

Architecture of a Vital Sign's Telemonitoring System Supported in Cloud Computing

Julio R. Ribon*, R. Martin Monroy and Diana M. Del Risco

Department of System Engineering, University of Cartagena, Bolivar, Colombia; jrodriguezr@unicartagena.edu.co, mmonroyr@unicartagena.edu.co, diana_m2r@ingenieros.com

Abstract

Background/Objectives: This paper proposes a conceptual model and an architecture that enables telemonitoring of patients in Intensive Care Units (ICU). This helps improving not only the quality of life of patients but also the response time of doctors as well. **Methods:** The methodology used in the construction of the architectural model is Rational Unified Process (RUP) and the diagrams used in the description of the architecture are based on Unified Modeling Language, which is considered a standard in software development. **Findings:** This paper proposes a solution that contributes in solving the problem that arises in ICU is related to the information that medical staff is not aware of when they leave the hospital, and by this, they miss vital information related to the condition of the patient. This paper is useful for patients, doctors, nurses, hospitals, and health services entities. To check the validity of the model, a simulated profile was implemented. It is supported in cloud computing to provide ubiquity, access, scalability, and data integrity. After defining functional requirements, the conceptual model is obtained, then the architecture for the implementation is defined, and the simulated profile is briefly described. Finally, conclusions are drawn. **Novelty:** This work is novel because it considers a business model based on cloud computing to define the architecture that allows on-demand telemonitoring equipment that measures patient signals, also making it possible for doctors to have permanent information about the state of these.

Keywords: Architecture, Cloud Computing, Telemedicine, Telemonitoring, Vital Signs

1. Introduction

Technology and Medical Science have joined and as a result, they have generated multiple applications in many fields related to health^{1,2}. The advance and rapid progress of the Information and Communication Technologies (ICT) has allowed the evolution of remote medical systems, making possible the realization of Telemonitoring^{1,3}, that consists in the use of ICTs to obtain patient information remotely and relevant patient data, allowing health professionals to make real-time decisions and provide health care in a timely manner⁴.

In this document, a Telemonitoring System provides the tools needed to capture, receive and transmit the vital signs that are monitored in the patient.

In many countries, e.g. Colombia, every health service has responsibilities levels and complexity levels, this can

be described per the Health Services Provider responsibility level and the person who executes the procedures. In the case of the Third and Fourth Level in Colombia, the medical specialists with the participation of a general doctor are the direct responsible of the health attention in the country.

In Colombia, the health statistics are not very optimistic, despite the efforts made to improve them there are still many problems that are not properly attended. Specifically, in Intensive Care Unit (ICU), one of the issues is directly related to the lack of knowledge of the critical patient once the health specialists leave the hospital, which directly affects the patient's quality of life.

There have been some projects that in one way or another focused in Telemonitoring as a solution in the patient's remote attention In⁵ present the approach of an e-health system for cardiac telemonitoring; the solution allows to

*Author for correspondence

measure the cardiac pulse, analyze it and determine whether a person is having a cardiac arrhythmia or not.

In³ design and development of low cost, light weight, portable Telecardiac systems are used for remote monitoring of cardiac patients. This solution alerts the physician on a mobile phone about the imminent fatal condition and location of the patient.

However, this initiative does not describe how the process of monitoring patients is when the specialist leaves the hospital.

In⁴ attempt are to analyze various telemedicine projects. The study also suggests mobile-based model for healthcare. The findings also reveal the limitations of implementing telemedicine such as delay in response time, lack of infrastructures and others.

This document exposes a conceptual model and its architecture to make possible the Telemonitoring process in critical or intermediate care patients in fourth level health assistance units, to provide support not only to the labor of specialists in the treatment and care of patients in ICU, but also to improve the quality of life and quality of the attention of the patients. This is useful for the medical community, which is in continuous search of solutions in telemedicine to social issues, and benefits many actors such as: Health Services Providers, Health Services Institutions, specialist doctors and mainly the patients that are being treated.

The structure of this paper is described as follows. First, the material and methods used for the development of the investigation are shown. Then, the conceptual model is briefly described. Later, the architecture to implement the model is explained. Continuing, a study case is presented and finally conclusions are drawn.

2. Material and Methods

This work is based on a descriptive methodology to characterize and identify various aspects, dimensions or components of the phenomenon to investigate.

The methodology used in the construction of the architectural model is RUP - Rational Unified Process⁶. This methodology was used because it focuses on architecture, which helps to easily connect and integrate processes, methods, techniques and notations in software engineering.

The diagrams used in the description of the architecture are based on UML⁷ as modeling language, which is considered a standard in software development.

It was necessary to make a review in the literature, it allowed to form the concept of telemonitoring's domain among the different areas in telemedicine. Simultaneously it permitted the definition of procedures and techniques that could be used to support different processes in the Telemonitoring of patients and critical management in ICU.

To identify the specifications and requirements for the design of the conceptual model that enables the Telemonitoring of patients in intensive or intermediate care was necessary to gather information enough to detect the necessities related to the Telemonitoring of patients in ICU for the design of the conceptual model initially proposed.

Based on the design of the model proposed the next step was to develop a simulated profile in which the Telemonitoring process could be observed, using Rational Unified Process (RUP). The model View 4+1 was used to describe the architecture⁸.

3. Results and Discussion

3.1 Conceptual Model

This section explains a conceptual model of a Telemonitoring system for patients in critical or intermediate care units with fourth level attention needs, such system allows the Telemonitoring of vital signs of patients in ICU and alerts the appropriate staff once a crisis arises. For this is necessary to make a definition of the requirements that provide support to the model proposed and consequently to the architecture that implements it.

3.1.1 Specifications and System Requirements

The requirements can be defined as the description of the needs or wishes that are expected from a certain product. It is possible to say that the functional requirements are declarations of the services that the system will provide and they describe the functionalities or the services that are expected from it. They provide a consistent definition of the functionalities of the system: inputs, outputs, exceptions, etc. The description of the functional requirements for the development of the system that is expected from the model proposed can be found next.

There are four basic structures that every Telemonitoring system should have⁹:

1. Capture station and medical data send: manages, digitalizes and sends information to remote stations.

2. Medical Data's Communications Grid: communications infrastructure that enables through physical ways and the use of specific protocols the transmission of medical data.
3. Receiving stations of medical data: informatics structures that enable the reception and retrieval of medical data in its original format, as well as handle and reproduce it per the medical needs.
4. Storage system and consult of medical data: structure that stores medical data to enable the access from remote stations.

In⁹ show that for a Telemonitoring system of patients in critical or intermediate care to capture vital signs or enables the Telemonitoring of vital signs it's necessary to consider certain functions that could be classified in three steps. These are mentioned below:

1. Capture and emission of vital signs of the patient that is being observed.
 - Acquisition of the vital signs to monitor.
 - Caption, digitalization, management and compression of the signs acquired.
 - Generation and emission of the vital signs to be transmitted through the selected communication mean.
2. Transmission of the vital signs of the patient that is being observed.
 - Acceptance of the medical signs that are being transmitted.
 - Transmission of the vital signs.
 - Delivery of the vital signs to the observation unit.
3. Reception, replication and management in the observation unit for the vital signs of the patient that's being observed.
 - Reception of the vital signs transmitted.
 - Conversion and deployment of the vital signs received.
 - Management, impression and record of the vital signs received.

From the mentioned before it's possible to set the specification and requirements that the conceptual model must include to carry out the development of a Telemonitoring system for patients in critical or intermediate care in fourth level medical assistance units. These requirements are:

1. Visualize notifications related to the changes in the critical condition of a patient in ICU

The system must alert the medical staff and notify the remote stations (mobile devices in this case) through messages about any relevant change in the condition of the patient observed. This will allow taking opportune measures that could contribute in the improvement of the patient's condition.

2. Visualize Telemonitoring of vital signs of patients in ICU.

The system must allow Telemonitoring of vital signs of patients in ICU and visualize the results in a local station, as well as transmit a picture to a remote station with the results provided on screen.

3. Manage Telemonitoring of vital signs of patients in ICU: Capture, transmission and replication.

The system must allow the management of vital signs of patients in ICU. This refers specifically to the three most basic functions: capture, emission of the patient's vital signs, transmission of the patient's telemonitored vital signs, reception, and replication of telemonitored vital signs.

4. Integrate sources and conform a critical data repository that could be added later to a patient's clinical history.

The system must allow the storage of the information collected from the patient observed so that it could be added later to the clinical history. This information is exclusively related to the relevant changes in the health conditions of the patient observed.

5. Show the critical information of patients in ICU and notify the relevant changes in their conditions.

The system must show on screen in the local station the relevant critical changes that a patient is going through during the Telemonitoring process, which simultaneously should be notified in the remote station so that the specialist could attend it as priority and provide a timely response.

6. Manage patient's responses in ICU.

The system must allow keeping a register of the relevant critical changes in the condition of a patient so that it serves as a support in the proper management of a patient's treatment.

3.1.2 Conceptual Model for a Telemonitoring System

The medical and nursing staff in ICU is constantly moving inside and outside the unit, in the case of specialist

doctors they even move from one hospital to another. They have total access to the clinical history in ICU and many devices that monitor the condition of the critical patient, such as: vital signs monitors, fans and infusion bombs. Specialist doctors make solicitude of the tests that are needed to back up a proper diagnosis and treatment according to the condition of the patient. Through specialized software, it's possible to keep control over the devices that monitor the patient and the information registered by them. Figure 1 illustrates a summary of what has been mentioned above.

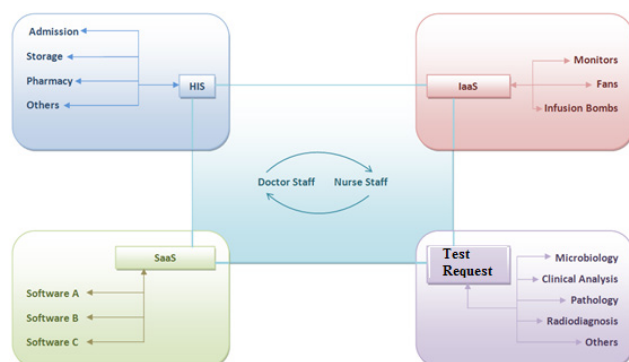


Figure 1. Conceptual model.

Infrastructure as a Service (IaaS)¹⁰ and Software as a Service (SaaS)¹¹ belong to a business model named Cloud Computing^{12,13}, which has been implemented to define the architecture that will offer support and validity to the conceptual model proposed, because it's thanks to the cloud computing that is possible to provide scalability, ubiquity and integrity to the data.

The parameters of the patient's vital signs are detected by the devices that are available in ICU and are captured by a local station, from which the specialist doctor can order the realization of the test that the patient needs. Once the results are available it's possible to determine a treatment or any other course of action in order to improve the patient's health. This order or ideas can be seen in Figure 2.

3.2 System Architecture

There are two components that describe the Telemonitoring system for patients in critical and intermediate care in ICU. These components are part of the business model previously mentioned before, also known as Cloud computing, these are: IaaS and SaaS. IaaS provides the infrastructure services in the cloud that enables

the data and information storage, simultaneously; this allows the formation of scalable data repositories. In other words, the availability in storage space grows as the needs demand it. On the other hand, SaaS refers to the applications that final users use to get access to the services offered in the cloud through the internet.

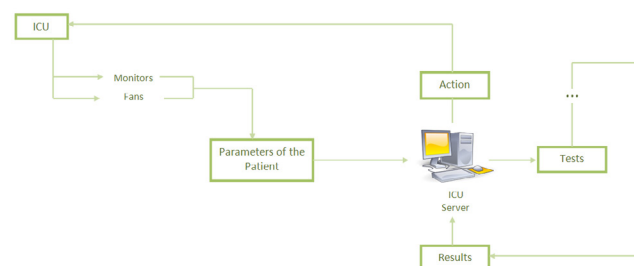


Figure 2. The patient's vital signs are detected by the devices.

Figure 3 shows the requirement identified in a previous section which could be fulfilled in each layer mentioned before.

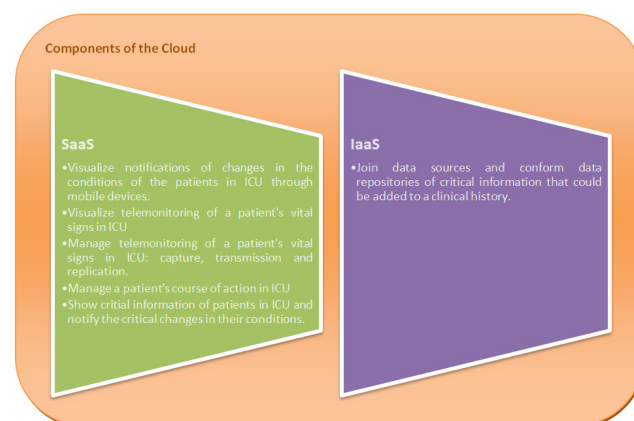


Figure 3. Functional requirements served by the cloud computing architecture.

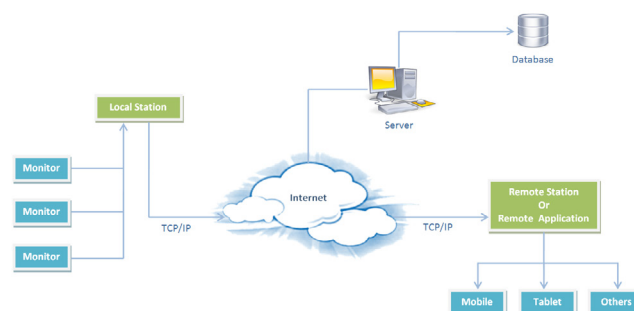


Figure 4. Schema of the solution.

The vital signs that are monitored from the patient in ICU are captured in a local station, which through cer-

tain protocols for sending and capturing information, the remote applications can connect and obtain data from the databases in the remote servers that eventually will grow according to the needs that are required (Figure 4).

The architecture is described in a high level of abstraction. The architecture is based on cloud computing and contemplates the components and the logical and physical structure that the Telemonitoring system should have.

There are many processes' that occur during the Telemonitoring of a patient in ICU. The main process' that could be present in a Telemonitoring system are: Monitoring, Alert and Manage. It all starts from the intention of Telemonitoring the vital signs of a patient, then proceeds with the monitoring that's executed in the patient and supervised by the health professionals, and finally ends with the intention of assign a treatment to the patient when the case demands it.

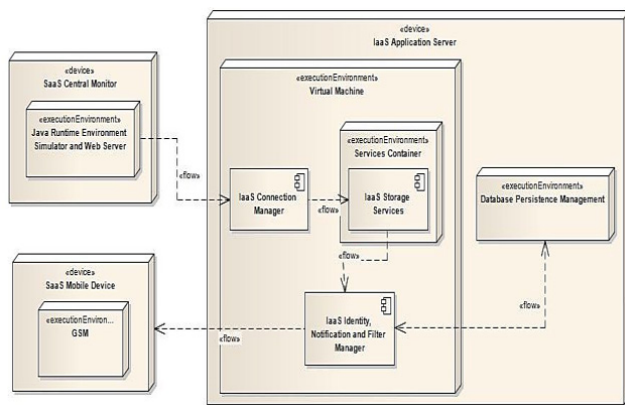


Figure 5. Physical view.

An altered condition in the Telemonitoring process of a patient is initially originated in the monitor of vital signs that is connected to the patient and later it is transmitted to a local station; The system generates an alarm that is recognized by the application and is transmitted to the registered mobile devices, both the nurse's and the doctor's mobiles, to let them know of the crisis that has just raised even if they are out of the ICU. Simultaneously this is stored in a data register so that in the future it'll be possible to add this directly to the patient's clinical history or make studies from these registers.

The next View of the Architecture refers to the elements of the model (Figure 5), also known as "components", and the way they interact with each other as well as identify which are the consumers nodes in the cloud and which are the providers of those services. Figure 5 illustrates these aspects:

3.2.1 SaaS Central Monitor

It's one of the components that are part of the Software as a Service. In this device is carried out the Telemonitoring of the patient's vital signs and the alarms are generated in the case that a crisis arises.

3.2.2 SaaS Mobile Device

It's the second component that's part of the Software as a Service. The notifications are shown on this device. They are created once a crisis arises in the hospital where the patient is being monitored. The doctor can get to know what the patient's current situation is by using this mean.

3.2.3 IaaS Application Server

This component runs in a virtual machine and hosts the storage services in the *Services Container*. The *IaaS Storage Services* is the one responsible of responding to the requests for storage demands, while the *Identity, Notification, and Filter Manager* and the *Connection Manager* are indispensable complementary artifacts that provide support. The *Connection Manager* provides the facilities to join the Telemonitoring activity with IaaS Services to keep a proper record of the patients observed. The *Identity, Notification and Filter Manager* manage the authentications and validations that are needed to set a connection with the *Database Persistence Management* for the storage of the information.

In the SaaS layer (Figure 5) the Central Monitor is located, which is where the alarms are initially generated indicating a critical change in the condition of the patient under observation. The Mobile Device is the appliance where the alarms are extended by using a notification directed to the health staff in charge of the patient.

In the IaaS layer (Figure 5) the IaaS Application Server is located in which are found the IaaS Storage Services along with other artifacts that provide support, such as: the IaaS Connection Manager and the IaaS Authentication, Notification, and Filter Manager. They are in constant communication with the data repositories in which the information is stored by means of the Database Storage Management.

3.3 Case Study: Telemonitoring of Arterial Pressure of a Patient and Notification to a Mobile using SMS

In an Intensive Care Unit, the vital signs of a patient can be monitored from different devices to ensure the

proper observation of the patient to give quality and stability and keep his vital signs within the standards. Through the reading of the cardiac frequency, the temperature, the levels of oxygen in the blood, and the arterial pressure; the doctors and nurses can check the condition of the patient, as well as establish a diagnosis and administer proper care for an improvement in the health of the patient.

In this case of study the profile will focus on simulating the monitoring of the arterial pressure of one or many patients, to recreate a similar environment to the one that day by day occurs in an ICU. Before proceeding it is important to give relevant information, thus, keeping in mind that the pattern that will be monitored is the arterial pressure it is imperative to highlight which are the normal conditions and the critical ones that a patient can reach given the case.

The arterial pressure is a measurement of the force made against the walls of the blood vessels as the heart pumps blood through the body¹⁴. The reading of this vital sign is generally associated to two values, it is possible that one or both values could be high, for example: 120/80 mmHg. The superior value is named "Systolic Pressure" and the inferior value is known as "Diastolic Pressure". Its unit of measurement is the millimeter of mercury (mmHg).

The normal ranges for this measurement goes from 90/60 mmHg to 130/80 mmHg, a fall of just 20 mmHg will have very serious consequences. When the arterial pressure is low, meaning, below the normal standards it is considered that the patient is suffering from Arterial Hypotension¹⁵, this means that the heart and the brain as well as other areas in the body are not being properly irrigated and the blood doesn't get there. The opposite means that if the arterial pressure is above the normal standards then it's a case of Arterial Hypertension^{15,16}, which can be categorized per the following criteria^{15,16}:

- a. I Slight: SAT: 140-159 mmHg --- DAT: 90-99 mmHg
- b. II Moderated: SAT: 160-179 mmHg --- DAT: 100-109 mmHg
- c. III Serious: SAT: 180-209 mmHg --- DAT: 110-119 mmHg
- d. IV Very Serious: SAT > 210 mmHg --- DAT > 120 mmHg

Where: SAT (Systolic Arterial Tension) y DAT (Diastolic Arterial Tension)

With the purpose of offering a better response from the medical staff when a crisis arises in the telemonitored patient, by using the initiative of notifying through text messages is pretended to attend to the requirements that enable implementing an efficient Telemonitoring system in ICU.

Currently in ICU, the patients are monitored from their stations and their vital signs are transmitted to the nurse staff where an alarm is generated if the monitor of vital signs of the patient detects abnormal parameters in his condition, thus entering a critical stage. Given that the medical specialists constantly move inside and outside the ICU in the hospital, once they leave they lose knowledge of the condition of the patient. In critical patients, the conditions can go from one stage to another in seconds, either favorably or adversely and only the notifications from the nurses can alert the specialist to respond against the crisis that arises.

Without a doubt, previously mentioned represents a problem, given that important fragments of time are lost that could help the patient in getting over the crisis that he's going through. This causes inefficiency to the process and that is why an improvement in the monitoring system is proposed through a notification system. Because of what's been mentioned before, it's possible to make a good optimization in the attention and care to the critical patient process. Figure 6 illustrates the schema of the solution proposed in this paper.

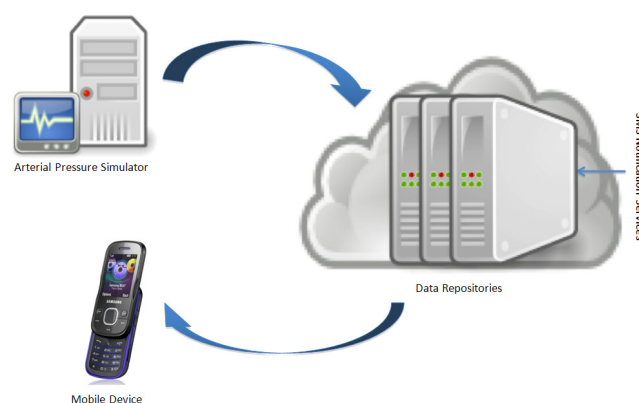


Figure 6. Telemonitoring of arterial pressure.

To validate the model and complete the Telemonitoring system that enables alert's notifications to the medical staff it was necessary to implement the components of the architecture exposed before. Such profile contemplates the basic functionalities that attend the requirements of

the design before mentioned. A simulated profile has been developed by using the JAVA programming language and a virtual environment supported in LINUX to make the data repositories and the notification system. The result was a simulated profile supported in cloud computing. The elements to integrate are:

3.3.1 Vital Signs Simulator (Arterial Pressure)

It was developed based on a JAVA platform, which means that its implementation doesn't depend on the platform it is executed if it has the proper virtual machine installed (Java Virtual Machine).

3.3.2 Notifications Manager

It is formed by three important components that are part of the same package named In¹², these are: Gammu-SMSD-Inject, Gammu-SMSD y Gammu-Monitor. Together they allow capturing the alert signal that was produced and save it in the data repositories to send it through text messages to the registered mobile devices. They all run in a LINUX environment.

3.3.3 Mobile Device

This is an ordinary cell phone; it doesn't require any additional software on it so smart phones or last technology devices are not the only option to fit in the profile; however, it must be compatible with the notification manager. The list of compatibility can be found on the author's website (<http://es.wammu.eu/phones/>). In this case an Internet Mobile Modem Device will be used with the reference Huawei E153 to enable the connectivity among the mobile devices and the system through SMS sending.

It is important to explain who are the main actors and their interests in the process:

- *Specialists Doctors*: they are not permanently in ICU and because they constantly move inside and outside the hospital, they lose the notion of what's going on in the Intensive Care Unit once they leave. Their interest is to have the knowledge about the condition of the critical patient and if anything happens, they want to know about it as soon as possible.
- *Patient*: he stays in ICU if his condition gets stable to guarantee that his life is out of danger and he won't go through another crisis, meanwhile he's constantly monitored using many devices.

Their interest is to be assisted as soon as possible when a crisis arises.

For this case study, the simulation consisted of running nine simulators simultaneously, to test the stability and functionality of the system. Since in an ICU the vital signs of a patient are monitored from the nurses' central, thus they all get to the same end so the same thing happens with the alerts.

The simulator sends a series of packages that indicates to IaaS component when a critical situation or an abnormal condition happens, then this is stored in the data repositories and simultaneously it activates the notification components to transmit the alert that's generated to the mobile devices that were previously registered in the system. This is sketched in the Figure 5.

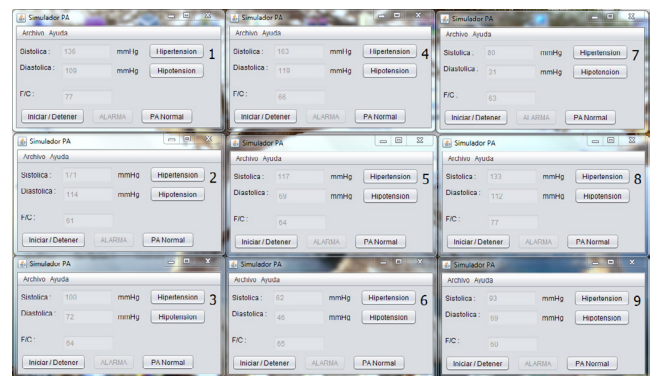


Figure 7. Simultaneous arterial pressure simulators (simulate several telemonitoring stations - Spanish messages).

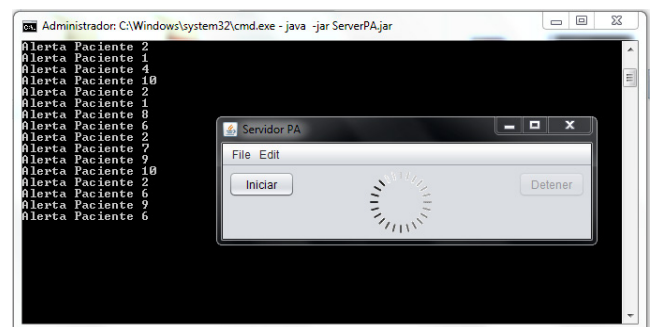


Figure 8. The notifications generated by the notification system in IaaS (Spanish messages).

Following the architecture proposed it's possible to see the way the different components are distributed within the cloud computing model. In the SaaS layer, the simulator of vital signs is located and it runs in a JAVA environment, this makes possible to deploy on any platform. In the same way, the technology that interacts with

the mobile device(s), which is GSM in this case, the cell phone represents the role of the services consumer.

In the IaaS layer, the data storage services are located (data repositories) using a MySQL database engine to save the information. Through the GAMMU components the connectivity and authentication processes are managed to deploy the notifications into the proper mobiles by using SMS or text messages. The reason because it has been chosen is that it guarantees that the device will always receive the notification; given that the GSM technology has high coverage and low costs.

The tests show that this profile although it's simple is very stable and very functional. Notifications reached their proper destination (Figure 7, Figure 8 and Figure 9).



Figure 9. SMS text message on a doctor's mobile device (Spanish messages).

4. Conclusions

Telemedicine is an area still in development and Telemonitoring is a branch that has many applications in different fields that must be explored yet.

The definition of the requirements made possible the design of the conceptual model proposed in this paper and consequently, the architecture for the implementation of Telemonitoring systems. They all were validated through the implementation of a simple simulated profile.

The architecture that was designed is supported in a business model named cloud computing, by using a services-oriented model distributed in two levels: SaaS (Software as a Service) and IaaS (Infrastructure as a Service), this enables a better access, stability, ubiquity and integrity of the information. This architecture contributes to the solution of the problem mentioned at the beginning of this work, given that it enables the integration of a notification system, which can make the management in ICU more effective, to the traditional way of business that's been carried on till this day.

A simulated profile was developed and implemented to test and validate the functionality of the architecture designed. The resulting components were of a simple development but at the same time stable, most of it is open source technology supported in free technologies, such as: Gammu, Wammu, Linux, and JAVA so it can do independently from the platform.

The results achieved as a final contribution of this investigation make possible to settle that there is a high viability of implementing this system in real scenarios for many reasons: first, the technology already exists and they give the right support for these systems; secondly, the ICU already have a mechanism for monitoring the vital signs of the patients in a local station; and finally, because it is possible to integrate the components that were developed to extend the alarms and the later notifications, even though it requires an extra programming labor to fulfill the setup of the system.

In future Works, it is suggested to refine the requirements that enabled the conceptual model proposed, to refine some statements or add certain conditions that were possibly left out. The model focus could change, no make it only applies to adult ICU, but also for neonatal ICU, emergencies or even surgical procedures. The possibilities are unlimited and these kinds of projects benefit the academic and medical community.

5. References

1. Kaur G, Sharma D, Kaur V. Telemedicine in transient phase: emergence of M-health care services. *Indian Journal of Science and Technology*. 2016 Apr; 9(15):1–6. Crossref.
2. Brindha G. Emerging trends of telemedicine in India. *Indian Journal of Science and Technology*. 2013 May; 6(5S):4572–8.
3. Kavya G, Thulasibai V. VLSI implementation of telemonitoring system for high risk cardiac patients. *Indian Journal of Science and Technology*. 2014 May; 7(5):571–6.

4. Cuevas JR, Dominguez EL, Velasquez YH. Telemonitoring system for patients with chronic kidney disease undergoing peritoneal dialysis. *Institute of Electrical and Electronics Engineers (IEEE) Latin America Transactions*. 2016 Apr; 14(4):2000–6. Crossref.
5. Laura VE, Salinas SA. E-health prototype system for cardiac telemonitoring. *In the Proceedings of the 38th Annual International Conference of the Institute of Electrical and Electronics Engineers (IEEE) Engineering in Medicine and Biology Society (EMBC), USA*; 2016 Aug 16–20. p. 4399–402.
6. Erida L, Marenglen B. Customizing rational unified process in a systems integration scenario. *In the Proceedings of the Institute of Electrical and Electronics Engineers (IEEE) 6th International Conference on Complex, Intelligent, and Software Intensive Systems*; 2012 Jul 4–6. p. 76–83.
7. Object Management Group. Unified modeling language [Internet]. 2016 [cited 2016 Dec 28]. Available from: <http://www.omg.org/spec/UML/>.
8. Kruchten PB. The 4+1 view model of architecture. *Institute of Electrical and Electronics Engineers (IEEE) Software*. 1995 Nov; 12(6):42–50. Crossref.
9. Oscar VV, Gómez M. Ernesto. Communications platform for the monitoring of Intensive Care Unit (ICU). *Santa Clara Hospital Article in Spanish - Redalyc*. 2009; 14:107–18.
10. Montana C. 30th International Conference on Advanced Information Networking and Applications Workshops (WAINA); 2016. p. 843–8.
11. Singh A, Sharma S, Kumar SR, Yadav SA. Overview of PaaS and SaaS and its application in cloud computing. *In the Proceedings of the Institute of Electrical and Electronics Engineers (IEEE) International Conference on Innovation and Challenges in Cyber Security (ICICCS), Noida, India*; 2016 Feb 3–5. p. 172–6.
12. Kirubakaramoorthi R, Arivazhagan D, Helen D. Analysis of cloud computing technology. *Indian Journal of Science and Technology*. 2015 Sep; 8(21):1–3. Crossref.
13. Padmaja K, Seshadri R. A review on cloud computing technologies and security issues. *Indian Journal of Science and Technology*. 2016 Dec; 9(45):1–8. Crossref.
14. Cameron JS, Davidson AM, Grunfeld JP, Kerr DN, Ritz E, Winearls CG. *Oxford textbook of clinical nephrology*. 2nd Edition. Oxford University Press; 1997.
15. International Medical College. Hypertension and hypotension [Internet]. 2017 [cited 2017 Jan 11]. Available from: <http://www.med-college.de/en/wiki/artikel.php?id=117>.
16. Williams B, Poulter NR, Brown MJ, Davis M, McInnes GT, Potter JF, Sever PS, Thom SMcG. Guidelines for management of hypertension: report of the fourth working party of the British Hypertension Society 2004—BHS IV. *British Hypertension Society Guidelines, Journal of Human Hypertension*. 2004; 18:139–85. Crossref.
17. Gammu and Wammu. Gammu [Internet]. 2016 [cited 2016 Dec 20]. Available from: <https://wammu.eu/gammu/>.