

Delivering Mobile Diversity



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As mobile connections multiply and diversify, telecoms operators are looking to deploy new flexible network architectures.

Now interwoven into the fabric of daily life, mobile connectivity is being applied in all kinds of innovative ways. As well as delivering compelling consumer services, it is helping drive the development of the Internet of Things (IoT), which promises to transform many different parts of the economy. To deliver everything from high definition entertainment to remote control of industrial equipment, mobile networks need to juggle a diverse set of demands. Sometimes they need to prioritise throughput, sometimes responsiveness, sometimes battery life.



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Mobile operators are responding by deploying 4G and 4.5G networks alongside their legacy infrastructure. The next generation of mobile technologies - 5G - will further expand their options. Developed specifically to support a massive expansion in connectivity, 5G aims to deliver a step change in latency (sub 1ms on the radio access), capacity (x100 the capacity of 4G) and peak data rates (20 Gbps / 10 Gbps for downlink and uplink respectively). But rather than sweeping away its predecessors, 5G is likely to co-exist with both 4G and 4.5G networks for at least a decade. Leading operators, such as Vodafone, Telefónica, Deutsche Telekom and China Mobile, are deploying commercial and trial 4.5G networks now, while the first pilot 5G networks are likely to appear from 2018 onwards.

“China Mobile plans to commercially deploy 5G in 2020,” says Dajie Jiang of China Mobile Research Institute. “At the beginning, 5G will be deployed in regions where the network capacity is limited or some services (e.g. ultra-reliable and low latency communications) cannot be provided by 4G, and then gradually expand the coverage... 4G and 4.5G will exist for a long time in future and be continuously evolved with advanced features to address the emerging use cases, while 5G will gradually grow up.”

Dr. Choi Chang-soon, a senior manager at the 5G Tech Lab of SK Telecom, adds: “I am pretty sure operators will keep using 4G commercially for the time being. At least until 5G frequencies become widely available, 4G will be the main network for each operator for the time being.”

The GSMA, the global mobile operator trade group, notes that its members have invested heavily in 4G and anticipates the technology will evolve through a lengthy lifespan. In a paper¹ entitled *Unlocking Commercial Opportunities From 4G Evolution to 5G*, the GSMA says: “A significant proportion of the new business opportunities can and should be accessible using an evolved 4G network. This has crucial commercial implications since it means that 4G will continue to be used to support legacy services (including IMS-enabled communications services) and therefore maximises the return of investment (ROI) in 4G, which the GSMA estimates to be in the tune of \$1.7 trillion in the 10 years to 2020.”

By 2025, the GSMA forecasts that 5G will account for about 10% of total non-machine-to-machine (non-M2M) connections, whereas 4G will account for 60% of connections. Similarly, Juniper Research forecasts that 5G services will account for less than 10% of mobile services revenues by 2025².

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GSMA

¹ http://www.gsma.com/network2020/wp-content/uploads/2016/03/704_GSMA_unlocking_comm_opp_report_v6.pdf

² Source: <http://www.juniperresearch.com/press/press-releases/5g-revenues-forecast-to-exceed-65bn-usd-by-2025>

Release	Name	Status	Start date	End date
Rel-15	Release 15	Open	2016-06-01	
Rel-14	Release 14	Open	2014-09-17	2017-06-09 (SA#76)
Rel-13	Release 13	Frozen	2012-09-30	2016-03-11 (SA#71)
Rel-12	Release 12	Frozen	2011-06-26	2015-03-13 (SA#67)
Rel-11	Release 11	Frozen	2010-01-22	2013-03-06 (SA#59)
Rel-10	Release 10	Frozen	2009-01-20	2011-06-08 (SA#52)
Rel-9	Release 9	Frozen	2008-03-06	2010-03-25 (SA#47)
Rel-8	Release 8	Frozen	2006-01-23	2009-03-12 (SA#43)
Rel-7	Release 7	Closed	2003-10-06	2008-03-13 (SA#39)
Rel-6	Release 6	Closed	2000-03-28	2005-09-28 (SA#29)
Rel-5	Release 5	Closed	2000-05-01	2002-09-12 (SA#17)
Rel-4	Release 4	Closed	1998-08-01	2001-06-21 (SA#12)
R00	Release 2000	Closed	1999-03-30	
R99	Release 1999	Closed	1996-11-01	1999-12-17 (SA#6)
UMTS	UMTS	Closed	1994-08-18	1999-02-12 (SA#28)

Source: 3GPP

In any case, the distinction between 4G and 5G networks will become increasingly blurred. Release 14 of the 3GPP standards, which is due to be completed in 2017 (see graphic), will incorporate both 4G and 5G technologies. Although 5G introduces a new orthogonal frequency division multiplexing (OFDM)-based radio interface, called New Radio (NR), leading equipment vendor Huawei says operators will also have the option of upgrading 4G networks to meet the 5G requirements set out in the 3GPP specifications. “Technically, investments on 4G can still be used for 5G, thereby maximizing operators’ ROI,” Huawei says. “The technologies for 5G, such as multi-carrier, multi-antenna, short delay, and massive connections, can be fulfilled by 4G networks, so that operators can obtain 5G technology dividends with lower deployment costs.”

Multiple antenna deployments are already under way. Huawei says that 4.5G FDD (frequency division duplex) networks are being deployed using 4T4R/8T8R multi-antenna configurations, while 32T32R/64T64R and 128T128R have been put into trial commercial use on TDD networks (time division duplex). Huawei says that massive carrier aggregation (support for up to eight-carrier aggregation) is also being applied on 4.5G networks, while shorter transmission time interval (TTI) and vehicle-to-everything (V2X) technologies have been defined in 3GPP R14 standards. But new waveform, new codes, and control/user plane separation, together with the 5G new air interface technology, are likely to be defined in 3GPP R15 standards.

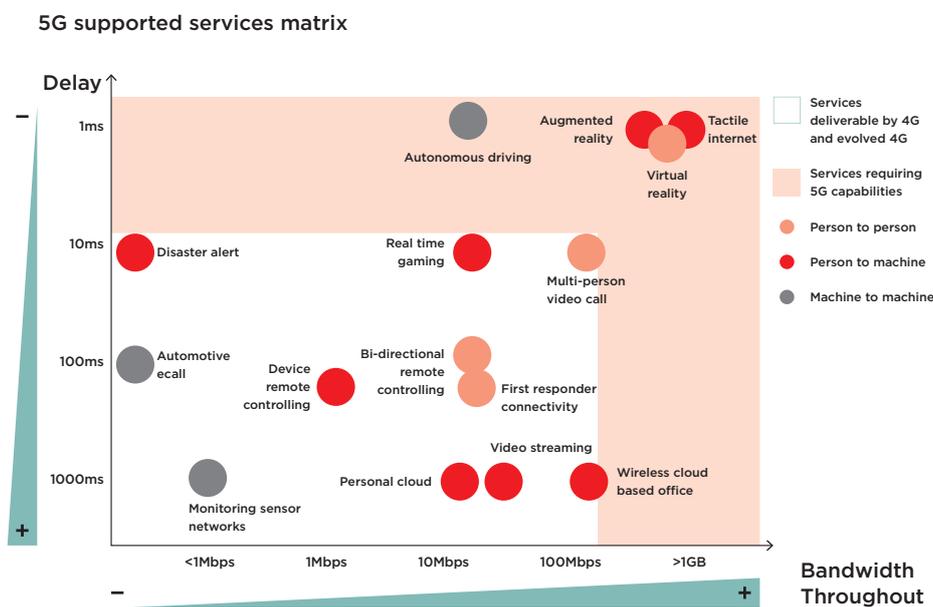


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Different technologies for different applications

Historically, mobile network technologies have been designed primarily to deliver communications, information and entertainment services, such as voice, messaging and Internet access, to human beings rather than machines. Although 2G, 3G and 4G networks are widely used to deliver machine-to-machine services and are supporting the emerging IoT, they weren't designed for this purpose. The GSMA notes that these legacy technologies are not optimised for

large scale IoT applications, have limited flexibility to support bespoke services across industry verticals and can't necessarily deliver the low levels of latency required by some applications, such as the so-called tactile Internet in which a user could remotely control a distant machine, such as a drone or a precision tool (see graphic). By contrast, 5G is intended to be very versatile, supporting three classes of applications: eMBB (enhanced mobile broadband), mMTC (massive machine type communications) and URLLC (ultra-reliable and low latency communications).



Source: GSMA paper: *Unlocking Commercial Opportunities From 4G Evolution to 5G*

Still, 5G isn't the only option. Some 4.5G technologies, such as Narrowband IoT, have been developed specifically to support the IoT by providing reliable and extensive coverage with low power requirements. Dajie Jiang of China Mobile says: "4G and 4.5G will meet the requirements of existing MBB services and also deliver some MTC services, for example, cellular-based IoT and LTE-based V2X."

In practice, much will depend on the availability of spectrum in specific markets and the restrictions individual governments place on which frequencies can be used with which technologies. In May 2016, the South Korean government, for example, said that trials of 5G services need to be carried out in the 28 GHz

frequency band, using TDD modulation, as well as with the existing LTE network infrastructure.

Dr. Choi Chang-soon of SK Telecom notes that if 5G can only be deployed in high frequency spectrum, such as the 28 GHz band, cell sizes will have to be small and coverage limited, which would be one of the challenges for early 5G commercialization. "From this perspective, it would be more important and practical for mobile operators to get wide bandwidth in lower frequency," says Dr. Choi Chang-soon. He anticipates that, as long as high frequency spectrum is only available for 5G, South Korea's operators will use LTE Advanced (4.5G) networks to provide the broad macro-coverage, while 5G will be used in hotspots to boost capacity.



Integrating different radio access networks

Over time, the question of which technology is used for a specific service or customer may become moot. That's because 5G hotspots are set to become part of a rich blend of radio networks in which connections are seamlessly passed between different access technologies. Rather than operating as separate networks, 4G, 4.5G and 5G are likely to be integrated into a single network architecture. This architecture may even integrate 3G networks, as well as radio technologies in unlicensed spectrum, such as Wi-Fi. Dajie Jiang of China Mobile says: "We expect 4G, 4.5G and 5G will be integrated more tightly than previous networks (e.g., 2G, 3G and 4G) to reduce the efforts of interworking and operational spending. ... 4G, 4.5G and 5G will be integrated tightly to provide a user centric network, where the best user experience could be offered."

Dr. Choi Chang-soon of SK Telecom agrees that smooth and efficient interworking between LTE-Advanced and 5G networks will be very important. In its 5G architecture design and implementation guidelines³, SK Telecom says: "At the initial stage, 5G RAN will be deployed by integrating the existing LTE-Advanced, its evolution technologies, and new radio access technologies. Due to their heterogeneous nature, it is important to build an infrastructure where different radio access technologies are seamlessly integrated."

Mobile operators plan to use network function virtualization (NFV), software-defined networks (SDN), CloudRAN and other solutions to manage this integration, optimise the resulting user experience and the provision of connectivity. "We would like to leverage NFV and SDN as much as possible," says Dajie Jiang of China Mobile. "For NFV, it could be an end-to-end management and orchestration solution for both RAN and core network. For the operator, it will enable a rapid service deployment and better control of the network."

The role of CloudRAN

CloudRAN is a cloud-based, distributed architecture that brings different radio networks together in to a single network. It combines the electronics of multiple base stations in a single location – the base station server – which then uses a virtualised operating system to prioritise workloads, both on-the-fly and to a predetermined schedule based on predicted needs and real-time needs. By coordinating the transmissions of adjacent base stations over a large area, the CloudRAN server optimises the use of network resources, providing both consumer devices and machines with the best available signal.

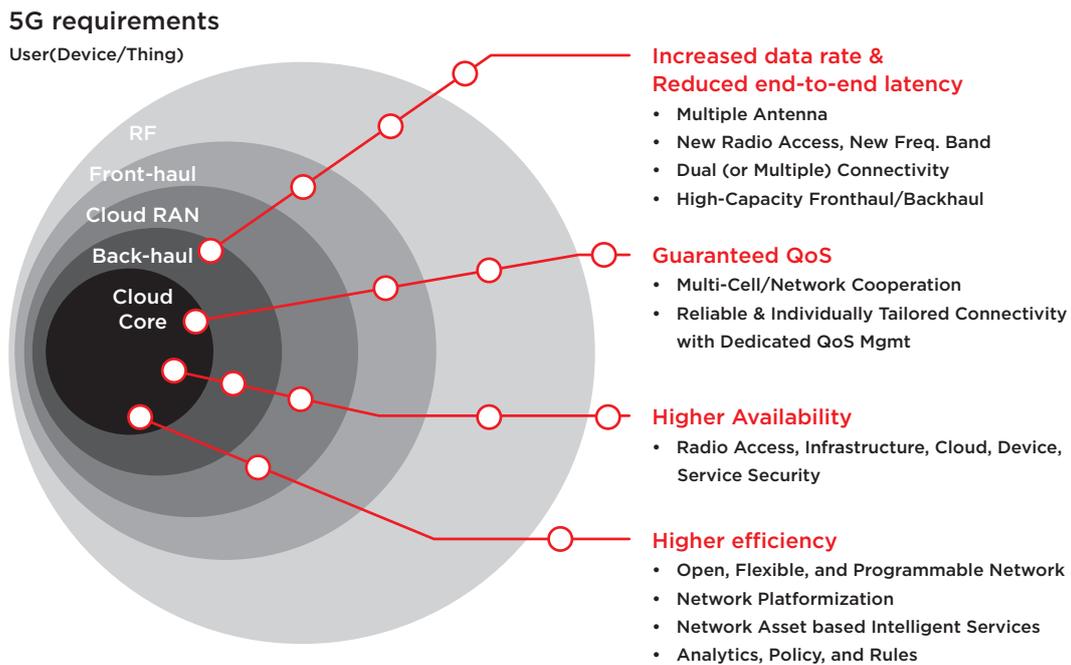
A CloudRAN solution promises multiple benefits, such as less inter-site interference and better performance when a user is in an area where the signals of multiple base stations overlap. The

³http://www.sktelecom.com/img/pds/press/151020_5G_architecture_design_and_implementation_guideline.PDF

architecture can also be used to implement network slicing, so that specific services are allocated specific network resources, helping to meet customers' quality of service (QoS) requirements. Moreover, by centralising control of resource management and scheduling, CloudRAN gives the mobile operator greater flexibility. Dajie Jiang of China Mobile Research Institute, says: "It will give us the capability of the flexible deployment, the automatic management and the rapid instantiation of customized wireless coverage."

Huawei describes CloudRAN as "a huge leap in radio network deployment". The equipment vendor says the concept is proven and well-accepted by operators who value the resulting agility and flexibility. Huawei believes CloudRAN will play a pivotal role in enabling operators to move beyond providing vanilla connectivity to providing a "platform-as-a-service" to other businesses.

In its 5G architecture design and implementation guidelines, SK Telecom says it will use CloudRAN (C-RAN) to provide a virtualized edge cloud platform, as well as seamless interworking and handover between 5G and 4G networks. In fact, the Korean operator plans to use CloudRAN for a variety of purposes: "Not only does C-RAN serve as flexible aggregation points for better performance optimization, it can also be a key enabler for a variety of radio access network technologies, e.g., new radio access technology (RAT), front-haul, and coordination among multi-RAT to satisfy 5G requirements." Indeed, SK Telecom regards a CloudRAN architecture as a key piece of the puzzle required to meet the 5G requirements of high throughput, low latency, guaranteed quality of service, high reliability and efficiency (see graphic)



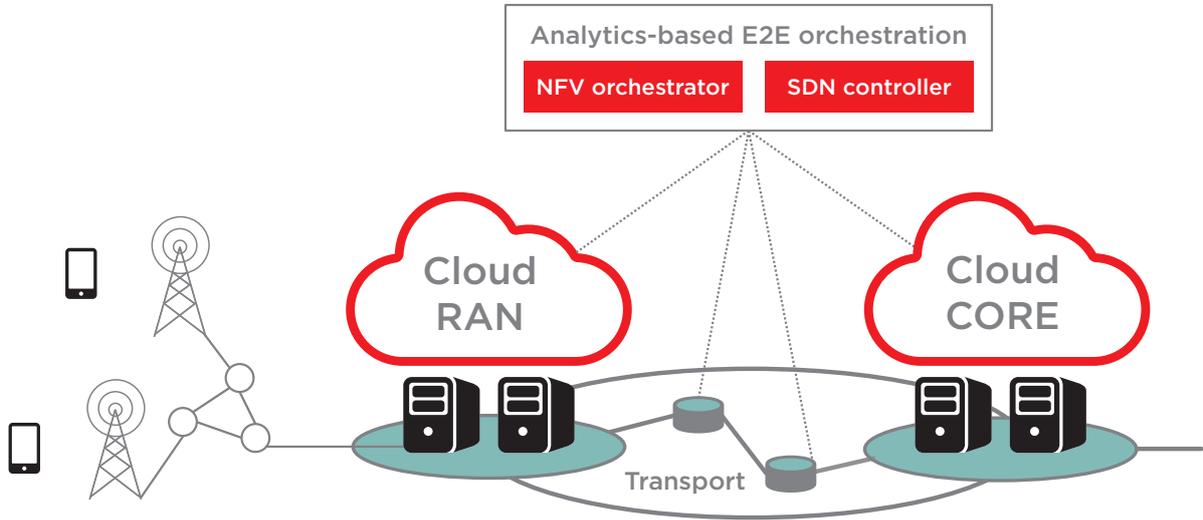
The whole 5G system is divided into 5 segments, namely Cloud Core, back-haul, Cloud RAN, front-haul, RF and Device. Circles are placed for each requirements for the most impacted segments.

Source: SK Telecom's 5G architecture design and implementation guidelines

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SK Telecom

SK Telecom plans to combine a CloudRAN architecture with cloud core networks which virtualise mobile network functions for flexibility and efficiency. It also intends to use a SDN controller to further enhance consistency and agility by separating the control plane functions from the data plane functions (see graphic).



Source: SK Telecom's 5G architecture design and implementation guidelines



How and when CloudRAN will be deployed

Huawei says it is now running joint tests of the CloudRAN architecture with China Mobile, Telecom Italia, Telefónica, Vodafone and other customers in preparation for commercial deployments towards the end of 2017 or the beginning of 2018. Dr. Choi Chang-soon of SK Telecom says the Korean operator is also trialling CloudRAN and will deploy the architecture commercially as soon as possible. That is likely to be in 2018 as 3GPP finalises the 5G standards, he adds.

China Mobile, which is expanding its 4G network to more than 1.1 million sites, is testing the impact of Huawei's CloudRAN architecture on interference at the edge of cells in different parts of China, including Nanjing, Dongguan, and Anhui. In June 2016, China Mobile said it had seen an improvement in the cell edge user experience by a factor of 100%.

China Mobile now plans to deploy CloudRAN in urban areas, including Shanghai, to meet the "challenging requirements for improved user experience in ultra-dense networking scenarios." Dajie Jiang of China Mobile Research Institute, adds: "Currently we have introduced the centralized BBU large scale deployment in several provinces, with the saving of accessory equipment and power consumption, reducing CAPEX 20% and OPEX 50-60%. ... Right now, more and more vendors joins us to define the CloudRAN equipment, and for optimistic estimation, it will become mature in 2018 at earliest."

Vodafone and Huawei have trialed a CloudRAN architecture at the ANZ Stadium in Sydney. "We managed to achieve 28 per cent higher data speeds at cell edge and 25 per cent overall cell average, which are significant improvements," Vodafone head of RAN, Yago Lopez, says. "The results exceeded our expectations so naturally we are very happy with the trial and are excited to begin implementing this technology over the next 18 months."

In July 2016, Telecom Italia said it is rolling out Europe's first live CloudRAN trials, using technology from Huawei, in Palermo. The trials are designed to deliver download speeds of 300Mbps to existing Telecom Italia customers in the region. Gabriela Styf Sjoman, Head of TIM Lab, says: "This innovative technology is part of TIM's path towards becoming a Digital Telco, securing to its clients a high quality user experience on digital new network technologies – such as CloudRAN – to guarantee customer satisfaction and create value through network solutions that are both technologically innovative and efficient."

Such trials will pave the way for a major shift in the way in which mobile networks operate. Once CloudRAN, NFV and SDN are deployed commercially, cellular networks will be configured very differently to those in use today. There will no longer be a clear delineation between different radio access networks, while Wi-Fi and other networks in unlicensed spectrum could be fully integrated into a mobile operator's proposition. Cloud-based servers will automatically select the best connection to provide a specific service, smoothly balancing the bandwidth demands of on-demand high-definition entertainment services with the latency and reliability demands of vital information services, such as environmental monitors and vehicle navigation.

In time, the concept of a distinct cell served by a single base station may become obsolete as the boundaries between different cells are blurred and connections are seamlessly and continuously swapped between base stations. Ultimately, the network will be smart enough to ensure that each device, machine and vehicle has the connectivity needs in real-time. For both consumers and companies, that would amount to a very compelling proposition.



About Huawei

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