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ORIGINAL RESEARCH

5G: a new era of wireless communication

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Abstract The increasing rate of connectivity is driving towards a new era of virtual reality which is possible with the high end speed internet. The connectivity between every object is forming a shape of latest technology, i.e. IoT (Internet of Things) which requires the enormous networking connection. Comparing to all those previous technologies, the outrageous demands which are placed on 5G are continuing getting very high, with data rates of up to 20 Gbps and the capacity a thousand times greater. 5G networks will be providing a flexible platform for the upcoming services such as IoT, Artificial Intelligence, Cloud computing, Natural Language Processing, machine communication and all the latest technologies. In this research paper important components of 5G will be discussed. All the important aspects like latency, MIMO, cell distribution, speed, mmWave, slicing, Spectrum will be briefly described which will form a new Platform for all the upcoming technologies.

Keywords 5G · Beamforming · Low latency · mmWave · Spectrum

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1 Introduction

We are in the digitalized era where everything around us operates on the click of a button, we are so used to the technology that we cannot think our lives without it. Life is changing fast and so is the speed of connectivity. With the latest technology comes high expectations, hence the need of high speed connectivity with everything around us became a necessity. Latest 5G is the fifth generation in the category of radio systems and advanced network architecture which will deliver extreme broadband, ultra-robustness with low latency connectivity and massive networking for humans and the Internet of Things (IoT). Exclusively by 5G, this programmable world will be transform our individual lives, economy and society. Before the evolution of 4G and LTE, it was impossible to think about the connectivity in Giga bytes per seconds that too wired but with the new technologies coming into frames it is now possible to connect the things with the speed of Gbps. 5G will be far more than being a new radio technology, it is a development of whole new technology which will be a prime and optimal topic for the researchers. It will combine the existing Radio Access Technologies (RATs), and it will add original RATs optimized for explicit bands and deployments, setups and use cases. 5G will furthermore implement a radically different network architecture based on Network Function Virtualization (NFV) and Software Defined Networking (SDN) technologies [3]. 5G networks drives to have be programmable, software driven besides managed holistically to enable a diverse and profitable range of services.

Networks will be offering speeds more than 10 Gbps and extremely low latency. 5G is the upcoming platform that will allow advancement in various industries, ranging from the IT industry to the Transportation industry, entertainment, agriculture and manufacturing industries. The emerging 5G communication technology is categorized by the smarter devices and the native support for the M2M communication. On that basis, the 5G terminals are capable of joining the existing ZigBee networks and have the potential to improve the data transmission [22].

2 Literature survey

Andrews et al. [1] has discussed how 5G will not be an incremental advance on 4G but a whole new technology of its kind. The former four generations of cellular technology have respectively been a major paradigm shift that has fragmented backward compatibility. They reviewed how 5G will be needing to be a paradigm shift which will include exact high carrier frequencies with massive bandwidths, extreme base station and device densities, and unprecedented numbers of antennas. They showed unlike the earlier four generations, it will resolve to be extremely integrative securing any new 5G spectrum and air interface together with LTE and WiFi to provide universal high-rate coverage and an unceasing user experience.

Boccardi et al. [2] reviewed how new research guidelines will lead to fundamental changes in the design of future fifth generation (5G) cellular networks. This paper describes major five technologies which will lead to architectural and component disorderly design changes: architectures of device-centric, millimeter wave (mmW), massive Multiple Input and Multiple Output (MIMO), smarter devices, and instinctive sustenance for machine-to-machine communications. The crucial ideas for each technology are described, alongside with their potential impact on 5G and the research challenges that remain.

Bangerter et al. [3] paper describes how evolution in the direction of 5G mobile communication networks will be considered by increasing number of wireless devices, service complexity and the requirement to access mobile services ubiquitously. This article presents an overview of future mobile communication generation (5G) with its evaluation, Challenges and Services. They proposed innovative network architecture for next generation 5G mobile networks with evolution of HETNET Architecture (5G). It serves with its key elements as Small cells, MULTI-RAT, D2D communication and Cloud-RAN to guarantee users with their Quality of service (QoS) requirement in a spectrum and energy efficient manner.

Li et al. [18] reviewed the prevailing 4G networks which are being widely used in the Internet of Things (IoT). They clarified how 5G networks are expected to massive enlarge today's IoT that can enhance cellular operations, network challenges, IoT security, and motivating the Internet future to the edge. They discussed prevailing IoT explanations which are facing various challenges such as large number of connection of nodes, security, and new standards. Their paper reviewed mainly the existing research state-of-the-art of 5G enabled IoT, key enabling technologies, and main research inclinations and challenges in 5G enabled IoT.

Panwar et al. [23] have investigated and discussed serious limitations of the fourth generation (4G) cellular networks and conforming new features of 5G networks. They have acknowledged challenges in 5G networks, new technologies for 5G networks, and present a comparative study of the proposed architectures that can be categorized on the basis of energy-efficiency, network hierarchy, and network types. Interestingly, the implementation issues, e.g., interference, QoS, handoff, security–privacy, channel access, and load balancing, hugely effect the realization of 5G networks. Furthermore, they have explained highlighting the feasibility of these models through an evaluation of existing real-experiments and testbeds.

3 Features of 5G

The world is at the emergence of a new generation of mobile networking and 5G is a future novelty platform for the next decade and beyond. It is being intended to boost existing services, but more importantly, it will expose new capabilities and efficiencies not possible with today's networks [19]. The innovative technologies require frequencies for their development and usage. The main objectives of 5G mobile communication systems, known also as IMT-2020, is to increase the existing data rates up to numerous gigabits per second with even more than 10 Gbit/s. One possibility is to consider the usage of higher frequencies in direction to increase the available bandwidth, which will be a necessity to attain such data rates [21]. Some vital features of the emerging network technology are as discussed below (Fig. 1) which acquire important information of the technology which will be used for the developing of such a large spectrum. These technologies are as discussed below.

3.1 More volume for improved mobile broadband experiences

When 3G accompanied high speed in the era of mobile data and 4G LTE delivered on the promise of Gigabit-class mobile networks, 5G is being aimed to elevate mobile broadband experiences to the next level [1]. 5G will mainly address main problems of smartphone users today.

Additionally, smartphones will be leading the way as the prevailing mobile broadband device for gratified formation and consumption. Today, the around 2 Billion smartphones are pouring over 80% of all mobile data traffic, and this portion is estimated to grow more in the years to come.

However, 5G can be broadly split into three use-case categories:

1. The massive broadband which will be delivering gigabytes of bandwidth on demand.
2. Critical machine-type communication (MTC) that demands instantaneous, synchronized eye-to-hand feedback to remotely control robots and deliver the tangible Internet.
3. Massive MTC which will connect billions of sensors and machines.

3.2 Introductory new spectrum opportunities to meet data demand

From the radio access perspective, there are three main pillars to meet the increasing data demand:

1. to densify the networks,
2. to deliver higher spectral efficiency,
3. to gain access to more spectrum.

To address these [2], 5G network Radios will natively support small cells, additional antennas with massive MIMO, as well as many other technology enhancements. The important aspect is the ability to mobilize higher spectrum bands that were previously not available for mobile applications. 4G LTE which primarily utilized lower bands—mostly in the sub-3 GHz range, which can deliver wider-area coverage but are intrinsically limited in bandwidth [16].

3.3 Virtual zero latency through full coverage and low power

The widespread range of spectrum which is accessible and the various use cases for 5G will request a configurable the structure of frame which will be malleable numerology. This is dissimilar to LTE, which has a fixed 10 ms frame and 1 ms Transmission Time Interval (TTI) that are inflexible and limit latency performance. The new 5G frame structure is self-contained and can deliver accommodations for bulky data packets spread efficiently with low overhead, as well as small, low latency performance packets that need be scheduled frequently. The main 5G sub frame could be in the variety of about 0.1–0.25 ms for short latency, and can be configurable to be optimized for wide area or local area needs, or for different bands [4].

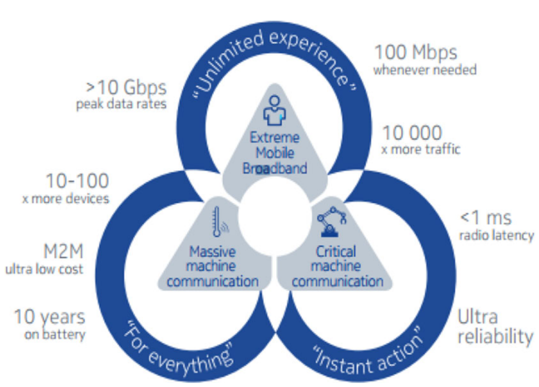

Fig. 1 Important features of 5G (white paper by Nokia) [4]

4 5G technology components

Associated to previous technologies, the demands placed on 5G are very extraordinary, with data rates of up to 20 Gbps and a capacity a thousand times greater. 5G mobile networks must also provide a flexible platform for new services such as massive IoT and critical machine communication. The demands require a number of new technologies [5].

For Geocasting, the group comprises of the set of all nodes within a specified geographical region. Hosts surrounded by the specified region at a given time form the geocast group at that time [20].

The key technology components include new spectrum, allowing 5G to make use of its full abilities to operate on any frequency band between 400 MHz and 90 GHz. These allow it to provide both the high data rates needed and the wide coverage required [15].

The accomplishment of the coming 5G networks will be determined by the adoption of a number of new technologies. These will also allow the benefits of 5G to be fully realized, taking full advantage of its high data rates and ability to use the wide range of bandwidths and spectrum [23]. The main new technology components are briefly described below.

4.1 New spectrum

The very high data rates of up to 20 Gbps require bandwidth up to 1–2 GHz, which is only offered at higher frequency bands. That spectrum is not yet used for any purpose. This means that 5G must use millimetre wave spectrum above 20 GHz and in fact 5G is the first radio technology designed to operate on any frequency band between 400 MHz and 90 GHz. The low bands are desired for coverage and the high bands for high data rates and capacity [6]. The frequencies above 30 GHz have wavelengths of less than 1 cm (10 mm) and are commonly known as millimetre waves (mmW). Lower frequencies at 24–28 GHz are also sometimes included in millimetre wave. LTE technology is defined only for frequencies below 6 GHz [13]. Below table illustrates Spectrum specialization for different ranges and Data rates (Table 1).

Table 1 Spectrum specializations [1]

Spectrum	5G spectrum Spectrum per operator (MHz)	Data rate (Gbps)
20-90 GHz (extreme local data rates)	2000	20
Below 6 GHz (high rates with urban macro sites)	200	2
Below 1 GHz (wide area and deep indoor)	20	0.2

4.2 Beamforming

Beamforming is an attractive solution for boosting mobile network performance [7]. It can provide higher spectral efficiency, providing much more capacity on existing base station sites. The method can also enhance link performance and increase the coverage area. Beamforming uses massive MIMO (Multiple Input Multiple Output) technology, which is supported by the latest 3GPP releases. Massive MIMO was added into LTE specifications in later 3GPP releases, while massive MIMO will be included in 5G specifications in the first 3GPP release [14]. The aim is make the 5G radio design fully optimized for massive MIMO beamforming. The underlying principle of beamforming is illustrated in Fig. 2.

Beamforming can also provide substantial capacity benefits at frequencies below 6 GHz. The aim here is to enhance radio network performance while reusing existing base station sites by adding new active antennas. The performance benefit of beamforming depends on several factors, including antenna configuration, environment, device capability and network algorithms.

4.3 Network slicing

The 5G network is premeditated to sustenance very assorted and extreme necessities for latency, throughput,

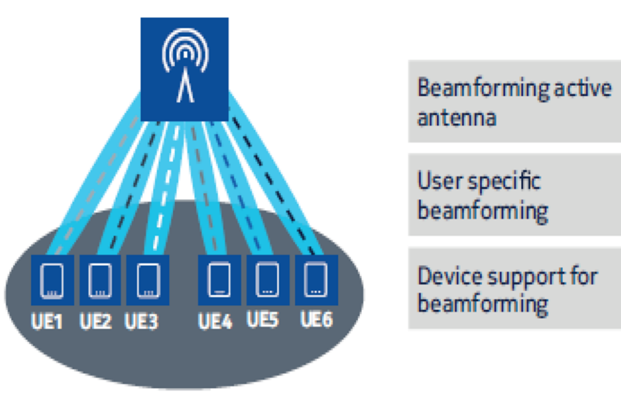

Fig. 2 Beamforming enhances radio capacity and coverage [4]

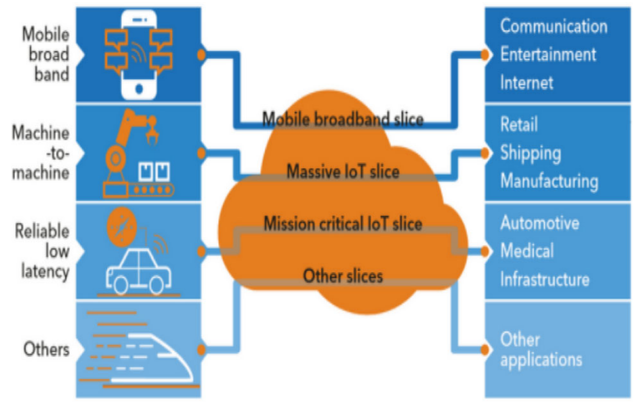

Fig. 3 Network slicing in 5G [5]

capacity and availability [8]. Network slicing will offer a solution which will meet the requirements of all use cases in a common network infrastructure. The concept of network slicing is illustrated in Fig. 3. The same network infrastructure can support, for example, smartphones, tablets, virtual reality connections, personal health devices, critical remote control or automotive connectivity [14]. With network slicing, different end-to-end logical networks with isolated properties are provided and operated independently. These enable operators to support different use cases, with devices able to connect to multiple slices simultaneously.

A 5G network needs to have tools for network slicing. LTE supports Quality of Service (QoS) differentiation but 5G requires something extra-dynamic, application based Quality of Experience (QoE). This approach is not achievable in LTE where the same QoS is applied for all traffic within a bearer [17].

4.4 LTE-5G interworking

5G can be deployed as a standalone solution without LTE. It can also use a non-standalone solution with dual connectivity to LTE where the device has two parallel radio connections: one to 5G and one to LTE [9]. Such an approach is practical during a 5G rollout phase, particularly if the LTE network uses low band and the 5G network uses high band with limited coverage. The first dual connectivity solution is based on the existing Evolved Packet Core (EPC). Both 5G base stations (gNodeB) and LTE base stations (eNodeB) are connected to the EPC. The control plane goes via LTE (Fig. 4). It is also possible to subsequently have non-standalone architecture with both 5G and LTE nodes connected to the new 5G core network (5G-CN). The control plane can go via LTE or via 5G. 5G is the first radio solution closely integrated with the existing radio

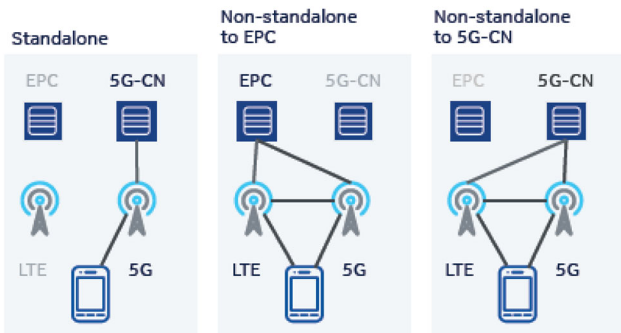

Fig. 4 Expected 5G architecture options [4]

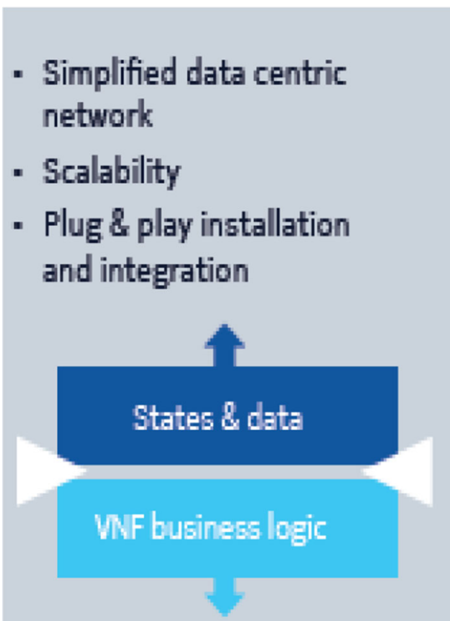

Fig. 5 Stateless virtual network [4]

network, offering a smooth rollout and a seamless experience for users [10].

4.5 Cloud implementation and edge computing

5G core and radio networks are designed for cloud implementation and for edge computing. The core network design for 5G includes a few innovations for cloud optimization:

(1) Stateless virtual network functions (Fig. 5) which radically simplify data centric network and software architecture and bring extreme scalability and plug and play installation [4].

2) Shared data layer (Fig. 6) optimized for cloud for massive scale and data propagation. It offers a unified solution for exposing data and open northbound interface [12].

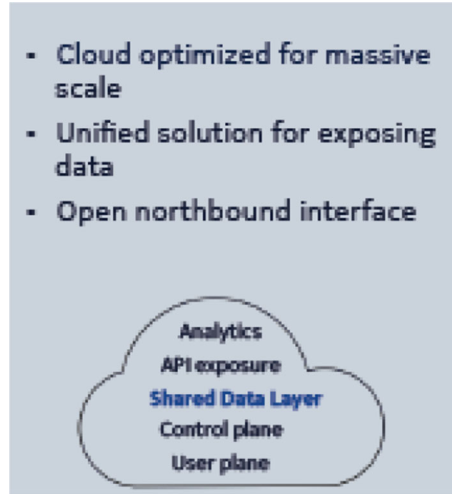

Fig. 6 Shared data layer [4]

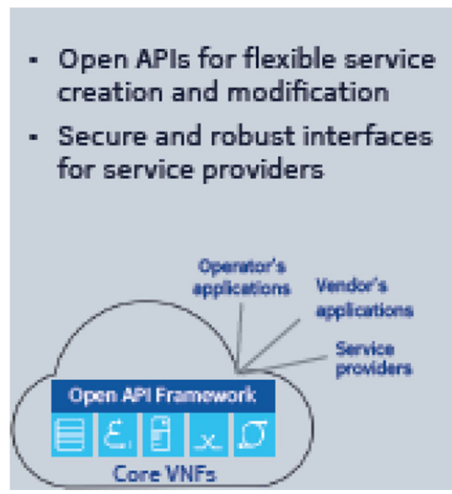

Fig. 7 Programmable core [4]

3) Programmable core (Fig. 7), offering open application program interfaces that allow flexible creation and modification of services and secure and robust interfaces for service providers.

A 5G radio network includes new interfaces that enable a flexible split of functionalities. The delay critical functions can be located close to the radio frequency (RF) and antenna, while the non-delay critical functions can be located in the edge cloud [11]. The cloud implementation enables network scalability, for example, when adding a large number of IoT connected devices. The future network architecture includes edge cloud, where multi-access edge computing (MEC) enables applications to run close to the radio access or where local breakout can be provided to local intranet or internet. The local cloud is an essential solution to bring low latency [14].

5 Conclusions

The expectations of 5G are very high, accessing data rates of up to 20 Gbps and a capacity a thousand times greater than previous technologies. 5G networks must also provide a flexible platform for new services such as massive IoT and critical machine communication. 5G has the ability to provide these capabilities and services but to bring them to full completion, a number of new technologies need to be accepted. Using new spectrum, massive MIMO beamforming, cloud and edge computing, network slicing and multiple connectivity technologies will ensure 5G can provide everything. Progress in this field is being rapid, with evidences of concept for many of the technological advances which will be a crucial part of the forthcoming 5G standard.

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