Research on cloud computing services in Medical Health Care: Issues and Challenges

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Abstract: Cloud computing has been emerging to be one of the most widely researched fields in the past decade due to its immense potential for offering services on a global scale. Most of the information technology and processing firms have undertaken a migration of their data processing centers towards cloud networks to improve the quality of service (QoS) delivered to their clients. This paper provides the findings of an extensive survey of literature related to cloud platforms, their implementations, type of services and issues that surround a successful implementation of cloud. The proposed study of cloud networks is limited to the field of medical health care which is experiencing a big revolution in recent times with the advent of big data and cloud computing. Cloud helps in establishing relationship between patient, doctors, hospital and medical institutions for providing the required assistance to the patient on demand. This is also executed in the shortest time possible and also in a remote communication network. The various aspects of cloud computing have been investigated in detail from the literature and presented in this paper.

Keywords: Cloud computing, software as a service, medical health care, platform as a service, load balancing, resource allocation.

I. INTRODUCTION

The recent decade has experienced a great transformation in the field of information handling and processing sector. This is largely attributed to the increasing volume of data being obtained from data acquisition devices. Technological innovations have facilitated acquisition of big data which are characterized by a steady stream of high definition data in the form of documents, images, audio or video. These high definition data are more preferred due to their utmost clarity and volume of information present in them which helps to arrive at concrete decisions regarding a problem. Unlike conventional data, high definition data require more sophisticated and carefully implemented handling, processing and storage frameworks due their characteristic high volume of data and a frequent streaming nature. In medical health care sector, this is more pronounced as most of the information regarding patients in the form of scan reports and imaging reports are mostly high definition in nature due to their enormous storage requirement. A typical patient report is quite large as it contains basic information apart from diagnosis and schedule of appointments including summary of preventive treatments. A multi- specialty hospital is frequented by thousands of people on a daily basis whose record handling, storage and retrieval from archive is quite essential for effective provision of health care to the patients. Moreover, some patients may not be able to frequent the hospital or even present themselves occasionally due to geographical separation in locations. In such cases, the data pertaining to the patient could be acquired and consecutive advice and prescriptions could be made with the help of cloud services. Typical cloud architecture is depicted in figure 1.

As seen from the above figure, it could be seen that conventional cloud architectures could be segmented into three stages. The first one is the infrastructure (IaaS) which contains both hardware and software required to make the cloud work. They are vested with the primary duties of networking, storage and virtualization. Hypervisor is a critical term with respect to virtualization and it is a low level program which enables sharing of cloud resources among several users on demand. Any infrastructure level implementation in cloud should be able to provide optimal tradeoff between four factors namely intelligent monitoring [44], scalability [30] [38], security [4][18][22] and transparency [21][28]. Intelligent monitoring refers to autonomous decision making capabilities of nodes in cloud which allocate resources based on incoming demand and nature of demand. Scalability refers to flexibility of the

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cloud to accommodate new resources based on demand while security refers to privacy of data shared over the network from cloud.

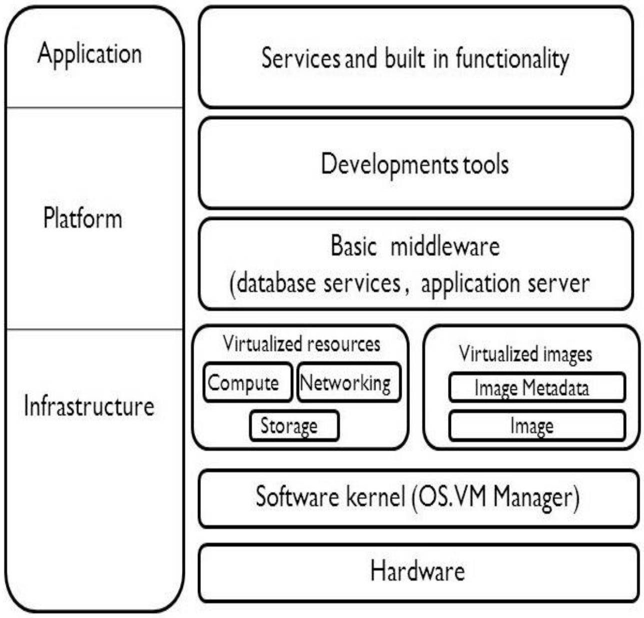

Figure 1 Illustration of cloud architecture

Transparency refers to complete display of resources and load balancing methods to accommodate scalability based on user demands. The second layer referred to as the platform (PaaS) is concerned with provision of resources to deliver services to applications. A prominent platform service is the Microsoft Azure. The third layer is the service based layer (SaaS) which is web based suitable and compatible for the user to access the services provided to them on demand from the cloud. This layer should be designed such that users can get the desired service at any point of time from across the globe. It could be observed that successful cloud implementations depend on several factors which include reliability, security, interoperability [41], portability [29], availability which cumulatively contribute towards the overall QoS or quality of service. Three essential parameters have been investigated in this survey namely load balancing techniques for resource allocation, profit oriented scheduling approaches and power management methods.

II. RELATED WORK

For ease of interpretability, this section has been divided into three sections namely load balancing, scheduling methodologies and power management techniques with the findings from the literature comprehensively presented for each of the above.

A. Load balancing and efficient resource allocation

Load balancing is an essential parameter focused towards improving the overall capacity and utility of cloud server for provision of services. It is evident that the nature of consumer demands in dynamic in nature and hence directly reflected in the cloud server. An efficient cloud server is able to manage and coordinate the distribution and integration of resources as and when required to efficiently deliver the service to the user on demand. When situations such as heavy incoming traffic of requests are encountered, the server has to decide upon the service level priorities and also distribute the load among multiple servers to ease the congestion. Load balancing algorithms provide this function and are classified as shown in figure 2.

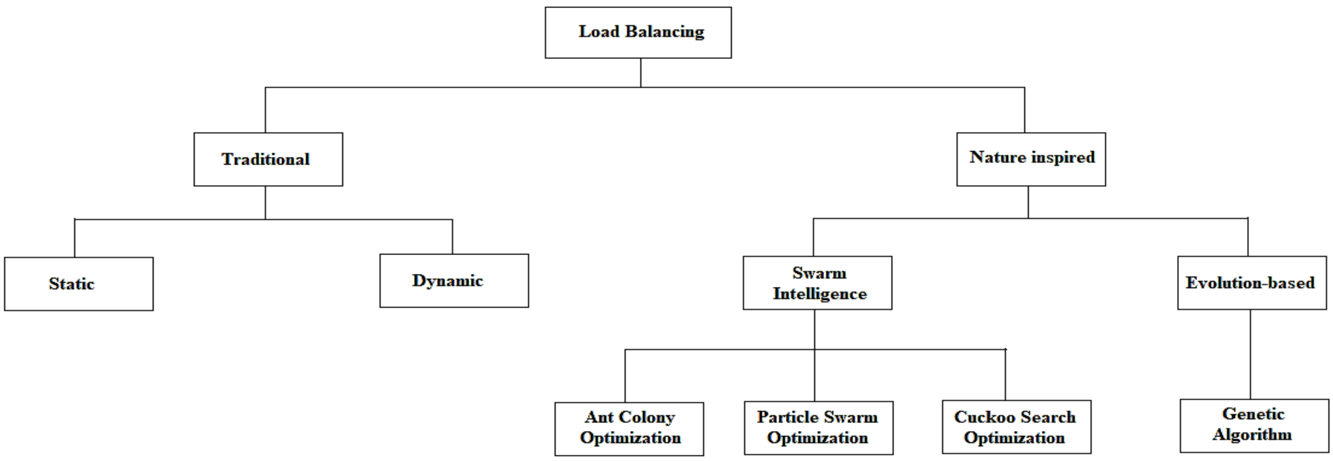

Figure 2 Classification of Cloud load balancing algorithms

A dynamic load balancing which is able to adapt itself to input changes in user requests/demands is experimented in the literature [42] without incurring any computational overheads. This is achieved by using a global optimal scheduling policy which necessitates multiple clusters [12] [19] and scalability in resources when required. To work upon the reduction in cost and space in the above method, a centralized scheme for load balancing in found in the literature [34] but at the cost of increasing computational overhead due to the centralized structure.

Traditional load balancing algorithms in cloud computing environments are few such as Equally Spread Current Execution Load [26], Round-Robin Scheduling [12], Least-Connection Scheduling ([15], Weighted Round-Robin Scheduling [19], Throttled load balancing algorithm [13][40]. Round robin scheduling is conventionally used in

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many implementations as they report high efficiency [16] [28] [31] when the nodes in the network are characterized by similar characteristic features. Hence, they exhibit maximum performance in clustered architectures. When hardware and software components are inconsistent with their features in a given network, round robin scheduling is not an ideal choice. Another conventional algorithm is the least squares algorithm which selects servers based on their activity score. As the name indicates, the server with least activity is chosen as the candidate for the current service provision to consumers. This is based on a continuous polling approach and ensures that no server is idle hence saving power. A variant of this is the least bandwidth algorithm which chooses the server based on least bandwidth score. Dynamic load balancing algorithms proposed in the literature [44] use a queue policy for the incoming traffic and allocate the load to the available nodes.

As observed from the literature it could be seen that evolutionary algorithms have been playing a significant role. They are characterized by self organizing capabilities, parallelism, intelligence. Based on ant colony algorithm, load-adaptive cloud resource scheduling model was proposed [33]. Another variant is the works of [29] which integrates specific advantages of Ant Colony Optimization in NP-hard problems and adapts to dynamic characteristics of cloud computing [37], [4], [35] [38] (Hybrid GA-ACO). Other algorithms include PSO as the optimization algorithm [43], [20], [26]. [46] proposed the improve particle swarm optimization algorithm in resources scheduling strategy of the cloud computing. Rodriguez et al., 2014 suggest a resource provisioning and scheduling strategy for scientific workflows on Infrastructure as a Service (IaaS) clouds. Dynamic Adaptive Particle Swarm Optimization algorithm (DAPSO) was implemented by [2], to improve the performance of the elementary PSO algorithm.

A cuckoo search algorithm for web service composition problem named 'CSA-WSC' was represented by [19], in the distributed cloud environment to improve the quality of service (QoS) which delivers web service composition.

B. Scheduling and Resource allocation

Resource allocation and scheduling are interrelated and play a vital role in the success of any cloud computing network as it is the essential driving factor behind the cloud resource management services in the network. There have been many techniques and frameworks proposed to address this issue in the literature. A few contributions in recent times have been elaborated in this section. A job oriented framework for resource scheduling [31] has been reported in the literature which is found to actively address the resource scheduling issue in an optimal manner by using a weighting approach with ranks assigned to every task and the scheduling is done based on their ranks. Three time-oriented scheduling algorithms have been experimented and compared in this research article which includes round robin approach, pre-emptive and shortest remaining time first algorithm. Experimental analysis and observations indicate that the latter two algorithms have a lower waiting time and turnaround time when compared to the round robin method of scheduling. On the other side, thermal and power aware scheduling [17] have also been discussed and experimented in the literature. In thermal scheduling, the tasks are allocated so as to optimize the temperature of the data centre on the whole. Findings from the literature motivate the implementation of energy aware scheduling approaches [7]. The research works [30] highlight a task based model for efficient scheduling with profit and penalty taken as two essential attributes in the task model. Total utility function has been taken as the parameter for evaluation in each case of the task being allocated with the resource and a profit label is assigned to the total utility function if the task is completed within the stipulated or allocated period of time. Another variant of scheduling found in the literature [10] is the Nephele's framework model.

Four different algorithms with slight modifications have been implemented and tested in the paper and it is found that Nephele's architecture outperforms the other conventional scheduling algorithms in terms of profit, total utility and utility gain. Genetic based algorithms [23] [35] have also been extensively found in the literature which is based on the following constraints that the nature of incoming tasks is periodic and non pre-emptive. Experimental results indicate a high degree of utilization of available population of resources and a variant of genetic based algorithm in the form of simulated annealing [27] is also reported in the literature A comparative study of recent and critical techniques has been consolidated in table 1 with their advantages and issues not investigated which help in formulating the problem objective in this thesis.

Table 1Comparative study of scheduling techniques

Technique	Methodology	Merits	Demerits
Energy Efficient Scheduling [13]	Based on optimal solution of temperature of data centres proportional to energy consumed by peripherals.	Addresses the issues of latency, energy consumption	Cost wise not economical and does not address trust worthiness of the scheduler
Job Oriented Model [7]	Based on sequencing of job orders and assignment of ranks with weights to the job sequences.	Optimal bandwidth and completion time	Increased computational overhead in terms of time and reliability
Dynamic	Load balancing technique based on	Increased reliability due to	Increased latency due to inability to

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Scheduling[22]	varying conditions of input load or service requests.	improved adaptability.	adapt to varying load conditions at the input.
Task scheduling based [18]	Works on the principle of total utility function and assignment of penalty functions.	Increased QoS reported due to low latency and optimal reliability.	User privileges not addressed thereby compromising on confidentiality. Scalability issue not addressed
Genetic Based models [37]	Based on search space with extensions in simulated annealing procedures.	Increased QoS due to optimal bandwidth and priority scheduling. Quick convergence is also characteristic of this technique	Does not account for computational complexity and scalability.
Fuzzy neural models[40]	Based on a hybrid approach with fuzzification of inputs to crisp values based on membership functions	Error convergence is optimal with quick response time reported.	Issues of scalability and energy consumption observed to below par in terms of optimality.
Round Robin scheduling[13]	Works on a cyclic model without priority of tasks for scheduling.	Increased throughput and response time observed.	Limited by Migration issues
Migration based VM models[39]	Based on migration of low load server to high load server.	Increased boot up time reported in the experimentations. Energy savings is also reported in literature.	Throughput and scalability towards dynamic load balancing not addressed.
Cost based scheduling model [37]	Based on assigning cost function by the scheduler and task assignment based on weights.	Effectively proposes a cost efficient model with medium scale cloud data.	Increased latency and computational overhead.

C. Energy Efficiency and Power Management

Another critical parameter in efficient implementation of cloud networks s power management [1] [7] and efficient savings in energy consumption by cloud networks. Virtual machines providing services to clients on a demand basis are abstracted from physical machines which are housed in data centers (DCs) placed on a global scale to provide coverage and accessibility throughout [9][15]. These data centers have to be equipped with auxiliary units such as cooling systems for the physical units and its accessories which contribute to the power consumed [22]. It could be seen that the relationship over the decade has undergone an exponential rise in carbon dioxide emissions which severely influences the environment.

The major share of energy consumption in these data centres goes to the computing equipment and the cooling systems installed in these nodes [16]. Statistics indicate the consumption of electricity increased by up to 41% during the financial crisis in the European Union. The energy consumed by the computing devices and cooling systems contribute to 6%. On the other hand, the impact of emissions on the environment has taken a heavy toll with over 130 million metric tons of carbon dioxide. Statistics also report the usage of up to 1.5 million mega watts of power in 2010 and 3.5 million mega watts in 2016. On a worldwide scale, the energy consumption is placed at 26GW with an annual growth rate of 11% which has increased to 16% in 2016. Hence, there is a great necessity for designing an energy efficient cloud computing network with optimal energy consumption. Several research contributions have been found in the literature a few of which have been discussed in this section. Many contributions in the literature [36] have been found to optimal towards scheduling and provision of services but lack adequate optimization in energy savings.

III. FINDINGS OF THE SURVEY

Based on the exhaustive survey presented in this paper regarding certain critical issues, the following inferences have been drawn which could serve to be a strong problem formulation for future research.

The merits of cloud computing are many a few of which are listed below.

- It basically reduces the cost on installation and maintenance of hardware and software for running and managing the IT and financial services.
- Clouds offer increased level of security of network and data and are quite updated with recent in-house information on a daily basis.
- It offers global access in the sense that the clients and employees can access data at any point of time and at any place on the globe. This eliminates the discomfort to run for data or information from place to place or to the source of information.
- It provides ease of administration with all nodes working on the same platform which are compliant with a number of accounting standards and benchmarks.
- Global access of data in the cloud enables the business concerns to expand quickly and with ease.

Effective cloud implementations are limited by the following research challenges listed below.

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- Grid loads are more CPU intensive, whereas cloud loads consume other resources, such as memory, more intensively.
- Secondly, CPU load is much noisier in clouds than in Grids.
- Thirdly, the host load stability differs between infrastructures, being less stable in clouds.
- Increasing volumes of data to be handled in real time in a cloud environment require complex hardware/software functionalities in data centers which require more power and computational time.
- Since the given objective lies in improving the efficiency or in other words termed as Quality of Service (QoS), customer satisfaction to provision of services from the cloud depends greatly on the availability of resources and effective manner in which the task scheduler allocates the jobs thereby providing access to clients as and when required in the least possible time.
- The last part involves formulation of an energy efficient framework based on carbon footprint to reduce the energy consumed by each data centre in terms of hardware and software utilizations and make the data centres scavenge for their own power thereby reducing energy wastage.
- SaaS in the cloud can offer healthcare organizations on-demand hosted services, providing quick access to business applications and fulfilling customer relationship management (CRM).
- With IaaS cloud solutions can offer on-demand computing and large storage for medical facilities.
- With PaaS the cloud can offer a security-enhanced environment for web-based services and the deployment of cloud applications.
- Transforming healthcare via the cloud is about more than just the delivery of medical information from multiple computers at anytime, anywhere, and on any mobile device. It's also about the benefits of being able to connect medical centres and cloud users for the purpose of sharing patients' health data over the Internet.

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