International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 22 (2017) pp. 12510-12518
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IoT Platform for Healthcare System: Protocols Interoperability

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Abstract—

Recent developments in healthcare connectivity technologies have spurred the adoption of an IoT platform for remote sensing (WBS), actuating and intelligent patients monitoring using advanced analytics and real-time data processing. As the pace and the scale of such solutions increase rapidly, there will soon be a problem of getting these disparate solutions to work seamlessly together to realize a large scale Internet of Things. The real-world entities (cars, homes, and people) augmented with new generation of devices (smart phones, tablets) wireless sensors (ECG sensor, Body temperature, Blood Sensor (SPO2)) are connected to the Internet, enabling them to publish their generated data on the Web. By mashing up these "Smart Things" with the services and data available on the Web, it is creating new platforms. The healthcare system advices and alerts in real time the doctors/medical assistants about the changing of vital parameters of the patients, such as body temperature, pulse and Oxygen in Blood and about important changes in environmental parameters, in order to take preventive measures. This paper proposes a general architecture of an IoT platform for patients monitoring at risk. The goal of this platform is the interoperability protocols, for interconnecting different WBS.

Index Terms: IoT platform, Healthcare, WBS, Interoperability protocols, Android.

IoT platform is an ambitious paradigm, which significantly increases the scale of connected devices from personal electronics to industrial machines and sensors, which wirelessly are connected to the Internet. In order to manage the complexity of such a scale, interworking solutions that can reuse pre-existing technologies seamlessly with newer and more efficient technologies is a requirement. Covering a wide variety of use cases, in various environments and serving diverse requirements, no single wireless standard can adequately exist. A number of different standardization bodies and groups are actively working on creating more inter-operable protocol stacks and open standards for the Internet of Things. With numerous standards deployed in the market, spreading over multiple frequency bands and using different communication protocols, choosing the right wireless connectivity technology for an IoT healthcare system can be relatively challenging. Ongoing standardization efforts towards harmonizing internet protocols for wireless body sensor networks-based internet of things have raised hopes of global interoperable solutions.

IoT is an advanced automation and analytics system, which exploits networking, sensing, data, and technology to deliver complete IoT platform for healthcare systems. These systems allow greater transparency, control, and performance when applied to any industry or system. IoT systems have applications across industries through their unique flexibility and ability to be suitable in any environment. They enhance data collection, automation, operations, and much more through smart devices and powerful enabling technology.

One of the challenges of medical care is the distribution of accurate and current information to patients. Healthcare also struggles with guidance given the complexity of following guidance. IoT devices not only improve facilities and professional practice, but also health in the daily lives of individuals. IoT devices give direct, 24/7 access to the patient in a less intrusive way than other options. They take healthcare out of facilities and into the home, office, or social space. They empower individuals in attending to their own health, and allow providers to deliver better and more granular care to patients. This results in fewer accidents from miscommunication, improved patient satisfaction, and better preventive care.

Public healthcare has received increasing attention given the exponential growth human population and medical expenses. The intelligent use of resources enabled by Internet of Things has raised the expectations of the technical as well as the consumer community. However, there are many challenges in designing an IoT platform for healthcare system, like security, authentication and exchanging data. This paper devoted to study general architecture of an IoT healthcare system for patients monitoring at risk. The use of different WBS (different protocols) is the challenge; in fact, each sensor has its own protocol. For interconnecting several sensors in the same IoT platform, it is necessary to develop an automatic protocols conversion. This platform must work regardless to the Internet connection (Wi-Fi, Ethernet) and whatever the protocol of the sensors (Wi-Fi, ZigBee, Bluetooth, Ethernet ...).

The remainder of this paper is organized as follows. Section 2 describes some related works, and Section 3 explains some characteristics of IoT platform. Section 4 discusses the architecture of IoT healthcare system. Section 5 shows the connectivity and interoperability protocols. Section 6 presents basic devices and technologies. Section 7 focuses on healthcare monitoring parameters. Section 8 shows the web and mobile interfaces developed to meet patients' and doctors' needs. Section 9 the summary integration of interoperability protocols. Finally draws some conclusions and discusses some possible directions for future research.

RELATED WORKS

Since the model proposed considers only routing layer, it fails to formulate a cross-layer optimization problem. Considerations on other layers, such as power control technique, are neglected. In [1], the authors propose a mathematical optimization problem that jointly considers network topology design and cross-layer optimization in WBSs.

Furthermore, Wireless body sensor network (WBS) may engage different technologies at different levels [2]- [7]. So many issues of research are then opened to be studied such as energy consumption, architecture, routing solution and communication protocols. In [8], the authors propose solutions to the energy minimization problem and network lifetime maximization problem based on intelligent time and power resource allocation in WBS context. Both problems are formulated and solved as geometric programming. In [9], the authors propose a relay based routing protocol for Wireless in Body Sensor Network. Network lifetime maximization and end-to-end-delay problems are formulated and solved with linear programming. However, No systematic scheme is proposed to address the optimal relay location consideration.

For comparative purposes, many works are focused on the revision of each type of health sensor and the way of communication with the server or the other sensors. Wen-Tsai Sung et al. [10] proposed a measurement system which monitors the physical condition of the users. It helps them to maintain healthy physiological conditions. These three modules (ECG, blood pressure and oxygen saturation) will record the physiological signals and then send the data to a mobile device. The system focuses upon three communication system for data transmission (RS-232, ZigBee, and Bluetooth). The data is viewed on an Android mobile device and then immediately sent to the cloud server through Internet. RenGuey Lee, et al. [11] proposed a system to prevent and control the physiological parameters affected by both chronic diseases: hypertension and arrhythmia. The system is a role-based smart mobile care system with alert mechanism. Each of these persons uses a mobile phone device to communicate with the server setup. This system uses physiological signal recognition algorithms in commercial mobile phones with Bluetooth communication capability. William Walker, et al. [12] proposed a system to monitor the blood pressure of a patient. The data has been transferred to a monitoring center using wireless sensor network. The data is displayed and stored there. The Blood Pressure data acquisition module is interfaced with a user-friendly graphical user interface. It monitors current and past measurements for all patients through wireless transmission. Zhe Yang et al. [13] propose an architecture of an ECG monitoring system based on the Internet of Things cloud. The ECG data gathered from the human body is transmitted directly to the IoT cloud using Wi-Fi.

In conclusion, there are many ways to communicate with the sensors such wired link, Bluetooth, ZigBee, Wi-Fi. This paper proposes a general architecture of an IoT platform for patients monitoring. The IoT platform proposes to unify most used protocols into one specific multi-protocol unit for automatic universal connectivity. The novelty of this platform is the automatic protocols conversion, for suitable WBS interconnection. The IoT platform is designed to gather Biometric information. This information can be used to monitor in real time the patient's state of health or to get sensitive data in order to be subsequently analysed for medical diagnosis, using an Android application and web services.

CHARACTERISTICS OF IOT PLATFORM

IoT based systems are essentially called as applications because of their purposeful nature. However, each of the IoT system [14], should exhibit certain characteristics, in order to be called as a full-fledged IoT system or application. These characteristics state that:

- The central object (or the **thing**) should have unique identification such that it can be distinguished from various objects of the network. Without having unique identification, it becomes extremely hard or limiting useful application development.
- Most of the objects should be able to detect presence of other objects and thus follow rules of autonomy. If objects can detect other objects' presence, they can further interact with each other or work accordingly.
- Objects of IoT should be capable of autonomous data capture most of the times [15]. While most of the sensors do fulfill this criterion, this applies to larger system as well.
- Applications of IoT and objects that are part of that should be inter-operable between different communication technologies [16]. Since not all the IoT applications may have same protocol or technology in use, it is essential to have interoperability.
- There should be service-based interaction between objects; which means if there are two or more objects in vicinity or in contact they should be able to communicate directly with each other and exchange information and data if necessary [17].
- One of the characteristic that could make IoT platform smarter is having possible cooperation between autonomous objects. If two autonomous objects can

interact and cooperate with each other to accomplish any preset or necessary task, it can intensify value of such application manifold.

- In addition to above points, IoT platform and their parts should also have low power operations [9] as and where possible, should be contextual in nature, programmable by users, should have redundancy (fail-safe operations) built-in and most importantly secure.

ARCHITECTURE OF IOT HEALTHCARE SYSTEM.

The basic functions of a smart IoT healthcare application include ECG waveform [18] and display pulse and oxygen in blood, body temperature, etc. Also through smart phone screen and cloud storage, indication as well as simple user interface through buttons.

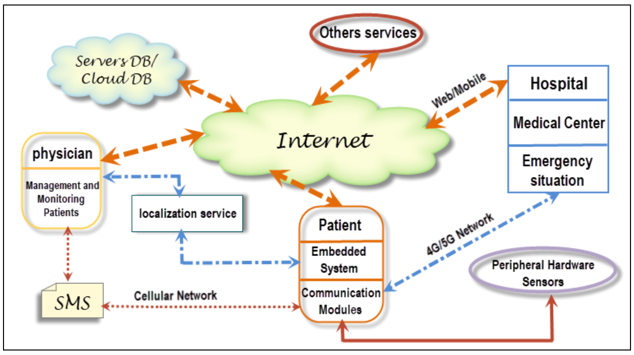

Figure. 1: Architecture of IoT healthcare system.

More features, such as patient record storage through convenient media, multiple levels of diagnostic capabilities are also assisting doctors and patients without specific trainings to understand how to use smart IoT healthcare application and their indications conditions.

The IoT platform measures Pulse, Oxygen in Blood, body temperature, ECG waveform and others services. You can save your results for future reference and keep track of multiple patients with individual profiles, figure1. This IoT platform has access to the following:

Wireless network communication, Full network access, allows the application to create network sockets and use custom network protocols. The android interface receives data from WBS through Wi-Fi, ZigBee, Ethernet or Bluetooth, so this permission is required to send data to the Web/mobile web.

The configuration of protocols communication on the device, and accept connections. Access Bluetooth, ZigBee, Ethernet or Wi-Fi settings, allows the application to configure the local device, and to discover remote devices. The Networking, allows information about network connections such as which networks exist and are connected.

CONNECTIVITY

Connectivity is essential in any networked system. This may be wired or wireless in nature, each of which may be decided based upon what entire application warrants. If an application is very much distributed geographically, more than one type of connectivity may be used. Such as one could use Wi-Fi or ZigBee for local network communication and use 4G or 5G for long range communication [19]. The main job of this link is to transfer information gathered by end node and processed by processing node to the application software or based service. Connectivity is always in duplex form, which means it acts as back and forth channel for communication between application software and local hardware. Bluetooth, Wi-Fi, ZigBee, etc. are typical types of local connectivity used for house or office automation projects. GSM, 4G, 5G and RF are other types of connectivity used for long-range communication. Some of the Bluetooth, GSM or RF modules are readily available in marketplace while rest of the complex modules need to be built specifically depending on the application complexity.

A. Multi-protocol platform

- **ZigBee:** The ZigBee protocol has developed a very low-cost, very low-power consumption, two-way, wireless communications standard. Solutions that adopt ZigBee are embedded standards in consumer electronics, PC peripherals, and medical sensor applications.

- **Bluetooth:** The functional requirement for Bluetooth networking encapsulation protocol includes the following, support for common networking protocols such as IPv4, IPv6, IPX, and other existing or emerging networking protocols as defined by the Network protocol types. Many protocols used to network various computer peripherals together. Although IPv4 and IPv6 are perceived as the most important networking protocols, it is a requirement that Bluetooth Networking is able to supports other popular protocols Low Overhead.

- **Wi-Fi:** Wi-Fi Direct is a new technology defined by the Wi-Fi Alliance aimed at enhancing direct device-to-device communications in Wi-Fi. Thus, given the wide base of devices with Wi-Fi capabilities, and the fact that it can fully implemented in software over traditional Wi-Fi radios, this technology expected to have a significant impact.

B. Sensors Interoperability.

To connect several sensors in the same platform, there are sensors that run on Bluetooth, Another run on ZigBee and we use Wi-Fi to collect data from platform to the web/mobile web. To solve the problem of data exchange, we must think about the protocols conversion. Then we make a design and synthesis of an electronic system for this purpose.

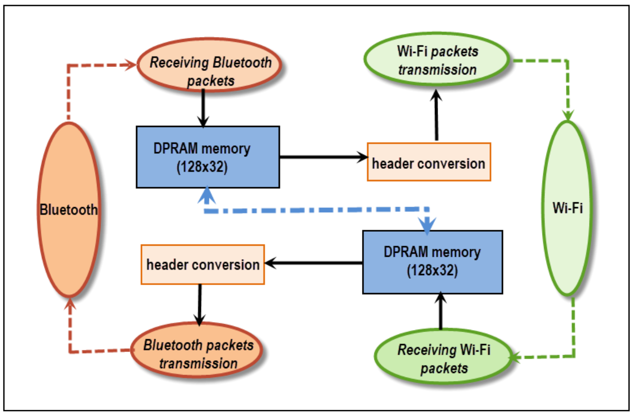

Figure. 2 HTML interface of the universal exchanger.

The HTML interface (fig.2) shows the exchange of protocols:

- Wi-Fi to Bluetooth
- Ethernet to Bluetooth
- Ethernet to Wi-Fi
- Zigbee to Bluetooth
- Zigbee to Wi-Fi

Fig. 2. Protocols conversion.

For protocols conversion between Bluetooth and Wi-Fi as is shown in figure 2, storage Bluetooth packets in the DPRAM (128x32) and then header extraction and converting to Wi-Fi packets transmission. On the other side, for protocols conversion between Wi-Fi and Bluetooth, receiving Wi-Fi packets storage in second DPRAM (128x32), header extraction, and then convert to Bluetooth header for transmission packets. Moreover, for more storage space the two DPRAM are connected. This system automatically converts all connected protocols. Now there is no problem for the interoperability.

Basic devices and technologies.

C. Wireless Body Sensor Network Overview.

Wireless Body Sensor Network (WBSN) is a key enabling IoT technology. It connects a set of sensors into a network through wireless communication [20], and integrates this network into a higher-level system through a network gateway. The sensor nodes are normally lightweight, inexpensive [21], easy to deploy and maintain, but the capability and functionality are limited by resources (sensors, processors, memories, energy sources, etc.). We have thoroughly reviewed the architectures, applications, protocols and challenges. Among them, the energy efficiency challenges, the communication reliability, and emphasized system mobility in the design of our WBSN platform for Healthcare [22], [23].

D. ***Sensing capabilities.***

- A capability that can capture measurements about the device and its external environment. Derived sensing capabilities from the available hardware on Android devices and from creative use of it.
- A capability may use values directly from hardware that can measure physical quantities, such as the Pulse and Oxygen in Blood Sensor (SPO2), (fig.3). It may use hardware that the user typically interacts with, android interface.
- A capability may even use a combination of hardware and software processing, such as speech recognition. Whatever the source, the resulting data can inform an application about the device's state and the environment in which it resides.
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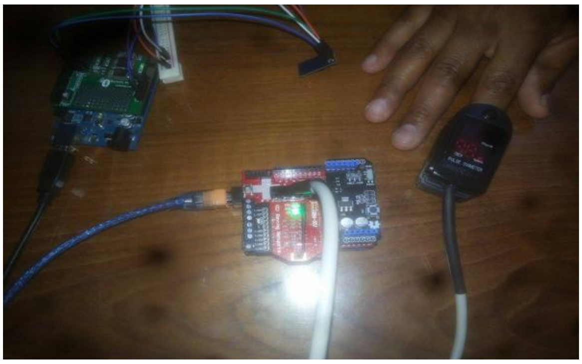


Figure 3: Pulses and Oxygen in Blood Sensor (SPO2).

WBS FOR HEALTHCARE MONITORING PARAMETERS

E. ***Key Principles****:*

The following key principles should be kept in mind throughout the process:

• This is an IoT healthcare problem, not a technology problem. The patient is in the center of interest more than the technology.

• There is often more than one way to achieve a clinical or care objective the first technology solution that appears may not be the best.

• The simpler the technology is the better. WBSs for IoT healthcare are mission critical; reliability is of paramount importance.

It has to work at the home, not just in the laboratory.

F. *Methodology.*

The following methodology is valid for any WBS in IoT-healthcare system:

- Understand the problem. A clinician may already have analyzed the problem, and have come up with a technology outline for the engineer to develop. However, further analysis may pay dividends. At-home IoT-healthcare means that the appropriate environment to formulate any technology solution is not the clinic or the laboratory, but the home.

- Ethnographic observation of user behavior, where an understanding of how people live and why they live as they do, their constraints and their priorities day to day, can be very beneficial and has informed many of the solutions in which the designers are involved.

- Understand the end user. Who will use the solution in the longer term? What are their constraints or priorities? How do they feel about the type of solution envisaged? Usage modeling, where multidisciplinary teams use persona to explore the user experience from several perspectives, can be useful here.

- To understand the collected data. In order to test a clinical hypothesis or to achieve a care objective, some information about the activity or health state of the patient must be collected. The clinician and the engineer share the collected data (WBS). The information that the clinician needs is important, not the data that the sensor has the technological capability to collect.

- Understand the environment; many BWS deployments do not achieve their objectives because they failed to take into account the differences between the laboratory/clinical environment and the home environment. Building methods and materials vary from location to location; these may affect the technology. Other equipment in the home may interfere with the sensor technology.

- Keep in mind that the sensor network must be as unobtrusive as possible solutions that require the patient to change his or her day-to-day behavior or which impact on comfort, privacy, or dignity are unlikely to be successful on a long-term basis. Almost all at-home solutions aim to be long-term.

- Select sensors and actuators: Take into account the data, the environment, and the placement. What impacts have these on power consumption, size and weight, form factor, Bluetooth communications, and computational capability? Where at all possible, use components that are available off the shelf, avoiding experimental or prototype technology. Remember this is an IoT-healthcare problem, not a technology research project. Aim for a low-cost, light-touch solution.

- Specify and build the aggregate: The aggregate receives data from all the sensors in the network, and may transmit it to an analysis engine or data visualization system. Alternatively, it may itself process the data and trigger responses by actuators or by communications with caregivers, doctors, and so forth. Commonly, actuators take the form of local PCs or mobile devices such as smart phones.

- Identify and deploy analysis and visualization capability: Ensure that the technology is in place to convert the data from the BWS into clinical information, and to allow the clinician to access this information in an appropriate manner. This may be out of the scope of a purely sensor-network project, but it is important that in such a case the precise nature of the interface between the network and the back-end data analysis/clinician system clearly defined.

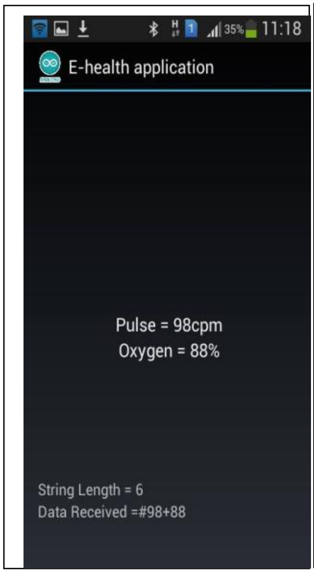
WEB AND MOBILE INTERFACES FOR IOT PLATFORM

G. *Android interfaces.*

Android gives you the freedom to implement your own device specifications and drivers. The hardware abstraction layer (HAL) provides a standard method for creating software hooks between the Android platform stack and your hardware.

The Android operating system is also open source, so you can contribute your own interfaces and enhancements. To ensure devices maintain a high level of quality and offer a consistent user experience, each device must pass tests in the compatibility test suite (CTS). The CTS verifies devices meet a quality standard that ensures applications run reliably and users have a good experience, figure 6. For details on the CTS, before porting Android to your hardware, take a moment to understand the Android system architecture at a high level. Because your drivers and the HAL interact with Android, knowing how Android works can help you navigate the many layers of code in the Android Open Source Project (AOSP) source tree.

Internet of Things based health care systems play a significant role in Information and Communication Technologies and has contribution in development of medical information systems. The developing of IoT based health care systems must ensure and increase the safety of patients, the quality of life and other health care activities. The tracking, tracing and monitoring of patients and health care actors activities are challenging research directions. We propose a general architecture of a smart IoT healthcare application for patients monitoring at risk in the smart phone. The system advices and alerts via android interface in real time the doctors/medical assistants about the changing of vital parameters or the movement of the patients and about important changes in environmental parameters, in order to take preventive measures.



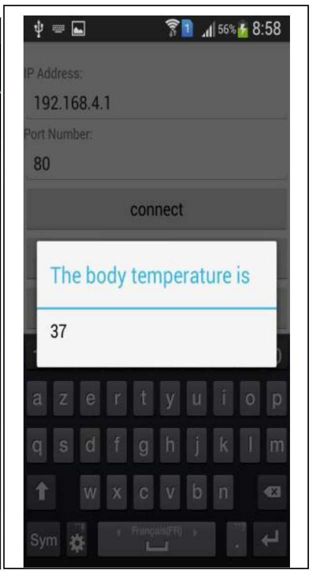


Figure 4: Android interface: (SPO2) data receiving. **Figure 5:** Body temperature.

Pulse oximetry a noninvasive method of indicating the arterial oxygen saturation of functional hemoglobin. Oxygen saturation defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Hemoglobin and Deoxyhemoglobin. Two different light wavelengths used to measure the actual difference in the absorption spectra of HbO2 and Hb. The bloodstream is affected by the concentration of HbO2 and Hb, and their absorption coefficients are measured using two wavelengths 660 nm (red light spectra) and 940 nm (infrared light spectra). Deoxygenated and oxygenated hemoglobin absorb different wavelengths. Figure 4 shows the data transfer (Pulse=98cpm, Oxygen=88%, in blood) from sensor to the android interface.

This sensor allows to measure body temperature. It is of great medical importance to measure body temperature. The reason is that a number of diseases accompanied by characteristic changes in body temperature. Likewise, the course of certain diseases can monitored by measuring body temperature, and the physician can evaluate the efficiency of a treatment initiated (fig.5).

All data will be transferred in real time to the doctor in two ways the first a mobile interface and the second via web.

H. Web interfaces

The goal of this application is to replace a traditional and manual system with an intelligent computing solution that allows physicians to manage patients and their medical records by replacing conventional medical records on paper with computerized medical records and on the other hand allowing patients to follow their doctors and update them about their state of health (Fig.6).

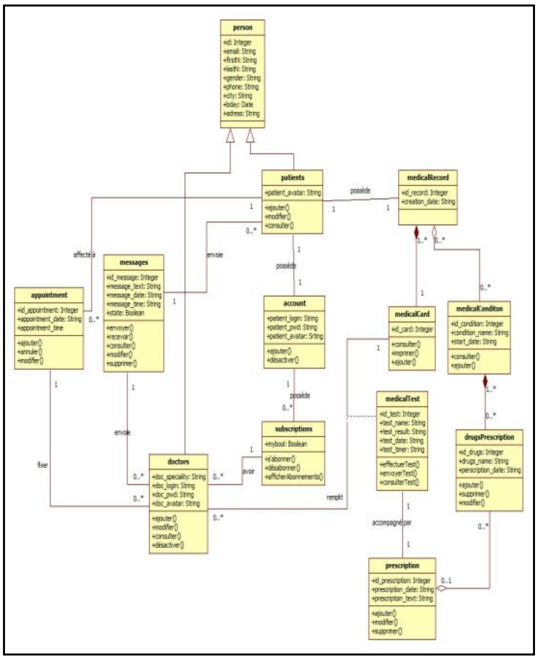


Figure 6: General Class Diagram.

DocCom (Fig.7) is the web application developed to meet the needs of patients, doctors, analytical laboratories and hospitals. Each user can create an account, the patient send medical analysis to the doctor via DocCom application, the doctor answers by a medical prescription or by an appointment at the hospital. In the critical case of a patient, his doctor receives an alert on his smart phone and on the web application DocCom, so that the doctor will do the necessary actions.

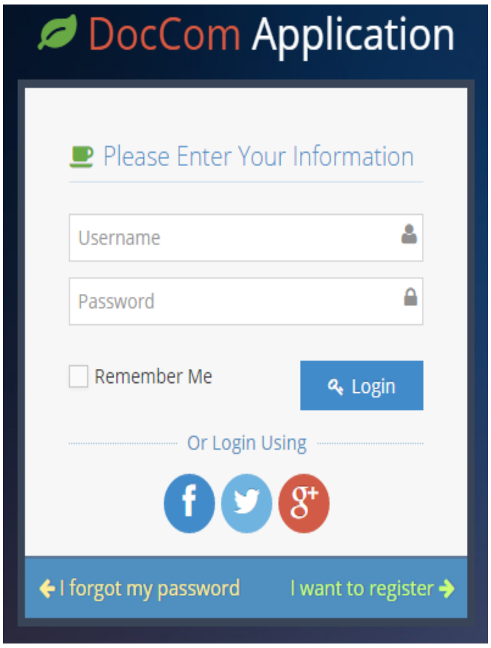


Figure 7: Users' web authentication.

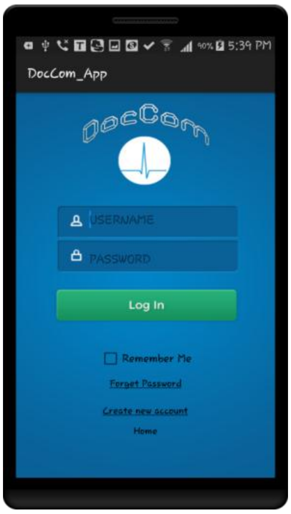


Figure 8: Users' mobile authentication.

The web Application offers security for every doctor, in fact everyone must make a registration in his specialty domain (Fig.9). Via popup, the doctor sees the new mails and alert messages.

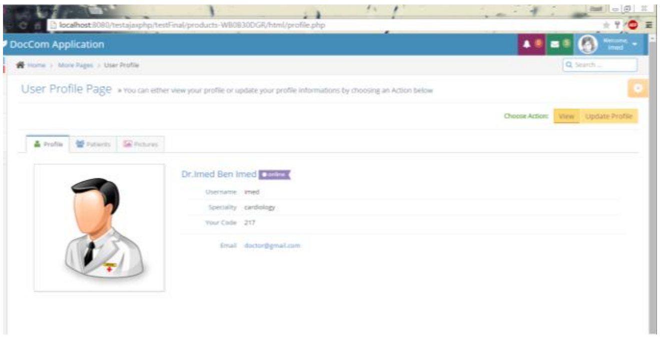


Figure. 9: Medical consultation interface.

The patient management done via figure 10; the doctor can add or remove patients. On the top of this interface, there are some popup, mailing notification and alert messages.

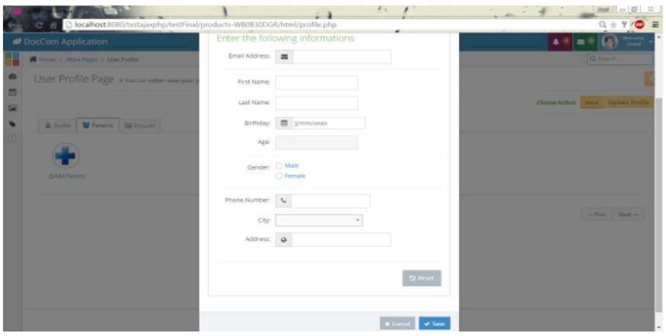


Figure. 10: Adding new patient

Through the patient profile page, doctor sees the patient profile, consult medical test and write medical prescription for patient. The doctor consults medical test history (Fig.11).

The web and mobile application allows:

- The patient to connect via IoT platform.
- Sensing the health parameters.
- Contacting the doctor,
- Sending in real time and easily the results of performed medical tests.
- Following the medical record.

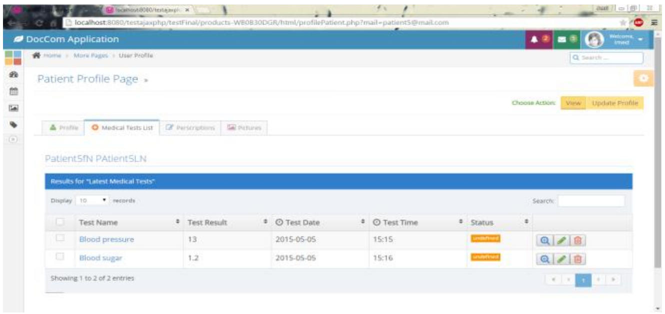


Figure 11: Medical consultation Management.

IOT PLATFORM: INTEGRATION OF INTEROPERABILITY PROTOCOLS.

The most comprehensive coverage so far of HDL and its applications to the design and simulation of real, industry standard circuits. It does not focus only on the HDL language, but also on its use in building and testing digital circuits. In other words, besides explaining HDL in detail, it also shows why, how, and which types of circuits are inferred from the language constructs, and how any of the four simulation categories can be implemented, all demonstrated by means of numerous examples. A rigorous distinction is madid between VHDL for synthesis and VHDL for simulation. In both cases, the VHDL codes are always complete, not just partial sketches, and accompanied by circuit theory, code comments, and simulation results whenever applicable. The fundamental concepts of digital electronics and digital design are result of a very practical, self-contained approach. Recent advances in FPGA technology have enabled these devices applied to a variety of applications traditionally reserved for ASICs. FPGAs are well suited to data path designs, such as those encountered in digital applications. The density of the new programmable devices is such that a nontrivial number of arithmetic operations such as those encountered in wireless communication implemented on a single device. The advantages of the FPGA approach to digital filter implementation include higher sampling rates than are available from traditional DSP chips, lower costs than an ASIC for moderate volume applications, and more flexibility than the alternate approaches.\

I. Synthesis results

The interoperability protocols between different protocols like (ZigBee, Bluetooth, Ethernet, Wi-Fi …), for transferring information: This environment allows the implementation of wire and wireless communication system on programmable circuits, the use of FPGAs circuits offer the advantage of the possibility of re-programming circuits. This improves the application performance in coming from tests. The synthesis results show the complexity of system design, performed by imposing constraints to minimize the propagation delay or integration area. The optimized delay improves the performance of wireless communication system in terms of speed or rate of operation. The synthesis results is established by the development environment Xilinx ISE 14.4 Suite.

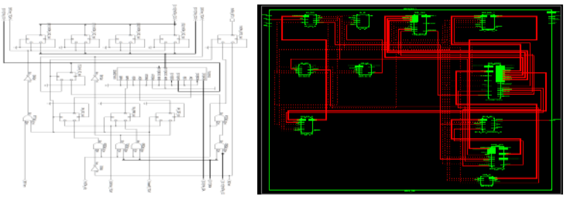


Figure 12: Synthesis RTL schematic (Wi-Fi transmission).

Synthesis module provides the following protocols conversion results: 1581 ports (I/O), D flip-flops 1344 and sub modules called function generator (FG) which are the numbers of 1703 table1. These characteristics depend much on the target technology.

TABLE 1: Synthesis Results

function generator (FGs)	*1703*
Ports (I/O)	*1581*
CLB Slices	*1401*
D flip-flops	*1344*

The synthesis results of the emission are given in the following table, we can see that the clock frequency is moderately high (566.8 MHz), which helps at the right flow of data from one area to another. The synthesis step performed using the Xilinx ISE 14.4 Suite tool to evaluate the performance of the circuit in terms of function generator, operating frequency. Xilinx ISE 14.4 Suite is a design environment that enables simulation and synthesis of a complex so that it is a projection on a target system technology figure 12.

CONCLUSIONS AND FUTURE WORKS

The IoT platform for health care system designed in order to help patients, doctors to measure biometric sensor data. The using of Wireless Body Sensor and information technologies provides remotely clinical health care. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. Save lives in critical care and emergencies.

Web and mobile application allows:

- The patient to connect via IoT platform.
- Sensing the health parameters.
- Contacting the doctor,
- Sending in real time and easily the results of performed medical tests.
- Following the medical record.

While it is obvious that there are numerous approaches towards the Internet of Things, thus leading to a creative variety of applications in the Internet of Things, we favor an architectural approach that based on extensions to a successful standardized open architecture. However, the Internet of Things requires a more holistic architecture as described before. This can build on the same design principles as the platform of health care system. These include layering of standards, separation of data models and interfaces, provision of extension mechanisms, specification of data models and interfaces.

There are a number of technologies driving this trend. The other elements is going from wired to wireless, and finally sensors, which are the sense organs of the IoT.

Though today's 5G networks incorporate the latest technologies and continue to offer faster data access. The rapid consumption of wireless data continues to outpace the industry's ability to meet demand. However, faster data and greater access are only part of the story. The mobile Internet has painted a picture of continued innovation and inspired researchers all over the world to think beyond faster data and greater capacity. These new networks, referred to as fifth generation or 6G, may transform our lives yet again and unleash enormous economic potential.

It is clear 6G networks must accommodate many more users and devices while delivering more data to each user at any instant in time. Researchers envision not only a 6G network with unprecedented data rates and mobile access but also an opportunity to redefine the network to accommodate a wealth of new and diverse connected devices.

REFERENCES

[1] Yang Zhou, Zhengguo Sheng, Chinmaya Mahapatra, Victor C.M. Leung, Peyman Servati Topology design and cross-layer optimization for wireless body sensor networks Ad Hoc Networks, Volume 59, 1 May 2017, Pages 48-62.

[2] Sergey A. Matyunin, Research on Characteristics of Fiber Optic Sensors for Anthropomorphous Robots. Procedia Engineering, Volume 176, 2017, Pages 128-136.

[3] R. Latha, P. Vetrivelan, M. Jagannath, Balancing

emergency message dissemination and network lifetime in wireless body area network using ant colony optimization and Bayesian game formulation. Informatics in Medicine Unlocked, In Press, Corrected Proof, Available online 5 January 2017.

[4] Nguyen Quang Vinh, INS/GPS Integration System Using Street Return Algorithm and Compass Sensor. Procedia Computer Science, Volume 103, 2017, Pages 475-482.

[5] Yang Kuang, Tingwen Ruan, Zheng Jun Chew, Meiling Zhu, Energy harvesting during human walking to power a wireless sensor node. Sensors and Actuators A: Physical, Volume 254, 1 February 2017, Pages 69-77

[6] S.R. Thekkethil, K.E. Reby Roy, R.J. Thomas, H. Neumann, R. Ramalingam, Mathematical Model for a Novel Cryogenic Flow Sensor Using Fibre Bragg Gratings. Procedia Technology, Volume 24, 2016, Pages 477-484.

[7] Nathaniel Heintzman, Samantha Kleinberg, Using uncertain data from body-worn sensors to gain insight into type 1 diabetes. Journal of Biomedical Informatics, Volume 63, October 2016, Pages 259-268.

[8] X. Zhou, T. Zhang, L. Song, Q. Zhang, Energy efficiency optimization by resource allocation in wireless body area networks, in: Vehicular Technology conference (VTC Spring), 2014 IEEE 79th, IEEE, 2014, pp. 1–6.

[9] N. Javaid, A. Ahmad, Y. Khan, Z. A. Khan, T. A. Alghamdi, A relay based routing protocol for wireless in-body sensor networks, Wireless Personal Communications 80 (3) (2015) 1063–1078.

[10] Wen-Tsai~Sung, Jui~Ho~Chen, and Kung-Wei~Chang, “Mobile Physiological Measurement Platform with Cloud and Analysis Functions Implemented via IPSO”, IEEE Sensors Journal, Vol. 14, No. 1, January 2014.

[11] Ren-Guey Lee, Member, IEEE, KueiChien Chen, Chun Chieh Hsiao, and Chwan Lu Tseng, “ A Mobile Care System With Alert Mechanism”, IEEE Transactions Information Technology in Biomedecine”, Vol. 11, No. 5, September 2007.

[12] William Walker, Todd Polk, AbhimanHande and Dinesh Bhatia, Department of Electrical Engineering, University of Texas at Dallas,H. Nuyujukian, IstvanMody, and Jack W. Judy, Senior Member, IEEE, “Remote Blood Pressure Monitoring Using a Wireless Sensor Network”.

[13] Zhe Yang, Qihao Zhou, Lei Lei, Kan Zheng, An IoT-cloud Based Wearable ECG Monitoring System for Smart Healthcare, Journal of Medical Systems (2016).

[14] Nasri, F.; Moussa, N.; Mtibaa, A., "Smart mobile system for health parameters follow ship based on WSN and android," in Computer and Information Technology (WCCIT), 2013 World Congress on , vol., no., pp.1-6, 22-24 June 2013.

[15] Domingo, M. C. (2012). An overview of the Internet of Things for people with disabilities. Journal of Network and Computer Applications, 35(2), 584-596.

[16] M. L., Sicotte, Claude. (2010).The added value of thorough economic evaluation of telemedicine networks. The European Journal of Health Economics, 11(1), 45-55.

[17] Pawar, P.; Jones, V.; Beijnum, B. F. V.; Hermens, H., 2012. A framework for the omparison of mobile patient monitoring systems. Journal of Biomedical Informatics, 45(3), 544-556.

[18] Nasri Farah.; Moussa Neila.; Mtibaa Abdellatif ”Intelligent Mobile System for Healthcare Based on WSN and Android”, International Journal of Computer Trends and Technology (IJCTT) – volume 12 number 4 – Jun 2014.

[19] Klasnja, P., Pratt, W. (2012). Healthcare in the pocket: Mapping the space of mobile- phone health interventions, Journal of Biomedical Informatics, 45(1), 184-198.

[20] Alemdar, H., Ersoy C. (2010). Wireless sensor networks for healthcare: A survey. Computer Networks, 54(15), 2688-2710.

[21] Pioggia, G. (2011). Personal Health System architecture for stress monitoring and support to clinical decisions. Computer Communications, 35 (11), 1296-1305.

[22] Dolan, B.(2011). 10Reasons why Google Health failed. MobiHealth news by Chester Street Publishing Inc, 27 Jun.

[23] Farah Nasri, Abdellatif Mtibaa; Smart Mobile Healthcare System based on WBSN and 5G; (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 8, No. 10, 2017.