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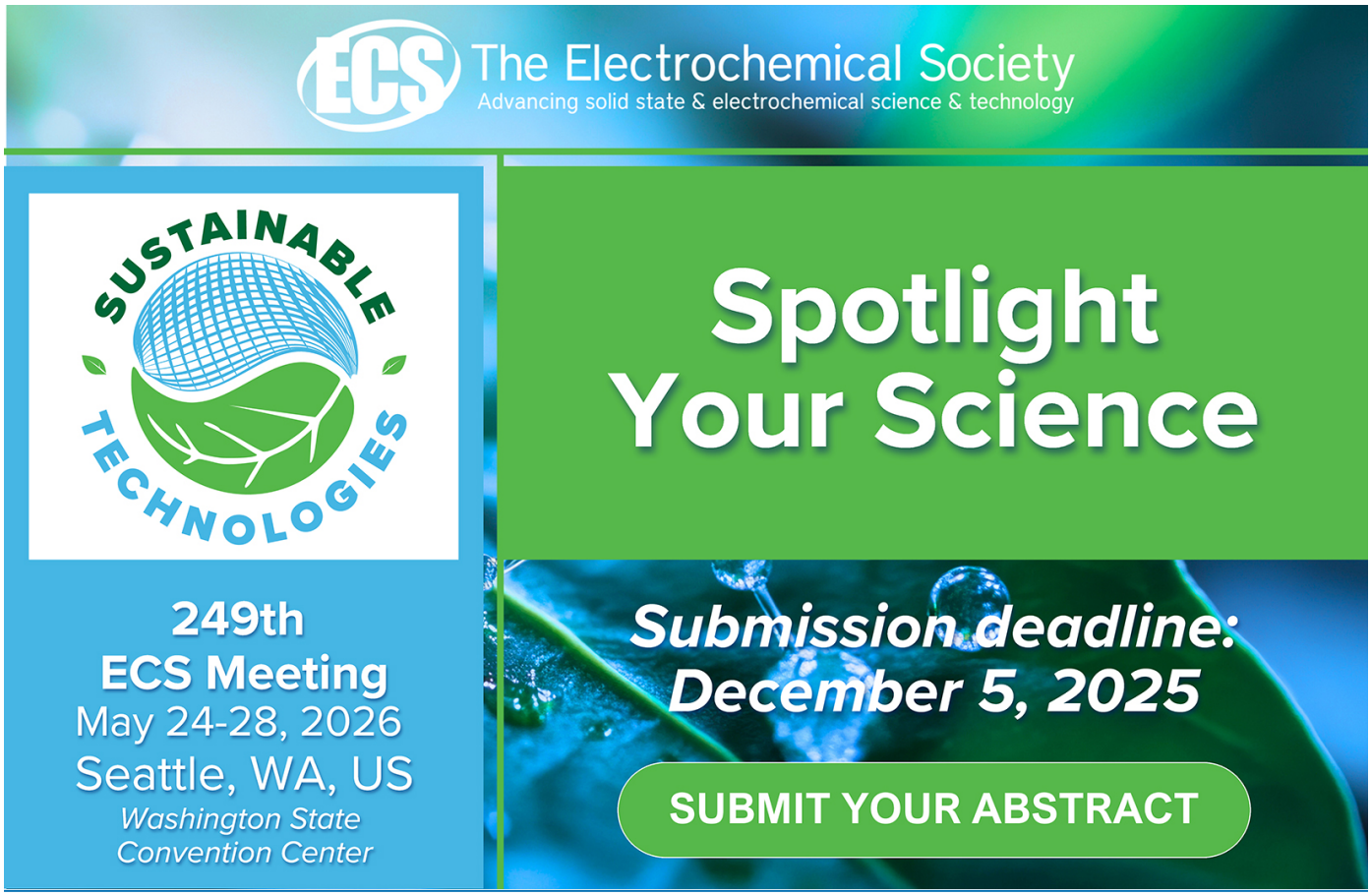
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Design of a metropolitan network based on fiber optic and wireless links to support COVID-19 monitoring

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Abstract. This article aims to design a metropolitan network based on fiber optic and wireless links to support the monitoring of COVID-19. Its main function is to support the monitoring and control of the COVID-19, through intelligent technologies of both software and hardware needed to obtain data in real-time, which facilitates decision making. There is currently no platform that allows real-time communication between the entities involved. This first phase was developed through a description of the integration of these bodies through the infrastructure of the Universidad Francisco de Paula Santander, Ocaña, Colombia. Among the results obtained, it is noted that the 28 GHz subcarrier can cross the 25 km fiber link without any problem and the physical topology of the Metropolitan network is designed, which integrates both wireless and wired technology, including their properties and physical, mechanical, and electrical characteristics more representative as distances, speeds, interfaces, coding, and signaling.

1. Introduction

Competitiveness, digital transformation, globalization, and the adoption of intelligent technology generate fundamental challenges in organizations such as universities and industries in the area of telecommunications worldwide. The solutions generated involve low energy consumption and infrastructure costs. A useful physical layer with limited flexibility and high cost is the common perception in such solutions is optical networks that support the transport of large volumes of data between two endpoints. Now, as a solution to the high costs and energy consumption, a new generation of optical components is presented. Everything, in the end, benefits the optical layer, where such solutions are based on integrated photonics, ensuring a higher level of flexibility, providing more freedom in the transport layer, simplifying the migration of the upper layers, allowing the overlapping of different layers in a single infrastructure and allowing the use of a single infrastructure in a fixed/mobile convergence scenario. According to [1-4], millimeter-wave bands are to be considered in modern environments, see Figure 1.

As part of the solution, the infrastructure must be faster, with greater data transport capacity, a wide range of service features, and, above all, transport services. This evolution involves the functional division and placement of the radio access network (RAN) functionality, which in the end will have a greater impact on the required transport services, higher bandwidth, latency, jitter, and deployment architectures [5-7]. In contrast, the available transport capacities and infrastructures may in turn restrict

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the possible alternatives for RAN deployment and radio interference coordination opportunities. For this reason, transport plays an important role in the deployment of 5G radio access networks.

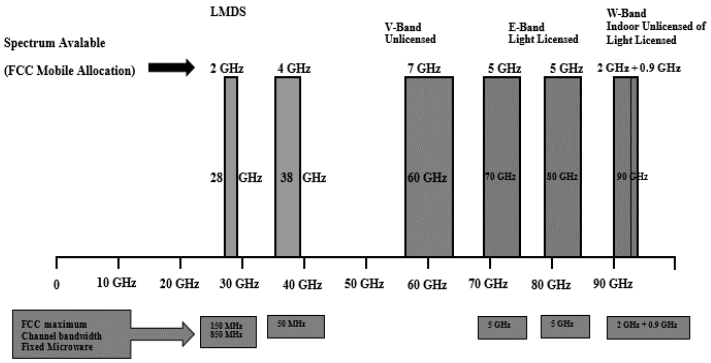


Figure 1. Spectrum for 5G in mmw. Adapted from [8].

As COVID-19 continues to spread, communities at large must not only take steps to prevent transmission, reduce the impact of the outbreak and take control measures [9,10] but must also monitor and track the incidence of COVID-19. The health crisis saturates medical centers or hospitals, the Internet of Things helps to reduce the crowding of these centers, there is the possibility for example that a patient can take the temperature and upload the data to the cloud using your mobile device, track the origin of an outbreak and dissect its spread, or ensure compliance with quarantine, the use of infrared thermometers connected, makes it possible to monitor patients [11]. Applications of artificial intelligence are also being used to combat Covid-19, both to help diagnose the disease and to accelerate the development of a vaccine. In China, robots are used in hospitals and hotels to deliver food to rooms occupied by people in treatment and quarantine [12]. Drones are used to transport medical specimens and take thermal images. Increasing capacity and coverage [13], can be achieved not only through continuous radio site densification but also through the introduction of technologies such as multiple-input multiple-output (MIMO).

The COVID-19 affected the majority of the company, which had repercussions in the creation of new strategies in the work environment, one of them was the adoption of the home office or telework. The municipality of Ocaña, Colombia, currently has internet service providers, which do not have the adequate capacity to assume the challenge of these strategies, even more so when winter appears, where the internet signal is null. The relief agencies (Civil Defense, Red Cross, and Fire Department) do not have an adequate network for communication between them. These are the ones in charge of transporting the people affected by COVID-19 in their ambulances. In some cases, the three agencies move to the same case because they do not have a call synchronization system, which generates discomfort among them and the community itself. Network infrastructures controlled directly by organizations seek to substantially improve the way data is sent and received between interconnected nodes, since the Universidad Francisco de Paula Santander (UFPS), Seccional Ocaña, Colombia, can provide services more efficiently to relief agencies by controlling bandwidth, latency, assigning permits, usage times, establishing secure interconnection protocols, implementing IPV6 and more aspects that seek to ensure that information flows safely and reliably between stakeholders [14-19]. The main objective of this proposal is to design a fiber optic system with wireless technology, to guarantee the availability, security, and reliability of the information among the entities involved.

2. Methodology

Figure 2 shows the initial experimental scheme, it has a continuous wave laser, an array waveguide grating (AWG), and an amplitude modulator (AM) module so that we could mount the data in an radio frequency (RF) subcarrier, the bessel type low pass filter module was changed for a bessel type filter so that it only allows the passage of a sideband of the subcarrier division multiplexing (SCM) and finally the demodulator module and the fiber optic module were added.

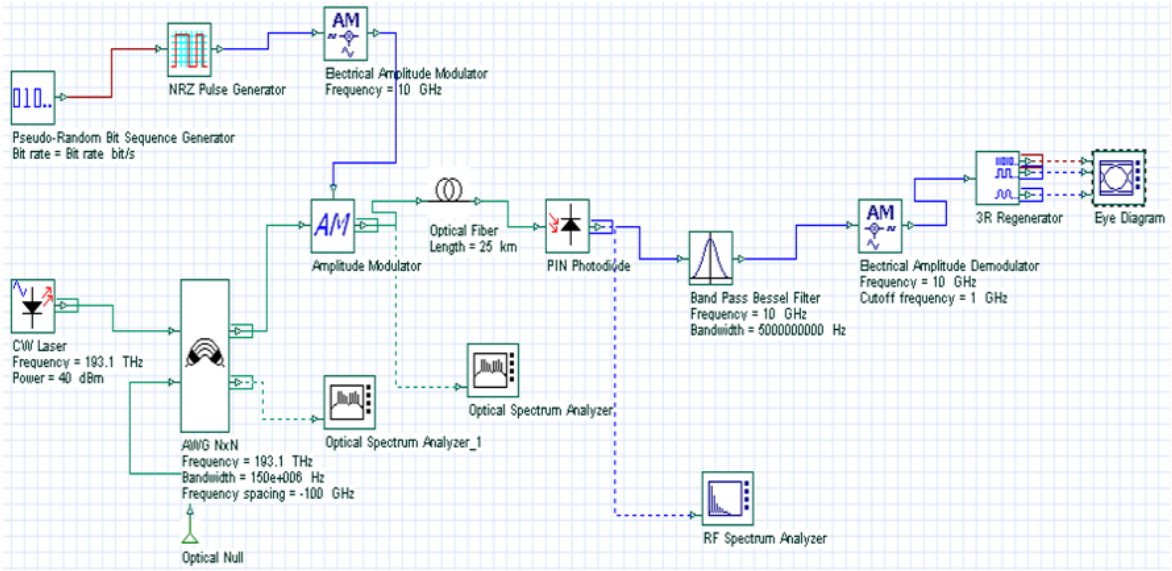


Figure 2. Initial experimental scheme.

2.1. Description local area network of existing technology in the entities involved

Table 1 shows in detail the technology in equipment, cabling, and bandwidth supported by it. The infrastructure of UFPS Ocaña, Colombia, has structured cabling in each of its sites and buildings in category 7A, it is noteworthy that its three sites are connected through single-mode fiber optic, which allows high-speed transmission [20,21]. The Hospital Emiro Quintero Cañizares, Colombia, has structured cabling in category 6A, and the Clinica Divino Niño and Clinica la Torcoroma, Ocaña, Colombia, have a 6A UTP cabling [22], the relief agencies have a category 5E wiring, additionally, they have towers (18 meters) of communications. Understanding that each of the entities involved has a basic network, we proceed to choose a place or office to centralize the information of each of the entities with the proposed platform.

Table 1. Current technology and wiring of the entities involved.

Entities	Technology equipment	Supported UTP/wideband cabling
UFPS Ocaña	Gigabit ethernet	Category 7a / 1000MHz
Hospital and clinics	Fast ethernet	Category 6a / 500MHz
Relief organizations	Ethernet	Category 5e / 100MHz

3. Results

Figure 3 shows the behavior of the Q factor, with a 28 GHz subcarrier in some length variations of the fiber link at 5 km, 10 km, 15 km, 20 km, and 25 km, for a 150 MHz passband, it is necessary to mention that the simulation was made through the Optisystem software, that is to say, that the results are subject to the own characteristics of the software, the obtained results are potentially good in consideration to the requirements of the final design.

3.1. General scheme of the network

Figure 4 illustrates the proposed hybrid architecture and is described below; the network architecture is composed of a fiber optic system that supports speeds up to 100 Gb/s for information flow. This feature provided by fiber optics allows minimizing the amount of time (latency), including delays, for data to travel from one point to another, also increasing performance and transfer capacity as seen in Equation (1).

$$\text{Goodput} = \text{Performance} - \text{Traffic overload}. \quad (1)$$

Taking advantage of the communication towers owned by the UFPS Ocaña, Colombia, and the relief agencies, wireless links are defined that allow communication to the follows institutions Hospital Emiro Quintero Cañizares, Clinica Divino Niño, and Clinica la Torcoroma, Colombia; that is to say, that the proposed design mixes a hybrid system between wired and wireless media [23-25]. Therefore, the use of switch layer 3 is proposed for the distribution layer, and they will be located on each one of the sites of the UFPS Ocaña, Colombia. Entities such as clinics and relief agencies will use Layer 2 switches and antennas that allow for 5G generation speeds. The main servers will be located at the spring headquarters and the backup servers at the Bellas Artes, UFPS Ocaña, Colombia. The topology to consider is the extended star.

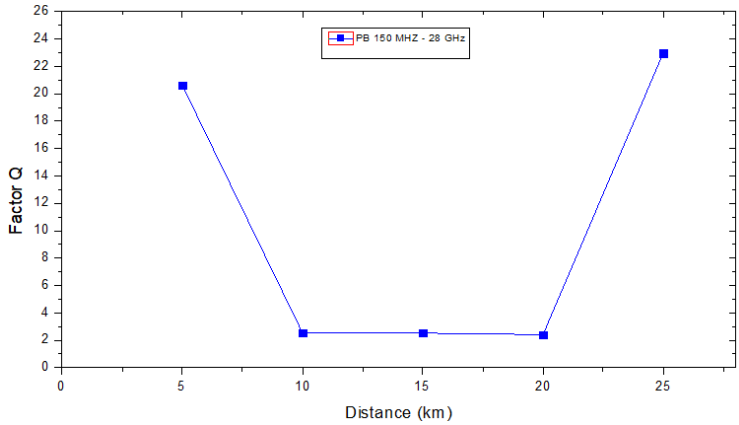


Figure 3. Behavior of the Q factor at a frequency of 28 GHz varying the distances 5 km, 10 km, 15 km, 20 km and 25 km.

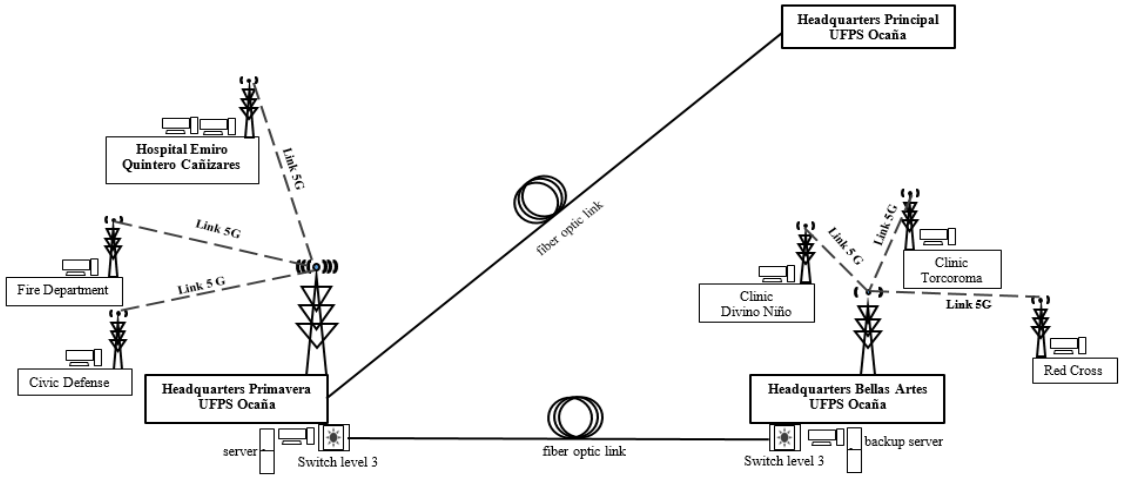


Figure 4. General scheme of the network.

4. Conclusions

Signal quality levels were measured in terms of Q factor, taking into account the frequency framework for 5G, in particular, a hybrid system mixing fiber optic and wireless links at a distance of 25 km and a frequency of 28 GHz is feasible, the design evaluation was implemented in the simulation software Optisystem, which involved adjusting it to the needs of the final design. During the design process it was found that although relief agencies have obsolete cabling, they do have communications towers that can be adapted for wireless communication with the fiber optic system. The Hospital Emiro Quintero Cañizares and the Clinica Divino Niño and Clinica la Torcoroma, Colombia, have acceptable structured wiring and adequate physical areas to establish command control nodes. UFPS Ocaña, Colombia, has a

single-mode fiber-optic system and a state-of-the-art server infrastructure. The proposed network infrastructure essentially seeks to enable all relief agencies to share information in real-time, allowing the information systems to be implemented to improve decision-making concerning incidents produced by the COVID-19. An added value is that having our own communications infrastructure will improve the efficiency and effectiveness in the handling of information since it seeks to ensure the confidentiality, integrity, and availability of data in a more secure way on the implemented systems.

COVID-19 will continue to force the generation of solutions based on intelligent technology to mitigate its impact on the development of the regions. Universities as knowledge-generating organizations must assume the role of leaders in these solutions. The data generated in this type of project must be analyzed and contribute to the objective of control and monitoring.

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