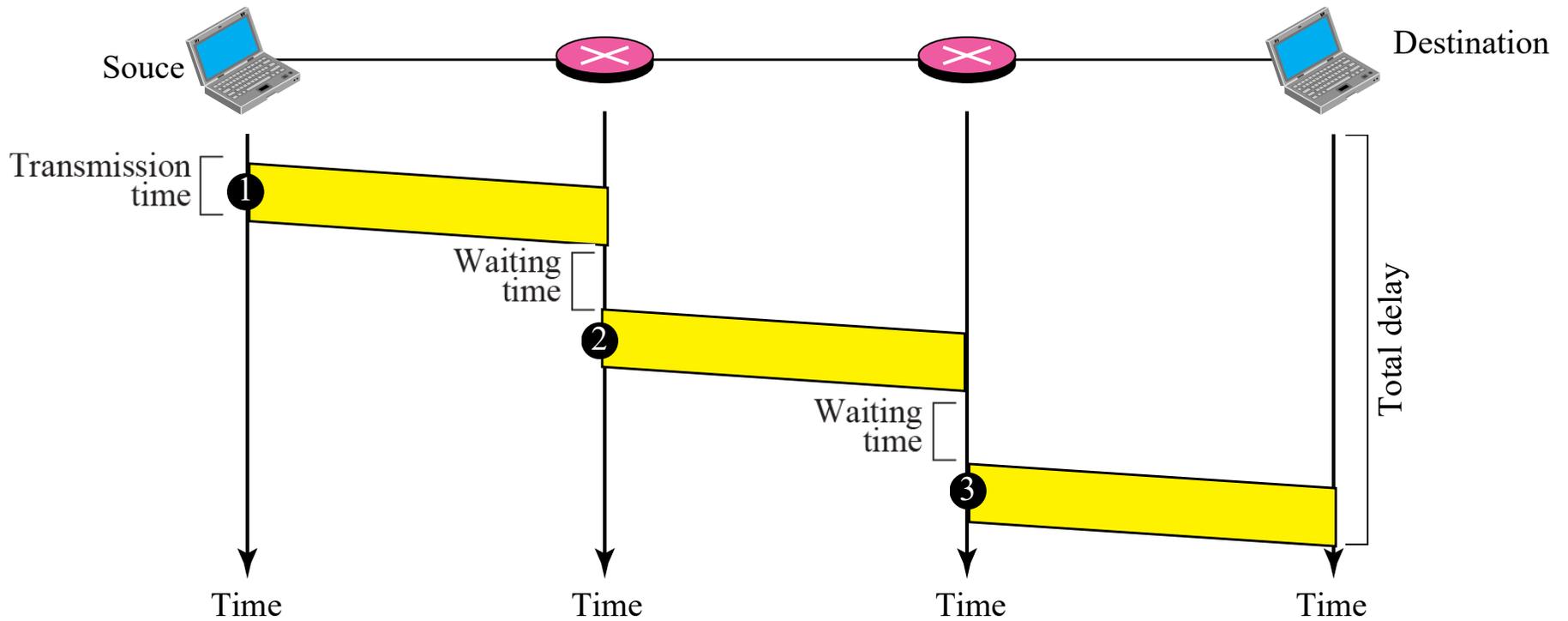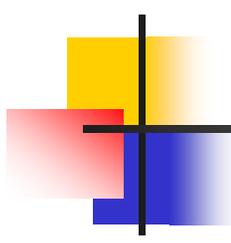
SA	DA	Data

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Figure 5 *Delay in a connectionless network*

Note

> *In a connection-oriented packet switched network, the forwarding decision is based on the label of the packet.*

Figure 6 *A connection-oriented packet switched network*
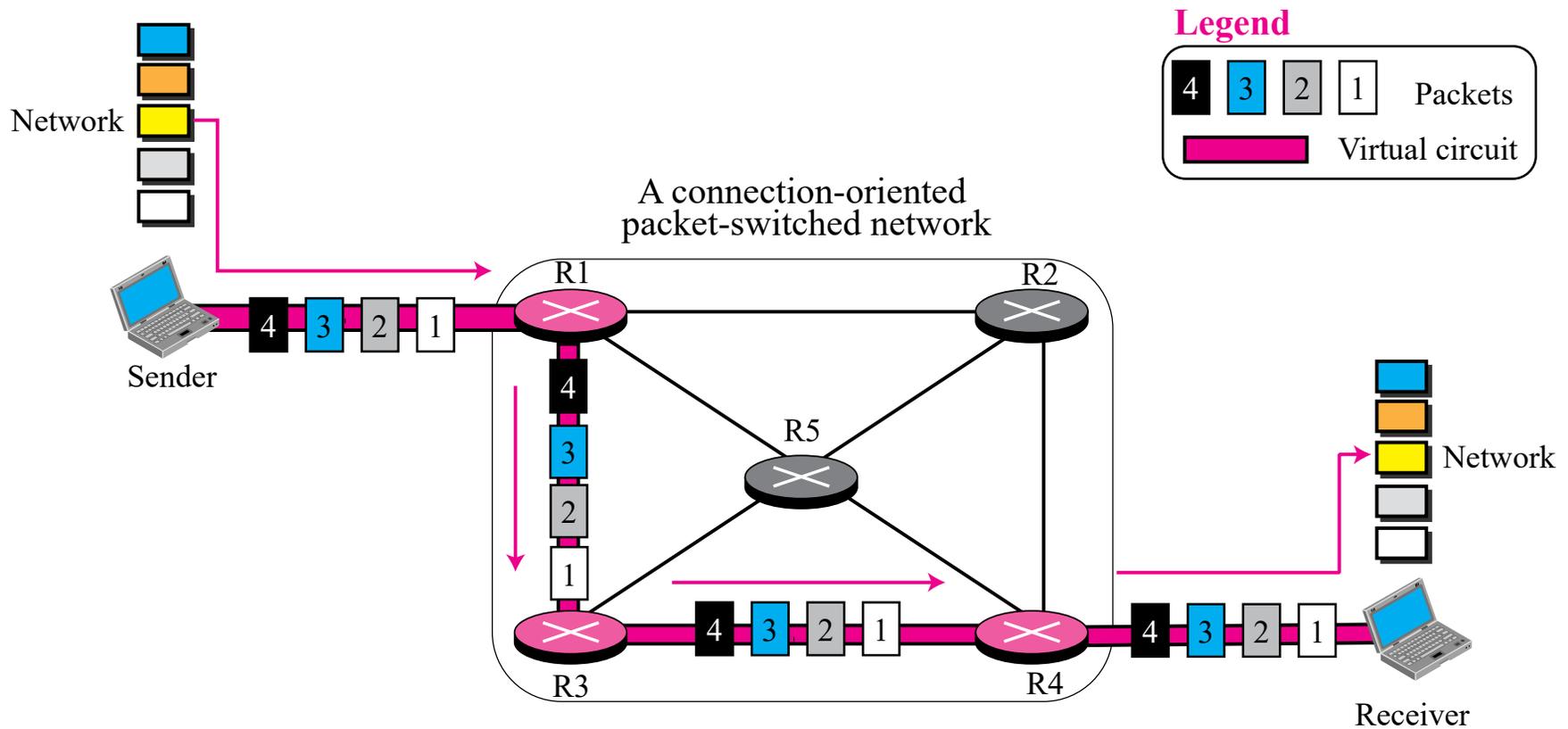
Figure 7 *Forwarding process in a connection-oriented network*

Routing Table

Incoming		Outgoing	
Port	Label	Port	Label
1	**L1**	2	**L2**
⋮	⋮	⋮	⋮

Legend
SA: Source address
DA: Destination address
L1, L2: Labels

Incoming
label

Outgoing
label

Figure 8 *Sending request packet in a virtual-circuit network*

A to B

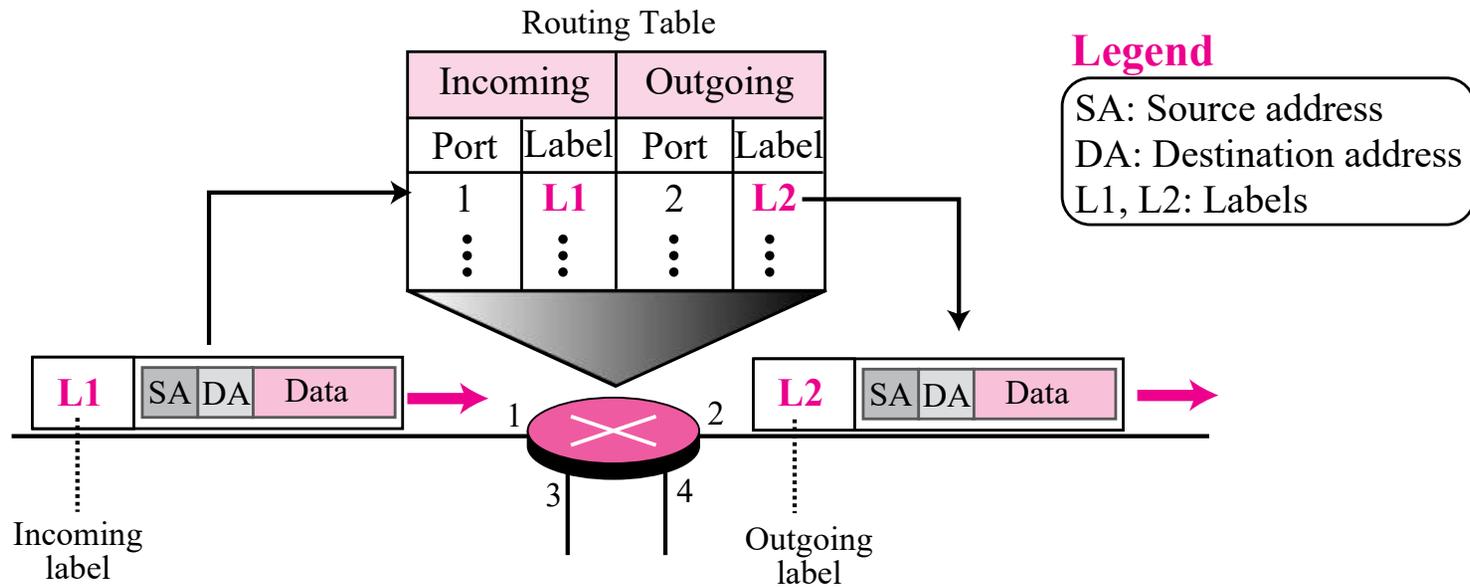| Incoming		Outgoing	
Port	Label	Port	Label
1	**14**	3	

Legend

A to B	Request packet
▬▬▬▬	Virtual circuit

A to B

Incoming		Outgoing	
Port	Label	Port	Label
1	**66**	3	

A to B

A to B

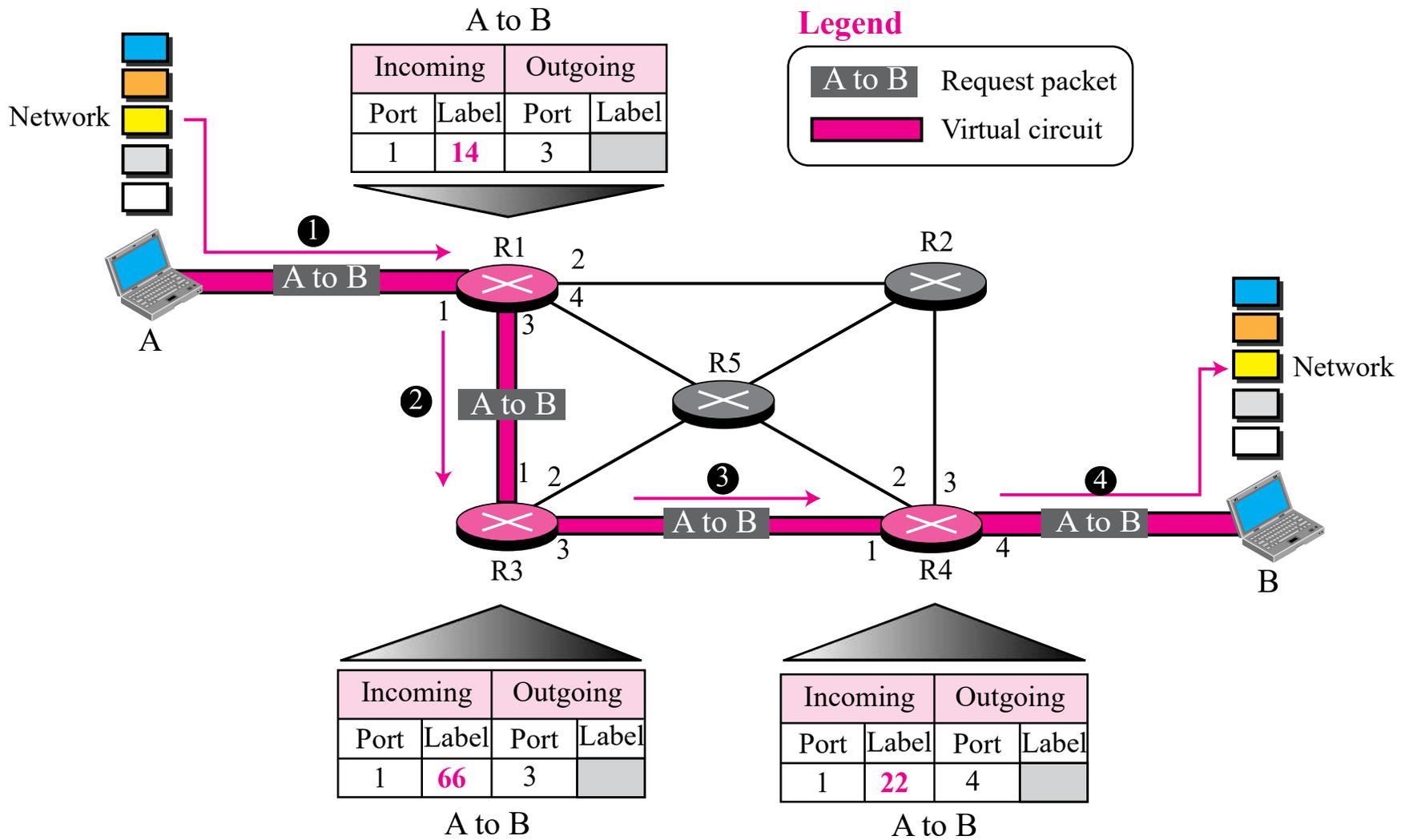| Incoming		Outgoing	
Port	Label	Port	Label
1	**22**	4	

A to B

18

Figure 9 *Setup acknowledgement in a virtual-circuit network*

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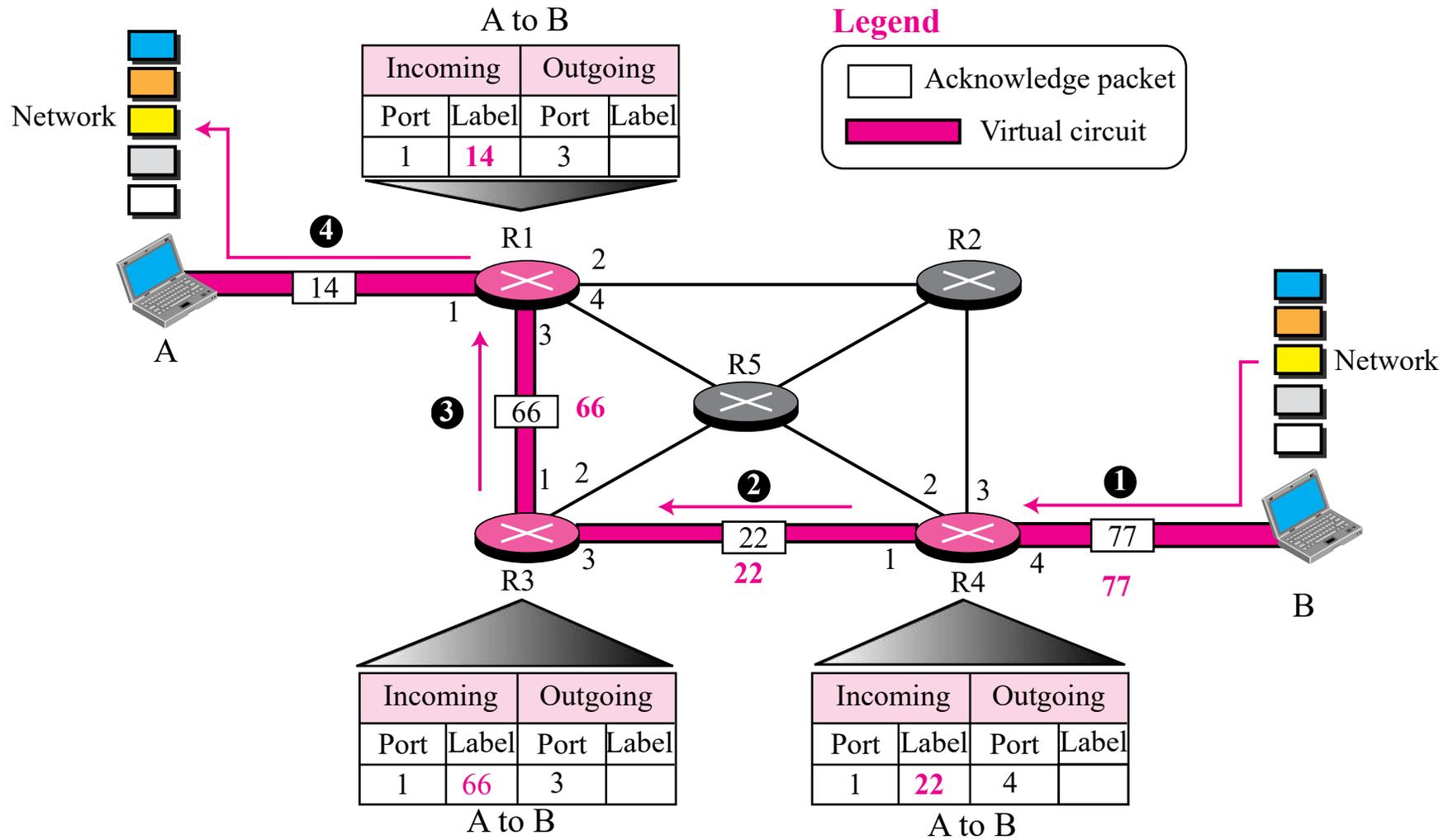
Figure 10 *Flow of one packet in an established virtual circuit*

| 14 | A | B | Data |

| 66 | A | B | Data |
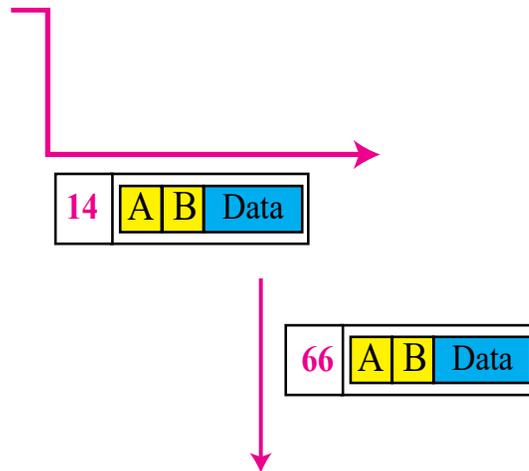
4 NETWORK LAYER SERVICES

We briefly discuss services provided by the network layer.

Our discussion is mostly based on the connectionless service.

Logical Addressing

- Since the network layer provides end-to end communication,

- Two computers that need to communicate with each other each need a universal identification system, referred to as logical address.

- This type of identification is provided in the network layer through a uniform and global addressing mechanism.

Figure 10 *An imaginary part of the Internet*
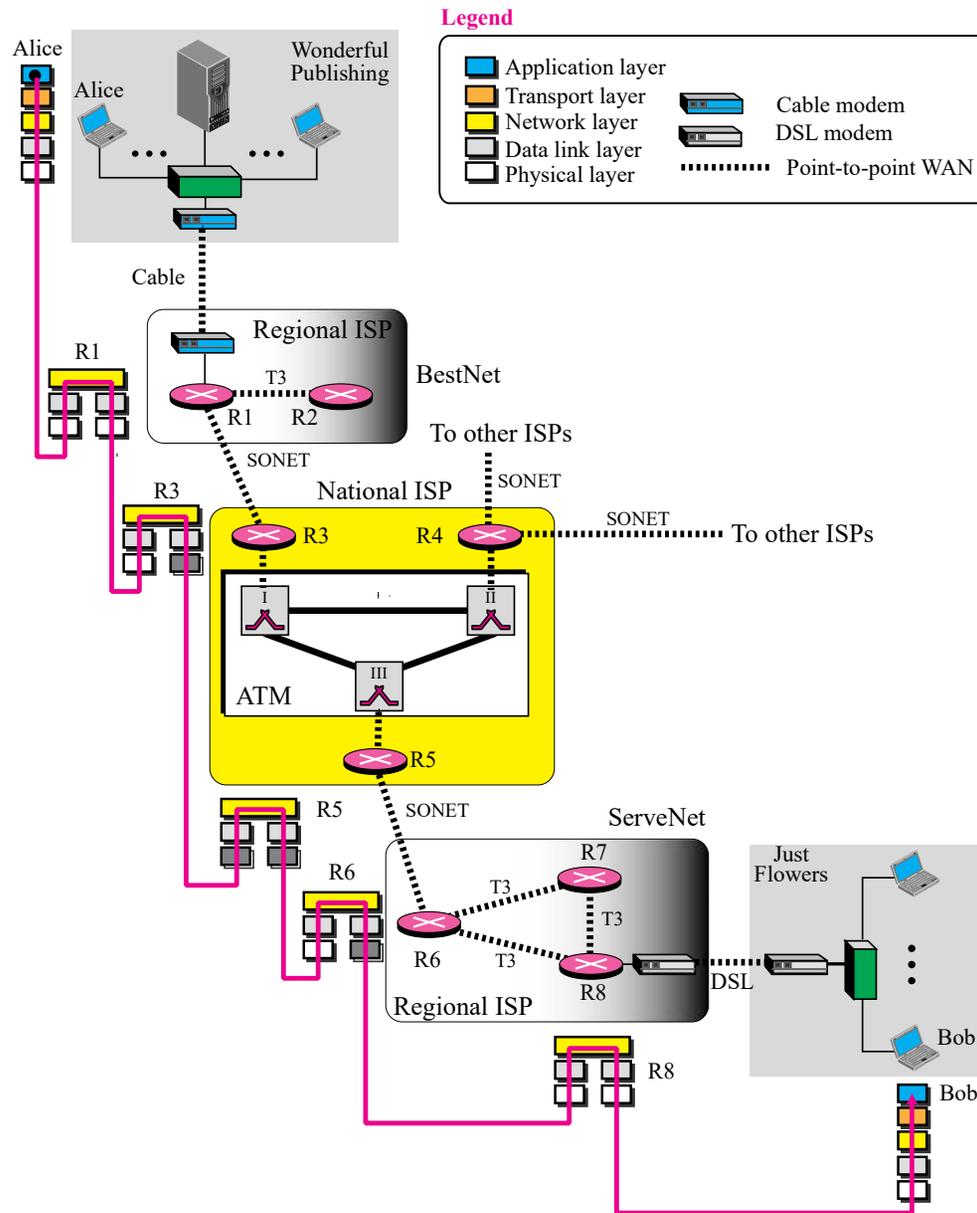
Services Provided at the Source Computer

- The network layer at the source computer provides four services:
  - packetizing,
  - Finding the logical address of the next hop,
  - finding the physical (MAC) address of the next hop,
  - and fragmenting the datagram if necessary

Packetizing

- The first duty of the network layer is to encapsulate the data coming from the upper layer in a datagram.

- This is done by adding a header to the data that contains the logical source and destination address of the packet

- protocol ID of the protocol that has requested the service, the data length, and possibly some options.

- The network layer also includes a checksum that is calculated only over the datagram header

Finding Logical Address of Next Hop

- The prepared datagram contains the source and destination addresses of the packet.

- The datagram may have to pass through many networks to reach its final destination.

- If the destination computer is not connected to the same network as the source, the datagram should be delivered to the next router.

- The source and destination address in the datagram does not tell anything about the logical address of the next hop.

- The network layer at the source computer needs to consult a routing table to find the
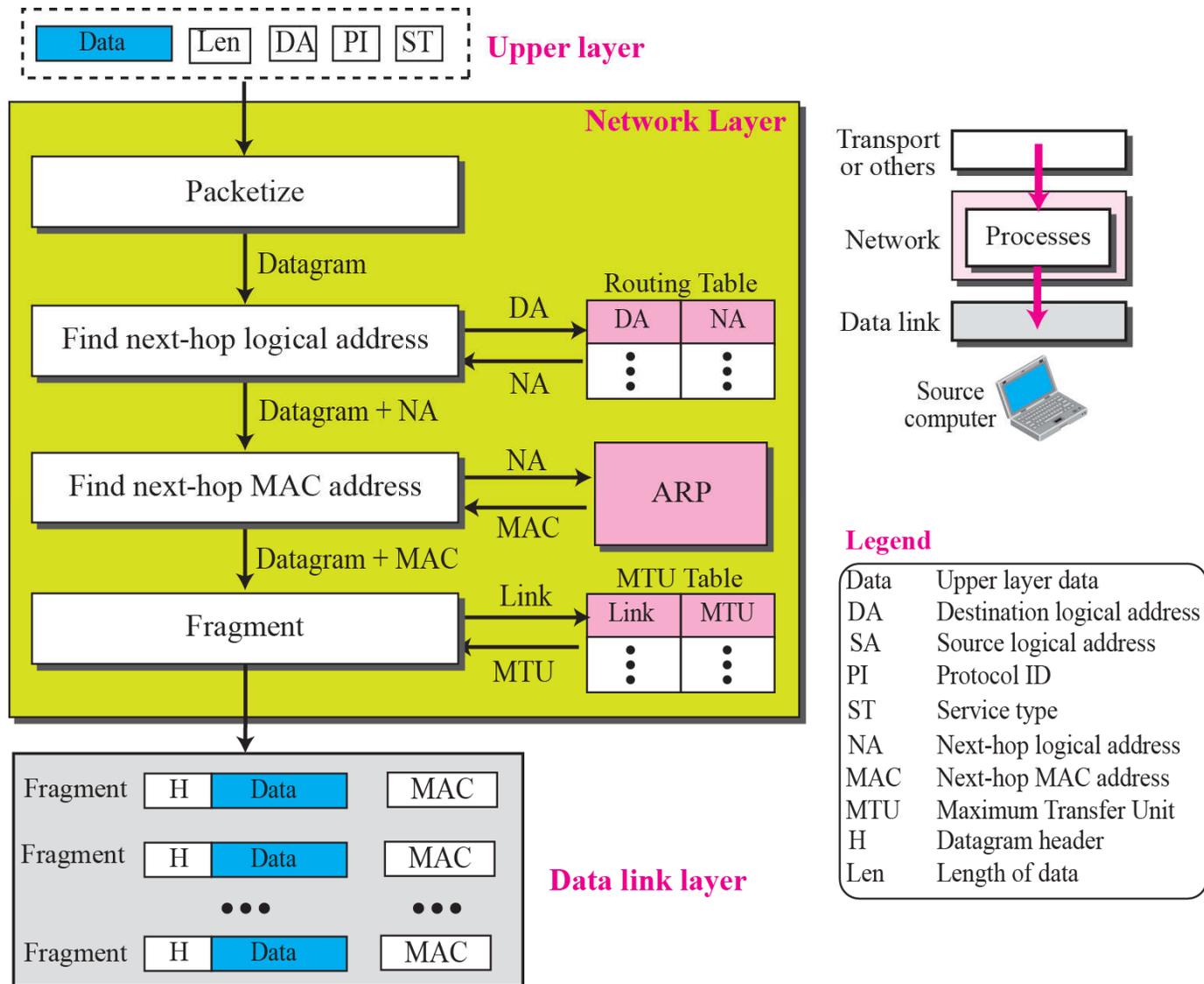logical address of the next hop.

Finding MAC Address of Next Hop

- The network layer does not actually deliver the datagram to the next hop; it is the duty of the data link layer to do the delivery.

- The data link layer needs the MAC address of the next hop to do the delivery.

- To find the MAC address of the next hop, the network layer could use another table to map the next-hop logical address to the MAC address

Fragmentation

- The datagram needs to be fragmented to smaller units before being passed to the data link layer.

- Fragmentation needs to preserve the information at the header of the datagram.

- In addition, some more information needs to be added to the header to define the position of the fragment in the whole datagram.

Figure 11 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

5 OTHER SERVICES

- Introduce some issues related to the network layer.
- These issues actually represent services that are normally discussed for the network layer, but they are either partially implemented at the network layer or not implemented at all.
- Some services are provided by some auxiliary protocols or by protocols added to the Internet later. Most of these issues resurface in future chapters.

Error Control

- **Error control** means including a mechanism for detecting corrupted, lost, or duplicate datagrams.

- Error control also includes a mechanism for correcting errors after they have been detected.

- The network layer in the Internet does not provide a real error control mechanism.

- At the surface level, it looks as though there is no need for error control at the network layer because each datagram passes through several networks before reaching its final destination.

Figure 12 *Error checking at the data link layer*

Source   Router   Router   Destination

Error checking   Error checking   Error checking

No error checking   **No error checking**
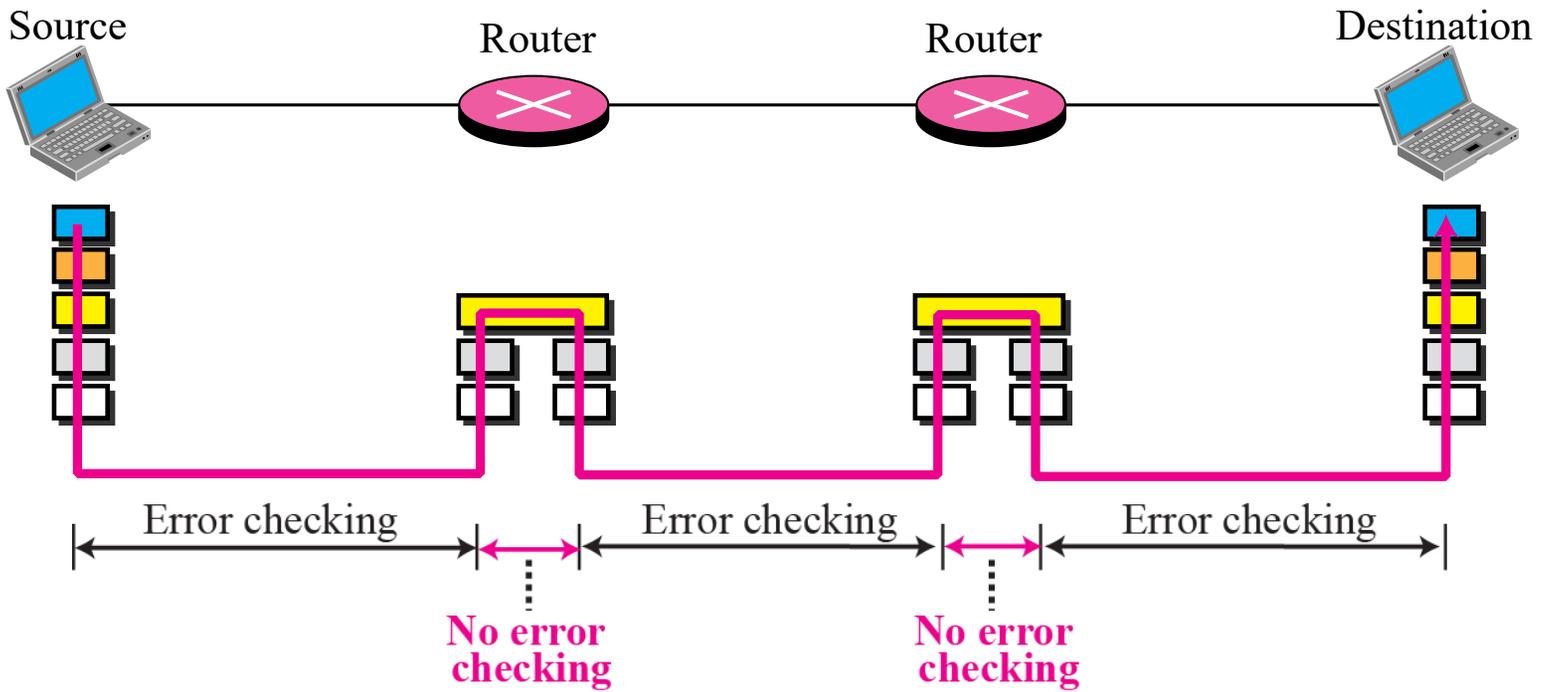
Flow Control

- **Flow control** detect the amount of data a source can send without crushing the receiver.

- If the upper layer at the source computer produces data faster than the upper layer at the destination computer can consume it, the receiver will be crushing with data.

- To control the flow of data, the receiver needs to send some feedback to the sender to inform the latter it is crash with data.
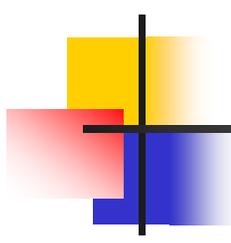
Note

No flow control is provided for the current version of Internet network layer.