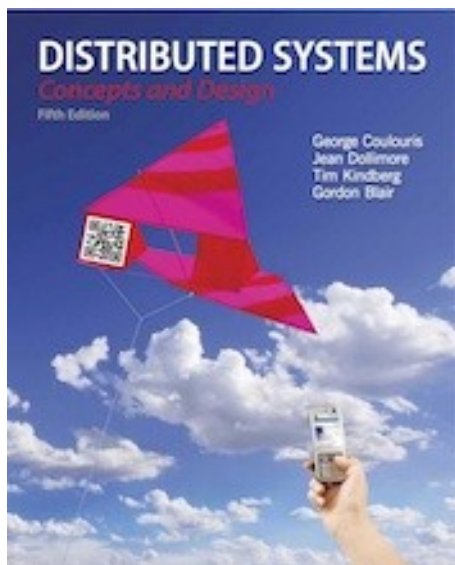


Slides for Chapter 3: Networking and Internetworking



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

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Figure 3.1 Network performance

	<i>Example</i>	<i>Range</i>	<i>Bandwidth (Mbps)</i>	<i>Latency (ms)</i>
<i>Wired:</i>				
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
<i>Wireless:</i>				
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

Figure 3.2

Conceptual layering of protocol software

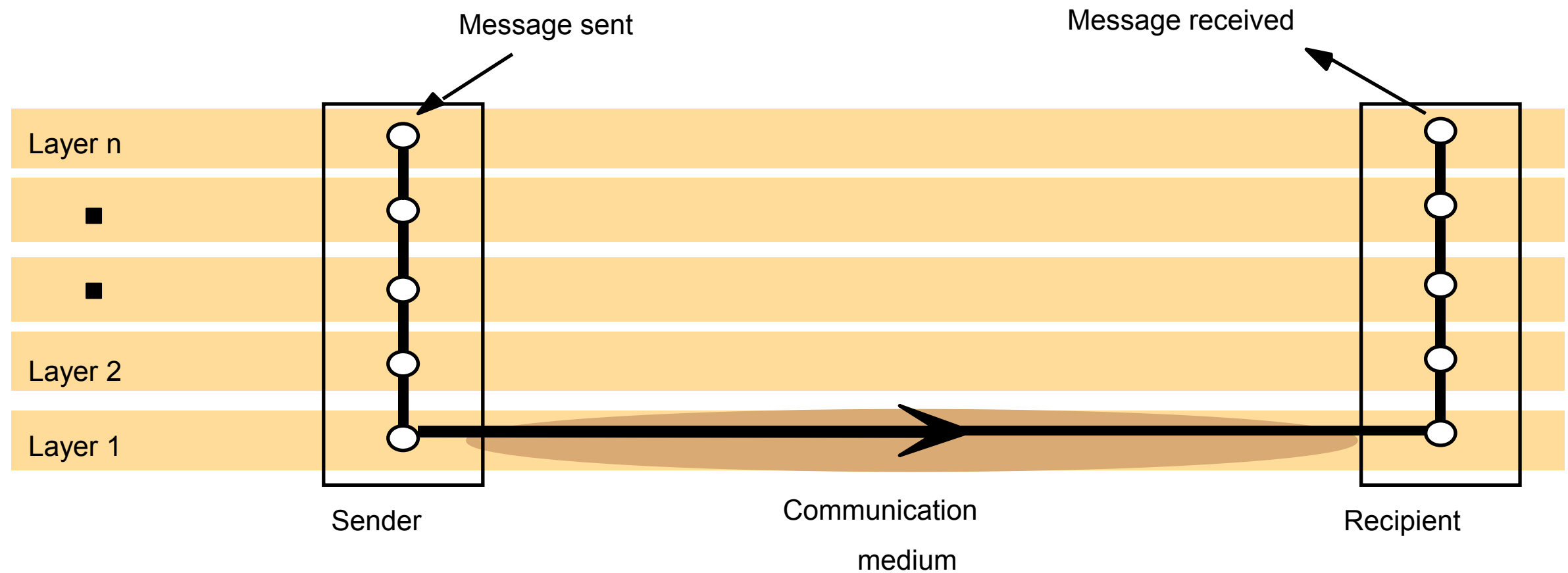


Figure 3.3

Encapsulation as it is applied in layered protocols

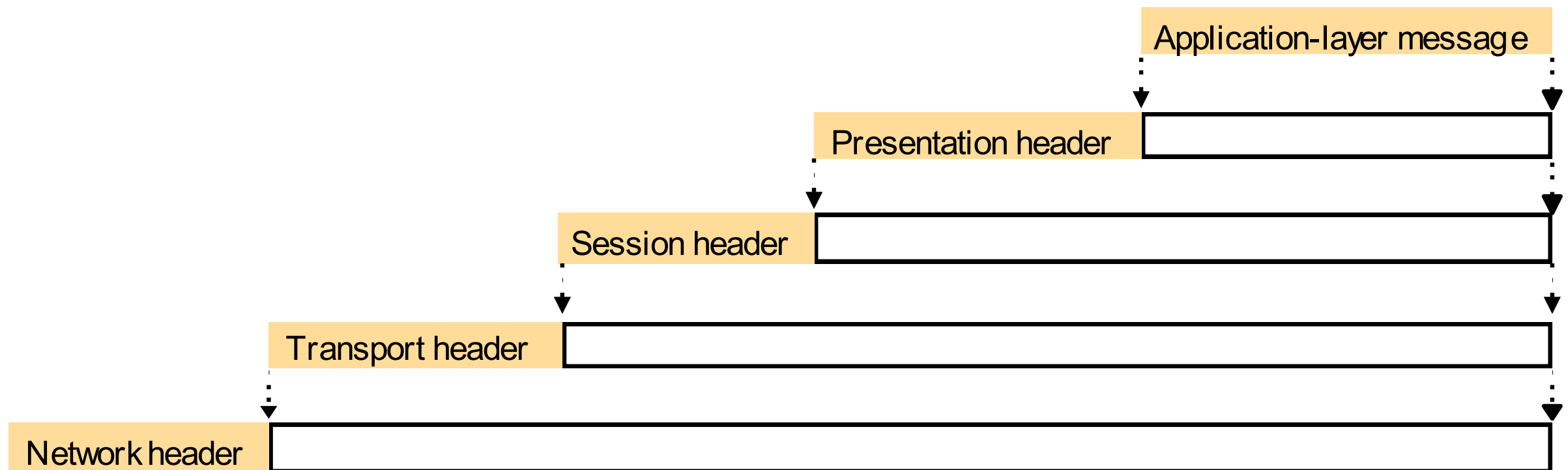


Figure 3.4

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

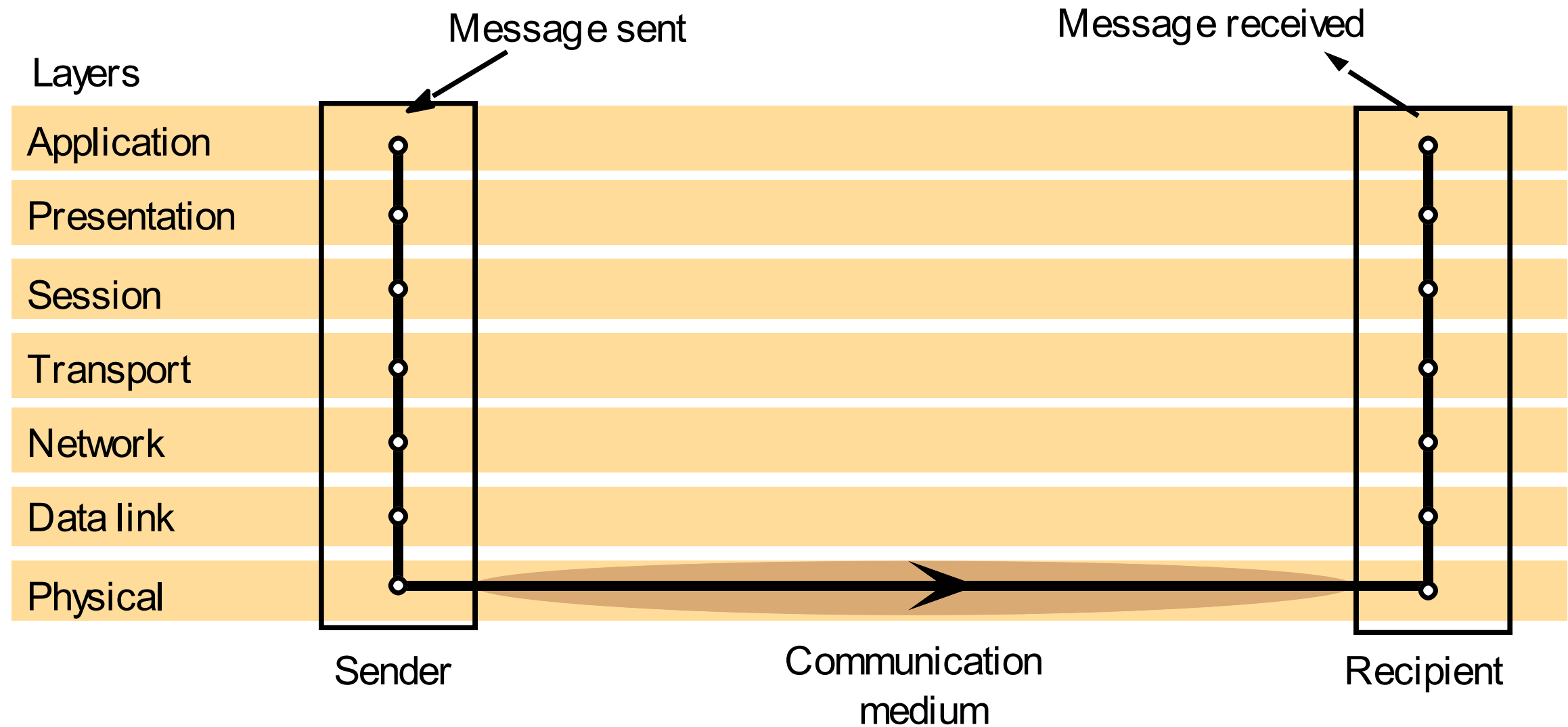


Figure 3.5

OSI protocol summary

<i>Layer</i>	<i>Description</i>	<i>Examples</i>
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

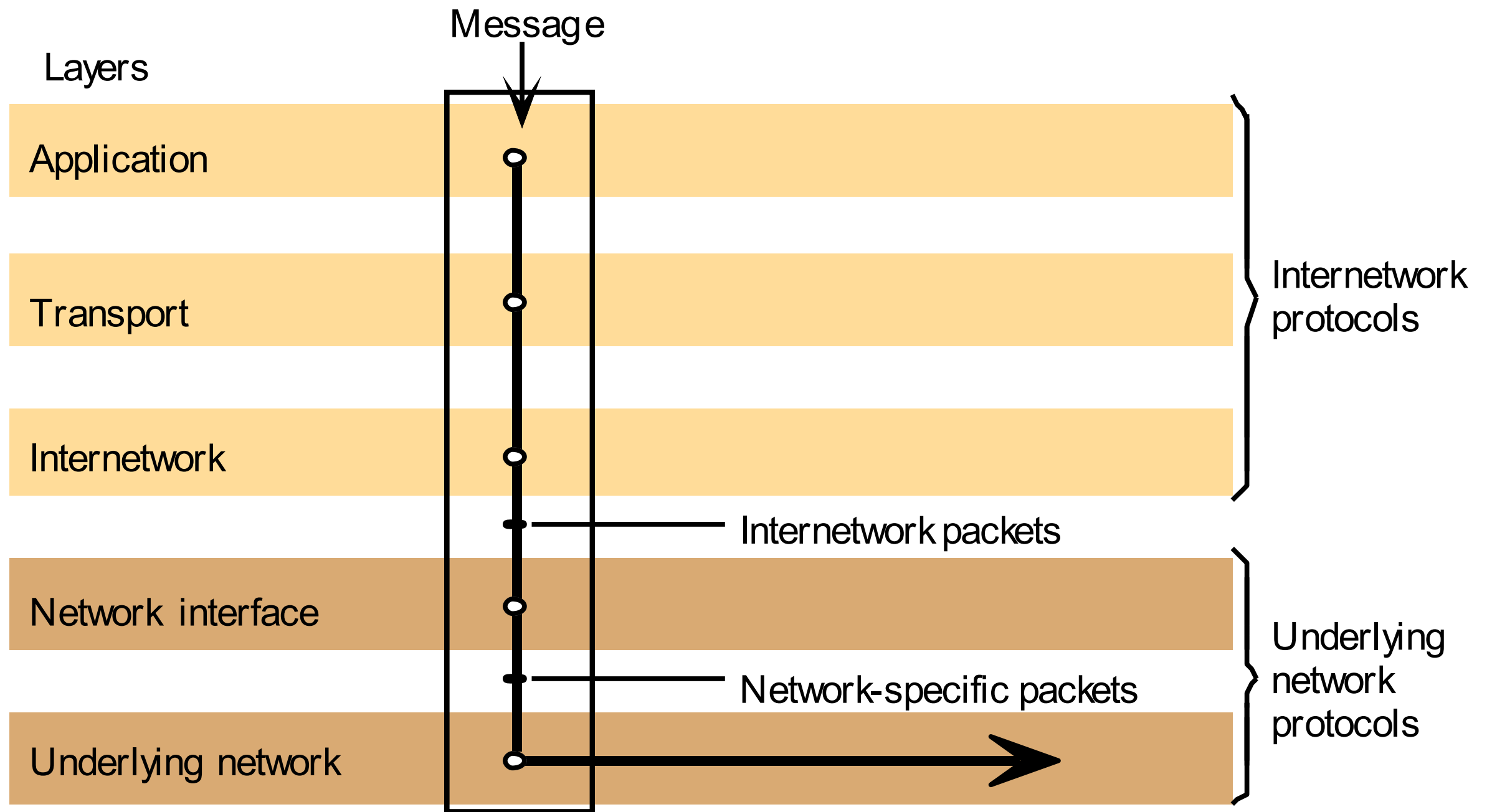


Figure 3.7 Routing in a wide area network

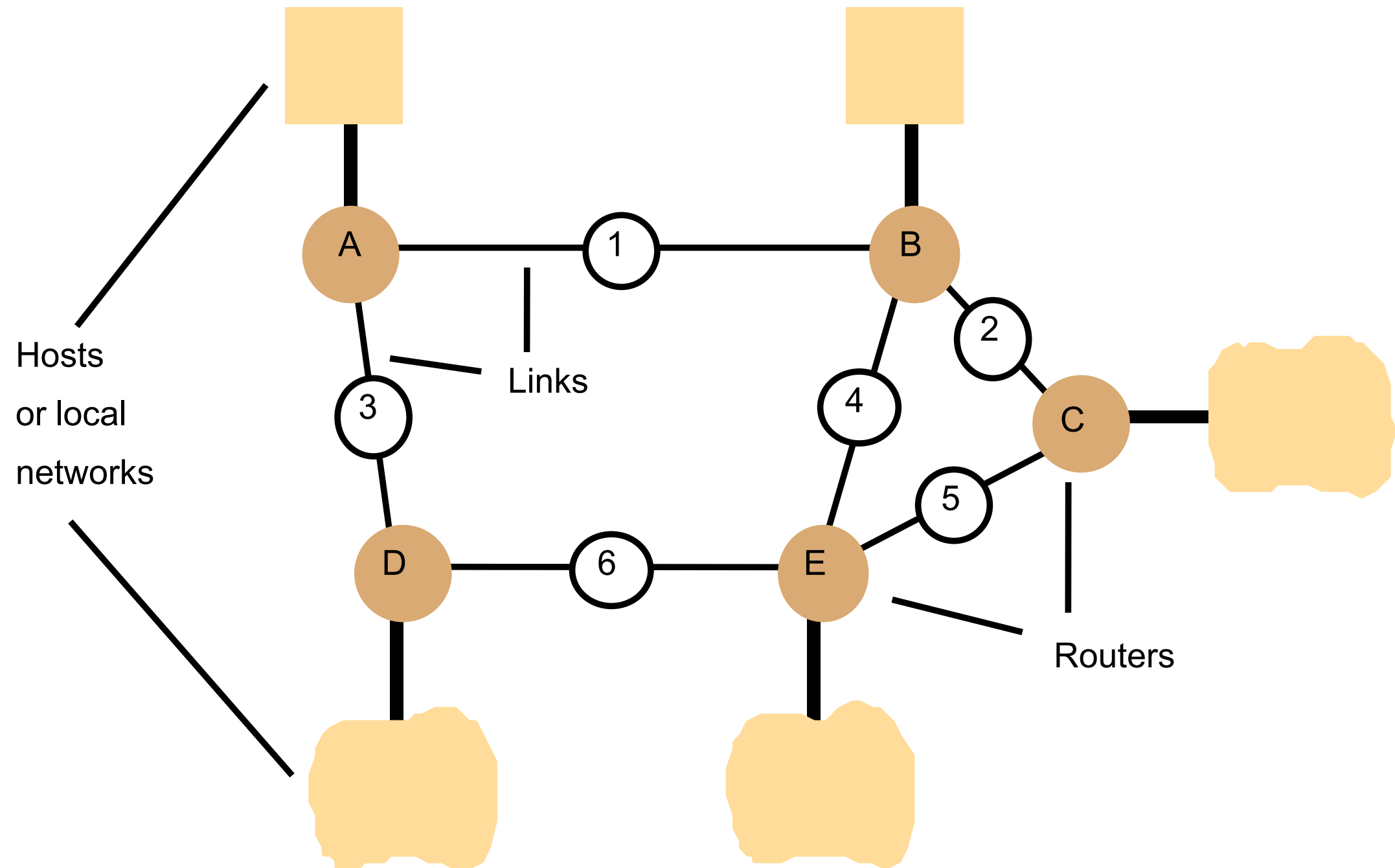


Figure 3.8

Routing tables for the network in Figure 3.7

<i>Routings from A</i>		
<i>To</i>	<i>Link</i>	<i>Cost</i>
A	local	0
B	1	1
C	1	2
D	3	1
E	1	2

<i>Routings from B</i>		
<i>To</i>	<i>Link</i>	<i>Cost</i>
A	1	1
B	local	0
C	2	1
D	1	2
E	4	1

<i>Routings from C</i>		
<i>To</i>	<i>Link</i>	<i>Cost</i>
A	2	2
B	2	1
C	local	0
D	5	2
E	5	1

<i>Routings from D</i>		
<i>To</i>	<i>Link</i>	<i>Cost</i>
A	3	1
B	3	2
C	6	2
D	local	0
E	6	1

<i>Routings from E</i>		
<i>To</i>	<i>Link</i>	<i>Cost</i>
A	4	2
B	4	1
C	5	1
D	6	1
E	local	0

Figure 3.9

Pseudo-code for RIP routing algorithm

Send: Each t seconds or when Tl changes, send Tl on each non-faulty outgoing link.

Receive: Whenever a routing table Tr is received on link n :

```
for all rows  $Rr$  in  $Tr$  {
  if ( $Rr.link \mid n$ ) {
     $Rr.cost = Rr.cost + 1$ ;
     $Rr.link = n$ ;
    if ( $Rr.destination$  is not in  $Tl$ ) add  $Rr$  to  $Tl$ ;
    // add new destination to  $Tl$ 
  } else for all rows  $Rl$  in  $Tl$  {
    if ( $Rr.destination = Rl.destination$  and
        ( $Rr.cost < Rl.cost$  or  $Rl.link = n$ ))  $Rl = Rr$ ;
    //  $Rr.cost < Rl.cost$  : remote node has better route
    //  $Rl.link = n$  : remote node is more authoritative
  }
}
```

Figure 3.10

Simplified view of part of a university campus network

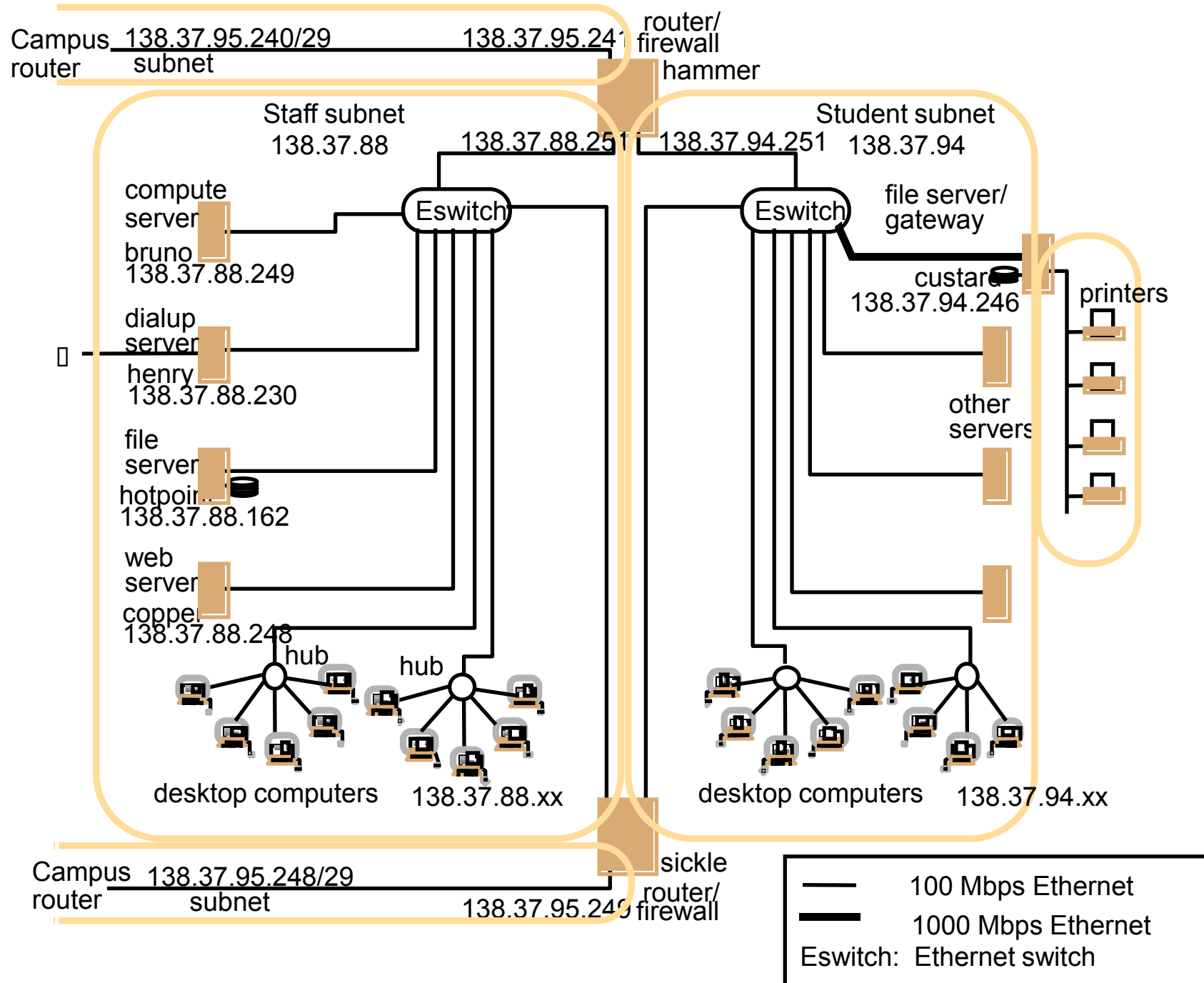


Figure 3.11 Tunnelling for IPv6 migration

IPv6 encapsulated in IPv4 packets

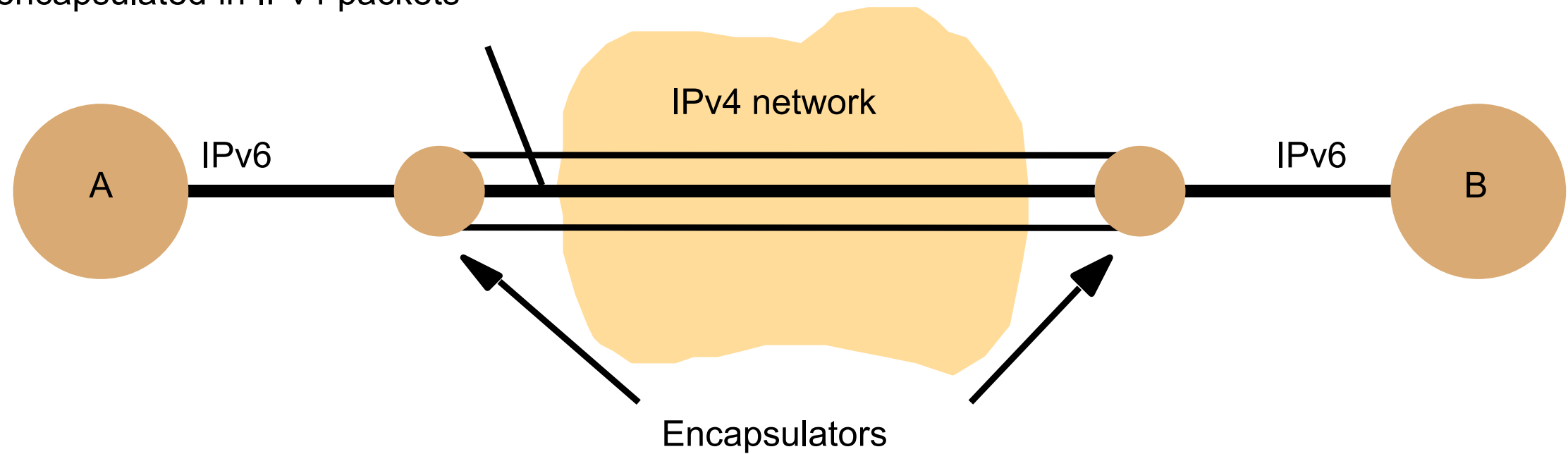


Figure 3.12 TCP/IP layers

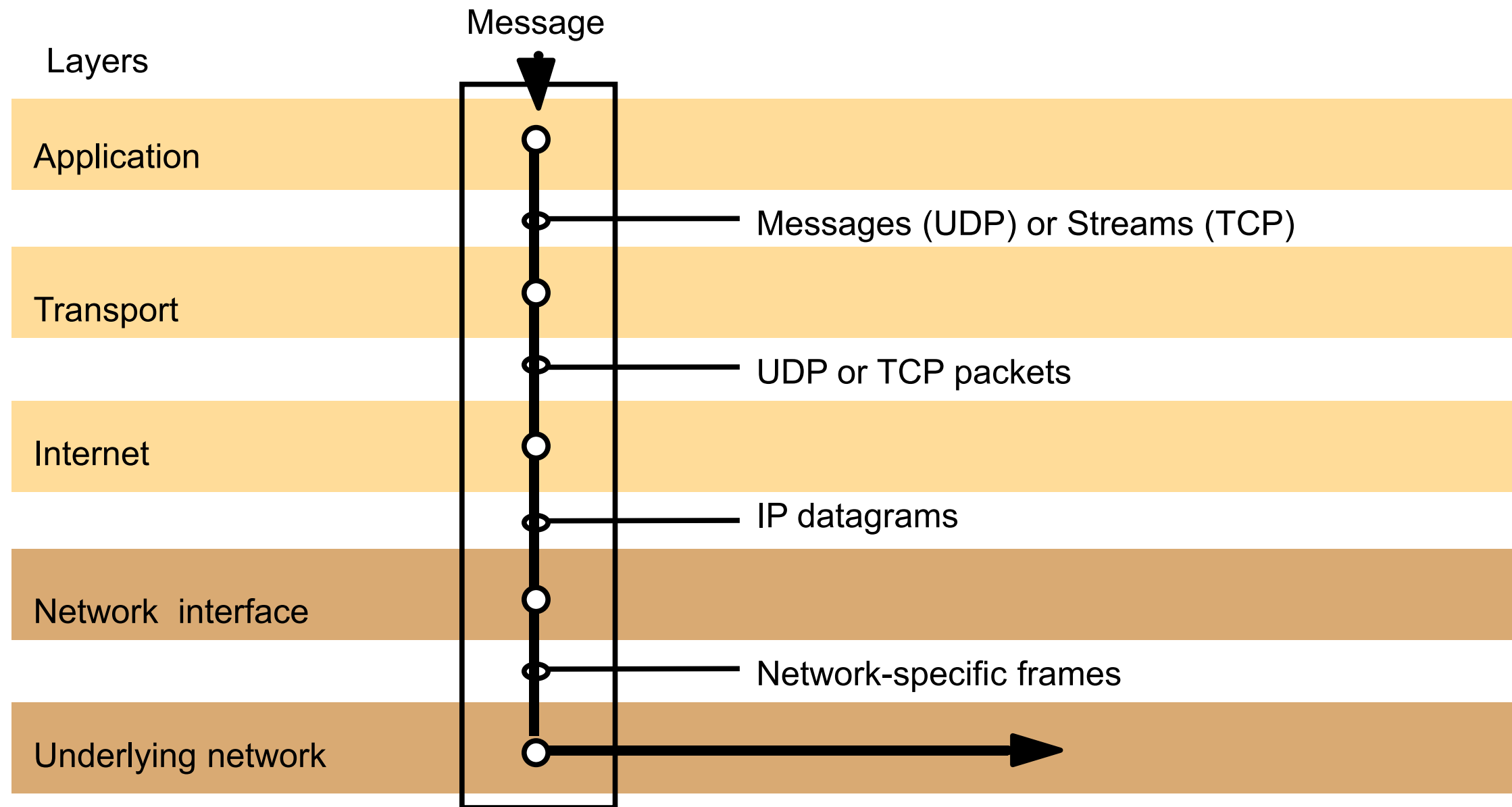


Figure 3.13

Encapsulation in a message transmitted via TCP over an Ethernet

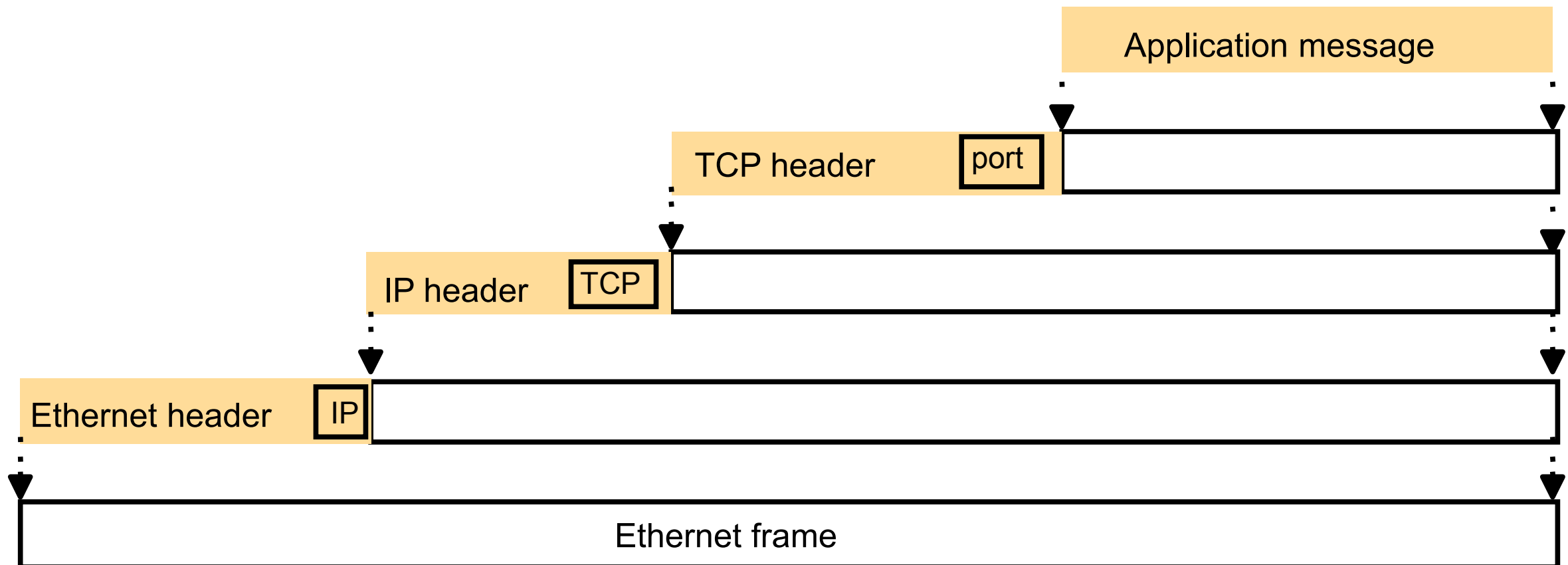


Figure 3.14

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

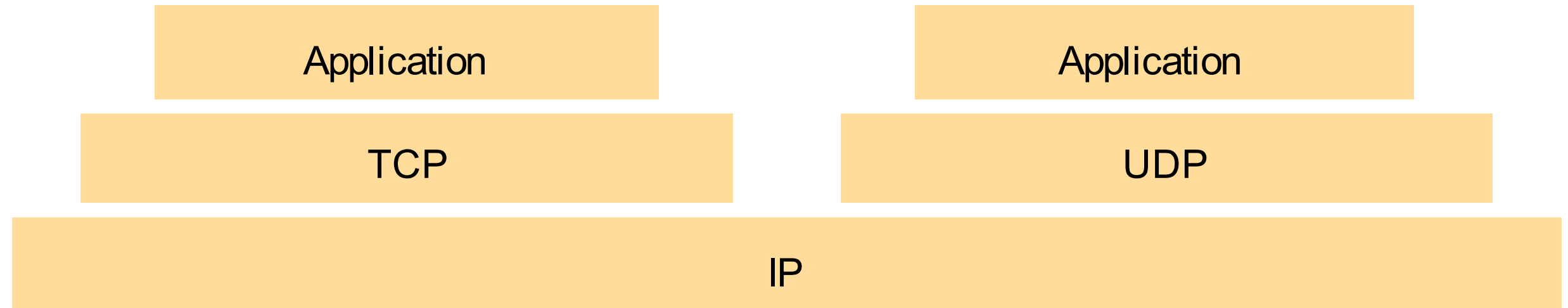


Figure 3.15

Internet address structure, showing field sizes in bits

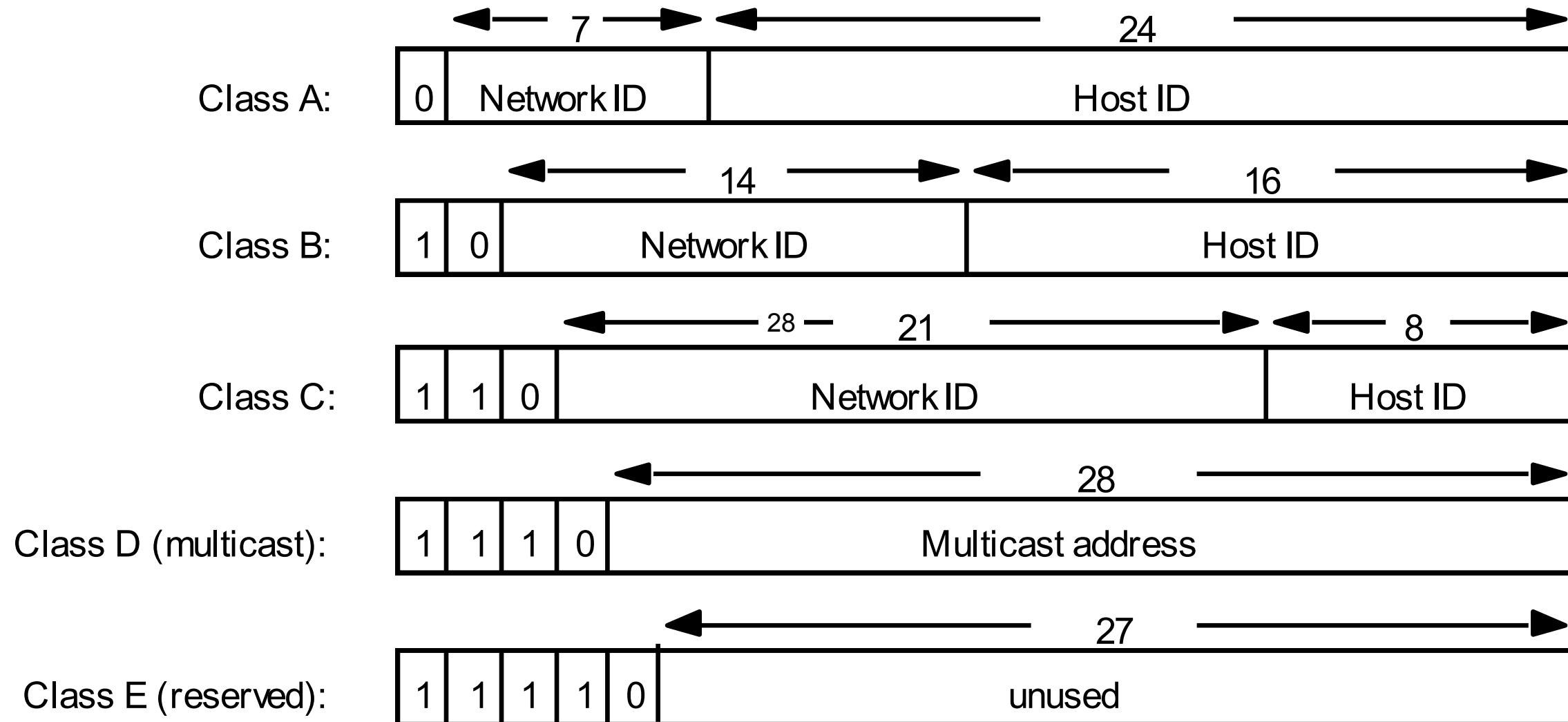


Figure 3.16

Decimal representation of Internet addresses

	octet 1	octet 2	octet 3		Range of addresses
Class A:	Network ID 1 to 127	0 to 255	Host ID 0 to 255	0 to 255	1.0.0.0 to 127.255.255.255
Class B:	128 to 191	Network ID 0 to 255	Host ID 0 to 255	0 to 255	128.0.0.0 to 191.255.255.255
Class C:	192 to 223	0 to 255	0 to 255	Host ID 1 to 254	192.0.0.0 to 223.255.255.255
Class D (multicast):	224 to 239	Multicast address		1 to 254	224.0.0.0 to 239.255.255.255
Class E (reserved):	240 to 255	0 to 255	0 to 255	1 to 254	240.0.0.0 to 255.255.255.255

Figure 3.17

IP packet layout

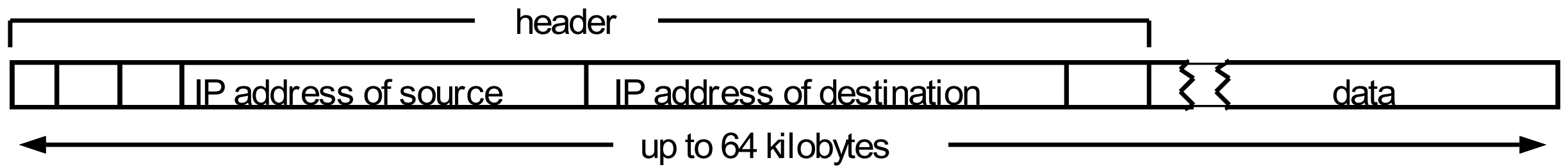


Figure 3.18

A typical NAT-based home network

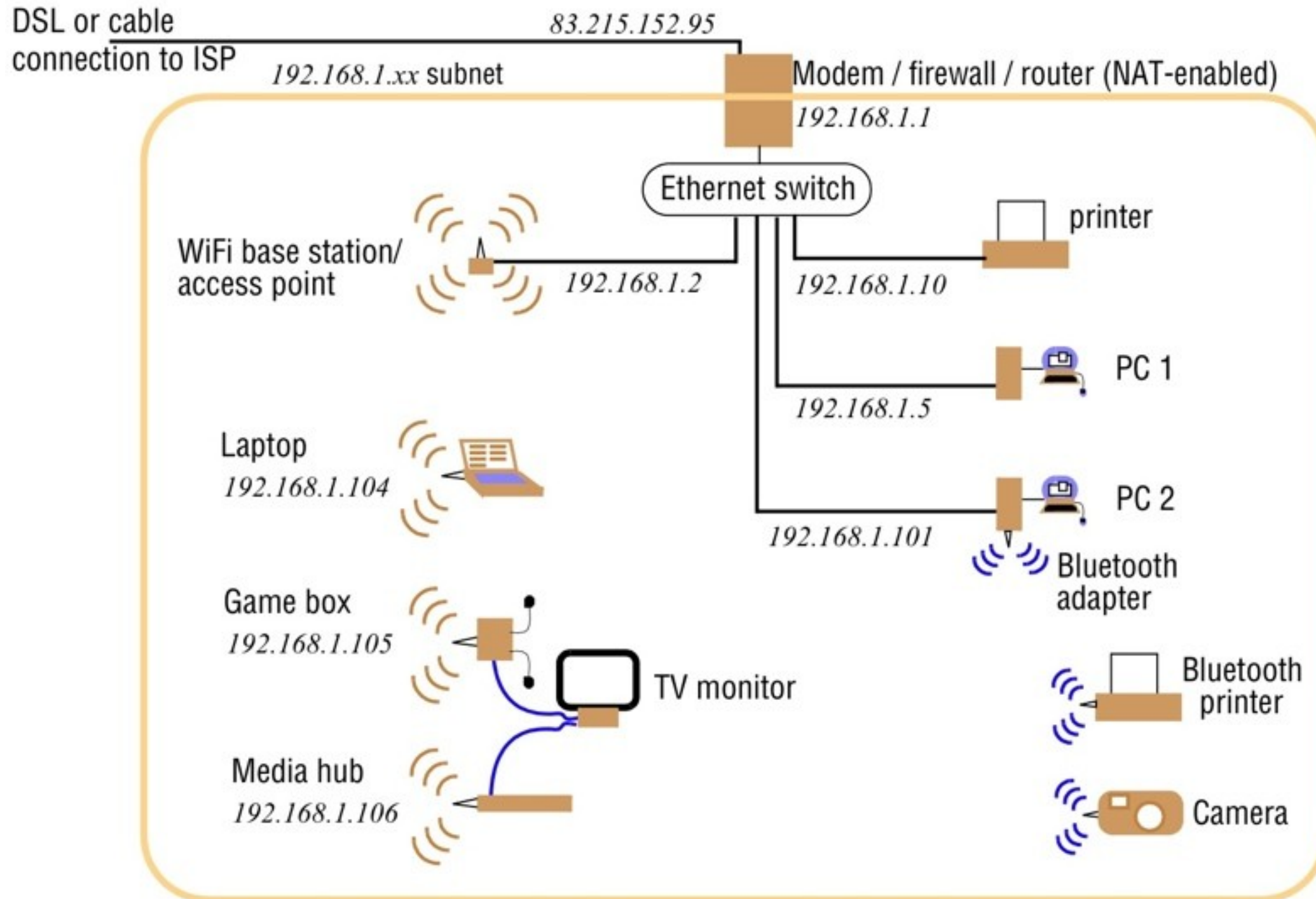


Figure 3.19

IPv6 header layout

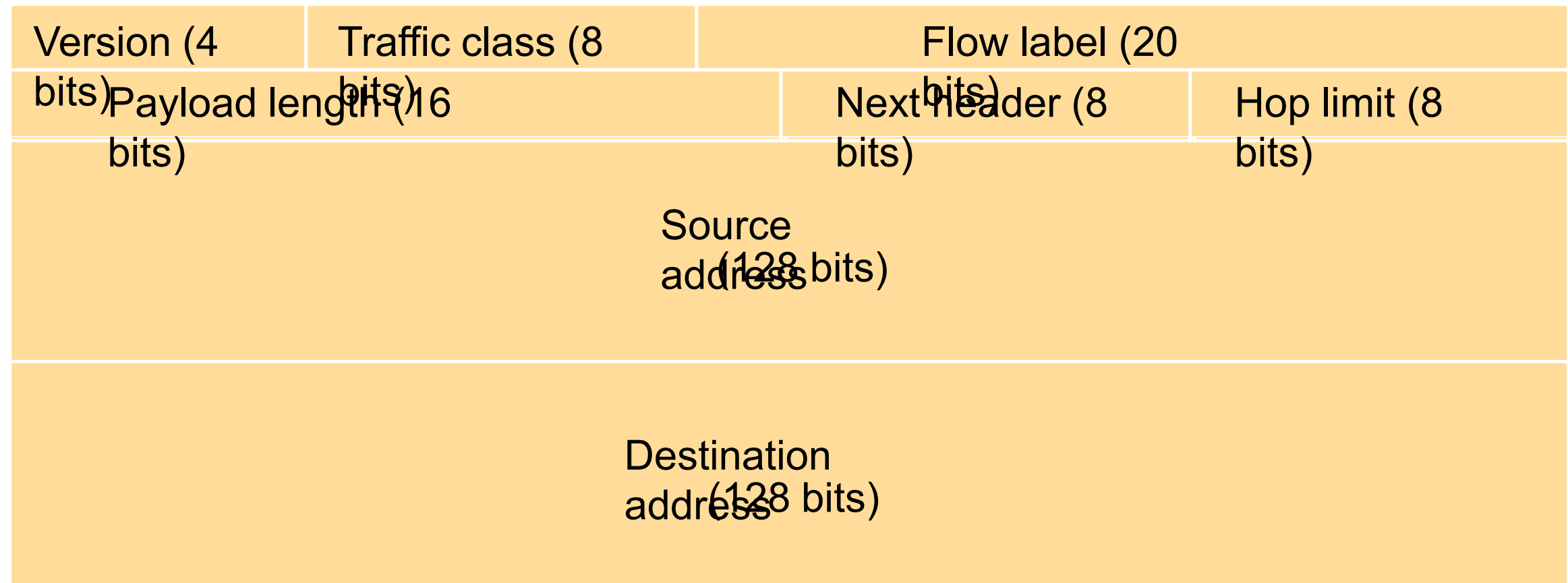


Figure 3.20

The MobileIP routing mechanism

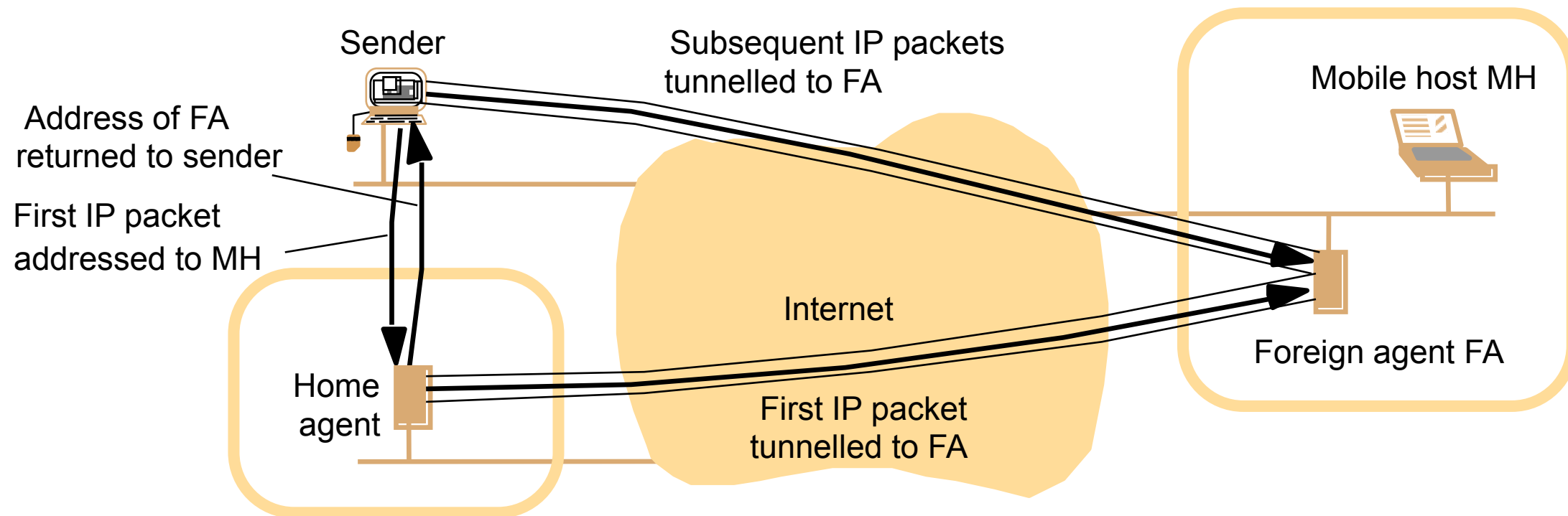
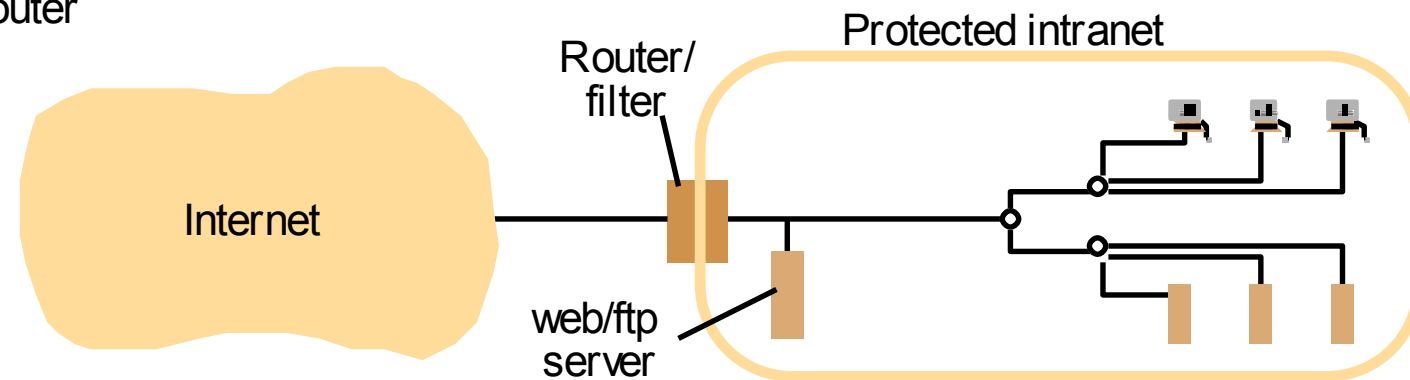


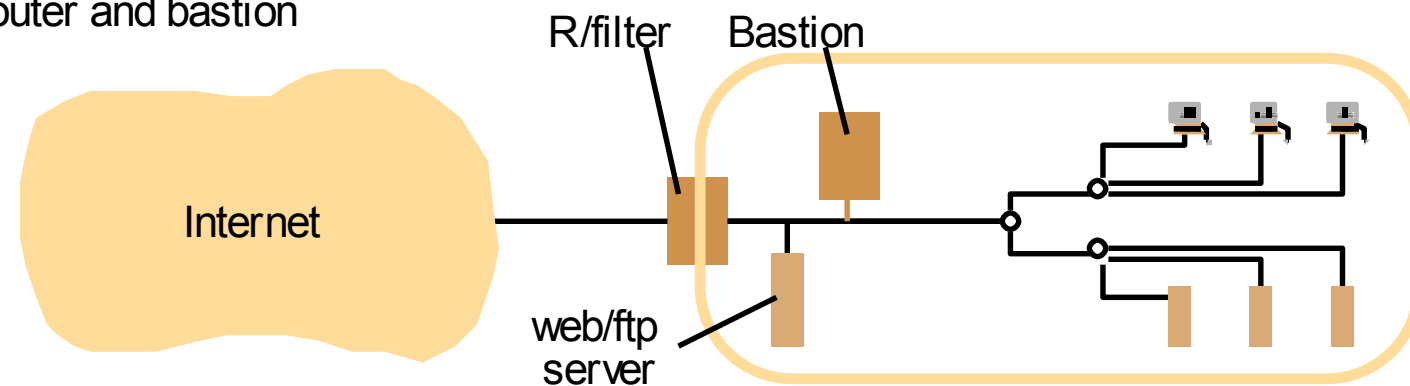
Figure 3.21

Firewall configurations

a) Filtering router



b) Filtering router and bastion



c) Screened subnet for bastion

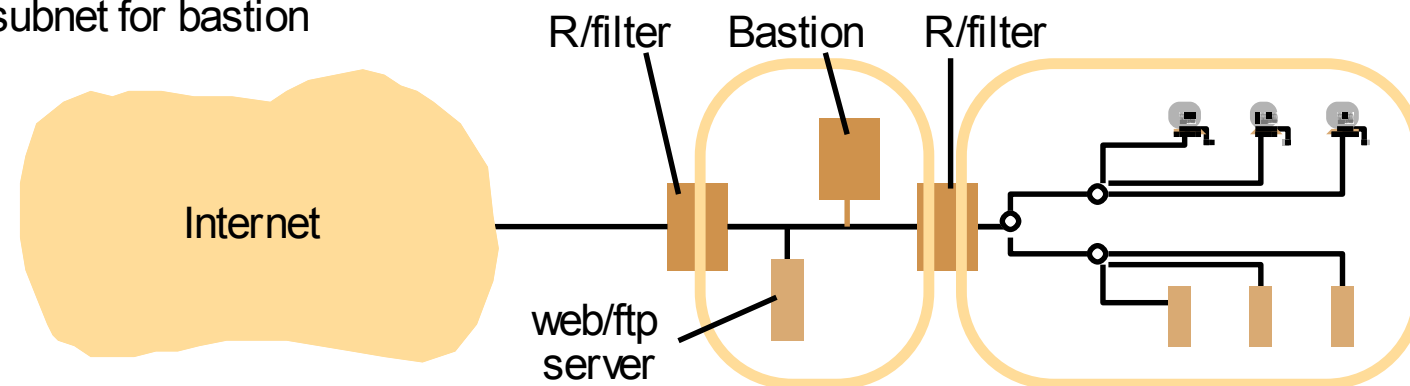


Figure 3.22

IEEE 802 network standards

<i>IEEE No.</i>	<i>Name</i>	<i>Title</i>	<i>Reference</i>
802.3	Ethernet	CSMA/CD Networks (Ethernet)	[IEEE 1985a]
802.4		Token Bus Networks	[IEEE 1985b]
802.5		Token Ring Networks	[IEEE 1985c]
802.6		Metropolitan Area Networks	[IEEE 1994]
802.11	WiFi	Wireless Local Area Networks	[IEEE 1999]
802.15.1	Bluetooth	Wireless Personal Area Networks	[IEEE 2002]
802.15.4	ZigBee	Wireless Sensor Networks	[IEEE 2003]
802.16	WiMAX	Wireless Metropolitan Area Networks	[IEEE 2004a]

Figure 3.23 Ethernet ranges and speeds

	<i>10Base5</i>	<i>10BaseT</i>	<i>100BaseT</i>	<i>1000BaseT</i>
Data rate	10 Mbps	10 Mbps	100 Mbps	1000 Mbps
<i>Max. segment lengths:</i>				
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

Figure 3.24 Wireless LAN configuration

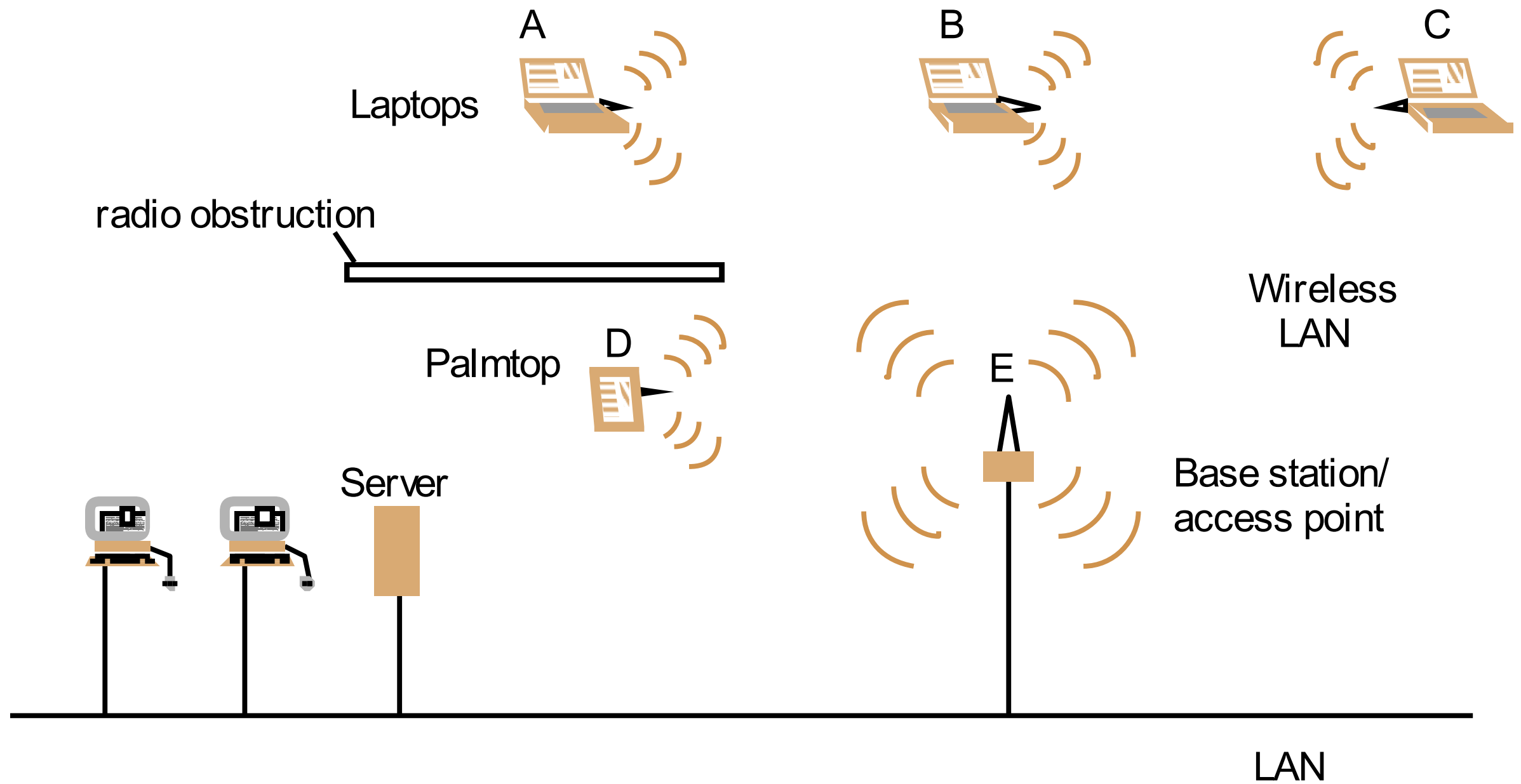
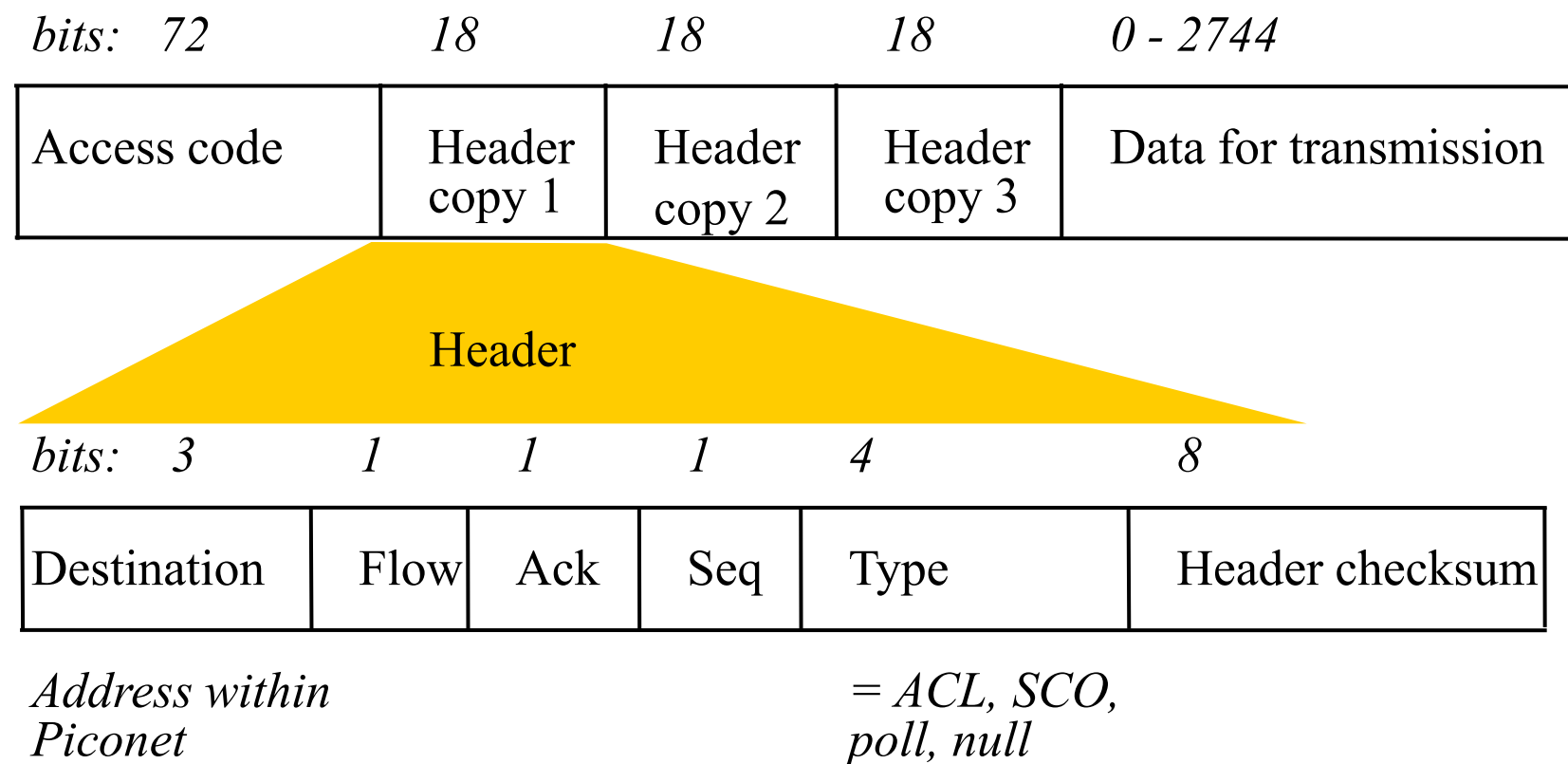


Figure 3.25 Bluetooth frame structure



SCO packets (e.g. for voice data) have a 240-bit payload containing 80 bits of data triplicated, filling exactly one timeslot.