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Technological Proposal of an LTE Network Simulator with Smart Meter

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Abstract

This research aimed to implement a simulator to model an LTE mobile communication network for advanced metering infrastructure in smart power grids. It started from the need to know if LTE networks can cohabit and converge with smart electric meters, ensuring that both have their own mobility characteristics. The construction of a simulator with static nodes was designed in three stages: construction and configuration, creation of the base model and design of the advanced model of the simulator. It was evident that the TNL -110 dBm parameter configuration shows a better coverage at 87.22%, PDR performance of 99.7% and Throughput above 1200 bps. The implementation of the simulator generates greater efficiency and reliability in the provision of mobile services with smart meters from the generation stage to distribution, which transcends benefits for the electricity grid company and the final consumer.

Keywords; *Smart Cities simulation, Smart meter, LTE network, Cañete.*

I. INTRODUCTION

Smart meters play an important role for the smart cities of tomorrow; These allow to combine technology and participation driven by the Internet of Things. [1] The Smart meter is a type of digital electric meter that collects information on energy consumption and sends it safely and reliably to a Smart Grid. Increasingly, the electrical industry is evolving from a centralized grid to one with greater consumer interaction. This is where smart power grids change the business model of power companies for the benefit of the end consumer. [2] argues that these state-of-the-art technologies enable two-way and interactive communication between the final consumer of energy and the electric companies, which allows satisfying the needs of the digital age, improving the efficiency and reliability of the electrical network.

The fourth generation technology known as 4G-LTE in the City of Cañete presents improvements in its bandwidth, low latency and data transfer speeds of 100Mbps; It uses radio access technology to have greater spectral efficiency and greater robustness. [3] Communication Networks and Smart Grids, in accordance with an appropriate methodology and management, can contribute and contribute with options that seek to offer additional services to consumers of mobile telephony. In this sense, the present proposal makes a simulated treatment of the participation of mobile networks for advanced measurement infrastructure (AMI) in Smart grids, which seeks the greatest efficiency and reliability in the provision of mobile services from the generation stages and distribution. [3] maintains that a Smart Grid intends that the operation in traditional production, distribution, generation and energy consumption systems reduce interruptions in service, which, when represented in costs, are significant for the different activities that depend on this input. [4] point out that LTE mobile communication networks are the best option for the transmission of data from the Smart meter to the electricity service operator, since it uses a

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transmission medium that allows a solid solution for the transmission of meter readings smart. [3] proposes an integration of different communication technologies to develop an advanced measurement infrastructure, through an integration in all stages of delivery of the electricity supply, as well as the structure that allows adequate management of operations in Smart Grid and asserts that LTE networks are the best option for data collection from smart meters. The city of Cañete located in the south of Peru has 4G LTE mobile technology. Nevertheless; It is necessary to validate if this LTE network, where different types of data such as social networks, emails, videos, video chats and audios are managed, can coexist with the electrical power network to transmit information to the Smart meters operations center. It is here the relevance of the research that focuses on creating a simulator to observe if the use of LTE networks for the automatic reading of Smart meters is valid. [5] when implementing this type of solution to the private or public server that delivers the electricity, it will be able to collect data in advance and analyze consumption prediction models; exactly how much energy must be produced to satisfy the entire population and/or users in periods of low and high demand.

II. THEORETICAL BACKGROUND

2.1. Smart meters

A smart electric meter measures energy consumption in detail and provides other functionalities and / or services that conventional meters do not. [6] maintains that, based on their functionalities, smart meters are divided into two groups: (a) AMR, they are enabled for telemetry and (b) AMI, they are enabled to carry out remote management tasks. [7] Smart meters, unlike conventional meters, have a measurement technology, 100% automated control, remote and data encryption. Undoubtedly, smart meters will change the way we manage energy and LTE mobile communication networks, which leads us to envision the start of smart cities. [6] In addition, the security of advanced measurement infrastructure is essential to gain consumer trust and protect your data. The same authors argue that benefits, such as saving on energy bills and the reduced cost of meter reading, are an incalculable benefit, which transforms the obsolete energy system into an intelligent system.

2.2. AMIAdvanced measurement infrastructure

It is a cutting-edge technology that allows traditional meters to be exchanged for smart meters in the customer's homes, buildings or companies; which gives the electric service company the ability to monitor and collect information related to electric energy consumption that allows better management in predicting energy consumption. [6] An intelligent network envisages the use of advanced digital meters through two communication channels with the ability to connect and disconnect services remotely, monitor voltage and current, and record waveforms. The relevance of the Smart meters to replace the current meters in the City of Cañete is then asserted. [7] This infrastructure makes it possible to manage the reliability and safety of the energy that is being used, which generates an awareness of energy savings given that the consumer will have the decision to choose which electrical devices to use at a certain time of day. This helps to reduce electrical energy through resources such as carbon and fuel, which allows the entry of new renewable generation sources in favor of the environment. Figure 1 shows the AMI scope in Smart Grid.

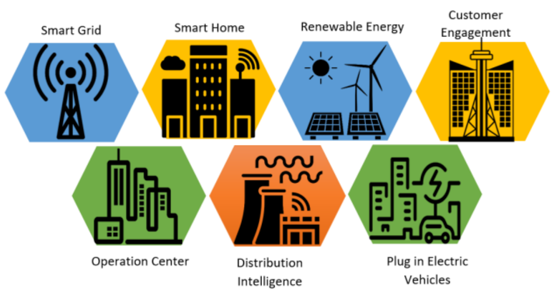

Figure 1. AMI scope in smart grid

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2.3. Communication infrastructure for smart grid

[5] Advanced metering infrastructure is a set of systems and networks to measure, store, analyze, collect, and use energy consumption data at all stages of electricity service delivery. This infrastructure has several elements: the smart meter, the network infrastructure, the measurement data management system (MDMS) and the support systems, which include power management software and display units in the home. [8] The characteristics of the electricity network of the future will be viable with the incorporation of artificial intelligence based on ICT such as: (a) Sensors and advanced measurement systems, (b) Communication networks and data processing, (c) Action and control systems. [9] Any necessary infrastructure that guarantees proposals in Smart Grid must achieve the following: (a) an improvement in the quality of the customer experience, (b) an increase in the productivity of electrical energy, (c) an improvement in the energy utilization, (d) a reduction in carbon fuel consumption and a reduction in gas emissions and (e) Ease of generating new renewable resources.

2.4. Infrastructure required for smart metering

[10] To carry out intelligent measurement, different types of telecommunications technologies can be used according to the application area and the transmission channel. There are 3 types of zones according to the type of communication: (a) HAN; Local area network known as BAM [11], is an integrated system that allows communication between different smart devices within homes. [12] (b) NAN; Neighborhood area network, allows the connection between multiple HANs, is an interconnection system between smart meters. The main element that constitutes it is the concentrator that detects and manages the smart meters automatically, takes readings of consumption and transfers the information to the control centers. (c) WAN; Wide area network that connects multiple distribution systems and acts as a bridge between NANs - HANs and the public services network. WAN offers a backhaul network to connect the utility to customer facilities.

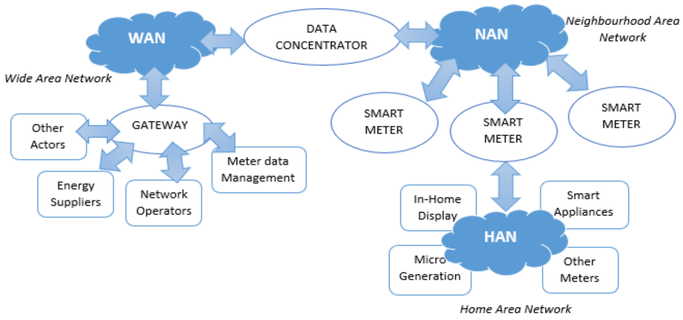

Fig. 2. Smart Metering Communications

III. METHODOLOGY

The research involves the construction of a simulator to measure the performance analysis of the LTE network for AMI in Smart Grid; This was based on the diagnosis of the field work, for which different stages with characteristics of the mobile network are established, building static nodes to evaluate the performance of the communication network. The proposal has three stages: (a) Construction of the simulator and configuration of the work environment, (b) Creation of a base model to validate that it has the characteristics of LTE networks, and (c) Advanced model that uses real base station locations. As a final result, the Optimized Model is achieved to validate if the LTE network supports and gives sufficient coverage to the AMI nodes.

3.1 Construction of the simulator and configuration of the working environment

The working environment was built under the 64bit Linux Mint operating system using OMNeT ++ with the INET library considering the specialization package for LTE SimuLTE and encoded in C ++ language, which are Open Source. High-performance equipment with the following characteristics was used, as shown in Table 1.

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Description	Values
Processor	**Intel Xeon E3-1220 V5 3.0 GHz**
RAM	**1 TB**
Hard Disk	**16 GB**
Operating System	**Ubuntu 16.04 LTS**

Table 1. Server Characteristics

AMI nodes and UE nodes differ because AMIs do not have mobility configured and UE nodes have them configured as shown in Figure 3. The base station is shown as eNodeB interconnected to the router whose function is to route the traffic of the nodes to AMI and VoIP servers; and vice versa.

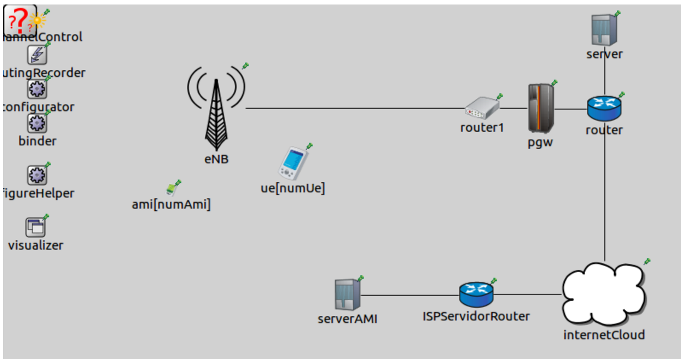

Figure 3. Proposed network architecture

3.2 Construction of the base model

This model serves to validate the operation of the simulator with the characteristics of the LTE mobile network where traffic from UE nodes is combined with traffic from AMI nodes in an urban propagation model [3]. While UE nodes have slow mobility and random address, AMI nodes do not. The eNodeB has a coverage of 500 square meters; Regarding the position of the Smart meters, 24 of them are located in the range of a block, replacing conventional meters. Figure 4 shows the graphical representation of the complete base model with a total of 80 AMI nodes and 80 UE nodes.

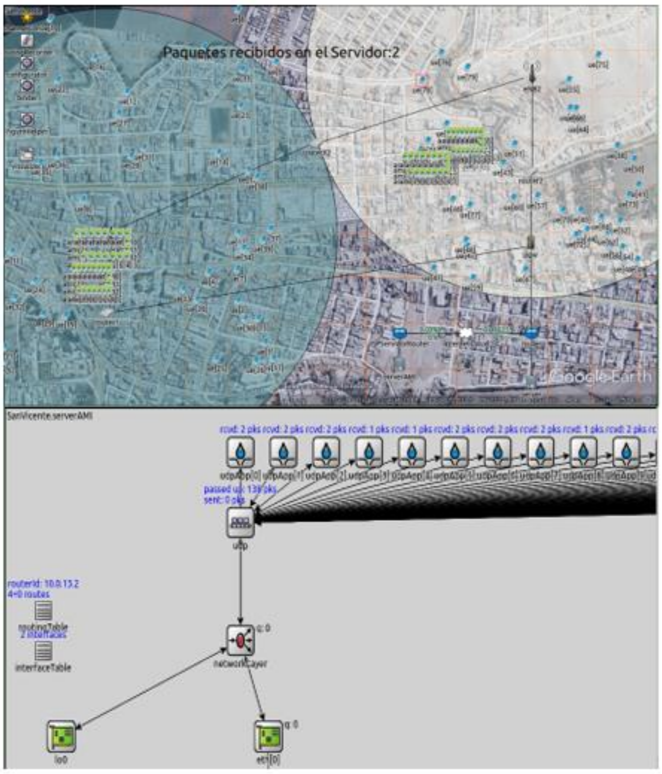

Figure 4. Base Stage

3.3. Construction of the advanced model

We use real parameters within an urban space using geo-referenced data from the base station towers of a mobile phone company in the city of Cañete. These locations of a telephony operator are used as shown in Figure 5, to position the eNodeB nodes within the simulator. Of which a specific area is covered by choosing the points with the description: Cañete1 and Cañete2. Table 2 shows the detail of the chosen stations.

Figure 5. Location of base stations of a mobile operator

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Table 2. Base station location

ID	UBIGEO	DEPARTMENT	PROVINCE	DISTRICT	CCPP	LAT_PR	LONG_PR	CLASIF
1878	1505010001	Lima	Cañete	San Vicente de Cañete	San Vicente de Cañete	13.07693	-76.38585	Urbano
1881	1505010053	Lima	Cañete	San Vicente de Cañete	Los Girasoles	13.07013	-76.38487	Rural

IV. RESULTS

4.1. Optimized model

The optimized model has two stages were performed over an area of 500 m2 based on what is specified in ITU-R M.2135-1 for macro urban stages [13]. Where TNL parameter at -101dBm was used as stage (a) and TNL parameter at -110 dBm was used as stage (b). [3] The location provided by the coverage algorithm is used for the AMIs nodes. The simulation parameters are detailed in the data sheet of table 3 and the simulator results are shown in the right column in the same table.

Table 3. Simulation parameters

Technical Sheet		Simulator Results	
Modified eNodeB	BS4	Stage (a): Where TNL is (-101 dBm)	Stage (b): Where TNL is (-110 dBm)
eNodeB´s New Locations	EB1878 | EB1881		
Lengths	-76.388 |-76.380		
Latitudes	-13.076 |-13.071		
Initial Reference	RM_003		
Smart Meters	80 units	PDR AMI 99.9%	PDR AMI 99.9%
Mobile Terminals	80 units	PDR UE 37.2%	PDR UE 54.9%
Coverage	85%	63.8%	88.02%
Loss	15%	36.2%	11.98%
Max Distance eNodeB - EU	500m	-	-
Simulation time	600s	-	-

4.2.Coverage results

To simulate the optimized model, TNL (Thermal Noise Level) parameters were used at -110 dBm where it rises to 88.02% coverage for the AMIs nodes. Figure 6 shows the results corresponding to the AMIs nodes. The graph on the left shows the (%) coverage for AMIs nodes, where the optimal stage represents good coverage at 87.22%. and the results repeat the theory that the optimizing algorithm does not consider radio interference since the TNL should be -101 dBm.

4.3. PDR (Packet delivery ratio) performance results

In figure 6, the center graph shows the PDR (%) for the AMIs nodes where the percentage is displayed at 99.97% of delivered packages, the complete and constant data of the AMIs nodes that were active, connected and were delivered were obtained successfully on the AMI collector.

4.4. Throughput result (bps)

In the same figure mentioned, the right graph shows that the throughput remains above 12000 bps for both stages where stage b presents the best result.

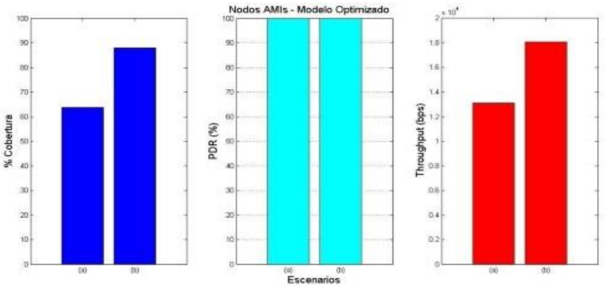

Figure 6. Result of the optimized model

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V. DISCUSSION

Thus, after the construction of the simulator applied in the city of Cañete where the eNodeB nodes were located, it was confirmed that LTE is a technology that provides improvements in the speed of data transmission, in the coverage and quality of service of mobile signals. The benefit of this technological proposal by applying an LTE network simulator with smart electric meters generates greater efficiency and reliability in the provision of mobile services from the generation and distribution stages. This coincides favorably with what has been asserted by [3], [4], [5] who maintain that LTE Networks are undoubtedly one of the best options for transmitting data from a smart meter to an electrical service operator.

Applying an LTE network simulator with smart electrical meters shows favorable results for the benefit of the electrical network company and the final consumer; and at the same time, it is evident that both technologies can coexist. [5] and [14] maintain that electricity companies will be able to obtain optimal consumption prediction models through this state-of-the-art infrastructure, which will generate maximum user confidence, allowing savings in energy consumption.

Based on the validation and relevance of the simulator applied in the city of Cañete, it is required that the simulator be proposed in new more specific stages or with different parameters, transforming cities into a broader concept such as Smart Cities. [5] and [14] coincide in pointing out that smart electric meters and LTE networks are a way to envision the start of tomorrow's smart cities, for which new research in 4.5G and 5G technologies must be carried out.

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