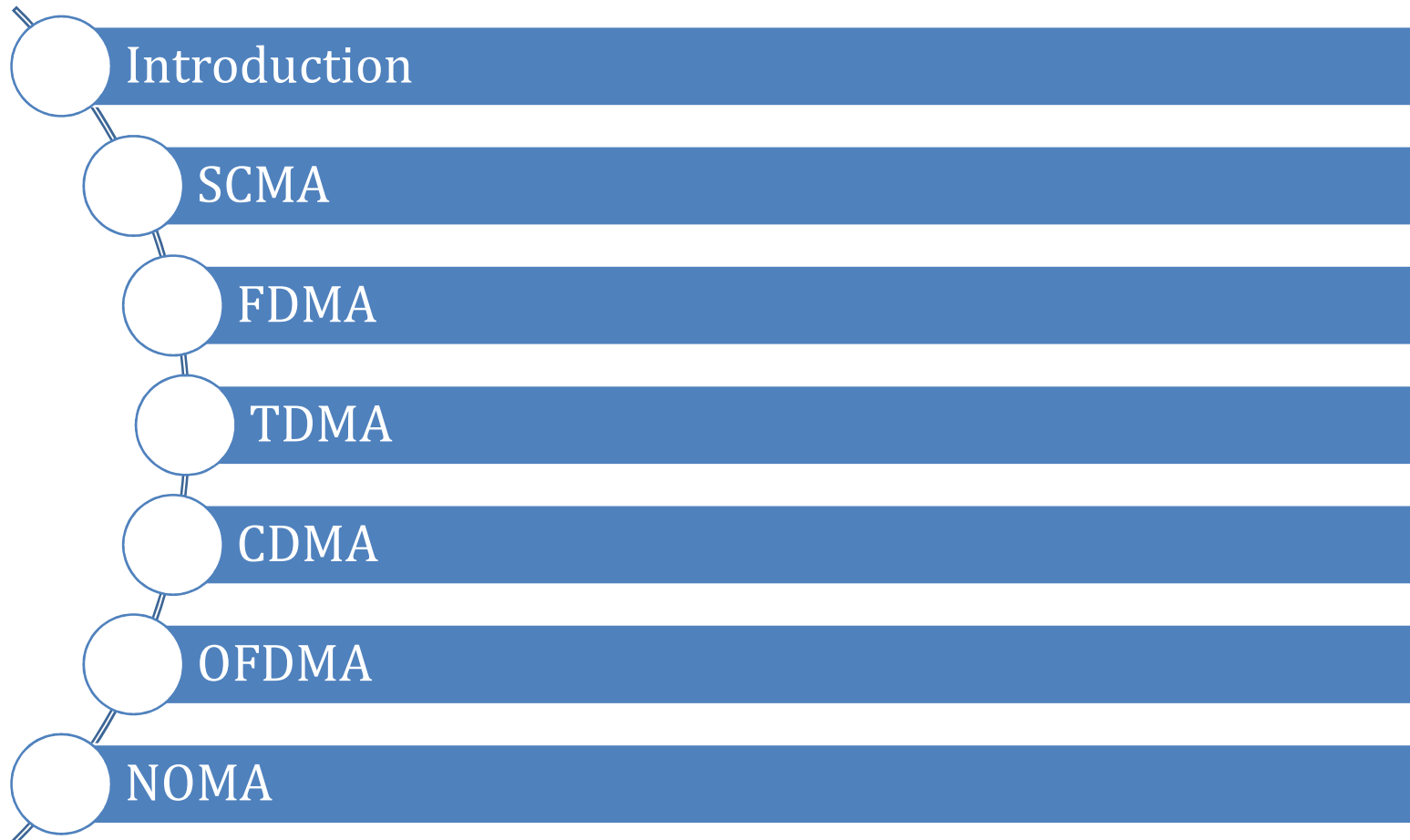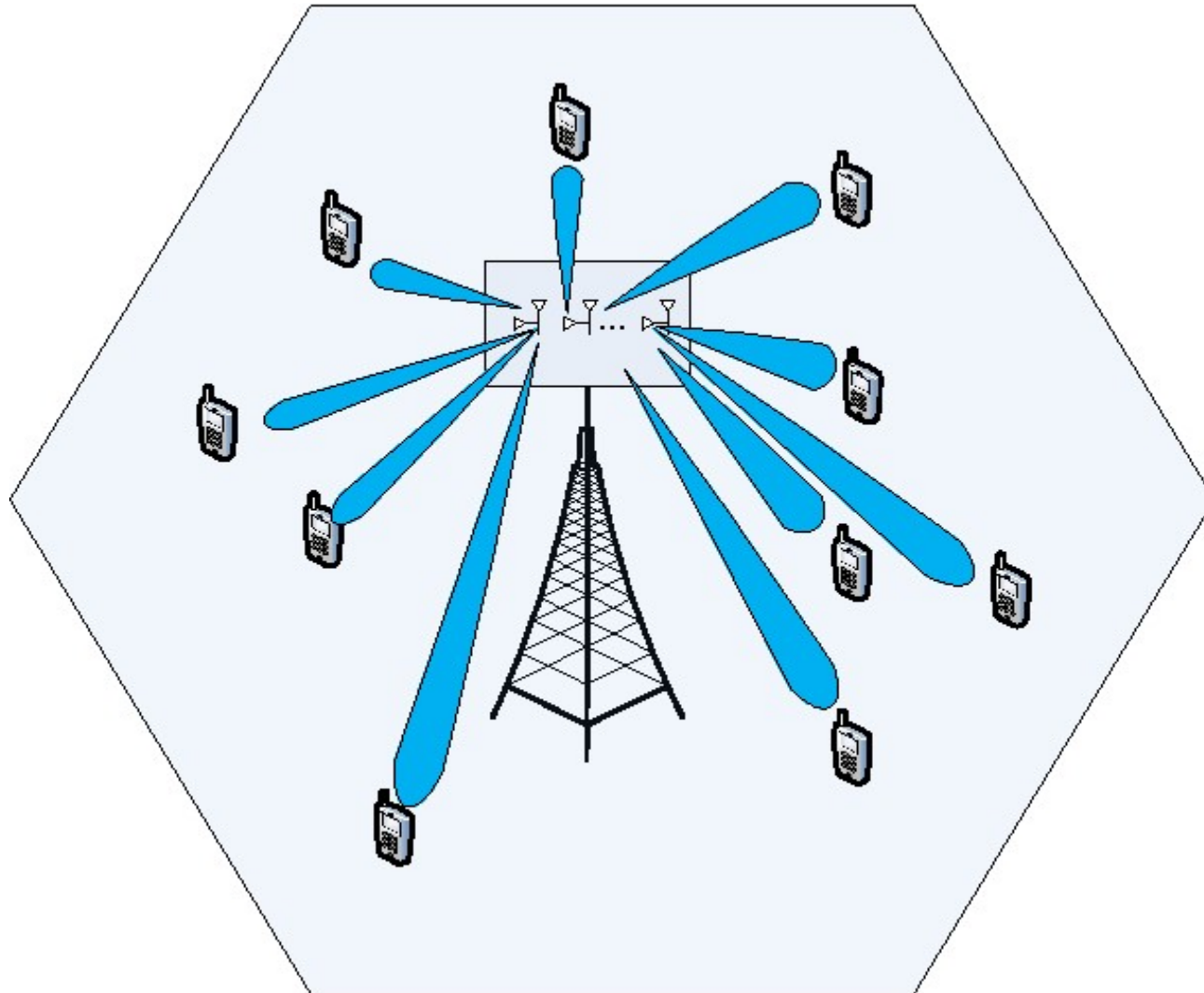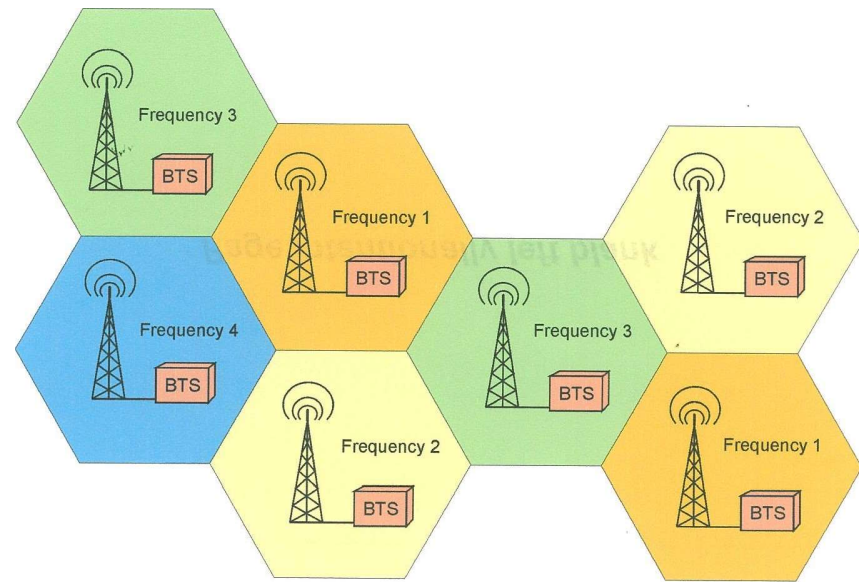# Multiple Access Methods

## Huy Bui – April, 2021

# Agenda

- Introduction
- SCMA
- FDMA
- TDMA
- CDMA
- OFDMA
- NOMA

# Introduction

# SCMA



Frequency 1
120 ° - Sektor

Frequency 2
120 ° - Sektor

BTS BTS
BTS

120 ° - Sektor

Frequency 3

Frequency 3
BTS

Frequency 1
BTS

Frequency 2
BTS

Frequency 4
BTS

Frequency 3
BTS

Frequency 2
BTS
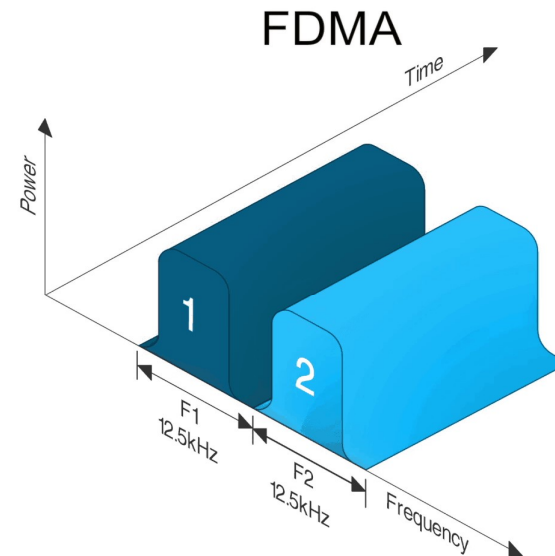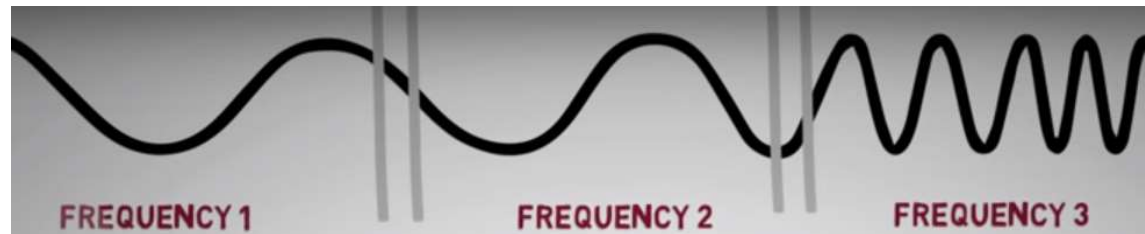
Frequency 1
BTS

# SCMA



DSP

Antenna Array

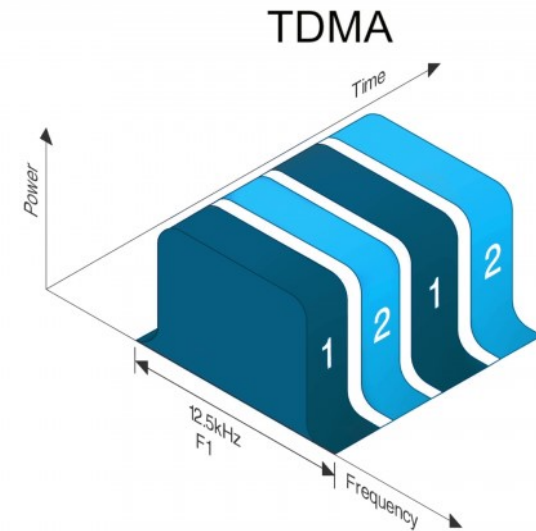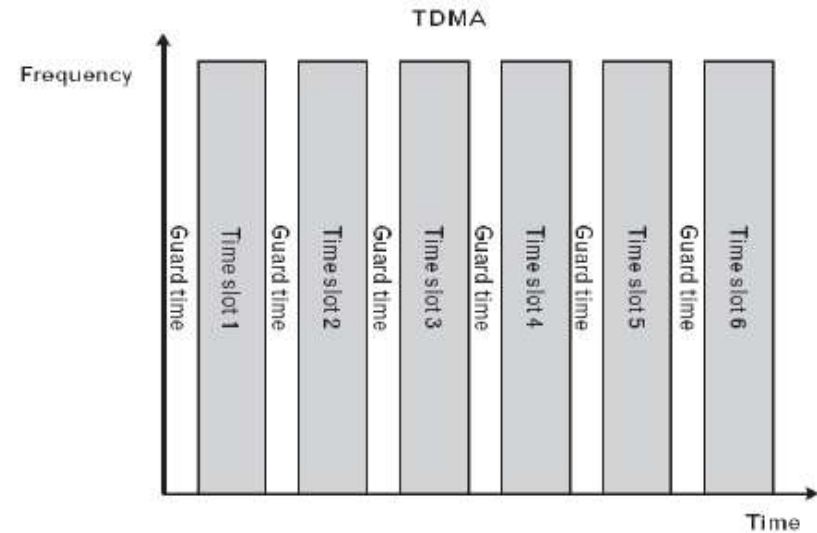Resulting Signal
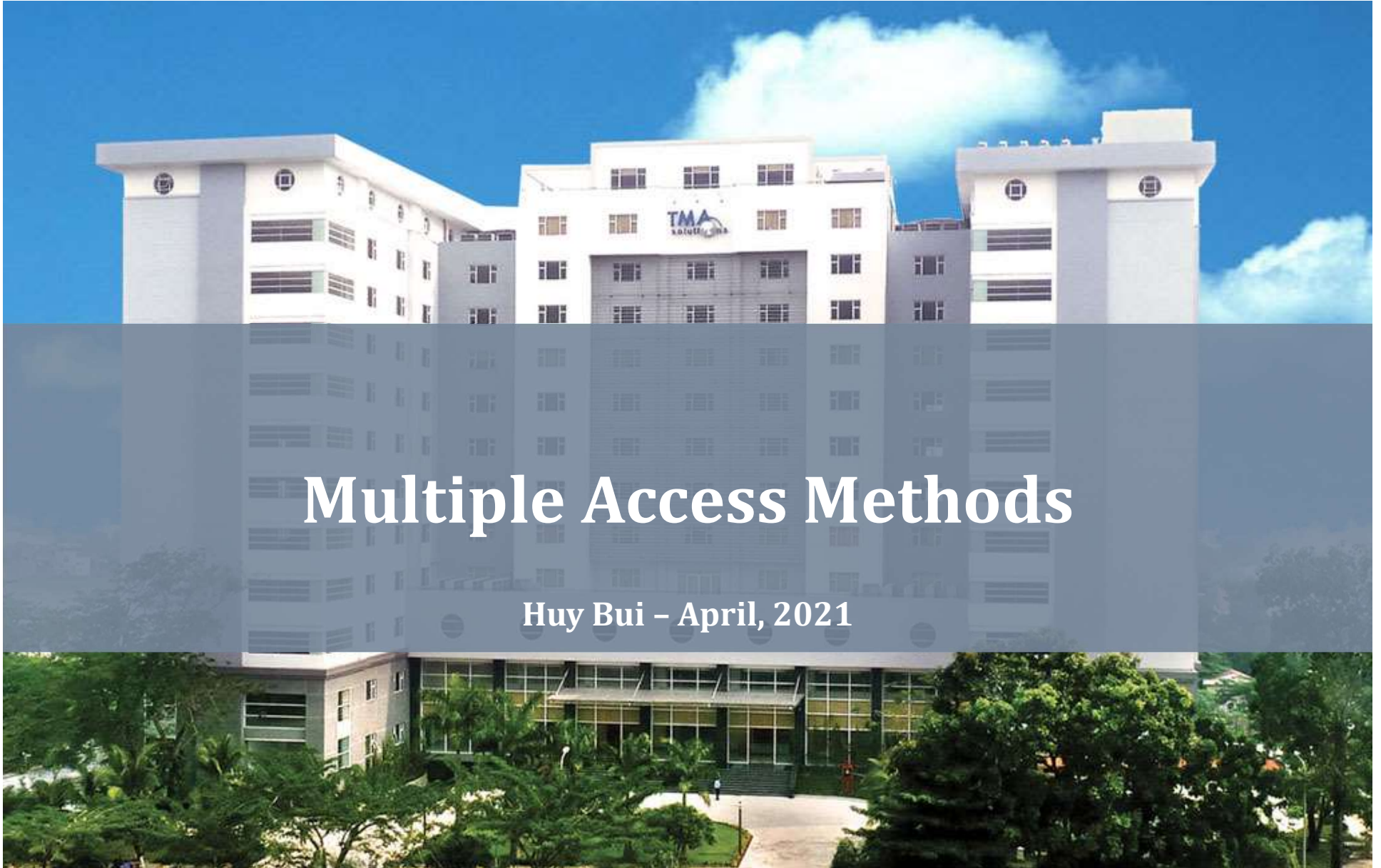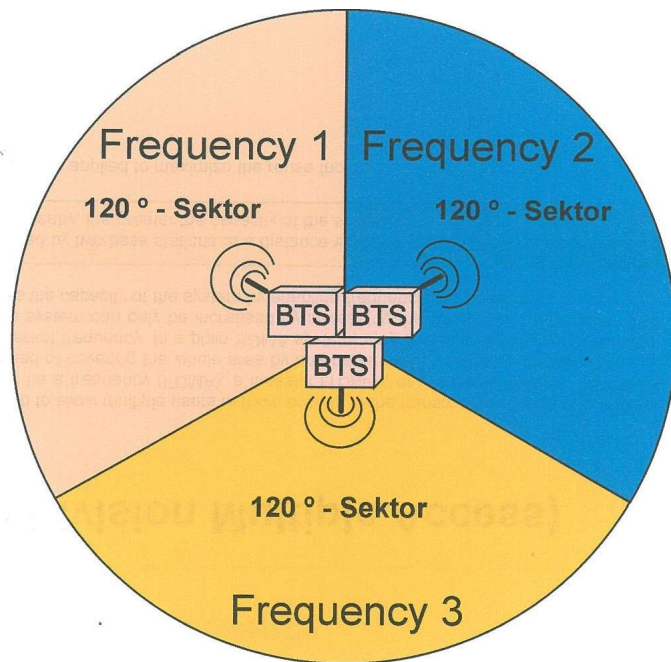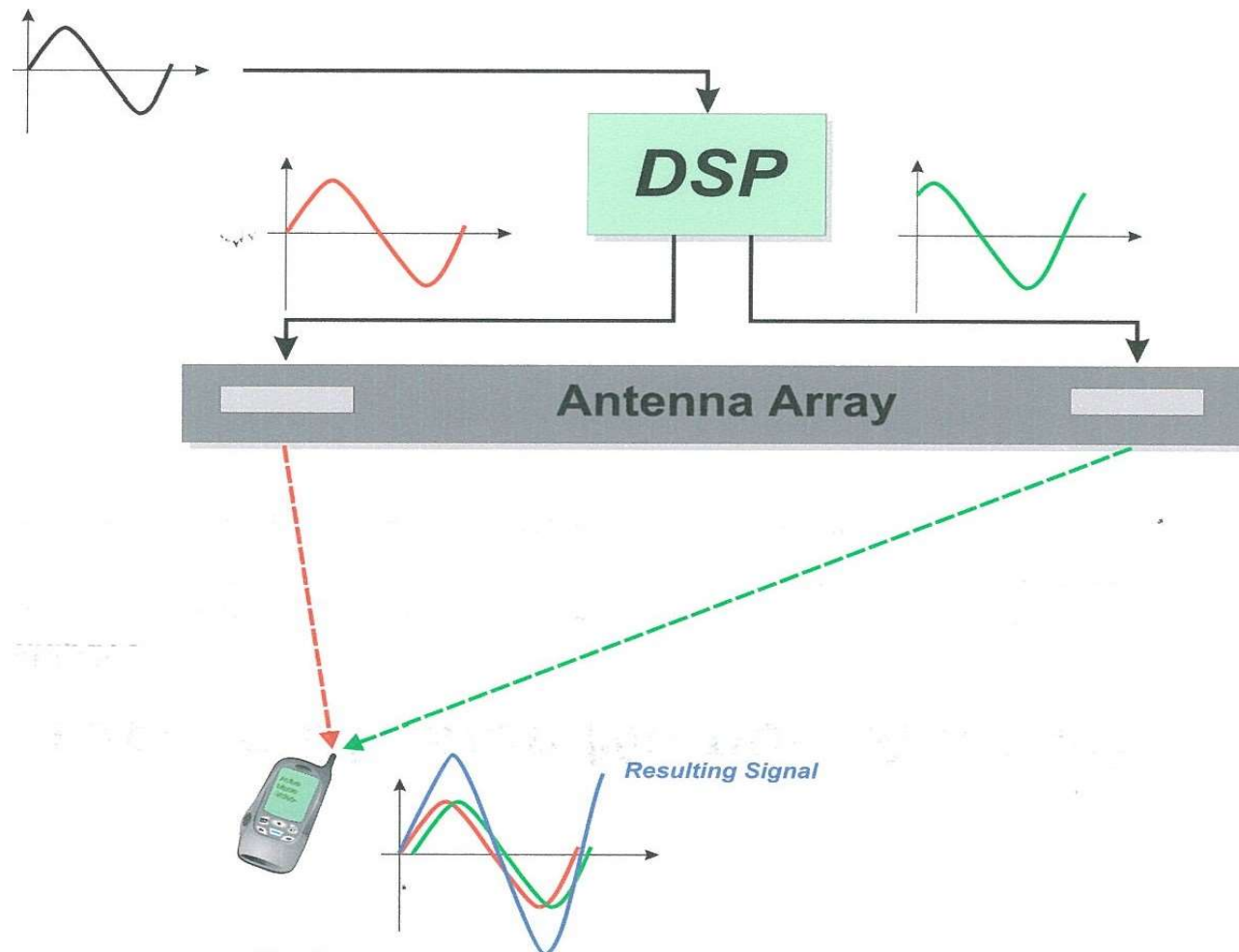
# FDMA

- ❑ One frequency for one UE
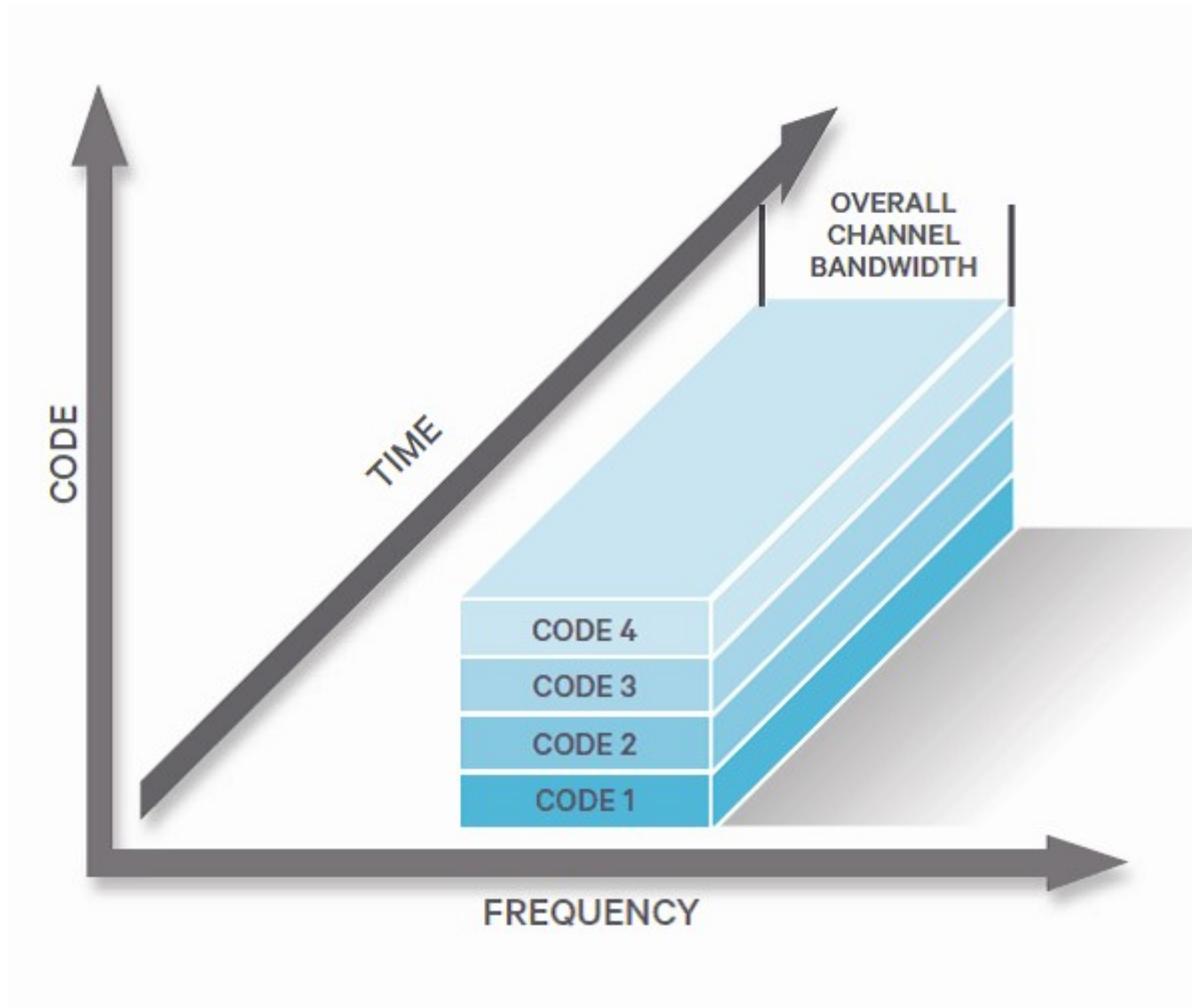- ❑ Gap between 2 frequency



FDMA

# TDMA

- ❑ One frequency for more than one UE

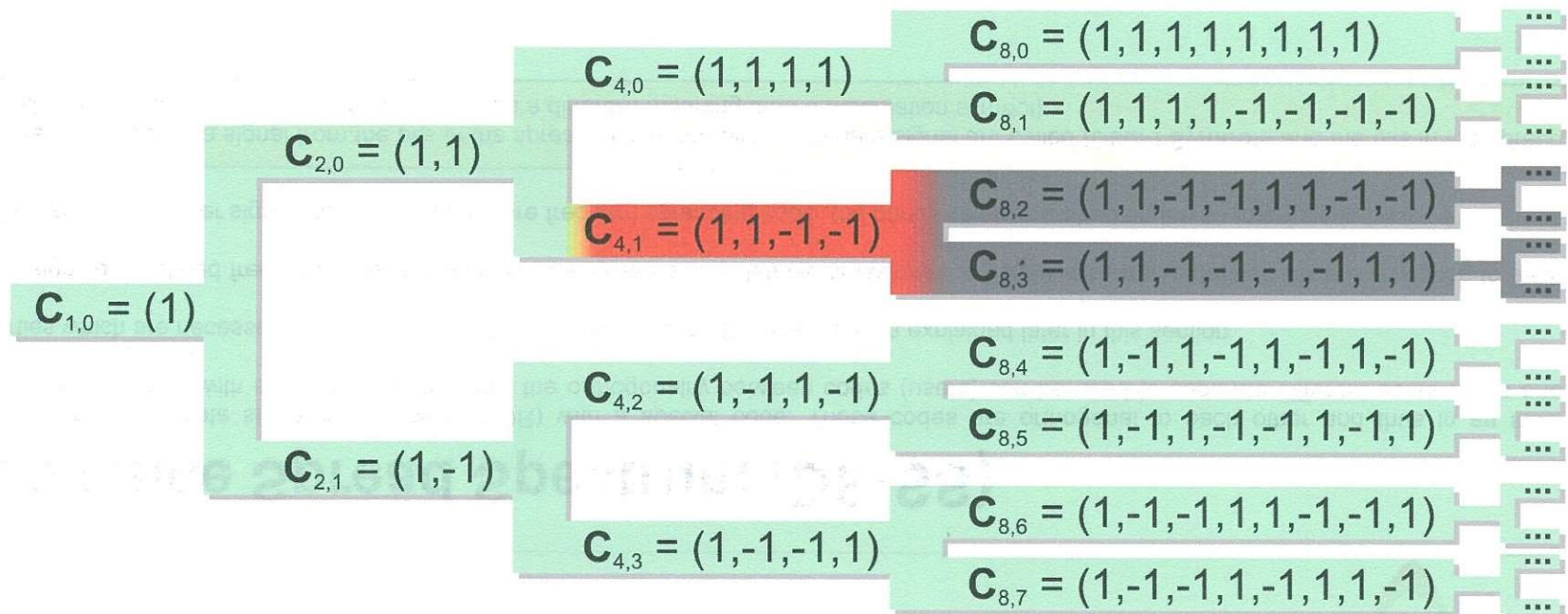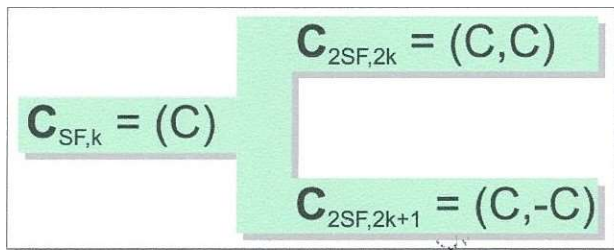- ❑ Each time slot used for one UE

- ❑ Guard time between 2 time slots

# CDMA

# Spreading Codes

$$\mathbf{C}_{SF,k} = (C)$$

$$\mathbf{C}_{2SF,2k} = (C,C)$$

$$\mathbf{C}_{2SF,2k+1} = (C,-C)$$

$\mathbf{C}_{1,0} = (1)$

$\mathbf{C}_{2,0} = (1,1)$

$\mathbf{C}_{2,1} = (1,-1)$

$\mathbf{C}_{4,0} = (1,1,1,1)$

$\mathbf{C}_{4,1} = (1,1,-1,-1)$

$\mathbf{C}_{4,2} = (1,-1,1,-1)$

$\mathbf{C}_{4,3} = (1,-1,-1,1)$

$\mathbf{C}_{8,0} = (1,1,1,1,1,1,1,1)$

$\mathbf{C}_{8,1} = (1,1,1,1,-1,-1,-1,-1)$

$\mathbf{C}_{8,2} = (1,1,-1,-1,1,1,-1,-1)$

$\mathbf{C}_{8,3} = (1,1,-1,-1,-1,-1,1,1)$

$\mathbf{C}_{8,4} = (1,-1,1,-1,1,-1,1,-1)$

$\mathbf{C}_{8,5} = (1,-1,1,-1,-1,1,-1,1)$

$\mathbf{C}_{8,6} = (1,-1,-1,1,1,-1,-1,1)$

$\mathbf{C}_{8,7} = (1,-1,-1,1,-1,1,1,-1)$
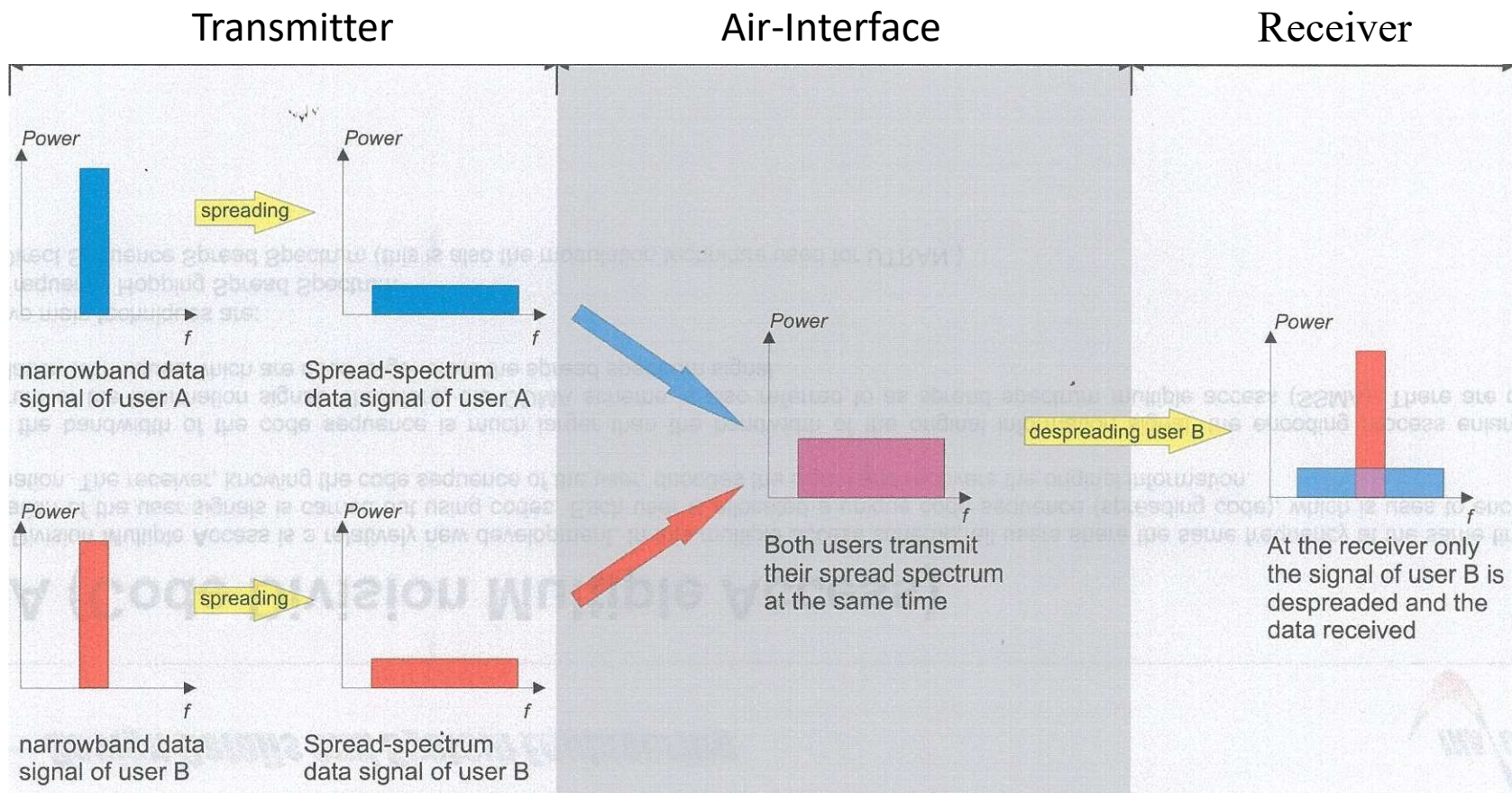
*SF = 1*    *SF = 2*        *SF = 4*                    *SF = 8*

# Multi-access capability



Transmitter      Air-Interface      Receiver

Power — spreading — Power

narrowband data signal of user A    Spread-spectrum data signal of user A

narrowband data signal of user B    Spread-spectrum data signal of user B

Power — Both users transmit their spread spectrum at the same time — despreading user B

Power — At the receiver only the signal of user B is despreaded and the data received

# Spreading



**Before Spreading**

*Narrowband Signal*

Power

Noise Power Level →

Frequency

Small Bandwidth = High Power Spectral Density

**After Spreading**

*Wideband Signal*

Power

Noise Power Level →

Frequency

Large Bandwidth = Low Power Spectral Density
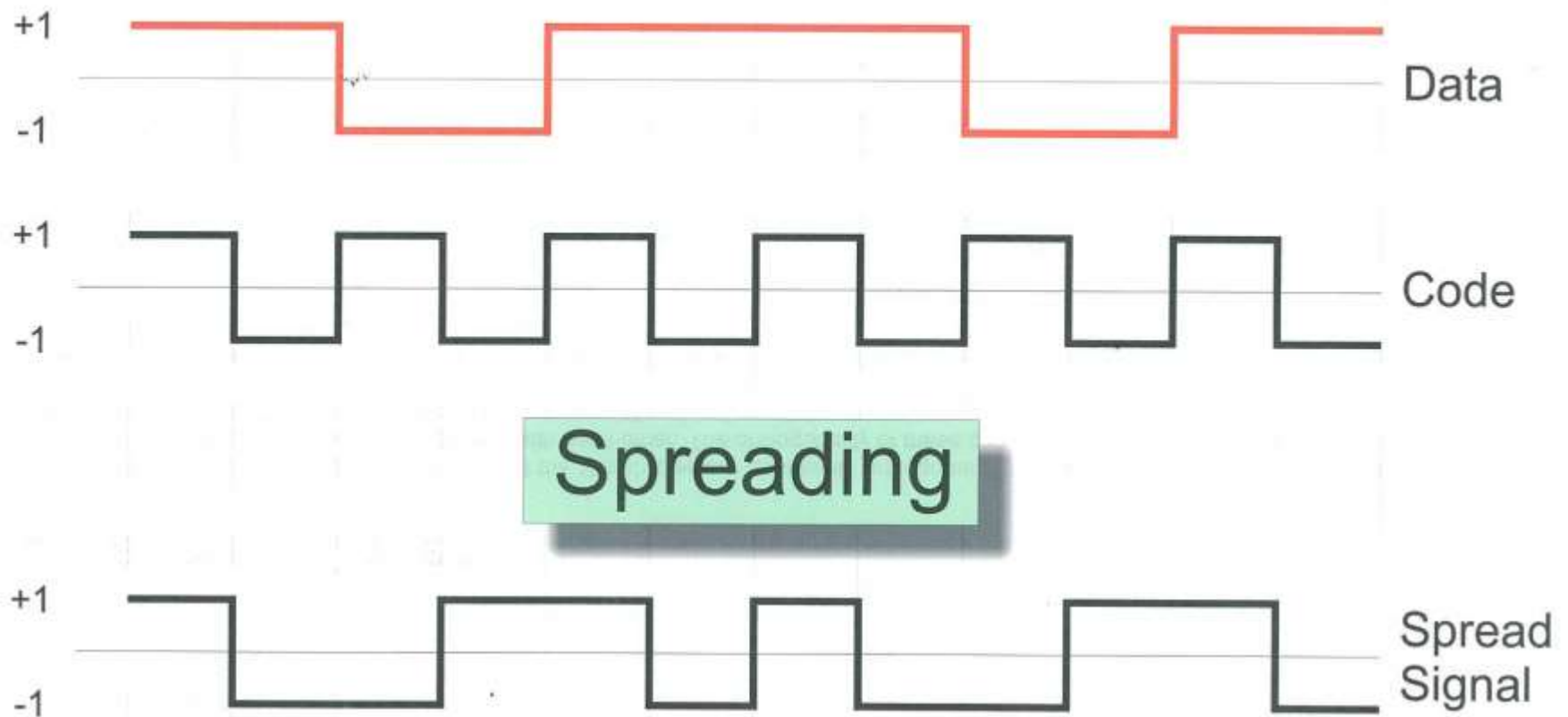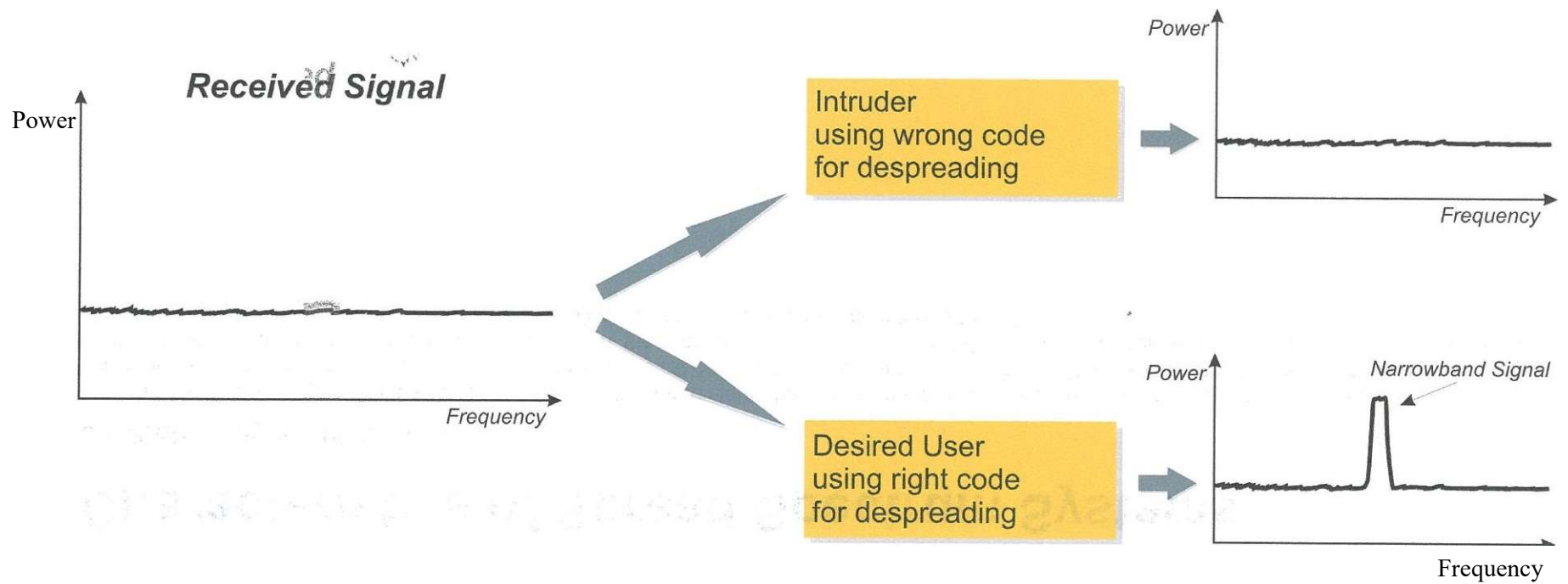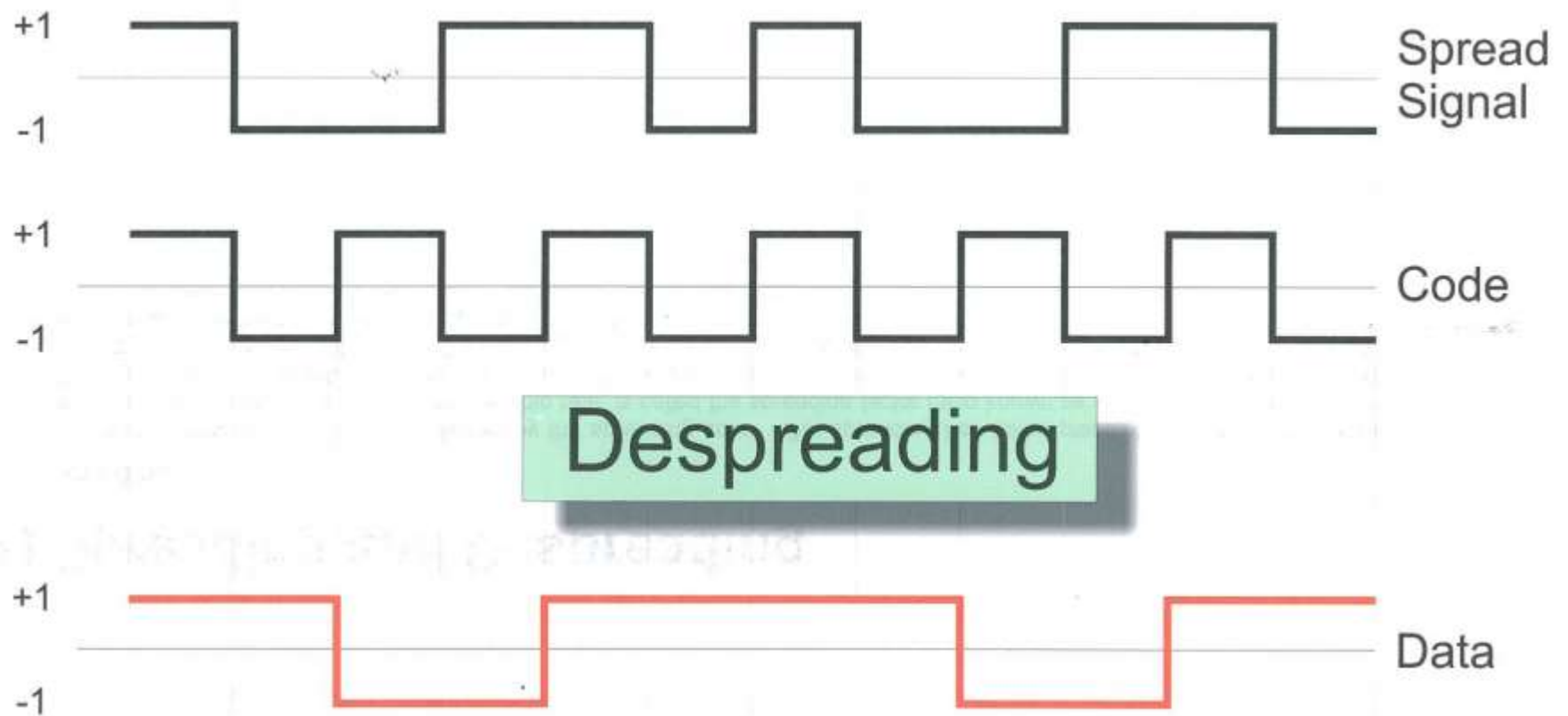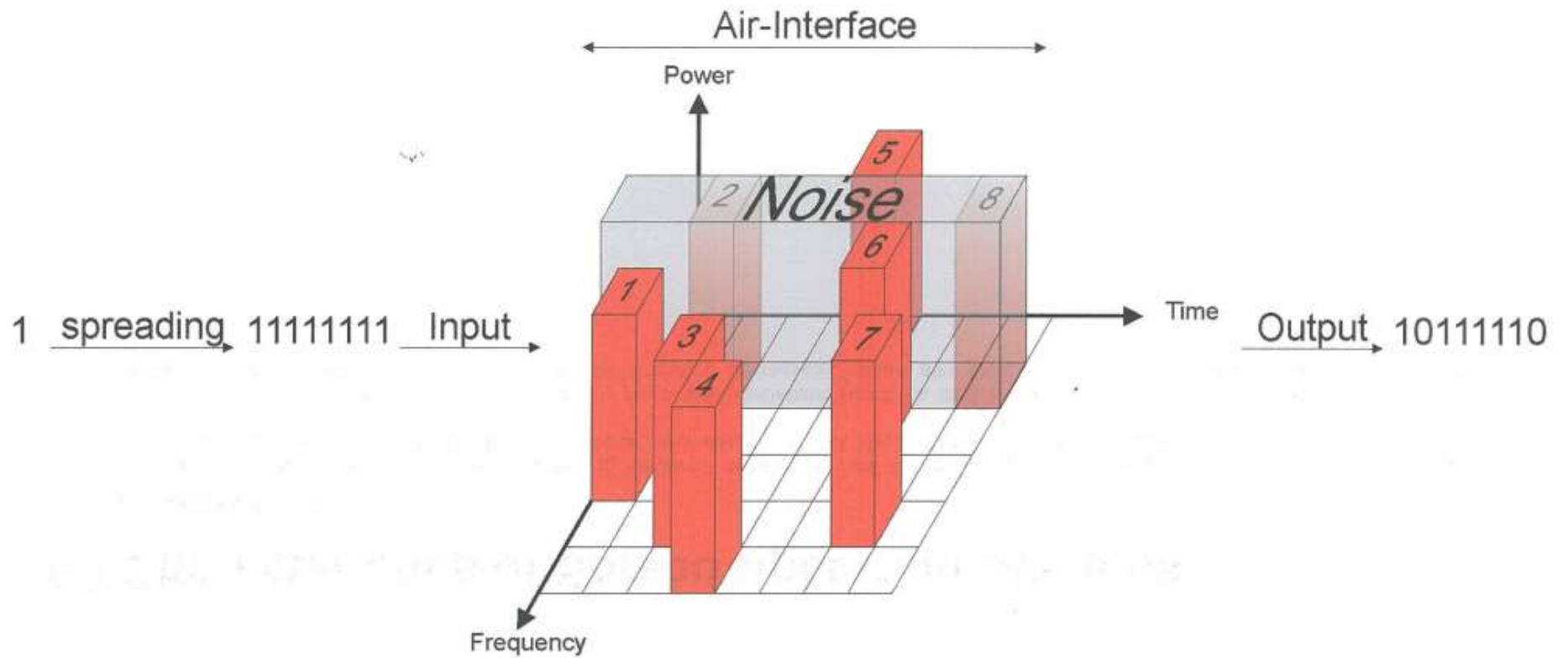
# Spreading
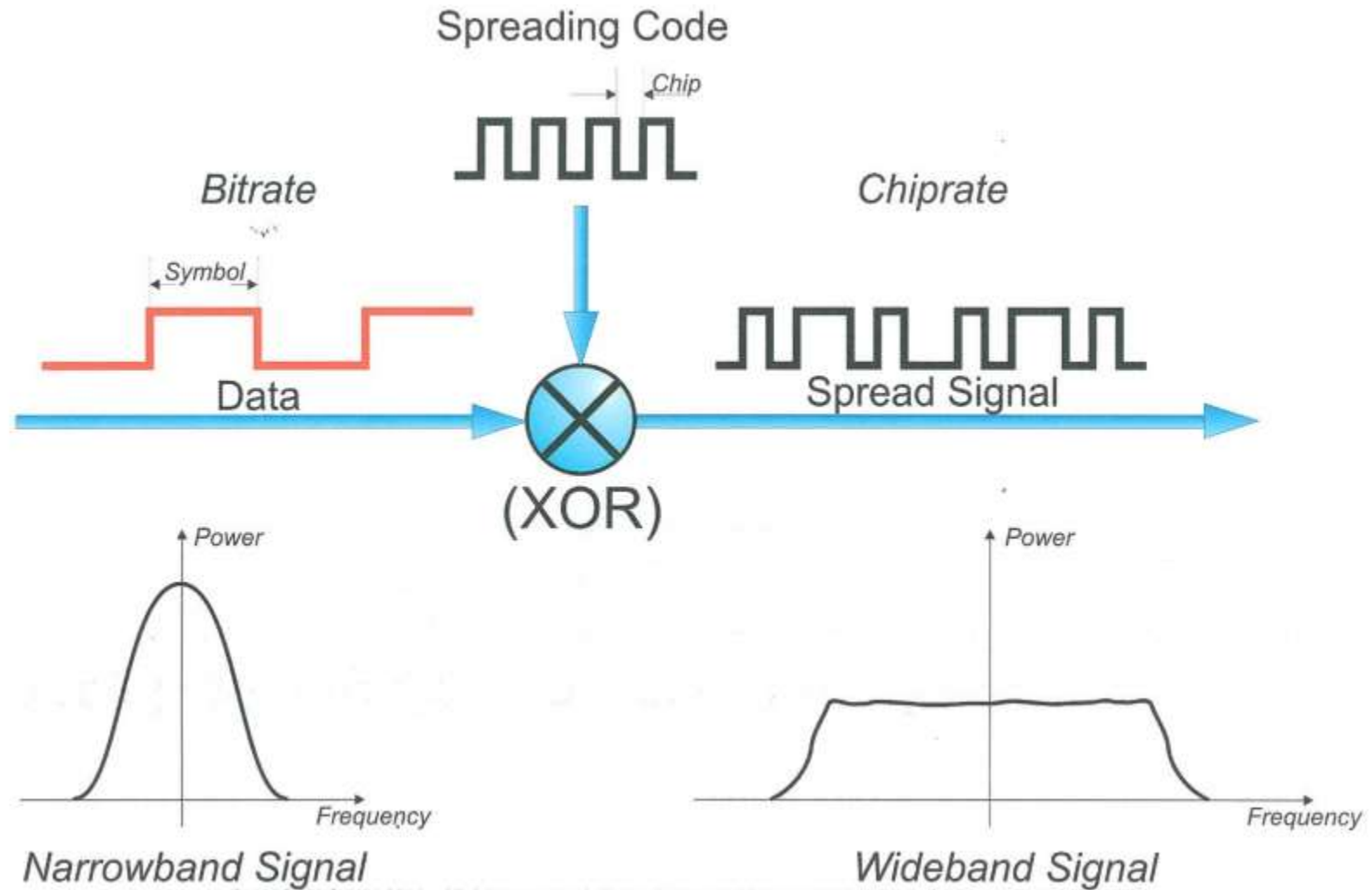
# Spreading

# De-spreading

# De-spreading

# Noise cancelation

# OFDMA

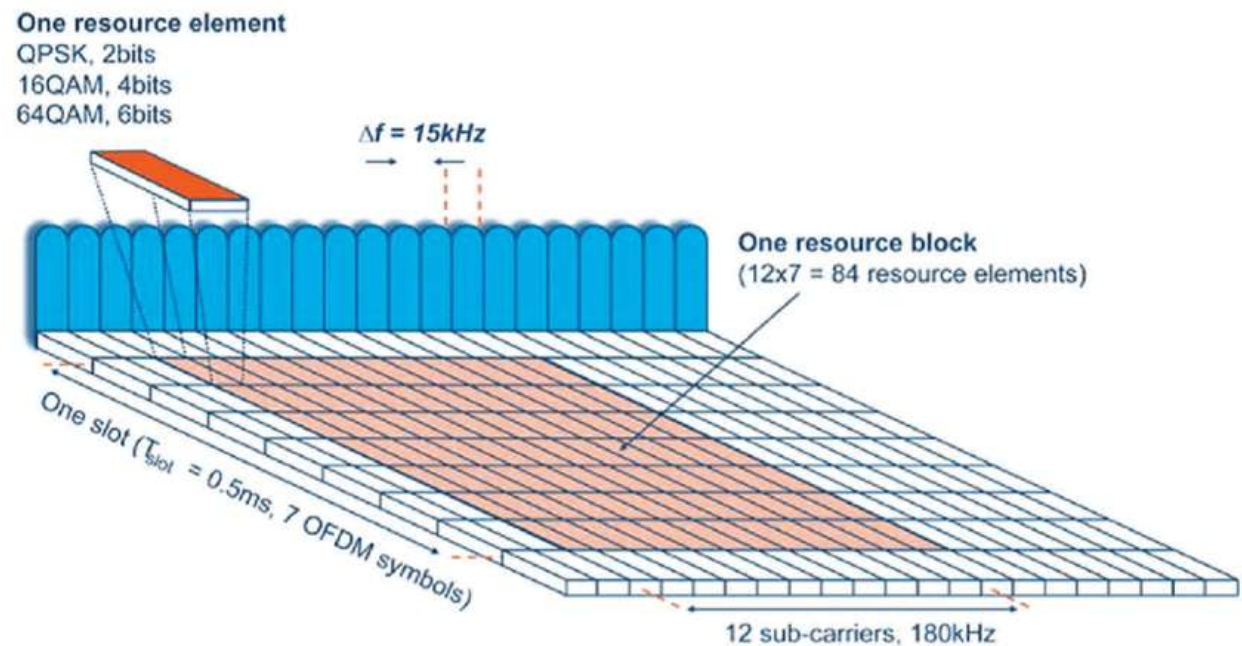- ❑ Wifi 802.11 ax

- ❑ WiMAX

- ❑ 4G

- ❑ 5G

- ❑ Satellite

**One resource element**
QPSK, 2bits
16QAM, 4bits
64QAM, 6bits

$\Delta f = 15kHz$

**One resource block**
(12x7 = 84 resource elements)

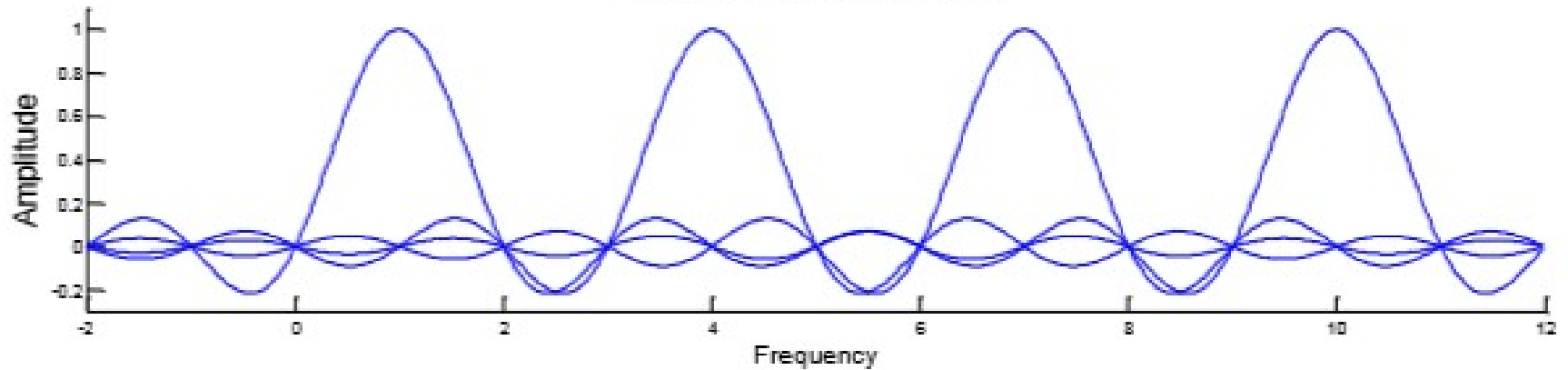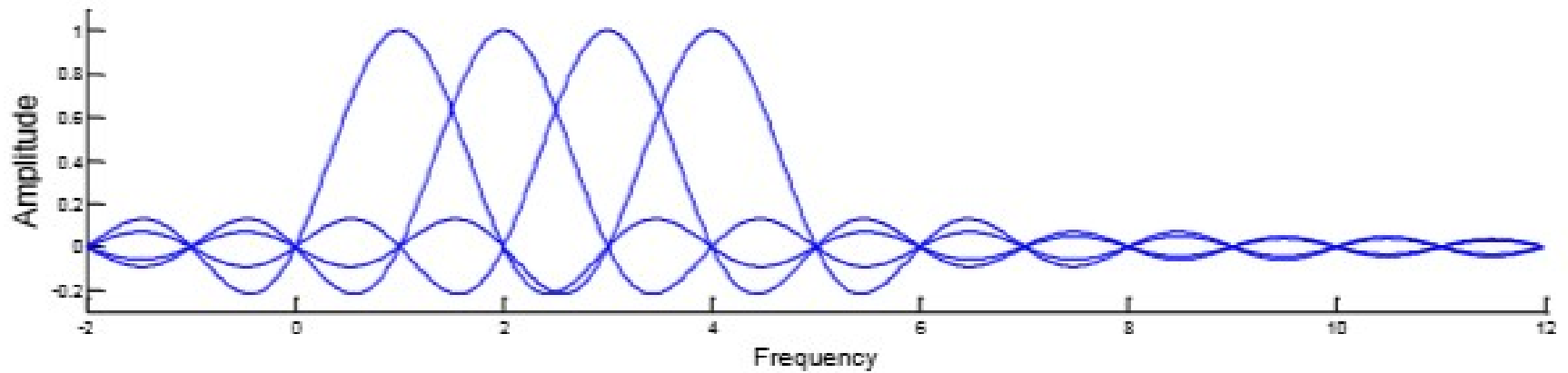One slot ($T_{slot}$ = 0.5ms, 7 OFDM symbols)

12 sub-carriers, 180kHz

# OFDM vs FDM



(a) Spectrum for FDM signal

(b) Spectrum for OFDM signal

# OFDM vs OFDMA
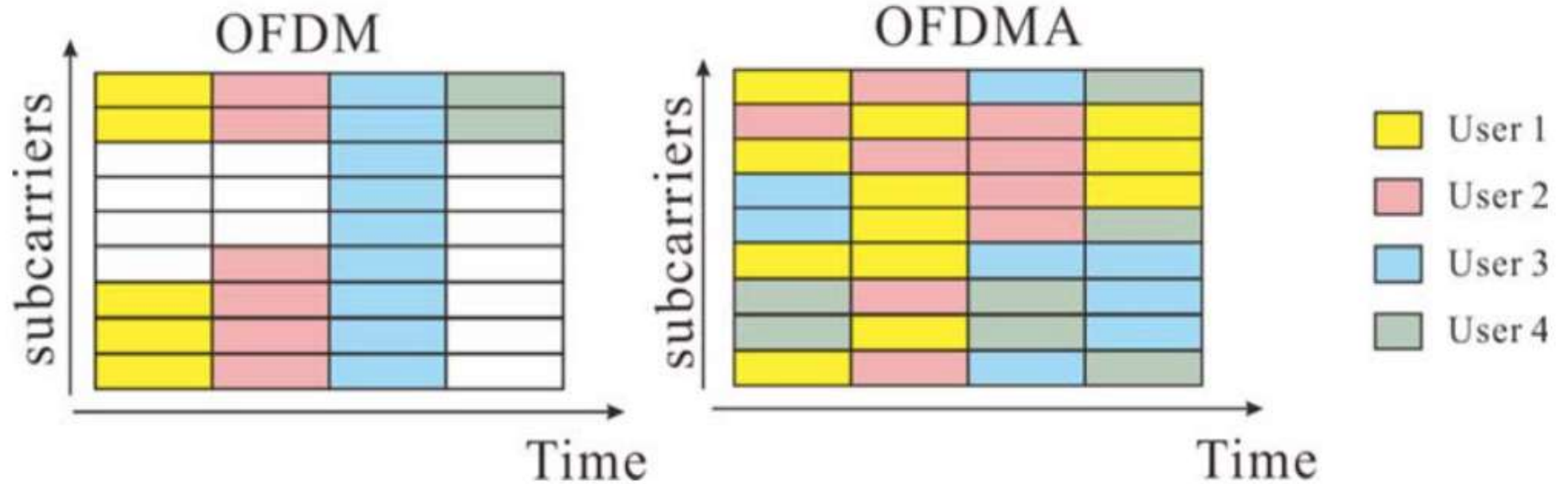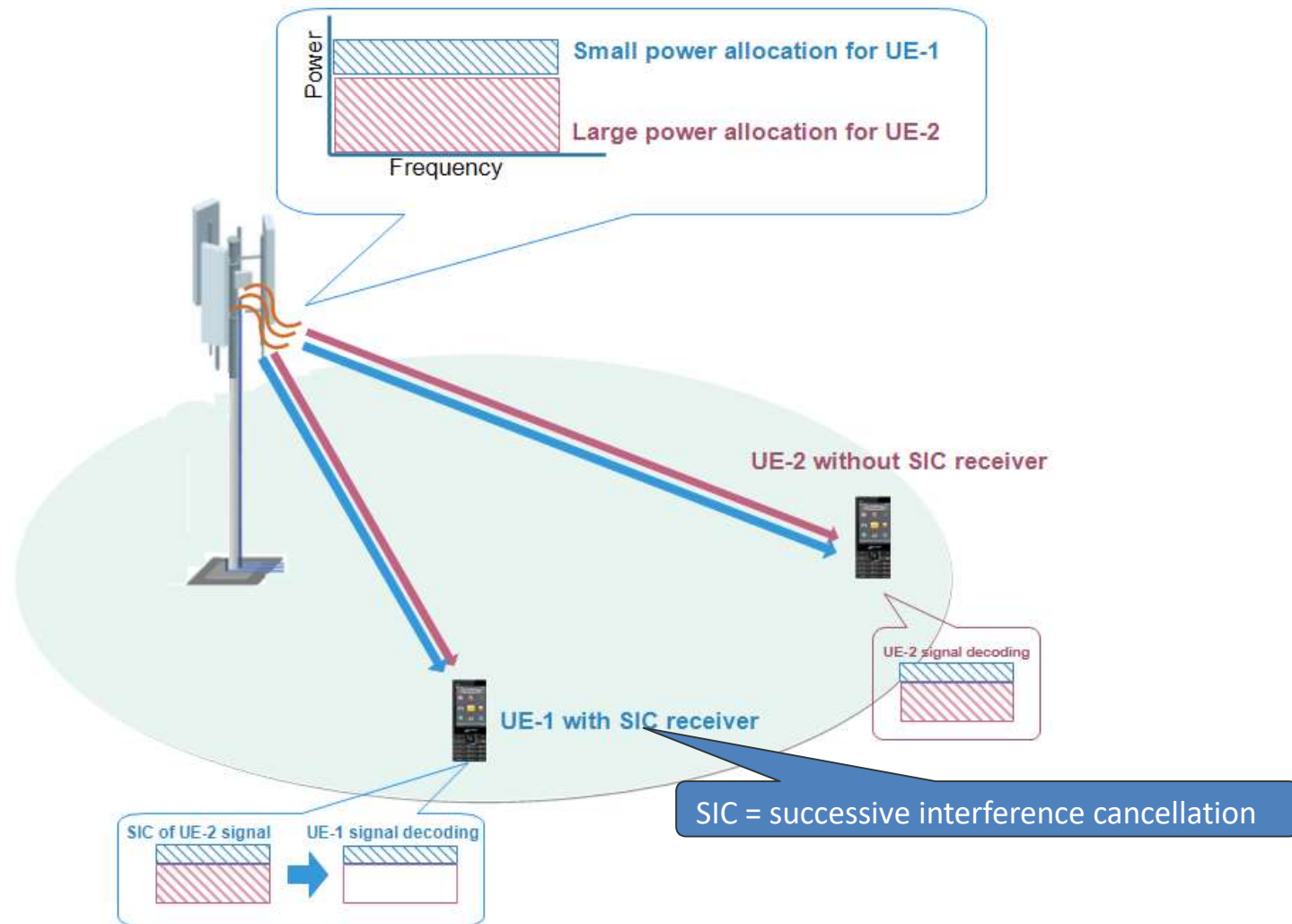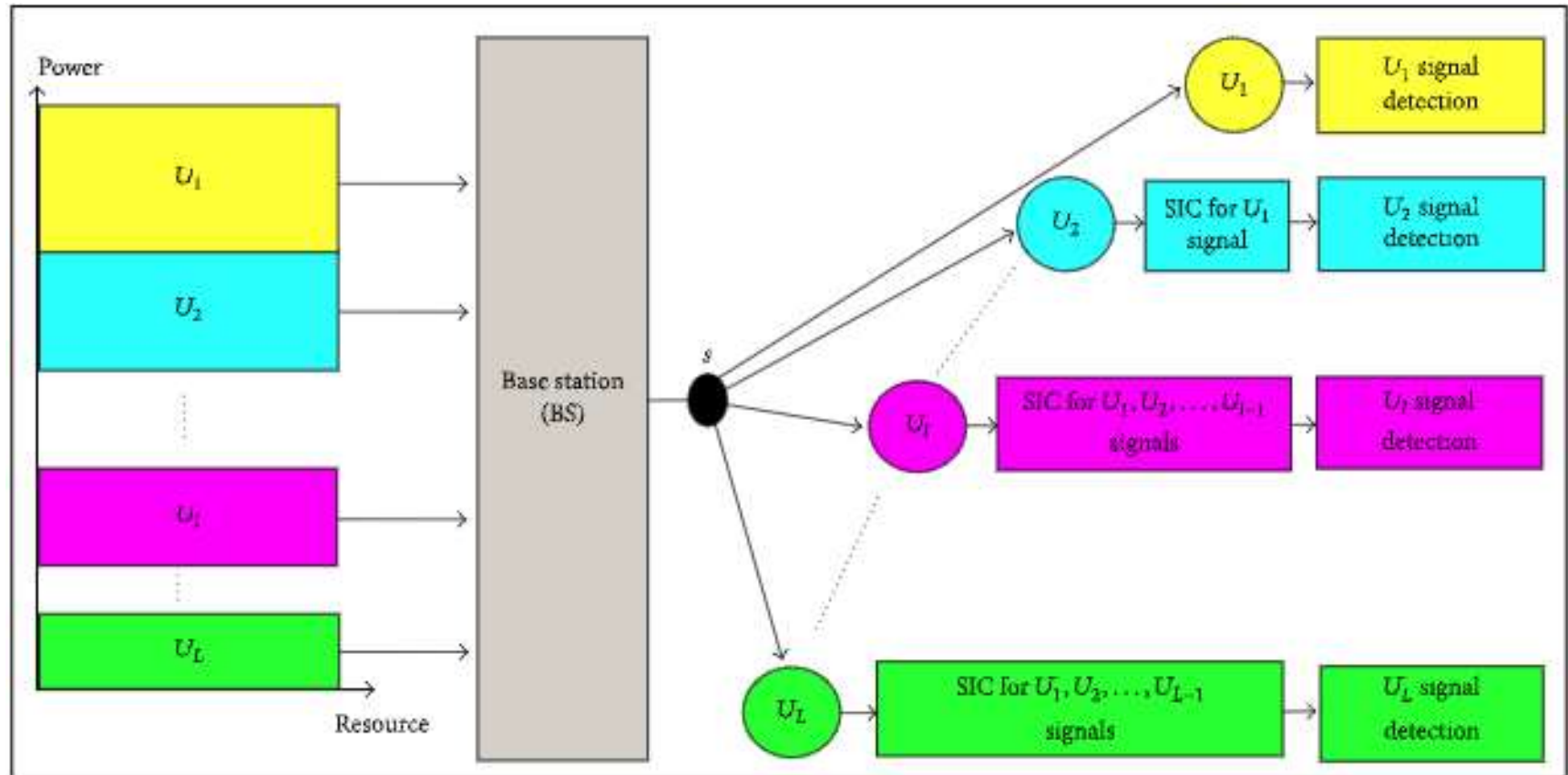
# Mapping

| Generation | MAS | Application |
| --- | --- | --- |
| 1G | FDMA | AMPS |
| 2G | TDMA | GSM |
| 3G | CDMA | UMTS |
| 4G | OFDMA | LTE |
| 5G | ??? | NR? |

# NOMA

# NOMA

# NOMA vs OFDMA

**NOMA**

Power / Frequency chart:
UE-1
UE-2

**OFDMA**

Power / Frequency chart:
UE-1    UE-2

BTS

UE-2 signal decoding

UE-2

SIC of UE-2 signal    →    UE-1 signal decoding

UE-1

BTS

Both signals with reduced power

UE-2

Both signals with high power

UE-1

# NOMA vs OMA



Orthogonal multiple access (OMA)

Non-orthogonal multiple access (NOMA)

UE 1
UE 2
UE 3
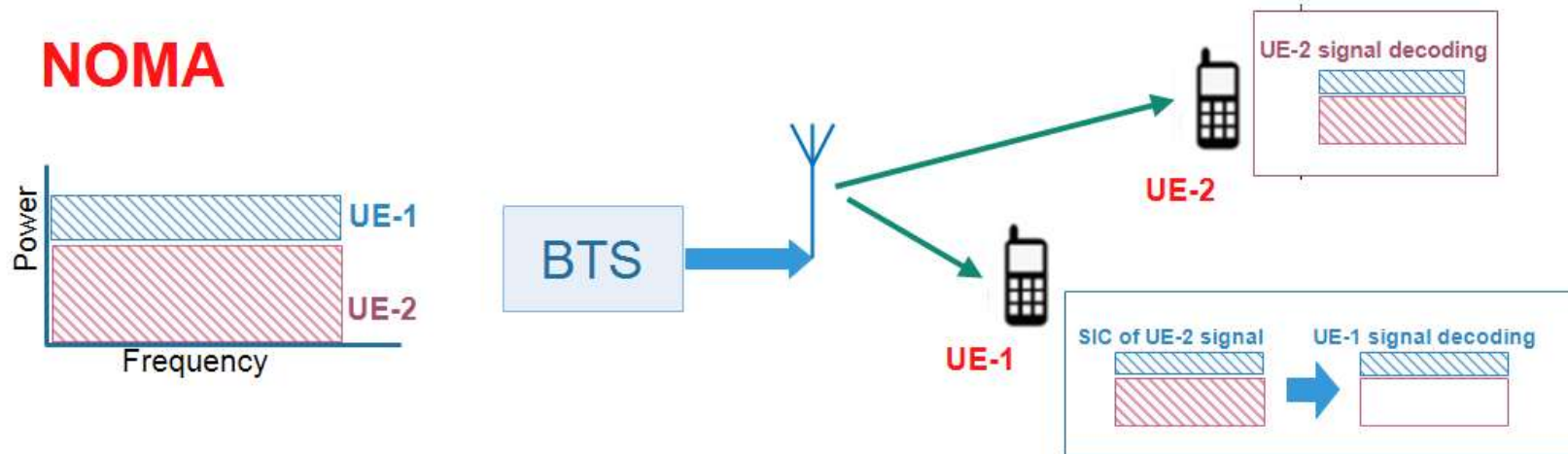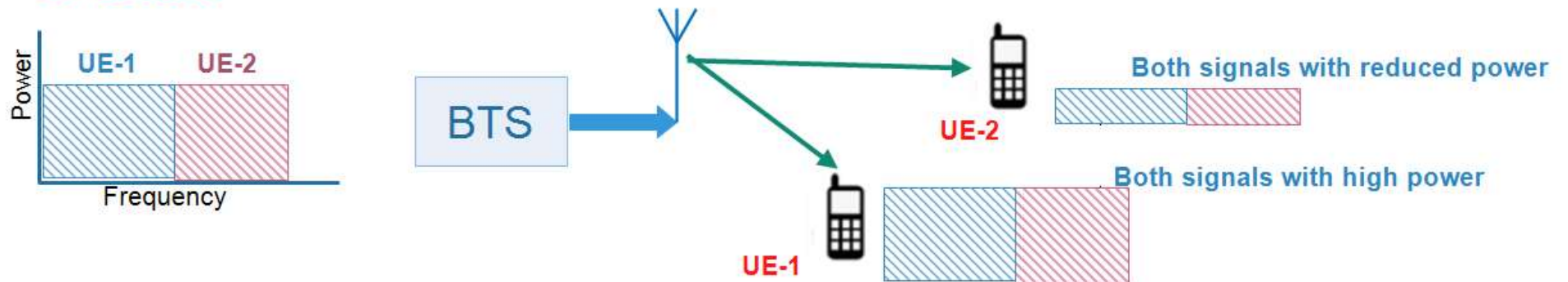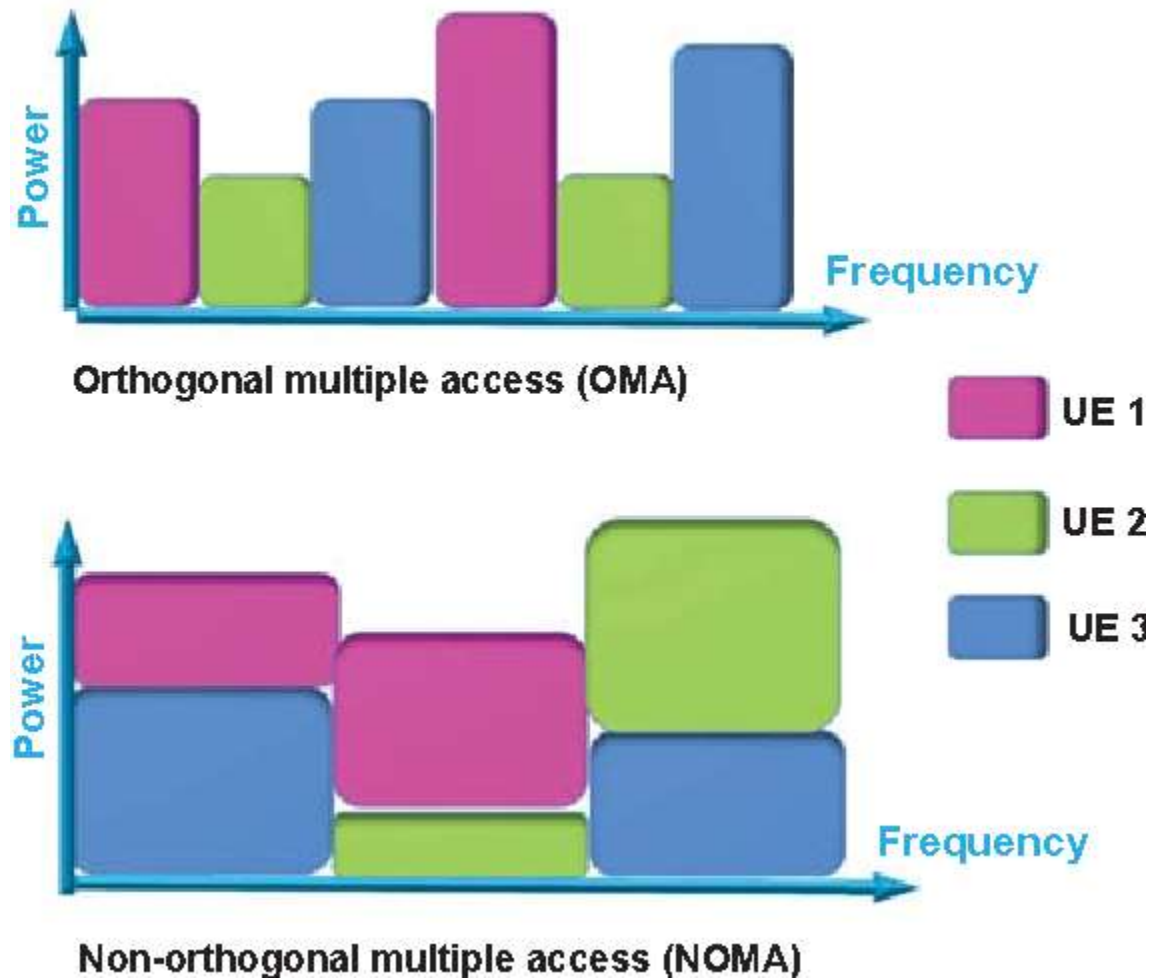
# Data rate
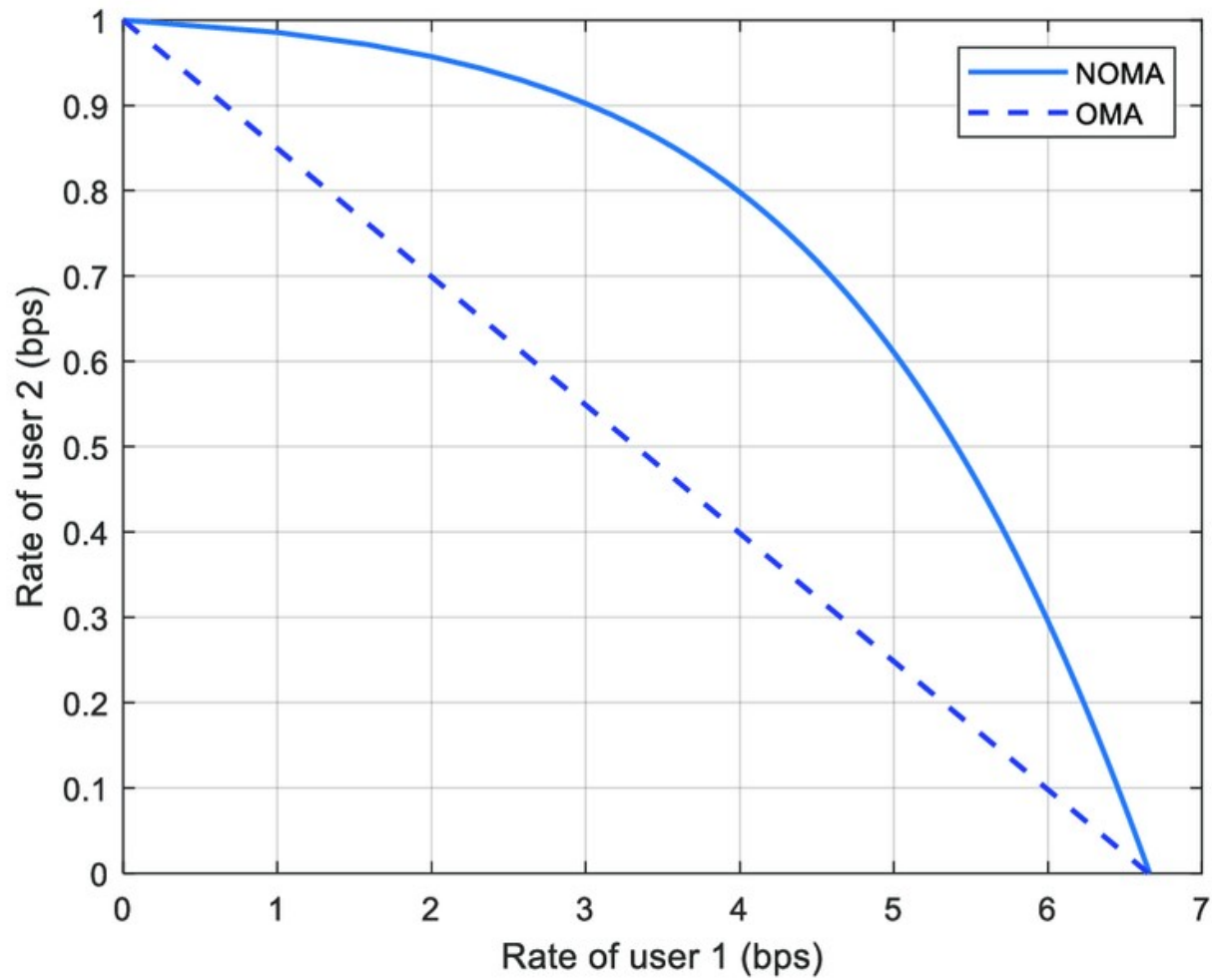
# Thank you

| | | | |
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| Mobile: | +84 908-676-212 | Australia number: | + 61 414-734-277 |
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