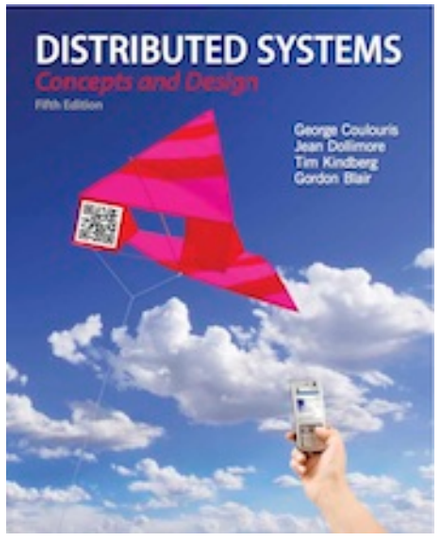
Slides for Chapter 3:
Networking and Internetworking



From Coulouris, Dollimore, Kindberg and Blair
Distributed Systems:
Concepts and Design

Some Terms

Transmission media (wire, cable, fiber, wireless channels): what delivers the bits at the lowest level (Layer 1)

Communication subsystem: the collection of HW+SW components that provide communication facilities for a DS.

Host: computers/devices using the net

Node: any computer or switching device addached to the network

Subnet: a unit of routing; collection of nodes on the same physical network

Internet: a single comm. system across all hosts on it

Performance

Latency: delay after a send operation executed & before data starts to arrive at destination computer

Data transfer rate (DTR): speed at which data can be transferred between computers in the network, once transmission has begun (bits/sec)

Message transmission time =

Latency + length/DTR

Figure 1.6
Growth of the Internet (computers and web servers)

Date	*Computers*	*Web servers*	*Percentage*
1993, July	1,776,000	130	0.008
1995, July	6,642,000	23,500	0.4
1997, July	19,540,000	1,203,096	6
1999, July	56,218,000	6,598,697	12
2001, July	125,888,197	31,299,592	25
2003, July	~200,000,000	42,298,371	21
2005, July	353,284,187	67,571,581	19
2020	1,000,000,000		

Figure 3.1
Network performance

	Example	*Range*	*Bandwidth (Mbps)*	*Latency (ms)*
Wired:				
LAN	Ethernet	1–2 kms	10–10,000	1–10
WAN	IP routing	worldwide	0.010–600	100–500
MAN	ATM	2–50 kms	1–600	10
Internetwork	Internet	worldwide	0.5–600	100–500
Wireless:				
WPAN	Bluetooth (IEEE 802.15.1)	10–30m	0.5–2	5–20
WLAN	WiFi (IEEE 802.11)	0.15–1.5 km	11–108	5–20
WMAN	WiMAX (IEEE 802.16)	5–50 km	1.5–20	5–20
WWAN	3G phone	cell: 1–-5	348–14.4	100–500

km

Figure 3.2
Conceptual layering of protocol software

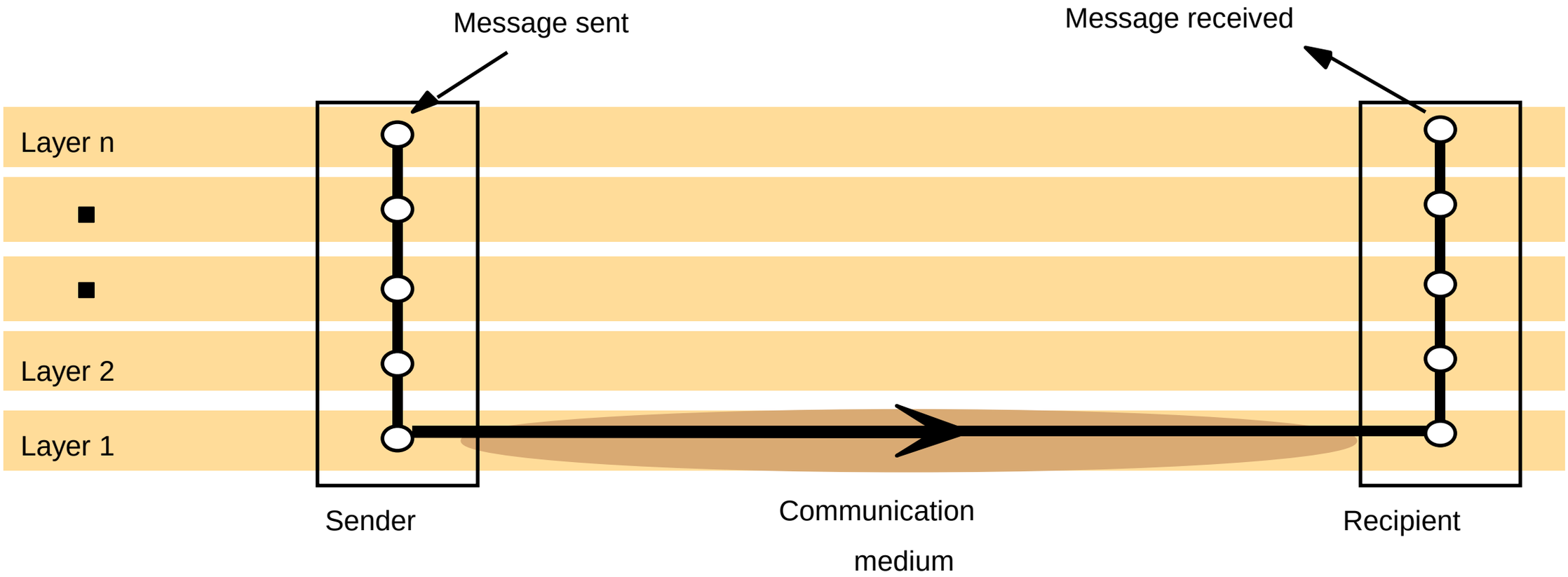


Figure 3.3
Encapsulation as it is applied in layered protocols

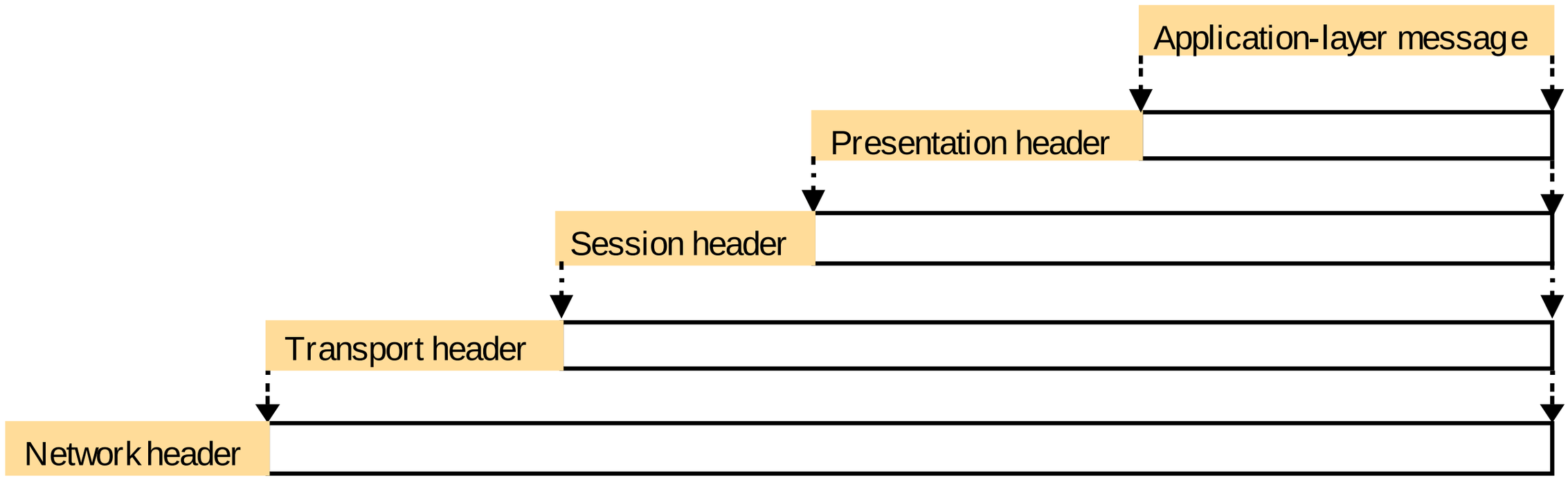


Figure 3.4
Protocol layers in the ISO Open Systems Interconnection (OSI) model

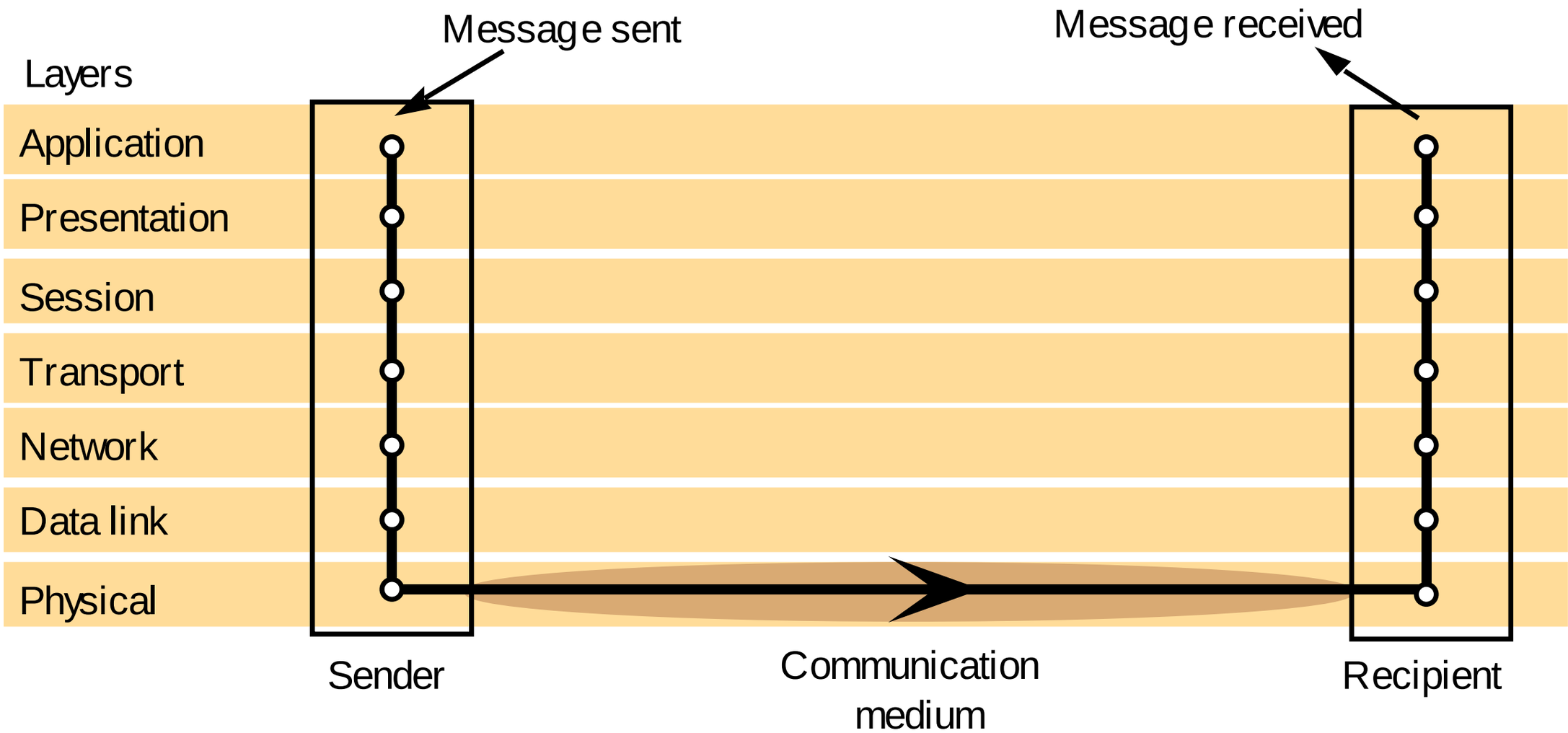


Figure 3.5
OSI protocol summary

Layer	*Description*	*Examples*
Application	Protocols that are designed to meet the communication requirements of specific applications, often defining the interface to a service.	HTTP, FTP , SMTP, CORBA IIOP
Presentation	Protocols at this level transmit data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption is also performed in this layer, if required.	Secure Sockets (SSL),CORBA Data Rep.
Session	At this level reliability and adaptation are performed, such as detection of failures and automatic recovery.	
Transport	This is the lowest level at which messages (rather than packets) are handled. Messages are addressed to communication ports attached to processes, Protocols in this layer may be connection-oriented or connectionless.	TCP, UDP
Network	Transfers data packets between computers in a specific network. In a WAN or an internetwork this involves the generation of a route passing through routers. In a single LAN no routing is required.	IP, ATM virtual circuits
Data link	Responsible for transmission of packets between nodes that are directly connected by a physical link. In a WAN transmission is between pairs of routers or between routers and hosts. In a LAN it is between any pair of hosts.	Ethernet MAC, ATM cell transfer, PPP
Physical	The circuits and hardware that drive the network. It transmits sequences of binary data by analogue signalling, using amplitude or frequency modulation of electrical signals (on cable circuits), light signals (on fibre optic circuits) or other electromagnetic signals (on radio and microwave circuits).	Ethernet base- band signalling, ISDN

Figure 3.6
Internetwork layers

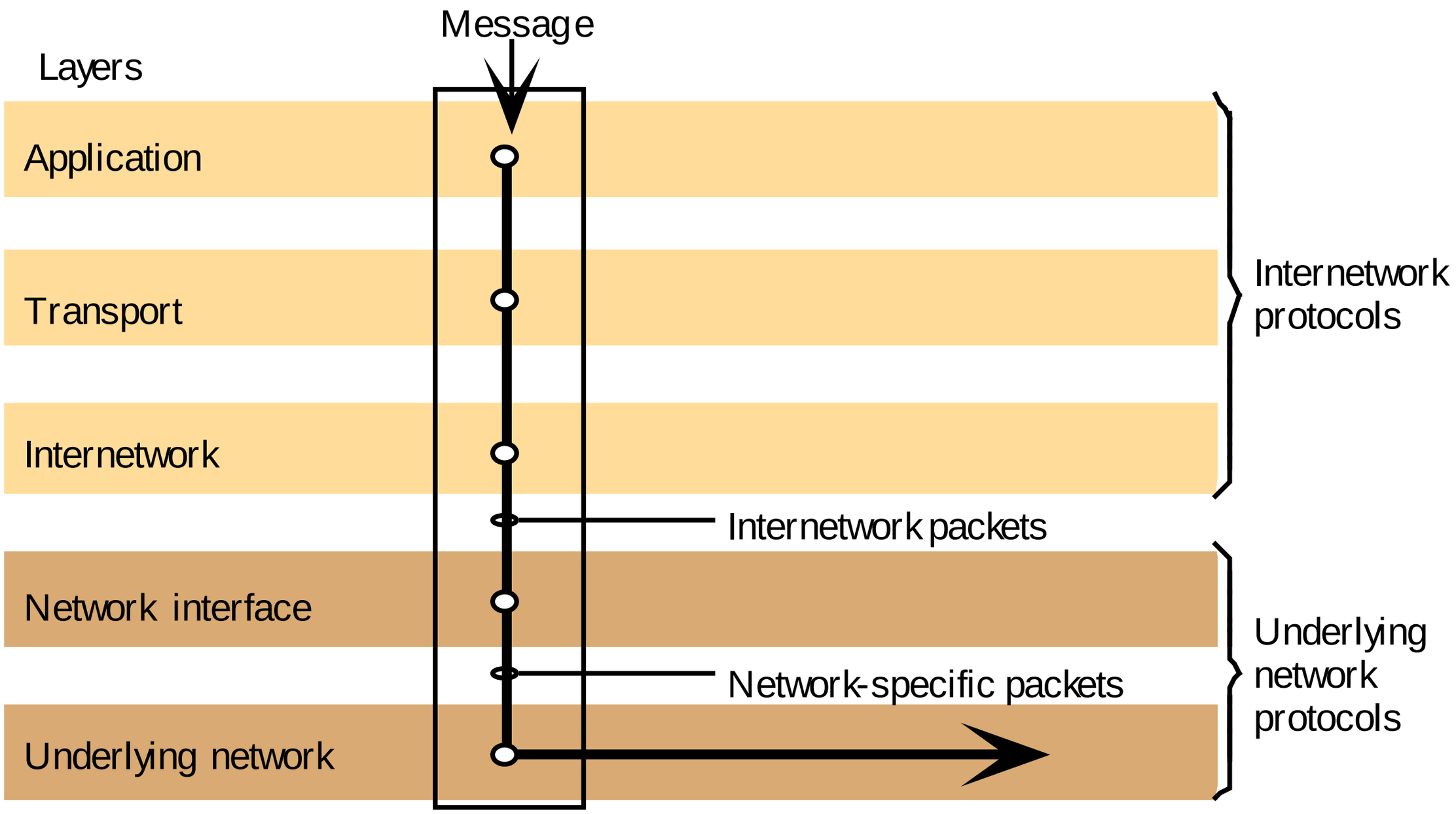


Figure 3.7
Routing in a wide area network

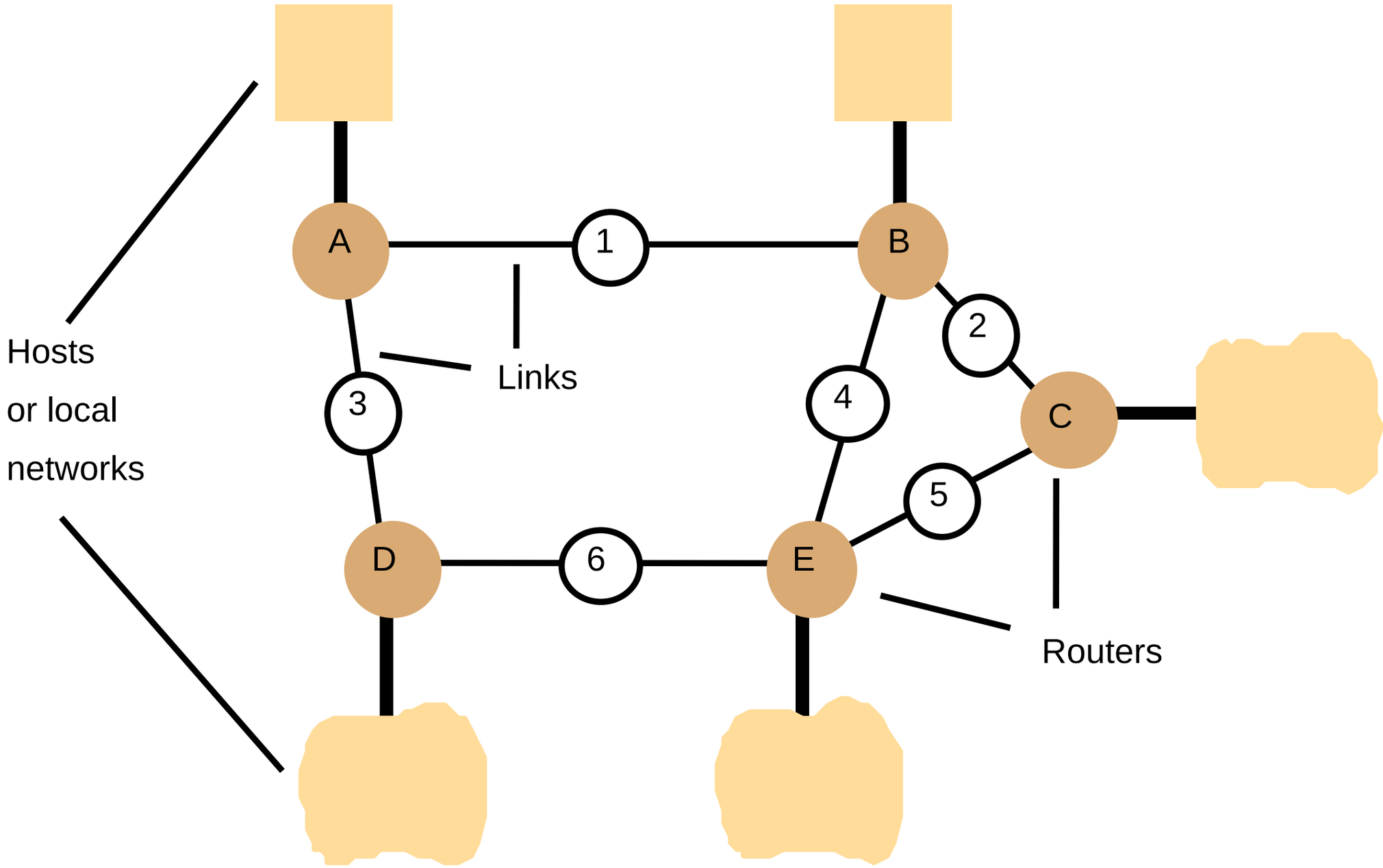


Figure 3.8
Routing tables for the network in Figure 3.7

Routings from A

To	*Link*	*Cost*
A	local	0
B	1	1
C	1	2
D	3	1
E	1	2

Routings from B

To	*Link*	*Cost*
A	1	1
B	local	0
C	2	1
D	1	2
E	4	1

Routings from C

To	*Link*	*Cost*
A	2	2
B	2	1
C	local	0
D	5	2
E	5	1

Routings from D

To	*Link*	*Cost*
A	3	1
B	3	2
C	6	2
D	local	0
E	6	1

Routings from E

To	*Link*	*Cost*
A	4	2
B	4	1
C	5	1
D	6	1
E	local	0

Figure 3.12
TCP/IP layers

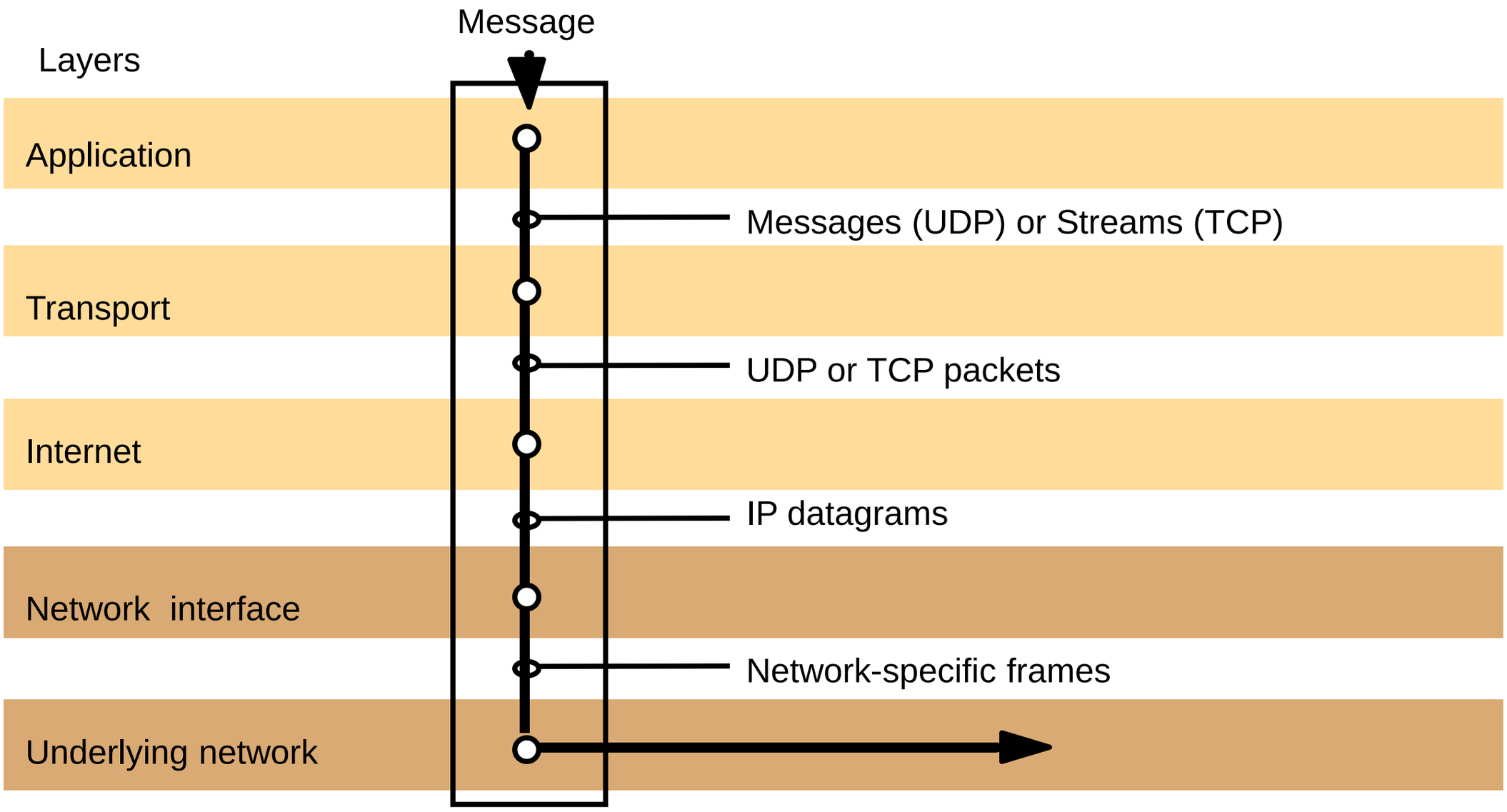


Figure 3.13
Encapsulation in a message transmitted via TCP over an Ethernet

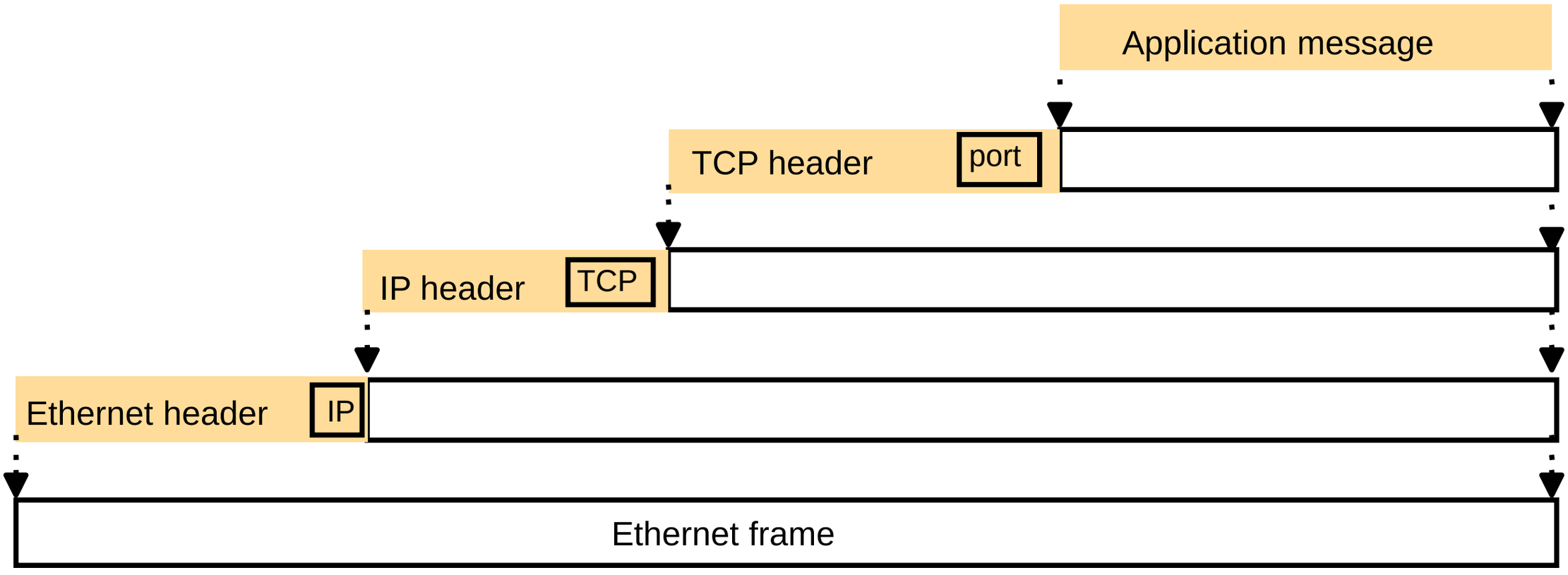


Figure 3.14
The programmer's conceptual view of a TCP/IP Internet

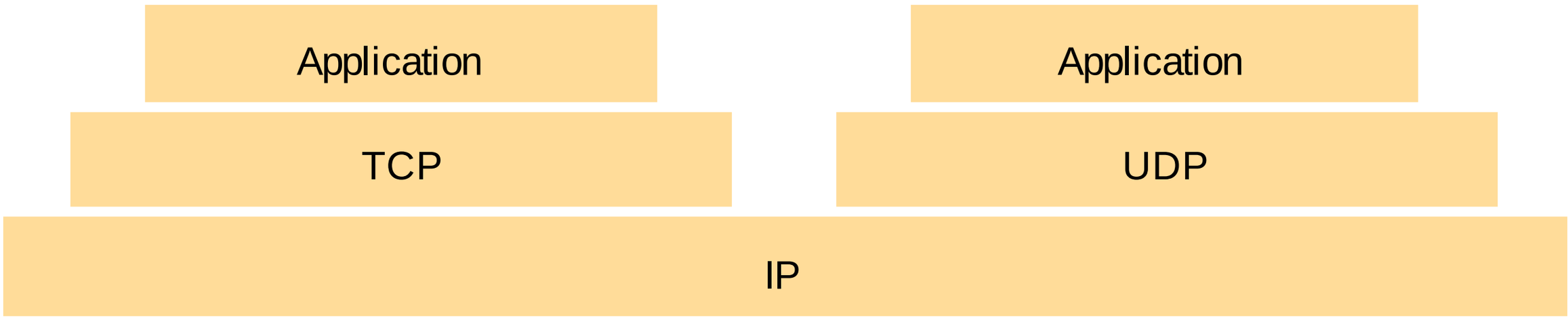


Figure 3.15
Internet address structure, showing field sizes in bits

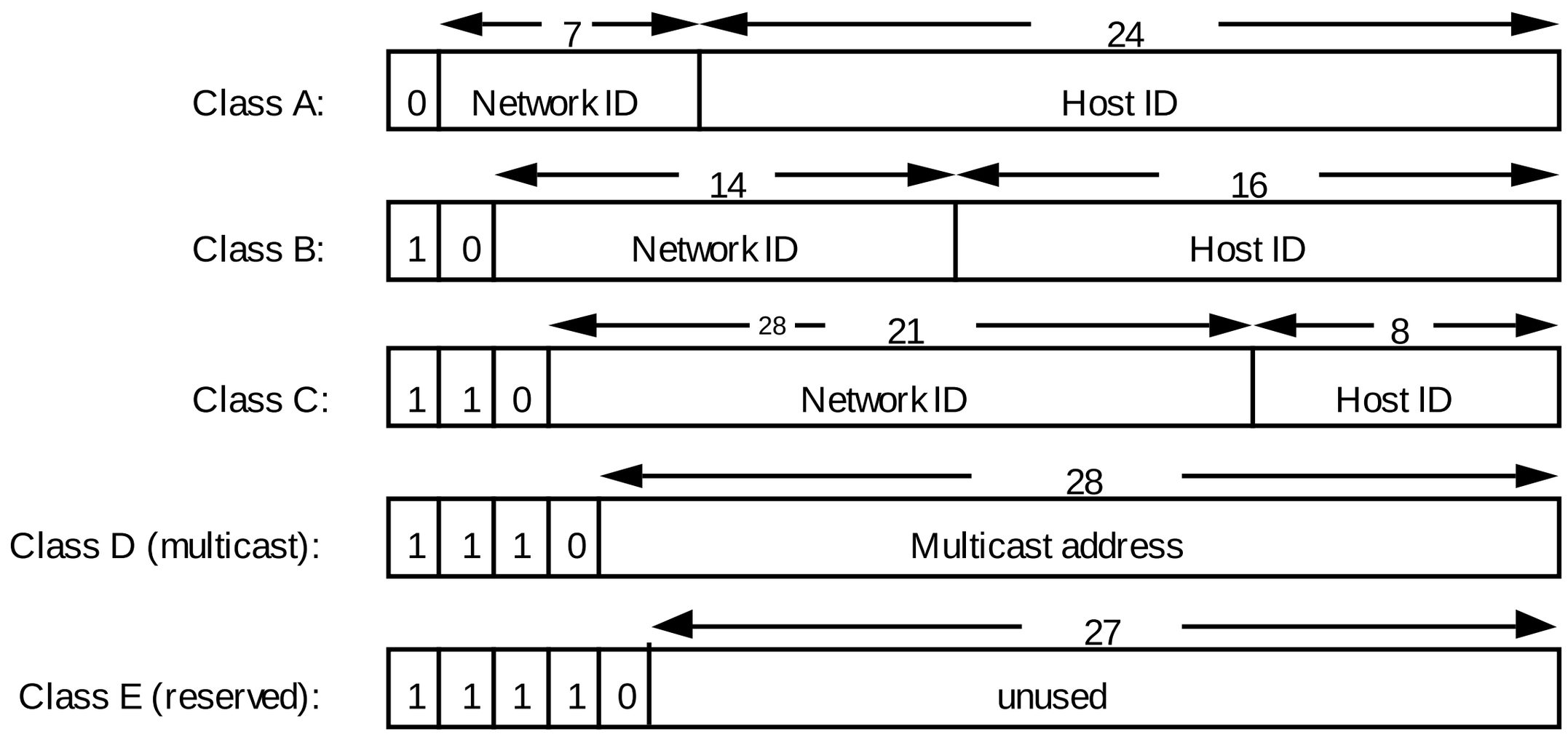


Figure 3.16
Decimal representation of Internet addresses

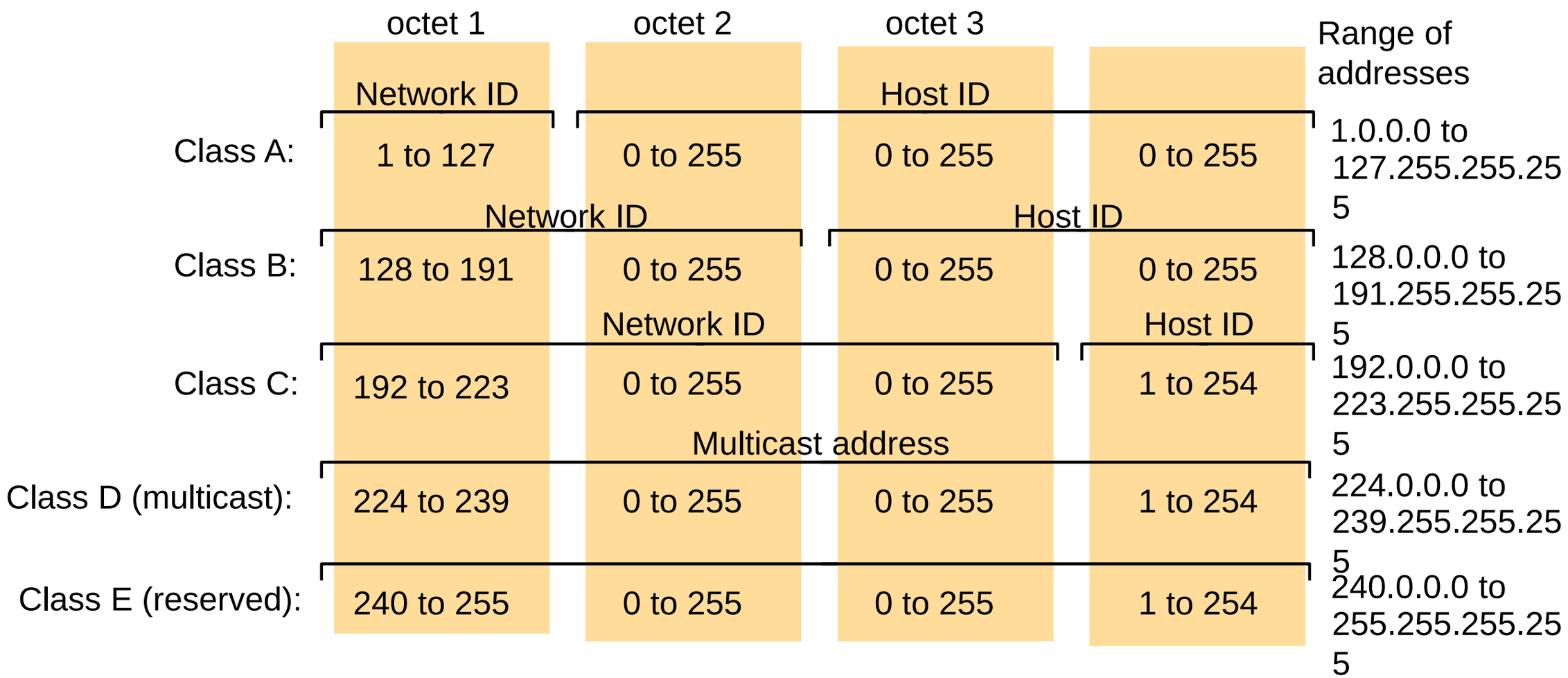


Figure 3.17
IP packet layout

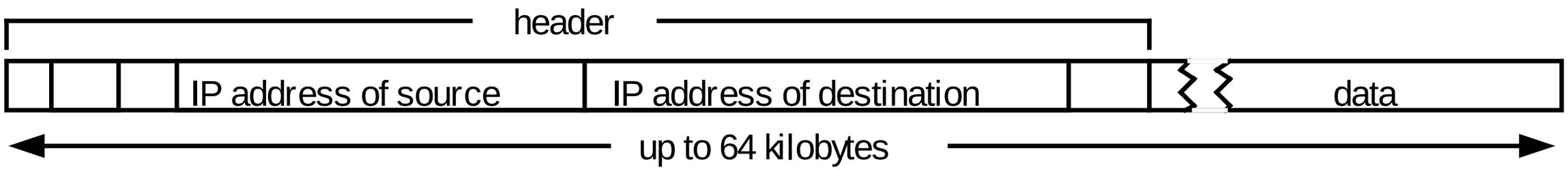


Figure 3.18
A typical NAT-based home network

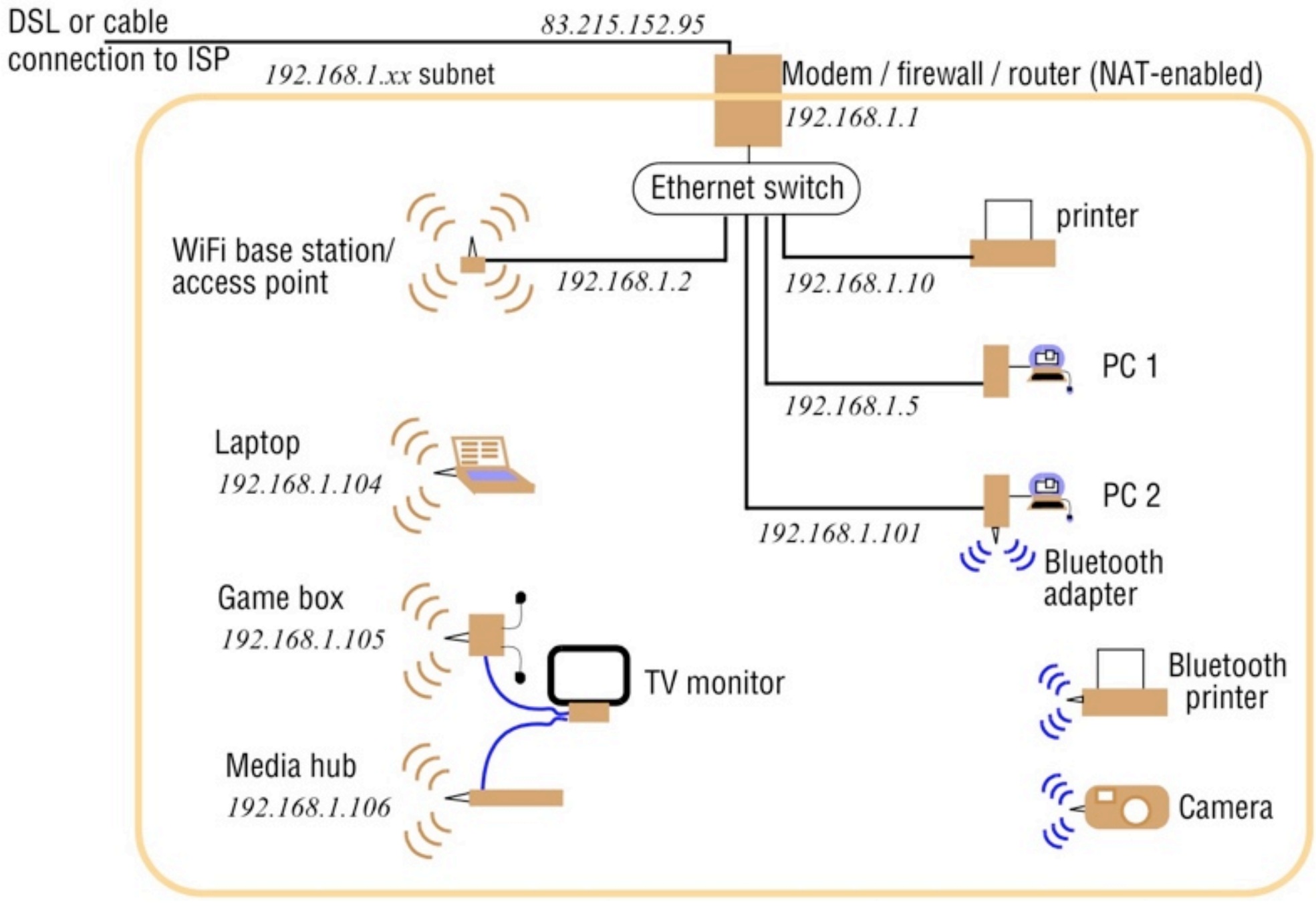


Figure 3.19
IPv6 header layout

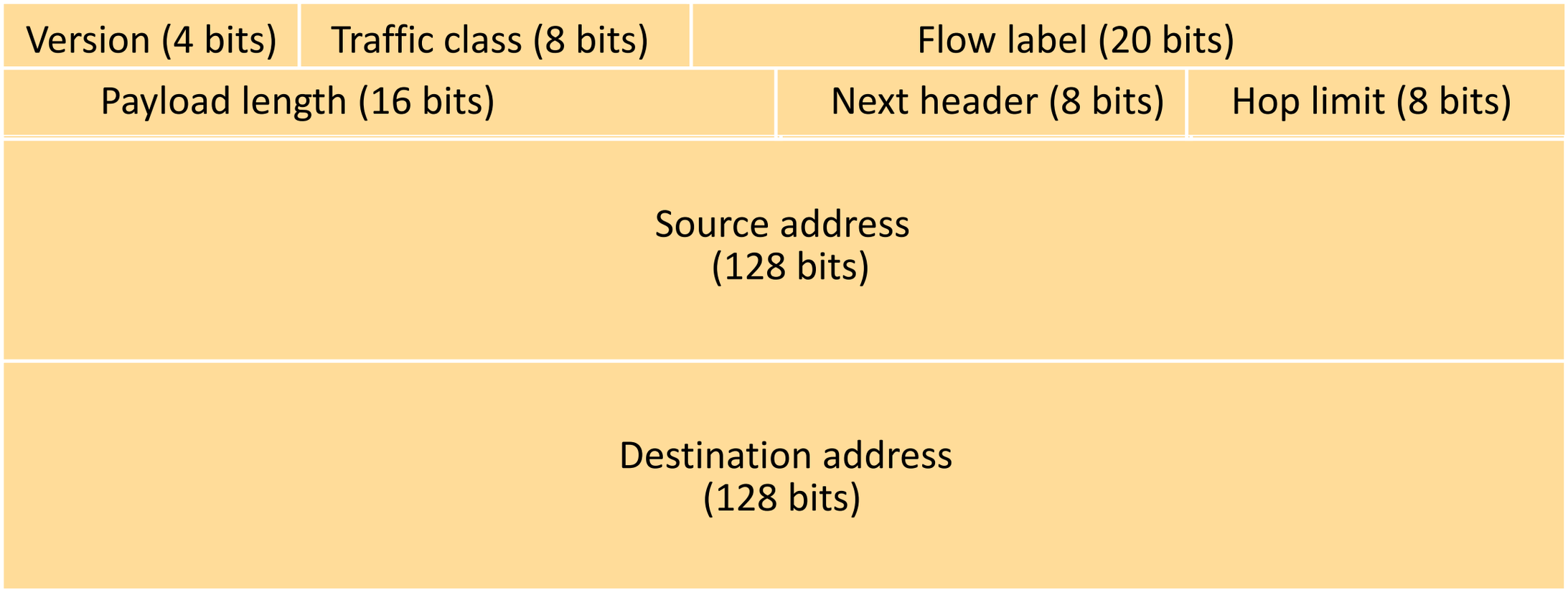


Figure 3.23
Ethernet ranges and speeds

	10Base5	*10BaseT*	*100BaseT*	*1000BaseT*
Data rate	10 Mbps	10 Mbps	100 Mbps	1000 Mbps
Max. segment lengths:				
Twisted wire (UTP)	100 m	100 m	100 m	25 m
Coaxial cable (STP)	500 m	500 m	500 m	25 m
Multi-mode fibre	2000 m	2000 m	500 m	500 m
Mono-mode fibre	25000 m	25000 m	20000 m	2000 m