A review of cloud computing-based medical and healthcare system implementations

Samar Abdallah, EltayebHYPERLINK "https://link.springer.com/article/10.1007/s00521-020-05110-3" E. HYPERLINK "https://link.springer.com/article/10.1007/s00521-020-05110-3"AbedElgabar- Faculty of Computer Science and Information Technology, Al-Neelain University

EltayebE.AbedElgabar Faculty of Computer Science and Information Technology, Al-Neelain University

Abdelaziz Mahmoud Faculty of Computer Science and Information Technology, Al-Neelain University

Abstract:

Existing medical structures forpatients' information storage are not scalable sufficient for the increasing range of sufferers and applications cloud computing is a promising platform for medical information systems in order to reduce costs and improve accessibility. Cloud computing concept is becoming one of the popular IT infrastructures for enabling medical information system integration and sharing. The assurance of the pleasant of statistics used in healthcare systems is an urgent need to assist the continuity and first-rate of care. Identification of records exceptional dimensions in healthcare clouds is a difficult issue as data pleasant of cloud-based health information structures occur some problems such as the apo propriateness of use, and provenance. The objective of this study is to explore the recent state and developments of cloud computing in healthcare area in term of implementation, benefits, challenges and future directions. This study provides the importance of cloud computing for the medical and health information system practical usage. It shows how cloud computing deliver and contribute tob wards in the medical and healthcare system. The outcomes of this study assumed that human factors are very important, especially organization support which others considered as significant.

Key words: medical information system, healthcare, cloud computing, patients' information.

مراجعة تطبيق الأنظمة الطبية وأنظمة الرعاية الصحية القائمة على الحوسبة السحابية

أ.سمر الحاج عبدالله – باحثة – جامعة النيلين
د.الطيب السماني عبدالجبار- كلية علوم الحاسوب وتقانة المعلومات- جامعة النيلين.
د. عبدالعزيز محمود جمع محمد - كلية علوم الحاسوب وتقانة المعلومات- جامعة النيلين.

المستخلص:

الهياكل الطبية الحالية لتخزين معلومات المرضى ليست قابلة للتطوير بشكل كافٍ نسبة لتزايد المرضى بشكل كبير، وتعتبر تطبيقات الحوسبة السحابية هي منصة واعدة وتقنية حديثة لأنظمة المعلومات الطبية من أجل تقليل التكاليف وتحسين إمكانية الوصول. أصبح مفهوم الحوسبة السحابية أحد البنى التحتية لتكنولوجيا المعلومات الشائعة لتمكين تكامل أنظمة المعلومات الطبية ومشاركتها. إن ضمان تخزين وإسترجاع إحصائيات البيانات المستخدمة في الأنظمة الطبية وأنظمة الرعاية الصحية هو حاجة ملحة للمساعدة في استمرارية الرعاية الطبية بجودة عالية. يعد تحديد السجلات الطبية و المتعددة الأبعاد في حوسبة سحابية خاصة بالرعاية الصحية مشكلة صعبة نظرًا لأن البيانات المستخدمة لهياكل المعلومات الصحية المستندة إلى السحابة تحدث بعض المشكلات مثل ملاءمة الاستخدام والمصدر. الهدف من هذه الدراسة هو استكشاف الدراسات السابقة والاوراق العلمية ذات الصلة بالمجال والتطورات الأخيرة التي تمت للحوسبة السحابية في مجال الانظمة الطبية وأنظمة الرعاية الصحية من حيث التنفيذ والفوائد والتحديات والتوجهات المستقبلية في المجال. تقدم هذه دراسة منهجية عن أهمية الحوسبة السحابية للاستخدام العملي لتطبيقات نظم المعلومات الطبية والصحية. وكذلك توضح الدراسة كيف تقدم الحوسبة السحابية وتساهم في النظام الطبي والرعاية الصحية. ومن أهم نتائج هذه الدراسة أن العوامل البشرية في مجال النظم الطبية وأنظمة الرعاية الصحية مهمة للغاية ، وخاصة الدعم التنظيمي الذي يعتبر مهمًا في معظم الحالات.

الكلمات المفتاحية: نظم المعلومات الطبية، الرعاية الصحية، الحوسبة السحابية، سجلات معلومات المرضى.

Introduction:

Cloud computing is the transfer of computing as a carrier alternatively than a product, whereby shared resources, software program and information are furnished to computer systems and other devices as a utility over the Internet. Cloud computing gives computation, software, information access, and storage services that do now not require end-user understanding of the bodily location and configuration of the device that offers the services. Parallels to this thinking can be drawn with the electrical energy grid, wherein end-users have strength without wanting to understand the thing devices or infrastructure re-

quired to provide the service [1].

As healthcare equipment provides proper monitoring and patient health records are shared and collected utilizing cloud computing services like (SaaS, which stands for storage as a service, cloud computing and health monitoring are increasingly being used in tandem. Recently, IT resources and services are employed on a daily basis on a larger scale in all sectors, including stock, education, the military, gaming, agriculture, and healthcare. The demand for IT employment services has increased since the IT sector provides services in a more authentic and practical manner than the conventional one. There is now no precise overview of stream research, regardless of various means of scattered registration in clinical consideration. This paper's motivation was to ascertain the situation of research and the assessment of future of cloud services [2].

Distributed computing assumes the vital phase in the discipline of clinical services as it gives the volume of offices, for example, digital medical help, smart cloud prepared gadgets, inserting away the medical records, on-request house on pay-more only as prices occur model, and several appreciably greater facilities [3]. Through distributed computing, there will be ease of series or transferring of patient's health record very easily, thru which one can retailer not only the money and time but the gas also. Keeping the current situation in mind, due to pandemic most humans are no longer allowed to gather at the equal time at the hospital, which is very unstable and infectious, with the assist of cloud net one can take advantage. It will be easy for medical doctors to keep the data; no be counted how long it can stay [4].

1.1 Motivation

Traditional medical information system creation serves to independent hospitals, so the hospitals face several difficulties in traditional medical systems such as:

- Lack of uniform standard data sharing, data storage and

communication between systems.

- Large number of medical equipment such as ultrasound, CT, radiology equipment, monitoring equipment, etc., producing a large amount of data of different storage forms and encoding methods.
- High cost for independent construction It costs much for any hospital to set up a complete platform combining all aspects such as hardware, software, management, maintenance, for the existing HIS construction. Even for medium and large hospitals, the independent construction of HIS is a heavy burden.
- Difficult a separate medical information system for administration, upgrades and maintenance separate management and maintenance of the hospital is required. Problems that occur during operation, such as technical defects; improper use lack of software or specialists needed to manage and maintain the medical information system ongoing investment that brings high costs to hospitals. but independent Each hospital requires separate maintenance and upgrades to progress. Therefore, many medical systems cannot receive sufficient technical services [5].
- This paper is organized as follows: Section 2 introduces basic background related cloud computing. Section 3 provides the growing uses of cloud computing. The applications of cloud computing in medical and healthcare and the benefits of cloud adoption in medical and healthcare presented in Section 4 and 5 respectively. Section 6 provides the challenges of medical cloud computing and Section 7 shows the advantage of cloud computing in medical areas. Finally, conclusion and future work are given in Section 8.

C loud Computing Background

The word “cloud” has different definitions, but it is frequently used

as an Internet metaphor (which is commonly illustrated as cloud illustrations in many ICT textbooks). However, some people claim that the term "cloud computing" was coined by Google CEO (Eric Schmidt), who is reported to have spoken it during a conference in 2006 [6]. Depending on who you ask, there will likely be a variety of offered definitions when looking for a definition of cloud computing. An endless stream of definitions for cloud computing are likely to come up in a quick Google search.

Some authors such as [7] [8] claim that there doesn't appear to be a single definition or industry standard for cloud computing. The worldwide management consulting firm McKinsey did a study and found 22 definitions of cloud computing [9].

It is probably safe to define it as a delivery method that makes use of developments in ICT technologies like virtualization and grid computing for remotely delivering a variety of services, such as software and virtual hardware (as opposed to physical hardware), provisioned (by data centers owned and operated by cloud providers and/or end users) according to user demands and through public (like the Internet), private networks, or a mix (i.e., hybrid) of the two delivery modes. The ICT services offered include:

- Business-related computer programs (software as a service – SaaS).
- Fast and almost unlimited processing capabilities and large and almost unlimited storage facilities (infrastructure as a service – IaaS).
- Development tools and hosting options for clients preferring to create and manage their own Web applications (platform as a service – PaaS).

End users such as client companie, can utilize cloud software placed on their own data centers (private clouds) or deployed on their own data centers to access cloud computing services from cloud vendors through their data centers whatever is public clouds or hybrid clouds. Community clouds, a brand-new class of cloud

computing service, are being promoted as a potential upgrade to the existing cloud-based ICT delivery models. In community clouds, cloud services can be offered typically by a single company and used by a variety of businesses and professions that are related to those of the offering organization. There are not many examples right now to back up this strategy's viability. In addition, this technology allows individual physical resources (servers, operating systems, applications, storage devices, etc.) to be viewed as multiple logical resources Grid computing uses software to combine the computing power of different computers connected to a grid to solve a single problem, often a large amount of computing power problem. Grid computing also uses software that allows parts of a program to be split up and offloaded onto up to thousands of computers Therefore, grid technology can be said to be a technology that realizes network distributed parallel processing and distributed/large-scale cluster computing.

Cloud Computing Types

The types of cloud computing can be divided into four categorize as follows:

Public cloud is cloud computing delivered and shared over the Internet across the organization. It is typically created from IT infrastructure not owned by the end user.

A private cloud is cloud computing that is dedicated to an organization Every cloud becomes a private cloud because the underlying IT Infrastructure is dedicated to a single customer and completely isolated access.

A hybrid cloud is an environment that uses both public and private clouds orHybrid cloud characteristics are complex, and requirements may vary. Depending on who you ask for example, a hybrid cloud should include at least one private cloud and at least one public cloud; two or more private clouds; two or more public clouds a bare metal or virtual environment connected to one or more pub-

lic or private clouds.

A multi-cloud is a cloud approach consisting of multiple cloud services, multiple clouds provider (public or private). Can be consider all hybrid clouds are multi-cloud, but not all multi-cloud is a hybrid cloud. Multiple clouds become hybrid clouds are connected by some form of integration orchestration.

Cloud Service Types

In cloud technologies, information is passed from clients to organizations across virtual data centers. This virtual data centers have all the information to be process. Figure 1 shows the cloud computing service. The cloud computing technology models as cloud service types consist of [10].

- Software as a service known as SaaS.
- Platform as a service known as PaaS.
- Infrastructure as a service known as IaaS.

Figure 1: Cloud computing service

•Cloud computing service models:

Cloud computing has important three carrier models the place each presents a huge variety of services for the users based on their desires and demands. Infrastructure as a carrier (IaaS), Platform as a provider (PaaS) and software program as a carrier (SaaS). Infrastructure as a carrier delivers infrastructure as servers, operating systems on demand based totally on the users' desires instead than investing in the infrastructure. At the same time, IaaS permits scaling the capacities of the infrastructure and sharing its resources. For instance [11]:

- Amazon
- VMware: Vblocks to build clouds using VMware infrastructure
- IBM cloudburst

- Juniper.
- 3 Tera
- Rackspace

Platform as a service lets users to build applications over the Internet with no any software license; to accomplish this, PaaS maintains applications developed over a web interface, extensibility, database integration, team collaboration, and presenting and subscription processing. For instance:

- Oracle
- IBM: blue cloud computing platform
- Google: enables developing application on data centers
- AT&T
- Microsoft: windows azure
- 3Tera: cloud ware for offering applications
- NetSuite: suit cloud for on demand services

Software as a service, or SaaS, is software that is distributed and deployed over the internet utilizing a pay-per-use business model without the need for the user to manage upgrades or patches. SaaS also provides integration across various software products. For instance:

- SAP
- Oracle
- Salesforce.com: CRM solutions on the cloud
- Google: google applications like google calendar and google docs

The growing uses of cloud computing

Numerous public cloud computing services are available. Many of those perform a range of functions, including allowing customers to instantly establish hundreds or even thousands of virtual computers such as servers; gain unlimited storage space for their data; and gain access to the necessary level of software functionality for

Microsoft office package like word processing, spreadsheets, etc. and business-related operations for example, CRM. In fact, one could easily build their complete IT infrastructure in the cloud. A small business from California called 3tera has created software called AppLogic that can automate the development of intricate corporate systems. A designer can utilize the software's straightforward graphical user interface to drag and drop icons that represent conventional components onto a page in a Web browser. Once the designer is ready, the software creates the virtual IT infrastructure in minutes with the click of a button [12]. In addition, several cloud computing-based healthcare solutions have emerged recently.

As noted in [13], increasing life expectancy has resulted in an aging population requiring healthcare in many developed countries, but resources to meet these increased needs; medical specialists, community support, and financial means are running low. This situation is challenging many healthcare providers are looking for more innovative and cost-effective solutions to address this growing problem, therefore cloud computing has development potential some of the solutions needed to address these issues [14].

Figure 2: Key benefits of cloud computing in healthcare [2]

- **Applications of Cloud Computing in Healthcare**

medical ecosystem Large, diverse and highly complex systems, including health insurance Companies, hospital and doctor networks, laboratories, pharmacies, patients and other entities [15] and all that must work within some state regulations. For this ecosystem to work effectively and quickly, several critical information is exchanged quickly and accurately between the two in a confidential and secure manner between these entities secure Patient information is considered sensitive and a privacy concern healthcare industry.

Probably one of the reasons it's negatively impacting the progress of healthcare's migration to the cloud. Sharing should then be handled with innovative technologies and tools enter the cloud. But there are many other data, information and services. People who can definitely benefit from collaboration because they use the cloud. It can span cities, states, and even countries in the stream. The scenario seems to be a private cloud implementation for the first reason Security concerns and public infrastructure [15]. It recommends laying out the layout first identify top priorities for the healthcare industry and which cloud to evaluate. The computing aspect can be effectively applied to their advantage. In today's world increasing healthcare costs, the quality of services provided to patients, view customers, data protection, data security and integrity, and disaster recovery As a top priority [16]. Some of the unique features such as a scalable infrastructure, as a data center that provides persistent data, so you can partially use the security model, fast access to information, etc. These priorities can be addressed.

Infrastructure and dynamic scalability

As the customer base in the healthcare industry continues to expand, providers of healthcare solutions are growing, and so are their businesses. As business grows, organizations invest heavily in more computers capacity and IT resources to meet growing demand. These computing resources it is provided to accommodate fairly complex and dynamic environments. With cloud Computing now offers organizations an alternative to address this problem. or the cloud offers Infrastructure-as-a-Service and Platform-as-a-Service businesses a model that allows organizations to leverage or adapt their existing infrastructure match your business and your needs. Additional servers can be added or removed as needed in the shortest possible time. Instead of storing data like hospitals information, doctor networks, pharmacies, their locations, etc pri-

vate on-premises servers that can be offloaded to cloud-based data centers storage. Mainly software updates provider. This ultimately frees up multiple resources and reduces costs of maintain them for healthcare solution providers.

Since the cloud gives scalable infrastructure, the groups might also be able to higher alter and optimize their resource capability planning. For some of the clinics that are small to medium sized and can't have enough money large IT investments and body of workers can take remarkable advantage from cloud computing with their cost high-quality price structure and low value maintenance. An instance for this is Amazon's S3 that gives scalable storage structure [17]. The eHealth cloud is being constructed by way of Telstra and the Royal Australian College of General Practitioners and is expected to host healthcare functions such as "clinical software, decision-support tools for diagnosis and management, care plans, referral tools, prescriptions, training, and different administrative and medical services" [18].

- **Information Sharing**

Health corporations do no longer feature in silo. They have to continuously interact with different corporations as noted above. A lot of statistics are despatched and received in orst der to manner claims, provide purchaser guide services, new member acquisitions, techniques issuer requests etc. In today's world providers store the EMRs in their own databases [١٩]. If some of these facts can be moved to the cloud and shared across these companies and structures, it may also lead to better and fas ter coordination of offering and finally more client satisfaction. A new product, Accenture and AT&T designed a cloud-based system for medical imaging services, known as Accenture medical imaging solutions [٢٠]. The service is designed for healthcare professionals to review medical images such as X-rays, MRIs and CT scans so they can see more patients at once than they do today.

The service will provide centralized management of these images so healthcare providers can view, exchange and share them in a faster and safer environment.

Availability

High availability of cloud services can only help healthcare organizations provide uninterrupted services with minimal downtime. The cloud can be programmatically controlled, allowing near real-time scalability. Clusters can be created with multiple nodes for high availability [21]. And because resources are fixed at the start of the compute, the workload can be adjusted to scale the application up or down as needed. There are also predictions that managing health apps in the cloud will make them more widely available all the time. This can significantly reduce maintenance costs.

Cloud monitoring tools

In addition to the rise of cloud computing, some third-party vendors are also developingTools that can help monitor services provided in the cloud Health care Organizations are working with these vendors to adapt these tools.

The Benefits of Cloud Adoption in medical and healthcare

Healthcare cloud computing brings a new economic model, realize certain benefits that benefit the general healthcare community Through cloud adoption in health services, patients and healthcare organizations will gain a huge advantage in the quality of service to patients, Collaboration between healthcare organizations and reduced IT costs in healthcare companies This collaborative approach makes health care possible Services work together to provide a faster and more efficient service Responses that contribute to improving the quality of patient services by sharing Information on health facilities. Therefore, hospitals, clinics, Imaging centers, pharmacies and insurance companies can effectively share Patient medical records, prescription information, x-rays, test results, doctor's recommendation, doctor's availability,..etc. It's available by

authorized entities anytime, anywhere. All this information will be used make decisions, get better diagnosis and treatment for better treatment as a result, scheduling doctor's appointments, speeding up insurance approvals, and more. Considerable improvement in the quality of service for patients. When you move to the cloud, for medical institutions, there is another very important favourable factor, what is the IT cost. By adopting a cloud model, all IT processes will be migrated to a remote cloud computing infrastructure, all processes will be executed and stored. The cloud medical application can allow these organizations only pay for what they use; accordingly, there is no reason buy expensive hardware infrastructure, software licenses or maintenance, training on-premises personnel are responsible for maintenance, security, replication, because the cloud computer vendors will take care of that. Human life is priceless, medical resources are limited, consuming health services cloud providers correspond to profitable concepts where patients and health organizations benefit from this new technology by improving patients provide quality of service through a highly integrated distributed platform the medical processes and reduce IT infrastructure investment or maintenance costs result in a better healthcare environment.

• **Cloud storage** is the backbone of the platform, health data collected daily from sensors such as blood glucose meters and blood pressure monitors activity. The author reduced the cost of storing and managing data adoption of cloud frameworks. Plus, an access control module for multiple tenants is implemented between tenant databases and shared databases to protect Security and privacy of patient data.

• **The Healthcare Data Annotation Layer** solve the problem of data heterogeneity that often occurs during data processing process. Different hospitals have different equipment, so data is generated frequently Heterogeneous, increasing complexity of automated health data.

Interaction and understanding between medical institutions The author suggested one Open Linked Life Data (LLD) sets to annotate personal health data, Integrate distributed data into patient-centric patterns in the cloud application.

• **Patient health record** the health data stored in the cloud to support clinical decision making because similar historical data is a valuable resource for treatment plan similar disease cases. The mining algorithm is implemented to derive clinic routes from personal health data.

Figure 3 shows that each part is specially designed to handle predefined part tasks and can be implemented to meet various medical and healthcare needs. It has a cloud platform, cloud service, web service API and a user interface. This stage can help practitioners sending raw data to monitor and assess health status after processing the information from the end user to the cloud then displayed results to physicians [22] [23].

Figure 3: Plat form of cloud computing medical system

Challenges of medical cloud computing

The key features considered when designing and implementing medical healthcare systems must address challenges related to the following concepts:

•Data storage: there are big one's electronic health records require the involvement of many medical patients and hospitals.

•Computationally efficient: required to form medical record system model runs in scalable with minimal computation.

•Data exchange: medical information systems need doing patients data exchange.

•Efficiency: a key requirement for medical and healthcare systems is required more performance efficiency in terms of scalability, computational complexity, and security.

Table 1: Challenges of cloud computing in the healthcare sector [24]

Challenges	% Percentage
Technological	59%
Human	16%
Organizational	14%
Environmental	11%

Based on study [24] as shown in table 1, the tasks that cloud computing produces are technological, human, organizational, and environmental. The technological sector is more percentage than other sectors. On the other hand, the environmental sector is the less percentage.

- **Advantage of cloud computing in medical areas**

Medical cloud system is a flexible, stable and reliable system and proves data sharing, storing and exchanging issues is available. Thus, medical cloud systems can easily share cross different hospitals. And can offers advantages as below:

Scalability: Always scale your nodes as needed. Add Node Networking is as easy as connecting a Linux box to your network and copying a few configurations file. Hadoop also provides details of available disk space cluster. So, according to this report, we can decide to add node or not.

Cost effective: Linux nodes are always cheap. no need to invest Not only the OS, but also the hardware has a lot to do with it.

Best Strategy: Hadoop Platforms Can Also Offer Distributed Files. Also, a system that uses a joint allocation mechanism to find the optimal strategy medical cloud search.

Replication: because the replication location service is included in the MIFAS middleware data Can be saved in completed state and data can be easily shared in various private Cloud.

Ease of management: Provides an easy-to-use management inter-

face and through them Interface simplifies setup and management of private cloud environments at medical system. Moreover, the goal of medical cloud system is not just access to medical image files in the cloud Improve information sharing by sharing patients and their caregivers.

Conclusion and Future Work

In this study we review the recent studies in cloud computing that adopted in medical and healthcare implementation issues. In addition, the potential of using cloud computing in providing recently in medical and healthcare presents several exciting opportunities for professionals and organizations working in this field. We highlighted the cloud computing challenges in the medical and healthcare sector as well. By use of cloud computing for medical establishment systems offers opportunities for savings cost and advanced solutions. The study shows the increasing interest in this area by both medical and healthcare applications in cloud suppliers. The future works may be launches the access for other factors to be observed which may be developed from other studies perspectives to discover unseen factors which may influence the cloud adoption in medical and healthcare implementation. Moreover, analyzing the culture of the population and how it influences the adoption of the cloud in medical areas is very important. The security issues can be considered as well. Moreover, Medical data storage using Quantum aware blockchain is a new trend mentioned in [25].

References

(1)Kanagaraj, G. and A. Sumathi. Proposal of an open-source cloud computing system for exchanging medical images of a hospital information system. in 3rd International Conference on Trendz in Information Sciences & Computing (TISC2011). 2011. IEEE.

(2)Faridi, F., et al., Cloud computing approaches in health care. Materials Today: Proceedings, 2022. **51**: p. 1217-1223.

(3)3. Li, M., et al., Scalable and secure sharing of personal health records in cloud computing using attribute-based encryption. IEEE transactions on parallel and distributed systems, 2012. **24**(1): p. 131-143.

(4)Löhr, H., A.-R. Sadeghi, and M. Winandy. Securing the e-health cloud. in Proceedings of the 1st acm international health informatics symposium. 2010.

(5)Hu, W., X. Hou, and C. Zang, Study on and realization of hospital information integration based on XML. Journal of Huaihai Institute of Technology, 2008. **17**: p. 36-39.

(6)Regalado, A., Who coined the term "cloud computing"? The Business Technology Forum. 2011.

(7)Grossman, R.L., The case for cloud computing. IT professional, 2009. **11**(2): p. 23-27.

(8)Voas, J. and J. Zhang, Cloud computing: New wine or just a new bottle? IT professional, 2009. **11**(2): p. 15-17.

(9)Katz, R., et al. Cloud computing in higher education. in EDUCAUSE.[Online],[Retrieved October 5, 2010], http://net. educause. edu/section_params/conf/CCW. 2010.

(10)Sreenivas, V., B. ArunaKumari, and J. VenkataRao, Enhancing the security for information with virtual data centers in cloud, in Future Wireless Networks and Information Systems. 2012, Springer. p. 277-282.

(11)Mekawie, N. and K. Yehia, Challenges of deploying cloud computing in eHealth. Procedia Computer Science, 2021. **181**: p. 1049-1057.

(12)Carr, N., The big switch: Rewiring the world, from Edison to Google. 2009: WW Norton & Company.

(13)13. Alagöz, F., et al. From cloud computing to mobile Internet, from user focus to culture and hedonism: the crucible of mobile health care and wellness applications. in 5th Interna-

tional Conference on Pervasive Computing and Applications. 2010. IEEE.
(14)Sultan, N., Making use of cloud computing for healthcare provision: Opportunities and challenges. International Journal of Information Management, 2014. **34**(2): p. 177-184.
(15)Wan, D., et al., Six questions every health industry executive should ask about cloud computing. Accenture Institute for Health & Public Service Value, 2010.
(16)Alliance, C.S., Top threats to cloud computing v1. 0. White Paper, 2010. **23**.
(17)Kuo, M.-H., Opportunities and challenges of cloud computing to improve health care services. Journal of medical Internet research, 2011. **13**(3): p. e1867.
(18)Ahuja, S.P., S. Mani, and J. Zambrano, A survey of the state of cloud computing in healthcare. Network and Communication Technologies, 2012. **1**(2): p. 12.
(19)Zhang, R. and L. Liu. Security models and requirements for healthcare application clouds. in 2010 IEEE 3rd International Conference on cloud Computing. 2010. IEEE.
(20)Violino, B., Accenture, AT&T Offer Cloud-Based Medical Imaging. 2011.
(21)Kupferman, J., Scaling into the cloud. CS270 Advanced Operating Systems, 2009, 2009.
(22)Yang, G., et al., A health-IoT platform based on the integration of intelligent packaging, unobtrusive bio-sensor, and intelligent medicine box. IEEE transactions on industrial informatics, 2014. **10**(4): p. 2180-2191.
(23)Singh, D., et al. Semantic edge computing and IoT architecture for military health services in battlefield. in 2017 14th IEEE annual consumer communications & networking conference (CCNC). 2017. IEEE.
(24)Morais, D., et al., The influence of cloud computing on the healthcare industry: a review of applications, opportunities, and challenges for the CIO. Procedia Computer Science, 2022. **203**: p. 714-720.
(25)Mahajan, H.B., et al., Integration of Healthcare 4.0 and blockchain into secure cloud-based electronic health records systems. Applied Nanoscience, 2022: p. 1-14.