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A SHORT TALE OF SOCIETY 5.0
HOW TO LIVE AND FUNCTION IN THE TIMES OF INDUSTRY 4.0 AND 5G NETWORK

ATTACHMENT 1

CONCEPT, FUNCTIONALITY AND BENEFITS FROM BUILDING 5G

In fact, in order to generally understand what benefits we will have from the services provided by 5G networks, we do not need to know what the concept of their construction is, nor do we study in detail what technical consequences have raising certain parameters and introducing new functionalities.

However, we strongly encourage you to read the next two chapters, because we did it in the most accessible and understandable way. We will justify this by referring to the history of technology. Only a few dozen years ago, every driver had to pass the exam on the knowledge of the construction and operation of the car and most of its subsystems. Today it sounds ridiculous and no longer makes sense, but in the early days of motoring it was very necessary and practical. The cars were more faulty, there were no mobile phones, traffic was very light, repair workshops less available, etc. A driver who came across a small flaw had to either be able to repair it himself, or to wait for hours for help.

To really encourage the society and decision makers to put the 5G network investment program on the first place on the to-do list, one should be aware of what is weak in current networks and be convinced that all weaknesses will be removed.

Most readers of this short story at some point will say: well, you convinced me - it makes sense. But a moment later they must ask themselves about its impact on whether the construction of the 5G network will take place sooner or later. Well, this influence is decisive. First, telecommunications operators will not invest in something that customers will not buy. We are clients of the network in many ways - as individuals, and workers of all kinds. When we understand the benefits and convenience of new services, we will buy it as an efficient tool that facilitates and accelerates work, and as a convenient home service. Then we will perceive every administrative slowdown in the development of this system as the inefficiency of the company, but also of the entire state structure. We can react to this when purchasing telecommunications services and during each subsequent election. The sooner we understand this, the less delay we will have in relation to the most innovative and cooperating societies.

Therefore, at least at the beginning of development, we should get to know the very large number of new 5G network possibilities in the best way possible. Thanks to this, everyone will be able to compare what we have with what we can have. We are convinced that this is possible by describing the benefits in simple words.

Social interest and support for the investment will raise when users start to use it in a creative way, often different than its initial purpose was. The case of a SMS, which was supposed to be a message within signal network of the operator, is not a single extraordinary one in the history of technology. We hope that many engineers and entrepreneurs will be inspired to more detailed and creative familiarization with new features of wireless networks and possibilities of a full optical fiber network, even if they have not even started to think about their benefits coming from this new technology.

WEAKNEESSES OF MODERN TELECOMMUNICATIONS NETWORK

The assessment of whether something is weak, good or very good is the result of a comparison. If we have no idea that there could be something better, we agree with what we have and adapt to it. Change is always initiated by innovators. They are people who want and can do something better, more efficiently. However, real progress begins when people find out and become convinced that they can also benefit from this improvement. That is why we limit ourselves briefly to points, which can be radically improved and highlight what it will give us.

GUARANTEE OF HIGH QUALITY TRANSMISSION

In current networks, guaranteeing quality is so expensive that very few use it. The operator cannot offer it to us cheaper because the technical solutions at their use do not allow it. When we disruptions during a conversation, but we understand them - we can live with them. However, how often we have to waste

hours traveling, because we can't get along over the net.

Virtually everyone has a smartphone and knows perfectly well how much time they save each day if the network worked. It is completely real to turn off all high power radio and television transmitters, because the quality of transmission in the 5G network will make them unnecessary. This is another important contribution to saving money, environment and reduction of PEM emissions. However, when we work in the network, and because of its low quality, we do only half of what we could do during the day, our employer can pay us only half of what he could pay.

FUNCTIONALITIES AND ADVATNAGES OF 5G NETWORKS

The most important technological solutions of the 5G network include:

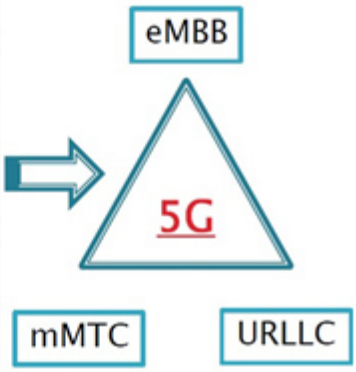
– Massive MIMO (Massive Multiple Input, Multiple Output) using ultra short waves (pilot working in LTE),
– Beam forming,
– Multi-RAT (Multi-Radio Access Technology),
– Technology for building micro and pico cells,
– Network slicing,
– FQAM modulation (pilot working in LTE),
– The use of various multiple access techniques,
– Full duplex - the ability to send and receive data at the same time, on the same frequency,
– Using band aggregation at different frequencies in a 100 MHz block.

All this has a positive effect on increasing the capacity of the network, its total throughput and reliability.

It is worth mentioning here that the changes will take place anywhere in the network: from the physical layer, to the radio and transport layer. Changes will take place in the area of cloud and virtualization, web applications.

5G - Areas of Network changes - ergo investment site

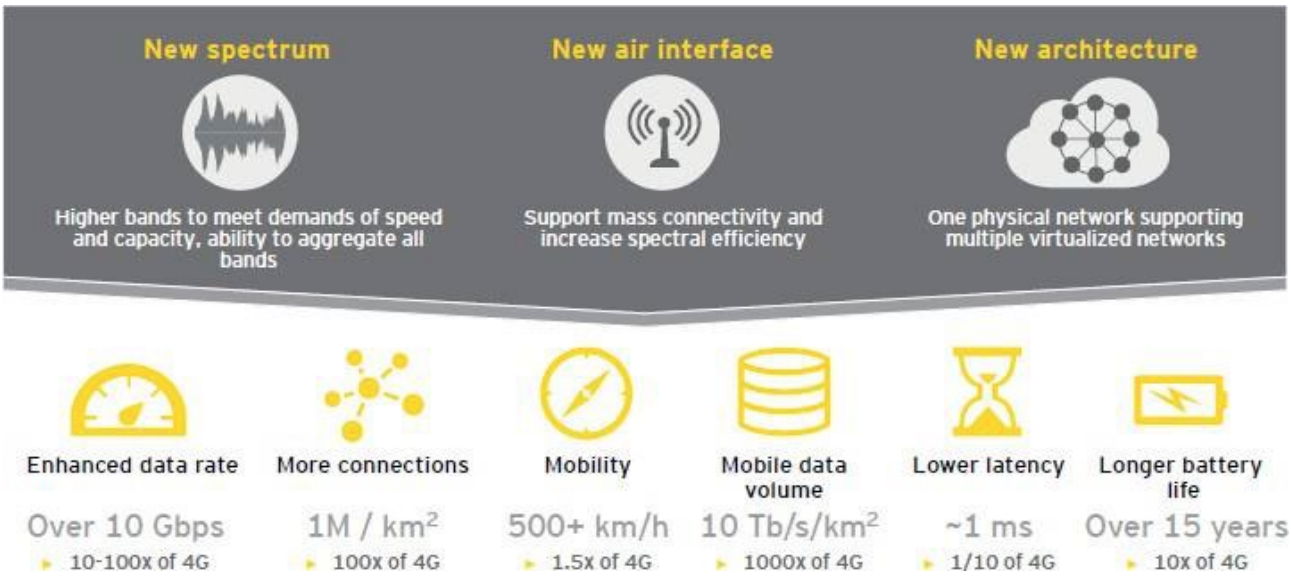
Area	Technologies			
Physical sphere	Ghost	*Makro Stations with new LF band*	*Micro Stations with new MF band*	*Pico Station new HF band*
Radio sphere	LTE evolution	NB-IoT	NR	Massive MIMO
Transport	Fronthaul	Backhaul	Resource differentiation	RAN transport interaction
Cloud	NFV	SDN	Virtual data center	PaaS
Network Apps	Cloud enabled	Scalability	Distributed deployment	Cloud native
Management	Orchestration	Analytics	Automation	Security



5G networks have many advantages that include:

– 20 Gbps peak data download speed,
– 10 Gbps peak data upload speed,
– 100 Mbps download speed experienced by the user,
– 50 Mbps data transfer speed experienced by the user more connections in one cell: 1 million/1 km^2,
– mobility - operation of the network even at speeds of 500 km/h,

– the ability to send a huge amount of data (10 Tb/s/km^2),
– very low delays - 1 millisecond,
– extended battery life - up to 15 years.



Summary of 5G advantages

SEPARATELY EQUIPMENT AND SOFTWARE VIRTUALIZATION

In order to increase the performance, scalability and capabilities of 5G networks, a number of technologies have been used, such as Software Defined Networking (SDN), Network Functions Visualization (NFV), Mobile Edge Computing (MEC), Fog Computing (FC), Cloud-RAN (C- RAN), Ultra Dense Network (UDN), and Self organizing network (SON).

Of these technologies, it is noteworthy that the software is separated from the hardware and the virtualization of functions on the network. This is a significant change compared to the previous generation of networks when individual network elements were connected with specific hardware and software. Currently, the telecommunications network is more and more reduced to IT systems, based on servers and software, and less on ready integrated circuits and off-the-shelf devices.

Software Defined Networking (SDN) is a programmable computer network that allows you to control the network in a completely programmable way. In SDN, the network architecture consists of separating the intelligent management device, which then only performs the tasks of sending data in packets between ports. SDN is a logically centralized solution in which the so-called control layer and data transfer layer. All decisions about controlling traffic in the network are made in it by the SDN controller, which is part of the control layer. The driver manages OpenFlow switches (IP) with the help of the OpenFlow protocol.

The 5G network also uses Network Functions Virtualization (NFV), which allows you to create virtual networks in a programmable way. NFV uses distributed cloud infrastructure (so-called distributed data centers) for accelerated and more reliable installation of such networks. To create virtual networks, previously prepared templates (blueprints) are used, which contain a set of virtual network functions, all configuration data, or connections between them. The use of network virtualization allows the separation of network services from the equipment used and is one of the key aspects of 5G networks.

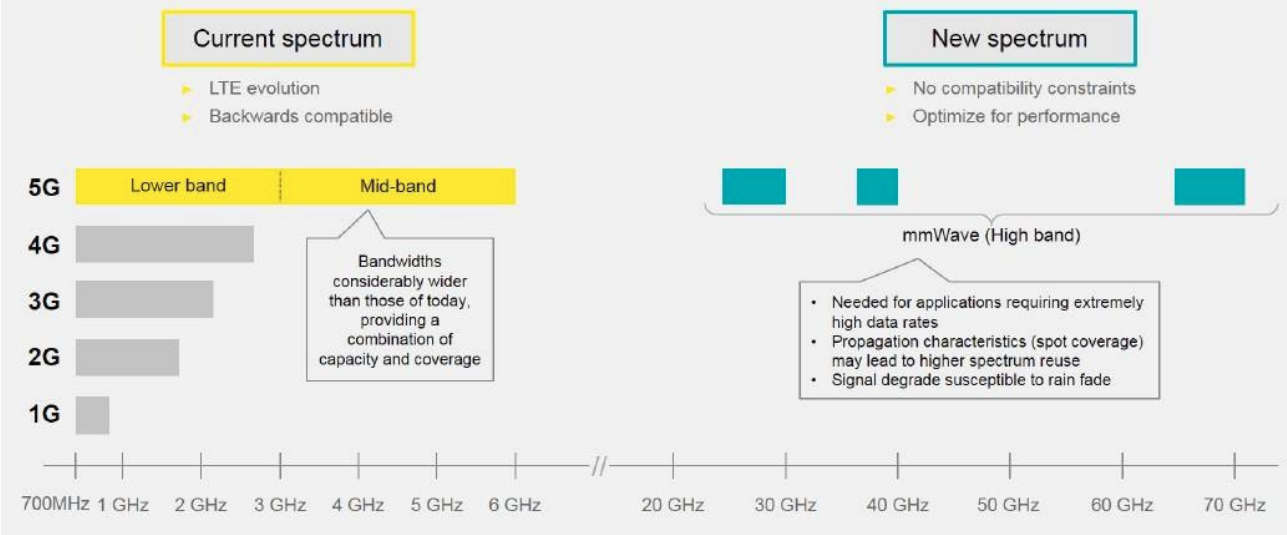
5G NETWORK ACCESS LAYER

1. BANDWIDTH UTILIZATION

Of all previous generations of wireless communication systems standardized by the 3GPP (3rd Generation Partnership Project), the 5G standard has the highest spectral efficiency value (bit / Hz), up to five times higher than for the 4G (LTE) standard. The result is that, in the long term, all existing radio systems will naturally switch to 5G technology in each band. It results directly from the fact that sending more data ensures higher quality of services for the same number of users. You can also provide the service with the existing parameters to a much larger number of users. Of course, this is also related to the current distribution of user devices enabling data transmission in various sets of wireless technology, such as "2G only", 2G / 3G, 2G / 3G / 4G, and finally the latest 2G / 3G / 4G / 5G. With the increase in the number of devices adapted to operate in 5G networks (which usually happens over time and is also a function of the price of such solutions for the end customer), operators will allocate more frequency resources from their radio band for the needs of 5G technology. A process analogous to what is currently happening in the process of 4G technology replacing 3G technology, for which the 2100 MHz band was originally intended. A similar situation took place in the 1800 MHz band - there was a migration here from the GSM network to the LTE (4G) network.

Due to the way the operator builds the network and the collision of capacitive and range needs, operators most often build a network based on two sets of frequencies: the lower ones ensuring the so-called "Deep indoor", that is, indoor building coverage and network coverage in poorly urbanized or even rural areas, and higher frequencies ensuring network capacity in a limited area, where the number of network users is very high - city centers, office parks, economic zones, locations public facilities such as stadiums, train stations or airports.

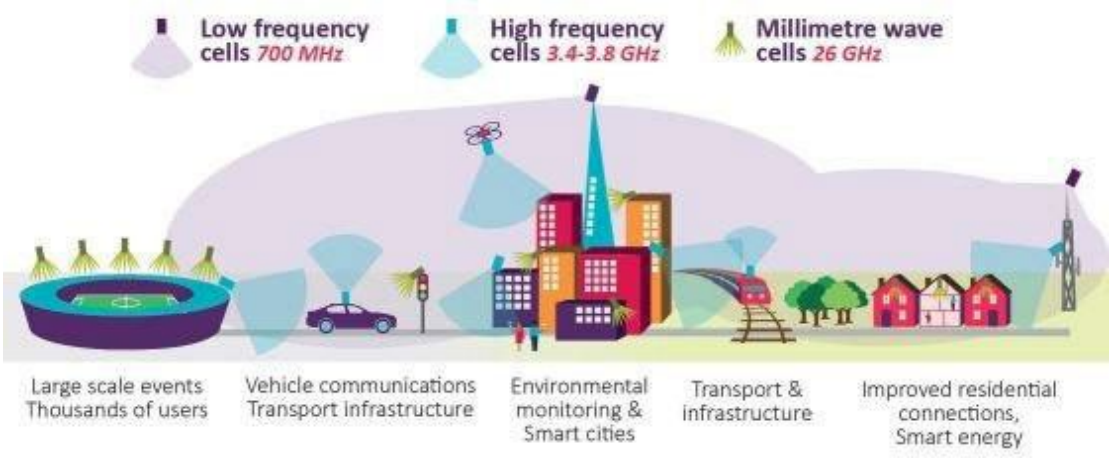
Due to the very essence of 5G technology, already at the standardization stage three main frequency bands are foreseen and they should be used already at the first stage of implementing 5G technology. This, of course, does not exhaust the target bands on which this technology will work. And so the first global capacitive band for 5G technology are ranges around 3.5 GHz, this band is usually marked with the letter C. In the world there are ranges with a total width of 400 MHz and will be distributed among operators. Technically, the optimal channel width for a single operator is 100 MHz. The second band provided for 5G technology as a layer ensuring indoor building coverage and coverage in rural areas is the 700 MHz band. However, it should be remembered that in this case the bandwidth is 30 MHz to be shared between operators. There is no huge flow rates here. It is a layer to provide high-quality basic voice service and support for IoT (Internet of Thins) devices, because it has a low demand for data transmission, and for occasional data transmission. The third frequency range provided for the 5G technology is the millimeter band, 26 GHz was adopted in Europe, the total width of the available ranges covers the 2 GHz band, and the width of the radio channel for a single operator reaches 400 MHz. This makes it possible to provide services with ultrahigh, by today's standards, data rates of up to 10 Gbps, when the communicating transceiver antennas "see each other". In the technical literature it is said that LoS (Line of Sight) is provided.



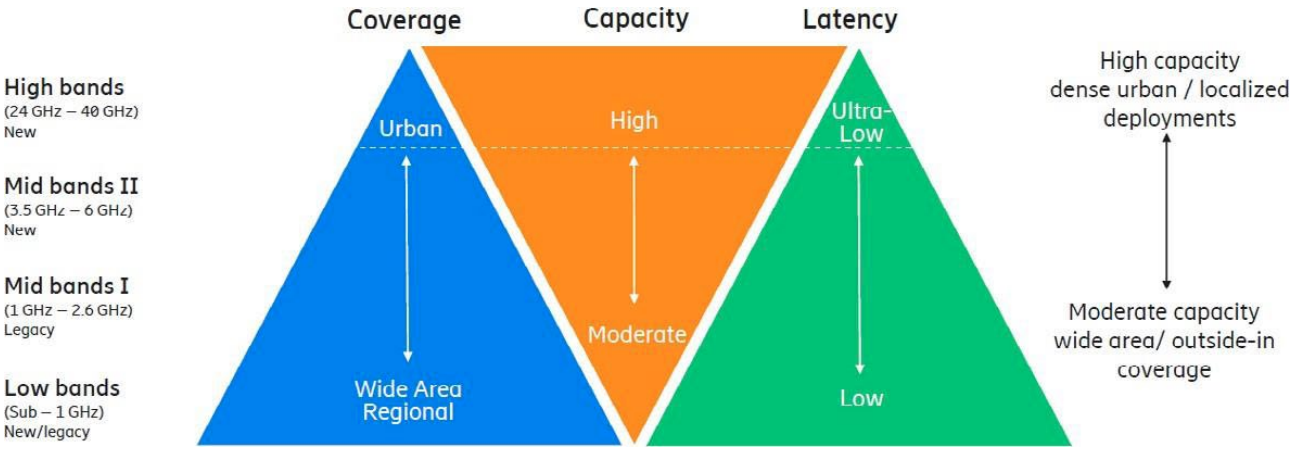
Current and new band of 5G network

Over time, it can be expected that additional frequency bands will be added to the radio resources available to operators to provide additional network capacity and even higher bit rates.

The use of individual bands in various scenarios and areas is presented in the graphics below:



Compromise in spectrum between bandwidth, range and delay:

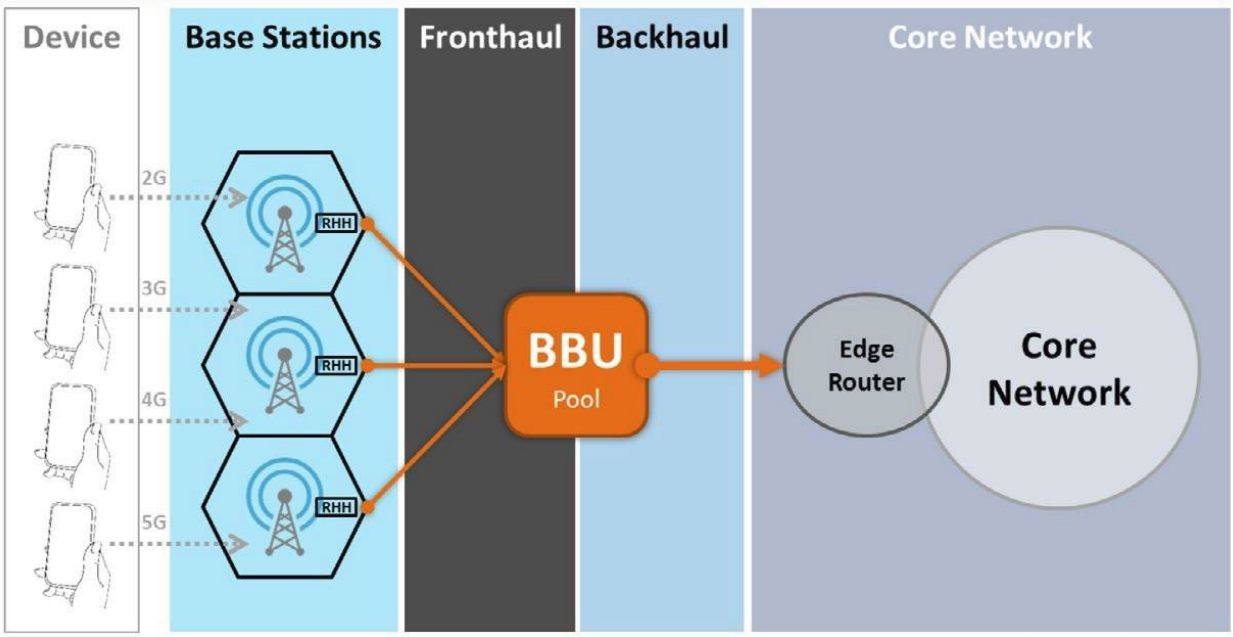


2. REDUCTION OF ENERGY CONSUMPTION

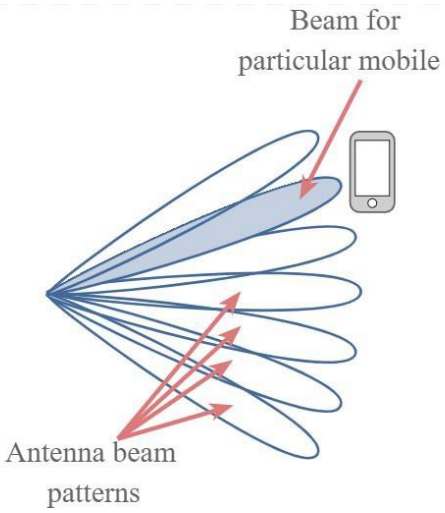
A very important issue from the commercial implementation of 5G technology is the reduction of electricity consumption. From the operator's point of view, electricity is operating costs, so-called OPEX. Therefore, operators strive to reduce any expenditure qualified as OPEX as much as possible.

The reduction of energy consumption happens on many levels. First of all, this takes place in the user's end terminals, where manufacturers try to ensure the operation of the device with the lowest possible power of the transmitter. Let's also remember that the biggest energy thief of portable terminals (smart-phones) is a high-resolution colour touch screen. Hence, many applications switch to the so-called dark skins that allow the same access to information, but with a dark background when it comes to the value of the message. This causes that the screen of the phone consumes much less energy, which in practice translates directly into the life of the device, extending the life of the battery in the context of the time the device is working on one battery charge.

From the point of view of the operator network, the largest demand for energy consumption is the access network (Radio Access Network), where signals from and to the user are logically formed and through amplifiers they reach transmission antennas, which are sent to network users. Basically, the signal forming part called the Base Band Unit (BBU) is not the most energy-consuming.



Until now, the greatest demand has been generated by the so-called Remote Radio Unit (RRU), which acts as a signal amplifier. Currently, in 5G technology, RRU is still an element that requires power, but due to the implementation of MIMO technology and Active Antennas, they are becoming another element with high power demand. In total, however, the devices emit less energy into space. The main processes related to energy saving take place here. First, the beam power is controlled, which was not the case for earlier generations. The direction of the signal beam directed to a specific user and its power is very precisely determined. The idea is for the user to receive the expected level of service with the lowest possible power consumption. Artificial Intelligence (AI) processors are built into Active Antennas, which task is to constantly monitor energy consumption and ensure that this consumption is optimal.



Beam tracking and forming

From the point of view of the tasks of maintaining and managing the operator's network (O&M), a holistic approach to the issue of energy consumption is very important. Therefore, AI mechanisms are implemented in the software that allow you to control the level of energy consumed by the base stations in relation to the users' needs. For example, at night, where the number of active users of wireless systems is the lowest during the day, it is possible to switch off individual technologies or frequency bands in order to achieve energy saving. Services are still available on selected frequency bands, but by temporarily disabling unnecessary resources, we are able to save about 30% of energy per year.

In countries where this is economically justified, solar panels are mounted on and near base stations to collect clean solar energy, which can then be fed into the base station. This is the best example of the emphasis placed on energy savings. It also manifests itself in replacing typical air conditioning with passive and gravitational cooling systems. This is to allow achieving the required effect at a lower financial and energy cost.

As it is seen in the approach to all elements of the telecommunications network, great emphasis is placed on minimizing energy consumption.

3. ELECTRONIC EMISSION DIRECTION CONTROL

A huge generation change is the use of so-called Massive MIMO antennas, i.e. Active Antenna Units (AAU). Their main feature is having integrated in one device 32 or even 64 transmitters and receivers based on 192 small antennas that control the beams both vertically and horizontally. This allows the scenario to be implemented in practice that the antenna beam follows the terminal of the end user along with its movement in the field of view of the base station antenna and directing the signal with the lowest power ensuring still high quality of data transmission. The same antennas can also support - thanks to beam targeting - users located on different floors of the building in the area of operation of the antenna. In previous generations, passive antennas with fixed parameters were used, i.e. the so-called main leaflet, in which the user should be in order to obtain optimal parameters of sending and receiving information.

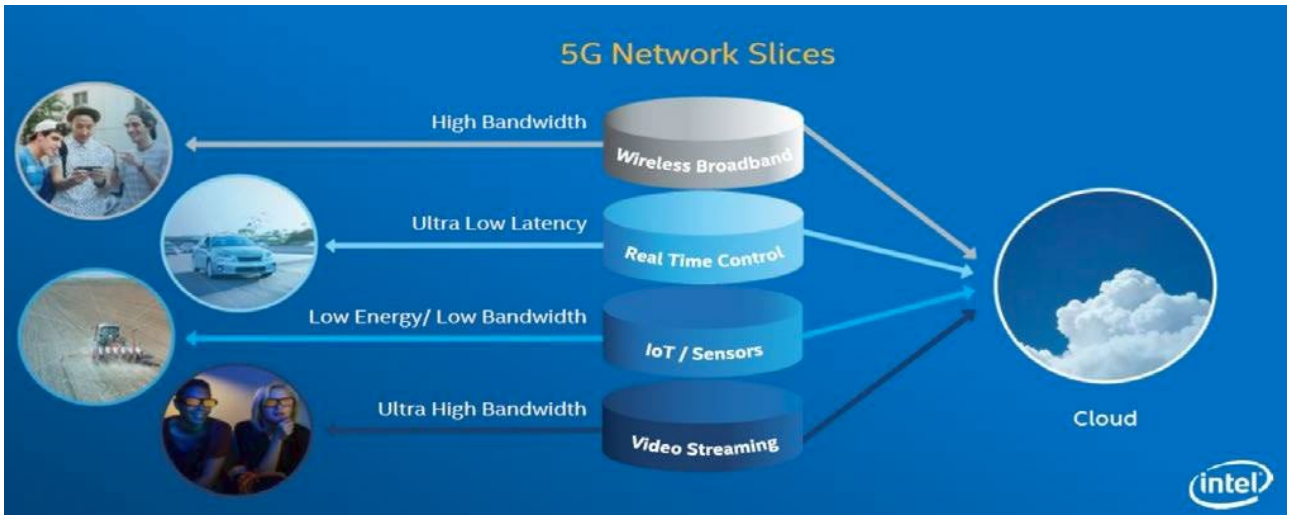
Currently, the antenna "tracks" the user and adapts to his needs. Thanks to such solutions, we are able to deliver to a single sector of the base station a capacity of up to 15 Gbps in a 100 MHz radio channel using an antenna with a 64T64R configuration. If the 32T32R configuration is used, we can provide up to 10 Gbps capacity in the sector. When we refer to 4G (LTE) technology in the 20 MHz channel, we could achieve a capacity of 150 Mbps. Even if we multiply this value 5x to achieve a comparable radio channel width, the maximum capacity would still not exceed 750 Mbps. This comparison allows us to easily illustrate how powerful Massive MIMO antennas are in today's networks.

4. CONNECTION OF RADIO DEVICES WITH THE WIRED NETWORK

A typical base station supporting 2G, 3G and 4G technologies in the most common configuration of 3 sectors in the country requires about 500 Mbps transmission upstream from a single base station (3 x 150 Mbps for LTE and the remaining band for 2G and 3G technologies). Such bit rates can be achieved by means of point-to-point radio links, which was often used by operators due to the fact of possible quick implementation in the constructed network. Some of the operators have been investing heavily in fiber optic networks for several years, trying to connect as many base stations as possible using fiber optics. This makes the operator independent of atmospheric conditions, distance from the transmission node to the base station, fees related to transmission in the licensed radio band for point-to-point links and limitations on the capacity of such solutions. If you decide to launch 5G technology on a selected base station, you must provide for an additional demand for data transmissions from the 5G layer. And so in the most modest configuration it will be at least 2.5 Gbps per sector, through 5Gbps and 10 Gbps, and even 15 Gbps per sector. So we are talking about total bit rates from about 8 Gbps to even 45 Gbps for a single base station. The transmission network must follow such requirements, otherwise it will be the bottleneck of the 5G technology being implemented. In practice, almost all base stations with transmission requirements above 10 Gbps should be connected to the operator's network using fiber optic links, for which the rates in question do not pose any challenge. This is a typical example of the coexistence of the latest achievements of cable and wireless networks in human service.

NETWORK SLICING

This is a kind of virtualization of network architecture that allows for considerable flexibility in creating services in a network with different parameters or even entire virtual networks with different parameters. The networks thus created can be used for different purposes and with different quality and parameters. For example, one layer of the network can be used to provide critical communication for the internet of things, another for autonomous vehicles, and a third for internet access. The use of network layering allows you to optimize the use of resources, providing a guarantee of quality of service on the entire communication line (end-to-end).

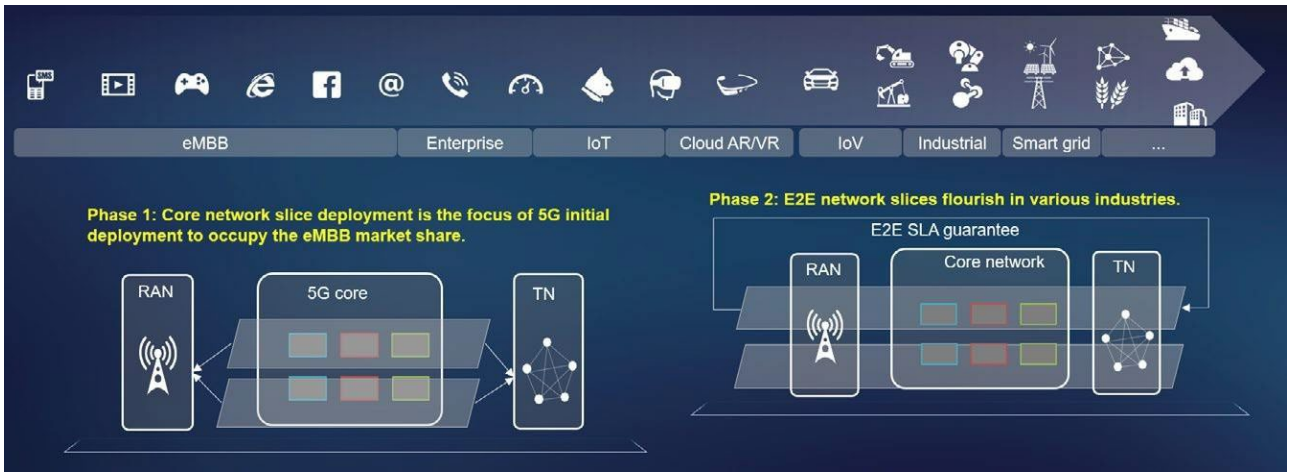


Simplified network slicing concept

Services in 5G will vary depending on the development phase of the 5G network. In the initial phase, eMBB services are implemented, including Cloud VR / AR. Later, ultra-reliable services such as IoV and industrial control are implemented. To ensure quality, network layering will be implemented in two phases:

1. In the first phase, network layering will first be implemented at the core network layer. Flexible service coordination and automated service deployment will ensure secure service isolation and independent

operations, thereby accelerating layering.
2. In the second phase, network layering will be implemented from end to end (E2E). Thanks to the intelligent E2E guarantee and network layering, new services will appear in each of the key sectors.



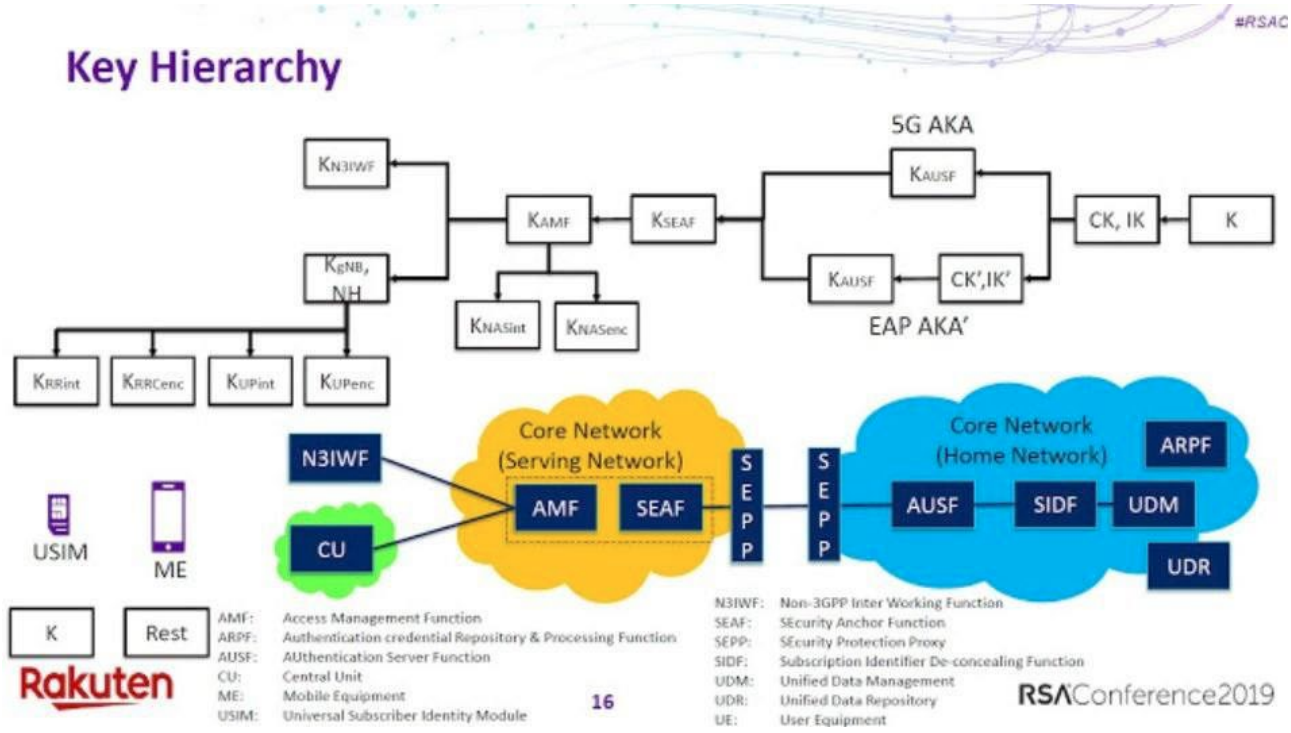
Introduction of network layering in two phases

Network layering is characterized by:

1. On-demand network layer management:
   – architecture focused on micro services,
   – managing multiple layers,
   – the possibility of multi-layer isolation of individual networks.
2. Automated implementation:
   – automated launching of network stratification for individual services,
   – starting network layer based on ready-made templates on demand,
   – layering automation testing,
   – intelligent management and maintenance of network layering.
3. Intelligent quality assurance of network layering:
   – layer selection from end to end (E2E),
   – transfer and sharing of the network layer identifier,
   – E2E quality optimization.

DIGITAL SAFETY OF 5G NETWORKS

– Resistance to criminal attacks,
– Eavesdropping resistance,
– Resistance to cyber-attacks of an intelligence and subversive nature,
– Resistance to military attacks.



BENEFITS OF BUILDING A 5G NETWORK (FROM THE VIEW OF SOCIETY, INCLUDING BUSINESS)

The implementation of the 5G network will bring many benefits to society. We are not yet fully aware as technology users of the scope of this generational change. 5G is just entering the market in line with Releas 15 3GPP, and remember that Release 16 3GPP will expand the possibilities of 5G technology.

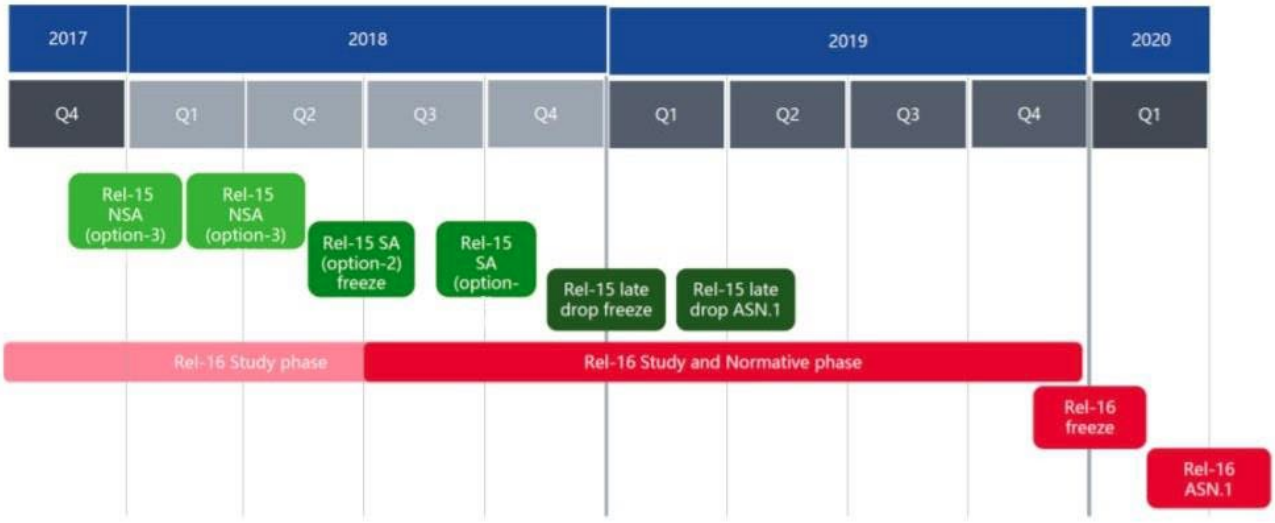


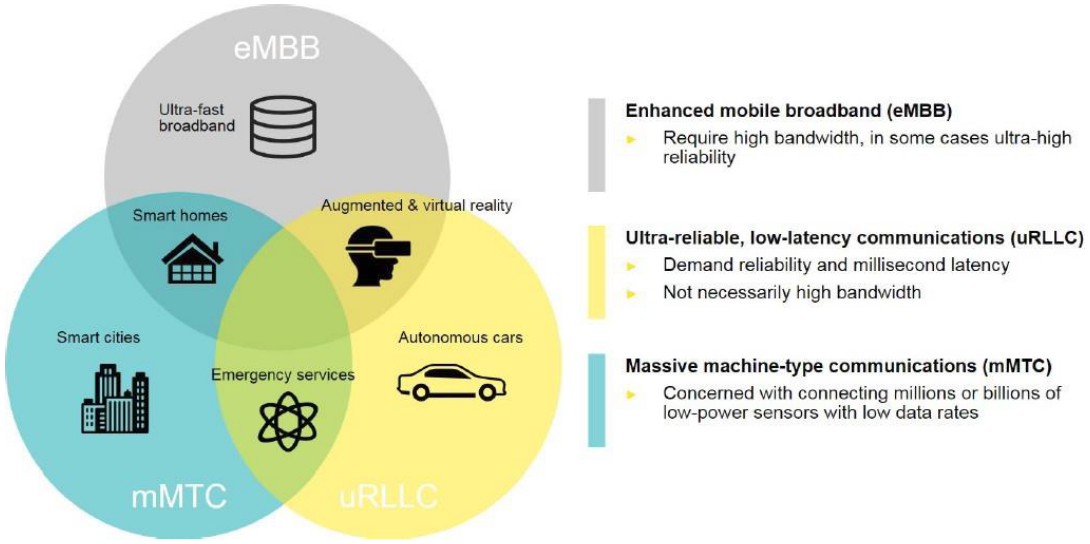
Figure 2 - 3GPP 5G Specification Timeline

Ultimately, we have three main functionalities supported natively by 5G technologies: eMBB, M-IoT and uRLLC. Future services will be created on this basis.

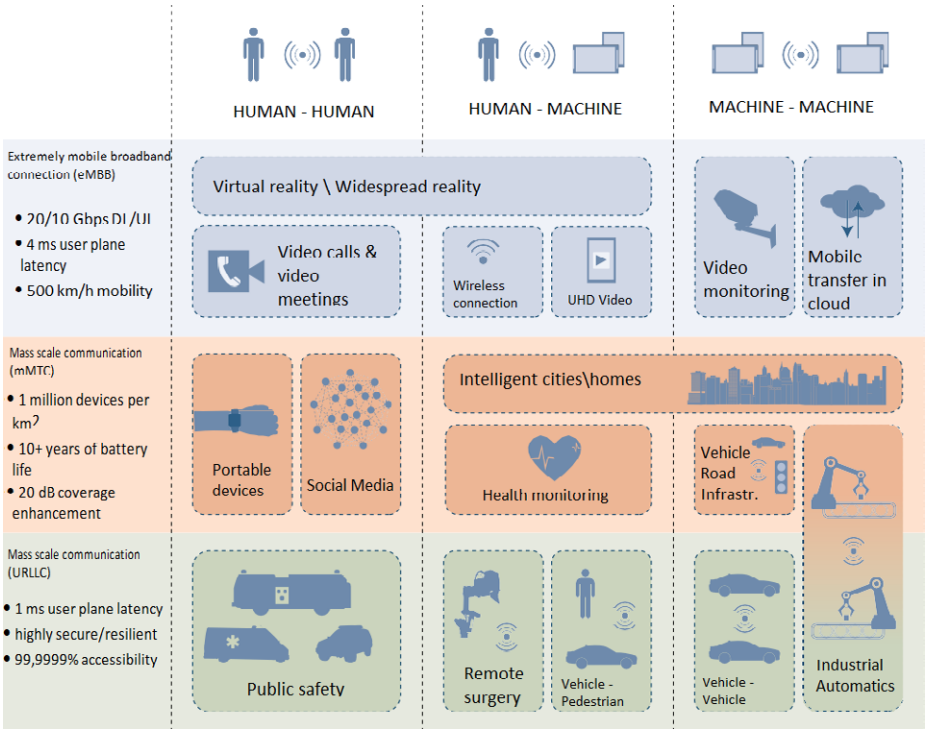
The current standard mainly defines services based on eMBB (Enchanced Mobile Broadband), i.e. in the simplest terms, very fast data transmission using wireless technology. 5G infrastructure providers

and network operators are still wondering and considering what so-called "killer application" for 5G technology will consist of. Usually both suppliers and operators are wrong about theirs predictions, and the market finds its own idea of using technology opportunities. Only the full implementation of all the advantages of 5G technology together with release 16 will create a full base for seeking new applications and services. Let's remember that we have to implement standard features related to massive MTC (Machine Type Communication), i.e. support for up to 1 million devices per square kilometer. We do not see such needs today, but tomorrow we can discover interesting applications in this area. The second important element of 5G technology is uRLLC (ultra-Reliable Low Latency Connections), i.e. connections with an extremely short delay reaching 1-2 milliseconds on the radio link. Until now, such short delays were beyond the reach of wireless technology, even for 4G technology the delay in the radio interface was at the level of 10-20 milliseconds.

Examples of applications are shown in the diagram below:



Application of 5G - blocks:



AND WHAT CAN 5G TECHNOLOGY OFFER TODAY AND TOMORROW?

The simplest application is the FWA (Fixed Wireless Access) service, which is a wireless version of a fixed link implemented using fiber optics. Of course, the advantages of optical fiber are indisputable, but it is not always possible to provide a service using it mainly due to two factors, the time of implementation and the cost of such an operation. Also, the user does not always want to be associated with the location where he will use this type of service. An alternative then appears to implement similar functionality using 5G technology. The advantage is the short TTM (Time To Market) and the lack of any customer-dedicated network activities (investments). The customer receives the terminal device and after installing the SIM card he can start using the service under the conditions agreed with the operator.

From the consumers' point of view, the biggest initial benefit of 5G networks will be offering gigabyte connections, with very low delays suitable for all transactions and entertainment, in particular for virtual reality and games.

The second family of solutions based on basic functionality is a network of sensors that perform specialized functions such as property supervision, supervision of industrial or agricultural production, supervision of atmospheric factors, management of locks on rivers, production line, car fleet, etc. In principle, this limits us only imagination and financial effectiveness of implementing the idea in practice.

The third branch of applications is the use of very short delays in practice, from trivial playing on the stock market in real time, through online games with other players, ending with remote complicated operations. The first such remote operations have already taken place in China, both on animals and on humans. These types of applications can be of invaluable importance where access to highly qualified medical staff is impossible, and with the help of a specialized robot controlled by a doctor you can help the patient almost immediately.

The next element of the puzzle in the 5G area is the cloud, in which we can implement a lot of applications, starting with "remote PC" services involving the lack of the need to buy a physical laptop. We simply buy access to a PC in the cloud and use a 5G smartphone to connect to it from anywhere in the world. All we need is access to a screen, e.g. TV, bluetooth keyboard and mouse, and we work exactly like a physical laptop, but no initial investment in equipment is required.

The next development step is "cloud gaming", and therefore access to video games without the need for a specialized infrastructure such as a PC with the appropriate configuration or a console dedicated to games. A similar set in the form of a screen, controller and smartphone are able to provide us with an identical gaming experience by sending a video stream directly to us from the cloud. This thread can be additionally extended with VR (Virtual Reality), AR (Augmented Reality) or a mix of both technologies. Cloud gaming, at least in theory, will be able to create smartphones that will last longer on the battery, because their processors will have little energy demand. All computing power will "work" in the cloud, and phones will only display its effects.

Based on the sensors, we are able to build a self-service network of consumption meters and forecast demand in real time, implement garbage collection using the "just in time" method by providing car drivers with tips on the optimal route for waste collection, which saves fuel and working time.

Another application of the 5G technology can be the so-called connected car where the 5G technology enables efficient communication between V2V (Vehicle to Vehicle) cars or a car with V2I (Vehicle to Infrastructure) infrastructure. This is important in the event of a type of road accident

accident to inform about the situation on the road much earlier than the next cars will appear in the vicinity of the accident. This has typical preventive significance. In the case of autonomous cars, 5G technology will also provide entertainment for passengers and drivers who will no longer actively participate in driving the car.

Another branch of applications are drones and specialized functions such as support for services of eg firefighters in the process of extinguishing fires of complex objects, in preventive forest monitoring, in transport of parcels, blood or transplant organs.

5G technology can also support effective education by using VR / AR techniques in the educational

process, and also support monitoring of public health remotely.

5G networks will also be used in communications for civil protection and crisis response services (so-called Public protection and disaster relief - PPDR). Typical communication scenarios for services include:

– communication enabling to secure mass events, e.g. sports,
– supervision of border control and their monitoring using electronic devices and drones,
– the use of video communications in emergencies, as well as the transmission of any files and information requiring high bandwidth,
– crisis management, incident management and traffic control and population migration,
– support for the response of any rescue services, e.g. during fires, floods.

In the European Union, the 700MHz band was indicated as particularly important for the implementation of the abovementioned communication.

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