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Experimental Study of High Performance Computing in Three Tier Architecture for E-Health Care Application

RAMALINGAM H M[1] NAGESH H R[2] AND PALLIKONDA RAJASEKARAN M[3]

[1]*Senior Assistant professor, Department of ECE, MITE ,Moodabidri India. E-mail: hmr4ever@gmail.com*
[2]*Professor & HoD, Department of ISE,AJIET, Mangalore, India. E-mail: nageshhr@ajiet.edu.in*
[3]*Professor Department of ECE, Department of ECE, KARE, Tamilnadu India. E-mail:mpraja80@gmai,com*

***Abstract*:**

The technological advancements in the field of Bio-informatics provided various methods and architectures for continuous monitoring of health status of different patients to prevent from life threatening events. Various systems available in healthcare monitoring require highly skilled professionals, major systems are in use have sensors with wires for data acquisition, causing discomfort to the patients while monitoring. It also requires more labor works to collect, analyze and store the medical information. Such systems provided a limited number of services at high maintenance cost. To resolve these issues and enable physicians to work more efficiently, best among all technologies need to be integrated. Our proposed concept would help to reduce response time in emergency situations by utilizing Wireless Sensor Network to monitor patients with the integration of best available technologies. This paper is based on the experimental study of high performance computing in a multi layered architecture which includes the integration of Wireless-Sensor with grid and cloud computing.

Keywords*—sensor grid; e-Health; cloud, High performance computing;*

1. Introduction

Healthcare monitoring systems are one of the most critical and important diagnostic systems in the serious care units of hospitals providing continuous display and interpretation of the patients' vital functions. The need for continuous health monitoring is essential in life threatening situations of a patient or in a critical physiological state. Most of the people in the world do not have the opportunity to get optimum healthcare which is limited by its cost and accessibility. The past few decades have seen major advancement in medical field [2]. Wireless Sensor Network is rapidly emerging as an important area in mobile computing. Various sensors attached in the patient's body will measure the physiological signs and transmit the data through a mesh network to the central server [3]. Wireless Sensor Network research has recently gained unprecedented momentum in both industries and academics, especially for its potential applications in medical field [15], [19]. The amount of sensors used in real time monitoring will continuously measure and transmit the sensory data to the central server, as the complexity of the

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received data is high so it requires a powerful computing environment to receive and process the data. The simple solution is to make a distributed or parallel computing mechanism to handle the complex computations. The universal access of health records and remote monitoring of patient's real time physiological signs required a well established network system. Cloud computing helps in giving universal access of patient's clinical data and treatment details, drug information, laboratory reports, etc. Community Cloud is widely used in a number of fields such as, education, agriculture, weather monitoring and healthcare applications [4]**.** Cloud computing has devolved a standard approach to provide large amount of computational power and computing resources to healthcare information systems.

The healthcare monitoring system is benefited by cloud computing as it has the advantages of gathering sensitive information from the patient and producing medical report to have authorization, and financial data needed for optimal treatment [5]. Nowadays in order to reduce the service cost and to improve the utilization of resources, healthcare providers focus on automating processes. A group of hospitals could share resources with systems connected in that group using this pooling process that will automatically minimize the cost and improve utilization [6]. The resources can be delivered when and where they are needed. The real time availability of patient's information can be processed by doctors and medical experts for analysis from anywhere through internet devices at all time. At present there is no adept framework to support the amalgamation of Wireless Sensor Networks with cloud [21]. The proposed architecture is advanced architecture which integrates Wireless Sensor Network, high performance computing and cloud for E-healthcare application to support the storage, processing and medical information sharing tasks. Java based parallel processing is chosen to implement grid middleware functions. It also provides a platform for medical professionals to share the information with distributed storage and computational resources to accelerate the analysis, diagnosis and alert when a life threatening event occurs, through e-mail or SMS services for further follow up of the patients.

2. Related works

Carlos Serodio, Pedro Mestre, et al [13] explained how life support systems utilize wireless sensors and they showcased a context aware system also in the paper range of results carried out in indoor environment and provided a viable solution. Hande Alemdar, Cem Ersoy, provided a survey on Wireless sensor networks for healthcare [19] in that they explained design considerations and challenges with various examples it spokes about security, energy efficiency, scalability and comprehensive analysis. Various wearable bio sensors for healthcare applications are discussed with experimental analysis [20].

Cardiology Unit at La Paz Hospital in Madrid, Spain wireless sensor system was implemented and the real time physiological signs of the patients like ECG, skin temperature and heart rate were monitored, the system architecture and the system deployment were explained [18]. Making wireless body are network by interconnecting wireless bio sensors and computing gateways [12]. The requirement of wireless sensor grid to handle continuous patient monitoring applications was explained [3], [16], [17].

The data exchange between hospitals and the information sharing via cloud computing was discussed by B.Perumal, M.Pallikonda Rajasekaran, H.M.Ramalingam [16] and the papers [5], [6], [8] explained the wireless sensor integration to the cloud and different methods followed to utilize the full potential of cloud computing. Various job scheduling algorithms in grid computing implementation [1],

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[8] and handling big data was reviewed [11]. Various web based parallel and distributed processing [14] and different load balancing methodologies for grid computing [9] are explained.

Nathan Botts, Brian Thoms, et al [10] explained a cloud based architectural design, which focused on making an automated telemedicine system. in their work they experimented how consumers and care provider utilizing the google's cloud computing environment. In paper [7] how cloud computing and wireless sensor can be integrated and provided different style architecture.

Based on the survey done above, it is found that none of the solutions satisfies the requirements completely. To overcome the above said technical issues, a new concept that integrates the concepts of medical sensors with high performance computing and community cloud to create a platform to support automated data gathering in telemedicine environment is identified. Java based open source tool is used to the paralleling the tasks and distributed storage of all the medical sensor data rather than storing in local computer. The progress of uploading the medical data to the cloud is done through a service provided by the cloud in order to avoid the complexity of storing data in the computer. The data in the cloud are accessed by medical experts and also by other hospital experts. Through this way of distributing the health data, the patients can access their data at low cost and the medical experts can give their immediate aid to the patients.

3. Methodology

Modern scientific advances in medical field have made possible, the low-cost WSNs, which can able to sense and communicate one or more patient's vital parameter to the central server, which is the driver node for analysis [16]. The proposed three tier architecture is illustrated in Figure.1 which shows all the integral part of the architecture.

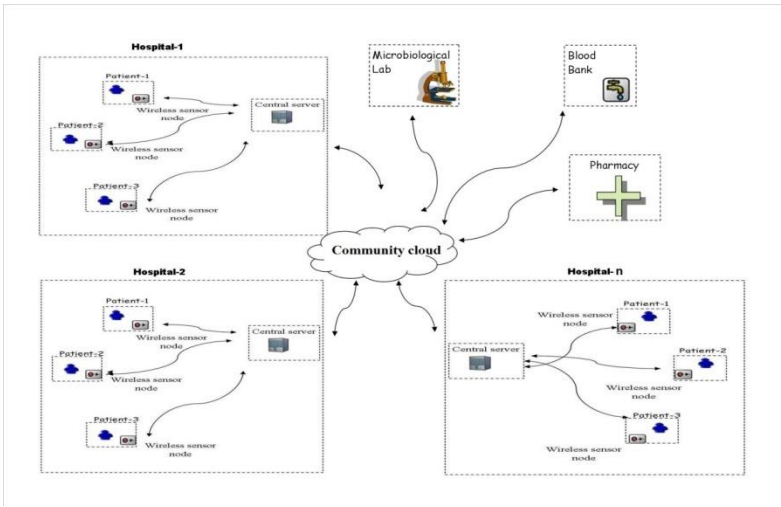

Fig.1. Proposed Architecture for E-healthcare application [16]

In Tier one WBAN could be setup in the hospital to sense physiological signals of the patients. Medical sensors are attached to the patient's body to monitor the physiological signals. The wireless sensor gateway receives the information from the bio sensors and transmits it to the central server for analysis. The node is attached to the central server through the USB interface. In the architecture, the

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Wireless Sensor Network data of various patients are monitored in different hospitals. The data acquired from different patients in each hospital and are transformed to their respective central server [3]. Figure 2 represents the test bed connection followed to collect vital signs from the patients. The tier two consist of Grid inside every hospital, available computational resources inside the hospital will be utilized while using grid computing. Because in real time N-number of sensors form N-number of patients be connected to the hospital server. So the grid provides the enormous computational power to handle the above.

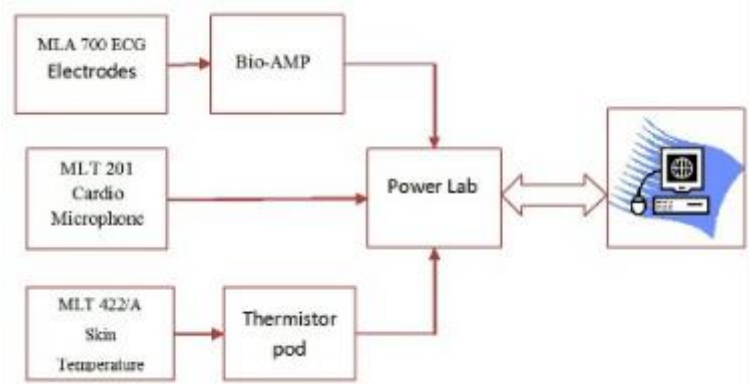

Fig.2. Test bed connection

Tier three is the community cloud; the data collected from various hospitals will be updated in the cloud regularly. Cloud architectures are designed by software applications that are used with internet on demand services [17]. To access medical data on the cloud, the medical experts have to authenticate their entry. The secure web server allows authenticated users to access real time patient's information to consult with medical specialist/experts located at remote places [3]. When the queries are requested from medical experts, the system fetches the medical data from the distributed database and sends it to the experts for monitoring and analyzing health data. In this experimental study the remote access of live patient monitoring is achieved and the parallel processing to improve the computational efficiency is performed. The HPC with different nodes and its efficiency is analyzed by performing 100 iterations of 300*300 matrix multiplications with dynamic task allocation.

4. Results and discussion

As per the architecture tier one is the WBAN inside the hospital to collect vital signs from the patients, that information is stored in the central server of the hospital. Here the tier two acts between the available resources inside the hospital to make grid to increase the performance of the overall system. Parallel computing framework based on Java is used as the backbone of the architecture, which is configured in four nodes for this experimental study. In this study one server node with four client nodes are considered, where the server node schedule the tasks dynamically between the available client nodes. Client nodes complete the assigned tasks and send back the results to the server node. The table-1 shows comparison of the high performance computing to perform 100 iterations of 300*300 matrix multiplications. Which gives a clear idea about the parallel computation implementation and the

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experimental results shows that the efficiency of the HPC depends on the availability of the idle nodes and the network condition.

Table-1 Parallel processing comparison

System setup	Total time taken to complete task		
	Test-1	Test-2	Test-3
1 Server and 1 Node	1min 18 sec	1 min 11 sec	1 min 9 sec
1 Server with 2 Nodes	34 sec	31 sec	27sec
1 Server with 3 Nodes	23 sec	21sec	25sec

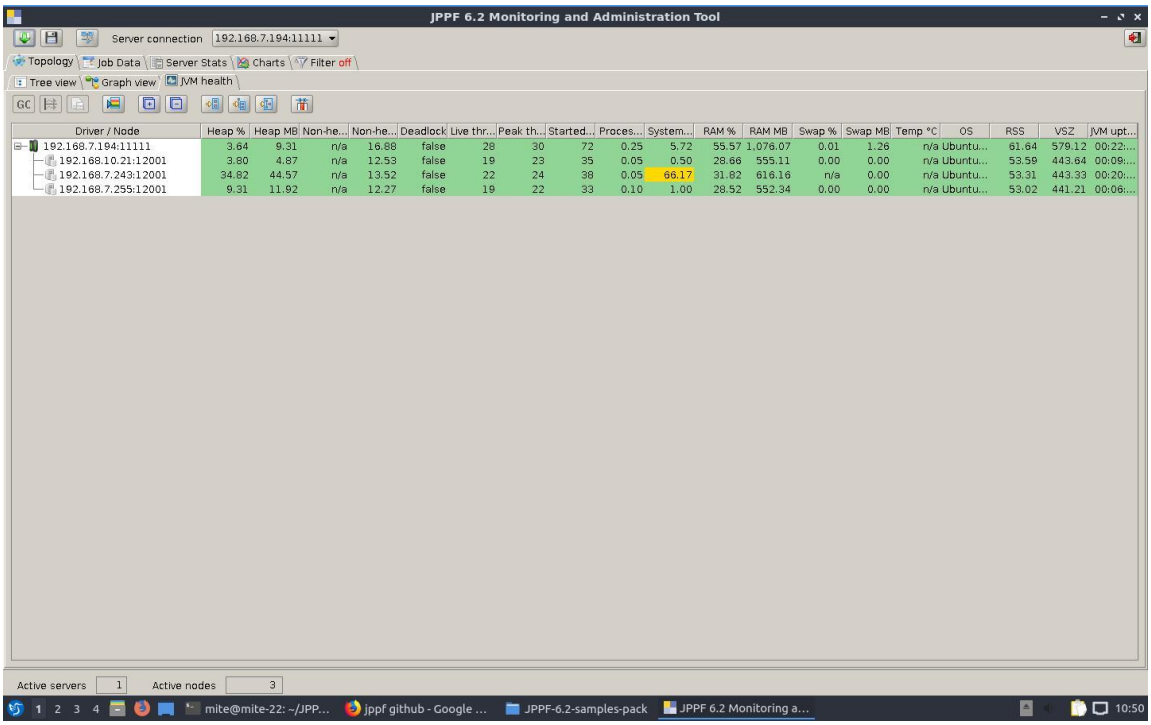

Fig-3 Parallel proceeding monitoring screen

For these experimental study server and client nodes having a CPU clock of 2.2GHz dual core processor with 2GB of RAM and Linux operating system running on it is used. These nodes are LAN connected with a gigabit switch. The observation gives the task execution time depends on various factors like availability of idle resources, network condition and other major tasks execution at the time.

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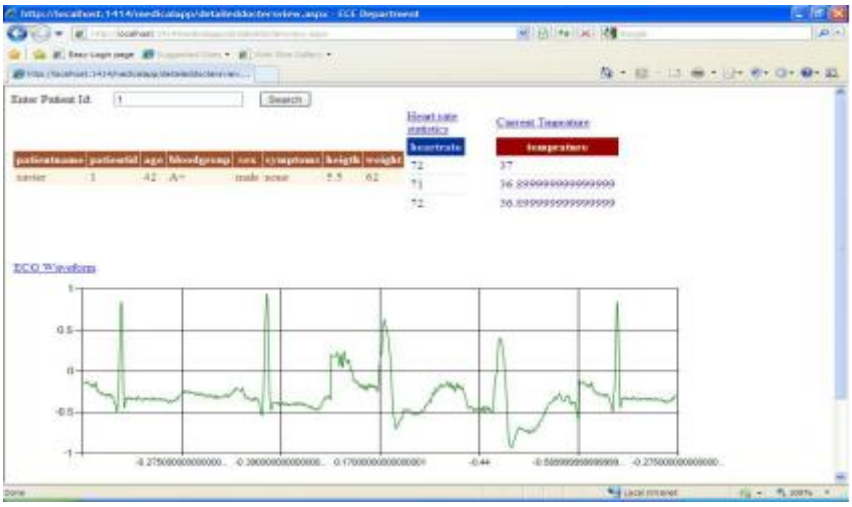

Fig.4. Detailed Patient Record View to the care takers

Community cloud is the tier three in the architecture, which provide seamless access to the health records and able to perform remote monitoring, figure- 4 showing the care takers view of the patients details. Similarly all the information collected from various sensors attached to various patients can easily be viewed by the care takers and doctors using their credentials. The use of HPC and cloud in the architecture the resource

5. Conclusion and Future Work

The experimental study shows how high performance computing and Wireless sensor cloud can support the needs of vulnerable health populations and their care takers. This experimental study gave broad knowledge of High performance computing implementation using Java Parallel processing. It is clear from the study that the dynamic scheduling of jobs the efficiency and task completion of the HPC depends on various aspects like node availability, network condition. In the future work we need to integrate the sensory data analysis in the parallel processing environment in order to identify the available resources been shared whenever it is required by the grid.

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