

Mobile Cloud CloudAIR White Paper

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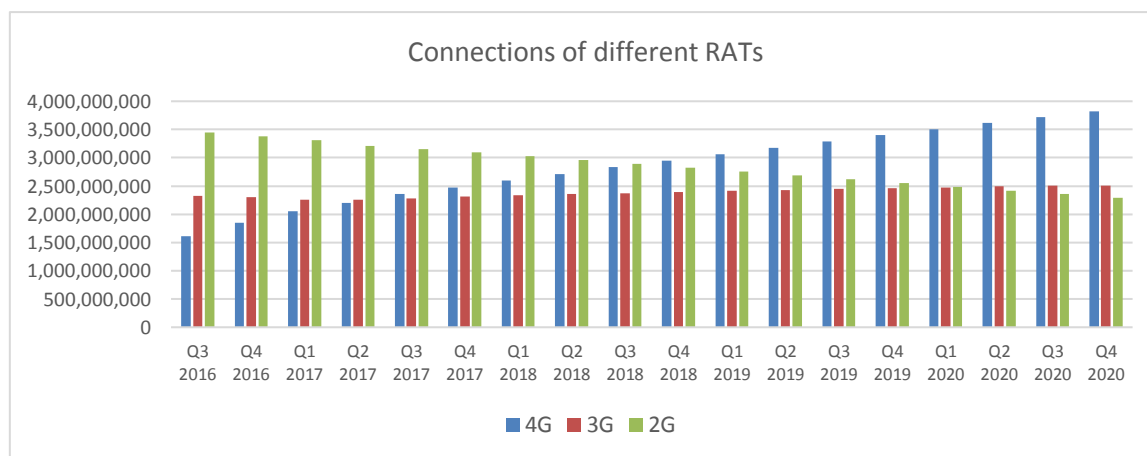
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Abstract: The emergence of new services, new applications, and new industries puts forward higher requirements for the mobile network. CloudAIR redefines wireless air interface resource allocation with the idea of cloud, breaks the air resource allocation problem, solves the network challenges that operators face in the multi-RAT and multi-band scenario, and protects the existing investment to achieve the rapid deployment of 5G.

Introduction: With the emergence of new services, new applications, and new industries, more and more demands are put forward for the mobile network: more connected users, higher experience rates, and richer application services. To address these demands, newer technologies and more recent RATs are continuously introduced into existing networks. At present, the global population coverage rates of 2G, 3G, and 4G, reach 95%, 85%, and 72% respectively. With the acceleration of 5G standards, it is expected that 5G will be commercially deployed in a small scale in some regions (such as China, the United States, South Korea, Japan, Western Europe, etc.) in 2018. The coexistence of multiple RATs and multiple bands has become a normal phenomenon in the current network. How to rapidly introduce a new RAT, how to realize the service balance between different RATs, and how to realize smooth network evolution become the problems each operator must be confronted with.

The number of GSM subscribers has been declining in most countries and regions in the past 10 years, but remaining users still enjoy notable penetration rates. M2M applications still do not require high-speed data connections, such as point of sale terminal and cargo tracking devices using GSM connections for wide coverage. This means that the GSM network cannot be switched off without a suitable transition plan. Consequently, mobile operators will operate their GSM networks with high costs and low yields during this period. The ‘golden spectrum’ occupied by the GSM network, such as 900MHz and 1800MHz, cannot be used for new radio technologies such as LTE until the spectrum is released.



The problem all the operators are confronted with is essentially the contradiction between the explosive growth of network demand and the limited air interface resources. In order to solve this problem, Huawei released the CloudAIR solution in November 2016. This solution redefines wireless air interface resource allocation by introducing the idea of “cloud”. It breaks the limitation of air interface resource allocation, from fixed configuration to dynamic sharing, realizes on-demand network resource allocation, smoothens network evolution, and increases the utilization efficiency of air interface resources.

Overview of CloudAIR

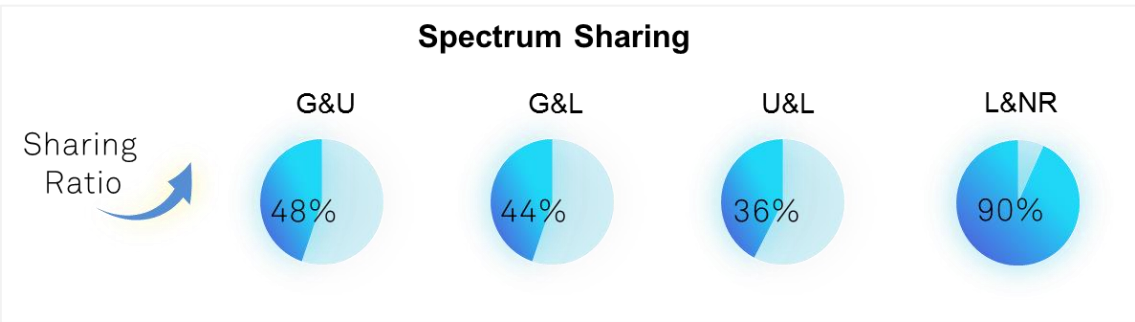
CloudAIR mainly consists of three parts: **spectrum cloudification**, **channel cloudification**, **power cloudification**. Unlike the traditional "Refarming" mode, spectrum cloudification enables multiple systems to dynamically schedule the same spectrum at the same time, improving spectrum utilization. Channel cloudification combines high-band downlink channels and low-band uplink channels to eliminate the C-Band uplink coverage bottleneck and achieve the fast full network coverage of 5G. Different from the

traditional “refarming (static configuration)” mode, power cloudification makes it possible to share power resources, increasing cell capacity.

Huawei's CloudAIR solution has been deployed in many countries. It is estimated that CloudAIR will be deployed on more than 30 networks by the end of 2017 and the number will reach 100 by the end of 2018. CloudAIR has become the benchmark for building a multi-band multi-RAT network. Together with some operators, Huawei conducted extensive researches on air interface cloud technologies and actively promoted the standardization of wireless cloudification.



To keep pace with the evolution of multi-band multi-RAT networks, the development of CloudAIR can solve the network efficiency problem on existing networks in the current network and fast introduce 5G network. It includes GU spectrum sharing, GL spectrum sharing, 5G NR uplink / downlink decoupling, UL spectrum sharing, UL power sharing, and LTE inter-carrier power sharing. As the CloudAIR solution is deployed in more and more networks, its technologies continue to meet the needs of different operators in the world. Anti-interference technology is the core technology of CloudAIR. With the advanced digital filters (asymmetric filtering, etc.) and intelligent scheduling avoidance interference algorithms (faster intelligent scheduling), the spectrum sharing ratio between RATs is continuously increasing. Taking GL spectrum sharing for example, the spectrum sharing ratio is increased from 24% to 44%, and in the future will be even higher.

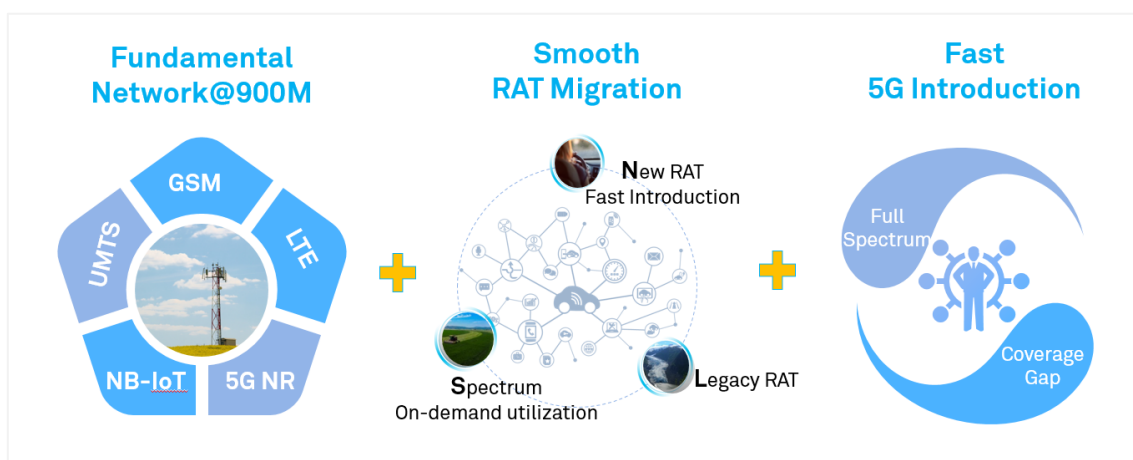


Spectrum-based MBB2020 target network planning is one of the most important strategies for each operator. 900MHz will become a basic coverage layer, 1800MHz / 2100MHz will become a basic capacity layer, and 3.5GHz will become as a layer for ultra-experience. The continuous breakthrough of key technologies enables more and more operators in the world to use CloudAIR and enjoy the benefits brought by mobile network cloudification. CloudAIR enables the fundamental network in 900MHz, smooth RAT migration, and fast 5G introduction.

Ultra Capacity	3.5G	NR
Capacity Layer	1.8/2.1G	LTE / NR UL
Coverage Layer	900M	GSM / UMTS / LTE / NB-IoT / NR

900MHz has good coverage performance and is one of the most widely deployed frequency bands in the world. It supports all air interface technologies (2G / 3G / 4G / NB-IoT / 5G) in the wireless network and the corresponding terminal industry chain is mature. Therefore, 900MHz will become the fundamental coverage layer to support all services.

1800MHz / 2100MHz will become the mainstream band of 3G / 4G. Because of the balance between the spectrum bandwidth and the coverage performance, these are the best capacity layer. As recognized in the industry, 3.5GHz is the first band of 5G. Its advantage is high bandwidth and large capacity, so it is the bearer layer of MBB's ultra-experience. As users gradually migrate from 2G to 3G, 4G, and 5G, network evolution not only ensures the experience of existing users but also increases spectrum utilization. CloudAIR is the best solution for this.



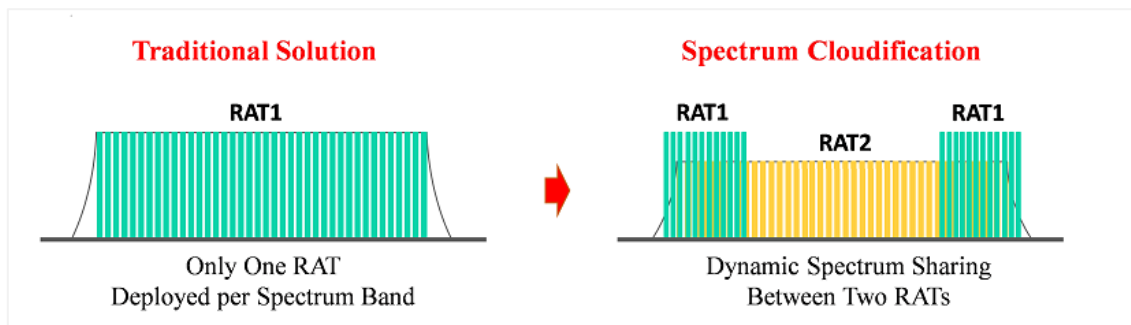
Fundamental Network in Golden Low Band@900MHz

900MHz can support all air interface technologies (2G / 3G / 4G / NB-IoT / 5G) and CloudAIR can help operators to build the fundamental network, supporting all services in 900MHz. For voice services, VoLTE and VoNR enable 4G/5G HD voice services. For



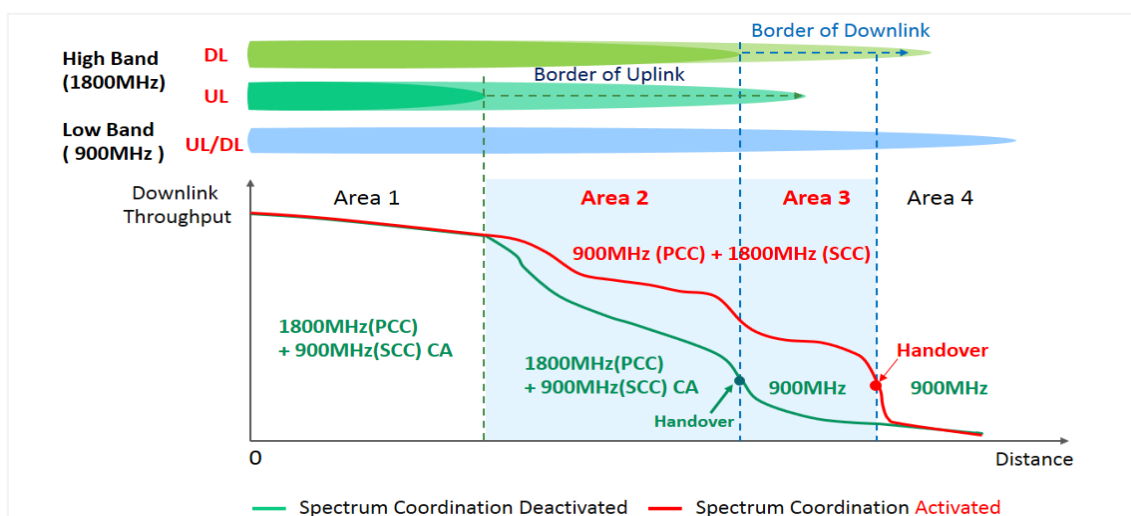
the Internet of Things service, most of the leading operators choose 900MHz for NB-IoT and all leading module vendors have 900MHz NB-IoT modules. For MBB services, basic data traffic requirements can be met based on the 4G/5G network deployment.

Considering the MBB evolution process, spectrum cloudification, such as G/U spectrum sharing, G/L spectrum sharing, and U/L spectrum sharing, is very suitable for the MBB user migration in 900MHz. Spectrum can be allocated dynamically based on traffic requirements: when there is less traffic in the GSM network, more spectrum resources can be automatically used for UMTS or LTE.



According to the spectrum resource sharing mechanism, the operator only needs to perform one-time network planning in the case of the phase-out of the legacy network. It also makes the network O&M easier with lower costs.

Considering the MBB coverage and indoor capacity boosting requirements, channel cloudification, such as LTE spectrum coordination can take advantage of both high and low bands, which expands the coverage area of high band, enhances user throughput, and improves user experience. It can be used not only for FDD high and low bands, but also for TDD high bands and FDD low bands.



Commercial Case 1: GU Spectrum Sharing

Operator A was experiencing massive traffic growth annually but lacked the ability to acquire additional spectrum to meet its growing MBB traffic needs. With legacy use declining but taking up valuable spectrum, options were limited.

Problem: MBB traffic increased by 166% in less than one year. GSM occupies 4.6MHz of 900MHz spectrum, UMTS occupies 4.2MHz, and no expansion spectrum is available to offer LTE services. How to quickly meet the requirements at the lowest cost without acquiring new spectrum?

Solution: CloudAIR: G111+UMTS shared both RAN technologies on a 5MHz channel simultaneously, plus 3MHz for LTE

Results: CloudAIR G111+UMTS enabled a stable GSM KPI and a UMTS capacity of 60% compared to a 5MHz channel. Besides this, LTE PS traffic increased by 10% after the L900MHz deployment and LTE coverage improves by 11% compared with L1800MHz. Operator A saves 660 million USD for new spectrum auction and reduces 33% L1800MHz site with this solution. It is forecasted that this solution will contribute 57.4M USD income in 2017, and the ROI is less than 1 year.

Commercial Case 2: GL Spectrum Sharing

Operator T in Country S expected to serve their customers with the fastest LTE network and widest coverage. The operator wanted to reuse the existing GSM base stations to deploy LTE 900MHz to improve the LTE network coverage and performance with lower TCO.

Problem: Operator T has 7.5MHz in 900MHz, and GSM S222 is the mainstream for 2G users' requirement, so the configuration is GSM4.5MHz+ LTE3MHz. In order to achieve expected LTE strategy, the operator wants to deploy 5MHz LTE network to increase the MBB experience while keeping GSM performance stable.

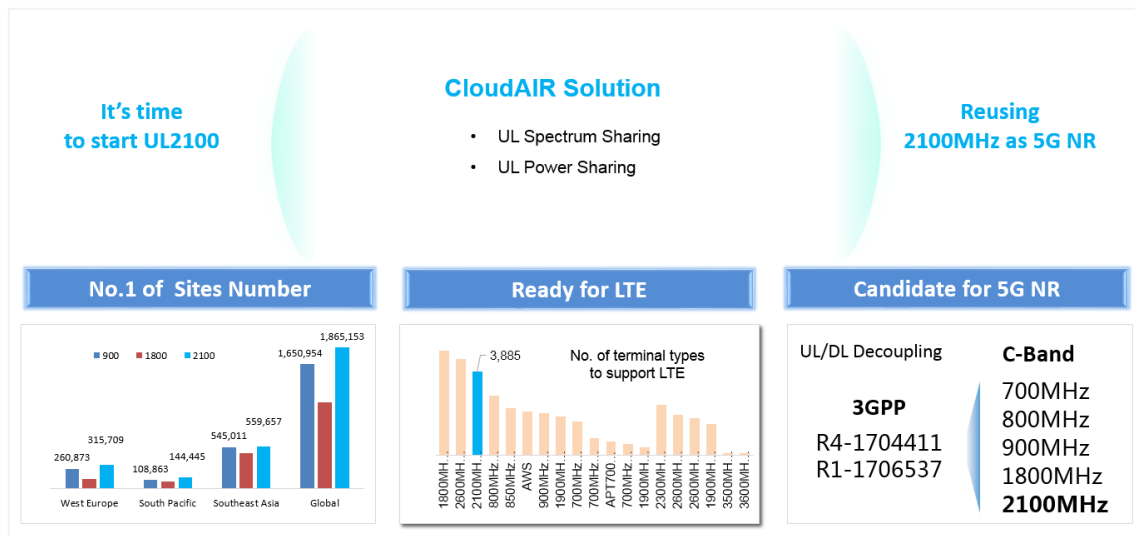
Solution: CloudAIR GL spectrum concurrency solution. It can deploy LTE 5M on the 7.5M spectrum while GSM 3.6MHz.

Results: The LTE downlink performance was improved significantly after the deployment of the GL spectrum concurrency solution. The drive test result showed that the average downlink throughput of LTE increased by 52% compared with LTE 3M, and the GSM KPIs kept stable. With LTE900MHz, both the spectrum utilization and LTE coverage were improved. It can be expected that the revenue will be increased in the future based on the traffic data boosting.

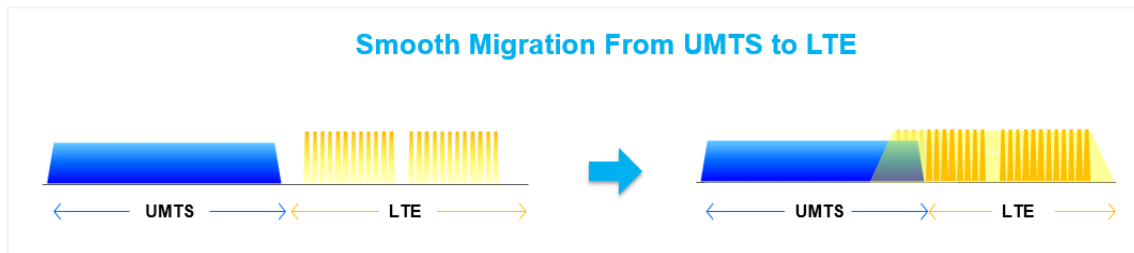
Spectrum cloudification changes the way of spectrum resource allocation and the way in which networks are rolled out. This gives operators a path to smooth network evolution with lower cost as they deploy UMTS, LTE and 5G services.

Smooth RAT Migration

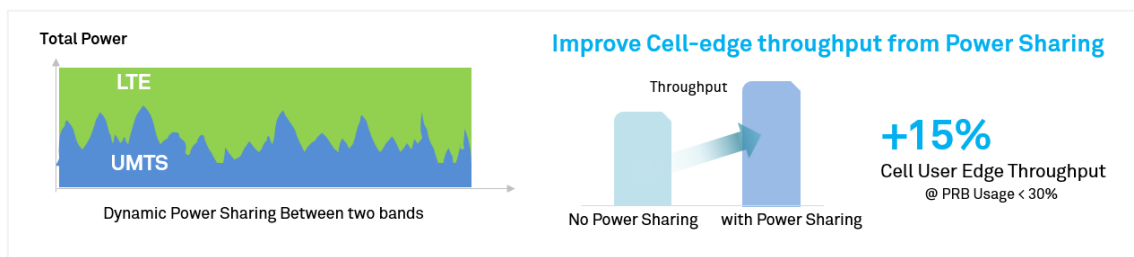
CloudAIR makes the RAT migration smoother. 2100MHz is used as an example. Since most terminals of 2100MHz support LTE mode and the number of 2100MHz sites is the largest in the world, 3G migration to 4G in 2100MHz band is a very cost-effective solution. With the deployment of 5G in the future, 2100MHz is also a very good choice for the basic capacity layer of 5G in low-frequency band.



Spectrum Cloudification, such as UMTS and LTE spectrum sharing, makes it possible to dynamically allocate spectrum resources based on traffic requirements. When there is less traffic in the UMTS network, more spectrum resources can be automatically used for LTE. UMTS and LTE spectrum can support non-standard bandwidth of UMTS and LTE, making the network configuration more flexible.



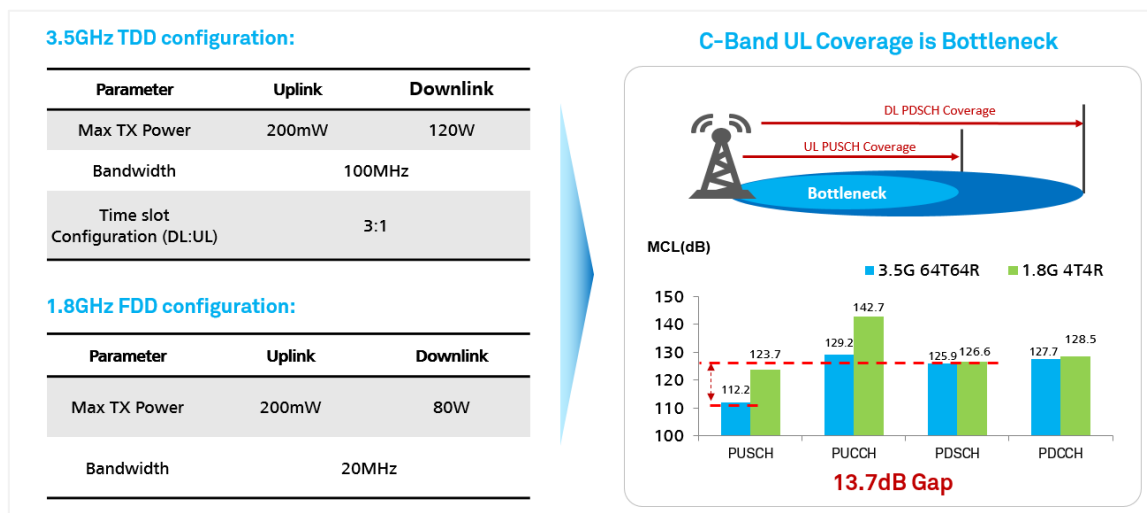
Power cloudification, such as UMTS and LTE power sharing can dynamically adjust the radio transmission power between different carriers and technologies according to current network requirements. Power cloudification can significantly enhance power utilization, cell capacity, and user experience for all users without the need to change the user device.



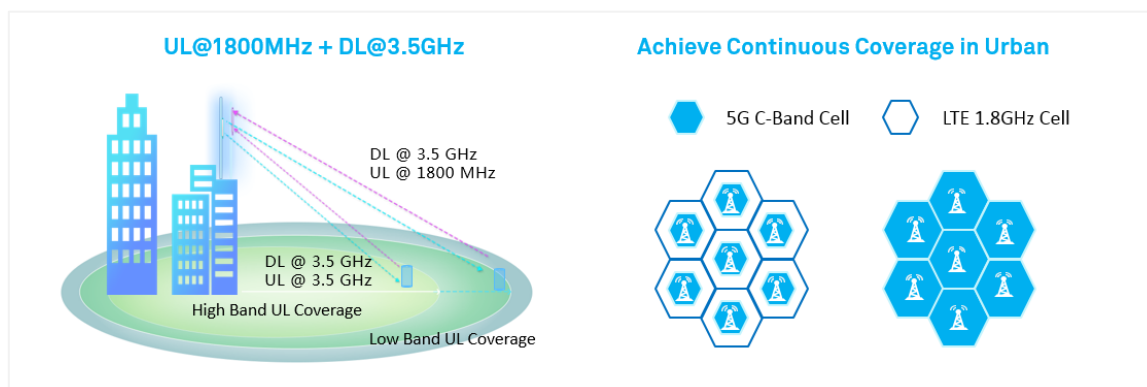
Fast 5G Introduction

In 2017, Huawei completed the out-of-field testing of uplink and downlink decoupling to achieve technological breakthroughs. In terms of standardization, Huawei teamed up with global Tier 1 operators (China Mobile, China Telecom, China Unicom, VDF, Telefonica, Italy TI, Orange, Etc.), to promote the uplink and downlink decoupling, LNR spectrum sharing and other technologies standardization. In March 2017, these proposals formally incorporated into the 3GPP work item, and it is expected that the uplink and downlink decoupling will freeze at the end of this year. The spectrum sharing of LNR will be frozen in 2018 R15.

Compared with Sub-3GHz spectrum, the 3.5 GHz ('C-Band') has larger spectrum resources resulting in higher capacity, which will be a key band for early 5G network deployments. Many countries, such as China, Japan, Korea, the United States, are planning to deploy early 5G networks on the 3.5GHz band, however, uplink coverage restriction is a major challenge on this band. By using Massive MIMO technology, the downlink coverage of 3.5GHz is basically equal to that of 1800MHz 4T4R, but the uplink and downlink coverage gap is large. Test data shows that there is a gap of 13.7 dB between the uplink and downlink coverage of 3.5GHz. As the power of the module increases, the BF/CRS-Free algorithms are continuously optimized for NR to reduce the downlink interference, the uplink and downlink coverage gap will be further expanded. This will make it very difficult for operators to build a network in 3.5GHz that has the same uplink coverage as the downlink.



To address this challenge, Huawei has proposed a UL/DL decoupling scheme. When the UE is at the near point, both the uplink and downlink services are carried on the high band (for example, 3.5GHz); when the UE is at the middle or far point, the downlink service is carried in the high band while the uplink service is carried in the low band (for example, 700MHz/800MHz/900MHz/1800MHz). If 3.5 GHz high-frequency and 1800 MHz low-frequency are deployed in the same site, UL/DL decoupling can help operators quickly build a 5G network that has the same coverage as the FDD 1800 MHz network.



As described above, when the UE is at the middle or far point, the uplink service is carried in the low frequency while the low frequency also carries the uplink service of LTE. This requires that the uplink spectrum be shared to NR, that is, uplink spectrum must be dynamically shared.

At present, NR UL and DL decoupling has been included in 3GPP R15 WI and will become the fundamental technology of 5G. Up to now, the RAN4-proposed uplink sharing and channel decoupling candidate spectrum combination is illustrated in the figure below. With the gradual development of 3GPP protocols, the spectrum combination will be clear.

Band combination for NR-LTE uplink sharing(R4-1704411)	
Frequency ranges for NR	Operators whose request is including in the frequency range
1710-1785MHz (UL)/3.3-4.2 GHz*(DL&UL) (1800MHz)	China Telecom, China Unicom, CMCC, Deutsche Telekom
832-862MHz (UL)/3.3-4.2 GHz*(DL&UL) (800MHz)	Orange, Telefonica, Etisalat, Deutsche Telekom
880-915MHz (UL)/3.3-4.2 GHz*(DL&UL) (900MHz)	CMCC
703-748MHz (UL)/3.3-4.2 GHz* (DL&UL) (700MHz)	Orange, Telefonica, Etisalat

Conclusion: Spectrum cloudification enables dynamic sharing of the same spectrum by multiple RATs in modern radio networks. Compared with refarming, this changes the way operators deploy new wireless technologies at lower cost, shorter time, and wider coverage. Since spectrum cloudification applies to technologies up to 5G, areas with 4G coverage now enjoy 5G coverage. Thus, 5G coverage is faster and further. Power cloudification improves resource utilization of transmission power. This improves the capacity of networks shared by different carriers and technologies. Channel cloudification converts the network to reach consistently good experience especially in 5G era.

Huawei cooperates with global partners in promoting the CloudAIR solution. More and more operators choose CloudAIR solutions, and the uplink / downlink decoupling and LNR spectrum sharing in CloudAIR will become the industry standard.