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Serverless Based Functions Aware Framework for Healthcare Application

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ABSTRACT

These days, the usage of Internet of Medical Things (IoMT) to deal with the different diseases has been increasing with time in the practice. Cloud computing is a paradigm which offers services based on internet to run IoMT application in the efficient way. However, due to long latency, cloud computing introduces fog server which brings service at the edge of hospital network. All existing fog-cloud based system charged servicing rent based on hourly, weekly, monthly, and yearly.
The result a lot of cost wastage for the patients whenever, they do not require service, but still, they are paying for rented services. To cope with the useless renting cost, the study devises the serverless function as a service system which offers services to run IoMT application with their usage instead of resource provisioning as existing studied exploited in the system. The virtual machine based healthcare charged based on hour, week, month, and year, and however, healthcare sensors need service at specific time. Therefore, there is a lot cost of services in the ideal time where services are free but users paid money due to rent from providers. This paper suggests serverless function as a service based system which charge only for usage instead of renting cost for execution inside system. Simulation results shows that, the proposed system not only minimize the IoMT application cost but improved the resource utilization of the system.

Key words: E-Blood Analysis, Healthcare, IoMT, QoS

1. INTRODUCTION

The explosive usage of healthcare sensors and devices to deal with the patient has grown day by day [1]. The digitization of technology convergences from traditional sensors to the advent devices because of an emerging invention of communication technologies [2]. Therefore, the internet of things (IoT) is an embryonic network which connects sensors, devices, communication technologies, and server as network to improve the healthcare applications for the patients [3].

Cloud Computing is an incipient model which offers different internet based services based on different prices [4].
There are three main types of cloud services such as software as a service, product as a service and infrastructure as service. The healthcare applications exploit all types of cloud with the different purpose [5].
The cloud based healthcare system based on IoT network has gained a lot popularity in both academic and industry. Many healthcare monitoring system suggested to offer different services to the patients. Many existing studies [6-10] suggested different pricing model for healthcare applications such as E-Blood-Pressure, E-Blood Analysis, EEG, and ECG and so on. Every provider rent services based on different pricing model such as on-demand, on-reserve, and spot-instants [11]. The duration of resource based on hours, weekly, month, and yearly. However, there is a lot of challenges in the current resource provisioning model for healthcare applications [12].

The study identified the following challenges in the current works. (i) All services have hourly, weekly, monthly, and yearly duration to run E-Blood, E-Blood-Pressure and so tasks. Whereas, the tasks are not real-time, and does not need services 24/7 at any time. Therefore, the ideal situation of resource without executing is the wastage of resources and costly for the healthcare applications. (ii) Each task has deadline, therefore, the tradeoff between cost and deadline is a challenging task during process of applications in the system. (iii) These studies exploited cloud infrastructure as a service based on virtualization technology based on virtual machines. Whereas, there are different types of virtual machines of each vendors (Amazon, IBM, Google, Alibaba, Azure). Each virtual machine has different execution cost with different time duration. Therefore, advance booking of services will lead challenge for those applications which often call services based their usage for any time instead of provision.

In this paper, the authors proposed a novel healthcare system which includes effective and cost model for applications. The goal is to decrease execution cos of tasks in the cloud. The study considered containers which execution the function of tasks. The study care for its function usage (execution memory) instead of charge for hour, month, or year. The proposed healthcare system offers real-time services based on cloud function which can manage the big-data inside system without balancing situation during processing. All quality of services (QoS) requirements of tasks to be met within proposed system. The proposed system works in the following way.

1. Each task to be run on function inside container without caring of scale-up and scale-down problem.
2. Each task charge for its execution and usage (execution and memory) instead of hourly or weekly provisioning model.
3. Each task can schedule on one function at a time. In contrast, each function can run one task at a time.
4. The big-data analytics can easily manage in the proposed cloud system.
5. The healthcare system consists of fog and cloud servers which offers different function inside system.
6. The scheduling method ensures the deadline of tasks inside system.
7. The study has priority queue that handles and execute tasks based on its deadline priorities.

The proposed healthcare system consist of different components: Priority Queue, Task Scheduling, and Cost Estimation model. The problem formulates as the scheduling problem and all proposed methods are greedy and iterative methods. The paper is organized in the following structure. Section 2 shows the current efforts to boost the performance of healthcare system. Section 3 demonstrates the problem description and system depiction in the detail. Section 4 articulates the proposed schemes of the considered problem. Section 5 spectacles the performance evaluation and result discussion. Section 6 summaries the conclusion and future work of the study.

2. RELATED WORK

The usage of the Internet of Medical Things (IoMT) network has been growing more and more and connected with different health sensors and devices. The fog cloud computing boosting the performance of IoMT by offloading and scheduling and rich resources for execution. The fog servers offering services at the edge of network and cloud servers handles the big-data analytics. However, many efforts have been made to boost the performance IoMT applications in the distributed fog cloud network.

The study [1] investigated the healthcare offloading problem for heart-patient and suggested distributed medical care network. The goal was to minimize cost and latency of the applications. However, they did not consider the QoS of applications. The study [2] examined the healthcare offloading problem for ECG and recommended distributed medical care network. The goal was to minimize cost and latency of the applications. However, they did not consider the runtime cost of applications. The study [3] scrutinized the healthcare offloading problem for abnormal patients and advised distributed medical care network. The goal was to minimize cost and response-time of the applications. However, they did not consider the deadline of applications. The study [4] explored the healthcare offloading problem for online appointment data and proposed distributed medical care grid. The goal was to minimize cost and delay of the applications. However, they did not consider the QoS of applications. The study [2] examined the healthcare offloading problem for ECG and recommended distributed medical care network. The goal was to minimize cost and latency of the applications. However, they did not consider the QoS of applications. The study [5] scrutinized the healthcare scheduling problem for uncharacteristic heart patients and advised distributed machine learning aware medical system. The goal was to minimize cost and makespan of the applications. However, they did not consider the deadline and communication time of applications.

The study [6] investigated scheduling problem for daily-check-system and submitted distributed fog cloud medical care network. The goal was to minimize cost and tardiness of the applications. However, they did not consider the resource-constraint limitation of applications. The study [7] surveyed fog cloud aware healthcare system for blood-pressure patients which required 24/7 services to monitor their data. The goal was to maximize service efficiency and minimize the latency of the applications.

However, they did not consider the runtime cost of applications. The study [8] scrutinized the cost-efficient scheduling for cardio patient. The goal was to minimize cost and response-time of the applications. However, they did not consider the deadline of applications. The study [9] explored the healthcare offloading problem for mobility aware and ambulance location data and proposed distributed medical care grid. The goal was to minimize cost and delay of the applications. However, they did not consider the QoS of applications. The study [10] examined the healthcare offloading problem for EEG and recommended distributed medical care network. The goal was to minimize cost and latency of the applications. However, they did not consider the QoS of applications. The study [11]-[13] scrutinized the healthcare scheduling problem for healthcare and outpatients and advised distributed machine learning aware medical system. The goal was to minimize cost and makespan of the applications. However, they did not consider the deadline and communication time of applications. However, all studies only focused virtual machine based resource provisioning with time-duration rule (e.g., hour, day, week, month, and year). There is a lot of ideal and wastage cost with this resource provisioning. Whereas, virtual machines have long

boot-time (e.g., 30 seconds to start new virtual machine during scalability) and communication overhead.

This study formulates healthcare offloading problem and proposed serverless based fog-cloud system in order to minimize operational cost of the applications and meet their deadlines as well as minimize execution time during scheduling [14],[15].

3. PROPOSED SYSTEM

The proposed system consists of three main layers such as user interface, fog layer, and cloud layer as shown in Figure 1. The study extended or improved the existing idea as mentioned in [13]. However, they suggested their frameworks on the virtual machines. Therefore, this study is different from existing healthcare system.

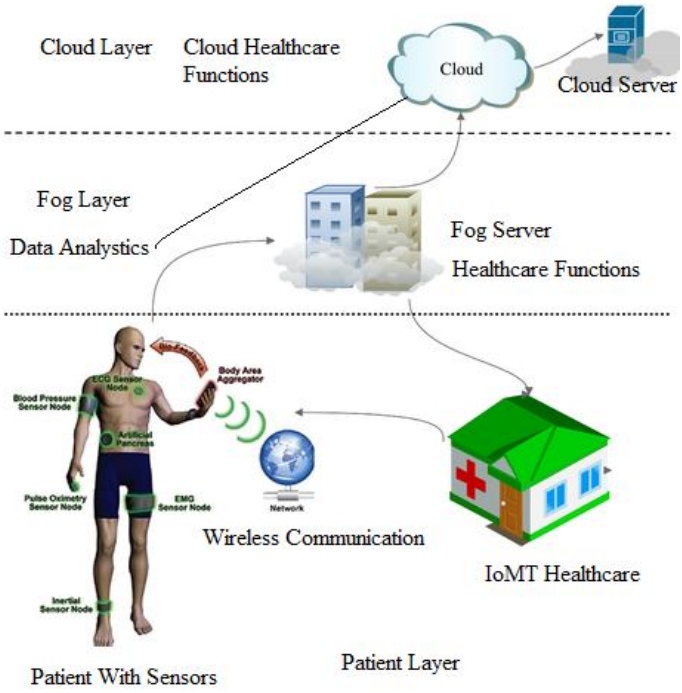

Figure 1 Proposed IoMT System for Patients

The layers of the proposed system defines as follows.

1. Patient Layer: The body area network consists of different sensors and devices which are connected to the body of the patients. For instance, ECG, Blood-Pressure, EEG, Heartbeat, and so on. All sensors are offloading their data to the fog server which is located inside hospitals. The fog server is the extended version of the cloud computing which brings cloud services at the edge of hospitals. The sensors are flexible which can add and remove functions at the runtime. All the sensors are connected to the wireless communication and offload their generated data to the hospital fog server for further processing. There are many choices for the patients he/she can access service 24/7 and offload data to the system for further analyzing.
2. Fog Layer: This layer consists of fog server which is located inside hospital. The real-time data generated by different sensors process at the fog layer in order to reduce the communication cost of the applications. The big data is a big concern, due to limited resource of fog server, the data further offloaded to the public for further analyzing. The fog server offers functions which are run inside containers. Each function can easily scale up and down inside container to run each task in the system. Each function is a complete business goal which can run each sensor generate data effectively under their deadlines. For instance, Heartbeat function can run heartbeat sensor data in the efficient way. The cost is charged only based on its operation (e.g., execution time (MS) X memory (MB). In this way, we can reduce the operation cost of applications rather than virtual machines.
3. Cloud Layer: It is located at the remote network and fog server connected to the cloud via Internet for the further analyzing on sensors data. In the simple way, fog-cloud are co-operative network in the Internet of Medical Things network. The goal is to minimize operational cost and meet the deadline of tasks during offloading and scheduling. The cloud function also data analyzing in the co-operated system.

4. PERFORMANCE EVOLUTION

The study analyzed the performance of healthcare system by implementing fog-cloud network along virtual machine as well as function inside hospital. The study denotes the result analysis of the all studies and proposed function based study in Table 1. The results in Table 1 consists of different columns: Study, Task, Fog, Cloud, Fog-Cloud, VM and Function Cost. All studies exploited individual fog and cloud for the healthcare applications and implemented virtual machine based services to run the different sensors data in the system. The function container based system as shown in Table 1 has lower cost, execution time with co-operative fog-cloud. The main goal is functions are executed inside containers that have small boot-time (e.g., 8) as compared virtual machines (e.g., 28). Whereas, function charged for the only usage time instead of ideal time with the provisioning model (hour, day, week, monthly). Therefore, function has no wastage resources and ideal time and minimum execution for all healthcare sensors during execution in the system.

Table 1: Caste Result Analysis

Study	Task	Fog	Cloud	Fog-Cloud	VM Cost	Function Cost
[1,2]	Heartbeat	100 (ms)	200 (ms)	50 (ms)	10$	5$
[3,4,5]	ECG	300 (ms	600 (ms)	150 (ms)	15$	8$

		)				
[6]	EEG	400 (ms)	800 (ms)	120 (ms)	17$	10$
[7]	Blood-pre .	80 (ms)	200 (ms)	70 (ms)	6$	3$
[8]	Oxygen	180 (ms)	700 (ms)	120 (ms)	6$	3$
[9]	Chest	600 (ms)	900 (ms)	500 (ms)	7$	2$
[10,11 ,12]	Body	900 (ms)	1200 (ms)	480 (ms)	10$	4$

Whereas, Table 2 denotes the performance of the system based on boot-time, ideal-time, VM wastage, and function. It is noted that, function has minimum operation cost and ideal time as compared virtual machine based system in the healthcare distributed network.

Table 2: Resource Utilization and Resource Wastage

Study	Task	Boot-Time	Ideal	VM Wastage	Function
[1,2]	Heartbeat	15 (ms)	100 (ms)	10%	3%
[3,4,5]	ECG	30 (ms)	200 (ms)	22%	2%
[6]	EEG	4 (ms)	100 (ms)	12%	2%
[7]	Blood-pre.	8 (ms)	600 (ms)	14%	4%
[8]	Oxygen	1 (ms)	100 (ms)	15%	5%
[9]	Chest	60 (ms)	300 (ms)	16%	6%

5. CONCLUSION

The study devises the serverless function as a service system which offers services to run IoMT application with their usage instead of resource provisioning as existing studied exploited in the system. The simulation results as shown in Table 1 and Table 2, the proposed system outperform in term of operational cost, and improve overall resource utilization of the system. The function and container are lightweight and charged for their wastage. By this way, all healthcare system can minimizes the operational cost of the IoMT applications. In the future work, the study will extend the proposed system with perspective security, because due to distributed system, there is security risk to the patient data during offloading and scheduling in the system.

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