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GigaRadio

Inspiring Mobile Innovation

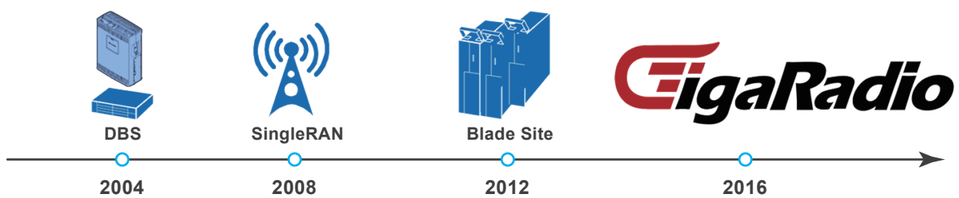
GigaRadio, Inspiring Mobile Innovation

Contents

1.Executive Summary

There is an accelerating technology shift to Mobile Broadband (MBB) networks across the world. MBB connections accounted for almost 50% of total connections in 2015. This number will increase to more than 70% by 2020. We expect the number of MBB users around the world to reach 6.7 billion by 2020, while each user is expected to use as much as 5 GB of data per month. Meanwhile, there is already a need for wide scale development of an Internet of Things (IoT). By 2020, there will be some 3 billion cellular IoT connections worldwide.

Innovation never stops to meet the MBB increasing demands. Huawei introduced Distributed Base Station (DBS) solution in 2004 and since then, Huawei develop a trend in the industry by coming up with major innovations in base station technologies after every four years. Huawei introduced Software Defined Radio (SDR) based SingleRAN base station in 2008, Blade Site solution in 2012 and Innovative GigaRadio in 2016 to meet the needs of the modern day MBB network requirements.

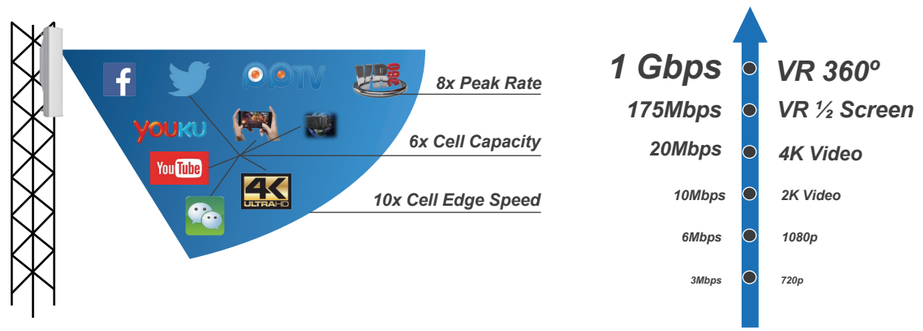


After the introduction of LTE in 3GPP release R8, 3GPP R10 was the main release called LTE Advanced. LTE Advanced Pro was introduced in 3GPP release R13, which is also known as 4.5G. Since October 2014, Huawei has set the tone for 4.5G technologies and set the benchmarks for 4.5G networks, which has been widely accepted by global operators. Namely Gbps (with a peak rate of over 1 Gbps); Experience 4.0 (both video and voice services delivered with High Definition experience); Connection+ (empowering vertical markets, including NB-IoT for cellular narrowband internet of things, Wireless to the "X" (WTTx) for home broadband & Enterprises and LiTRA (LTE Integrated Trunking Radio Access) for public safety networks based on public LTE networks.

Huawei GigaRadio is the new generation base station with innovative technologies. It covers a broad range of diversified products and solutions, which empowers 4.5G, TDD+, UMTS+ as well as compatible with GSM, UMTS and LTE. GigaRadio will guarantee MBB operators to be the market leaders and maintain competitiveness.

2.GigaRadio, Giga Everywhere

Mobile data traffic around the world is increasing at double-digit rates annually. This is hardly surprising, given the ubiquity of MBB networks, popularity of smartphones with larger screens, and availability of content-rich services for mobile phones. Video is an increasingly popular means of sharing the experiences and connecting with the things and people. Both 360-degree video and Virtual Reality (VR) create immersive environments that produces a sense of connectedness, detail, and intimacy. Such kind of services will put high requirements on MBB networks.



GigaRadio is Huawei wireless product portfolio, which enables flexible connectivity for diverse services such as Multi-RAT, Multi-Band, Multi-Sector and Multi-Layer by providing common network architecture across different technologies. It covers a broad range of diversified products and solutions that provides rich connectivity, high-speed performance and scalability of MBB networks. This will enable MBB operators for building a better-connected world. GigaRadio fulfills the needs of today and future mobile networks. It gives an evolutionary path for future 5G technologies, thus will smoothly evolve from the network architecture of SingleRAN to CloudRAN.

2.1 Enable Gbps Experience

GigaRadio base station provides xGbps speed capabilities to the mobile site to allow users to experience Gbps speed; a single module supports more than 1 Gbps capacity for a sector. Gbps represents an overall improvement in the data peak rates, capacity, and cell edge throughput. For example, using 3CC CA, 4x4 MIMO, and 256QAM in 4.5G network will deliver a peak rate of 1.2 Gbps. That is an 8 times faster than the 150 Mbps peak rate of 4G.

GigaRadio enables 6 times more capacity in comparison to the traditional base station solution. The average capacity of 4G eNodeB is 100 Mbps, whereas with GigaRadio base station it supports 6 times more capacity. Such as for 2K video GigaRadio base station support 75 channels simultaneous video playback whereas the traditional one can support only 12 video channels of 2K video.

GigaRadio boosts the cell edge throughput by 10 times improving the average cell edge throughput, from 3 Mbps to 30 Mbps,meeting the requirements of 2K/4K HD video anywhere anytime. New types of terminals and services such as Virtual Reality (VR), Augmented Reality (AR) and 4K video services are some of the applications, which will require gigabit capabilities in the network to let user enjoy it with a truly immersive experience.

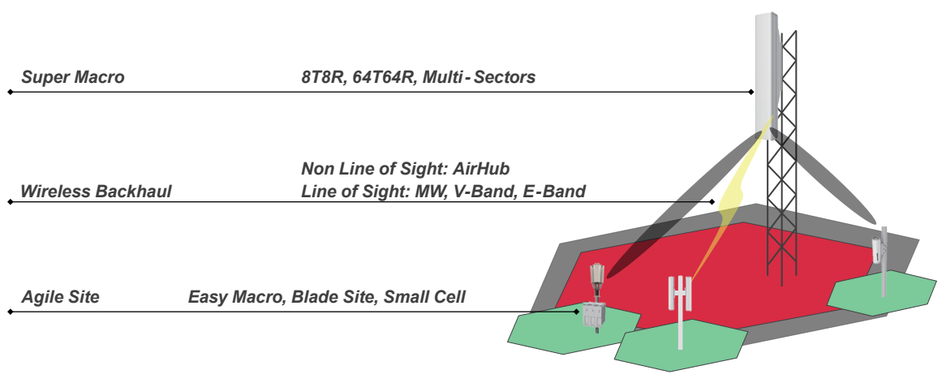
To enable Gbps experience, Massive MIMO has been incorporated into GigaRadio, which is becoming a mature wireless communication technology.Massive MIMO technology allows more antennas of transmitter and receiver, which provides more possible signal paths and better performance in terms of data rate and link reliability.

Deploying capacity based indoor mobile connectivity is one of the key trends in the mobile networks, Where mobile operators are experiencing high traffic demands in indoor environments. More than 70% of traffic has been generated in indoors environment. That is why it becomes a norm for mobile operators to provide small cell based solutions to deal with the data usage requirements of the indoors environment. Small cell based solutions are now essential part of the mobile networks and business strategies.

GigaRadio based small cell solutions are addressing the challenges of the indoor Giga capacity by enabling Distributed MIMO (D-MIMO) technologies.D-MIMO uses distributed multiple-antenna technology inter-cell communication and coordination based on inter-cell high-speed interfaces. It allows multiple antennas to be used for a single UE. It helps networks to evolve from the legacy cell-centric network architecture to user-centric network architecture. For example, this technology can combine eight 2T2R cells into one 16T16R cell, evaluate the uplink signal quality of terminals, determine their locations, and choose appropriate antenna combinations for transmission to them. In addition, the use of spatial multiplexing technology allows multiple terminals to use the same radio resources, significantly increasing spectral efficiency. This will allow a user to enjoy Gbps service experience everywhere.

2.2 Empower Radio Densification

“Radio Densification” a literally term now used in mobile networks. Such kind of approach is used to densify the radio network for the expansion of the system resources and keeping the persistent network experience, which is one of the key successful factors in MBB network deployment. GigaRadio agile solution pack provides variety of products and solutions, catered to meet the network densification requirements with Giga everywhere capabilities easily and flexibly.



The user experience at anytime anywhere requires an excellent mobile infrastructure by improving network coverage, expanding system capacity and providing excellent mobile broadband services. The focus is wherever are the subscribers there demands for data usage is growing and there access to services at various locations such as dense urban city centers, CBD districts, public parks, rural areas will require dense radio infrastructure to address the growing demands of the data.

GigaRadio Agile site solutions termed as a zero footprint solution such as Easy Macro and Blade Site allows the site densification, coping with the challenges of the site acquisition and environment challenges as well.

GigaRadio AirHub a diversified solution that is based on relay technology. With the incorporation of Agile Site, it provides flexible mobile backhaul solution with Non Line of Sight (NLOS) to the agile sites without the challenges of backhaul.

GigaRadio Active Antenna Unit (AAU) solves the challenges coming from multi-band and multi-RAT networks. The new bands bring site space challenges for the existing site. With its compact design, fast and flexible deployment capability and enhanced MIMO (eMIMO) technologies improves the spectrum efficiency and site capacity. Thus bringing huge TCO savings, which is vital for mobile operators.

3. GigaRadio, Key Technologies

The key value proposition of the GigaRadio is to improve spectrum efficiency by 2 times, enhance the performance by 30% and brings 20% OPEX savings. Mobile operators' benefits from it and thus improve overall competitiveness. Here are some of the key technologies of GigaRadio:

3.1 2X Integration

GigaRadio provides highly integrated products such as Blade RRU which supports 2 times higher integration compared with its predecessor. It support more flexible multi channels and multi-bands capabilities to benefit operators in building best experience centric MBB networks. In comparison to its predecessor, the Blade RRU now support 4T4R with 12L volume as previously it supports 2T2R with 12L volume. Further advancement on achieving the highest level of integration, the latest Blade RRU support 8L RRU which is the smallest RRU in volume. It support 20 watt per litre that is one of the most integrated RRU available today in industry.

The new 4.3-10 connector system is designed to meet the rising performance needs of MBB network equipment and the requirements of more compact connector sizes. The 4.3-10 connector is more compact. (40% smaller and 67% lighter than 7/16), best electrical performances, excellent PIM and Voltage Standing Wave Ratio (VSWR) performances, Low couple torque or tool free coupling mechanism as well as easy installation.

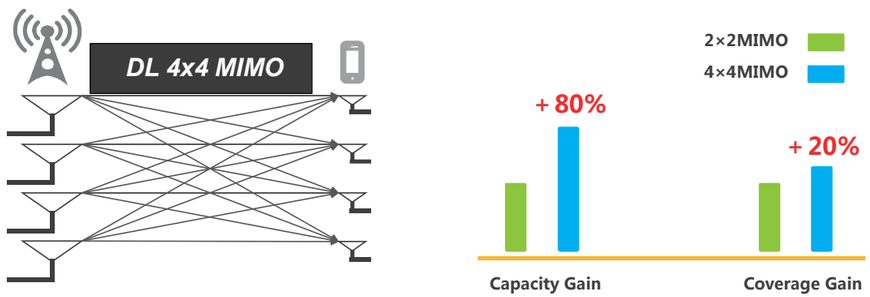
3.2 Spectrum Efficiency

Spectrum is most valuable assets and which is scarce and limited. It costs more than 800M USD in Thailand, 500M USD in Germany and 700M USD in India for 10MHz by spectrum auction in 2015.To increase spectrum efficiency is the key for building the valuable radio sites.

GigaRadio 4T4R RF modules brings significant gains over 2T2R in terms of coverage, capacity, and users' perceived throughput. It improves the spectrum efficiency by 2 times in theory and 1.8 times in reality. The mobile operators benefits when migrate from 2T2R to 2T4R or 4T4R technology for both coverage and capacity in uplink and downlink. An operator investing into 4T4R platform can cumulate several competitive advantages including:

1. Better coverage (mainly due to 4RX diversity)
2. Better end-users' service experience at the cell edge (strategic in today modern communications)
3. Higher DL cell capacity (both peak and average throughput)
4. Higher end-users' throughput
5. Competitive network capacity solution in case of limited spectrum resources

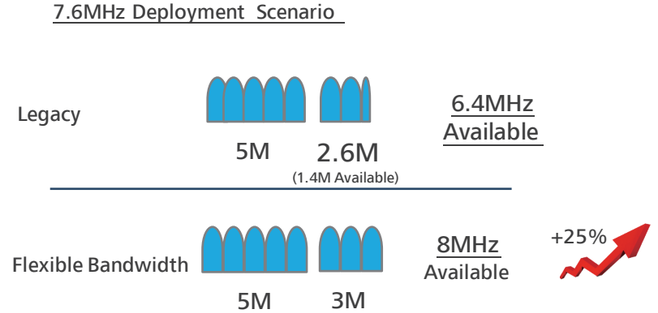
High Capacity Gain from 4X4 MIMO



High Order Modulation 256QAM was introduced in 3GPP Release R12 as a supplement to the existing modulation schemes (QPSK, 16QAM, and 64QAM); 256QAM is used to increase the bit rates of transmission to UEs when radio conditions are favorable. 256QAM allows eight bits to be transmitted per symbol supporting a large transport block size (TBS).256QAM increases the peak rate by 33% compared with 64QAM modulation.It can be used for both indoor micro cells and outdoor macro cells.

Flexible bandwidth efficiently utilize more bandwidths ranging from 1.4 MHz to 20 MHz, rather than the 6 standard bandwidths used in LTE (including 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz). This will improve the use of spectrum refarmed from 2G and 3G and ultimately improve the spectrum efficiency.

Assume that an operator has a 7.6 MHZ bandwidth.Before applying flexible bandwidth technology it uses only a 5MHz standard bandwidth, (equal to 25 RBs) used in Cell A and 1.4 MHz standard bandwidth in Cell B (equal to 6 RBs) and the remaining 1.2MHz is wasted. After enabling flexible bandwidth solution, cells with standard bandwidths of 5 MHz and 3 MHz can overlap so that all the 7.6MHZ bandwidth (equal to 40 RBs) can be used. Therefore, the RB usage increases by more than 25%.



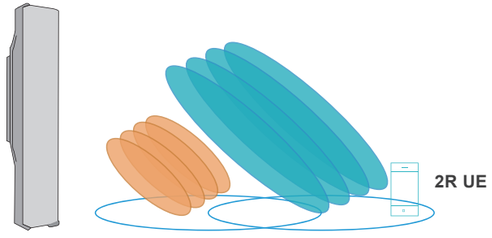
3.3 Best in Class Performance

Performance has been attributed to many factors in the network some of the key GigaRadio technologies which increases network performance.

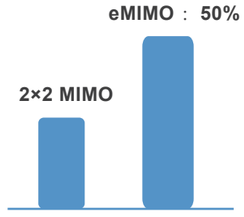
Enhanced Multiple Input Multiple Output (eMIMO) technologies comes with package of various MIMO related solutions. Such as Multi User MIMO (MU-MIMO), Coordinated Beamforming,and Advance Beamforming (ABF) which offers spatial multiplexing gains, increasing cell capacity and user-perceived throughput when the network is heavily loaded.Overall, from 30% to 50% gains can be achieved by deploying eMIMO features in the mobile network.

MU-MIMO is a type of spatial multiplexing. It enables multiple UEs to use the same Physical Resource Block (PRBs) in a Transmission Time Interval (TTI). MU-MIMO offers spatial multiplexing gains, increasing cell capacity and user-perceived throughput when the network is heavily loaded. Where as when the network is lightly loaded, coordinated pilot scheduling can reduce interference between intra-frequency neighboring cells, thereby improving signal quality and effectively increasing user-perceived throughput.

ABF uses closed loop 4T4R MIMO combing both vertical and horizontal beamforming to enhance the spectral efficiency by using the existing 2R terminals.



ABF:Advanced Beamforming



Average capacity gain

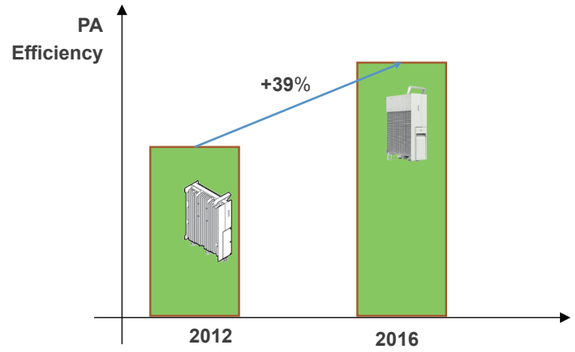
3D Beamforming technologies fully utilize radio resources in both the micro- and macro-spatial domains. 3D array reinforces the free transmission of radio signals in the spatial domain by controlling the horizontal and vertical domains of the array's beam pattern.

Passive intermodulation (PIM) free solution is trying to leverage precious spectrum in the most efficient way. PIM is the generation of interfering signals caused by nonlinearities in the mechanical components of a wireless system, especially in the wideband wireless communication system. Typical, the PIM signal generated by transmitting signals will degrade receiving signal since receiver cannot tell the difference between PIM signal and the “real” receiving signal. This phenomenon may happens in both intra-band wireless communication system and inter-band communication system, such as two carriers in 1800MHz, or two carriers co-existing in both 700 and 800MHz. The traditional solution to solve this problem is using two dedicate radio and antenna system for both carriers respectively, which is not realistic due to high cost. Huawei PIM free solution offers a feasible and cost effective solution to deploy carriers in single antenna system, which guarantee receiving signal quality though there is generated PIM signal in receiver bandwidth. As a PIM free radio system, Huawei GigaRadio solution is developed equipped with both advanced algorithm and physical structure optimization.

3.4 Energy Efficiency

GigaRadio products and solution adapt various innovative technologies and techniques to improve the energy efficiency in the mobile networks.

Improvement in PA efficiency technologies has vital effect on achieving the better energy consumptions in mobile networks. Since 2012, the Power Amplifier (PA) efficiency of Huawei RF technology has been improved 39%. This involves latest material, leading advanced algorithm, optimize structure design and adopting envelope-tracking technology to improve theoverall energy efficiency.



Huawei PA Efficiency Development

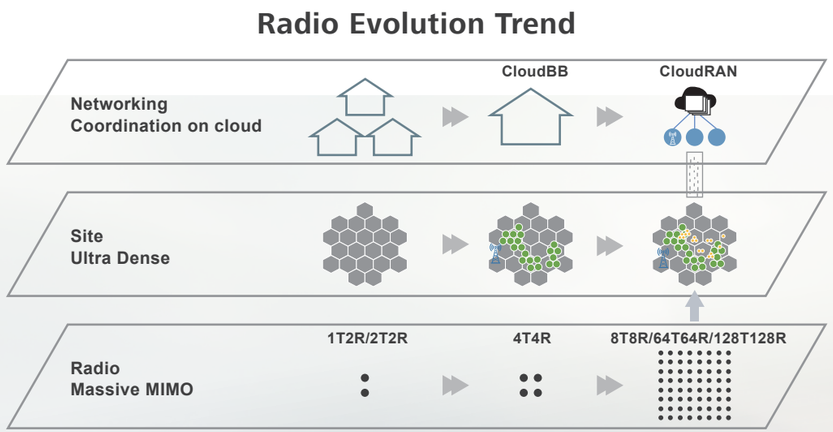
The finest design in the RF equipment’s allows taking advantage on leaf cooling technologies such as bio-heatsink helps to maximize the cooling surface as leaf evolution and the chimney effect maximize the speed of airflow to utilize the natural way for cooling in the systems. Thus helping mobile operators to bring energy savings and emission reduction to construct a greener network innovative solution and green energy utilization.Overall GigaRadio reduces the power consumption up to 30% enabling mobile networks to be more environmental friendly.

GigaRadio agile site solution such as Easy Macro and Blade Site are environmental friendly site solution, which can be adapted various scenarios. Blade Site a zero footprint site solution which uses natural heat dissipation technology and the need of air conditioners are not required any more in outdoor environments which further helps to improve power consumptions and bring more energy savings.

4. Driving Future Evolution

GigaRadio is agile, scalable, efficient and future proof; it will drive the mobile operators easily towards future 5G technology. It will also provide a clear path for mobile operators towards investment protection and high performance network to improve user experience and rapidly evolve to meet changing network demands.

GigaRadio can easily realize to transform the mobile networks from dense network to ultra-dense Network. In future, mobile networks expected to cope with extreme capacity, coordination and resource management requirements.



GigaRadio will smoothly support the network architecture evolving from SingleRAN to CloudRAN architecture. Thus enabling flexible connectivity for diverse services such as Multi-RAT, Multi-Band and Multi-Sector by providing common network architecture across different technologies & Layers. CloudRAN termed, as a new benchmark for RAN will be capable to support one architecture for multi-technologies and ready for 5G.

5. Glossary

AAU – Active Antenna Unit
ABF – Advanced Beamforming
MBB – Mobile Broadband
NB-IoT- Narrow Band Internet of Things
LPWA-Low Power Wide Area
MNO – Mobile Network Operator
MIMO- Multi-in-Multi-Out
eMIMO- Enhanced Multi in Multi Out
IoT- Internet of Things
DBS - Distributed Base Station
DL – Down Link
UL – Up Link
VR – Virtual Reality
3DBF –3 Dimensional Beamforming

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Spirit of Craftsmanship