

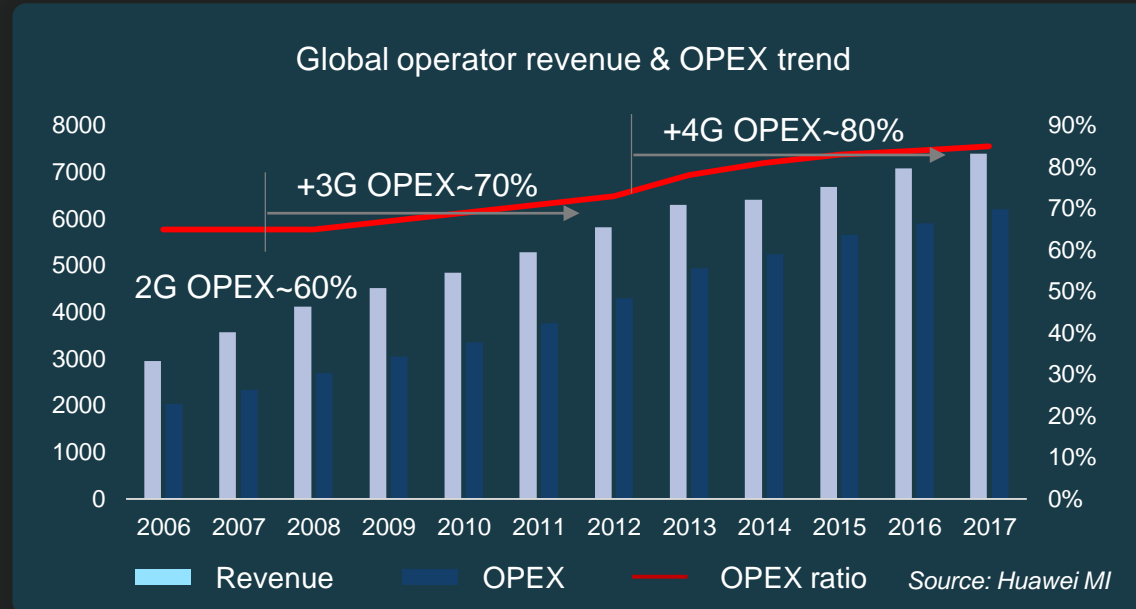
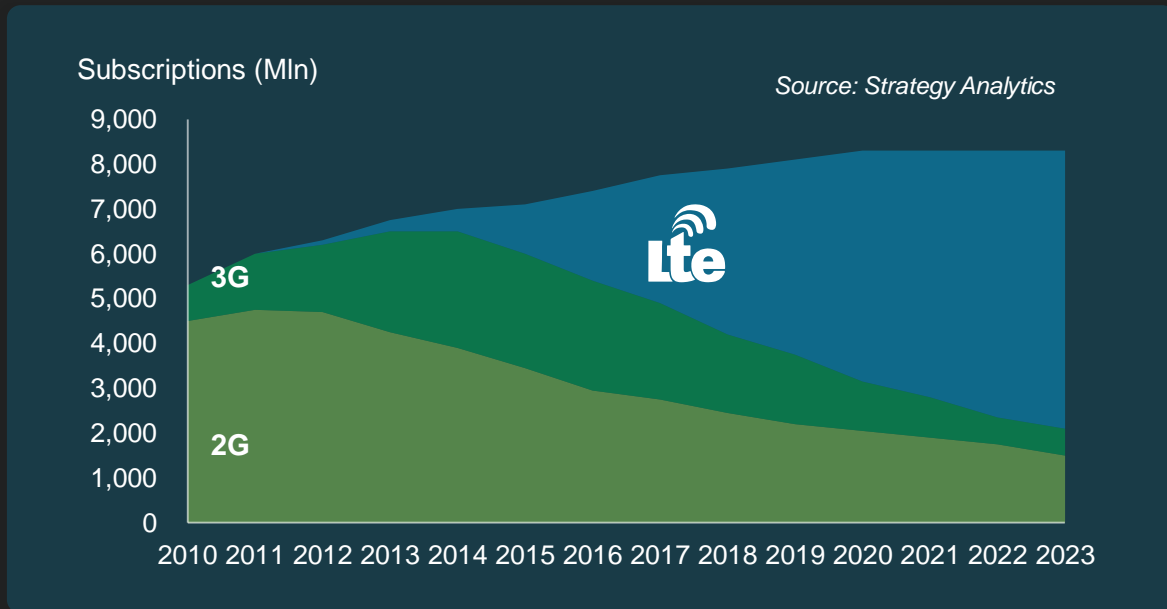
# LTE Evolution Trend in 5G Era and Market Requirement to Device

Department: Huawei LTE Product line

Date: 2019.09

# Operation Efficiency is Driving 2G/3G Migrate to LTE

Keep 2G/3G is getting uneconomical due to its insignificant contribution

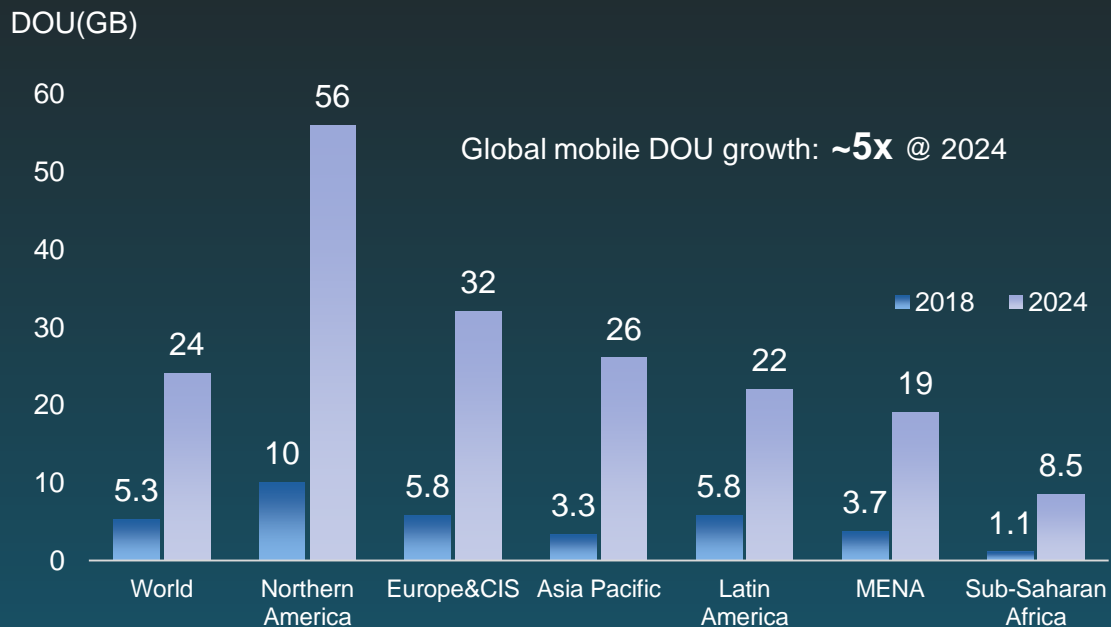


Migrate 2G or 3G to LTE is accelerating worldwide



# Huge Market Space for LTE Growth

## 10x LTE Traffic Growth @ 2025



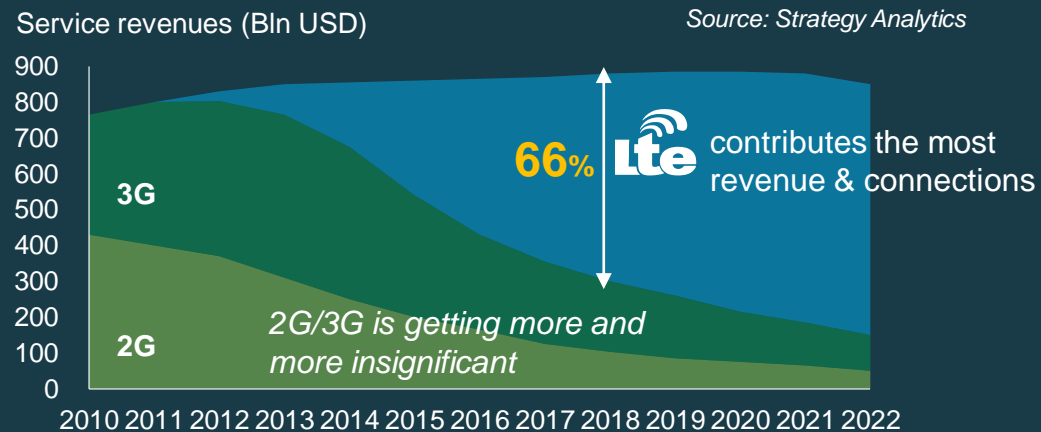
Mobile data usage: >5x @ 2024  
Mobile internet user: ~1.4x @ 2025 (3.6B >> 5.0B)  
LTE connections ratio: ~1.3x @ 2025 (45% >> 60%)

---

LTE traffic growth: ~10x @ 2025 (vs 2018)

Source: The Mobile Economy 2019 (GSMA)

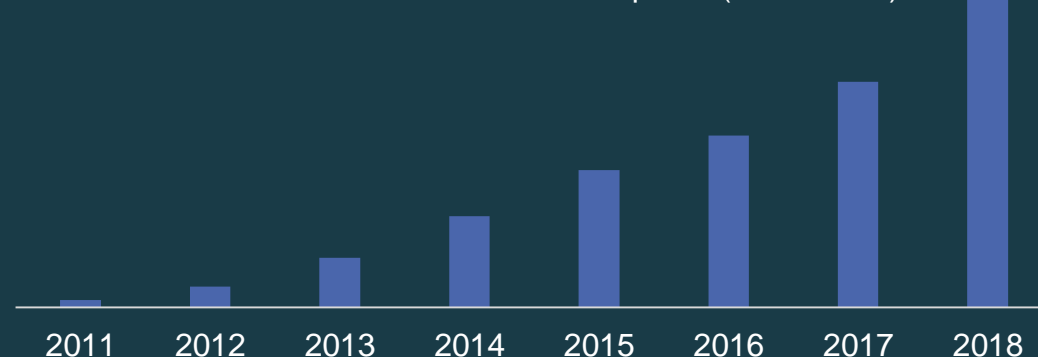
## Major contributor to operators' revenue



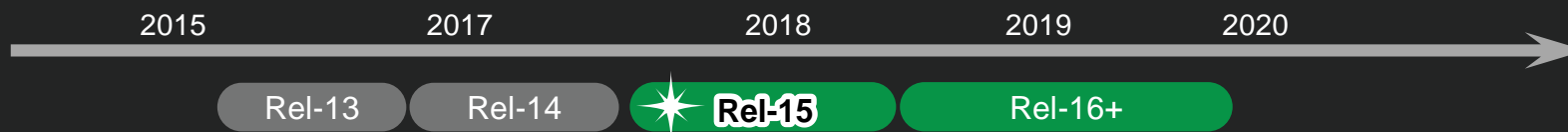
## Increasing shipment of LTE eNodeB

SRC: Dell'oro




Worldwide eNodeB shipment(All vendors)



# LTE is Continuously Evolving along with 5G NR



**5G NR**

-  **eMBB:** M-MIMO, C-Band, mmWave... → xGbps ~ 20Gbps
-  **mMTC:** NB-IoT/eMTC in-band @ NR → 1M connections / km<sup>2</sup>
-  **URLLC:** Mini slot → Min 0.5ms

 **Spectrum Sharing & Dual Connection** 

**Lte**

-  **eMBB:** Massive MIMO, Massive CA... → xGbps
-  **mMTC:** NB-IoT & eMTC → 1M connections / km<sup>2</sup>
-  **URLLC:** short TTI → Min 1ms





# Future Target Network: LTE Evolution + NR



**5G NR:** *Extreme Experience*

**LTE Evolution:** *Ubiquitous Experience Foundation*

**2G/3G:** *User migration to 4G for better experience*

2G/3G user migration

- Low cost VoLTE feature phone

4G experience improvement

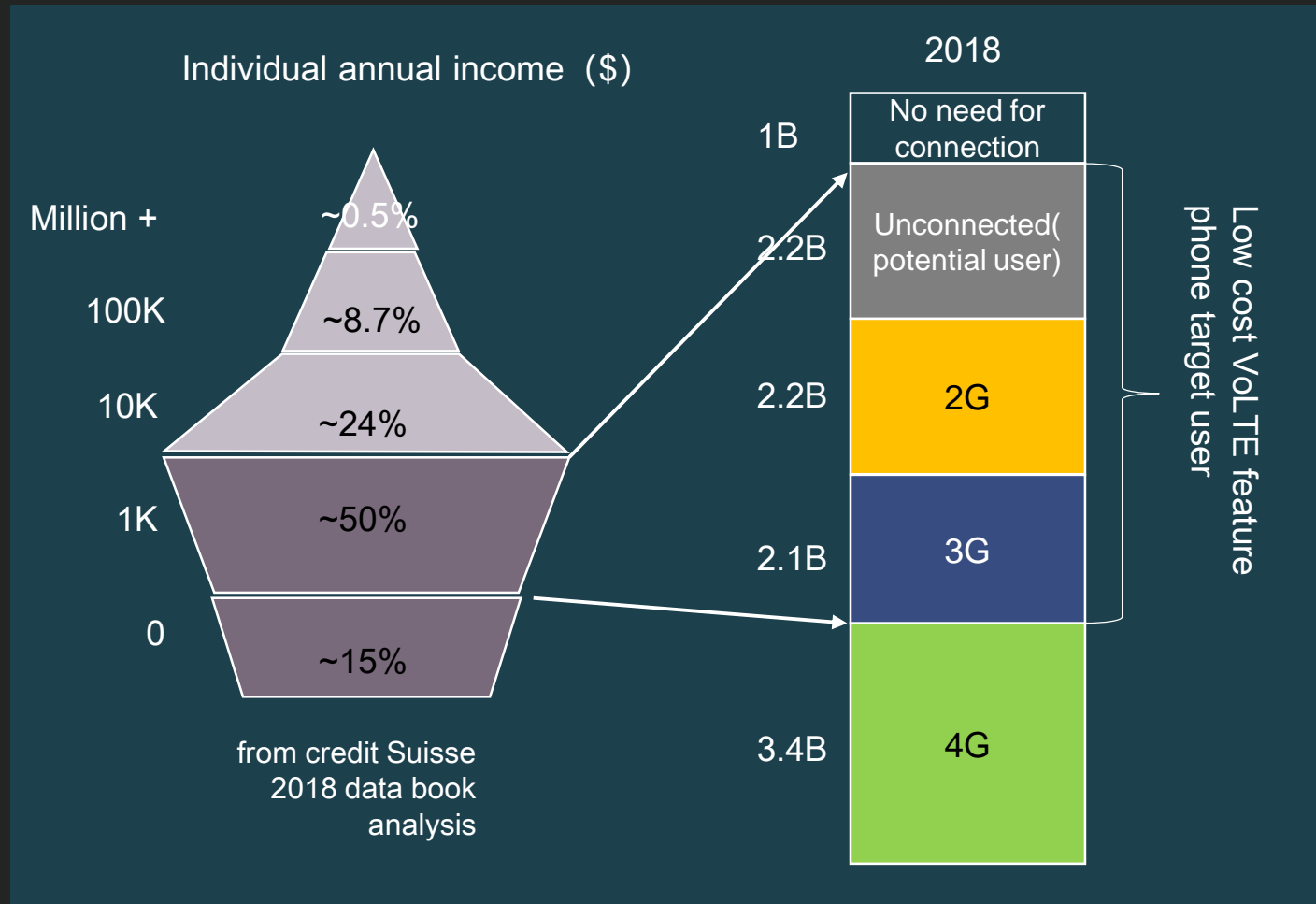
- 4Rx, TM9, SRS antenna selection, Massive CA, T+F CA, FUA, sTTI

5G +4G coordination

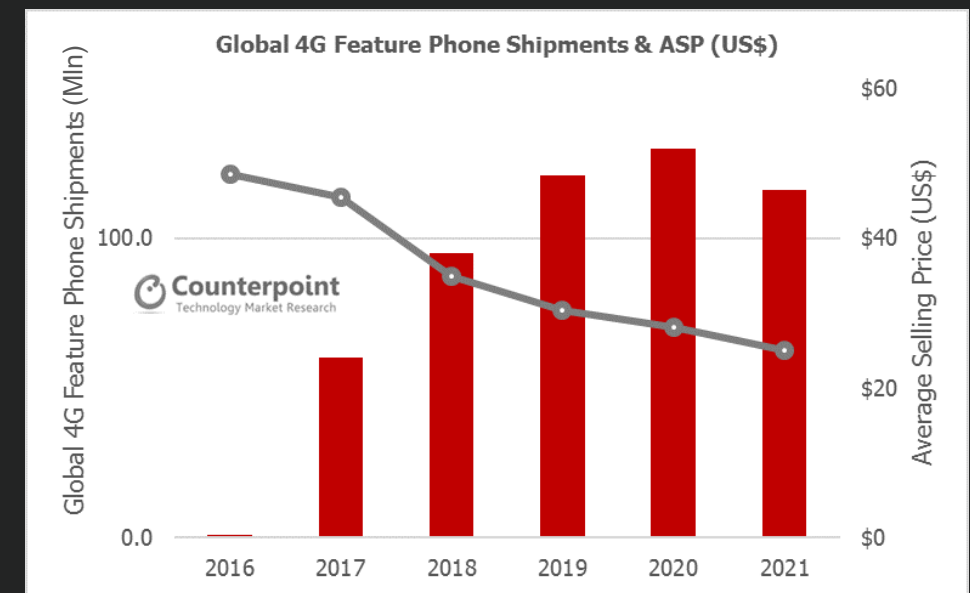
- DC, Option5
- 4Rx, TM9, SRS antenna selection, Massive CA, T+F CA, FUA, sTTI
- VoLTE

# 2G3G User Migration Requires a Large Number of Low-cost Feature Phones

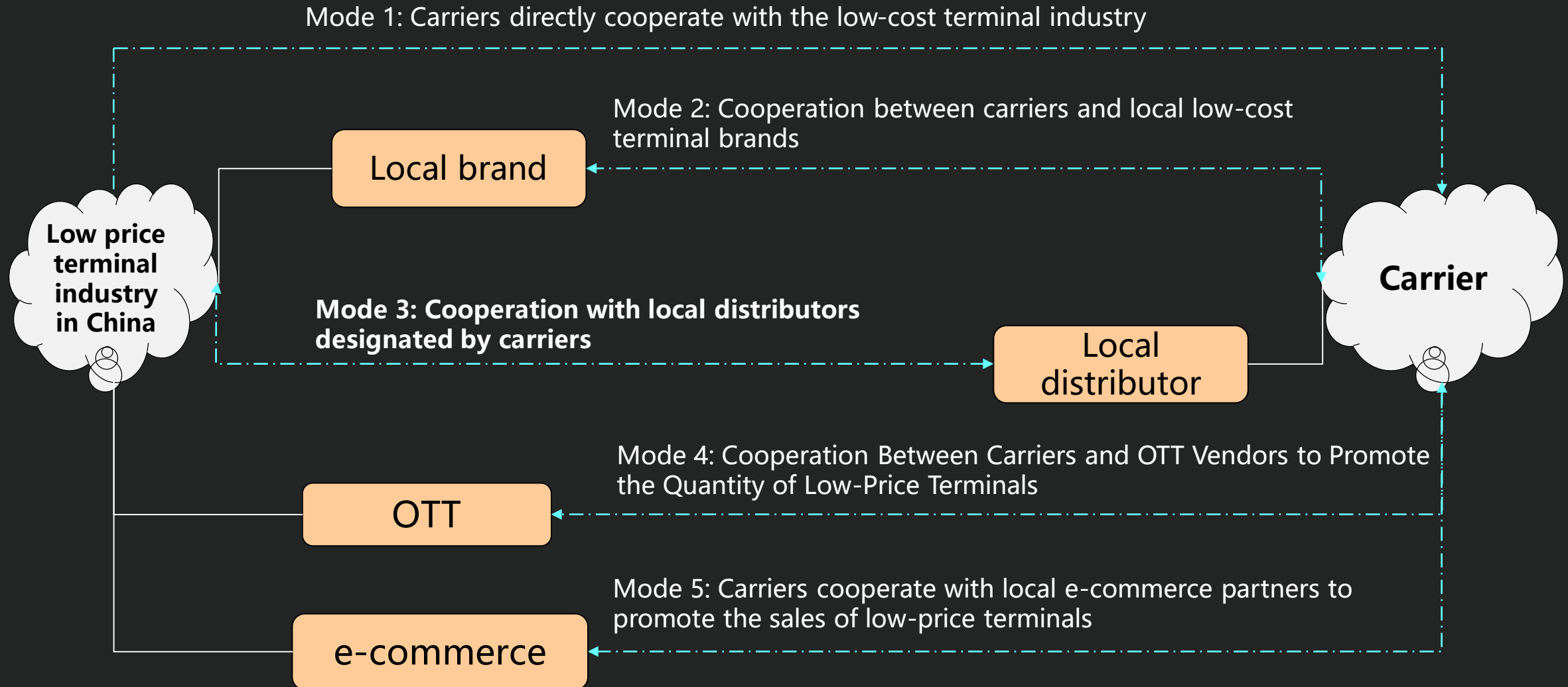
User migration in 5G era



Massive 4G feature phones are required



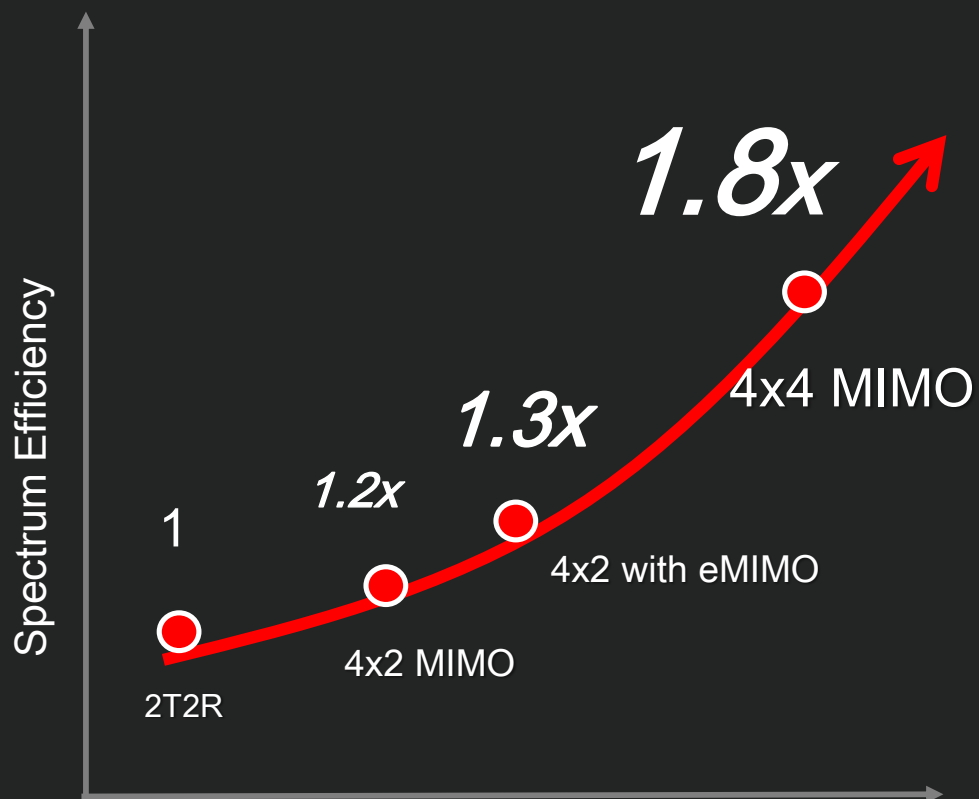
# Five Cooperation Modes to Reduce Feature Phone Channel Cost



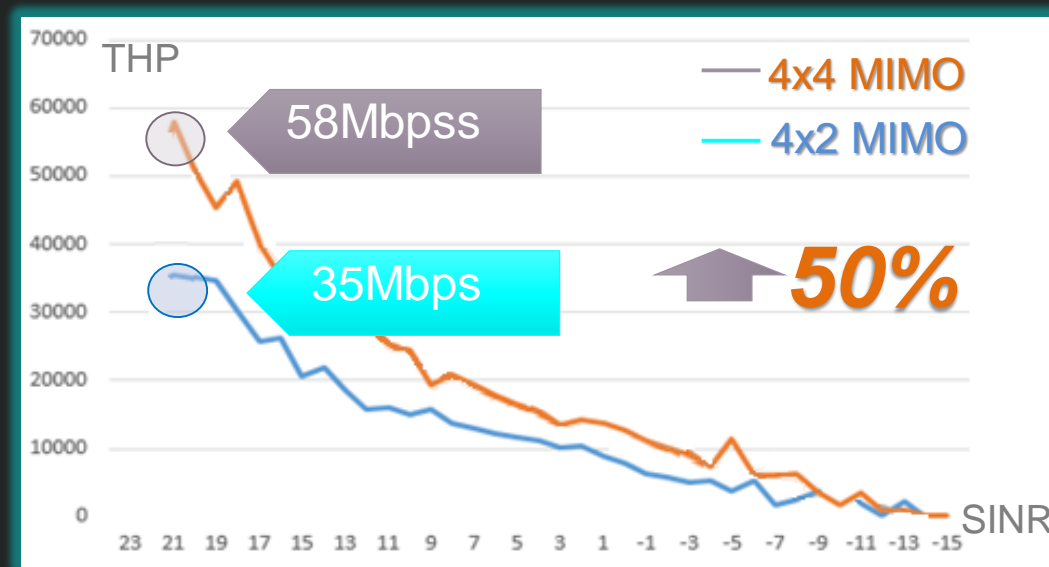


# 4x4 MIMO to Achieves Obvious Capacity and Experience Gain

## 1.8x Spectrum Efficiency with 4x4 MIMO



## DL 4x4 MIMO vs DL 4x2 MIMO User Throughput Comparison



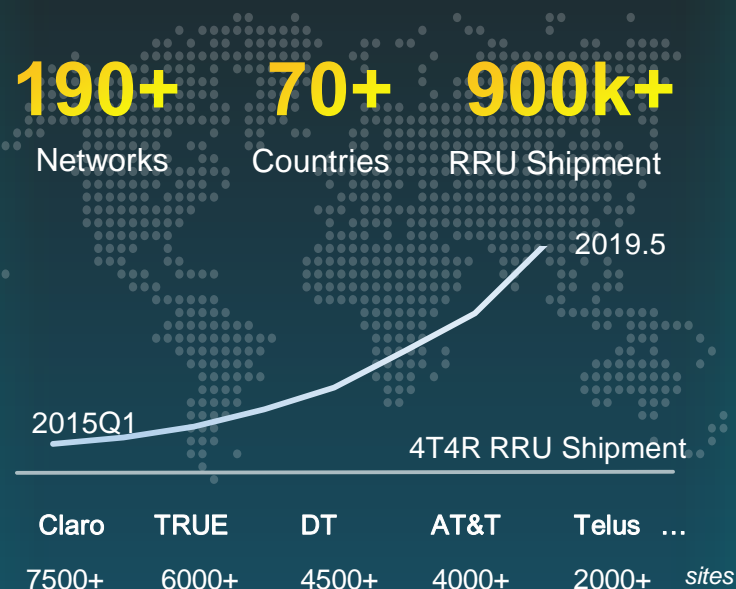
Field test in commercial network with cell bandwidth 10MHz

- Comparing with DL 4x2 MIMO, Average DL throughput of DL 4x4 MIMO can improve above **50%**.



# 4x4 MIMO Became Industry Consensus

## 190+ Networks



Full Series 4T4R RRU, Hardware Ready for 5G NR

High & Low  
Bands 4T4R

Single &  
Multi-Band

Legacy 2T  
RRU  
Combined

UL Coverage gain +3dB, Capacity +30% (2R UE) /  
+80% (4R UE) (Baseline: 2T2R, 2Rx UE)

## 60+ Smartphones

iPhone XS   Mate20 pro  
P30 Pro   Mate10 pro  
SS S10   SS Note9  
...

**60+**  
Types 4R  
Smartphones  
(SRC:GSA)

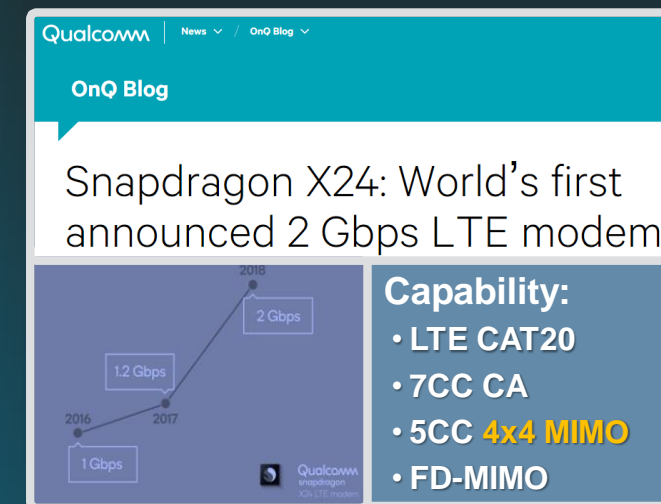
## Covers Almost All Major Brands

Apple	Samsung	HUAWEI
LG	OPPO	VIVO
MI	HTC	Sony   ASUS ...

\*Terminal may have different capabilities in different regions and countries

## Mature Chipset Ecosystem

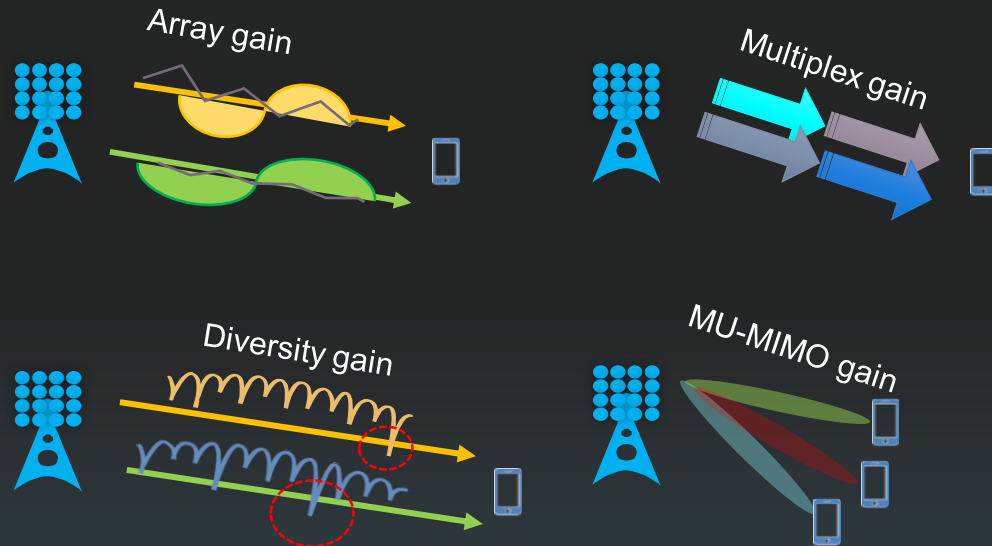
### 2Gbps LTE Smartphone is coming



Mid-range chipset support 4x4 MIMO from 2018

Qualcomm HiSilicon Samsung  
Intel GCT ...

# Operators Widely Adopt FDD M-MIMO to Improve Network Capacity



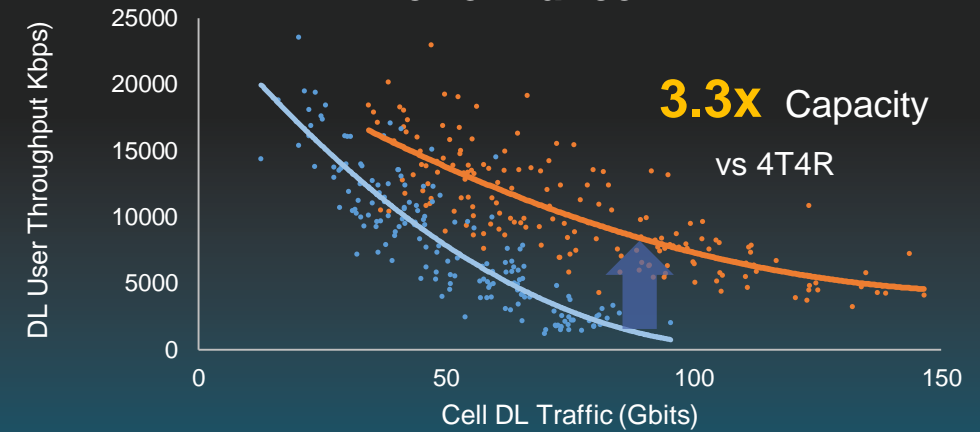
User Throughput gain

1.3~1.5x

Cell capacity gain

3~5x

## Performance



Case: Operator in Thailand

## Commercialization

World **1st** Commercial  
Scaled Deployment



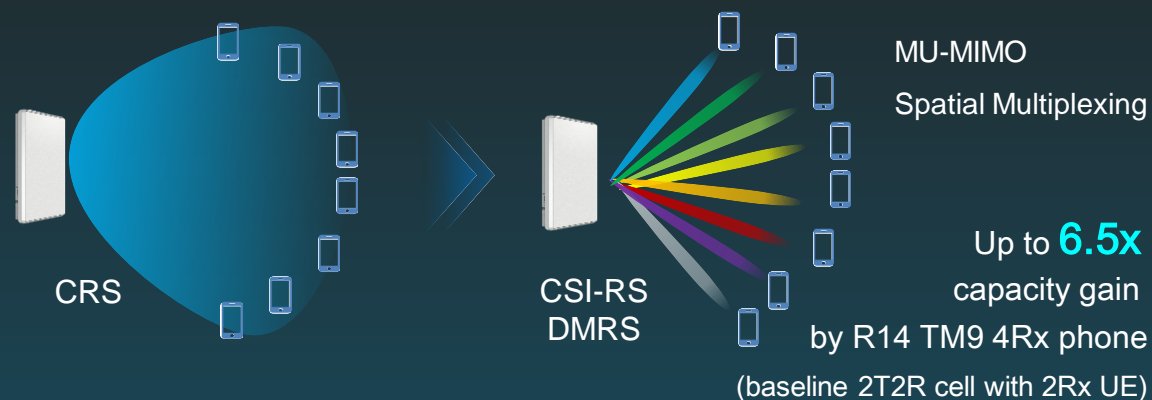
**50+**

commercial networks  
deployed M-MIMO

# TM9 Enables FDD M-MIMO to Offer Dynamic Beamforming

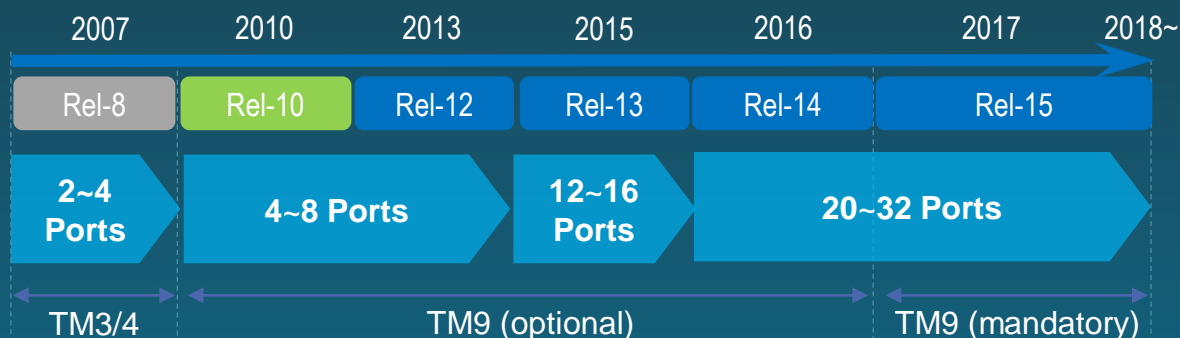
## Beamforming Enabled by TM9

### UE-level Dynamic Beamforming



UEs use the **dedicate** RB resource      UEs **share** the same RB resource

### TM9 continuously evolution in 3GPP protocol



## TM9 Ecosystem is Taking Off

All Mainstream chipset already support TM9.

**20+** phones activated TM9

Huawei	Sony XZ	SS	OPPO	VIVO	Xiaomi	
Mate20	Premium	S9	R15	X21	MIN2S	...

**30+** Commercial Networks activated TM9

HKT, Turkcell, ...

### Joint white paper regarding to TM9 industry

Drafted by:

China Unicom  
Huawei  
Ericsson

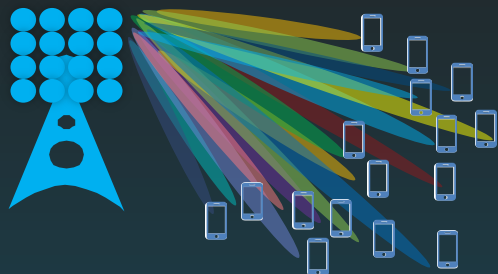
Qualcomm  
Intel  
SAMSUNG

Mediatek  
VIVO

Scan QR code to  
download the  
whitepaper:



# TDD M-MIMO, Massive Deployed in the World



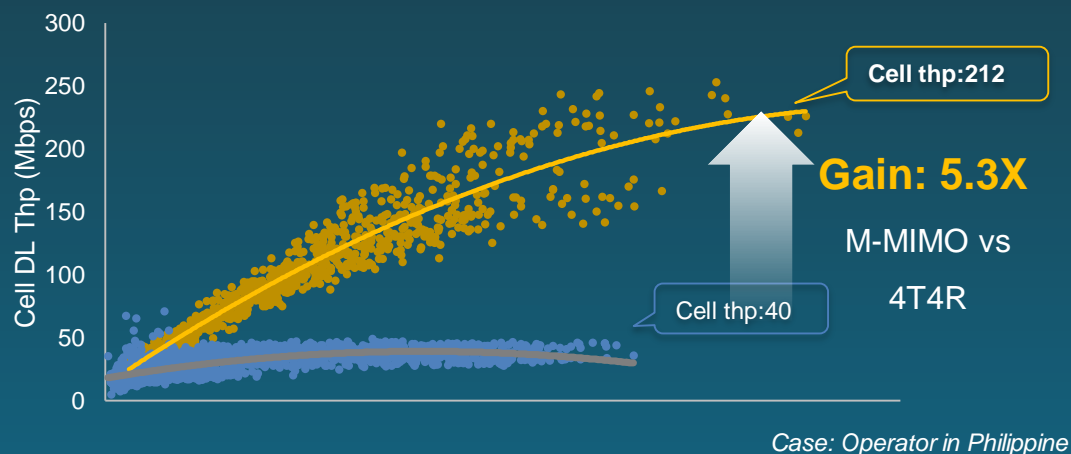
## Up to 5x Capacity

- 16 Streams @ Downlink
- 8 Streams @ Uplink

Hardware ready for 5G NR

### Baseline:

- TDD 20MHz 4T4R or 8T8R or FDD 2T2R paired 20MHz.
- May vary with traffic load, user distribution, traffic patterns.



## Global Commercial Progress

50+

Commercial Networks

100K+

Massive MIMO sales

China Mobile

SoftBank

T-Mobile

Globe

Vodafone

Telefonica

Hi3G

Bharti Airtel

Smart

Axiata

entel

## Best Commercial Proven Performance



China CBD

**3x** Tput / 400 users



Japan Festival

**5x** Tput / 600 users\*



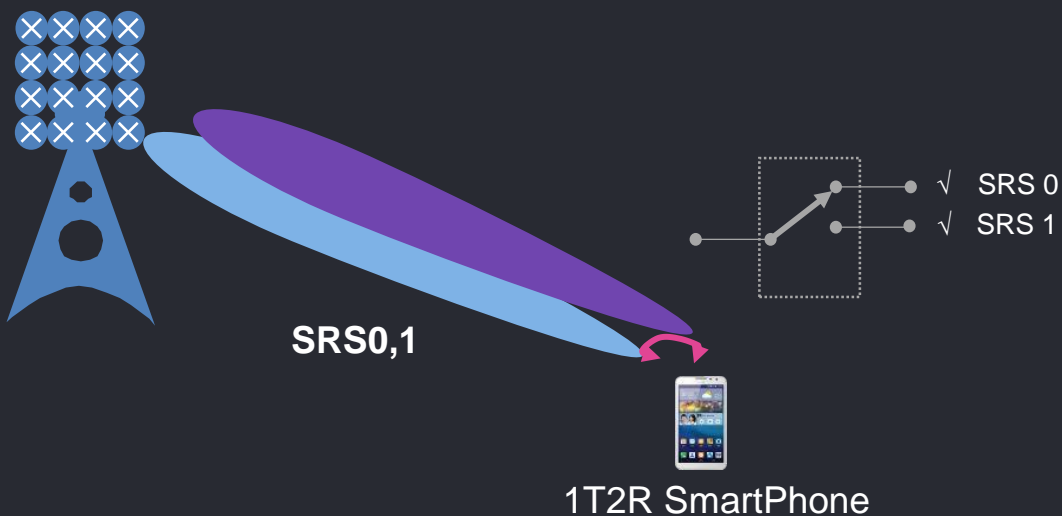
Philippines WTTx

**5x** Tput / ~130 users

# SRS 2T/4T Antenna Switch Significantly Improve User Experience

## Two Antenna Switch , More Accurate Estimation

8T8R or Massive MIMO



- More accurate downlink beamforming weight

## SRS Antenna Switch Increase User Experience



eNB:20MHz,8T8R  
Field Test in Shenzhen

UE: Qualcomm MSM8998  
Model(1T2R)  
Support SRS Antenna Switch

Near Point: **+36.78%**    Middle Point: **+33.81%**    Far Point: **+9.73%**

Descripti on	MAC Throughput DL(Mbit/s)	Gain (Ant vs Unant)
OFF-1	27.82	35.50%
ON-1	37.69	
OFF-2	27.46	42.01%
ON-2	38.99	
OFF-3	28.09	35.30%
ON-3	38.01	
OFF-4	29.27	38.48%
ON-4	40.53	
OFF-5	30.29	34.04%
ON-5	40.61	
OFF-6	28.05	24.68%
ON-6	34.98	
OFF-7	27.52	47.92%
ON-7	40.7	
OFF-8	27.75	36.33%
ON-8	37.83	
average gain		36.78%

Descripti on	MAC Throughput DL(Mbit/s)	Gain (Ant vs Unant)
OFF-1	53.54	31.06%
ON-1	70.17	
OFF-2	51.89	37.90%
ON-2	71.56	
OFF-3	53.82	37.18%
ON-3	73.83	
OFF-4	52.61	32.58%
ON-4	69.76	
OFF-5	51.12	34.88%
ON-5	68.95	
OFF-6	50.74	31.79%
ON-6	66.87	
OFF-7	52.16	33.02%
ON-7	69.38	
OFF-8	50.8	32.07%
ON-8	67.09	
average gain		33.81%

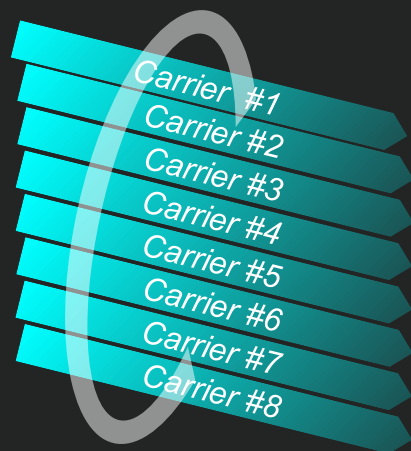
Descripti on	MAC Throughput DL(Mbit/s)	Gain (Ant vs Unant)
OFF-1	78.32	12.57%
ON-1	88.17	
OFF-2	80.68	7.55%
ON-2	86.77	
OFF-3	80.84	4.69%
ON-3	84.63	
OFF-4	82.22	9.57%
ON-4	90.08	
OFF-5	82.46	5.77%
ON-5	77.95	
OFF-6	82.79	6.06%
ON-6	78.06	
OFF-7	69.4	15.59%
ON-7	80.22	
OFF-8	77.38	16.07%
ON-8	89.81	
average gain		9.73%



# Massive CA to Reach Gbps Peak Throughput

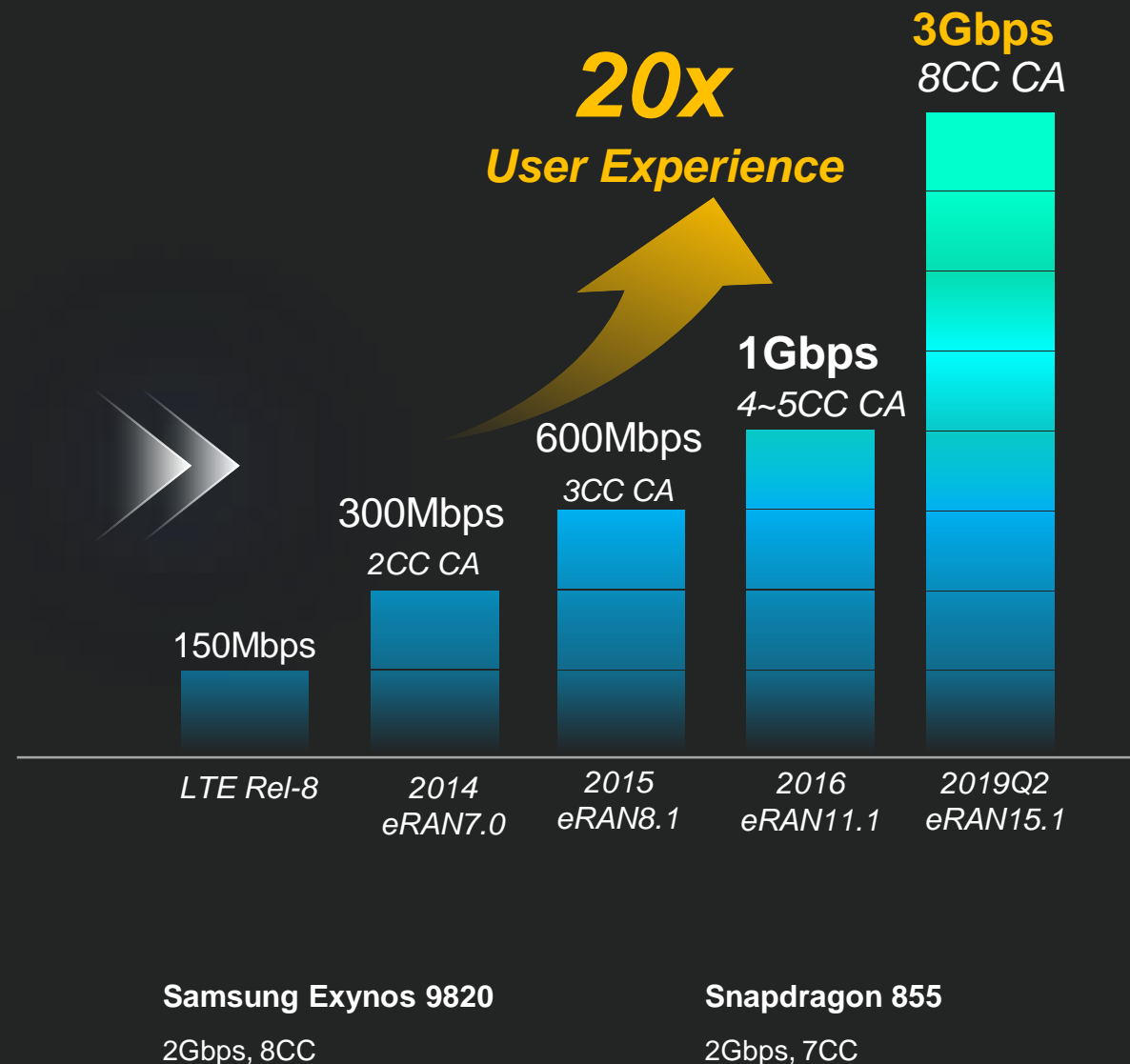


## 3Gbps Peak Rate



- 8CC CA (FDD+TDD)
- 4x4 MIMO
- 256QAM

- 26 networks released **Gbps** network;
- 160 devices support **1Gbps**;
- 8 devices support **5CC** CA;
- **1.4Gbps** achieved with Galaxy S10+ in Australia commercial network(**6CC** CA)



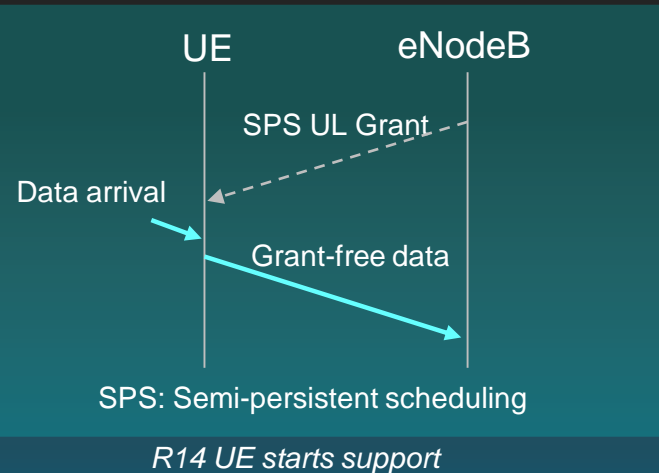
# Low Latency is Inspiring New Business Opportunities

Phase I: One Way Latency < 25ms @ Radio (even at cell edge & heavy load)

## Radio Scheduling Acceleration

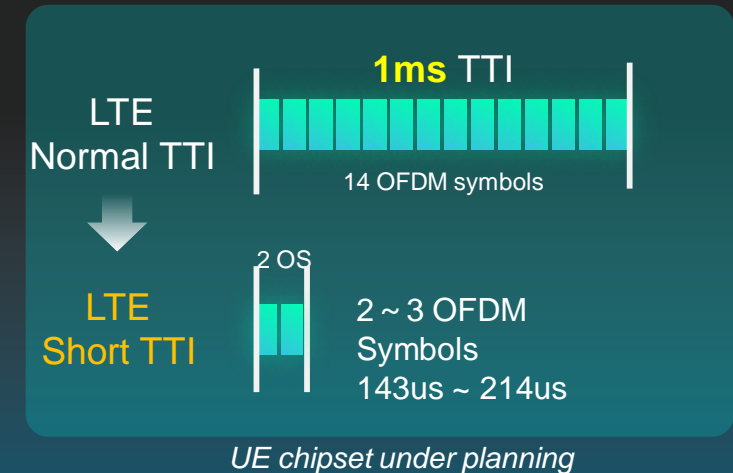


## Fast Uplink Access (R14)

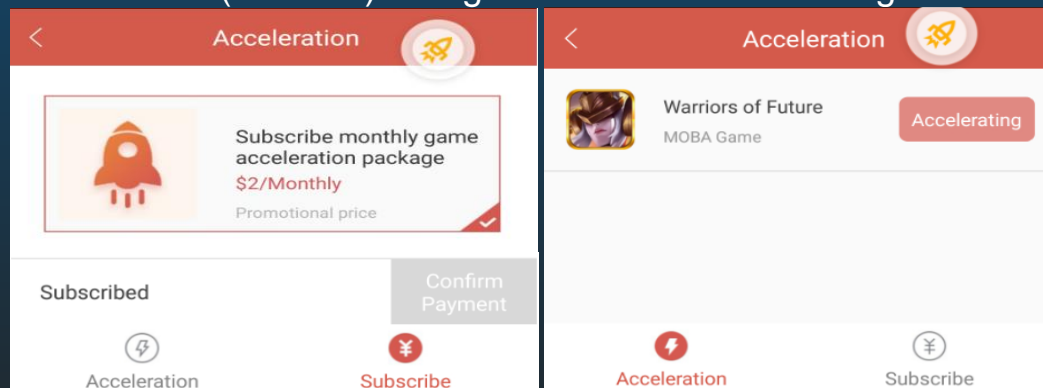


Phase II: One Way Latency 1~10ms @ Radio

## Short TTI (R15)



## China Mobile(Sichuan) charge for service accelerating



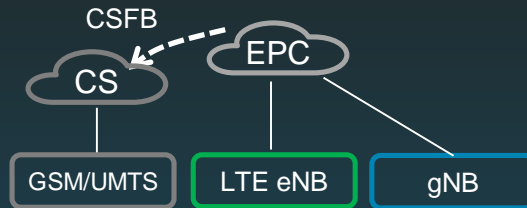
## Users are willing to pay for low latency experience



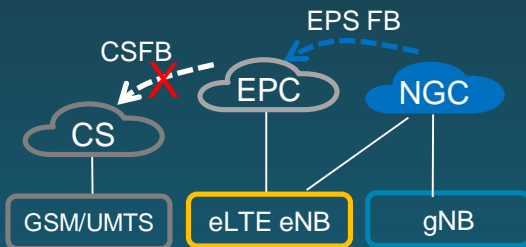
**2 Million** Game Users/Month pay for low latency experience

# Large Market Demand for VoLTE Phone

## VoLTE is 5G Voice Foundation

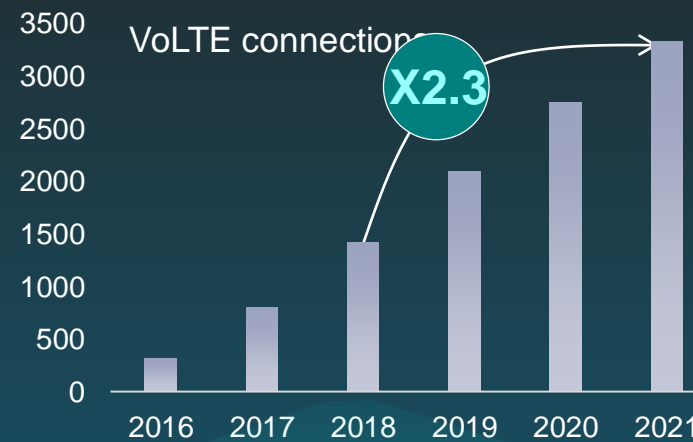


- EPC is not connected to IMS
- CSFB Access delay > 6s



- Voice call could **NOT** be established because the protocol was not defined

## 2x VoLTE Connections@2021



中国移动  
China Mobile

**356M** VoLTE users: **53.4%**  
of 4G users

1. VoLTE/ViLTE snapshot of 2019 (GSA)
2. VoLTE Market Growth and Network Deployment Trends (Ovum)
3. CMCC 2018 annual report

## Mature VoLTE Ecosystem

188



VoLTE  
Networks

2142



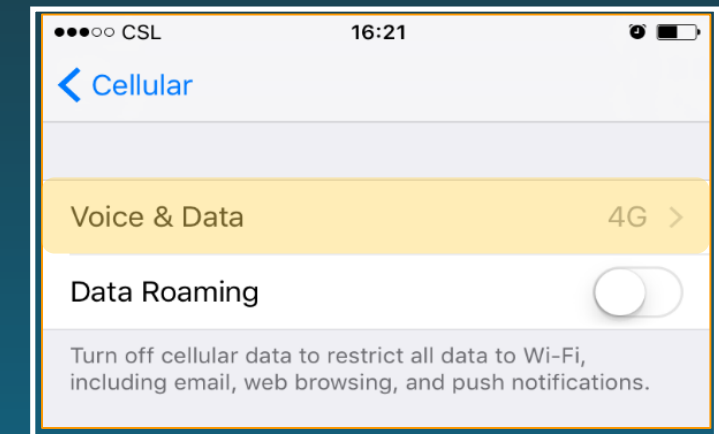
VoLTE  
Devices

<20\$



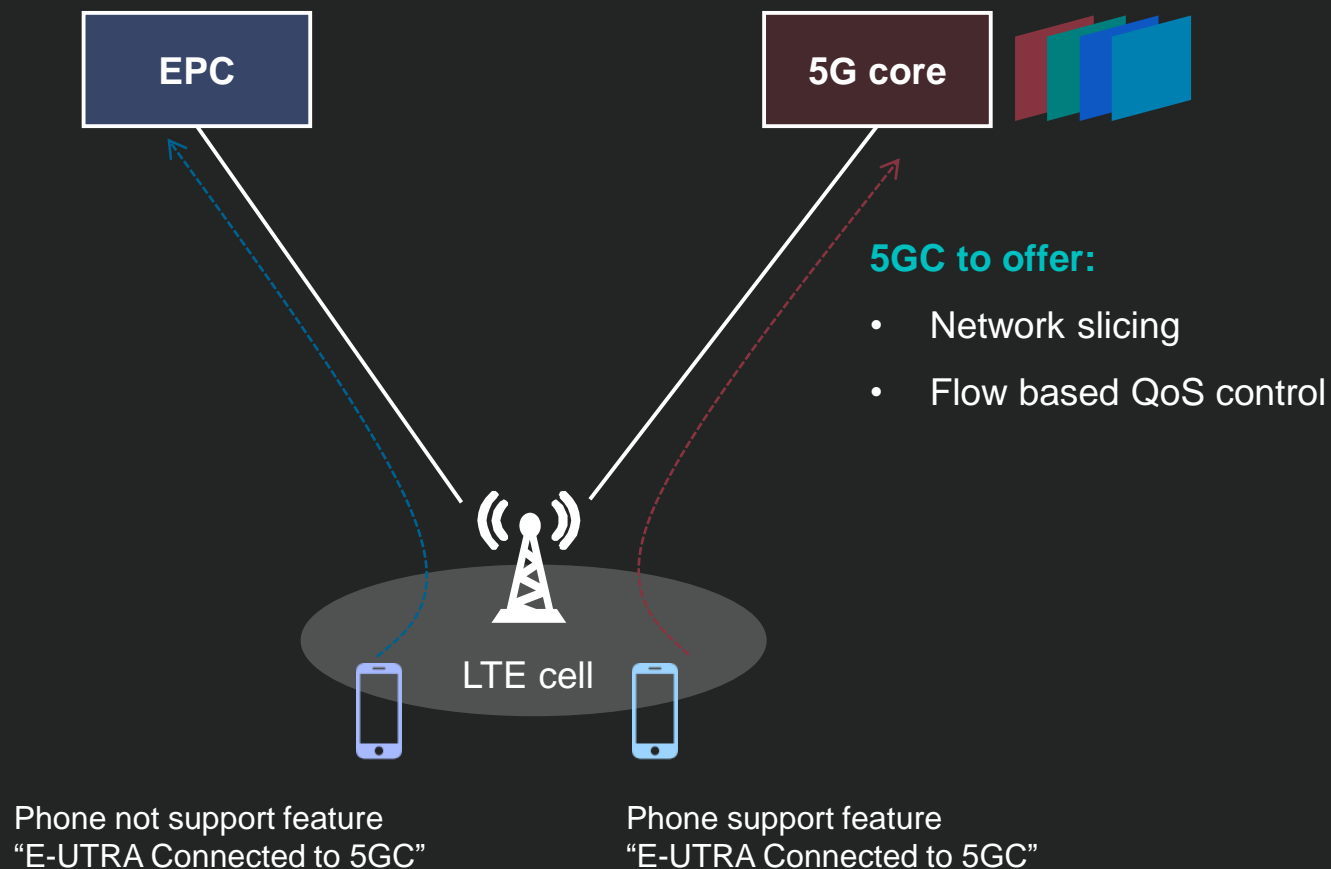
Low Cost  
VoLTE Phones

**Recommend Phone to Switch on VoLTE by Default**



# LTE Phone Connect to 5GC to Get 5G-Like Experience

## Connect to 5GC



Phone connect to 5GC to achieve:

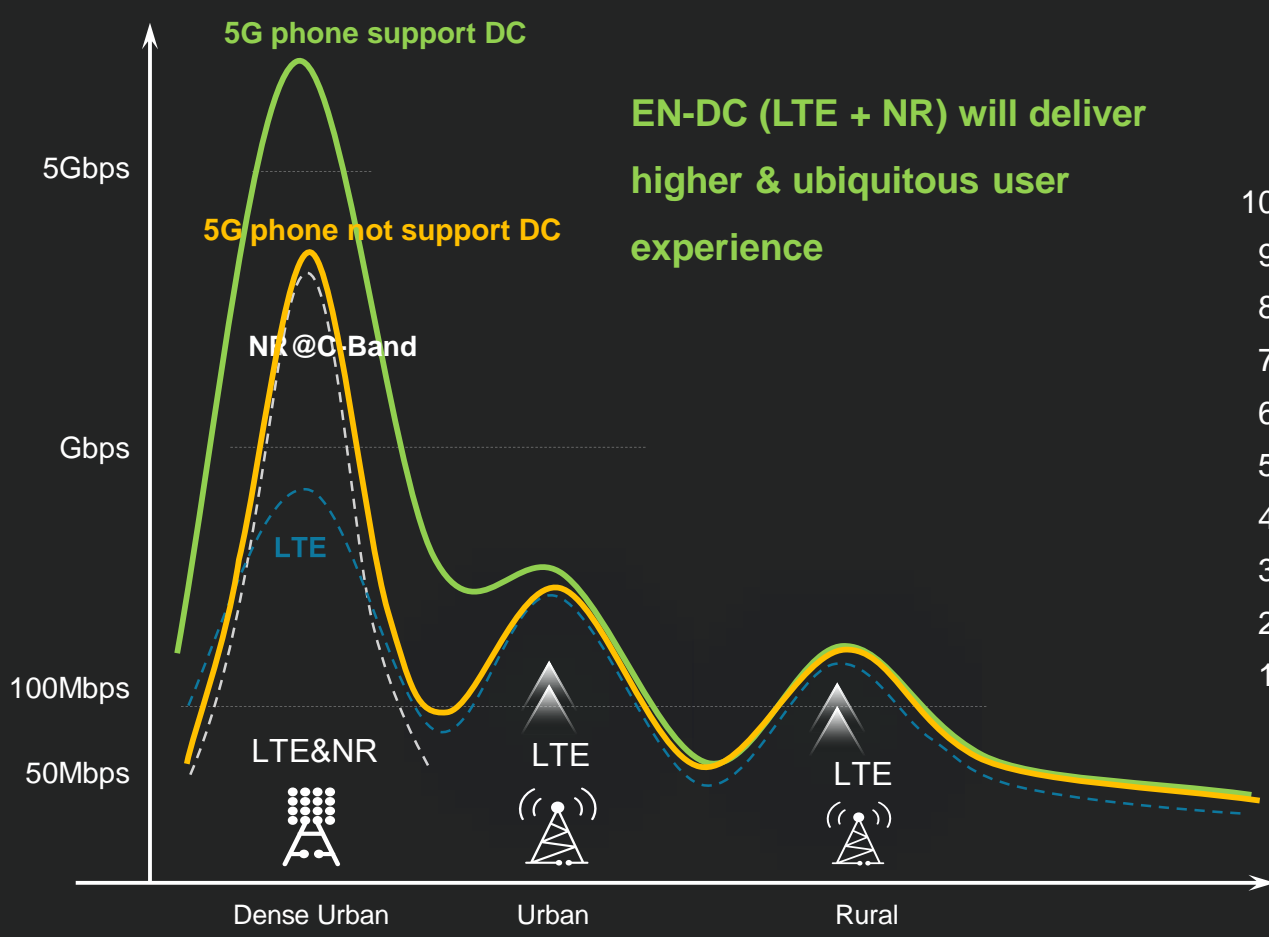
- 5G-like service experience (Game, Sports on-line video, VR/AR...);
- Fast launch 5G new service by LTE network;

Easy to implement on Phone :

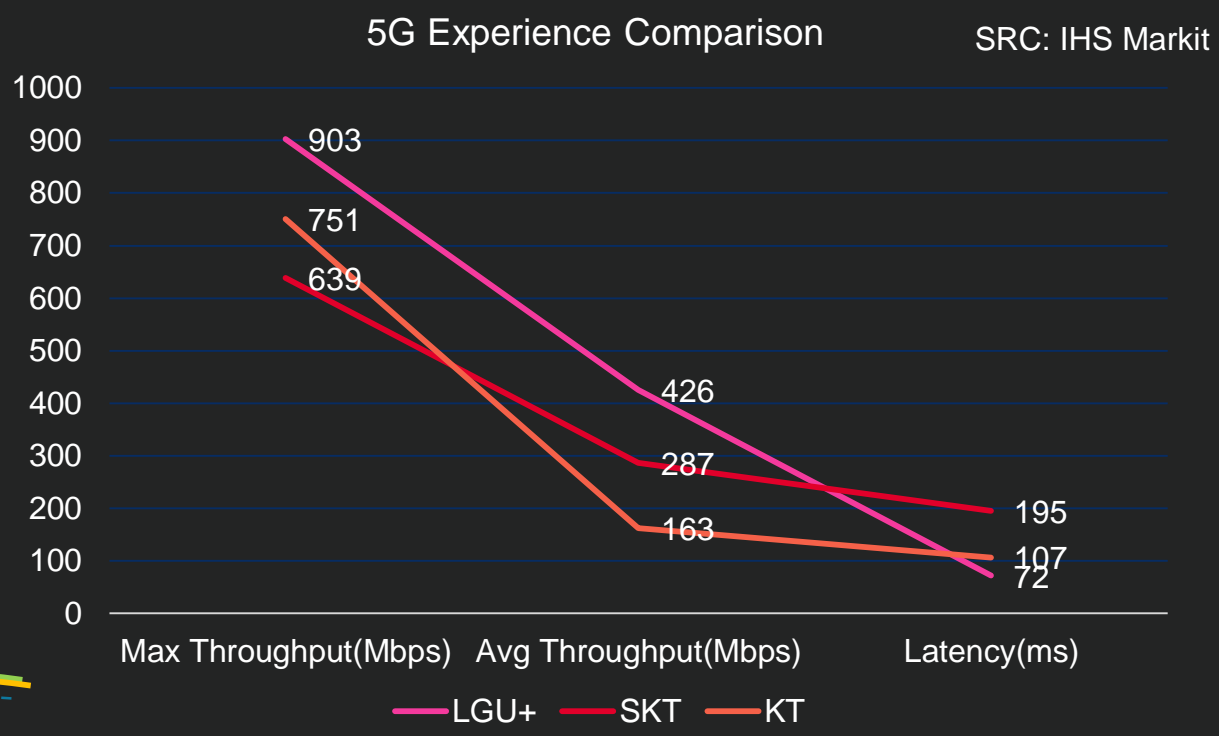
- No hardware change;
- Support R15 "E-UTRA Connected to 5GC" related protocol.

# EN-DC Boost 5G User Experience with Broad LTE Coverage

## EN-DC Enables Higher Experience for DC UE

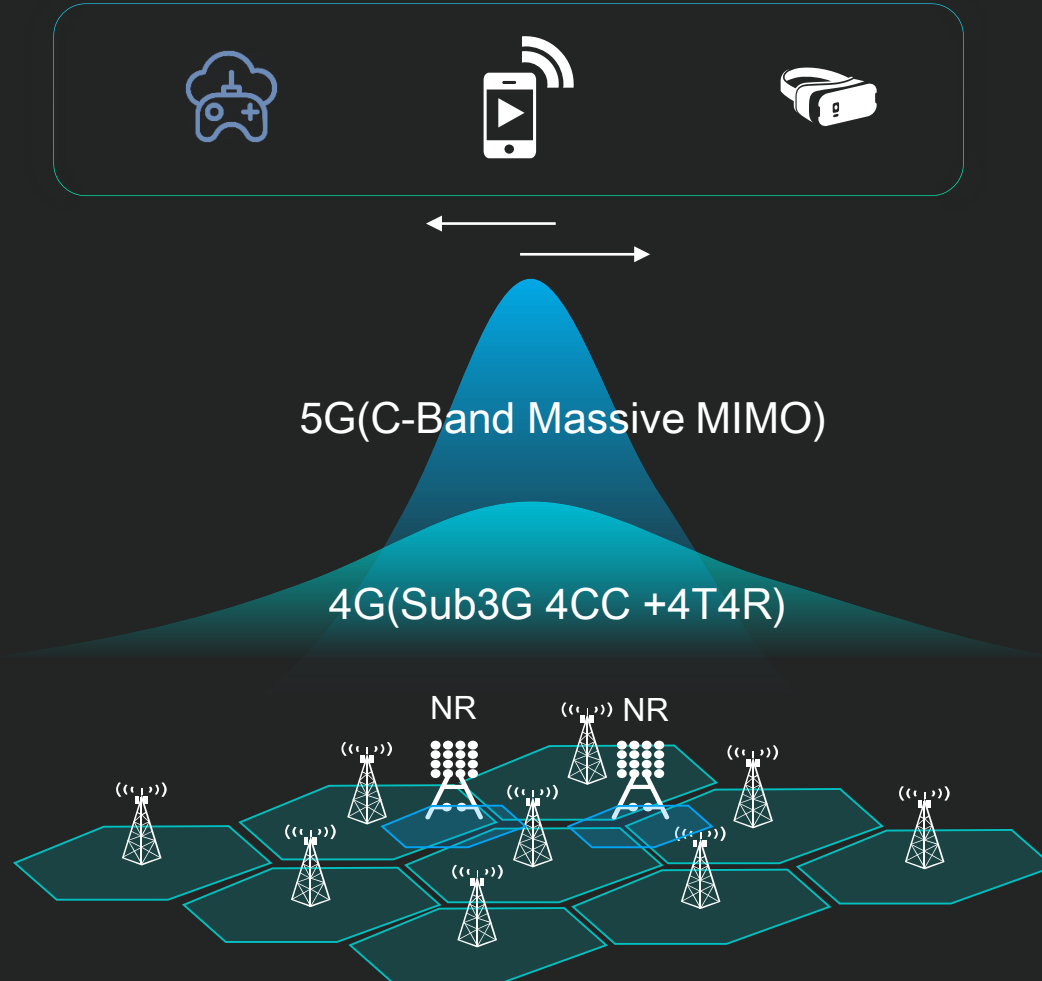


## U+ win best throughput and latency with DC enabled





# Service experience continuity Demand 5G phone to support LTE evolution features



5G phone dual mode phone to support LTE evolution features to achieve smooth experience between 5G and 4G:

- 4Rx,
- TM9,
- SRS antenna selection,
- Massive CA,
- T+F CA,
- sTTI

# Summary

Category	Industry Trend	Impact on Mobile Phones
2G/3G user migration	2G/3G will gradually refarming to 4G	Huge requirement on low cost VoLTE phone
4G Capacity and experience improvement	4T4R is basic configuration in 5G era	4Rx phone can get better experience
	Massive MIMO is being used to improve capacity	Phone support TM9, SRS antenna selection can get better experience
	Massive CA is being used to improve user experience	Phone support Massive CA, T+F CA can get better experience
	Operators are offering low latency based service	Phone support FUA, sTTI to achieve short latency
5G +4G coordination to build 5G era target network	LTE+NR coordination to build 5G era target network	Support DC, connect to 5GC to get better experience;
	LTE will be 5G era experience foundation	5G phone support 4Rx, TM9, SRS antenna selection, Massive CA, T+F CA, sTTI to achieve smooth experience between 5G and 4G
	VoLTE will be 5G era voice foundation	VoLTE default on

# Thank you.

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

**Copyright©2019 Huawei Technologies Co., Ltd.  
All Rights Reserved.**

The information in this document may contain predictive statements including, without limitation, statements regarding the future financial and operating results, future product portfolio, new technology, etc. There are a number of factors that could cause actual results and developments to differ materially from those expressed or implied in the predictive statements. Therefore, such information is provided for reference purpose only and constitutes neither an offer nor an acceptance. Huawei may change the information at any time without notice.

