4G Radio Access Network Solution

ZHU LONGMING

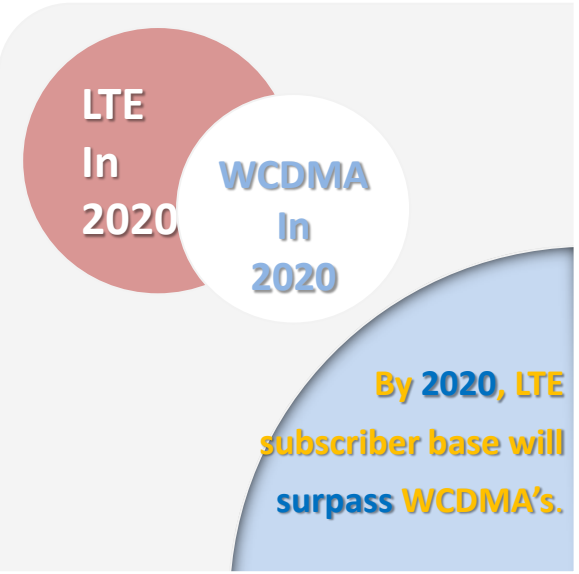
Chongqing, China
20, October 2016

ZTE
Tomorrow never waits

Part I

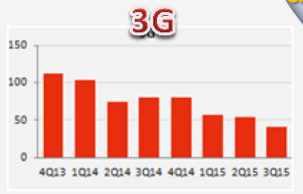
Convergence

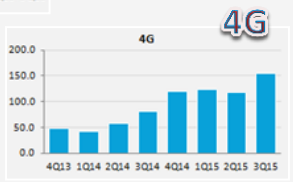
4G Dominating the Growth of Mobile World



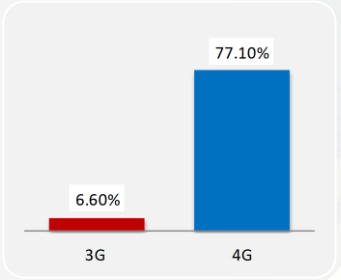
By **2020**, LTE subscriber base will **surpass** WCDMA's.

In last 8 quarters, net addition of WCDMA is downward, while LTE is growing

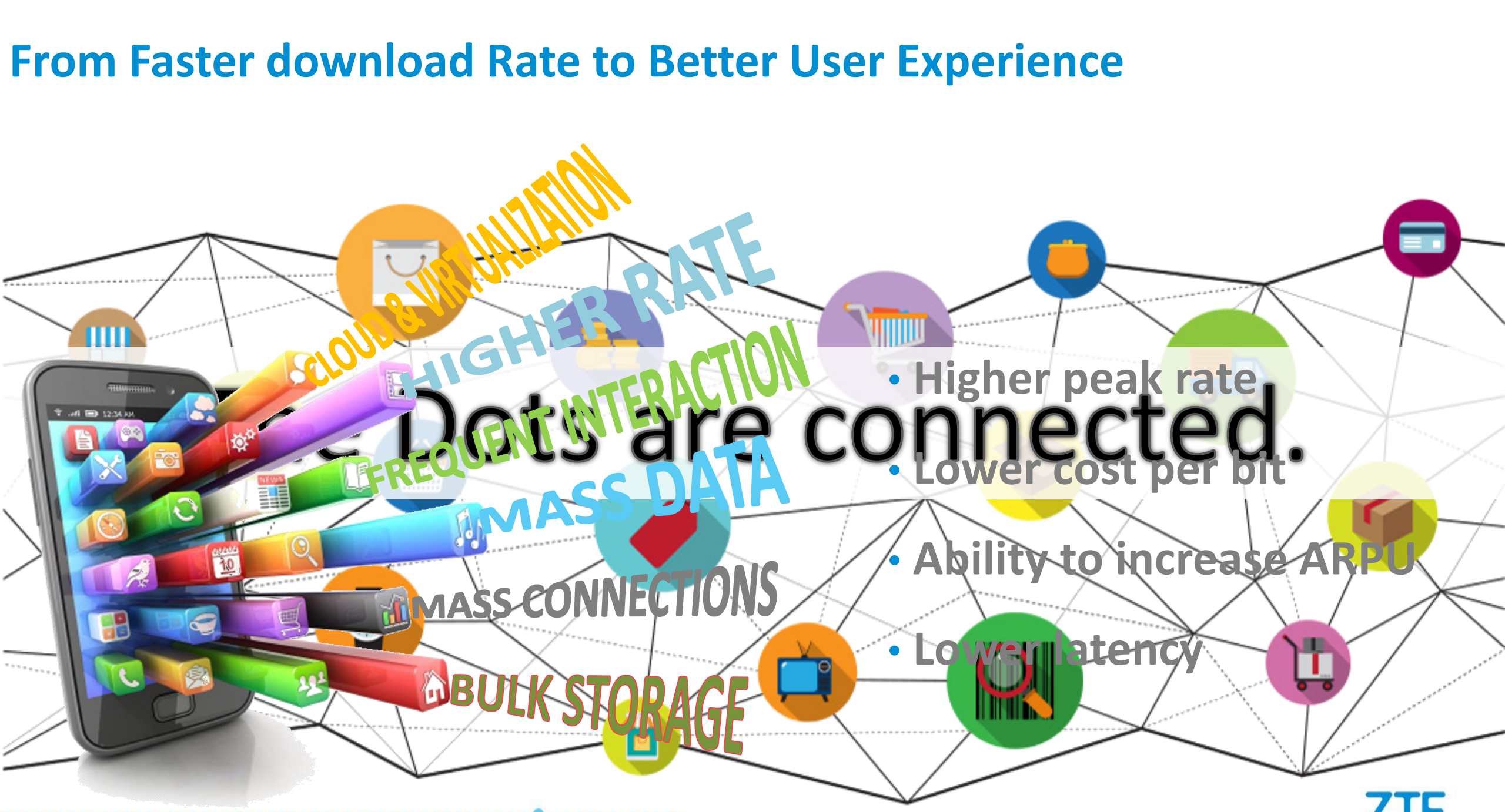




Growth by Generation in last 4 quarters, 4G is **77%**, 3G is **6.6%**.



From Faster download Rate to Better User Experience



Convergence Ongoing: Spectrum & Technology

5G, Future down the Road

Visions: 2020-2030

5G

Network Architecture
Slicing
Ability Required

Mobility
500 km/h
High-speed Railway

Connections
1,000 k
Connection Per KM^2

Throughput
10 Gbps
Per Connection

Latency
1 ms
E2E Latency

Applications

- Smart City
- Smart Device
- Smart Car
- New User Experience

Superior LTE Network – Coverage, Efficiency & Experience

Better Coverage Everywhere

Macro Coverage

Multi mode, High capacity & Easy deployment

Deep Coverage

Zero Footprint & Fast Deployment

Indoor Coverage

The art of performance & cost

Higher Spectral Efficiency

Virtual 6 Sectors

Better User Experience

CA

HD Video

eVoLTE

4G

High Efficiency MBB

Pre 5G

Coordinated Ultra MBB

5G

Everything Connected

Part II

Coverage

①Macro Coverage - New RRU, Ultra High Speed Access

World smallest

4T4R RRU

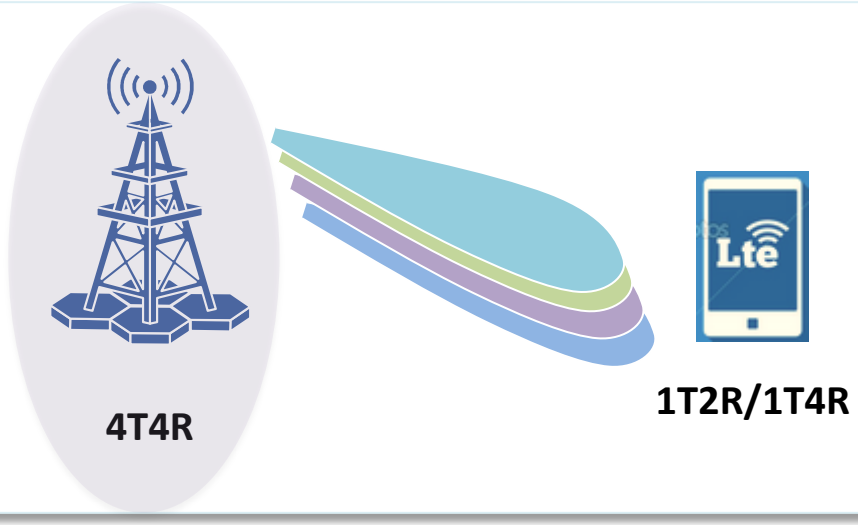
- 4*4 MIMO
- 12L / 4*40W
- More powerful & more flexible

World smallest

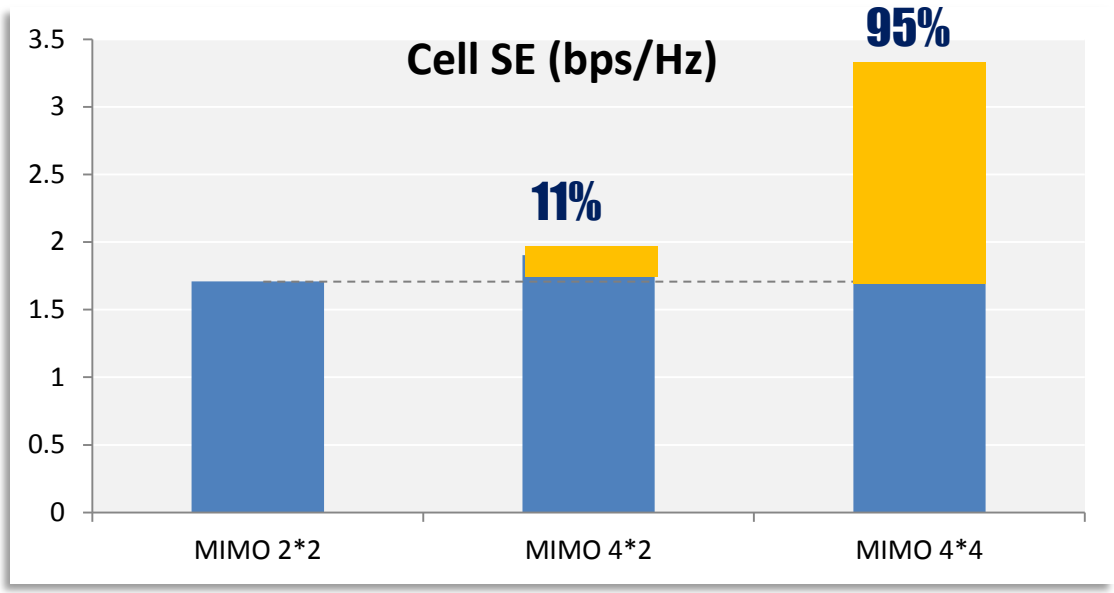
2T RRU

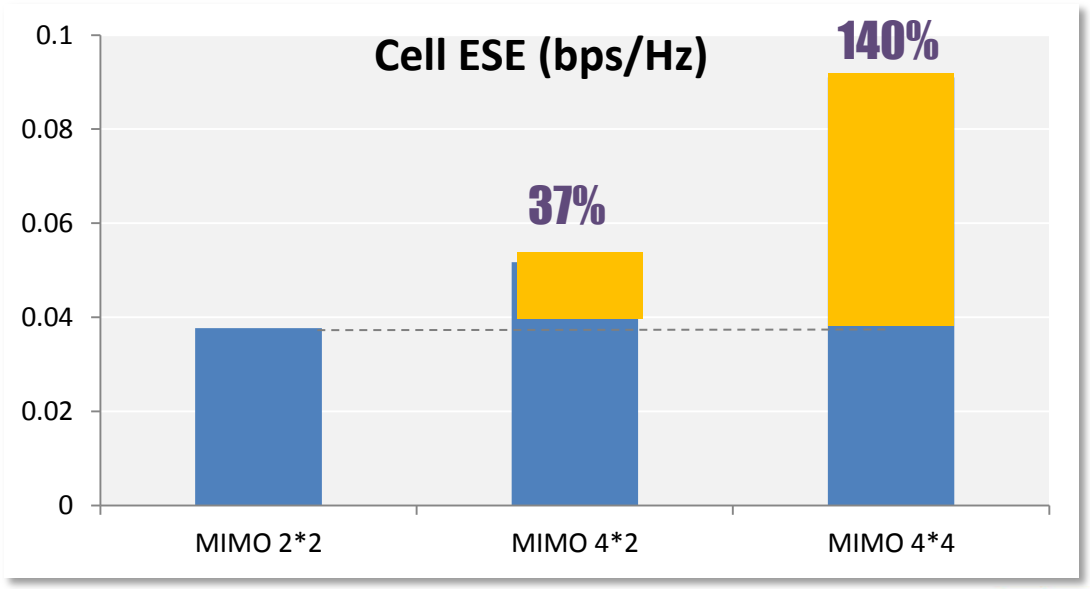
- Full bandwidth
- 2T2R & 2T4R
- 2*60W@8L/2*80W@12L
- Powerful but smaller

4*4 MIMO – Improving Network Capacity



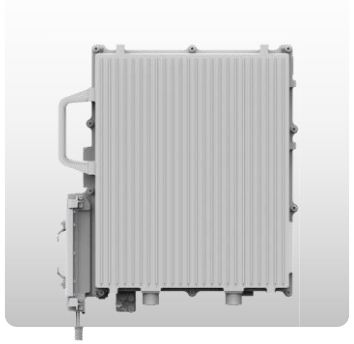
- 4*4MIMO has >90% capacity gain than 2*2MIMO while edge users enjoy 140% capacity gain from 4*4 MIMO
- Cell throughput improvement with 4*4 MIMO mainly benefits from the increase of 2-stream UE ratio





Simplify Network Deployment with UBR

Commercial 2T UBR



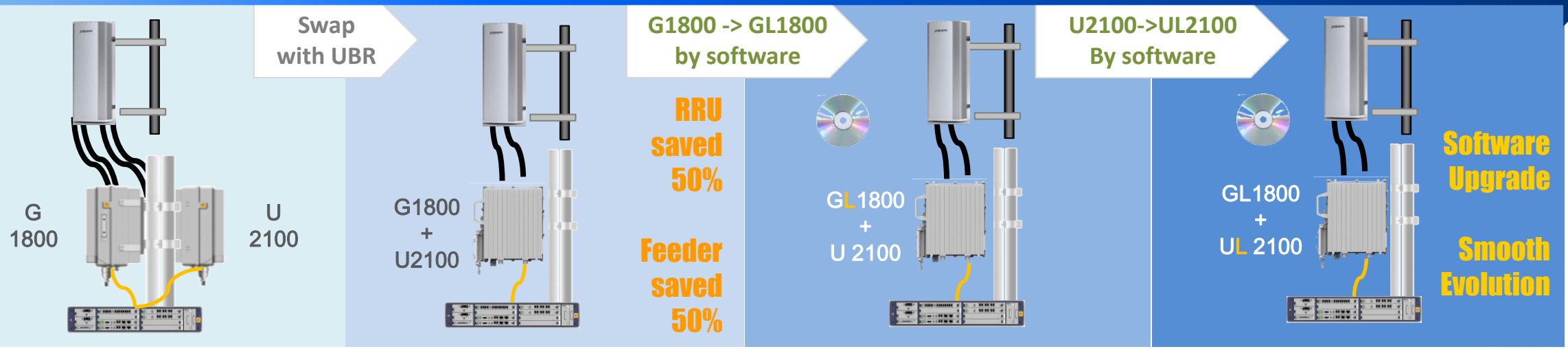
Industry 1st 365M Ultra Broadband RRU!
Commercially deployed
16L/16KG
2T2R, 2*100W

Commercial Case

AIS

- AIS in Thailand
- 5000+ Units Deployed
- 1.8G LTE + 2.1G UMTS/LTE

2 in 1, UBR simplify the configuration greatly GUL Multi-mode, UBR supports smooth evolution



ZTE

②Deep Coverage – Product Portfolio for Coverage Everywhere

iMacro
macro coverage with zero footprint

- *UBR AAU @ 16L/15KG*
- *L/GL/UL/GU/ GUL*
- *1.8G ~2.1G Ultra broadband*
- *2*40W*

Pole/wall
zero-footprint installation
Great for **street coverage, etc.**

Pad BBU/RRU
invisible deployment

- *Pad BBU 4L/4kg*
- *Pad RRU, 4.9L/5Kg 2*5W,2T2R, L: 2CS U: 4 CS*

Known as "**Invisible Deployment**"
For **deep coverage** in **downtown & scenic area**.

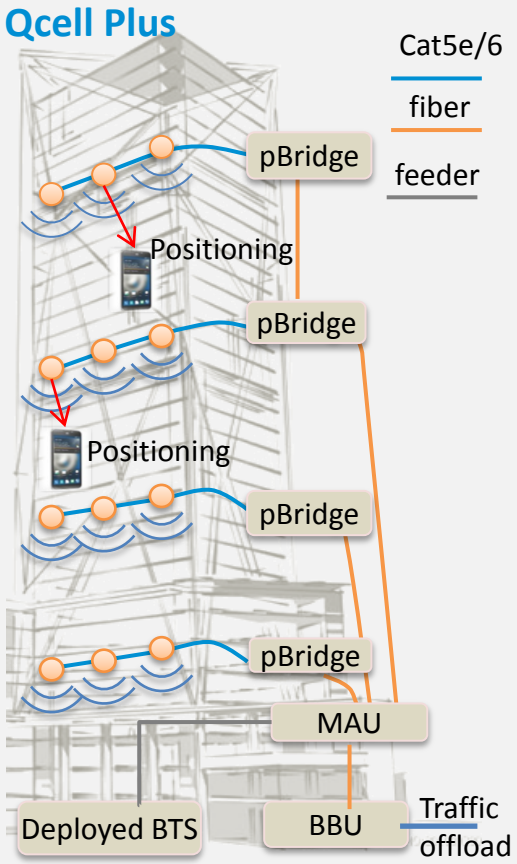
BS8922
micro BTS for hot & blind spot

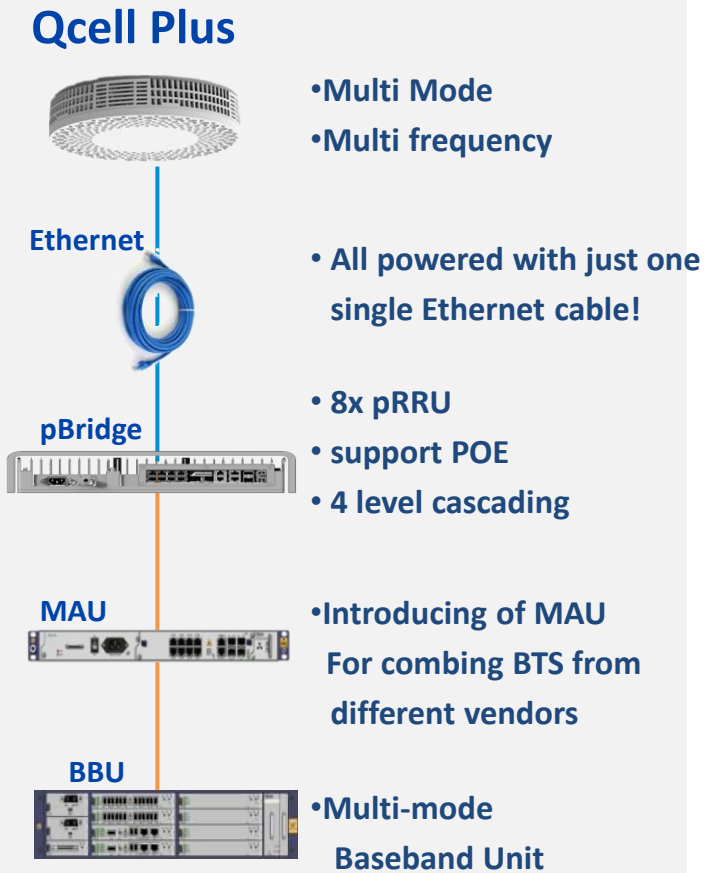
- *7L/8Kg*
- *2*5W*
- *U/L*
- *1.8/1.9/2.1*
- *Support cascading Pad RRU*

BBU-and-antenna-integrated
for **all-in-one deployment**
for **Hot & Blind Spot Coverage**

③Indoor Coverage – Qcell Plus, LAA-enabled

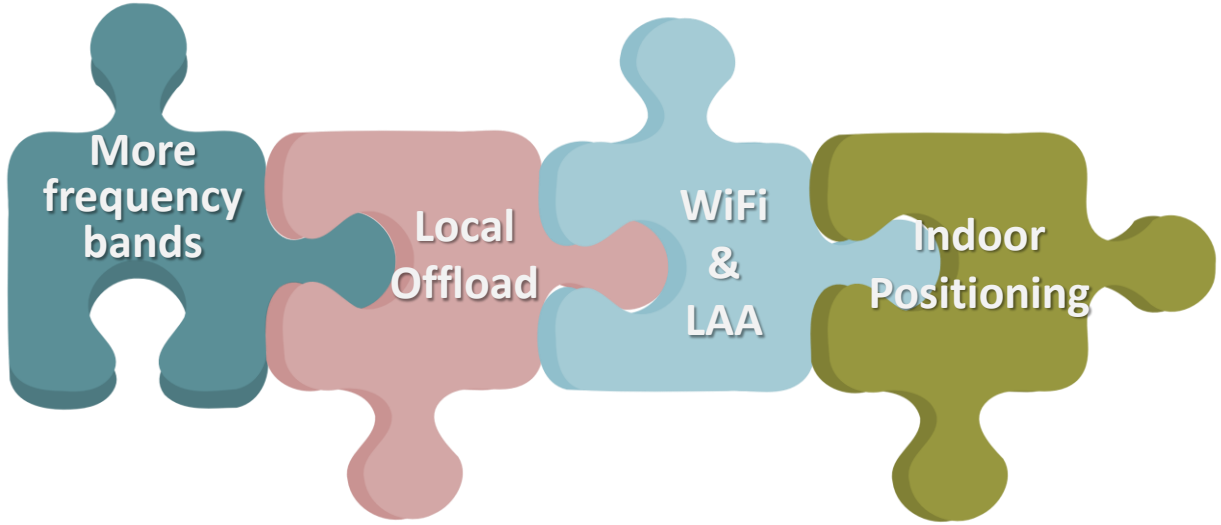
Multi-mode & multi-freq. with single Ethernet cable





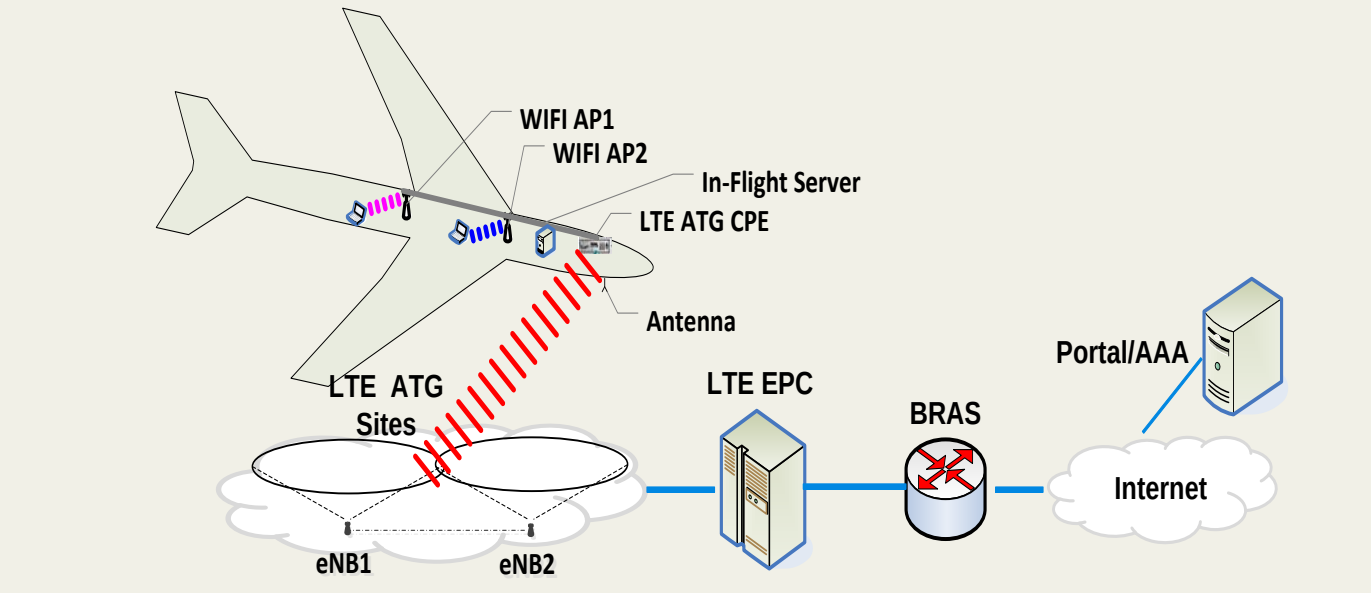
- •Multi Mode
- •Multi frequency
- • All powered with just one single Ethernet cable!
- • 8x pRRU
- • support POE
- • 4 level cascading
- •Introducing of MAU For combing BTS from different vendors
- •Multi-mode Baseband Unit

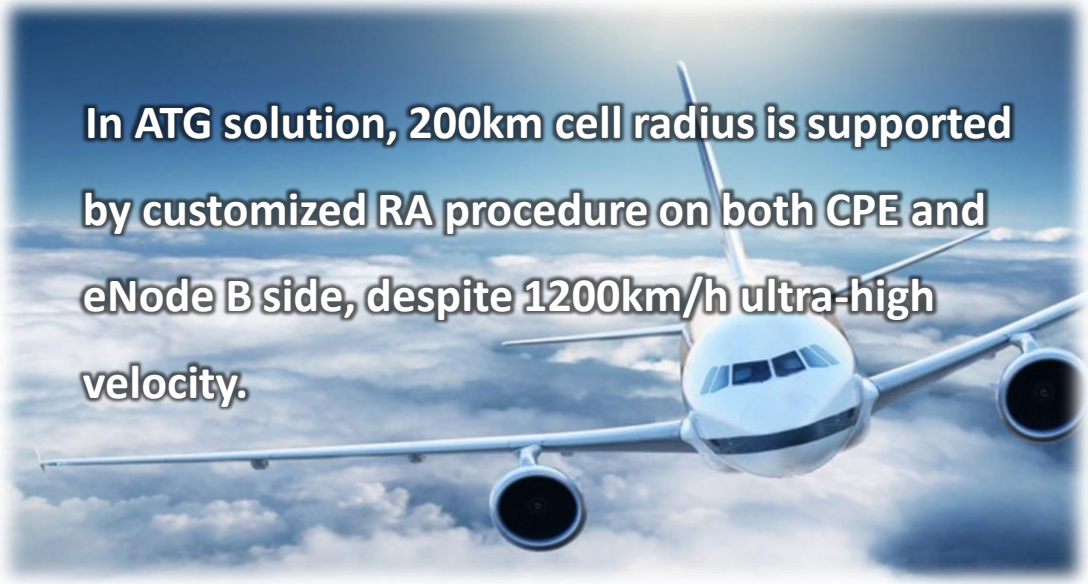
Qcell Plus – what's new



	Qcell	Qcell Plus
Configuration	G1.8+L1.8+U 2.1+L2.6/ L1.8G+U2.1G+L2.1G	1.8G+2.1G+LAA(5.8G)+ WiFi
Availability	Now	2016Q4

④Remote Coverage, ATG (Air To Ground) Solution

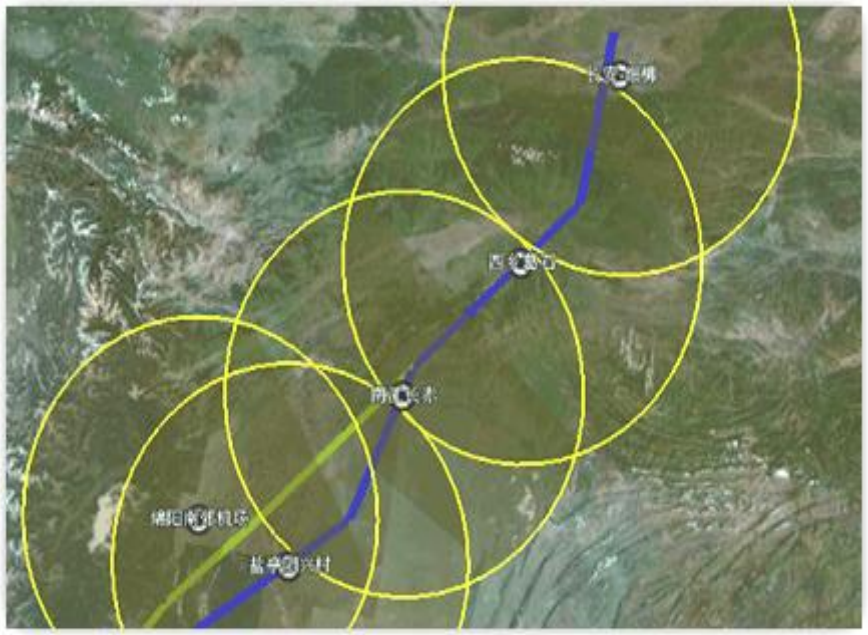




Highlights

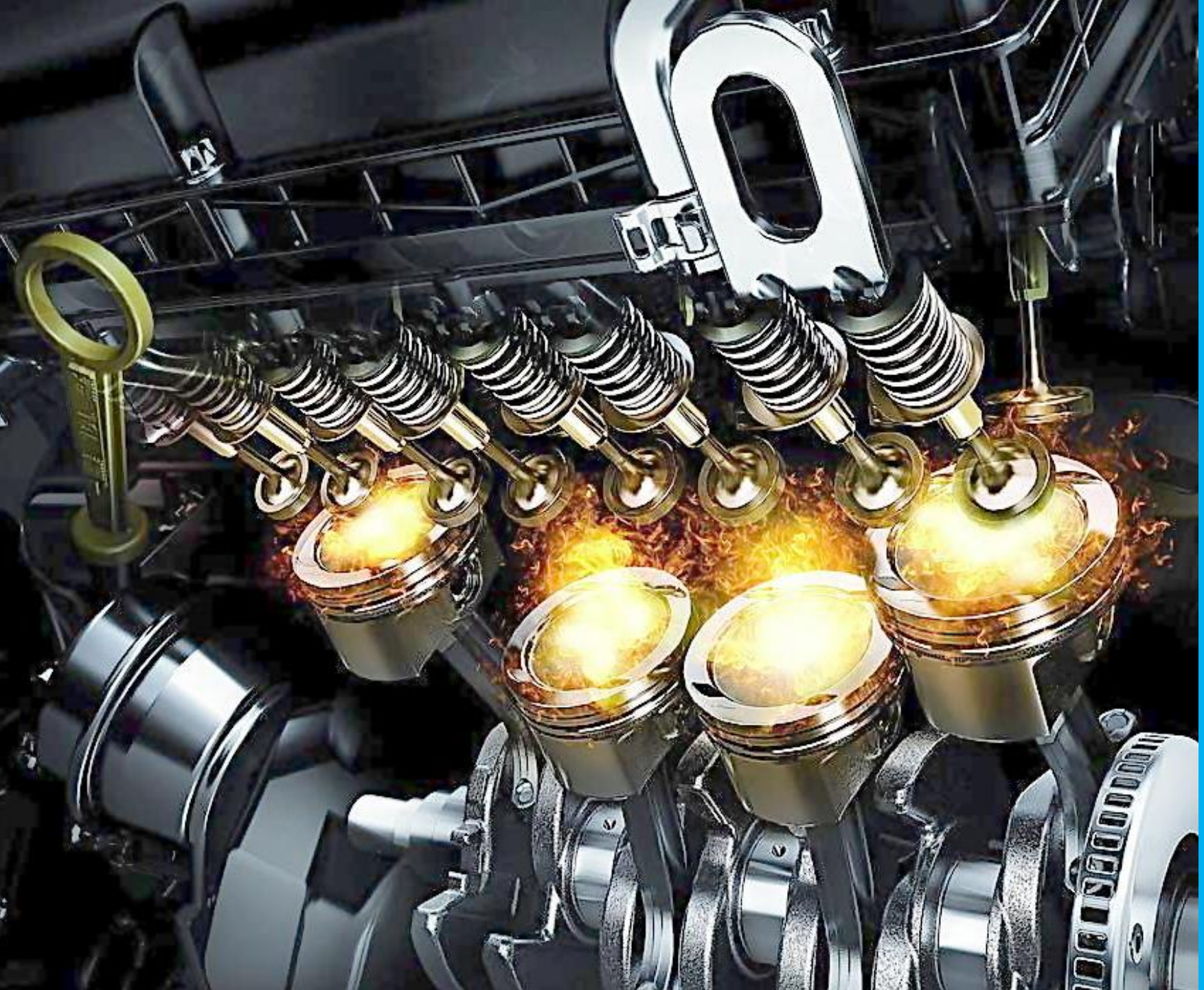
- **Adaptive tracking and compensation algorithm** for large Doppler frequency offset @ 1200km/h velocity.
- **Customized design for random access** to cell with radius of 200km and velocity of 1200km/h.
- **Super cell technology** to mitigate interference and minimize handover.
- **Remote device management** of LTE CPE.

Enjoy 4G in the Airplane with ATG Solution



- Beijing –> Chengdu
- Distance: 1700km
- Max Speed: >1200km/h
- BS quantity: 12
- Bandwidth: 5M
- DL Throughput: 30~35M

- On Feb 8th, 2016, Spring Festival Gala live broadcasted on an Air China flight.
- On Apr 16th, 2014, Flight CA116 of Air China—— the world's first Ground-Air broadband application based on 4G technology with entire technical support provided by ZTE.
- ZTE has deployed ATG solution across the U.S. to provide services for Aircell's customers since 2007.

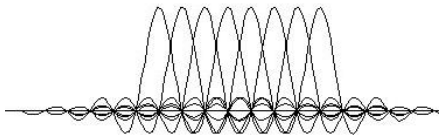


Part III

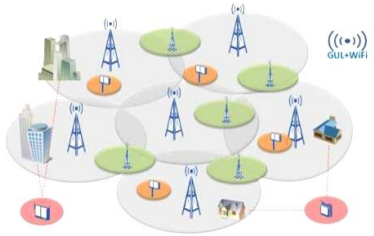
Efficiency

①Cloud Radio - Decrease Inter-cell Interference of LTE Network

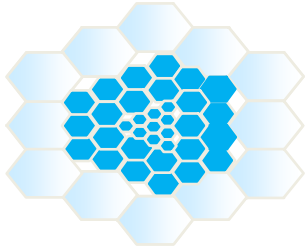
Severe Interference in LTE



OFDM



HetNet

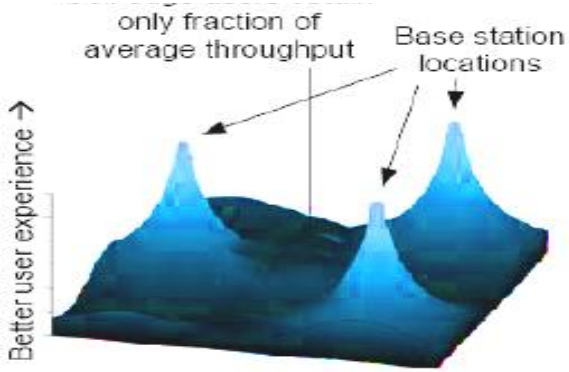


Dense Cell

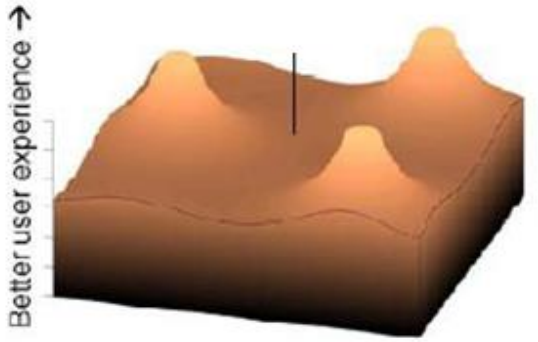
Over 50% Performance Problems in LTE network are caused by Interference

CLOUD RADIO - Enhanced CoMP

Very Good at Cell Center, Poor at Cell Edge



Cell Edge QoE is obviously improved



ZTE CLOUD RADIO™ Solution can efficiently decrease cell interference, improve cell-edge user throughput.

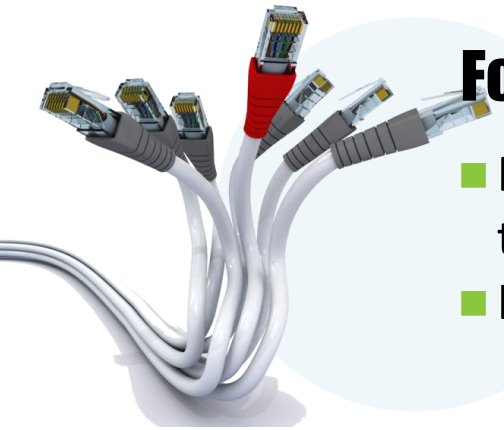
Cloud Radio - User Experience Improvement with Any Backhaul

For any network type

- Distributed or Centralized Deployment
- HomoNet or HetNet

For any LTE Terminals

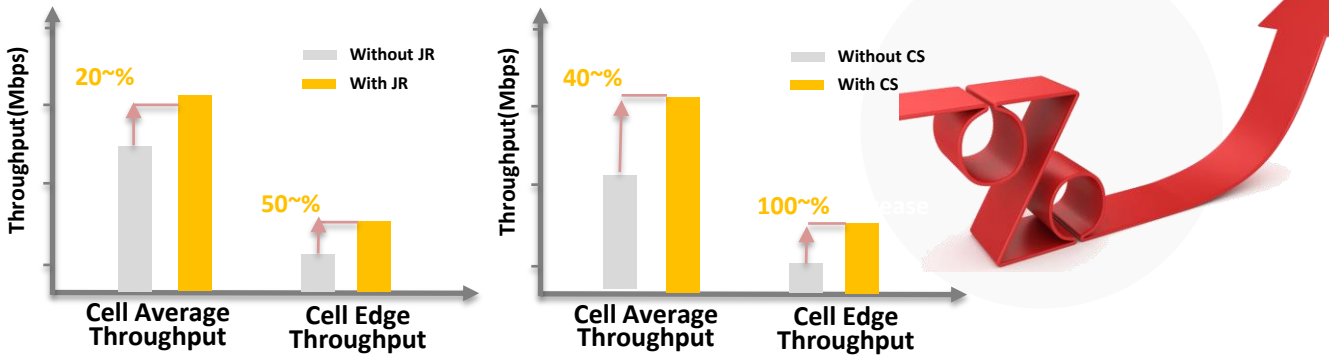
- R8/R9 Compatibility



For any backhaul

- For almost any backhaul transmission
- Industry leader & best solution

Benefits of Cloud Radio



- Improved Cell Edge Experiences (10MHz LTE BW)
  - UL: cell edge **50%** / cell average **20%**
  - DL : cell edge **100%** / cell average **40%**
- Relaxed requirements on bandwidth & delay
  - BW: **50Mbps** << 3GPP.
  - Delay: **8ms** >> 3GPP.

②Magic Radio – the Magic of Maximizing Spectrum Utilization

Static Solution

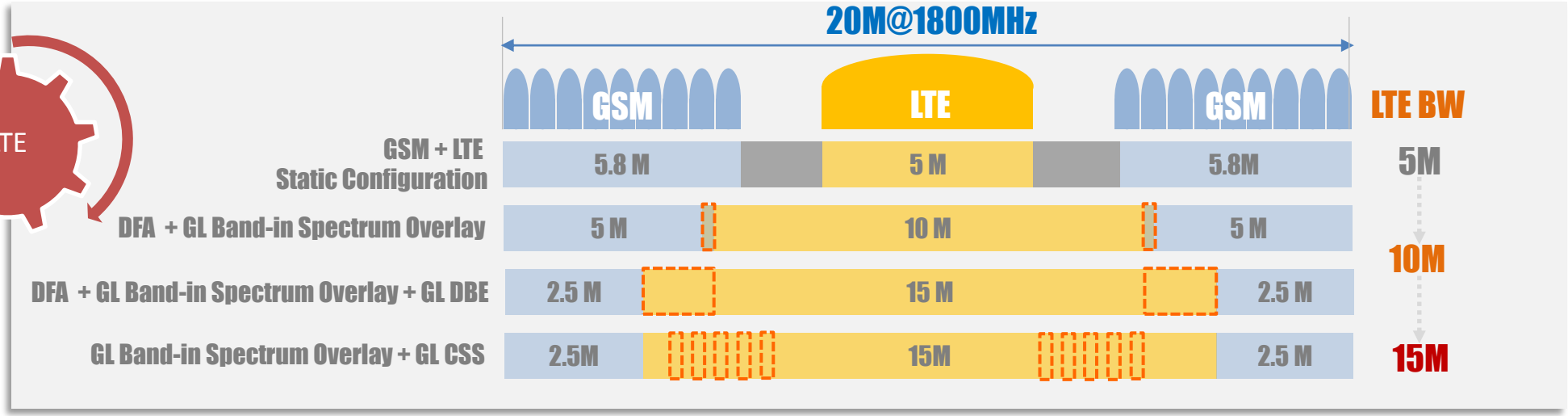
Inefficiency of spectral utilization between GSM, UMTS & LTE

Magic Radio Solution

Spectrum Efficiency Improvement >100%

More than Magic

Magic Radio 1.0 – Flexible GSM/LTE Spectrum Allocation



Magic Radio 1.0 has been successfully Verified in Field Network

May, 2015 — 中国移动 China Mobile

Dynamic Frequency Allocation

Achieve the same capacity with only 65% spectrum resource.

Aug, 2015 — China unicom中国联通

GSM/LTE Dynamic Bandwidth Extension

>50% spectrum efficiency improvement

Nov, 2015 — China unicom中国联通

GSM/LTE Band-in Spectrum Overlay

More GSM spectrum while not affecting LTE performance

Dec, 2015 — China unicom中国联通

GSM/LTE Collaborated Spectrum Scheduling

>40% spectrum efficiency improvement

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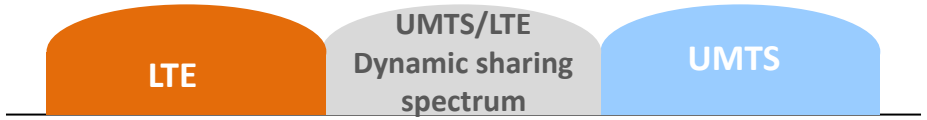
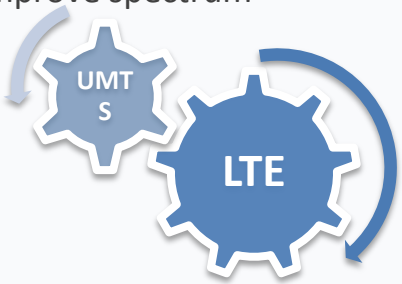
Magic Radio 2.0 – Extending to UMTS and LTE

Spectrum Sharing between UMTS&LTE



Traffic Load Based Dynamic spectrum sharing

- Spectrum sharing between UMTS and LTE can be implemented in U/L reframing scenario
- When UMTS low traffic load, part of UMTS spectrum can be dynamically used as LTE spectrum to improve spectrum utilization
- Achieving co-frequency UMTS/LTE neighbor cell configuration with less interference and higher capacity

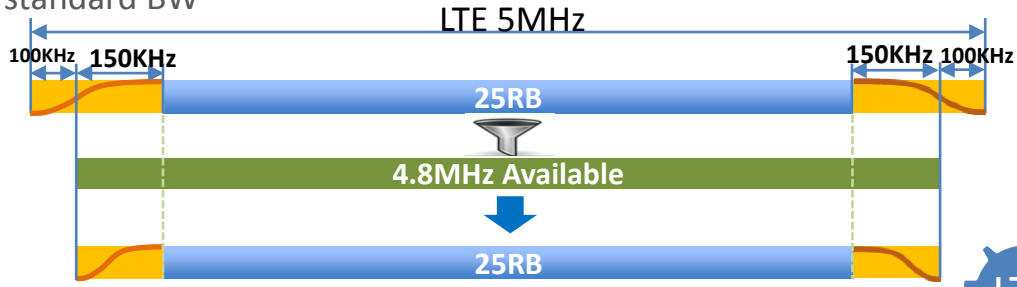


Intra-LTE Spectrum Sharing

Single Carrier Configuration

Non-standard BW can be configured as standard BW

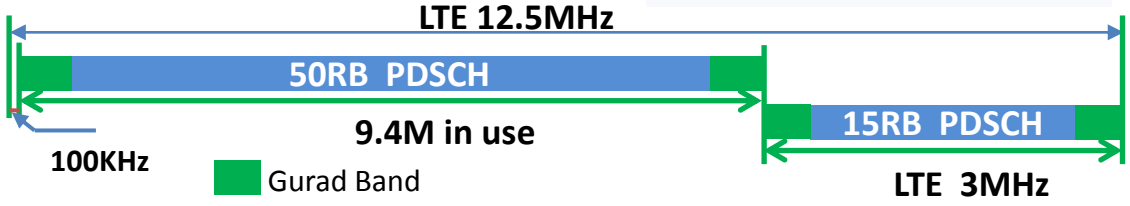
- Without capacity loss
- High BW utilization



Multi-Carrier Configuration

Less BW can be configured as one non-standard BW plus one standard BW

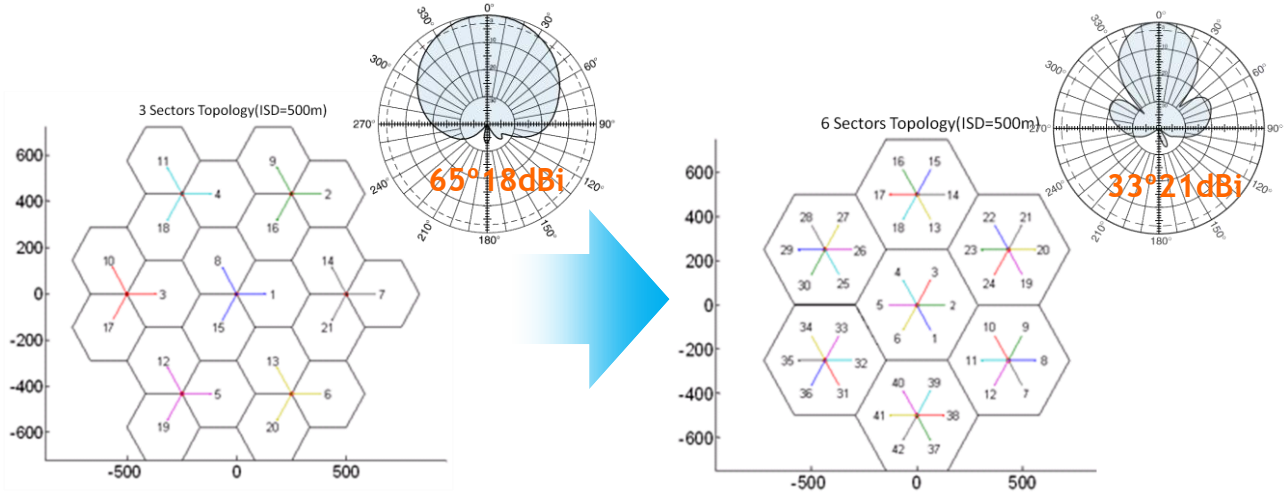
- No capacity loss
- Flexible BW configuration
- Higher spectrum efficiency



Magic Than MAGIC

③Virtual 6 Sectors - Enhance Network Capacity and Coverage

3 Sectors---->Traditional 6 sectors



Advantages

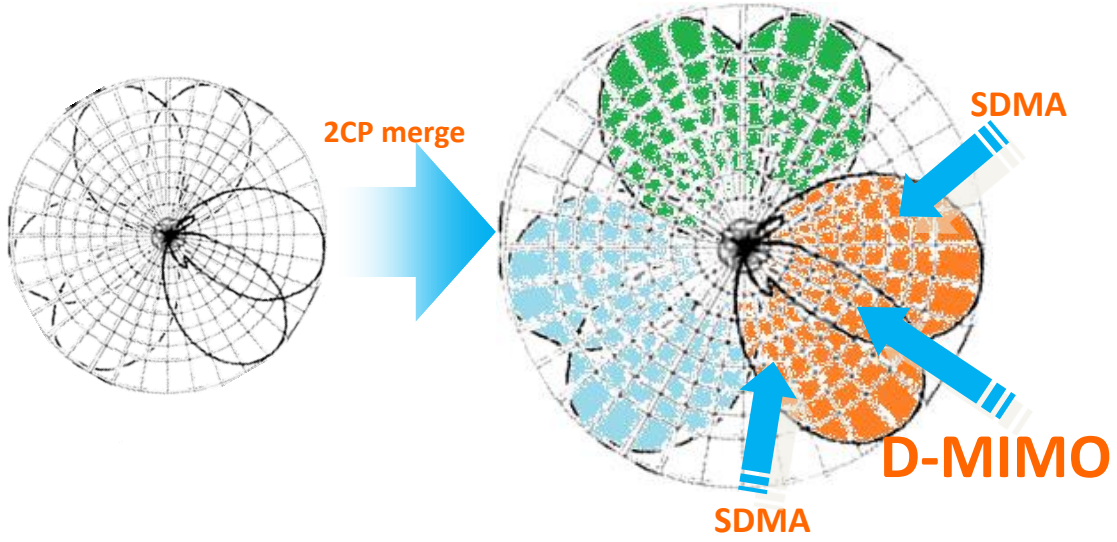
- Improve cell radius about **20%** and site coverage area about **50%** for new site
- Increase **60%** single site capacity

Disadvantage

- Serious interference ,worse coverage quality
- Heavy impact on network planning and optimization. PCI and neighbor planning become more complex
- Handover rate rise

How to solve the problem of traditional 6 sectors and improve network-scale capacity

Virtual 6 sectors



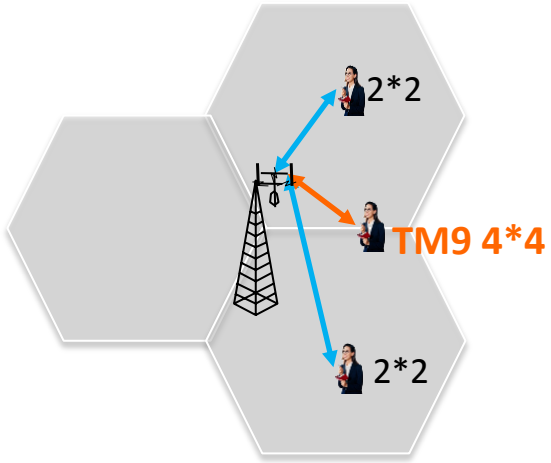
- **Super cell** , two physical cells combine into one and form a 3 sector structure
- Capacity improvement by **D-MIMO** and **SDMA**

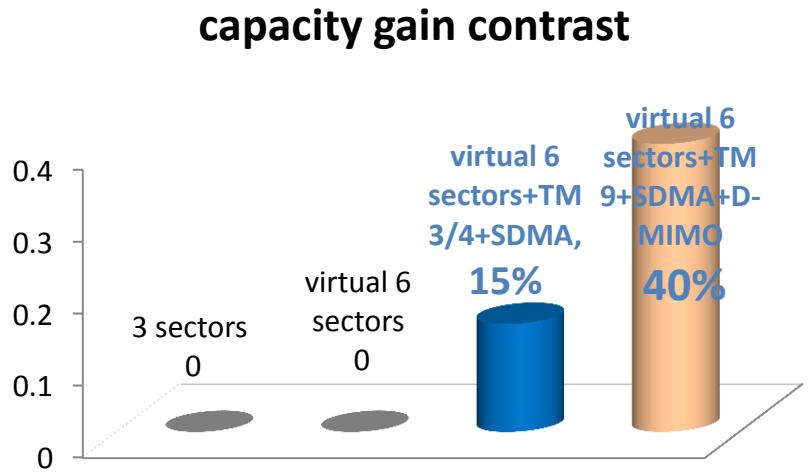
Applicable to single site deployment

Applicable to large-scale deployment

ZTE

D-MIMO&SDMA Improve the Capacity of Virtual 6 Sectors

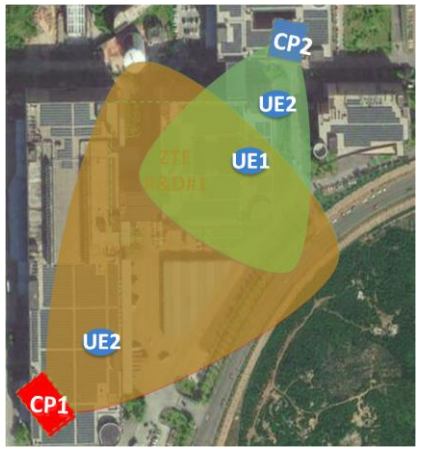


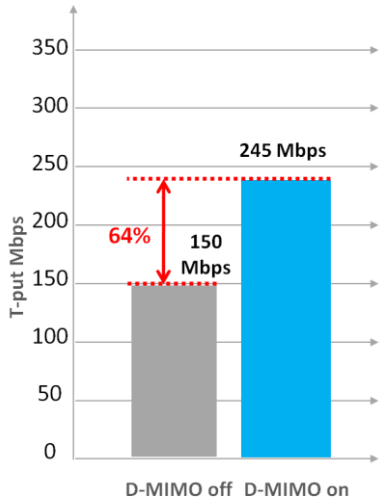


D-MIMO &SDMA

- 2 sectors combined Super Cell
- CP Non-overlap Area: 2*2 MIMO, SDMA
- CP Overlap Area: 4*2/4*4MIMO, D-MIMO
- **Gains vary depending on terminal type**
- **Smooth upgrade to 4T4R**

Test Scenario

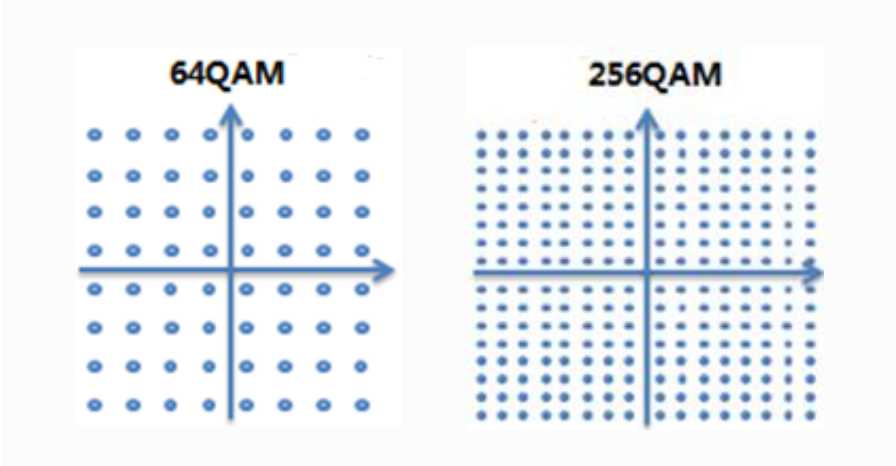


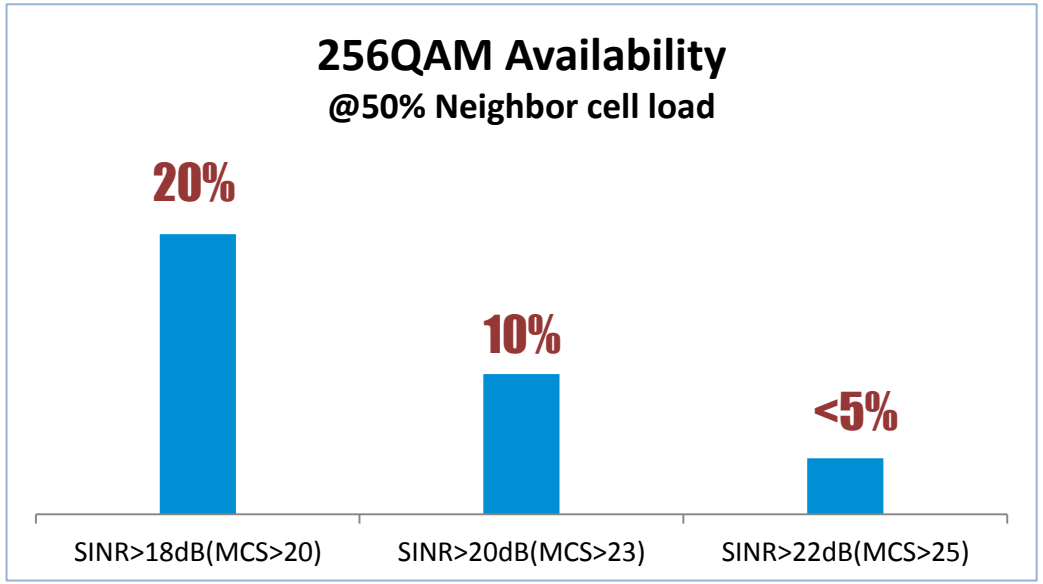


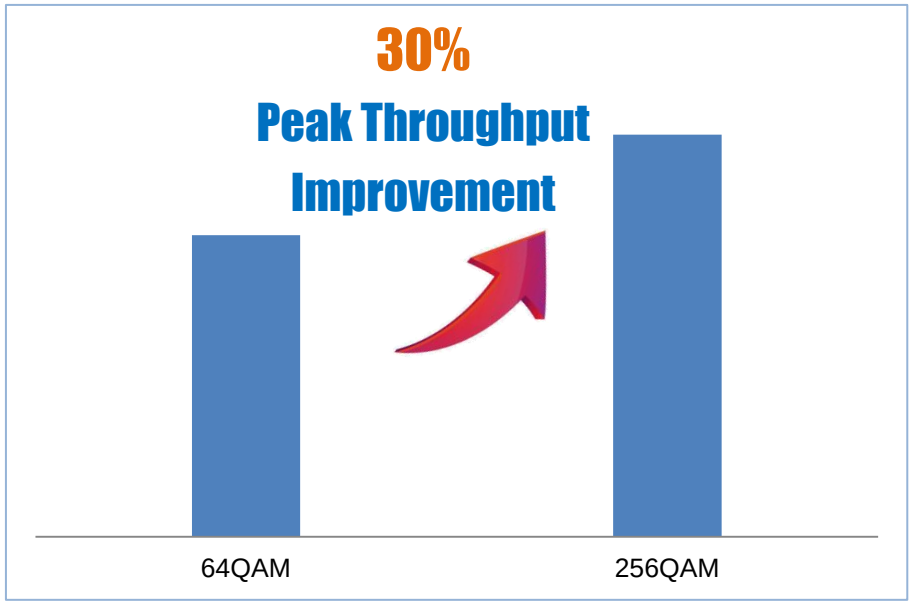
- CP: 2 antenna RRU
- UE:TM9 4*4, ZTE self-developed UE
- D-MIMO on: UE single peak throughput reached **245Mbps**
- SDMA+D-MIMO on: 3UE total average **220+ Mbps**
- Capacity gain: **40%**

Data Sources: ShenZhen outfield test

④256QAM – Improving Spectrum Efficiency







UE Requirement

R12 UE

Application Scenario

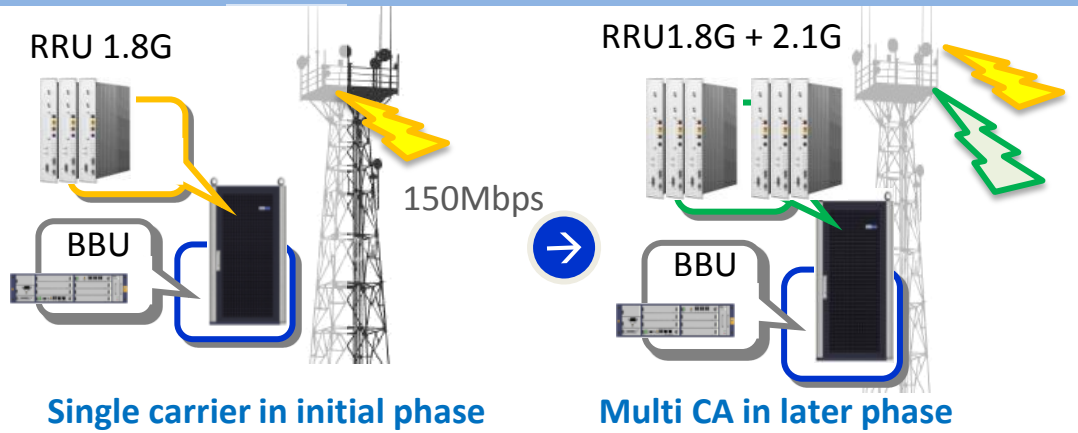
- Hotspot and indoor
- Good channel condition with high SINR

Part IV

Experience

①Carrier Aggregation – Higher Throughput, Better Experience

Single Carrier -> 2CC CA -> 3CC CA -> *5CC CA* & more

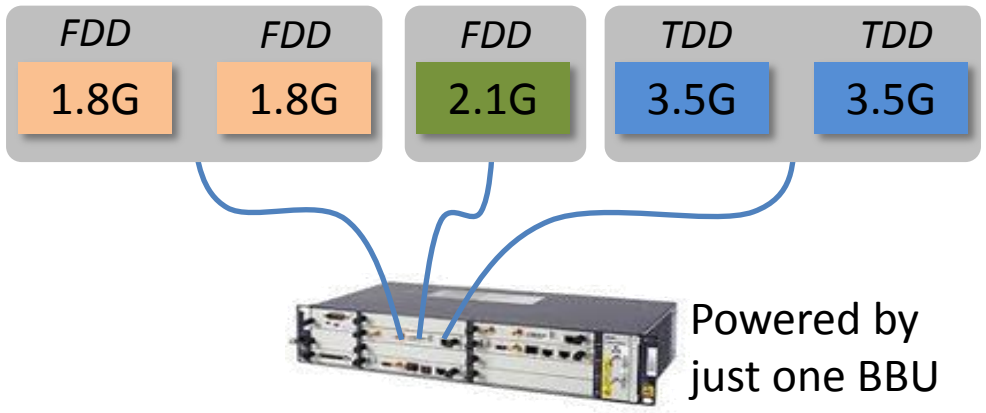


Single carrier in initial phase

Multi CA in later phase

- CA supported by BBU with no additional requirements on RRU
- Hardware-ready for all CA – software upgrade only
- CA support with macro, micro & pico cell, anywhere you need

FDD/TDD 5CC-CA + 4*4 MIMO Demo in *MWC: 1.3+ Gbps*



Powered by just one BBU

CA supported in all RRUs

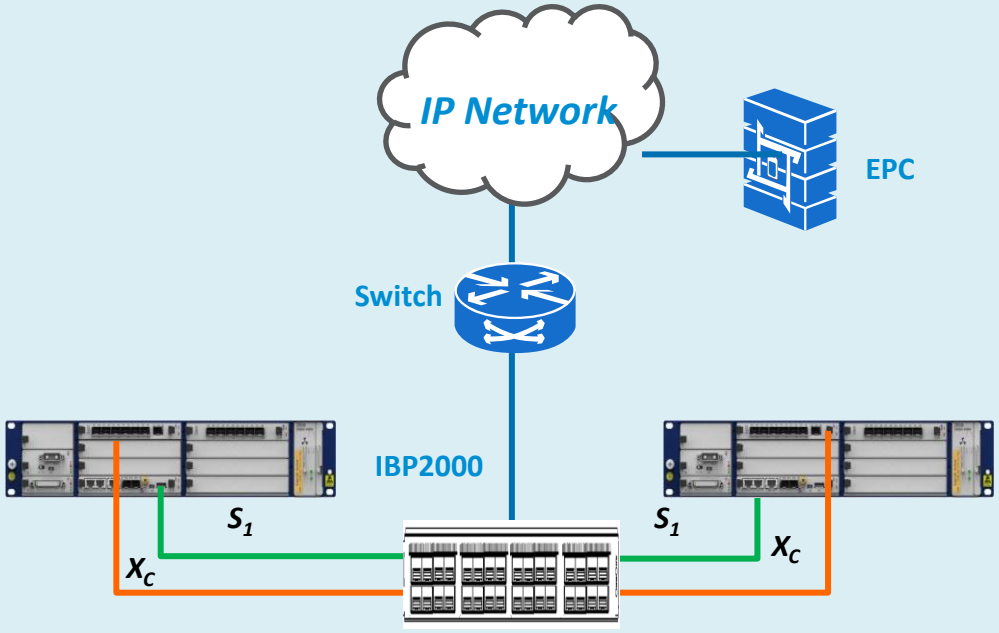
Macro

Micro

Qcell

Carrier Aggregation in Cloud – More Flexible Deployment

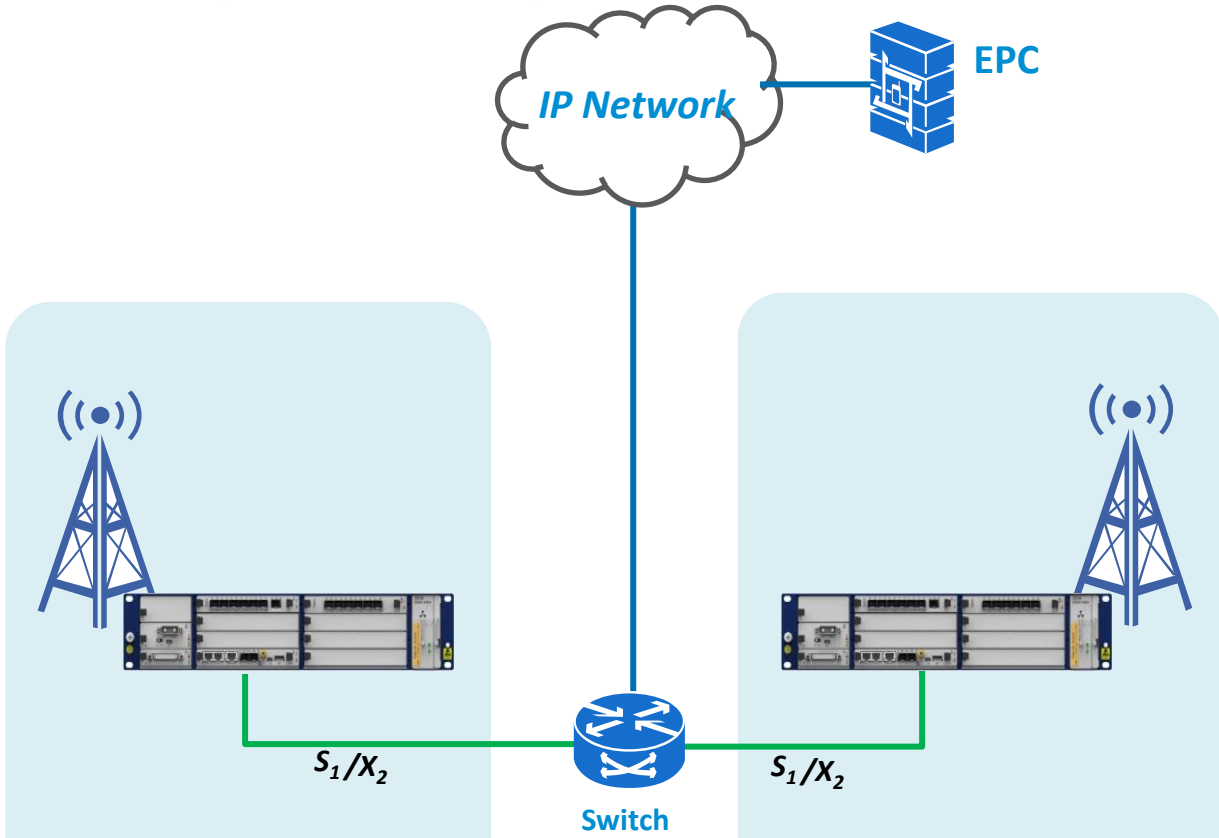
Cloud CA(Centralized)



***Xc**: Inter-BBU Coordinated Data*

Room for BBUs centralized deployment

Cloud CA(Distributed)



***X2 Interface** : Include Inter-BBU Coordinated Data*

②eVoLTE - Brings Enhanced and Evolved VoLTE Performance

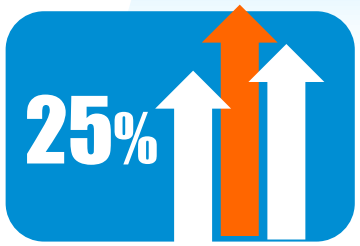
Better User Experience

eVoLTE

Evolved and Enhanced

Cloud Architecture

Smooth Evolution



Enhanced KPI

E2E Convenient OAM

eVoLTE - Comprehensive Features for RAN

COVERAGE	QUALITY	CAPACITY	BATTERY
• TTI Bundling • RoHC • Inter-eNB JR based on relax transmission delay (Voice) • ECN/ECN-A	• Active grant per 40ms for VoLTE in uplink • PUCCH resource allocate adjustment • Frequency selective scheduling based on NI • Init target BLER could be adjusted for QCI=1 • Inactive Timer for QCI=1 service	• SPS • Active Delay Scheduling • DRX configuration optimization	• SPS Power Saving • Long DRX • VoLTE DRX

ZTE

eVoLTE - More Profits and Lower TCO by Improving KPI

More Subscriptions

Traditional

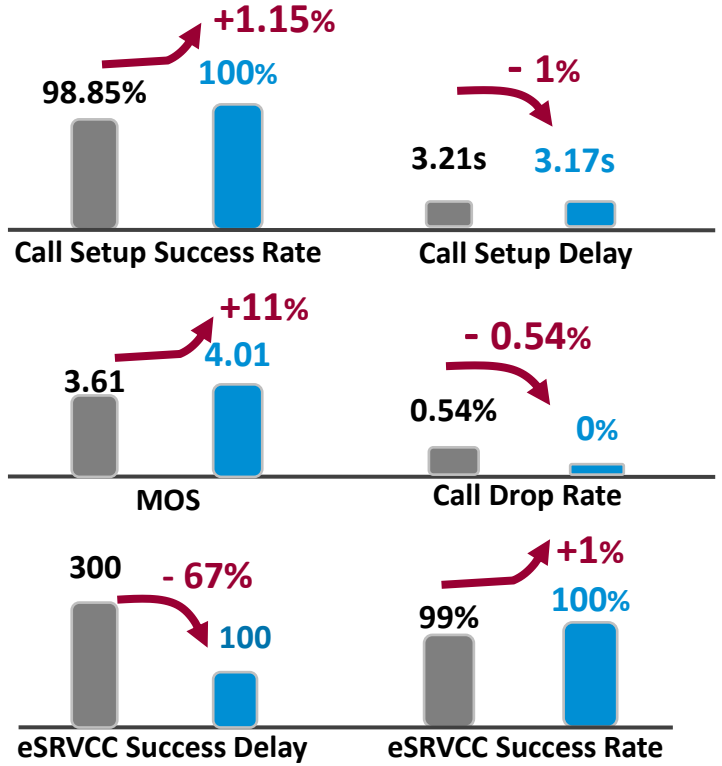
eVoLTE

+ 50% Users

Fewer Sites

- 20% Sites

Better Performance



25% Improved

③Video Optimization

Quality Assessment

- No systematic assessment mechanism is no good start
- ZTE's comprehensive system of quality assessment sets the solid ground of video optimization

Network Planning

- Network planning targeting at video optimization
- Requirements analysis, modeling, implementation & tests

Total Solution

- Everything included: RAN, CN, transmission and service platform
- At RAN and CN: TCP acceleration & CDN closer to RAN

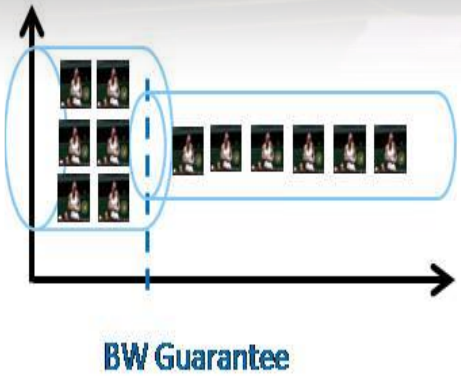
User Experience

- Video streaming user experience can be greatly improved only by implementing a good quality assessment system, tailored network planning, plus the total solution.

Video Optimization - Scheduling Optimization for Streaming

Principle

- Video traffic has high priority during the initial playing phase
- GBR scheduling is used during the **stable playing** phase



During video initial playing phase, higher priority and more RB is given to video traffic in order to:

- Reduce initial buffering time
- Guarantee the smoothness of video playing
- Reduce the number of stalling
- Better experience

Smooth Video Playing
Reduce Initial waiting time
Better View Experience

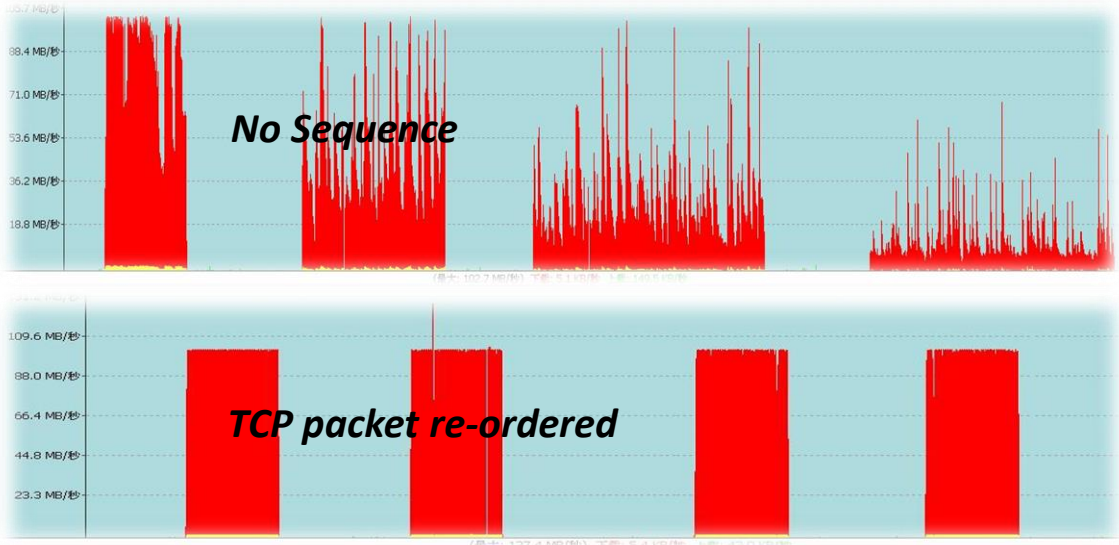
④TCP Optimization - Better User Experience in RAN

TCP Optimization

- TCP Optimization
  - TCP packet re-ordered
  - Maximizing uplink and downlink TCP traffic
  - TCP ACK split
- TCP RTT Optimization

Test Result

Position	TCP RTT Optimization	Average RSRP (dBm)	DL_PDCP_Tput (kbps)	DL_L1_Tput (kbps)
Near point	**Open**	-77.5888	**89351**	**90054.5**
	Close	-76.3195	86874.6	87605.3
Medium point	**Open**	-95.1096	**70564.5**	**71052.9**
	Close	-98.7974	65170	65634.2
Far point	**Open**	-110.422	**32803.8**	**33010.6**
	Close	-113.283	32374.4	32583.4



Part V

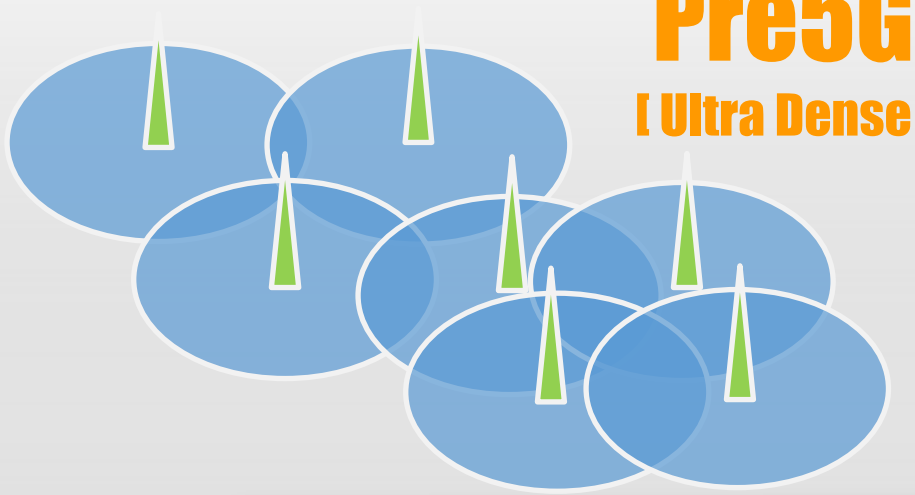
Future

①Ultra Dense Network Improves the Network Capacity

Based On Existing Network Architecture

Pre5G UDN

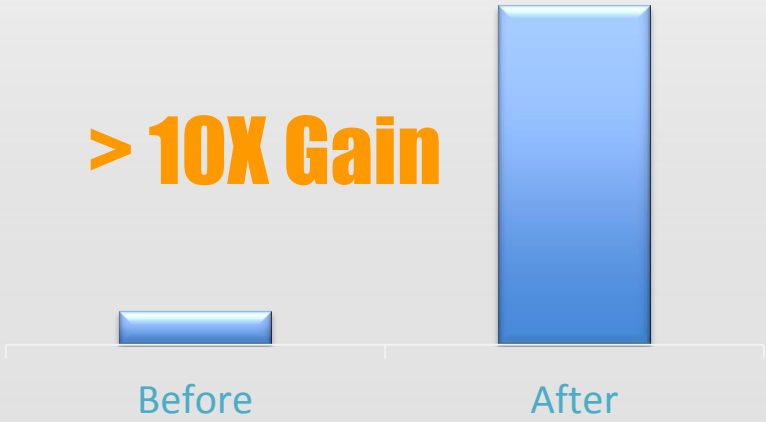
[Ultra Dense Network]



R8/R9 Terminal Compatible

Increasing Flow Density

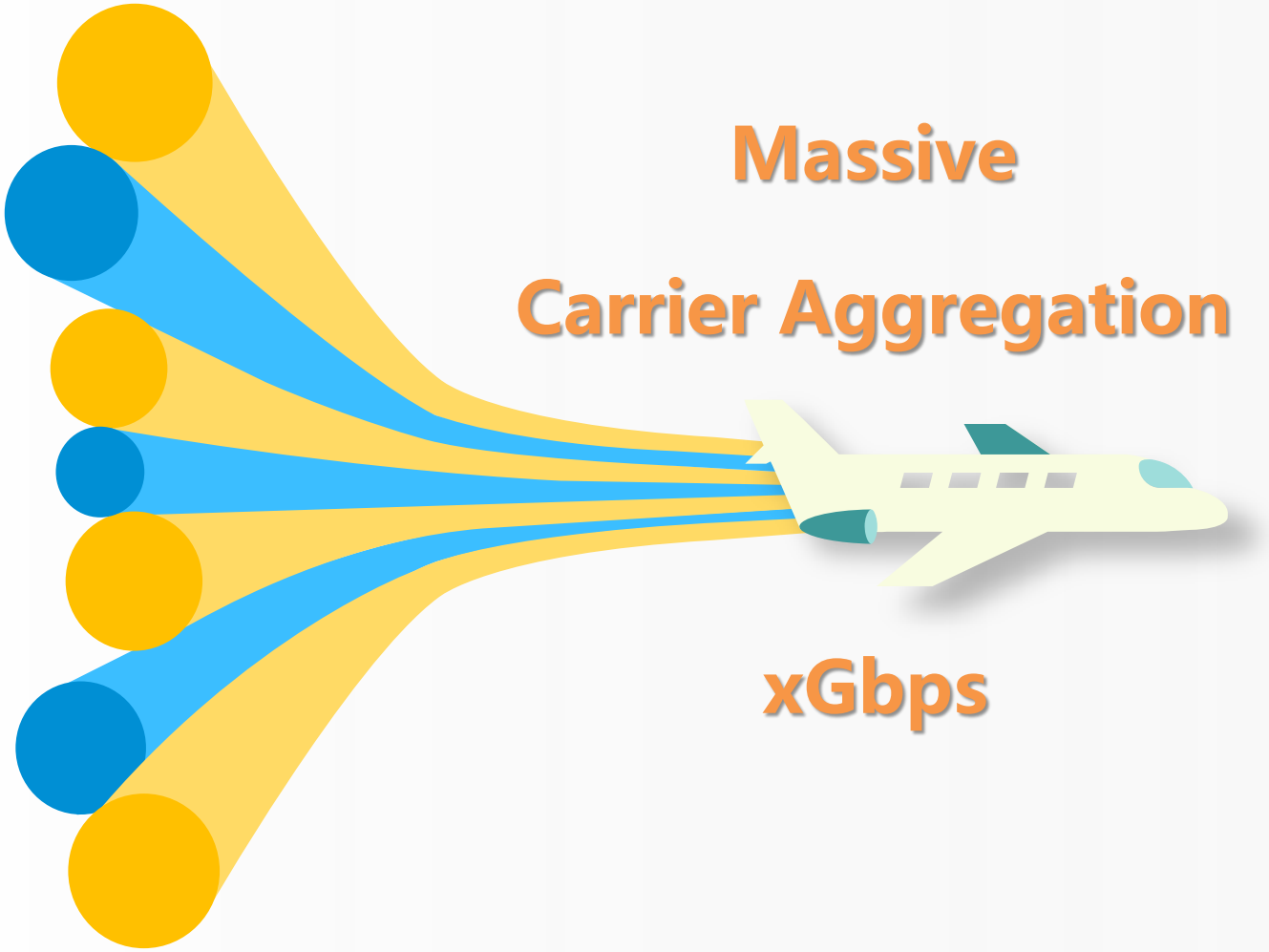
> 10X Gain

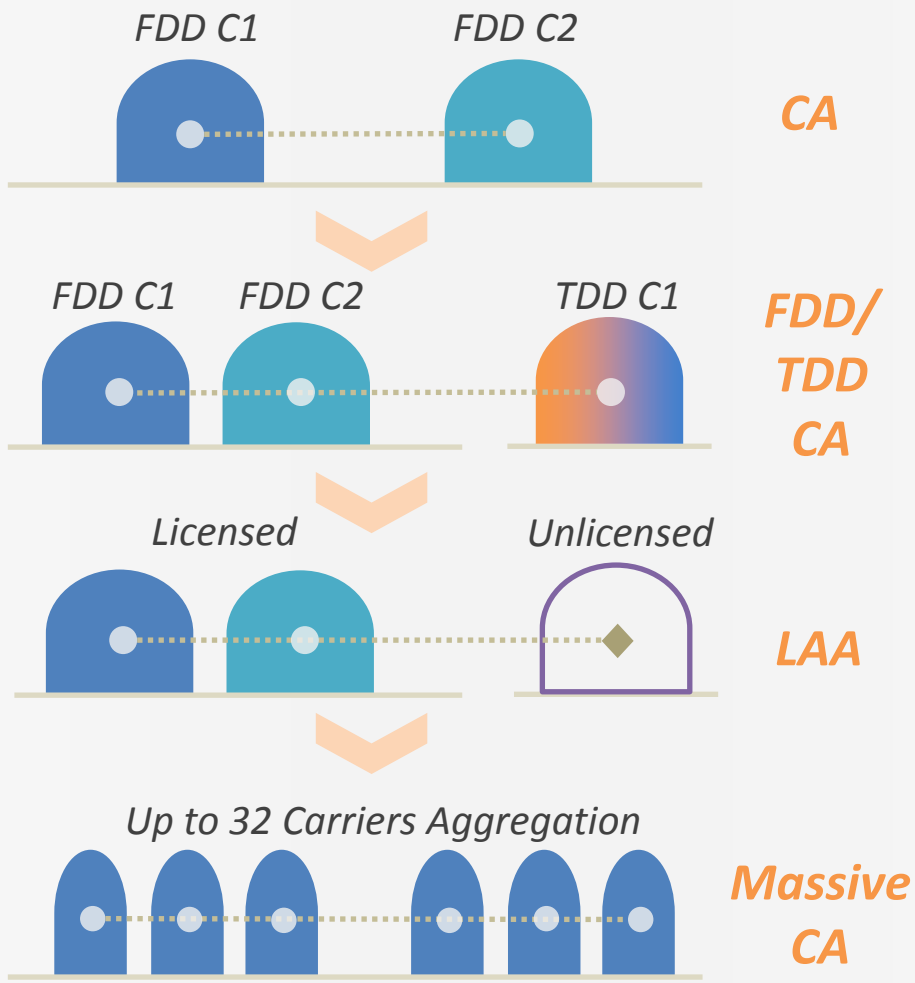


User experience oriented

- Stable user experience
- Seamless handover

②Massive CA to Extend the Peak Rate



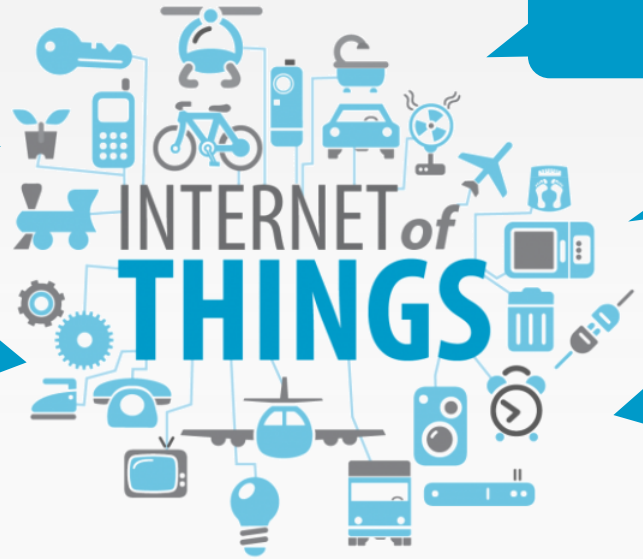


③NB-IoT to Connect Everything

Characteristics

Massive Number of devices

Enhanced power efficiency



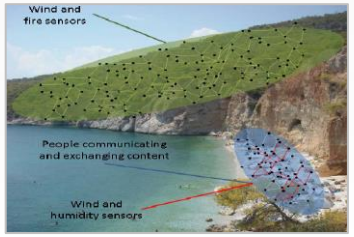
Broad coverage

Lowest possible cost

Low throughput
Low mobility

Scenarios

Smart homes



Environment

Agritech

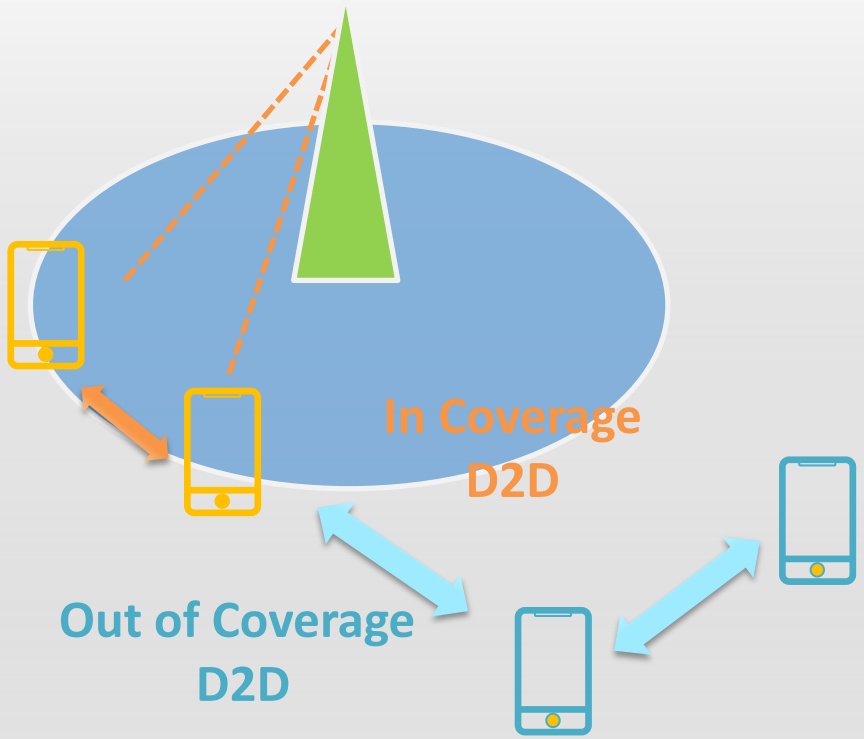
Wearable

Smart Logistics

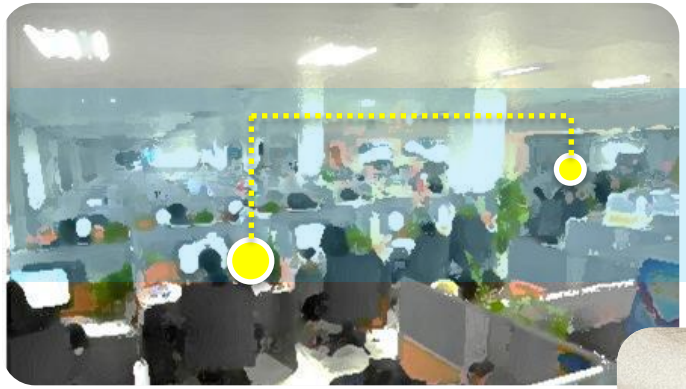
Smart cities

④D2D Makes the Communication More Direct

Device to Device Communication

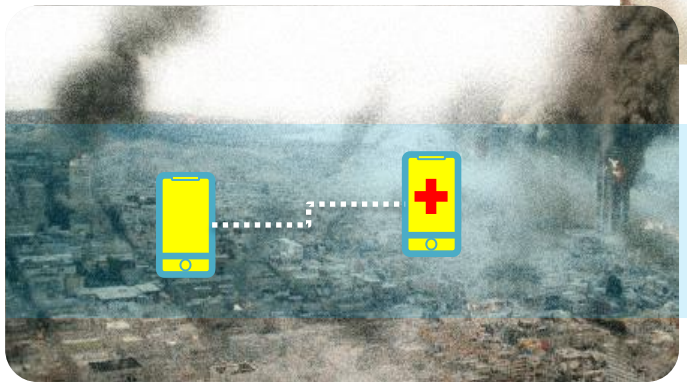


- Spectrum Efficiency Improvement
- More applicable scenarios
- Better User Experience



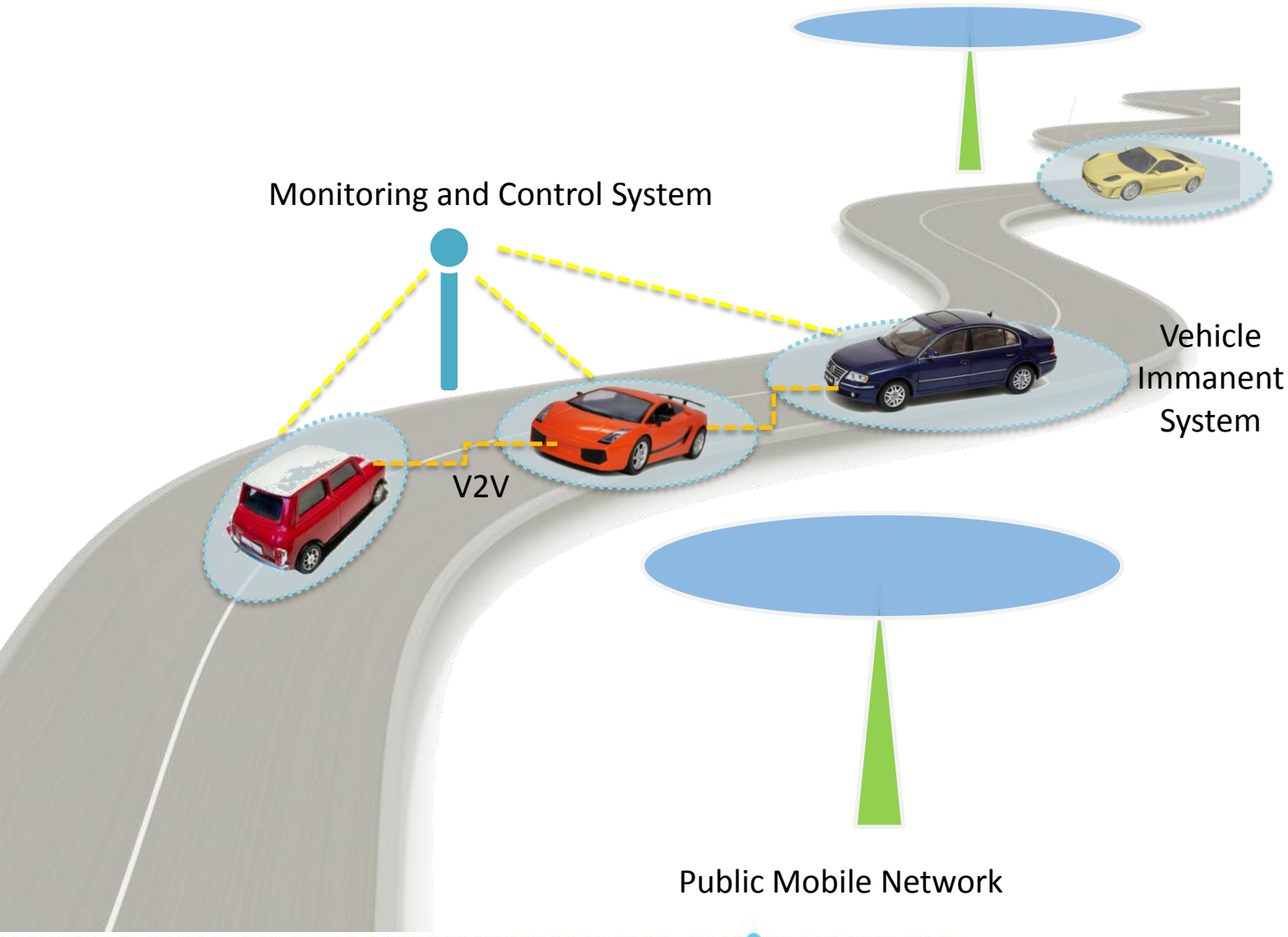
Local Social Network

Location Based Promotion



Emergency Communication

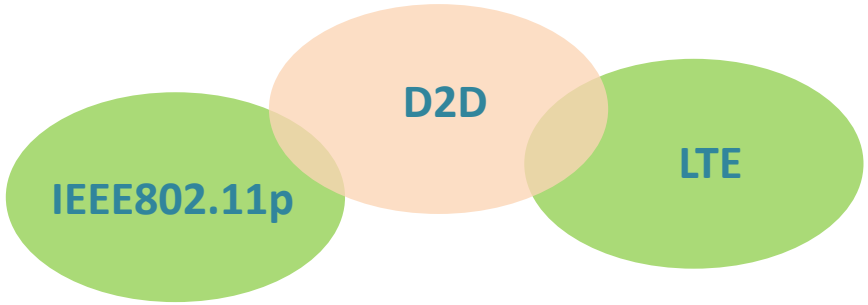
⑤V2X Makes the World Safer and More Efficient



High Reliability

Low Latency Requirement

High Speed Communication



Superior Network
for
A Better Connected World

Trainer: ZHU LONGMING
E-mail: zhu.longming@zte.com.cn
Department: Wireless Product @ZTE CORPORATION
Address: Shenzhen, China

Thank you

ZTE
Tomorrow never waits