



**EEE3430-01 Communication
Theory : Spring Semester 2024**

Note 1. Introduction

**Prof. Sooyong Choi, Ph.D.
School of Electrical and Electronic
Engineering**



YONSEI UNIVERSITY

Communication Systems

통신, 通信, Communication 정보(Information), 신호(Signal)

통신 (명사) 소식을 전함.
우편이나 전신, 전화 따위로 정보나 의사를 전달함.
신문이나 잡지에 실을 기사의 자료를 보냄. 또는 그 자료.
<통신> 정보 전달을 다루는 과학기술. 정보를 모아 전류나 자기장으로 바꾼 다음 전기적 계통이나 공간을 통하여 다른 지점에 전달하면 수신자가 이해할 수 있도록 다시 바꾸는 기술이다.

Communications (Systems)

- Transmit information-bearing signals through a communication channel separating the transmitter from the receiver
- Communicate instantaneously with people

Communication Systems and Media

- Telephone,
- Radio, Television
- Satellite
- Electronic mail
- Facsimile and so on

Evolution of Cellular Comms

■ Mobile telephone

■ 1G : Early 1980s

- AMPS (Advanced Mobile Phone Service) : USA, analog , FM

■ 2G : 1990s , digital mobile phone service

- GSM(Global Service for Mobile) : Europe
- USDC (IS-54) : USA
- PHS(Personal Handphone Service) : Japan
- IS-95 : Korea, mid-1990s, Spread Spectrum based CDMA
- Simple data service

■ 3G : IMT-2000(International Mobile Telecommunication)

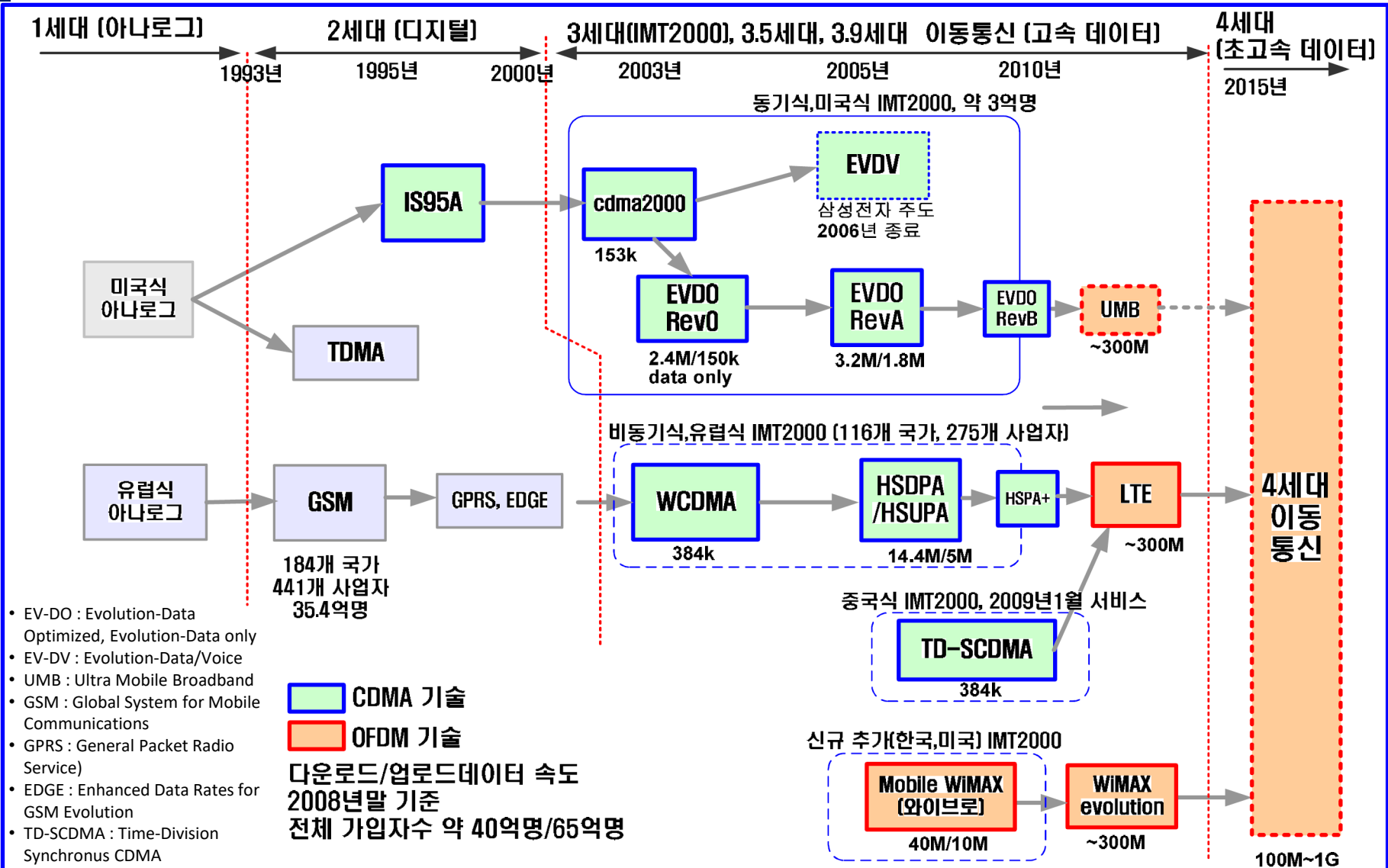
- Maximum 2Mbps data service
- ITU (International Telecommunication Union) standard

■ 4G : Beyond 3G standard – LTE → LTE-A Systems

- 2010~2015 : Commercialization, Above 100Mbps
- UL : 86.4Mbps(20MHz, 1×2 MIMO) & 172M(20M, 2×4) → 500M(100M, 4×4)
- DL : 172.8Mbps(20MHz, 2×2 MIMO) & 326.4M (20M, 4×4) → 1G(100M, 4×4)

■ 5G : Beyond 4G

이동통신의 발전



4G & 5G: 성능요소 및 목표

Capacity

- Peak data rate
- User Experienced data rate
- Spectrum Efficiency
- Area Traffic Capacity
- Network energy efficiency
- Mobility

4G

Massive Connectivity

- Connection density
- Network energy efficiency

5G

Reliability & Latency

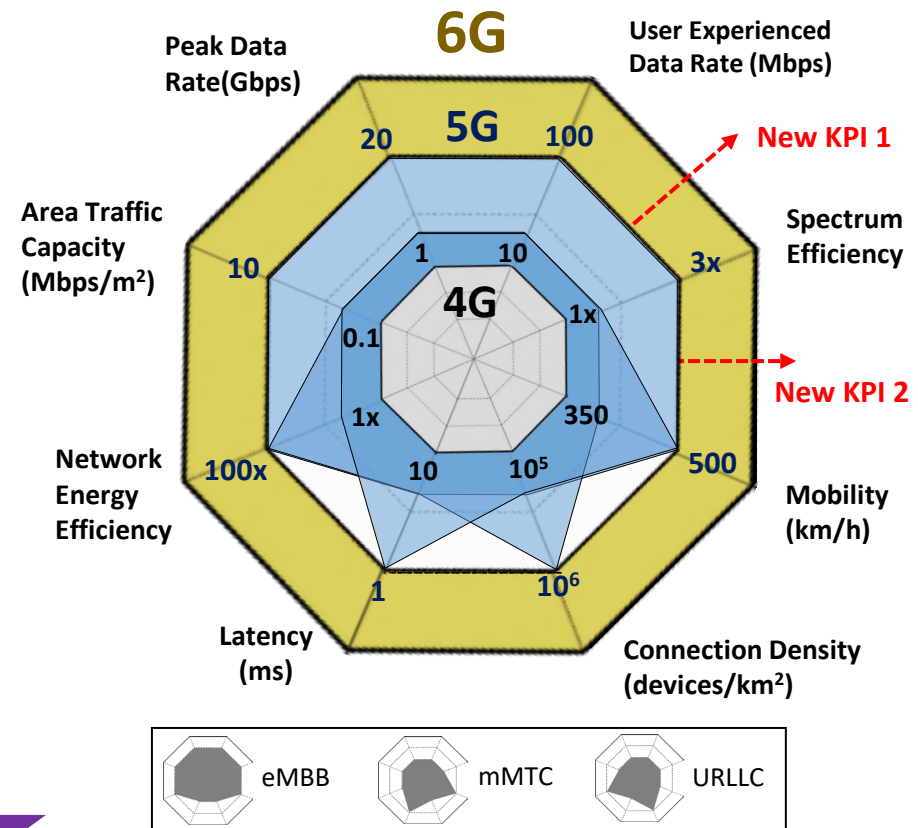
- Latency
- Mobility

New Scenarios in 6G

- New services & applications
- New performance indicators
- New core technologies
(Need to study & investigate!)

6G

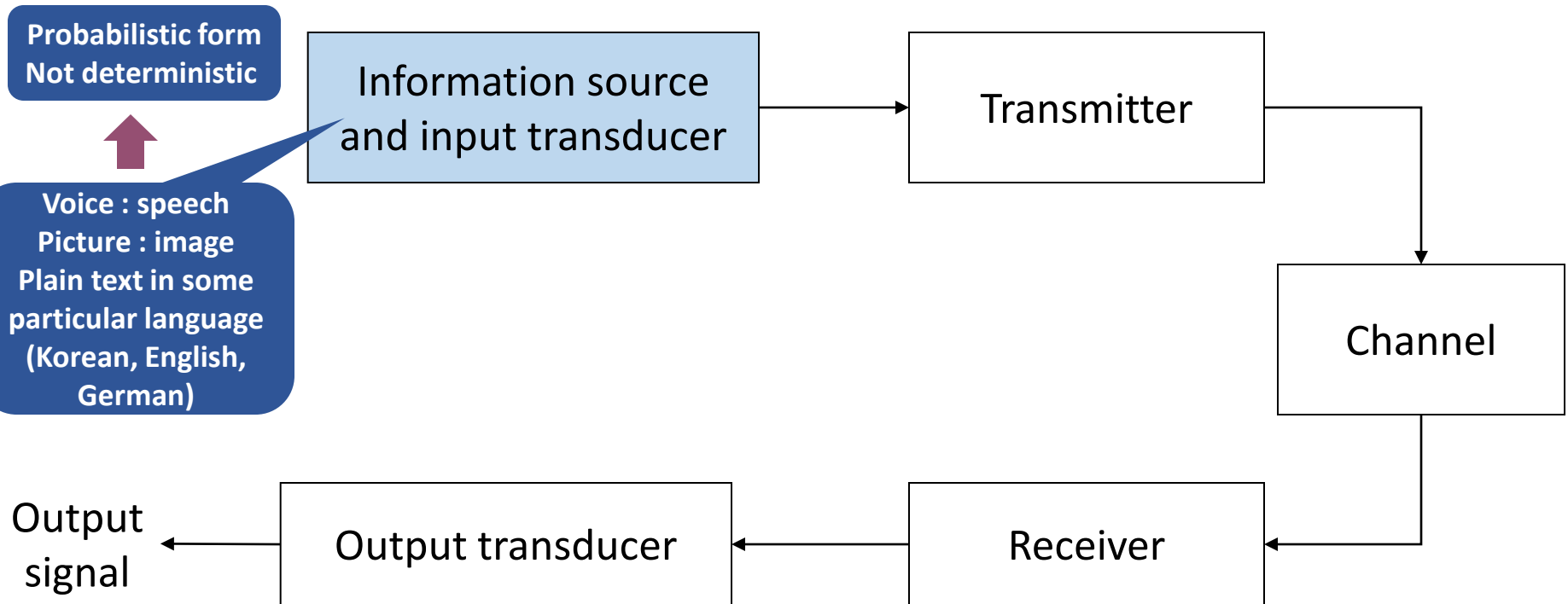
KPI : Key Performance Indicator
eMBB : enhanced Mobile Broadband
mMTC : massive Machine Type Comm.
URLLC : Ultra-Reliable & Low Latency Comm.



Elements of an Electrical Comm . System

■ Electrical communication systems

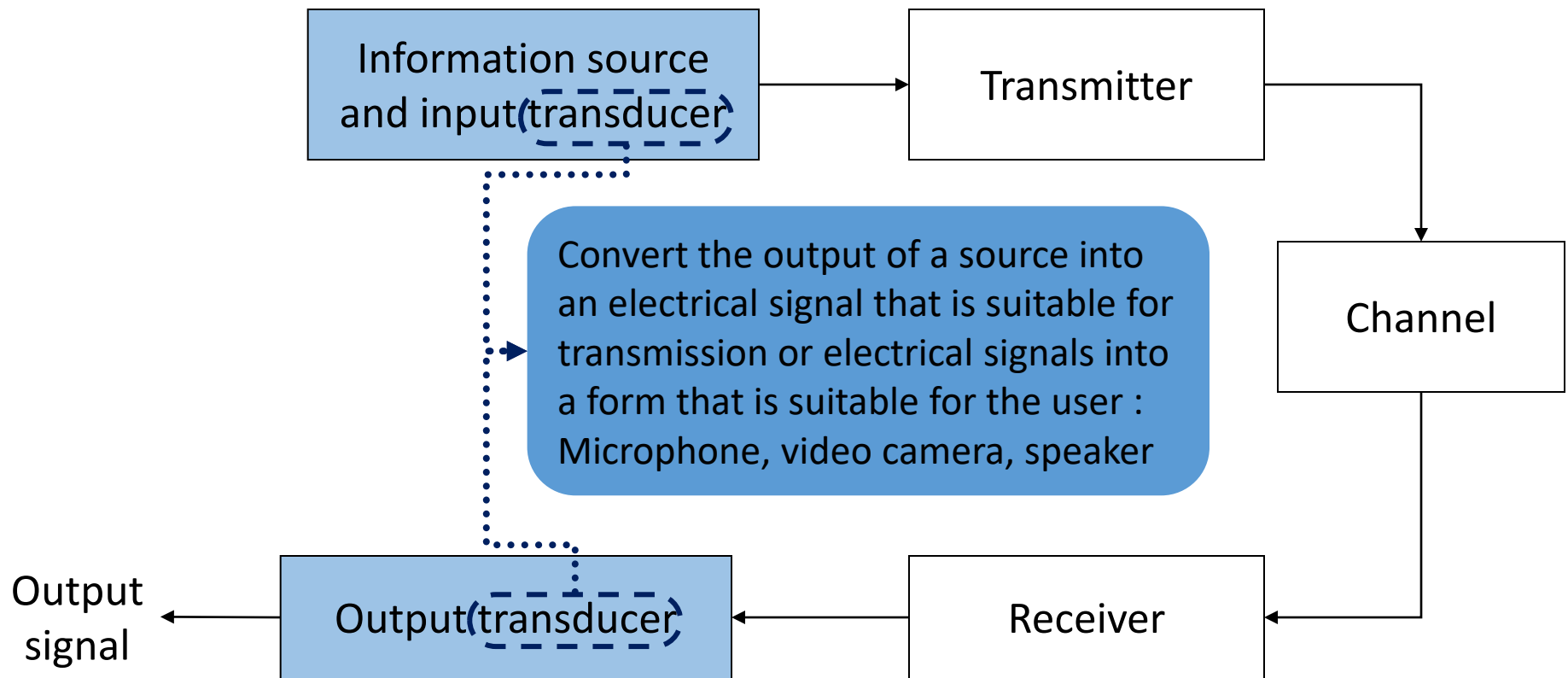
- Send messages or information from a source that generates to one or more destinations



Elements of an Electrical Comm . System

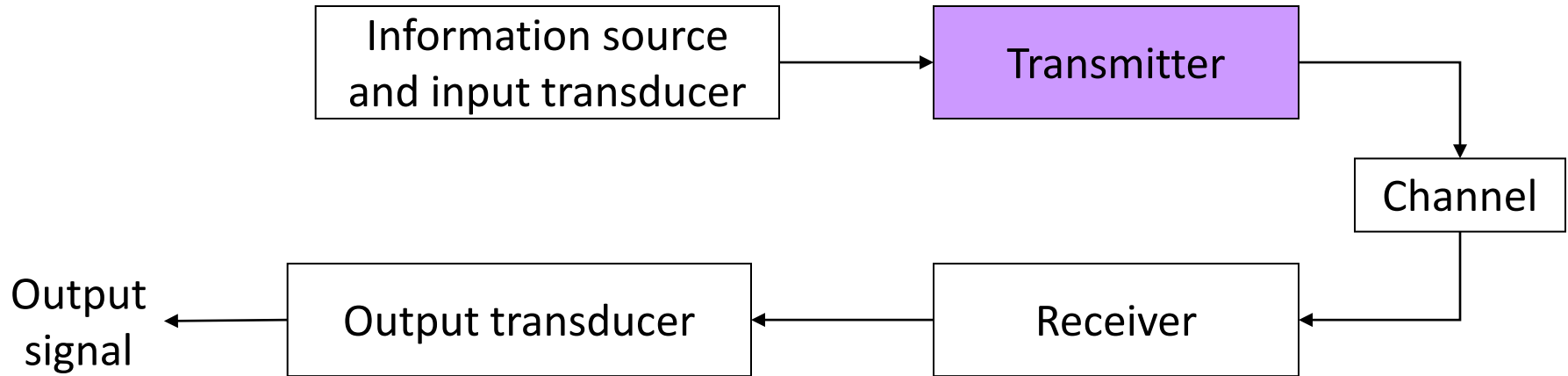
■ Electrical communication systems

- Send messages or information from a source that generates to one or more destinations



Elements of an Electrical Comm . System

– Transmitter



■ Transmitter

- Converts the electrical signal into a form that is suitable for transmission through the physical channel or transmission medium
- Functions performed at the transmitter
 - **Modulation**
 - **Filtering** of the information-bearing signal
 - **Amplification** of the modulated signal
 - **Radiation** of the signal by means of a transmitting antenna in the case of wireless transmission

■ Federal Communications Commission

- Specifies the frequency range for each transmission station

Elements of an Electrical Comm . System

– Transmitter

■ Modulation

- The transmitter matches the message(information) signal to the channel (characteristics) via a process *modulation*
- The information signal is **translated in frequency** to match the allocation of the channel through the process of modulation

■ *Carrier modulation*

1. *Amplitude : AM* – AM radio broadcast

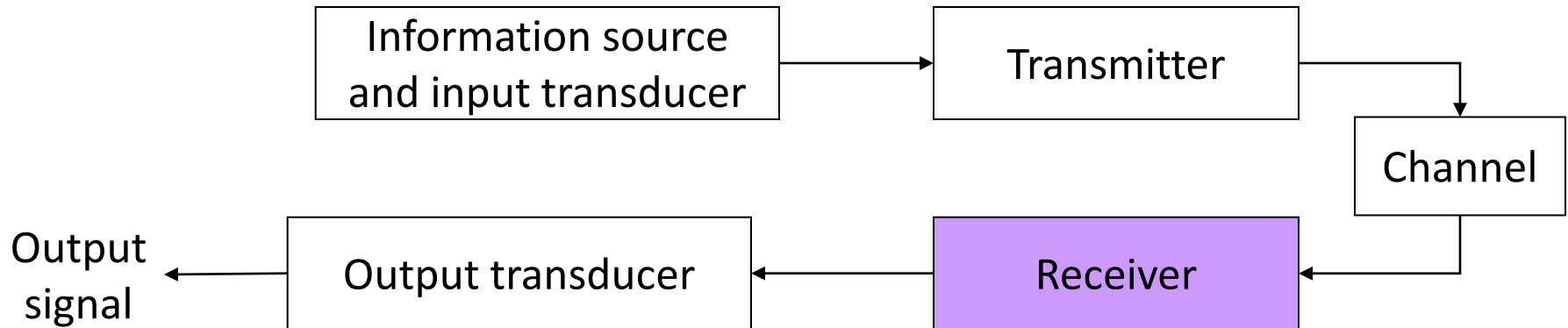
- The information signal is contained in the amplitude variations of the sinusoidal carrier, which is the center frequency in the frequency band allocated to the radio transmitting station

2. *Frequency : FM* – FM radio : Frequency variations of the sinusoidal carrier

3. *Phase : PM* – Impressing the information signal on a sinusoidal carrier

- The choice of **the type of modulation** is based on several factors
 - Amount of **bandwidth** allocated
 - **Types of noise and interference** the signal encounters over the channel
 - **Electronic devices** available for signal amplification prior to transmission
- **Transmission of multiple messages from many users over the same physical channel**

Elements of an Electrical Comm. System – Receiver



- Function : *Recover the message signal contained in the received signal*
- Carrier demodulation
 - Extract the message from the sinusoidal carrier in the presence of distortions – noise and interference
 - The **fidelity** of the received message signal is a function of **the type of modulation** and the **strength of the additive noise**
- Function performed at the receiver
 - **Signal filtering**
 - **Noise suppression**

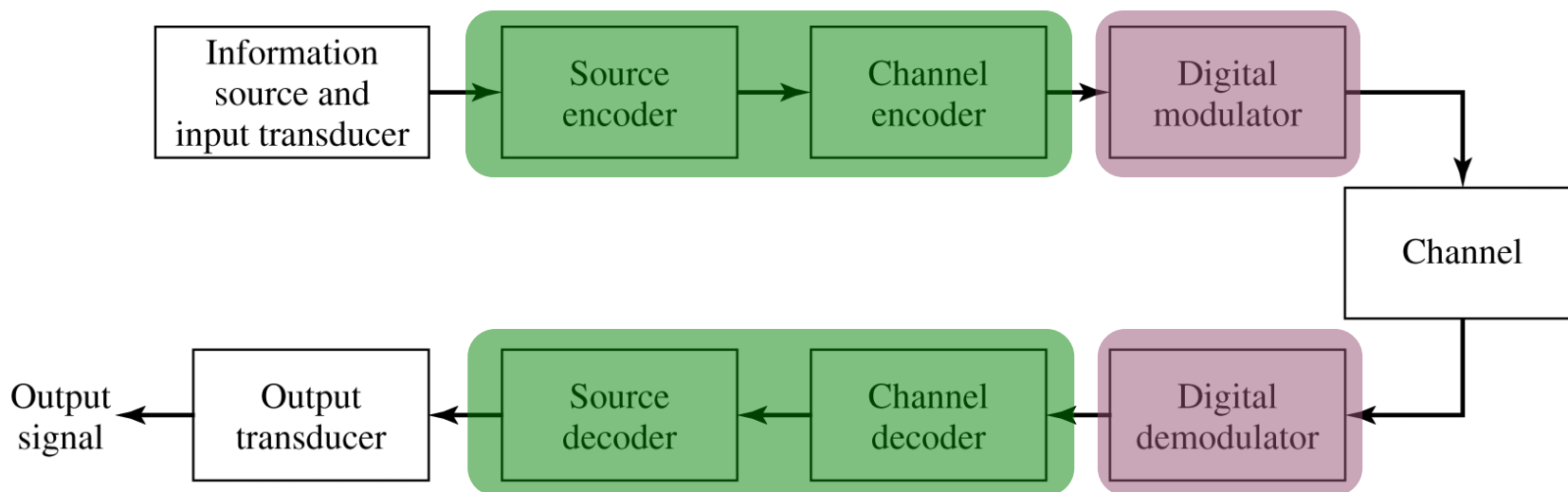
Digital Communication Systems

■ The source output may be either

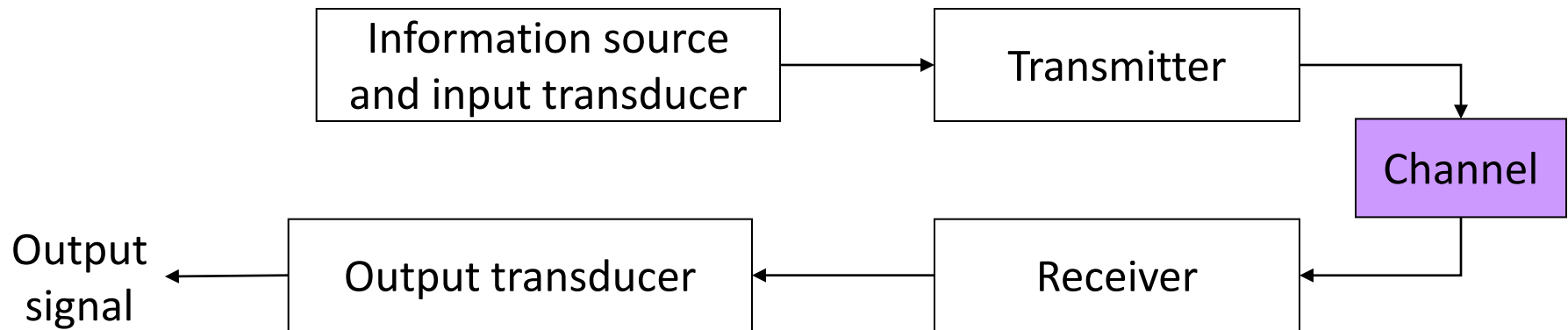
- Analog signal : Audio or video signal – Continuous time-varying waveform
 - Analog signals can be
 - Transmitted directly via carrier modulation over the com. channel
 - Demodulated accordingly at the receiver

⇒ *Analog communication systems*

- Digital signal : Output of a computer which is discrete in time and has a finite number of output characters
 - Figure : Functional diagram and the basic elements of a digital com. system



Elements of an Electrical Comm. System – Channel



- The **physical medium** used to send the signal from the transmitter to the receiver
 - Wireless transmission : Atmosphere (free space)
 - Telephone channel : A variety of physical media
 - Wirelines, fiber optics cables, and wireless (microwave radio)
 - The transmitted signal is **corrupted in a random manner** by a variety of possible mechanisms

Elements of an Electrical Comm. System – Channel

■ **Additive noise** : Most common form of signal degradation

- Generated at the front end of the receiver
 - Signal amplification is performed
- Often called thermal noise

■ **Additional additive disturbances in Wireless transmission**

- **Man-made noise** : Automobile ignition noise
- **Atmosphere noise** by a receiving antenna
 - Electrical discharges from thunderstorms
- **Interference** from other users of the channel in both wireless and wireline communication systems
- **Multipath propagation** : Non-additive signal disturbance – fading

■ **Both additive and non-additive signal distortions**

- Usually characterized as **random phenomena** and described in **statistical terms**
- The effect of these signal distortions must be considered in the design of the communication system

Communication Channels

- Provides the connection between the transmitter and the receiver

■ Physical channels

- A pair of wires : Carry the electrical signal
- Optical fiber : Carries the information on a modulated light beam
- Underwater ocean channel : The information is transmitted acoustically
- Free space : The information bearing signal is radiated by use of antenna
- Data storage media : Magnetic tape, magnetic disks, and optical disks

■ Additive noise

- One common problem in signal transmission through any channel
- Generated internally by components such as resistors and solid-state devices
- Thermal noise

- Other types of interference : Signal attenuation, amplitude and phase distortion, and multipath distortion

Communication Channels

■ Power

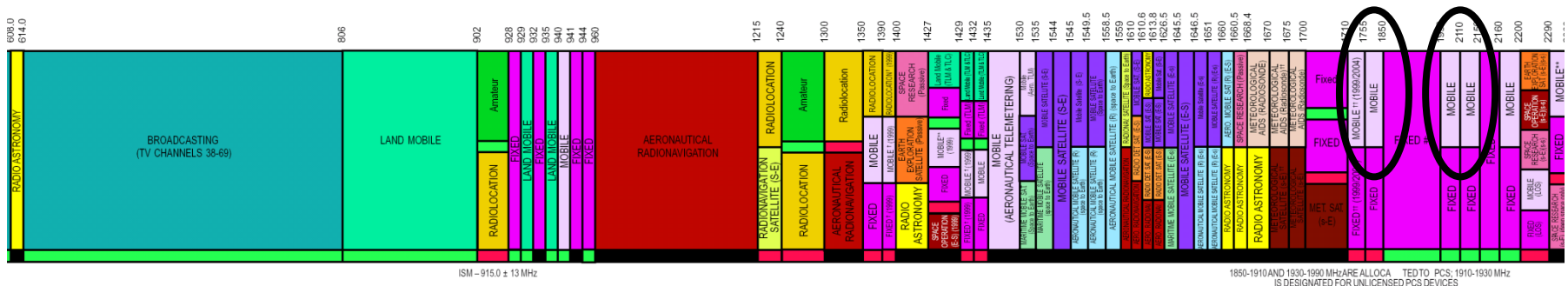
- Minimize the effect of noise by increasing the power in the transmitted signal
- Equipment and other practical constraints limit the power level in the transmitted signal

■ Bandwidth

- Due to the physical limitations of the medium and the electronic components used to implement the transmitter and the receiver

■ Power and bandwidth limitations

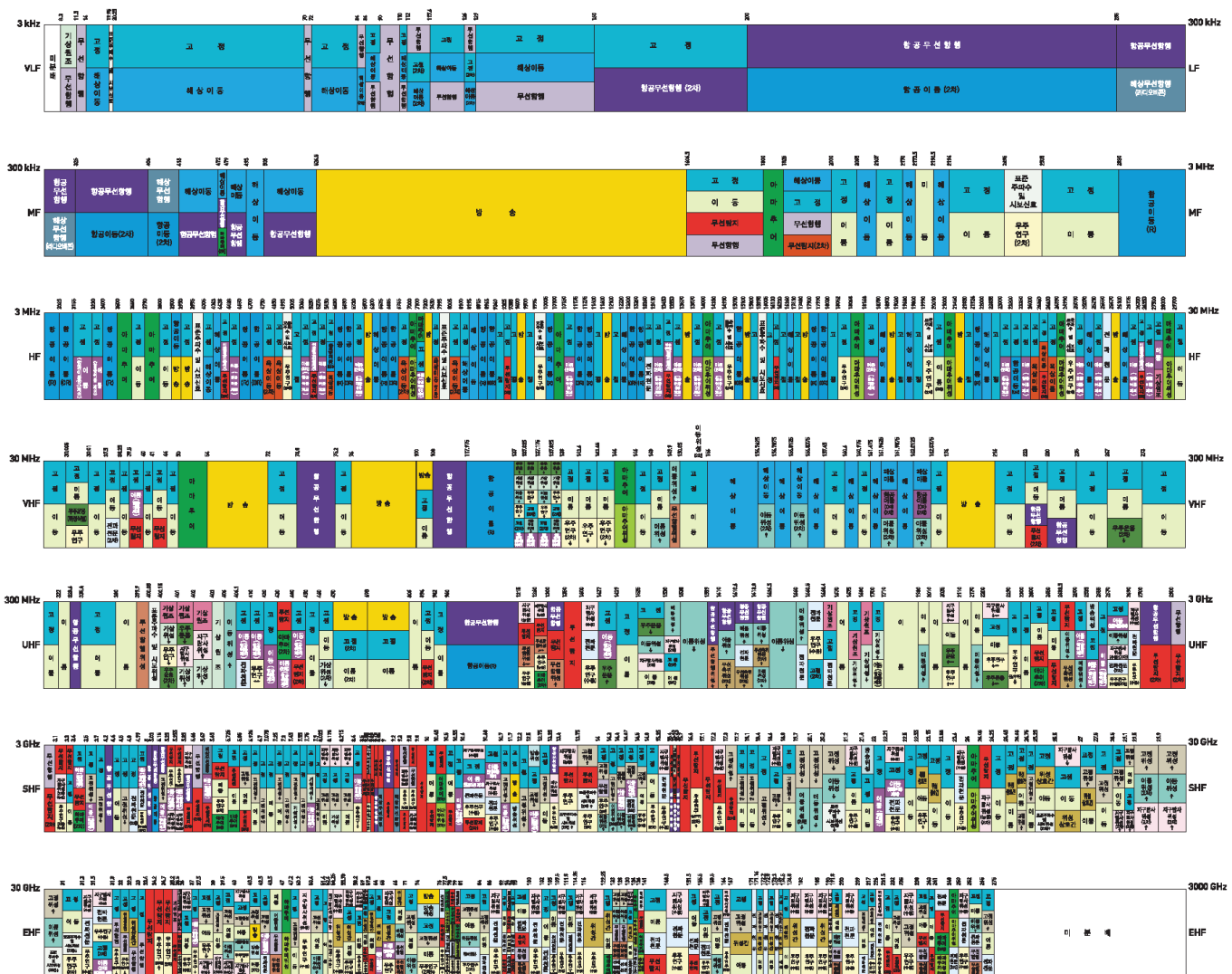
- Result in constraining the amount of data that can be transmitted reliably over any communication channel



대한민국 주파수 분배도표

(2015.1)

고 령	육상이동위성
고 령 위성	이동 (항공이동제외)
기상정보	위성상표지
기상위성	이 동
무선탐지	이동위성
무선탐지위성	전력전송
무선탐침	지구궤도위성
무선탐침위성	항공이동
방송	항공이동위성
방송위성	항공무선탐침
마라주이	해상이동
마라주이위성	해상이동위성
우주연구	해상무선탐침
우주운동	표준주파수 및 시계위성
육상이동	지구궤도위성 우주나침반



Communication Resources & Design

- The systems are designed to provide for the efficient utilization of the two primary communication resources
 - *Transmitted power* : The average power of the transmitted signal
 - *Channel bandwidth* : The width of the passband of the channel
- Classify communication channel
 - *Power-limited channel*
 - Wireless channels, Satellite channels, Deep-space links, ...
 - *Band-limited channel*
 - Telephone channels, Television channels, ...
- The design of a communication system – Tradeoff between signal-to-noise ratio and channel bandwidth