AGENT BASED RESOURCE MANAGEMENT IN SENSOR CLOUD

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ABSTRACT: Considering the major issues of Wireless Sensor Network (WSN) like less bandwidth, energy and storage the research has begun to find the new adoption which overcomes the drawbacks of the WSN. The cloud computing has emerged the major computation technology that can compute, store the computational result for long period and also provides the accessibility anywhere and anytime. The sensor cloud combination overcomes most of the issues which are coming due to the lack of energy, bandwidth and limited accessibility. The sensor cloud collects the resource from sensors and through the gateway the resources are systematically stored in the cloud database using advanced resource management technologies avoids storage of resource in sensor nodes. Now user/controller sitting any side can access the data at any point of time. The agents are included to further reduce the energy consumption, improving the efficiency and important is managing the resources in the cloud database according to their priority or emergency and providing the same to users within less time. This paper proposes some of the new agent based resource management techniques which will further enhance the overall efficiency of the sensor cloud.

Index Terms: Agents, Sensor Cloud, Resource Management, Server, Gateway, WSN, Bandwidth, Efficiency, Delay.

1. INTRODUCTION

Sensor cloud is a new model for cloud computing that uses the physical sensors to gather its data and transmit all sensory data into a cloud computing infrastructure. Sensor cloud is a well-designed sensor data storage, visualization and remote management platform that support powerful cloud computing technologies to provide great data scalability, rapid visualization, and user programmable analysis (Kian Tee Lan, 2010; R. Shea, 2013). In other words, sensor cloud can be defined as, an infrastructure that allows truly pervasive computation using sensors as interface between physical and cyber worlds, the data-compute clusters as the cyber backbone and the internet as the communication medium (Intellisys, 2014; David Irwin, 2010).

A sensor cloud collects and processes information from several sensor networks enables information sharing on big-scale and collaborate the applications on cloud among users. It integrates several networks with number of sensing applications and cloud computing platform by allowing applications to be cross-disciplinary that may traversed over organizational varieties. Sensor cloud enables users to easily gather, access, processing, visualizing and analyzing, storing, sharing and searching large number of sensor data from several types of applications (Wen-Yaw Chung, 2013). These huge quantity of data are stored, processed, analyzed and then visualized by using the computational information technology and storage resources of the cloud (Charalampos Doukas, 2011).

Agents on the other hand are autonomous, proactive, works quickly, learn from the environmental conditions and acts accordingly (A. Rogers, 2009). The agents is a software program which migrates from one system/node to another and gathers, processes the information and lastly stores in one of the system for quick accessing or processing. In this paper, the agents are available at cloud server and they receive the information from the physical sensors and based on the available resource management methods the information is stored in one of the server. It also offers easy accessibility to end users and controllers. The agent also provides the report to the controllers regarding the statistics of the data/information or how and where the resources are stored in the server (A. Weiss, 2007) (Seenuvasan P, 2017).

2. BACKGROUND

2.1 Wireless sensor network

Wireless sensor networks are used for monitoring environmental conditions like temperature, pressure, humidity, sound etc. in recent year wireless sensor networks are most widely used in military and many more applications. Wireless sensor network consists of set of sensor nodes and these sensor node sense the environmental parameters and updates the user/controller. The lifetime of sensor nodes depends on battery capacity and energy efficiency. Sensor nodes perform several functions hence these nodes are known as multifunctional. Sensor nodes are small in size, low cost and low power. Sensor nodes are capable of communicating wirelessly with each other in small distance. Energy efficiency is a critical issue in wireless sensor network as it depicts the lifetime of the network. Microcontroller, transreceiver, external memory, ADC, sensing unit, processing unit and power source are the components of sensor nodes (W. Heinzelman, 1999). Microcontroller is used for controlling functionality of other components in the sensor node. Microcontroller is low cost and low power consumption. Trans-receiver combines the functions of both transmitter and receiver into single device. Sensor nodes use power supply for sensing, communicating and processing data. ADC is used for digitizing analog signal produced by the sensor. The work of sensing unit is to sense the environmental parameters and sensed information will be sent to processing unit for processing of data and storage is used to store the data with time.

Issues in wireless sensor network are (Akyildiz, I.F, 1999)Node deployment, Energy Consumption without losing accuracy, Node/Link Heterogeneity, Fault Tolerance, Scalability, Transmission media, Coverage, Data Aggregation. Applications of wireless sensor network **(**Akyildiz, I.F, 1999**)**(M. Kocakulak, 2017) are Process management, Health care monitoring, Environmental/Earth sensing, Industrial monitoring, WSN for IoT applications, Military Applications, Traffic Monitoring.

2.2 Cloud Computing

Cloud computing involves deploying groups of remote servers and software networked that allow centralized data storage and online access to computer services or resources.

Cloud computing can be defined as "A model for conveying information technology facilities in which resources are regained from the internet through web-based tools and applications, rather than a direct link to a server" or "The storing and accessing of applications and computer data often through a web browser rather

than running installed software on your personal computer or office server". the cloud computing is the set of hardware, software, networks, storage, services and interfaces that combine to deliver phases of computing as a service. The cloud computing has emerged a popular paradigm for proving reliable resources, software and information on demand using virtual servers ((A. Weiss, 2007)). Cloud computing allows people to do things they want to do on a computer without the need for them to purchase and form an IT infrastructure or to understand the fundamental technology. Cloud computing technology helps to do more with less expenses, higher quality services, reduced risk, less complexity and more importantly scalability.

Some of the popular cloud characteristic includes, on-demand service, ubiquitous network access, location independent resource pooling and rapid elasticity (A. Weiss, 2007). Models of the cloud computing are mainly classified into three types, public clouds, private clouds and hybrid clouds. In public clouds, service provider makes resources, such as applications and storage, available to the general public over the Internet. Public cloud services may be free or offered on a pay-per-usage model. In A private cloud is a particular model of cloud computing that involves a distinct and secure cloud based environment in which only the specified client can operate. As with other cloud models, private clouds will provide computing power as a service within a virtualized environment using an underlying pool of physical computing resource. However, under the private cloud model, the cloud (the pool of resource) is only accessible by a single organization providing that organization with greater control and privacy. Hybrid cloud combine elements of public and private clouds (Felici M, 2013).

The service models of cloud computing are categorized into three types, Software as a service (SaaS), Infrastructure as a Service (IaaS), most basic cloud service model and lastly Platform as a Service (PaaS) (Felici M, 2013).

3. ARCHITECTURE OF SENSOR CLOUD

The general architecture of cloud computing is as shown in below figure 1. The architecture of the sensor cloud has following components,

Physical Sensor Network: It is the actual sensor network, where physical sensors are deployed either manually or random way. Sensor may have homogenous or heterogeneous property. All the sensors will sense the required information and transfer to sink node using one of the energy optical routing techniques.

Sink Node: All the nodes in the sensor network will finally send the information to sink node. Sink node has control over all the sensing nodes in the network. Sink node maintains the database of all the sensor nodes and it will be updated always.

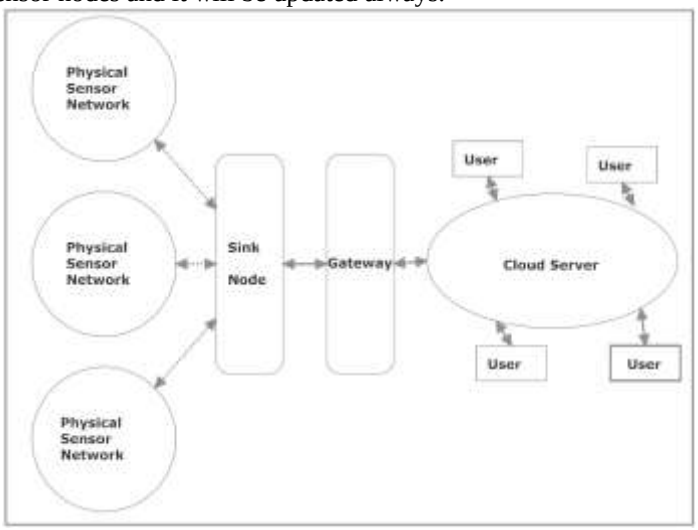

Figure1: Sensor Cloud Architecture

Gateway: It is the middleware between physical sensor network and the cloud server. The sensed information can be sent to cloud server using basic networking technologies like wired or wireless networks. Wireless networking is preferred for data transmission i.e. Bluetooth technology.

Cloud Server: It is the end point where all the sensed data are stored. Different users can access the data based on their interest.

Users: Users are the end people who utilizes the services provided by the sensor cloud. User can also inject the query into the network and he/she waits for the results. Users can access any kind of data, if data is public then there will be no cost to view/access data and if data is secured then user need a password to access the data.

Virtual Sensors Group: It is the virtual network of actual physical sensor network available at the cloud. It gives the actual status of the physical network and also updates the database all time. If any node is moving out of battery energy or if the node is about to die then virtual network removes that node from the network and reform the routing table once again.

a) Advantages of Sensor Cloud

In this section some of the major advantages of the sensor cloud are depicted.

1. **Scalability:** if the number of resources are increased then it can be possible to add extra services into cloud computing without paying extra money. Hence huge sensory raw data can be processed easily using sensor cloud.
2. **Increased data storage and processing power:** Date can be stored in servers and hence avoiding storage of information in personal computer and information can be accessed by many applications. Need of processing power also becomes less.
3. **Dynamic provisioning of services:** Services provided by the sensor cloud can be accessed anywhere anytime. Users no need to stick to their own computers.
4. **Multi-tenancy:** Multi services from multiple service providers can be integrated onto a single network. Sensor cloud allows the accessibility of data anywhere anytime.
5. **Collaboration:** sensor cloud enables collaborations among several users and applications, hence huge sensor data can be processed easily.
6. **Analyze:** data analyzing from huge sensory data and distribution of data according to user requirement is very quick in sensor cloud.
7. **Visualization:** through sensor cloud platform information from multimedia sensors can easily be visualized in the form of pictures or diagrams and future trend can be predicted (Wasai Shadab Ansari, 2013; H. T. Dinh, 2011).
8. **Resource optimization:** Sensor-Cloud enables resource sharing capability to many numbers of applications.

b) Disadvantages of Sensor Cloud

The disadvantages of sensor cloud are listed below (Irfan Gul, 2011)

1. Structure doesn't give to a great degree precise statistics as in case of conventional allocation of physical sensors statistics.
2. The operations provided are not rapid adequate as assessed to amenities agreed by straight exchange of human projections.
3. Sensor-Cloud required enormously extensive organization pattern in order to follow the clients.
4. Cloud-Sensor architecture is susceptible and additional level to complicated share outer interruption attacks.

Issues in Sensor Cloud: Sensor cloud focuses on following issues like, power issue, authorization issue, network management, energy, security, pricing, resource management, fault tolerance, routing, clock synchronization and programming.

Applications of Sensor Cloud: Sensor cloud can be used in many application because of its attractive features(Sean Barker, 2010) like agriculture applications, healthcare applications, weather application and military application. Sensor cloud can also be used for many others applications also like, transportation and vehicle

traffic applications, earth observation, telemetric etc. (H. T. Dinh, 2011).

4. AGENT BASED RESOURCE MANAGEMENT IN SENSOR CLOUD

Physical sensor nodes have limited battery power, limited bandwidth and less memory storage. Data sensed by the sensor can't be stored for long period and processing of such a huge data is a tedious job. Cloud computing provides scalable processing power and numerous classes of connectable services. Through cloud computing huge amount of data can be stored and processed easily hence problems with sensor nodes can be solved easily. Managing the resources at the cloud server is a research issue in sensor cloud where huge data from different sensor networks comes and stored here. Raw sensed information from sensor nodes are classified in many ways like information may be regarding the physical signal which is usually represented in text format or the information may be represented in multimedia format. Sensing the data and transferring the data into the cloud from sensor nodes is challenging task where data are coming from different platforms and have different format. Arranging the data at the cloud server is tedious work in sensor cloud. The resource allocator should be selected in such a way that it should complete the task within the time and allocation should be error free and cost optimized. In this section we are discussing some of the agent based platforms which helps in allocating the sensory resources into the sensor cloud server and it is be accessible for all users. The agents plays a vital role in placing the right resource in right database. The agents are programmed in such a way that, if any data is coming from the sensor network then agent will apply resource management technique onto it and those data will be saved in defined server/platform for easy accessibility to end users and controllers which is shown in figure 2.The figure shows the wireless sensor network which consist of many nodes which are interconnected to one another and send the sensed data to sink node. The data from the sink node is sent to cloud via gateway. At the sensor cloud server, the data is initially received by the agents and according to the type of data the agent will use one of the resource management method to store the data in particular database/server/platform etc. Lastly the stored data can be accessed by the end users or controllers for further processing. Various agent based resource management methods are proposed in this. All holdswell in most of the conditions and improve the efficiency of the overall system. There are different models for data storage in cloud server namely, file repository, database module, service module, resource configuration module (Lihong Jiang, 2014).

The Date storage operator will perform following operations (Rahul Khanna, 2014),

1) Precisely measure real-time energy depletion and estimate power usage effectiveness.

2) Deduce temperature, humidity, and subfloor pressure difference data from several sensor nodes by live-imaging maps.

3) Truthfully measure server specific performance features and drifts for evolving statistical models that can predict resource utilization and energy consumption.

4) Perfect association between server performance characteristics, energy consumption, and environmental parameters (temperature, humidity, subfloor pressure, etc.).

5) Establish baseline energy consumption and detect improvement chances by efficient provisioning and filling of server resources.

6) Using monitoring infrastructure, improve automation policy that achieves adaptive workload provisioning, air-flow control, and air-conditioning control.

7) Monitor environmental situations to confirm agreement as per the American Society of Heating, Refrigerating, and Air-Conditioning Engineers and convey alerts if the ranges are surpassed.

Few mathematical models were proposed for the selection of cloud service provider which satisfy the consumer need at maximum level and few data allocation problems which select the best storage systems which meet the user's data necessities and optimize cost and/or access latency/bandwidth.

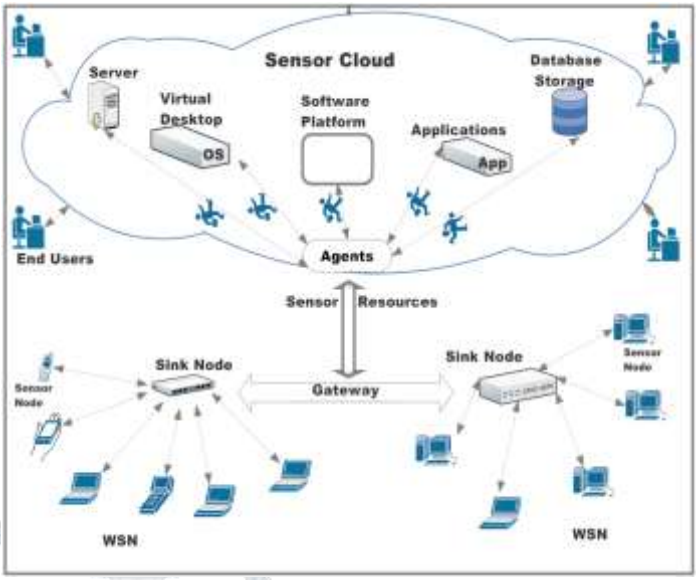

Figure2: Agent based resource management in sensor cloud

a) Utility based model:

This methodology customs utility functions in a QoS management framework with the goals to encounter the least requirements and maximize the entire utility for the consumer. By calculating the utility value related to each provider, the best provider will be the one with the highest utility value which is given in equation 1(Maria Salama, 2013).

$$f(U_i) = \sum_{j=1}^{m} \left(\sum_{l=1}^{aj} P_{ijl} * w_{jl} \right) * W_j \qquad (1)$$

Where the calculation of the utility value u_{ij} is addressed as follows. Any class dimension j, where $j \in \{1,..,m\}$, is defined by a group of measurable parameters P_{jl}, where $j \in \{1,..,q_j\}$, and q_j is the size of this group. For example; a quality dimension like the performance is defined in terms of measurable parameters like response time, worst-case execution time, and throughput. Each of these parameter P_{jl} is further associated with a weight w_{jl}, where for $w_{jl} \in [0,1]$, and $\sum_{l=1}^{aj} w_{jl} = 1$. Varying P_{jl}, different parameters can be considered for one QoS dimension.

b) Resource allocation model

In this case the inputs are a list of user's requirements and the storage services' capabilities. The output of this first stage is a list of compatible storage services for each dataset in the application; these lists constitute the input for our data allocation problem. We use integer linear programming to model this problem. The general idea is to include the cost, latency, and bandwidth as parameters in the objective function that needs to be minimized.

Let us consider the dataset (xi,j), an integer variable is introduced that represents the amount of computation required per month and an assignment of computation to cloud sites. Additional linear constraints are used to enforce different restrictions. For example, that each dataset is stored in at least one storage system and that each site can support the computations that accesses each dataset.

The objective function is the following one, where each wi is the combination of a weight assigned by the user and a normalizing factor which is depicted in equation 2:

*min(w1*avg storage cost + w2*avg compute cost + w3*avg latency + w4*avgbandwidth)* (2)

It needs to be combined every term in order to evaluate cost, latency and bandwidth. In this case all parameters have been normalized.

Using game theory, grid computing and parallel computing the resources are managed in a better way along with that data

aggregation techniques can also be employed to minimize large data into small one.

5. METHODS FOR AGENTS BASED RESOURCE MANAGEMENT IN SENSOR CLOUDS

Following are the methodologies used for resource management in sensor cloud.

a). Agent based priority-wise resource management
b). Agent based resource storage in cloud computing types
c). Agent based resource aggregation
d). Agent based resource management based on organization modes
e). Saving resources in cubes (Multidimensional)
f). Grid computing

a). Agent based priority-wise resource management

The sensed information from the physical sensor are sent to the sensor cloud using gateway. At the server side the agent will check the importance of the data (Resource) and accordingly the data is stored inside the database. The agents always keep on tracking the incoming from the WSN and check for information status before they are stored in cloud database. The resources are classified in-terms of priority of the data.

If the information is very critical and need to be transferred/processed immediately then the agent will check for its priority level and assign it as high priority information and it will be processed at first. The agent works based the threshold level defined to them during their initiation.

If the information is moderately critical, then it is labeled as nominally prioritized information by the agents. This information is sent when high priority information is empty.

If the information is non-critical or general data then it is labeled as non-priority information by the agents. The information available in this section is sent to required users when both priority & nominally priority are empty. Sometimes the timing are set for sending of information to particular end user.

Examples for priority, nominal priority and non-priority information are as follows.

Priority information: Military data, Accident information, Emergency data like fire in forest, leakage in power plants.

Nominally Priority information: Traffic Analysis, Product information.

Non Priority Information: Temperature, Humidity, Pressure information.

b). Agent based resource storage in cloud computing types

Generally cloud computing is classified into three types namely, public cloud, private cloud and hybrid clouds. Based on the data coming from the physical sensor, the agent will store the data either in public, private or hybrid clouds. The classification is done based on the data type, which will be decided by agent's intelligence. The agents are programmed in such a way that they should recognize the type of data and accordingly they should store the data in one of the cloud computing types.

If the data is private then, agent should store data in private clouds. If any users want to access such data, then they need a valid user id and password to access the information. There is a need of security algorithms in order to protect the private data. Some of the popular encryption algorithms are Data Encryption System (DES), Advanced Encryption System (AES), RSA or cipher key management.

If the sensed information from the physical sensor is general (non-private) then agent will store such data in the public clouds at the sensor cloud server. Any information which don't require encryption or non-private information can be stored here. There is no requirement of user id and password to access the information. If any user request information then they can connect to the server and they can access the data. Only authenticated users are allowed to access the information. No standard security approaches are required.

In case of hybrid clouds, the physical information from the sensors is stored in the server where users can access data it in two ways. Agent's intelligence is essential in this case to decide whether the data requires security or not. Firstly, User need valid user id and password to access few data which are stored with security approaches. Secondly, some other data which can be accessed by the users without used id and password. In the second case security is not the important aspect.

Based on the importance of the data, agents will store it in private or public clouds. Encryption algorithms can be applied to few data if they important and can't be accessed by the third party or unwanted users/systems.

The filtering techniques are included to divide the data. That is private data and public data.

c). Agent based resource aggregation

Data aggregation is one of the data saving method in sensor cloud. The sensor may send duplicate information or multiple copies of same information. If all data is stored in the clouds then it leads to wastage of important space and delay rises effecting overall system efficiency. Hence, in this case the agents will cross check the data before they stored in the cloud servers.

An algorithm/ filtering technology is employed before storing the data into the sensor cloud. This approach will store only required information inside the serve and removes redundant information.

The techniques used for data aggregation are minimum, maximum, summation, average or fusion. If similar information appears at the sensor cloud server then above mentioned techniques are used and it will give the unique information which reflects the similarity between the data appears at the output and same is being stored in the senor cloud server.

Data aggregation reduces the memory used by the sensory data. Hence information from other resource can also be stored in left space, hence the resources are managed(J. Johnson, 1999).

Example:

If sensor1 and sensor2 sends the temperature information 42^{o}C and 43^{o}C respectively then, instead of keeping both sensory information at the server side. The data aggregation technique is employed to eliminate duplicate/redundant data and store only one data which reflects both the information's at the sensor cloud server. Different techniques produce different results and all results reflect the inputs are as shown below.

Maximum: Max (33, 35) = 35^{o}C
Minimum: Min (32, 33) = 32^{o}C
Average: Avg (33, 34) = 33.5^{o}C

d). Agent based resource management based on organization modes

In this method of resource management in sensor cloud, instead of keeping all data at one server, the server is subdivided into few categories based on the data coming from different organizations. The data coming from different organizations are stored separately in the sub server using the agents. The agents are programmed in such a way, if information related to one of the organization arrives then agents will take those information to that particular organization's server and dies. The different agents are defined for each of the organization. In this the large bandwidth is divided and assigned to each organization. If data is coming from one of the organization then agents will route those data to a server which is assigned to them. Some of the organizations are operated with huge amount of data, in this case two or more servers are assigned for storage of data.

Different sectors have different kinds of applications running on it. Hence to work out their applications a particular operating system is employed and output data is stored inside the servers. Allotment of bandwidth is done based on the type of organizations. Few organizations requires encryption and they are provided with proper encryption techniques to provided security along with

authentication process. If organization doesn't require any encryption technique then only authentication process is acquired.

e). Saving resources in Cubes (Multidimensional)

This is non agent resource management method for sensor clouds. Multidimensional cubes are the latest and easy way to store the sensed data from sensors. Each multidimensional cube is used to store sensory information. Based on the number of sensors the dimensionality can be increased. It is easy to store the updated data into the cubes and also useful for end users to retrieve from the cubes.

A label is provided to each of the sensed information and users will retrieve by providing proper label. Admin can update, edit and delete the data available inside the cubes.

Figure3 shows the multidimensional cubes for storing physical sensor information into the sensor cloud server. In this case A is having set of data coming from one set of sensor group. Whenever there is an update then updated data is saved inside the cube at different dimensionality. Similarly different data are stored at different locations inside the cube. It's easy to find the location of the stored data and easy to retrieve.

f). Grid Computing

This is also one of the non-agent methodology. Grid computing is one of the popular resource management technique, where data from different administrator are stores at one place. The size of the server may vary from small entity size to large hub servers. The data type can be anything. A unique ID has been assigned to each of the data incoming to the main server.

Grid computing alarms the application of the resources of several computers in a network to a single problem at the same time - typically to a scientific or technical problem that necessitates a great number of computer processing cycles or entree to large quantities of data (Balachandar R. Amarnath, 2009).

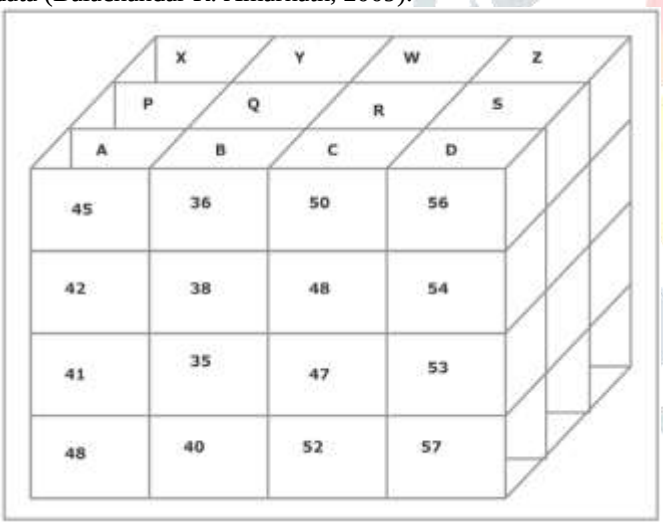

Figure3: Multidimensional Cubes for sensor cloud server

Grid computing seems to be a favorable trend in Resource Sharing for three reasons:

1) Its capability to mark more cost-effective use of a specified volume of computer resources,

2) It is a technique to reaction difficulties that can't be advanced without a massive extent of computing power.

3) It proposes that the resources of several computers can be supportively and possibly synergistically attached and managed as collaboration toward a collective objective.

The data can be properly utilized by using proper data fetching technologies i.e providing location of the data or unique ID provided to information.

Multiple data can be stored by using grid computing, different data from different clusters are taken and stored inside the large server calling as grid computation. Inside the server, the data may be of homogenous or heterogeneous property. In homogenous, all data of same type. In heterogeneous, all data are not same type.

Grid computing can also be used to fulfill the communication task using multiple resources. The grid computing are also responsible for aggregation of data incoming from clusters.

The following graphs show the improvement of accuracy and delay parameters in sensor cloud when agents are included. The graphs have been drawn by comparing number of packets arrived at the cloud and those packets are stored in the cloud with or without use of agents. Accuracy and delay parameters are considered in this and the simulation results are as shown in figure 4 and 5. The result shows that, agents will decrease the delay in dispatching the information into right storage with greater accuracy than compare to the resource management process without agents. The simulation is done with initial of 100 packets arrived at the clouds later it has been increased upto 1000 packets and the results are depicted below.

6. CONCLUSION

The purpose of going through this research is to preserve the scarce resources and storing them in a database with proper management, so that preserving and accessibility should become easy. Physical sensor nodes don't have enough storage and computation capability due to lack of bandwidth and memory, adding cloud computing along with them will be beneficial and solution for many issues. Agent based resource management still improves the overall efficiency of the system and improves the network lifetime. The agent paradigm is the most important part in improving network lifetime factor as it is quick, autonomous and work on behalf of the nodes/systems. Agents play a vital role in selecting the resources and keeping them in a particular position for further easy accessibility and further process. Various agent based resource management methods are proposed in this paper which will manage the resources, reduces delay and improves overall system efficiency.

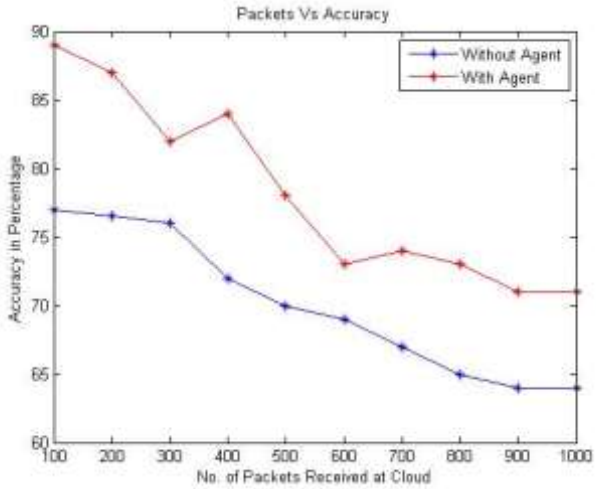

Figure4: No. of Packets Arrived Vs Accuracy

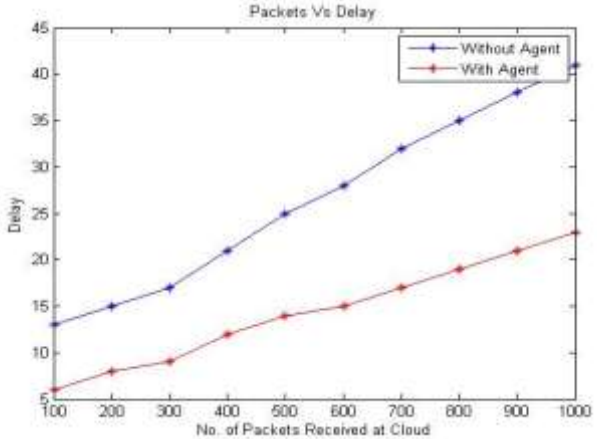

Figure5: No. Packets arrived Vs Delay

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