D Kommunikation & Rechnernetze

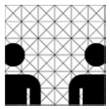
D1 Einführung und Motivation

D2 Technischer Überblick

D3 Lokale Rechnernetze

D4 Einige Gemeinsamkeiten von Betriebssystemen und Rechnernetzen: Architekturmodelle und Dienst-hierarchien

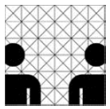
D2 aus: Coulouris/Dollimore/Kindberg: **“Distributed Systems - Concepts and Design”, 5. Ausg., Pearson, 2012**



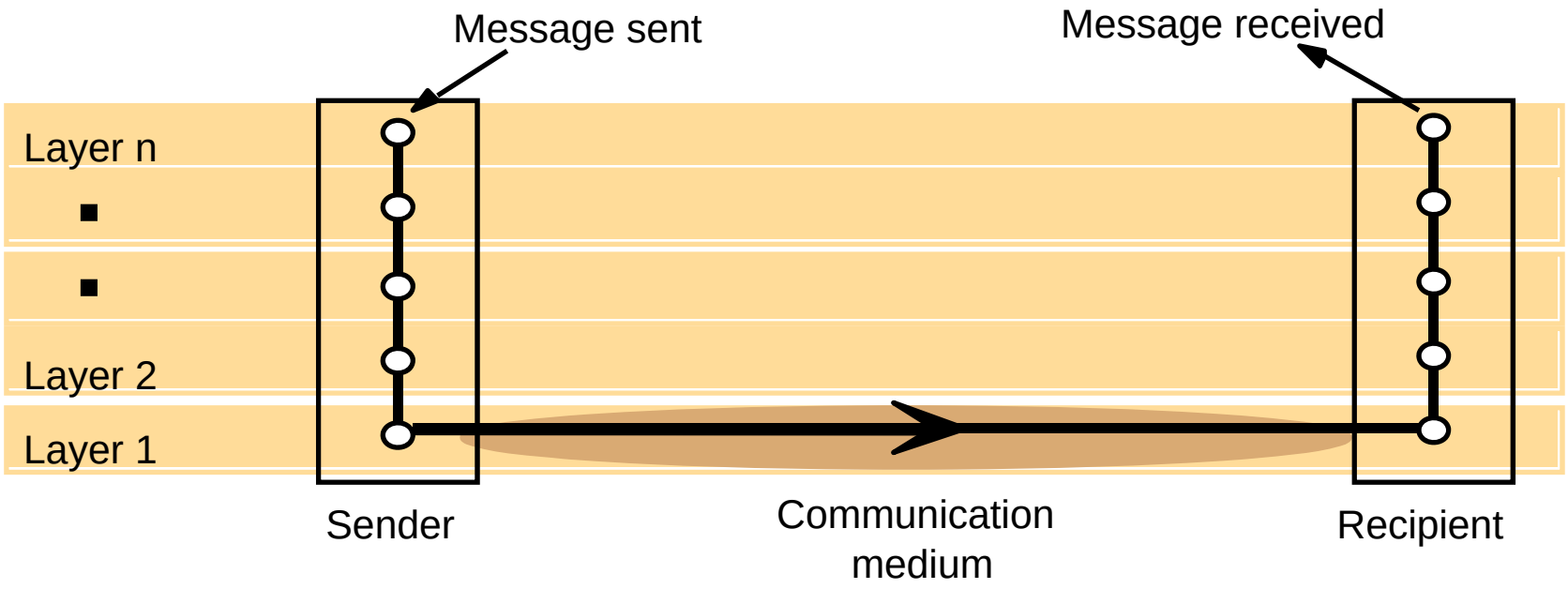
Communication Systems: Network types

	Range	*Bandwidth (Mbps)*	*Latency (ms)*
LAN	1-2 kms	10-1000	1-10
WAN	worldwide	0.010-600	100-500
MAN	2-50 kms	1-150	10
Wireless LAN	0.15-1.5 km	2-11	5-20
Wireless WAN	worldwide	0.010-2	100-500
Internet	worldwide	0.05-600	100-500
WPAN (Bluetooth)	10-30m	0.5-2	5-20
WiFi	0.15-1.5 km	11-108	5-20
WiMAX	5-50 km	1.5-20	5-20
WWAN/GSM3G	worldwide	348-14.4	100-500
LTE	worldwide	100-300	…

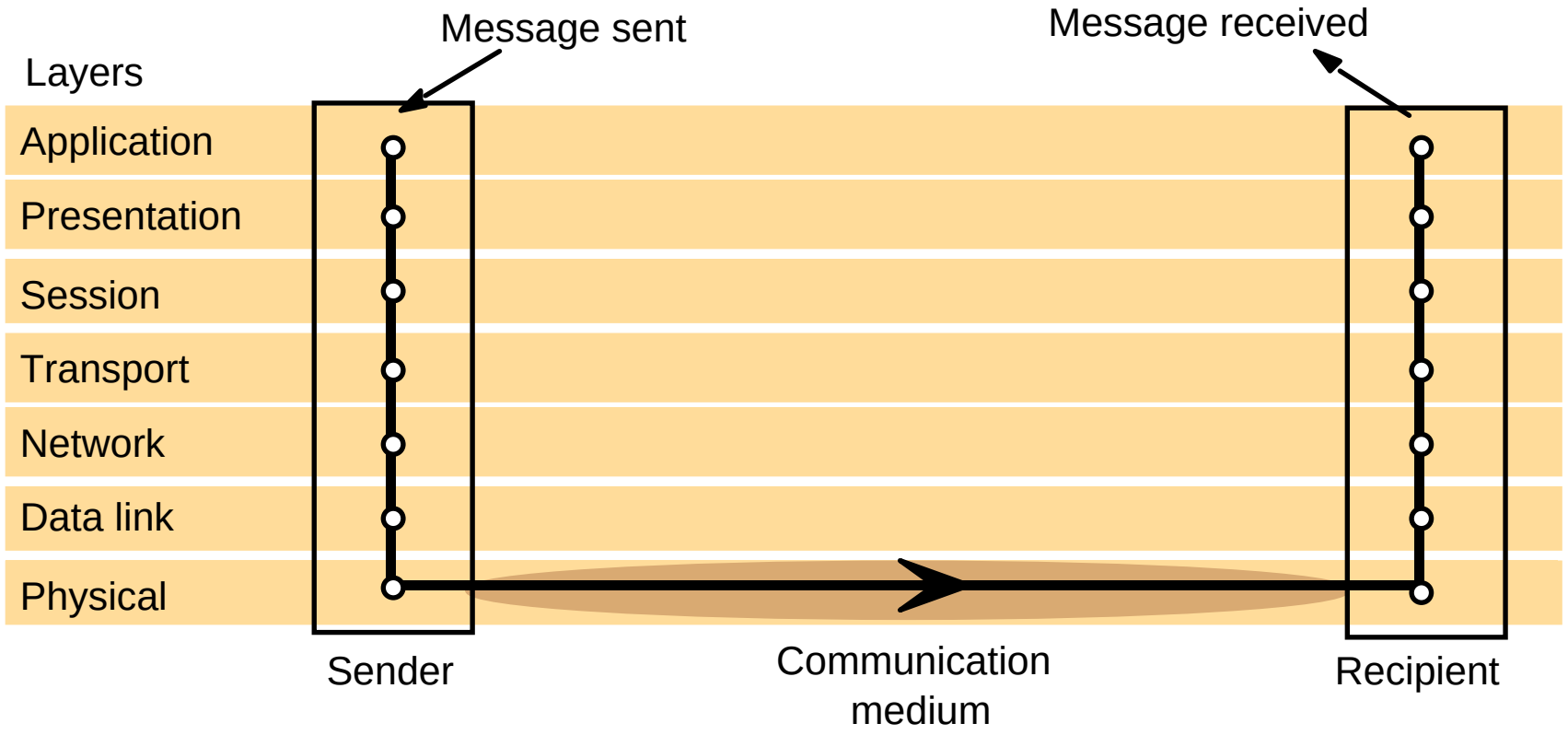
(Stand: ab ca. 2000+)



Principles of Communication Networks (1): *Conceptual layering of protocol software*

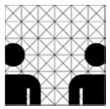


Example: Protocol Layers in the ISO Open Systems Interconnection (ISO/OSI) Model Example

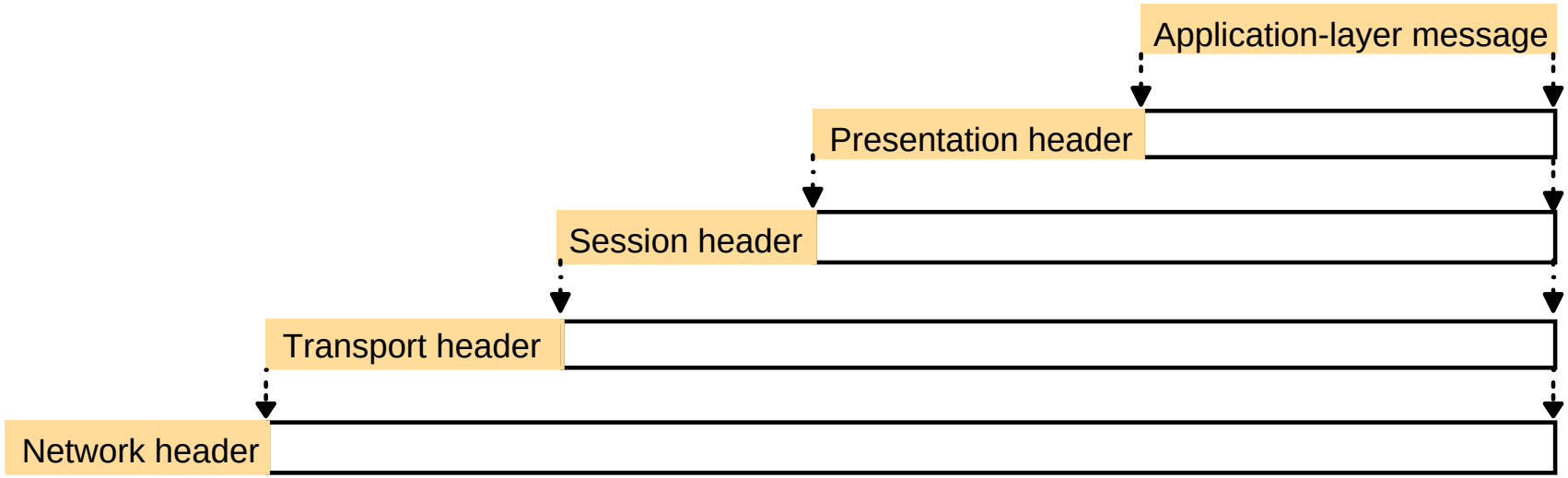


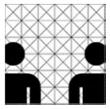
ISO/OSI Protocol Layer Summary

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

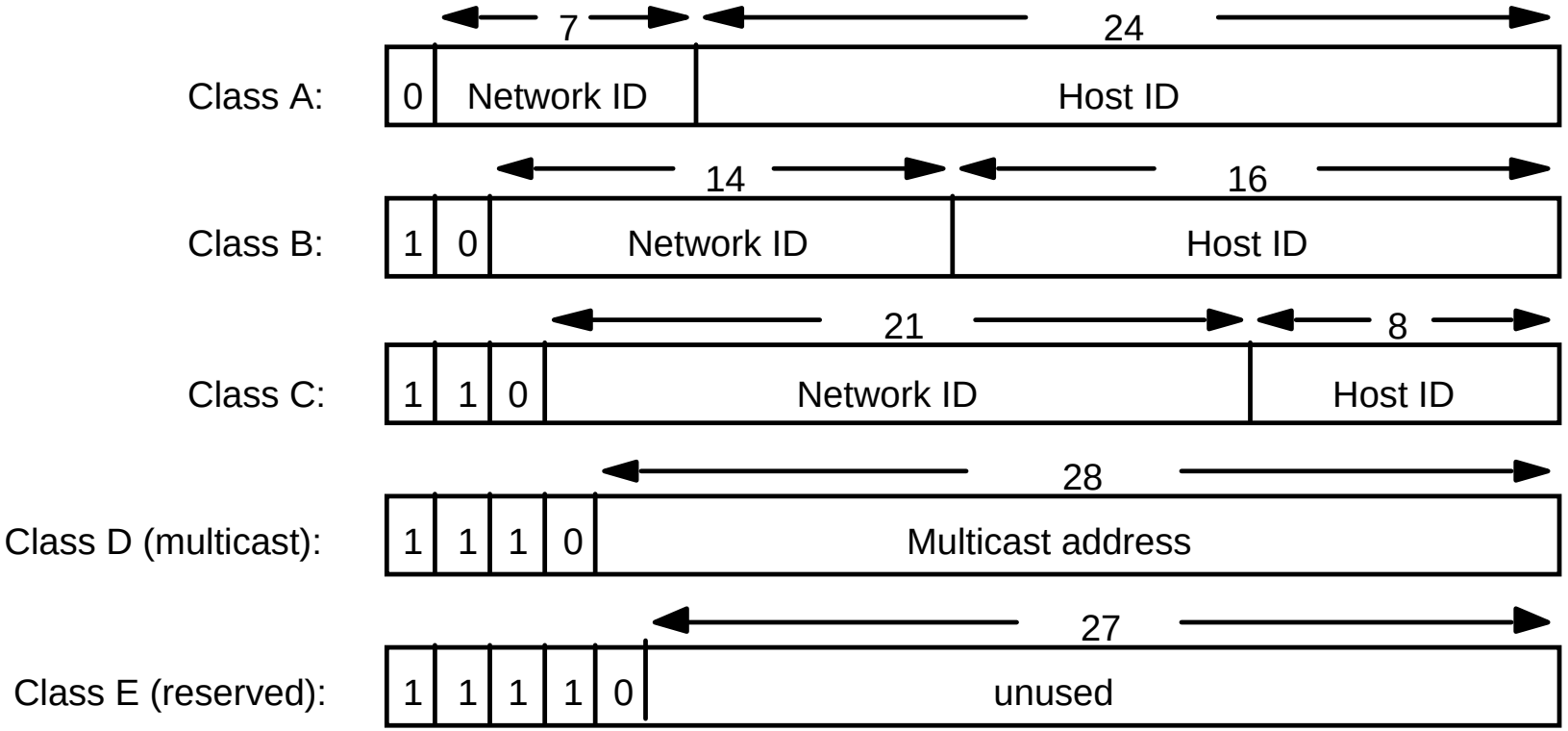


Layering of Protocol Data Units – Encapsulation as it is applied in layered protocols

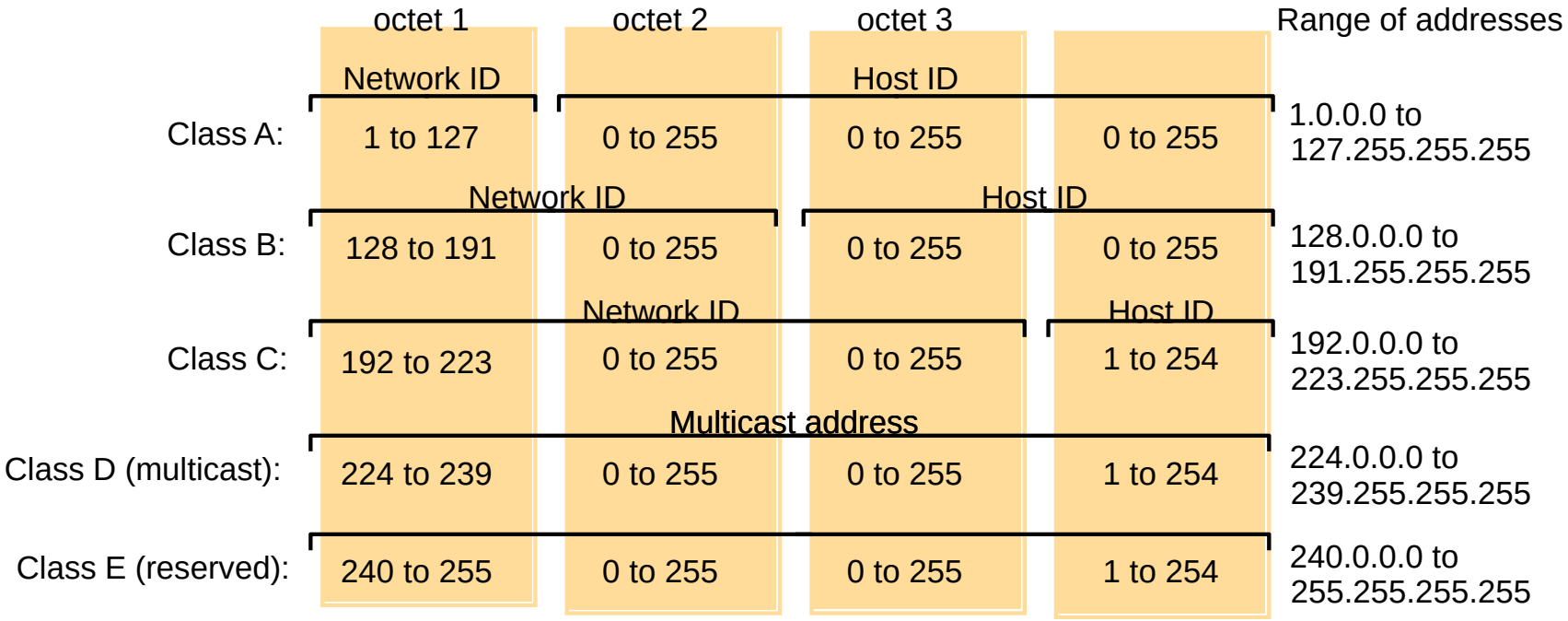


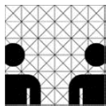


Principles of Communication Networks (2): *Addressing* – Internet address structure, showing field sizes in bits

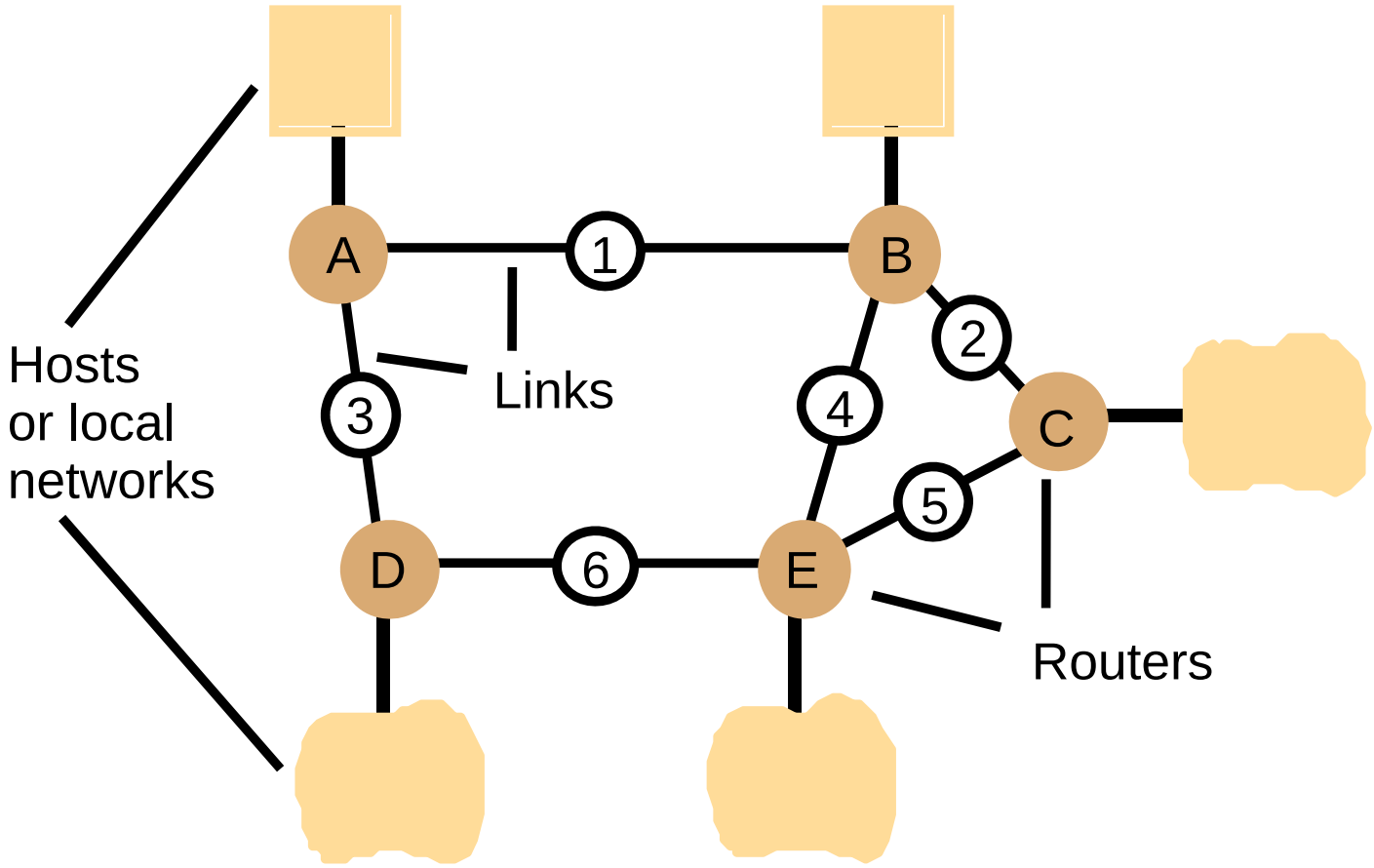


Decimal representation of Internet addresses





Principles of Communication Networks (3): *Routing* in a wide area network



Routing tables for the network in previous foil

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

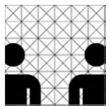
To	*Link*	*Cost*
A	2	2
B	2	1
C	local	0
D	5	2
E	5	1

Routings from D

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

Routings from E

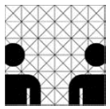
To	*Link*	*Cost*
A	4	2
B	4	1
C	5	1
D	6	1
E	local	0



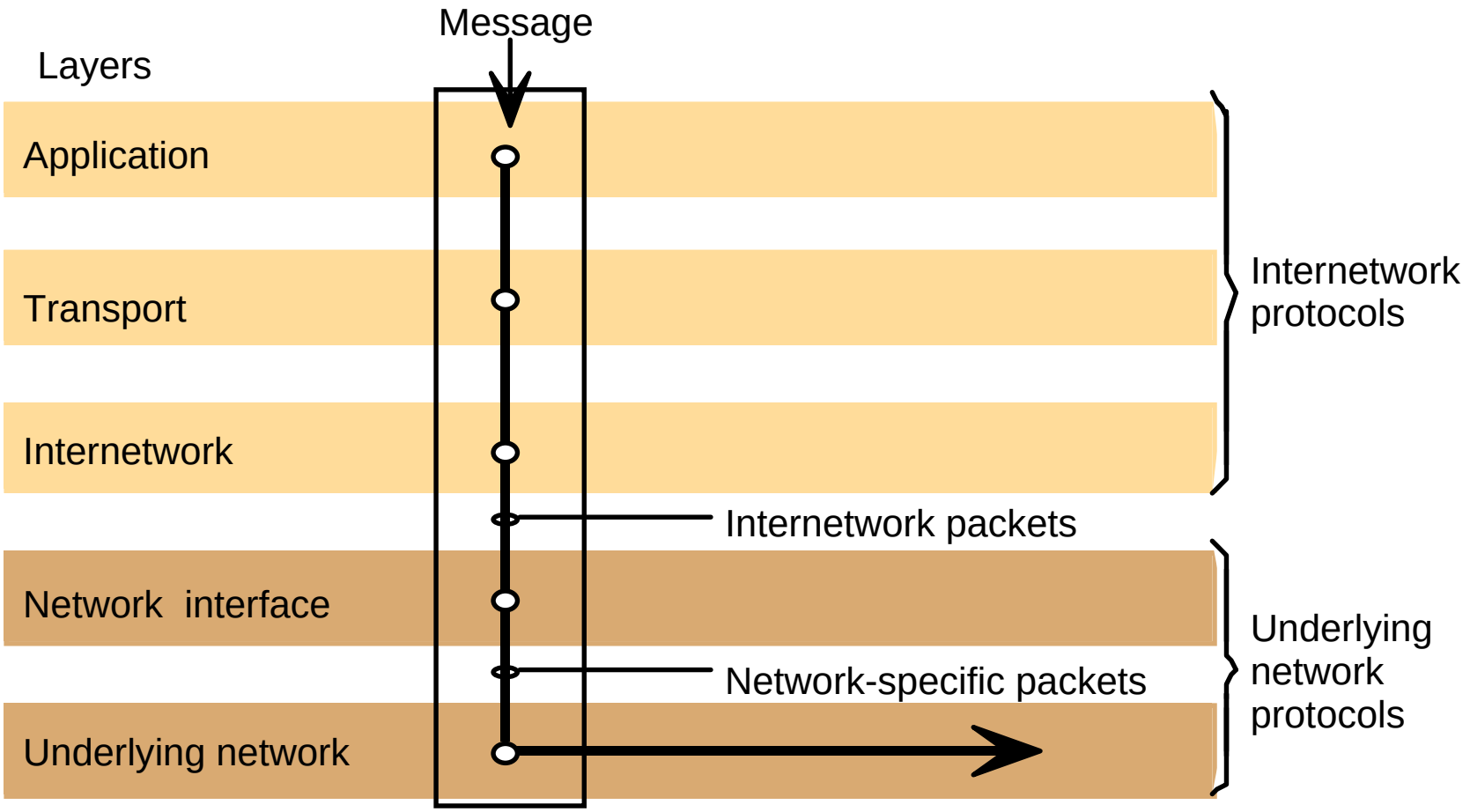
Example routing algorithm (Router Info Protocol, RIP)

Send: Each *t* seconds or when local table *Tl* changes, send *Tl* on each non-faulty outgoing link.
Receive: Whenever a routing table *Tr* is received on link *n*:

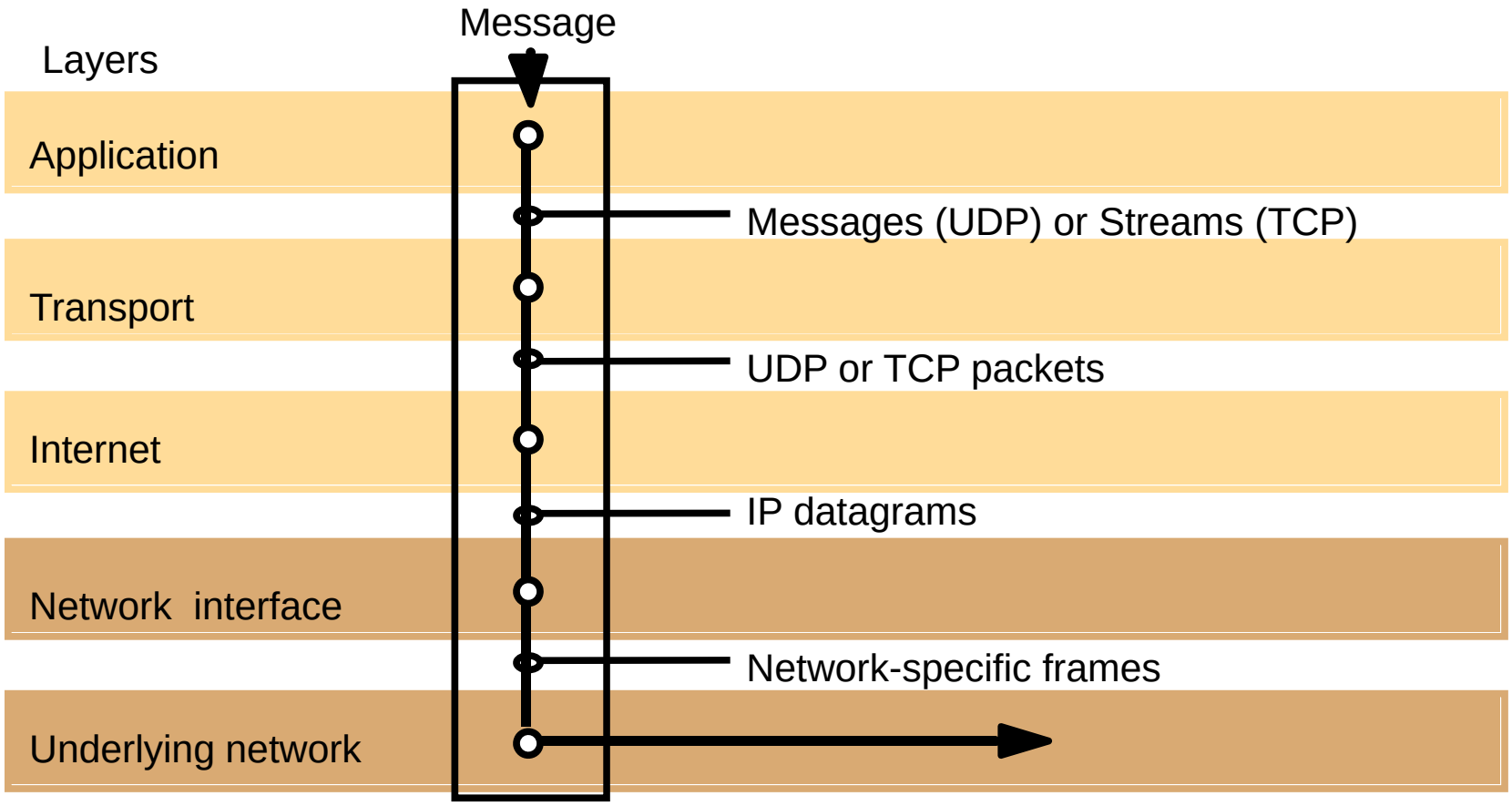
```
for all rows Rr in Tr {
    if (Rr.link ≠ n) {
        Rr.cost = Rr.cost + 1;
        Rr.link = n;
        if (Rr.destination is not in Tl) add Rr to Tl;
         // add new destination to Tl
        else for all rows Rl in Tl {
            if (Rr.destination = Rl.destination and
                    (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
        }
    }
}
```



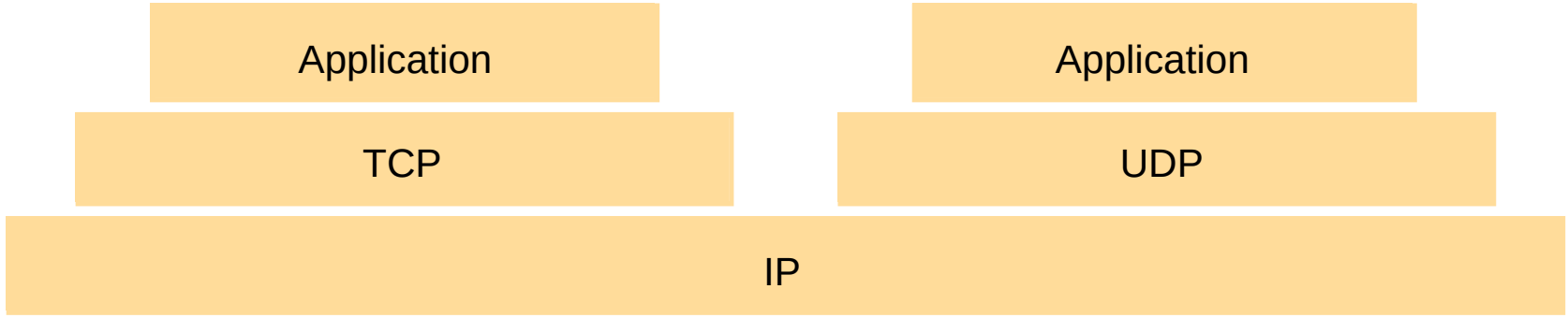
Principles of Communication Networks (4): Simplified Internetwork Layers

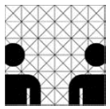


Example: TCP/IP Protocol Layers

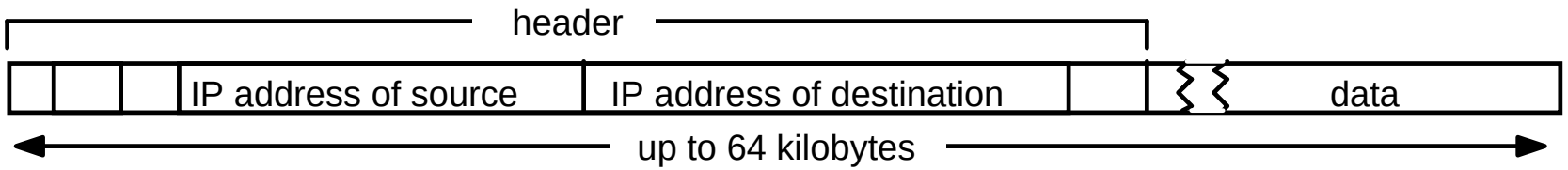


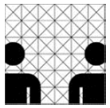
The programmer's conceptual view of a TCP/IP Internet



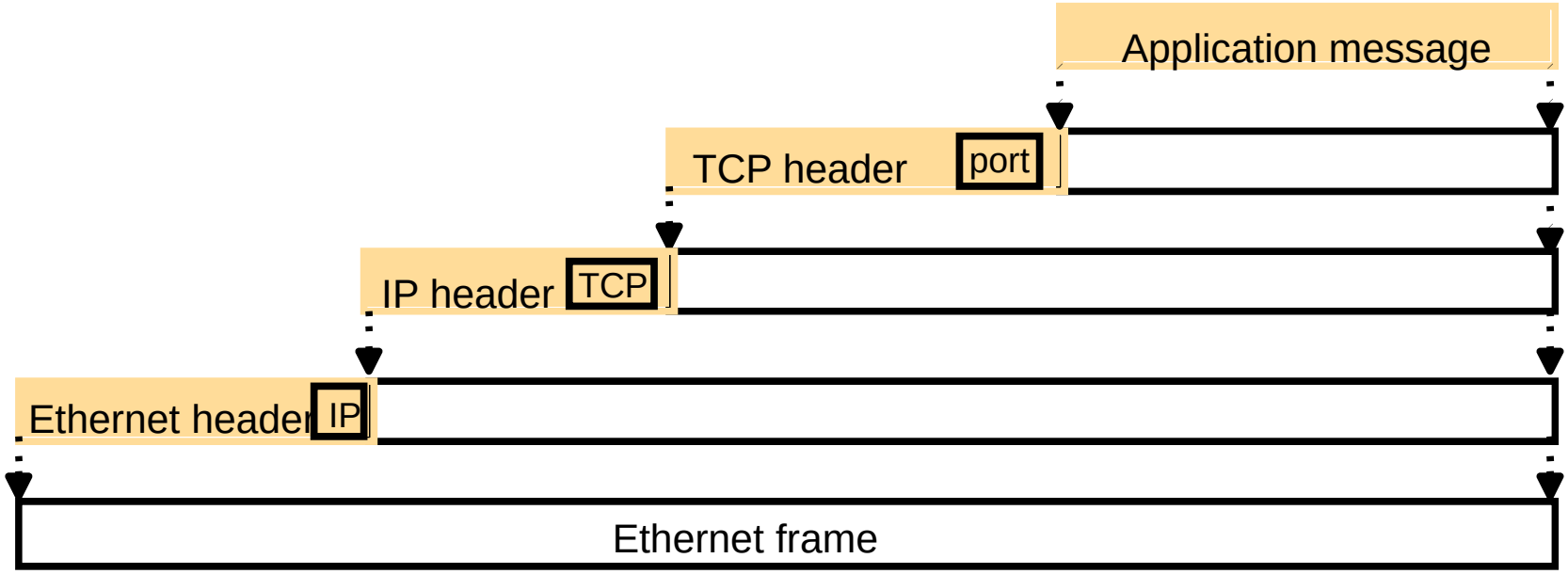


IP packet layout

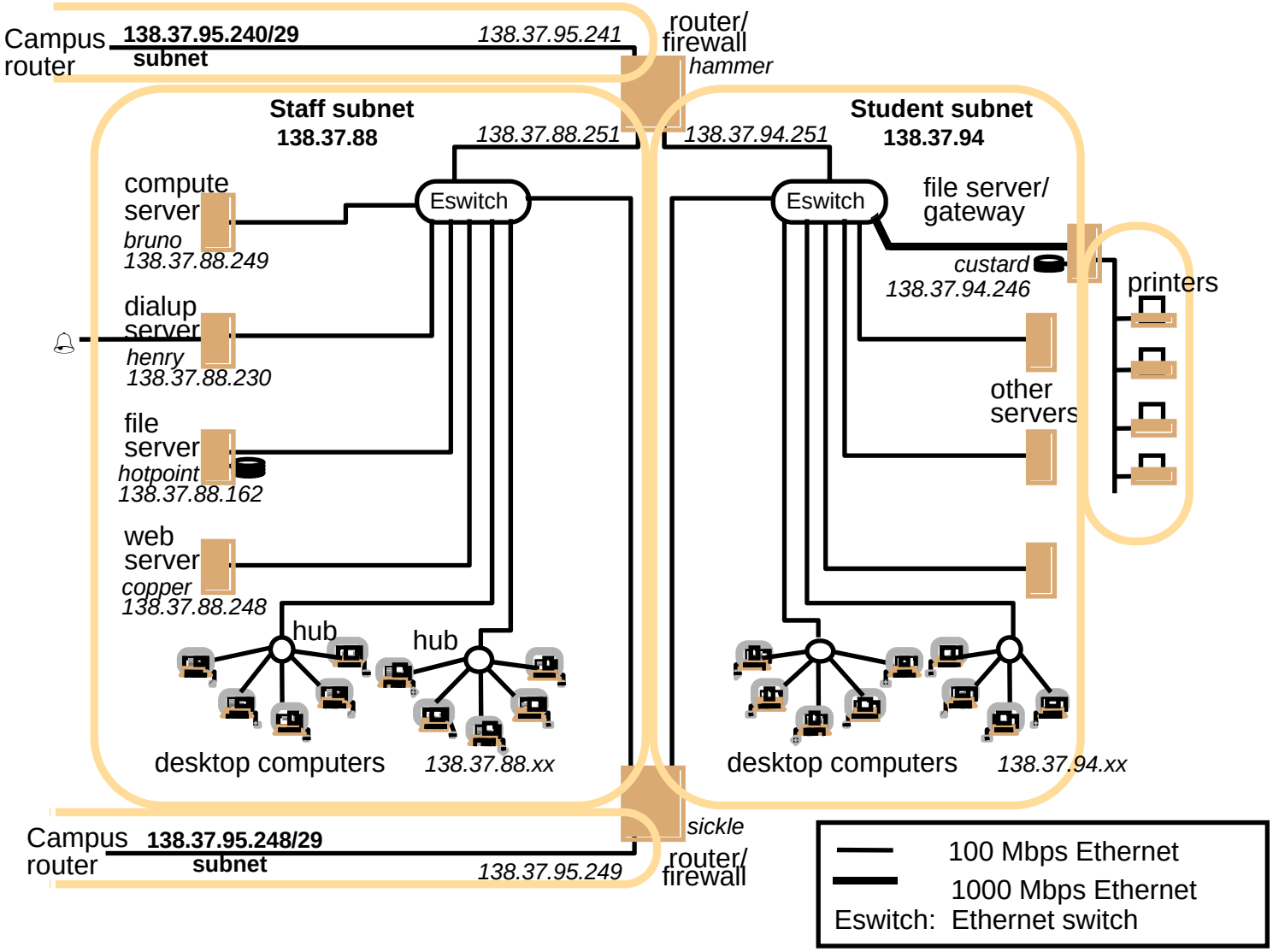


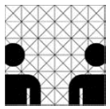


Message encapsulation in data packets transmitted via TCP over an Ethernet

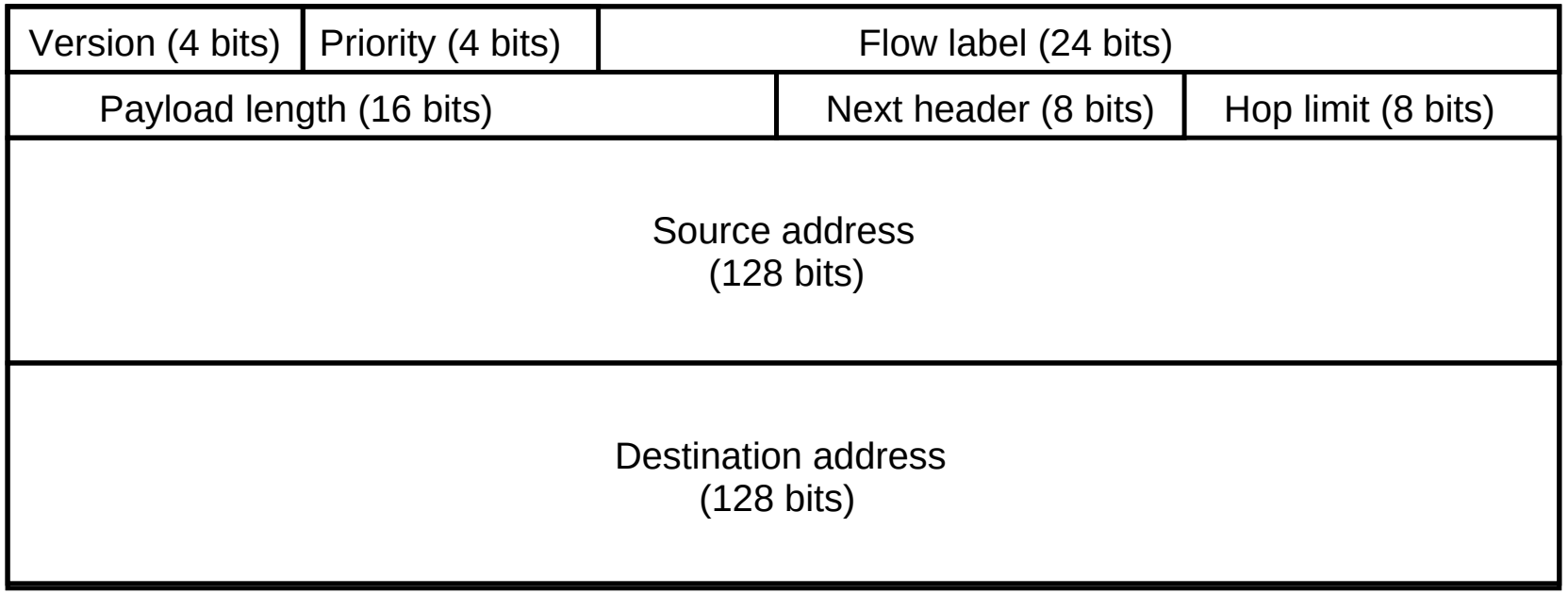


Example: Simplified View of a Computer Science Department Network

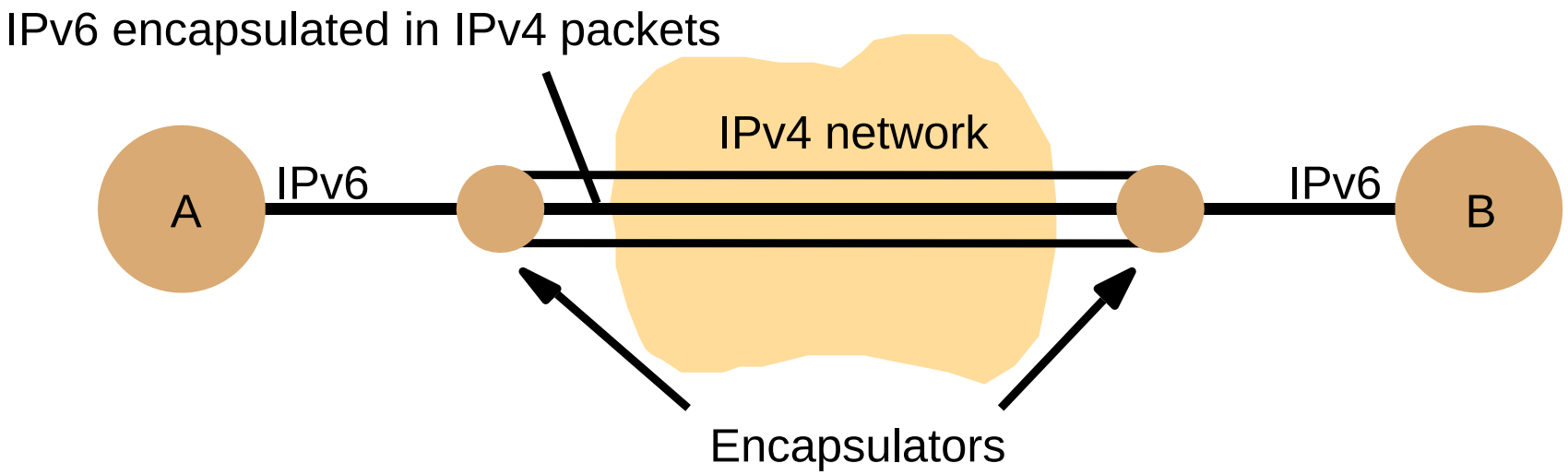




Principles of Communication Networks (5): Extension A: *IPv6 – Header Layout*

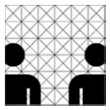


Tunnelling for IPv6 migration

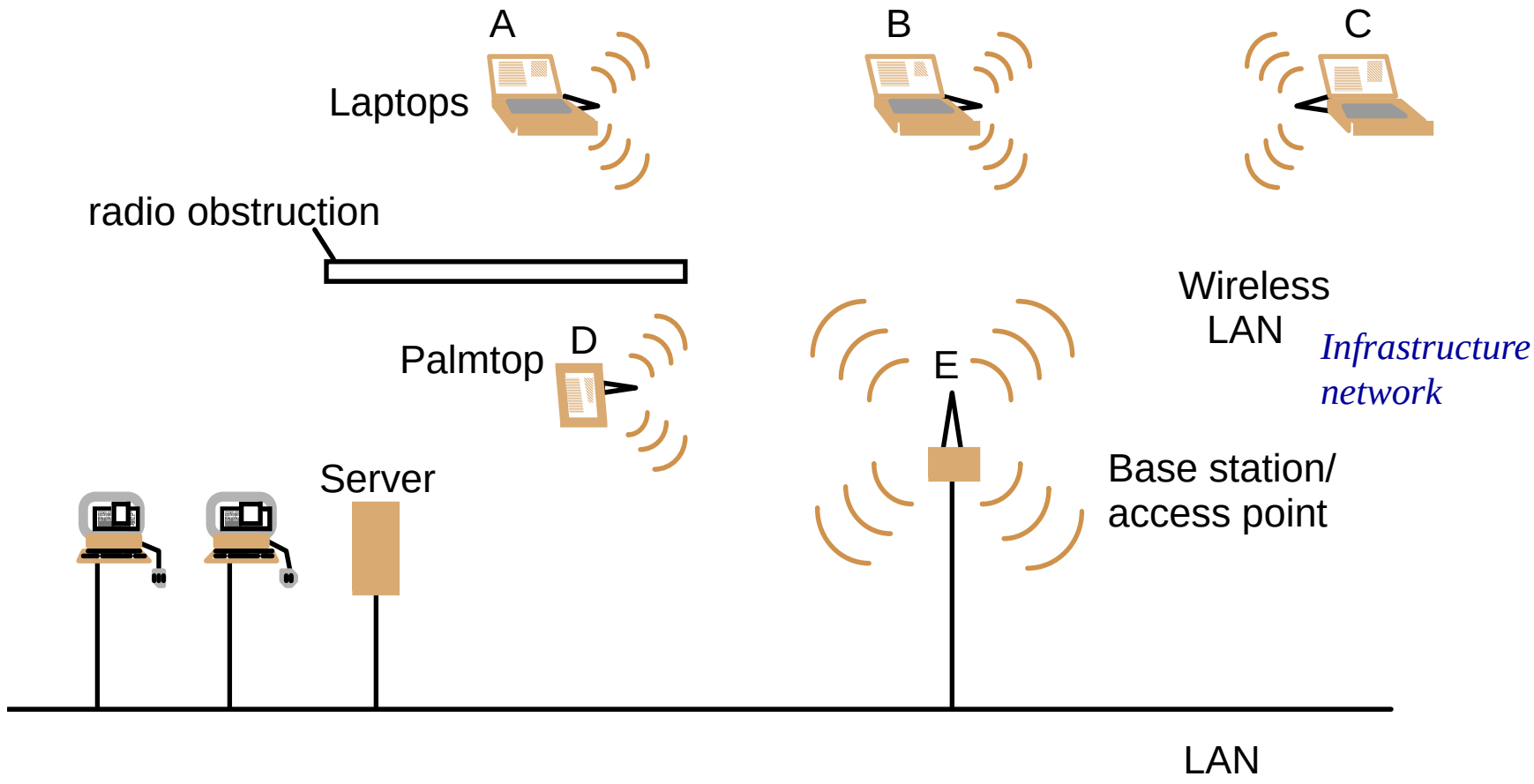


IPv4: seit 1984 – Adressengpass bei 2^{32} (ca. 4,3 Mrd) Adressen, ab 2011 akut

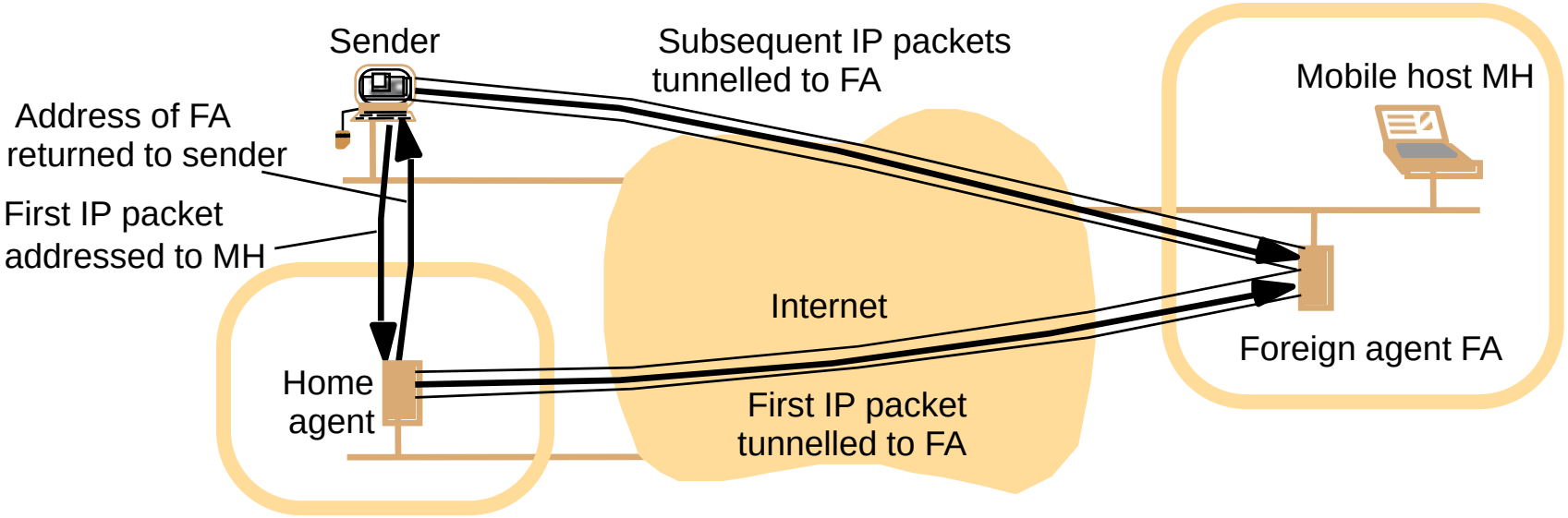
IPv6: 10 Jahre Einführung – max. 2^{128} Adressen (ca.$3,4*10^{38}$)



Extension B: *Wireless* LAN configuration



MobileIP routing mechanism



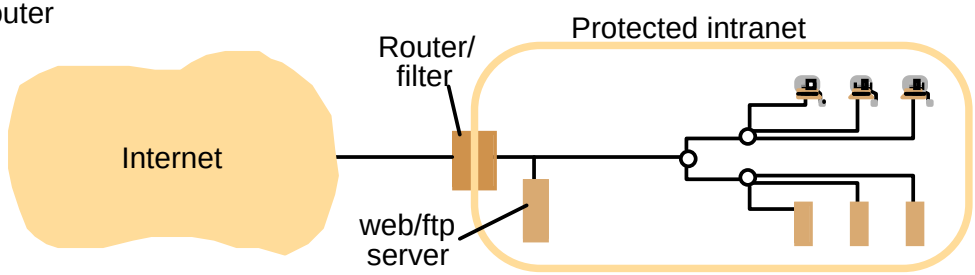
Extension C: Basic Security – *Firewall* configurations

Firewall goals:

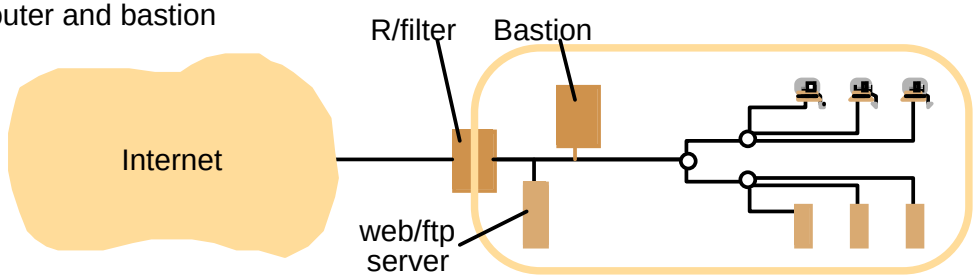
- service control
- behaviour control
- user control

*A **bastion host** is a special purpose computer on a network specifically designed and configured to withstand attacks.*
The computer generally hosts a single application, for example a proxy server, and all other services are removed or limited to reduce the threat to the computer. It is hardened in this manner primarily due to its location and purpose, which is either on the outside of the firewall or in the DMZ and usually involves access from untrusted networks or computers.

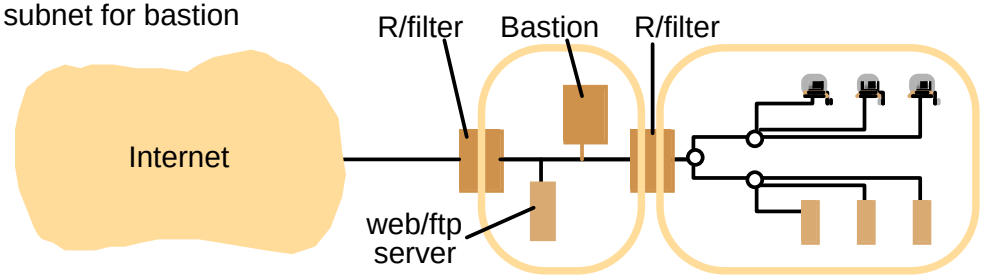
a) Filtering router



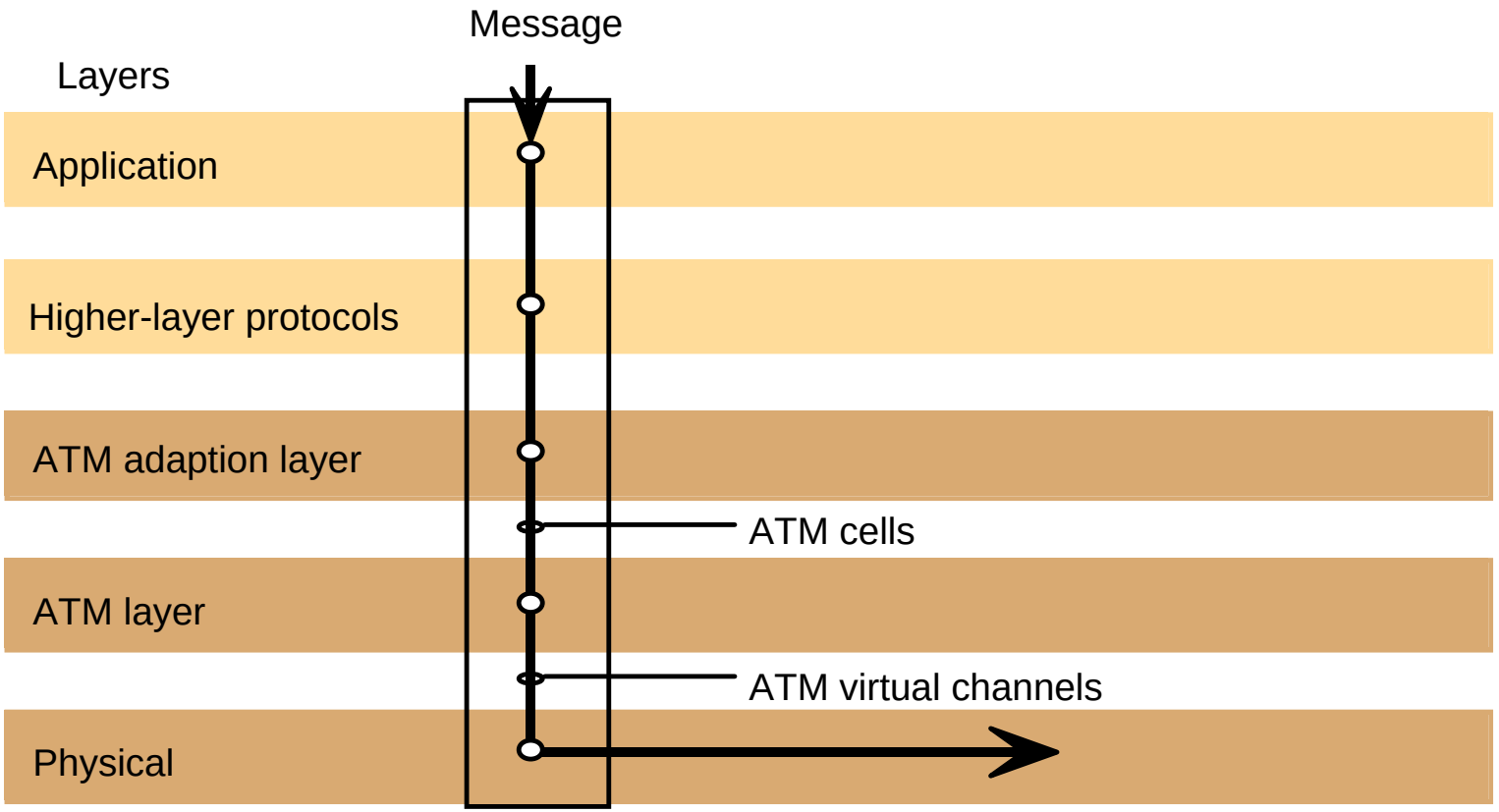
b) Filtering router and bastion



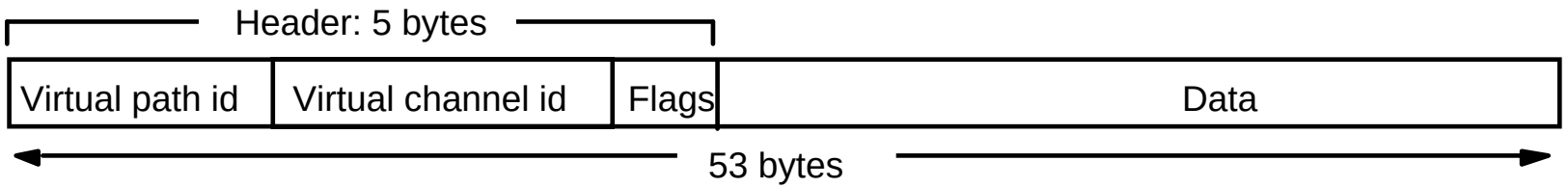
c) Screened subnet for bastion



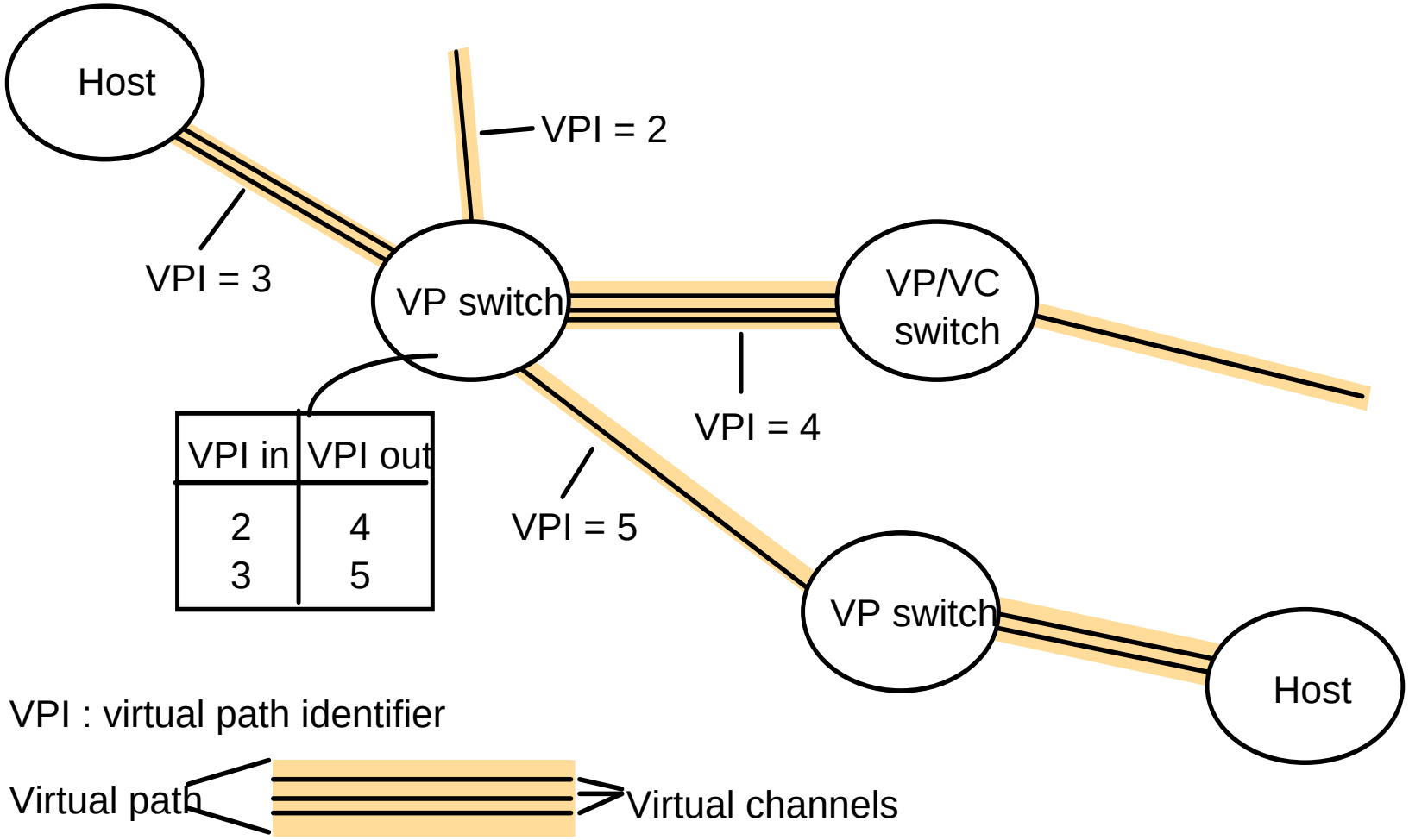
Extension D: Making Communication *faster*: ATM protocol layers



ATM cell layout

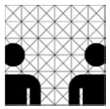


Switching virtual paths in an ATM network



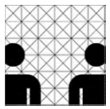
Standardisation: IEEE 802.x local network standards

IEEE No.	*Name*	*Title*	*Reference*
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]

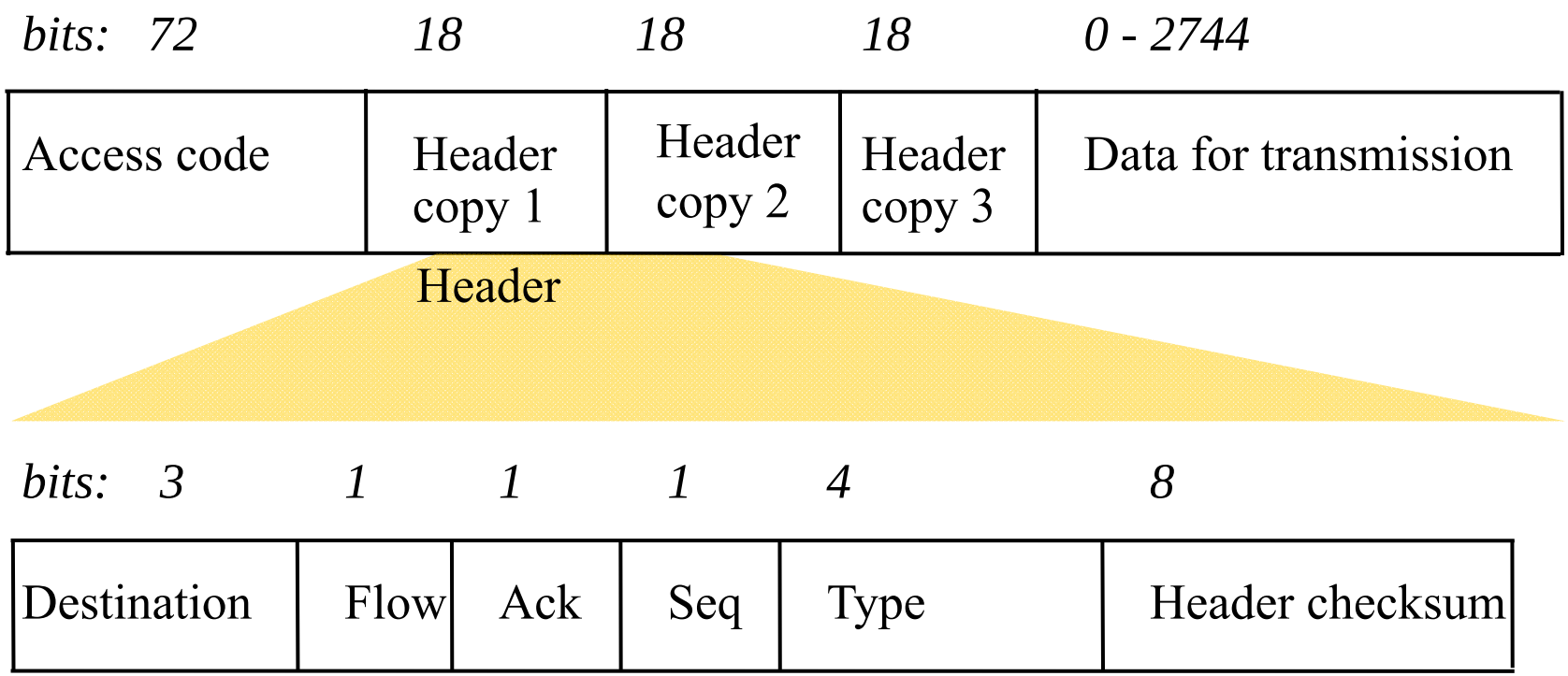


Ethernet ranges and speeds

	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



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.