ERICSSON

5G: WHAT IS IT?

MORE THAN JUST IMPROVED PERFORMANCE AND GREATER FLEXIBILITY, THE NEXT GENERATION IS A SHIFT IN MINDSET

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ABSTRACT

Mobile technology has experienced a number of generation changes, which have transformed the cellular landscape into a global set of interconnected networks. By 2020, these networks will support voice, video and a complex range of communication services for more than 9 billion subscriptions and billions of connected devices. Around the same time, the next generation, 5G, of telecom technology, performance levels, equipment and devices will become commercially available.

But what is 5G? It is the next chapter of telecom networks designed to meet a more advanced and more complex set of performance requirements. But 5G represents a new way of thinking. It encompasses innovative network design for deploying machine-type communication (MTC). And 5G networks will be able to efficiently support applications with widely varying operational parameters, providing greater flexibility to deploy services. As such, 5G is an important enabler of the Networked Society.

A SHIFT IN MINDSET

The coming generation is evolution rather than revolution, enabling communication, media, machine-to-machine (M2M) communication and much more everywhere. The aim is for 5G networks to be highly efficient and faster, as well as being able to support more users, more devices, more services, and new use cases without a corresponding impact on cost or carbon footprint.

The Networked Society

Mobile communication has transformed from clunky, heavy and not so portable devices that supported a single service (voice) into a complex interconnected environment, built on integrated multi-technology platforms that support millions of applications and billions of subscribers, delivering content to a multitude of devices and screens, to enterprises and consumers, with a potentially massive benefit to society.

The Networked Society is taking shape. New use cases are emerging every day. Communication is transitioning from a person-to-person model to anything-to-anything anywhere; where people, objects and things, mobile and fixed are part of an all-communicating system.

Some of the early signs of the Networked Society are already visible, but not all development is happening at the same time and at the same pace all over the world. Networks have reached varying levels of maturity in different regions. Rules governing spectrum use are different from place to place. Smartphone penetration varies, as do price models and the types of applications that people and businesses need and use.

When everything gets connected, there is massive potential to turn data into information, and then use that information to provide useful services for businesses, people and society. But there are also several significant challenges: security, governance, automation, sustainability and cost.

As more things get connected and applications involve multiple data sources and complex event chains, providing end-to-end security becomes challenging. Automation is vital for managing operations of vast amounts of data and billions of devices.

Providing energy for the billions of devices that will be connected, building the networks that will provide them with connectivity and operating those networks, without increasing the telecom industry's carbon footprint, is a formidable goal. Hand in hand with environmental impact is the issue of cost. Devices and sensors need to be produced so that they are affordable in all parts of the world – not just from a manufacturing perspective, but also from an operational perspective. So, in some cases, devices and sensors will be built with efficient architecture and connectivity, designed specifically for the use case at hand – maximizing sleep cycles, and minimizing the amount of information communicated as well as the frequency of communications.

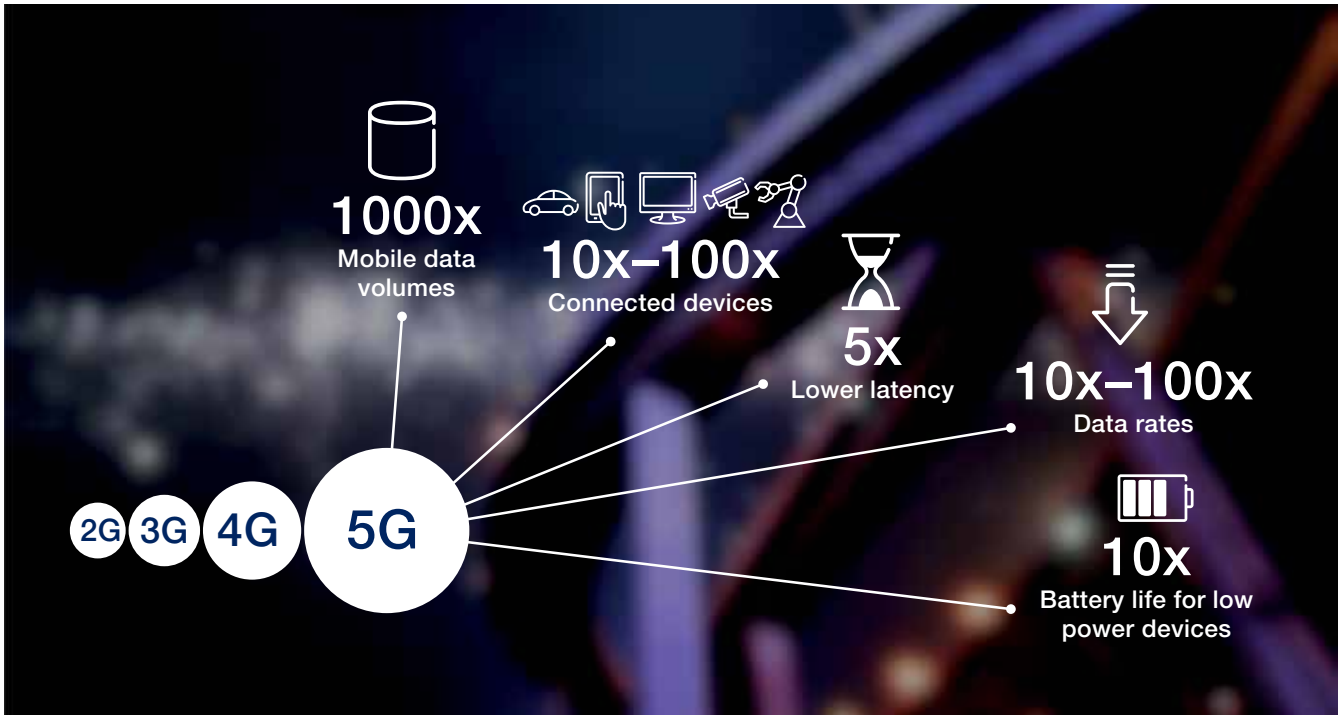
The first generation of mobile technology was primarily about getting things together – building the platform, and getting things to work. The 2nd generation was about mass-market uptake, deregulation, improved speeds and additional services like SMS and support for data. With 3G, things got faster, new services were developed, and mobile broadband established itself. With 4G – where we are today – data volumes have overridden voice, mobile broadband usage has surpassed traditional services, LTE networks provide advanced support for data, and cellular network technologies are being integrated including Wi-Fi with support for Wi-Fi calling. Today, society has begun to embrace the benefit that connectivity brings and how we can use connectivity to build smart applications – that, say, help commuters to get to work efficiently, locate traffic accidents, and operate machines in hazardous environments remotely – and provide the next billion users with access to the internet.

Machine-type communication will be one of the bigger changes in 5G networks. Everything will be connected: houseplants, bike helmets, water systems, crops, containers, financial structures and endangered species. By connecting things, we create a snapshot of the world, from the water quality in Northern Europe to the temperature of the ice in Antarctica. But, what makes 5G truly interesting is what we do with the information that is available to us and how it can bring benefit to people.

Up to now, telecom vendors have provided the technology platform, operators have provided services to consumers and developers have created the applications and services on top. But, this model is changing as telecoms, cloud computing, IT, data analysis and application building merge.

To put a picture on the Networked Society, change can be exemplified by TV. TV consumption is shifting from being state-funded, provided over the air to the TV-set in the living room, to cable-TV over fiber/satellite to a number of set-top boxes, to smart TV provided over the internet from multiple content providers to any device, anywhere. There are a few use cases in between,

Figure 1: Estimated 5G requirement levels



Source: METIS

and the level of maturity of the TV experience varies in different parts of the world, but TV exemplifies the journey that many industries are experiencing as they transform from the analog one-size-fits-all model to the digital one model per use case.

What is 5G?

Like previous generations, 5G is a set of evolved network technologies. But 5G aims to provide unlimited access to information and the ability to share data anywhere, anytime by anyone and anything for the benefit of people, businesses and society. The exact performance levels and requirements that systems and equipment will need to meet to label themselves 5G are yet to be defined. The standardization activities are expected to start around 2016, leading to commercial availability of equipment and devices sometime around 2020. But this does not mean that vendors and manufacturers are waiting around. Like most other ICT players, Ericsson is working to ensure that 5G will enable the thousands of new use cases, to evolve existing technologies, research complementary ones, and work toward a smooth transition to 5G that provides benefit without impact on carbon footprint.

In contrast to previous generations, 5G is much more than another new set of technologies that will require massive equipment upgrades. The aim of 5G is to build on the maturity that telecom systems have already reached; 5G will bring the evolved versions of existing radio-access, cloud and core technologies together with some new complementary technologies, to cater for more traffic, more devices and more types of devices, with different operating requirements and thousands of different use cases.

Figure 1 shows the estimated performance levels that 5G technologies will need to meet – in comparison with today's levels.

How will we get there?

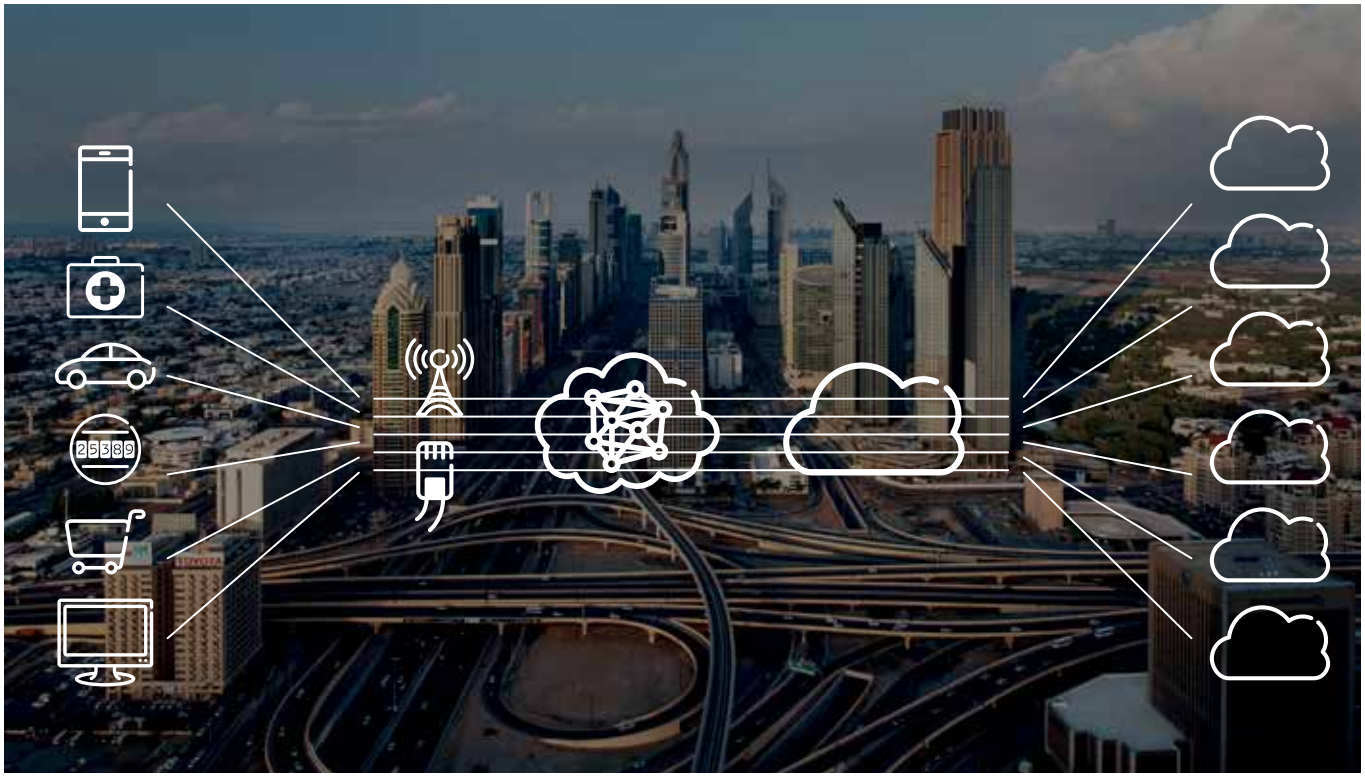
As a technology enabler, 5G will allow businesses to transform to make the most of connectivity, but 5G technologies are not being developed in isolation. Factors like security, long-term sustainability, cost, and the need to provide connectivity to the next billion subscribers play a significant role in shaping the direction of technology development.

While the detailed specifications for 5G have yet to be set, it is clear that flexibility to cater for thousands of use cases is the key to 5G and what it will enable. The parameters that 5G technology will be developed upon include:

- traffic capacity;
- data throughput;
- data integrity;
- latency;
- energy consumption;
- technology convergence; and
- smart communication.

5G TECHNOLOGY

Figure 2: One network, multiple industries



Source: Ericsson

Spectrum

While spectrum usage and allocation varies from country to country, one aspect of spectrum usage is common to all: as demand for connectivity rises, the need for additional spectrum increases.

Each generation of mobile technology has improved user experience through the ability to utilize additional – typically higher – frequency bands and wider transmission bandwidths; as this increases both traffic capacity and achievable data rates. And 5G is no exception; it will also utilize additional spectrum.

Controlling spectrum through licensing is essential to avoid interference. Control also provides a base level of security, and allows operators to meet their quality-of-service requirements. However, while control is essential, it makes spectrum an expensive commodity, and so innovative ways to further enhance the efficiency of the spectrum usage are constantly being pursued.

Today's 4G technologies already provide link-level performance close to what is theoretically possible. And so, achieving performance and capability enhancements – in the form of traffic capacity and higher data rates – is more likely to result from system-level features such as more advanced multi-antenna transmission, and tighter multi-site/multi-layer coordination and transmission.

In some specific use cases, fulfilling the extreme capacity and data rate requirements, will require extensive densification of network deployments, with much shorter inter-site distances compared with those of today.

Additional spectrum will, however, be needed to satisfy future service demands. Using more of the spectrum below 6GHz will fulfill part of this need. But a substantial amount of extra spectrum can only be made available if higher frequency bands – 10GHz and upwards – can be utilized. The ability to use

5G TECHNOLOGY

these higher bands is a significant step in establishing very wide transmission bandwidths that will enable multi-Gbps speeds to homes, buildings and industries.

Global harmonization of spectrum and how it is used, including licensing and fees, is highly beneficial for all telecom players. While the responsibility for this lies with national regulators and not the wider telecom industry, ICT companies like Ericsson are working together with the national agencies to promote a common evolution of mobile broadband.

New levels of abstraction

One of the root causes of network complexity lies in the traditional way technology has developed. The design of network elements, such as routers and switches, has traditionally been closed; they tend to have their own management systems with vertically integrated forwarding and control components, and often use proprietary interfaces and features. The goal of network management is, however, to ensure that the entire network behaves as desired – an objective that is much more important than the capabilities of any single network element.

Ericsson's approach to software-defined networking (SDN), namely service provider SDN, provides network-wide programmability that will allow operators to manage networks in a controlled manner and allow networks to be scaled to adapt to new applications and users, as well as providing a flexible platform to roll out new services rapidly – a vital aspect of MTC.

Modern virtualization technologies, such as Network Functions Virtualization (NFV), in combination with existing tools for storage and computing, ensure virtualization and abstraction for the entire set of critical resources. The general aim of technologies like SDN and NFV is to deliver functions, networks and infrastructure as services rather than as features of vertically integrated – inflexible – systems. Using an anything-as-a-service (XaaS) approach enables operators to offer communication services at the right price points, and serve next generations of user devices. By being able to provide coverage or capacity as a service, for example, operators will be able to offer connectivity for any-type communication and any workload, covering the thousands of new M2M use cases.

Building systems in boxes and levels to reduce complexity is not a new approach, but the separation of control and data in telecom networks is a key shift in network design that will enable operators to build flexible networks – networks that adapt quickly to change, manage resources efficiently and can be shared and virtualized.

Sharing has proven to be a good solution to city congestion, manifesting itself in initiatives such as community bikes and car sharing. Cloud-based services offering virtual slices of network performance enable one set of resources to be shared by all types of workloads and use cases. This model ensures that operators can focus on providing services, adapting the amount of performance or capacity required to demand, and guarantee that resources are utilized in an optimal manner.

Communication to fit

But even with all the technology in place to design and build effective networks that can be shared,

virtualized, created and reallocated dynamically, attention needs to be paid to the load in terms of the data that billions of devices, things and objects will consume and transmit over 5G networks. Data requires both storage and transmission, so as the need for both of these commodities rises, operational costs will also increase unless the amount of data is kept to a minimum.

Similar to bare bones architecture, bare bones (smart) communication will be a requirement for efficient use of 5G connectivity. Like other aspects of 5G, communication will shift from the one-size-fits-all model to a one-model-per-use case. Applications built on sensor data will demand just the data needed, when they need it, enabling devices to maximize sleep cycles and optimize use of bandwidth. Applications could possibly run in different modes, like power-save or data-save, as well as, data-on-demand or low-latency mode, for example. Applications can be offered to users and paid for on the basis of these cost- or power-saving modes or the need for immediate-data modes.

Self-organizing networks

The trade-off for flexibility that 5G technologies bring comes in the form of management overhead – as a result of network complexity. Finding faults, for example, may take time and require manual intervention in legacy systems. For 5G base stations, this will not be the case; self-healing applications will detect anomalies and try to repair any issues without impacting network reliability.

The self-organizing networks (SON) concept as it is today, which basically allows base stations to automatically configure themselves including Automatic Neighbor Relations (ANR), will be much further developed in 5G systems. Advanced SON techniques will not only apply to physical network elements, but will enable operators to, for example, balance load in a multi-radio-access technology environment, and support traffic steering as well as dynamic spectrum allocation.

Capillary networks

Capillary networks use short-range radio to provide local connectivity to groups of devices with a common function or purpose – and connect to the global communication infrastructure through a capillary gateway. A capillary network might, for example, connect a group of building sensors that provide relevant information to real-estate management. Or, a capillary network might connect goods in transit to a monitoring application.

Whatever the application, capillary networks work with entirely different sets of requirements compared with existing communication systems. The use cases for MTC vary greatly from one application to the next, and so rather than building systems with a one-size-fits-all approach, capillary networks will be designed to fit the application.

Connecting the billions of devices that will be part of the Networked Society directly to the cellular network is simply not feasible – configuration alone would cause a massive overhead in time and computational power. Capillary networks provide an efficient way to offload connectivity for groups of sensors with a common purpose and geographical location.

KEY EXPECTATIONS OF 5G

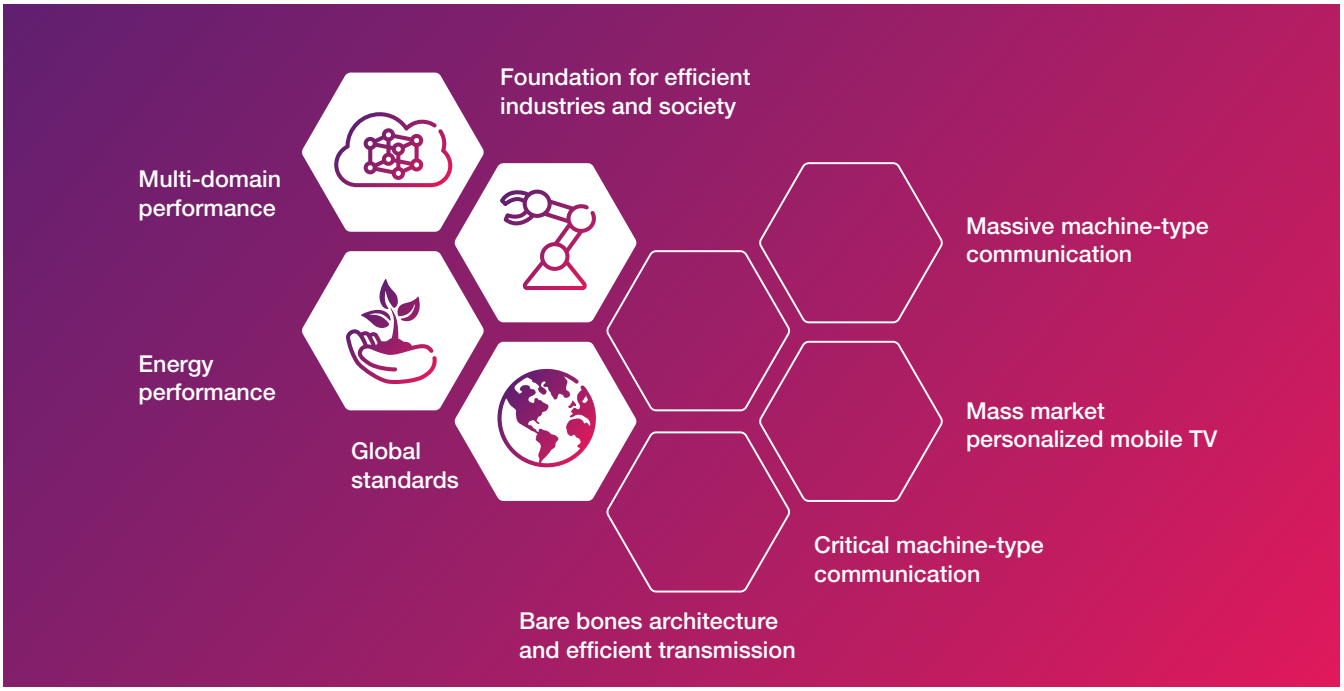
The estimated performance levels that 5G technologies will need to cater for:

- 1,000 times traffic volumes;
- tens of billions of connected devices;
- 10-100 times higher achievable user data rates;
- latency reduced by up to a factor of five;

each other. Today, it's all about bundles aimed to keep users loyal. These include incentives like free voice and SMS in your home network, low-priced devices, application-specific bandwidth deals, data storage, images and video support, as well as self-service portals and cloud-based seamless backup.

People no longer use networks to just talk to each other; now they send each other messages, pictures and links. People share stuff that is bandwidth hungry; they watch movies on the way to work, and they

Figure 4: 5G expectations



- 10 times the battery life;
- different devices: from mobiles, tablets and wearables, to connectivity embedded in cars, trucks, bikes, cereal packets… anything; and
- data integrity.

Consumer and business needs have evolved. The one-size-fits-all model no longer works. Looking back, the first generation of mobile was primarily voice; users paid for the calls they made, and they owned their phones. People used mobile to talk to

access up to the minute traffic reports before they hit the morning jams.

This is what we are doing today – just five years after data traffic overtook voice in mobile networks. By 2020, it won't be just people and systems creating and sharing data; billions of things will also be an integral part of the communications infrastructure.

This infrastructure will encompass cloud computing, virtualization, massive uptake of mobile broadband, more data than ever, more and new devices, and new business models.

ERICSSON'S VISION FOR 5G

Ericsson's vision of the Networked Society is about enabling change and change-makers; bringing benefit to people, business and society. The platform for this vision is a flexible, reliable, fast, secure, sustainable and affordable network that provides connectivity for billions of people, industries and things, everywhere and anytime.

Building such a network requires a new way of thinking. New technologies will be needed that will, for example, enable communication at higher frequencies. Local networks will be needed to enable application-specific networks, such as building monitoring. Services will need to be built to minimize connectivity requirements, and flexibility will be needed to, for example, create low-latency communication links dynamically.

Ericsson believes that 5G is the technology evolution that will enable such flexible networks to be built and provide connectivity for the many future use cases.

But Ericsson cannot build this future platform alone; all ICT players need to share a common understanding of the complete network ecosystem and build toward it.

Ericsson is the driving force behind the Networked Society – a world leader in communications technology and services. Our long-term relationships with every major telecom operator in the world allow people, businesses and societies to fulfill their potential and create a more sustainable future.

Our services, software and infrastructure – especially in mobility, broadband and the cloud – are enabling the telecom industry and other sectors to do better business, increase efficiency, improve the user experience and capture new opportunities.

With more than 110,000 professionals and customers in 180 countries, we combine global scale with technology and services leadership. We support networks that connect more than 2.5 billion subscribers. Forty percent of the world's mobile traffic is carried over Ericsson networks. And our investments in research and development ensure that our solutions – and our customers – stay in front.

Founded in 1876, Ericsson has its headquarters in Stockholm, Sweden. Net sales in 2013 were SEK 227.4 billion (USD 34.9 billion). Ericsson is listed on NASDAQ OMX stock exchange in Stockholm and the NASDAQ in New York.

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