Sensor Grid Middleware for Health Care Monitoring

T. Vigneswari and M. A. Maluk Mohammed

***Abstract*—A sensor grid middleware for health care monitoring is proposed in this paper. The proposed middleware hides the heterogeneity between the sensors and the grid. Sensors are attached to the patient's body. The vital sign values collected by the sensors are transmitted to the grid through a mobile device. In the grid, the vital sign values are sent to an appropriate node which contains Software as Service (SaaS).The SaaS receives the vital sign values and analyze whether they exceed the normal value. In this case, the physician looking after the patient is sent an alert message. The physician recommends proper medication based on the patients report he receives.**

***Index Terms*—Sensor grid, telemedicine, middleware, distributed pipe communication, software as service (SaaS)**

I. Introduction

Telemedicine utilizes the growth in the field of information and technology to increase the affinity of patients towards the doctors. The status of the patient can be monitored by the doctor without mobilizing the patient which saves cost and time. Any telemedicine system should possess features such as [12] cost, easy to use, better availability and security.

Sensor grid [1], [2], [3] is an evolving technology which integrates Grid computing and sensor networks. The major reasons for merging grid and sensor networks as sensor grid is as follows: i) Huge set of real time data generated by sensors can be processed and stored in grid nodes. ii) Set of sensors can be shared by different user based on the application they are using.iii) Pervasive seamless access to sensor data is made possible. Sensor grid finds its application in wide area such as health care monitoring, habitat monitoring, agriculture, target locating, pollution monitoring etc. Sensor networks can be shared by different applications thus reducing the deployment of sensors separately for each application. Sensor grid distributes the data acquisition and processing capability of sensor networks through grid.

This paper proposes a sensor grid middleware for health care monitoring. The sensor grid middleware enables sensor to send data to grid where storage and analysis is done efficiently A two layered P2P architecture is identified for arranging the grid nodes. This P2P structure provides a decentralized control over the resources which is desirable for any grid. The patients are abstracted as objects and encapsulate all the details about the patient as well as sensors attached to the patient.

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II. Related Works

An ubiquitous health care system has been discussed in [4]. It monitors the patient vital signs by using sensor networks and analyzes it in the grid. A Sensor Grid gateway which connects the sensor network and grid middleware transparently was available. A middleware to support the sensor grid gateway to manage the sensor networks was also made available.

Grid infrastructure [5] has been utilized to manipulate the mammography digital images. Instead of a specialist spending his time in reading the images, workstations analyzes and diagnoses the images and identify the presence of breast cancer.

The project in [6] discuss about a grid based health monitoring to provide homecare. The grid integrates P2P resource sharing to record, monitor and mine data about the health status of the patient. This platform has been built with the ability to provide alert about health status and notification about intake of medicine.

A noninvasive sensor based application for sleep medicine and movement monitoring was discussed in[7]. This application allows clinicians to collect data from in home without disturbing the patients by using low cost and disposable pressure monitoring and data acquisition system.

Hridhaya [8] was developed to decrease the visit of patients suffering from Cardio Vascular System. It can be used with mobile phones or PDAs. The ECG of the patient is received through mobile devices and a decision support system checks for the possibility for occurrence of cardio vascular disease. This system is based on the convergence of Grid, Web 20 and SaS.

The existing systems discussed above monitors the patients and provide necessary care needed for them through grid and sensor networks. But issues such as load balancing, fault tolerance and security have not been discussed in detail.

However, a scalable and fault-tolerant P2P grid architecture for the telemedicine is proposed in [9].This context-aware mobile telemedicine use the grid for request forwarding and load balancing in terms of patient requests. But it just forward patients vital sign value to the physician. our proposed system has SaaS to analyze the values and interacts with the physician only if the values are abnormal.

Vishwa, a two layered peer-to-peer middleware is discussed in [10]. Structured and unstructured P2P layers are available for task mobility and storage of data. Fault tolerance and load balancing are handled efficiently in this framework. It focus on decentralized components for administration and management that accounts for better scalability and reconfigurability

Our proposed system differs from the above system by providing object abstraction for sensors to improve fault tolerance and pipe communication initiated by objects for acquisition of data from sensors.

III. Architecture

A. Overview

Sensors are attached to the patient's body. The vital parameter values are sent to the grid through a mobile device. The grid is designed as a two layered P2P architecture as shown in figure1. The first layer is the structured P2P layer. It is used for analyzing the values. An application to analyze the values is made available in the grid nodes as SaaS. During the analysis if the SaaS finds the parameter values exceed beyond normal values, an alert message is sent to the physician .The physician advices proper medication accordingly. The sensors are also abstracted as objects and stored in this layer in object store. The object store replaces the centralized coordinator seen in other systems. The nodes are divided into zones based on their proximity. The objects of the nodes of same zone are stored in an object store available in a node of that system. The second layer is a structured P2P layer. It is used for storing the vital parameter values. The patient or physician can retrieve the data from the data base to know the history of a particular patient. This can be shared with some researchers also with proper access rights if they need the values for their research. Distributed pipe communication is used for all the communications that takes place between the sensors and grid nodes.

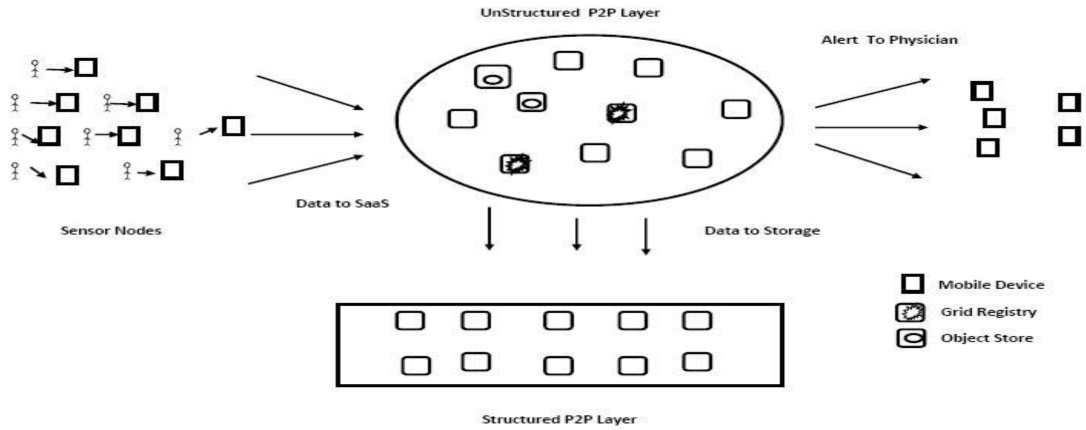

Fig. 1. Architecture overview.

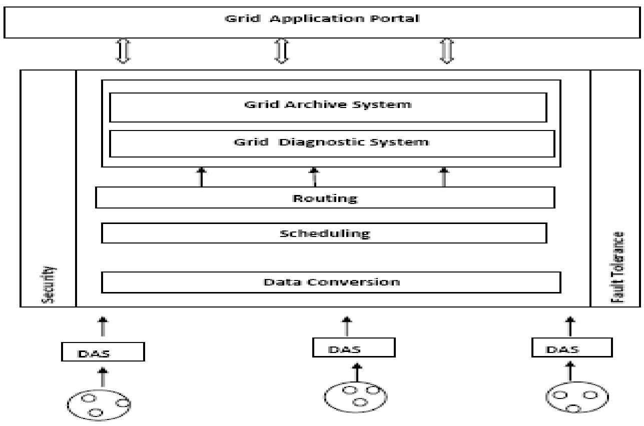

Fig. 2. Middleware architecture.

A. Detailed Architecture:

A sensor grid middleware has been developed to perform the task explained in the architectural overview. The Middleware components are shown below in the figure 2 and explained in this section.

Grid registry: The nodes that are willing to participate in the Grid register themselves in the registry. Various forms of nodes are seen in this registry. Mobile nodes are Mobile devices that receive sensor data and send it to storage and SaaS. They are also called as Data acquisition systems. SaaS Nodes are Nodes which are willing to run SaaS. Once they are registered the SaaS code (mobile code) is transferred to this node. Storage nodes are nodes that store the database of patient. Querying and retrieving mechanism are provided. Patient history is available for doctors, patient and others who have access rights.

Middleware components

Data Conversion:

The vital sign values received from sensors in patient body by a data acquisition system. Usually the data acquisition system is any mobile device. The data should be converted into a standard form accepted by Grid. Therefore the vital sign values are converted to into xml format .Along with this XSL document is also generated. At the application end by using XSLT it can be converted to HTML.

Scheduling:

The vital sign values sent by the sensors should be scheduled to the computing nodes for analyzing and for storage at data archive system. The SaaS nodes and storage archive nodes advertise load factors at constant interval. Based on this the node with lesser load factor is selected for computation. Along with this another factor called alert factor is also used .Whenever a physician receives an alert regarding a patient, the alert factor for the particular patient is incremented by a certain value. During the scheduling the patient object with higher alert factor is scheduled first.

Routing:

The nodes participating in the grid are grouped into zones based on their locality. Chord and Pastry [10] based routing are used. Pastry based routing is used within the zone and Chord based routing is used across the zone.

Grid Diagnostic and Archive system:

The nodes of the Grid Diagnostic system have SaaS code deployed in it. The SaaS in the grid node check the value of the vital sign values against the normal value. If the received value is more than the normal value then an alert message is sent to the physician and also a care taker. Grid Notification service is used for this. The SaaS node act as the source and the physician subscribes for notification if the patients vital sign values are abnormal.

The Grid Archive system stores the patient history in a data base with timestamp for continuous monitoring. The major focus of this system is easy retrieval and high availability. Each patient is abstracted as an object and has an unique object id. The Data acquisition system sends the object id with data. Based on this data is stored appropriately in particular patients' record. At any time data can be manipulated by using queries. The patient, physician and the care taker can access the data with proper access rights.

Usually database of the patient is available at the edge node of the hospital. They are also replicated at the hospital edge nodes, zone and a central repository. In order to perform updations efficiently replication is done at nodes with lesser proximity.

Fault tolerance :

The Failures may occur at any one of the level

1) Sensors: Sensors are likely to send their data at proper intervals. The patient object initiates pipe communication at this scheduled interval. If the pipe is not able to receive the data then we may consider that there is some problem with sensor. A notification may be sent to the patient and doctor in this case. If the sensor has failed, then a new sensor is attached and it is connected with the object of the failed sensor. Thus the system is transparent to hardware failures.
2) Computing nodes: Whenever a data is sent to SaaS for analysis, it sends an acknowledgement. Then after completion of analysis it sends a notification. If the notification is not received, the object sends a status query about the status of node .Based on the response to the query the task is moved to another live node if the current node has failed.

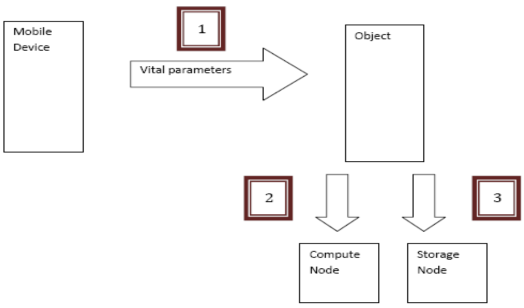

Fig. 3. Pipe communication

3) Storage Nodes: Replication is available for dealing with storage failures. Replica is stored at edge node at hospital, a node in the region of hospital and some nodes that are in nearest proximity .

Distributed pipe communication

Pipes are the communication channels that are created to send and receive values in between tasks. Distributed pipe paradigm is used in this proposed work. Distributed pipe (DP)[11] is used to perform anonymous remote computation. The user application need not have the concern about the location of the task execution. Task can also be moved to another node without the intervention of the user if the current executing node is overloaded to provide load balancing. In our proposed work pipe communication is used for the communication between the components in our system.

The object abstraction of the sensors has methods to initiate the pipe communication. Three pipe communications are established to process the values sent by any sensor and it is shown in the figure 3 below.

1) At constant interval a pipe is created by the object to receive the values from the mobile device to which the sensor send the values
2) Once the value is received the pipe is created to send the value to the node containing the SaS for computation. This node is located in the unstructured P2P layer.
3) A pipe communication is established to store the received values in a node in structured P2P layer.

During execution, if any node is overloaded, the job can be transferred to any other suitable node with lesser load. In the same way if a node fails during execution, the job can be transferred to another node without involving the user.

IV. Implementation

The implementation of above said proposal is in its initial stage by using c#. A web portal is available which act as the entry point to grid. The users can login and view the details. A simple grid prototype has been developed by using simgrid V3.6.2 simulation tool. The SaaS is deployed in the grid nodes. The SaaS is designed to receive the values of Temperature, Blood pressure, Haemoglobin. To start with the sensor values are obtained by using a random number generator. The figure 5and figure 6 below shows alert message and patient detail.

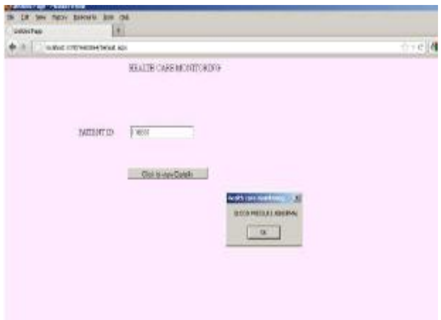

Fig. 4. Alert message.

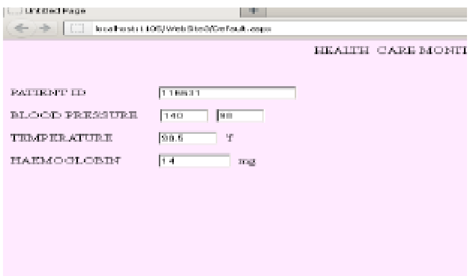

Fig. 5. Patient detail display.

V. Conclusion

Sensor grid provides the synergy by combining the features of both the grid and sensor networks. In this paper we have introduced middleware for a two layered P2P sensor grid architecture for telemedicine. The functionalities of the middleware provide a scalable and fault tolerant distributed system. Distributed Pipe paradigm and object abstraction for sensor to initiate pipe communication is proposed to provide better dynamic load balancing. To extend this architecture the grid may be designed as knowledge grids which to some extent can advice the quantity of medicine to be taken for some particular cases.

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