5G Communications Technologies and Solutions

Foreword

- During the World Radiocommunication Conference 2015 held in Geneva, Switzerland from October 26 to 30, ITU Radiocommunication Sector (ITU-R) officially approved the resolution on promoting future 5G research and formally decided on "IMT-2020" as the official name of 5G.
- 5G is a new-generation communications technology. Its standards evolution and industry development have attracted much attention and will be promoted by multiple parties. In addition, for mobile Internet and IoT scenarios, 5G brings new technologies and transformations.

Objectives

Upon completion of this course, you will be able to:

- Understand 5G standards evolution and industry development.
- Master key technologies and points for 5G communications.
- Distinguish between three 5G scenarios and their supported applications.
- Be familiar with 5G business solutions and know the key to the success of operators'.

Contents

1. **5G Standards Evolution and Industry Development**
2. Key 5G Technologies
3. Three 5G Application Scenarios
4. 5G Business Solutions

Vision 2025: Towards an Intelligent World

All Things Sensing

All Things Connected

All Things Intelligent

1

Live with Robots

Smart home robot usage: 14%

2

Super Vision

Enterprise AR/VR usage: 10%

3

4

Smart Assistance

Personal smart assistant usage: 90%

5

Smooth Navigation

IoV penetration rate: 15%

Work with Robots

Man-machine ratio in the manufacturing industry: 103/10,000

6

Enhanced Creativity

AI usage by large enterprises: 97%

7

Seamless Communication

Enterprise data usage efficiency: 86%

8

9

Connected Economy

Commercial applications on the cloud: 85%

10

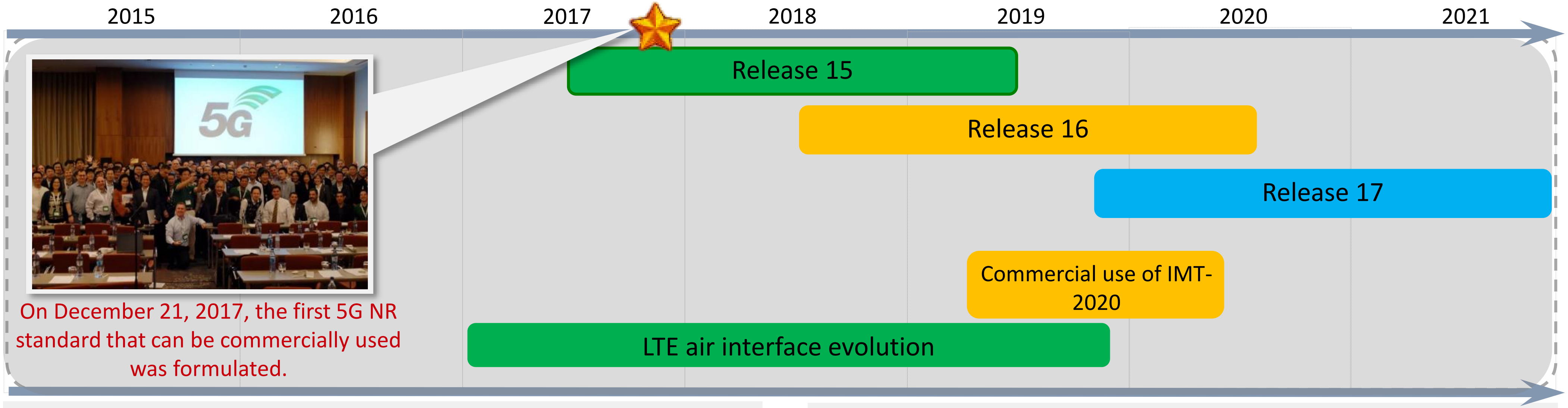
Rapid 5G Coverage

5G coverage rate: 58%

Global Digital Governance

Global data volume generated per year: 180 ZB

Evolution of 5G Communications Technical Standards



2015 2016 2017 2018 2019 2020 2021

Release 15

Release 16

Release 17

Commercial use of IMT-2020

LTE air interface evolution

On December 21, 2017, the first 5G NR standard that can be commercially used was formulated.

R15

NR technical framework

- ✓ New waveform
- ✓ Numerology, frame structure
- ✓ Coding, modulation, & channel
- ✓ M-MIMO
- ✓ Flexible duplex

Network architecture: ready

- ✓ UL and DL decoupling
- ✓ CU-DU high-layer split
- ✓ NSA/SA

Industry application basic design

- ✓ URLLC

R16

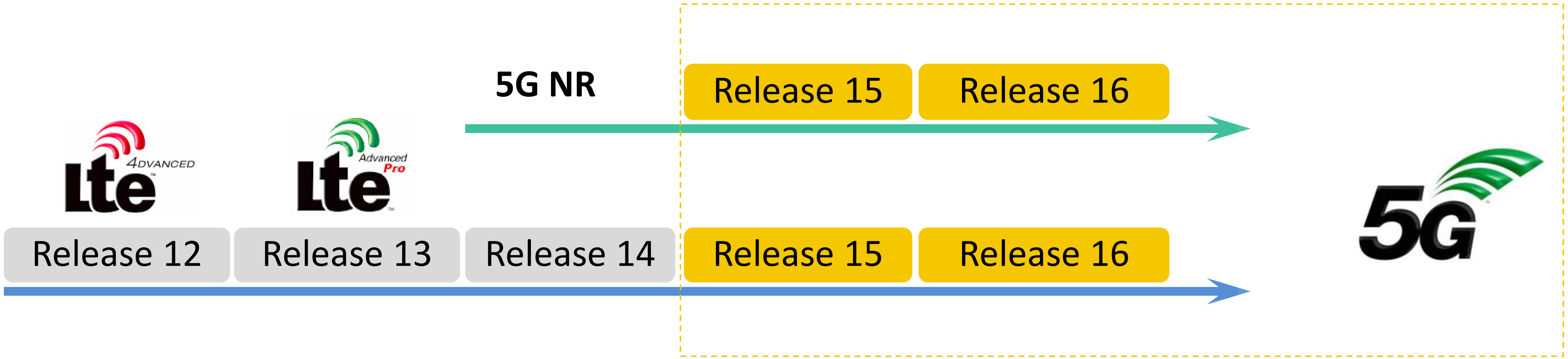
Function enhancement

- ✓ 2-step RACH
- ✓ IAB
- ✓ Mobility enhancement
- ✓ Enhanced dual connectivity (DC) and carrier aggregation (CA)
- ✓ MIMO enhancement
- ✓ UE power saving

Vertical industry exploration

- ✓ URLLC enhancement
- ✓ 5G+TSN
- ✓ NPN
- ✓ 5G LAN
- ✓ 5G V2X
- ✓ NR-U
- ✓ NR positioning

3GPP Release 15: New 5G Technology Standards



5G NR

Release 15 Release 16

Release 12 Release 13 Release 14 Release 15 Release 16

4DVANCED
Lte
Advanced
Pro
Lte
5G

These include:

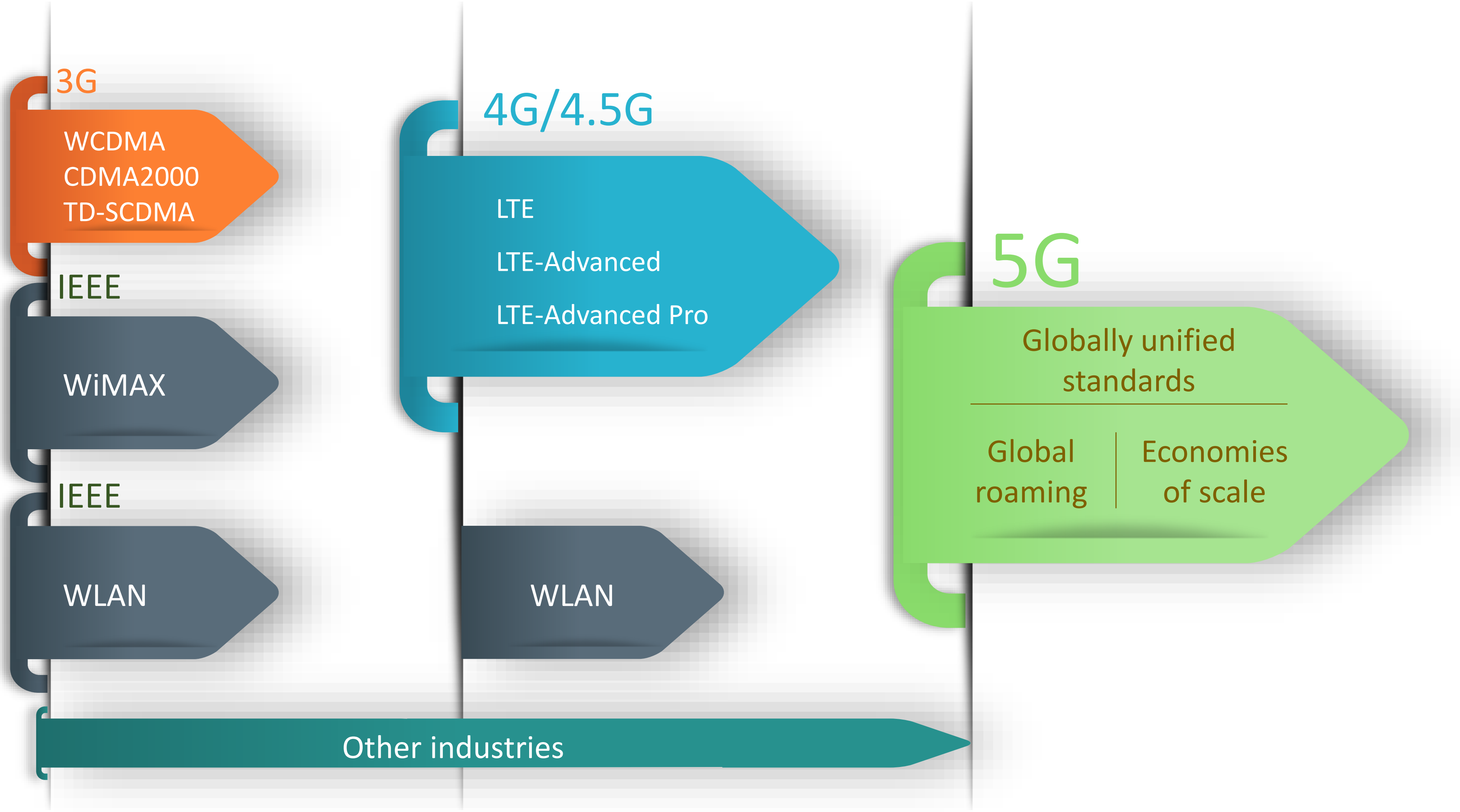
New radio

LTE Advanced Pro evolution

Next generation core (NGC)

EPC evolution

5G Unified Standards



3G

WCDMA
CDMA2000
TD-SCDMA

IEEE

WiMAX

IEEE

WLAN

4G/4.5G

LTE

LTE-Advanced

LTE-Advanced Pro

WLAN

5G

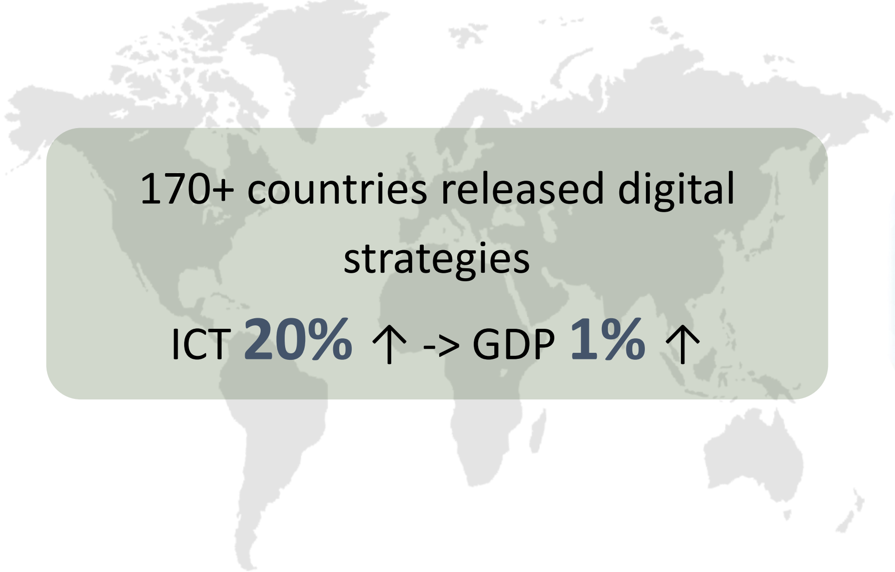
Globally unified standards

Global roaming

Economies of scale

Other industries

More Countries Value 5G & AI as Key to National Digitization



170+ countries released digital strategies

ICT **20%** ↑ -> GDP **1%** ↑

5G plays an important role in the national digital strategy.

South Korea	5G+strategy: Build global top strategic products based on 5G by 2026.
Germany	Build a high-performance 5G network by 2025. 5G is the basis for digital value creation.
US	National security strategy: 5G creates a new market of US$250 billion
UK	Leading 5G, building a world-leading digital economy
China	Three ministries in China established the IMT-2020 (5G) Promotion Group in February 2013
Japan	5G is the foundation of economic, social, and national life.

20+ countries released national AI strategies.

US: US AI Plan

UK: Industrial Strategy: AI Sector Deal

China: Next Generation Artificial Intelligence Development Plan

Russia: National AI Strategy 2030

Canada: Pan-Canadian Artificial Intelligence Strategy

UAE: National Artificial Intelligence Strategy 2031

Singapore: Smart Nation 2025

India: National Artificial Intelligence Strategy

Widespread Proliferation of 5G Product Types

- On the eve of the 2018 Mobile World Congress, Huawei announced Balong 5G01, the world's first commercially available 5G chipset compliant with 3GPP specifications. It supports global mainstream 5G frequency bands, including the low ones (sub-6 GHz) and high ones (mmWave). Theoretically, the data download rate can be up to 2.3 Gbps.
- Huawei also launched the first 3GPP-compliant 5G commercial terminal: HUAWEI 5G CPE. There are two types of CPEs, one for low frequency bands (sub-6 GHz) and the other for high frequency bands (mmWave). The tested peak downlink rate can reach 2 Gbps.
- In addition, Huawei unveiled its first 5G foldable phone, HUAWEI Mate X.
- On March 26, 2020, Huawei launched the 5G mobile phones Huawei P40 and P40 Pro globally.

Balong 5G01

Balong 5G 01

5G CPE

Mate X

P40 Pro

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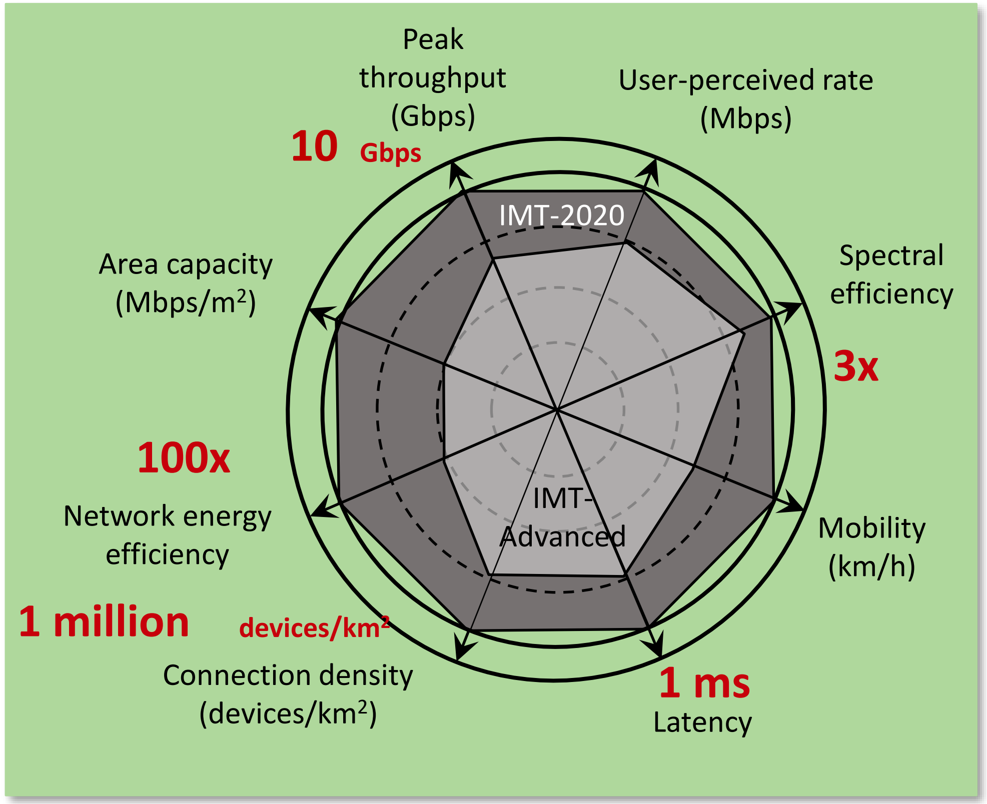
5G Key Performance Indicators

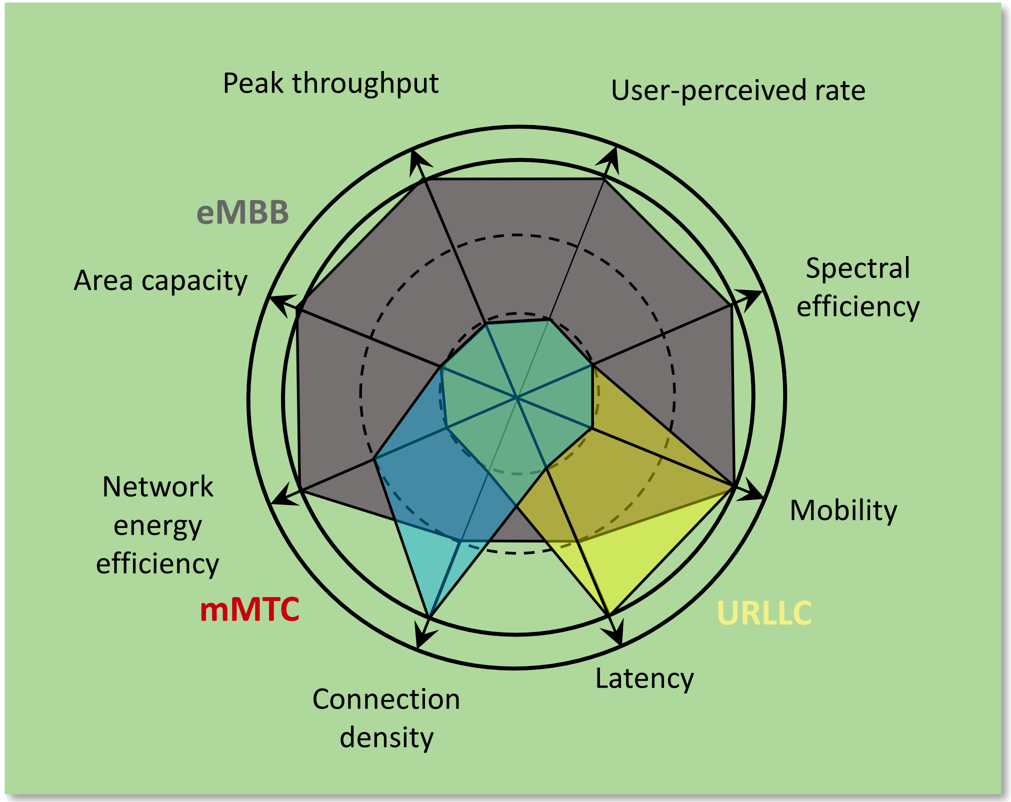
	Latency	**Throughput**	**Connections**	**Network Architecture**
5G	**1 ms** E2E latency	**10 Gbps** per connection	**1 million** per km^2	**Slicing** capability requirements
	30 to 50x	100x	100x	NFV/SDN
LTE	30 to 50 ms	100 Mbps	10,000	Flexibility

5G Key Capability Requirements

Key capability requirements
(IMT-2020 vs. IMT-Advanced)



Different application scenarios have different requirements on 5G network capabilities.



Three Key 5G Innovations

New Architecture

Using both low and high frequency bands for new experience

New Radio

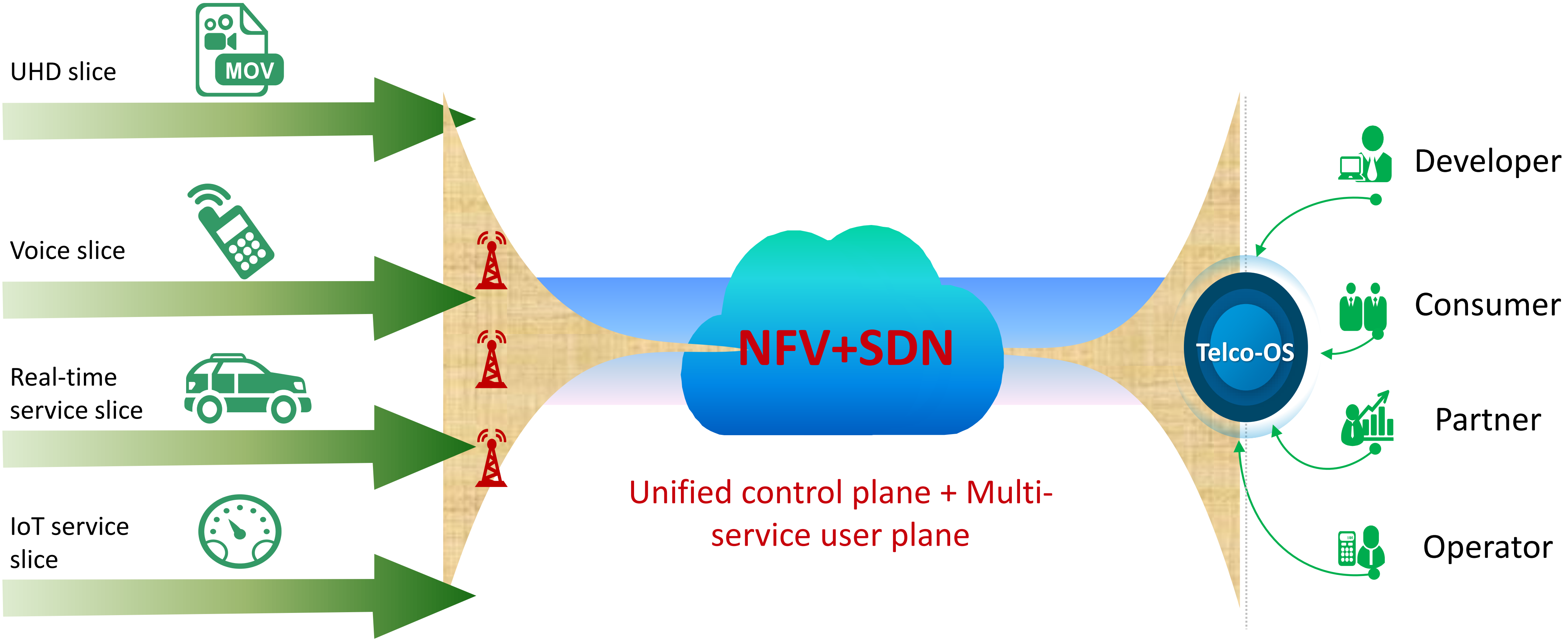
One physical network for hundreds of industries

Full Spectrum

Flexible adaptation to various services

Improved spectral efficiency

5G New Architecture - One Network for Hundreds of Industries



UHD slice

MOV

Voice slice

Real-time service slice

IoT service slice

NFV+SDN

Telco-OS

Developer

Consumer

Partner

Operator

Unified control plane + Multi-service user plane

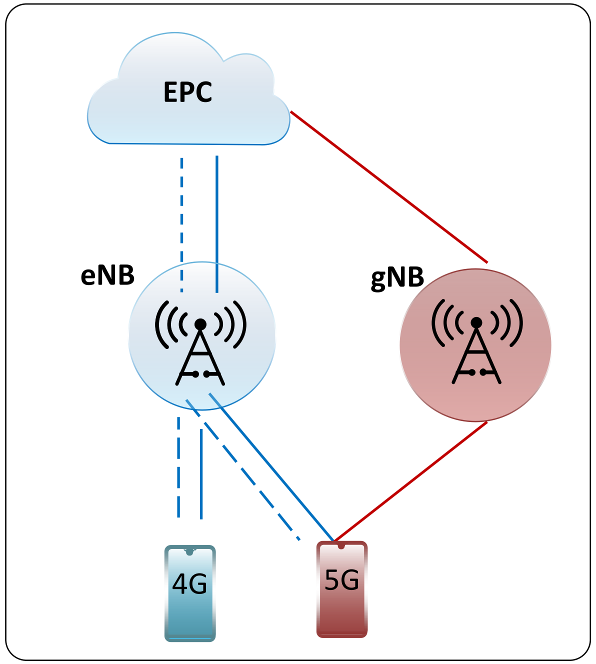
Slice QoS defined by industry requirements

Architecture based on cloud and big data

Operations based on Internet architecture

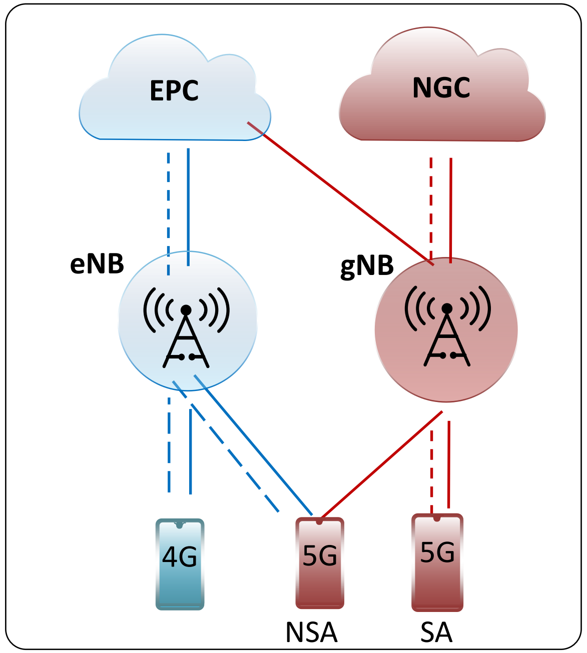
5G Networking Mode

2019
NSA Option 3x


EPC
eNB
gNB
4G
5G

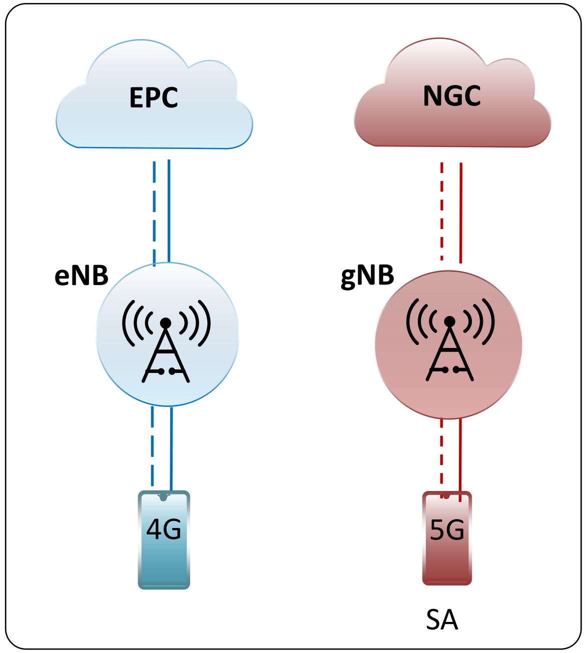
Enabling eMBB services:
- Quick deployment in the early stage
- LTE as the anchor point
- LTE&NR DC

2020 to 2023
Long-term coexistence of NSA and SA


EPC
NGC
eNB
gNB
4G
5G
5G
NSA
SA

Enabling 5G 2B services:
- One network adapts to both NSA and SA networking.
- Uplink enhancement (such as super uplink and NR uplink CA)

2023+
SA as the target architecture


EPC
NGC
eNB
gNB
4G
5G
SA

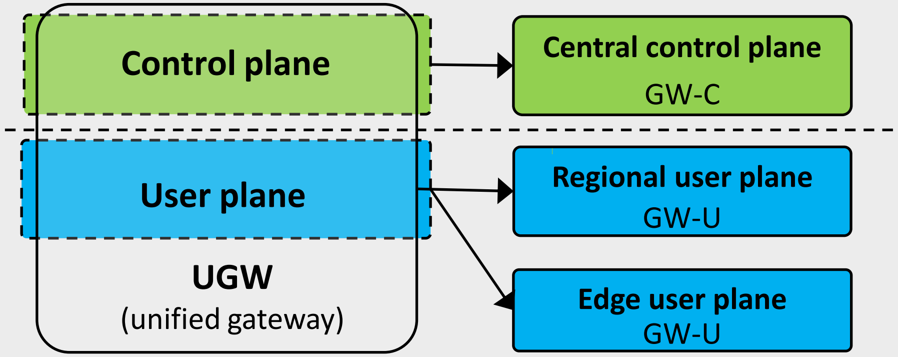
Fully enabling vertical services:
- NR carrier aggregation

Operators Will Begin Deploying SA Networks in 2020

	Service	User Experience	Deployment Complexity	Ecosystem Maturity
NSA 	● **eMBB and FWA: supported** ● URLLC and network slicing: not supported	● **EN-DC**: enhancing uplink coverage ● EN-DC: improving user experience	● LTE base station software upgrade to support NSA ● EPC software upgrade	● Mature in 2019
SA 	● All-scenario services are supported ● **Vertical industries** enabled by network slicing and high uplink bandwidth	● Limited uplink coverage (for C-band) ● Ultra-large uplink or **sub-3G NR**: Mandatory	● Super uplink or sub-3G NR ● **NGC**: mandatory	● Driven by Chinese and American markets ● **Mature in 2020**

NGC: Service-oriented, with Four Types of Services

1 Control and user plane separation



Control plane

User plane

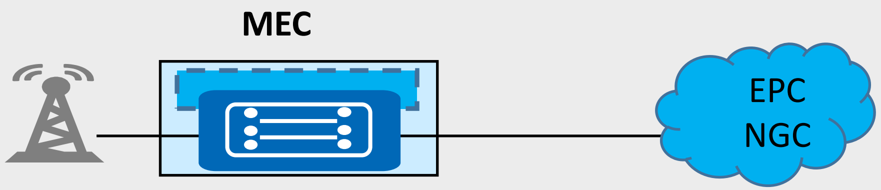
UGW
(unified gateway)

Central control plane
GW-C

Regional user plane
GW-U

Edge user plane
GW-U

2 Mobile edge computing



MEC

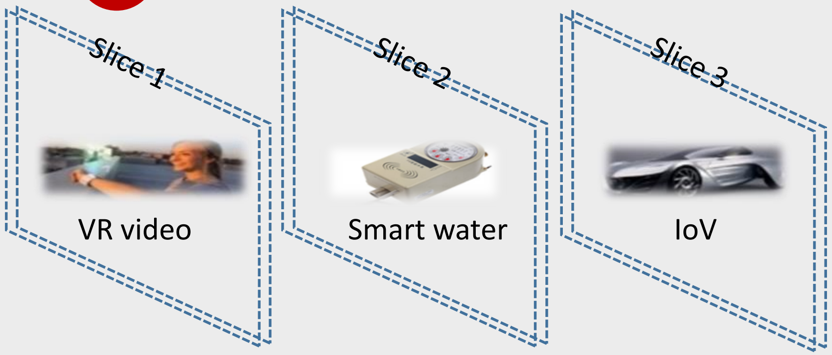
EPC
NGC

Application scenarios: campus/enterprise campus, smart stadium, IoV, etc.

3 Network function reconstruction

- All-cloud network
- Network architecture reconstruction
- Software function reconstruction

4 Network slicing



Slice 1

VR video

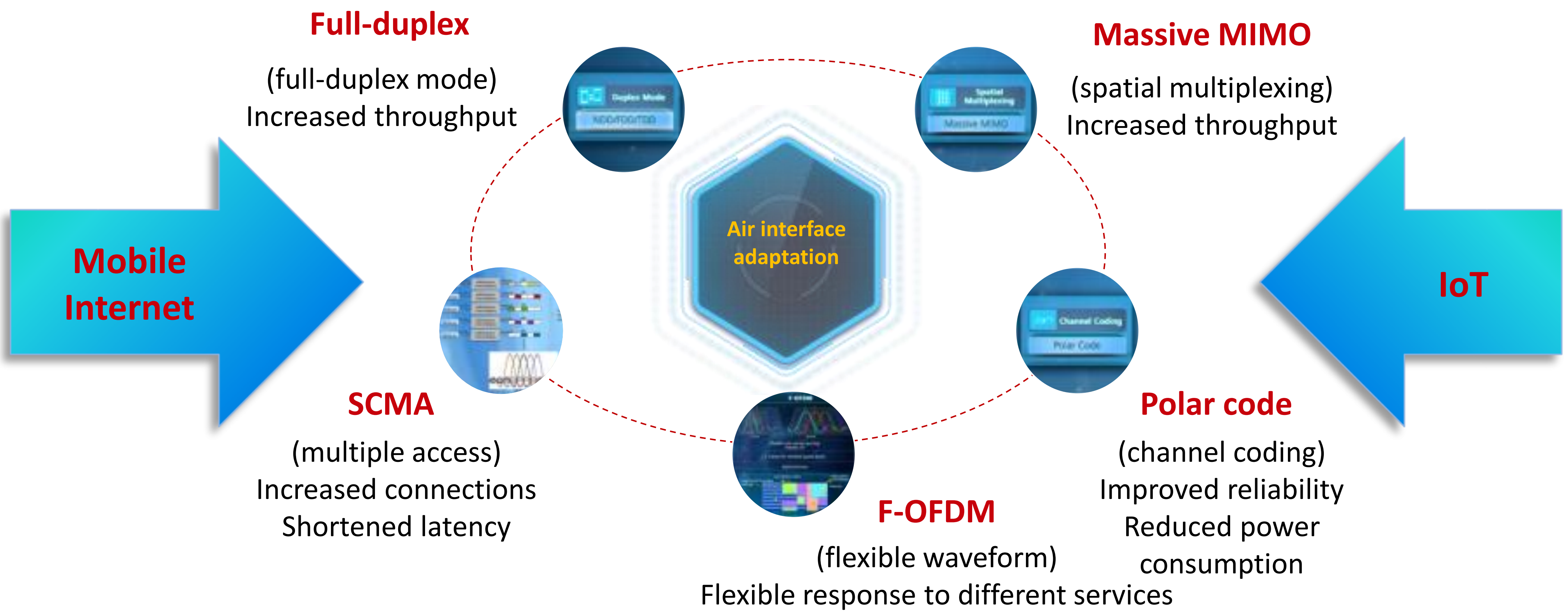
Slice 2

Smart water

Slice 3

IoV

5G New Radio



Mobile Internet

IoT

Air interface adaptation

Full-duplex

(full-duplex mode)
Increased throughput

Massive MIMO

(spatial multiplexing)
Increased throughput

SCMA

(multiple access)
Increased connections
Shortened latency

F-OFDM

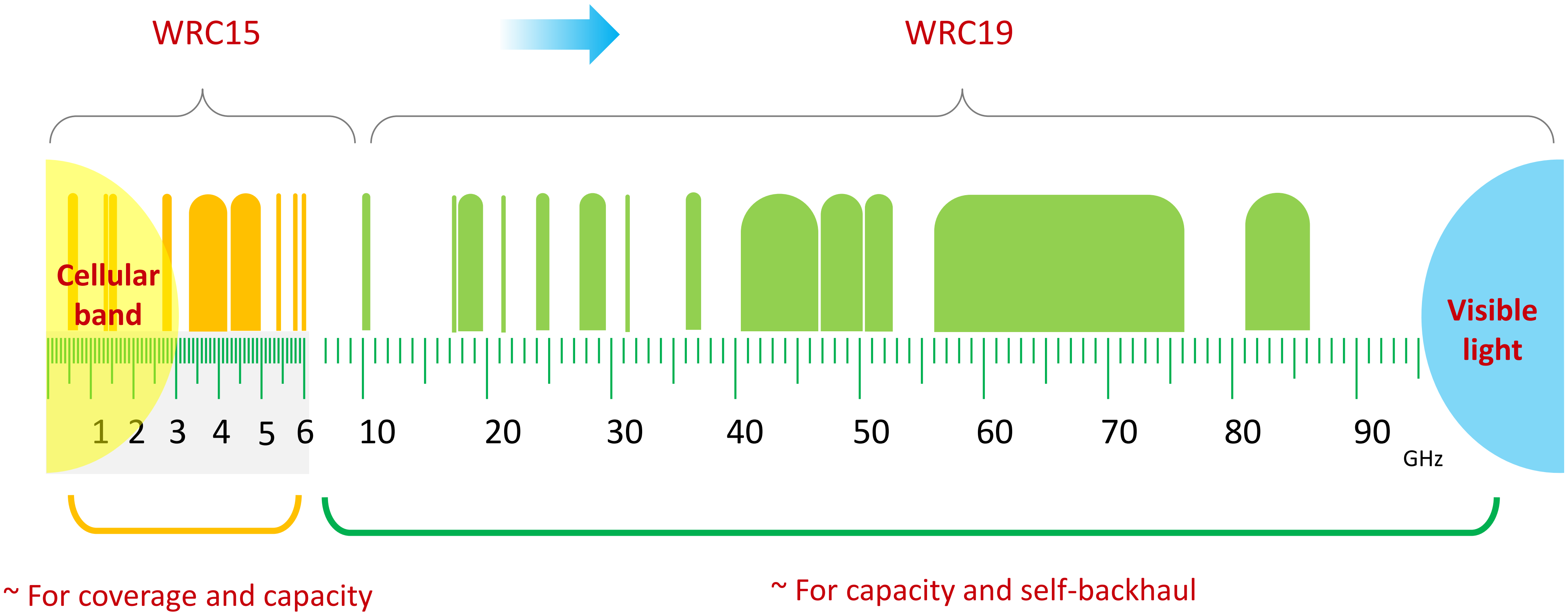
(flexible waveform)
Flexible response to different services

Polar code

(channel coding)
Improved reliability
Reduced power consumption

The new radio can flexibly adapt to different services, delivering a three-fold improvement of spectral efficiency.

5G Aggregates All Frequency Bands


WRC15
WRC19
Cellular band
Visible light
1
2
3
4
5
6
10
20
30
40
50
60
70
80
90
GHz

~ For coverage and capacity

~ For capacity and self-backhaul

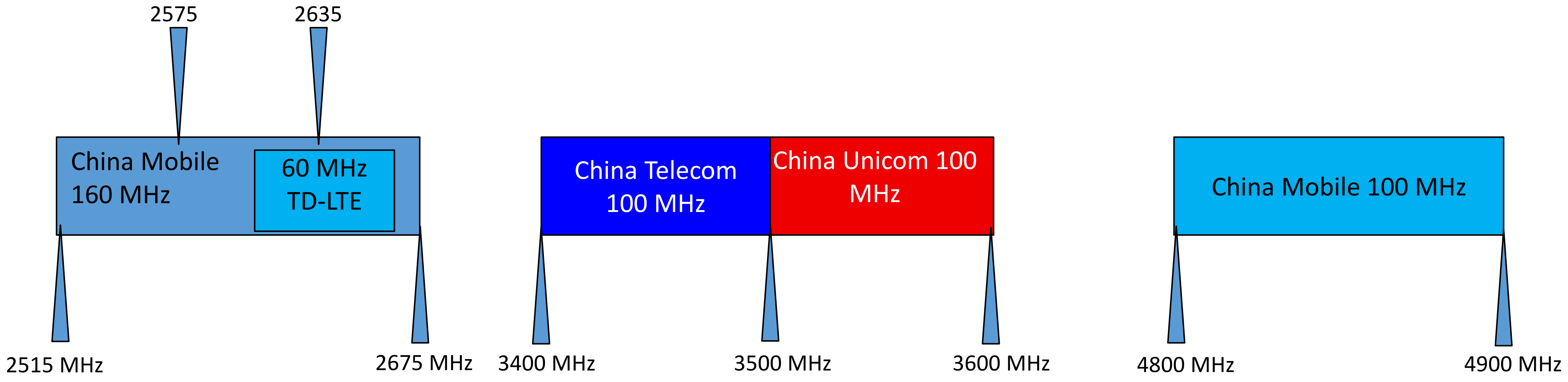
C-band (3.4–3.6 GHz) can provide at least 200 MHz global frequency bands.

WRC19 candidate bands for IMT above 6 GHz: 24.25-27.5, 37-40.5, 42.5-43.5, 45.5-47, 47.2-50.2, 50.4-52.6, 66-76, 81-86 GHz

28 GHz (27.5–29.5 GHz) for industrial use

Allocation of Mid and Low 5G Bands in China

- The MIIT has approved the license for the use of the medium and low frequency bands for 5G by China's three major operators.
  - China Telecom: 3400–3500 MHz (100 MHz)
  - China Unicom: 3500–3600 MHz (100 MHz)
  - China Mobile: 2515–2675 MHz and 4800–4900 MHz
    - 2515–2575 MHz, 2635–2675 MHz, and 4800–4900 MHz frequency bands are newly added, and the 2575–2635 MHz frequency band is refarmed from China Mobile's existing TD-LTE (4G) frequency band.


2575
2635
China Mobile 160 MHz
60 MHz TD-LTE
China Telecom 100 MHz
China Unicom 100 MHz
China Mobile 100 MHz
2515 MHz
2675 MHz
3400 MHz
3500 MHz
3600 MHz
4800 MHz
4900 MHz

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eMBB

- In eMBB scenarios, 5G needs to provide enhanced mobile Internet services:
    - Services such as VR/AR/MR require higher rates.

VR

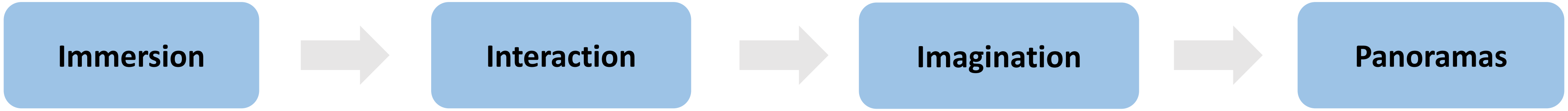
Everything you see is unreal.

AR

You can tell the difference between the 'real' and the 'virtual'.

MR

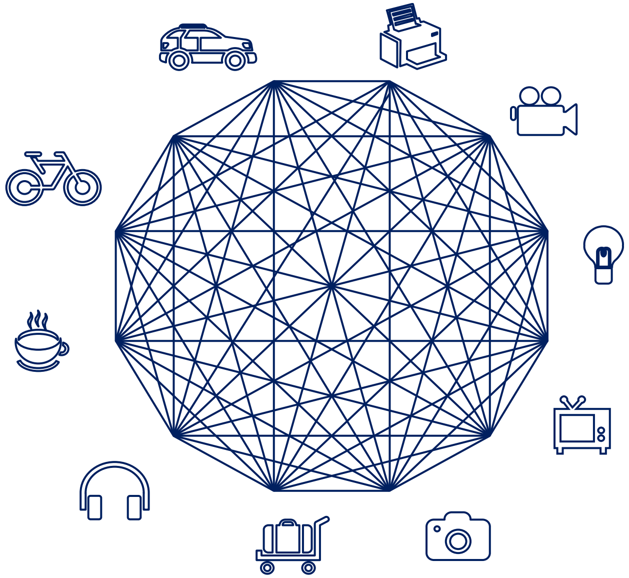
You cannot tell the difference between the 'real' and the 'virtual'.



Immersion → **Interaction** → **Imagination** → **Panoramas**

mMTC

- In mMTC scenarios, 5G needs to provide IoT services with massive connections.
  - Internet of everything – large-scale IoT

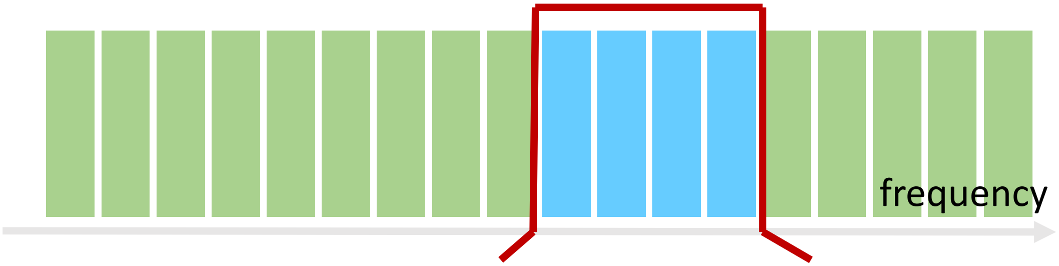


All things connected

NB-IoT Already Evolved to NR

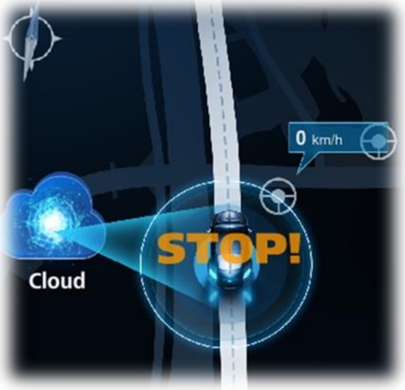
The ITU-R WP 5D#35e remote conference held by the International Telecommunication Union (ITU) announced that 3GPP 5G technologies (including NB-IoT) meet the requirements of IMT-2020 5G technical standards and are officially accepted as ITU IMT-2020 5G technical standards.

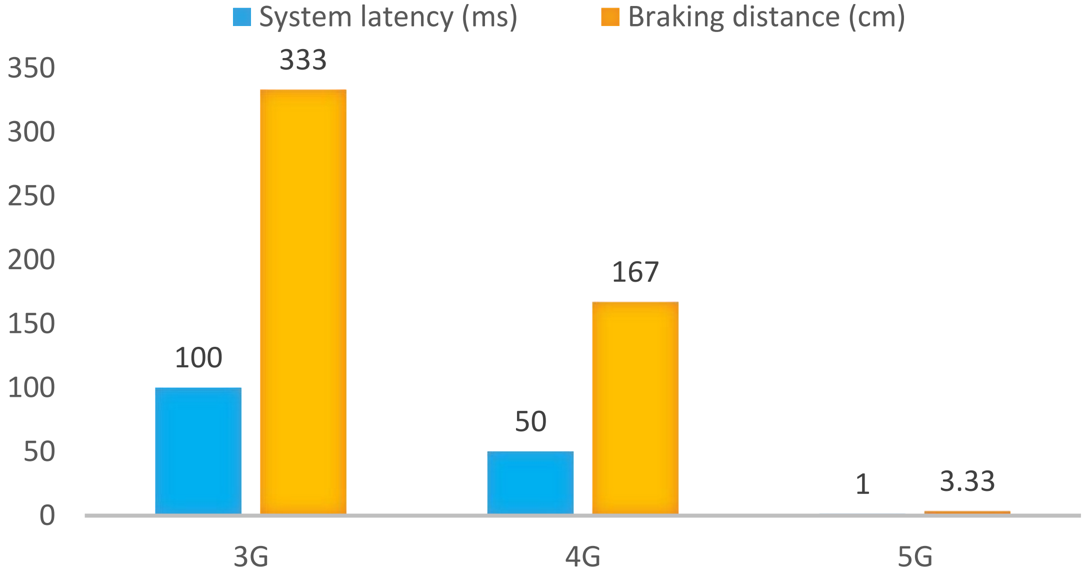
NB-IoT systems embedded into 5G



URLLC

- In URLLC scenarios, 5G needs to provide ultra-high reliability and ultra-low latency services.
  - In V2X scenarios, services such as assisted driving and automated driving require low latency.
  - Scenarios demanding high real-time performance, such as smart healthcare and remote surgery, require low latency.




Relationship between system delay and braking distance

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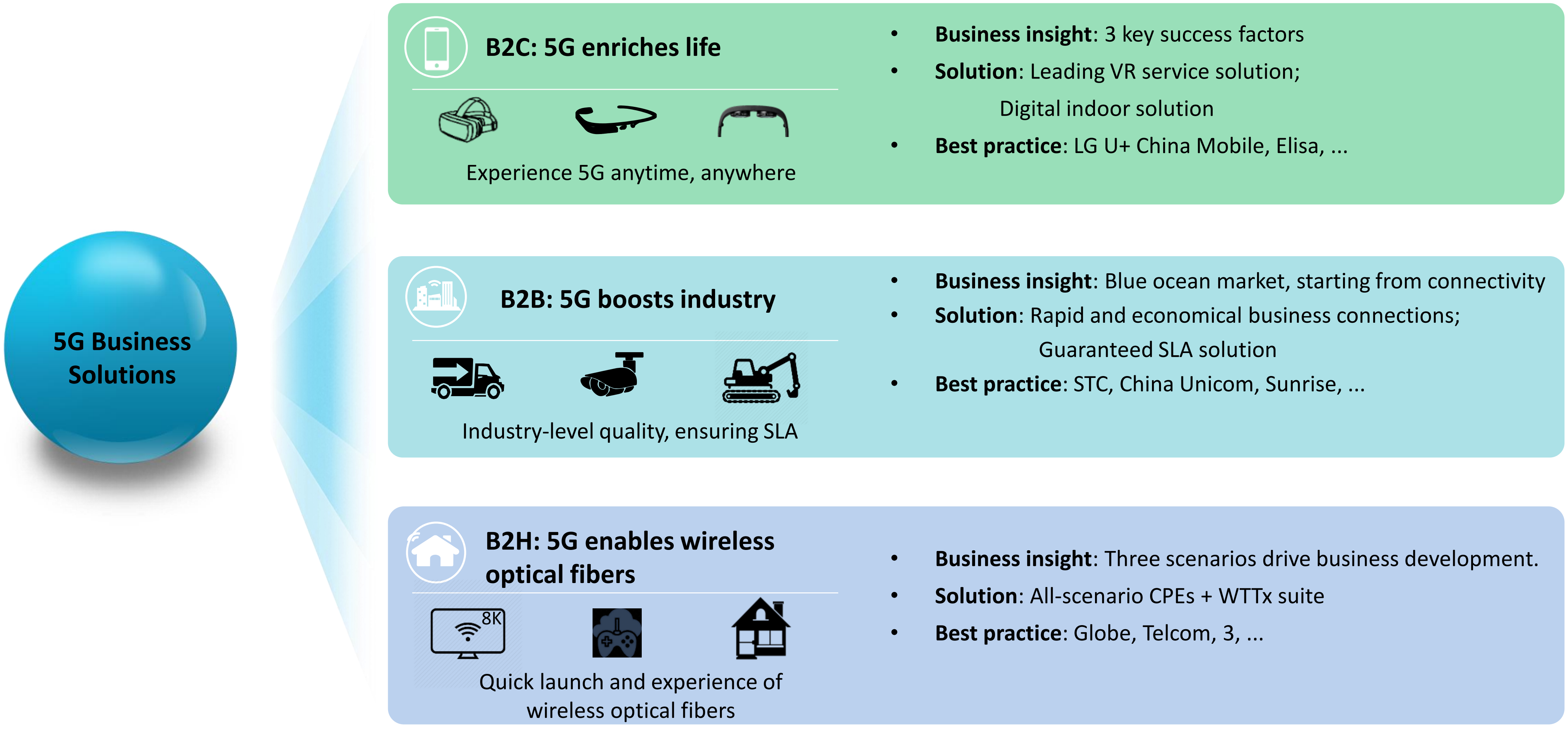
Three 5G Business Solutions Driving Business Success



5G Business Solutions

B2C: 5G enriches life

Experience 5G anytime, anywhere

- **Business insight**: 3 key success factors
- **Solution**: Leading VR service solution;
  Digital indoor solution
- **Best practice**: LG U+ China Mobile, Elisa, ...

B2B: 5G boosts industry

Industry-level quality, ensuring SLA

- **Business insight**: Blue ocean market, starting from connectivity
- **Solution**: Rapid and economical business connections;
  Guaranteed SLA solution
- **Best practice**: STC, China Unicom, Sunrise, ...

B2H: 5G enables wireless optical fibers

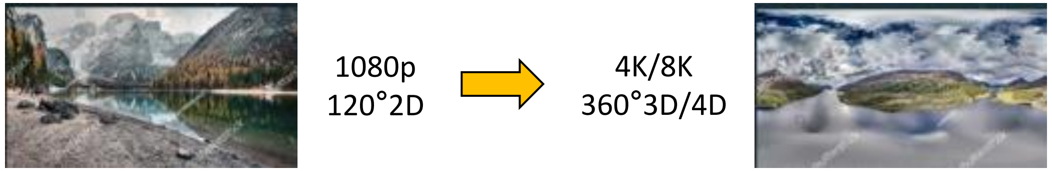
Quick launch and experience of wireless optical fibers

- **Business insight**: Three scenarios drive business development.
- **Solution**: All-scenario CPEs + WTTx suite
- **Best practice**: Globe, Telcom, 3, ...

B2C Industry Insight: Three Key Success Factors

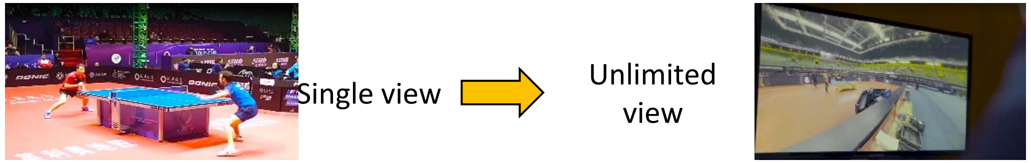
5G Brings More New Services

New video: more details, immersive experience


1080p
120°2D

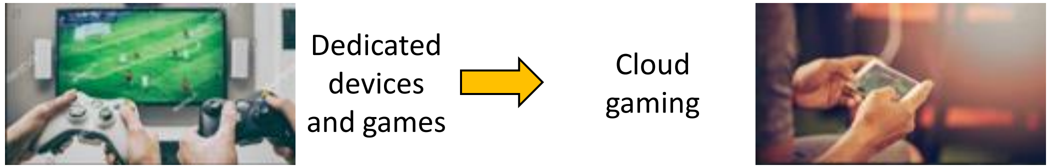
4K/8K
360°3D/4D

New live broadcast: onsite-like experience


Single view

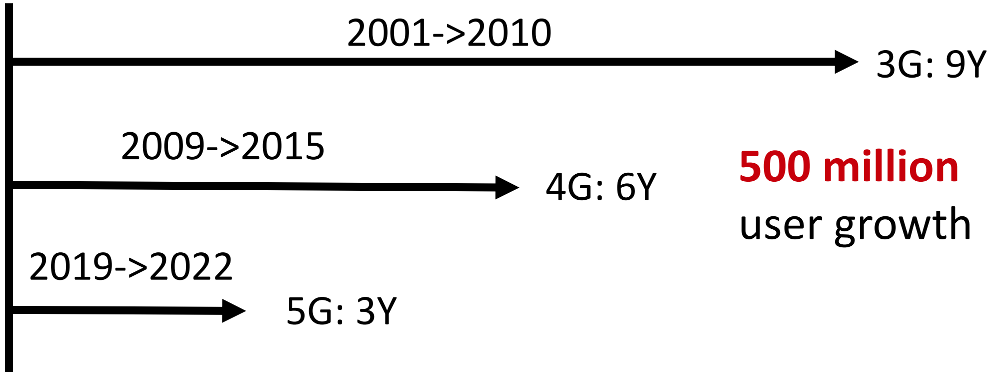
Unlimited view

New games: any game, any device


Dedicated devices and games

Cloud gaming

Rapid Increase of 5G B2C Users


2001->2010
3G: 9Y

2009->2015
4G: 6Y

2019->2022
5G: 3Y

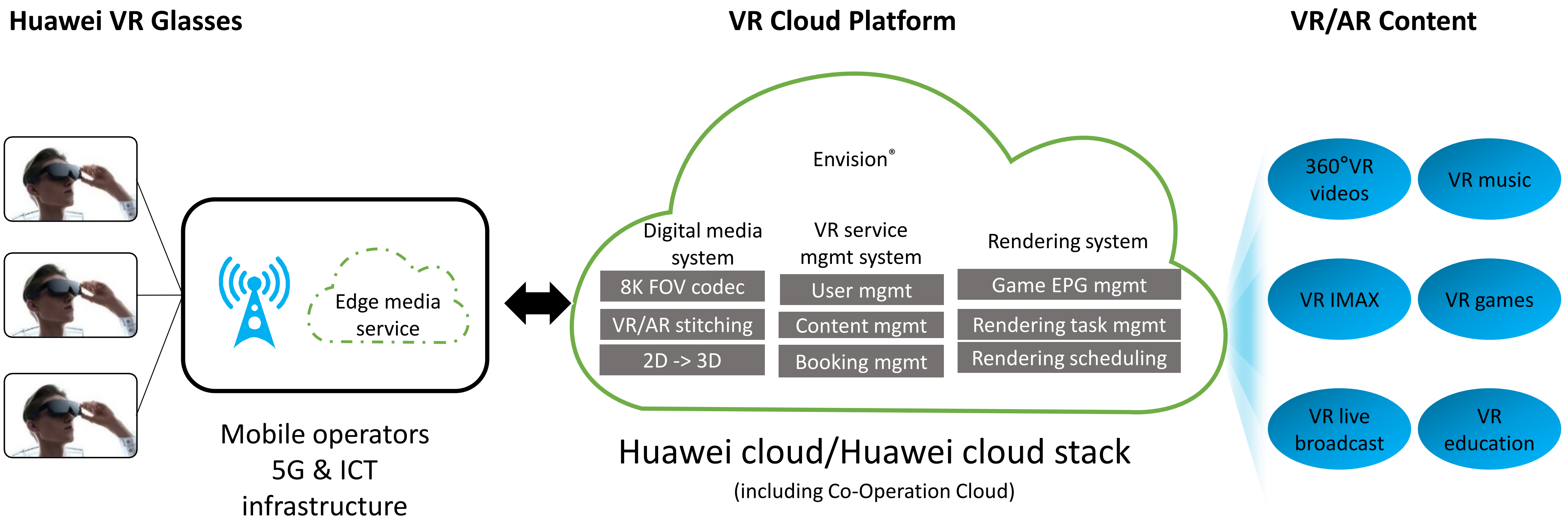
500 million user growth

5G will be two times faster than 4G and three times faster than 3G, reaching 500 million users.

Three Key Factors for 5G B2C Success

- ✓ High-quality network
- ✓ Rich content
- ✓ Flexible multi-dimension tariffs

Solution: Driving VR/AR Business Success



Huawei VR Glasses

VR Cloud Platform

VR/AR Content

Edge media service

Mobile operators
5G & ICT
infrastructure

Envision®

Digital media system
- 8K FOV codec
- VR/AR stitching
- 2D -> 3D

VR service mgmt system
- User mgmt
- Content mgmt
- Booking mgmt

Rendering system
- Game EPG mgmt
- Rendering task mgmt
- Rendering scheduling

Huawei cloud/Huawei cloud stack
(including Co-Operation Cloud)

- 360°VR videos
- VR music
- VR IMAX
- VR games
- VR live broadcast
- VR education

Commercial cases:

- China Telecom: e-Cloud VR
- China Unicom: Wo Video

B2B Industry Insight: Blue Ocean Market, Starting from Connectivity

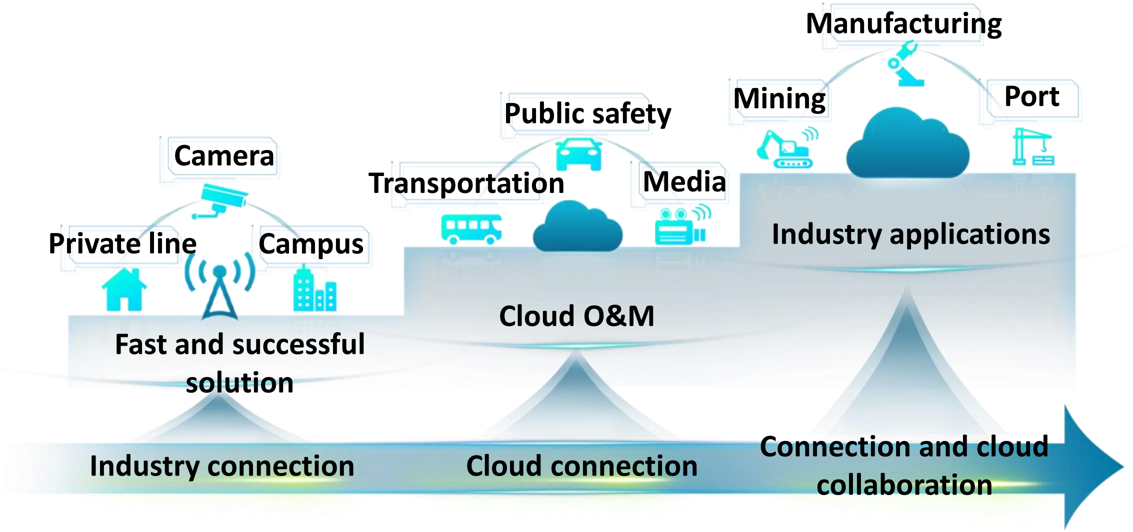
B2B Services: Blue Ocean Market for Operators' Business

5G value chain: **1.83** trillion

5G-driven GDP growth: **6.9** trillion

Job opportunities: **11** million

5G B2B Success Starts from Connectivity


Manufacturing
Mining
Port
Public safety
Camera
Transportation
Media
Industry applications
Private line
Campus
Cloud O&M
Fast and successful solution
Industry connection
Cloud connection
Connection and cloud collaboration

5G private line

5G campus

5G public safety

5G transportation

5G port

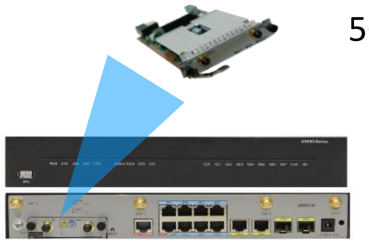
5G manufacturing

Solution: Fast and Economical Business Connection

Fixed Private Line Scenario

The AR650 gateway facilitates 5G connections on enterprise private networks, meeting enterprise VPN and security requirements.

Enterprise private line



Video surveillance

Cameras with built-in 5G modules facilitate HD video surveillance.

Wireless Private Line Scenario

The world's first industrial-grade CPE facilitates remote control in industrial scenarios and provides more stable connections in complex environments.

Remote control

Live broadcast

The video codec with built-in 5G modules makes the 5G backpack lighter and makes the battery power supply last longer.

Built-in 5G module

B2H Industry Insight: Three Scenarios Drive Service Development

FWA as the main service at the early stage of 5G

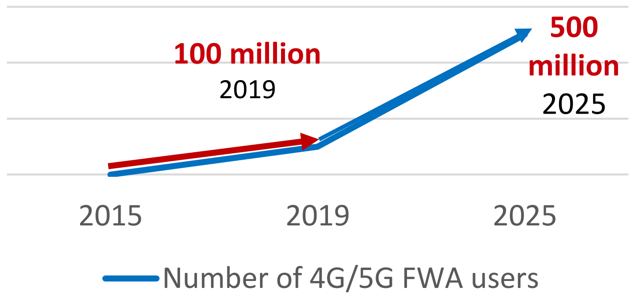
230+
4G FWA network

10+
countries lead the use of FWA.

30+
5G FWA network

10+
networks have more than 1 million users.

Rapid growth of 4G/5G FWA users



New "MFC" = Mobile + FWA

Mobile-First Convergence

ARPU
3x

Mobile churn rate: **0.5x**

Ultimate gigabit experience

4G FWA
5-50 Mbps

5G FWA
100-1000+Mbps

Equal profit with eMBB

5x spectral efficiency VS eMBB
(The coverage range of an outdoor CPE is 30+ dB greater than that of a mobile phone.)

All-scenario support

4G FWA
Basic broadband

5G FWA
Premium broadband

- ✓ Connection of unconnected households
- ✓ Copper line replacement
- ✓ Optical fiber replacement

Better business prospects

5G FWA
- High-quality user experience
- Guaranteed bit rate

Flexible investment
- **C-band & sub-3 GHz**: hybrid eMBB/FWA
- **mmWave**: on-demand deployment

Fast ROI
Two-year ROI@FWA + eMBB

Solution: Fast HBB Connection - 5G FWA Series

5x spectrum performance increases FWA profitability

VS

@same resource

50 GB

Smart phones

250 GB

N5866 (outdoor)

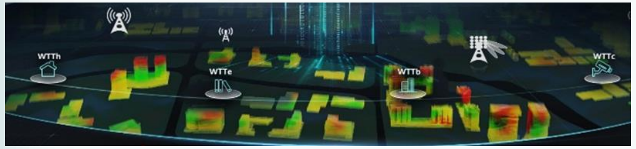
High-performance CPE

✓Higher antenna gain (11 dBi)

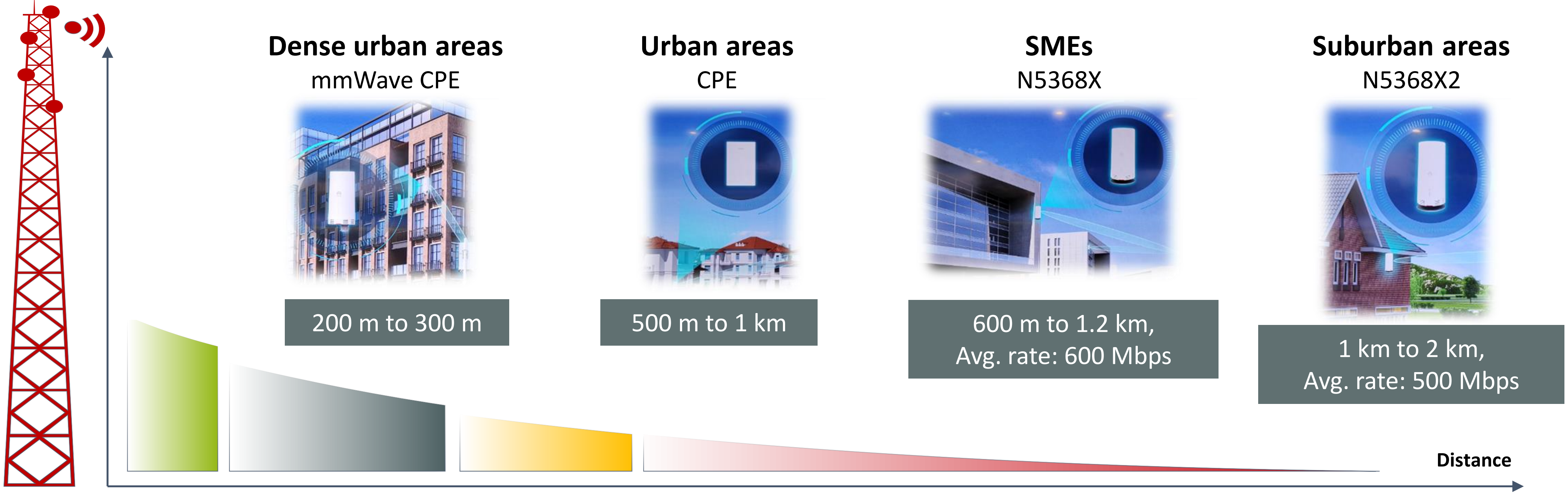
✓4R/8R CPE, doubling capacity

E2E capability of the WTTx suite

WTTx suite



- 1-minute service provisioning
- Easy digital installation within 1 hour
- 1 unified operation platform



Dense urban areas

mmWave CPE

200 m to 300 m

Urban areas

CPE

500 m to 1 km

SMEs

N5368X

600 m to 1.2 km,
Avg. rate: 600 Mbps

Suburban areas

N5368X2

1 km to 2 km,
Avg. rate: 500 Mbps

Distance

300 MHz (indoor)

500 MB (near a window)

> 800 MHz (outdoor)

Quiz

1. (Multiple Choice) What are the three 5G application scenarios defined by ITU?
   A. eMBB
   B. eMTC
   C. mMTC
   D. uRLLC
2. (Multiple Choice) Which two of the three 5G application scenarios are closely related to IoT?
   A. eMBB
   B. eMTC
   C. mMTC
   D. uRLLC

Summary

- In this course, you have learned about the most popular wireless communications technology: 5G, including its standards evolution, industry development process, and key technologies.
- You have also learned about the three application scenarios of 5G: mMTC, URLLC, eMBB, and 5G solutions in the industry.
- If you want to learn more about 5G technology details, please attend the 5G course training.

Thank you.

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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