I^2PHEN : A Novel Interoperable IoT Platform for Medical Telemonitoring

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Abstract. Medical telemonitoring is an undergoing development field all over the world. We propose in this paper our novel platform I^2PHEN (**I***oT* **I***nteroperable* **P***latform for low power* **HE***alth mo***N***itoring*) that allows the monitoring of a patient's health parameters using connected objects (blood pressure monitor, thermometer, glucometer, ...) which communicate with the remote platform. The central server can then trigger alerts that were previously defined with the medical teams. For our platform we chose the LPWAN networks (Low-Power Wide Area Network) that offer a cost-effective alternative and are less expensive in terms of energy than cellular networks for transmitting small amounts of data from sensors and energy efficient battery powered objects over long distances.
This field being new, and not widely used in the medical area, it is necessary to propose new solutions to remove some scientific barriers. The first obstacle is the availability and the reliability of these new networks, and more generally obtaining a better quality of service (QoS) necessary in the critical area of telemedicine: our *COMMA* first protocol is an answer. The second obstacle, and probably the most difficult, is to propose interoperable solutions in which connected objects can interact, through these new networks, with the remote platform using a local gateway: our *MARC* protocol is the answer.
Keywords: Medical Telemonitoring, IoT, Interoperability, LPWAN, LoRaWan, Continua, Adaptive Data Rate.

1 Introduction

Medical telemonitoring allows a health professional to remotely interpret data needed for medical follow-up of a patient [1] [2]. It is intended, for example, for seniors and people with chronic diseases.

The use of telemonitoring presents several advantages for patients as well as for medical professionals in all stages of chronic diseases, beginning from the preventive stage up to the post-treatment stage [3]. It allows, among others, improving remote medical care, fostering their home support, allowing early prevention of possible hospitalizations, Improving the coordination between the different medical team, ... The main goal of telemonitoring is to improve the quality of life of older patients and to reduce public spending through home care.

Existing platforms for patient health parameters monitoring are realized with the help of connected objects and connected medical devices (blood pressure monitor, thermometer, glucometer) which communicate with a local smartphone platform or systems like Arduino and Raspberry pi [4] [5] [6] [7]. The server retrieving these health parameters can then trigger alerts according to a set of criteria previously defined in collaboration with the medical teams.

In this article we present our new platform I^2PHEN (**I***oT* **I***nteroperable* **P***latform for low power* **HE***alth mo***N***itoring*) which allows to solve the issues of health device interoperability, but also to energy saving, as well as the mobility of patients.

After this introduction, the first section of this paper presents the state of the art in this field, the next section introduces the new platform I^2PHEN, followed by our two new protocols, COMMA (*COMmunication protocol for optiMization of trAnsmitter energy*) and MARC (*Monitoring distributed AlgoRithm using Connected health objects*).

2 State of the Art: IoT Standards

2.1 IoT Application Environments

The Internet of Things designates all physical objects connected to the Internet allowing a communication between our smart objects and their digital existence. The main evolutive factors are the energy consumption, in relation to the lifetime of batteries, and the public network coverage for objects to be connected everywhere regardless of a third-party gateway like a smartphone.

For wireless communication on a small distance, protocols such as ZigBee, Zwave and Bluetooth Low Energy (BLE) have been thought for low energy consumption in a relatively small environment, for example a house, and allow the development of Smart Homes. BLE technology, also called Bluetooth Smart is a protocol created less than 10 years ago and has very good specifications for low-power wireless communications compared to conventional Bluetooth. The design has been thought for very low power consumption devices, making it ideal for autonomous battery powered sensor nodes. Bluetooth Smart can therefore be used to communicate between relatively close local objects (less than 100m).

For object deployment in a larger environment as well as in nature, other means of communication are employed. Cellular networks are massively used around the world to interconnect smartphones outside the home and to participate in the Internet of Things. Telephone operators offer a coverage of the territory using different cellular technologies : 2G, 3G, 4G and soon 5G. The use of 2G is particularly interesting for battery-powered sensors because it is relatively energy-efficient compared to other technologies. Initiatives are underway by the 3GPP consortium to standardize this type of connection and offer versions adapted to objects, with low energy consumption. The 5G will include a low power consumption mode. However, the key communication factor *IoT* is the arrival of Low-Power Wide-Area-Network, or LPWAN [8] : extended networks with low energy consumption. LPWANs pave the way for new wireless (radio wave) technologies designed specifically for low bit rate IoT applications. The major advantage is the very long-range communication coverage up to several tens of km while a GSM network is of the order of 1 to 2 km. Another important advantage is the very low energy consumption (an economy factor of 10 compared to Wifi or 3G) with the possibility of hibernation (asynchronous mode).

The LoRaWan and Sigfox protocols are part of LPWAN networks. They use public frequency bands : these bands can be used free of charge provided that the maximum duty cycle and the maximum transmission power are respected. These two protocols are low-power alternatives for exchanging data over a very large distance with a very low bit rate. They are ideal for exchanging small non-continuous messages between objects, or through a gateway. They cannot be applied for streaming, nor for sending images, but can be used to transmit sensors data.

2.2 Health Domain, *Continua* : an Interoperability Standard for Health Sensors

Like standard connected objects, the number of CHO (Connected Health Objects) and CMD (Connected Medical Devices) is significantly growing. Their number has risen from 46 million in 2015 to 101 million in 2018. By 2020, their number is estimated at 161 million with a market expected to reach 400 million euros [9].

It is important to distinguish CMDs from CHOs in e-health. Medical Devices (MD) are governed by the European directive 93/42CEE (26) and are subject to the label ”medical device” . The notion of CMD therefore simply signifies the adjunction of a connectivity to the DM [10].

The *Personnal Connected Health Alliance* (PCHA) [11] [12] is an international non-profit and open group of nearly 240 health care providers, and develops the Continua standard. The main goal of Continua is to facilitate and secure the integration of new models of health sensors dealing with hospital information systems and telemedicine platforms. It is the only internationally recognized standard for connected health that is supported by the European institutions (DG Health and DG Connect) and since early 2017 by the Office of the National Coordinator (ONC) in the United States. It defines the structure of the data exchanged, the means of communication, the steps in communication with objects as well as the safety of the devices. This allows a much faster and cheaper integration of new sensors (Plug & Play) provided that they comply with the Continua standard. Currently about 200 connected objects and medical devices have Continua certification.

Continua is a standard based on existing standards, such as IEEE 11073 for personal health sensors, HL7, HL7 FHIR or SNOMED CT (nomenclature of clinical terms in the medical community), as well as the PCD-01 IHE transaction (definition of profiles for heart rate, blood pressure, weight, ldots).

The PHD and IEEE 11073 standards have the concept of agents and managers. Agents are personal medical devices and are usually small inexpensive devices powered by batteries, with no display nor user interface. Managers are typically small computers or smartphones with larger computing resources and routing capabilities required to convey information autonomously from the source to the target.

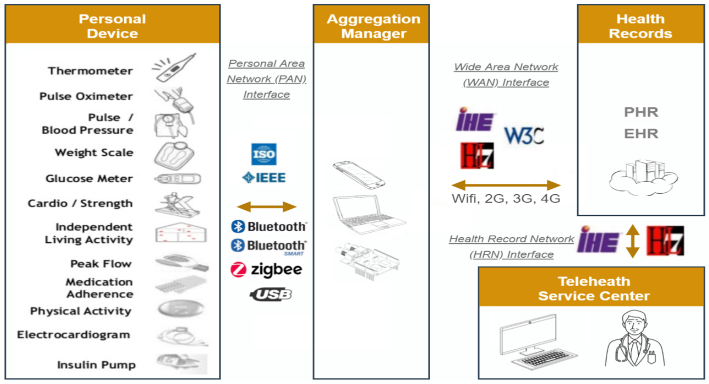

Fig. 1. Continua Architecture

2.3 Communication Aspects of Health IoT

Communication between the Object and the Local Gateway: The PHD and IEEE 11073 standards define the messages that travel between the agent and the manager, but not how these messages should be moved. Continua is a standard that includes PHD IEEE 11073 but also defines transport layers, security, ... Four transports have been defined: Bluetooth (with Health Device Profile HDP), Bluetooth Low Energy, USB Personal Healthcare Device Class and ZigBee Health Care Profile.

Communication between the Local Gateway and the Network Core (Backend) LoRaWAN is a telecommunication protocol that enables low-speed radio communication of low-power objects communicating using LoRa technology. It is a part of the Low Power Wide Area Networks (LPWAN) [13] and it specifically allows a very long distance communication(a distance between a bridge and an equipment up to 5 km in urban areas and 15 km in rural areas), a very low energy consumption by sending a message every hour, the system consumes on average 5 µA (this corresponds to a lifetime of 5 years for a battery of 400 mAh).

It is a cost-effective and cheaper alternative to cellular networks for transmitting very small amounts of data. The LoRaWan protocol is based on spread spectrum modulation technology. LoRa, for Long Range, is the name given to the physical radio-frequency layer. Semtech's LoRa chips operate on 434 and 868MHz frequency bands in Europe and 915MHz for the rest of the world. These frequency bands are called ISM, ie, they are reserved for Industrial, Scientific and Medical fields. It can be used free of charge provided that you respect the maximal transmission power that is usually 25 mW for LPWAN, and the duty cycle (*limited flight time*).

The 868MHz frequency band, used in Europe, is a European Low Power Networks (LPWAN) public bandwidth that LoRaWan uses for communication. ERC-REC-70-3E [14] defined by the CEPT (European Conference of Postal and Telecommunications Administrations) for Europe and applications by country, such as ARCEP 2014-1263 for France. This frequency band, which ranges from 865MHz to 870MHz, is split into 6 channels with different regulations per channel (figure 2).

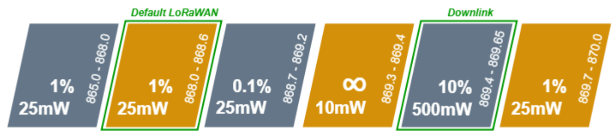

Fig. 2. The European Public Frequency Band 868 MHz

The first 865-688 MHz channel and the last 869.7-870 MHz channel are not used by the LoRaWAN protocol by default, but they can be extended for LoRa channels. The second channel is used by default in the LoRaWan protocol. It is on this frequency band that the 3 standardized LoRaWan sub-channels of 125 kHz each are located. It is on the width of these subbands that spread spectrum will be used during radio communication. The third channel 868.7-869.2 MHz is an area where the duty cycle is 0.1%. This area is interesting when an object emits very small amount of data per day : the risk of collision is actually lower and the reliability of communication is increased. Thus this sub-band is interesting for conserving energy or to communicate a priority message. The fourth sub-band 869.3-869.4 MHz is not usable for long-range LPWAN because the maximum power is only 10 mW, but without duty cycle it is a good area for the communication of local objects without message limitation. The 869.4-869.65 MHz channel is particularly interesting because you can communicate with 500mW and a duty cycle of 10 %. An object would not be able to use such power when running on battery power, but from the point of view of the network core it is a very good channel for downlink communications. Having a greater power will maximize the chances of the device to receive a message from the gateway, the antenna of it is often less efficient than the gateway, especially because of interference. For LoRaWAN, the duty cycle is managed on each channel. Therefore, by alternating bands 1, 2 and 6, it is possible to use up to 3% of duty cycle.

By default the operation is based on the ALOHA type for which the principle is simple: the data can be sent at any time by the transmitters and when a packet is lost due to a collision, it will be re-transmitted after a random time. The equipment therefore sends data without controlling whether the channel that it uses is available. Although several LoRa simultaneous transmissions can be processed by a single remote gateway (antenna), the nature of access to ALOHA support inevitably leads to the presence of transmission collisions and therefore loss of messages. A pre-listen (LBT) listening procedure (*Listen Before Talk*) can be used beforehand to guarantee a measured RSSI (*Received Signal Strength Indication*) of less than 90 dBm before any data transmission to significantly reduce collisions. LoRaWan also relies on the LoRaMAC protocol, which defines the interaction between nodes and remote gateways.

The ADR (*Adaptive Data Rate*) mechanism [15] [16] is used to improve transmission time and energy consumption in the network. The protocol is based on the fact that LoRaWAn allows objects to individually modify transmission parameters, including Spreading Factor (*SF*), transmit power, and frequency bandwidth. The combination of these parameters makes it possible to adapt the flow rate (DR) and the transmission power (TX). The principle of the algorithm will then be to minimize these communication parameters while still ensuring exchanges between the device and the gateway. SNR (*Signal to Noise Radio*) are used by the gateway to evaluate the quality of each message exchange. By keeping a history of the SNRs on the last X communications, it is possible to evaluate the optimal transmission power to reach the remote antenna under minimal conditions. When a message is not received, for example during a change in environmental condition, the sending power is incremented step by step until the connectivity is restored. The ADR can therefore be activated when a terminal has sufficiently stable RF (*Radio Frequency*) conditions, and therefore generally useful for static devices. But it should be noted that the ADR algorithm can not be used in continuously moving systems.

In the end the adaptation of the bit rate also improves the reliability of the network in terms of performance since the messages are sent with less power, there is less chance of collisions with other messages and less chance of saturating the network by overflooding it (the more collisions and loss of messages, the more messages are sent with higher power, and more collisions will happen).

The LoRaWan protocol defines different device classes (A, B and C). This enables to setup a communication strategy per equipment in order to be the most reactive possible and more energy efficient. The A-Class is the most energy efficient. It defines that the device can send data whenever it wants and without any control. However, receiving a message is done only on receiving windows opened after emissions. Receiving windows are only opened after an emission, as this enables to notify the backend when a downlink message can be sent to be received by the device (figure 3).

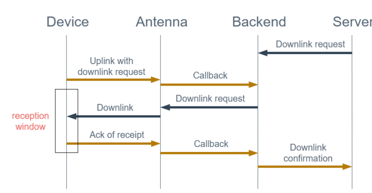

Fig. 3. Message Reception by Equipment with Receiving Window

The B-Class is based on receiving window openings at regular intervals. This requires some synchronization between the equipment and the server. This class offers a compromise between energy saving and regular downlink communication needs. The C-Class is the most energy greedy because the equipment is always listening. This allows bi-directional communications that are not scheduled at any time. However, the reception power consumption is between 10 and 11.2 mA, which reduces the battery lifetime from 400 mAh to 40 hours where it could last 5 years according to Bellini [17].

Communication between the Network Core (Backend) and the Processing Server (Medical Assessment) We use the Continua Design Guidelines, not for creating a new health device, but for receiving health data on a local gateway. This data will be sent from health devices already certified Continua (there are currently about 200) [18] [19].

3 Contribution

We have just presented the state of the art on long-range and low-power networks as well as interoperability between connected medical health devices. Medical telemonitoring platforms using IoT technologies are very recent. They have appeared in the last two years in the literature [20, 21] but still remain in the research field, and are not very applicable in the industry.

We have inspired ourselves on this research field to develop, from end to end, our own medical remote monitoring platform and providing additional insight on the interoperability of connected medical devices. Our research focused on the reliability of Lora networks in a mobile environment (COMMA algorithm) as well as intelligent monitoring (MARC algorithm). We will present in the platform section.

3.1 Our novel platform I^{2}PHEN

In order to address the issues of interoperability of health devices, and also to save energy, and reduce costs and patient mobility, we decided to design a new mobile remote surveillance platform called I^{2}PHEN (**I***oT* **I***nteroperable* **P***latform for low power* **HE***alth mo***N***itoring*). This platform uses a local gateway to receive data from Continua-certified connected objects as well as to transfer this data to the remote gateway. Figure 4 describes the overall architecture of the platform.

We developed our first prototype of the I^{2}PHEN platform. We used an Arduino UNO type gateway with a USB CSR 4.0 dongle to use Bluetooth LE and exchange messages with Continua-certified connected objects. In addition we have chosen a Dragino LoRa Shield module which is a long-range transceiver compatible with Arduino. It is based on an open-source library. The LoRa Shield includes a Semtech SX1276 chip, a low-power extended-spectrum transmitter for sending LoRa messages. We use the

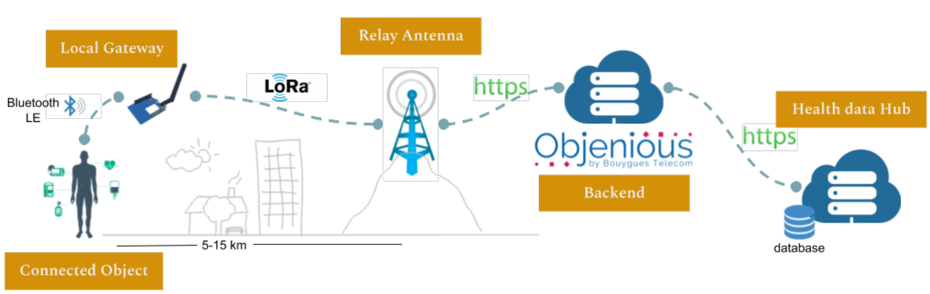

Fig. 4. I^{2}PHEN Platform Architecture

arduino-LMIC library from IBM LMIC (LoraMAC-in-C), slightly modified to run in the Arduino environment and allowing to use the SX1276 transponders. This library makes it possible to send and receive LoRa messages at the backend server (network core) with the advantages of LoRaMAC protocol.

For the network core, we have chosen Objenious, a subsidiary of Bouygues Telecoms which offers a LoRa-compatible network with antennas located throughout the French territory. This network uses the 868MHz frequency band. All transmitted packets will include an AppEUI field and a DevEUI field to identify the declared application and the gateway on the backbone. The latter can ignore received packets whose gateway identifier is not recognized. Finally, this gateway offers the possibility of transferring the data to our own health data hosting server without having to save it on our own.

The I^2PHEN data server deals with sensible patients' health data, and must comply with the country-specific directive (in France HDS certification delivered by the french aothority ASIP Santé *Agence française de la Santé Numérique*). This server stores the health data in a noSQL database of ElasticSearch type and in JSON format. In addition, on this server will be implemented an algorithm for detecting personalized alerts according to the vital parameters of the patient. We can quote the works of Hristoskova *et al.* [22] based on ontologies.

In medical telemonitoring, we need to ensure high reliability in the communication of health data, which is not necessarily the case currently with LoRa technology. That's why we have implemented several improvements to increase the reliability of communication while continuing to save energy. In addition, the properties of integrity, confidentiality and traceability will be preserved.

The gateway has three modes of operation resulting from different use cases of health devices and their degree of urgency: (1)ALL+ mode in which the gateway is permanently awake. It is therefore able to receive data from a permanently connected health device. We can thus take into consideration the health devices that constantly monitor a patient. This is called MBAN (*Medical Body Area Network*). The local gateway will also be able to receive a message from the remote gateway at any time. The use of C-class LoRaWan protocol will allow the gateway to request at any time measurements from the connected health device, to get them back in real time and to receive an analysis feedback from the server and/or the opinion of a specialist. This mode of operation has the only disadvantage of being very energy-greedy, and consequently of not being able to operate on battery. (2) ALL- mode which is based on the same operation as ALL +, except that the device is not listening permanently on LoRaWan long distance communication. However, a message will be sent every X minutes to the remote gateway for the purpose of receiving messages descending over a short time window (see principle of class A of the section 2.3). This message will also guarantee to the server that the local gateway is still in operation. (3) MANUAL mode which corresponds to the situation whereby a health device is not permanently on the patient and measurements are done manually (like a tensiometer for example). At the time of manual measurement with the health device, the bridge must be woken manually. The health data can then be transferred to the latter which will transmit to the remote gateway.

The use of a particular mode to the detriment of another is related to the different use cases of the platform according to the medical follow-up sought for the patient. For example, in the case of a blood glucose test taken twice a day by a patient with diabetes, it is advisable to use a manual mode. In the case of an automatic heart rate measurement, the ALL + mode will be strongly recommended for real-time monitoring.

To allow the awareness, the local gateway is equipped with a multi-color LED: orange during the long distance transfer and green for a few seconds once the acknowledgment of receipt received, the LED will turn red in case of connectivity problem .

The communication protocols are secured end-to-end in the I^2PHEN platform. Communications established according to the Continua standard (USB, Bluetooth, ...) are already secured. For LoRa messages, we use 128-bit AES key-based identification key management, coupled with device identification fields (DevEUI and AppEui) and an OTAA activation procedure (Over the Air) defined by LoRAWAN. Finally, between the network core and the IoT server we communicate by secure https requests. The figure 5 shows the different transport levels of our platform.

3.2 Two Original Protocols

Within I^2PHEN we propose two new protocols that remove important obstacles in the world of Health IoTs.

COMMA (*COMmunication protocol for optiMization of trAnsmitter energy*) The *ADR* algorithm allows a significant energy saving in static systems with a relatively stable environment. In the context of a constantly moving object, the ADR algorithm can not be applied because the environment changes regularly over time and the optimal calculated communication parameters can no longer be applied. However, in the daily use of the remote monitoring platform by an active person, we find that mobility is relative: individuals move regularly, but spend most of their time in known environments. For example, a given person will spend most of his time at home and then at work.

In this daily mobility, it is not recommended to disable the ADR algorithm: the idea is to do it when the object itself detects that it is moving. In addition, the LoRaWan technology is not suitable for a continuous flow of data, because of its design and its duty cycle limitation on its 868 MHz ISM frequency band, which does not allow an adaptive flow in real time. Therefore, the ADR algorithm does not allow a fast modification of the optimal parameters, because it is done incrementally, based on a history of the last 20 communications until finding the optimal parameters. If the new environmental conditions are very different from the previous ones, it can take a lot of time,

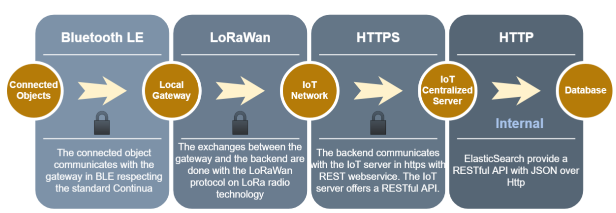

Fig. 5. The End-to-End Communication

and therefore cause a significant loss of energy as well as the *duty cycle*. We propose in the COMMA algorithm a faster adaptation solution of the ADR algorithm during a sudden change generated by a change of environment.

The proposed improvement is based on the use of communication histories of the different connection points of the individual (home, work, ...) in order to find a faster adaptation of the optimal communication parameters. To achieve a quick adaptation depending on the environment in which the object is located we must be able to associate a known environment encountered on a previously completed communication history. To do this, we use a multilateration technique from a LoRaWAN message received by at least 3 remote gateways to geolocate the local platform [23]. Note that the use of a GPS sensor was dropped because its energy consumption was not compatible with the expectations of the platform. The system is also able to detect a change of environment and disable the ADR in case of mobility in progress or unstable environment.

MARC (*Monitoring distributed AlgoRithm using Connected health objects* The MARC algorithm improves the patient's monitoring conditions by providing the IoT server with an artificial intelligence that allows to detect abnormal measurements or lack of measurements and trigger alerts, to retrieve back information and confirmation of receipt to the local gateway, to request new measurements, to manage the duty cycle to guarantee communication time in case of problems.

Since the algorithm is on the IoT server, it is able to know the history of patient's health data, but also the history (doctor and management team, patient medical follow-up, level of criticality and parameters for triggering an alert). The algorithm must also be able to know how the local gateways of the patients work. It is by gathering all these data that the algorithm can, when receiving a new measurement, detect if it is abnormal using ontologies [22] and triggering either:

- A request for a new measurement directly to the connected object or the patient. To send a descending message, the server contacts the network core that sends the message. In the case of an ALL- or MANUAL mode of operation, it will then be necessary to pay attention to return the message quickly after reception : in the time range where the local gateway will be listening to a descending message. It is therefore necessary to have a fast algorithm in the analysis of new measurements.
- Medical assistance (care team). In this case, a human intervention can then take place as a telephone call, or an intervention of emergency services for example.

4 Discussion

The I^{2}PHEN platform presented here is an end-to-end remote monitoring platform that spans a wide range of different technologies, standards and communication protocols. Many improvements can be made at all levels: on the platform itself (hardware and electronics), communication networks (algorithms, quality of service, or technological choice) or at the server medical data recovery level. Among these ideas, we thought about the possibility of going without a local gateway to transfer medical data to the remote gateway. Indeed, it would be possible to integrate a LoRa chip directly into the medical device. However, without the local platform, the interoperable aspect of the platform that works with all Continua-certified objects is lost, and in the case of a multi-pathological platform would lead to a multiplication of LoRa chips (and by consequence of subscriptions to networks). Moreover, the LoRaWAN technology makes it possible to create your own network freely (unlike competitors such as Sigfox or Nb-IoT ...) with remote gateways that you dispose yourself (this is among other things why this technology has been retained). This makes it easy to cover a health facility such as a hospital or a nursing home at a lower cost (around 100 euros per antenna). There is an open source network core called The Things Network which can then be used to retrieve data from antennas, manage downstream messages and manage the fleet of medical devices. The use of the free frequency band remains unchanged, their usage is still limited in time and power. If the gateways are close enough to the medical devices, the frequency band limited to 10mW but unlimited in time can be used (figure 2). At the end, it would be possible to create a pool of connected medical devices in a medical facility at lower cost with this technology.

For the sake of confidentiality related to this research work in collaboration with the Maincare company, we will not publish the test results in this article. The tests of the platform are presented in another article currently in finalization, in which we will present in more details the COMMA algorithm operation and its contribution in energy saving in a mobile environment.

5 Conclusion

LPWAN networks like LoRaWan are very interesting alternatives in the world of the Internet of Things. With their low energy consumption, their large ranges and their use in mobility, this makes them major players in the development of connected devices and contributes greatly to the Internet of Things in the various sectors of activity such as the environment and industry.

However, these networks also have their weaknesses, due to their limitation of use (maximum use time on the free frequency bands and very small message sizes among others), as well as their relatively low reliability (message losses due to interference or network coverage, low quality of service by default).

However, it is interesting for us to use these networks as well as their main characteristics (energy saving and mobility in particular) in the critical area of health care, and more particularly of remote monitoring. In this article, we introduced I^{2}PHEN, a remote medical telemonitoring platform that stands out for its ability to be mobile and energy efficient using LoRaWAN technology. In order to meet the requirements of remote patient monitoring, in the critical area of health, it was necessary for us to provide sufficient quality of service to ensure the exchange of messages. The COMMA algorithm based on ADR allows this directly by the acknowledgment and retransmission of lost messages, but also indirectly by the decrease of the sending power thus generating fewer collisions.

By coupling this technology with the Continua standard proposed by the PCHA, we offer an interoperability solution to the platform. The use of the various recommendations of the standard makes it possible, among other things, to easily use several hundreds of connected medical devices that already exist on the market, to reinforce the security and to standardize the medical data collected.

The last essential brick for telemonitoring remote patients is the real-time monitoring of the medical data collected. The MARC algorithm that we developed allows us to generate alerts when abnormal values are detected, and to interact with the patient's medical circle.

In the end, we propose in this article a remote medical telemonitoring platform, I^2PHEN, energy saving and mobile. This platform can meet specific needs for many patients around the world. Thanks to its mobility, it promotes continuity of care outside the home, such as work, various activities or travel times, which a conventional telemonitoring platform can not provide. Saving energy allows to offer a less restrictive solution, avoiding daily recharges. Finally, the interoperability aspect offers a wide range of connected medical devices (blood pressure monitor, blood glucose meter, oximeter, etc.) and an easy integration of new devices. This makes it possible to propose a solution of care for the patients suffering from multipathological chronic diseases for which different measurements of constants are necessary.

The first version of I^2PHEN is in vivo test. The first results will enable us to produce publications soon.

6 Acknowledgement

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