5G TECHNOLOGY AND ITS SPECTRUM ACCESS

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ABSTRACT

5G is a term used to describe the forthcoming fifth generation of mobile network technology. It's not a reference to any specific standard of that technology, in the way that 4G and LTE have become closely entwined. That's because no such 5G standard has yet been fully agreed upon, though a couple of likely technologies are emerging. We'll discuss those in a moment. Most of us today still connect to the internet on our phones using crusty old 3G technology, while those who live in the right areas can connect via 4G.4G offers download speeds that are roughly equivalent to your superfast broadband (around 30-40Mbps) at home. 5G will go well beyond that. 5G wireless networks will support 1,000-fold gains in capacity, connections for at least 100 billion devices, and a 10 Gb/s individual user experience capable of extremely low latency and response times. Deployment of these networks will emerge between 2020 and 2030. 5G radio access will be built upon both new radio access technologies (RAT) and evolved existing wireless technologies (LTE, HSPA, GSM and WiFi). Breakthroughs in wireless network innovation will also drive economic and societal growth in entirely new ways. 5G will realize networks capable of providing zero-distance connectivity between people and connected machines.

INTRODUCTION

The current status of the 5G technology for cellular systems is very much in the early development stages. Several companies are looking into the technologies that could be used to become part of the system. Many of the technologies to be used for 5G will start to appear in the systems used for 4G and then as the new 5G cellular system starts to formulate in a more concrete manner, they will be incorporated into the new 5G cellular system.

As the different generations of cellular telecommunications have evolved, each one has brought its own improvements. The same will be true of 5G technology.

- ***First generation, 1G:*** These phones were analogue and were the first mobile or cellular phones to be used. Although revolutionary in their time they offered very low levels of spectrum efficiency and security.

- ***Second generation, 2G:*** These were based around digital technology and offered much better spectrum efficiency, security and new features such as text messages and low data rate communications.
- ***Third generation, 3G:*** The aim of this technology was to provide high speed data. The original technology was enhanced to allow data up to 14 Mbps and more.
- ***Fourth generation, 4G:*** This was an all-IP based technology capable of providing data rates up to 1 Gbps.\

NEXT WAVE OF DIGITAL SOCIETY

A. Advent of the technology:

The advent of 5G technologies and ICT networks signify the coming next wave of a globally connected Digital Society:

• Right now, all over the world, mobile access to the internet is becoming wholly fundamental to doing business in all industries. Flexible working practices facilitated by mobile networks and devices are already essential, and are allowing enterprises to conduct operations across boundaries that previously inhibited growth.

• Growing mobile access to the internet, cloud-based services and Big Data analytics is allowing anyone, anywhere to leverage "Big Wisdom" – a whole new kind of globally connected and shared knowledge base.

• The continuing rise in the relevance of social media as an important part of how we interact with the internet is also opening up new kinds of intelligent analytics ready to be harnessed for tangible business and everyday life benefits.

• Transformation and convergence of ICT network infrastructure is driving business innovation and growth. Not only is ICT an increasingly effective tool for enhancing efficiency, but it is now a vital driver of economy and social growth.

B. Internet evolution:

5G will drive the future evolution of the internet itself. What we mean when we refer to the "internet" is likely to change:

• Implementing the next generation of ubiquitous ultra-broadband network infrastructure will require a rethinking, restructuring and redesigning of approaches to mobile network construction and expansion.

• Integration of mass-scale cloud architectures will infuse mobile networks with capabilities for flexibly delivering services at unprecedented speeds while meeting forecasts for tremendous growth in mobile data traffic, diversification of mobile app innovation, IoT connectivity, and security.

To achieve these goals, developments in 5G will primarily focus on two fundamental aspects for eliminating infrastructure bottlenecks: massive capacity and massive connectivity

C. 5G Specifications:

Although the standards bodies have not yet defined the parameters needed to meet a 5G performance level yet, other organizations have set their own aims, that may eventually influence the final specifications.

Typical parameters for a 5G standard may include:

SUGGESTED 5G WIRELESS PERFORMANCE	
PARAMETER	SUGGESTED PERFORMANCE
Network capacity	10 000 times current network
Peak data rate	10 Gbps
Cell edge data rate	100 Mbps
Latency	< 1 ms

REQUIREMENTS

The three fundamental requirements for building 5G wireless networks are:

• Capabilities for supporting massive capacity and massive connectivity

• Support for an increasingly diverse set of services, application and users – all with extremely diverging requirements for work and life

• Flexible and efficient use of all available non-contiguous spectrum for wildly different network deployment scenarios

Mobile networks will increasingly become the primary means of network access for person-to-person and person-to-machine connectivity. These networks will need to match advances in fixed networking in terms of delivered quality of service, reliability and security. To do so, 5G technologies will need to be capable of delivering fiber-like 10 Gb/s speeds to make possible ultra-high definition visual communications and immersive multimedia interactions. These technologies will depend on ultra-wide bandwidth with sub-millisecond latencies.

A. Smart cities:

5G will provide the foundational infrastructure for building smart cities, which will push mobile network performance and capability requirements to their extremes.

Low latency and extremely high reliability, however, will also be essential requirements for the likes of mobile industrial automation, vehicular connectivity, and other IoT applications. Applications like smart sensors and text-based messaging are examples of extremely high volume applications that will require very low data rates and will not be sensitive to latency.

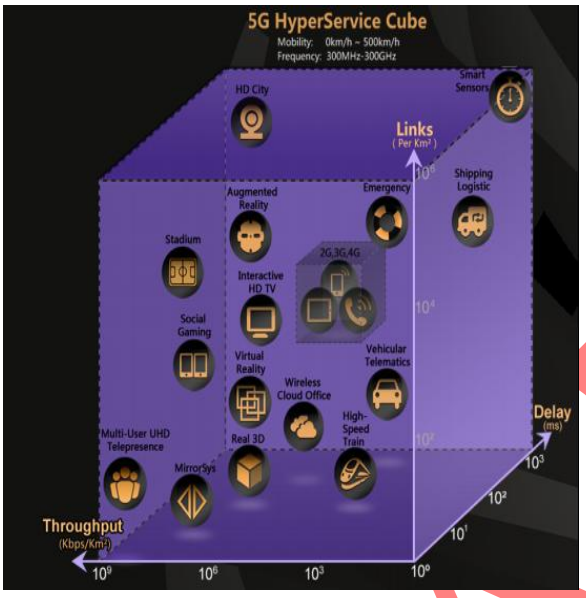
B. Complex performance requirements

An increasingly diverse and wide range of mobile services will have differing performance requirements:

• Latency from one millisecond to a few seconds

• Always-on users per cell from a few hundred to several millions
• Duty cycles from mere milliseconds to entire days
• Signaling loads from less than 1% to almost 100%

The "5G HyperService Cube" below gives a multi-dimensional overview in terms of throughput, latency and number of connections required for the many types of services 5G networks will need to run:



5G networks faces significant design challenges to simultaneously meet all of the above service requirements. They must be built to meet a number of individual user and enterprise needs.

C. Spectrum impact

Other than flexible and efficient use of all available non-contiguous spectrum in different network deployment scenarios, freeing up additional spectrum will also be required to support thousand-fold capacity increases by 2020 – and even higher increases looking forward to 2040 and beyond.

But while a global consensus is forming that 500MHz to 1GHz bandwidth of additional mobile spectrum is needed, the following considerations will be need to be addressed:

• Spectrum bands availability by region and the local laws that govern

their usage will need to be harmonized so the global circulation and economies-of-scale for mobile devices are not negatively impacted.

• Exactly how all available and new IMT bands will be used to achieve 10 Gb/s for an individual end user is a major challenge for designing working 5G systems.

To sufficiently maximize spectrum efficiency, all-spectrum access and programmable air interface technologies will need to be capable of mapping service requirements to the best

suitable combinations of frequency and radio resources. The continuing deep integration of SDN and cloud architecture technologies will help realize this, and will facilitate the on-demand customization of mobile network technologies that better ensure QoS, increase network TVO, decrease network TCO, and reduce energy consumption.

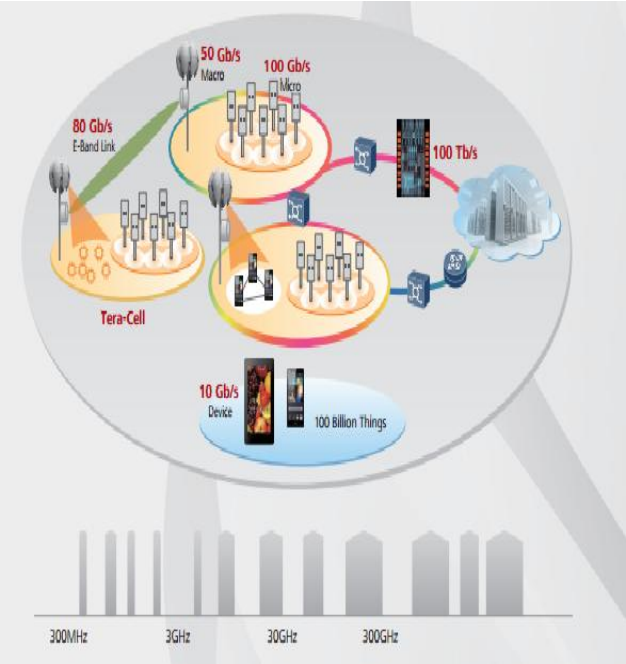
AREAS OF RESEARCH

There are several key areas that are being investigated by research organisations. These include:

- ***Millimetre***-Wave technologies: Using frequencies much higher in the frequency spectrum opens up more spectrum and also provides the possibility of having much wide channel bandwidth - possibly 1 - 2 GHz. However this poses new challenges for handset development where maximum frequencies of around 2 GHz and bandwidths of 10 - 20 MHz are currently in use. For 5G, frequencies of above 50GHz are being considered and this will present some real challenges in terms of the circuit design, the technology, and also the way the system is used as these frequencies do not travel as far and are absorbed almost completely by obstacles.
- ***Future PHY / MAC:*** This area presents many possibilities from the use of new modulation formats including GFDM, Generalised Frequency Division Multiplexing, as well as FBMC, Filter Bank Multi-Carrier, UFMC, Universal Filtered MultiCarrier and other schemes to the management of the multiple access schemes. All these need to be developed. Higher levels of processing that will be available by the time 5G is launched mean that multicarrier systems will not require to be orthogonal as in the case of OFDM. This provides considerably more flexibility.
- ***Massive MIMO:*** Although MIMO is being used in many applications from LTE to Wi-Fi, etc, the numbers of antennas is fairly limited -. Using microwave frequencies opens up the possibility of using many tens of antennas on a single equipment becomes a real possibility because of the antenna sizes and spacings in terms of a wavelength.
- ***Dense networks*** Reducing the size of cells provides a much more overall effective use of the available spectrum. Techniques to ensure that small cells in the macro-network and deployed as femtocells can operate satisfactorily are required.

ALL SPECTRUM ACCESS

New designs for all-spectrum radio access nodes will require breakthroughs in fundamental radio technologies like the air interface, RAN, radio frequency transceiver and devices. New radio backhaul and new fiber access for the fixed network will be an integral part of next generation commercial network solutions. The following figure gives a basic overview of such a 5G radio access architecture.

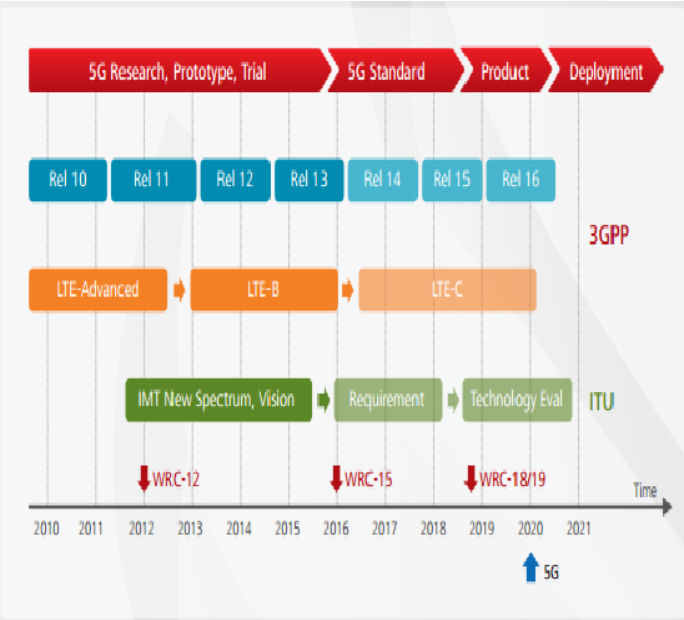


5G TECHNOLOGY TIMELINE

No dates have been set yet for the development of 5G, but a number of companies and organisations have set their own 5G timelines so they can plan ahead.

One major enabler for 5G will be the release of spectrum, and it is anticipated that the new spectrum will be agreed at the World Radio Communication Conference, WRC to be held in 2015. The International Telecommunications Union, ITU is currently at work on the International Mobile telecommunications, IMT spectrum requirements for 2020 and beyond. After WRC-15, ITU will have a clearer path for determining network system and technology requirements.

estimations of the development of 5G technology estimate that the basic research phase will take place until around 2016 and then the standards will be developed between 2016 and 2018. Product development will then be a major activity between about 2018 and 2020, and early deployment will occur around 2020.



CONCLUSION

5G is the next frontier of innovation for entire mobile industry.
The three major design objectives for 5G:

- Implementation of massive capacity and massive connectivity.
- Support for an increasingly diverse set of services, applications and users – all with extremely diverging requirements
- Flexible and efficient use of all available non-contiguous spectrum for wildly different network deployment scenarios

An adaptive network solution framework will become a necessity for accommodating both LTE and air interface evolution; Cloud, SDN and NFV technologies will reshape the entire mobile ecosystem; and 5G will speed up the creation of massive-scale services and applications.
The next decade promises breakthrough developments in several fundamental RAN technologies that will be required for implementing commercial-ready 5G network solutions:

- Multiple access and advanced waveform technologies combined with coding and modulation algorithms
- Interference management
- Access protocols
- Service delivery architecture
- Mass-scale MIMO
- Single frequency full duplex radio technologies

• 5G devices

• Virtualized and cloud-based radio access infrastructure

5G success depends on the entire ICT ecosystem. Its growth will be built upon global LTE success. ICT ecosystem innovation will also be a major driver in creating a bigger 5G market.

"If we get 5G right, there won't be a 6G," said Professor Sutton during Pocket-lint's lesson on the technology.

The idea is that if the correct infrastructure is put in place, unlike when 1G, 2G and 3G were devised, it will be based on a flexible system that can be upgraded rather than requiring replacement. In years past, mobile data technologies were built around hardware, while 5G will be software driven. Software can be updated easily, hardware less so.

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