5G revolution and the Italian use cases

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Abstract

The 5G is a breakthrough transformation for fixed and mobile networks. It enables high performances more than the current networks. For this reason, 5G is one of the next cornerstones of digitalization, from the industries' competitiveness and improvement in communication and standards of living point of view. This paper provides a technical analysis of 5G technology, characterizing it as the technological boost to innovate all communication networks. 5G technology is a research, innovation and standardization product that interests the entire industrial world and communities. The network is evolving to manage both broadband connection and very low latency, critical communications. We will assist to an increasing number of hyper-connected devices. Therefore, the approach chosen to build this infrastructure for Gigabit Society is to create new industrial partnerships, signing agreements between technology and academic leaders.

Keywords

5G

1. Introduction

In the last years Telecommunications have become more and more innovative. They led to a very disruptive technological change in the society. The data transfer from users has been characterized by a rapid growth and considerable increase, beyond any prediction. In fact, in 1995 the GSM reached 10 kbit/s per channel. Today, with 4G we can reach 100 Mbit/s per channel [1].

From the managing point of view, the presence of many digital devices implies powerful and efficient communication networks. They have to enable high capacity in order to guarantee low latency during the data transfer, limited energy consumption and stable connectivity. For this reason, the development of 5G have to be encouraged. As ETSI (European Telecommunications Standards Institute) states [2], "*5G should deliver significantly increased operational performance, offering full mobility and coverage. 5G needs to cater offering acceptable levels of energy consumption, equipment cost and network deployment, and operation cost. It needs to support a wide variety of applications and services*". From the architecture point of view, the first release of 5G is similar to 4G. It is composed of radio access network and network core, Evolved Packet Core and Internet Multimedia System [2]. In Figure 1 it is reported the use cases defined by the ETSI insti-
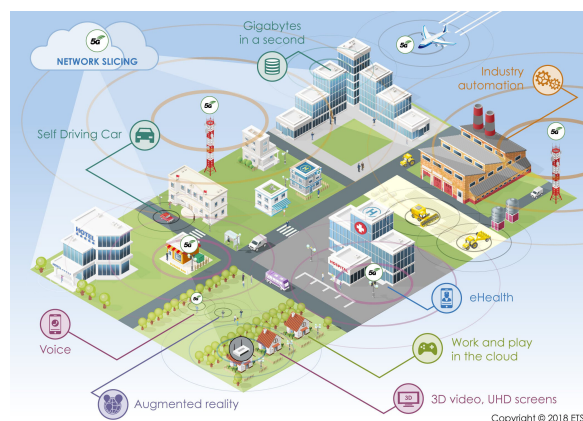

Figure 1: 5G use cases envisaged by ETSI [2].

tute. The deployment of 5G system foresees to be deployed in many different scenarios. They include ultra dense access points and smart objects belonging to the Internet of Things ecosystem [3]. Moreover, the 5G system is able to integrate different radio access technologies, including the satellite components [4, 5]. One of the key elements of 5G system is the Network Virtualization Function (NVF) feature. Authors in [6] presented an overview of some 5G initiatives to exploit NFV approach. It can facilitate the 5G diffusion and its integration with terrestrial and satellite system. From a market point of view, the integration of several communication technologies enabled by the 5G system brings to new business opportunities in the entire Information and Communication (ICT) sector. The supplier companies in communication services, communications services, cloud and software can benefit

Figure 2: Qualcomm Snapdragon 855.

from 5G system deployment. On the other side, in general they can increase the growth of telecommunication sector in terms of efficiency, business and user experience. In fact, by the end of 2025, the 5G is expected to reach 2.6 billion subscriptions and then to cover up to 65% of the world's population. It means that 5G will be able to generate the 45% of total mobile data traffic worldwide. Thus makes faster the adoption of 5G on a global scale [7].

The paper is organized as follow. In Section 2 the hardware enabling the 5G is described. In Section 3 the 5G experimentation carried in Italy is presented. The Section 4 provides a brief list of main communication vendor companies pf 5G equipment. The Section 5 the impact of 5G technology in the connected vehicles is analyzed. The Section 6 summarizes the main conclusions.

2. Hardware

The general standardisation process of a radio mobile technology foresees different steps.

One of the most important regards the assessment of radio interface technologies, proposed by independent evaluation groups. Qualcomm, an American research and development company in the wireless telecommunications field founded in 1985, in the first half of 2018 proposed several 5G trials with some American operators, AT&T and Verizon. The Qualcomm President, Cristiano Amon, announced the availability of Snapdragon 855 (the dedicated 5G chipset for high-end smartphones) in the first half of 2019. The products with Snapdragon 855 are able to connect to the 5G network (see fig. 2).

The new applications supported by the 5G require high level of computation capabilities supported by the

hardware involved in 5G systems. The IoT nodes need to optimize data processing in order to reduce energy consumption and extend battery life. For this reason, 5G will impact also on microprocessors' design. As known in the literature, specific or re-configurable hardware accelerators represent a good solution to speed-up data processing and in some cases also to reduce the power consumption as shown for example in [8, 9, 10].

In fact, Qualcomm pushes on the introduction of new smartphones supporting Android operating system and each equipped by 2 chipsets. The new SoC is characterized by a powerful processor and the Snapdragon X55 modem. It allows to manage 2 platforms, one for the 4G and the other for the 5G. Moreover, it updates the different components. In a specific article by Digital Day, the main processor's features are described: "*The block diagram shows how the processor is divided: the CPU now occupies a relatively small portion, comparing it to the three true processors that handle all the usual operations: the DSP hexagon 698 designed to speed up machine learning calculations, the GPU Adreno 650 and the Image signal Processor Spectra 480. Together with the sensing Hub, that is to say with the "safe zone", which stores sensitive data in temporary memory, and with the module that handles sensor data, these processors make up what is today the most advanced SoC in the world*".

Considering the extremely high number of applications supported by the 5G, Embedded microprocessors shall be able to perform several operations as for example speech quality enhancement [11] and machine learning

In particular for what concerns Machine Learning, In the last few years, we assisted in its incredible growing up [12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23].

This has been possible for three main reasons

1. The big availability of data introduced by the internet
2. The increase of computational power of digital circuits that allowed the possibility to efficiently implement neural networks and more in general ML systems [24, 25].
3. The introduction of new Machine Learning models that allows emulating the brain-behavior in a very efficient way [26, 27].

A new processor, dedicated to machine learning and to models' acceleration, is called Hexagon 689. The NPU analog component from Huawei is a module that gets to 15 trillion operations per second. It reached with an efficiency that is 35% higher than that of the Snapdragon 855 Hexagon.

The Hexagon, however, works in a different way compared to NPU. Thus because it can ask for help from GPU or CPU based on the different kind of neural network or model that it has to handle. The new CPU is 25% faster and more efficient than the previous one. it consists of 8 cores divided into 3 clusters. One of them from a single core Cortex a77 at 2.85 GHz and with a 512 KB second level cache. The other three which work at 2.4 GHz. All the cores have a 256 KB cache. The remaining 4 cores are deputed for background tasks and for applications that do not require an intensive use of CPU work at 1.8 GHz, Cortex A55 4. Each of them have a 128KB cache.

Each core shares a 4 MB cache. The self-organizing networks (SON) should take to fewer drops of signal, higher data speed and lower costs for operators, adapting dynamically to different environments. Regression techniques are evaluated. In fact estimating route loss has been analyzed by researchers when they adopted the machine learning techniques in order to obtain more efficient and accurate route loss models. It has been demonstrated that the machine learning use provides adaptability to network designers that rely on signal propagation models.

Different vendor companies launched new devices compatible with the 5G. Among the first ones, Oppo Reno 5G, talked about Snapdragon X50, joined by SoC Qualcomm. The chipset characteristics are the same of the previous version. A second device has been launched by Samsung, the Galaxy S10 5G. It represents a special variant, with a design similar to the other models except for the 5G support sided by modem SoC Exynos 9820. A bigger display comes thanks to a Dynamic Amoled panel of 6,7". The real revolution comes with Nokia. It started with 5G network adopting a dedicated device, a mid-rage smartphone. The new Nokia 8.2 5G, in addiction to a reduced price, is equipped by a waterfall display, a selfie retractable camera and a Snapdragon 735 5G processor.

3. Experimentation in Italy

In Italy several experimentations have been carried in the last years. In particular, TIM and Ericsson developed a 5G antenna with millimeter waves (mmW) and performed several preliminary test in Turin (see fig. 3).

In 2017 the Italian Ministry of Economic Development (MISE) launched the first 5G experimentation to be held in 5 italian cities and in collaboration with the operators (TIM, Vodafone, Wind Tre) and vendors (Ericsson, Nokia, Huawei and ZTE).

In Turin, the project sees the realization of a Smart

Figure 3: 5G antenna installed in Turin by Tim/Ericsson

City Control Room. It enables several important applications supported by 5G, as smart traffic, smart parking and smart lighting. A download datarate of 20 GBbps was reached. The value is 20 times faster than the 4G. According to Tim CEO's expectations, the 5G network is going to involve more and more users over the years, changing radically the habits, perspectives and potential. One of the most promising aspect is represented by virtual reality. It allows to live senses and emotions from hundreds of kilometers away. Not only calls and safe navigation, fast and stable, but also the best use of artistic and cultural heritage, through designed applications and created for valorize stripes of territory unknown by tourists, improvement of the education condition, healthcare more connected with the possibility to do also small remote surgeries.

The project, in the south of Italy between Bari and Matera, is branded Tim, Fastweb and Huawei, with 52 partners involved.

With the first experiments, in 2018, the 75% of network coverage of cities has been reached. The high radio performances have been reached through the use of "Massive MIMO" antenna, characterized by active
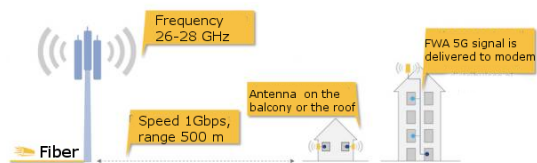
Figure 4: 5G antenna installed in Turin by Tim/Ericsson

elements that enable the coordinated use of an independent number of radiant elements. the resulting effect allows to increase antenna directivity and to dynamically orient the transmission of the radio signal in the direction of the various customers. In this way, everyone could use the best performance that the antenna is able to offer thanks to techniques for spatial distribution of radio resources. Vodafone carried out the 5G experimentation in Milan, in collaboration with Nokia. They defined 41 Use Cases and 28 partners. At the end of 2019, the network coverage has reached 100% of the Lombard metropolitan area. With a total of 90 Million euros for total investment, several important applications were tested, as healthcare and wellness, security and surveillance, mobility and transports, manufacture and industry 4.0. The healthcare sector can benefit a lot from 5G. Thanks to a broadband connection and high speed data rates offered by 5G, it can be possible to guarantee high reliability for new ambulance intervention protocols avoiding delays and the repetition of examinations. The real time management of critical situations during transport can also be enable, together with the remote consultation. The possibility to exchange the traffic information coming from widespread sensors deployed along the road infrastructure and vehicles can both enable the smart mobility and enrich the driving assistance system. Fastweb and Ericsson carried out the 5G experimentation in Rome in order to create a digital laboratory useful for the touristic sector. They developed new applications in the urban mobility and security, in terms of innovative high-definition surveillance solutions. The development for a new experimentation has been taken in agreement from Fastweb and Samsung for 5G Fixed Wireless Access Network (FWA) on commercial frequencies, always on the Italian territory.

This project shows that the 5G FWA networks are able to replace the FTTH network (filbert-to-the-home) to realize Gbps-based connections. In this way, the 5G FWA technical and commercial feasibility on millimetre bands has been proved. The European Corealis

project is experimented in some cities in Tuscany. The project aim is to digitalize the harbour operations and to make them more efficient and sustainable using the 5G network.

4. Vendors in the world

In 2019 Nokia became the leader 5G vendor in North America. As confirmed by Nokia Bells Labs President, Marcus Weldon: "It is to allow new geographical areas to experiment for the first time the possibilities of the 5G, to push on the technology and redefine the limits and to offer excellent performances reaching new records in the field, highlighting the first transmission data end-to-end on a commercial network 5G New Radio 3GPP. Nokia has managed to reach 23 records related to 5G in multiple technological areas".

The inventors of patents, launched by Nokia, work at Near Bell Labs in Aalborg, in Denmark: "In Nokia it has been long understood the importance of open standardization, aimed at enabling others to create, based on our innovation, new products for people around the world. Through licensing, other sectors and activities can benefit from Nokia's innovation, while we seek to develop an even more connected world", said Jenni Lukander, Nokia Technologies President. Nokia is the only end-to-end products supplier, that covers all 5G network elements. Nokia 5G products were contracted by all US national operators, all South Korea operators and all the three Japanese national operators. That is to say two-thirds of the global business of access networks in a typical year.

China is the most powerful mobile market with 1 Billion connections from smartphones reached at the end of 2018. 5G will represent a real turning point: it is the reference point for Asian Countries of this new technology in the world. China worked on 5G in collaboration with his three national operators. In July, despite the USA persistence, Huawei has claimed to have signed 91 more commercial agreements for 5G network supply all over the world, of which at least 28 of them being in Europe. While the USA accuse Huawei of telecommunications espionage, the Chinese giant signed the agreement for the 5G network's development in Russia. The agreement has been signed close to a meeting between the Russian leader Vladimir Putin and the Chinese leader, Xi Jinping.

	Nokia	Huawei	Tim	Ericsson	Qualcomm	Vodafone	Fastweb
Virtual reality	x		x	x			
FWA	x			x			x
e-health	x	x	x	x	x	x	x
Sensors networks				x	x		
Smart city		x					
Connected automotive	x	x	x	x	x	x	
Cloud robotics	x	x		x			
Cloud virtual e augmented reality		x					
Smart manufacturing	x	x		x	x		
Connected drones		x			x		

Table 1

Use case made by major vendors
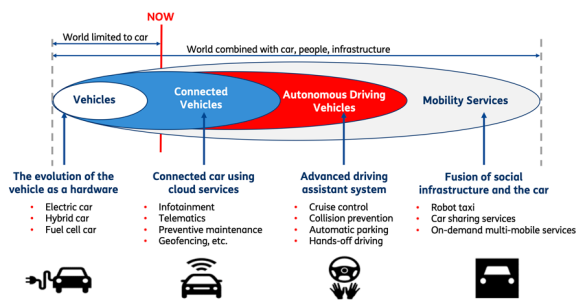
Figure 5: Evolution of the mobility Service with connected vehicles [29].

5. Connected Automotive

Transport systems are evolving towards the "Smart Mobility" thanks to the evolution of wireless networks and to advances in connected devices. Authors in [28] analyse possible 5G deployment and costs to support the transport system evolution. In Figure 5 shows the evolution expected to provide the Mobility Service starting from the connected vehicles and passing through the Autonomous Driving Vehicles [29].

TIM, connected vehicles experimentation
A powerful management of the people and goods mobility needs to assure firstly their safety, secondly, the reduction of wasted time, money losses, and the environmental impact. It can offer various points of evolution for the telephone operator's business.

Transport systems are evolving towards connected, cooperating and automated mobility paradigms CCAM (Connected, Cooperative and Automated Mobility). In this scenario the vehicle becomes an integral part of a connected system that includes intelligent road infrastructures, distributed sensors, private and public controls. The network is able to exchange data and information by creating a distributed cooperative environment that is considered the main activator of services.

The latest network technologies have created M2M (machine to machine) communications based on the three-level architecture. TIM has carried out experiments in the field of Smart Mobility, through a set of use cases. The goal is to provide a service with connected cars.

The use case experimentation focuses on two issues: the dangerous events between connected cars and the autonomous parking service. The reporting of dangerous events is part of the use of assisted driving. In this context, the notifications relating are potentially dangerous situations to be transmitted over the network. It is essential to assure very low latency for the data transmissions. It should be reached exploiting the characteristics of the Multi-Access Edge Computing (MEC). It allows applications to run on the access nodes of the mobile network. The parking service is part of autonomous driving. It allows to create driving scenarios without direct intervention by a driver on the vehicle. In the case of Valent Parking, a remote operator moves the vehicle thanks to the real-time video streaming that gives information about surrounding environment. Finally, the system forwards a notification to the owner of the successful parking. In Figure 6 it is reported a possible subdivision of the functionalities that can be performed at three main levels:

- Cloud level. This is the actual situation. The applications as vehicle telemetry and Intelligent Transport Systems run on it.

- Network level. The system intelligence should be moved On this level. The MEC functionalities can be deployed in order to reduce the round trip time of the request/response of the connected
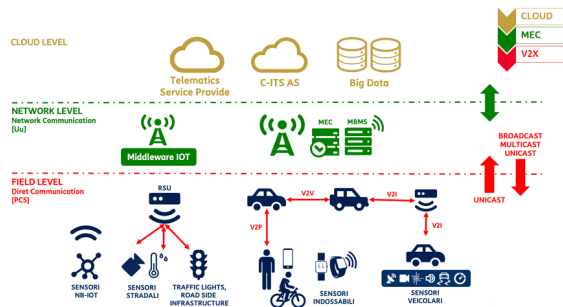
Figure 6: Organization of the information systems in connected vehicles [29].

vehicles.

- Device level. This is the final step. Vehicles and sensors alongside the road infrastructure can exchange data directly without any interaction with the communication network. In hit way, the delay of the signal transmission should be very accurate.

6. Conclusion

In the last years the major telecommunications leaders have demonstrated their interest on the 5G development, not only from a new network standard point of view. 5G is an important enabler of new applications and services to offer to the end users. In the whole ICT sector, the companies have been forced to change in order to catch the right opportunities coming from more challenging the user requirements. In order to do this, we need an more decentralized network infrastructure, able to support the elaboration and storage closer to the end user. It also implies the compliance with regulations and the necessity to guarantee the network resilience and scalability. In this paper, the authors provides an overview of the telecommunication sector considering the last and the future trends regarding the 5G. After the analysis of hardware supporting the 5G, the paper presents the main important 5G experimentation carried out in Italy, together with the 5G applications for the smart mobility. As the next steps, the authors will focus on the performance analysis and comparative analysis with the previous communication standards.

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