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Multi-tier cloud infrastructure support for reliable global health awareness system

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ABSTRACT

The exceptional outbreaks of a number of epidemic diseases such as Ebola, SARS, Zika and H1N1 and their wide distribution over multiple regions calls for a reliable global health awareness system. This system is needed to achieve early detection of such emergencies. Furthermore, such health awareness system should be capable of predicting the outbreaks patterns to facilitate future countermeasure planning. This health awareness system should cover large scale regions that can be extended to multiple countries, continents and ultimately the globe. Many advanced and industrial countries are still struggling in building such system effectively even with the availability of resources and domain experts. The realization of a reliable health awareness system is accompanied with multiple challenges such as the availability of resources and experts, the global agreements about the system from the legislative and control point of view and the availability of the infrastructure that will support the system functionality with a reasonable cost. This paper presents a novel global health awareness system that overcomes the aforementioned challenges. The system is exploiting the emerging cloud computing services availability over the globe. To handle the large scale requirements, we introduce a multi-tier based cloud system that spans over four tiers starting from the monitored subjects to a centralized global cloud system. Also, we present a mixed integer optimization formulation to tackle the issues related to the latency of detecting outbreaks. Our results show that processing the data in multi-tier health awareness system will reduce the overall delay significantly and enable efficient health data sharing.

1. Introduction

With the frequent spreading and outbreaks of infectious diseases and human immunodeficiency viruses in the last few decades, the need for global health awareness system increased due to their importance in countering such emergencies. Many recent examples show the importance of building a global health awareness system for surveillance and disease control. The outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003, the avian influenza H5N1 in 2005, the sudden emergence of H1N1 in 2009 and Ebola outbreak in March 2014 are just few examples [1–5]. The availability of health awareness system is crucial for the detection and prevention of emerging diseases. Actually, such awareness system is with great importance for all the countries in the worlds regardless of their health system status. Moreover, public health monitoring

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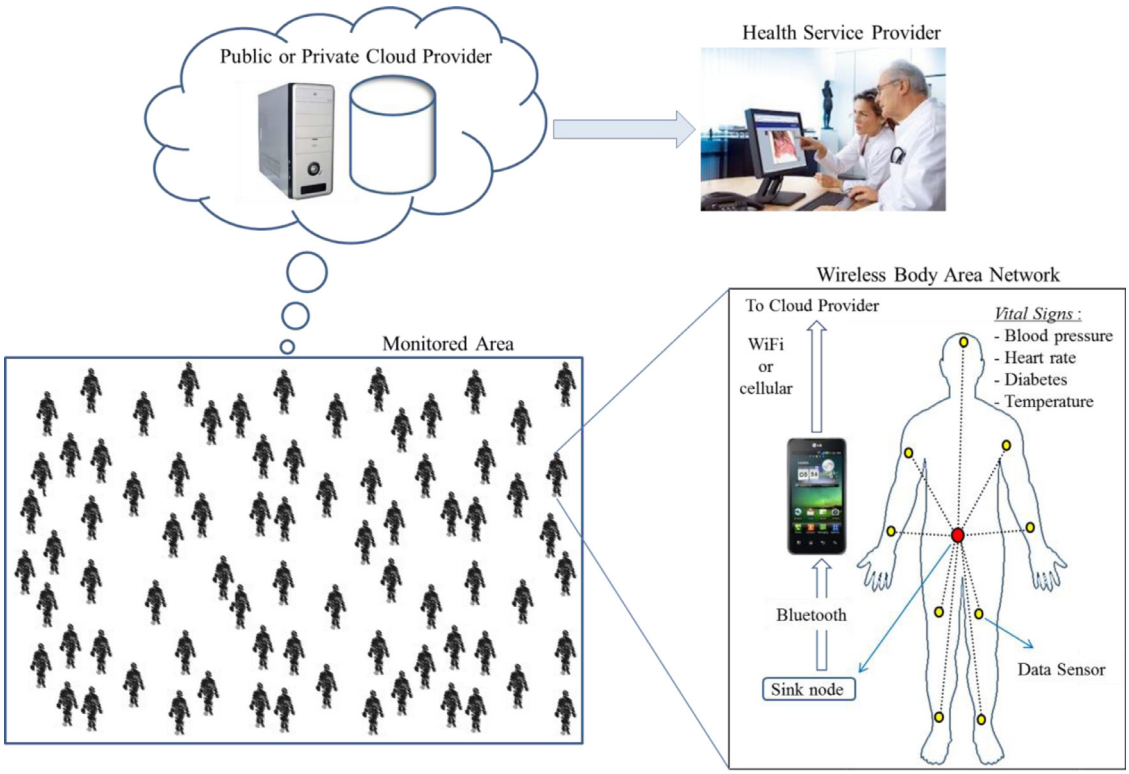

Fig. 1. Healthcare data collection system using wireless body area networks.

and awareness are considered as a major national security concerns for many countries. Such system can provide important health data in a timely manner allowing health organizations to prepare for encountering any sudden emergencies [6].

Emerging health care systems are using Wireless Body Area Network (WBAN) for their efficient data collection and communication. WBAN is a group of communicating sensors that are wearable or implanted on a human body is called. These sensors communicate wirelessly in order to collect the body's vital signs like heart rate, temperature, blood pressure and blood glucose [7]. Via Bluetooth, the collected data by the sensor nodes are transmitted to on-body smart phone or tablet PCs. The data is then forwarded using cellular or WiFi technology in real time routine to a public cloud provider in order to deliver the needed information to a healthcare service provider like clinic or hospital [8,9]. WBAN infrastructure is considered as the basic block of our proposed global health awareness system. Fig. 1 shows the proposed healthcare data collection system using WBANs. The required information for the health service is generated in the cloud service provider and using the collected data from the monitored area of WBANs. It depends on the normality of the generated information. The healthcare service provider will take a necessary action if there is any abnormality in the collected information. Otherwise, the cloud service provider will delete the stored data after a certain period of time. The data is called abnormal if it is not within a range that is determined by National Institutes of Health (NIH) [8].

The proposed system in Fig. 1 can be used to detect an epidemic disease in early stages before it spreads over a wide region, like a city or a country. The proposed system should be smart, efficient and working in a large scale manner, as we will discuss in Section 4. A large scale system for monitoring users with smart devices is proposed in this paper and as shown in Fig. 1. The vital signs of each user are collected and transmitted to the cloud provider [9] using an efficient big data collection model of WBANs system prototype. 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 of this system 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 of such outbreaks [10].

The combination of emerging computing models such as Internet of Things (IoT) and cloud computing in large scale applications, as in healthcare awareness, need to have unlimited storage space and processing power [11]. Recently, medical and health applications are showing an increasing momentum within the core of such phenomena, IoT and cloud models are delivering what is needed for such large scale applications. These needs for large scale storage are included in such models due to the increasing amount of generated data. Similarly, generated data needs to have a scalable storage and cost efficient computing capacity in order to provide the required quality of the needed services with minimum cost. Recently,