Introduction to Wireless Communications

2019. 5.

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Wireless Communication Systems

10MHz X 3

Lte

5G

SK telecom world

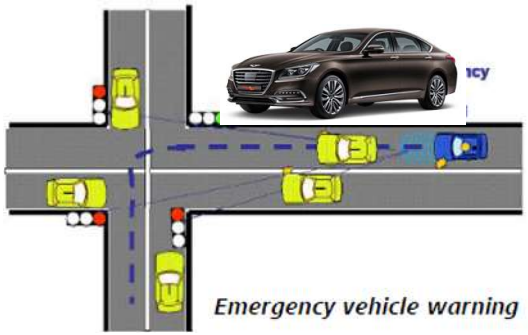
olleh kt

LG U+

ERICSSON

LG

SAMSUNG 삼성전자



200KHz

Cellular IoT
(LTE-M, NB-IoT)

LPWA (LoRa)

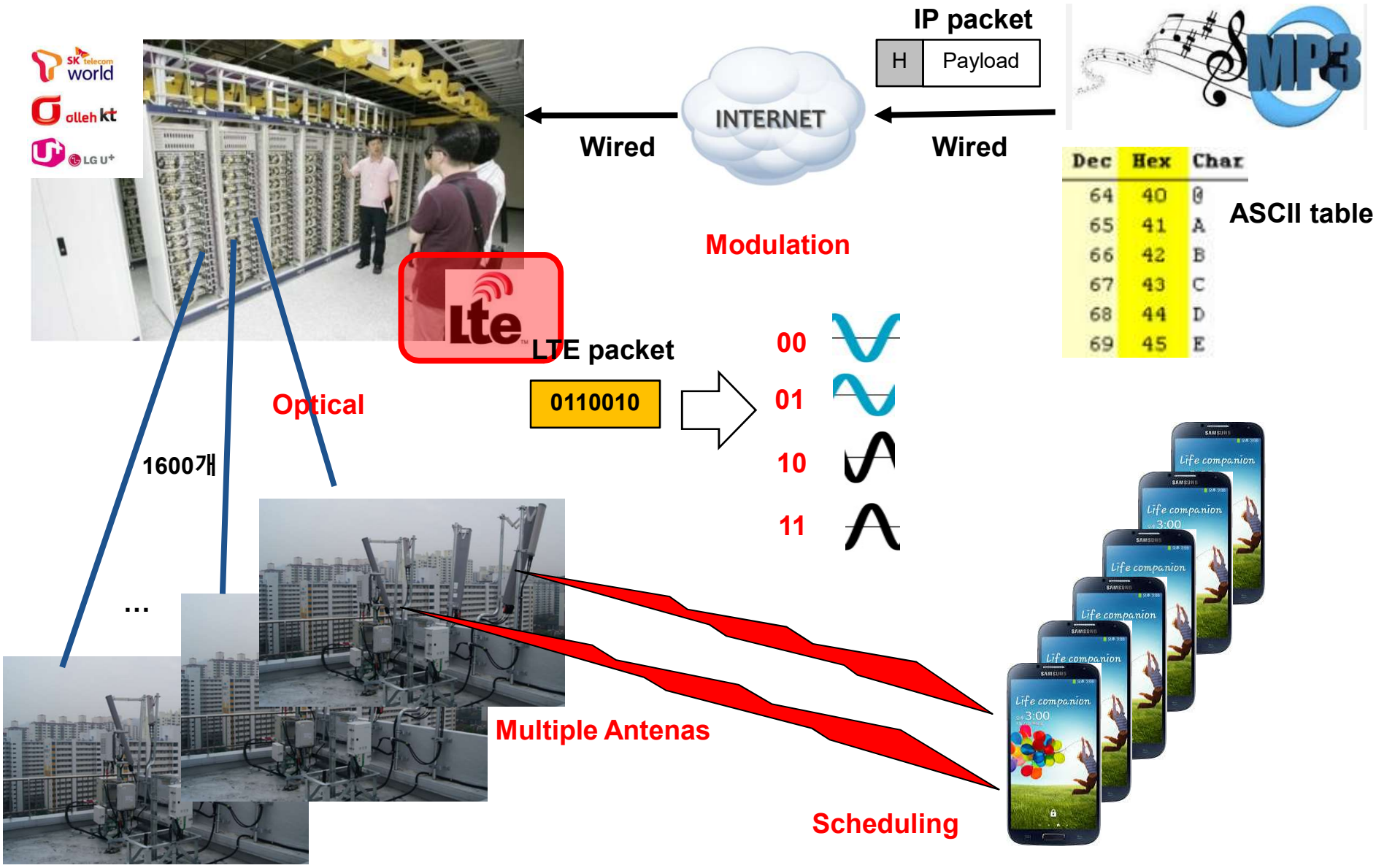
free @900MHz

원격 검침/리포팅

무인자전거 (현재 서비스)

어린이 안전

How to transmit data from the source to the dest ?



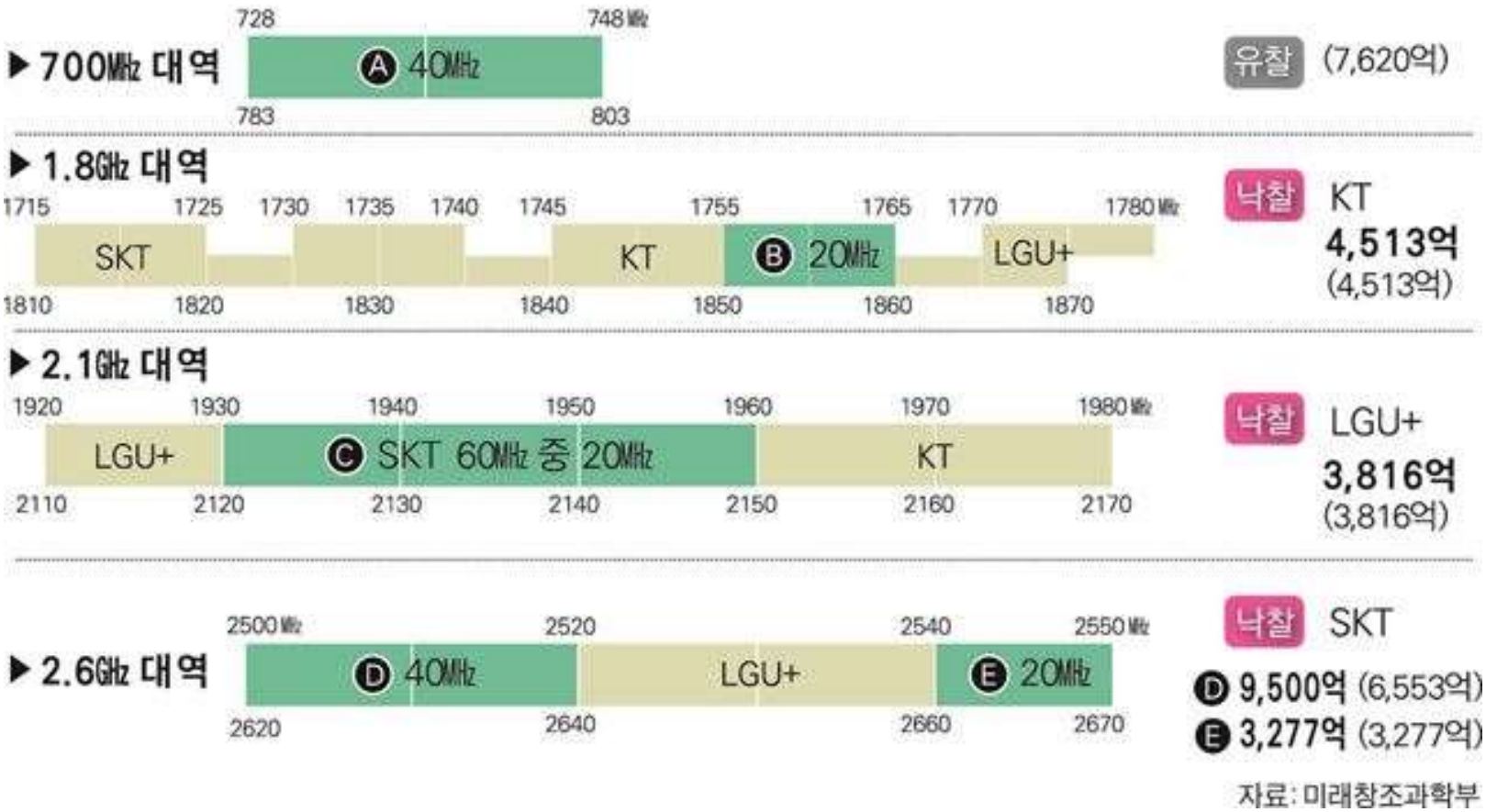
4G 주파수 경매 2016/05

'광대역 LTE' 나눠가진 이통3사 "주파수경매 결과만족"

SKT '2.6㎓' 싹쓸이, KT '1.8㎓', LGU+ '2.1㎓' 확보…총 낙찰가 2조1106억

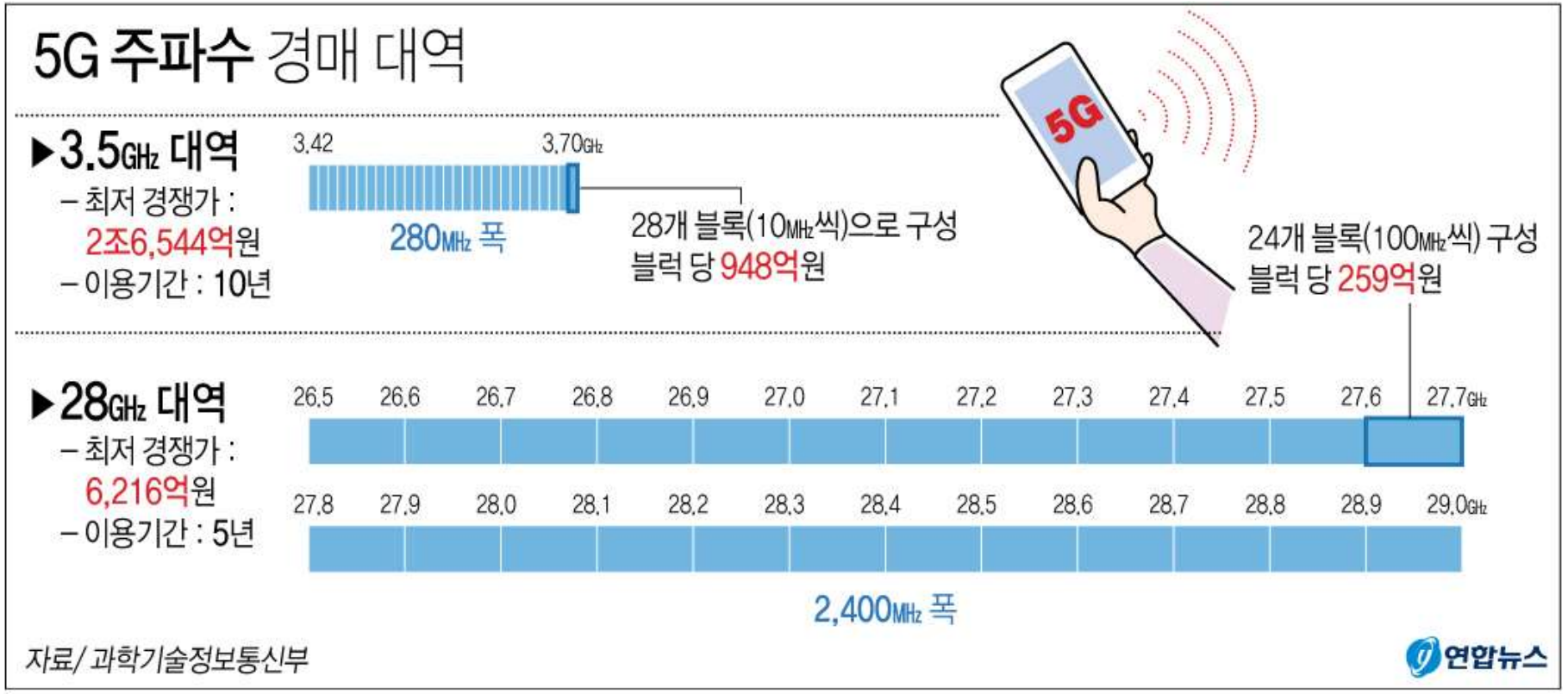
(서울=뉴스1) 주성호 기자 | 2016-05-02 17:01:32 송고 | 2016-05-02 17:11:28 최종수정

이통 3사 주파수 경매 결과 (단위: 원, 괄호안은 최저 경쟁가) 금번 경매대상



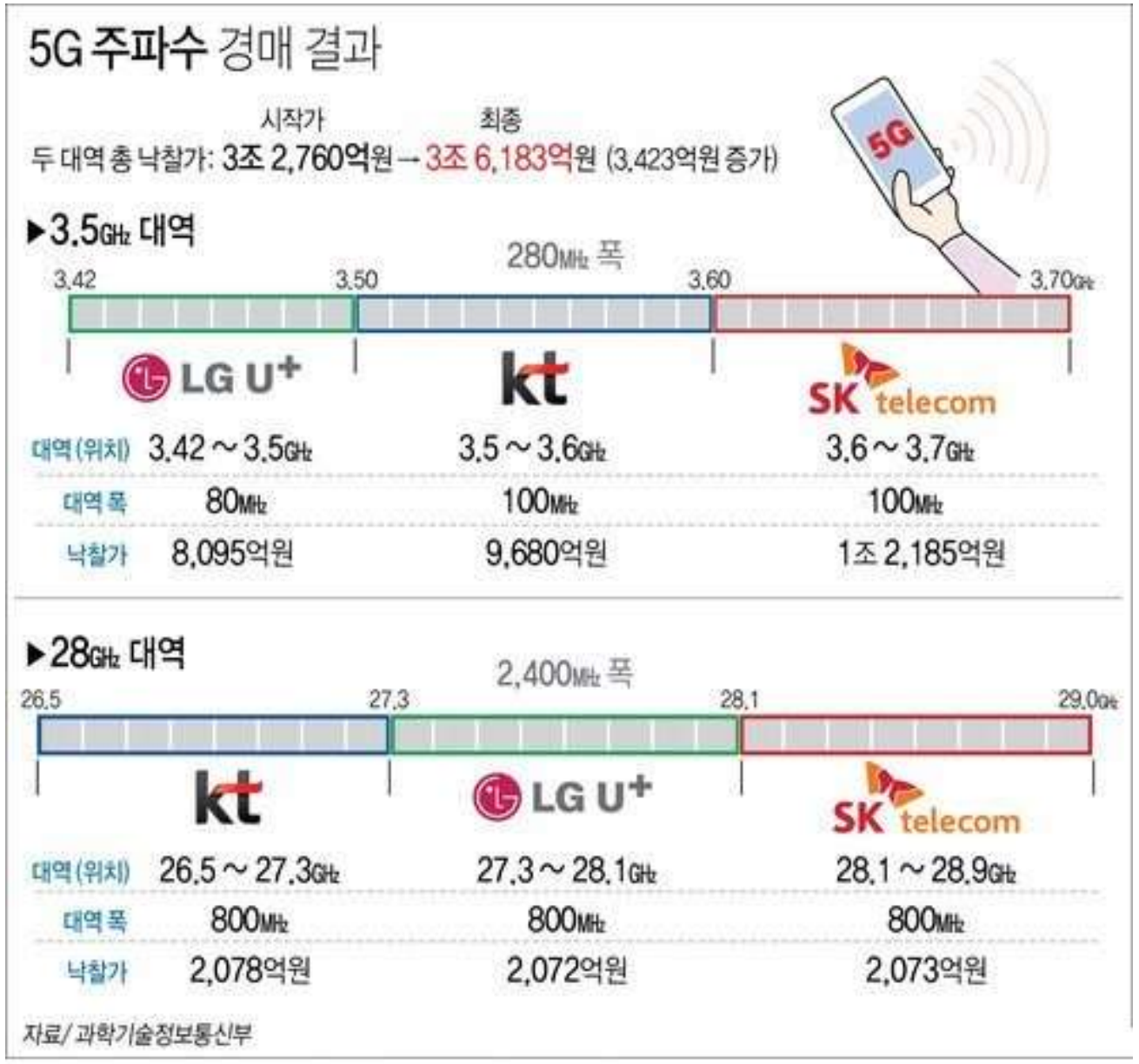
자료: 미래창조과학부

5G 주파수 경매 (1/2)

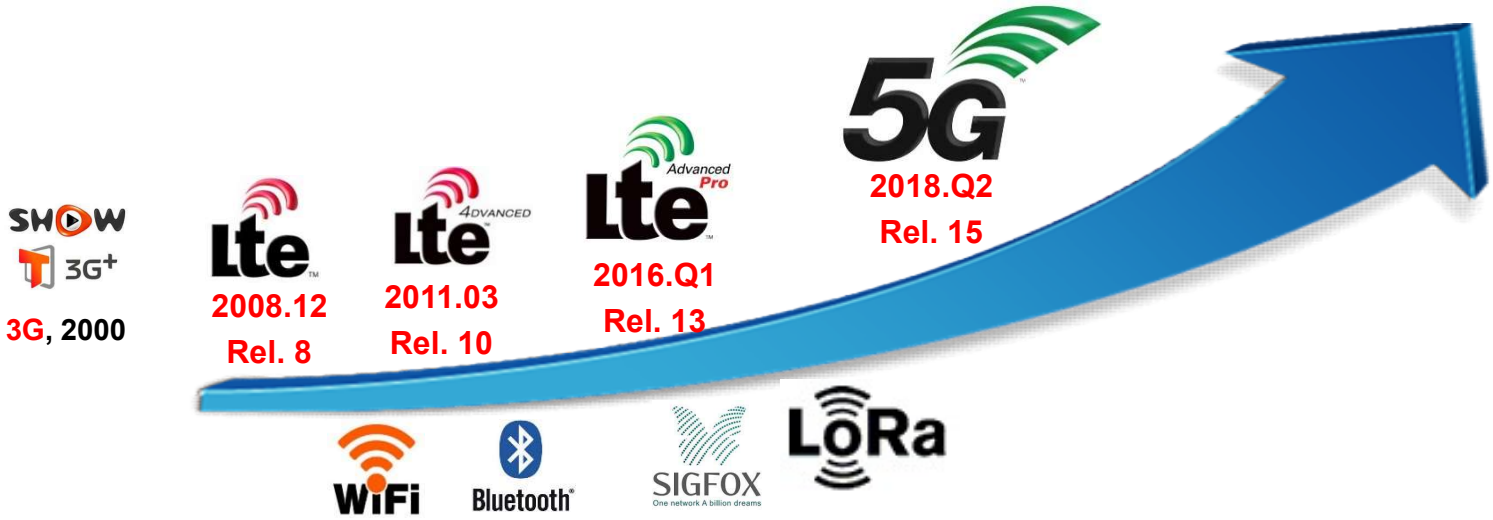


김토일 기자 / 20180419 / 페이스북 tuney.kr/LeYN1, 트위터 @yonhap_graphics

5G 주파수 경매 (2/2) – 2018/06



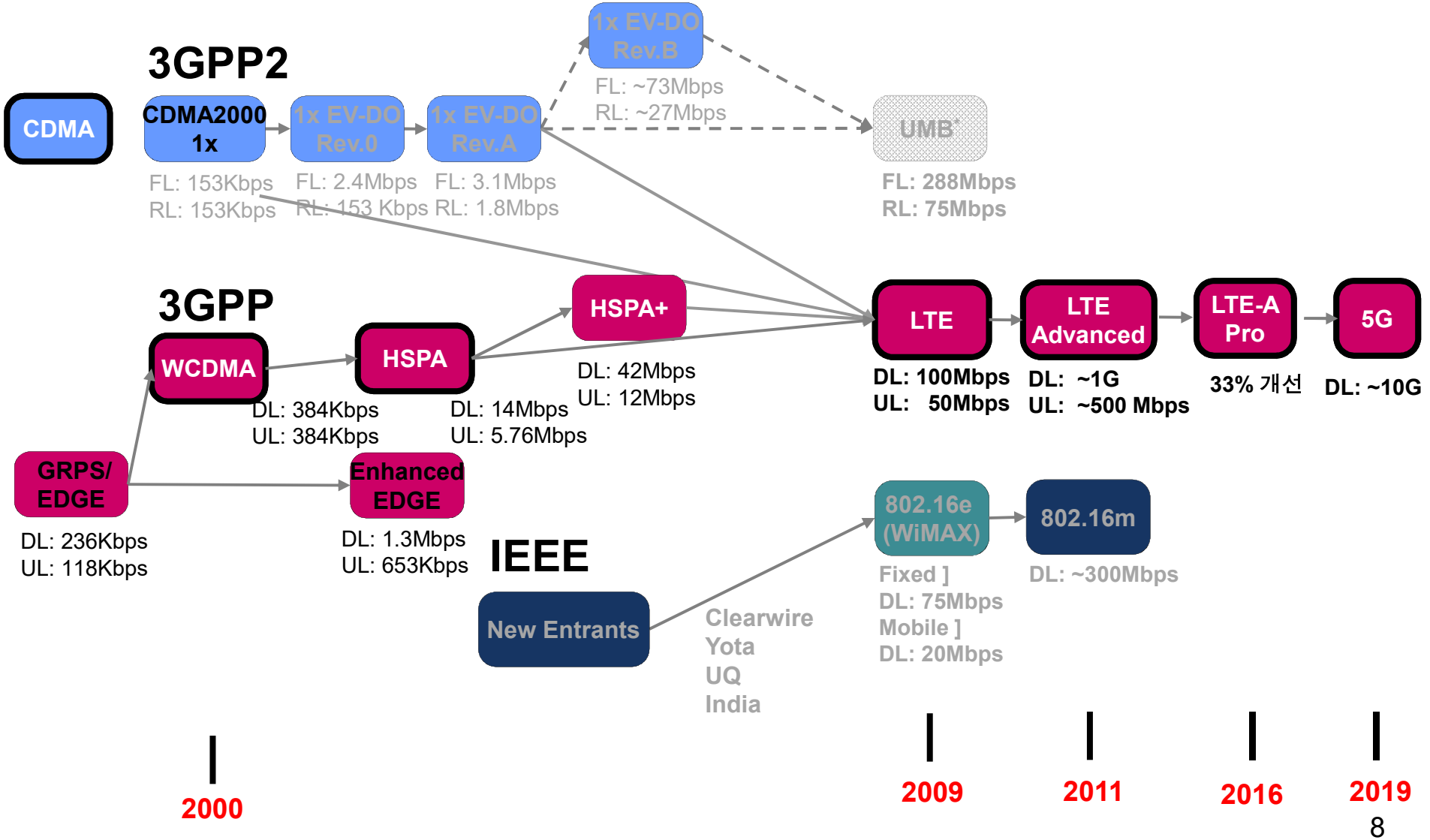
LTE Evolution



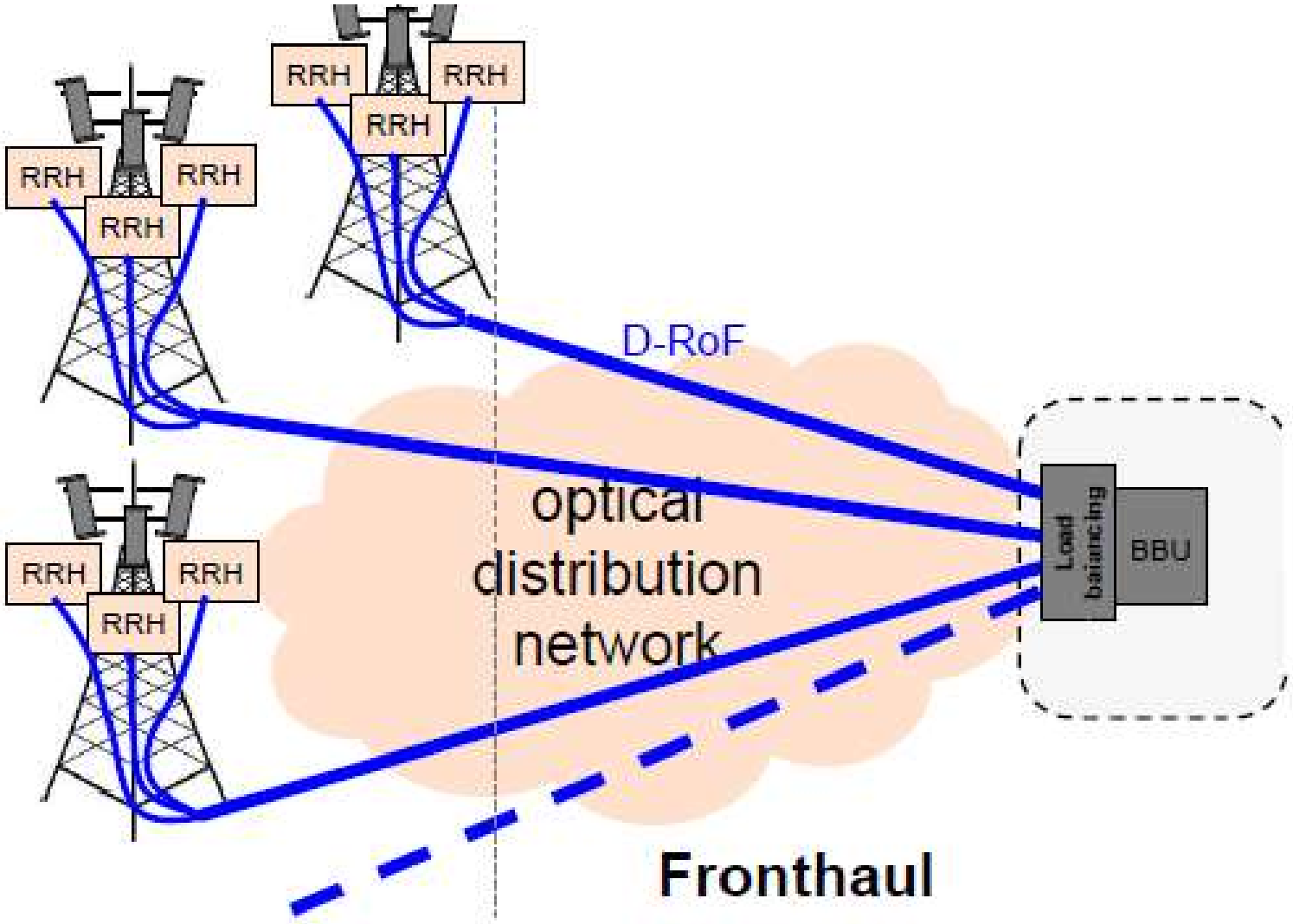
384Kbps 1Gbps 10Gbps

Standards and Evolution

- **ITU-R** is responsible for radio communication.
- **3GPP**, 3GPP2, IEEE : Collaboration between groups of telecommunication associations



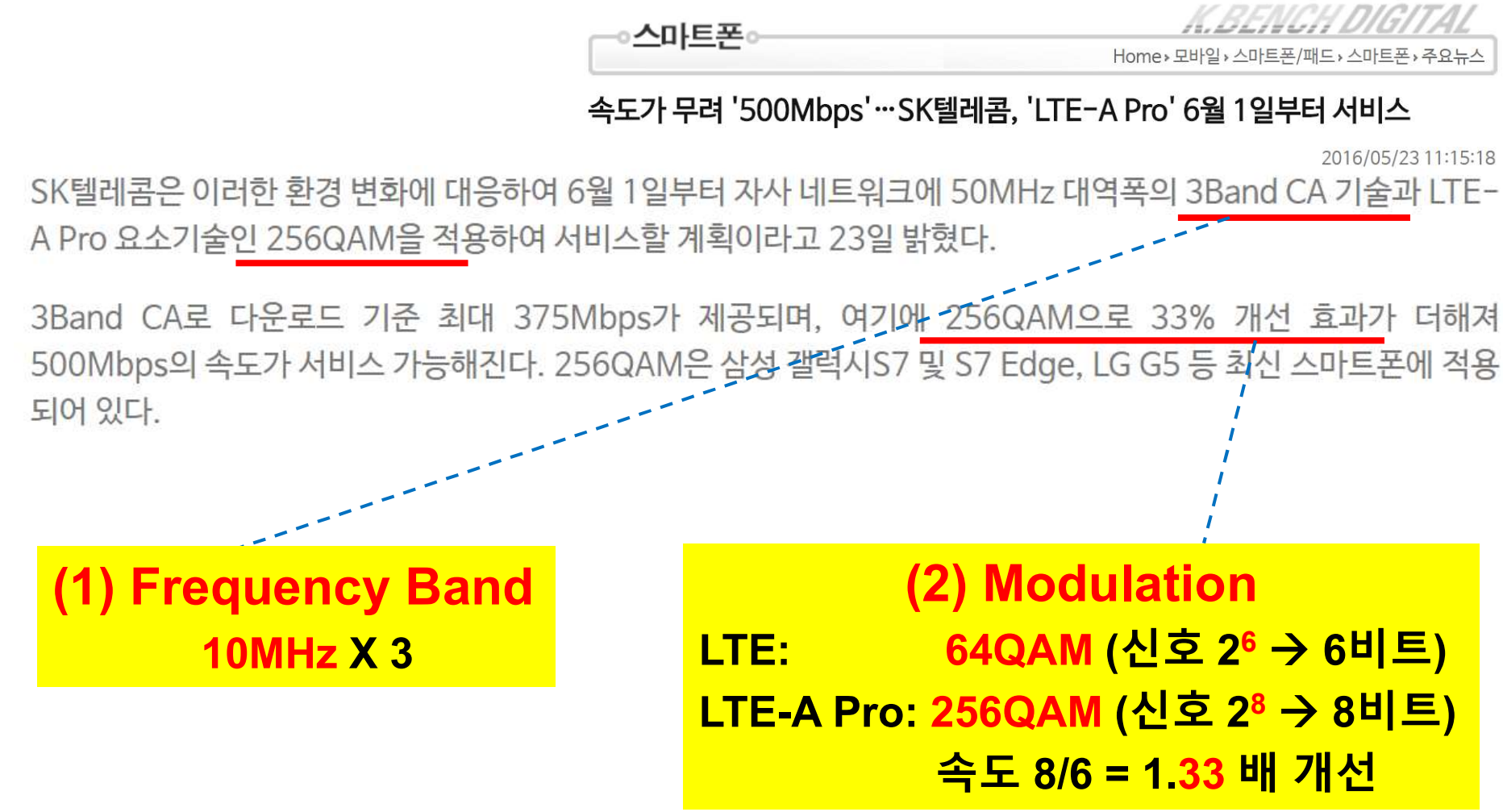
Cloud RAN



RRH: Remote Radio Head
BBU: Baseband Unit
D-RoF: Digital-Radio over Fiber

RRH

How to increase data rate ? (1/3)



스마트폰

K.BENCH DIGITAL

Home › 모바일 › 스마트폰/패드 › 스마트폰 › 주요뉴스

속도가 무려 '500Mbps'…SK텔레콤, 'LTE-A Pro' 6월 1일부터 서비스

2016/05/23 11:15:18

SK텔레콤은 이러한 환경 변화에 대응하여 6월 1일부터 자사 네트워크에 50MHz 대역폭의 3Band CA 기술과 LTE-A Pro 요소기술인 256QAM을 적용하여 서비스할 계획이라고 23일 밝혔다.

3Band CA로 다운로드 기준 최대 375Mbps가 제공되며, 여기에 256QAM으로 33% 개선 효과가 더해져 500Mbps의 속도가 서비스 가능해진다. 256QAM은 삼성 갤럭시S7 및 S7 Edge, LG G5 등 최신 스마트폰에 적용되어 있다.

(1) Frequency Band

10MHz X 3

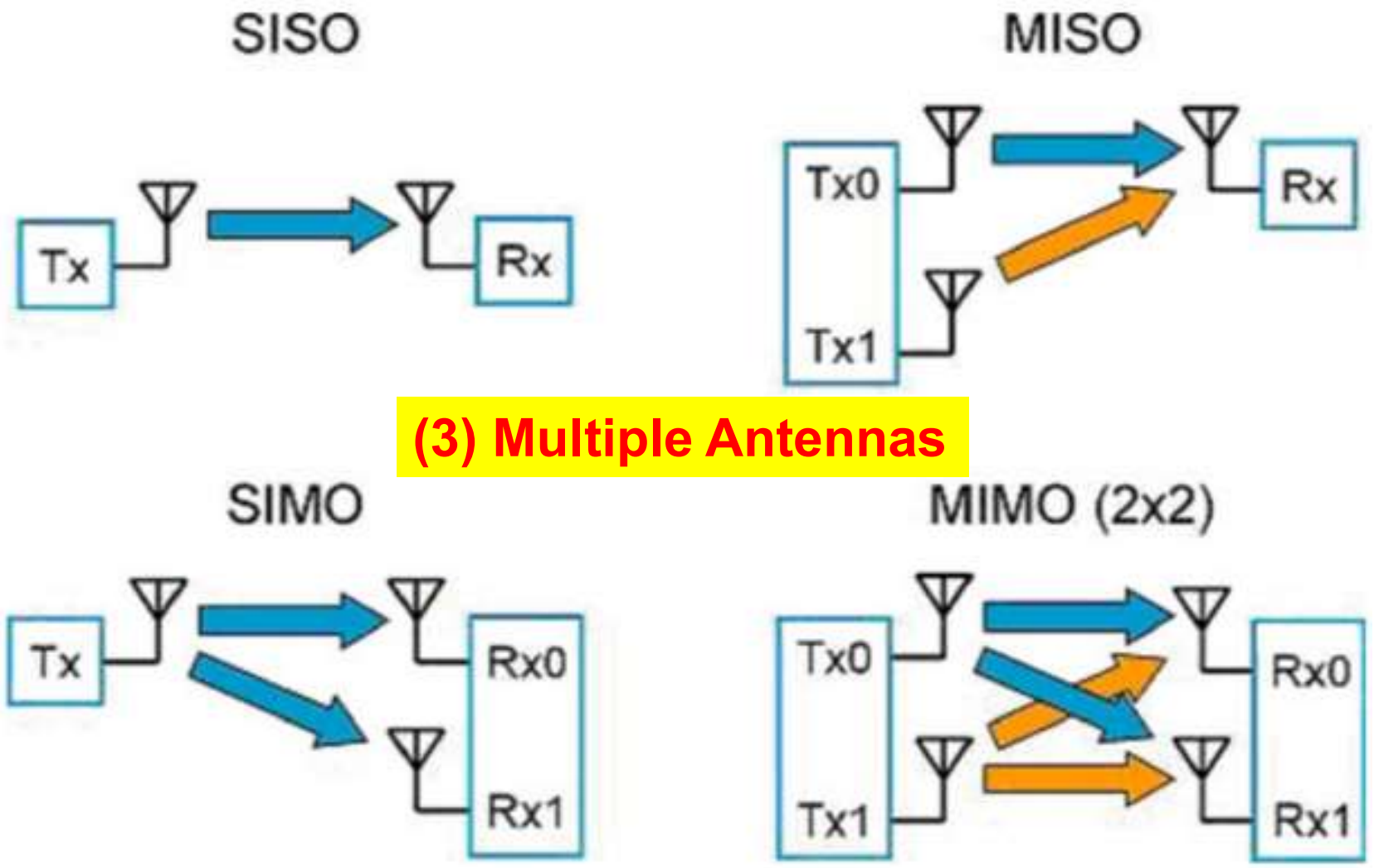
(2) Modulation

LTE: 64QAM (신호 2^6 → 6비트)

LTE-A Pro: 256QAM (신호 2^8 → 8비트)

속도 8/6 = 1.33 배 개선

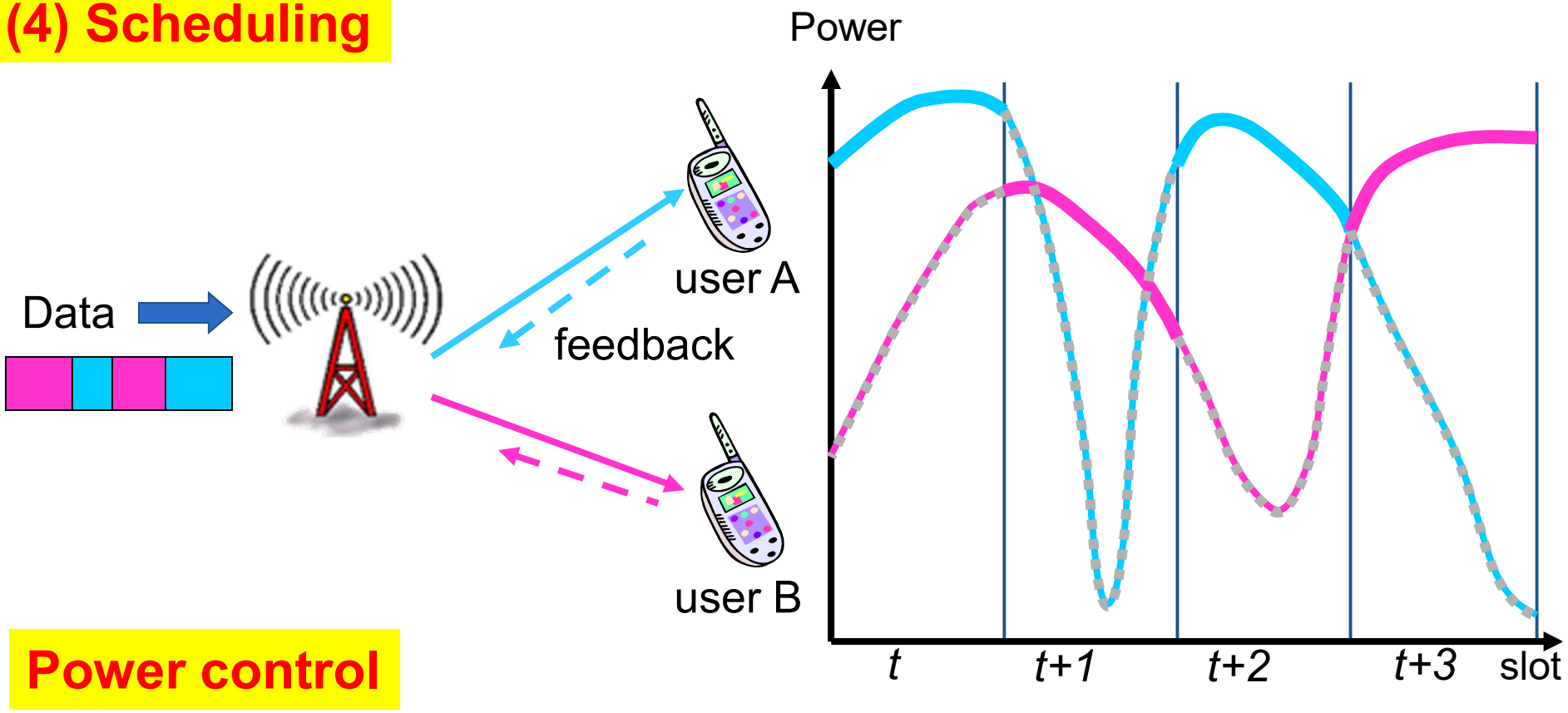
How to increase data rate ? (2/3)



- SISO: Single Input Single Output
- MIMO: Multiple Input Multiple Output

How to increase data rate ? (3/3)

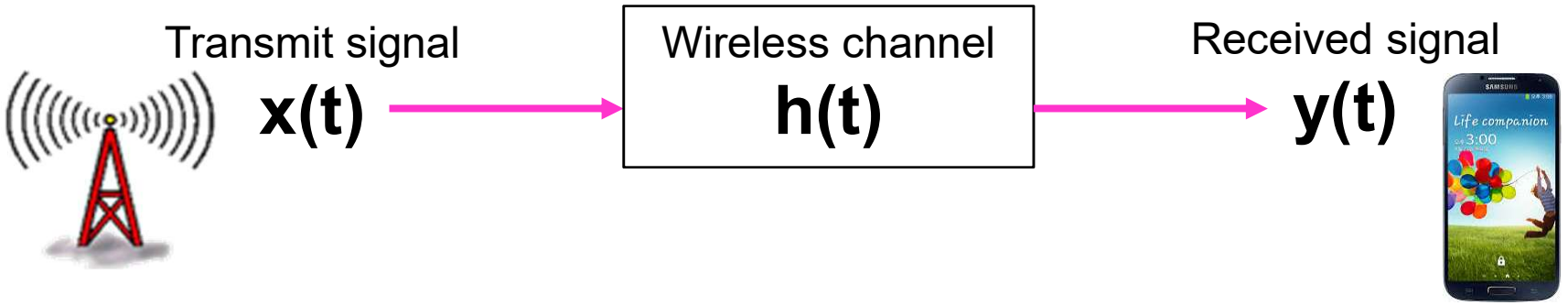
(4) Scheduling



Power control

기초 이론 (1/2)

Find $x(t)$ from $y(t)$?



$$y(t) = h(t)*x(t) \rightarrow Y(f) = H(f)X(f)$$

STEP 1. BS transmits a known signal, $\tilde{x}(t)$, to the MS.

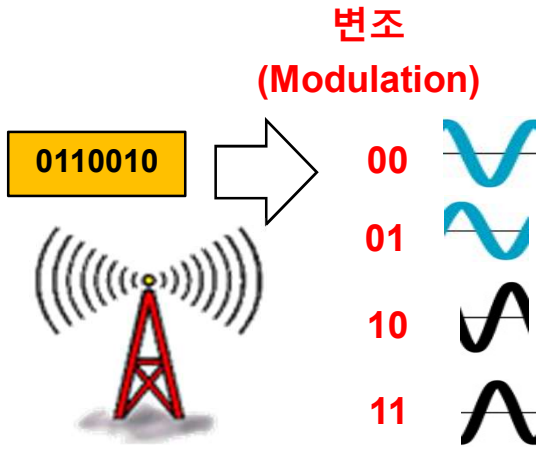
MS estimates the channel, $h(t)$, from $H(f) = Y(f)\tilde{X}^{-1}(f)$

STEP 2. BS transmits a data, $x(t)$, to the MS.

MS can find, $x(t)$, from $X(f) = H^{-1}(f)Y(f)$

기초 이론 (2/2)

<디지털통신>



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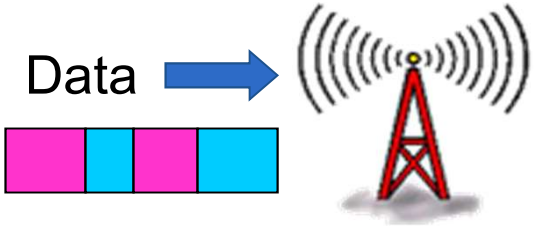
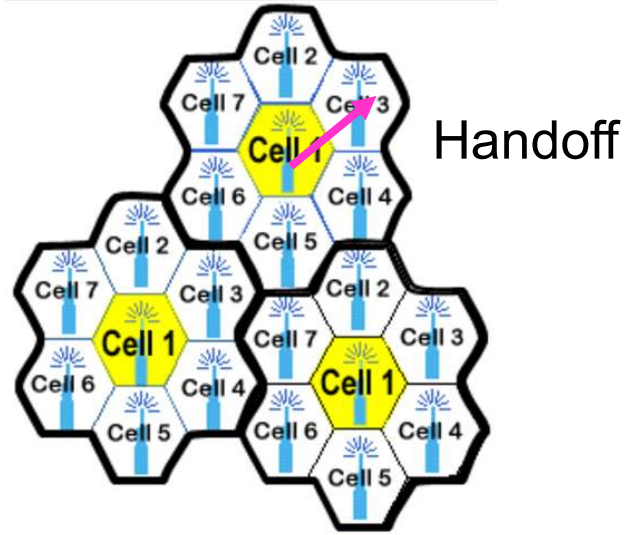


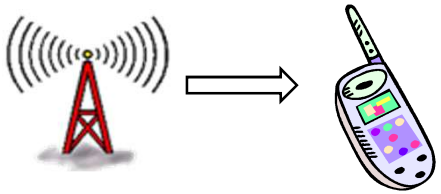
Who first ? → Scheduling
Multiple access, retransmission

<이동통신공학>



Mathmatical Approaches

Channel estimation/ MIMO precoding



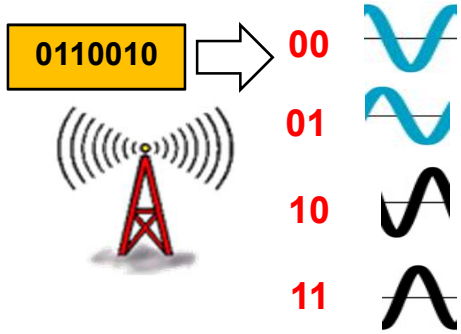
To find, $x(t)$,

$y(t) = h(t)*x(t)$

$Y(f) = H(f)X(f)$

$\hat{X}(f) = H^{-1}(f)X(f)$

Modulation



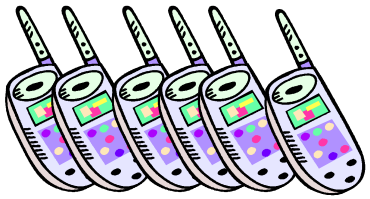
To convert the 2GHz

$\int \cos x \cos x$

vs $\int \cos x \cos y$

Scheduling

Who first ? → Scheduling

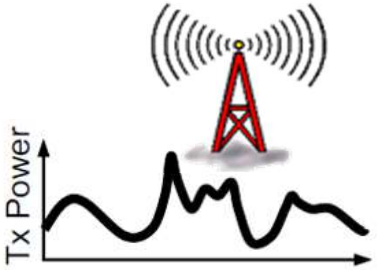


Fair allocation ?

$R_k(t)$ vs $\frac{R_k(t)}{T_k(t)}$

$R_k(t)$: k번째 단말 순간 전송률
$T_k(t)$: k번째 단말 평균 전송률

Power allocation



Maximize the rate

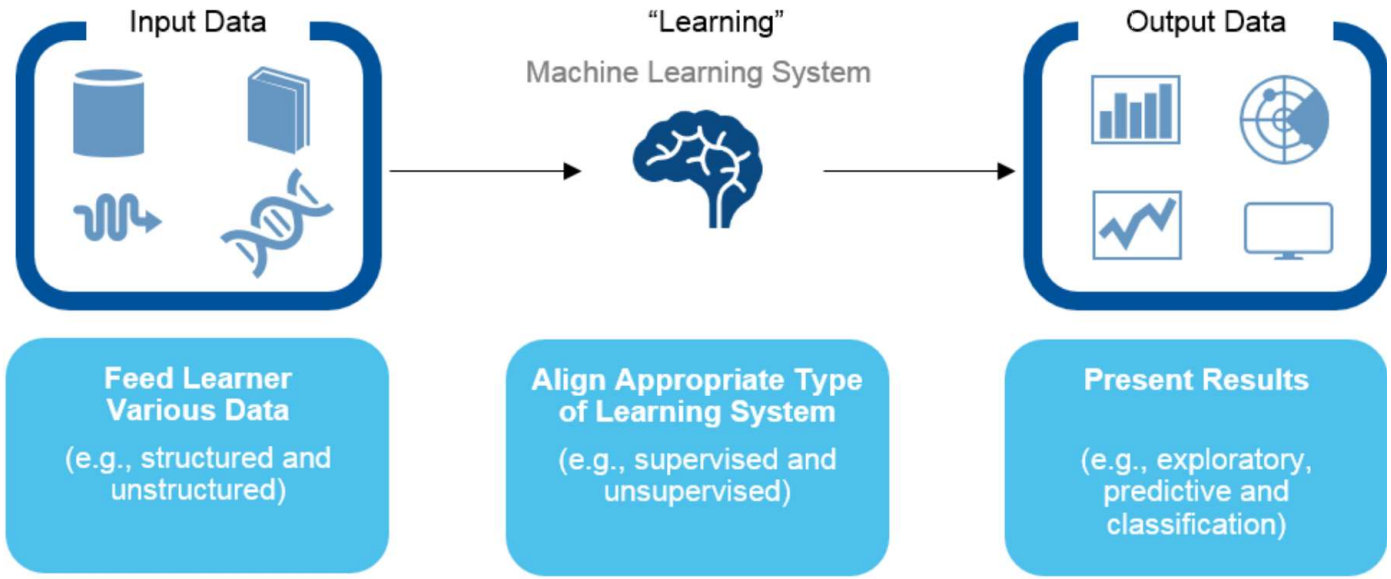
$$\max \sum_{k=1}^{K} \log(1 + h_k p_k)$$

$$\text{s.t. } p_k \geq 0, \quad \sum_{k=1}^{K} p_k = 1$$

p_k: k번째 단말 할당 power
h_k: k번째 단말 채널 상태

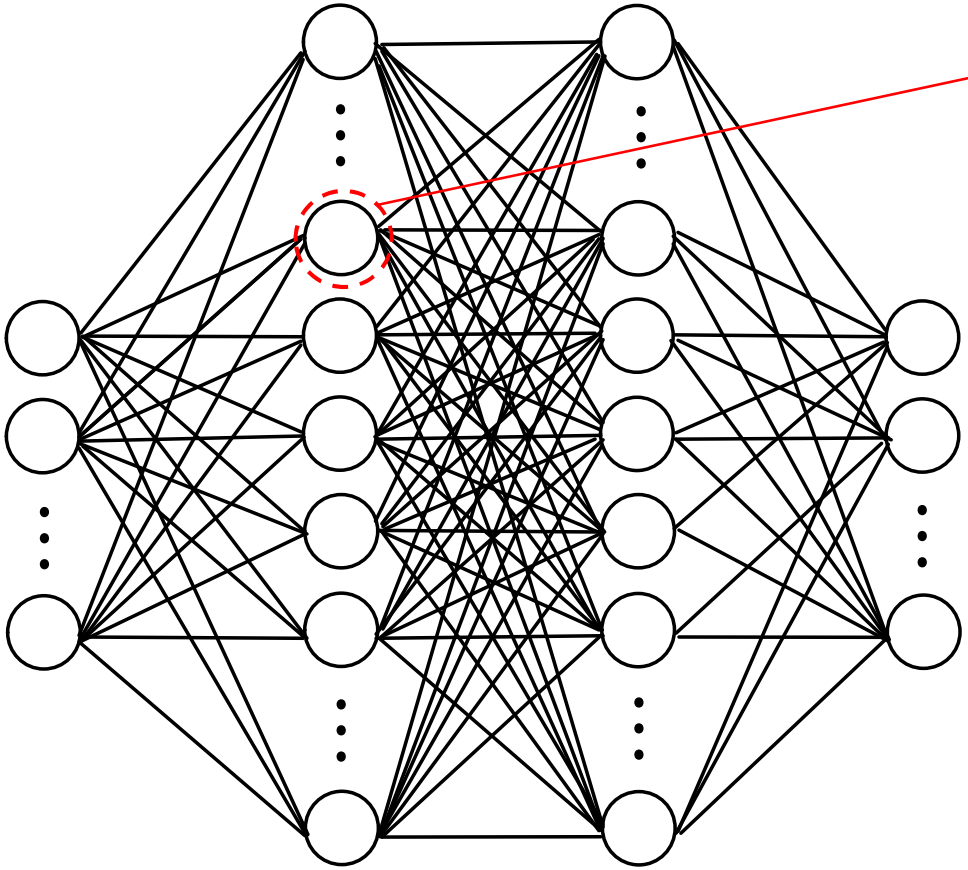
ML-based Approach

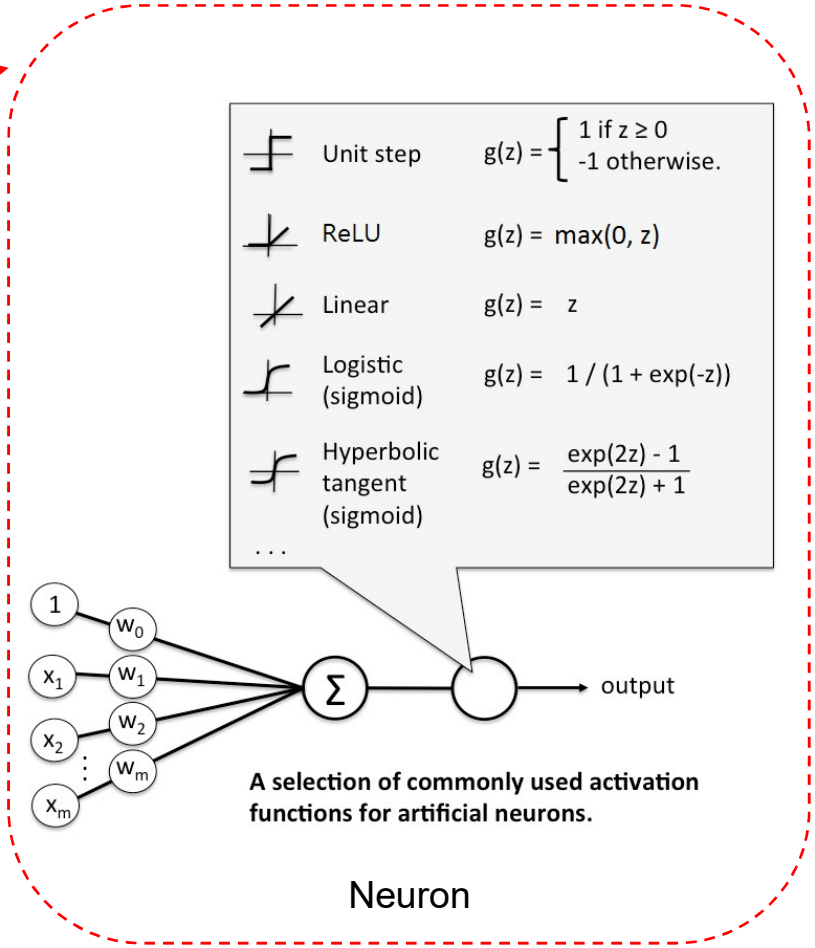
- Primary goal of ML is to allow the computers learn automatically without human intervention and adjust actions accordingly to achieve the goal.
  - ML focuses on the development of programs that can access **data** and use it **learn** for themselves
  - In particular, deep learning (DL) has been very successful in many field (vision, speech, game, …)



Deep Neural Network Structure

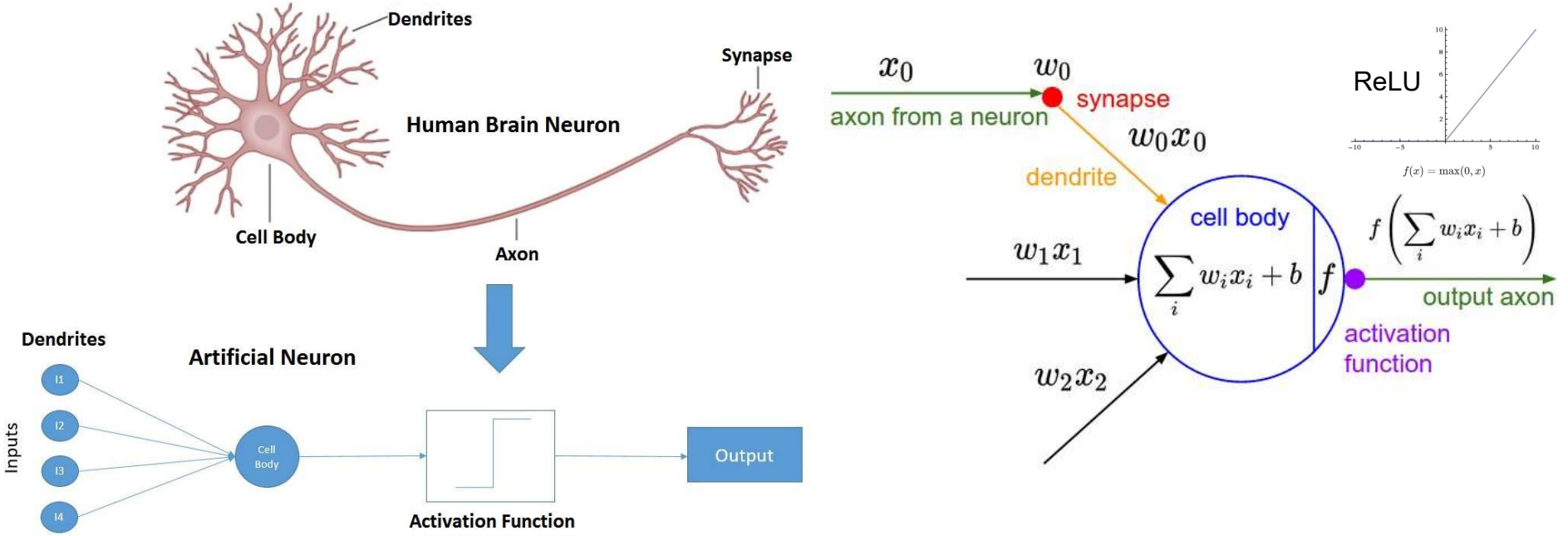
- Neuron is a basic bulding block of deep neural network





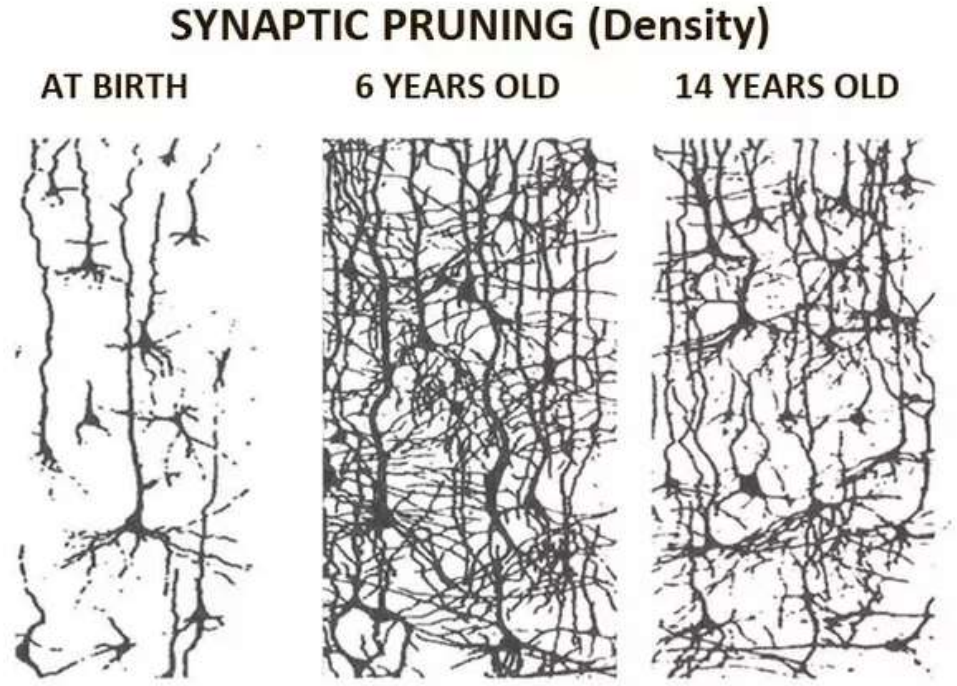
Neural Network vs. Human Brain

- Neurons are the fundamental units of the brain which contains **Dendrites**, **Axons**, **Synapses**, etc.
  - **Dendrites** act as a receiver
  - **Axon** acts as a transmitter of signals to and from other Neurons.
  - **Synapse** are the weights assigned to each input neurons.



Neural Network Learning

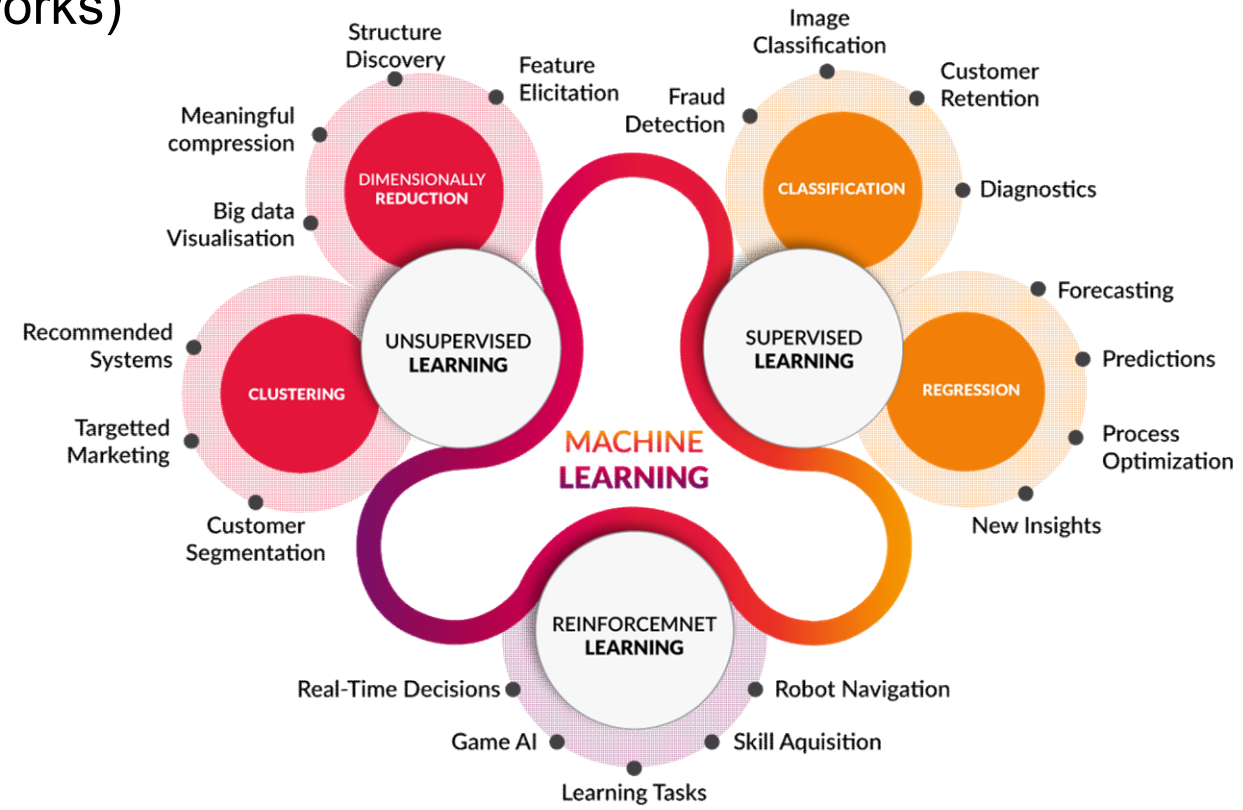
- The human brain possesses about 1 quadrillion (1million billion) neurons and the connection that wire them together is known as synapses.



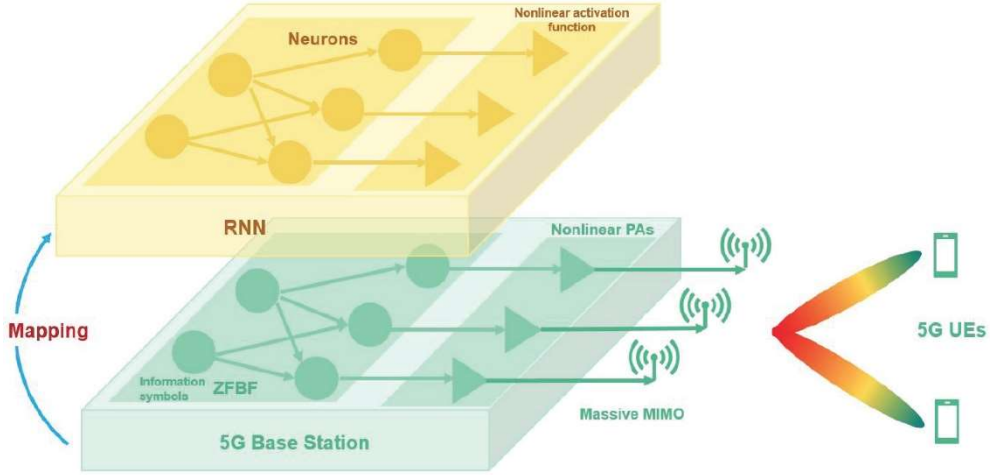
Synapses (neural connections) are created with astonishing speed towards 7 years old, the "synaptic growth spurts" become dense. By teenage years, pruning occurs to remove excess connections in order to make a more refined and efficient adult brain.

ML Techniques

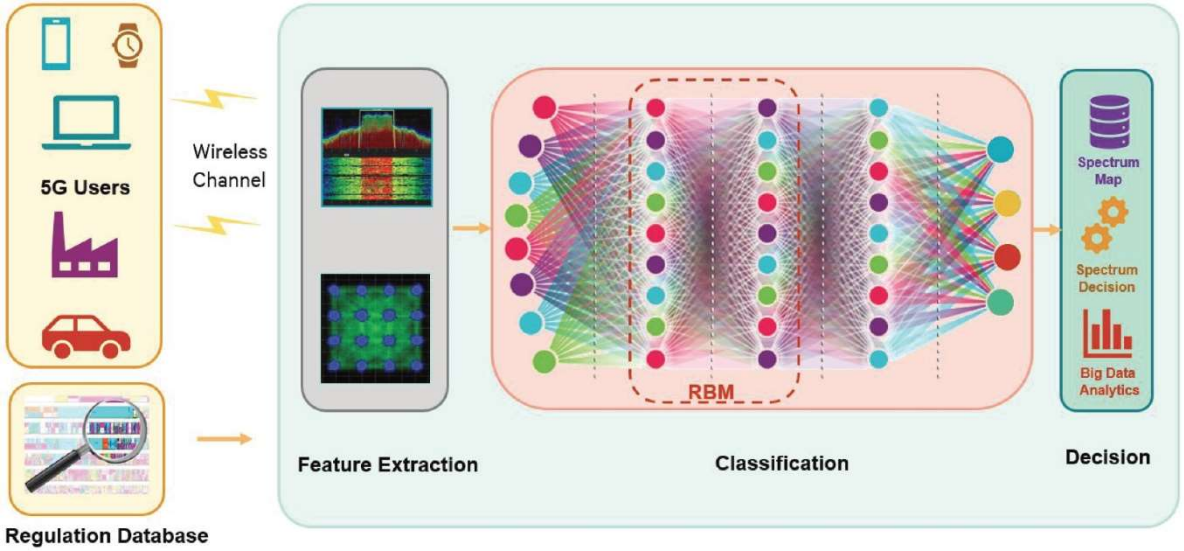
- Loosely speaking, there are three types of ML techniques
  - **Supervised** learning (e.g., CNN, RNN, LSTM)
  - **Unsupervised** learning (e.g., K-means clustering, autoencoder, …)
  - **Reinforcement** learning (e.g., Q-learning, Deep Q-Learning)
  - New types of learning techniques (e.g., Generative Adversarial Networks)



AI Technolgies for Wireless Communications (1/2)



RNN-based Solution for 5G MIMO



Reconfigurable Deep Learning Framework for AI-aided 5G BS systems

AI Technolgies for Wireless Communications (2/2)