Network Layer

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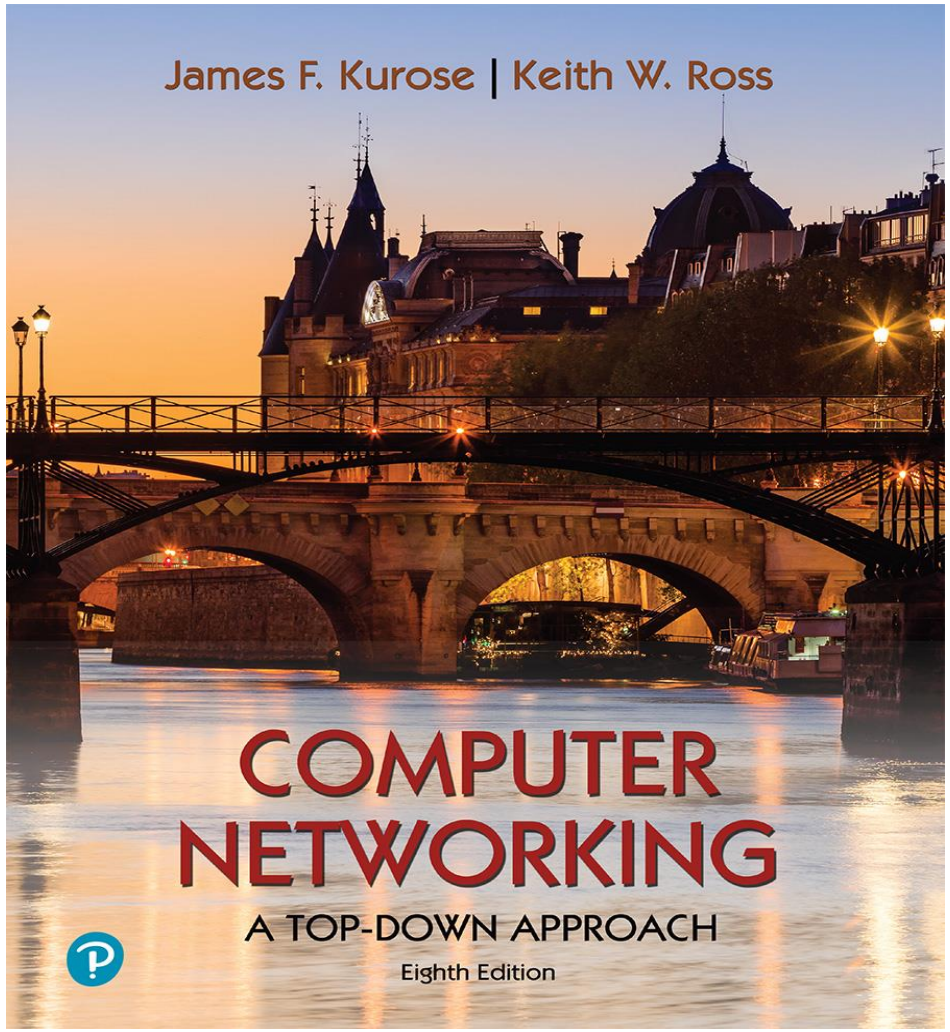
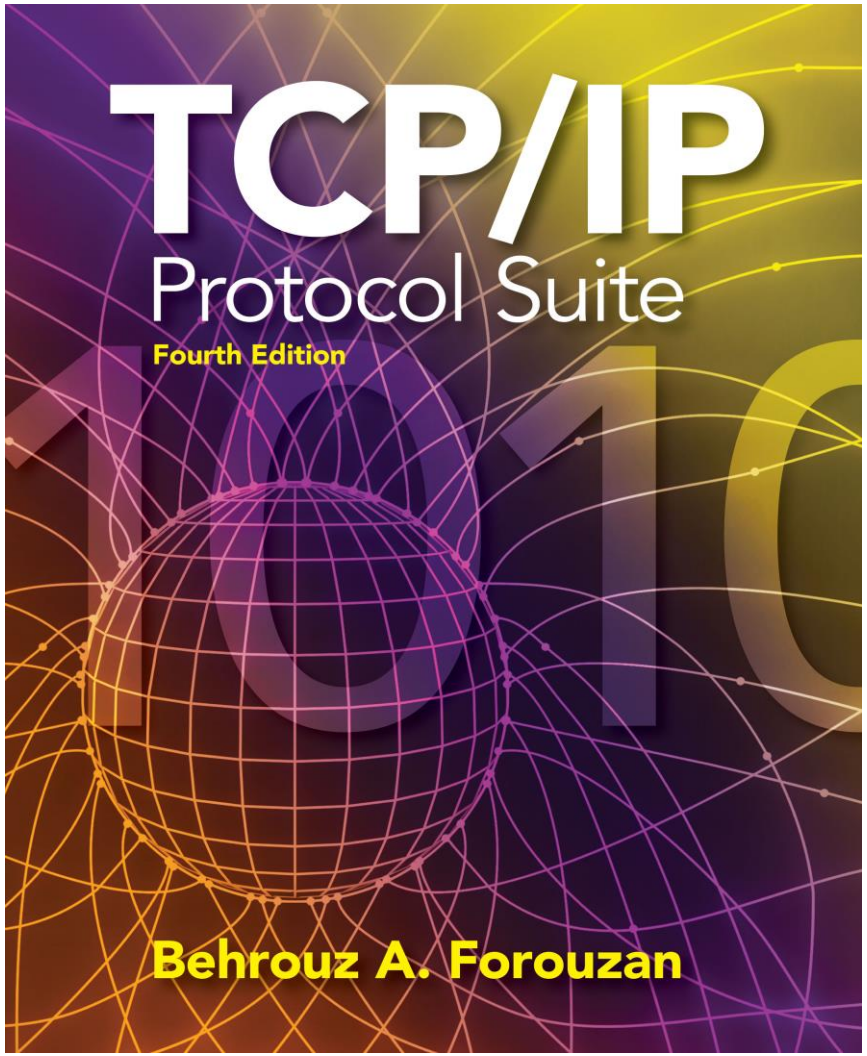
Sources



Computer Networking: A Top-Down Approach

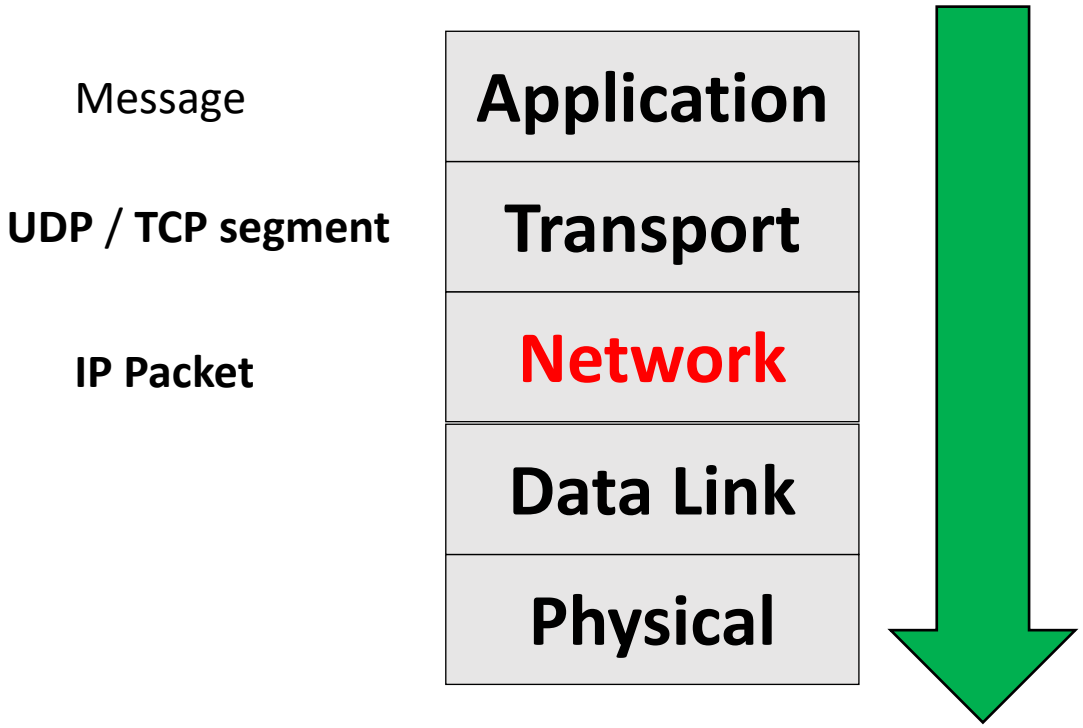


TCP/IP Protocol Suite

Outline

- Introduction to Network Layer (Overview)
- Network Layer Services
- IP Header Format - Fragmentation
- IP addressing
  - Subnetting, Supernetting
  - IP allocation - Dynamic Host Configuration Protocol (DHCP)
- Network Address Translation (NAT)
- Address Resolution Protocol (ARP)
- Internet Control Message Protocol (ICMP)
- Routing (RIP, OSPF, BGP)

Top-Down Approach



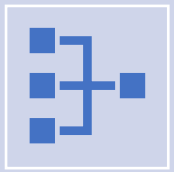
Internet protocol stack

application: supporting network applications

HTTP, SMTP, IMAP, FTP

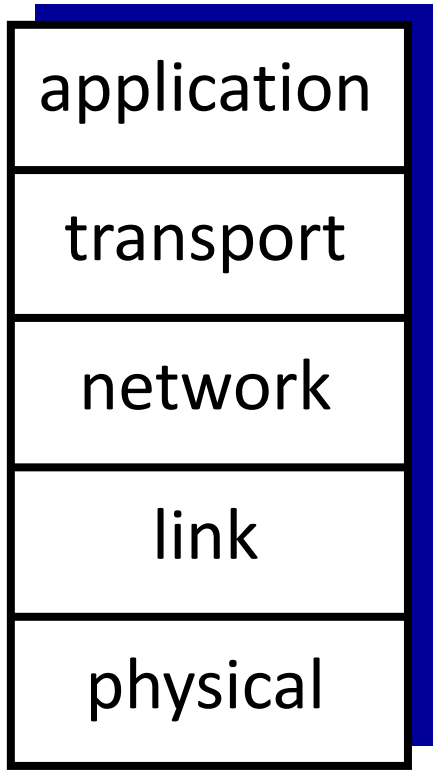
transport: process-process data transfer

TCP, UDP

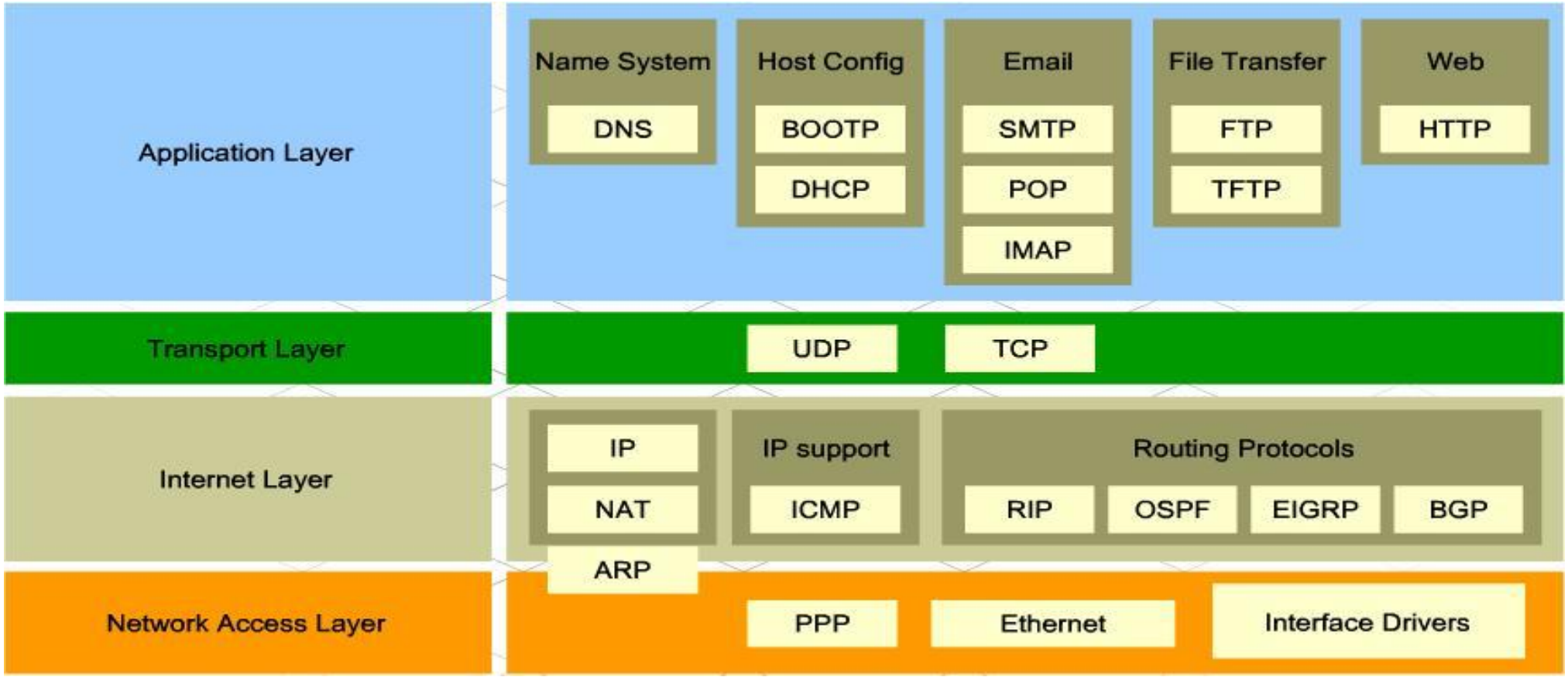


network: routing of datagrams from source to destination

IP, routing protocols

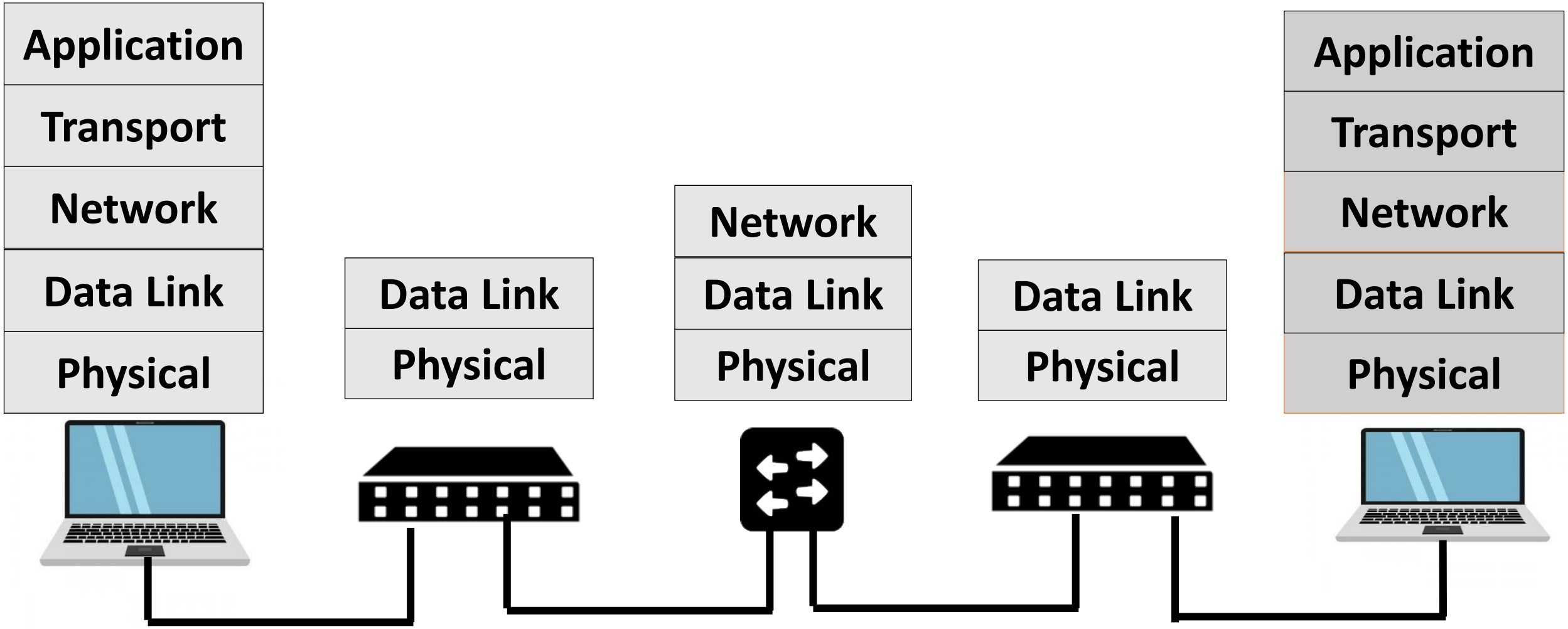


Protocols @ Different layers

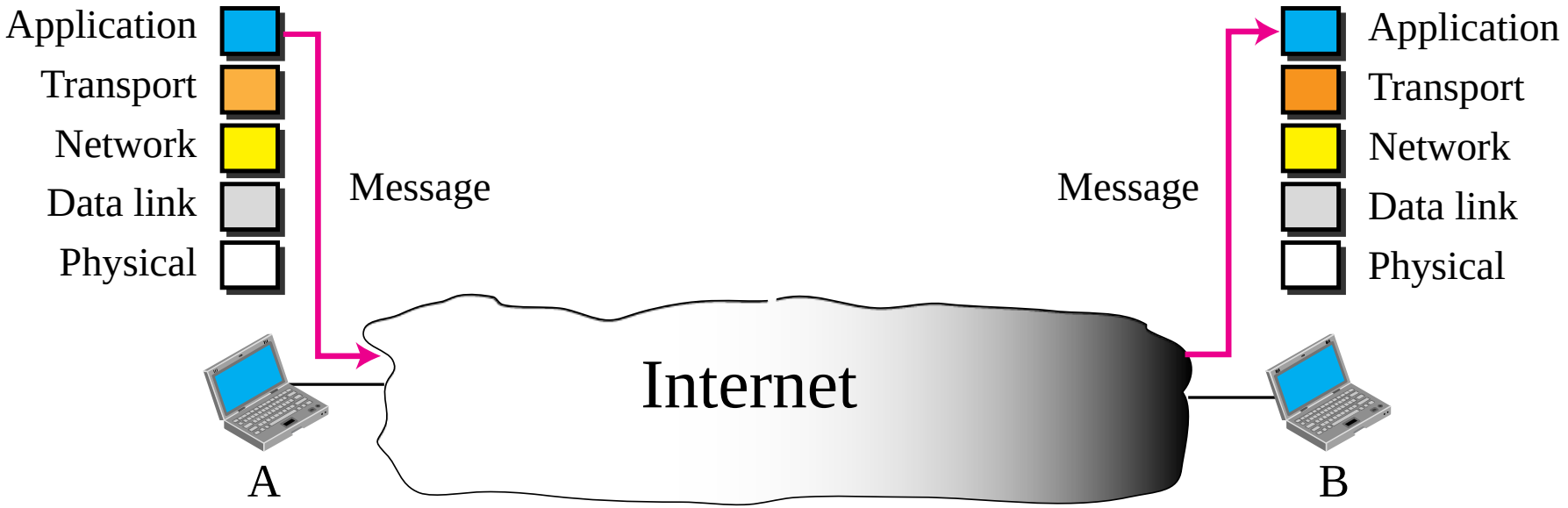


Source: http://walkwidnetwork.blogspot.com/2013/04/application-layer-internet-protocol.html

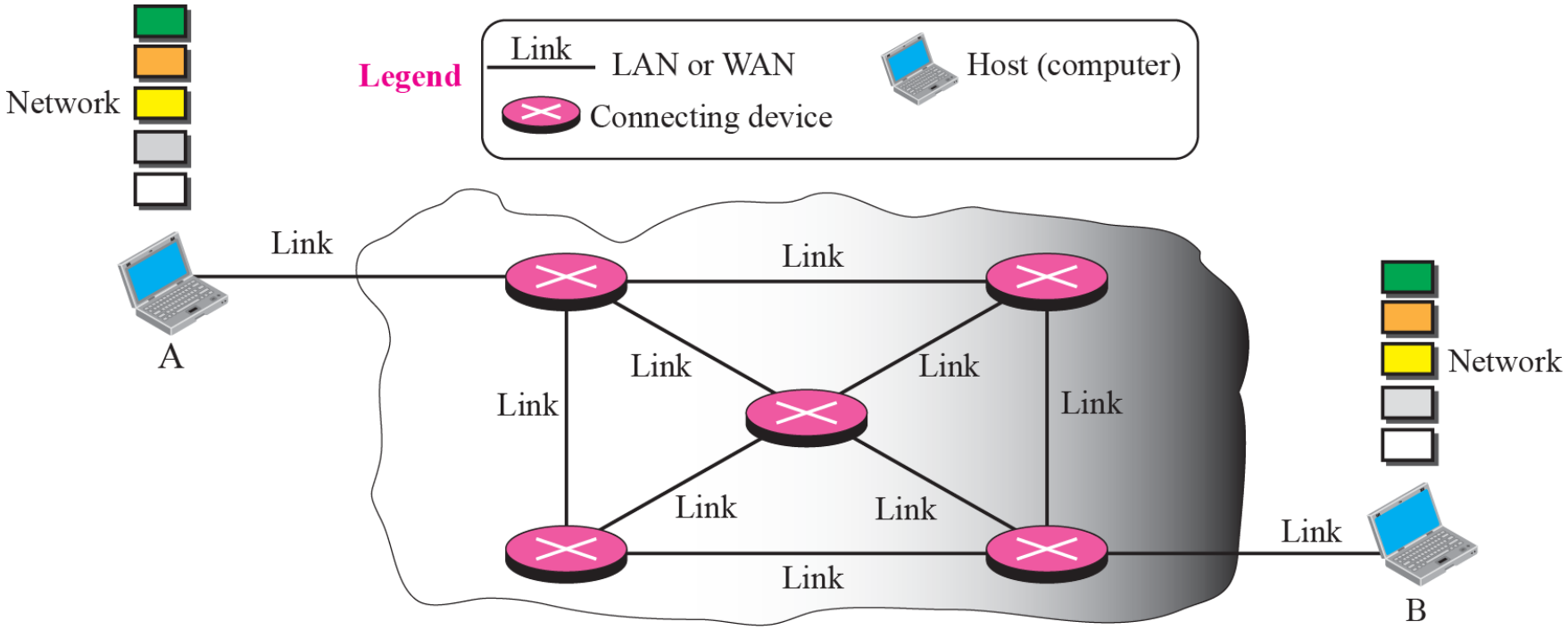
Communication between two remote Machine



Internet as a Black Box

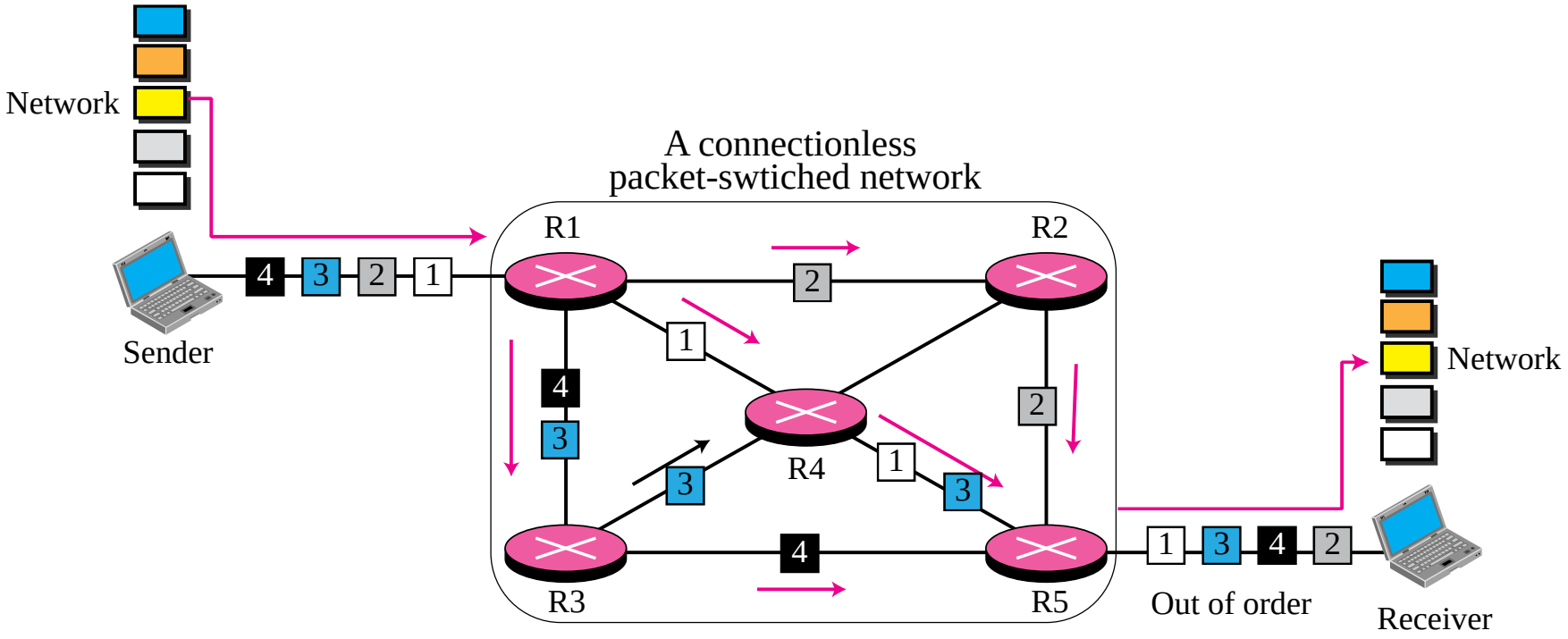


Internet as a combination of LANs and WANs connected together

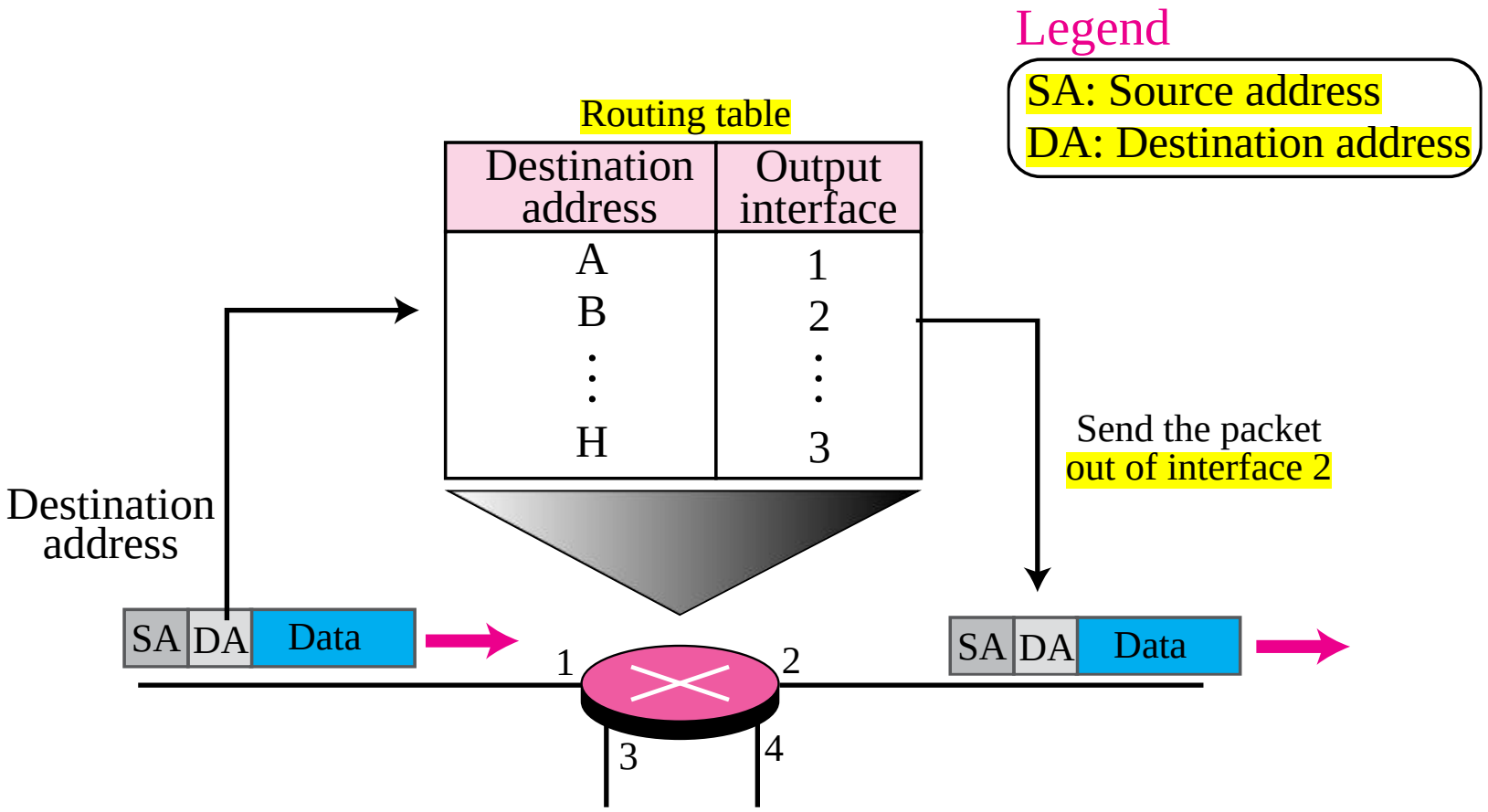


An internet as a combination of links and connecting devices

A connectionless packet-switched network



Forwarding process in a connectionless network



Destination-based forwarding

forwarding table

Destination Address Range	Link Interface
11001000 00010111 00010000 00000000 through 11001000 00010111 00010000 00000100	0
11001000 00010111 00010000 00000101 through 11001000 00010111 00010000 00000111	3
11001000 00010111 00011000 11111111	
11001000 00010111 00011001 00000000 through 11001000 00010111 00011111 11111111	2
otherwise	3

Q: but what happens if ranges don't divide up so nicely?

Longest prefix matching

longest prefix match

when looking for forwarding table entry for given destination address, use *longest* address prefix that matches destination address.

Destination Address Range				Link interface
11001000	00010111	00010***	********	0
11001000	00010111	00011000	********	1
11001000	00010111	00011***	********	2
otherwise				3

examples:

11001000	00010111	00010110	10100001	which interface?
11001000	00010111	00011000	10101010	which interface?

Longest prefix matching

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when looking for forwarding table entry for given destination address, use *longest* address prefix that matches destination address.

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match!

examples:

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examples:

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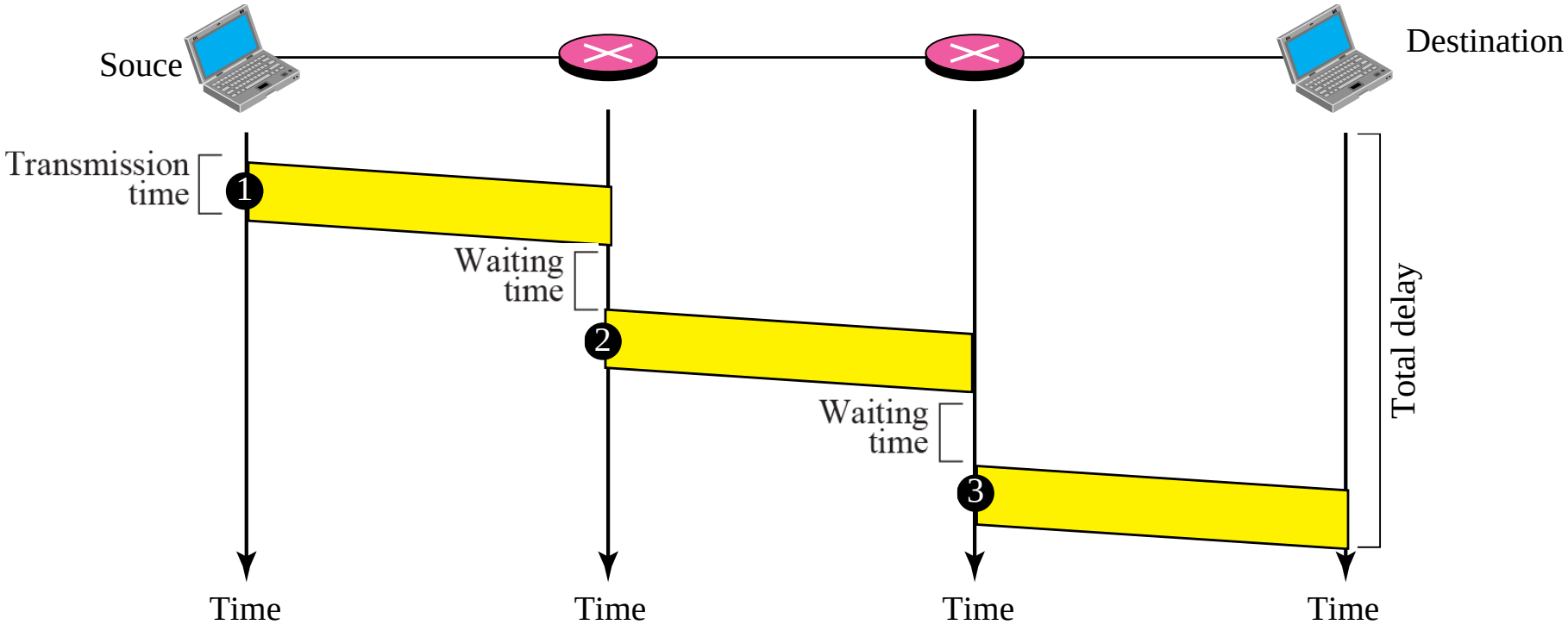
Delay in a connectionless network



Two key network-layer functions

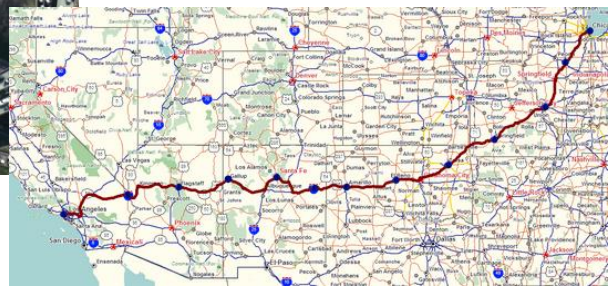
network-layer functions:

- *forwarding:* move packets from a router's input link to appropriate router output link
  - *routing:* determine route taken by packets from source to destination
    - *routing algorithms*

analogy: taking a trip

- *forwarding:* process of getting through single interchange
  - *routing:* process of planning trip from source to destination

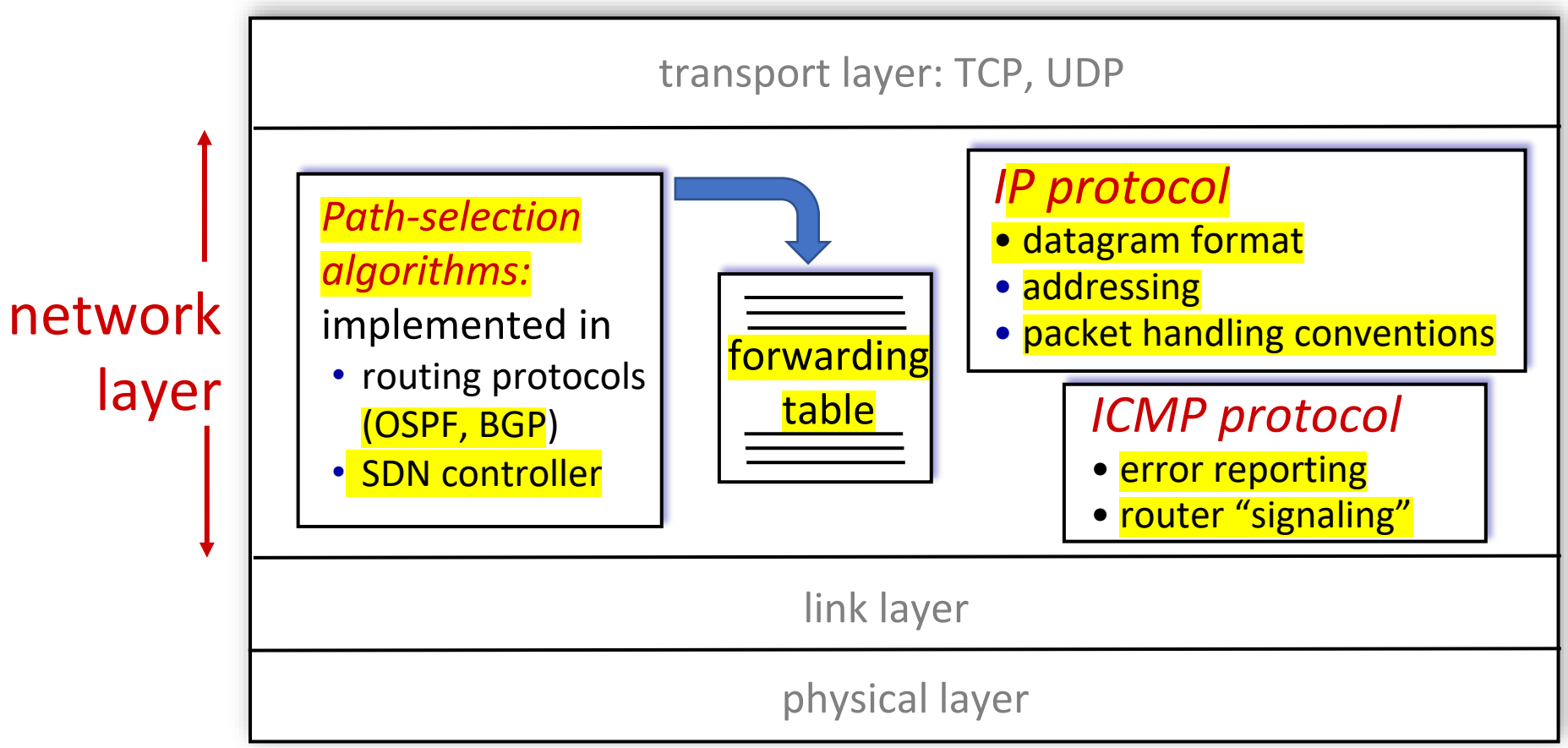
forwarding



routing

Network Layer: Internet

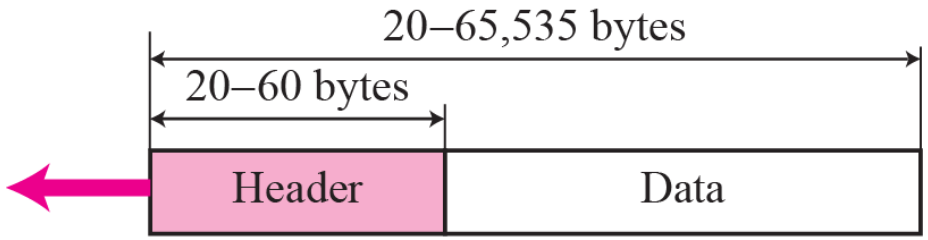
host, router network layer functions:



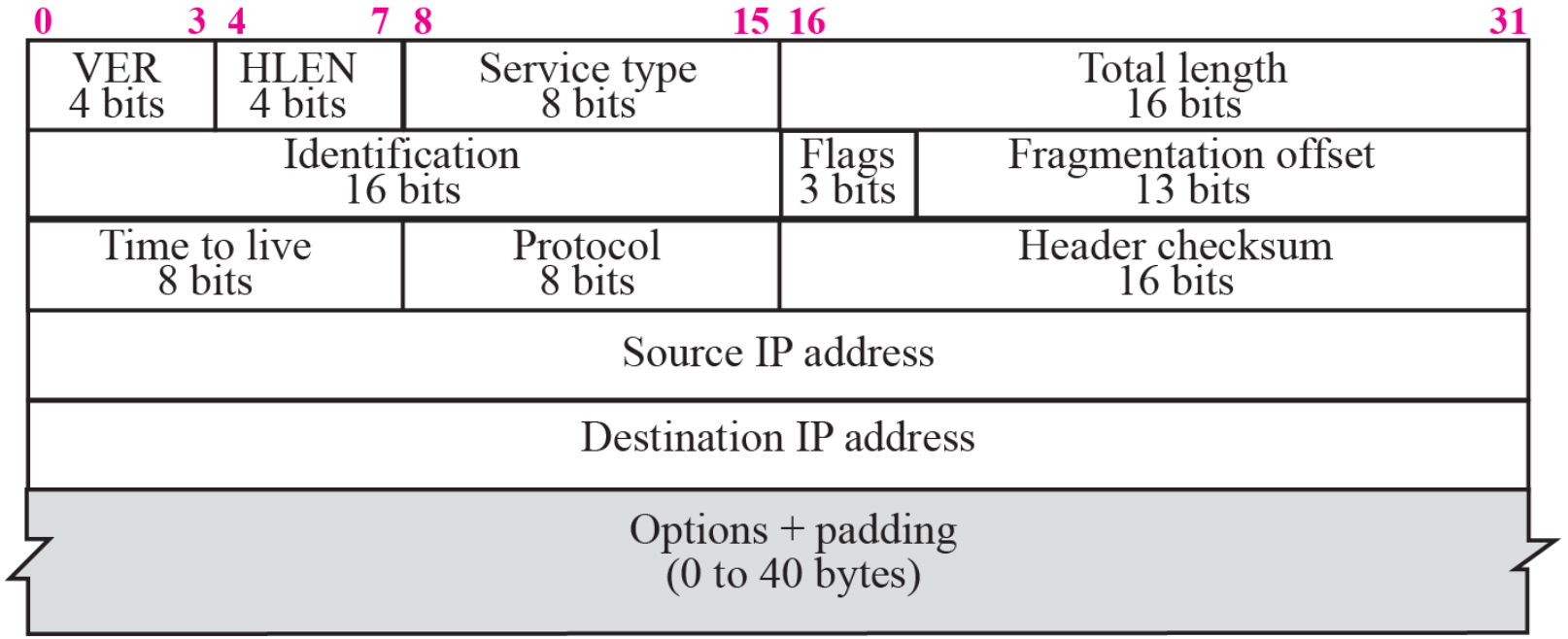
IP Header

- **Packets in the network (internet) layer are called *datagrams*.**
- **A datagram is a variable-length packet consisting of two parts: header and data.**
- **The header is 20 to 60 bytes in length and contains information essential to routing and delivery.**

IP datagram

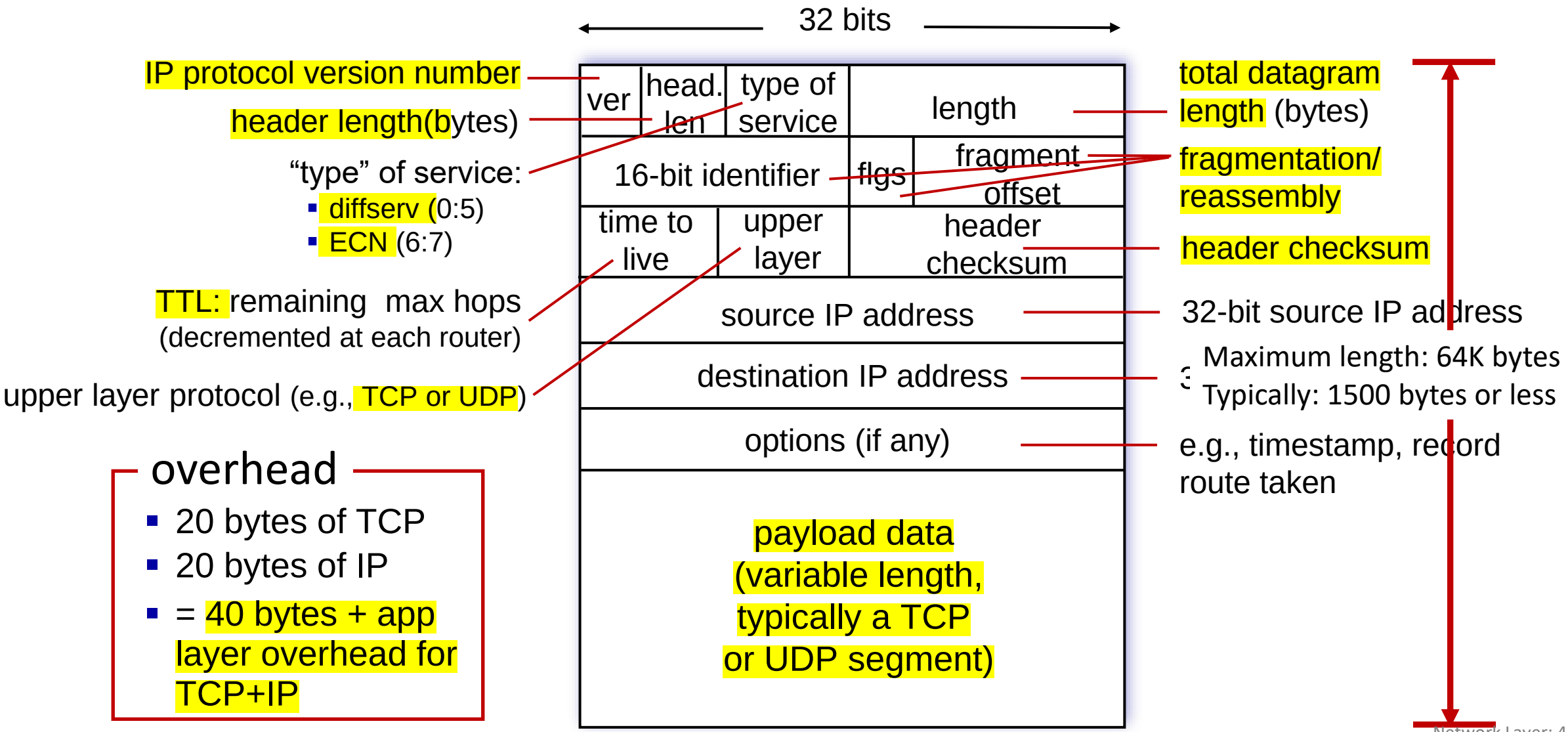


a. IP datagram



b. Header format

IP Datagram format



overhead

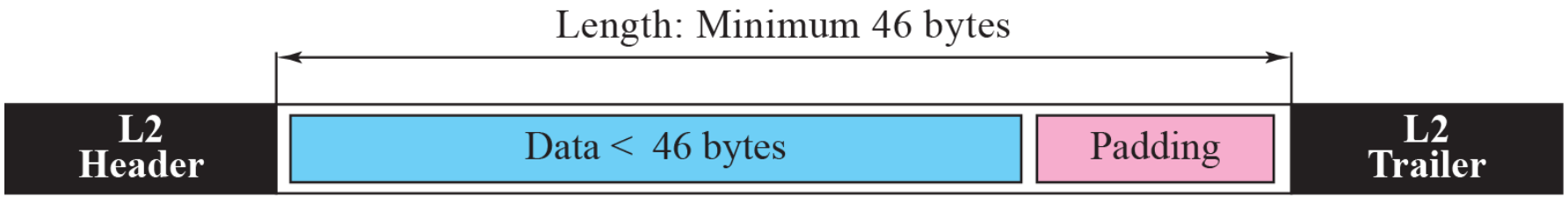
- 20 bytes of TCP
- 20 bytes of IP
- = 40 bytes + app layer overhead for TCP+IP

The total length field defines the total length of the datagram including the header.

Checksum in IP covers only the header, not the data.

Fragmentation at routers, reassembling at destination only.

Encapsulation of a small datagram in an Ethernet frame



Multiplexing

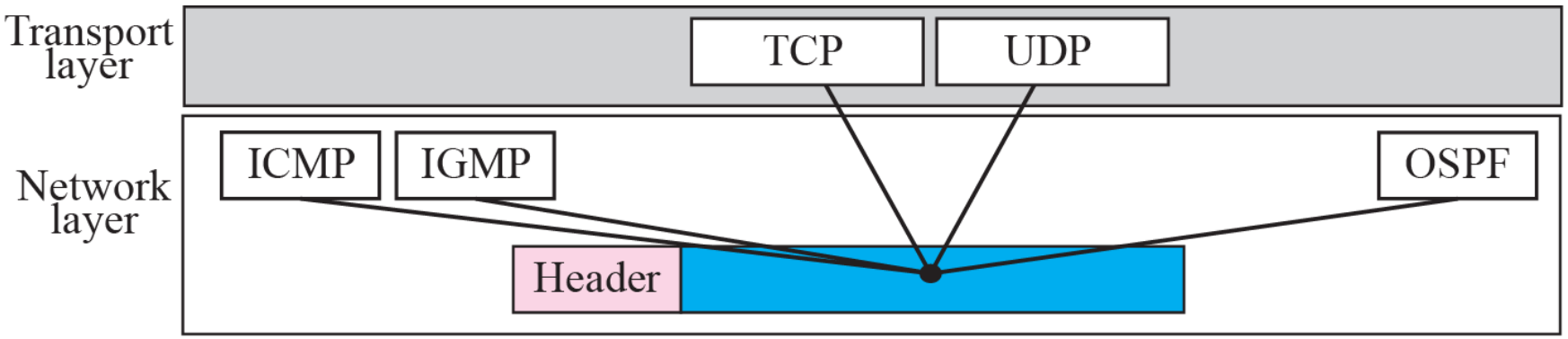


Table 7.2 *Protocols*

Value	*Protocol*	*Value*	*Protocol*
1	ICMP	17	UDP
2	IGMP	89	OSPF
6	TCP		

Example

An IP packet has arrived with the first 8 bits as shown:

```
01000010
```

The receiver discards the packet. Why?

Solution

There is an error in this packet. The 4 left-most bits (0100) show the version, which is correct. The next 4 bits (0010) show the wrong header length ($2 \times 4 = 8$). The minimum number of bytes in the header must be 20. The packet has been corrupted in transmission.

Example

In an IP packet, the value of HLEN is 1000 in binary. How many bytes of options are being carried by this packet?

Solution

The HLEN value is 8, which means the total number of bytes in the header is 8 × 4 or 32 bytes. The first 20 bytes are the base header, the next 12 bytes are the options.

Example

In an IP packet, the value of HLEN is 5_{16} and the value of the total length field is 0028_{16}. How many bytes of data are being carried by this packet?

Solution

The HLEN value is 5, which means the total number of bytes in the header is 5 × 4 or 20 bytes (no options). The total length is 40 bytes, which means the packet is carrying 20 bytes of data (40 − 20).

Example

An IP packet has arrived with the first few hexadecimal digits as shown below:

```
450000280001000000102 . . .
```

How many hops can this packet travel before being dropped? The data belong to what upper layer protocol?

Solution

To find the time-to-live field, we skip 8 bytes (16 hexadecimal digits). The time-to-live field is the ninth byte, which is 01. This means the packet can travel only one hop. The protocol field is the next byte (02), which means that the upper layer protocol is IGMP.