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A Survey of Mobile Cloud Computing Model and Big Data Analysis for Healthcare Applications

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Abstract: This paper reviews networked healthcare and the role of mobile cloud computing and big data analytics in its enablement. The motivation and development of networked healthcare applications and systems are presented along with the adoption of cloud computing in healthcare. A cloudlet-based mobile cloud-computing infrastructure to be used for healthcare big data applications is described. The techniques, tools, and applications of big data analytics are reviewed. Conclusions are drawn concerning the design of networked healthcare systems using big data and mobile cloud-computing technologies.

Keywords: Healthcare Systems, Big Data Analytics, Mobile Cloud Computing, Cloudlet Infrastructure, Health Applications.

INTRODUCTION

Mobile devices such as smartphones and tablets have become an essential part of our lives, because of their powerful capabilities. Users depend on their mobile devices to make calls, create and edit documents, performing image processing, access the online social networks websites (Facebook, twitter, etc.), organize meetings and make a video and audio calls. On the other hand, the current proliferation of Cloud Computing (CC) paradigm makes a big evolution in Information Technology (IT).The concept of CC relies on a network-based resource sharing to increase resource availability and to reduce the economic and management costs. The cloud is simply a collection of high-performance servers with a huge amount of storage

Resources connected together and accessible through the Internet. The cloud resources are provided to the users as a service in pay as you use service model. In spite of the benefits provided by the mobile smartphones, resources connected together and accessible through the Internet. The cloud resources are provided to the users as a service in pay as you use service model. In spite of the benefits provided by the mobile smartphones, and the way they make the life easier; they have many weaknesses, such as limited battery lifetime, limited processing capabilities, and limited storage capacity. It is very important to take into account these limitations since they are hindering

Mobile users from doing their daily tasks in an efficient way. One solution to overcome these limitations is to integrate Cloud Computing technology with Mobile Cloud Computing (MCC) [1].

The mobility feature of the mobile device changed the way that people use different technologies all over the world. There is no need anymore to stay in your office to do your job or daily activities. The users can move to many locations based on many parameters for easier life such as efficiency, stable and fast internet connection and data privacy concerns to impose the need to protect the users' data from unauthorized disclosure especially over non-secure wireless channels. All these features of mobile devices and integrating them into our life speed up the transition towards greener and smarter cities.

MCC expands the capabilities and benefits of the mobile devices and overcomes their limitations, so the users will not be worried about the memory size and required CPU power to run intensive tasks that consume a considerable amount of energy and require extra memory. For example, multimedia applications which are known to be among the most common applications in today's mobile devices involve sharing and creating images and video files. These applications require high computing capabilities, big space to be stored, and may be more security protection which are challenges for mobile devices. Mobile cloud computing resolves these issues by storing the large multimedia file on the cloud, and it will be available to the mobile users when requested resulting in better performance. And since the energy drains an important issue in mobile devices and sometimes limits the optimum utilization of these devices, the researchers are motivated to find optimization methods to reduce the consumed energy by mobile devices in the cloud and mobile computing environments.

Besides all the great benefits of using the mobile cloud computing, there are still some limitations such as the delays encountered when the mobile devices access the cloud services from far distance which are mainly due to/from the mobile devices.

It is believed that using the cloudlet concept between the enterprise cloud and the mobile device has a good impact in reducing connection latencies and power consumption.

There are many challenges associated with storing data on the cloud, and mainly is to protect the privacy of the users' data from unauthorized access and from malicious attacks. Also, availability of the owners' data at any time request is an issue. The integrity is also a concern in which the data should not be altered or modified by intruders. Many cryptographic techniques can be used to provide a solution to these information security concerns.

Healthcare applications require large amounts of computational and communication resources, and involve dynamic access to large amounts of data within and outside the health organization leading to the need for networked healthcare mobile cloud computing could provide the necessary computational resources at the right place and right time through cloudlet and fog computing based architectures. Moreover, big data and relevant technologies could provide the data management and analytics solutions that are necessary to reduce healthcare costs and improve the system and clinical inefficiencies. Big data refers to the emerging technologies that are designed to extract value from data having four Vs characteristics; volume, variety, velocity, and veracity. Big data is set to affect the future network traffic and hence the network architectures.

Cloud computing vs. mobile cloud computing

Cloud computing

''Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services'' [4]. A cluster of computer hardware and software that offer the services to the general public (probably for a price) makes up a 'public cloud'. Computing is therefore offered as a utility much like electricity, water, gas etc. where you only pay per use. For example, Amazon's Elastic cloud, Microsoft's Azure platform, Google's App Engine and Salesforce are some public clouds that are available today. However, cloud computing does not include 'private clouds' which refer to data centers internal to an organization. Therefore, cloud computing can be defined as the aggregation of computing as a utility and software as a service. Virtualization of resources is a key requirement for a cloud provider for it is needed by statistical multiplexing that is required for scalability of the cloud, and also to create the illusion of infinite resources to the cloud us. [5] Holds the view that ''different utility computing offerings will be distinguished based on the level of abstraction presented to the programmer and the level of management of the resources''. To take an example from the existing cloud providers, an instance of Amazon's EC2 is very much like a physical machine and gives the cloud user almost full control of the software stack with a thin API. This gives the user a lot of flexibility in coding; however, it also means that Amazon has little automatic scalability and failover features. In contrast, Google's App Engine enforces an API on the user but offers impressive automatic scalability and failover options. Microsoft's Azure platform is something in between the for mentioned providers by giving the user some choice in the language and offers somewhat automatic scaling and failover functions. Each of the aforementioned providers has different options for virtualizing computation, storage, and communication.

Mobile cloud computing

The cloudlet concept proposed by Satyanarayanan [3] [6] is another approach to mobile cloud computing. Illustrates this approach where the mobile device offloads its workload to a local 'cloudlet' [25] comprised of several multi-core computers with connectivity to the remote cloud servers. Plug Computers8 can be considered good candidates for cloudlet servers because of their form factor, diversity and low power consumption. They have the same general architecture as a normal computer, but are less powerful, smaller, and less expensive, making them ideal for role small scale servers installed in the public infrastructure. These cloudlets would be situated in common areas such as coffee shops so that mobile devices can connect and function as a thin client to the cloudlet as opposed to a remote cloud server which would present latency and bandwidth issues.

Mobile cloud computing would also be based on the basic cloud computing concepts. As discussed by Mei et al. in [5] there are certain requirements that need to be met in a cloud such as an adaptability, scalability, availability and self-awareness. These are also valid requirements for mobile cloud computing. For example, a mobile computing cloud also needs to be aware of its availability and quality of service and enable diverse mobile computing entities to dynamically plug themselves in, on the requirements and workload. And in order for mobile users to efficiently take advantage of the cloud, a suitable method of self-assuming one's own quality is needed—since the internal status and the external environment is subject to change. However, in addition to the similar requirements, a mobile cloud needs to consider other aspects such as mobility, low connectivity and finite source of power as well.

Emerging and future MCC applications

Application Catagory	References
Crowd sourcing (crowd computing)	[35][36][37]
Collective sensing	[38][39][40][41]
Traffic/environment monitoring	[42][43][44][45]
Mobile cloud social networking	[46][47][48]
Mobile cloud healthcare	[49][50][51]
Location-based mobile cloud service	[52][53]
Augmented reality and mobile gaming	[54][55]

Related work

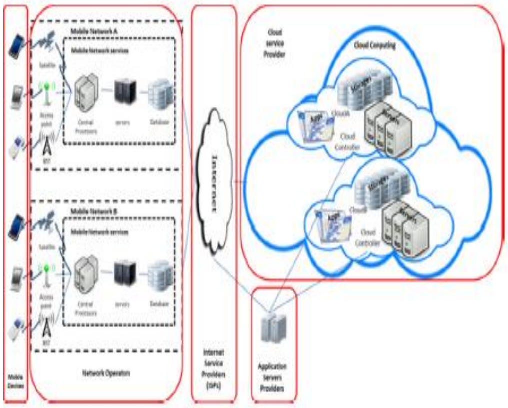
There are much related works in the literature about cloud and mobile cloud computing and their useful applications in many life aspects including health and financial transactions. Not neglecting the important issue of securing users sensitive data on the cloud, a secure framework for cloud computing based on data classification is proposed in [7]. This framework categorizes the data based on its confidentiality and selects the suitable encryption mechanism to provide the appropriate protection for each data category. The authors in [8] presented a prototype implementation of cloudlet architecture. They pointed out the advantages of such architecture in real-time applications. In the straightforward approach, the cloudlet is _xed near wireless access points. But in this prototype, a cloudlet can be chosen dynamically from the resources inside the network to manage the running applications on the component model. In [9], a large scale Cloudlet MCC model was deployed for the purpose of reducing network delay and power dissipation especially for intensive jobs such as multimedia applications. Also, the large-scale deployment covering large areas allows the mobile users to stay connected with the cloud services remotely while they are moving within this area with less broadband communication needs while satisfying high-quality service requirements. The impact of using cloudlet along with mobile cloud computing on some interactive applications (including video streaming) was analyzed in [10]. The authors compared the two models in terms of system throughput and data transfer delay. Their results indicated that in most cases, the use of the cloudlet-based model outperformed the cloud-based model. A framework to provide personalized emotion-aware services by mobile cloud computing is proposed in [11].Energy conservation is a major concern in cloud computing systems with a huge number of operating data centers that consume large amounts of power. Moreover, the prediction of how much this consumption will increase depends on the dynamic expansion of their infrastructures to meet the increasing demand for huge computation and massive communication. The authors in [12] proposed resources management and optimization policies in the Cloud such as using virtualization, VM live migration, and server consolidation. They presented an energy efficient network resources management approach and proposed a practical multi-level Cloud Resource-Network Management (CRNM) algorithm, which is implemented in a virtual Cloud environment using Snooze framework as the Cloud energy efficiency manager. The results showed a saving of more than 70% of power consumption in Cloud data centers compared to other non-power aware algorithms.

Networked healthcare

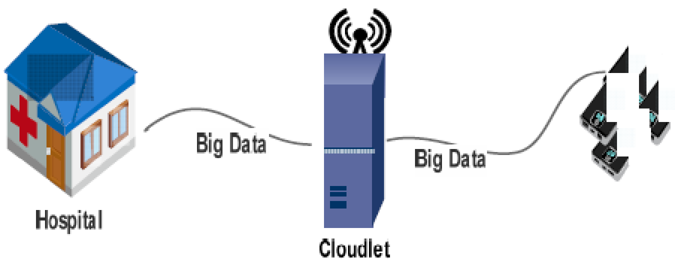
This section provides the motivation for networked healthcare followed by a review of the literature on the state-of-the-art of networked healthcare architectural and performance studies including those implemented on cloud computing platforms. Healthcare, like many other sectors, has grown rapidly with the massive growth in ICT. The increasing role and benefits of ICT in healthcare are becoming visible in the health informatics, bioengineering, and Healthcare Information Systems (HIS). We can now imagine a near future where healthcare providers can port powerful analytics and decision support tools to mobile computing devices aiding clinicians at the point of care helping them with the synthesis of data from multiple sources, and context-aware decision-making [13]. Major drivers for ICT-based healthcare include demands for increased access to and quality of healthcare, rising healthcare costs, system inefficiencies, variations in quality of care, high prevalence of medical errors, greater public analysis of government spending, ageing population and the fact that patients and the public want a greater say in decisions about their health and healthcare. The scientific developments that are yet to reach their required potential for providing personalized healthcare include genetic and molecular research, translation of knowledge into clinical practice, new processes and relationships in product development and knowledge management [14]. However, we believe that the major hurdles for the healthcare industry in realizing the full potential of ICT include the social reasons including privacy of health data and public trust [15].The key management strategies that healthcare executives should focus on over the coming years include Collaboration, Open Systems, and Innovation [16]. The key health information technologies (HIT), according to them to be deployed over the next decade include Electronic Health Record (EHR), Personal Health Record (PHR), and Health Information Exchange (HIE) systems. They projected that by 2020, 80% of healthcare provider organizations will have implemented EHR systems in the US, and 80% of the general population will have started using PHR systems in the US. A vision of Medical Informatics in 2040 is presented in [17]. The authors believe that transformation of healthcare will be enabled through the implementation of technologies including genomic information systems & bio-repositories integrated with EHR systems; nanotechnology, advanced user interface solutions, e.g. wearable systems, health apps, health information exchange (HIE) with other industries/sectors such as pharma and manufacturing, Home-based TeleHealth solutions interconnecting patients with health care providers, and medical robotic devices interfaced to health IT (HIT) systems. The United States Department of Health and Human Services [14] envisions personalized health care and gives a perspective on how far and how quickly we have come in treatment strategies of dangerous diseases including cancer, diabetes and heart attacks. In 2014, Apple introduced the mobile health platform Health Kit [18], a cloud API made available for IOS 8 [19]. Health Kit benefits by the Apple's partnership with this enterprise with Mayo Clinic and software company Epic Systems.

Mobile cloud computing infrastructure and healthcare Big data

There are many mobile cloud computing infrastructures for different usages including the healthcare [34] applications. The traditional infrastructures involve set of cloud resources accessed remotely by the users of different types of devices via through the Internet as shown in Figure.



The massive spread of mobile applications in all and every area of the people's life resulted in huge amounts of data that need to be processed and analyzed efficiently in less time and power complexity which imposes the need for new competitive MCC models other than the traditional one. Performance Enhancement Framework using the Cloudlet was proposed in [20]. The cloudlet can be considered as a closer cloud with many advantages and capabilities to avoid several limitations of the distant cloud. And so, a limited resources cloudlet will not help and might have a bad impact on the performance. So, it is believed that the cloudlet scheme which is introduced as a middle stage between the cloud. The cloudlet concept and the mobile device has a good chance to overcome the challenges associated with MCC such as latencies and power consumption [21].But, in some cases, the mobile user has no choice other than connecting directly to the EC. This happens when the mobile device needs to update stored in the Enterprise Cloud or request certain services that are not available in the Cloudlet. Motivated by the cloudlet concept, the authors in [22] built a mobile cloud system to be used in different applications such as universities. Their system uses different sensors to carry out many tasks. They proposed and implemented two main applications in traffic management and detection and the data from sensors is processed in the mobile cloud system. In the same context, the researcher in [23] introduced an efficient cloudlet MCC model in which the mobile users communicate directly to the cloudlet instead of the enterprise cloud. Their model can be applied in many environments including hospitals were big amounts of data need to be saved and processed. The Big Data [32]is a recent term associated with the huge amounts of stored /obtained data due to the revolutionary advances in different technologies including cloud computing, the spread of social media, and wireless communication technologies. It is defined according to the size of data (volume), types of data based on the producing source (variety), and the time-frequency to generate the data (velocity); every, minute, day, month, or a decade [24]. Some of this big amount of data could be processed offline, but some applications need real time processing for this data such as health applications where the data analysis and extracting the right decisions makes a difference between patients life and death. Below Figure shows Mobile cloud computing for healthcare big data applications. In this MCC model, the cloudlets are placed nearby the hospital and cover an area that can be accessed by authorized people who can access the patients' information and follow their status remotely.



CONCLUSION

Healthcare industry is data-intensive and data-driven industries. Massive amounts of data are generated from health care providers, public and private payers, ancillary service providers such as labs and pharmacies, and health care consumers alike. With the developments and new inventions in mobile devices, wearable devices, network, and social networks, even personal health data are accumulated and available. Storage and efficient access of those data have been primary concern and interests. The challenge is, however, not just in storage and access, but also in making this data usable**,** as more and more data is being collected, there will be increasing demand for big data analytics which is in its infancy for the healthcare domain. Unraveling the Big Data [24] related complexities can provide many insights about making the right decisions at the right time for the patients. Efficiently utilizing the colossal healthcare data repositories can yield some immediate returns in terms of patient outcomes and lowering care costs. A big data analytics[28] platform in healthcare that supports the key functions necessary for processing the data is on immediate demand. The criteria for platform evaluation may include availability, continuity, ease of use, scalability, ability to manipulate at different levels of granularity, privacy and security enablement, and quality assurance Real-time big data analytics [28] is a key requirement in healthcare [26]. The lag between data collection and processing has to be addressed and resolved. The numerous analytics algorithms, models [29] and methods are also needed to be dynamically available for large-scale adoption.

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