2020 IT 21
Global Conference
Digital New Deal
Technology Essentials
디지털 뉴딜 기술 핵심

Keynote Speech 3

차세대 이동 통신의 전망과 과제

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[요약문]

2019년 세계 최초로 5G 상용화가 국내에서 이루어진 이후, 5G 기술은 다양한 산업의 핵심 인프라에 적용되고 있으며 고품질 통신 서비스에서 스마트 공장, 차량 간 통신 및 기타 새로운 서비스에 이르기까지 통신이 필요한 모든 분야에 활용되고 있다. 이와 함께 미래의 네트워크는 방대한 양의 정보를 처리 할 수 있는 능력을 요구할 것이며 더 강력한 네트워크 장비가 필요하게 될 뿐만 아니라, 비용을 낮추고 장비를 더 유연하게 만들 수 있도록 통신 기술의 소프트웨어화가 점점 더 중요해질 것이다. 현재 통신 기술이 직면하고 있는 기술적 과제들을 극복하기 위한 해결책으로 생각해 볼 수 있는 것이 소프트웨어의 기능을 강화하고 AI를 발전시키는 데 있다. 더 나아가 학계와 산업계 모두 차세대 통신 시스템인 6G를 구축하기위한 연구 활동에 착수하고 있다. 본 강연에서는 5G 시스템의 상용화를 성공적으로 이끌기 위해서 기술이 진보하고 있는 방향과 차세대통신으로서 6G에 대한 기술 및 사회 동향, 서비스, 요구 사항, 후보 기술 등 다양한 측면에 대한 포괄적인 개요를 소개하고자 한다.

[발표자 약력]

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관심분야: Beyond 5G & 6G 이동통신 기술, IoT Connectivity 등

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Challenges and Prospect of Next-Generation Mobile Communications

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Sept. 25th, 2020

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- Samsung 6G White Paper
- Megatrends in 2030
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Global 5G Commercial Launches

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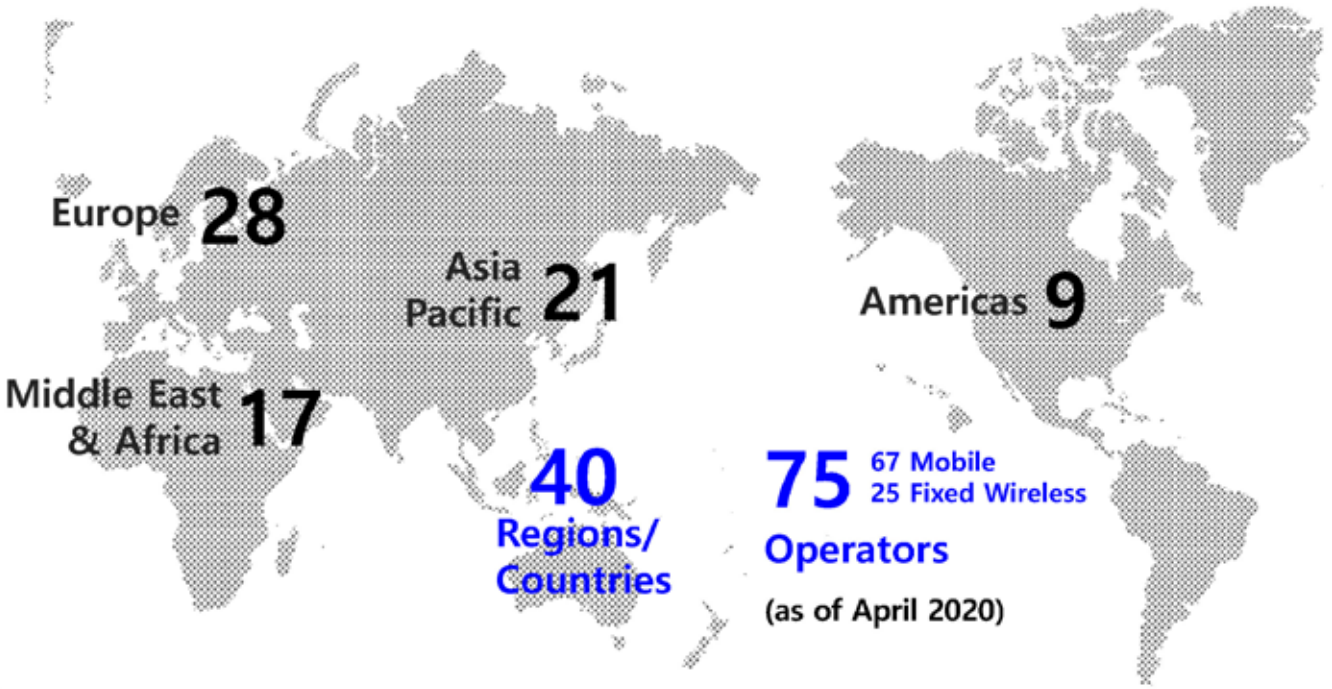

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5G Traffic Analysis in Korea

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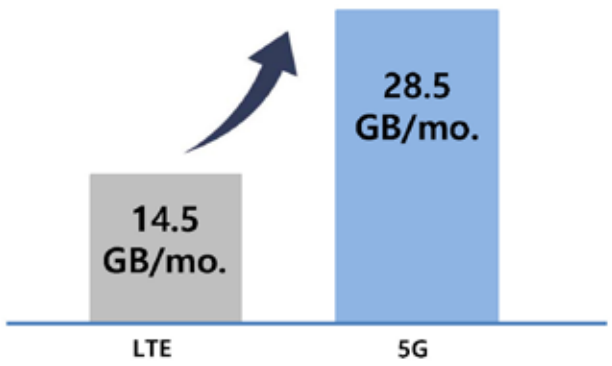
Average Data Usage/Month



5G Subscriber Data Usage

x7
of LTE subscribers

VR

x3.6
of LTE subscribers

Video Streaming

x2.7
of LTE subscribers

Game

Source: SK Telecom, as of Feb. 2020

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5G Requirements & Use Cases

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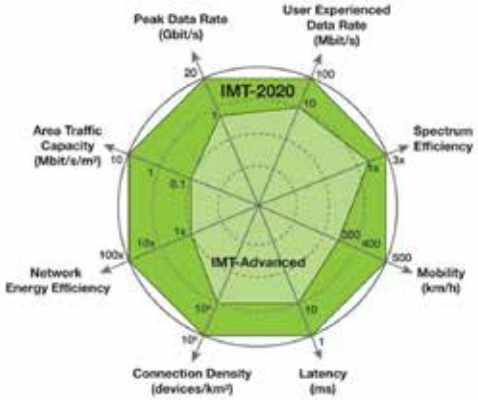
- **Ultra Fast (eMBB), instantaneous (URLLC), massive connectivity (mMTC)**



[ITU-R document 5D/TEMP/625]

	Performance	Applications
eMBB Enhanced Mobile Broadband	• Peak Rate: 20 Gbps (4G: 1 Gbps) • UX Rate: 100 Mbps	• High definition (HD) videos • Virtual reality (VR) • Augmented reality (AR) 4G 240 sec 5G 4 sec
URLLC Ultra Reliable & Low Latency Communications	• Latency: 1 ms (4G: 10 ms)	• Remote robot control • Connected autonomous vehicles • Interactive gaming 4G 5G
mMTC Massive Machine-Type Communications	• Connection: 10^6 devices/km² ($4G: 10^5$ devices/km²)	• Smart city • Smart agriculture 4G 100,000 5G 1,000,000

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5G Features: Network Slicing & New Spectrum

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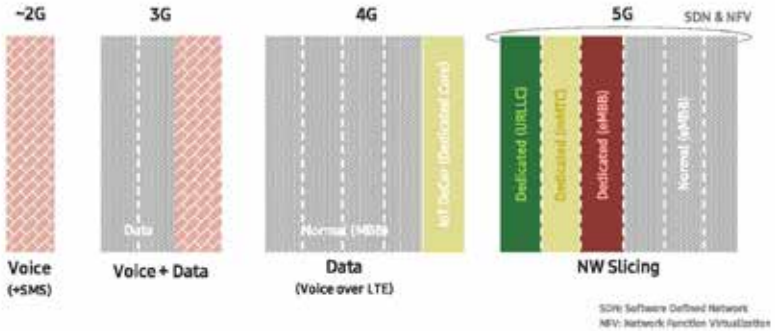
Network Slicing

Flexibility to support various services in a single network



New Spectrum

Use of new spectrum including mmWave bands (e.g., 28 & 39 GHz)

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Challenges in 5G

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mmWave

- Short Range of mmWave
- Increased management complexity with a lot more cell sites

New Technologies (e.g., Network Slicing)

- Various requirements, e.g., URLLC
- New services w/ net. slicing

Massive Connectivity

- Machine Type Devices

Complicated network management requir
automation & scalability

AI/ML for scalable automation

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Where Can AI/ML Be Used?

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Planning

Coverage / KPI Prediction | Site Parameter Design

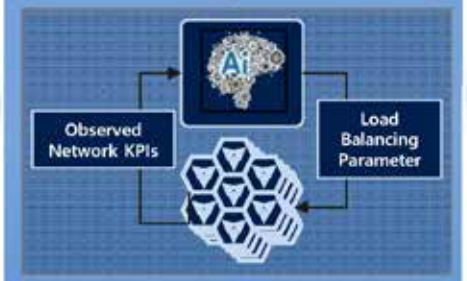
- Coverage prediction for mmWave
- Service availability/grade
- Location/height, beam azimuth/tilt

Deploy

Operation

Optimization

Network Slicing | Orchestration

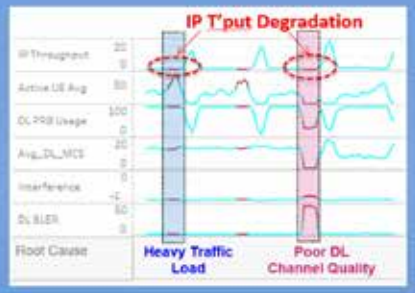


- E2E network slice life cycle mgmt.
- Parameter optimization (i.e., LB)
- E2E service orchestration with service types (eMBB, URLLC, mMTC)

Control

Analytics

Monitoring | RCA / Prediction



- Comprehensive/multi-dimensional network KPI monitoring/analysis
- Capacity forecasting/prediction
- Root cause analysis (RCA)

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Standards and Industry Looking at AI/ML

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Standard groups looking into leveraging AI for network automation

	MDAS (Management Data Analytics Service)	NWDAF (Network Data Analytics Function)	O-RAN RIC (RAN Intelligent Controller)
Organization	3GPP SA WG5	3GPP SA WG2	O-RAN Alliance
Target	Data analytics at OAM Management Plane for network performance and fault management *OAM: Operation, Administration and Management	Data analytics at Core Network (CN) Control Plane for network performance and service quality optimization	Automation of control and configuration of nodes (e.g., RU, DU, CU) at RAN for OPEX minimization * RAN: Radio Access Network (or BS)
Use cases	Per-NF/NS load analysis RAN coverage conf. optimization RAN resource & congestion analysis * NF: Network Function * NS: Network Slice	Per-NF/NS load analysis Analysis/prediction of . Per-UE/App service quality . UE mobility & traffic pattern	Traffic steering QoS-based resource optimization RAN slice SLA assurance * QoS: Quality of Service * SLA: Service Level Agreement

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Intelligent RAN – Cell Design

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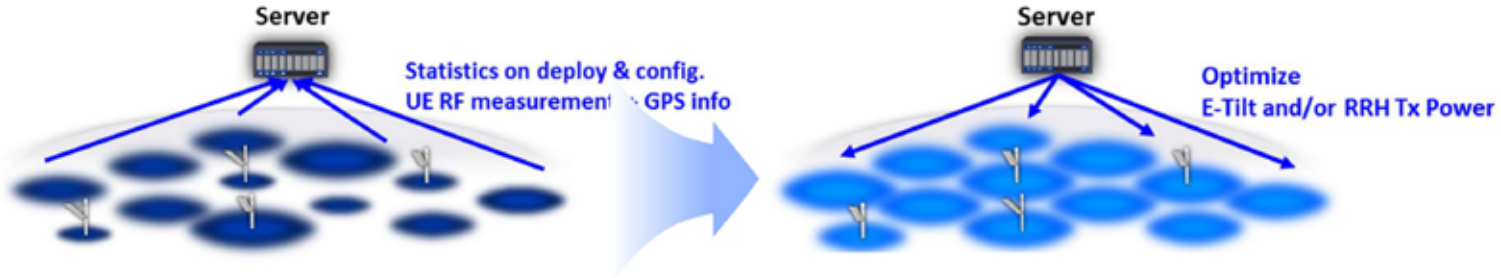
☐ Antenna tilting and optimizing transmit power

- Real-time parameter optimization based on UE locations, received power, and transmit power
- Antenna tilting adjustment for optimizing system coverage and capacity maximization

  case 1) coverage poor → tilting angle up → coverage expanded & performance down at center

  case 2) coverage good → tilting angle down → coverage shrink & performance up at center



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Intelligent RAN – Parameter Optimization

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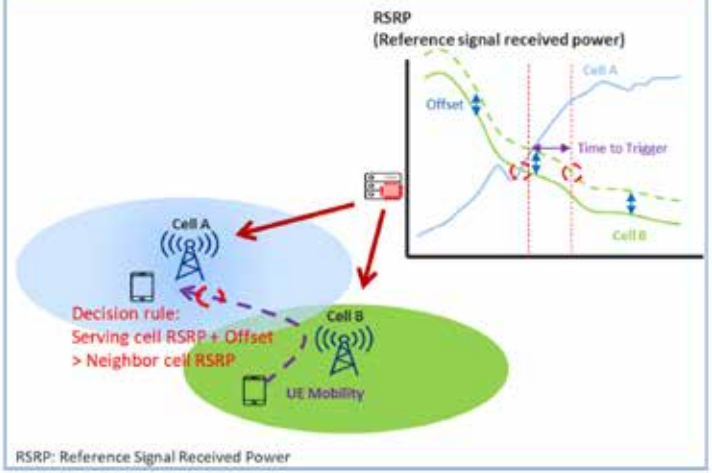
☐ Optimization of network configuration parameters and scheduler function

Handover Performance Index

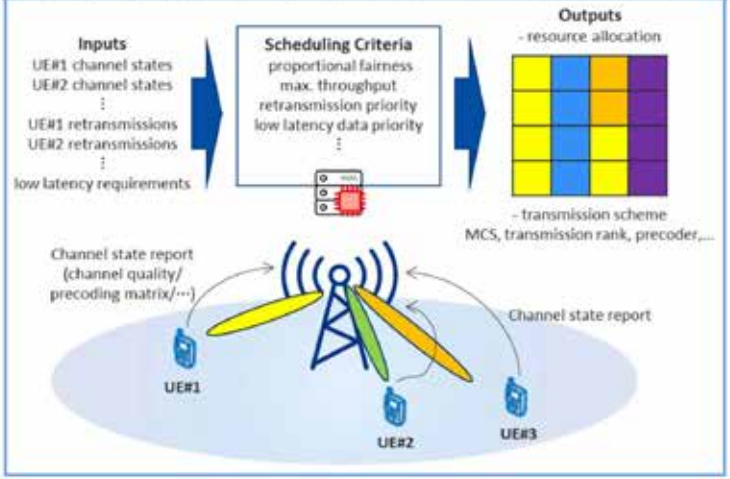
- HO parameters affect failure rate and UE receiver performance



RSRP: Reference Signal Received Power

NW Scheduler Function Optimization

- Scheduling optimization/automation according to channel state report from UEs & KPIs



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Evolution of Cellular Communications

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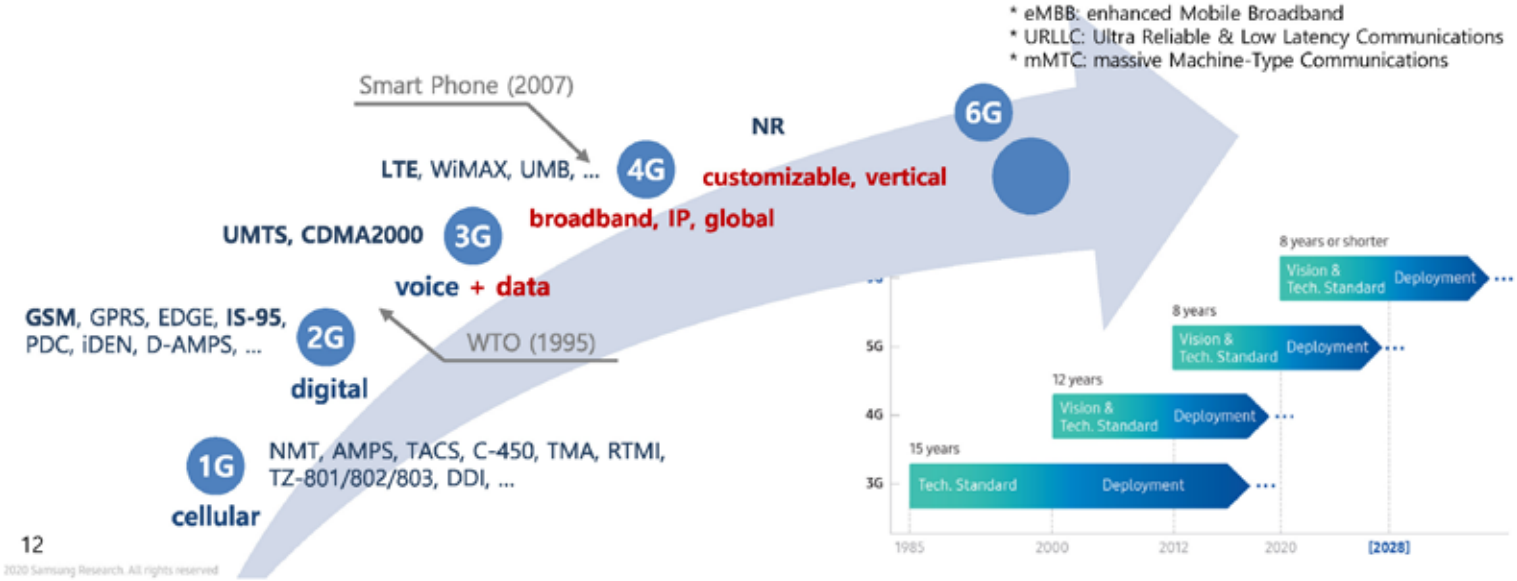
- International standards for cellular communications became mainstream beginning 3G (IMT-2000)
- Success of 4G (IMT-Advanced) triggered ***IT+Comm. convergence*** and ***global competition***
- 5G (IMT-2020) designed to enable 3 use cases: eMBB, URLLC, mMTC



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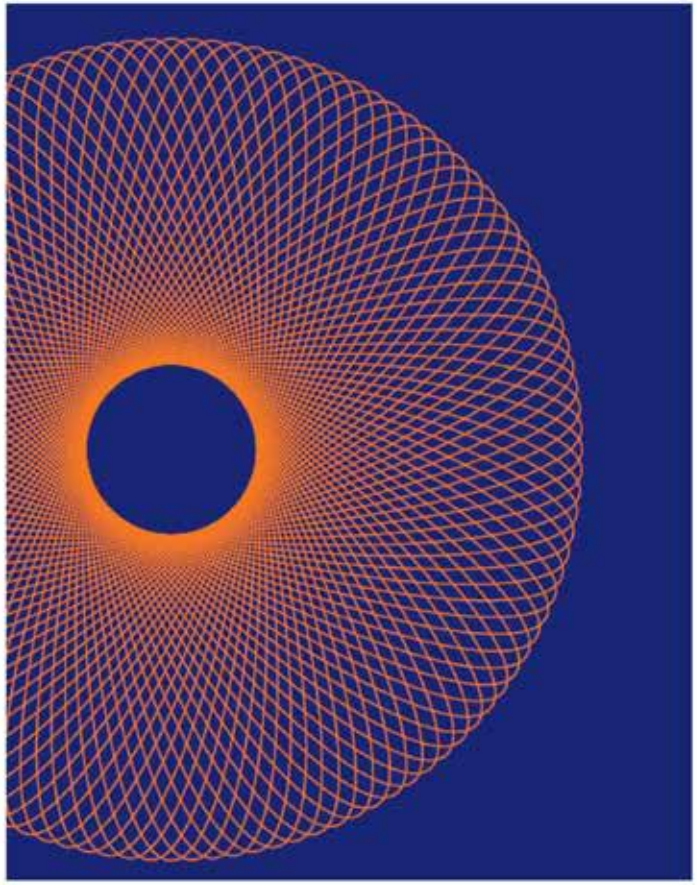

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6G

The Next Hyper——Connected Experience for All.

Samsung 6G White Paper

https://cdn.codeground.org/nsr/downloads/researchareas/6G%20Vision.pdf

Megatrends in 2030

☐ **Thinking about the next generation – 6G**

Connected Machines

- **Machines as Main Users**
  - 500 billion devices will be connected by 2030, including vehicles, robots, drones, home appliances, etc.
  - Mobile devices with various form-factors: AR glasses, VR headsets, and hologram devices

Artificial Intelligence

- **AI – New Tool for Wireless Communications**
  - Embedded AI in various entities will play roles of improving network performance, reducing costs, saving energy, etc.

Openness & Social Issues

- Softwarization and open source/interface are big technical trends
- Wireless communications and its infrastructure help address many social issues and resolve them

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6G Services

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☐ **New services to be introduced via hyper-connectivity involving humans and things**

Truly Immersive XR

* Extended Reality

- Sufficient wireless capacity to be secured for higher data rate to realize Virtual Reality, Augmented Reality, Mixed Reality, etc.

High-fidelity Mobile Hologram

- Next-generation media technology presenting gestures and facial expressions by means of a holographic display

Digital Replica

- Replicate physical entities and interact with them in a virtual world without temporal or spatial constraints

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6G Requirements

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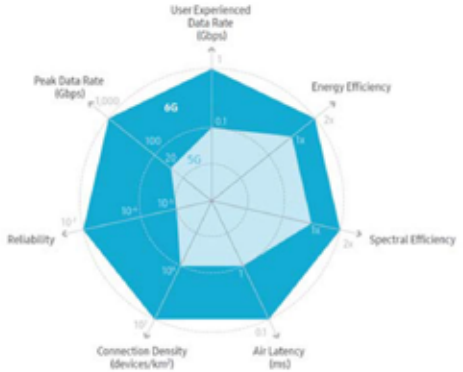
☐ 6G services require substantial computing power, far higher data rate, and ultra-low latency

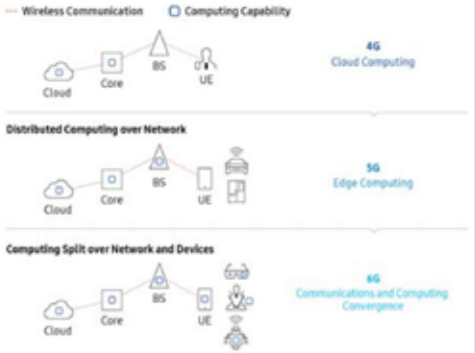
Performance Requirements

- Advanced multimedia services need higher data rate, spectral efficiency, and extremely low latency



Architectural Requirements

- Communications and computing convergence: split computing, native AI, etc.



Trustworthiness Requirements

- Openness of communication systems requires solutions for security and privacy threats:
  - Secure-by-design approach
  - Identification that AI accesses personal information
  - Mechanisms to utilize tremendous amount of information maintaining the privacy

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6G Candidate Technologies

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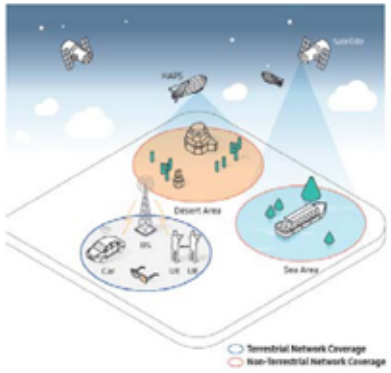
- Terahertz Band
- Novel Antenna Technology
- Evolution of Duplex Technology
- Evolution of Network Topology
- Intelligent Spectrum Sharing
- Comprehensive AI
- Split Computing
- High-precision Network

[Frequency bands over generations]



[Integrated network of terrestrial and non-terrestrial networks]

[Intelligent spectrum sharing]

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Key Enabling Technologies for 6G

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- **Terahertz Technology**
  - Up to 3 THz band includes enormous available bandwidth for potential 6G services
  - THz communication can also provide high-precision positioning capability
  - Inherent technical challenges with ultra-high frequency to be overcome:
    Severe path loss, atmospheric absorption, RF power amp efficiency, ADC/DAC, etc.

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Key Enabling Technologies for 6G

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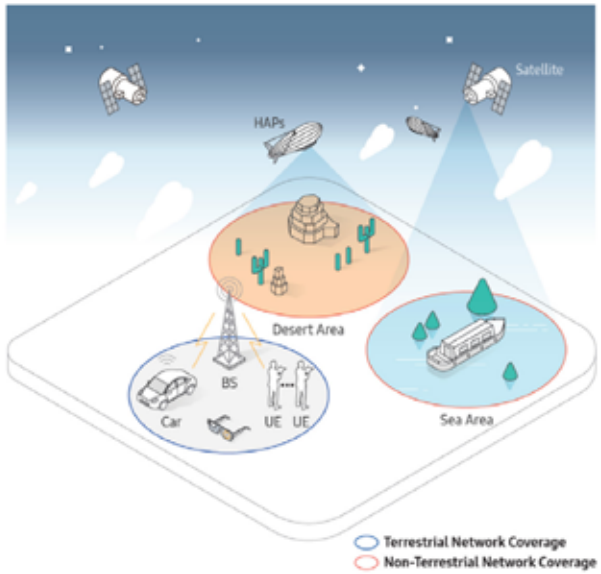
▪ Evolution of Network Topology

- Existing technologies include relay in 4G and IAB in 5G to enable flexible network
  * Integrated Access and Backhaul
- 6G expects more:
  1) Automated configuration & optimization of new network entities
  2) Enhanced mobility support for mobile network entities
  3) Enhanced service continuity for user devices
  4) Non-terrestrial network (NTN), such as satellite & HAPS
     * High-Altitude Platform Systems



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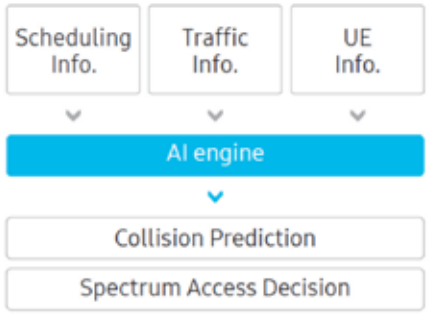
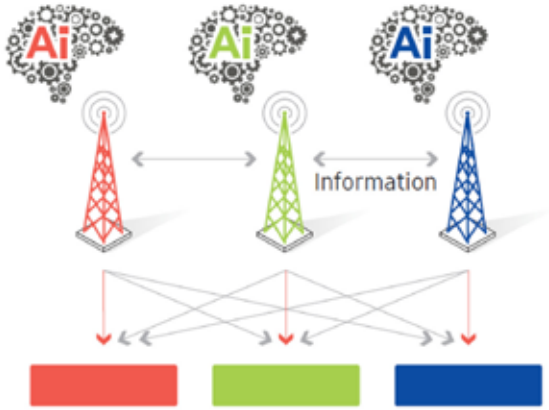
Key Enabling Technologies for 6G

▪ Spectrum Sharing

- Allowing opportunistic use of underutilized spectrum can increase efficiency
- Traffic and spectrum usage pattern varies according to time, areas, and operators
- AI could realize dynamic spectrum via sharing limited amount of information among network entities





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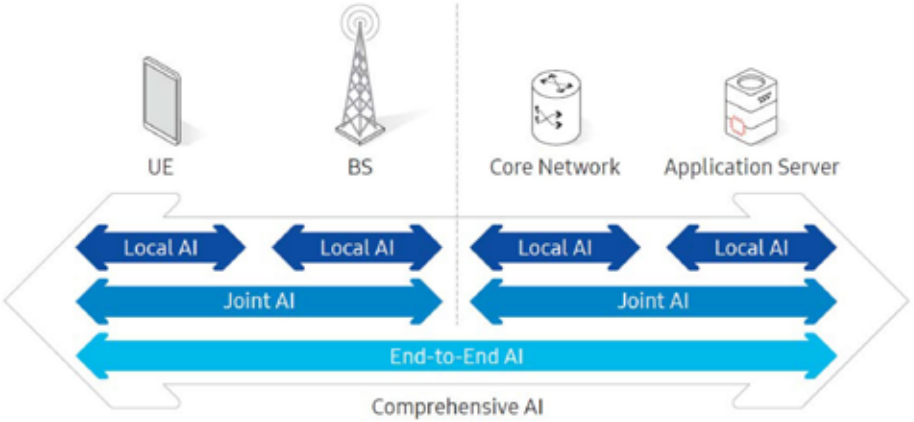
Key Enabling Technologies for 6G

- **Comprehensive AI**
  - Comprehensive AI help better optimize the overall system performance and network operation
  - Application of AI can be categorized into three levels: 1) local AI, 2) joint AI, and 3) E2E AI



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Key Enabling Technologies for 6G

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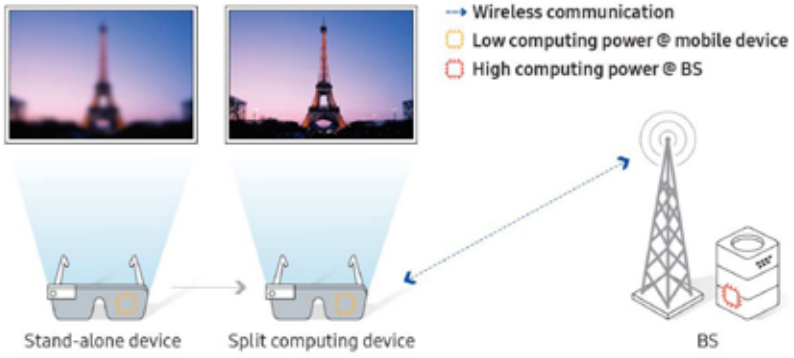
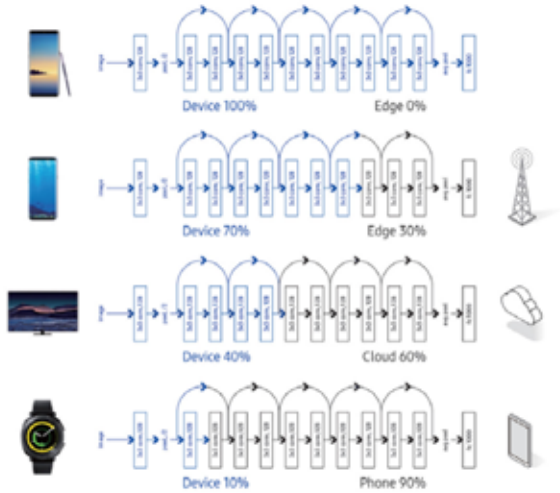
- **Split Computing**
  - Future applications, such as truly immersive XR, mobile holograms, and digital replica, require extensive computing to deliver real-time immersive user experiences
  - Split computing makes use of reachable resources over the network,
    e.g., BSs, MEC servers
    * Base stations, Mobile Edge Computing





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Conclusion

- **What is happening now**
  - 5G commercialization
  - AI/ML-based network automation
  - Start of 6G research for 10 years down the road
- **What will be the future like**
  - Wider spread of 5G commercialization
  - Heavier usage of AI/ML for communication and network
  - Research and PoC of various candidate technologies for 6G
  - 6G commercialization as early as in year 2028!

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Thank You

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