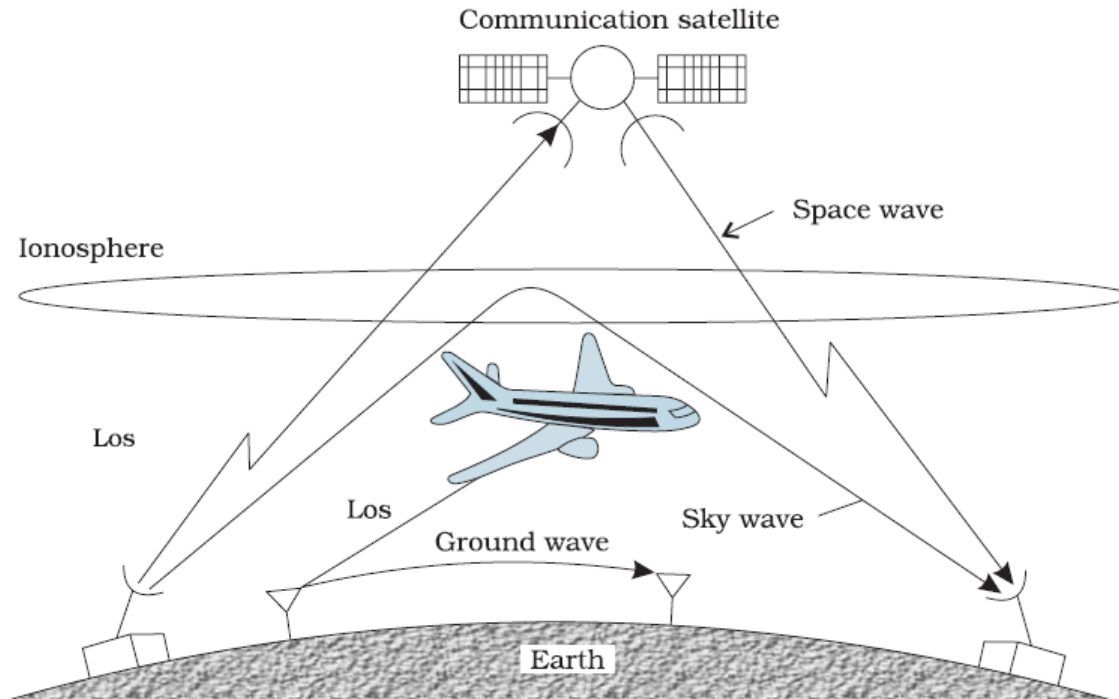


Mobile and Wireless Networks

IP over wireless

Signal propagation

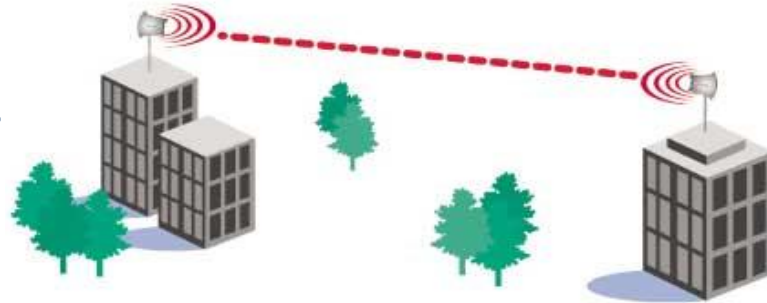
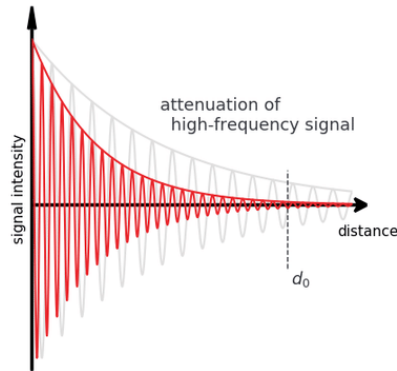
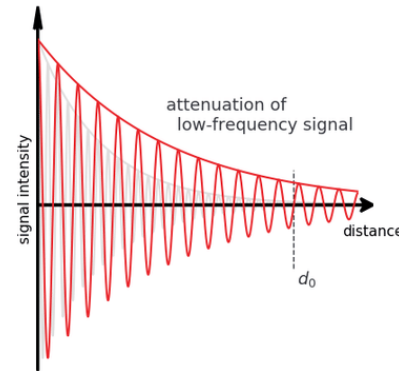


Signal propagation

Classification Band	Initials	Frequency Range	Characteristics
Extremely low	ELF	< 300 Hz	Ground wave
Infra low	ILF	300 Hz - 3 kHz	
Very low	VLF	3 kHz - 30 kHz	
Low	LF	30 kHz - 300 kHz	
Medium	MF	300 kHz - 3 MHz	Ground/Sky wave
High	HF	3 MHz - 30 MHz	Sky wave
Very high	VHF	30 MHz - 300 MHz	Space wave
Ultra high	UHF	300 MHz - 3 GHz	
Super high	SHF	3 GHz - 30 GHz	
Extremely high	EHF	30 GHz - 300 GHz	
Tremendously high	THF	300 GHz - 3000 GHz	

Signal propagation

- Signal attenuation due to
 - Distance
 - Obstacles



Signal propagation

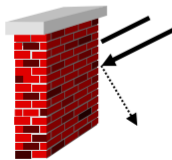
Propagation in free space always like light (straight line)

Receiving power proportional to $1/d^2$

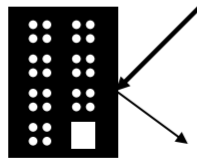
(d = distance between sender and receiver)

Receiving power additionally influenced by

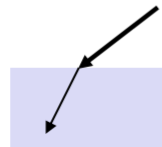
- ❑ fading (frequency dependent)
- ❑ shadowing
- ❑ reflection at large obstacles
- ❑ refraction depending on the density of a medium
- ❑ scattering at small obstacles
- ❑ diffraction at edges



shadowing



reflection



refraction

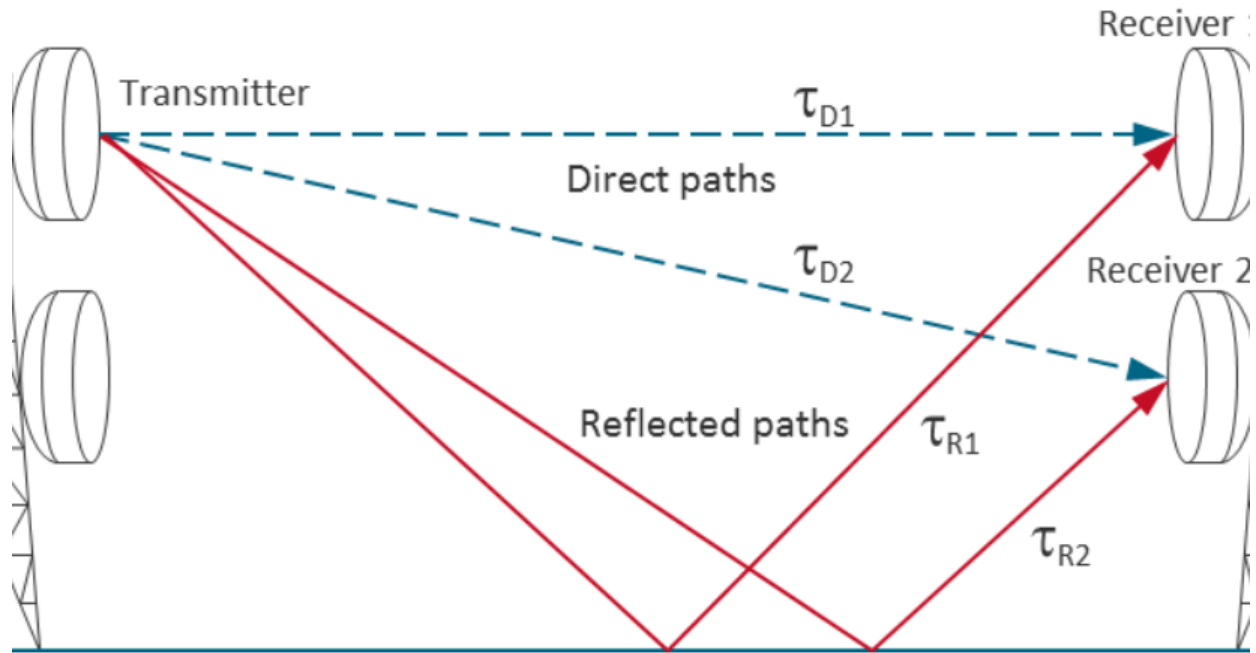


scattering



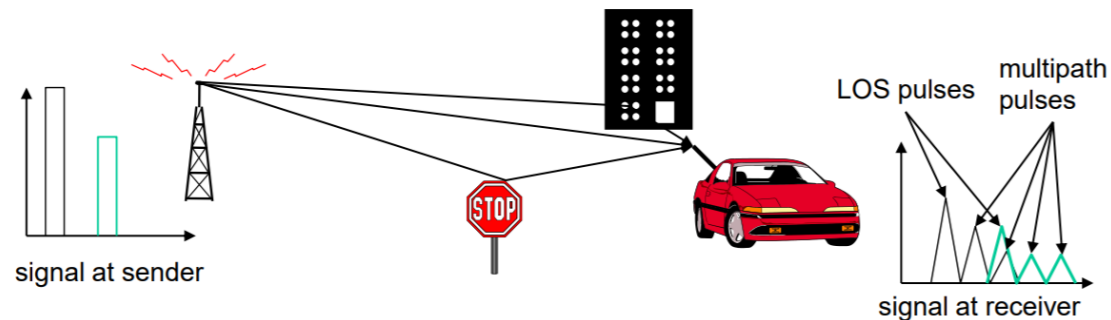
diffraction

Multipath propagation



Multipath propagation

Signal can take many different paths between sender and receiver due to reflection, scattering, diffraction



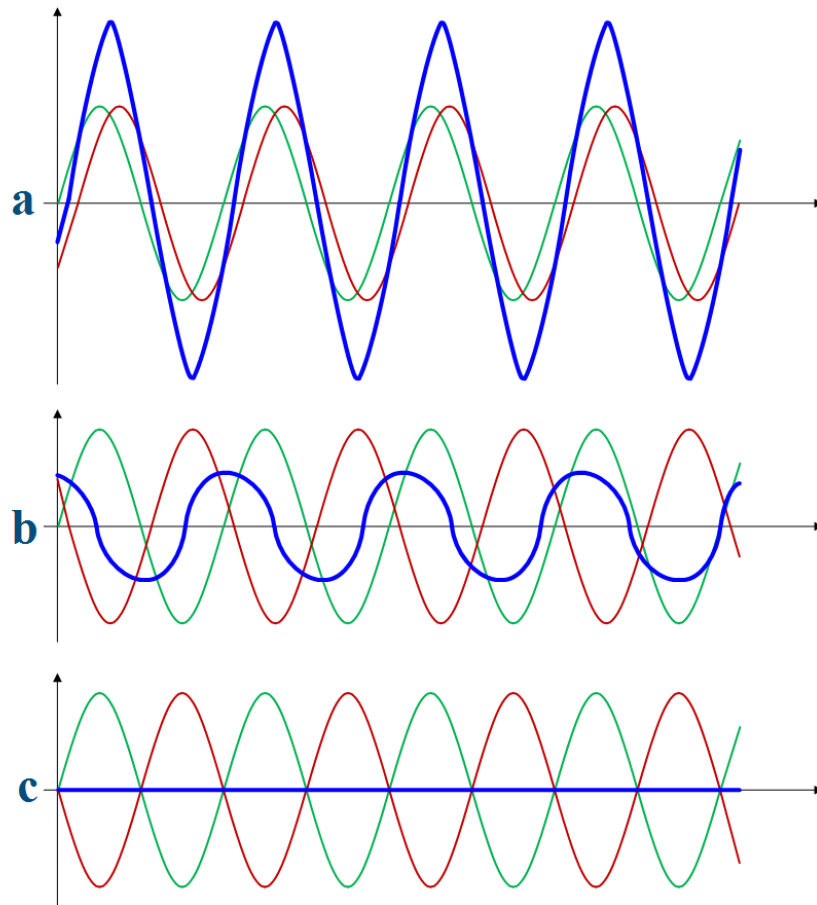
Time dispersion: signal is dispersed over time

→ interference with “neighbor” symbols, Inter Symbol Interference (ISI)

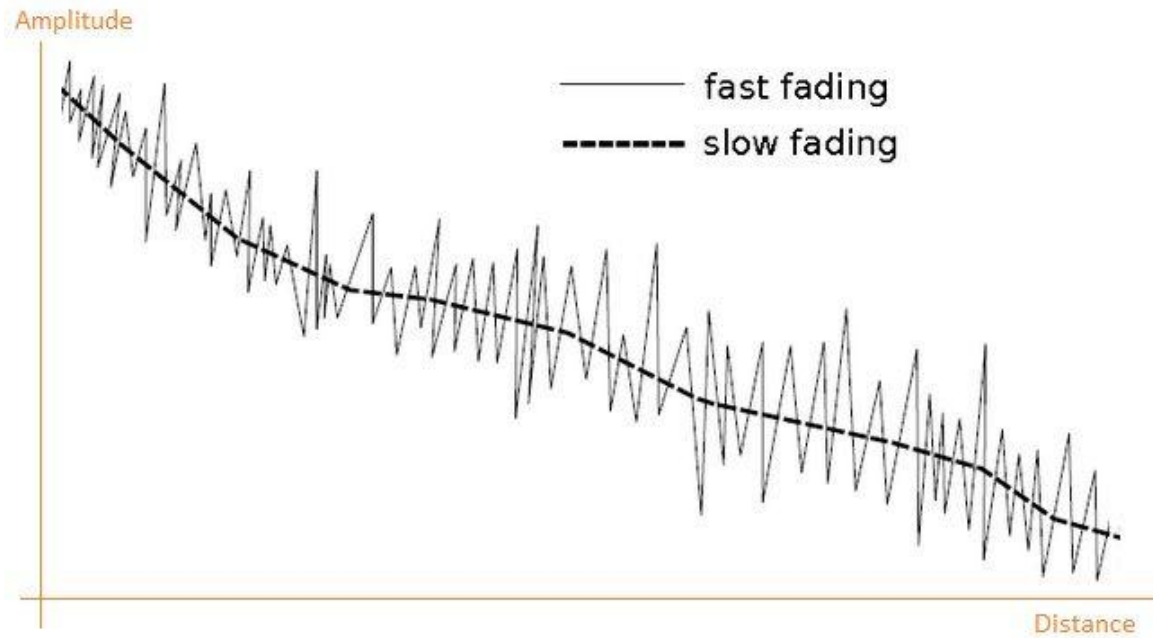
The signal reaches a receiver directly and phase shifted

→ distorted signal depending on the phases of the different parts

Multipath propagation



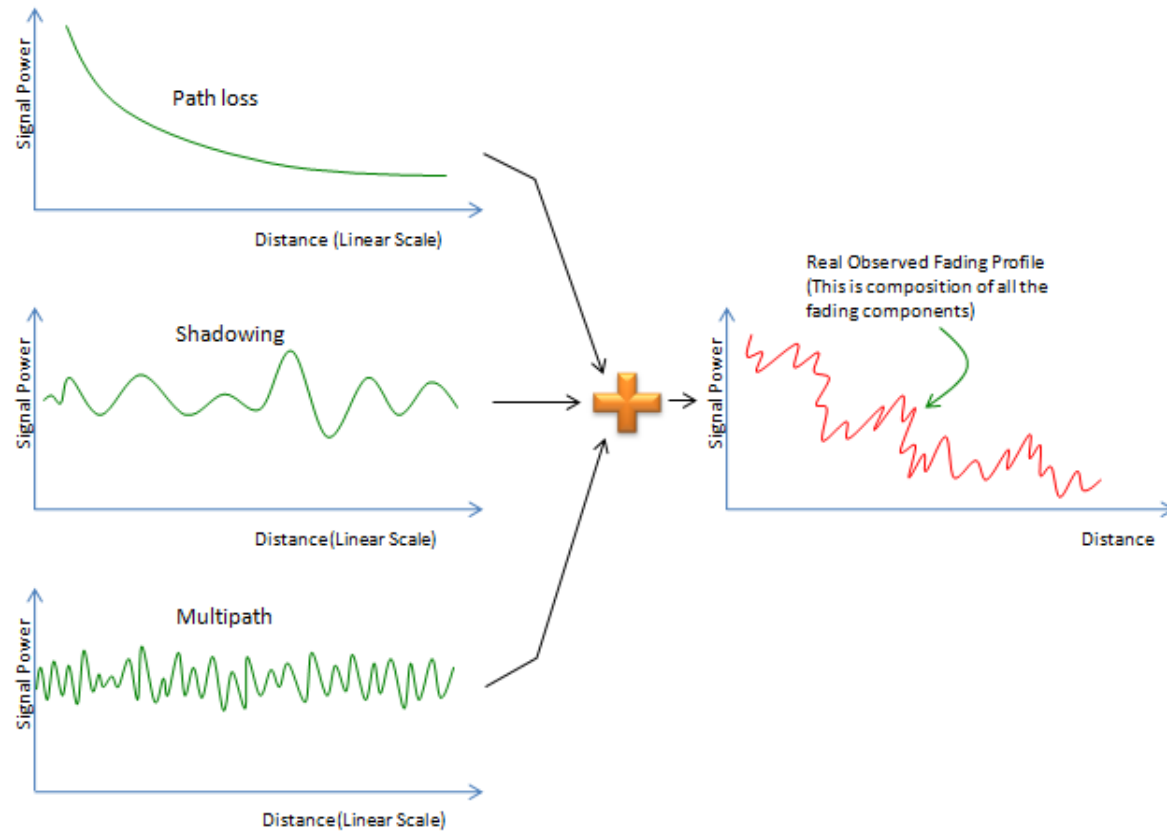
Fading



Fading

- Large-scale fading (slow - shadowing)
 - Long term variation in the mean signal level caused by the mobile unit moving into the shadow of surrounding objects
- Small-scale fading (fast - multipath)
 - Short term fluctuation in the signal amplitude caused by the local multipath

Fading



Noise and interference

- Transmissions from other sources
 - Many devices transmitting in the same frequency
 - E.g., 2.4 GHz wireless telephone, Bluetooth and Wi-Fi use the same frequency band
 - Electromagnetic noise (e.g., microwave oven)



Effects of mobility

Channel characteristics change over time and location

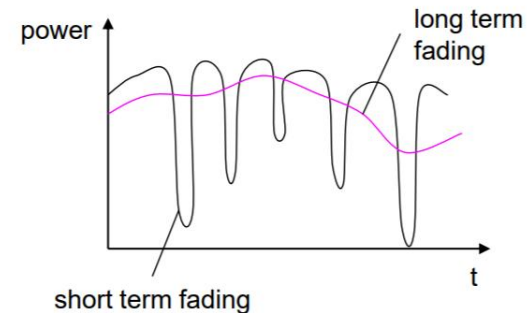
- ❑ signal paths change
- ❑ different delay variations of different signal parts
- ❑ different phases of signal parts

→ quick changes in the power received (short term fading)

Additional changes in

- ❑ distance to sender
- ❑ obstacles further away

→ slow changes in the average power received (long term fading)



How we handle errors

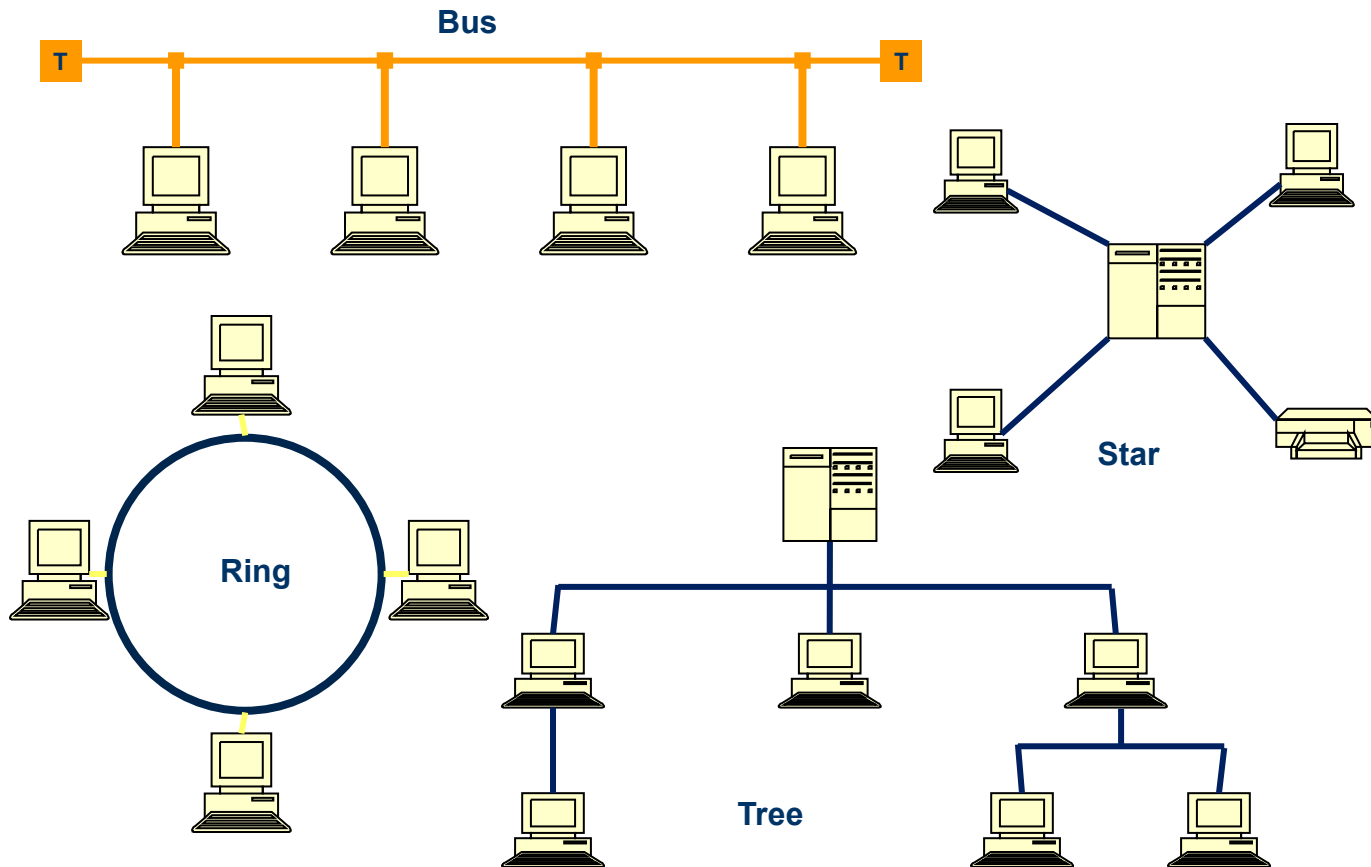
- Fixed vs. Wireless

- Fixed: Errors due to congestion
 - Wireless: many different reasons

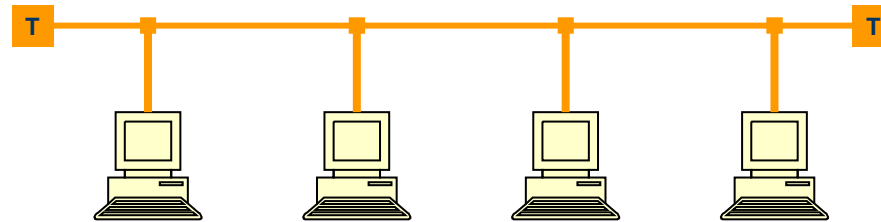
- What to do

- Increase of transmitting power
 - Increased power consumption (bad for the battery)
 - Increased interference to other receivers
 - Error detection and correction
 - More powerful codes (processing, channel overhead)
 - retransmissions (power consumption, channel overhead)

Network Topologies

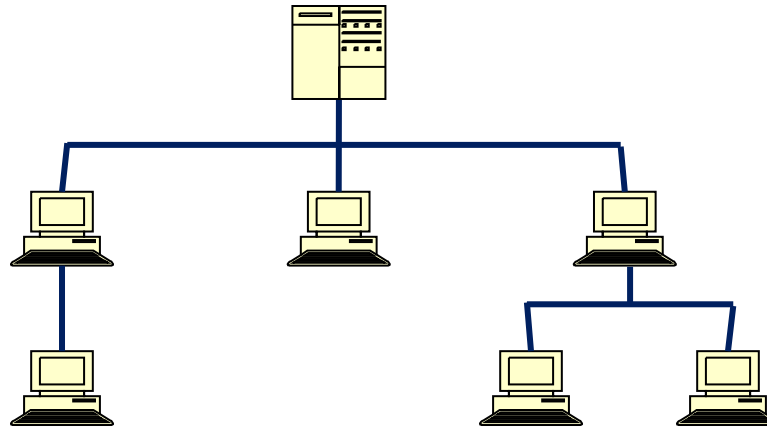


Bus



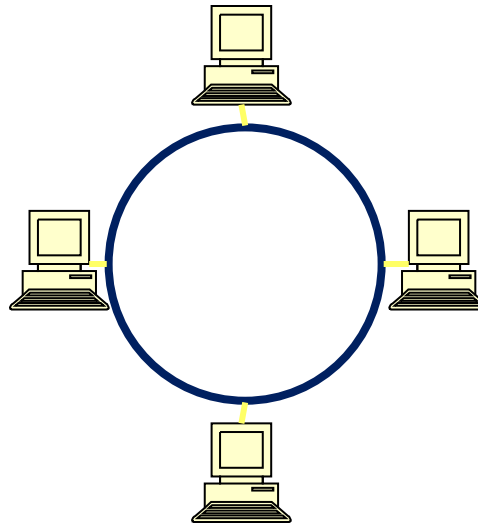
- All terminals on the bus
- Terminals can be connected/disconnected seamlessly
- End points
- Only one message at a time
- Low cable cost

Tree



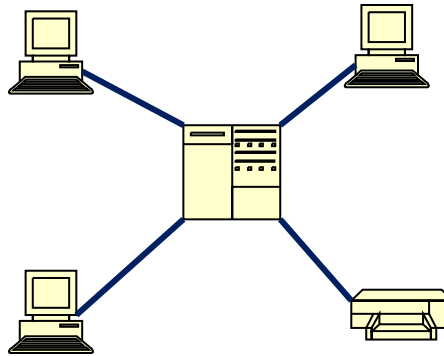
- Parent node can be a bottleneck
- Parent node out of order -> all tree out of order
- Add nodes at the lowest level

Ring



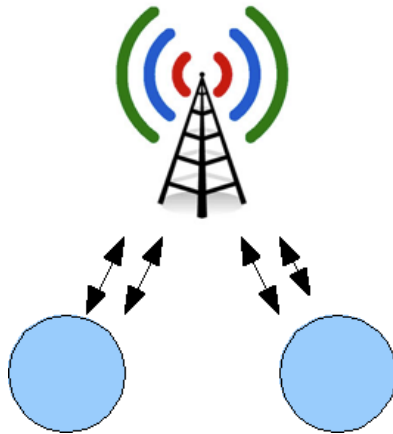
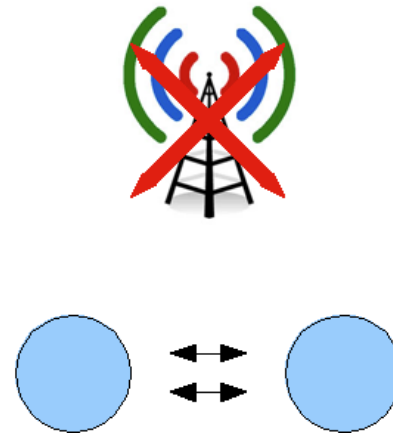
- Hop by hop transmissions
- Transmit/receive/check/forward
- Networks keep working on node errors

Star



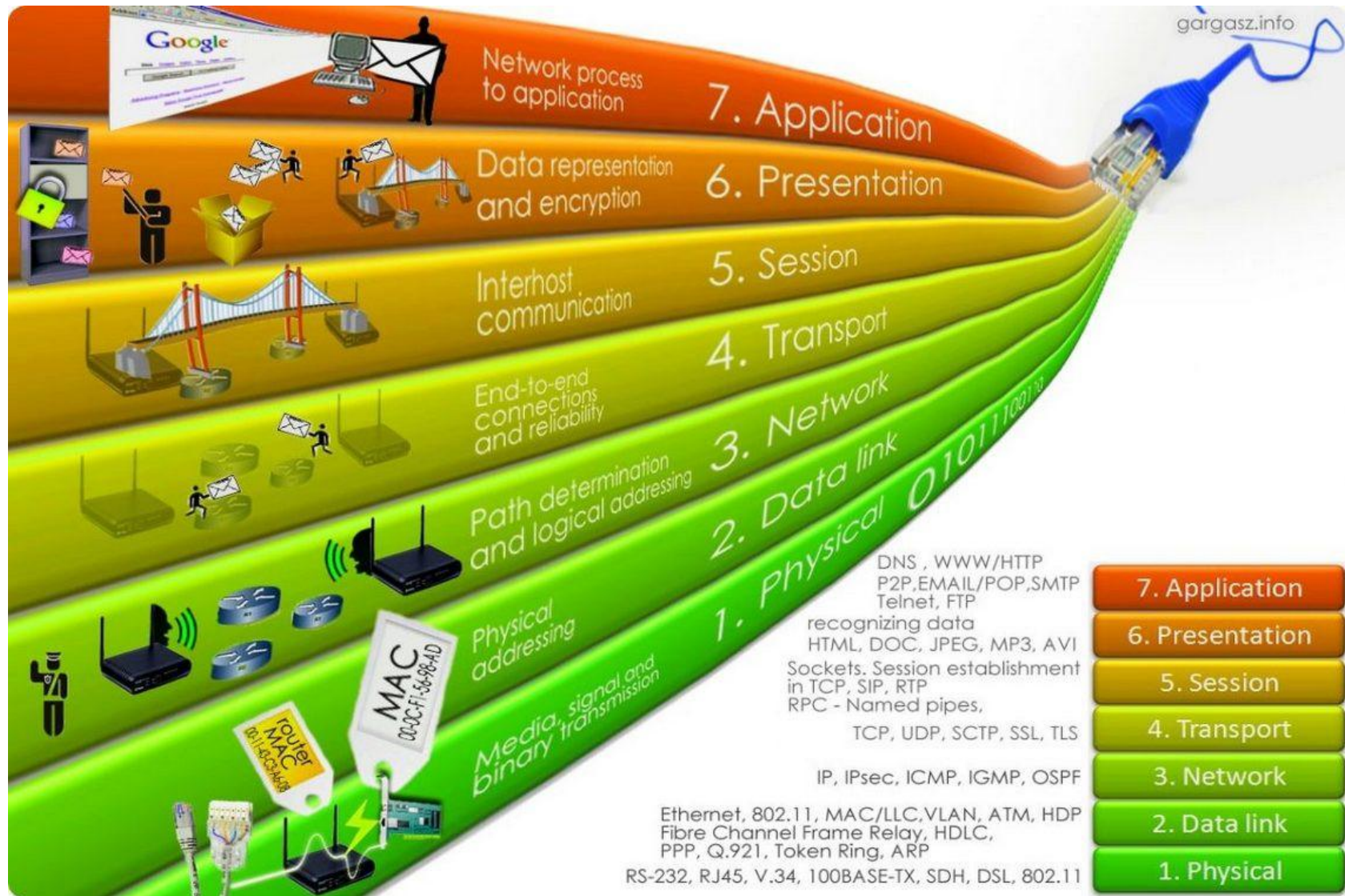
- All nodes connected in a central node
- Single point of failure

Mobile network topologies



- Cellular or Ad-hoc
- Common medium (bus)
- All traffic through a node (star)
- Hop-by-hop transmissions (ring)
- Multiple access control
 - Error control
 - Mobility

OSI Model



OSI Model

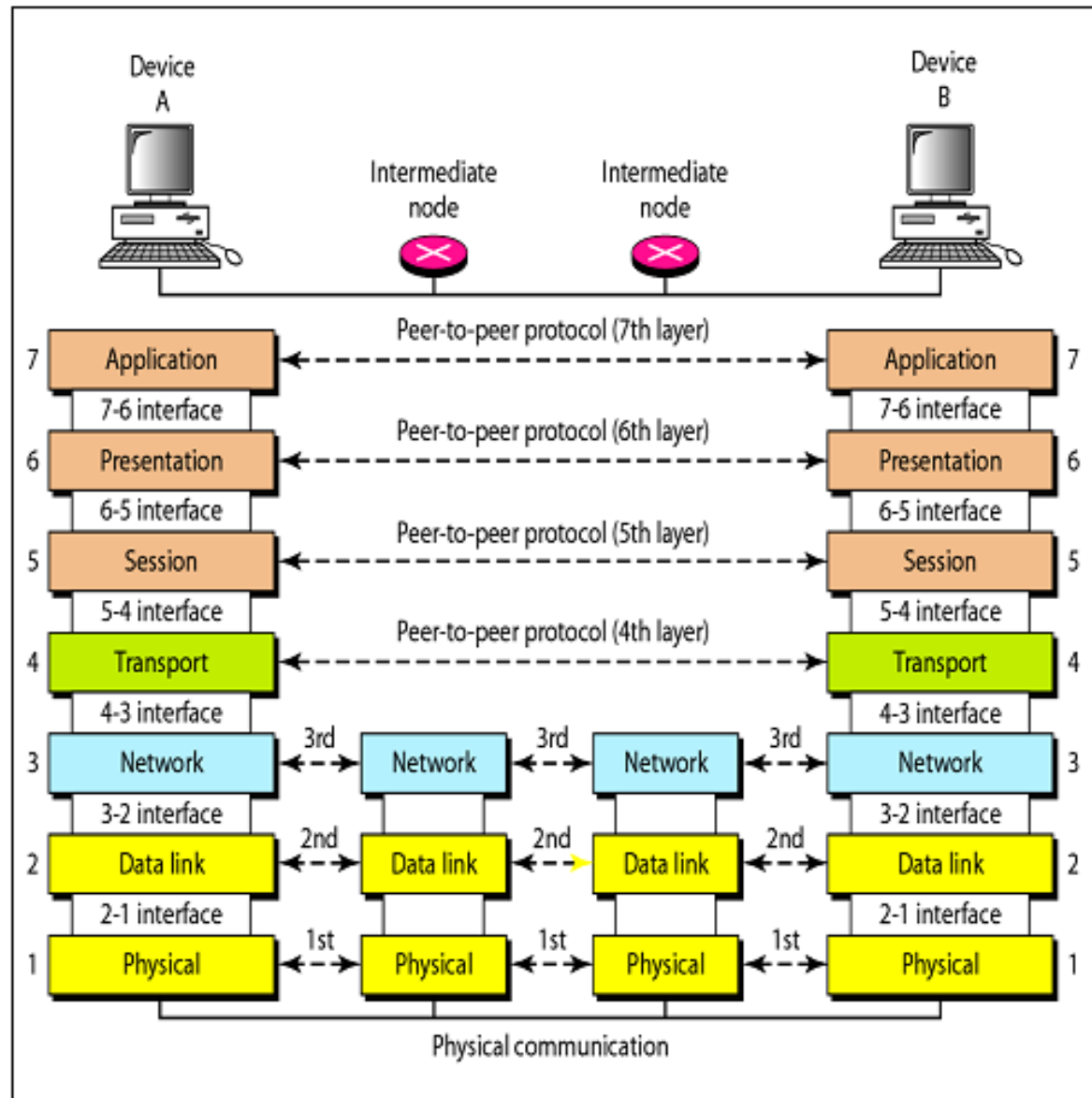
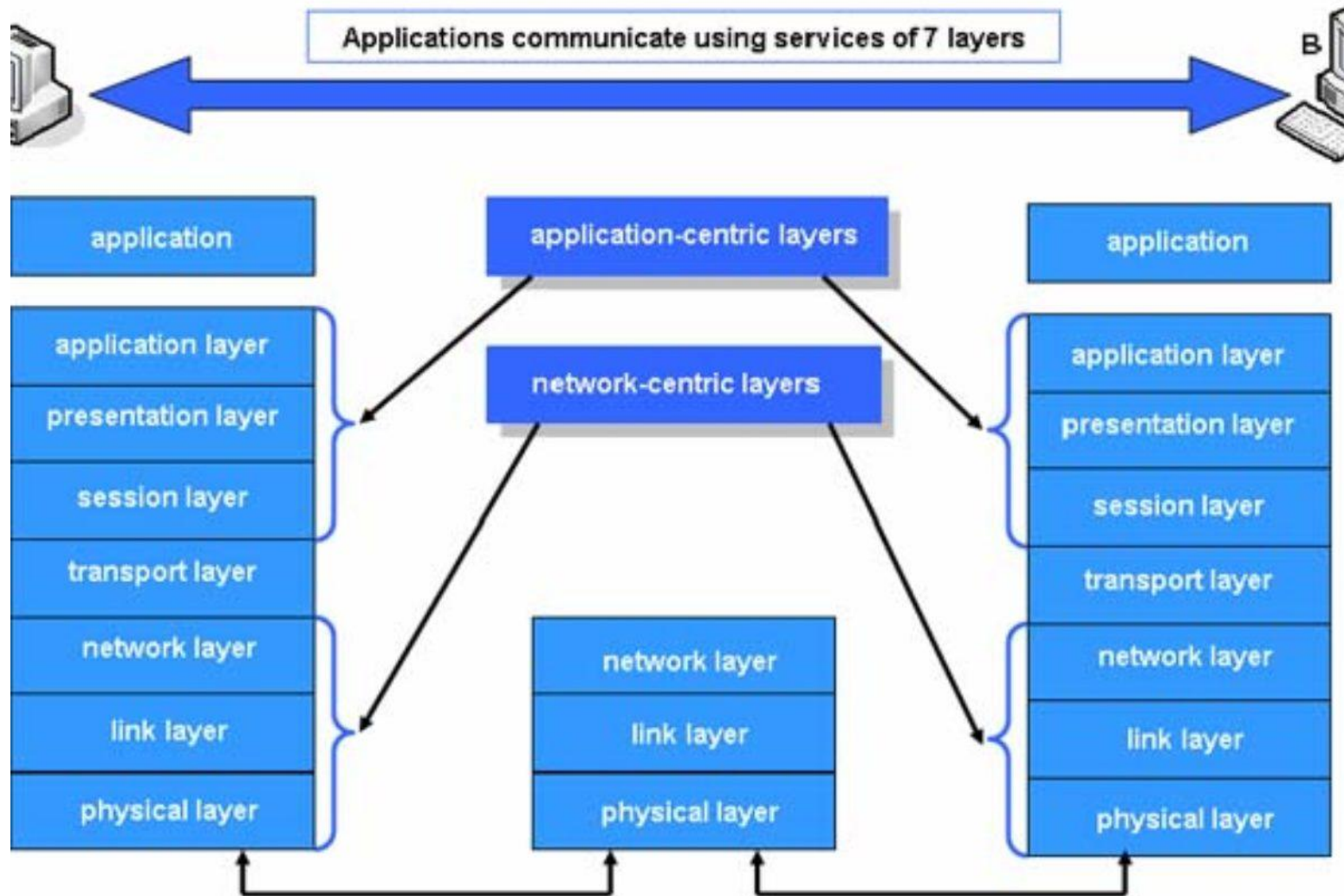
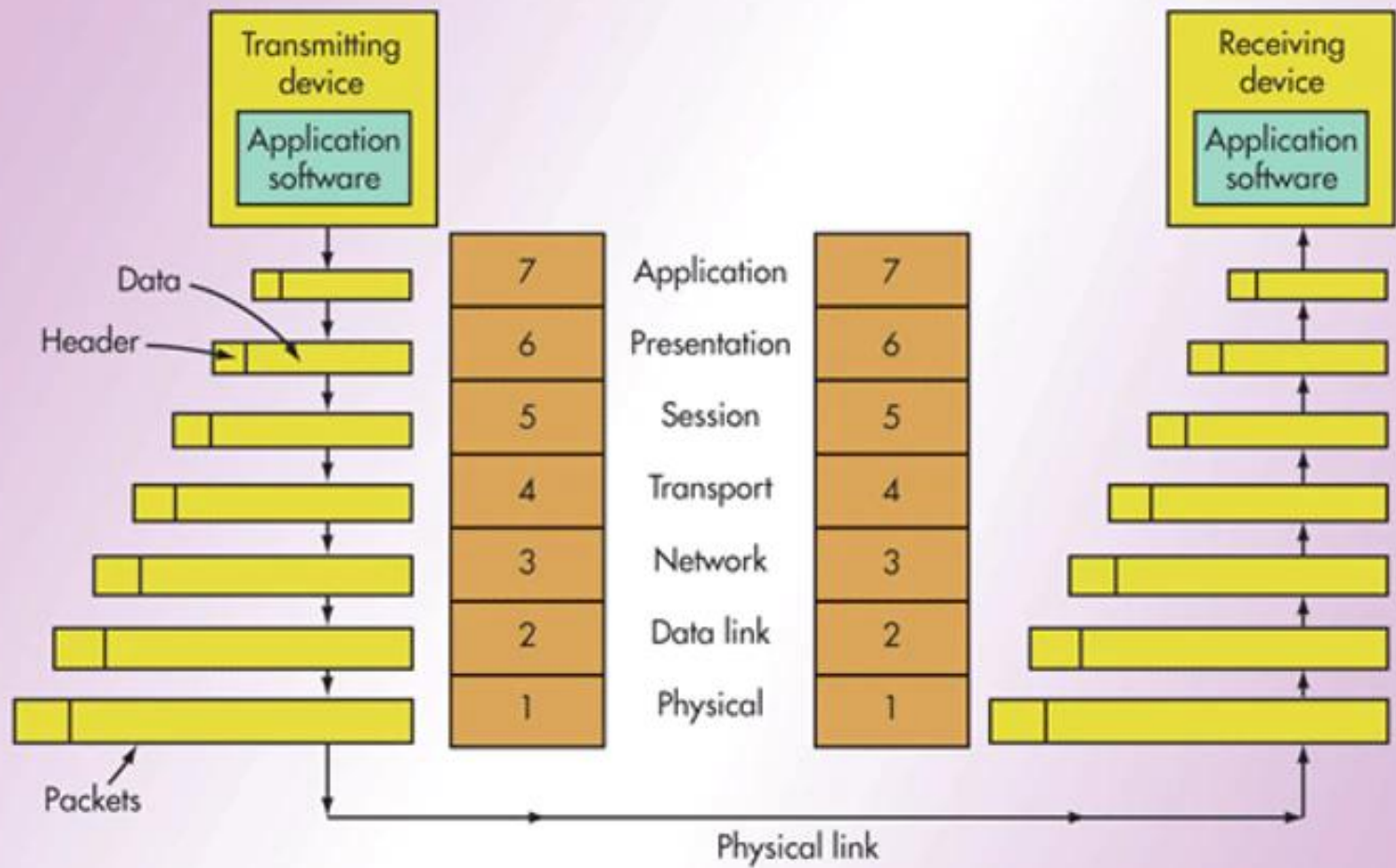


Fig: Communication & Interfaces in the OSI model

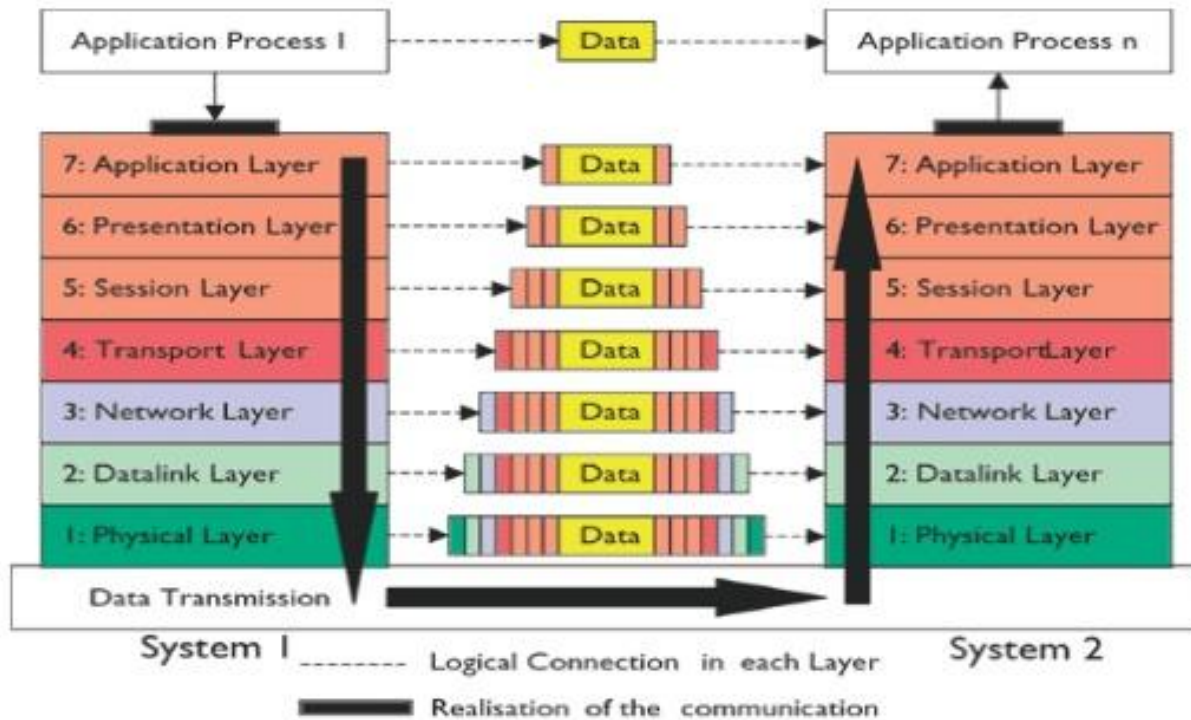
ISO 7-Layer Model



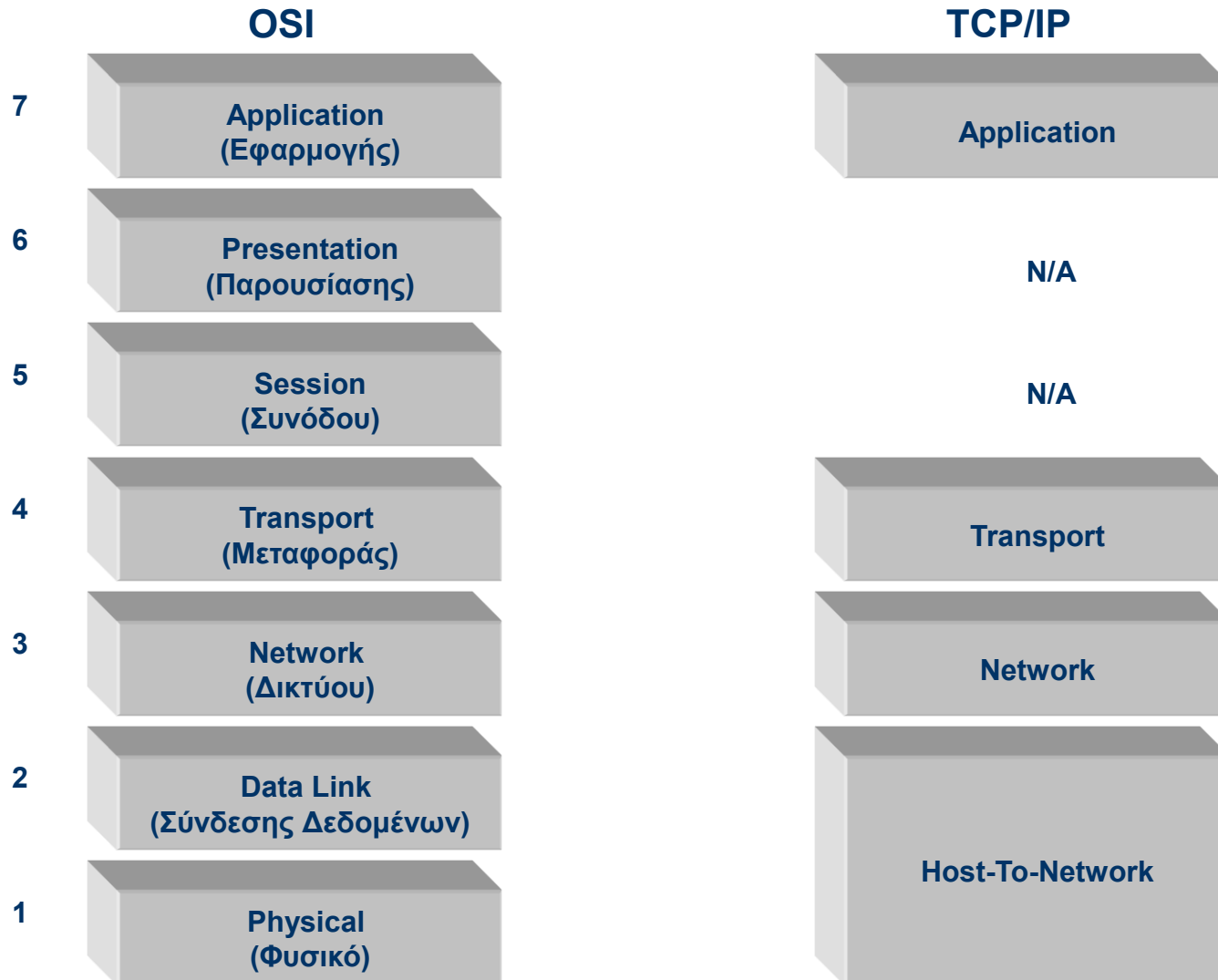


Data Transmission in the OSI Reference Model

OSI LAYERS MODEL



Reference model - TCP/IP

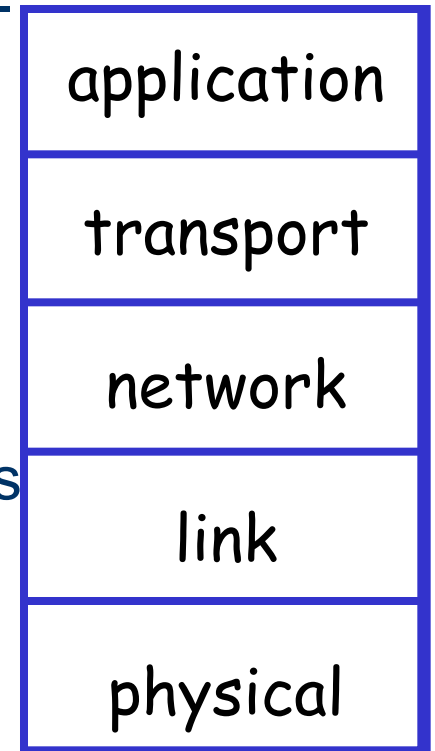


Reference Model ISO/OSI

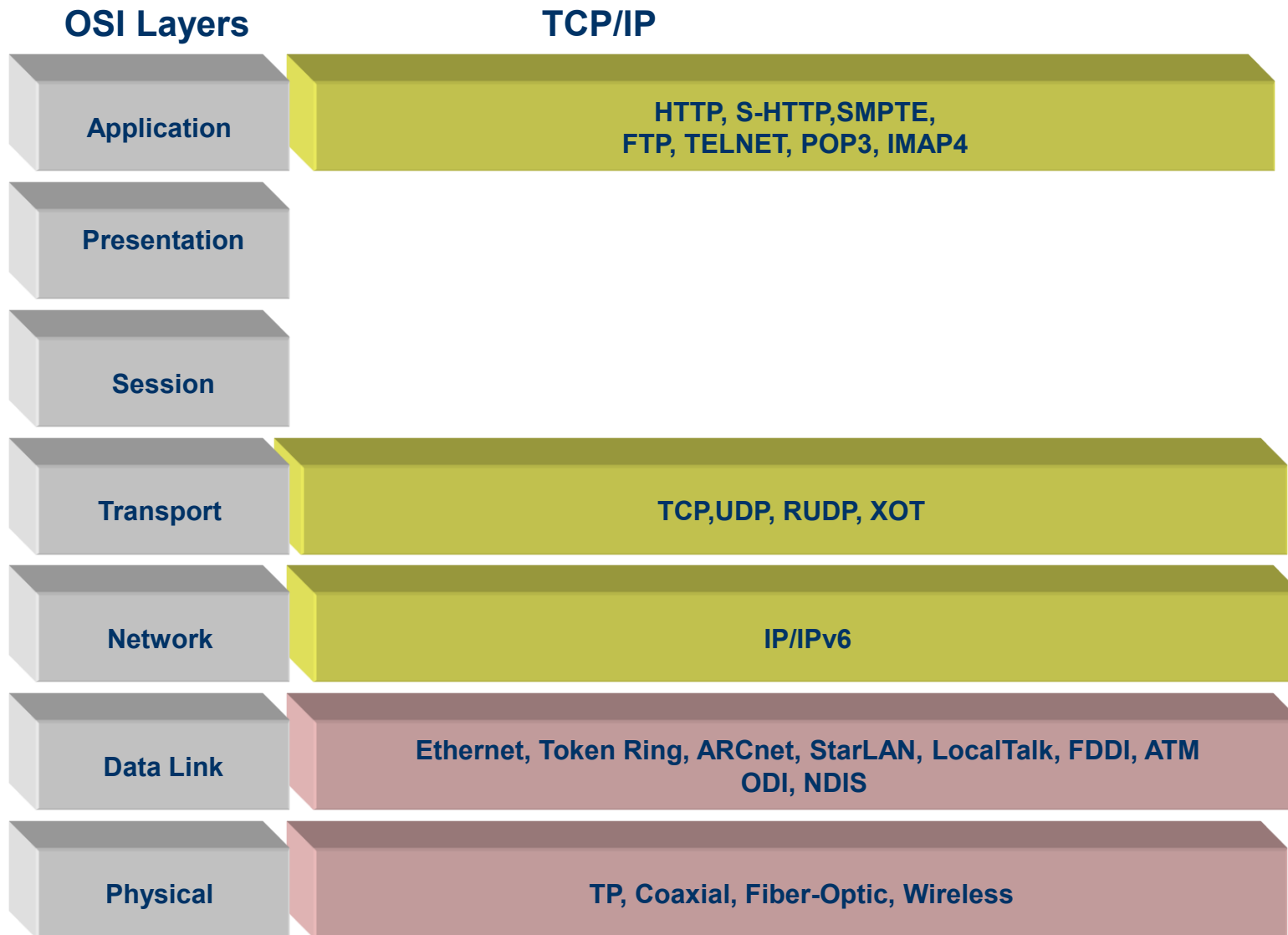
- **presentation:** cryptography, compression, description of application data
- **session:** synchronizing of data exchange, different flows per application
- Internet does not support these two layers
- If needed, they are supported at the application layers

Internet Protocol Stack

- **application:** support of network applications
 - **FTP, SMTP, HTTP**
- **transport:** transfer of application messages end-to-end
 - **TCP, UDP**
- **network:** routing of datagrams from source to destination
 - **IP, routing protocols**
- **link:** transfer of data between neighboring nodes in the network
 - **PPP, Ethernet, 802.11 (WiFi)**
- **physical:** bits “over the line”

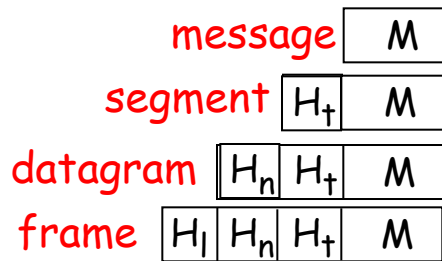
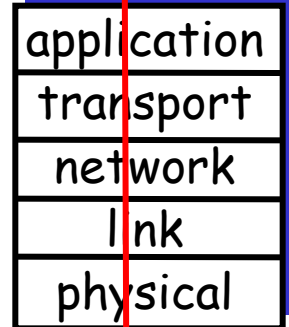
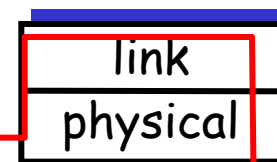
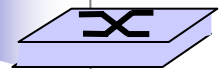


Reference model - TCP/IP



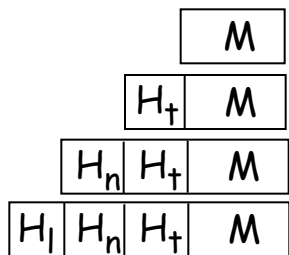
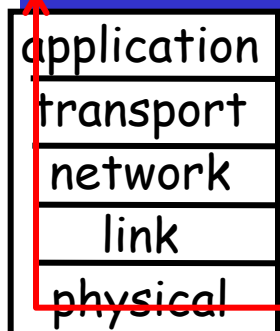
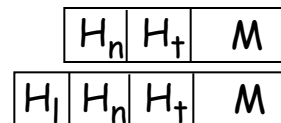
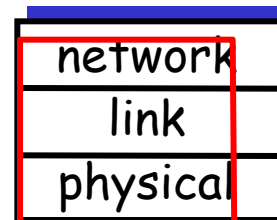
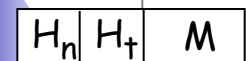
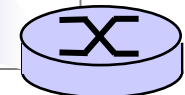
Encapsulation

source

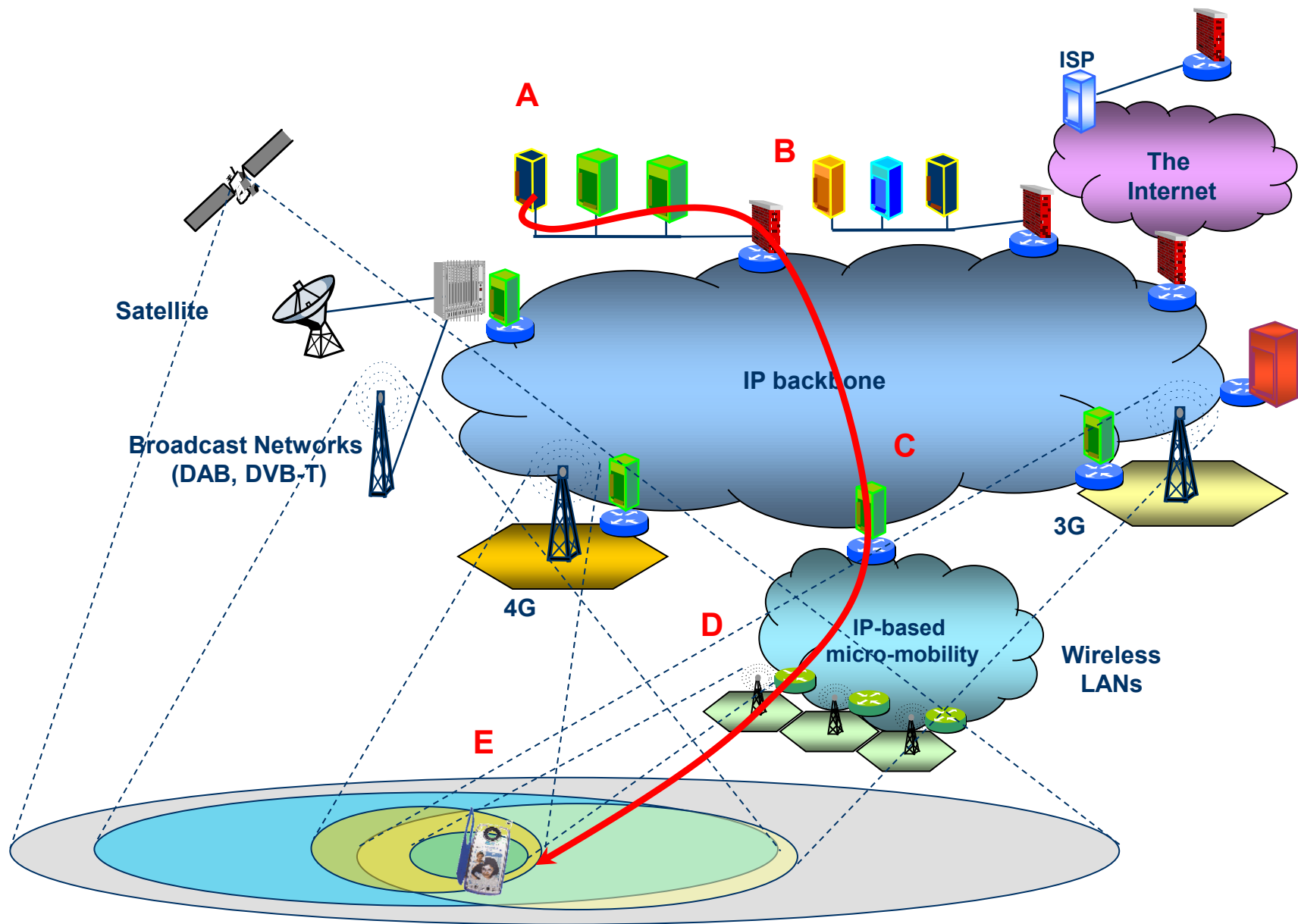


switch

destination



router





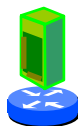
A



E



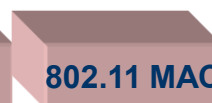
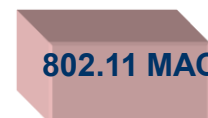
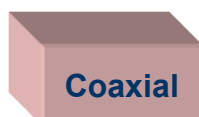
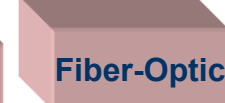
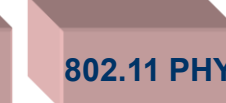
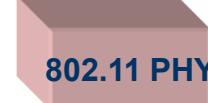
B



C



D



Protocol “Layers”

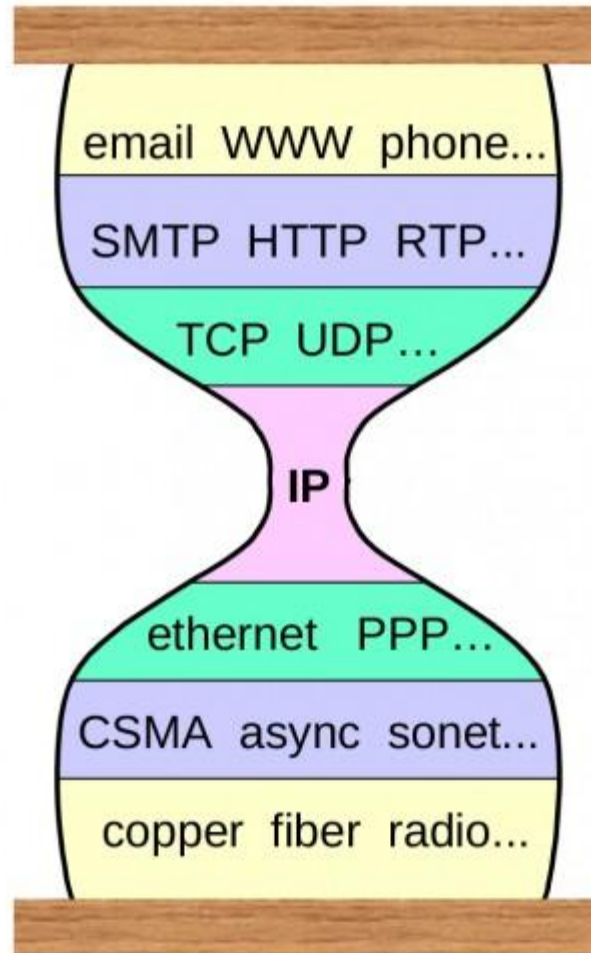
Networks are complicated!

- Many “pieces”:
 - Hosts
 - Routers
 - Links of different types
 - Applications
 - Protocols
 - Hardware, software

Question:

How to organize such a complicated system

Why we call them IP networks?



Problems of IP in wireless and mobile networks

1. Low performance in wireless environments

- No error avoidance, detection or correction

2. “Best Effort” (no QoS guarantees)

- No prioritization of traffic

3. No mobility support

- Routing based on the (static) IP address

1. Low performance in wireless environments

- No error correction in IP
- Based on anything provided by TCP/UDP or application

TCP

- Designed for non-real-time applications
- Corrects errors through retransmissions
- TCP translates loss of packets as congestion to the route

UDP

- Designed for real-time applications
- No error correction

TCP operation

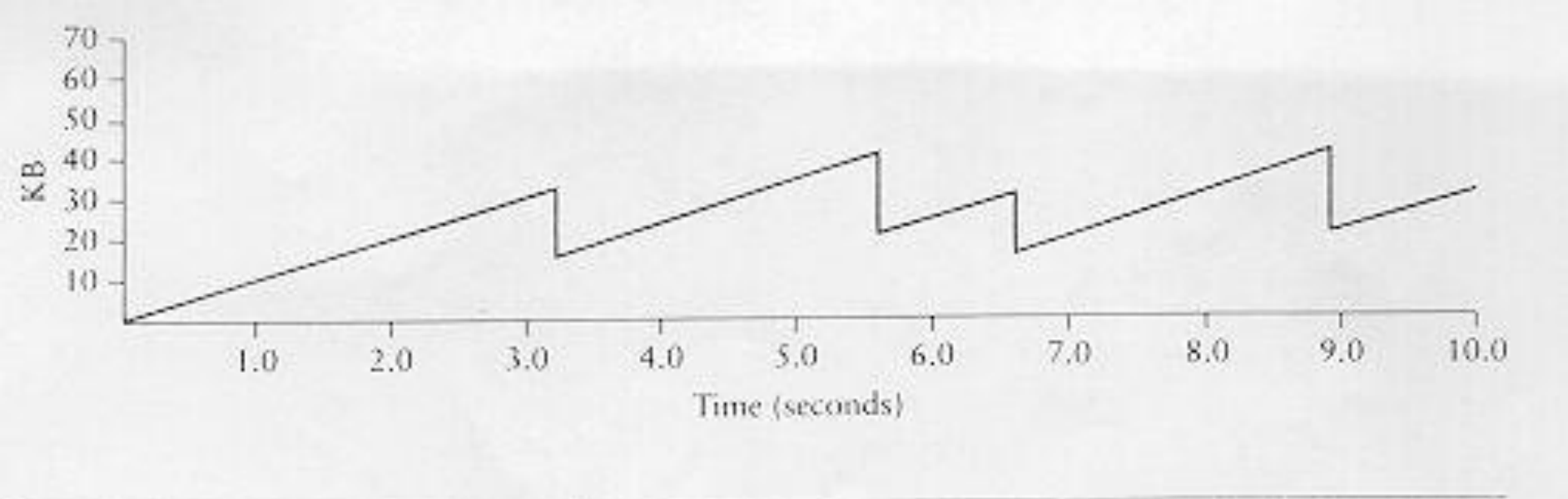
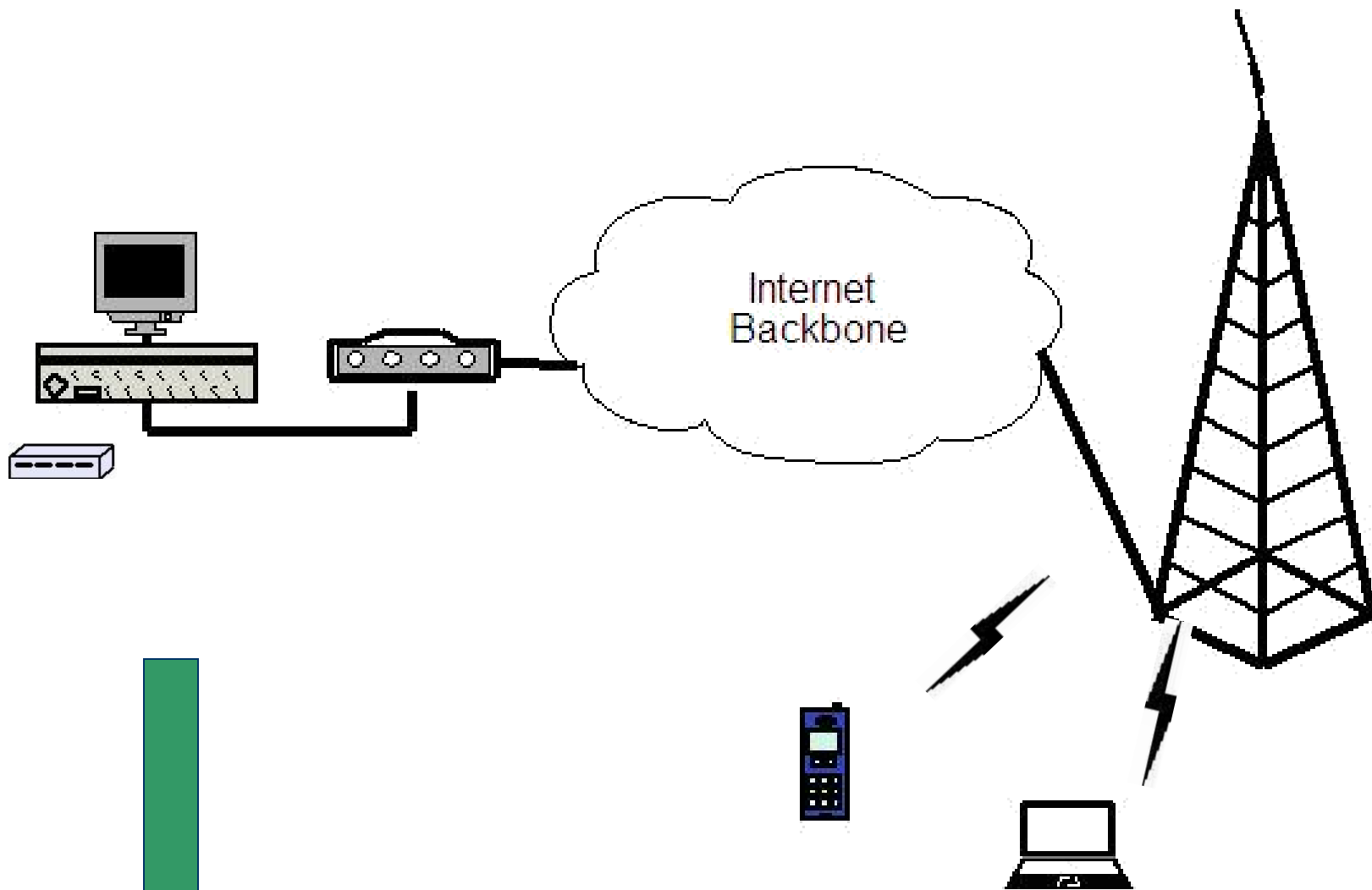


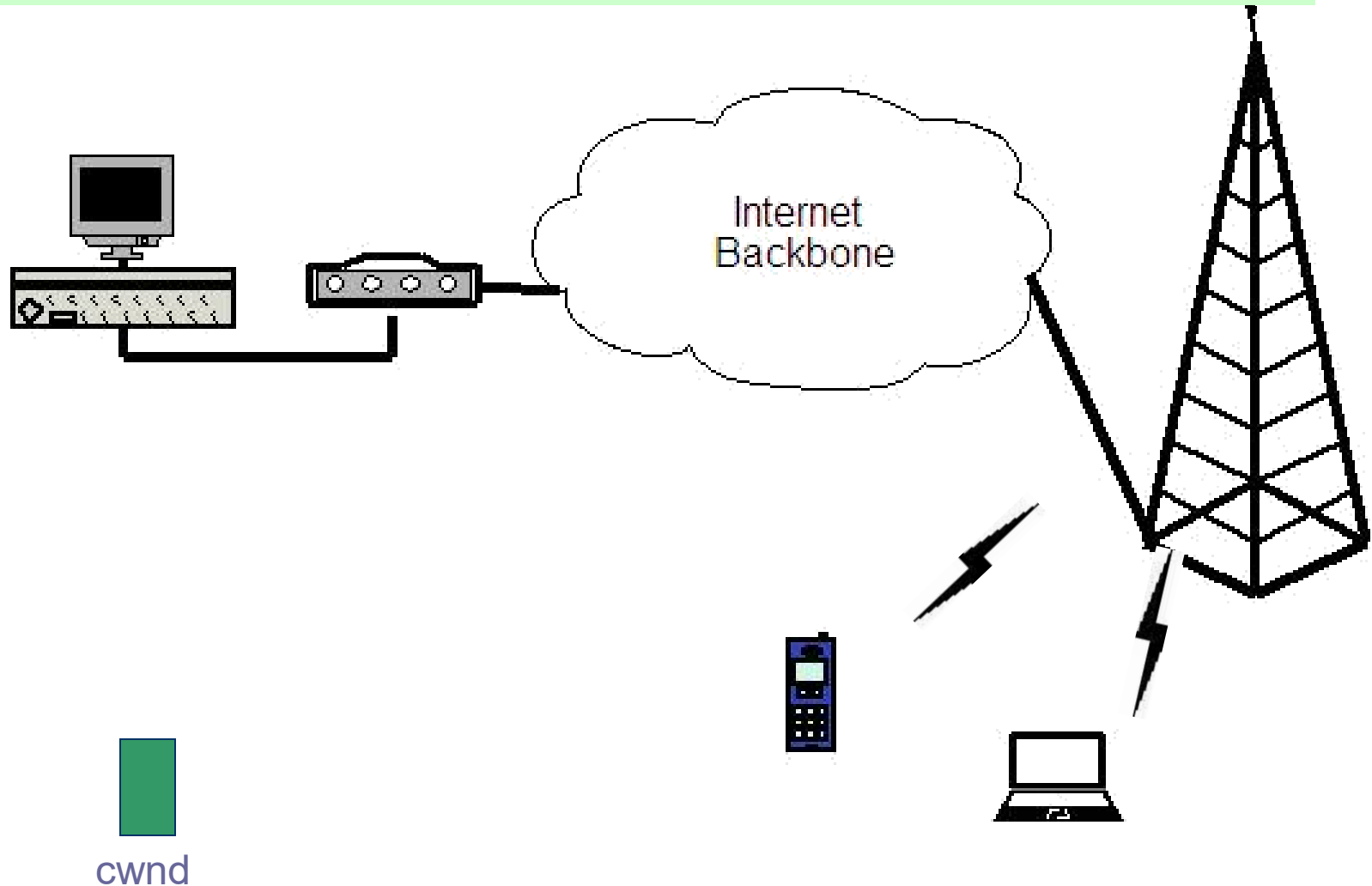
Figure 6.9 Typical TCP sawtooth pattern.

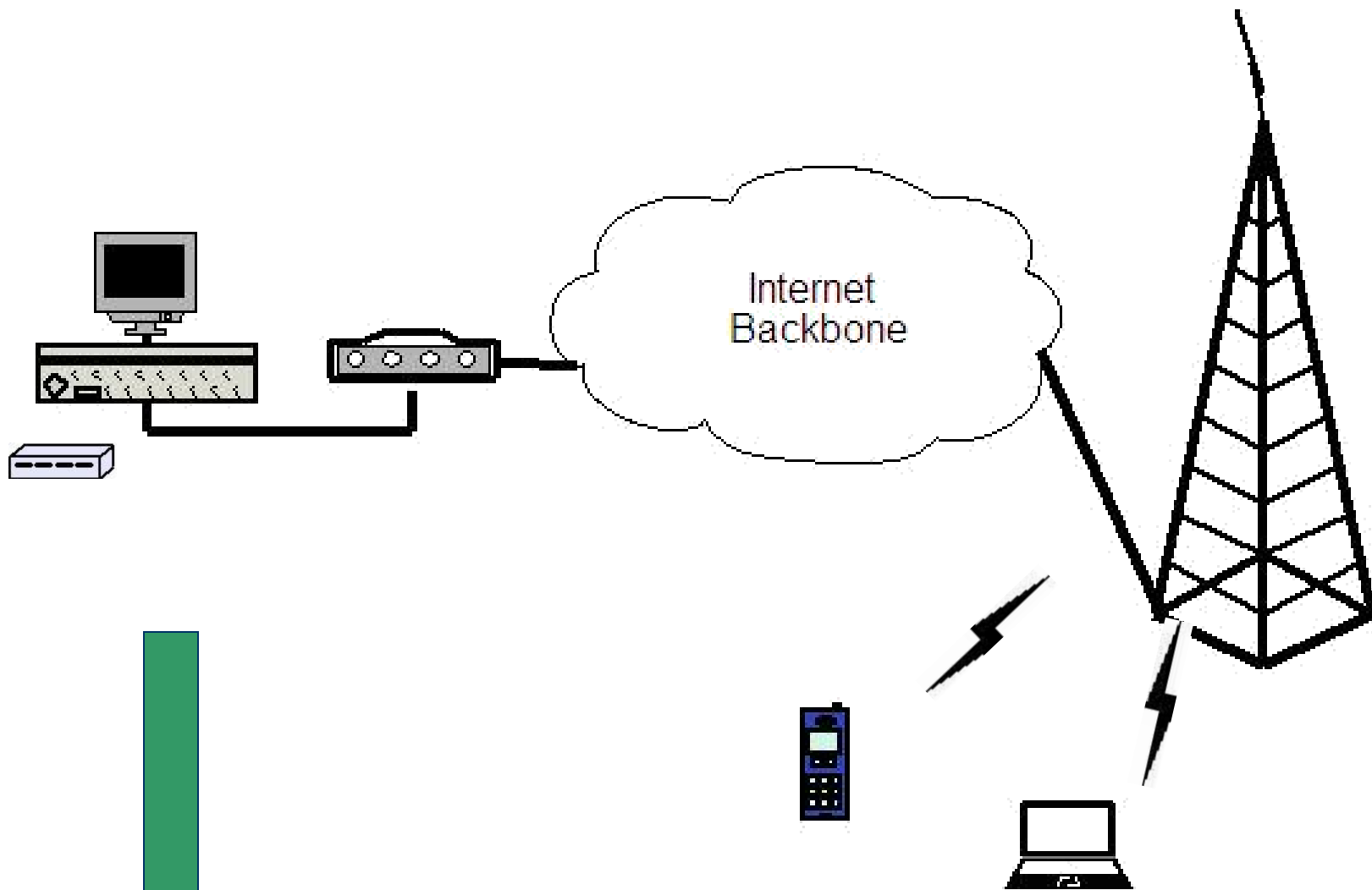




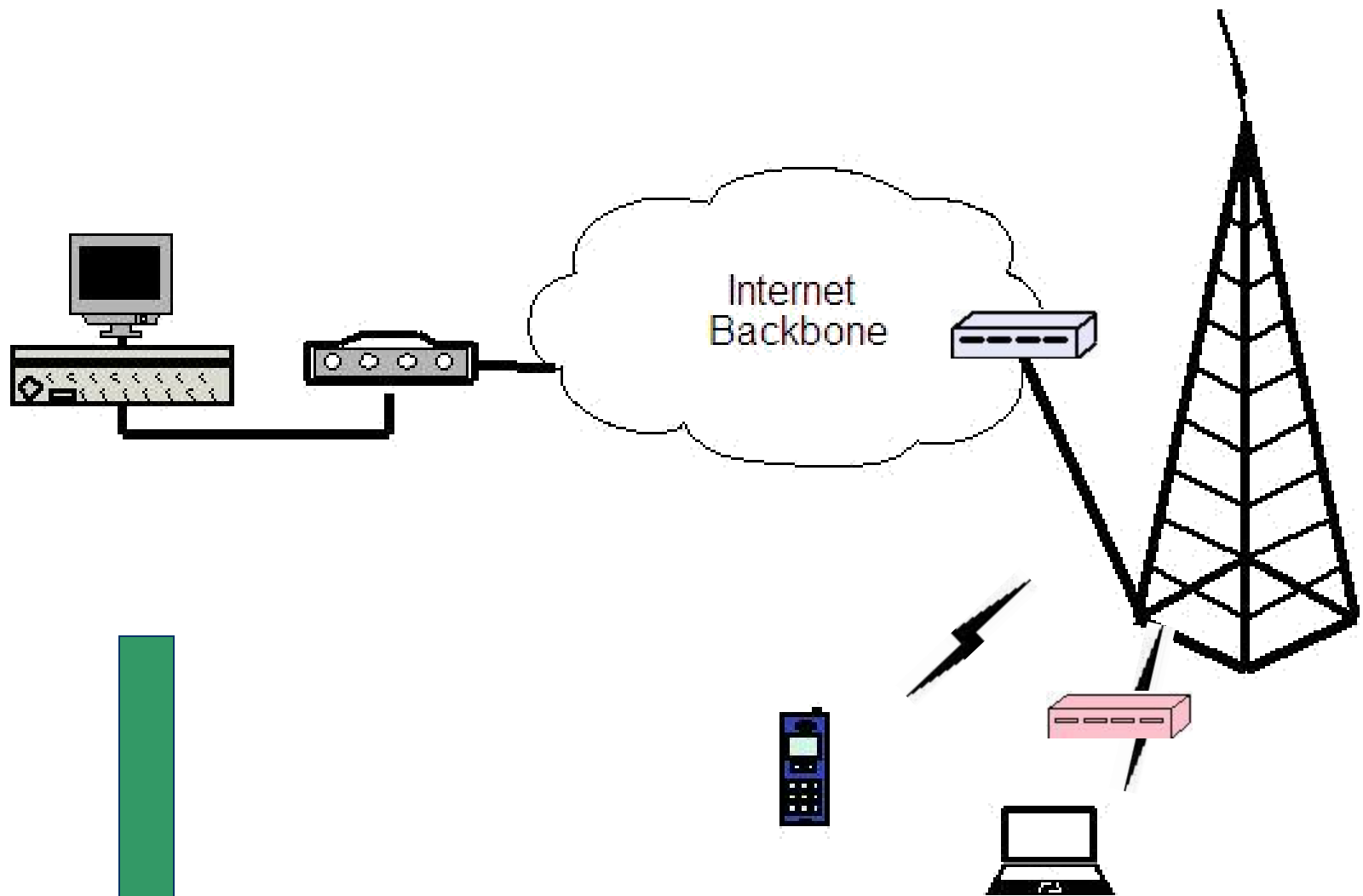
cwnd

Loss of packet due to congestion
Reduction of cwnd
Reduction of data traffic



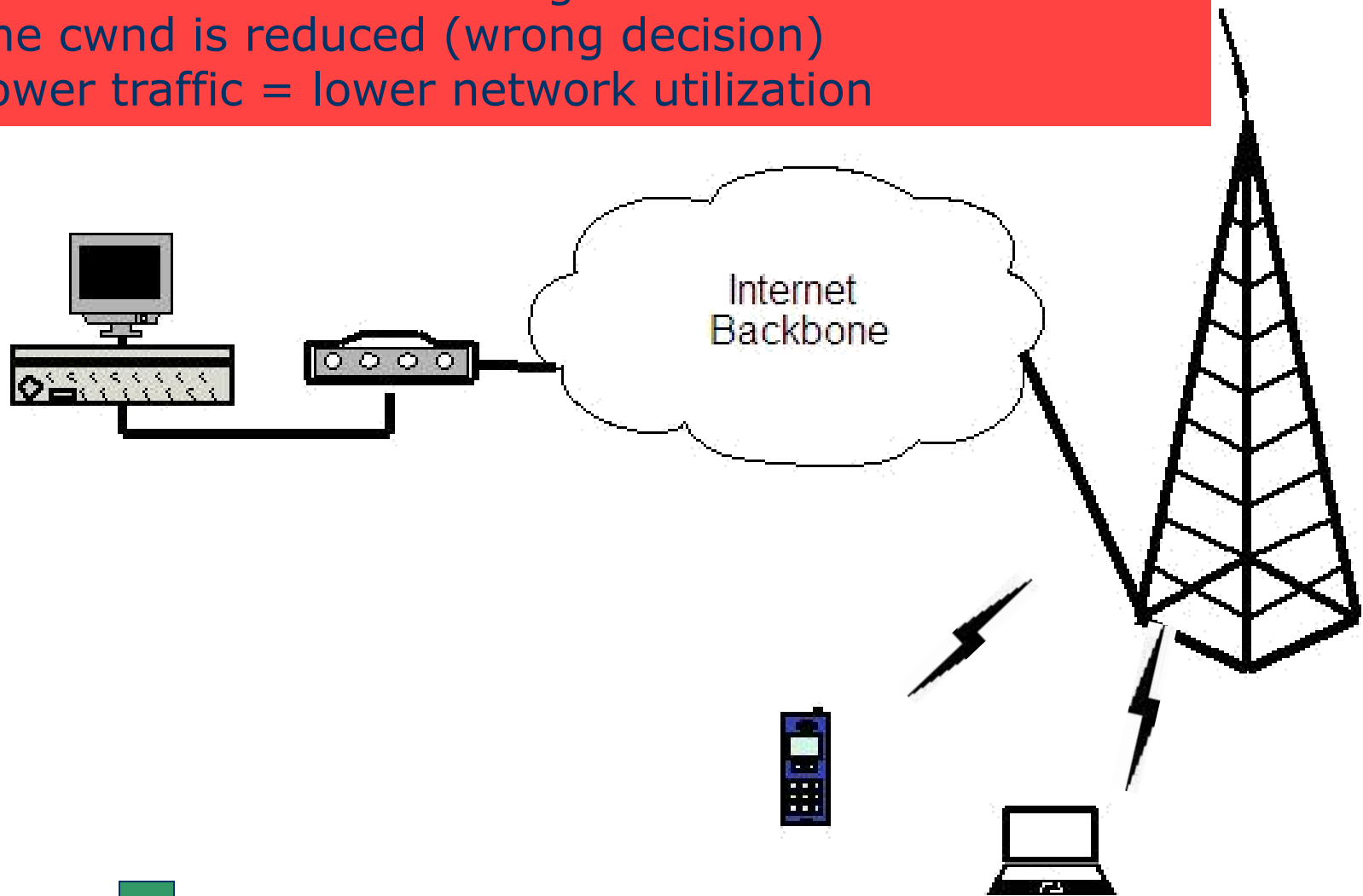


cwnd



cwnd

Loss of packet due to the wireless channel
TCP translates this as congestion
The cwnd is reduced (wrong decision)
Lower traffic = lower network utilization




cwnd

2. «Best Effort»

- All types of information are formed as IP packets and sent to the network
- IP does not have mechanism to guarantee quality characteristics for each traffic flow (delay, packet loss, etc.)
- Only UDP or TCP traffic is not enough
- The need for QoS guarantees is much bigger due to the low capacity and high error rate
- Conclusion: Traditional protocols like Ethernet is insufficient.



A



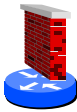
E



C



D



B

HTTP

HTTP

TCP

TCP

IP

IP

IP

IP

IP

Ethernet

Ethernet

ATM

ATM

Ethernet

Ethernet

802.11 MAC

802.11 MAC

Coaxial

Coaxial

Fiber-Optic

Fiber-Optic

Coaxial

Coaxial

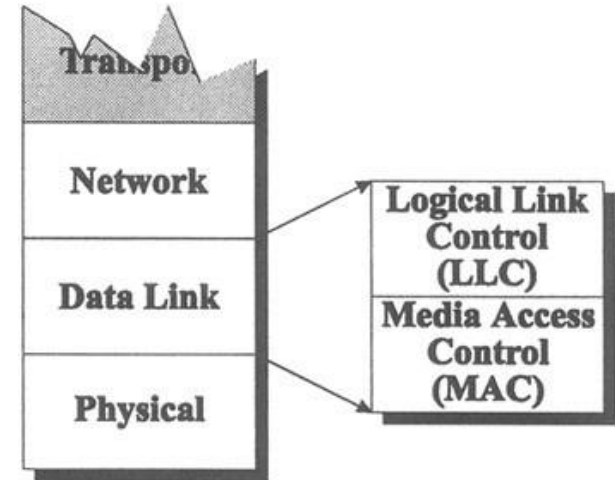
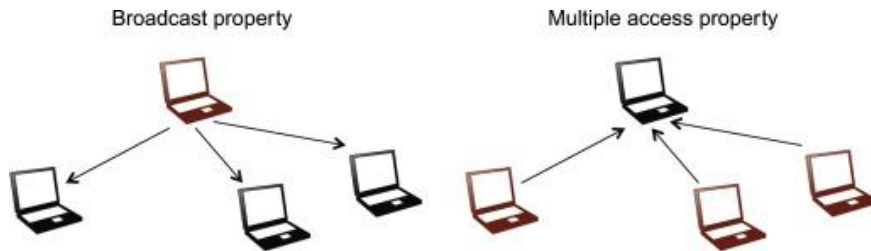
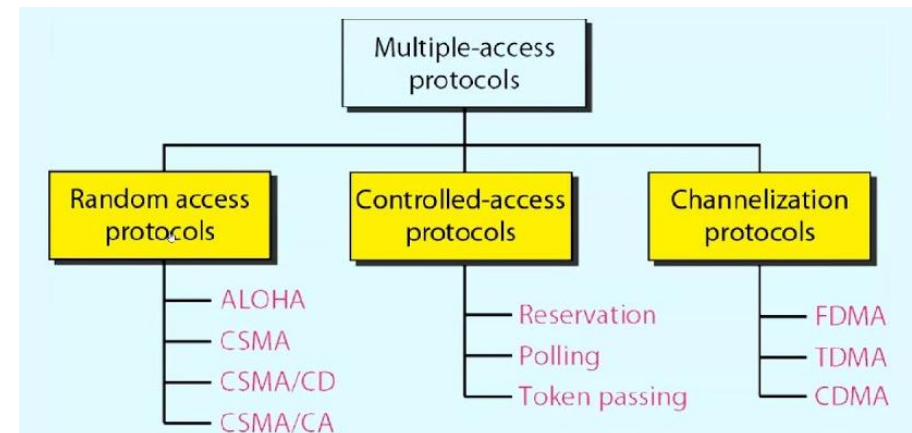
802.11 PHY

802.11 PHY

QoS
support

Radio Resource Management

- Multiple Access Control protocols
- Used mainly for uplink
- Trade-off between complexity and efficiency



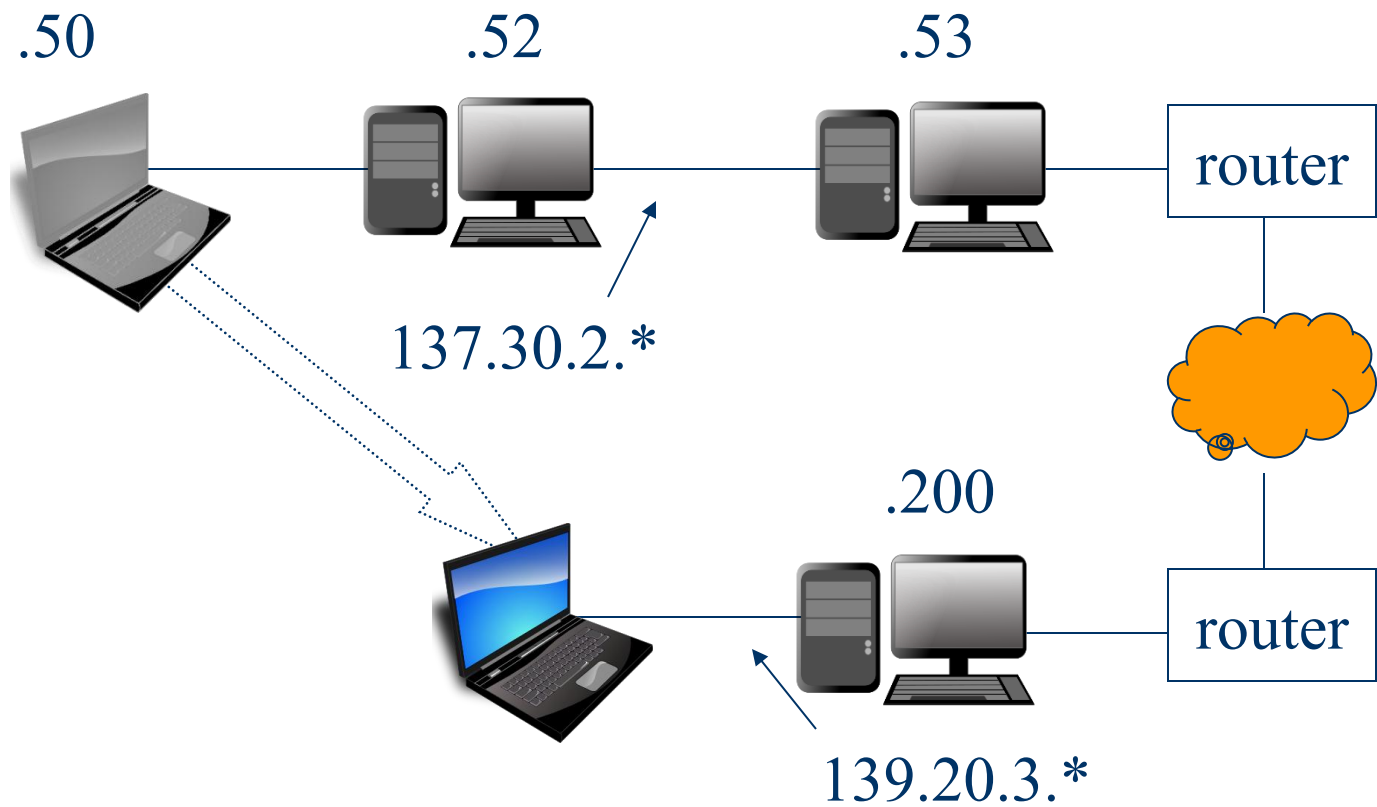
3. IP does not support mobility

- Packet routing is based on a static scheme of IP addresses
- A static address depends on the static connection point of the terminal to the network
- If the connection point changes without change of address the packets are routed to the old connection point
- But if the address changes how this can be communicated to the rest of the world?
- Impossible to inform the network each time a terminal changes its connection point

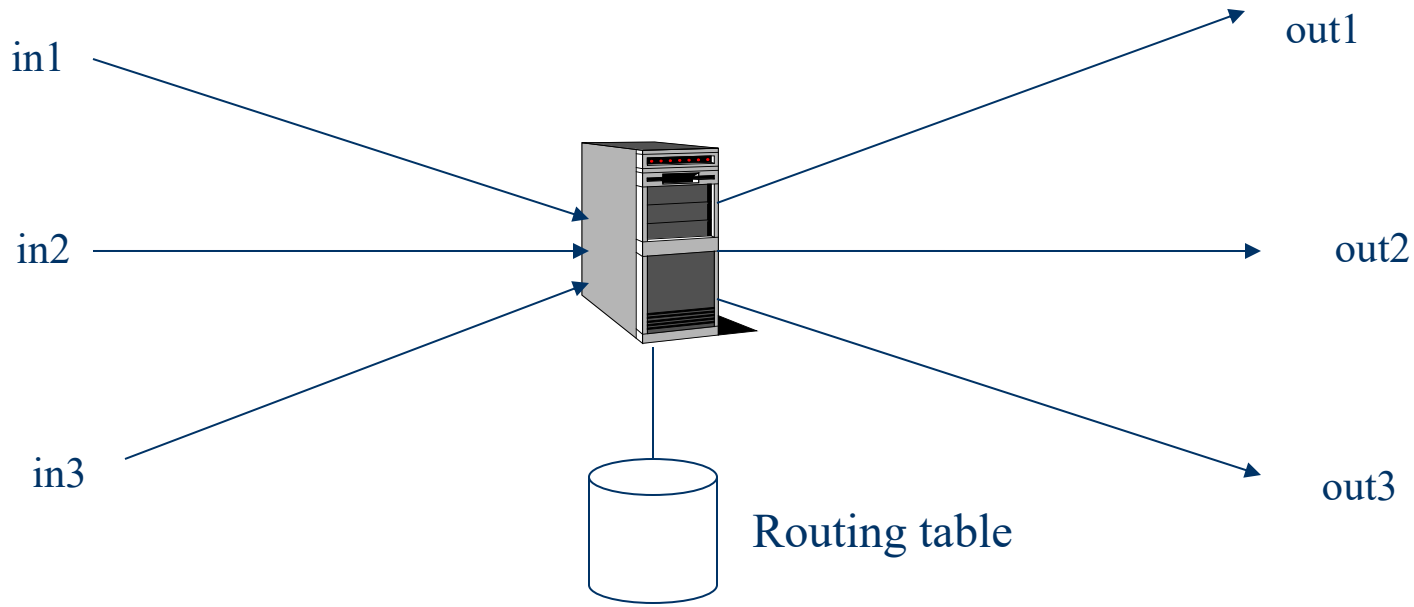
IP Header

ver.		TOS	total length				IP
IP ID						offset	
TTL	protocol		checksum				
32 bit Source IP address							
32 bit Destination IP address							
Options							
Source Port			Destination Port				

IP

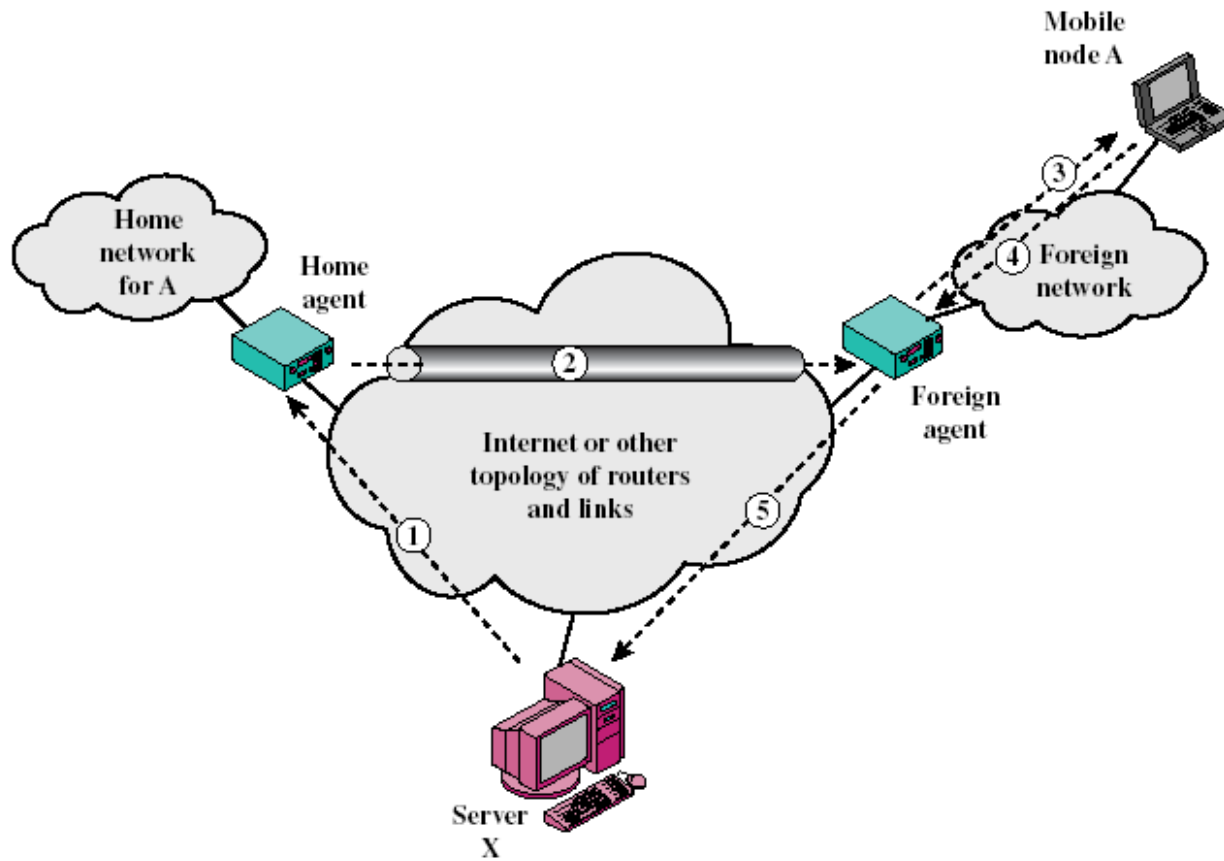


IP routing



137.30.2.x	out1
137.30.3.x	out2
default	out3

Mobile IP



Mobile IP terminology

