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INTERNET OF THINGS (IOT) AND HEALTH CARE

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ABSTRACT

The IoT is defined as the connection of everyday objects with the internet and its application has already spread to many areas, such as the provision of health services.

The IoT in medicine (IoMT) refers to medical devices connected to information technology systems through the internet. These devices are interconnected through wifi networks that allow them to connect to cloud platforms where the data obtained is recorded and stored. The interconnection of these devices and the communication between machines allows health professionals to improve and speed up the treatment of patients thanks to the possibility of accessing information instantly and monitoring patients remotely. The use of IoMT is spreading rapidly and is becoming more frequent and there are already many millions of connected medical devices today.

The development of the IoMT is a consequence of the advancement of technologies such as smartphones and other wireless devices, the existence of higher quality Wi-Fi networks, such as 5G and the appearance of platforms and servers in the cloud or the design of sensors each. increasingly complex that are capable of recording and transferring data.

KEYWORDS: Internet of Thing, IoT, IoTM, provision of health services.

INTRODUCTION

Currently, the data and information generated are a growing value in our society and it is important that companies in the health sector are aware that it is useless to have complete and updated databases if they are not available 24 hours a day, throughout the year, because the availability of information must be continuous.[1]

Data information is a vital element that flows in today's society, since everything has a digital presence, that is, it can be monitored and analyzed. The technology that we carry in our mobile devices, such as wearables, and the IoT have the potential to revolutionize the way we think and interact.[2]

These wearable devices can provide real-time information on the health status of the user of the device, which helps to alert healthcare professionals and users themselves of any risk to their health before the problem becomes greater. A pocket scanner, such as the Scanadu Scout, allows a person to carry out a basic medical check-up on their own from home. This means that you do not need to go to the hospital if you have only minor and not serious complaints. In addition, it offers accurate data for diagnosis in the event that the patient requires treatment. The possibility of accessing the body of international knowledge on health and offering this information to users through devices and the cloud significantly helps the diagnostic process itself. Nowadays, it is very normal to search the Internet for the symptoms of a disease and carry out a first diagnosis without the need for a healthcare professional.[3]

Smart devices also offer a field of possibilities in the field of preventive medicine. Cloud applications, combined with wearable devices, allow sports fans to keep track of their status and consult tables on the Internet with their weight, heart rate and other statistics that help them reach the goals they have set for their physical and health condition. Everyday technologies and wearable smart devices provide users with targets that assist them in measuring their physical activity to prevent the risk of obesity, diabetes, and other weight-related health problems. Mobility plays an increasingly important role in health care. The Internet of Things, health care applications and those that allow you to keep track of your diet from portable devices generate a large amount of data in health care. Some of this data is essential and needs to be recorded, but there is a lot of specific information that can be discarded. In healthcare, much, if not all, of the data must be kept frequently throughout a person's life and beyond. The use of data within healthcare is essential and it has never been necessary to maintain high accessibility to them.[4]

Medical research requires long-term access to data in order to identify trends that may not be necessary at the time the information is collected. And a long-term analysis of that information is what allows us to identify patterns and be able to act with that information. The data has also been used to track mutations and try to minimize the potential impact of such changes.

A process of transformation of the IoT is taking place, since the volume of data related to that information related to the state of health is increasing and its availability supports our health and our future.

Businesses have a need for reliable access to data at all times, as downtime comes at an economic cost. Temporary service interruptions cost many millions of dollars a year in downtime and millions of data that cannot be recovered. As in the case of a hospital, data loss in critical situations can mean the difference between life and death. Data availability is of the utmost importance and these temporary outages, when they do occur, should not last more than a few minutes. [5]

When the server fails and data is momentarily lost. In the case of a company that is not in the health sector, the economic costs of data loss are enormous, but in healthcare organizations the cost can affect people's health. So it is very important that the companies that provide their services are aware that it is useless to have complete and updated databases if they cannot have them at all times. Continuous availability is crucial today. The problem of limited availability leads to losses, decreased productivity and direct loss of data due to the inability to recover backup copies. [6]

At present, these challenges are added to contexts of crisis. In a tight economic environment, companies need one hundred percent guarantee that the company's Information Technology (IT) infrastructure is not going to fail at a critical time. The reliability and stability of the computer system, which provides immediate uninterrupted access to files and applications, allows companies to offer continuous availability and becomes a very important area.

The use of the IoT in the provision of health services is increasing considerably. And mainly its benefits are focusing on diagnosis, disease control, and rapid information management.

In recent years, various initiatives have emerged to incorporate the IoT into the provision of health services. Until now, most have been aimed at improving care as such, with the monitoring of some markers and the follow-up of complicated cases from home. However, these deployments and use cases have been just the beginning.

These changes will happen even in fields as delicate and critical as medicine, where it is difficult to imagine machines acting as doctors. However, technologies such as the IoMT and will help to reduce the number of patients, as well as in the prevention of diseases thanks to its potential. Well-being is not a problem that only concerns what happens in hospitals and is that, most of the time, patients get sick outside the places where the doctors are. Therefore, prevention is necessary and this is where the IoMT is focused. Technological specialization applied to the health sector acts in several ways: in the management and collection of data to detect and prevent diseases, implementation of protocols for action in emergencies, saving time and money, or monitoring patients and machines in real time, in other aspects.

This is possible since the IoT is a technology that directly connects all electronic devices for medical, health and pharmaceutical use with each other. This allows patients to develop their lives without having to go to a consultation since devices such as gadgets take care of data management and manipulation by automatically sending them to data centers.

An example of the potential of the technology occurred when an Apple smartwatch saved a patient's life by detecting a strange increase in heart rate that prevented massive blood loss, ultimately saving his life. If we imagine a world of electronic devices like this connected to each other, we can get an idea of the diseases and accidents that could be avoided.

And it is that a simple gadget can monitor health status and send this information in real time to medical practitioners with notifications of our health status and warnings of danger. And not only that: all this information can be used in the pharmaceutical and research fields, being of great help to reduce costs in medicines and prescriptions.

More advanced and integrated approaches are already beginning to be used in the field of digital transformation of health systems with regard to aspects of health data where the IoT plays an increasingly important role. With the help of connected objects in a health ecosystem, the work of health personnel can be much more immediate and precise, in addition to facilitating the management of hospitals, or even of health units that provide primary care, and thereby improve the well-being of the patient.

The medical spectrum on which the IoT can focus is huge as it is such a huge ecosystem that it begins to include new technologies for self-monitoring, the pharmaceutical industry, health care insurance, construction of buildings or facilities that will subsequently provide care. medical, robotics, biosensors, smart beds, smart pills and telemedicine, among others.

It is a fact that by including this type of technology, actions can be achieved that reduce possible latent neglect in health units. Such as smart beds capable of self-monitoring and warning as soon as they are vacated, and regulating the pressure and position of the patient to save time and that health personnel have the availability to focus on all users in the same way.

Of course, the entry of the IoT to the health sector does not come without challenges. Information on the health status of patients is delicate, and the sensors are required to be accurate, and the algorithms that interpret them are well calibrated. But in addition, patients must be assured that their information is preserved and not available without their consent.

Another major challenge facing the use of IoT in medicine is the economic gap that occurs between different countries. To fully exploit the potential of new technologies, the use of smartphones and wearables is essential, but access to these devices is not universal. If the IoT in the home refers to the interconnectivity of virtual assistants, household appliances and other consumer electronics devices, in the medical sector, sensors are also incorporated into other devices to turn them into smart objects, such as X-ray devices, nebulizers, defibrillators, wheelchairs, etc.

On the other hand, the application of the IoMT is not limited to the devices present in hospitals and health centers, but also in devices for patients, which allow them to be permanently connected with their PC doctor.

One of the main uses of the health IoT is for patient monitoring, which with this technology can access their data in real time and offer remote medical care. In this sense, it represents a great advance for telemedicine or remote home health care.

The collection and management of data on vital functions or state of the organism of different patients allows to act more quickly in the prevention of health problems. And it helps emergency teams to develop action protocols more quickly and effectively.

In addition, the Big Data provided by smart devices allow the elaboration of much more complete databases that allow to streamline processes and improve operations. This is a huge plus when it comes to verifying medical information and avoiding fraud. The goal is that, in the future. all this information can be standardized and incorporated into a public database.

The connection in the cloud allows access to data from anywhere and at any time, and also facilitates the exchange and transmission of information between different devices. All this with the intention of improving the connections between doctors-patients-medical team.

In the other hand, the IoMT also contributes to improving logistics operations in hospitals or health centers, such as the use of identification codes that allow monitoring and control of patients' medications.

Advantages and Disadvantages of the IoMT
The use of IoMT is still in an early stage of development, but its potential is enormous.
Table 1 lists the advantages and disadvantages of the IoMT.

Benefits of IoMT

- Saving financial resources is one of the main benefits. Medical diagnosis consumes a large part of hospital bills. Technology can transform check-ups so that instead of going to the doctor, they are done at home with gadgets.
- Improvement of quality of life by preventing diseases and reporting possible health problems. - More efficiency and use of personnel, nurses and doctors can do other more important tasks than the realization of tests that now the devices do.
- Automate operations and manage all collected data. This fact minimizes the work of doctors who can take advantage of to train or treat people.
- It allows to offer a personalized service and in real time to the patient.
- Facilitates telemedicine or home health care, without the need for the patient to have to wait to be treated.
- Favors the creation of related and interconnected databases between different medical devices and equipment. -It allows access to medical information immediately, from anywhere and at any time. - Improves the management of resources in hospitals and health centers and reduces waiting times.
- Reduce the costs of service and maintenance of medical equipment.
- Reduce diagnostic errors thanks to the use of shared databases and the large amount of information stored in the cloud.
- Facilitates the automation of processes and operations, allowing doctors to save time on administrative or diagnostic tasks. It can be combined with other technologies, such as artificial intelligence (AI), augmented reality or robotics.

Disadvantages of the IoMT

- For patients. Some of them still do not trust the use of this technology and prefer the medical visit.
- No standardization. There are countless software and equipment, but there is no standard that allows all devices to be connected to each other and work without interference.
- Security risks. The IoMT also faces the challenge of ensuring that all information is stored in a totally secure way, especially considering that health information is part of the so-called sensitive data.

- Lack of regulations. Being a relatively recent technology in some countries, there are still no clearly defined laws on the application of the IoMT.
- High cost. It is proven that the use of IoMT is profitable in the medium-long term, and requires an investment in hardware, software and equipment. In addition, it is also necessary to invest time in the training and learning of professionals.

Table 1. Advantages and disadvantages of the IoMT.

IoT applications in medicine

The IoMT is currently being applied in many areas such as those that are collected in the following table 2. And due to this, the diagnosis and treatment techniques of patients are changing and will continue to do so in the future. In the not too distant future, the IoMT will allow remote operations using devices connected to each other through instructions given by doctors located miles from the operation.

The combination of IoMT technology, with others such as data analysis, the cloud, artificial intelligence, augmented reality and virtual will be of great help and much more complete information will be available for diagnosing thanks to data collection carried out by the devices carried by the patients and therefore the diagnoses will be faster and more precise thanks to the union of these trends.

The field of hearing is a successful case of the use of the IoT, as is the case of hearing aids that serve to improve hearing examinations, prevent hearing loss or to collect data in the case of needing a hearing implant. And you're not the only one in the industry that benefits from IoT, cardiologists and surgeons do too. This is the case of the Cyber Surgery robot that makes spinal operations faster and safer by freeing the surgeon from work.

Since the devices will be able to collect health data such as oxygen levels, blood sugar, blood pressure or heart rate and send it to data centers that, using big data and artificial intelligence models, can help detect possible patterns and anticipate the appearance of diseases.

The IoMT in combination with these technologies will create a new paradigm and transform society, as is the case with telemedicine.

Smart technology is more present than ever in healthcare institutions and some hospitals have already started to implement “smart beds” in their facilities, beds that detect when they are occupied or when a patient is trying to get up. In addition, they offer the necessary support to save nurses manual interaction, since they have software that interprets pressure changes in different parts of the patient's body, identifying movements, no matter how slight, and sending signals to a patient. computer that is responsible for moving the elements of the bed in a lateral and / or vertical way.

Another smart technology application in healthcare is the home medicine dispenser, which automatically uploads data to the cloud when the patient is not taking medication and the healthcare team is alerted.

-Monitoring of sugar levels.

Glucose level monitoring systems or CGM allow to know what the blood glucose levels of the patients are. In this sense, teams such as Eversense or Freestyle LibreLink have been an important advance by allowing access to data through Android, iOS devices or even through smartwatches. Thanks to smart CGMs, clinicians can access patient information, verify data in real time, and detect patterns or trends. Its use is primarily intended for the elderly or parents of children with diabetes.

-Supply of insulin.

In relation to the previous point, there is also an evolution of smart CGMs that are not only capable of measuring blood glucose levels, but also closing the loop through the supply of insulin when the patient has low levels. An example is the OpenAPS system, developed in 2015.

-Smart contact lenses.

Triggerfish are smart contact lenses developed by the Swiss company Sensimed, which detect changes in the dimensions of the pupil, iris or retina that can be symptoms of the appearance of glaucoma. This information is sent immediately to the health center, thus speeding up the diagnosis and treatment processes. -Monitoring of the heart rate. MoMe Kardia is a device created by InfoBionic and is capable of continuously monitoring the patient's heart rate. Thanks to this system, the data collected is sent constantly and in real time to the specialist's office, allowing the patient to be supervised at all times.

-Digital audiometers.

The IoMT can also be aimed at detecting and treating hearing problems. Kiversal has developed a digital audiometer called Audixi 10 that allows the patient to always be in communication with the doctor and provide data continuously. This streamlines data transfer and analysis. Among other functions, it has connectivity via USB or through the Internet and can be connected to a wide variety of devices such as printers to export data. In addition, it includes a calendar or appointment manager that the doctor and patient can access locally or remotely.

-Smart pills.

One of the examples of smart pills used in medicine is the Ability MyCite. It is a pill developed by Otsuka Pharmaceutical Co. and Ltd. and Proteus Digital Health, which is intended to treat people with schizophrenia or bipolar disorder. This pill incorporates a digital sensor that is activated by dissolving gastric acids in the stomach, sending a signal to a mobile application. In this way, doctors can know what time the medication has been taken and if the patient is following the treatment.

- Monitoring of the heart rate.

MoMe Kardia is a device created by InfoBionic and is capable of continuously monitoring the patient's heart rate. Thanks to this system, the data collected is sent constantly and in real time to the specialist's office, **allowing the patient to be supervised at all times.**

-Coagulation tests.

Roche Diagnostics launched Bluetooth-equipped blood clotting systems. And you can monitor the status of patients in real time and avoid risks of bleeding or cardiovascular and cerebrovascular accidents.

-Microchip implants.

Biohax International has created an implant that is placed in the individual's hand and that allows the activation of numerous devices through NFC technology, since this technology is designed to perform everyday functions of the day to day, such as handling household electronics, make payments, identification at access controls and much more. However, its possibilities are endless and work is already under way on incorporating options related to health, such as monitoring of vital functions.

-Smart inhalers.

RespiroTM is an inhaler designed by Amiko that is programmed to improve the care of patients with respiratory problems. In particular, it is oriented to the analysis of respiratory therapies, studying the response of individuals to said therapies and their impact on the lung health of patients. Another product is ADAMM, which helps people with respiratory problems, a portable monitor developed by Health Care Originals capable of detecting the symptoms of an asthma attack before it occurs. When the monitor detects risk, it vibrates to warn the patient, while sending an alarm message to the doctor's mobile phone or computer.

- Cancer treatments.

At the American Society of Clinical Oncology meeting, data from a project involving more than 300 patients for the treatment of head and neck cancer were presented. It consists of a device that contained a scale with Bluetooth, some blood pressure cuffs and a monitoring app. This smart monitoring system (CYCORE), aimed to track patients' symptoms and measure their body's responses to treatment. The results were defining and showed that the patients who had used this system suffered less severe symptoms and resisted treatment much better than the patients who continued with the usual process of weekly visits without daily monitoring.

- eSim cards.

As one of the problems of the IoMT is the lack of interoperability. Devices are required that can operate with each other and exchange data, which is complicated with current Sim cards, which are based on the exchange of information in private. But eSim do allow the use of different operator profiles and the exchange of data between devices from different providers, which facilitates interconnection between devices and minimizes the use of public networks, which reduces risks to data security.

-Smart Watches.

There are also consumer electronics devices that can be applied to the IoT in medicine. This is the example of smart watches such as the Apple Watch, which incorporates numerous HealthCare functions, including the ability to share information on vital signs, detect falls or a new Api on movement disorder that allows detecting symptoms of Parkinson's disease.

- Obstetrics and Gynecology.

In some Latin American and African countries, with very high maternal and neonatal death rates, IoT devices are being implemented, such as the one from the company MySignals (Libelium eHealth Development), which includes 15 sensors to monitor up to twenty biometric parameters such as the pulse , respiratory rate, blood oxygen, electrocardiogram signals, blood pressure, muscle electromyography signals, glucose levels, galvanic skin response, lung capacity, snoring waves, patient position, air flow and parameters of the body scale. With the aim of monitoring patients at risk of high blood pressure, in order to reduce deaths. Therefore, monitoring blood pressure, EKG, oxygen level, and temperature provide information that indicates immediate risk of seizures and can receive assistance before this happens. The medical team can then rely on this information to decide whether it is necessary to induce labor immediately (Figure 1).

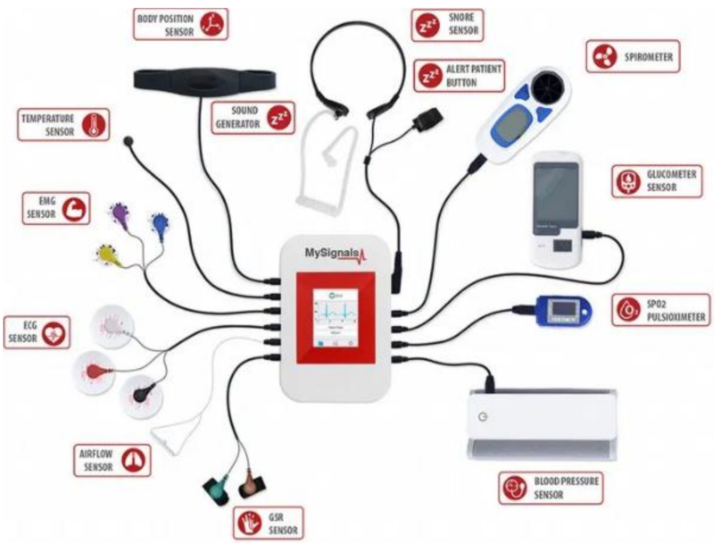

Figure 1. Example of implementation of IoT devices of the company My Signals (Libelium eHealth Development) that includes 15 sensors to monitor up to twenty biometric parameters. Taken from https://www.computerworld.es/negocio/mysignals-nueva-plataforma-de-iot-para-desarrollar-aplicaciones-y-productos-de-ehealth.

There have been big open challenges of cloud and fog computing in the context of IoT. Since both approaches have different benefits and will see a broader adaptation. A suitable solution is for both paradigms to combine to achieve seamless integration of cloud and fog resources in a common pool of IoT resources.

The basic concept of IoT is shown in Figure 2.

Figure 2. Outline of the IoT concept.

Future developments will include mechanisms for fog-cloud interaction, such as automatic resource provisioning, replication, and migration, which are essential to meet the resilience and reliability requirements of the IoT.[9-11]
The value-added service will need to be defined only once and will be automatically provisioned and relocated on demand, to a suitable compute node. Existing services could be combined to create innovative new services. Advances in security and privacy will help keep sensitive data private across all processing nodes from different vendors. Despite the remaining challenges, cloud and fog computing are indispensable tools for realizing a more seamless IoT ecosystem.[9,12]

The two main paradigms for the treatment of large amounts of data. The concept of big data is based on the posterior analysis of the data in batches, while the big stream rewards a real-time analysis, in addition to being able to act more quickly in case of detecting any inconsistencies in the data series.[13-14]

Unlike classic wireless sensor networks (WSN) that generally only serve a single application, one of the main benefits of the shift to IoT lies in the common use of the same hardware or device by heterogeneous applications. In addition, the IoT revolution is not derived only from the number of connected devices, but from the solutions and services offered on the data. The basic requirements of such services can be briefly summarized as follows: non-volatile storage of historical data, data processing, and efficient near-real-time distribution of data. In general, an IoT environment is divided into three different layers or environments, which are cloud, fog and edge, as we can see collected and summarized in Figure 3.

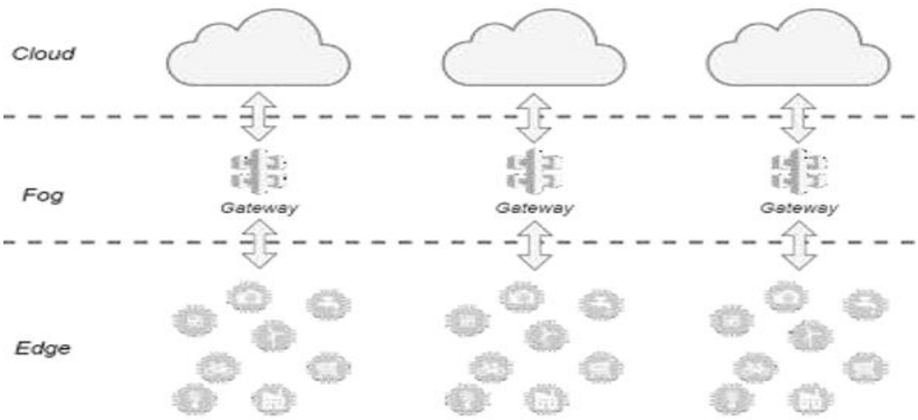

Figure 3. Different layer hierarchies involved in IoT scenarios. The fog layer functions as an extension of the cloud to the edge of the network, where it can support the collection, processing, and distribution of data.[14-17]

Traditionally all the computing power resided in the cloud, the rest of the layers only had the commitment to generate and transmit the data. Cloud computing offers convenient, ubiquitous, and on-demand access to configurable computing resources, which can be accessed via the Internet and generally reside in third-party data centers. Along with these resources, cloud service providers offer fast and configurable networks for data distribution, as well as reliable, non-volatile and replicated storage. Due to its flexibility, reliability, and usage-based payment model, cloud computing is well positioned to meet specific requirements in the context of IoT.[17]

Although this architecture currently works well, it is not suitable for latency-sensitive applications, as data centers in the cloud are not located, neither with connected objects, nor with consumers of value-added services. From a network topology standpoint, cloud data centers are several leaps away from producers and consumers of IoT data. Physical distance causes additional latencies that may not be acceptable for applications sensitive to it, such as device health reporting tasks. Therefore, rather than forcing all IoT communications through a cloud broker, a push has been given to promote data storage, processing and distribution closer to the edge of the network, towards producers and consumers of data.[18,19]

One of the main challenges is that commonly used devices, such as sensor nodes, smartphones, and wearable technologies, are generally battery-powered, making complex storage or processing of a large amount of data unfeasible. The connected objects belonging to a network can also often be too limited to perform those tasks as reliably and quickly as necessary. Devices with restrictive features can save energy by transferring their data to a cloud-based platform where it will be distributed to multiple relevant applications and services, which will process the data accordingly. With the passage of time, IoT devices are increasingly connected to the internet and becoming more and more powerful, but in general they are not capable of large enough processing. Therefore, in recent years, computing power has been placed in the fog (Fog computing), which can be seen as an extension of cloud computing, but which allows services closer to the edge of the network, where cloud and fog computing paradigms share many characteristics.[20,21]

Cloud computing is primarily targeting applications and services that would not be feasible in the cloud. One reason would be to eliminate bandwidth bottlenecks and improve latency for the most common tasks in the context of IoT. To achieve this, fog computing uses the local processing power available today, such as in network hardware or local gateway nodes (gateways), mobile phones, or additional hardware that would have to be deployed in the future between IoT devices and the cloud.

Also in recent years, new developments of IoT devices have appeared with very powerful computing characteristics, capable of performing processing on themselves and obtaining results at the same edge layer.

Edge computing primarily offers two enhancements. One is that the results are obtained on the same device, so in the case of notifying the user it is immediate, and the other is that it is due to the reduction of traffic to the upper layers, since with the sending of aggregates or the results themselves may be sufficient.

For cloud and fog-based computing approaches in the context of IoT, different advantages and challenges are presented and specific use cases of IoT that benefit from cloud and fog computing, respectively, are described.

The primary concern when looking at cloud and fog computing is the actual role these technologies are expected to play in IoT systems.

The basic architecture reference model, it has three layers[19-21]
-Device layer,
-Connectivity layer and
-Application layer.

Generally, cloud and fog technology will be used to realize the connectivity layer by transmitting device data and enabling value-added services at the application layer.

An example would be the stay and care of a patient in the Hospital in which he would be fully monitored and the information available at all times for health personnel from any point (Figure 3).

Figure 3. Patient fully monitored during his stay in the hospital.

CONCLUSIONS

The diagnosis, treatment and monitoring of diseases and medical conditions are oriented towards the incorporation of development technologies created not only in hospitals, but also in large corporations dedicated to the development and implementation of software.

Today, concepts such as nanotechnology, big data, wearables, are developed to monitor the health status of the general population and each person gets used to having in his pocket, monitoring blood pressure, cholesterol levels, weight, index of body mass, up to the tracking of more advanced programmable biotech equipment that can keep the heart beating.

Wearables are those devices that we carry and that we get used to having, such as a wristwatch that shows the heartbeat and at the same time, reminds us of the day's agenda.

The interconnection seems to point to simple and ideal solutions to send reports and diagnoses in real time to the doctor. The objective is not only to carry out early clinical diagnoses, the goal goes further, it is to prevent serious health conditions, launching alerts in real time when something is not going well in our body.

The implications of devices and patients being linked to the cloud. The information is a key piece to determine trends, risk factors, daily habits that can improve or worsen a certain medical condition; the collection of data, big data, will help improve health schemes and programs, there will be real-time information on the areas of medical devices that require more attention and the results that previously took years to collect, measure, empty and publish , today they are obtained through fast and simple applications that we install on our mobile device. Therefore, the IoMT is going to revolutionize the care of the patient of the future, as well as many other areas of companies and society.

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