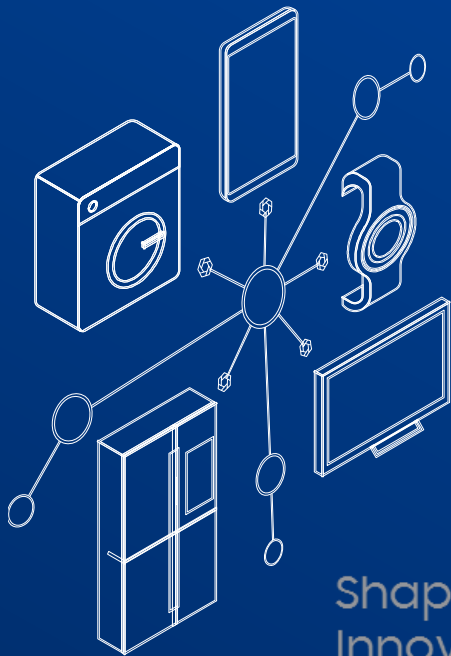




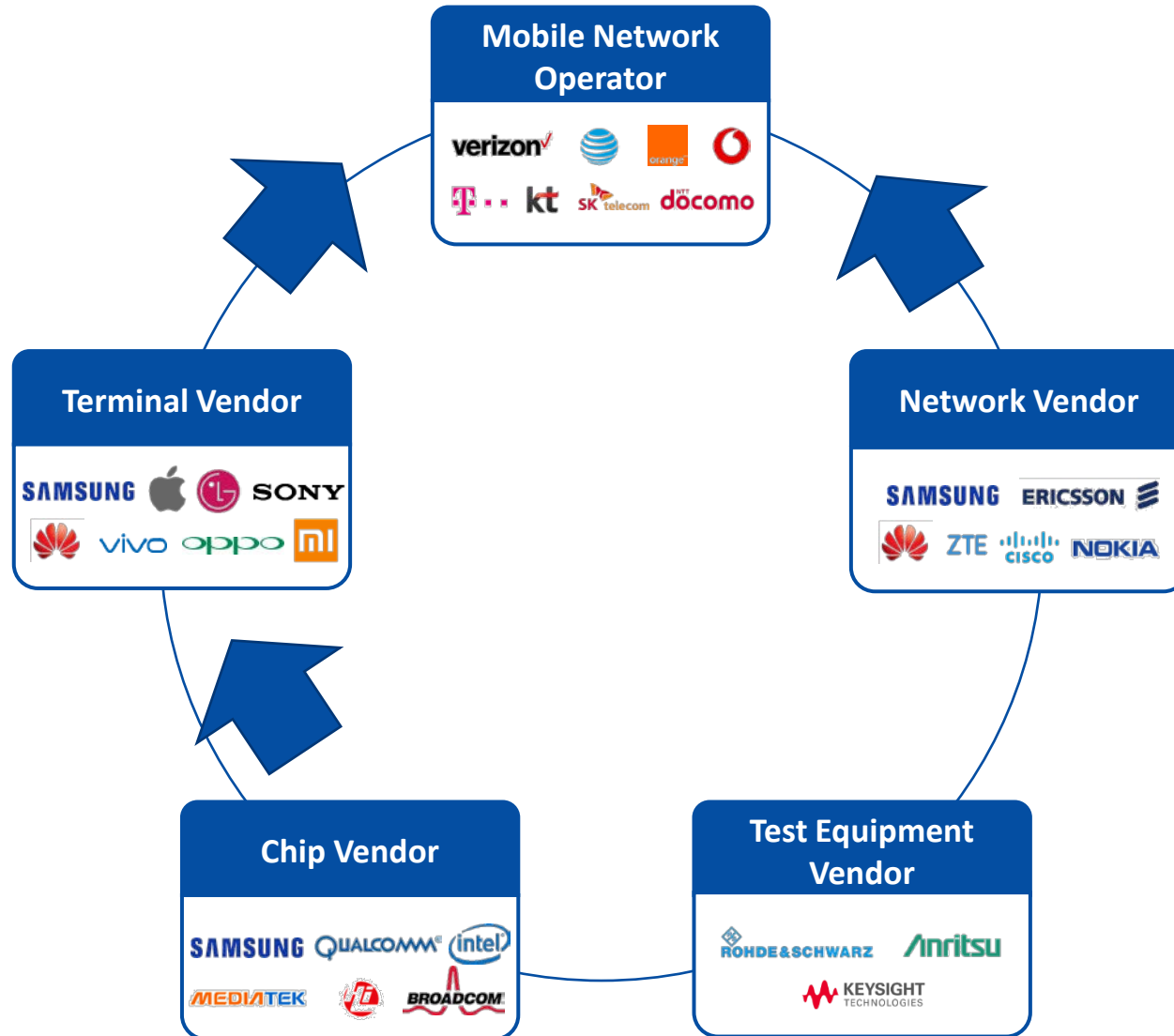
Shape the Future with
Innovation and Intelligence

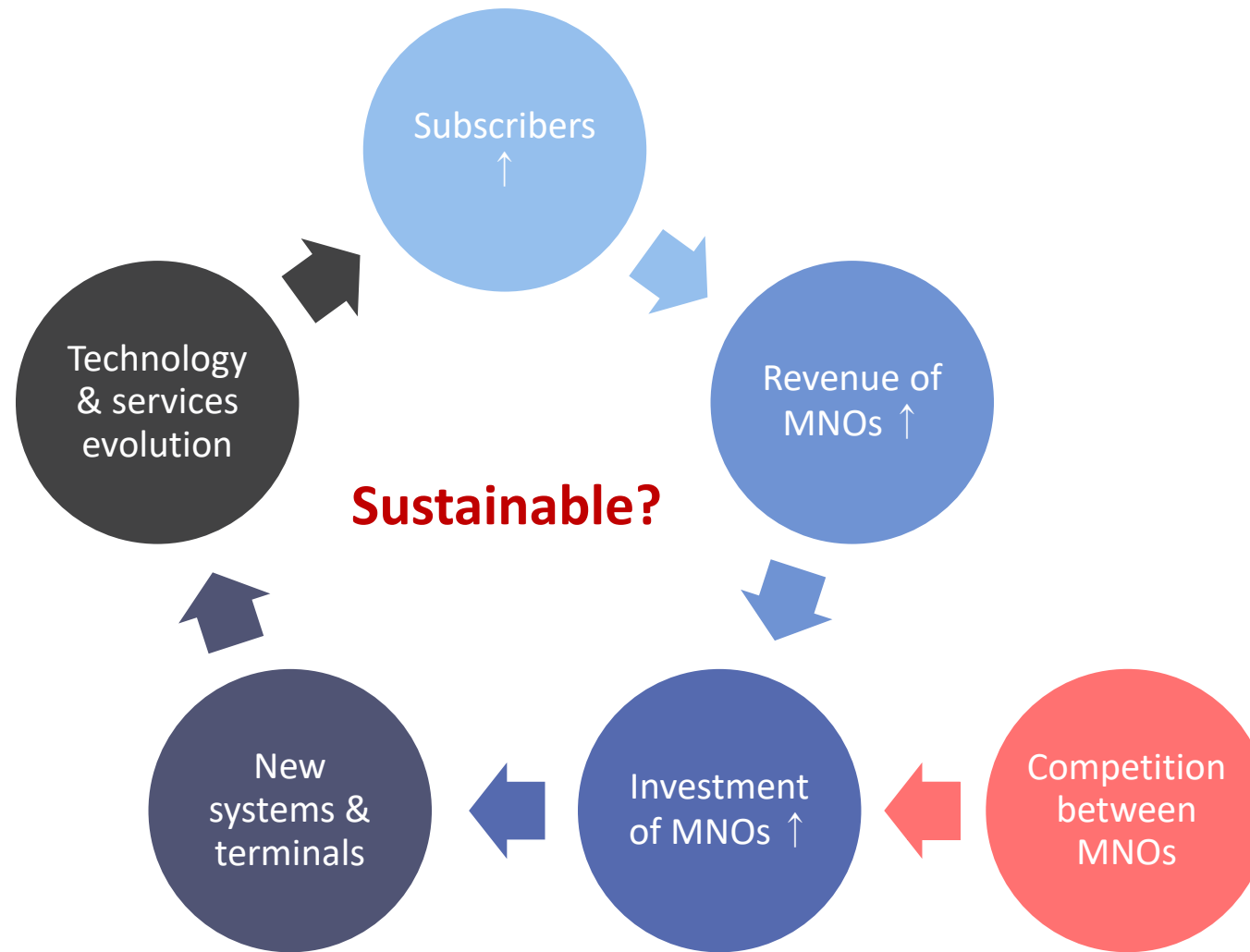
Moving Toward 6G

March 26, 2019
Juho Lee

Ecosystem of Mobile Industry

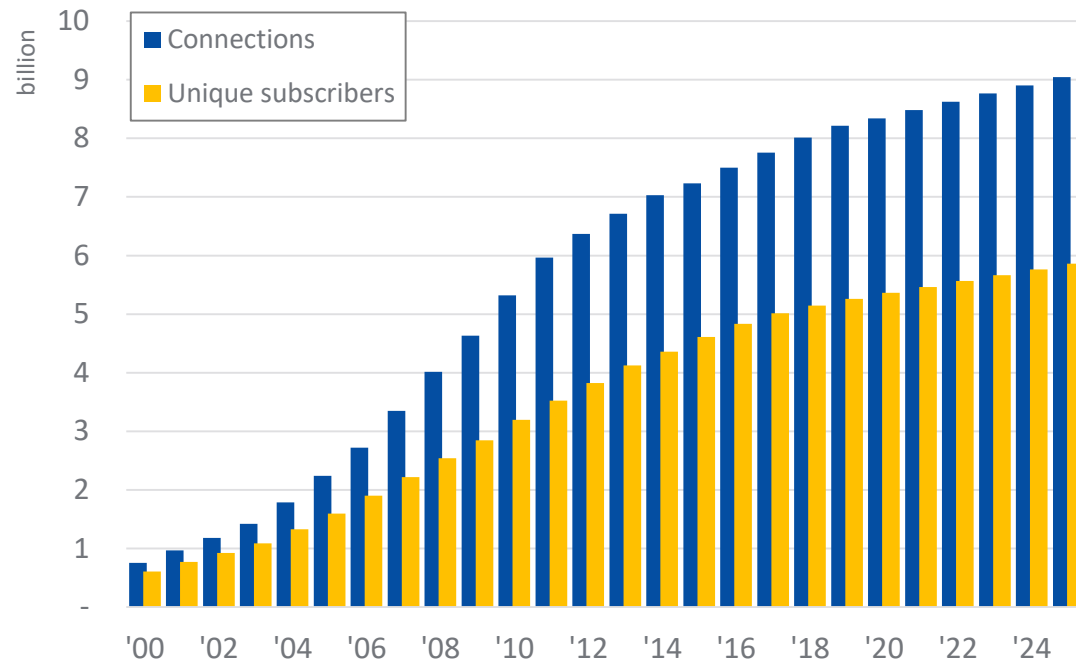
SAMSUNG Research





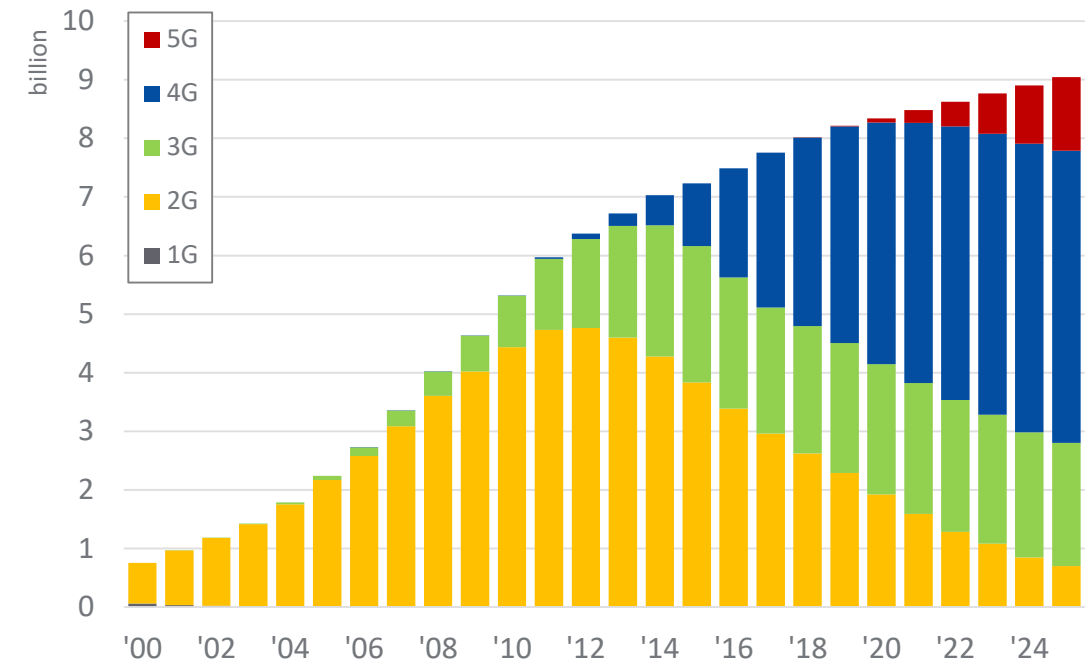
Rapid growth of Mobile service

- Subscribers: 0.77bn ('01) → 3.5bn ('11) → 5.5bn ('21)
- Connections: 0.97bn ('01) → 6.0bn ('11) → 8.5bn ('21)



5G launch from 2019

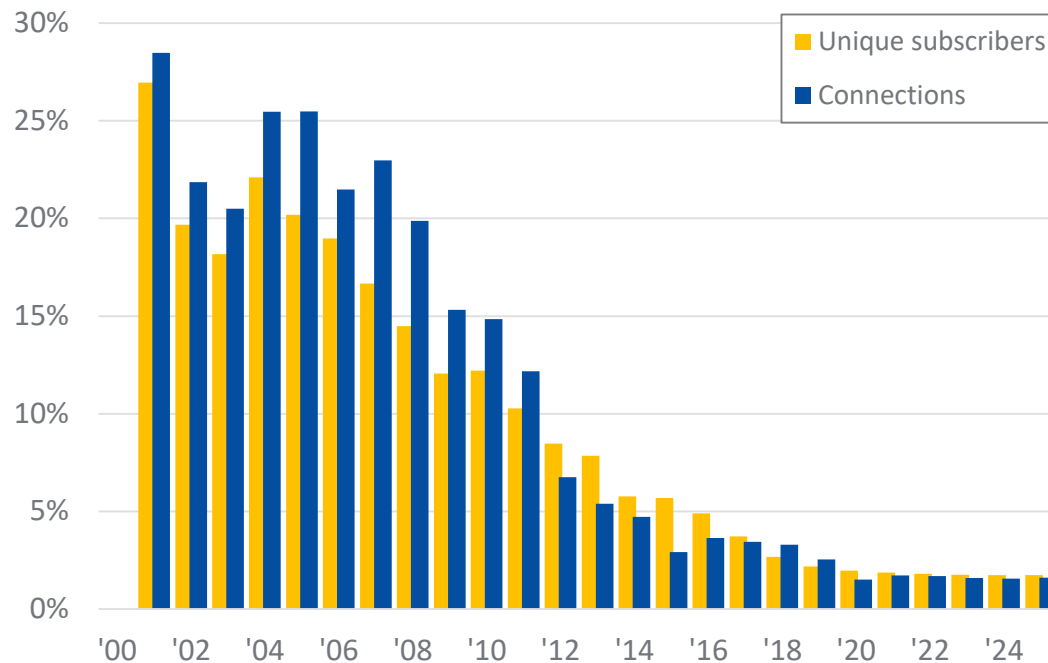
- 2017: 2G (38%), 3G (28%), 4G (34%), 5G (0%)
- 2025: 2G (8%), 3G (23%), 4G (55%), 5G (14%)



[GSMA Market data, Apr. 2018]

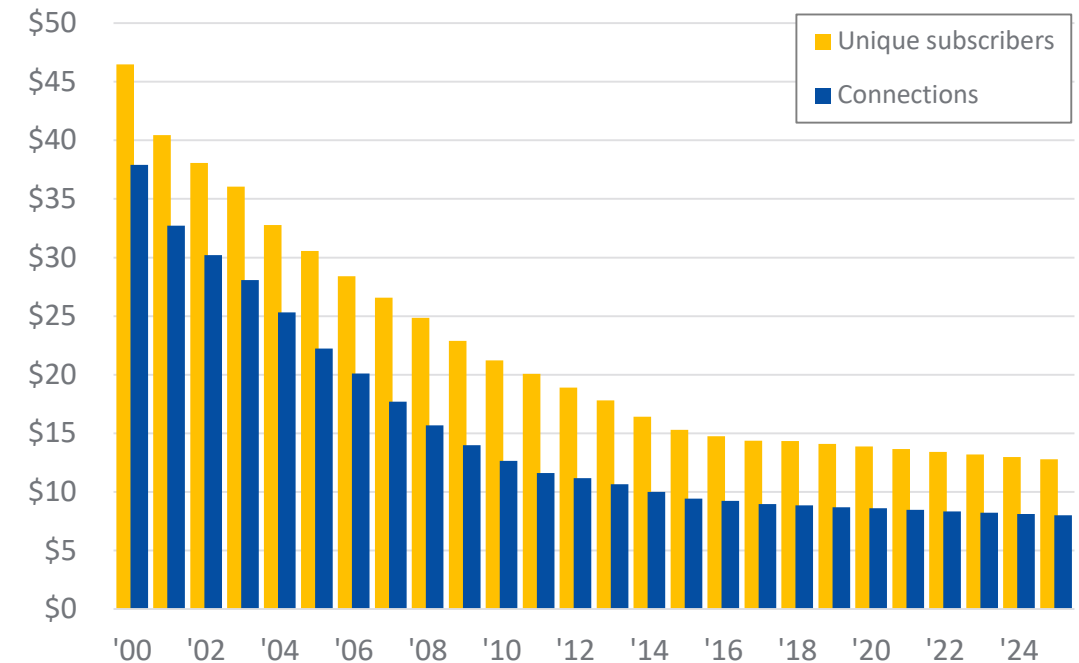
Growth Rate ↓

- Subscribers: 27% ('01) → 10% ('11) → 2% ('21)
- Connections: 28% ('01) → 12% ('11) → 2% ('21)



ARPU ↓

- Subscribers: \$40.5 ('01) → \$20.1 ('11) → \$13.6 ('21)
- Connections: \$37.9 ('01) → \$11.6 ('11) → \$8.5 ('21)

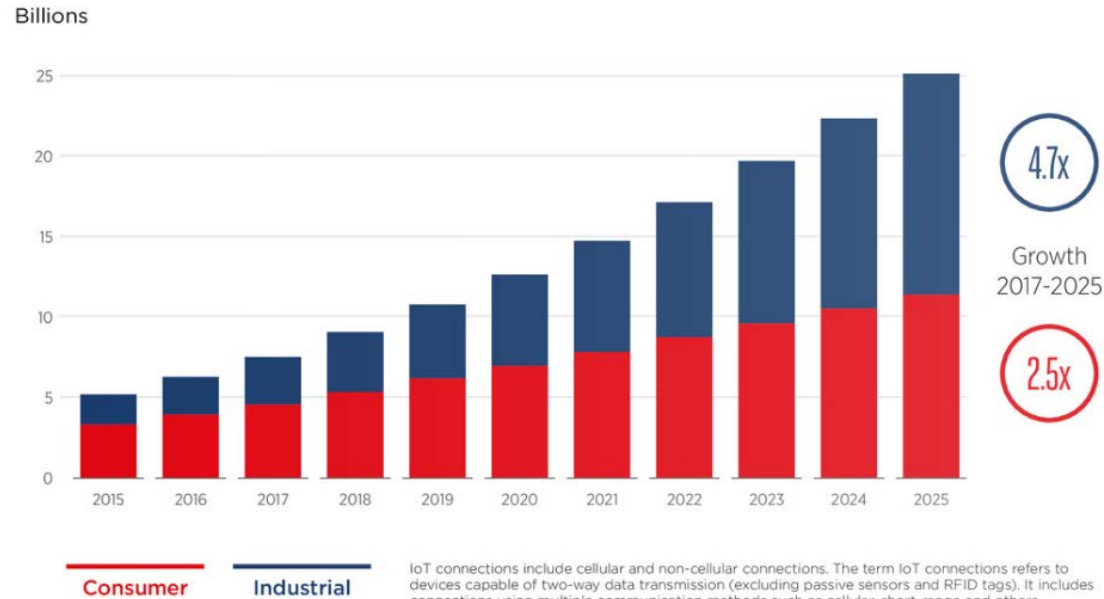


[GSMA Market data, Apr. 2018]

New Growth Engine, IoT

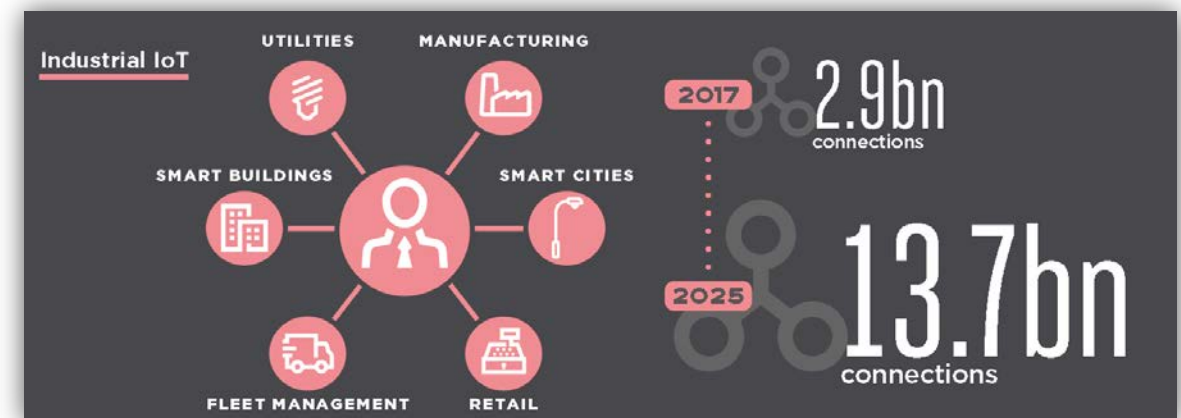
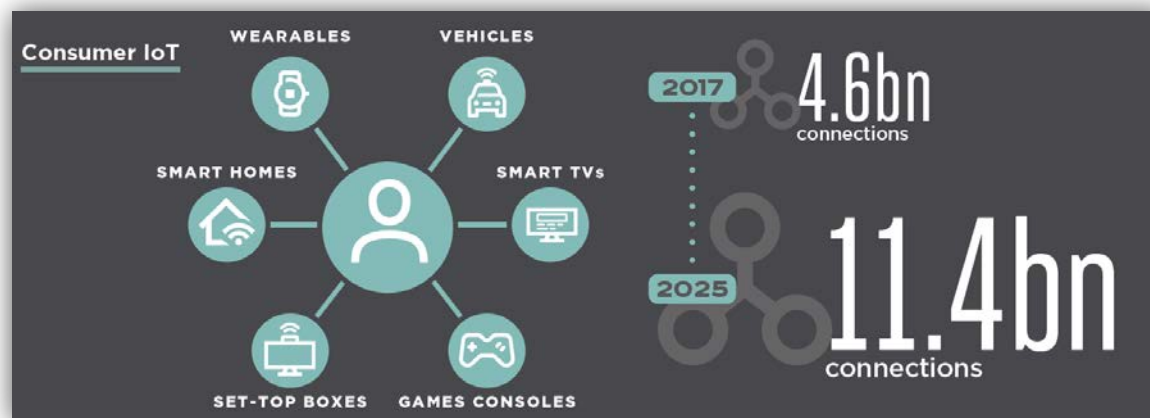
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IoT connections worldwide



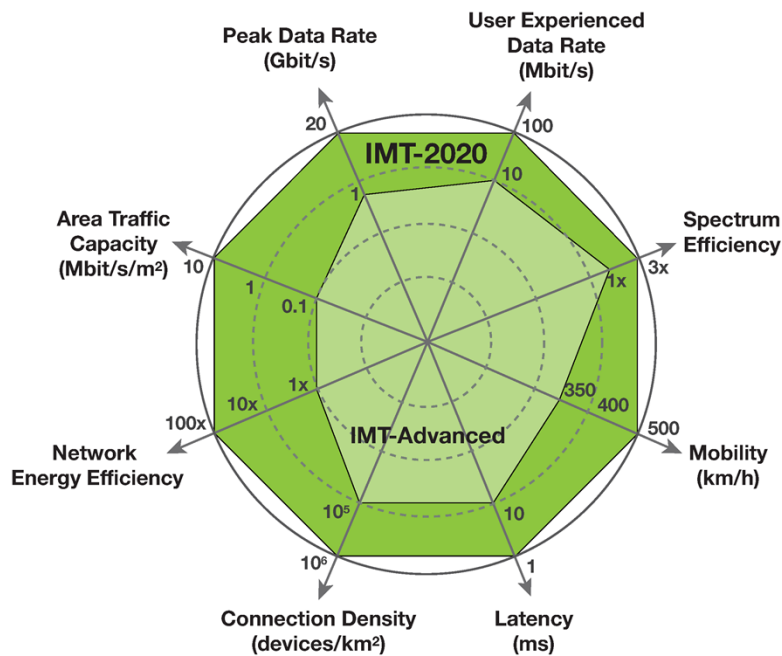
IoT to lead the new growth

- Connections of Industrial IoT:
2.9bn ('17) → 13.7bn ('25)
- Connections of Consumer IoT:
4.6bn ('17) → 11.4bn ('25)



[GSMA Intelligence]

5G Requirements & Performance



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

Performance

Applications

eMBB

Enhanced Mobile Broadband



- Peak Rate: 20Gbps (4G : 1Gbps)
- UX Rate : 100~1000Mbps

- High definition (HD) videos
- Virtual reality (VR)
- Augmented reality (AR)

Download of 15GB HD video



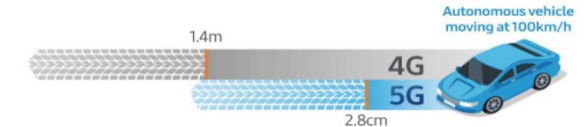
URLLC

Ultra Reliable & Low Latency Communications



- Latency: 1ms (4G : 10ms)

- Remote robot control
- Connected autonomous vehicles
- Interactive gaming



mMTC

Massive Machine-Type Communications



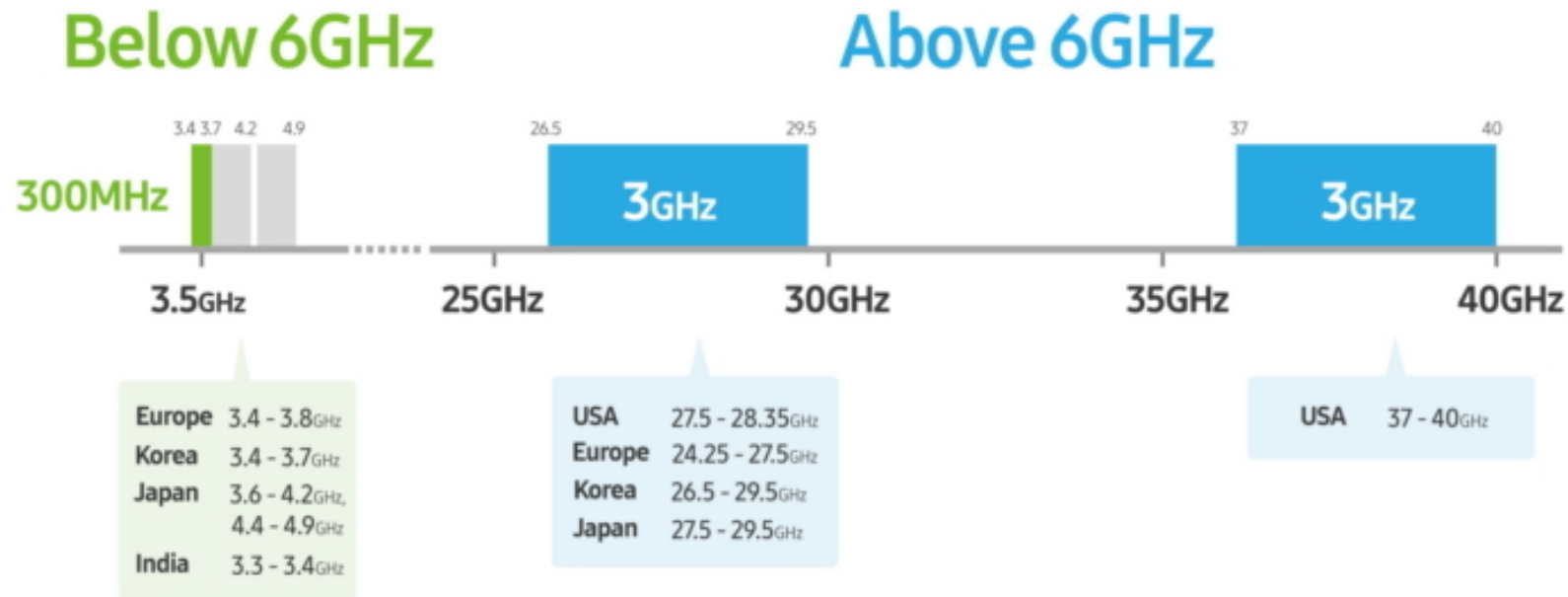
- Connection : 10⁶ devices/km² (4G : 10⁵ devices/km²)

- Smart city
- Smart agriculture

Within an area of 1km²



Above 6GHz is now available as new spectrum for 5G.



Evolution of 5G Standards in 3GPP

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2019

2020

2021

Rel.15
(ASN.1 '18.9)

Rel.15 late drop
(ASN.1 '19.6)

Rel.16
(ASN.1 '20.6)

Rel.17
(ASN.1 '21.9)

Rel-15 (Phase 1)

Overview

- eMBB* (~275Gbps)
- URLLC* (<1ms, 10^{-5} reliability)
- mmWave (~52.6GHz, 400MHz)

Key features

- eMBB/URLLC support
 - NR-MIMO, mmWave BF
 - LDPC
 - Reduced TTI
- Deployment options
 - NSA/SA, NR-NR DC (Late drop)

Rel-16 (Phase 2)

Vertical Support

- Smart Factory
 - Industrial IoT, URLLC enh.
 - NR-Unlicensed
- Connected Car
 - NR-V2X
- Int. Access & Backhaul (IAB)

Performance Enhancement

- eMBB enhancement
 - eNR-MIMO, Positioning
 - Mobility enh., Power Saving
- System work (SA4) on VoNR

Rel-17 (Phase 3?)

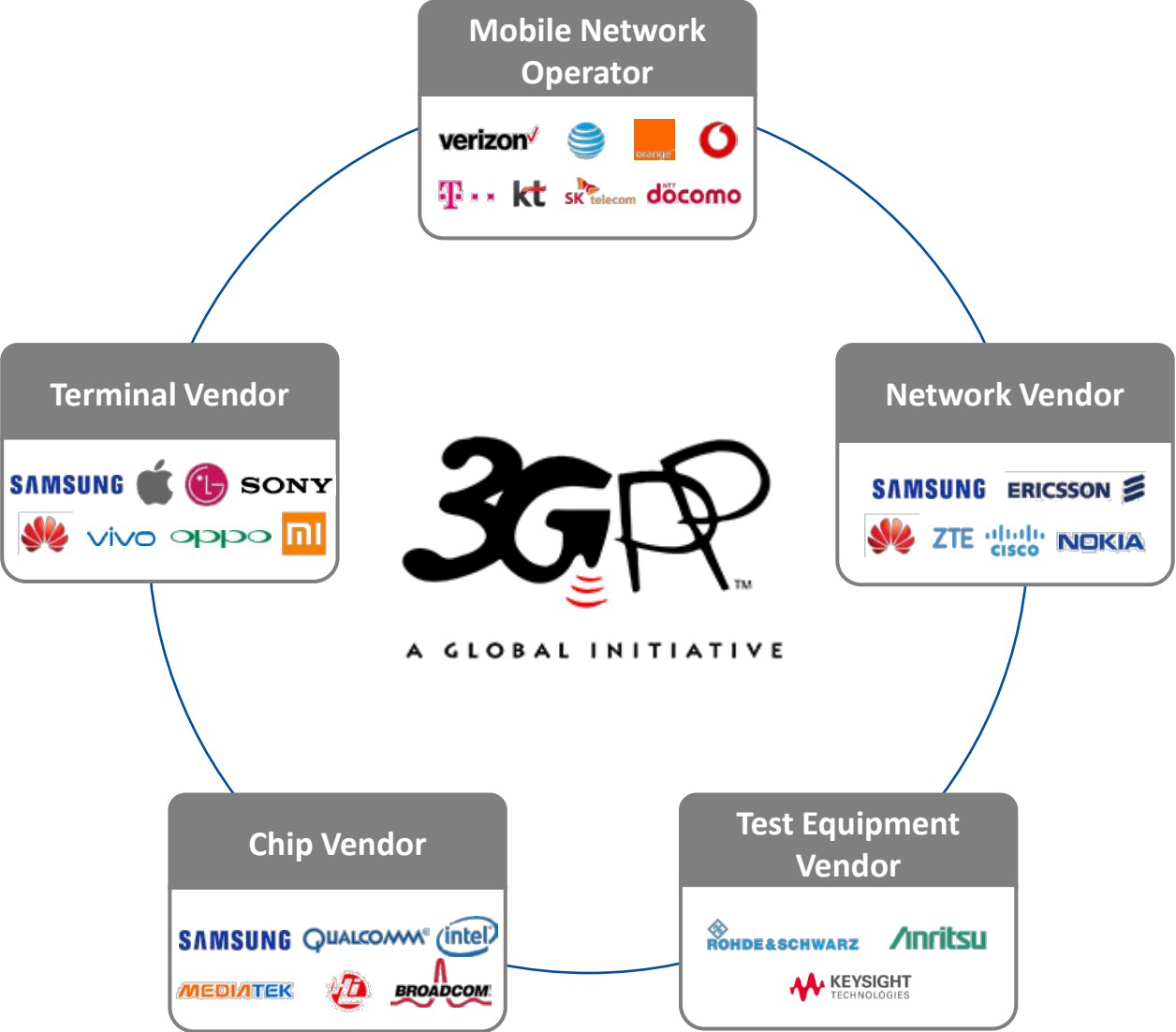
Self-dependent System

- Additional Services
 - NR-MTC
 - Broadcast/Multicast
- New features
 - SI on waveform for >52.6GHz

Improvements

- Enhancement features
 - RAN: NR-U, power saving, *sidelink enh.(inc. public safety)*, etc.
 - System: MEC, *Vertical LAN*, NW Analytics, etc.

Expansion in Ecosystem



Newcomers

Automotive (5GAA)

SAIC, DAIMLER, JAGUAR, BMW, Ford

V2X

Automation (5G-AICA)

BOSCH, SIEMENS, YOKOGAWA, FESTO

Smart Factory

Government

South Korea, USA, UK, Germany

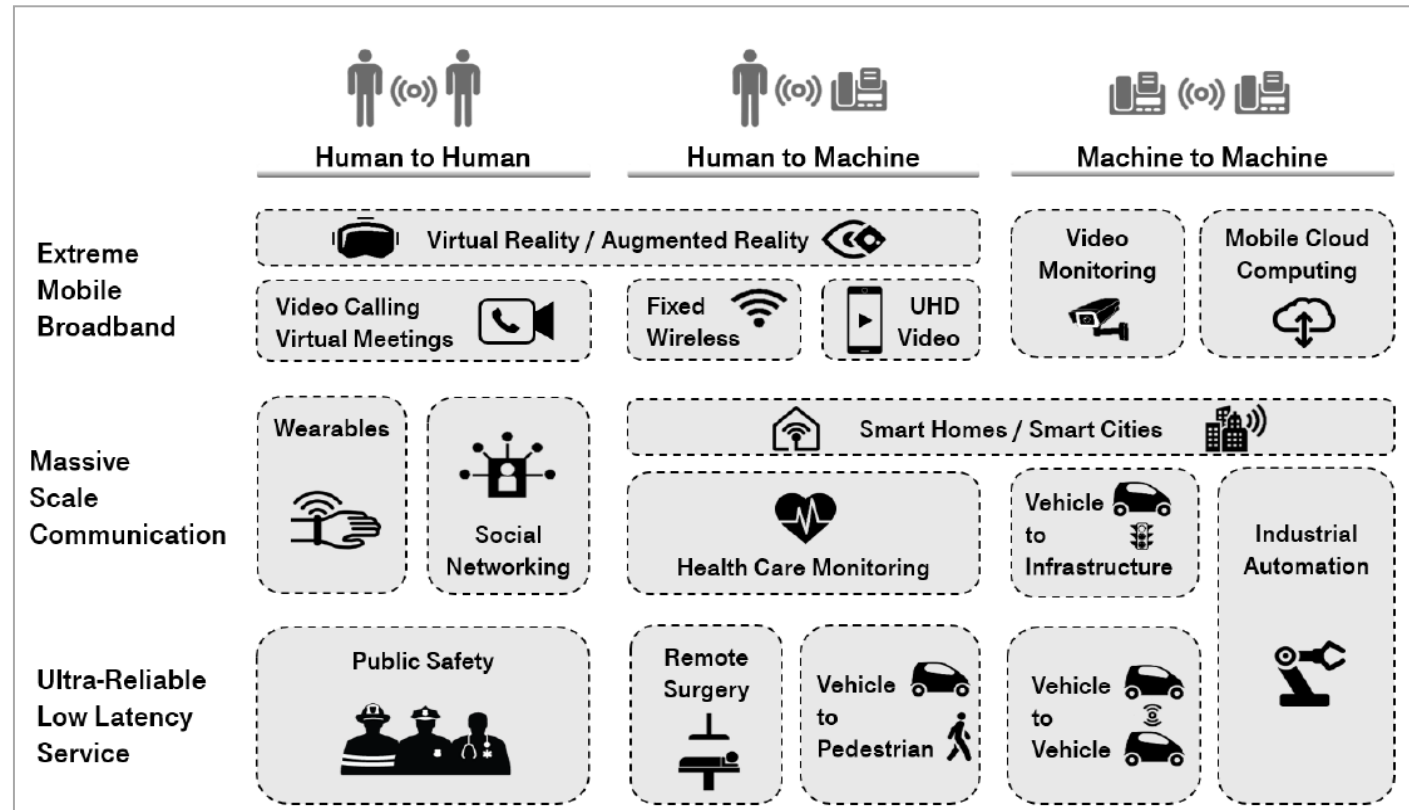
Public Safety

Satellite

THALES, AIRBUS

Non-Terrestrial Networks

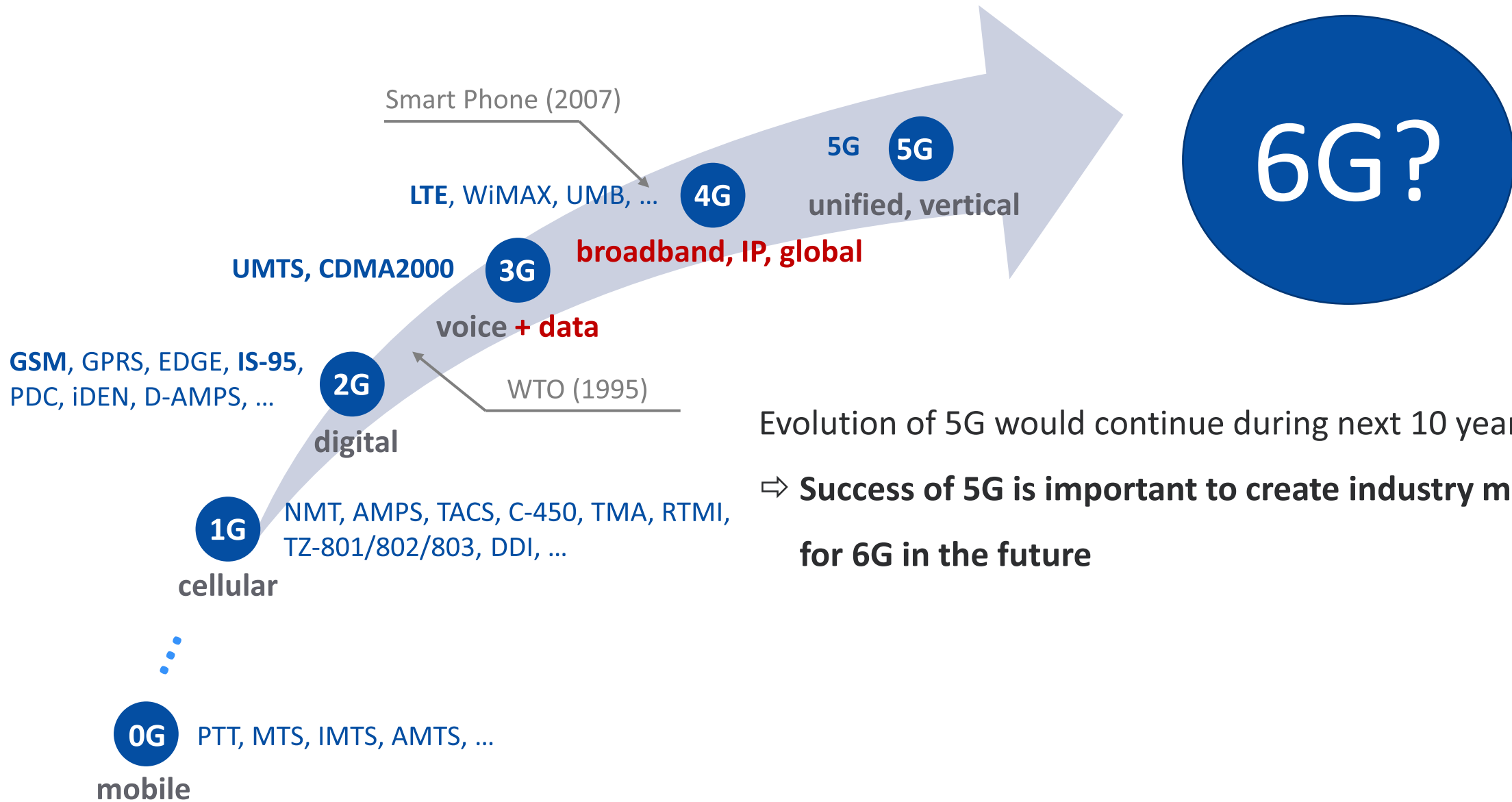
5G expected to support much more verticals and services



[5G Americas, Nov. 2017]

Standard-Driven Evolution in Mobile Communications

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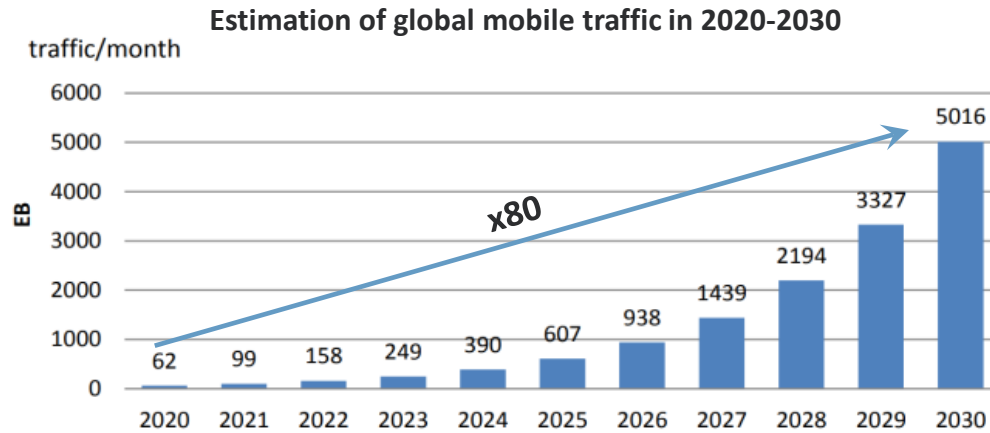
Evolution of 5G would continue during next 10 years

⇒ **Success of 5G is important to create industry momentum for 6G in the future**

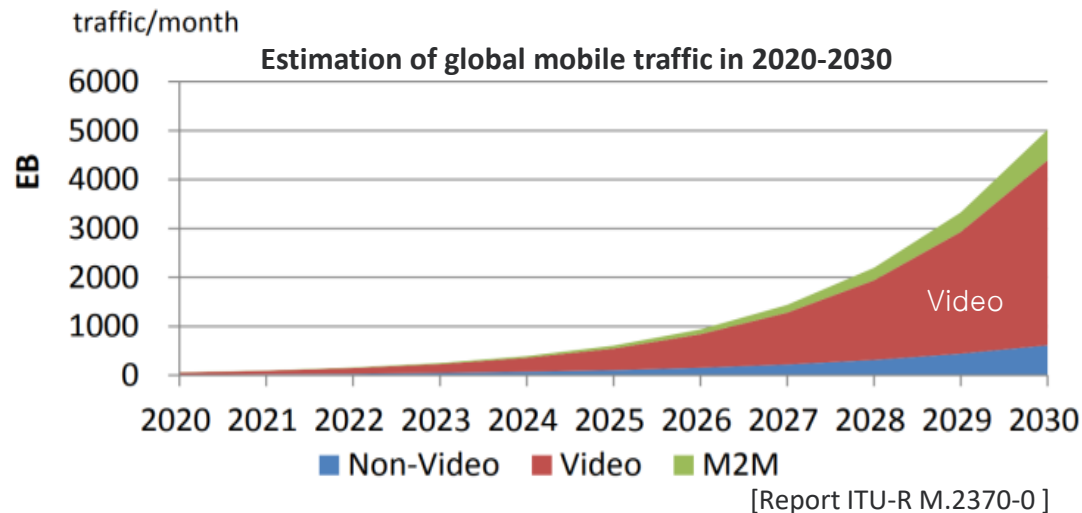
Mega-Trend toward 6G: Super-enhanced Mobile Broadband

SAMSUNG Research

x 80 Increase of Mobile Traffic



75% of Mobile Traffic: Video



Super-high-definition Video

8K – Super HI-VISION TV
7680x4320

4K – UltraHD TV
3840x2160

2K – HD
1920x1080

1080i and 1080p
HDTV **uncompressed**:
10 bit@1920x1080@24fps
= 127MB/sec ~ **1Gbps**

64 K Digital Cinema
~ **256Gbps**

61440x34560

Super-immersive Multimedia



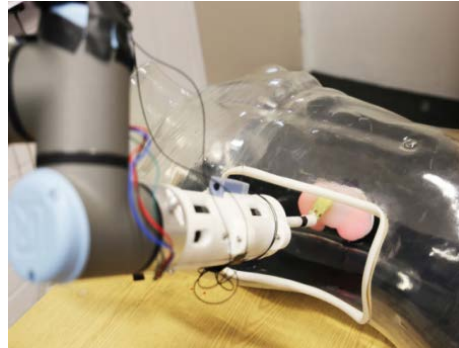
Mega-Trend toward 6G: Enhanced Latency, Positioning & Connectivity

SAMSUNG Research

Zero Perceived Latency

Internet of Skill

3D scanning & transmission: 100 Tera-pixel/m² [Technical Gazette]



Everything Connected at 2030



[CISCO]

Super-Precision Positioning



Commercial UAV



Ground robotics navigation



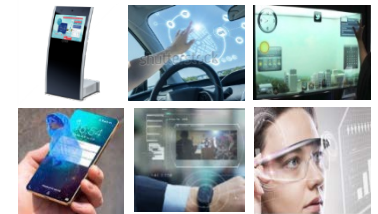
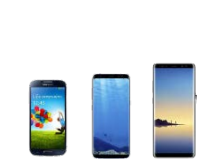
Lane-level navigation



Industrial navigation and tracking

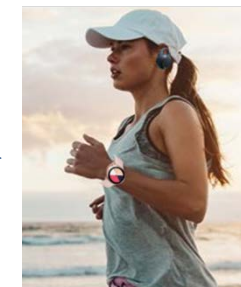


Heavy machine navigation



2010

Various Devices



2020

Ubiquitous Devices



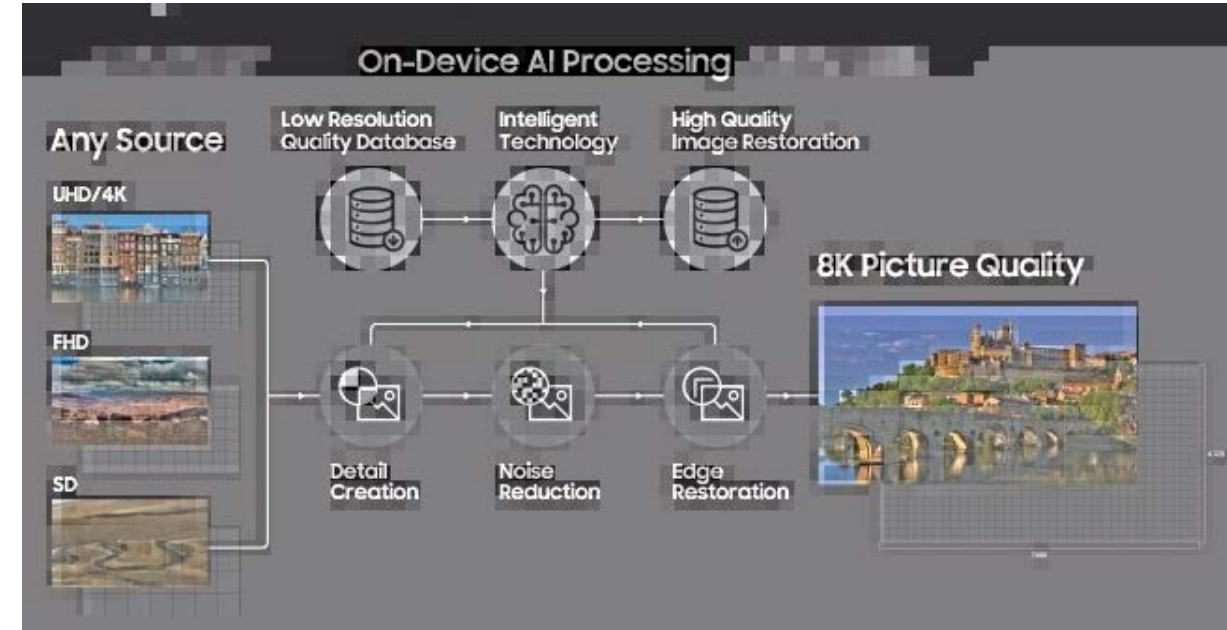
2030

Mega-Trend toward 6G: Artificial Intelligence

SAMSUNG Research



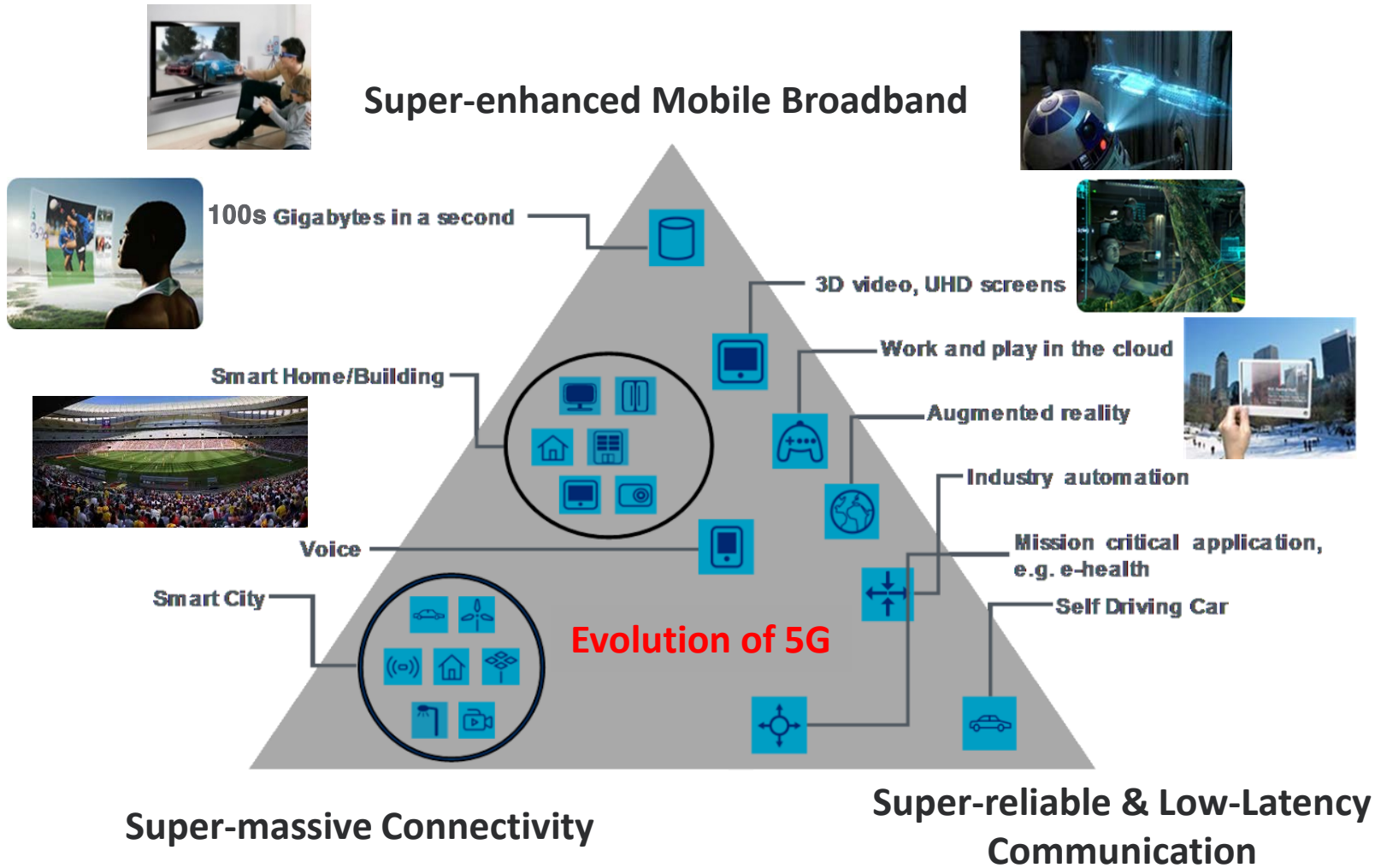
AI-Powered Cloud Computing



AI-Powered Device Processing

Moving Toward 6G

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Super-high Precision Positioning



AI-powered Communications



Thank you!