Low-Cost System for Interoperability Between Outpatient Medical Devices with Medical Records

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Abstract: In these times with the evolution of technology, many solutions related to the interaction between the different actors and systems related to the health sector are being presented, it is the case of the interactivity between the different medical equipment and health information systems. In this paper we present a method to apply these concepts related to interoperability between medical equipment and information systems through the use and exploitation of IoT technology with XML messages to achieve interoperability, the method proposes the update of medical equipment through IoT devices, to export the signals captured in patients. The method proposes the use of a signal receiving station, which must be located in the health center, this application is responsible for generating the XML message from the signals received and finally the methodology proposes the exploitation of the message, by using the message with the information systems that work the health center. As a result we indicate an example of message generation from patient data and information that can be captured in an ambulance and finally the conclusions are related to indicate the necessary requirements for implementation and scaling, we must indicate that throughout the work refers to a demonstration by sending information from an ambulance.

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1 INTRODUCTION

When we talk about interoperability, we refer to the way in which different automated and computerized systems can communicate with each other automatically, without the need for the intervention of an operator, these automated communication tasks are translated under an application that makes it possible for these very different systems to communicate with each other, thanks to the different communication protocols, It is in this line that we present the following work to indicate the importance, uses, applications and techniques that govern the ecosystems of interoperability, we found a work where the intention is to check with a low cost system, can improve the management of hospital services, through communication between hospital care systems and HIS systems (Auccahuasi, et al. 2021).

Interoperability is also reflected in the use of biomedical and electronic devices where an electronic part is used, i.e. implanted in the patient's body, which replaces the biological structure of the heart, where iEEG signals are processed and recorded with the use of IoMT technology (Subash, et al. 2020).

The use and exploitation of wireless technology, in order to provide solutions to the problems related to the health of the population. Thanks to the use of IoMT, which is mainly related to the use of IoT technology applied to the health sector, solutions are being implemented in health centers, in order to support diagnosis, optimizing medical resources, with which security and interoperability can be monitored, within the framework of the coexistence between IoMT and blockchain technology (Li, et al. 2021).

In the use of IoMT technology, applied to medical devices, which collect information about the health of people through the internet, where data will be obtained from patients in order to be treated, we found works where different samples were analyzed for the discovery of tumors by analyzing the characteristics of images to discover their presence. The technique uses a set of advanced features with which brain tumors can be discovered with respect to their developed degree, which was first validated 10 times comparing it with traditional methods such as CART, Random Forest, Naive Bayes and Random Tree obtaining results that reveal that the set of features can replace traditional techniques with an accuracy and mean F with results on a higher performance during the evaluation (Khan, et al. 2020).

We found works referred about accuracy and consistency about fetal monitoring interpretation, for which a framework for intelligent analysis and automatic interpretation of digital cardiotocographic signals recorded from fetal monitors based on Internet of Medical Things (IoMT) is developed, which implemented a method and system with which to assess fetal conditions during pregnancy showing accurate warning signs being used by media centers applied in patients from home with which the data segment is analyzed in a record by automatic scoring functions such as Kreb's, Fischer, classification, where the results have been compared with the interpretations of obstetricians concluding that the results are accurate compared to traditional examinations (Sridhar Raj & Madiajagan, 2021).

In the use of devices related to diagnostic assistance, we found works where an interface is developed to send information related to heart activity through a framework to the doctor's workstation, under an E-health approach, with which the reconstruction of the signals can be performed, thus proving that the developed framework meets the functions of interoperability, making possible the transmission of secure medical information (Lu, Qi, & Fu, 2019).

The use and exploitation of IoMT technology is addressing countless limitations of traditional healthcare systems, as well as assessing the quality of care provided to patients, among others. With the use of IoMT systems and interoperability, unparalleled benefits are being realized that are improving the quality and efficiency of treatments and thereby improving the health of patients (Adewole, et al. 2021).

When we address the issues of interoperability under the IoMT approaches, it is not only to be able to send and receive information related to the health of patients, but it is also related to the procedures necessary to ensure the integrity of the signals, from sending to receiving, trying to ensure the consistency of the data and avoid the loss that could bring a problem related to the variation in the signals, which would cause a bad diagnosis, we find works where emphasis is placed on the use of different solutions based on the detection of attacks through the use of applications that ensure the information sent through the IoMT protocols (Kumar, Gupta, & Tripathi, 2021), (Alsubaei, et al. 2019).

Among the various solutions that can be developed, these are also the use of devices that make possible the use of emerging technology, we find works where reference is made to the use and

exploitation of RFID devices, as an authentication mechanism to enter the ecosystem of the IOMT, which ensures the integrity of the signals from the transmitter to the receiver, and evidenced in the display systems (Kang, et al. 2021).

After having described several works related to the use of IoMT, IoT and RFID technologies, we realize that more and more equipment comes with these built-in protocols, which enable connectivity with information systems, allowing interoperability between equipment and information systems dedicated to the field of health, in this proposal, We also present as a complement a proposal for the design of an application based on the XML standard to achieve interoperability. The proposal can be scaled using different components as well as presenting more complex developments in the part of the applications.

From the works described, we can indicate that the issue of interoperability between different systems and equipment is achieved by working with the use of IoT techniques and one of its variants IoMT, in this work we propose to use the same techniques, but in an environment of direct communication between medical devices that can be connected in ambulances, which have connection to the information systems of health centers, for which we use IoT devices that have the ability to acquire signals and can be sent to various servers and services through wireless connections. We present the procedures to implement the method in a clinical environment.

2 MATERIALS AND METHODS

In the development of the methodology, we present 4 main components that we describe below, with the intention of being able to indicate the necessary steps to be able to be replicated in this way, where we start with an analysis of the problematic situation, we continue with the analysis of the various devices that we can use to update the medical devices that we wish to interconnect, we continue with the description of the communication protocol where we present how an XML-based message can perform the communication between the medical device and the computer system and finally we describe the protocol to demonstrate the usefulness of the methodology.

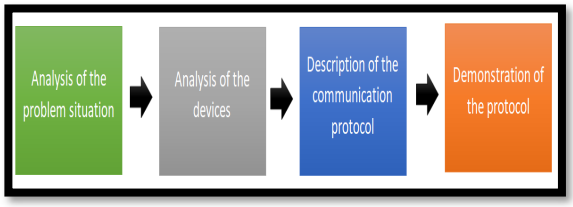

Figure 1: Description of the methodology.

In Figure 1, we present the description of the methods to be developed, starting with the analysis of the problematic situation, analysis of the devices, description of the communication protocol and ending with the demonstration of the protocol.

2.1 Description of the Problem Situation

The problem situation that we can describe is related to describe a low cost mechanism to connect between various medical devices with various information systems, we can indicate as an example to demonstrate the methodology presented, what happens in a traffic accident situation, when the patient is in the ambulance, is subjected to various equipment to monitor vital signs, in a conventional situation, the ambulance arrives at a health center for care, it is at this moment that the care begins in the health center, with which the doctors treating the patient just begin to know the patient's condition.

With the proposed methodology, having as interoperability mechanisms, the connection of an IoT device in the medical device, as well as information systems may have the ability to read an XML file and to execute update procedures to your system, with these implementations and / or updates to both the medical device and information systems, connectivity is achieved and therefore interoperability, As a demonstrative example we can indicate that in the case of ambulance, we have a team that measures vital signs and these are connected to an IoT device, which becomes a Smart medical equipment, which has the ability to connect with different internet services, the proposed method consists of creating a message using XML language with the data acquired from the patient and that can be shared with the information systems that are in the health center to which the ambulance is going.

The information systems must have the capacity to receive and read the XML messages and the data obtained to update the systems, with which following the simulation with respect to the case of

the ambulance, in the health center know at all times the status of the patient who is about to arrive and can be prepared to receive them to apply their procedures, due to the knowledge in advance of the patient's condition, doctors can know and schedule procedures in order to reduce the time of care and thus to reduce the risk of any complication.

2.2 Analysis of the Devices

The heart of the presented method, are the IoT devices that we describe below, these are frequently used in many solutions based on IoT, is used for its ease of use, its reliability in the work and its low cost, which allows to be used in many products, these devices allow connectivity with web services, allows to perform data acquisition systems which allows to capture and send them through their communication protocols, as well as to adapt different communication protocols with in the case of communication.

The bass devices that have been considered to propose their use, are decided exclusively in the implementation of IoT based solutions, for which they have the following characteristics:

For the case of the ESP32 model, according to figure 2, among the main advantages, is its high performance processor that allows to perform various tasks simultaneously, with this feature we can perform the acquisition of data and send them to a station in the cloud, has WIFI connectivity with Bluetooth integrated into the same chip, allowing dual band communication simultaneously and one of its main advantages compared to similar devices, is its low power consumption and robust design, which allows to be very small in size, complementing the advantages, the device has a number of modules and development kits, allowing to integrate many solutions.

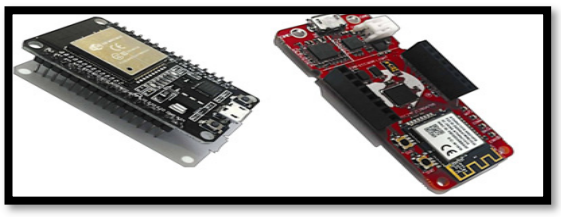

Figure 2: IoT devices.

One of the fundamental characteristics of this device is that it has integrated three advanced processing modules, the first is an encryption which ensures the sending and receiving of data, the second chip is the WI-FI module that allows the connection to nearby networks and the third is a module of light and temperature sensors, which allows to complement the different solutions that you want to complement.

2.3 Description of the Communication Protocol

The communication protocol described, in order to demonstrate the method, consists of three components, each of them with a fundamental characteristic that together allow coherence in the exploitation of resources for the benefit of patients' health.

The first component is made up of IoT devices that will be connected as update mechanisms of the medical equipment that you want to work, in the demonstration case, described in the problematic situation, we have that in an ambulance the most important equipment is the vital signs monitor, which allows us to have the information of the state of the patients, to be able to export the signals that allow us to monitor the patient's condition in the ambulance, it is necessary to attach to the medical equipment, IoT devices, so that they can connect to a communications network that can be the WIFI network of ambulances and transmit the signals to the health facility that awaits the patient.

The coupling between the medical device and the IoT device can be done through different communication protocols that the medical equipment may have, such as RS-232, RS-485, universal serial port. Through these communication protocols the signal is exported to the IoT devices who will transmit the data.

The second component is related to the configuration of IoT devices, as mentioned, these devices have a particularity that can connect different data acquisition mechanisms and at the same time configure a wireless network to send the data received, with this mode of operation, we can record the signals coming from the vital signs equipment as well as the patient's personal data. These data are transmitted to the health center, previously the ambulance has to be equipped with internet communication through a WI-FI network.

A third component is related to the design of an algorithm that can convert the values entered in the IoT devices and convert them into a message that has the XML format, this algorithm must be installed on a computer in the health center, so that when the information is received from the ambulance, automatically becomes XML message, Complementing this algorithm, a program should be created to read the XML message and this data can

be displayed on a monitor and also enter the different clinical information systems that the health center has, such as the system of electronic medical records, HIS systems, where you can start the process of patient admission, know your medical history, if you are allergic or other important information that streamlines the care process.

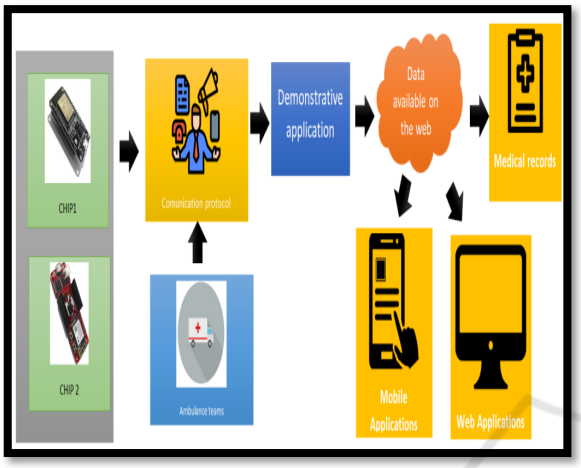

Figure 3: Description of the communication protocol.

Figure 3 shows the diagram of the protocol described, where the elements that make up each of the components, the workflow mode as well as the interactions with the devices and systems can be seen. The following are the main procedures of the protocol, as well as its corresponding flowchart, which describes the use, application and generation of the XML message.

1. Received a sample of the received signal
2. Retrieve the data
3. Generate the XML message
4. Verify that the data satisfies the information need.
5. Send the XML message to the different systems

2.4 Demonstration of the Communication Protocol

The demonstration of the protocol is intended to describe the data transmitted by the IoT device located in the ambulance to the receiving station located in the health center, where the data is processed and the XML message is generated and then exported to the different information systems. Figure 4 shows graphically how the XML message is generated.

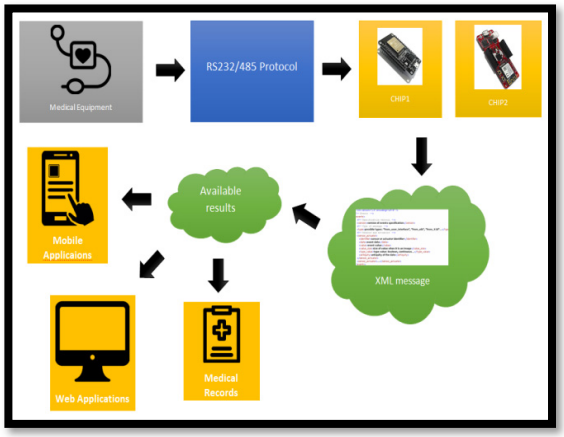

Figure 4: Diagram for XML message generation.

Figure 4 shows the sequence of processes to generate the XML message, one of the important considerations is the export of the signals that allow the identification of the patient's status by the medical equipment, the export of the signals can be done through the communication protocols that the equipment has, in this case it can be RS-232 or RS-485, through which it can be entered to the inputs of the IoT devices, with this information is generated in XML message and exported to the different information systems that the health center has.

3 RESULTS

The results we present are related to present an example of how an XML message would be generated in an application, after receiving the signal from the IoT device of the ambulance. Below we present an example of the message where the application that generates the message is identified, the patient data that can be the name and surname, age and document number. Also the message contains the information of a device that measures medical parameters; the possible values to have are heart rate and oxygen saturation.

The data that can be contained in the XML message can be configured depending on the information that is available.

Information of the application that generates the XML message.
<ns0:device medical
xmlns:ns0="http://myapplication.php">

Patient data information

```
<header>
  <firstName>John</firstName>
  <lastName>Scott</lastName>
</header>

<body>
  <header>
  <document>78985</document>
 </header>
 <body>
  <age>
  <document>25</document>
  </age>
 </header>
```

Patient data information
Heart rate

```
</header>
 <body>
  <heart rate>
  <document>55</document>
  </heart rate>
 </header>
```

Oxygen saturation

```
</header>
 <body>
  <Oxygen saturation>
  <document>80</document>
  </Oxygen saturation>
 </header>
```

We must take into account that the data with which the XML message is generated, depends on the parameters recorded by the medical equipment, in our demonstration example, mention is made of a solution that tries to send the signals that are in an ambulance, so that the hospital center can know the patient's condition before they arrive at the health center. If more medical data is required, it is necessary to have medical equipment that can acquire the signals to be analyzed.

One of the important considerations in the development of the application for the generation of the XML message, is related to the computer tools that can be used, the choice of the tool will depend on the mechanism as the signal is received from the ambulance, normally it can be received through a serial console, where we can configure to a buffering mechanism, from which you can retrieve the information to generate the message, the programming of this application will depend on the experience of the programmer.

4 CONCLUSIONS

The conclusions we reached are dedicated to three components that are part of the method presented, first with the adequacy and updating of medical equipment that can have the ability to export signals wirelessly, for which it must perform a procedure for updating and adequacy of the IoT device, in this sense is a fundamental part of this procedure.

A second component is the application that must have the ability to transform the received signal and be able to transform it into a message in XML, this work is also very important, because it is required to be able to read the signal and transform the data, and then be included in the message, this process can be done continuously, if continuous values are required, or periodically when it is required to know the status of patients in a transfer procedure in an emergency, this mechanism is vital because you can have the information in a real-time configuration.

The third component is related to the exploitation of the XML message, where it is proposed to have a monitor in the emergency room where the patient's status can be monitored in real time, as well as to be able to communicate with the hospital computer systems that the health center has, such as the electronic medical records, to know the patient's medical history, with the pharmacy system to be able to have available the medicines required when the patient arrives at the emergency room, with the computer systems of the insurance companies, if required to know if the patient has any insurance, among other applications that can help to reduce the time of care and thus minimize the effects of lack of care.

As limitations, we can point out that the need for connectivity, this technological requirement is very important because the ambulance, must have the connectivity, in this way the information can be sent to the health center, you can also resort to mobile internet networks, through mobile equipment, with this configuration the IoT device sends the information through the mobile device.

The future work that we can recommend is related to exploiting interoperability through the use of XML messages between different devices and information systems, thus taking advantage of the information and computational resources available.

Finally we can indicate that the presented method can be applied and scaled, depending on the

experience in the management of IoT devices, as well as the development of applications where the information can be used in many applications, in the demonstration of the method two IoT devices can be identified, but they are not exclusive, other models can be used, as long as they meet the conditions of connectivity.

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