Efficient Large-scale Medical Data (eHealth Big Data) Analytics in Internet of Things

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***Abstract*—Recent technologies such as Big Data could be used in order to help the improvement of other fields except for the telecommunication field. Due to the Health field, the Big Data technology could contribute with the aim to help for the purpose of analysis and management of the huge amounts of health data. The main objective of this research proposal is an analytical study of the technologies IoT, Cloud Computing (CC) and large-scale data (Big Data) to resolve various issues facing the health sector in relation to these technologies. The purpose of the research proposal is the collection of medical (e-health) big data in real time. The collection will be performed by sensor devices and actuators, which will wear patients who suffer from various ailments. Then is following, the transfer of these data through a network to a cloud server. Additionally, these data will be processed in the cloud which makes its analysis so as to become meaningless. By the analysis of these data is done the data mining. Finally, to address the various problems in the health sector, the transfer of the analyzed health data will be held by the devices of the relevant persons. Also, in our study, we will deal with the security of medical data which constitute personal data and must be protected.**

***Index Terms*—Big Data, Cloud Computing, IoT, Healthcare**

I. Introduction

On the one hand, in the health sector, we are faced with many problems, for which they come to give solutions the IoT and the new technologies. Some of these problems is the rapidly aging due to the low birth rate (demography problem), the chronic diseases due to the increasing aging of the population (such as hypertension, heart failure, diabetes mellitus, etc.), the rate diseases (e.g. Alzheimer's disease), the hereditary diseases, the lack of health personnel and the health infrastructure, the difficult treatment of emergency cases (e.g. the accidents, the emergency obstetric care and so on), the organizational problem, the patients with mild disease (avian, etc.) that they need no monitoring and binding site on the already congested hospitals' infrastructure, and also, the corruption of information over time [1].

On the other hand, from our previous studies [1-16], we know that the rapid development of IoT and CC has brought the rapid growth of data. So, we are faced with major challenges related with the management, the analysis, and the transfer of such data. These challenges of large-scale data mainly concern [17-23]: their representation, reducing the redundancy that exists in them, the quality and the variety, the management of the life cycle, the confidentiality, their expendability, the energy management, the heterogeneity, the speed and the accuracy, the privacy and the security, the storing of them, the extracted knowledge from them, the creation or development of their analysis tools and algorithms or techniques as well as, other serious issues that need total improvement.

The latest findings therefore show us that there are some "gaps" in the way in which such data are transmitted through the levels of management, analysis, and transportation, but also, some problems that arise from their use, and which we will try to optimize by proposing new techniques and new algorithmic solutions.

The tools we will use for the development and implementation of this research will be the use of Big Data software technologies, IoT, and CC, as well as algorithms for the creation of platforms, both in code form and in flow chart form [2] [4] [13] [14].

II. Literature Review

In the new era of technology, a new and popular term is called "Large Scale Data or Big Data". This term is used to describe the amazingly rapid growth of structured, unstructured, and semi-structured data formats as well as, the large and complex data sets that traditional data processing applications are insufficient to manage them, analyze them, and transfer them [2] [3] [24].

As wireless and internet technologies evolve, a new technological trend has blossomed in recent years. The increasing use of the Internet by more and more users and the advanced networking technologies, lead us to the "Internet of

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Things" (IoT) [1] [25]. The IoT is an important and topical issue in industry technology, and we can say that it is the evolution of internet, computing, information, and communication systems. IoT is the main technology from the web technologies, which has revolutionized the data era, by the sensors installed on each device and object, and the actuators [1]. The sensor data can be environmental, medical, geographical, accounting, astronomy, etc., and are useful only when are analyzed. From all Big Data that are collected, those generated by IoT devices have different characteristics, some of which are the heterogeneity, the variety, the unstructured or semi-structured feature, the high redundancy, the noise, and so on. In the near future, it is estimated from surveys carried out, that the IoT data will be the most important of the Big Data [18].

Moreover, with the developments in networking technologies was born the "Cloud Computing" (CC). It is a new developing trend that will meet the needs of users to manage, store, access, and analyze Big Data and its' applications. The Big Data are stored in a remote location outside of the computer and can be accessed through an Internet service from anywhere there is available link. The Cloud Computing and the Big Data are two technologies closely related. The use of huge computing and the storage resource management is one of the goals of cloud computing, so that it can provide computing capacity in Big Data applications. Also, according to researchers [4] [18], there are several solutions for the processing and the storage of large-scale data provided by the use of cloud computing. The management of these data may be processed efficiently from the cloud, using the distributed storage technology. The efficient collection and analysis of big data can also improve the cloud, using the technology of parallel computing capacity. So, we can say that the significance of the IoT data are hidden in the effective integration of large-scale data technologies and cloud computing [4] [18]. Additionally, in recent years, with the burgeoning of cloud computing and mobile devices, they have begun to develop new technological advances that greatly affect society, science, and especially, medicine [26].

The ability of objects to communicate with each other, but, also with the humans and the internet, will affect the health sector, and in particular, healthcare [1]. The most amazing object of IoT is a sensor node (e.g. an Internet sensor or Web Sensor) [27]. As in all areas, so as in the health sector, with the development of new technologies and services, everything tends to be automated. Even though, all physical objects have smart sensors and actuators that are characterized by low cost and small size, through which we can collect information about them or from them in real time [1]. The sensors can communicate, perceive, and process data, and also, can convert data such as health data to digital form. The actuators on the other hand, convert the physical data to physical effects [28].

About those standards that were developed and created in recent years, appeared new challenges in terms of data security issues that are transmitted and used in these standards. That has resulted as need for further research on safety issues in the transport and management of data associated with both, the Big Data and IoT, and the CC. Therefore, in order to provide and establish a secure communication via the communication network, there have been developed encryption algorithms which play an important role in data security. Most of the encryption algorithms use a unique key for the encryption, which only the user knows and so only he/she can decrypt the data. Based on research done until now, we observe that the most widely used encryption method, which is used by several encryption algorithms, is the method of symmetric key. One of the most known encryption algorithm types is the AES algorithm [29, 30, 31].

The most important advantages from the integration of these new technologies in patients' healthcare are the security of personal data, the health data management in real time, and thus, the improved results for patients, the improved user experience, and the reduced healthcare costs [1] [4] [13] [14].

III. Proposed Architecture

The aim of the research proposal is the collection of medical (e-health) large-scale data (Big Data) in real time, by sensor devices (sensors) and actuators (actuators), which will be worn on patients (wearable devices) who suffer from chronic or rare or hereditary diseases. The collected data will then be transported (in real time) through our network to a "Cloud Server", and subsequently will be processed in the CC, which makes its analysis to mine knowledge from these IoT data which have no significance if they are not analyzed. Finally, the transfer (in real time) of the analyzed health data will be held into the devices (smartphones, tablets, PDAs, laptops, and so on) of the relevant persons (doctors, caregivers, other family members, etc) to address problems in the health sector [1-16].

Contrary to the practices used to date, pervasive data "came" to "stay", and to improve health care, with more accurate diagnoses, with shorter delays for the patient's treatment, and with fewer obstacles for patients when making treatment [1].

In this research, given the challenges which are growing in the healthcare sector, we propose and we are going to implement in the future a system shown in Figure 1, which provides to the relevant people and in real time, via sensors and other devices, medical information related to the health of a patient, so as to monitor the state of health out of the hospital, freeing thereby places (such as a hospital bed) and resources of the hospital (such as food), and further savings and provide more comfortable environment for the patient.

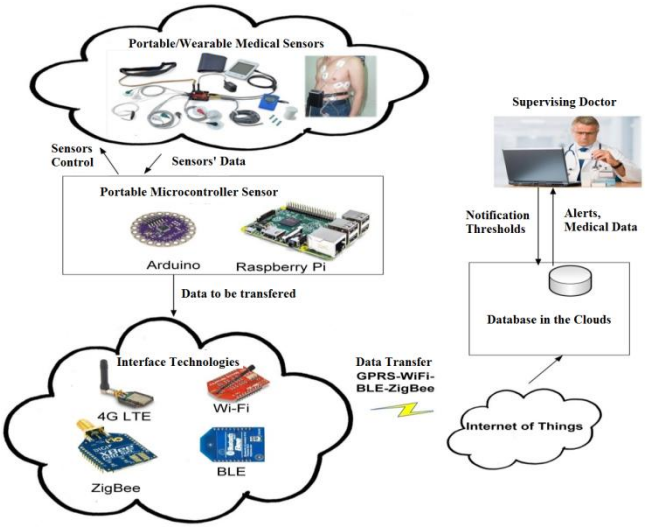

Figure 1: "The architecture of the proposed system".

At the same time, in this way, we will have the directly information of the patient for the state of his/her health, the timely information of the doctor-nurse about the state of health of the patient, the remote patient monitoring, the timely information of medical personnel for emergencies in order to correctly and quickly prepare for an emergency, the direct conversation of the patient and the doctor so that there is no distortion of information by playing the "broken telephone", as well as, the better organization records of physicians so that the information will not be altered with the passage of time [1] [8] [9] [11].

So, in addition to the improving healthcare for patients, this research proposal aims to address the challenges of these technologies, and the creation of a system which has advantages over the systems that have been proposed by other researchers [32, 33]. The researchers in [32] present the integrated architecture of their proposed system in which they use the "IPv6 over Low-power Wireless Personal Area Network" (6LoWPAN) technology which is scalable and has fault tolerance, so that the sensor nodes maintain the connection between them. Moreover, in [33] is presented a "pervasive healthcare system» ("an IoT-based pervasive healthcare system"), which gives patients a normal life without qualified medical staff to monitor their health, accurate medical data and an alarm system for emergencies. The two systems that have been applied in this investigation for the remote monitoring of patients are a wireless sensor network, which is based on low-power ZigBee technology, and a wireless sensor network, which is based on IP (Internet Protocol), and which uses Wi-Fi.

The system we proposed takes precedence over these two systems, because of the combination of more wireless data transmission technologies, such as the technologies 6LoWPAN, ZigBee, Wi-Fi, LoRaWAN, and Bluetooth Low Energy.

As a final benefit of this research proposal will be the presentation of proposals to optimize the integrated use of Big Data technologies, IoT, and CC, particularly in terms of the analysis of the networking levels of management and medical content data.

IV. Experimental Results

In this research for testing and real time simulation and monitoring of our network and the conditions in it, we are going to use many different tools. One of these, is the Contiki OS and the Cooja emulator. With the Cooja emulator we will create simulations of our system. These will help us to provide more realistic and detailed experimental results.

Moreover, we created an example simulation (Collect View) of the data collection process in the network with the use of Cooja emulator. In the following Figures (Figure 2-16), we can see the Contiki-Cooja Environment.

Specifically in Figure 2 we can see the environment of the cooja emulator. On startup we can see some basic windows that are already openned. The first on the left is the network window where we can build our network by adding, managing the network nodes. The second window at the top-center of Figure 2 is the simulation control window that has four buttons (one for starting the simulation, one to pause it, one to stop it, and one to reload it). The third window is for notes. The fourth window is the mote output window where the output of the nodes is shown. Finally, the fifth and last window is the timeline window where we can see the packets per seconds. Moreover, in Figure 3 we can see the average temperature of the nodes (sensors) and in Figure 4 we can see the temperature of the sensors. Then, in Figure 5 is shown the battery voltage of the sensors and Figure 6 shows the battery indicator. Furthermore, in Figure 7 and 8 are shown the relative humidity of the sensors and the latency of the network respectively. In Figure 9 we can see the packets received into the network over time and in Figure 10 the packets lost over time. Also, in Figure 11 we can see the packets received per node and in Figure 12 the hops per node. Moreover, the average power consumption is estimated in Figure 13, and the average radio duty cycle is estimated in Figure 14. Finally, the instantaneous power consumption and the history of the power consumption are shown in Figures 15 and 16 respectively.

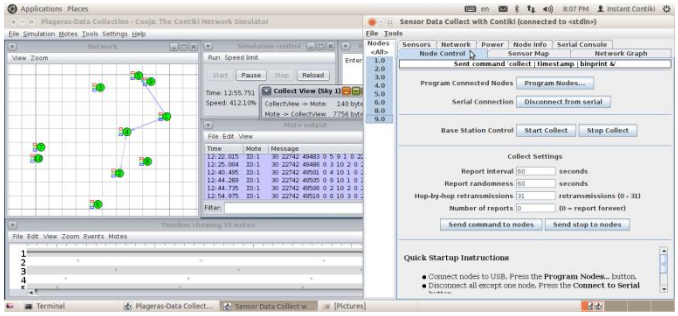

Figure 2. The Cooja Emulator.

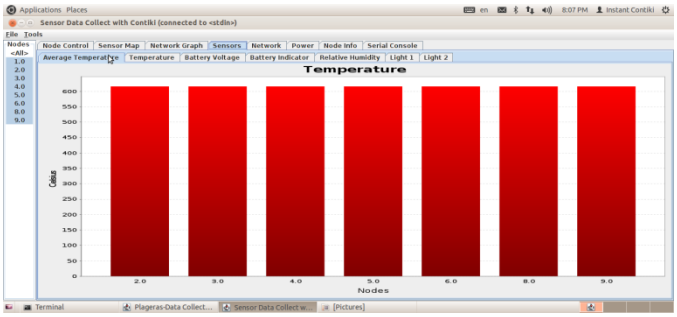

Figure 3. Sensors' Average Temperature.

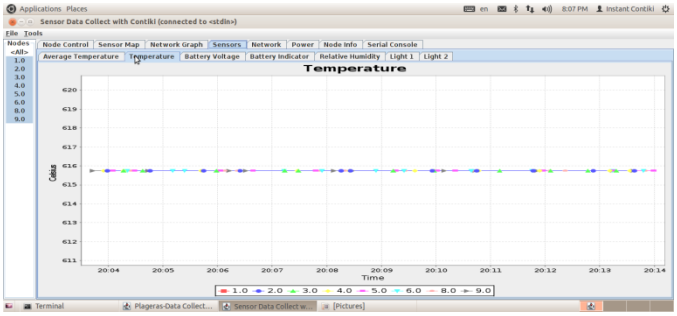

Figure 4. The Sensors' Temperature

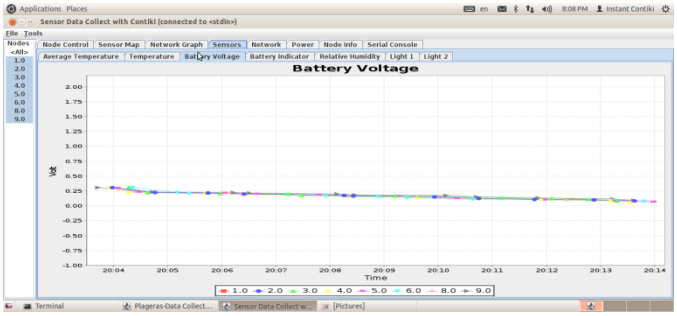

Figure 5. The Sensors' Battery Voltage.

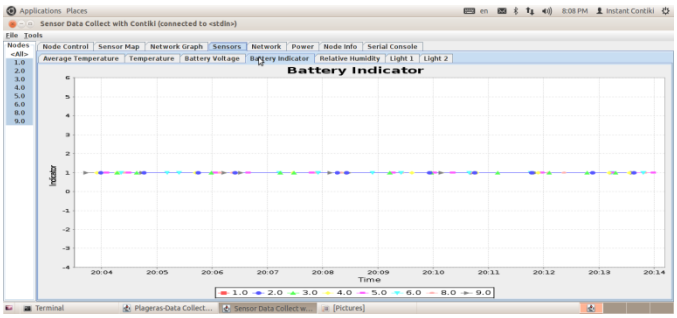

Figure 6. The Sensor' Battery Indicator.

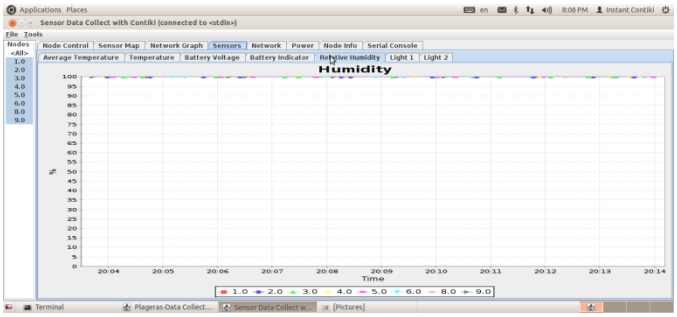

Figure 7. The Sensors' Relative Humidity.

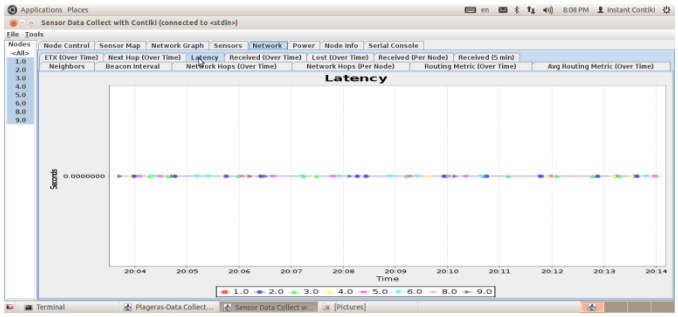

Figure 8. The Network's Latency.

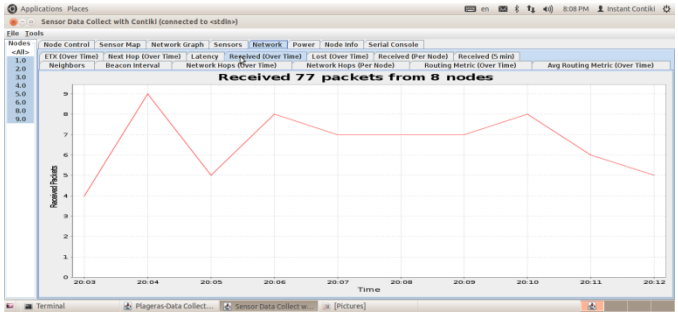

Figure 9. The Network's Packets Received (over time).

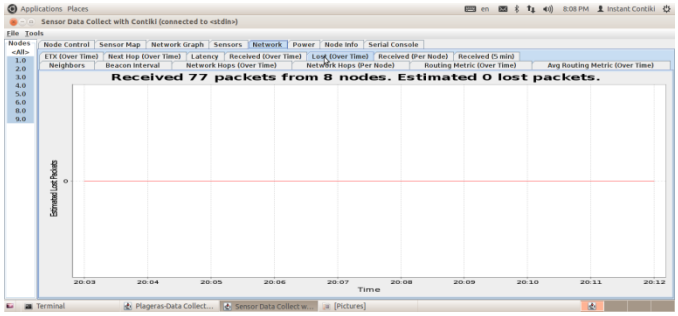

Figure 10. The Network's Packets Lost (over time).

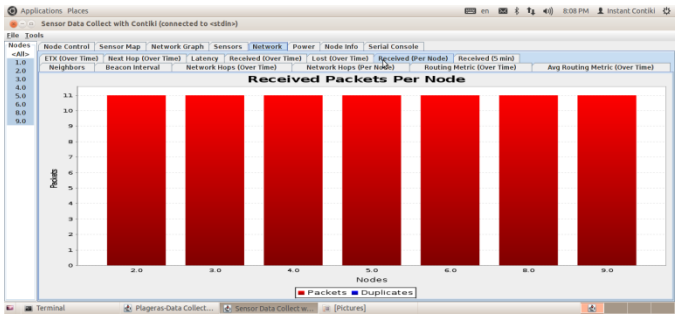

Figure 11. The Network's Packets Received per Node.

Figure 12. The Network's Hops per Node.

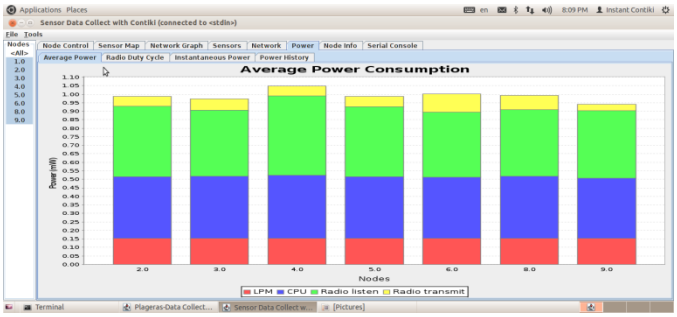

Figure 13. The Average Power Consumption.

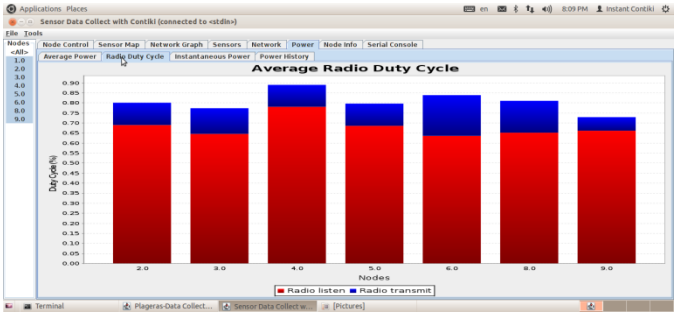

Figure 14. The Average Radio Duty Cycle.

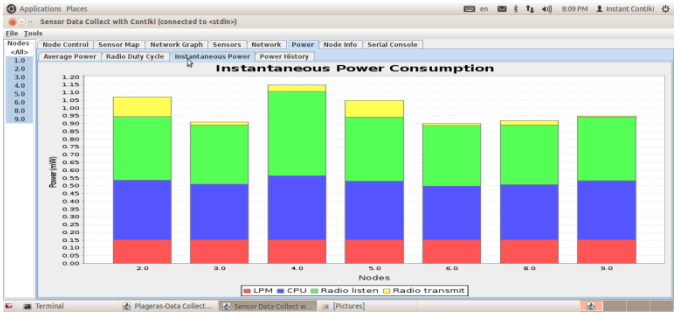

Figure 15. The Instantaneous Power Consumption.

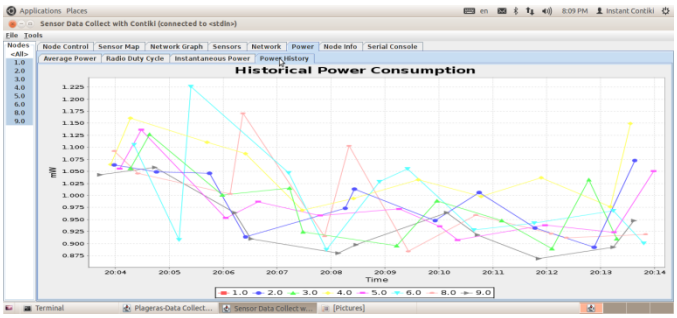

Figure 16. The History of the Power Consumption.

V. Contribution to Theoretical and Applied Scientific Knowledge

The results of this research contribute to the theoretical and in the future to the applied scientific knowledge. From the perspective of theoretical knowledge, we will propose new medical data transport protocols for real time communications via the Internet. These protocols will be well applied to different kind of sensors in the general scientific field of Wireless Sensor Networks (WSN). We will propose the best way to protect the transmitted medical data.

We will also investigate the smooth transition in real time of one wireless data transmission technology to another (e.g., Bluetooth Low Energy to LoRaWAN). Particular attention in this case is that there is no loss of data and the period of transition to be as soon as possible.

From the perspective of applied scientific knowledge, particular emphasis will be given to the Hybrid Transmission Data System. The Hybrid Data Transfer System will combine the main and the modern technologies of wireless data transfer such as Wi-Fi 802.11ac, ZigBee, Bluetooth Low Energy and LoRaWAN. Depending on the geographical topology of the system (distance and signal strength), the energy that feeds the sensors (battery status), the type of medical data (real time or not), and the amount of data shall be applied, in case of a different method of sending data, based on the above technology.

In case of adoption of a future expansion of this proposal for hospitals in the country, at a future time, and after further through research, will strengthen the economy of hospitals and mental health of patients. The not too sik patient would not need to be in an unfamiliar hospital only to monitor his health. All medical data will be recorded by sensors and then, will be sent in real time to the doctor on duty. By this way, the patient will feel comfortable in familiar surroundings and the Hospital will increase the available resources and beds will be released for more emerging situations.

Medical data will be collected by health sensors and sent to a medical research center, which already collaborates research fellows, for further study of the results.

VI. Innovation and Future Work

This research focuses in the field of bio-informatics and IoT. The novelty of our research is observed at the combination of these two regions. To transfer sensitive medical data, a hybrid wireless technology to send data which takes account of all modern methods of wireless data dispatch, will be investigated in the future. Also, we are going to propose new data transfer protocols that take into account the particularities of each wireless network protocol and optimally combine the latest wireless technology to send data. Methods for sending data, that will be included in this investigation, are the ZigBee, the Bluetooth Low Energy, the LoRaWAN, the Wi-Fi 802.11ac, and the 4G/LTE.

If the patient is walking a distance, from the access point to the Internet, and the energy of the sensor does not interest us, we will investigate the Wi-Fi 802.11ac protocol. If the sensors have limited power, there will be used the protocols Bluetooth Low Energy and ZigBee, with the help of a modified data transfer protocol that is based on the way in which processes the sensor data transfer protocol CoAP (Constrained Application Protocol). If the patient is at distance greater than 50 meters and less than 2 km from the Internet access point, then the data will be sent to investigate if we will use the LoRaWAN protocol. If the patient is in an area not covered by these protocols we will use 4G/LTE mobile network.

Particular emphasis will be given to the security of medical data in the future, which constitute personal data by applying innovative methods in their coding. It is quite important for both the patient and the doctor to have the supervision to

provide security in their communication and the data exchange. Security will be based on development and implementation of a communication protocol, which focuses on the secure transmission of medical data and provides encryption to them, with the help of encryption algorithms that will be processed [1] [4] [13] [14].

In future research, moreover, we will investigate the maximum upload rate in each protocol according to the distance. We will also investigate, which of the medical data can be sent in real time, and which with time delay. A smooth transition way is offered by the one wireless technology to the other, while minimizing delays and packet losses. Data compression algorithms will be proposed to reduce the sending rate, especially, when the network is congested. We are also going to explore ways for the quality assurance of the data dispatch service. Then we will ensure maximum data security in the hybrid wireless data network.

Finally, on the question of security, we will try through our research to create a new communication protocol for the data exchange, which focuses on the secure transmission of medical data, and provides the encryption of these data with the help of encryption algorithms that will be used to achieve the best possible protection of personal patient data.

VII. Conclusions

Regarding the analysis and management issue of the large-scale data in the Health field, a new type of technology could be used in order to help. The main objective of this research proposal is an analytical study of the technologies IoT, Cloud Computing and Big Data with the aim to resolve the various issues that we are facing in the health sector, in relation to these technologies. The main purpose of the research proposal is at first the collection of medical (e-health) big data in real time. The collection performed by sensor devices and actuators, which have been wearied by patients who suffer from various ailments (e.g. chronic, hereditary and rare diseases). Subsequently, takes place the transfer of these data through a network to a cloud server. Furthermore, these data are processed in the cloud, and then analyzed in order to gain some meaning for the user. By the analysis of these data takes place the data mining procedure. Finally, the transfer of the medical data that already analyzed will be provided by the devices that will be worn by specific persons, in order to address the various health problems. Also, in our study, we deal with the security of these medical data, which constitute personal data, and must be protected. For this reason, we apply innovative methods in their coding regarding their security.

As a future work, there will take place the development and the implementation of a communication protocol that provides a secure transmission of health data, as well as, it provides the encryption using the cryptographic algorithms which will process. Moreover, as a continuation of this research proposal and as its eventual benefits, there will be the presentation of proposals in order to optimize the integrated use of Big Data, IoT, and CC technologies, in particular, as regards the analysis of networking levels of management, and medical data content. As future proposal of this work will be a presentation of a number of innovative and optimized algorithms and methods, which improve the issues with use of these technologies with common denominator the analysis, management and transfer of Big Data. This will result in the convenience of users, but above all, the companies that will use Big Data, something which both related to the telecommunications industry and other sectors, as trade, health care, etc.

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