International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:11, No:2, 2017

Analytics Model in a Telehealth Center Based on Cloud Computing and Local Storage

L. Ramirez, E. Guillén, J. Sánchez

***Abstract*—**Some of the main goals about telecare such as monitoring, treatment, telediagnostic are deployed with the integration of applications with specific appliances. In order to achieve a coherent model to integrate software, hardware, and healthcare systems, different telehealth models with Internet of Things (IoT), cloud computing, artificial intelligence, etc. have been implemented, and their advantages are still under analysis. In this paper, we propose an integrated model based on IoT architecture and cloud computing telehealth center. Analytics module is presented as a solution to control an ideal diagnostic about some diseases. Specific features are then compared with the recently deployed conventional models in telemedicine. The main advantage of this model is the availability of controlling the security and privacy about patient information and the optimization on processing and acquiring clinical parameters according to technical characteristics.

***Keywords*—**Analytics, telemedicine, internet of things, cloud computing.

I. Introduction

THE needs for high rate of welfare and healthcare are today's challenges for emerging technologies in telemedicine. Multiple objectives must be analyzed in healthcare systems, such as models for self-care of health, hospital care, diseases prevention, and so on. The introduction of cloud computing and IoT has generated an increase in the development of software focused on telemedicine. Conventional healthcare model meant high costs and resources for big data; nowadays, it is optimized to improve the quality of the user's attention in short response times. Different models have been deployed; however, none integrates solutions based on the current problems in healthcare as patient history, analysis of disease in general. Currently develop healthcare models with analytics module is very important. Watson [1] presents the impact of the digital age on healthcare information systems. Watson exposes six main competition cores of these systems; which are electronic clinical records - EHR's, communication as remote control, analytics, security of information, telemedicine, and virtualization in the cloud.

IoT architecture fulfills the health professional's expectations with the technology. Constant monitoring of clinical parameters in patients prevents risks of different factors in health. A high number of sensors are used to diagnose, monitor, and treat medical variables. Nevertheless, the variables are treated individually and are not available for the professionals who can interpret information.

Gaynor [2] performed an analysis of the potential of telemedicine as a health service based on centralization of data, emerging technologies, and future models of healthcare. Requirements for certified health agencies that control patients at home are six standards of National Committee for Quality Assurance. Analytics module is implemented as an interface between the physician and the patient information. Finally, the study proposes three fundamental elements in the progress of telemedicine as a model for healthcare: The first one is the design of models that meet the needs of the specific population and health providers. The success is the data integration and sharing between systems. The second one is the validation of these models. The last one is to delete the limitations created about telemedicine watching future models as a centralization of the patient for medical care.

Implementation of analytics modules in care models is essential. Based on data collection in 1000 households at Pakistan, Mahmoud et al. [2] presented a cloud computing's architecture forecast health-shock. The system provides to inclusive actors in attention care an easy interpretation of the rules to explain the possible causes of health-shock. Likewise, Ola and Sedig [4] evaluated the performance of the computational tools in collective analysis of medical information. Despite the technological advances in artificial intelligence and analytics methods, cognitive data of easy interpretation do not arise. They developed an interactive visual tool for analysis of large data. The optimization of these data processing and the interpretation are an excellent development of care model as proposed in this paper.

A telemedicine model controlled by IoT was launched by Al-Majeed et al. [5]. The model uses the telecommunication technologies for the exchange of medical information and health services as the patient monitoring. The development of devices IoT 'Cogsense' system works with sensors for patient care and monitoring by health personnel. The interconnection of Cogsense devices is performed by a network cloud-enable. One of the main features of the Cogsense network is the analytics module. Analytics module processes information from cloud infrastructure with IoT algorithms and machine learning techniques. Cogsense is a solution to the limitations of the common telemedicine systems as costs of high-speed processing and response information, networking, and data analysis.

Popescu [6] presented a technological solution of autonomous systems in telemedicine. Most of telemedicine systems acquire information through a network of wireless

L. Ramirez, E. Guillén and J. Sanchez are with the Telecommunications Engineering Department, Universidad Militar Nueva Granada, Bogotá, Colombia (e-mail: Leonardo.ramirez@unimilitar.edu.co, edward.guillen@unimilitar.edu.co, u1400881@unimilitar.edu.co).

sensors controlled by software in cloud services. The proposed model follows the guidelines of an autonomous system interfaced with a telemedicine center. The telemedicine center is remotely controlled by different types of professionals.

The model presented in this paper with analytics facilitates the understanding of information from digital or analog systems, math variables of m-health apps, or simply big data. As shown in Fig. 1, there are several nodes that transmit and receive information of the proposed telehealth model. GISSIC and TIGUM research groups previously developed the software implemented in telehealth center.

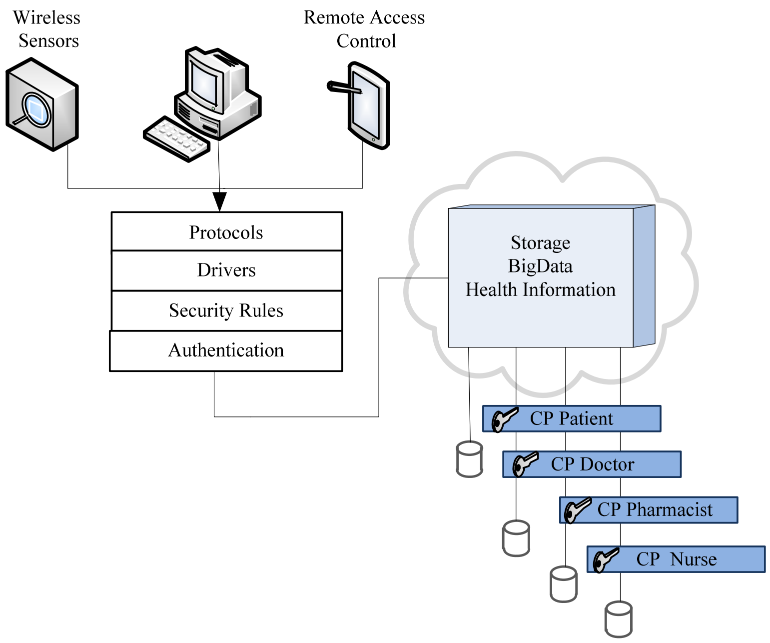

Fig. 1 Telemedicine center architecture

II. Analytics Module

A. Rules of Prediction

The tool retrieves data for statistical analyses of the registers and checks of different rules. The main rules are control of birthrate and mortality due to different factors, prevention and reduction of diseases in patients, control appointments, and sponsors of health. Analytics module determines the number of users in the system with different ages, gender, and socio-economic levels. Sentences carried out a control of the flow of information from the telehealth center. The rules are determined by a mathematical formula in common as shown in (1) where n is the total number of records stored in the table to consult. X is the number of required records of m which is the group of the rule set.

$$\sum_{i=1}^{n} \frac{Xm}{Xm-n} \tag{1}$$

Essential information for predictive analysis of control, monitoring or treatment is established by healthcare professional. The healthcare professional prescribes rules based on clinical parameters acquired and stored in the telehealth center. The proposed analytics algorithms pseudo-code is shown below:

```
PA: Prevention Alarm
CA: Control Alarm
CMA: Constant Monitoring Alarm
V: Clinic Parameter Variable
SF: Sampling Frequency

While (V start transmission conditional)
CMA transmission SF>2Fmáx

if (V ≠ max patient established)
PA = true;
FS ++ ;

else if (V> max control)
CA = true;
CA transmitted to physician

else(V= patient rule)
AMC = true;
AMC=FS initial established;
```

The type of variable-based clinic is necessary to establish parameters of QoS like the frequency of transmission, amount of data transmitted. In order to accomplish the objective, it optimizes costs and times of early response for healthcare. The sampling frequency of IoT sensors is calibrated depending on the physiological measurement. Optimal sampling of variables was processed by the interpolation of Whittaker-Shannon Sampling Theorem [7], as shown in (2) where n is the number of samples, and 2B means two samples per period of maximum frequency.

$$x_a(t) = \frac{1}{\pi}\sum_{n=-\infty}^{\infty} x\left(\frac{n}{2B}\right)\frac{sen[\pi(2Bt-n)]}{2Bt-n} \quad (2)$$

B. Security of Patient Medical Information

1) Authentication of Central System

The central hub of information generates queries to extract and enter the database information. The entrance to the platform has multiple levels of authentication; the type of profile, doctor, patient, nurse. The administrators of the network and databases previously authorize personal identification. Based on the type of health professionals, a profile enters in the system to perform their tasks. These tasks, based on the HRE of the patient, always include an authorization. Without the prior permission of the patient, medical information cannot be processed. However, in a case where an emergency raised, model simulates an authentication with some average biomedical devices.

2) Information Backup Configuration

Backups of the information stored in the databases in the architecture of the model network are replicated with the cloud services provider. This replication provides different levels of security as:

- Synchronization with a node slave who supports the availability of data.
- Different nodes perform a feedback to the central system, due to the increase in the latency and the volume of requests. These feedback nodes are targeted to both servers.
- The connections configuration on each server can be enabled differently according to the nodes of the system.
- The creation of roles and assignment groups of control to prevent possible fraud.

III. Performance Analysis

The study on the model proposed and implemented to scale, was performed on technical parameters of transmission, cost of implementation and operation. Based on resources development and availability, a comparison of cost performance is made with a conventional software model as shown in Fig. 2.

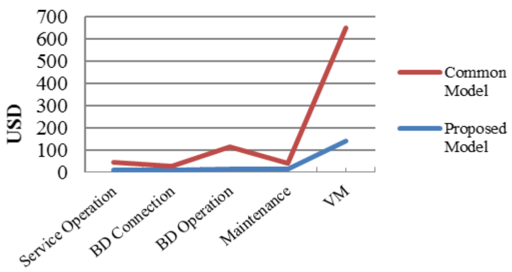

Fig. 2 Comparison between cost of the model telehealth centre and telemedicine software conventional architecture

The description of the virtual machines in both models has the same characteristics as the size of the disk, memory RAM, and number of processing cores. Local servers include processor and CAL license. BD operation is based on the technical and administrative operation such as licensing of software, support, and update primary storage and safety, maintenance of hardware, energy. The database connections with the developed software implies differences such as web server hosting, availability of servers such as streaming, FTP, proxy. Service operation is conducted according to interconnection elements with the server in the cloud as hours of gateway, hours of public IP address, hours of use of computing. Maintenance is the cost related to hardware, software, and security policies. The cost values are approximated to the tests performed.

For the module-based analytics implemented in the centre of Telehealth, there is an advantage of control and prevention of diseases, serious illnesses, and healthy lifestyle among others services.

IV. Conclusions

The main advantage of the proposed model is the ease of acquisition and processing of clinical settings using the algorithms described. The main objective is fulfilled through the simple delivery of information for interpretation of healthcare professional. As can be seen, the control over the system of IoT network architecture is optimized to avoid oversampling and high latencies during the transmission. The QoS transmission and reliable delivery of data parameters are controlled based on the secure architecture and raised model. A clear example of this is the bandwidth and availability, information security offering cloud service providers. Further, the goals of improving the quality of healthcare and protecting the information of the patient are met with success. According to current health reform, model maintains a constant balance of cost-benefit, interoperability and the rights of the patient satisfaction. Finally, the integrity and security of information is vital to the future implementation of this model for not to compromise the personal information of the patient as the EHR.

Acknowledgment

We thank the Universidad Militar Nueva Granada for their support of our research. Especially, the Special Research Fund, Vicerrectoria of Research and Engineering Faculty for financial support provided by the project code INV-ING-2108.

References

[1] Watson, A. R. (2016), Impact of the Digital Age on Transforming Healthcare' Healthcare Information Management Systems', Springer,pp. 219--233.
[2] Gaynor, M. G. (2015), 'Evaluation of Patient to Provider Oriented Telemedicine in Hospitals and Physician Practices', Muskie School Capstones. Paper 103.
[3] Mahmud, S.; Iqbal, R. & Doctor, F. (2015), 'Cloud enabled data analytics and visualization framework for health-shocks prediction', Future Generation Computer Systems.

[4] Ola, O. & Sedig, K. (2014), 'The challenge of big data in public health: an opportunity for visual analytics', Online journal of public health informatics 5(3), 223.
[5] Al-Majeed, S. S.; Al-Mejibli, I. S. & Karam, J. (2015), Home telehealth by Internet of Things (IoT), in 'Electrical and Computer Engineering (CCECE), 2015 IEEE 28th Canadian Conference on', pp. 609—613.
[6] Popescu, C. (2015), Autonomous Systems for Telemedicine, in 'Complex, Intelligent, and Software Intensive Systems (CISIS), 2015 Ninth International Conference on', pp. 297--301.
[7] Marks, R. (2012). Introduction to Shannon sampling and interpolation theory. Springer Science & Business Media.