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Evolutionary analysis of cellular mobile phone technologies

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Abstract— *This work presents a broad view of the evolutionary process in mobile systems focused on data transmission, through its characteristics it will be possible to understand the evolutionary process such as: Infrastructure, evolution of voice, data and image transmission signals. In the last decades several technologies in the area of telecommunication, known as generations, this terminology, with a number accompanied by a letter G, has a common history as: the evolution of information transmission technology without using wires, which begins with the first cell phones between 1970 and 1980 decades, during that period there were many changes, although the principle of wireless data transmission still remains. We seek to characterize this evolution until reaching the Fifth Generation, or 5G wireless device technology, which promises a higher data transmission speed compared to the other previous generations, showing dynamically the communication between different devices without the use of cables or other larger structures between devices.*

Keywords— ***Generations, Wireless technology, Mobile telephony.***

I. INTRODUCTION

The evolution of cellular mobile communication seeking to meet the needs of its users has enabled the emergence of several technologies. In this work, the evolution of cellular mobile communication, the technical requirements, technologies involved, characteristics and applications in the five generations of mobile communication networks will be presented.

The first generation mobile networks, wireless mobile phone technology depended on analog radio systems, so users could only make phone calls, but they could not send or receive text messages, as they depended on external modems attached to the devices for exchange data, and had download speeds that were always below 10 Kbits per second. The 1G network was replaced by the 2G that operated with a digital signal, not analog, with speeds of about 32 Kbps to 80 Kbps for the end user. Thus, users could send SMS and MMS messages and when GPRS was introduced in 1997, users could receive and send e-mails on the move [1].

[1]; [2] They mention that 3G started to be offered in 2001, in regions such as Japan, China and Europe through the UMTS system, allowing a greater amount of data, where at that time users could make video calls, share files, browse the Internet , watching TV, instant messaging and social media, quality streaming, downloads and playing online.

The introduction of 4G is five times faster, with speeds of up to 100Mbps download, 50Mbps upload and a latency (PING) of a maximum of 30 ms(milliseconds). All cell phone models launched since 2013 support this network [2].

The 5G network is to be launched, but is widely expected by the mobile phone industry, and there may be changes in the network, the way we use cell phones and the connection mold. Wireless technological evolution increasingly seeks to create smaller devices by changing the way we communicate.

The purpose of the proposed study is to describe the evolution of mobile network technologies and relate them to current 5G technology and their respective applications.

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II. MATERIALS AND METHODS

This study is a descriptive and qualitative research for the collection of information, consulting in different electronic media, also with a scientific basis. Descriptive research has the primary objective of describing the characteristics of a given population or phenomenon, and qualitative exploratory research that aims to provide greater familiarity with the problem, with a view to making it more explicit and in possession of this information. It will be addressedhow is the status of 5G technology.

III. RESULTS AND DISCUSSION

[2] It says that the basic architecture of a cellular system consists of three components: Mobile Station (MS), Switching and Control Center (SCC) and Radio Base Station (RBS). In terms, the mobile units are in direct communication with the Radio Base Stations (RBS) through a radio connected to the Control Center by physical means of transmission. Thus, an ERB can exchange data with a single SCC, a SCC can communicate with several RBSs, being a fundamental part of the Mobile Communication System, given its coordination of functions and actions linked to the state of calls and the system.

According to the evolution process of cellular networks, as stages marked by technological advances and divided in Generations.

First Generation Systems (1G)

The AMPS analog system (ADVANCED MOBILE PHONE SYSTEM) is a North American standard that uses the 800 MHz band, it was invented by Bell Labs that operates in the frequency range from 824MHz to 894MHz with low quality connections, excessive consumption of battery and the ability to intercept and listen to users' communication. In AMPS it was already possible to communicate data through protocols such as X.25, allowing rates between 9Kbps and 14Kbps, first installed in the USA in 1982 and then in England and Japan [2]. Thus, the characteristics of the first generation are: a frequency of 800 MHz and 900 MHz, bandwidth: 10 MHz, with analog technology, frequency modulation (FM), its service mode was only voice, given poor voice quality. Interference, battery life was low, cell phones were large, calls could be decoded using an FM demodulator, number of users was limited, roaming was not possible between similar systems [3].

Second Generation Systems (2G)

The second generation systems were marked by several technologies, namely: GSM (Global System for Mobile Communications), TDMA or D-AMPS (Time Division Multiple Access), IS-136 and IS-54 with digitized voice signal from 64Kbps on the IS-136 and compressed to 8Kbps on the IS-54 [4]. The OIS-136 and IS-54 are encryption and privacy algorithms accepted in TDMA, the modulation was done using the DQPSK technique with a rate of 48.6Kpbs for digitizing the voice and the data rate limited to 14Kbps [2]. In addition, CDMA (Multiple access by code division) has evolved to GPRS and EDGE, PDC (Personal digital cell phone) and PSC 1900 (Personal communication service), improving the quality of services [5].

The CDMA (Code Division Multiple Access) IS-95A or CMDAOne, has an architecture similar to that of AMPS and uses the same frequency range and some additional elements to compose the network as the BSC (Base Station Controller) responsible for controlling a group of ERB's, the HLR (Home Location Register) and the VLR (Visitor Location Register) which in turn are databases responsible for the information of subscribers and visitors on the network, the voice signal was digitized (via vocoders) at 13Kbps or 8Kbps . In CDMA the signal is modulated in QPSK uses spectral spreading techniques, and the GPS (Global Positioning System) system uses the CDMA technique with unique codes for its correlation properties which is much higher than TDMA, in CDMAOne the maximum data rate it is still limited to the same 14Kbps of TDMA [2].

GSM (Global System for Mobile Communications) is the most widely used digital cellular technology in the world and is based on TDMA networks, as it has a low cost of infrastructure and user authentication and entry into the network is done through data recorded on a smart card. Composed of some units such as CPU and ALU Timer, I / O Port, Security and Pure Logic, RAM, ROM and EEPROM memories, the user only needs to change the SIM Card to maintain the line and subscription data without the need for reprogramming on the cell phone [5]. Thus, GSM networks were allocated in 4 frequency bands: 850MHz, 900MHz, 1800MHz and 1900MHz. For the end user, the GPRS (General Packet Radio Service) increased data transfer rates in GSM networks to speeds of around 32 Kbps to 80 Kbps [4].

2.5G - Evolution of the Second Generation

The handsets decreased, however the data became 14Kbps and the networks started to use the following systems: multiple access by time division CDMA-One evolve to CDMA-1xRtt (CDMA IS-95C or CDMA2000 1x) and networks GSM-CSD and HSCSD for GSM-GPRS and GSM-EDGE networks. The EDGE

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standard (Enhanced Data Rates for Global Evolution) known as 2.75G, quadruples the speed improvements of the GPRS standard to a theoretical throughput of 384 Kbps, allowing to achieve theoretical throughputs of 473 kbit/s, being limited to the IMT-2000 specifications. (International Mobile Telecommunications-2000) from ITU (International Telecommunications Union), this evolution introduces a new hierarchical system of cells: macro-cells, micro-cells and pico-cells [3].

In the second generation the technology offered digital services, encrypted voice services and SMS text messages (short messaging service), access to e-mail and a small access to internet resource with a data rate of 64 ~ 144 kbps, and devices with IMEI and SIM card with some storage kbits, international roaming, limited number of users and hardware capacity, frequency from 850 to 1900 mhz.

Third Generation 3G Systems

At the end of the year 2000, the use of the third generation of wireless networks for mobile devices was made when smartphones appeared, with calls and SMS's, increased data transfer, real-time video transmission, access to streaming services, contact book, appointment book, calculator, world time, ring tones, personalized, color displays, digital photo camera, theme customization, digital service technology [4].

HSPA (High Speed Packet Access) is based on two protocols: HSDPA (High-Speed Downlink Packet Access) technology, a third generation 3.5G mobile phone protocol, where the speeds can reach approximately 8 to 10 Mbits / if used W-CDMA encoding and HSUPA (High Speed Uplink Packet Access). Both work using 5 MHz carriers, but HSDPA is directed to download, while HSUPA, in addition to this aspect, also focuses on uploading. HSPA + (HSPA Evolved) and 3.75G technology is one of the updates that work with rates of up to 168 Mb / s for download and 22 Mb / s for upload and among the factors that contribute to speeds is the use of MIMO (Multiple Input Multiple Output).

CDMA-2000 1xEV (Evolution Data) is an improved version that has two classifications: CDMA-2000 1xEV-DO (Data Only), which implements data channels; and CDMA-2000 1xEV-DV (Data and Voice), which allows the use of channels for both voice and data. CDMA-2000 technologies can work with various frequency bands, such as 450 MHz, 850 MHz, 1.9 GHz and 2.1 GHz [3]; [4].

Fourth Generation 4G

The service technology marked by LTE (Long Term Evolution) technology is based on data transmission using WCDMA and GSM technology.

It is based on IP technology in which it started to prioritize data traffic over voice traffic. It features features such as the Internet access service in real time with videos and Digital TV, Streaming and high definition video games, devices with IMEI, dual SIM memory card with 100 MHz bandwidth storage Mbits, latency time decreased to 5 ms and at theoretical average rates of 1 Gbps in the case of downlink, and 0.5 Gbps in the case of uplink and speeds of 100Mbps [6]. The actual rate achieved is 200 Mbps in Brazil for uplink and the frequency range used is between 2.5-2.690 MHz.The speed aspect, the level of compatibility of devices with LTE is determined in categories:

Category 1: download up to 10 Mb / s; upload up to 5 Mb / s; Category 2: download up to 50 Mb / s; upload up to 25 Mb / s; Category 3: download up to 100 Mb / s; upload up to 50 Mb / s; Category 4: download up to 150 Mb / s; upload up to 50 Mb / s; Category 5: download up to 300 Mb / s; upload up to 75 Mb / s.

While UMTS (Universal Mobile Telecommunications Service) and HSPA technologies are based on the W-CDMA standard, LTE uses the OFDMA (Orthogonal Frequency Division Multiple Access) specifications, which distributes transmission information among several parallel subsets of carriers favoring higher speeds for the downlink (download). Regarding uplink (upload), the scheme used is the SC-FDMA (Single Carrier Frequency Division Multiple Access), this manages to reduce the power and energy consumption by the devices [4]. The WMAN (Wireless Metropolitan Area Network), and IEEE 802.16 standards, the WiMAX (Worldwide Interoperability for Microwave Access), which provides for compatibility and interoperability between equipment based on the IEEE 802.16 standard compatible with Linux systems and IEEE 802.20, Mobile-Fi. The great similarity of the different 4G technologies is the use of the OFDM (Orthogonal Frequency Division Multiplexing) modulation technique [7].

Fifth Generation 5G

In 2015 the study of the 5G generation began, based on improvements to the LTE-M and NB-IoT, promising to improve three important characteristics: coverage, device density and battery life. The improvement of the architecture together with the advanced physical communication technology, such as high-order multiplexing and multi-input spatial

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multiplexing (MIMO), will provide greater simultaneous access capacity with intelligent and heterogeneous connection transmission accessed by a large number of devices wireless.

Technically, the 5G will introduce new elements like 5Gcore (5GC), and a new radio access technology called 5G New Radio (NR) is also expected to meet the requirements of IMT-2020. [7] describes the ITU-R and provides more advanced features compared to 4G LTE (IMT-Advanced) [8]. Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiplexing (OFDM), Operator Code Division Multiple Access (MCCDMA), Ultra WideBand (UWB), Local Multipoint Distribution Service (LMDS) and IPv6 network integrated and supported with each other, huge data capabilities, unlimited call volumes and infinite data will bring the world the opportunity for uninterrupted access to universal information, allowing consumers to enjoy high-speed streaming to devices in residential environments and for services collaboration between companies evolve [9]; [10].

This is how it should be understood: **Core Net Work,** the central element of the mobile communication system and its main activities is circuit switching, packet switching, charging, signaling with other networks and a database [11]. In the last generations of the mobile phone system, the (Home Location Register) and AUC (Autenthication Center) were introduced in the system with mechanisms for storing, identifying and authenticating users; **RAN** (Radio Access Network), aerial interface whose functions are: transmission and reception, channel coding and allocation, error correction and detection, power control, handover control, signal encryption, in addition to other functions; The **UE** (user equipment), set of the mobile terminal and its subscriber identifier USIM (Universal Subscriber Identity Module) [12]; [13].

In terms of physical characteristics, the spectrum can be divided into three frequency bands: up to 1GHz, up to 6GHze above 6GHz. The technical requirements established by ITU to IMT-2020, specify that telephone operators need at least 100 MHz of band and for frequencies above 6 GHz, the requirement is up to 1 GHz of band per operator [8]; [14].

Beamforming techniques can be used both at the transmitter and at the receiver, in order to increase the signal-to-noise ratio (SNR) and / or the margin of the communication budget link to compensate for losses in the mobile radio environment [13].

Every decade, a new generation of mobile services has emerged, with very different bandwidth and conditions for the use of the radio spectrum, leading to possible needs for periodic reorganization of the available radio frequency bands (spectrum refarming). Brazil takes another step towards the deployment of 5G in a faster way for population access, and the certification requirements for 5G equipment were built based on international standards. With the publication of these requirements, the equipment industries are preparing to submit the first requests for approval of 5G equipment with Anatel [9]; [15].

IV. CONCLUSION

The telephone networks since its emergence, has undergone many transformations in telecommunication, and with these changes new technologies have emerged, that enabled communication between mobile devices with high performance even in places of difficult access. The analog signal became digital, the telephony device that previously had a fixed location, became a mobile device, with internal storage capacity, and now has access to the internet through wireless technology.

The 5G Technology is not a new technology, despite the name, but the unification of two previous generations the 3G and the 4G, in addition to an improvement in devices such as antennas for the distribution of signals, so that there is no loss or interruption of the signal. There is an expectation around this technology, the 5G is not only a necessity, but also a big bet on the future in addition to connecting our phones or computers, the internet of things (IoT) aspires to hyperconnectivity, the ability to simultaneously connect our homes (domotics), cars, watches and cities to the network.

In order to process, analyze and take advantage of the amount of data that this would support, constant stability is required. The 4G cannot guarantee these multiple connections, so it is necessary to implement the 5G.

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