IoT Application of WSN on 5G Infrastructure

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***Abstract*—This article aims to present the integration of Wireless Sensor Networks (WSN), new generation networks or 5G, TCP / IP (IPv6) protocols with the Internet of Things (IoT) that aims to exchange information, applying security , QoS (Quality of Service) and configuration, these three aspects are the problems in the construction of a network in which confidentiality, integrity, availability, authentication, reconfiguration of topology, improvement, high quality of service, addressing, infrastructure , Network and node construction, for M2M (Machine to Machine) communication or end to end. Because 5G cellular networks, in particular, are attractive technologies to provide Internet connectivity to equipment (UE). It is intended to shed some light on the possible problems of integration that are imposed by the integration of wireless sensor networks and 5G that are manifested in the difference in traffic characteristics. For the development we studied the antecedents that integrate new technologies that integrated with the IoT has a good development, next step is to understand the logic of the architectures and finally based on the network traffic model Gauss-Markov we studied the variables as S (Speed), D (address), (length) L, (width) W, (certainty) d_c (uncertainty) d_u to obtain an error approaching zero in a 4G network that improves for 5G in budget packet delays in Very small times.**

Keywords— *Internet of Things, WSN, Network 5G, Internet Protocol, Machine to Machine, User Equipment.*

I. INTRODUCTION

An application on the networks called WSN (Wireless Sensor Network) that interacts with wired or wireless networks, mobile networks (LTE) or 5G migrations, sensors, protocols and most importantly the Internet has been developed.

For this development we have to think of scenarios of change under protocols Stack conformed as follows.

TABLE I. 6LOWPAN PROTOCOL STACK [2]

Application	
Transport	UDP/ICMP
Network	IPv6 ó 6LoWPAN
Data Link	IEEE 802.15
Physical	IEEE 802.15

The protocols refer to 6LoWPAN LowPowerWireless PAN.The solutions are divided into Non-solutions (Zigbee, Zwave, Insteon, Waveon) and solutions (Based on (IPv4 or IPv6)). [2]

II. ANTECEDENT'S

In the following studies we found that the authors address and contribute that Wireless Sensor Networks (WSN) are gaining more and more impact in our daily lives. They are finding a wide range of applications in various fields including health care, assisted and enhanced scenarios, industry and production, monitoring, control networks and many other fields. In the future, WSN is expected to integrate with the "Internet of Things", where sensor nodes dynamically join the Internet and use it to collaborate and perform their tasks. However, when WSN becomes a part of the Internet, we must carefully investigate and analyze the problems associated with this integration. Different approaches were used to integrate the WSN with IoT and outlined a set of challenges. [1]

The world's connection is realized with sensors in the WSN through gateways in the IP networks. The installation and maintenance of such infrastructure is expensive. As the number of smartphone users or EU grows exponentially each year, a powerful platform could be used as a scalable alternative WSN infrastructure. The main challenges of the use of the US as WSN gateway in IoT systems are studied. Challenges include (1) matching the performance of EU gateways and data rate of sensors at access point locations, (2) ensuring access to sensor data, and (3) providing accounting records of the service offered by the US. [3]

Performance evaluation of WSN protocols requires realistic data traffic models, since majorities are application-specific. A packet traffic model is derived from an application, mainly of (4) the degree of coverage at the event point, which is defined as the number of sensor nodes that detect the event point and (5) the distribution of the Events in the surveillance area. [4]

The wide range of applications that must be supported by cellular communications 5G and standardizations have now begun in the Association Project Third Generation (3GPP), there is still no conclusion on the detailed set 5G RAN (Radio Access Network) design. An overview of the 5G RAN design guidelines, key design considerations and functional innovations as identified and developed by leading players in the field. Represents the landscape of the air interface that is expected to 5G, and explains how it is likely to be harmonized and integrated into a 5G RAN overall, in the form of concrete control and user plane design considerations and architectural enablers to slice the network, at a common infrastructure. [15]

The spectrum requirements for 5G arise primarily from the combination of anticipated increases in traffic capacity demands and support for new use cases that will be enabled by the 5G ecosystem.

III. NETWORK AND D2D ARCHITECTURE

This WSN / LTE architecture can be used to extend network coverage and reduces the transmission power of the WSN gateway. The idea of using assisted uplink retransmission is used to reduce transmission power from the gateway device to Node B. The concept of reinstatement can be achieved by means of D2D (device to device) communications as show in Fig. 1. [13]

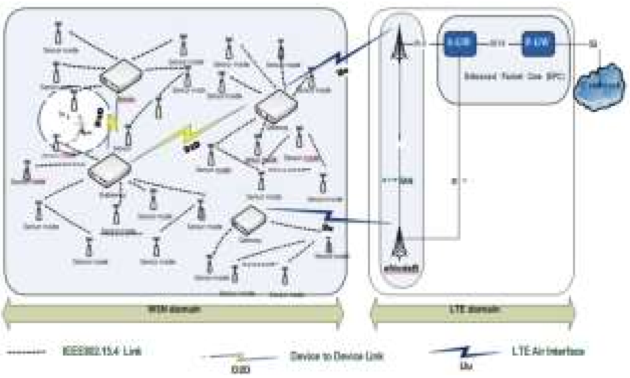

Fig. 1. WSN/LTE Arquitectura de red [13]

The schematic diagram of our D2D architecture is show in Fig. 2 for public safety applications. Each UE (User Equipments) initiates a D2D application; the use of a hierarchical approach creates a mobile cloud on demand. The D2D / SDN (Network Network Software) central controller residing on the Internet has a global view of all mobile clouds in its range, while local controllers (cloud headers) are aware of EU only in their neighborhood. Each SDN controller serves a Node B number depending on the implementation.

IV. 5G Y WSN NETWORKS

In (D2D) communications on 5G networks provides an effective infrastructure to enable different Smart City applications such as public security. In future intelligent cities, wireless sensor networks (WSNs) can be integrated with 5G networks using D2D communications allowing direct interaction between nearby user equipment (UE) trough cellular or ad hoc links, in order to optimize the use of the spectrum, And network power. In this paper, we propose a hierarchical D2D communication architecture, where a centralized network software (SDN) communicates with the head in the cloud to reduce the number of long-term requested communication links (LTE) to optimize the energy consumption. The concept of local controller and the center of our architecture allow to work in case of damage to the infrastructure and the traffic situation. The architecture helps to maintain communication between disaster victims and those who respond first by installing multi-hop route routing with the support of the SDN controller. In addition, highlight the strength and potential of our architecture by presenting a scenario of public security, where a part of the network is offline due to extraordinary events as disasters or terrorist attacks.

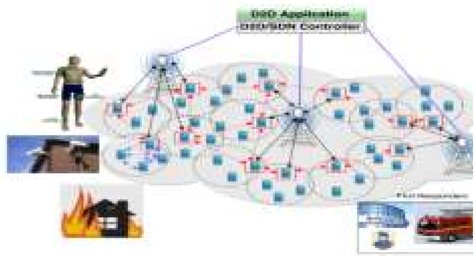

Fig. 2. Red D2D sobre 5G. [14]

In future smart cities there will be a dense deployment of WSN ranging from reserving water to public safety and the seamless integration of these wireless sensor networks with future 5G networks is an open question. In the present work, has proposed a novelty in the D2D communication architecture that is applicable to a wide range of applications. The central controller has a global SDN view of the red and consistently occupies the management of the UEs belonging to different clouds. Local controllers help make our architecture scalable and infrastructure independent.In the case of disaster situations and access point, the SDN controller can select the routing route of multiple jumps between disaster victims and it responds first to maintain communication between them. This helps that responds first to locate exactly the victims who are in critical condition and immediate help.

The mobile clouds of our architecture satisfy the needs of processing and storage of the networks of wireless sensors, where the information of the sensors can be processed and sent to the first recipients to decide his plan of rescue. [14] Our architecture based in the cloud, offers several advantages over the technical:

Scalability: the mobile clouds and drivers hierarchical make that our architecture very scalable. Cloud heads control the nearby EU and transmit their information to the central controller, which reduces the number of links of LTE and improving scalability.

• Energy and spectral efficiency: the EU communicates among them using wireless links and cloud transmits your information added to the controller SDN. This improves the efficiencies of power and spectral General of the network.

• Robustness: In case of disaster and traffic access point situation, UEs are still able to communicate with partial cellular infrastructure support, making the architecture reliable and robust. UEs outside cellular coverage are served by the UEs within cellular coverage

• Interference Reduction: The central controller has the global view of the network by managing multiple nodes B. As a global view allows the reduction of interference between neighboring nodes B and allows the UE to participate in multiple clouds.

SIGNALING FOR THE FORMATION OF CLOUDS: As we observe in Fig. 3 describes the formation and the operation of the clouds moving. The initiator broadcasts a request for the formation of clouds over the Wi-Fi interface. Those devices mobile in the area, interested in the exchange of said service, respond with their resources / services. The application SDN in each device mobile maintains a database of all the services and resources that a user mobile is willing to share. Once is receives a request formation of clouds from a EU start, all them EU concerned share the complete database with the initiator .The actions of this database of the initiator with the driver SDN central. The records of the driver SDN the cloud mobile and assigns a key from authentication to the cloud. The initiator then unicast the key of authentication for each EU, assuring it of any attack malicious. A time the cloud is form, them devices can communicate is by the rest of its operation, unless the head of the cloud sends a request of termination.

V. 5G Requirements

Due to the requirements of the service 5 G, is clear that the RAN 5 G should be designed to operate in a wide range of bands of spectrum with different features, such as wide of band of channel and conditions of propagation. You must also be able to climb a flat user (UP), related to the transmission of the application payload, and the flat Control (CP), related to the functionality of control and signaling, are handled individually. For scalability also towards several deployments possible and a landscape of applications in evolution, both RAN 5 G, as core of the network (CN) must be configurable by software, which means, for example, that is configurable what entities logical and physical are flowed through by packages CP and UP.

A common understanding is that the RAN 5G allows the integration of the LTE-A (Long-Term Evolution-Advanced) evolution and the new 5G radius at the RAN level, although integration doesn't always take place at this level. The RAN 5G should further cover the more sophisticated mechanisms of traffic differentiation than LTE-A to meet the QoS requirements plus several and more stringent and help vision in Next Generation Mobile Networks (NGMN), logical networks for different business cases in a shared physical infrastructure. Another feature required by LTE-A is the native and efficient support of communication forms such as multiconnectivity (for example, simultaneous communications of a device with multiple red names) and red-controlled (D2D) communication in the form of communication Point-to-point, multicast or broadcast. The RAN 5G must support in addition to a wide range of physical deployments, from distributed base stations and centralized cloud-RAN deployments or distributed edge clouds.

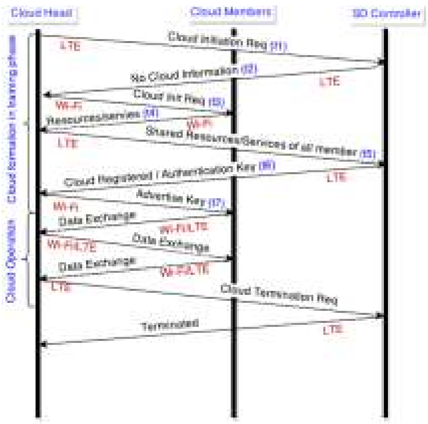

Fig. 3. Signage description for the cloud. [14]

The different kind of backhaul and fronthaul also must withstand is with a degradation constant of the performance in case of reduction of the quality of backhaul or fronthaul in terms of delay and capacity. Also, the auto-backhauling is considered as an important feature, where devices can also act as base and auto stations establish links backhaul wireless base stations appropriate donor. [15]

The figure 4 provides a description of this diversity of applications according to is linked with the three main scenarios of use described by the ITU.

Fig. 4. Three Usage Stage [13]

Contains many applications for the 5G. Some of them include enhancements to existing use cases of the 4G and also there are new and emerging. He video of high resolution (4 k, 8 k), the reality Virtual (VR) and the reality augmented (AR) for games u others purposes, the Internet of them things (IoT) and applications critical of Mission for purposes industrial and commercial is feature between these applications new and in emergence.

TABLE II. SCENARIO 1 - MOBILE BROADBAND OPTIMIZED

Application	Requirements
Video UHD (4k, 8k), video 3D (Including broadcasting	Links of high speed radio communications, Low latency (real time video).

services)	
Virtual reality	Links of high speed radio communications, Ultra low latency.
Augmented reality	Ultra high speed radio communication links, Low latency.
Internet touch	Ultra low latency.
Cloud games	Ultra high speed radio communication links, Low latency.
Broadband Kiosks	Ultra-high-speed radio links, Short range.
Vehicular (cars, buses, trains, air stations, etc.)	Ultra high speed radio communication links, Long cut range, Support for low to high Doppler environments.

To be enabled, these applications have requirements technical specific that should address is by the design right of the interface or interfaces of radio of 5 G and the access to ranges of frequencies appropriate. While some of these applications, as video of high resolution, would require speeds of connection ultrafast, others may need a performance very robust and a range of broad scope.It should be noted that some of the applications in Table 2, 3 and 4 (Potential requirements of the various 5G applications that impact the design of the radio communication link) will be supported by 4G systems evolved with the existing spectrum. However, 5G systems will provide additional capabilities and taking into consideration the spectrum required for the 5G should include all applications planned for future networks. [13]

TABLE III. SCENARIO 2. ULTRA RELIABLE COMMUNICATIONS

Application	Requirements
Industrial automation	Links to radio of high reliability, links of radio communication in high speed, low latency ultralow, short to long range, operation in congested environments.
Critical mission applications as electronic health, hazardous environments, rescue missions, etc.	Links of radio of high reliability, links of radio of high speed, latency low to ultralow, range short to long, operation in environments congested, penetration of floors / obstacles
Vehicles without driver	Links radio of ultrahigh reliability, high-speed radio links, latency down to ultralow, short range to long, operation in congested environments, operating near fast-moving obstacles.

TABLE IV. SCENARIO 3 - MASSIVE MACHINE COMMUNICATIONS

Application	Requirements
Smart home	Operation in congested environment, Obstacle penetration
Smart office	Operation in congested surroundings, Obstacle penetration, High reliability radio links
Smart city	Short range to long, Operation in congested surroundings, Operation near obstacles in fast movement, Links of high reliability radio communications, Penetration of floors / obstacles
Sensor networks (industrial, commercial, etc)	Short range to long, operation in congested environment, operation near obstacles in fast-moving ground-penetrating / obstacles, networks in mesh

PUBLIC SECURITY SCENARIO: In future smart cities there will be a dense deployment of WSN ranging from reserving water to public safety. These WSN and Things Internet (IoT) should be seamlessly integrated with future 5G networks. Our architecture of D2D communications in 5G networks makes this integration simple and simple. The concept of local and central SDN controllers helps our architecture to work in case of infrastructure collapses as well. In a city where most people's intelligences have body sensors to frequently check the body's health status such as blood pressure, glucose level and heart.

FREQUENCY FOR 5G: The Commission Federal of the communications of the United States (FCC) published a notification of research (NOI) in October 2014, which requested comments on several bands as potential bands for 5G. The information required was on issues technical and options of licensing for the following bands: [13]

- Bands of 24 GHz: 24.25-24.45 GHz y 25.05-25.25 GHz
- Band LMDS: 27.5-28.35 GHz, 29.1-29.25 GHz, y 31-31.3 GHz
- Band of 39 GHz: 38.6-40 GHz
- Bands of 37/42 GHz: 37.0-38.6 GHz y 42.0-42.5 GHz
- Bands of 60 GHz: 57-64 GHz y 64-71 GHz (extension)
- Bands of 70/80 GHz: 71-76 GHz, 81-86 GHz, 92-95 GHz

VI. MODEL TRAFFIC WSN

LTE networks are mainly for human-to-human communications. To use this system for the traffic generated by WSN, somehow, the nature of the communications through these networks must be changed. Therefore, we need to provide an understanding of the expected traffic patterns that arise from the use of wireless sensor networks. This will ultimately affect the LTE access settings as required by the WSN clients in such a way that it leads to efficient LTE network performance management. Since WSN have to interact with the environment in order to detect specific phenomena, since their traffic characteristics differ according to the application in question. WSN can be classified according to its applications to WSN by events or WSN event scheduled [4]. For intrusion detection, tracking, etc.), traffic models are described by event-based models. In event-based WSNs that are used in environmental monitoring applications and real-time monitoring applications, traffic is generated when the phenomenon of interest is detected. [13]

VII. VIII. Simulation And Results

The purpose of simulate the characteristics of traffic of a network of sensors wireless of detection or intruders. We use this as an application for the data that you can generate and Exchange through IoT. This characterization of the traffic is very important for the design robust of the network LTE / 5 G that is used to connect the WSN to Internet.

The parameters that define the certaintyd_c and uncertaintyd_u as target's detection of the sensor. These variables are important for the function of quality of the sensor:

$$P_d = \begin{cases} 1 \\ e^{-a(d-d_c)} \; du > d > dc \\ 0 \end{cases} \quad (1)$$

The factors of length (L) and width (W), is defined by the function of distribution for the sensor in the area.

$$f(x) = \begin{cases} \frac{1}{LW}, \; 0 \leq x < Ly \; 0 \leq y \leq W \\ 0, \; Otro\ valor \end{cases} \quad (2)$$

The following formulas [13] are cited for the development of WSN traffic:

$$\sum_{i=0}^{N} i \binom{N}{i} p^i (1-p)^{N-i} \quad (3)$$

The specification S (speed) and D (direction) make relationship of mobility of the model of Gauss-Markov.

$$S_n = aS_{n-1} + (1-r)S + \sqrt{1-r^2}SX_{n-1} \quad (4)$$

$$D_n = aD_{n-1} + (1-r)D + \sqrt{1-r^2}DX_{n-1} \quad (5)$$

The simulator [12] simwiser is the one used for the development and assignment of the values for the development and verification of the WSN traffic. Results of the simulation were cited [11] for proper testing. The parameters used for the simulation are following:

TABLE V. PARAMETTERS FOR SIMULATION [11]

Parameter	
Long	500 metters
Width	200 metters
Range Sure	5 metters
Uncertainty Range	10 mettwrs
Sensed Period t_s	10 ms
Heart Beat Period t_hb	10 ms
Average speed	1 m/s
Average distance	1 m
Sensitivity of Sensado	0.5
Simulation Time	10 s

The figure 5 shows the half number of packages generated to the density of deployed sensors in the area of coverage n = 0.1 node/m^2, n = 0.2 nodo/m^2, y n = 0.5 nodo/m^2. The first kind consists of the heartbeat packets, where each node generates a heartbeat packet every second t_{bs} as long as it is connected to the network. The generation of Heartbeat packages is independent of objective detection. The second kind of traffic is generated due to event detection (ie, target detection), where each sensor node generates one packet each t_s in case of target detection. The figure shows an increase of packets generated as the number of deployed nodes increases. From fig. 5 and Fig. 6, we can calculate the average number of packets generated, where this traffic has to be transmitted through the LTE network. This would determine the requirements of the LTE / 5G programming techniques to be used in order to support the required traffic rate and delay requirements. The amount of traffic driven by events shown in Fig. 7 in different ranges of uncertainty. As is shown in the figure, the amount of traffic generated is affected by the change in the range of uncertainty. Generally, the form of traffic driven by events still to the quadratic function with a part upper flat. The amount of traffic is greatly affected by system parameters such as the range of certainty, uncertainty range, detection sensitivity and node density. Therefore, it is not feasible to accurately predict the amount of traffic generated from WSN. It is also impracticable to generalize the WSN traffic pattern without considering the WSN features and the nature of the application. The QoS architecture has been defined for LTE-based QoS Class Identification (QCI). QCI is a scalar value that indicates a specific priority, a maximum delay, and a packet error rate. To achieve certain QoS parameters, traffic must be classified for QCI in the range 1-9 as shown in Table 6. The programming technique used in LTE mainly controls the QCI and GBR (Generated Bit Rate) parameters.

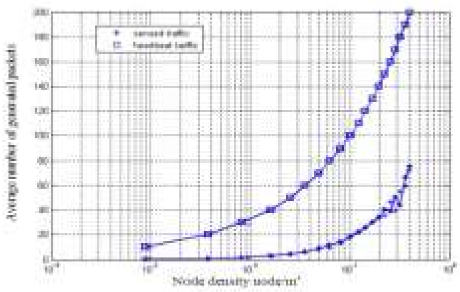

Fig. 5. Average Number and Node Density [11]

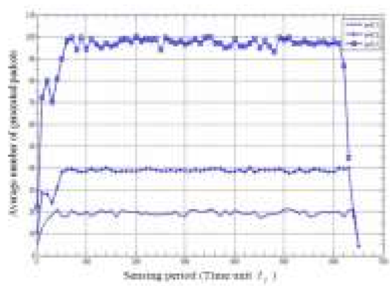

Fig. 6. Average number vs Census period (n) [11]

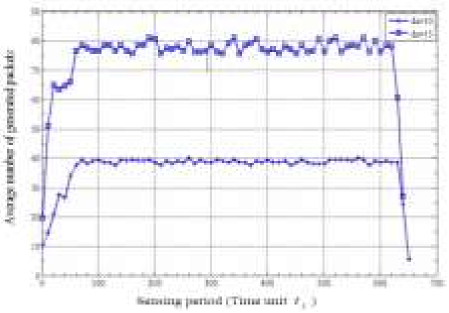

Fig. 7. Bytes per unit of time [11]

VIII. DISCUSSION

The purpose of this integration has been to develop ideas about the requirements for the integration of these new technologies that should be studied in the 5G programming technique to treat proper and efficient traffic WSN. The model used in LTE - 5G does not specify the standard or to the uplink or downlink. Therefore, they have introduced models LTE, WSN and 5 G that is used for different objectives. Not real time and real flow models are mixed in real-time and non-real time.The categories of QoS existing not can match with all the requirements of WSN due to the diversity of applications that is in a diversity of requirements of QoS. For example, the requirement of delay of WSN ranges of 20ms (WSN of detection or intrusion) to 15s (advanced measurement used for the consumption of energy for the network intelligent, the interruption and management of billing). Even within the same application, a WSN can generate different types of traffic; Have each type their own requirements of performance and delay. As we have illustrated in our study of detection of intruders WSN there are two types of traffic generated. The traffic of heartbeat can tolerate the delay. On the other hand, the traffic generated in the case of detection of events is considered high-priority packets and is therefore sensitive to delay. This means that we have different requirements of QoS resulting from the same WSN.

CONCLUSIONS

The possibility of integrating WSN with IoT through the use of LTE / 5G capabilities. In order to do this, we studied the characteristics of WSN traffic and compare this with the regular traffic that is normally supported in LTE networks. We present a network model for the purposes of our evaluation. Based on Gauss - Markov network traffic model, in this case we studied variables S (speed), D (direction), length (L), width (W), certainty of uncertainty and c d. With this is generated graphic to compare packages vs nodes, packages vs time of sensing and Bytes by unit of time (1s) and consolidate in a table the parameters: rate of loss of errors of packages, budget of delay of the package (ms), priority in range of (1-9) exchanging the order and type of resource (GBR and Non-GBR). The results are compared for the priority of the package.

The simulation results show that the boss of traffic generated from a WSN differs significantly the one that rests regularly for LTE. This difference in the boss of traffic illustrates the need of a new design technology of programming LTE to provide the QoS needed for the traffic WSN.The mobile networks of new generation or 5G that migrate 4G/LTE. They would have speeds of 10.000 Mbps which serious 10 times faster than the LTE.

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