Pervasive and Mobile Computing 28 (2016) 35–50

Contents lists available at ScienceDirect

Pervasive and Mobile Computing

journal homepage: www.elsevier.com/locate/pmc

A cloud supported model for efficient community health awareness

Muhannad Quwaider *, Yaser Jararweh

Jordan University of Science and Technology, Irbid, Jordan

ARTICLE INFO

Article history:
Available online 5 August 2015

Keywords:
Health awareness
Cloud computing
Big data
Data analytics
MapReduce processing delay

ABSTRACT

The needs for efficient and scalable community health awareness model become a crucial issue in today's health care applications. Many health care service providers need to provide their services for long terms, in real time and interactively. Many of these applications are based on the emerging Wireless Body Area networks (WBANs) technology. WBANs have developed as an effective solution for a wide range of healthcare, military, sports, general health and social applications. On the other hand, handling data in a large scale (currently known as Big Data) requires an efficient collection and processing model with scalable computing and storage capacity. Therefore, a new computing paradigm is needed such as Cloud Computing and Internet of Things (IoT). In this paper we present a novel cloud supported model for efficient community health awareness in the presence of a large scale WBANs data generation. The objective is to process this big data in order to detect the abnormal data using MapReduce infrastructure and user defined functions with minimum processing delay. The goal is to have a large monitored data of WBANs to be available to the end user or to the decision maker in reliable manner. While reducing data packet processing energy, the proposed work is minimizing the data processing delay by choosing cloudlet or local cloud model and MapReduce infrastructure. So, the overall delay is minimized, thus leading to detect the abnormal data in the cloud in real time mode. In this paper we present a multi-layer computing model composed of Local Cloud (LC) layer and Enterprise Cloud (EP) layer that aim to process the collected data from Monitored Subjects (MSs) in a large scale to generate useful facts, observations or to find abnormal phenomena within the monitored data. Performance results show that integrating the MapReduce capabilities with cloud computing model will reduce the processing delay. The proposed MapReduce infrastructure has also been applied in lower layer, such as LC in order to reduce the amount of communications and processing delay. Performance results show that applying MapReduce infrastructure in lower tire will significantly decrease the overall processing delay.

1. Introduction

1.1. Health monitoring awareness

Health care monitoring becomes costly for both individuals and service providers as results of the amount of large scale generated data (i.e. Big Data) that need to be efficiently processed. In fact, health care service providers are facing many

* Corresponding author. Tel.: +962 786118190; fax: +962 27201077.
E-mail address: mqquwaider@just.edu.jo (M. Quwaider).

http://dx.doi.org/10.1016/j.pmcj.2015.07.012
1574-1192/

challenges in terms of increasingly demands and cost for the health services that they are supposed to provide. For examples, health service providers are sometimes forced to invest a large amount of Capital Costs to meet increasing product and service demands while complying with new regulations and healthcare reform legislation. At the same time, health service providers face pressures from many consumers who increasingly demand a higher level of interaction—such as instant online access to information, products and services through their desktops and mobile devices. The aforementioned phenomena leads the fact that health care and Mobile Health (mHealth) applications are one of the major big data applications. Moreover, health care service providers and in fact the whole world; suffers from the existence of some viruses or diseases that have a wide spread nature and might affect the whole world [1]. This enforces such service providers to invest a lot of money in their research and treatment to find ways and approaches to first stop the wide spread of such viruses and diseases and then as a second step to find an effective solution to take care of such diseases. Hence, such service providers ended up with investing a lot of money in their sake of solving such problems but at the same time without finding proper and effective means for providing the best health care monitoring and treatment that should take care of such problems.

Many health care service providers need to provide their services for long terms in real time and interactively. Patients suffering from chronic diseases such as diabetes, asthma and heart attacks, as well as in elder care monitoring, particularly people who have medical problems and chronic conditions, are examples of those who require continuous long-term monitoring to detect changes in their condition as early as possible. On the other hand, continuous long-term monitoring is needed to detect some epidemic diseases, like Ebola outbreak for example, which has killed more than 7000 according to recent World Health Organization (WHO) estimation [1], making it the worst Ebola outbreak since the disease's discovery in 1976. Therefore, proposing smart health care monitoring system is needed for those who need long term health monitoring by presenting long term health care systems that respond to patients' needs in real time as well as solutions that have longevity in mind.

Wearable system in the real-time health monitoring is the most important skill in moving to more efficient and proactive health service. These systems permit persons to monitor the changes in their own vital signs. Then, these systems send responses to the service provider to maintain a standard healthiness position. On the other hand, a telemedical system can be integrated with the wearable systems to provide watchful health recruits when there is a change in the life-threatening. Furthermore, the proposed systems can be used for health monitoring of patients in ambulatory settings [2]. For example, they can be used as a part of analytic technique, optimal maintenance of a chronic condition, a supervised recovery from an acute event or surgical procedure, to monitor adherence to treatment guidelines (e.g., regular cardiovascular exercise), or to monitor effects of drug therapy.

1.2. Wireless Body Area Networks

Wireless Body Area Network (WBAN) consists of a group of communicating sensor nodes that are smartly distributed on the human body, as shown in Fig. 1, in order to monitor different vital body parameters and gather a lot of body information [3–7], like, temperature, blood pressure, blood glucose and heart rate. These sensor nodes can be implanted or wearable, and communicate through wireless technologies. Each node can transmit data to on-body smart phone or tablet pcs via Bluetooth, from where the data can be forwarded to a hospital, clinic, or a service provider using wireless communication technologies such as WiFi or cellular data communication in real-time manner [8,9]. If the stored data is normal, the service provider can decide deleting these data after a certain period of time. To provide confidentiality, as needed by the federal Health Insurance Portability and Accountability Act (HIPAA) [10], the collected data is encrypted using Attribute-Based Encryption [11,12]. The user's data is encrypted by using public keys in order to achieve fine-grained access control by freely choosing a set of attributes that are allowed to access his/her medical data. Due to the data sensitivity and security purpose, the stored data is deleted or decrypted for the service provider using users IDs for any data processes and decision need to be taken. We will not do any further discussions on data security because it is out of scope of this paper.

On the other hand, detecting an epidemic disease before it is spreading in a wide area, like a country or more, needs to have a smart system that is efficiently working in a large scale manner. In this paper, a large scale of users with smart phone is proposed. Like in Fig. 1, the vital signs of each user are collected and transmitted to the cloud [9] using an efficient big data collection model of WBANs system prototype. A scalable storage and processing infrastructure have been proposed for large scale WBANs system, which is efficiently capable to handle the big data generated by WBANs users. Having WBAN sensors installed with the textiles that users wear, the users need not worry about their operation. The user will only be required to carry a cell phone and when the system detects serious abnormalities, it will alert the cell phone, which in turn, will automatically call for help. The goal is to provide early detection of dangerous diseases so that the patient will be given medical attention within the first few critical hours, thus greatly improving his or her chances of survival. Moreover, early detection of dangerous diseases will reduce diffusions such as outbreaks [1].

1.3. Large scale data collection

The collected data (which will be of huge size) will be handled and processed intelligently in the cloud via a decision system. This decision system will be integrated within a cloud. Such data will be refined, analyzed and then smart decisions will be made. These decisions will be of great importance for the healthcare of the patients in their daily bases as well as