Role of Mobile Agent in Medical Information Retrieval in Mass Casualty Scene – A Performance Study in Web Environment

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Abstract: - Addressing health disorders at the early stage during mass casualty is one of the important issues to be thrown light nowadays. If mass casualty occurs in remote locations where proper health care equipments or analysis of medical information is not available, a special team must be appointed to monitor and control it. When an emergency occurs, especially in mass casualty incidents, lots of victims need medical attention. It is obvious that the faster and accurate the acquisition and analysis of data, the more effective the answer could be given. That is, the needs will be attended as early as possible and the affected population could be reduced. The common point in all cases is the analysis of information. Around it lies, the importance of responding to the emergency. Mobile agents play a vital role in communication between different remote locations. If the special team needs information from these locations or the remotely located medical officers needs information from the special team, mobile agents are useful. This paper discusses the use of mobile agent technology as an enabler of open distributed e-Health applications. More precisely, it describes the experiences based on this technology: concerning emergency scenarios.

Key-Words: - Mass Casualty, Emergency, Mobile Agents, Client-Server, Web Environment, Response Time, Throughput.

1 Introduction

Internet is both a powerful resource and challenge for applications like information retrieval. This paper concentrates on an emergency situation where information is needed in quick time. To fulfill this task, it is essential to prove how mobile agents can successfully applied in place of traditional client-server communication. The client-server communication is a connection oriented communication and works very slowly if there is more traffic on the Internet. This section briefs the importance of mobile agents and immediate health care in emergency situations.

1.1 Mobile Agents

Mobile Agent (MA) based approach has received great consideration in recent years as a promising alternative to the traditional Client-Server (CS) approach [1]. Web-related information processing is the actual motivation lies behind the usage of mobile agent system in recent years. Specifically, information retrieval / search process is one of the important applications where these mobile agents are used [2]. A data processing application can move to its data, avoiding the overhead of transferring the data through the network [3]. The main difference between mobile agents and client server architecture lies in mobility, network load reduction, dynamic adaptation, synchronous and autonomous execution, robust and fault tolerance etc [4]. For information retrieval application it is essential to provide correct key words and phrases. To make sure that even an ordinary user (for eg. school student) can make the search, [5] introduces a mobile agent that parses the search string, align synonyms, sift out keywords etc.

After retrieval, whenever mobile agents travel with the resultant data, it must be ensured that it reaches the destination successfully. A reliable model that proposes data sharing by mobile agents in the move, i.e. in between migration, to keep the data alive, was presented in [6]. To implement data sharing, communication among mobile agents is obvious. An agent monitor that monitors the movement of mobile agents and helps to share data among them was introduced in [7]. Reduction in response time, memory usage and witness dependency maintenance are the notable benefits of the work.

Agents can be a good resource to use for emergency management [8], since responding to an emergency requires many complex tasks performed by multiple factors under conditions of time and resource requirements. During emergency, agent-based systems can provide a number of important benefits:

- Agents have the ability to operate in highly dynamic environments.
- They can work in decentralized and distributed networks.
- They have the ability to search and collect distributed information, verify, process, analyze and interpret it for later use and management.

They are suitable for decision using the data collected by a single agent or exchanged with several agents. Despite having these advantages, only a few emergency management systems are based on agents.

Communications in the emergency situations are getting more and more important. This is due to the greater use of Internet enabled devices by the emergency personnel. Our proposal takes into account possible scenarios in the emergency scene: the existence of a network infrastructure with Internet connection.

1.2 Health Care in Emergency Situations

Health telematics can play a major role in improving the lives of patients; particularly for the sections of the society at the time of emergency, health attention is needed as a result of mass casualty [9]. However, mobile health-monitoring technology offer great potential help for such patients who may be able to afford good healthcare without waiting for long time or traveling long distance for treatment. These technologies bring significant benefits to both patient and doctor; doctors can focus more on priority tasks by saving time normally spent with analysis of diseases or accommodating more number of patients for treatment [10] and patients can move about in their environment without having to make extensive trips to the medical centers – especially if they reside in a remote location.

Many patients with non-life-threatening illnesses in need of health monitoring do not necessarily require hospitalizations – they simply require monitoring via a mobile system that encompasses intelligent capabilities to detect abnormalities, provide temporary advice and send urgent alerts to medical officer in the event of an emergency [11]. The fact that mobile health care can bring to these sufferers an increased contact with specialists in cities improves the overall quality of health service.

This paper investigates the use of mobile agent as an enabler of open distributed e-health applications during emergency situations [12]. For this, an application is described for retrieving necessary information of medical records upon request from an emergency scenario [13]. The mobile agent system allows remote health centers to request for critical information about the victims, such as infectious diseases, thus facilitating more accurate diagnosis and bringing forward decision making. Furthermore, information revolves around all stages of disaster like preparation, planning, training, response, recovery and evaluation [14]. Coordination, information sharing, and decision-making are the three fundamental axes for the management of an emergency situation [15]. Optimization of these three axes reduces the response time, one of the objectives of any system for managing the emergency.

2 Related Works

Cristina et al. (2009) proposes an RFID-based system, SIMOPAC, that integrates RFID and multi-agent technologies in health care in order to make patient emergency care as efficient and risk-free as possible, by providing doctors with as much information about a patient as quickly as possible [16]. Liz Carver and Murray Turoff (2007), discussed the human-computer interaction related to the systems dedicated to emergency management and how can influence the response. As a conclusion it was defined that a human being must be taken into account as part of the system and the hardware as part of the team. Thus, defining a communication between both is an easier task [17]. Cruz-Correia et al. (2005) has given a novel technology to achieve a Virtual Electronic Patient Medical Record (VEPMR) out of all the medical data about a patient which are spread over a set of different location [18]. This system is benefited by mobile agent technology. Here, roaming agents are used for local searches and thus avoid the need of centrally controlled database. Agents play a vital role in emergency management because it requires more critical works to be performed by various agents under conditions of time and resource necessity [19]. Finding information on an object's visual features is useful when specific keywords for the object are not known. To accomplish this task, a novel fast algorithm that searches the web pages by giving image of the object as input to mobile agent was presented by Hazem M El-Bakry and Nikos Mastorakis [20].

Because of the agents capacity to adapt to changing environments, mobile agents can easily deal with computer and network faults. They are especially suitable for hostile environments, where the agent can decide to visit alternative locations in case of failure. An example of fault tolerance based on mobile agents has been studied by Gu Su Kim and Young Ik Eom [21]. A model for e-learning system that supports interaction between human agent and software agents was represented in [22]. In this work software agents play a multiple role by gathering information, communicating it with others, delivering it on demand etc. A system based on mobile electronic triage tags for emergency situations [23], makes the victim information available at the base of operations as soon as possible, thus allowing an early medical source allocation and immediate action. Communication among mobile agents in multi-region environment, when they are in move, to share retrieved information and corresponding analysis of implementation in web environment was presented in [24]

3 Motivation

Consider an emergency scenario, where a group of people affected by an unknown infection in their eyes unexpectedly. The infection is spreading over different areas geographically. The local health care centers are not able to identify the reason for infection and even on identification there are no specialists to treat the victims. Naturally, it will take much time to search and enquire the specialists for each and every case. Like this so many groups of peoples may be there in various locations. If all of them started contacting the specialists by sending details of each and every patient, will definitely results in chaos and network congestion. As a result of which none of them get the service. Instead, if the specialist himself contact and advise all these groups, there would be no network traffic and chaos. But, it will take a lot of time to contact and advise all groups one by one. This is the situation where mobile agents are useful and it is discussed next section.

4 Mobile Agents in Emergency Situation

The scenario selected to analyze the benefits of mobile agents against traditional request – reply approach is given below.

(i) People whom detect having infection in their eyes visits nearby health center.

(ii) If analysis tool available, local medical officer analyze the received information and stores the result in local system.

(iii) Special medical officer dispatches an agent (if needed multiple agents) to all servers that store the results of basic tests taken on infected eyes.

(iv) If necessary details are not available on remote system, then
   a. Install the code that needed for analysis on local system
   b. Analyze the resultant data

(v) Collect the data

(vi) Sort out the nature of infection by the following means
   a. fully infected (F) which needs immediate care (like shifting to the place where treatment is available)
   b. partially infected (P) that needs medical consultation (locally)
   c. weakly infected (W) that needs advice to take precautionary measures etc.

(vii) Agent migrate to next server

To do this type of analysis, using traditional request-reply technique results in time consumption. One reason is, it will take large amount of time for communication. The other reason is network traffic because of large number of requests and replies all over the region. Now, mobile agents have a role to play. Instead of using conventional request-reply mechanism, mobile agents can be used to collect the information from various locations, analyze the data retrieved from remote server (RS), and dispatch the details of actions to be taken to each location. Both ways it is beneficial. Health officers from infected area can send a request to various servers from where they can get the solutions for their available data. Head officer for health care can collect the required data /

Fig. 1(a) Image of normal eye used as reference

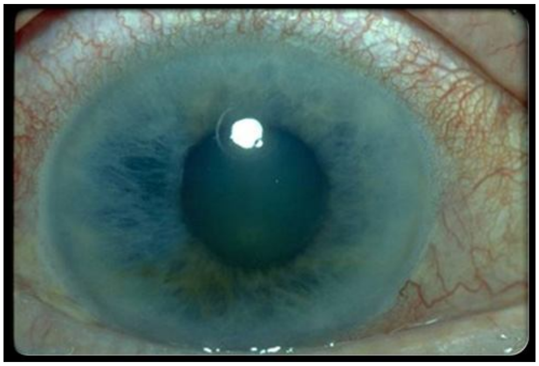

Fig. 1(b) Image of infected eye for testing

information from different locations for analysis and providing solutions for the problem.

The Mobile agent model is implemented in Wide Area Network (Internet) connected with various machines that have different configurations. This work was tested in real time web environment where servers are connected with internet connection. For simplicity, this experiment uses ten different servers that receive request or mobile agent with single request. Details of randomly selected five machines are given in Table 1.

For cost evaluation the following parameters were used.

(i) Turn Around Time (TAT)
(ii) Throughput.
(iii) Mobile Agent size

The time interval between when a query is sent from the source and when the response (data) is received at the requesting host is referred to as the TAT in this research work. The turn around time is measured in terms of request time and response time. Throughput is the number of severs visited within a given time period. Varying size of mobile agents on travel is considered as another parameter.

5 Results and Discussion

The results of the experiments conducted are discussed in this section. The discussion briefs the performance of mobile agent over client-server approach based on the parameters listed in previous section.

5.1 Turn Around Time

The request is sent as message passing or mobile agent between the identified servers. The time taken by the message or mobile agent to reach the server is recorded for different time intervals and days. The experiment conducted for this research work includes the time taken by a mobile agent to visit the servers at 3 different days and 6 different timings for each day.

Days : D_1 – 12.05.2011,
D_2 – 22.05.2011,
D_3 – 05.06.2011

Timings : t_1 – 02.00,
t_2 – 06.00,
t_3 – 10.00,
t_4 – 14.00,
t_5 – 18.00,
t_6 – 22.00

The idea behind selecting different days and timings are, to verify whether the performance of MA varies based on network load. Network traffic is not constant in all days and times. A consolidate snapshot is given in Table 2. To study the data retrieved in different timings as mentioned above, the graphical representation is given in Fig. 1.

On observing the data presented in Table 2 and Fig. 1, it can be shown that the turn around time is not the same in any situation between any two servers. If infers that depending on the network configuration and traffic the turn around time varies. At the same time, it is clear that the turn around time measured at time t_1 is much less compared to all other timings. Also, the time measured at time t_6 is relatively lesser when compared to other timings except time t_1. This clearly indicates that the time taken for mobile agent migration is better during early hours and late hours of the day. But, during middle hours it is almost same with minor variations. Another observation is, turn around time between remote servers RS3 and RS4 is always higher than any other migration during any given time. This infers that the network traffic between RS3 and RS4 is always high. At the same time, turn around time between home servers (HS) and RS1 is always less. This is because the HS and RS1 have the same gateway. The servers located in a single gateway can communicate in lesser time than that are located in different gateways.

5.2 Throughput

Here, the number of servers visited within a time period is experimented. The resultant scenario is given in Fig. 2 which clearly depicts that MA strategy performs better for large number of servers and for small number of servers, it is CS strategy. It indicates, in mass casualty scene, if the number of servers to be visited is very large, then adopting

MA strategy yields good results. If the number of servers to be visited is very few, then CS approach is better. The reason for this is, the CS approach includes the time taken to send the retrieved data to home server for every request. But in the case of mobile agent, only request time is counted, since the mobile agent does not return any data to home server immediately after data retrieval. Only after visiting last server, it will reply. This results in the reduction of almost half of the time taken by client-server approach. For applications like mass casualty, it is always essential to get the required data immediately. The importance of the situation demands the early response. So in this context, this paper finds the usage of MA is preferred over CS.

5.3 Mobile Agent Size

After analyzing subsections 5.1 and 5.2, it is evident that mobile agent plays an important role in emergency requirement over request reply technique. At the same time, the amount of data collected is another important criterion as this criterion has direct impact on network load. Experiments have been conducted to test the difference in response time for two cases. The size of data retrieved from each server and corresponding TAT for both MA and CS approach are detailed in Table 3.

5.3.1 Case–1

Prefixing the size of data collected from each server. That is, restricting the mobile agent to collect fixed size of data from each server. The mobile agent stop processing as soon as the amount of data collected reaches the threshold value.

5.3.2 Case–2

Mobile agent is not restricted for data size. It can collect as per the instruction in the code. But it has been assumed that the mobile agent is designed such that it can accommodate any data size that is collected from each server.

The comparison scenario of both these cases is given in Fig. 3. If case – 1 is considered, the response time increases linearly. At the same time, Case–2, shows a different scenario. It is not possible to say whether it is linear or exponent. For n = 2, TAT = 3866, but for n = 3, the TAT = 2972. Here the TAT decreases as data collected during third turn is less compared to second turn. Same in the case when n changes from 9 to 10. The TAT at

Table 3 : Turn around time and Size of data retrieved for CS and MA approach

RS No.	CS Approach	MA Approach	MA Approach
	TAT (Milli Sec)	TAT (Milli Sec)	Retrieved Data Size (KB)
1	1478	1592	2
2	2283	3866	5
3	4756	2972	3
4	7012	10488	13
5	10289	12423	14
6	14117	17033	17
7	19062	16322	15
8	22824	28578	35
9	24491	30126	31
10	27142	29513	27

this situation for n = 3 and n = 4, is given as 2972 and 10488 respectively. Here the TAT difference is almost three times. Same in the case when n changes from 7 to 8. From this, it is proved that the amount of data collected has a considerable impact in mobile agent approach. It really slows down the migration whenever data size collected increases and TAT decreases as data size decreases.

Table 3 : Turn around time and Size of data processed for CS and MA approach

RS No.	Processed Data Size (MB)	TAT - CS (Milli Sec)	TAT - MA (Milli Sec)
1	151	3284	2123
2	532	18337	8142
3	1000	21962	13498
4	80	13491	16162
5	8000	32786	12423
6	450	15665	9871
7	775	17389	8678
8	210	10524	6619
9	165	4423	3127
10	60	1084	2234

The same effect is experienced, when the size of data to be processed in each server varies. Related details are given in Table 4. Comparative performance for this situation is given in Fig. 4. Here, the reason for variation is based on processing time at each server and not based on migration time.

6 Conclusion and Future Work

In this paper, the possible implementation strategies for e-health service application using the client-server and mobile agent paradigms are discussed. Experiments have been performed to evaluate the performance of CS and MA approaches. The parameters used for analysis are communication time, number of servers, timings and data size. In emergency situation like mass casualty, using mobile agents gives better results than client server approach. The analysis is extended for varying size of data transferred and data processed. As a future work, one important aspect to look into is the non availability of servers or server failures. Server failure leads to mobile agent failure. There is a necessity to keep the mobile agent safe during its itinerary. A clear cut difference in finding the benefits between parallel and sequential mobile agents should be addressed. Our further focus on this research will be in this direction.

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Table 1 : Configurations of systems (randomly selected) used in experimentation

Type of server	System Details	IP Address	Distance (approx. in KM)	Nature of internet connection
HS	3.00 GHz Processor 504 MB RAM	192.168.1.10	-	BSNL Broadband, 2 Mbps
RS1	3.2 GHz Processor 1 GB RAM	192.168.1.8	<1	Reliance Net Connect Broadband, 3.1 Mbps
RS2	3.2 GHz Processor 2 GB RAM	113.112.196.238	30	Railtel Corporation Leased line, 8 Mpbs
RS3	3.0 GHz Processor 1 GB RAM	210.212.247.83	366	BSNL Broadband, 1 Mbps
RS4	3.0 GHz Processor 4 GB RAM	173.83.205.234	543	Tata Communications Broadband .750 Mbps
RS5	3.2 GHz Processor 2 GB RAM	113.112.196.248	32	BSNL Broadband, 2 Mbps

Table 2 : Recorded migration time of mobile agent between identified servers at day D_3

From	To	Distance (KM) approx.	Migration Time (milli second)					
			t_1	t_2	t_3	t_4	t_5	t_5
192.168.1.10	192.168.1.8	< 1	03897	06560	05325	05264	06035	04521
192.168.1.8	113.112.196.238	30	08121	12129	15228	16451	11832	12247
113.112.196.238	210.212.247.83	366	10026	16252	18213	16010	18765	13230
210.212.247.83	173.83.205.234	543	11211	22261	21295	21810	22810	28912
173.83.205.234	113.112.196.248	610	10973	17644	15293	16489	14998	13046
Total response time			44228	74846	75354	76024	74440	71956

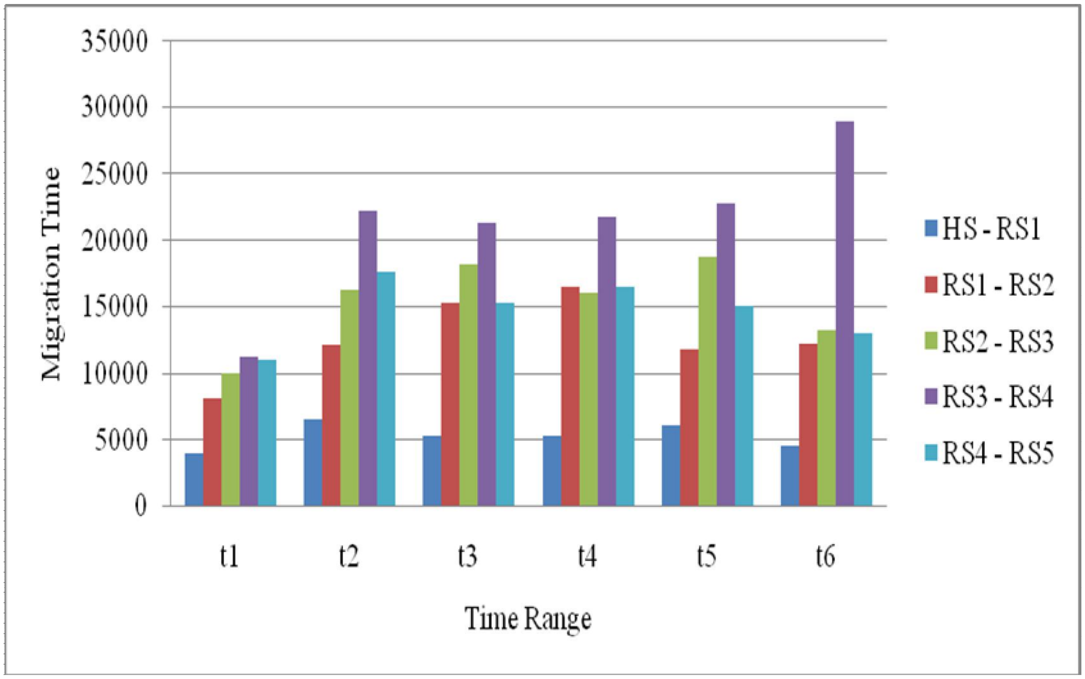

Fig. 1 : Migration time of mobile agents recorded at random timings.

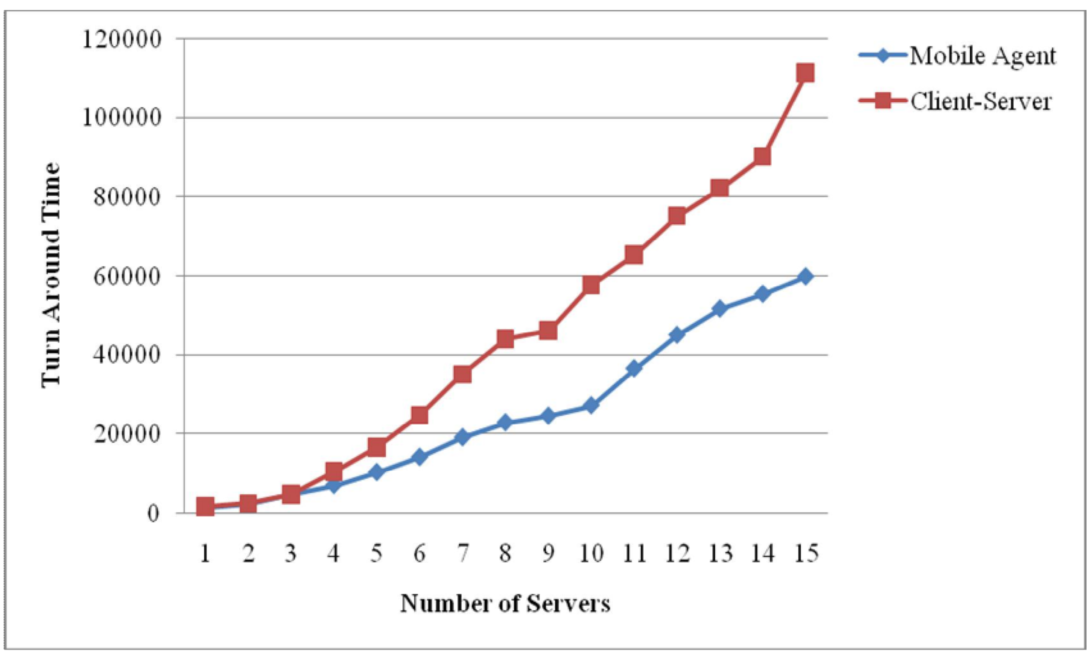

Fig 2 : Turn around time of mobile agent to visit number of servers sequentially

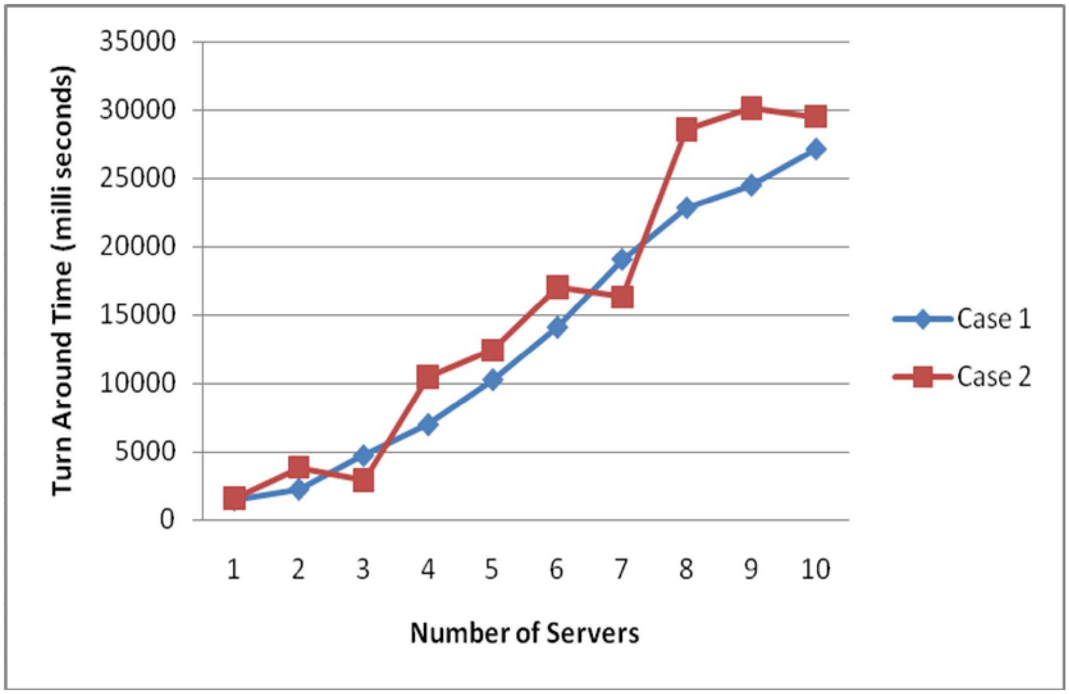

Fig. 3 Turn around time of mobile agents with fixed and varied data size (Retrieved Data)

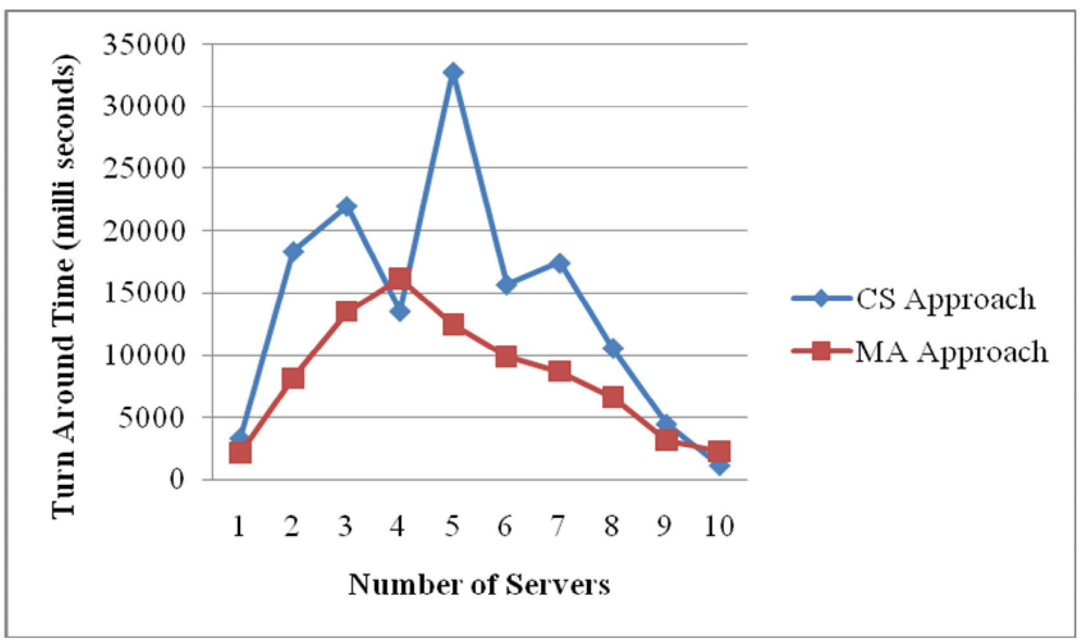

Fig. 4 Turn around time of mobile agents with fixed and varied data size (Processed Data)