Applications for 5G Networks

Gabriel Edmilson Pinto[1]
Renata Lopes Rosa[1]
Demostenes Zegarra Rodriguez[1]

UFLA - Universidade Federal de Lavras
DCC - Departmento de Ciência da Computação
P.O. Box 3037 - Campus da UFLA 37200-000 - Lavras (MG)- Brazil
[1](gabriel.edmilson, renata.rosa, demostenes.zegarra)@ufla.br

Abstract. The communication media has undergone major technological advances in recent decades, from telegraph services to the internet of things. These rapid changes have impacted the routine of humanity and its way of seeing the world in an impactful way. Currently, we are entering the fifth generation (5G) of mobile telephony, whose architecture promises extensive exchanges of messages in a short period of time, which was still difficult to obtain in the networks of the previous generation. Given this new technology, this work proposes to investigate its impacts and possible advances in the area of ââInternet of Things, an emerging technology that extends mobile networks to so-called smart objects.

Keywords: 5G, Orchestration, ââInternet of Things, mobile telephony.

(Received May 19th, 2021 / Accepted June 1st, 2021)

1 Introduction

Since the appearance of the first cell phones, society has never been the same in terms of communication needs. Initially, the objective was to meet the demands of telephony in a mobile way, since until then it only existed through landlines, as well as offering messaging services (SMS) that the old technology did not allow. This need for more means of establishing communications forced the Telecommunications sector to provide new structures that would support the huge amount of bits trafficked daily by the networks [29].

Four important characteristics, according to mousa2012prospective5G, differ between cell generations: radio access, data rates, bandwidth and switching technologies rodriguez2012quality,rodriguez2016video. The first generation of cellular systems, known as 1G, was predominantly analog. Its bandwidth was in the range of 10 to 30 KHz, according to the type and service of the system. The data rates offered were around 10 Kbps after the analog to digital conversion. Radio access was FDMA (*Frequency Division Multiple Access*) and switching was by circuit, suitable for voice services. The second generation (2G) started with a data rate of up to 9.6 Kbps and ended up reaching a rate of more than 300 Kbps with a bandwidth of 200 KHz, in addition to using packet switching where radio access passed to be the *Time Division Multiple Access* (TDMA) / FDMA.

The third generation (3G) systems started with a data rate of 2 Mbps that extended to approximately 50 Mbps in the last phases with a bandwidth of 5 MHz and its switching started to be exclusively through packets in the so called 3.5G. The fourth generation (4G) had peak data rates starting at 100 Mbps up to 1 Gbps [15]. In addition to cellular systems, current wireless technologies include wireless local area networks (WLAN) and wireless metropolitan networks (WMAN). In addition to new technologies [7, 24, 25, 3, 23, 22, 1, 2, 16, 21, 13] that have emerged with great impact, such as the Internet of Things (IoT).

The arrival of the fifth generation (5G) of mobile telephony aims to make an increasingly efficient data connection, being structured to support the increasing demands for wireless communication [5, 17, 8, 28, 32, 14, 20, 19, 18]. According to [31], the fifth generation is " a new network that aims to provide interoperability between standards and devices, with requirements that include, in addition to high transmission rates, low latency, high reliability and information security ' '. In order to fulfill all these established premises, the network must first undergo a structural transformation, drastically changing the current mobile internet architecture.

Several recent works have been focused on orchestration in 5G. In [33], a work is presented that is part of the European project 5GPPP 5g-EVE. This project involves validating the platform for extensive attempts, aiming to implement and test advanced 5G infrastructures in Europe. 5G-EVE has a particular focus on the development and interconnection of existing sites in France, Greece, Spain and Italy in order to form a single end-to-end 5G installation. The final system was based on multiple open source software such as ONAP, OAI, Docker and Kubernetes.

The 5G network provides massive support not only for current smartphones, but also for IoT devices. An NFVO platform with broad VNF support (*Virtualized Network Function*) is proposed by [26]. The authors implemented 4G LTE Evolved Packet Core (EPC) and 5G CN virtualization using the *OpenAirInterface* (OAI-CN) software, with a focus on microservice-oriented orchestration using Docker Swarm.

5G orchestration has become one of the most important aspects of today's mobile network services. In fact, 5G networks need orchestration procedures to integrate many heterogeneous paradigms and resource types, including NFV, SDN, Multi-access Computing / Mobile Edge, among others. In the field of NSs (Networking Slices), [4] made an important contribution. The authors presented an orchestration platform based on multi-domain standards capable of dealing with challenges required by vertically oriented 5G services. Following the path of NSs, a significant contribution is made by [11] with regard to improving the performance of these networks from the perspective of 5G orchestration. The authors suggested a solution in which a multi-tier orchestration layer with inter-orchestral coordination intelligence mediates the triggering of NFV, MEC (*Multi-access Edge Computing*) and native cloud.

As one of the main objectives expected with the establishment of 5G networks, the need to provision end-to-end services has made new orchestration mechanisms profitable and urgent. Thus, it was proposed by [6] a market oriented in which SPs and INPs interact to exchange and orchestrate resources, keeping in mind the strict QoS requirements. Thus, it is possible to infer how important orchestration in 5G networks is, considering the wide range of solutions that this technology will bring.

The internet of things aims to automate the daily activities of the human being and can contemplate any environment, such as home, work and leisure spaces. Increasingly, data traffic between mobile devices and collection points (such as servers) has increased to drastic levels. The purpose of this article is to show how the internet of things will be positively impacted with the fifth generation of mobile networks.

2 Related Works

The fifth generation of mobile networks not only promises a considerable increase in traditional bandwidth and updating its use cases, but also promotes new perspectives on emerging technologies, such as the internet of things. Focusing on critical latency IoT applications, [27] discuss structuring challenges and propose solutions for radio interfaces and network architecture, as well as new opportunities leveraged with the arrival of 5G.

Many works have indicated the need for the internet of things to move forward in a more autonomous, scalable, connected and with more independent local infrastructures. A contribution in this context is made by [9] where they defined the current possibilities of developing IoT services for the network, defining and collecting requirements for a reliable combination of IoT and 5G technologies that allow to explore the best of both . The authors point out that 5G ECA (Edge Computing Architecture) responds to the needs of IoT networks for fast and reliable communications with less *overhead*. This facilitates *offloading* computations by reducing minimum link costs and allows for better management of the infrastructure as a whole, adding decentralization that reduces the need to communicate with *Data Centers*.

The applications covered by the Internet of Things are widely variable. From small physiological measurement devices to large surveillance applications. Among these applications, we can highlight those of an industrial nature. According to [30], the biggest challenges about 5G support for industrial applications involving IoT can be grouped into the following categories: prove that quality of service (QoS) metrics match real life requirements such as latency, jitter, loss, *throughput*, availability and reliability; interoperability of network elements and segments; security and reliability requirements; scalability; providing effective solutions for communication between devices, not only between devices and the cloud; exploiting the capacity of *Multi-access Edge Computation* (MEC); efficient and economical solutions for virtuation of network functions (NFV) and software defined networks (SDN); large-scale maintenance and operations for networks and *end-points*; rapid standardizations; explore artificial intelligence technologies in solving problems and implementing private networks.

[12] carried out a systematic review in relation to the integration of *blockchain* (structure of storage of transactional recordings in various databases) with IoT devices aimed at industrial applications. The authors raised the following applications from *blockchain* for IoT with 5G enabled: Smart homes and cities; health care; industry 4.0; supply chain; agriculture; autonomous vehicles; unmanned aerial vehicles and multimedia and digital rights management. The discussion was divided as follows: first, the *background* of *blockchain*, IoT and 5G followed briefly with respective industrial applications; after that, problems and challenges were covered with a focus on industrial applications. These challenges consist of resource constraints on networks where IoT devices have their battery-based power (which is a resource limiter), high device growth, lack of standardization, 5G compatibility, low adoption rate in industries, policies internal data security and low storage capacity.

The problems reported by [12] are also cited in the work of [10] where the impacts of 5G-of-things (IoT with 5G enabled technology) on physical education are discussed. The authors present a game of " any sport of things ". Sensing devices are used with communication and cloud computing techniques. The objective was to evaluate the performance of students from kindergarten and high schools, in order to prevent accidents and injuries related to sports such as football. It was concluded that the energy resources of the sensors and the security of the network is still a major challenge for IoT applications, and its scenario should only become more critical with the arrival of 5G due to issues related to the more intensive use of these devices. .

The purpose of IoT applications is to generate products with an immediate impact on human life. IoT service providers have been working on vMEC (*Virtualized Multi-access Edge Computing*), where computing, storage and network resources are integrated and hosted at the edge of the network. Together with SDN and NFC, vMEC plays a very important role in bringing about a reduction in latency, an increase in bandwidth and the availability of trillions of devices around the world. It was proposed by HSIEH201894 a study with the architectural standard vMEC in order to establish network management with NFV platform for the demands of 5G. Open source software was used to build the virtualization platform.

The security and reliability of IoT applications in the context of 5G is part of the great challenges of IoT with the advancement of global demands for this technology. A review of the recent literature on network layer security in 5G IoT systems, including future challenges, was carried out by saleem2020bio. The authors came to the conclusion that bio-inspired techniques are more promising in raising 5G challenges linked to IoT. Among the techniques analyzed, the following stand out: bee colony, automated ant colony, artificial immunity systems, neural networks and swarm intelligence.

When analyzing the works present in the literature involving internet of things in the scenario of the fifth generation of mobile networks (5G), one can observe high expectations in relation to new technological concepts and activities that can be developed. However, it is also necessary to stick to the challenges present at the arrival of the fifth generation, as IoT devices are still very limited in relation to their energy storage and control resources.

3 Methodology

For many years, it has been possible to observe the beneficial effects of physical activity on a person's quality of life. Since the days of ancient civilizations, mainly Eastern, there have been records of the prescription of physical activities for the treatment and prevention of various diseases.

With the arrival of 5G, the improvement in bandwidth, connectivity and security in data transmission will enable the birth of several technologies capable of exploiting its resources to leverage methods capable of better conditions such as health. In the context of the internet of things, the increasingly frequent use of intelligent objects in the daily life of humanity indicates an auspicious fusion for the new generation.

The work proposed by lei20215g is based on the incentive to improve the practice of physical education, with a focus on elementary and high schools for having adolescents as a target audience. The project had an architecture with the objective of uniting the areas of sports and games within physical education to be explored by the 5G network based on internet of things for analyzing the performance of the simulated results.

The system would identify the athlete by means of radio frequency using RFID equipment, and orchestrate his measures based on attack movements, that is, the system works during a football game that requires at least two teams involved, which limits the range of these resources.

First, let us disregard the limit of resources to be used only in times of dispute - team competition - and also consider individual activities. With the new generation of telecommunication, several objects can come to be endowed with sensory intelligence. Therefore, maintaining the objective of promoting better quality of physical education in elementary and high schools, several objects could be sensed to act in conjunction with the sensing proposed by the work of [10], such as: strings capable of identifying turns complete - or partially complete -, step measurement in conjunction with heart rate analysis for walking and running, smart courts capable of identifying sports scores, smart markings for use in aerobic circuits, among others.

Taking advantage of the connectivity of things and the evolution of bandwidth to be provided by 5G, it is possible to explore in greater depth features *wearables* such as bracelets and smart watches. Installing an integrated circuit to a bracelet on the student's dominant arm, where radio frequency technologies (such as RFID) and acceleration, impact and heart rate sensors (such as MPU-6050, SW-420 and 4MD69 respectively), it is possible to build sports scenarios and aerobic activities from an internet of things perspective.

3.1 Sports Scenery

Generally, physical education classes in elementary and high schools are taught in multisport courts focused on, but not limited to, sports with the use of the ball, which gives the suffix " bol " to: football, handball, volleyball and basketball . We will focus on volleyball as an extension to the work of [10] that focused on football matches.

A volleyball match is made up of two teams of six players each facing each other on a court, without contact. The teams are separated by a net in the center of the court. Thus, upon entering the court, the coach user (responsible for the class and the game to be started) must indicate to the system the format of the teams identifying the ID of each bracelet. The bracelets are activated and begin to communicate with the starter system.

The game begins with one of the teams that must serve at the end of their side of the court that is furthest from the net. The serve consists of an impact movement on the ball (suitable for the sport) with the objective of crossing the net and not exceeding the other end of the court on the opponent's side. The opposing team must intercept the ball without it touching the ground. For this, some players play the role of lifters, who lift the ball so that the attacking players can attack making the ball pass the net always aiming to hit the ground on the opponent's side, thus scoring a score. Three touches are allowed on the ball, without being consecutive by the same player. To prevent the ball from hitting the ground during an attack, the opposing team must perform a defense known as a block, which sets up a defensive front with the arms so that the ball returns against the attacking team. In summary, for this work we will focus on the moments of impact: serve, block, lift and attack.

In theory, the impacted bracelets will be communicating to the system that the ball is on their side of the field. And so they can indicate whether the number of rings allowed has been made. And, by grading the impact with the ball, they can indicate what type of movement was performed. With regard to the level of impact identified by the sensors, the lowest impact indicates lifting, followed by blocking and attack / serve. The attack and the serve are very similar in terms of impact, so the system should use analysis of the movement of the game to identify when each occurred. For example, if recent touch movements (blocking and lifting) within a team have not been identified, then it appears that a greater impact is justified as a service, if not an attack.

The team that serves, with the exception of the first serve, is the one that scored last. Therefore, it is possible to maintain an automatic score with the scores based on the side that is making the withdrawal when the score is not null ($0\ times 0$). An internal wi-fi network can be used for communication. Thus, 12 nodes (players with smart bracelets) are arranged on the court, 6 on each side, in a configuration where three are closer to the network and 3 are further apart, and a S management device is responsible for receiving and analyzing the information. sensor reading.

Automation of the match does not replace the presence of the referee, as several sports faults cannot be identified in this way. At the end of the game, various information can be printed in a detailed report, such as: number of serves, blocks, withdrawals, attacks and contribution and performance of each player.

3.2 Aerobic Scenery

Unlike the sports scenario that evaluates the sensing of several points at the same time from a very similar perspective, the aerobic scenario focuses on an individual perspective, even if several users are active. This is because each user is only competing with himself, so the identification of another user interacting with him does not exist.

In this scenario, objects such as strings and points marked in a space act by identifying the user and storing information about him. For the rope, for example, the grip at each end of the rope can be sensed to identify loops that represent given jumps. Only one user can be using this goal at a time, not causing identification conflicts. For points on a track, it is possible to identify who is passing through it and thus defining the elapsed time to cover a route.

As in the sports scenario, the aerobic / individual scenario must connect to a database so that analyzes can be made and reports issued to verify student performance. An internal wi-fi network, enhanced by the 5G architecture will be fully capable of carrying out these readings.

3.3 Conclusions

The applications covered by the Internet of Things are widely variable and they are been explored more and more actually. Thus, this paper explored the sports scenarios, showing the different scenarios , such as the aerobic scenario. In future works, we pretend explore other scenarios, enhancing the 5G existing architecture.

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