



Pre5G

Building the Bridge to 5G

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1 Executive Summary

The mobile internet service has exponentially grown since the first LTE commercial network in 2009, but now there are some gaps between network capability and requirements such as the connection, user data rate, and latency. Currently 5G standardization has become the hot topic of Mobile Communications Industry, while the commercial launch of 5G will start from 2020. Shall we wait or do something in the next 5 years? In 2014, ZTE was the first vendor who propose Pre5G concept. In the past two years, ZTE has made remarkable achievements in this area. From technical side, ZTE's Pre5G includes both early commercialization of 5G key technologies and the key technologies of LTE-Advanced Pro defined by 3GPP, which will build the bridge connecting 4G and 5G, and fill the 5-years gap before 5G commercialization.

• Evolution, Compatibility, Cost-efficiency

Pre5G is not a completely new wireless technology. It focuses on evolution, compatibility and cost-efficiency.

- (1) Based on the smooth evolution of the existing 4G network, Pre5G is a highly cost-effective technology requiring a low cost investment and fast deployment;
- (2) Pre5G is compatible with 4G terminals. Users needn't change the terminal to use the new network and services;
- (3) Pre5G applies some 5G technologies to provide 5G-like experience in advance;
- (4) Pre5G focuses on meeting the requirements of high traffic areas, high end users and high rate services, so Pre5G can be deployed in specific regions with low investment.

• Performance

ZTE fully knows the gap between the existing network and future service trends, and understands the operators' pain points and requirements, and defined reasonable performance indexes for Pre5G, The table below shows the difference among 4G, Pre5G and 5G.

	Peak Data Rate (Mbps)	User Data Rate (Mbps)	Connection (X1000)	Spectrum Efficiency	Latency (ms)
4G	1000	10 (2-30)	1	1X	50
Pre5G	>1,000	50	100	3-6X	10
5G	10,000	100	1,000	3-6X	1

Table 1: Pre5G Performance Index

• Categories and Key Technologies

As a new technology package, Pre5G consists of LTE-A Pro technology, 5G technology and other features. ZTE has defined 3 categories:

- (1) Giga+ MBB: Massive MIMO, Massive CA, Pre UDN, 256QAM, LAA, LWA;
- (2) Massive IoT: NB-IoT;
- (3) Cloudization: Cloud Works, Cloud RAN;



Figure 1: Pre5G Categories

2 Giga+ MBB

◆ Giga+ MBB Experience

Ultra broadband experience always is the users' most important requirement, Pre5G can improve the experience beyond Giga level. The Giga+ MBB experience can mostly settle two aspects of the problem, one is hot-spot area traffic and the other is ultra-high speed service.

• Hot-spot Area Traffic

The hot-spot areas include CBDs, shopping malls, stadiums, railway stations, dense residences, etc. The amount of users who use the mobile voice and data service in hot-spot areas is around 10s of thousands per sq.km according to statistics. Meanwhile the coverage is always difficult due to the big and tall buildings in the areas. Pre5G designs various solutions to meet the requirements for hot spots like multi-antenna (Massive MIMO), carrier aggregation(Massive CA), high order modulation(256QAM), and ultra dense site networking(UDN).



Figure 2: Typical High Traffic Scenarios

• Ultra-high Speed Service

Ultra-high speed services include UHD video, UHD real-time game, VR in mobile, etc. Taking the UHD video as an example, currently mobile video in the main is 720P or 1080P resolution which needs a 2M to 4M user data rate. But more and more 2K and even 4K UHD video requirements are coming which need more than a 10M and even 30M user data rate, therefore the existing 4G network with less than 10M average user data rate in most of countries cannot meet the requirements of the UHD service. Pre5G puts forward 50M user data rate as the network performance target, and designs some new solutions and technologies like Massive CA, LAA, and LWA.

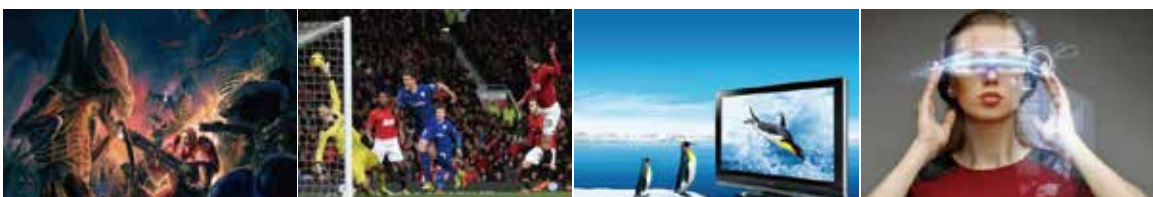


Figure 3: Typical Ultra-high Speed Services

◆ Key Technologies

• Massive MIMO

Massive MIMO applies the massive array antenna technology, utilizing the multi-antenna spatial multiplex to improve the spectrum efficiency up to 3-6 times greater than the traditional LTE BTS. On the one hand, Massive MIMO can provide 8 to 16 data streams to terminals to noticeably improve the network capacity and user experience when the antenna quantity of Massive MIMO is more than 100. On the other hand, Massive MIMO applies advanced 3D-beamforming to provide deeper and wider coverage especially for tall buildings in hot-spot areas. What's more important, Massive MIMO in the Pre5G stage doesn't change the air interface protocol, so it is compatible with existing 4G terminals.

In 2015, ZTE deployed Massive MIMO in the commercial 4G network in CMCC Guangzhou. These Massive MIMO BTSs have very good compatibility with the existing 4G network, and the downlink throughput exceeded 280M which is over 4 times greater than the 8T8R TDD BTS in same area of the commercial network. Meanwhile, Massive MIMO has also been tested in the field in Japan. In 2016, Massive MIMO will upgrade to higher performance and start its commercial launch.

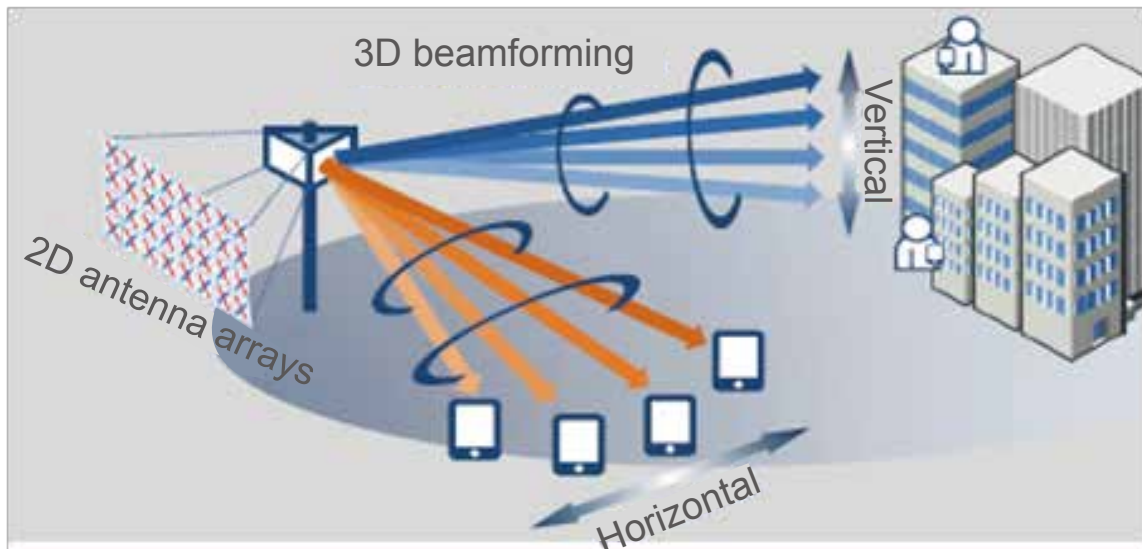


Figure 4: Massive MIMO Solution

- **Pre UDN**

Although UDN is a 5G technology, ZTE carried it out in the Pre5G stage and named it Pre UDN. Pre UDN is mainly applied to hot-spot areas to provide greater capacity through deploying dense sites. It uses some innovating solutions to improve coordination performance and lower the interference under dense networking conditions including D-MIMO and small cell on/off.

- **Massive CA**

Carrier Aggregation is one of the most important ways to improve cell capacity if there is enough spectrum. Massive CA supports over 5 carriers of aggregation and up to 32 CC according to the 3GPP standard. FDD and TDD dual-mode carrier aggregation represents most of the massive CA deployment scenarios due to limited FDD spectrum resources. Normally Massive CA needs carriers co-sites due to the ultra-high interaction data stream and low latency, but ZTE Massive CA solution based on the C-RAN architecture can realize CA in multi-sites.

In 2016 MWC, ZTE had finished 5 carriers aggregation demo using 5*20M(FDD+TDD) and 4*4MIMO. The peak throughput is up to 1.31 Gbps.



Figure 5: Massive CA Demo

- **256QAM (DL)**

Compared with 64QAM, 256QAM can improve peak throughput by 33%. 256QAM needs a good network condition including high SINR, low EVM and low mobility, so its typical application scenario is for indoor coverage.

ZTE had finished the 256QAM pre-commercial test and will launch in a commercial network in 2016.

- **LAA/LWA**

Unlicensed spectrum application is driven by 2 reasons, one is the expensive and limited licensed LTE spectrum, and the other is more MBB service requirements. There are two kinds of technologies for unlicensed spectrum application.

- (1) LAA: LAA applies the unlicensed spectrum as LTE mode and provides aggregation with the licensed LTE spectrum. According to simulations, LAA gets 3 times more throughput with a 20M licensed spectrum + 2*20M unlicensed spectrum aggregation.
- (2) LWA: LWA applies the unlicensed spectrum as WiFi mode. In the early phase, operators applied WiFi offload mode. In the LWA phase, WiFi data will aggregate with LTE data in the eNodeB side, and WiFi AP can be integrated in the eNodeB.

Both LAA and LWA can improve network performance and user experience. LAA is better than LWA due to LTE's advantage. But if the operator has a WLAN network, LWA is more cost-effective. Operators can flexibly select the LAA or LWA function based on the ZTE Qcell product which supports both LTE and WiFi access.

- **Multiple Technologies Combination for Giga+ MBB Experience**

Pre5G key technologies can not only be deployed alone but also be combined together to deploy for higher network performance. For example, we can deploy Massive MIMO, 256QAM and CA in one eNodeB at the same time. We can also deploy LAA or LWA based on the UDN network.

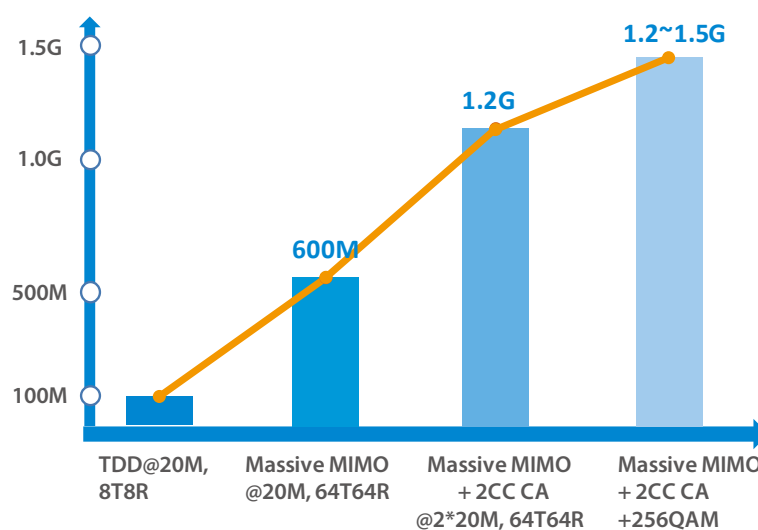


Figure 6: Capacity Improvement by Multiple Technologies Combination



3 Massive IoT

• IoT Market Prediction and Requirement

In the recent years, we've witnessed the rapid growth of IoT in multiple vertical industries. Machina Research predicts that entire Internet of Things revenue will rise from USD892 billion in 2015 to USD 4 trillion in 2025, of which the Low Power Wide Area(LPWA) market will be worth \$589 billion by 2020, or 47% of the total M2M market. The emerging IoT market will create tremendous business opportunities for mobile carriers, and become an important revenue source in next 10 years.



Automotive



Retail



Energy and Utilities



Banking, Finance & Insurance



Health



Manufacturing



Public Services



Transport and Logistics

Figure 7: IoT Typical Application Scenarios

The existing mobile networks are well designed for voice communication and MBB application, while they are expensive and inefficient when dealing with the massive connections of low data rate, cost sensitive, battery powered IoT terminals.

The key requirements of LPWA IoT market are:

- Wide and deep coverage, including coverage in basements and corners.
- Massive Connection, more than 50,000 connections per site.
- Low Cost, less than 5 dollars for an IoT communication module.
- Low energy consumption, an IoT device with two AA batteries can work 5 to 10 years.

◆ NB-IoT

In September 2015, the mobile industry has finally agreed that NB-IoT (Initiated by Ericsson, ZTE, Nokia, Intel etc) was the unified cellular IoT technology standard for the emerging Low Power Wide Area (LPWA) market. Obviously a Common and Global IoT standard will remove fragmentation, enabling mobile carriers to deliver industry standard solutions by extending their existing high-quality networks, service platforms and world-class customer management capabilities.

In the LPWA market, the LTE based NB-IoT solution has lots of advantages over the existing mobile access technologies, as shown below:

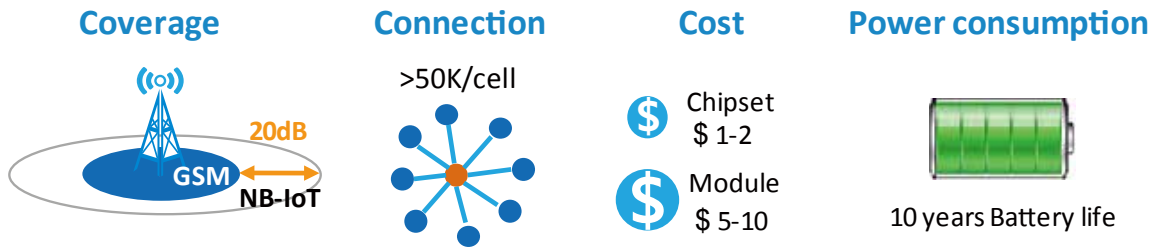


Figure 8: NB-IoT Technical Characteristic

At the same time, there are also some other LPWA technologies represented by LoRa and Sigfox which operated on unlicensed spectrum. Compared with NB-IoT, the ready-to-market capability and low cost module or subscription fees are the biggest advantages of these technologies.

On the contrary, NB-IoT has unparalleled advantages over LoRa and Sigfox regarding eco-system, reliability, security and operation cost. In addition, NB-IoT technology is quite easy for deployment on top of the existing LTE network.

Standard	Modulation	Bandwidth	Data Rate(bps)	Coverage	Capacity	Battery Life	Cost	Eco-system
eMTC(R13)	OFDMA	1.4MHz	200K-1000K	Normal	1200	18 months	15 \$	Good
NB-IoT	OFDMA/SC-FDMA	180KHz	350-160K	Very Good	52k	5-10 years	5\$	Strong
LoRa	Chirp Spread Spectrum	125k/250k/500KHz	300-50K	Good	10k-50k	5-10 years	8\$	Reinforce
Sigfox	UNB/GFSK	12.5KHz	100bps(EU)/600 bps(USA)	Good	100k	5-10 years	9\$	Risk

Table 2: Comparison of Multiple IoT Technologies

The history of mobile access technologies has told us that the eco-system is more important than the technology itself. With the worldwide support of mobile carriers, vendors, chipset manufactures and vertical industries, we do believe NB-IoT will play a dominant role in the future LPWA IoT market.

ZTE is an active promoter and an important contributor to NB-IoT standards. It has submitted more than 200 NB-IoT proposals in 3GPP, accounting for more than 15% of all the proposals. During the SI and WI phase, ZTE was in charge of multiple discussions of important topics, and released a large number of technical solutions and simulation results, such as narrow-band physical channel design and physical process optimization, transmission and content definition of system messages, physical downlink channel reuse and interval transmission etc, which made many advanced technical contributions for NB-IoT standards. ZTE's outstanding performance in the NB-IoT standardization process has proven its innovation capability in the key technologies of IoT and the determination of jointly promoting the industrialization of NB-IoT .

ZTE can deliver comprehensive NB-IoT solutions, covering communication modules in the perception layer, network access layer, the platform layer (IoT device management, data storage management, big data analysis, etc.) and the application layer, and made significant progress in smart home, smart meter, environment monitoring, smart parking and other fields. To date, ZTE has constructed a large-scale IoT gateway platform for China Mobile, and signed a strategy agreement with Shanghai Telecom, of which a very important cooperative project is to build an IoT ecosystem and explore the innovative applications.

The NB-IoT standard is expected to be frozen in June 2016 , ZTE will conduct field testing and performance verification of NB-IoT network together with operators in the third quarter of 2016 , and is expected to begin commercial launch of the NB-IoT network in the first quarter of 2017.



4 Cloudization

• Cloudization Trend and Benefit

Network Cloudization is an important research topic of 5G. The future oriented Cloudization technology can break through the constrains of existing network architectures and protocol standards, and help operators to build an open, flexible, effective, and cost-effective cloud network.

The executives of mobile operators and equipment vendors are quite optimistic about this trend. We are just in the window of the mobile network cloudization. Network virtualization and cloudization can help operators deal with the demand of mobile services more effectively, saving network costs and accelerating the development of new business.

• Cloudization Procedure

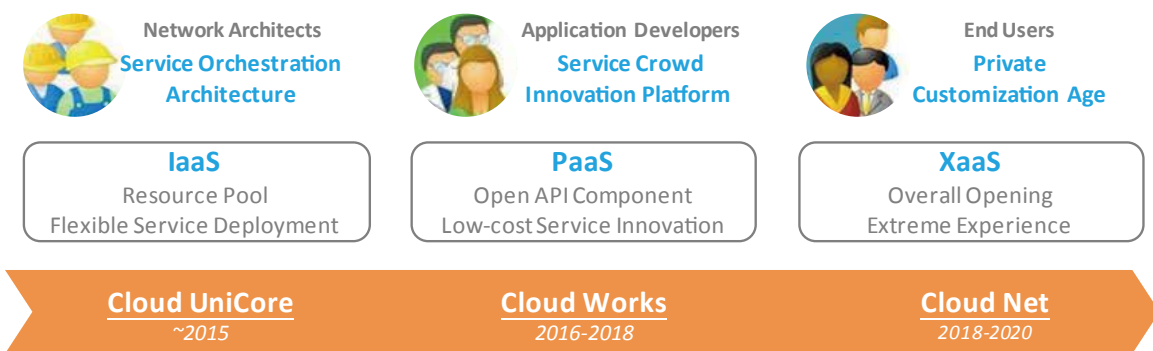


Figure 9: Cloudization Procedure

Network cloudization will be implemented step by step:

- Phase I, IaaS (based on Virtual Networking Functions, introduce NFV Orchestrator, NFV Manager, VIM(Virtualized Infrastructure Manager), Resource Pool);
- Phase II, PaaS (open and programmable network, from MANO to DevOps(Integrated solution of Dev Framework, service Framework and Ops Framework), support Flexible Combination of business logic components);
- Phase III, XaaS (fully opened networks capability to support end-to-end 5G sliced network and services innovation) .

Early cloudization technology research focused on the core network side, ZTE has helped operators successfully launched vIMS, vEPC in their commercial network. Currently, cloudization also extends to the radio network. ZTE has made remarkable achievements on the cloudization of the radio access network.

◆ Cloud Works

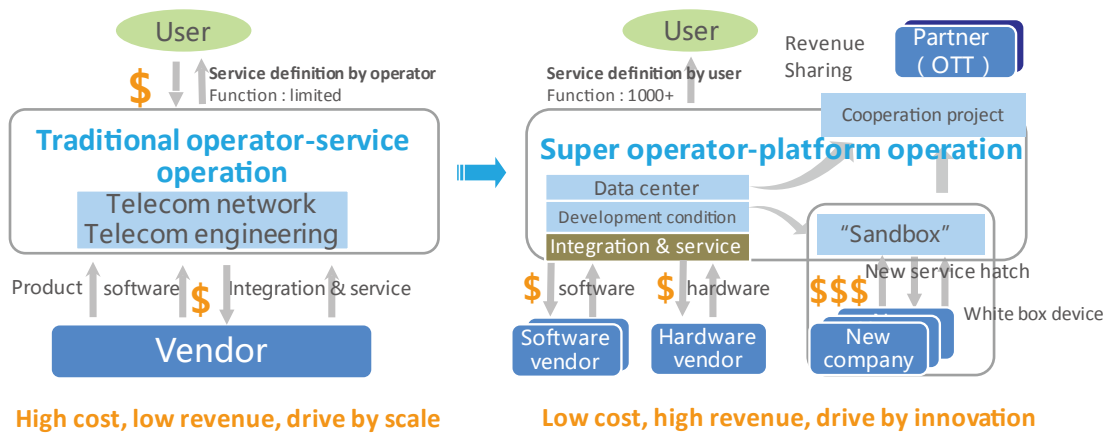


Figure 10: Cloud Works Solution Architecture

Cloud Works is ZTE's NFV PaaS solution. ZTE Cloud Works constructs a carrier-grade public innovation platform for operators. With the technologies such as the modularization of software functions, network slicing, PaaS can realize on demand generated services, on demand generated network, on demand Network function deployment. At the same time, NFV application Hosting, and highly efficient development environment and optimizations capabilities will help operators to build an open ecosystem, attracting developers, and realize endless personalized business innovation.

We firmly believe that network virtualization and cloudization can convert the conventional static network into a flexible and efficient dynamic network. With the combination of SDN and NFV technology, virtualized network could provide on-demand network slicing and optimum system performance for diversity vertical industries, and help the mobile operators to gain competitive advantages in the future.





5 Pre5G Deployment Strategy

ZTE fully understands the telecom industry development and proposes the end-to-end Pre5G network deployment strategy.

- If the operator has TDD spectrum, Massive MIMO should be deployed first in some hot-spot areas due to the mature industry chain.
- If the operator has abundant LTE spectrum, multi-carriers aggregation should be deployed from 2CC, 3CC then to massive CA step by step.
- For some indoor hot-spot areas, If the operator has only limited LTE spectrum, LAA or LWA should be the cost-efficient solution.
- If the operator wants to launch IoT service, ZTE suggests to deploy NB-IoT through upgrading the existing LTE network.
- Cloudization and virtualization are an essential trend, ZTE suggest that the operator deploy Cloud Works and Cloud RAN at the right time.
- The operator also should consider deploying the Pre5G technologies with a combination.

	eNodeB	CN	Transmission	Terminal
Massive MIMO	New deployment	No change	Expand to >1G/site	cat3-4
Pre UDN	Software upgrade + new sites	No change	No change for single site	cat3-4
DL 256QAM	Software upgrade	No change	Expand 30%/site	Cat 11-14
Massive CA	Software upgrade	No change	Expand to >1G/site	Cat 16
LAA	New deploy	No change	According to unlicensed carrier number	Cat 6+, R13
LWA	New deploy	No change	Small cell backhual	Cat 6+, R13
NB-IoT	New BP board	Upgrade	No change	IoT device
Cloud works	No change	New platform	No change	No change
Cloud RAN	Cloud BBU	Upgrade	No change	No change

Table 3: Pre5G End to End Deployment Strategy

6 Pre5G Industry Development

After first proposing the Pre5G concept, ZTE cooperates actively with industry partners and operators to promote ecosystem development rapidly while researching pre5G continually. ZTE has taken part in more than 40 standardization organizations, associations and forums. Presently, ZTE is a key member of several international standardization organizations, including ITU, 3GPP, IEEE and NGMN.

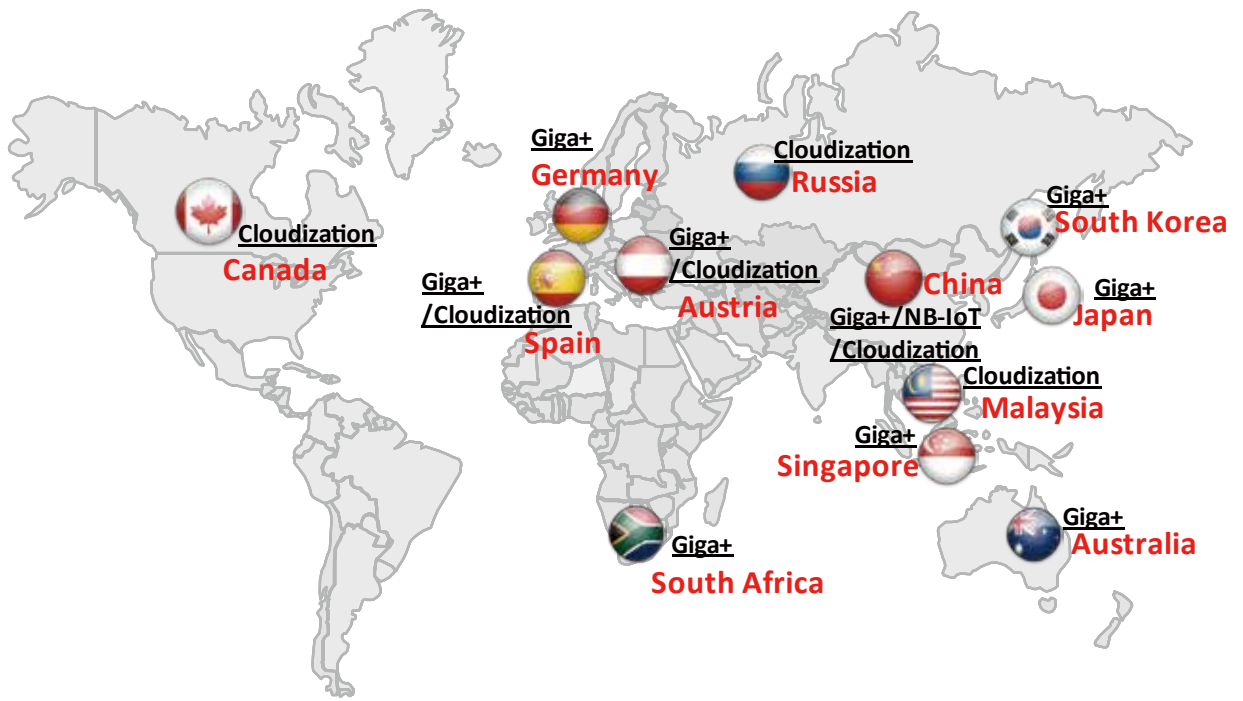
Because of excellent performance, in Feb. 2016, ZTE was awarded with “2016 MWC Best Mobile Technology Breakthrough” and “Outstanding overall Mobile Technology-The CTO’s Choice 2016” from GSMA in MWC2016.



Figure 11: Pre5G was Awarded in 2016 MWC

ZTE carries out in-depth cooperation with global operators in terms of customer demand, scenario study, new business applications, network innovation, and does its best to create the most suitable solution. ZTE has signed strategic cooperation agreements with leading operators, including China Mobile, DT, SoftBank, KT, U Mobile.

In 2016, the quantity of Pre5G commercial or pre-commercial networks will increase continually.



2016, ZTE Pre5G commercial and Pre-Commercial networks







ZTE

Tomorrow never waits

