Application and impact of 5G networks in industrial environments

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Abstract. 5G figures today as one of the newest technologies that promises to further accelerate the information flow on the network. Its application is not limited to mobile telephony, but has also been adding value in the most diverse segments such as industry, medicine, agribusiness, logistics and even in war environments. Its most diverse possibilities also bring with it some prerequisites for installation, as well as development needs in the area of information security to guarantee the sustainability of its operation. Applied to industrial environments, 5G is able to bring benefits in the safety of people and equipment, optimization of workflows, prediction of failures in production chains, among other possibilities. This article sets out to understand, through a systematic mapping of the literature, the facts that preceded its creation, the minimum requirements for its operation, as well as the impacts and demands on the industrial environment with its application in production chains in general.

Keywords: 5G, Industrial, Communication Networks.

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1 Introduction

The 5th generation telecommunications networks, or popularly 5G [4, 19, 18], are presented as one of the most recent efforts of technology companies in the search for ever faster and more stable means of communication [7, 17]. With the popularization of this tool, large centers in Brazil and around the world already have the infrastructure installed to provide mobile phone users with the benefits of a much better connection than what was previously offered [15]. As a result, this new telecommunications scenario served as a framework for the development of new solutions applied not only to mobile telephony, but to various environments that require a high flow of information with low latency, such as agriculture, industry, medicine, logistics, mining, among other areas [16, 20, 12, 26]. The present work intends to carry out a systematic review of the literature regarding the use of 5G in an industrial automation and instrumentation environment, evaluating requirements, applications, among other aspects related to the use of this tool in the manufacturing environment. Once wired, communication networks in industrial environments were difficult to implement, due to the infrastructure needed to interconnect the points. At short distances, for example, the risk of electromagnetic interference in the physical environment of the network required the setting up of separate infrastructure for the network, or even the use of shielded cables, which are more expensive, to mitigate possible disturbances. As for equipment located at great distances, it was necessary to use fiber optics to take the network to the desired point, which further increased the cost of the project. For mobile or even more remote machines, the use of radio frequency devices brought with it the interference inherent to the technology, with signal failures, pointing problems, physical barriers, etc. An example of a mobile application can be seen in the

company[28]. With the aim of improving its operational indicators of energy efficiency, particulate generation, work safety, productivity and equipment maintenance, the company Vale has been implementing autonomous trucks and drills in its operations that since 2019 have been operating without accidents. To this end, hundreds of sensors monitor vehicle parameters and their surroundings to ensure total operational safety, a very high volume of data to be processed and evaluated at all times. To ensure the correct flow of data, [13] showed that TelefÃ´nica (Vivo) signed a supply contract with Vale for the provision of the 5G private network, enabling the operations of the self-employed and contributing to the operational and financial gains associated with them. Another example of an application dependent on wide network coverage is in the new programs associated with Integrated Business Management Systems (ERP). In this sense, [23] offers a maintenance system that integrates with SAP ERP, promising agility in asset management. With the implementation of a mobile application, the company promises to connect to the SAP system, bringing in real time the necessary maintenance information and reducing the necessary interventions in equipment, saving money, paper, as well as increasing the efficiency of the teams. As it is a mobile device application, the need for a network connection is inherent for the tool to work in real time. In this sense, a private 5G network is again an option for information from the shop floor to reach maintenance planning, operation, production and other sectors of a company more quickly. Still, the company [27] offers online asset monitoring solutions with the aim of improving equipment availability. With the installation of a simple device in motors, reducers or even compressor elements, the vibration and temperature monitoring hardware sends real-time alerts about adverse conditions that occur, helping to prevent and predict failures and enabling better scheduling of maintenance. Furthermore, it also offers online power quality monitoring solutions, as well as its own ERP system for maintenance management. As it is a company focused on online monitoring solutions, its devices need to be connected to a network to extract their maximum utilization capacity, being able to use networks via cables, wifi, mobile telephony, etc. Again, companies have used private 5G networks in order to increase the coverage area and connect all devices, bringing to maintenance analysts all the wealth of information offered by monitoring. In this way, the present work aims to evaluate the 5G technology applied to industrial environments as an enabler of the most diverse solutions found in the market in the areas of asset monitoring, maintenance management, autonomous vehicles and equipment and also remote operation of machines. In this way, network applications, efficiency tests and also security requirements will be evaluated that can guarantee the functioning of the network within the expected standards.

2 Methodology

This work is characterized by a literature review research aimed at investigating the application of 5G in an industrial environment. Thus, articles were mapped that deal with the presentation of opportunities for applying this technology in industry, types of associated devices, evaluation methodologies and validation of its use, as well as the impacts of this use. In addition, some articles from other applications (outside the industry) were listed, whose differential for the application of 5G was also the ability to transmit a large amount of data with high availability, extracting from this new applications for the business chain, in order to compare with the advantages obtained in the industry. For this, a bibliographical survey of articles was carried out through the platforms Google Scholar, Elsevier and IEEEXPLORE, the last two having access intermediated by the CAFe UFLA platform. For the 3 research bases, the search term used was industrial 5G, from which articles were extracted that in their title and abstract demonstrated that the interaction of 5G with industrial networks was evaluated, such as case studies, performance evaluations of the network, in parallel with industry 4.0 and also with the feasibility of using IoT devices. For the articles that met the above criteria, an exploratory reading was carried out in order to support the theoretical studies carried out here. At that time, articles were excluded that, although evaluating 5G in the industry, had a greater focus on constructive aspects of the network, such as topologies, manufacturers, etc. It appears that this design stage is important in the application of 5G, but it depends on constructive aspects that are particular to each type of industrial segment. For example, in a fabric or cement factory, the same IoT devices can be used to monitor electric motors, but the 5G network will be completely different due to interference with civil infrastructure, coverage area, etc. would add to the assessment of the applicability of 5G in the manufacturing environment. After reading and interpreting the selected articles, a discussion was held on the material collected, covering the applications presented in this database, as well as drawing some parallels with other business segments such as logistics and medicine. Also, some additional aspects to the pure interpretation of technology were considered, such as impacts on work safety, technical detailing and

optimization of bureaucratic routines in the manufacturing environment.

3 Related works

Before discussing topics related to 5G in an industrial environment, it is necessary to understand the origin of this demand. In this sense, [8] developed a retrospective of the process of technological evolution of the industry, starting from the first optimizations carried out in car assemblers with the intention of obtaining leaner production, in less time and with higher quality. Going through the digitization of these processes, the generation of information about each stage of the production chain begins. With computerization, the need arises to connect all the data generated in order to transform them into useful information, which already makes clear the need for a network that interconnects all the bases within an industrial process for better data processing. Still, it remains to be noted that this information is not only added manually, but mostly today comes from sensors that automatically measure variables of interest for later interpretation. Still talking about the digitization of processes, [14] characterize this movement of computerization of production systems as the 4th industrial revolution, or industry 4.0, whose greatest demand is the connection of people, equipment and products in all phases of a process. productive process. Thus, in their work, the authors discuss possibilities of integration between 5G and the industrial ethernet network, wired or not, placing these two topologies as complementary and not exclusive in an industrial automation scenario. With regard to the application of communication technologies in a factory environment, [21] point out that industrial automation requires stable channels for its proper functioning, with low latency and high reliability in connections, which was usually only possible in wired infrastructure . However, they demonstrated that the new WiFi 6 and 5G technologies are fully capable of meeting these criteria and carried out an evaluation study of the application of these technologies during the engineering phase of new projects, comparing private 5G networks with the ethernet networks widely used in the environment. industrial. Continuing with regard to the evaluation of 5G networks, [1] demonstrated that a reliability of 99.95For a better analysis of the performance of industrial 5G networks, [3] chose real scenarios for the application of this technology in an industrial environment, namely: massive networks of wireless sensors, autonomous robots and augmented reality. In their studies, they managed to demonstrate that the 5G network fulfilled all the requirements for application in the industrial environment in these cases, in addition to bringing another theme to enrich the present analysis, the applications of Internet-of-things (IoT) devices in the industrial environment (IIoT). In the application scenario of IoT and 5G in industry, [11] demonstrated that 5th generation telecommunications networks are still in a very primitive stage of use. However, they developed their work in order to evaluate the interactions of IoT devices and technologies enabled by industrial 5G with humans present in production processes. In this sense, it became clear that it is necessary to understand humans as fundamental factors in the process of computerization of industrial processes, in the sense that applied technology will not replace them, but complement their activities. Thus, the example of remote operation of equipment and activities that offer the possibility of accidents was addressed, using technology so that human beings are not exposed to high-risk activities, acting remotely in solving tasks. Another scenario was the use of augmented reality to aid in solving activities, replacing the need to consult drawings or manuals, as well as enabling remote connection with specialists in the application area, bringing more security and effectiveness in the execution of maintenance activities, for example. Bringing another example of remote operation of equipment, [30] structured an operation scenario via 5G network of a manipulator with a pen at its tip. With the success of their experiments, it is possible to draw a parallel to the most varied applications of remote operation, such as the high-risk activities mentioned above, operation of trucks in mining companies, or also in surgeries performed remotely, as evaluated by [25] in his work. Also, [10] discussed potential applications of 5G in the logistics area, with its related requirements and challenges. Although this case is from a different area than the industrial one, the evaluation of this work was able to demonstrate that in logistics, 5G also acts as an enabler of IoT applications, artificial intelligence, among other tools that, if applied, are capable of bringing to the logistics such optimization that they can bring to the industrial environment evaluated here. In all the application scenarios evaluated here, the connectivity provided by 5G brings numerous benefits in optimizing the most varied industrial processes and also in other areas such as logistics and medicine. In this sense, the need to provide, along with connectivity, access security barriers to ensure the necessary protection for the systems comes to the fore. In the study of protocols and requirements for the defense of industrial networks with 5G applied, [24] demonstrated that the correct choice of the authentication protocol for IIoT devices is a key element for the correct and secure operation of the sys-

tem as a whole, and analyzed 3 authentication mechanisms in their own application. Finally, in the scenario of protection of communication networks with 5G, [29] evaluated that the information generated in the industrial process, however diverse they may be, will enter the network through some type of terminal, and it is necessary to ensure that access to them is controlled to ensure security on the network. In addition, this information needs to travel on the network in a massive and secure way, without impairing performance. Furthermore, it is necessary to guarantee a certain level of immunity to unforeseen disasters, a scenario in which the network needs to migrate information depending on the damage that occurs. From the analysis of network protection tools, [22] even addressed the application of machine learning and deep learning algorithms to ensure the necessary security in networks with IIoT. [9] studied a fuzzy-based protection algorithm. In addition to recalling several known cases of malicious attacks on industrial plants and their impacts, the authors demonstrated that a good protection system must have access control layers, intrusion detection and also a good event log for later evaluations.

4 Results

After extensive reading of studies related to the application of 5G in industrial environments, it was possible to verify that its possibilities are closely linked to the concepts of industry 4.0, bringing connectivity and speed in the flow of information from all stages of industrial production processes. It is imperative that the optimization of industrial flows has had several stages since its advent in the automotive industry in the last century, and many of these stages were related to purely organizational aspects linked to inventory management, time, demand and quality requirements. However, as the organizational measures were applied and concluded, the need arose to digitize processes, which has been carried out in recent years following the technological evolution of control, communication, data collection and storage systems. As processes become digital, the need for more connectivity then arises, which had its beginnings based on wired infrastructures until a technology emerged capable of maintaining minimum latency and speed requirements even wirelessly. In this scenario, communication networks have been evolving day after day to provide increasingly robust and stable links, culminating in the 5G network that is the focus of this study. The great advantage lies in offering the security and stability benefits of wired networks without the need to install large cabling structures, routing, etc., simplifying the deployment of these networks. Also, the possibility of wirelessly connecting processes has also been fostering the development of new devices based on IoT, which generate more data that, after being processed, become managerial and strategic information to be used in decisions related to the industrial production system. These applications often act in monitoring assets, bringing more predictability to industrial operations with the prediction of failures, etc. Furthermore, they enable safer ways of operation, ensuring greater occupational health and safety for an organization's employees. As a result, industrial 5G networks, in addition to connecting existing devices in processes, are also being used to connect more intelligent sensors, cameras, telemetry and surveillance devices, among other equipment that put to the test the large data transmission capacity. these communication networks. With this vast universe of applications, it is clear that 5G was not restricted to industrial environments, being also expanded to applications in agriculture, medicine, military systems, logistics, among other different possibilities of use, offering the same attributes found in the manufacturing environment to also bring value to other segments [5, 2, 6]. Finally, for any applications where communication networks are used, 5G or not, it is clear that security must be a fundamental factor to ensure full operation of any system associated with them. This is due to the fact that basically everyone is connected, and any vulnerability in the system can be a gateway to malicious intrusions capable of causing losses, delays or even damage to the most varied equipment and associated production processes. In this way, minimum requirements and security protocols are established that must be faithfully followed to ensure adequate protection for an organization's internal and external communication networks.

5 Conclusion

From the evaluation of all the material above, it appears that 5G communication networks are not the silver bullet to obtain gains in an industrial process. In fact, 5G acts as an enabling technology to enable the connection of the most diverse data sources in order to generate useful information for analysis and decision making. Still, it is not enough to deploy a robust communication network to connect various parts of a process if each of them is not minimally optimized, since digitizing and connecting an inefficient process will only make it inefficient faster. Therefore, after adopting organizational and managerial measures that make processes reasonably optimized, the implementation of a 5G network in an industrial process brings greater possibilities for gains in the organizational, security, and oper-

ational sustainability areas, among others that together guarantee the follow-up and evolution of the industry in the most varied segments. This scenario includes IoT devices, which bring more and more resources with small investments, adding more information in this industrial chain, supporting decision-making and also improving the predictability of industrial flows. In addition, the process of implementing 5G or any other type of network in an industrial process must follow the strictest information security standards, since connectivity brings its benefits, but if poorly implemented, it can bring critical vulnerabilities for any type of network. of organization. Therefore, it is extremely important that this process be conducted by specialized personnel and guided by strict governance that guarantees the sustainability of the systems without harming the operations of the industry in which it is applied.

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