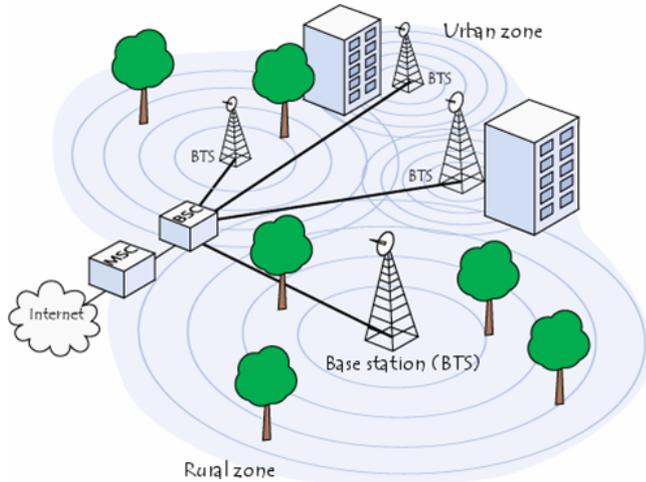


# ICT course: Mobile Wireless Communications

Lecturers:  
Dr. Nguyen Minh Huong

# First sight



## 1G

### 1<sup>ST</sup> GENERATION wireless network

- Basic voice service
- Analog-based protocols



THE NEED FOR SPEED in kilobits per second

2.4 kbps



## 2G

### 2<sup>ND</sup> GENERATION wireless network

- Designed for voice
- Improved coverage and capacity
- First digital standards (GSM, CDMA)



64 kbps



## 3G

### 3<sup>RD</sup> GENERATION wireless network

- Designed for voice with some data consideration (multimedia, text, internet)
- First mobile broadband



2,000 kbps



## 4G

### 4<sup>TH</sup> GENERATION wireless network

- Designed primarily for data
- IP-based protocols (LTE)
  - True mobile broadband



100,000 kbps

# Course Schedule: 36 hours

- Lectures: 24 hours

1. Introduction
2. Characteristics of mobile radio environment:
  - Propagation
  - Fading and mitigations
3. Cellular concept
4. Modulation techniques
5. Multiple Access techniques
6. Coding for error detection and correction
7. Applications – Mobile network Generations:
  - GSM
  - 3G/LTE-4G
  - 5G and future of mobile networks (discussion)

- Exercises: 12 hours

- References:

- [1]. Mischa Schwartz: Mobile Wireless Communication, CAMBRIDGE UNIVERSITY PRESS, 1st Edition (2005)
- [2]. Wireless Communications: Principles and Practice (2nd Edition) by Theodore S. Rappaport
- [3]. Google

# Lecture1: Introduction

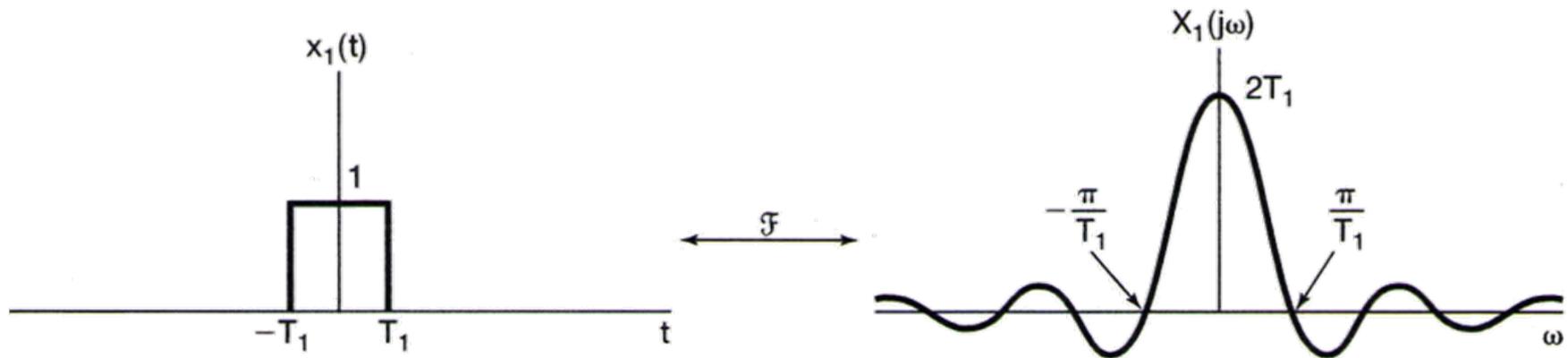
- ❑ Reminders of “signal and systems” course
- ❑ Introduction of Mobile communication Networks
- ❑ Basic elements of a digital communication systems
- ❑ The evolution of cellular networks

# Reminders:

- Common used terms:
  - Signal, waveform
  - Spectrum, Bandwidth
  - System
  - Dirac delta function
- Common used mathematic computations:
  - Fourier transform
  - Probability and random variables
  - Convolution

# Signals

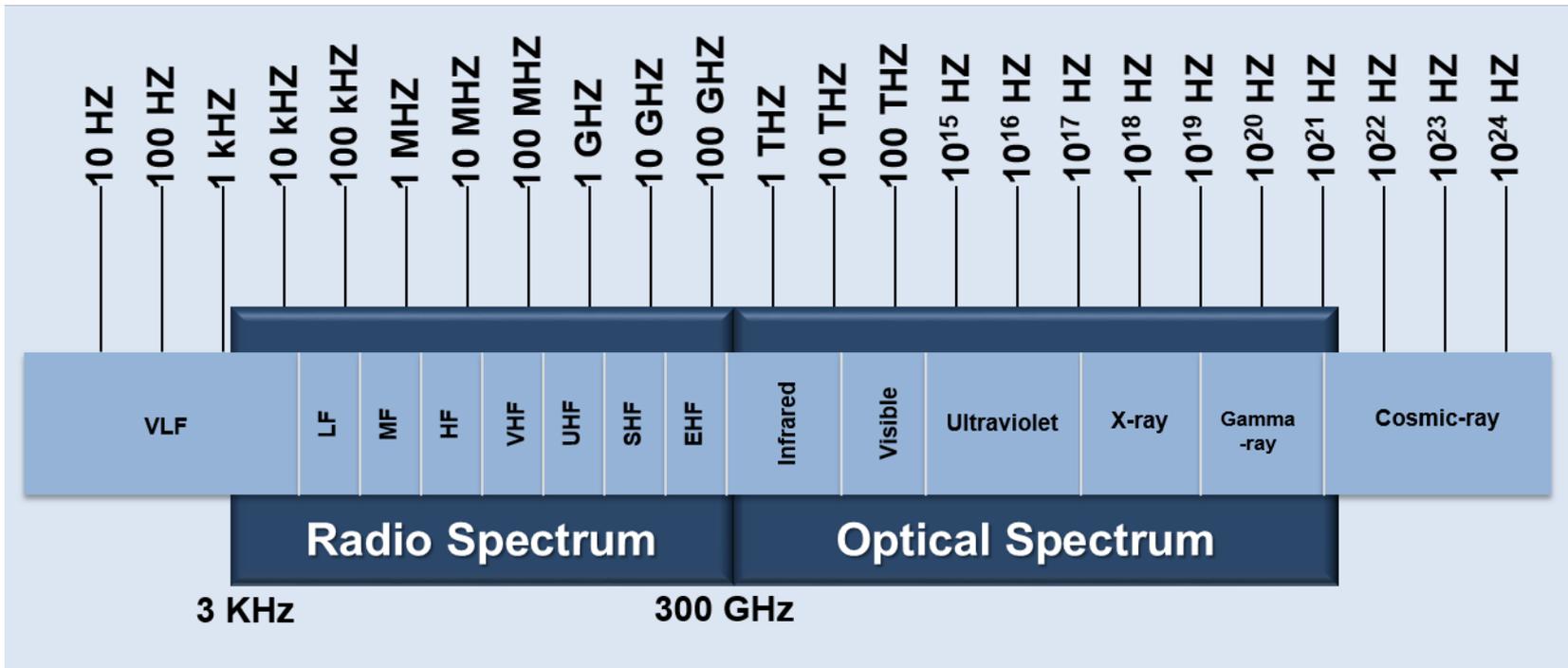
- Signal(electrical): a function conveys information
- Waveforms: electromagnetic wave
- Time domain and Frequency domain:



- Fourier transform:

$$X(\omega) = \int_{-\infty}^{+\infty} x(t)e^{-j\omega t} dt$$

# Electromagnetic Spectrum

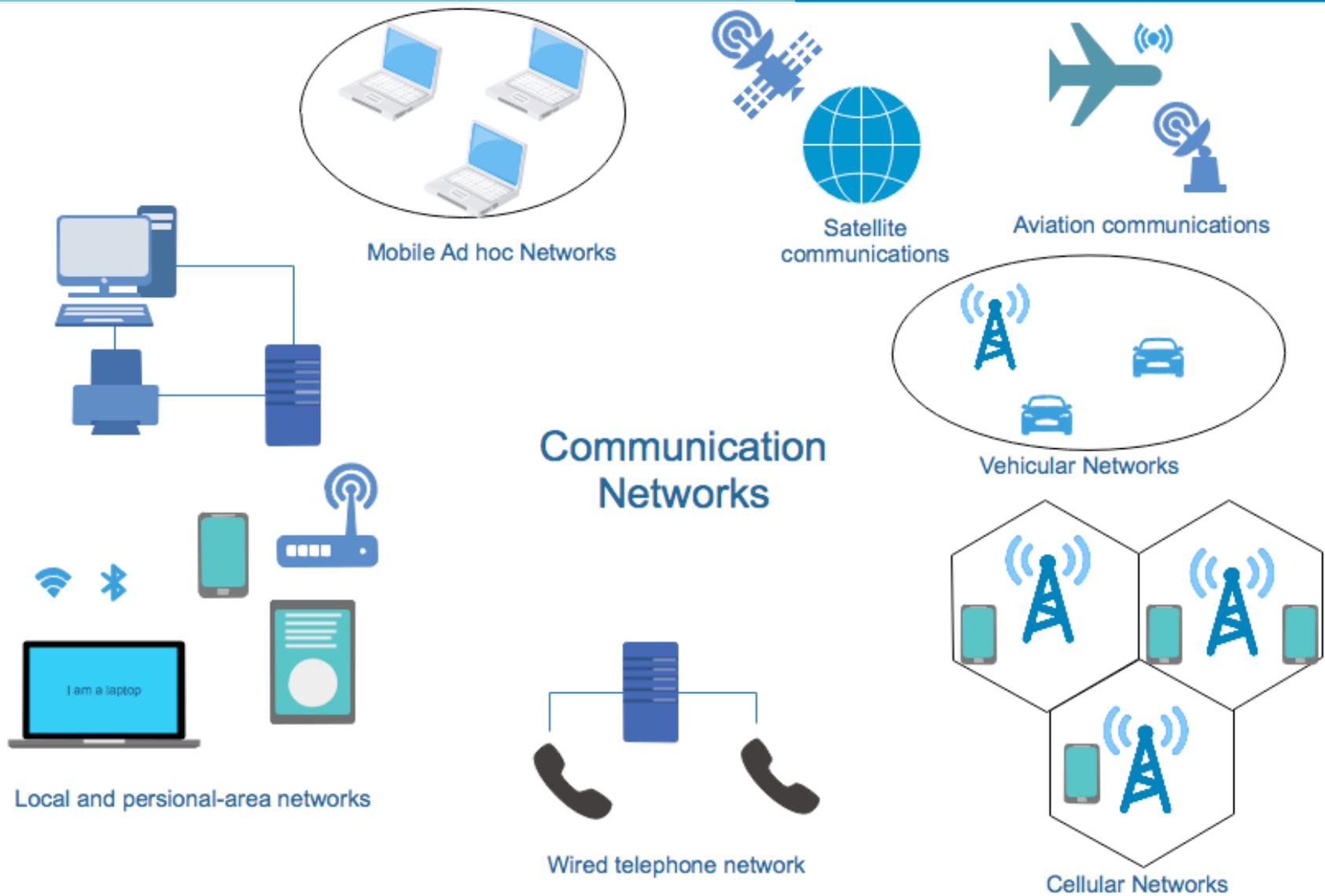


- Bandwidth: a range of frequencies

# Introduction of Mobile communication networks

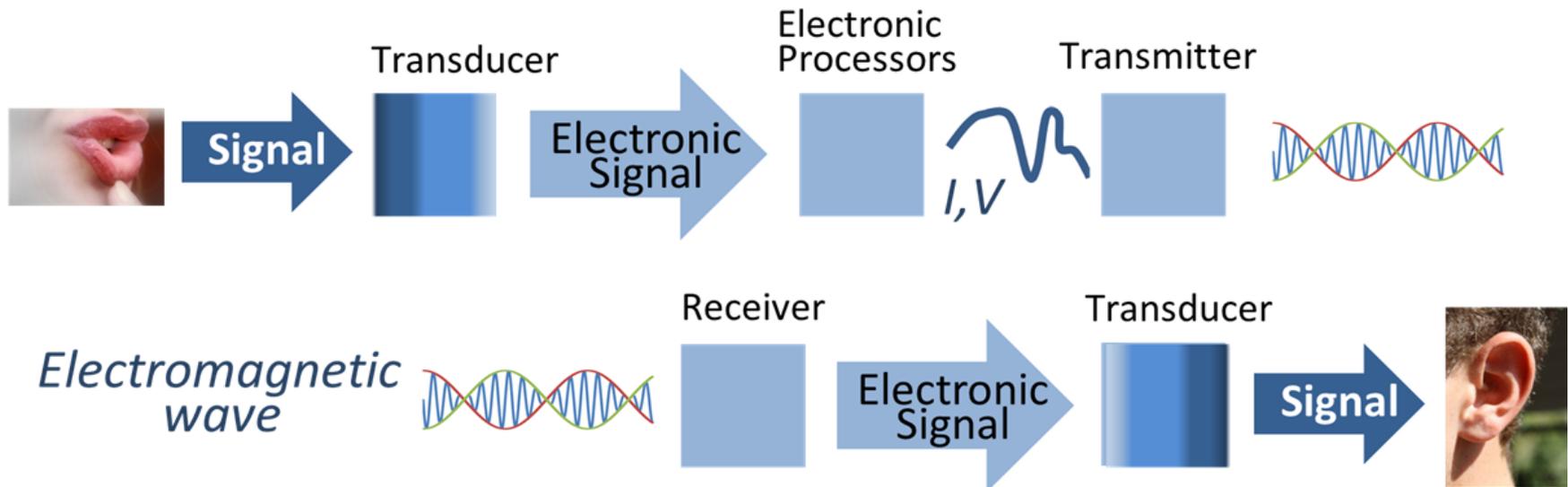
# Introduction of Mobile Communication Networks

- Communication Networks:
  - Wired networks
  - Wireless networks
- Wireless communication Networks:
  - Infrastructure or ad hoc
  - Mobile or fix
- Mobile communication Networks:
  - Cellular networks (mobile networks)
  - Wireless Local-area and personal-area networks (WLAN/PAN)



## Signal transmission using electronics signals

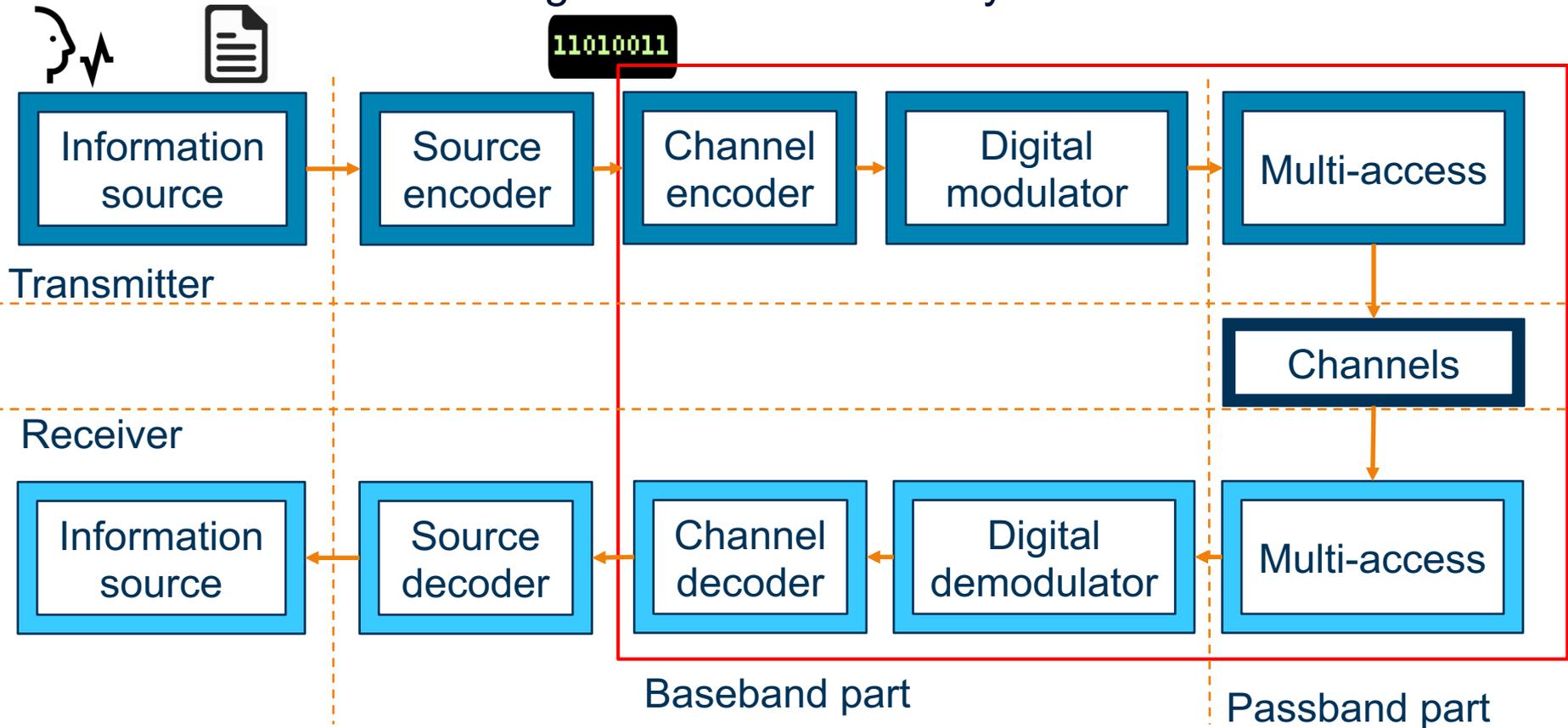
(source: Wikipedia)



# Digital Communication systems

# Digital communication systems

- Basic elements of a digital communication system

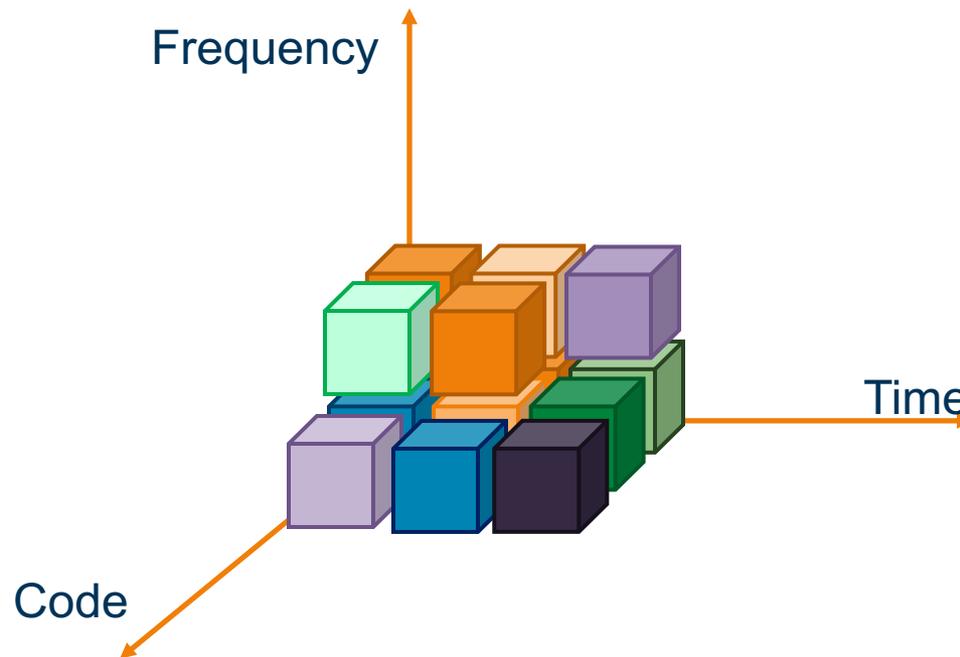


- Scope of this course:
  - Digital communication
  - Cellular networks
  - WLAN (optional)

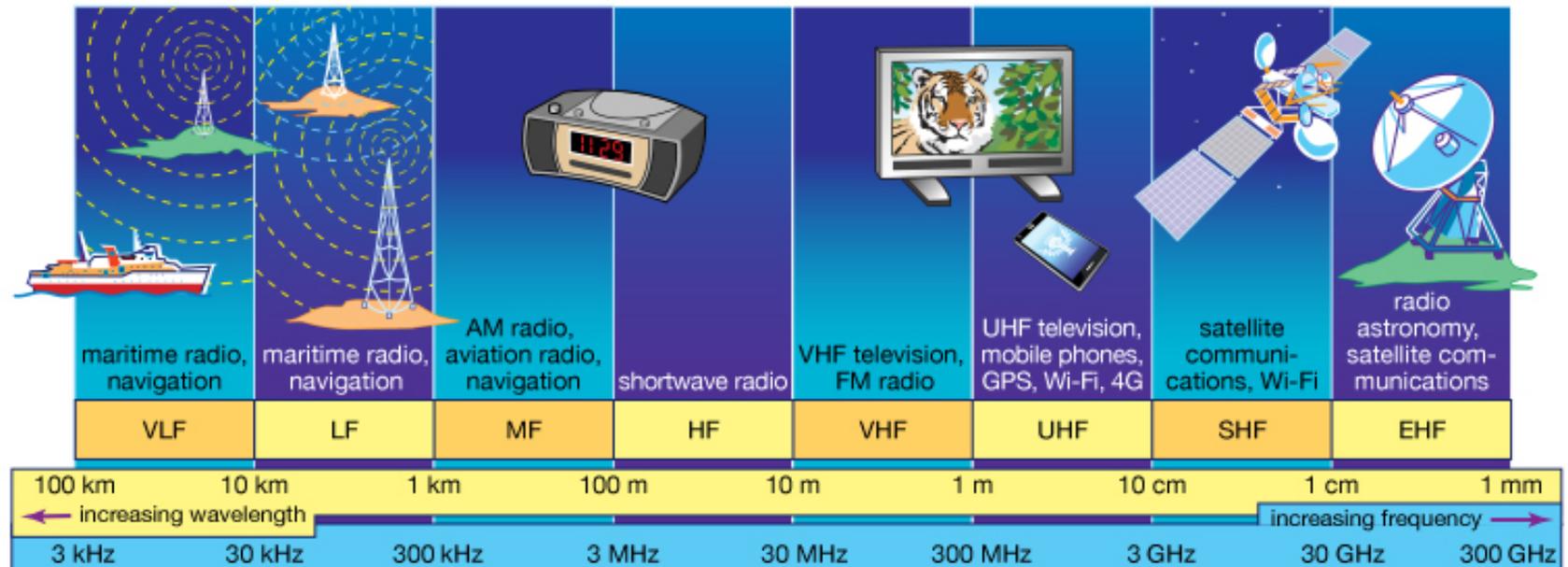
- **Information source:** either analog signal (voice, video) or digital signal (binary sequence)
- **Source encoder:** converts source information into binary sequence of digits (11010...).
  - **Data compression:** converting information into **as few digits as possible**
- **Channel encoder:** introduces some redundancy in the binary sequence which can be used at the receiver to overcome the effects of noise and interference encountered in the transmission of signal through the channel.

- **Digital Modulator:** serves as the interface to the communications channel
  - Mapping binary sequence into waveforms (modulating signals):
    - **Transmitting  $b$  bits at a time:  $b$  bits  $\equiv$  a symbol  $\rightarrow$  a waveform  $s_i(t)$**
    - **Number of waveforms:  $M = 2^b$**   
 **$\rightarrow$  M-ary modulation**
  - Conveying above information-bearing waveforms into carrier signal: varying properties of carrier signal with the modulating signal
  - Frequencies of carrier signal are within bandwidth of the channel

- **Multiple access:** allows several users to transmit over the same medium
  - Time Division Multiple Access (TDMA): one user per time slot
  - Frequency Division Multiple Access (FDMA): one user per frequency
  - Code-Division Multiple Access (CDMA): Multiple users can talk at the same time using different languages (“code”)



- Channels:
  - Wireline channels
  - Fiber optic channels
  - Wireless channels (radio): 3KHz-300GHz



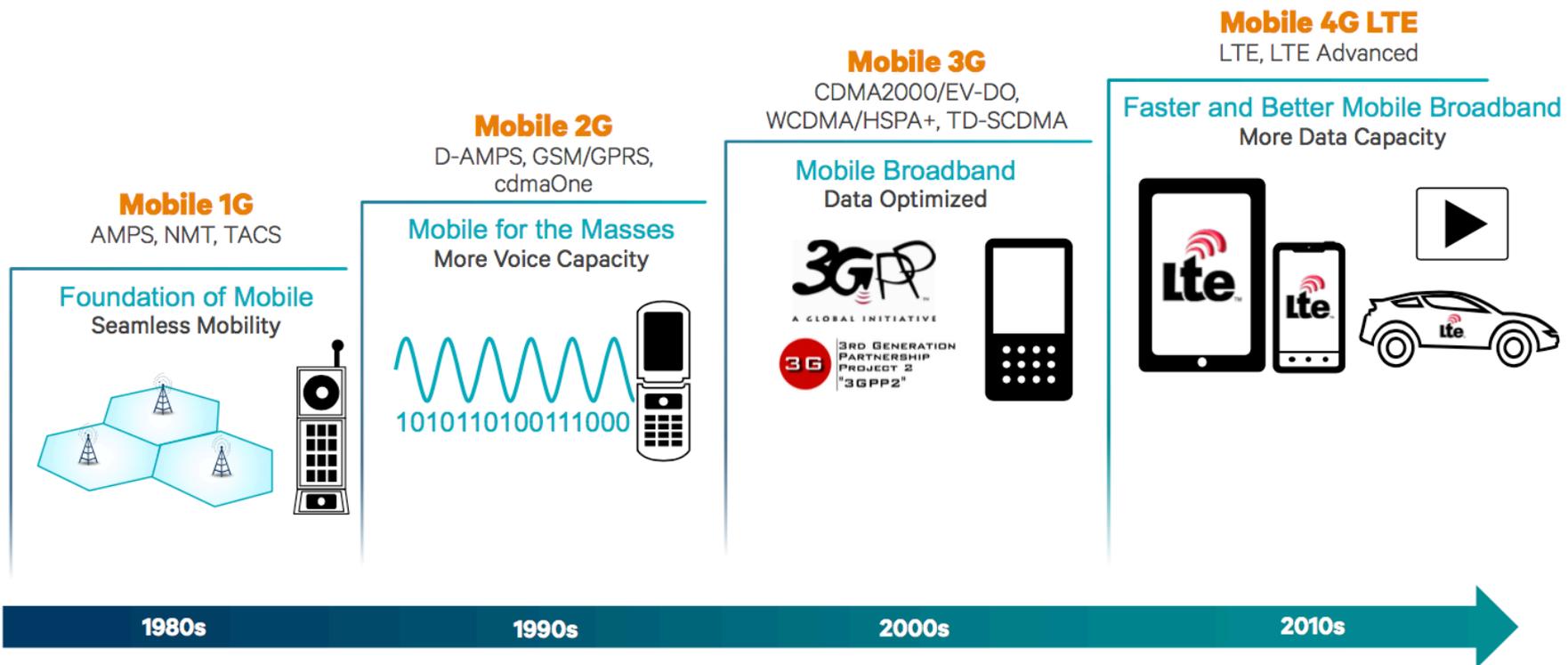
Spectrum of Radio services

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- Channel capacity: is the limiting information rate (in units of information per unit time) at which information can be reliably transmitted over a communications channel.

# The evolution of mobile networks

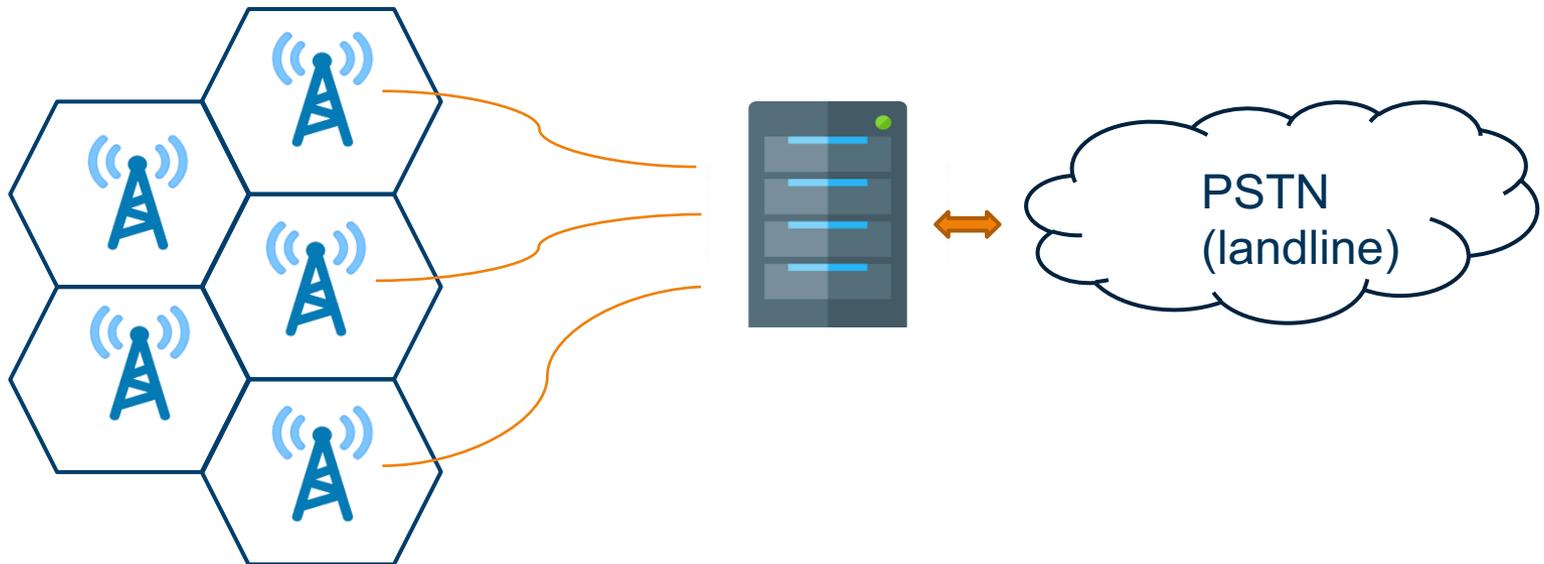
# The evolution of mobile networks



- Circuit-switching: provides voice communication
- Packet-switching: provides data communication

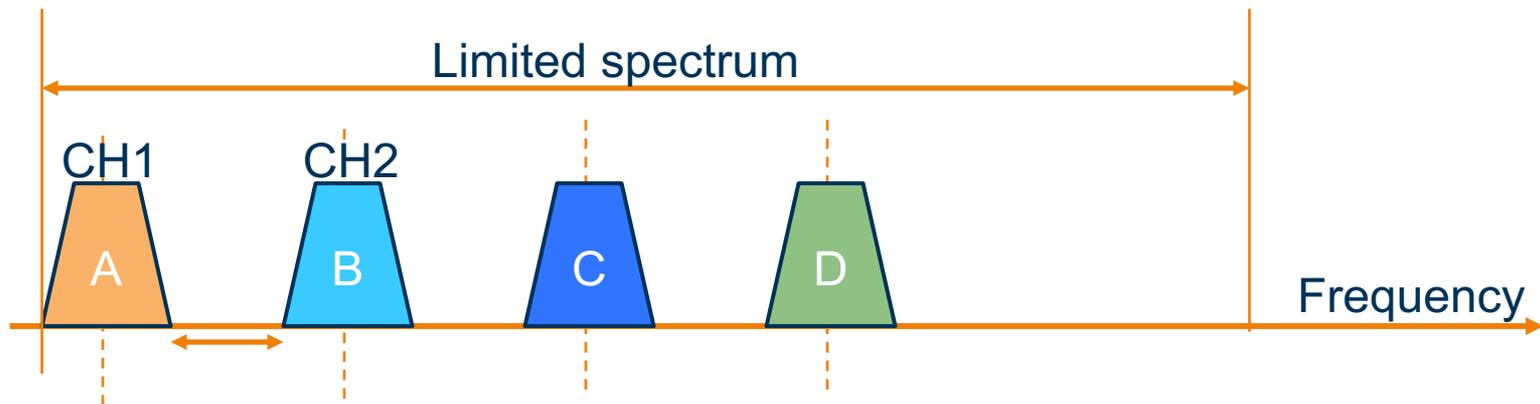
## 1<sup>st</sup> Generation

- Mobile 1G established the foundation of mobile
  - Cleared licensed spectrum
  - Frequency reuse: neighbor cells operate on different frequency to avoid interference
  - Coordinated networks for seamless mobility



# 1<sup>st</sup> Generation (cont)

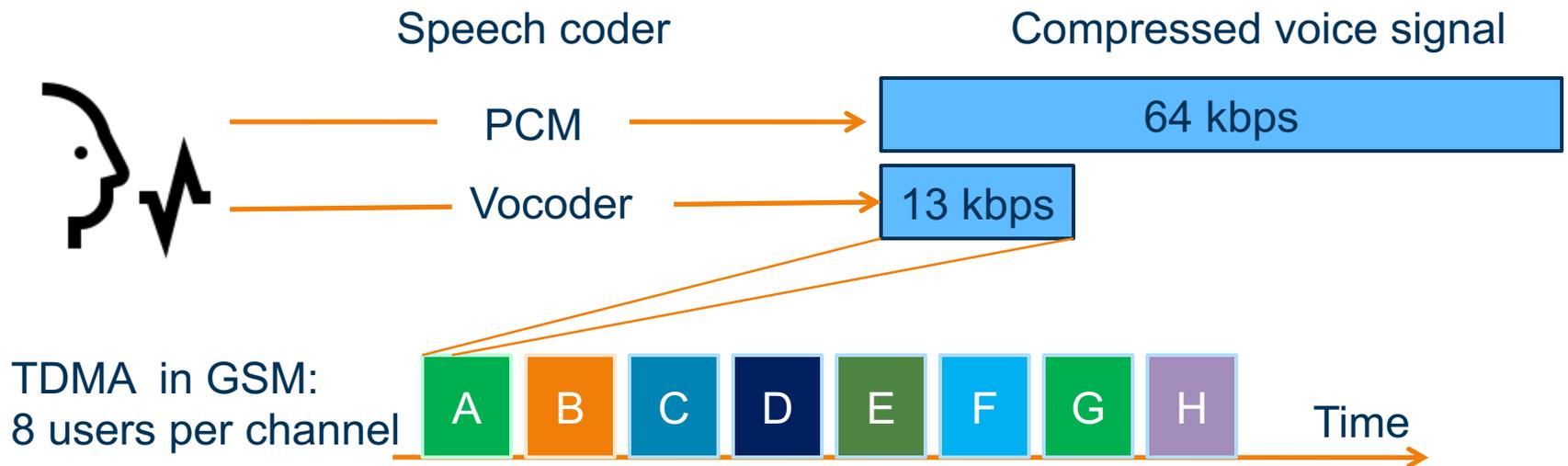
- Limited capacity:
  - Analog transmissions
  - Frequency Division Multiplexing Access (FDMA):
    - 1 user per channel



- → requires large gap between users to avoid interference
- Limited scalability:
  - Analog devices are heavy, power inefficient and high cost

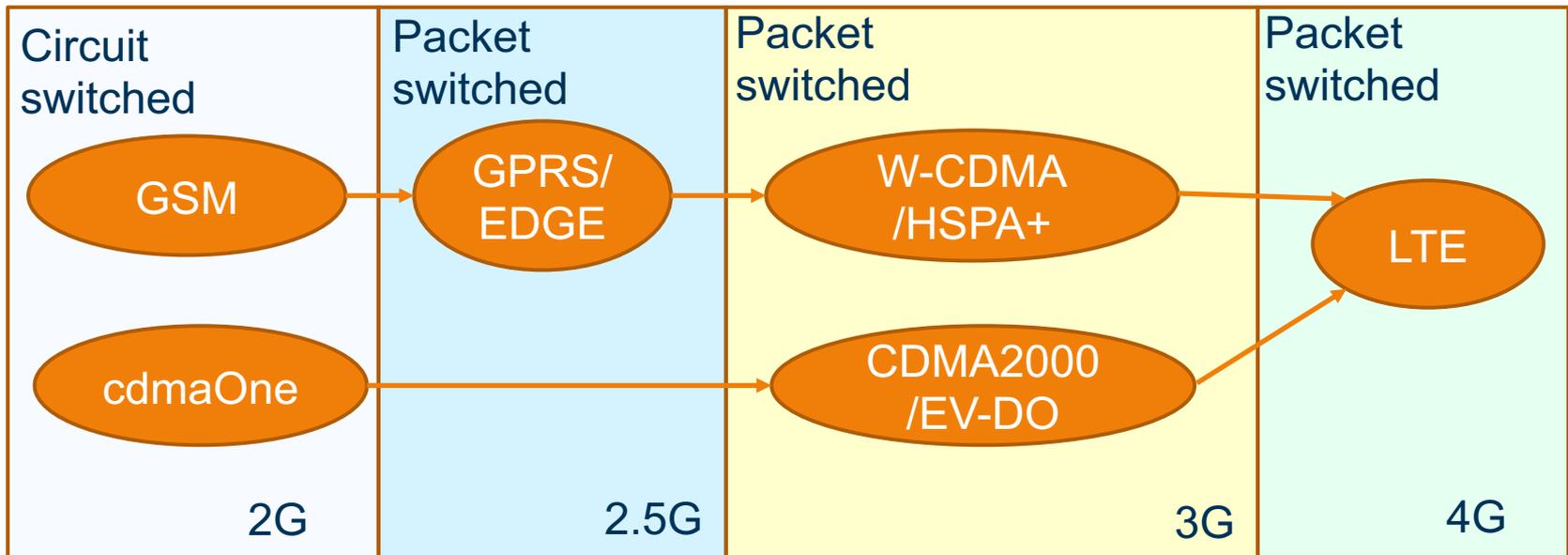
## 2<sup>nd</sup> Generation

- More voice capacity:
  - Digital transmission allows compressed voice and multiple user per channel
- Scalable Technology:
  - Digital components → cost less, more secure signal
  - Pocket-size devices



## 2.5G and 3<sup>rd</sup> Generation (3G)

- Providing multimedia traffic:
  - Voice: circuit-switched traffic
  - Data: packet-switched traffic, high bit rates
- Technologies:
  - CDMA-based technology: W-CDMA/HSPA+, cdma2000
  - TDMA-based technology: GPRS/EDGE



Technologies from GSM to LTE

## 4<sup>th</sup> Generation, 4G LTE/LTE advanced

- Demands for mobile services:
  - Faster and better broadband internet access
  - Data services for smart phones: games, mobile apps...
  - Huge number of subscribers→ higher data capacity
- Technologies:
  - Wider channels
  - More antennas: MIMO technique
  - Multiple access: OFDMA

## 5G and future of mobile communications

# Thank you for your attention!

- Homework:
  - Revise common used terms and communication system
  - Read about “radio environment”:
    - What are characteristics of radio channels?
    - Give examples of radio communications

# Lecture 2: Radio environment

# Lecture 3: Cellular concept

# Lecture 3': Channel assignment (optional)

# Lecture 4: Modulation techniques

# Lecture 5