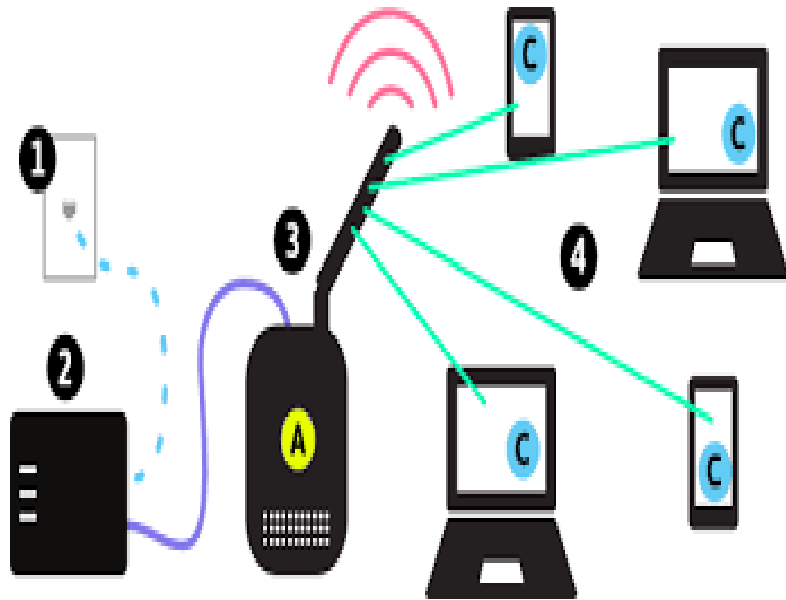

Wireless Networks and Protocols

MAP-TELE

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Agenda



Introduction to Wireless Networks and Protocols

- » What are Wireless networks
- » History of wireless networks
- » Standards
- » Evolution and trends

Fundamentals of wireless communications

- » Transmission
- » Wireless data links and MAC
- » Networking
- » Mobility management

Agenda



Telecommunications systems

- » GSM and GPRS
- » UMTS
- » TETRA
- » Broadcast and satellite: DVB, DMB

IEEE wireless data networks

- » WLAN: 802.11
- » WMAN: 802.16
- » WPAN: 802.15

Convergence and interoperability of wireless systems

- » 4G wireless networks
- » 3GPP and Mobile IPv6 approaches
- » Integration of ad-hoc networks

Agenda: QoS

Quality of service

- » Characterization and models
- » Case studies: 3GPP-QoS, IEEE-QoS, IP-QoS

Support for services and applications

- » Web services components: XML and SOAP, UDDI and WSDL
- » Services and applications platforms

The Various Types Of Traffic That QoS Measures



Bandwidth



Delay



Loss



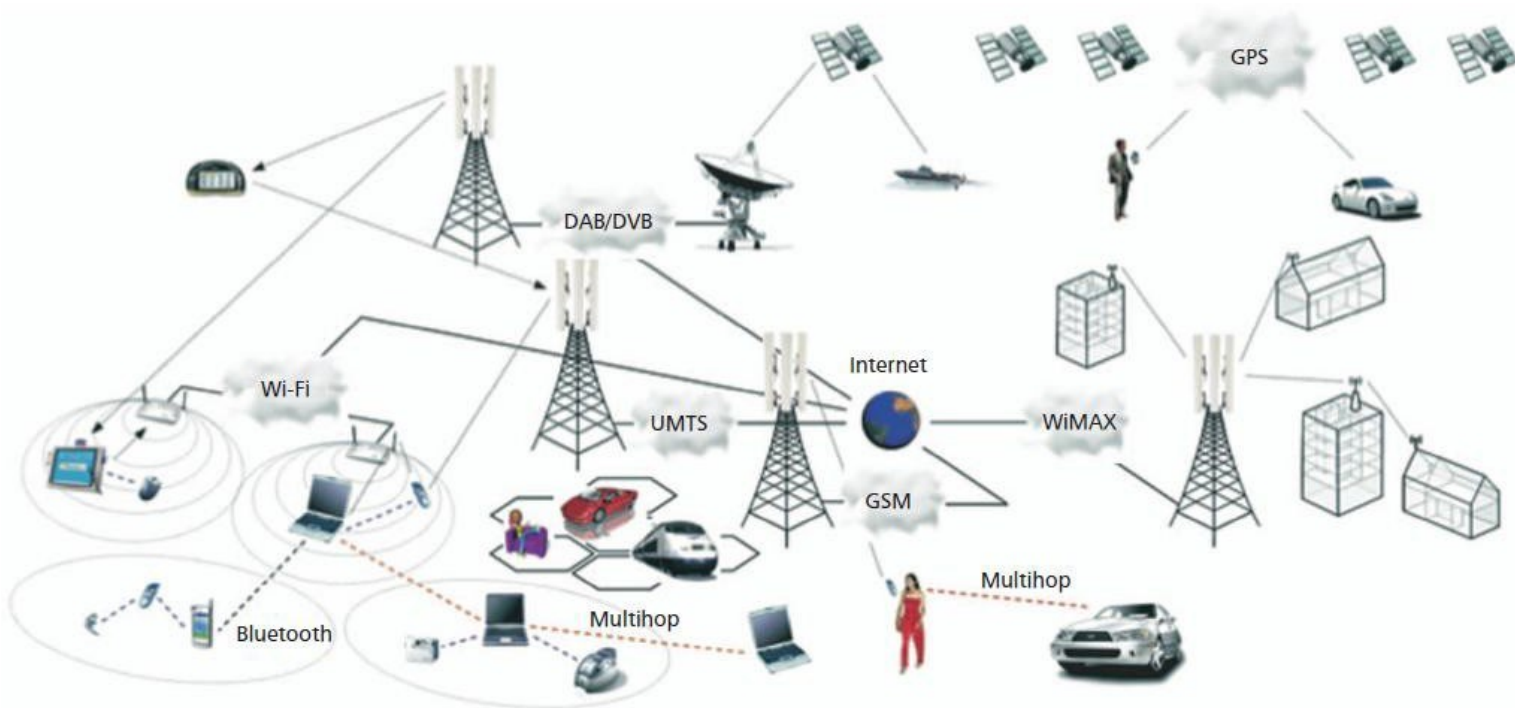
Jitter

Bibliography

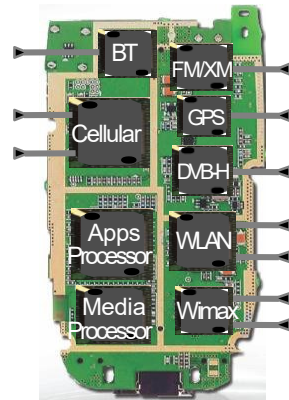
- ♦ Slides
- ♦ Recommended papers
- ♦ Chapters from multiple books
 - » Wireless and Mobile Network Architectures, Yi-Bing Lin, Imrich Chlamtac Wiley, 2001
 - » Wireless IP and Building the Mobile Internet, Sudhir Dixit, Ramjee Prasad, Artech House, 2002.
 - » Andrea Goldsmith. Wireless communications. 2006. Cambridge University Press
 - » The 3G IP Multimedia Subsystem, Merging the Internet and the Cellular Worlds, Gonzalo Camarillo and Miguel a. Garcia-Martin, Wiley, Second Edition, 2005
 - » Ad-hoc Wireless Networks, Architectures and Protocols, C. Silva Murthy, B. Manoj, Prentice Hall, 2004
 - » Advanced Wireless Networks - 4G Technologies, S. Glisic, Wiley, 2006.
 - » Mobile Communications, Jochen Schiller, Second Edition, Addison-Wesley, 2003
 - » Wireless Communications - Principles and Practice, Theodore S. Rappaport, Second Edition, Prentice Hall, 2002
 - » Mobile IP Technology and Applications, Stefan Raab and Madhavi W. Chandra, Cisco Press, 2005
 - » GSM cellular radio telephony, Joachim Tisal, John Wiley & Sons, 1997
 - » Wireless Communications and Networks, William Stallings, Prentice Hall, 2002
 - » WCDMA for UMTS : radio access for third generation mobile communications, Harri Holma, John Wiley & Sons, 2000
 - » UMTS networks : architecture, mobility and services, Heikki Kaaranen, et al, John Wiley & Sons, 2001

WNP – Wireless Networks

- ◆ About **wireless** communications systems
- ◆ Addressed from a **network** and system perspectives



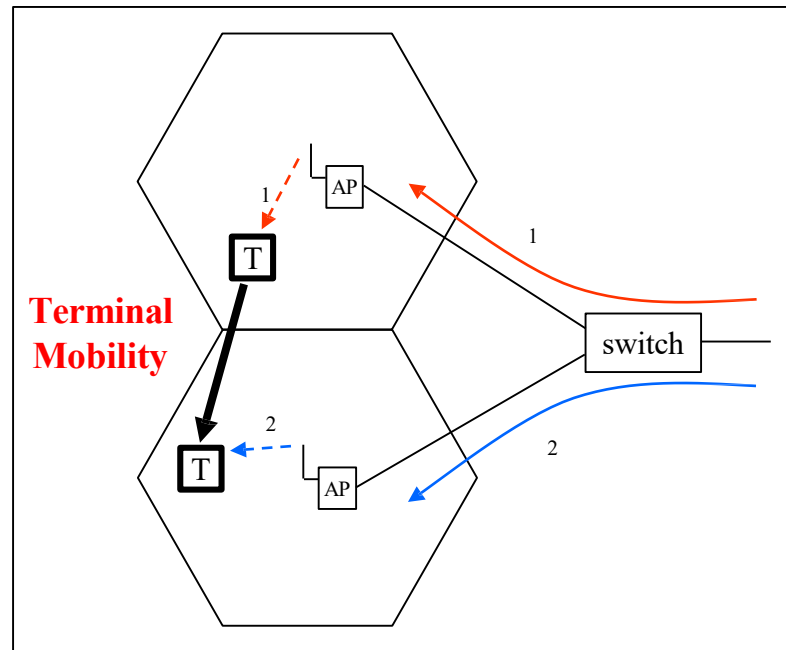
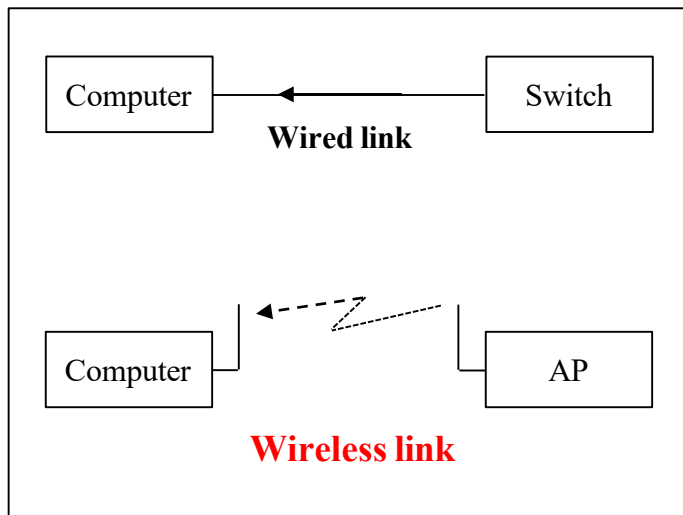
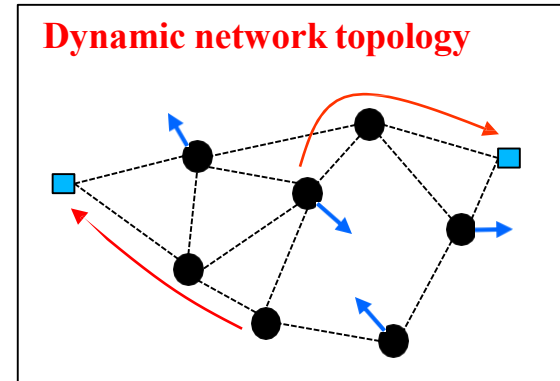
Common wireless communications systems



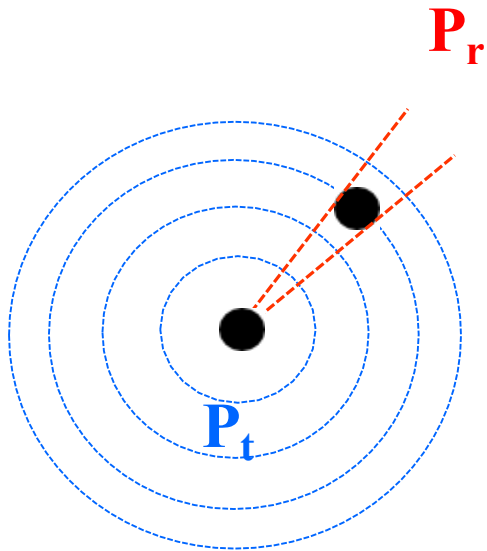
Mobile phone

Wired versus Wireless networks

- ♦ **Wireless Networks** characterised by
 - » wireless links
 - » mobility of nodes
 - » dynamic network topologies



Wireless Link



Low powers received = low SNR

- Large % of bits possibly received in error

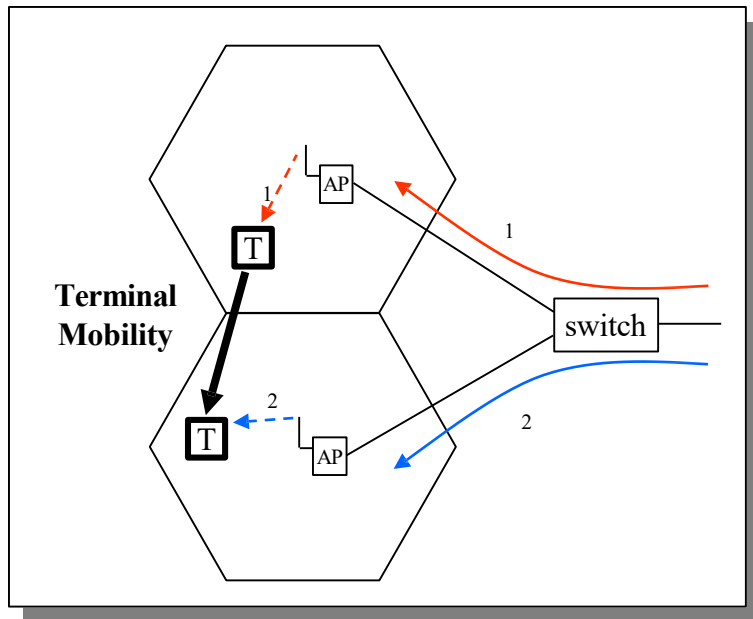
SNR varies with time and positions

- Variable capacity (bit/s) or variable error ratio (BER)

Broadcast nature

- Information easily accessible by third parties. **Need security mechanisms**

Mobility



Mobility: characteristic of portable terminals and moving objects

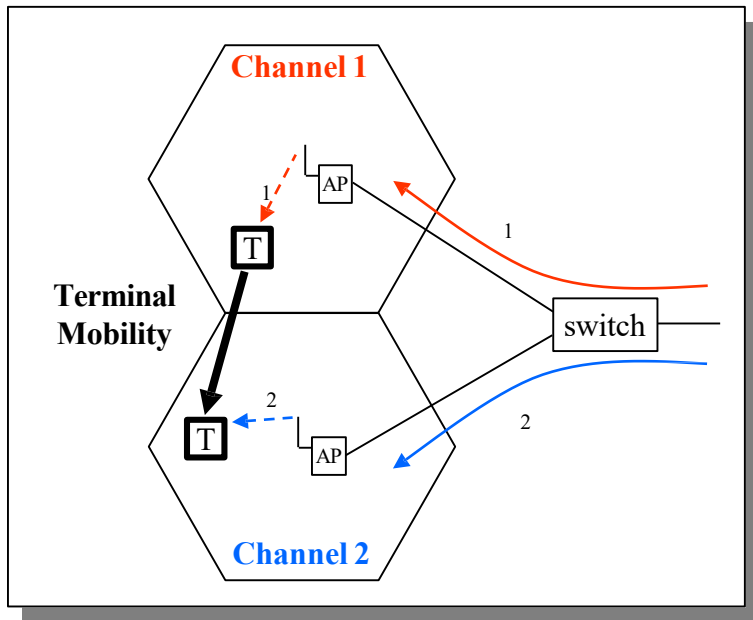
Problems introduced by mobile terminals

» Determine new location

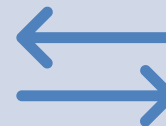
» Find radio resources in new location

» Determine the new path for data delivery

The problem



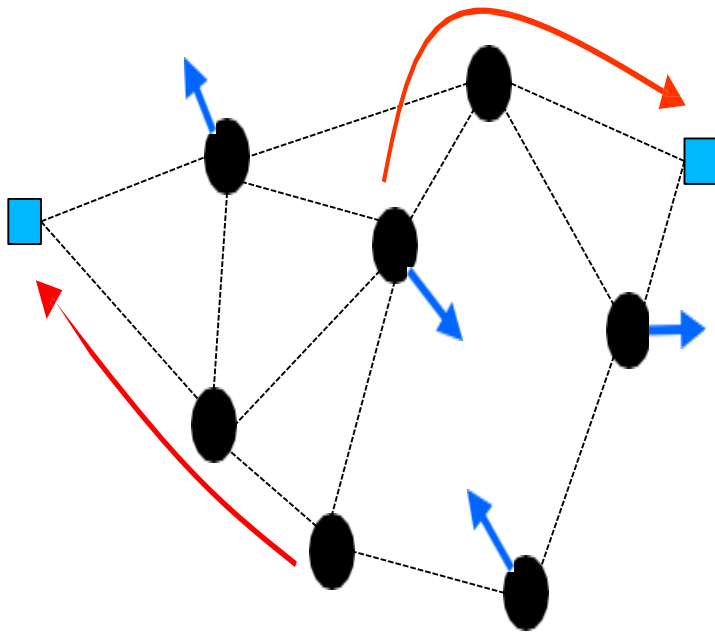
The terminal is receiving packets and, after moving to a new location, the terminal is expected to continue receiving packets



What procedure would you implement to manage the terminal mobility?

Dynamic Network Topology

Dynamic network topology



Nodes move



Capacity of a link (bit/s) varies along the time



Communication of a node interferes with a neighbor node



Shortest path between two nodes varies along the time



Capacity of the network becomes hard to characterize

History – Past and Radio

Past

- » Fire signals communicate the fall of Troy to Athens
- » 2nd century B.C., sets of torches to transmit characters
- » 1837, electric telegraph

Radio transmission

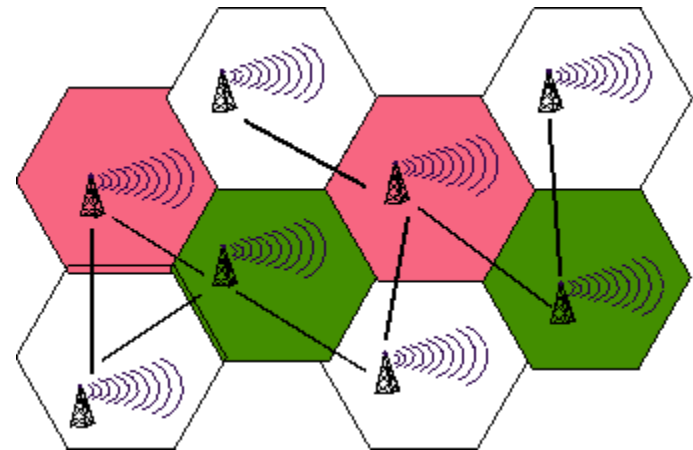
- » 1895, first radio transmission
- » 1906, amplitude-modulated (AM) radio
- » 1920, broadcast of radio news program
- » 1928, TV broadcast trials
- » 1933, frequency-modulated (FM) radio
- » 1946, Swedish police: radio phones installed in cars
- » 1950, mobile phone with direct dialling



Cell, 1st Generation

- ◆ 1950: Cellular network concept
- ◆ 1971, Finland: ARP, first cellular, mobile network
- ◆ 1982, NMT network covering Nordic countries
- ◆ 1983, AMPS in America
- ◆ 1985, TACS, Total Access Communications Service, in Europe

- 1st Generation: Analogue, Frequency Division Multiplexing



- The power of transmitted signal falls with square of distance.
- Users can operate on same frequency at separate locations

History – Packet Radio

1971, ALOHNET packet radio

- » computers communicate with central HUB

1980's ad-hoc, self-configurable packet networks

1985, Wireless LANs authorized to use ISM bands

1997, first WLAN standard

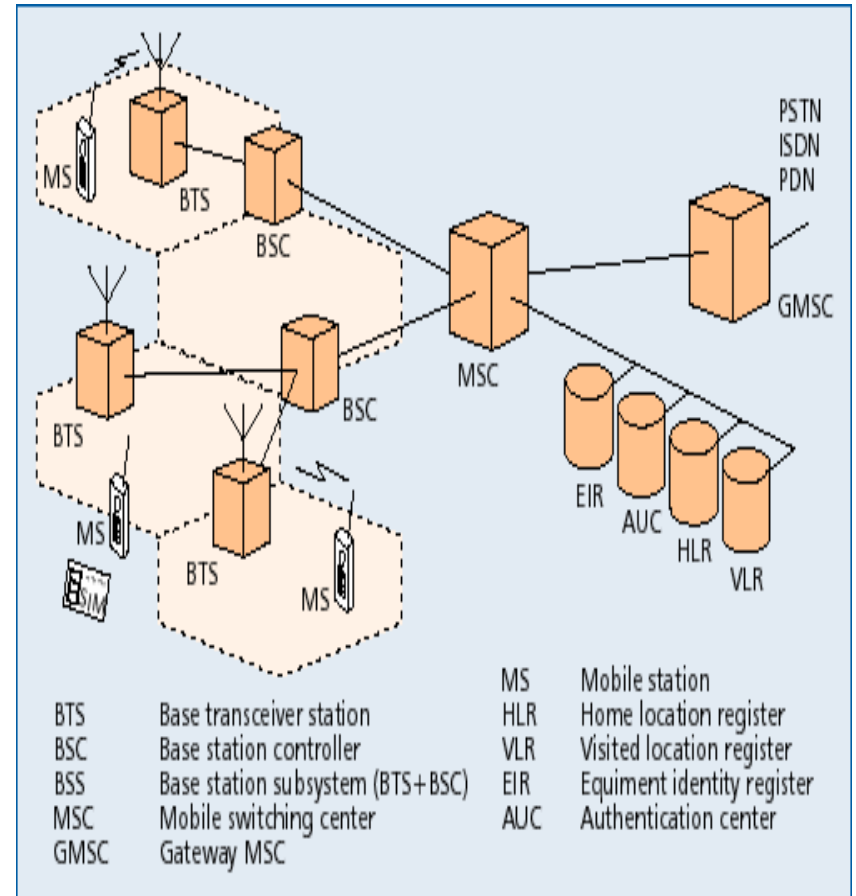
History – 2/3G

2nd Generation

- digital transmission and signalling; ISDN based
- » 1982, specification GSM is started
- » Early 1990's
 - Europe: GSM
 - USA: D-AMPS, cdmaOne
 - Japan: Personal Digital Cellular (PDC)

3G systems

- aimed at multimedia communication
- » 2001, Japan, first implementation of 3G systems



Types of Networks

WPAN - Wireless Personal Area Networks

- » short distances among a private group of devices

WLAN - Wireless Local Area Networks

- » areas such as an home, office or group of buildings

WMAN - Wireless Metropolitan Area Networks

- » from several blocks of buildings to entire cities

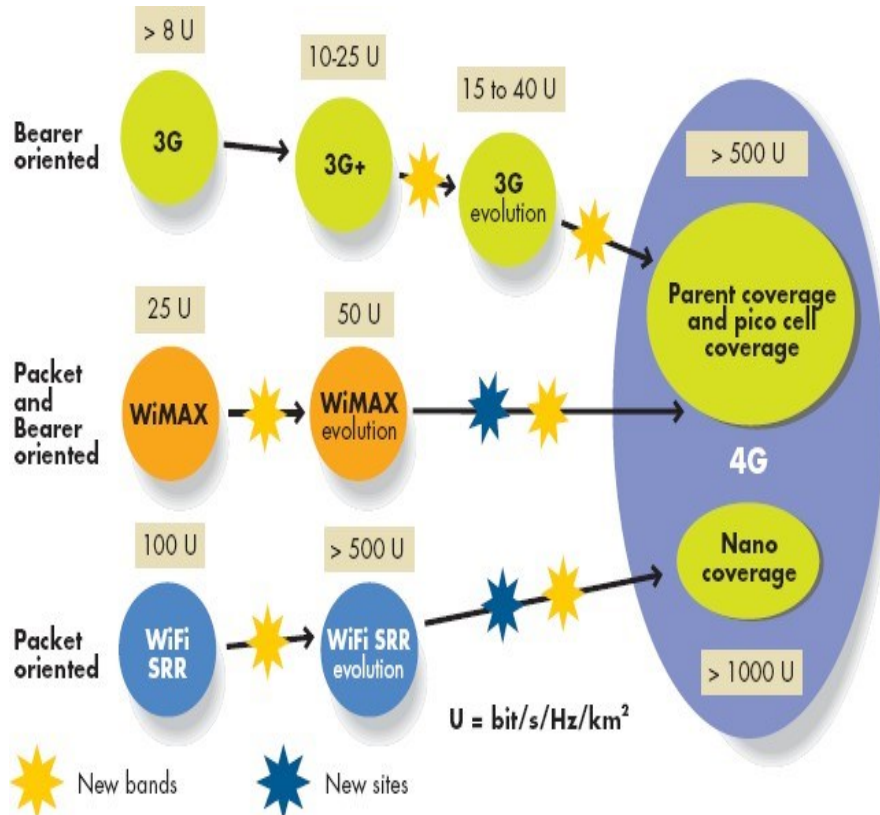
PLMN - Public Land Mobile Networks

- » regions and countries

Broadcast

- » single direction, audio and video

Comparison



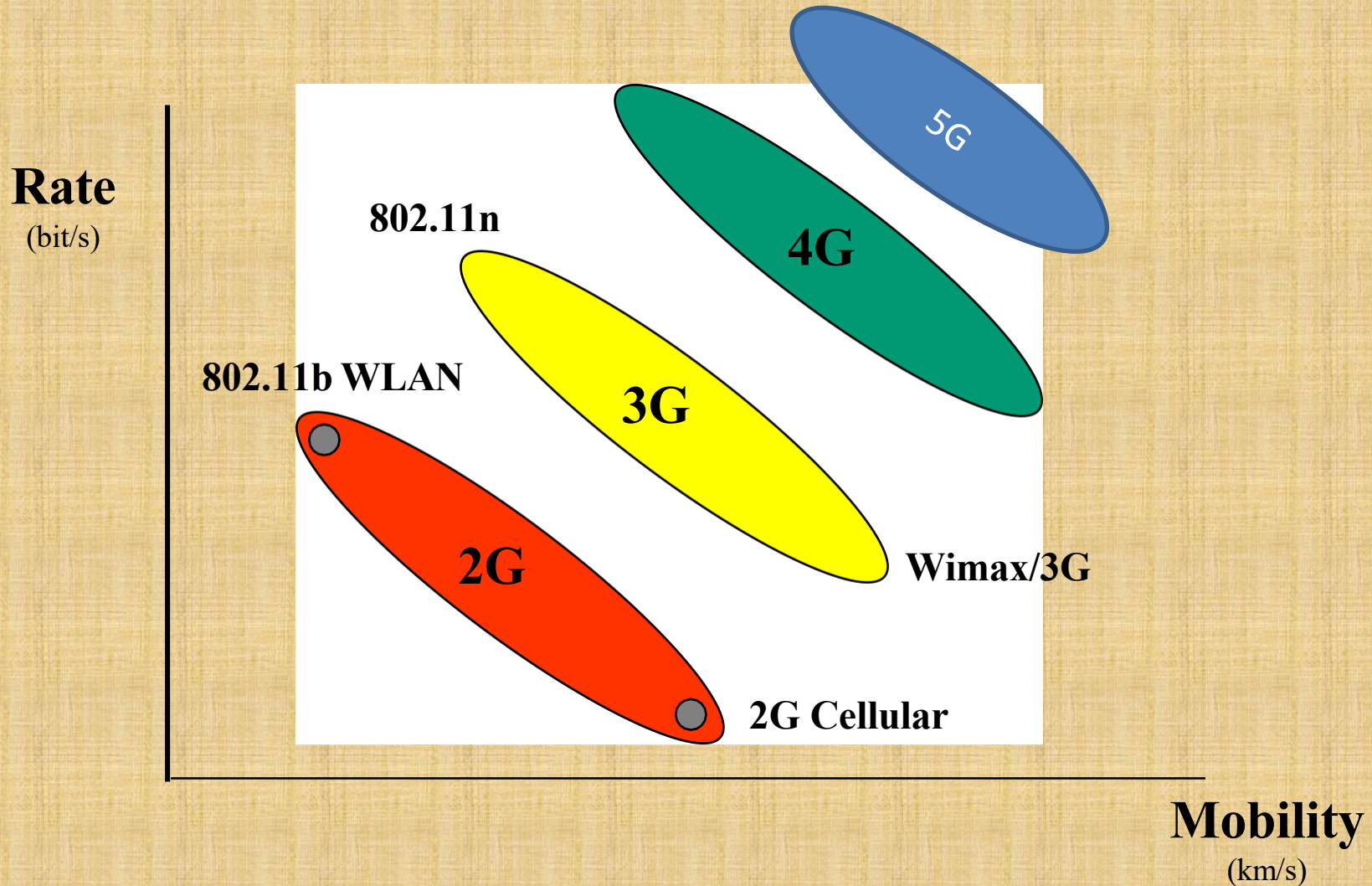
$U = \text{bit/s/Hz/km}^2$

PLMN → 10 to 40 U
(based on UMTS)

WMAN → 25 to 50 U

WLAN → 100 to 500 U

Evolution of Technologies



Standard Organizations - IEEE



IEEE - Institute of Electrical
and Electronics Engineers

802 Standards for Local
/Metropolitan Area Network,
wired and wireless

- » Wireless LANs (802.11)
- » Wireless Personal Area Networks (802.15),
- » Broadband Wireless Metropolitan Area Networks (802.16)
- » Mobile Broadband Wireless Access (802.20)
- » Media Independent Handoff Working Group (802.21)
- <http://standards.ieee.org/getieee802/index.html>

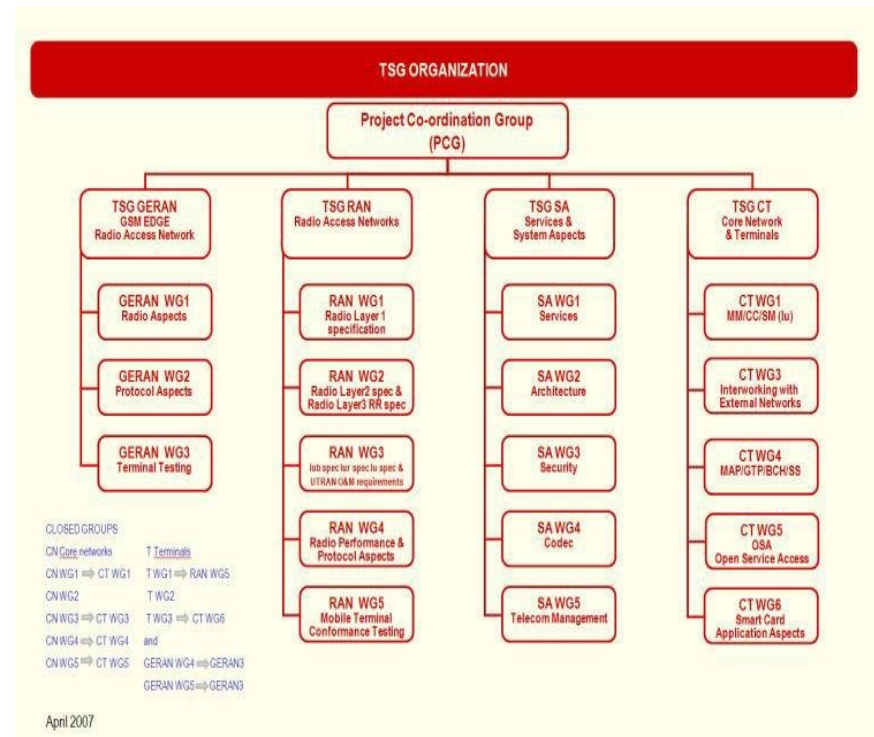
Layers 1 and 2
of the OSI
communications
model

Below the
TCP/IP layer

Standards – 3GPP

Scope of 3GPP

- » Specifications for the 3rd Generation mobile system
- » Maintain GSM, GPRS and EDGE
- » Specifications developed by Technical Specification Groups (TSG)
- <http://www.3gpp.org>



Standards - IETF

- ◆ Defines standards for the Internet, including
 - » TCP/IP
 - » key services
 - » routing protocols
 - » deployment of IP over technologies

<http://www.ietf.org>



Standards - Other

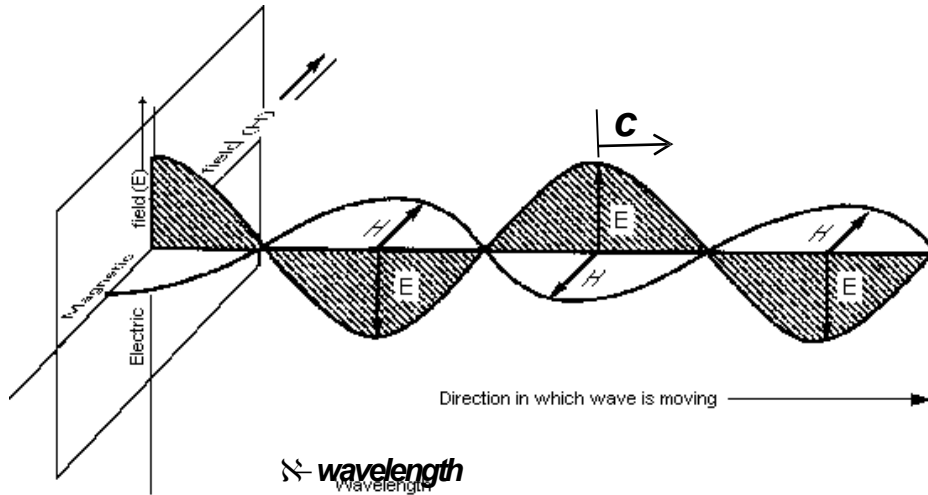


ITU - Worldwide

ETSI - Europe

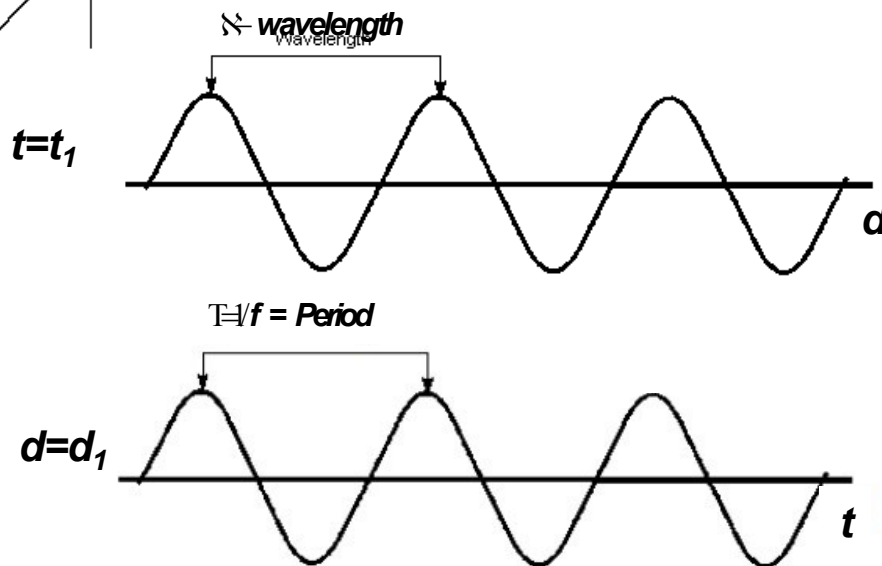
3GPP2 – American
3GPP

Electromagnetic Wave



$$\lambda = c/f$$

$c = 3 \times 10^8 \text{ m/s}$, speed of light



$$f_c = 3 \text{ GHz} \rightarrow \approx 10 \text{ cm}$$

$$f_c = 1 \text{ GHz} \rightarrow \approx 30 \text{ cm}$$

$$f_c = 300 \text{ MHz} \rightarrow \approx 1 \text{ m}$$

Frequencies for Radio Transmission

Frequency bands as defined by the ITU-R ***Radio Regulations***

$$band_i \in [0.3 \times 10^i Hz, 3 \times 10^i Hz[.$$

VLF	Very Low Frequency
VLF	Very Low Frequency
LF	Low Frequency
MF	Medium Frequency
HF	High Frequency
VHF	Very High Frequency
UHF	Ultra High Frequency
SHF	Super High Frequency
EHF	Extremely High Frequency

Band Number	Symbol	Frequency Range
4	VLF	3-30 kHz
5	LF	30-300 kHz
6	MF	3000-3000 kHz
7	HF	3-30 MHz
8	VHF	30-300 MHz
9	UHF	300-3000 MHz
10	SHF	3-30 GHz
11	EHF	30-300 GHz
12		300-3000 GHz

$$f_c = 3 \text{ GHz} \rightarrow \approx 10 \text{ cm}$$

$$f_c = 1 \text{ GHz} \rightarrow \approx 30 \text{ cm}$$

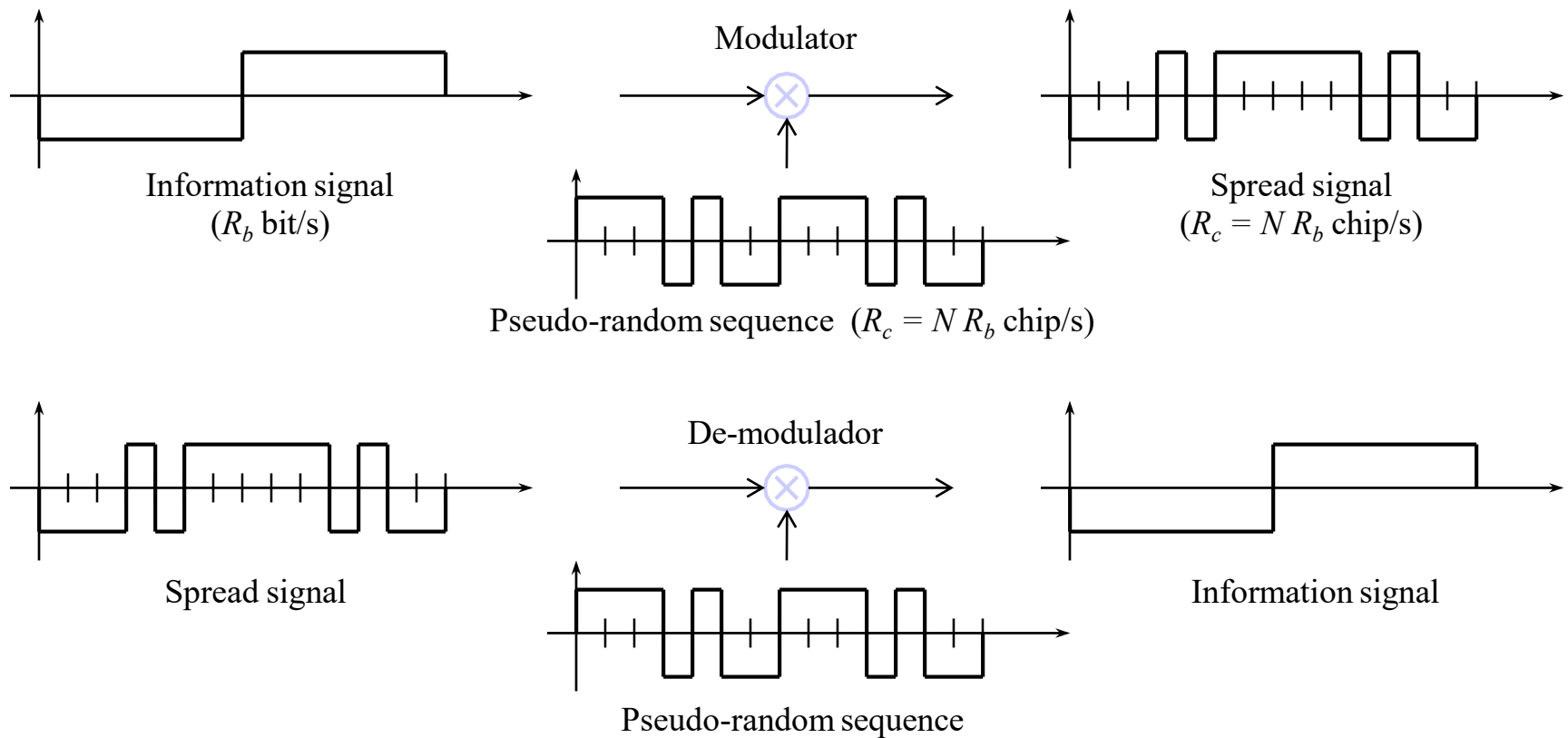
$$f_c = 300 \text{ MHz} \rightarrow \approx 1 \text{ m}$$

Wireless Systems in Europe

- In Portugal
ANACOM attributes the frequencies
<http://www.anacom.pt>
- FWA
Fixed Wireless Access
- ISM
Industrial, Scientific and Medical

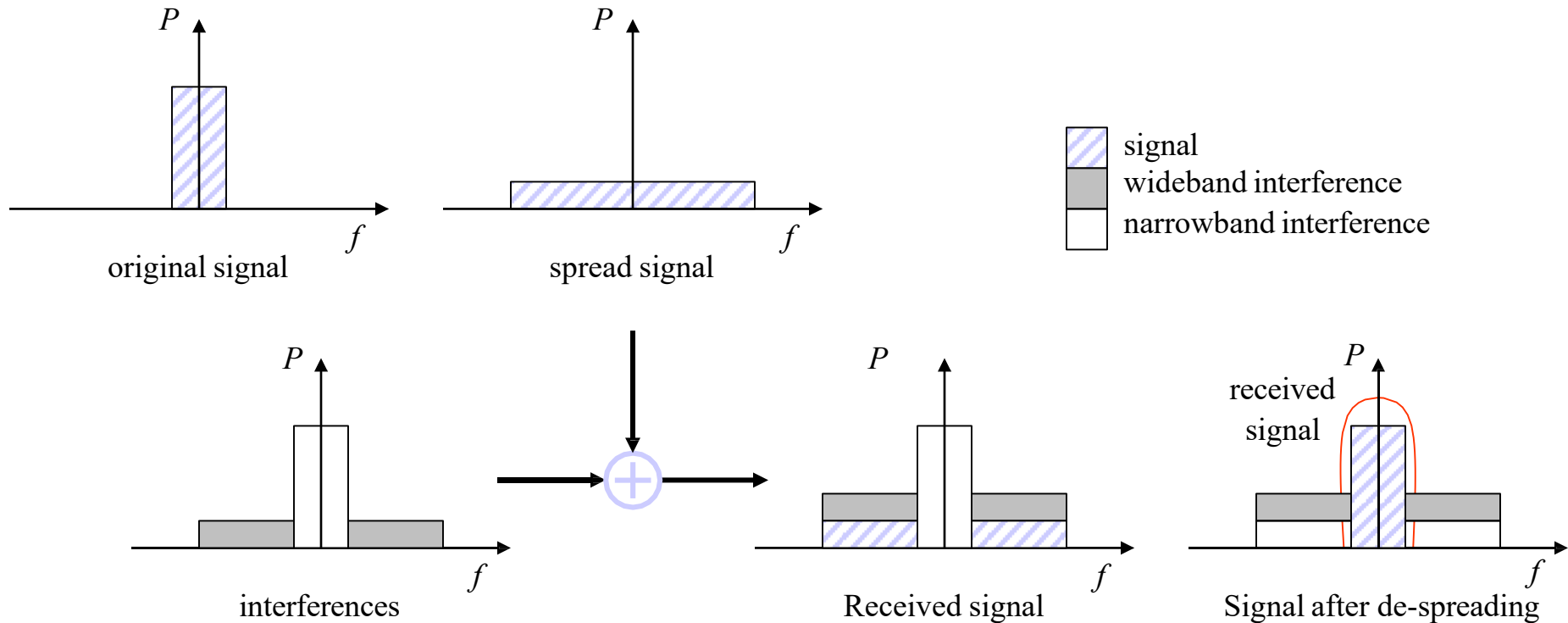
Wireless Systems in Europe	Frequency Range
Broadcast TV	47-68 MHz 174-216 MHz 470-582 MHz 582-862 MHz
2G PLMN (GSM)	890-914 MHz 935-959 MHz 1710-1785 MHz 1805-1880 MHz
3G PLMN (UMTS)	1900-1980 MHz 2010-2025 MHz 2110-2170 MHz
FWA	3400-3600 MHz 3600-4200 MHz 24.5-26.5 GHz 27.5-29.5 GHz
ISM	13553-13567 kHz 26957-27283 kHz 40.66-40.70 MHz 2400-2500 MHz 5725-5875 MHz 24-24.25 GHz

Spread Spectrum – Direct Sequence



Direct Sequence Spread Spectrum – Immunity to Interferences

Intro 79



Software Defined Radio

- ◆ Software Defined Radio
 - aims at implementing the radio functions in software
- ◆ Digital Signal Processors being integrated with microcontroller
 - better integration of radio and communications functions

Cognitive Radio

- ◆ Cognitive radio
 - » fills unused bands
 - » avoids interferences
 - » increases spectral efficiency

- ◆ Paves the way to
 - » dynamic spectrum licensing
 - » secondary markets in spectrum usage

Homework

1. Review slides

1. Detailed information about these topics can found at the Goldsmith's book
 - » Chap. 5 (sections 5.1, 5.2, 5.3, 5.5)
 - » Chap. 6 (sections 6.1, 6.3)
 - » Chap. 7 (sections 7.1, 7.2)
 - » Chap. 8 (section 8.1)
 - » Chap. 9 (section 9.1)
 - » Chap. 12 (sections 12.1, 12.2, 12.4)
 - » Chap. 13 (sections 13.1, 13.2, 13.3)