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Designing Architecture of WSNS Using Mobile Agent Technology and Cloud Computing Services to Retrieve Information Efficiently

Itfaq Ahmad Mir[1], Anwaar Ahmad Wani[2]

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Abstract: To design an efficient architecture for wireless sensor network has become a core research area in recent years. Depending on the environment, there are different types of Wireless sensor network: Terrestrial WSN, Underground WSN, Underwater WSN, multimedia WSN and mobile WSN. Our proposed work is based on mobile wireless sensor network. A Wireless Sensor Network is a network of tiny devices that can communicate with each other and transfer information from the monitored field through a wireless link. Sensors are the devices which detect the input from the physical environment such as humidity, light, heat and respond in the form of electrical signal that is transmitted to the central processing node for further processing. Sensor network faces some problems during data aggregation and transmission such as limited energy, bandwidth and limited storage. The process of transmitting data from source to destination consumes more energy and also requires high bandwidth. The central processing node receives a huge amount of data from the sensor nodes, which is also difficult to manage. To overcome these issues, an efficient architecture is proposed in which Mobile agent technology and cloud computing technologies are integrated with Wireless sensor network. These two technologies help to improve the network life time, efficient bandwidth utilization and data aggregation. Mobile agent is an emerging technology which plays an important role in wireless sensor network. Mobile agent is a software code which migrates from one node to another node, save its current state to the new node and can resumes its state from the saved state. This process provides increased connectivity and communicability in the network. The Cloud computing technology is used to overcome the problem of limited resources such as storage, processing power and fast information accessing. All the information is stored at cloud servers and available till devices are connected through internet. The aim of this paper is to design an efficient architecture of wireless sensor network in which mobile agent technology is used and compare the performance with existing WSN architecture. Also, NS-2.35 software tools is used to simulate the proposed Mobile agent based WSN architecture.

Keywords: - *Wireless Sensor Network, Mobile Agent Technology, NS-2.35, Cloud Computing*

Introduction:

Wireless sensor networks are a network of electronics devices (sensors) which operate on small batteries [1]. If these electronic devices run out of batteries, the complete wireless sensor network stops its working. Sensor nodes are used to perform some basic functions such as sensing, processing, and aggregating the information as well as interconnecting network [2]. Sensor nodes are constraints with limited computational power and communication power. These sensor nodes can sense environmental conditions such as air pressure, humidity, pollution etc. The following figure shows the block diagram of sensor node having communication interface, processing and memory unit and sensing unit.

1Sher-i-Kashmir University of Agriculture Science & Technology, Kashmir, UT-J&K.

Email:itfaq@skuastkashmir.ac.in(Corresponding Author)

2Higher Education Department, Government of Jammu and Kashmir, UT-J&K

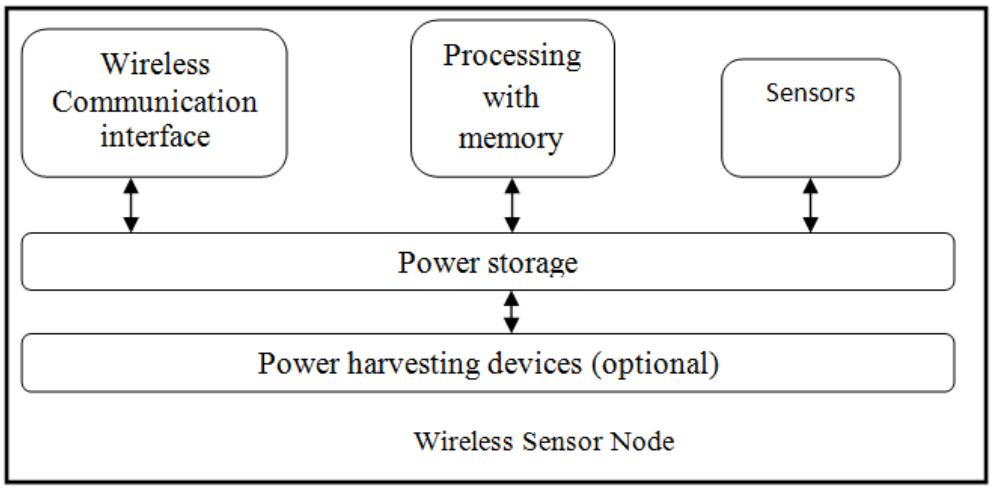

Figure 1.1: Block diagram of Sensor Node

A sensor node is a combination of three technologies that are sensing, processing and communication. According to the application, the sensing units sense the information in the form of electrical signal and transmit to the processing unit. Processing unit convert sensed electrical signals into digital signals with the help of Analog to Digital converter (ADC) and store in memory. The communication unit performs the task of sending and receiving of information between sensors or base station using communication channel. There are two type of communication one is direct communication and second is through gateway.

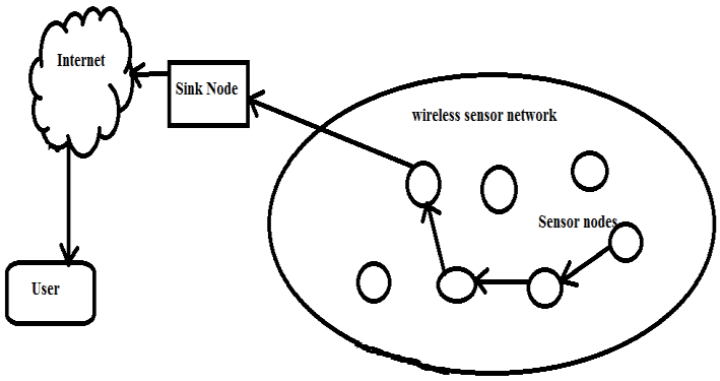

Figure 1.2: Wireless Sensor Networks Architecture

It is realized that Wireless Sensor Network work in a specific domain and it is also task oriented. Sensor networks are bundled with a specific application and it is impossible to use one network for different application because it can create the problem of redundant deployment and resource underutilization. But there are two approaches to overcome these issues. First is to allow different applications to share the collected information among different users and the second is to provide the capability to the individual sensor nodes to execute different application concurrently. The first approach is achieved using cloud computing technology, in which sink or gateway nodes will collect sensed data and store it in its cloud, cloud information is managed by host manager which is outside the WSN [3]. The host manager will collect data, process it and then provide to the multiple applications for their own purposes. Difference between these two approaches is that in first approach information is shared with multiple applications, while in second approach multiple applications are executed by every node of

WSN. Our research work is focuses on first approach in which cloud computing technology is used to serve multi-users[4].

Challenges and issues in WSN

Energy constraints: Sensor nodes are limited with battery backup. So it is necessary to design protocols to prolong network lifetime and utilize energy consumption in processing and communication.

Data Transmission: There are two mode of data transmission: continuous and query based. Sensor nodes deliver messages continuously to the base station in continuous mode while in query-based mode, massages are delivered when a specific query signal is generated by the base station. Transmission consumes more energy so data transmission is a very significant issue [5].

Network Lifetime: There are some applications which require running application as long as possible. So network lifetime is also a great challenge [6].

Flexibility: Wireless network should be flexible enough to increase number of nodes, manage node failure.

Lack of unique Identification: uniqueness of identification is not applicable due to large number of sensor nodes in WSN. It is also a great issue.

Data collection: The data generated by sensor nodes in a WSN is excessive. So it is a great challenge that how to combine identical data packets from different sensor nodes for best energy utilization.

Coverage Area: the coverage parameter is important to captures a whole view of the wireless sensor network instead of short range of network.

Fault tolerance: Fault-tolerant operation is critical issue. If faulty components increased in a network then it reduce network throughput, decreasing efficiency and performance of the network.

Mobile Agents

Mobile agent is raising technology in the distributed environment to control network traffic and network latency. In coming era, wireless and portable devices users will increase exponentially so it becomes a challenge, how to collect data efficiently from widely distributed areas. Now a day's mobile agent technology is used to collect data efficiently, rather than traditional model. Traditional model can lead the problem of high bandwidth and energy consumption but mobile agent technology solves the problem of bandwidth. In mobile agent approach, Base station send mobile agent to collect data from the target region. Then sensed data is collected, processed, refined by mobile agent and send back to the base station. The interest of users in wireless sensor technology is increasing exponentially. This force to the researchers to design a information retrieval system and tools that can efficiently find, collect and process the information. To achieve this goal, Mobile agent model is widely used in distributed applications. A mobile agent is a software entity that can migrate in the network with its execution code and current state to finish its works intelligently on the behalf of users [7]. Whenever user requires information, it send query to the base station, base station dispatch a mobile agent to fulfil the requirement of users. As it migrates from one node to another node it saved its current state to the new host and resumes its state from the saved state [8]. This process will save the bandwidth of wireless network and improve the efficiency of network. Once the mobile agent is migrated in the network, it works even after the disconnected from the sending host. Wireless sensor networks are unable to adapt the changes in the environment or these are difficult to program. [9][2].

There are several advantages of mobile agents: [10]

- Network load distributed.
- Overcome the problem of network latency
- They encapsulate protocols.
- They execute asynchronously and autonomously.
- They adapt dynamically.
- They are naturally heterogeneous.

Some energy efficiency related issues of mobile agent based WSN are:

- Mobile agent helps in eliminating application redundancy by performing local processing.
- Mobile agent removes spatial redundancy in data aggregation.
- Mobile agent also saves communication overhead by combining data itself.

Importance of Mobile Agent in Wireless Sensor Network

In client-server model, each sensor node will sense the information from the target field and initiates client-server interaction. In client-server interaction, clients

can access and store information in the servers at the same time. This approach requires high bandwidth to transfer data from source to destination and create heavy data traffic and higher burden on those nodes which are close to the gateway. [2]

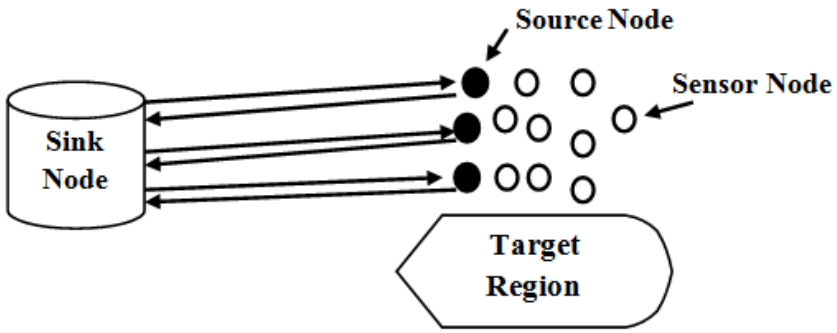

Figure 1.3: Clients –Server approach

To overcome these problems, mobile agent technology is used. Mobile agent system control data traffic by using single traffic flow and reduce the high bandwidth consumption by moving data processing element at sensed location [11].

Mobile agent system provides a higher degree of WSN re-tasking flexibility and facilitates collaborative information processing. Other good reasons to use mobile agents are:

- Mobile agents can work for heterogeneous network.
- Mobile agent provides the facility of collaborative information processing.
- Mobile agents can dynamically adapt according to the environment.
- They are fault-tolerant and they overcome network latency.

Framework for MA based WSN

Framework basically provides an environment to create and execute the mobile agent and combine them with sensor nodes to collect data. There are two type of framework: Real world framework and virtual world frame world that are parallel to each other [11][2].

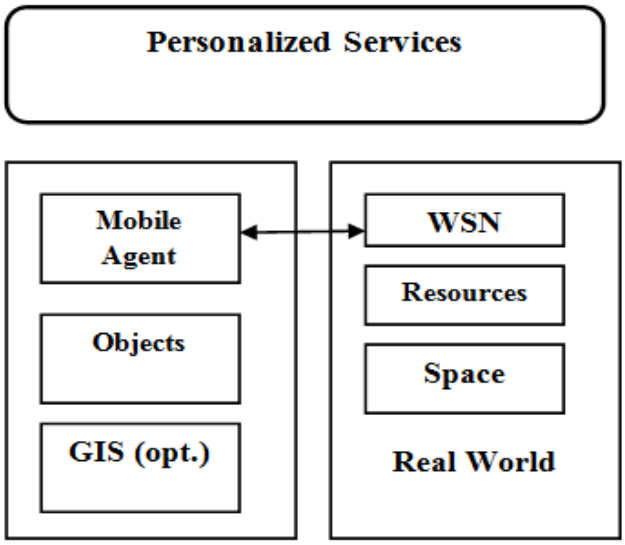

Figure 1.4: Agent based framework

Real world framework

In the real world framework, wireless sensor network will manage and monitor the deployed resources. When any sensor node wants to send services to its neighbouring node, sensor node must know the information about the requirements, constraints and environment of its neighbouring node. Sensor nodes cannot get such information due to limited energy, resources, limited memory and processing capability.

Virtual world framework

In the virtual world framework, software agents are used to manage and monitor the wireless sensor network and they will behave like real sensors [12]. Virtual world provide the platform to the agents to exchange the messages of sensor nodes and provide virtual world as remote host. The virtual world is used as super node with extended memory and CPU capacities. Virtual world remove high data traffic problem and improve WSN performance. Mobile agents in the virtual world extend the storage capacity and increase processing speed. So the virtual world will remove the problem of limited memory and CPU.

Need of cloud computing for WSN

Wireless sensor network has a vast area of applications such as medical, domestic, military, scientific etc. Energy or power has an important role in function of sensor networks. Some of new technologies are invented for energy saving in sensor network and other technology are deployed in sensor network for high efficiency , such as cloud computing It is a new technology which offer high storage at server and high computing power capabilities [13][14]. The cloud computing have an important role in computer world. When hardware limitations was increasing then programmer or scientists do work on better performance and enhance computing capabilities. Therefore cloud computing technology was created.

Now a day's researcher tries to combine two different technologies such as wireless sensor network technology and cloud computing technology. They design an architecture .This architecture can used different type of applications such as medical environment, industries etc. [15]

Cloud computing features:

There are following features of cloud computing: [16]

- **On demand Service**: Users are satisfied without interfere of programmer.
- **Elasticity in service:** all the resources are used by the user according their requirement in a flexible time period.
- **Service measurement:** the service provider has an idea of actual use of a particular tool at a fix time period.
- **Resource Combine/pooling:** All available services through server are pooling. so that all resources are useful on client request.
- **Wireless Network operate/access**: The user applications and software's can run on different platforms or different devices such as mobile phones, tablets, laptops and so on.

Literature Review:

Form last few years, the interest of mobile computing devices and wireless communications devices increases exponentially. The networks of low cost and multifunction sensor nodes are increased day by day. The sensor nodes are tiny devices having sensing, processing and transmitting capability. The study of our literature is focuses on Mobile agent technology which is used to collect information and also remove the data aggregation and bandwidth issues. The study also focuses on cloud computing technology to achieve additional processing power, storage and service on demand.

A.Vijayalakshmi [17] designs a middleware system to provide security for the Wireless Sensor Network. Middleware provides a software infrastructure in which hardware, software, network stacks and operating systems are glues together. Mobile agent is also presented in this paper in order to optimize the energy usages of sensor nodes.

Almir Davis[18] does a survey on the existing architecture of Wireless Sensor Network and classified into specific groups according to the behavior and data flow characteristics. The WSN architectures are classified into data-centric, according to locations, mobility based and according to the quality of services. Some architecture is also classified according to the network flow, heterogeneity- based and multipath. Each existing architecture are evaluated using some common parameters such as network lifetime, End-to –End delay. energy consumption, reliability, scalability, modularity and quality of services. The survey point out the advantages and disadvantages of different architectures.

Bo Chen[19] presents a Mobile Agent based multi-agent system which is used to increase the ability of traffic management system. This paper discuss about the standards and technology in which mobile agent systems are designed to detect and manage the real time traffic system. Mobile-C a mobile system is developed with IEEE- FIPA compliance. The system which is based on Mobile-C take the advantages of stationary as well as mobile agent. Mobile agents will reduce response time and data transmission time over the network. Dynamic algorithm and operations for mobile agent has been simulated using laser-based vehicle detection system and higher level agency. The simulated results represents that mobile agent technology is good for dynamic software component deployment.

Dai Ting [20] presents single mobile agent base Static Mobile Localization Algorithm (SMLA) and Dynamic Mobile Localization Algorithms (SMLA) for distributed computing system and also discusses about agent migration algorithms. There are two main factors related to agent migration: the number of nodes to be visit and the sequence of them. Node's sensor model and information collection model is also implemented in this paper. Target localization algorithm is used to transfer mobile agents for target tracking issues.

Daniel Massaguery[21] discuss about network exploration procedure. Network exploration is required for many tasks ranging from data collection to the network health monitoring. The genetic algorithm is used to find the optimal number of agents to explore the network and their paths. This paper also presents some network adaption strategies to overcome the unaccepted situations such as network failure, node failure. Mica2 mote running Agilla is used to evaluate the performance of WSN. Roch H. Glitho [22] shows the importance of Mobile Agent technology in information retrieval from Wireless Sensor Network. In this article, an example of electronic calendars is represented in multiple party program scheduling. Mobile agent will take the information about party scheduling from event organizer and pass it to the participants. It is also shows that the mobile agent technology is better than client server model.

Research methodology:

Random Deployment of sensor nodes There are many node deployment schemes have been proposed for wireless sensor networks .Some of them are random, grid, cluster and grid-cluster to increase network connectivity, without increasing storage requirements. Here we use the strategy for placement of SNs is random scattering from the air which is a most common deployment strategy used for large-scale open regions

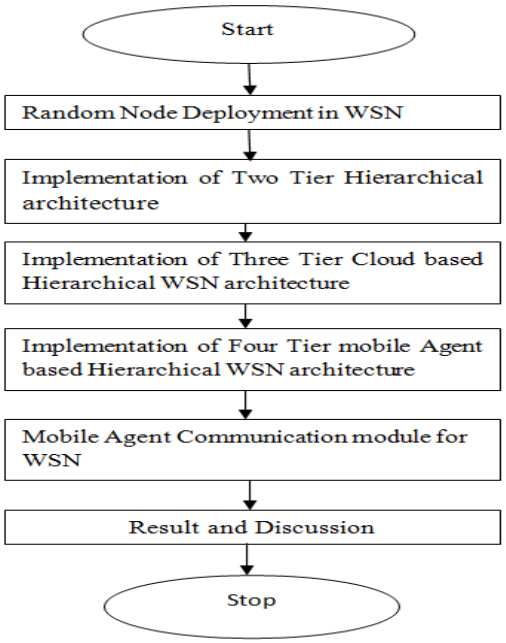

Figure 1.5: Proposed WSN architecture using mobile agent

Two-tier Hierarchical Architecture for WSN

In two tier hierarchical architecture of Wireless Sensor Network, firstly the sensor nodes are divided into different groups and coordinator nodes selected for each groups. All coordinator nodes are high powered nodes which communicate with their group members to collect sensed data and then transmit it to base station .Drawback of this architecture is that it send huge amount of redundant data to BS ,consume high transmission energy, require large storage space and also require high bandwidth speed etc.

Three-tier Hierarchical Architecture for WSN

Cloud computing technology is introduced in three tier hierarchical architecture to overcome the drawback of previous architecture. In this, coordinator nodes (CHs) collect data from group member nodes and store it to the clouds. Two or more groups of sensor nodes connected to a cloud with wireless channel. Cloud technology increases reliability, high availability and security of data in wireless sensor network .Whenever user request for data to the BS, BS collect data from cloud rather than CHs. There are two type of communication one is inter-network (sensor node send data to CH) and second is intra-network (CH send aggregated data to clouds) communication.

Mobile Agent Based four-tier (proposed) Hierarchical Architecture for WSN

In three-tier architecture Base station receives data from their respective clouds with wireless channel. To increase the efficiency of network, Mobile Agent technology is used in four-tier hierarchical architecture for WSN. When Base station requires data it sends multiple mobile agents to the clouds for collecting data. We have designed a new four-tier hierarchical architecture for wireless sensor network which includes Mobile Agent technology and cloud computing technology. The main purpose of mobile agent with cloud technology in our architecture is to reduce information redundancy, traffic load, query latency and communication overhead in order to increase network lifetime. It also ensures a good durability of the network, minimize the packet loss rate, improve packet transmission rate as compare to three tier architecture. If in any case CH loss there connectivity in network in that case base station can found data from cloud. Cloud technology provides data security, high data storage and computing capability. Mobile agent technology in four tier architecture improve the efficiency of network as compare to three tier architecture in term of throughput, packet loss and delay time.

In this work, route for mobile agent is predefined by Base station which is static itinerary planning. In future, we can implement dynamic rout planning for mobile agent in which route is dynamically decided by mobile agent itself to reduce route cost.

Integration of Cloud computing with Wireless Sensor Network.

Figure 1.6 shows the integrated architecture of Cloud Computing and Wireless Sensor Network. In this architecture, organizations and various researchers connected to the cloud through Identity and Access Management Unit (IAMU) which provide access to cloud based on policies stored in access policy. According to the type of services (SaaS, Paas, Iaas) user can send request to the Request Subscriber (RS) and Request Subscriber create subscription for each request and pass it to the Pub/Sub Broker.

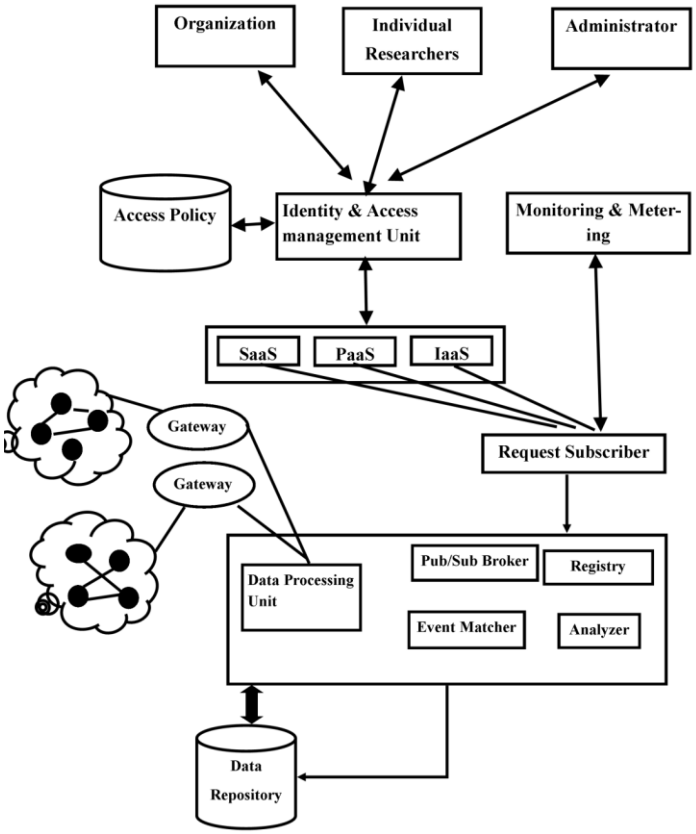

Figure 1.6: WSN and Cloud computing integrated architecture

Sensor network send collected data to the Data Processing Unit (DPU) of cloud through gateway. Then processing unit will process the data and convert into storage format and then send data into Data Repository (DR). Received data will be identified by Data Processing Unit which will create an event for each publish data and send event to the event queue. Event matcher will evaluate each subscription whenever a new event is published. If event matcher found a match, the published data is provided to the users. The services given to the users are monitored and metered by monitoring and metering unit. And according to the meter user have to pay for their services.

Experiment & Result

The proposed work is completed using two platform: Simulation of WSN architecture is done using NS-2.35 tool and practical implementation of Mobile Agent system is done using JADE (java based agent development environment).

Our proposed Mobile based hierarchical architecture is simulated in the 1000*1000 m2 areas with 25 number of nodes and the performance is compared with cloud based Wireless Sensor Network architecture. We assume the node parameters and physical layer parameters same for both architectures. The parameters are shown in Table 1.1 and Table 1.2. We assume the initial energy for each of the normal node is 100J.

Node parameters

Table 1.1: Node parameters

Parameters	**Values**
Network Area	1000 × 1000 m2
Number of Nodes	25
Base station Location	(467,50)
Initial Energy	100 J
Transmission Energy	34.32e-3
Receiving Energy	36.28 e-3
Ideal Energy	752 e-6
Sleeping Energy	144 e-9
Packet Size	1024
Max. Packet in queue	100

Physical Layer Parameters

Table 1.2 Physical Layer Parameters

Parameters	**Value**
Channel	Channel/wireless Channel
Radio-propagation model	Two ray ground
Antenna type	Omni direction
Link layer	LL
Queue type	Queue/Drop Tail/pri queue
Network interface type	Phy/wireless Phy
MAC type	Mac/802.11
Routing protocol	AODV

Simulation of Mobile Agent based Architecture of Wireless Sensor Network (MAAWSN) using NS-2.35

Here we create a new architecture that can work for different type of applications. In our Implemented proposed hierarchical architecture, we combine two different technologies one is cloud computing and other is Mobile Agent Technology for Wireless Sensor Network. Both technologies have their own advantages such as cloud computing provide on demand service, more storage ,high processing devices, better durability, security by encryption and decryption of data whereas mobile agent technology provide bandwidth utilization, remove redundant data, increase network lifetime, efficient data gathering etc. Here the following flowchart shows the different modules of our simulated work:

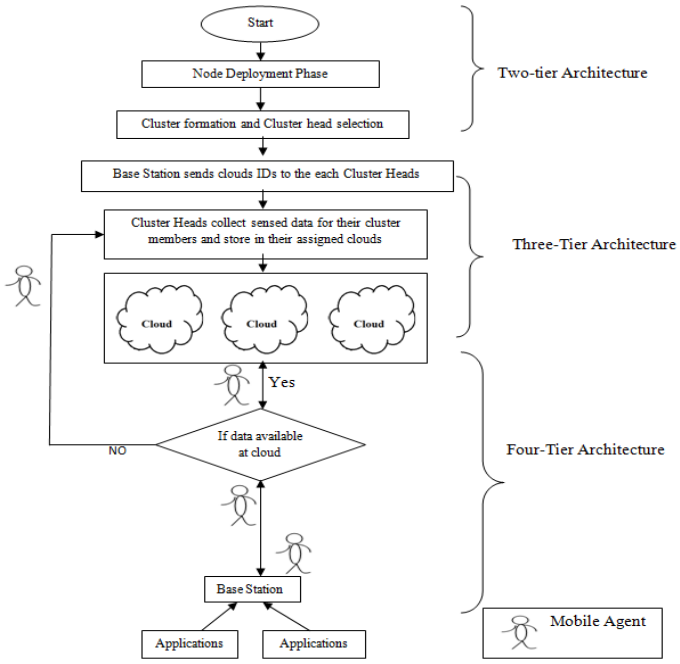

Figure 1.7: Proposed Architecture of Wireless Sensor Network using Mobile Agent

The following steps are used to simulate our proposed work

Step 1: Random deployment of sensor nodes

Step 2: Two tier hierarchical WSN architecture in which a coordinator node (CH) is selected over a group of sensors.

Step3: Three tier clouds based hierarchical WSN architecture, in which clouds works as intermediate between coordinator nodes and data collecting node i.e. Base Station(BS).

Step4: Simulation of four tier Mobile agents based hierarchical WSN architecture in NS-2.35.

Step5: Result and discussion

Two tier hierarchical WSN architecture

In two tier hierarchical architecture, all sensor nodes are divided into different groups. Each group is called clusters and they assigned with a cluster head having high energy as compare to other member nodes. In this architecture, all sensor nodes sends collected data to the cluster head and cluster heads process and refine the data and transmit to the host node (Base Station). Figure 1.8 shows different clusters, cluster heads and host node.

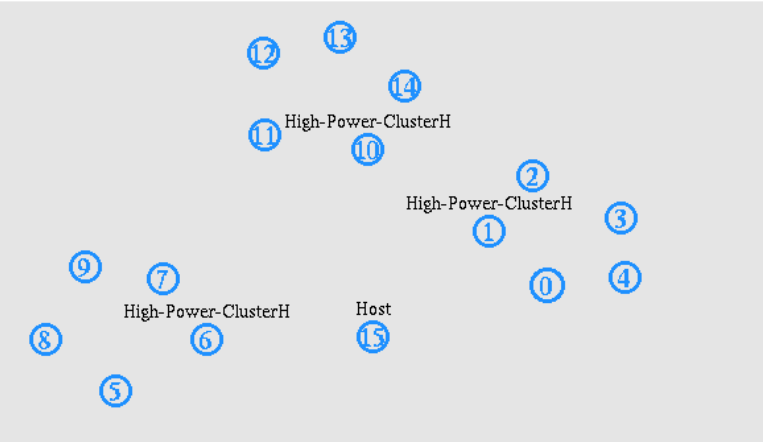

Figure 1.8: Cluster Head selection

Three tier clouds based hierarchical WSN architecture

In this architecture, cloud technology is used to increase the data storage capacity and other resource utilization. Data is aggregated at three levels such as at cluster head level, at clouds and at base station. As per user's requirement, base station will search data at clouds if it found data in clouds, it sends that data to user otherwise sends a query to each cluster heads. In this way, the architecture works in three tiers.

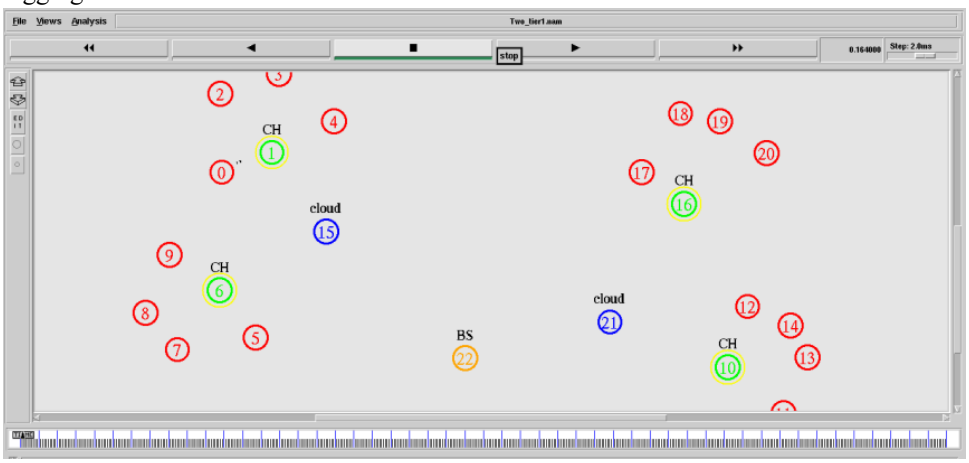

Figure 1.9: Three tier architecture of wireless Sensor Network

Experimental Results of Three tier architecture

The experimental result of this architecture is shown as follows:

Throughput: Throughput means the number of packets received successfully in a specific period of time. Here throughput is calculated using following formula:

Throughput= the total number of bits received/1000.

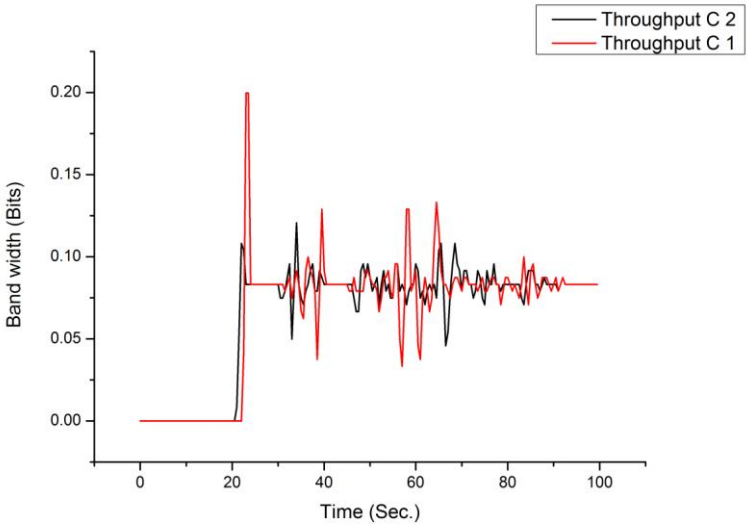

Figure 1.10: Throughput of three tier architecture

In above graph, red line and green line shows the throughput of cluster head1 and cluster head2. Similarly we can show the throughput of other cluster heads.

Average Delay: Delay it the time interval between transmission and receiving of packets.

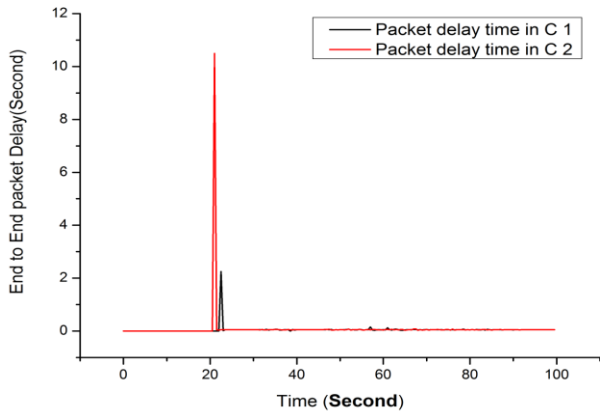

Figure 1.11: Average delay time

The above figure show the average time delay between packets. At time interval 20-25 the delay of cluster2 reached at peak level as compare to the cluster1 and after that it become normal time delay.

Packet Loss

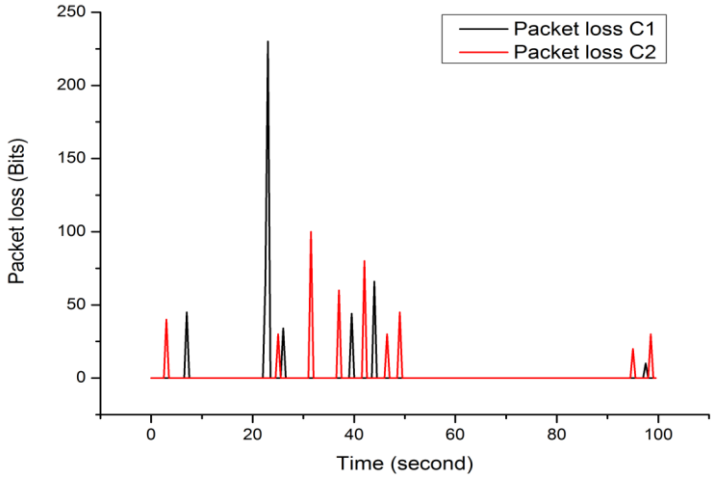

Figure 1.12: Packet loss of two clusters

This graph shows the packet loss of two clusters while Base Station receiving data from clouds. To improve the network efficiency, packet loss should be negligible. As we can see here that at time interval 25-30 the packet loss of cluster 1 is high as compare to cluster2 after that it become zero packet loss.

Experimental Results of Mobile agent based WSN architecture

The Experimental results are explained in term of throughput, packet delay and packet loss.

Throughput

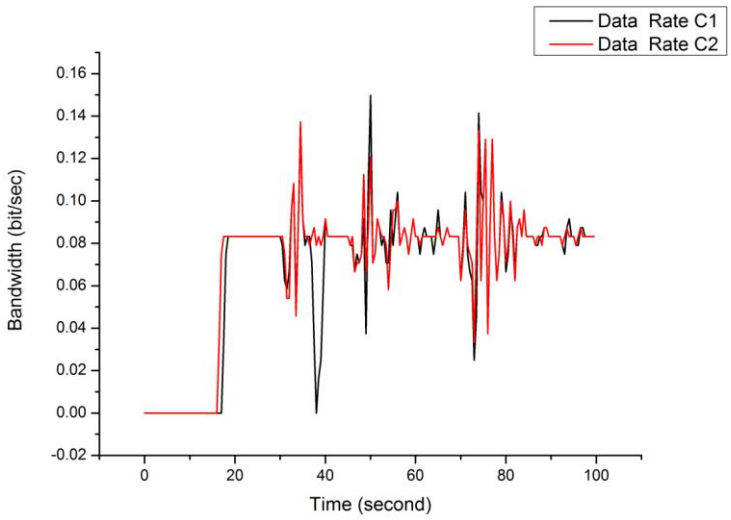

Figure 1.13: Throughput of proposed WSN architecture

Here red and green lines show the throughput of Mobile Agent1 and Mobile Agent2 while they are transferring data to the Base Station. Mobile agent improves the throughput of the wireless network.

Here red and green lines show the throughput of Mobile Agent1 and Mobile Agent2. There is no packet loss while mobile agent2 sends data to the base station. Therefore mobile agent technology increases the reliability of wireless sensor network architecture

Packet Loss

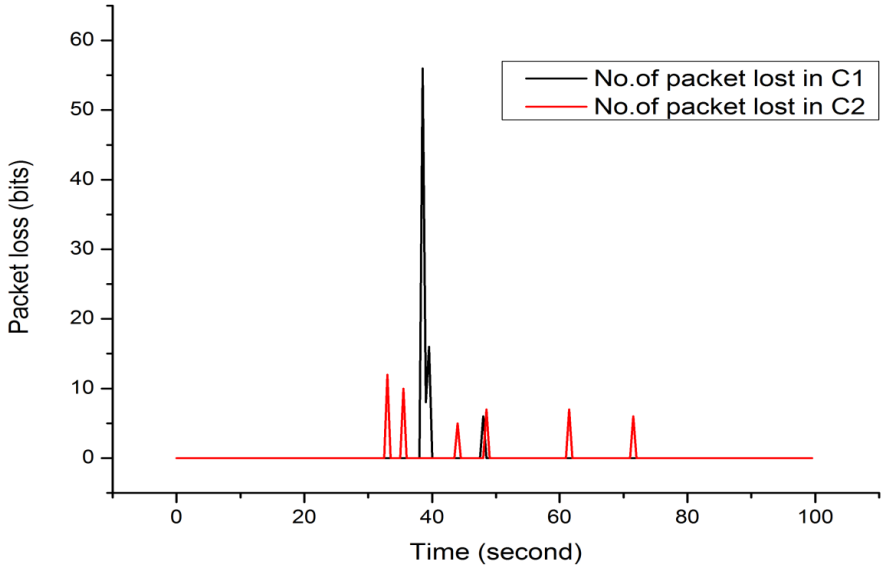

Figure 1.14: Packet loss of proposed WSN architecture

Time delay : The following code is used to compute the time delay for both mobile agents.

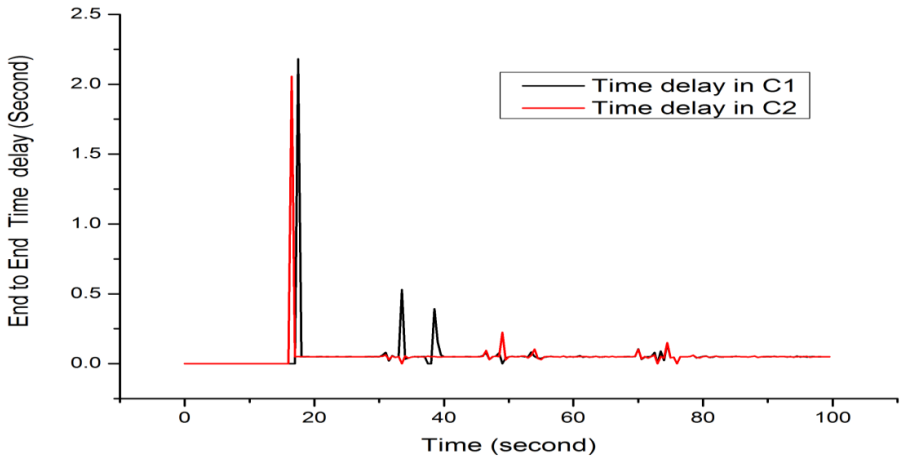

Figure 1.15: Time delay of four tier WSN architecture

Comparative Analysis of Three-tier and Proposed WSN Architecture

Throughput comparison between three tier and Mobile Agent based architecture of WSN

Throughput= the total number of bits received/1000.

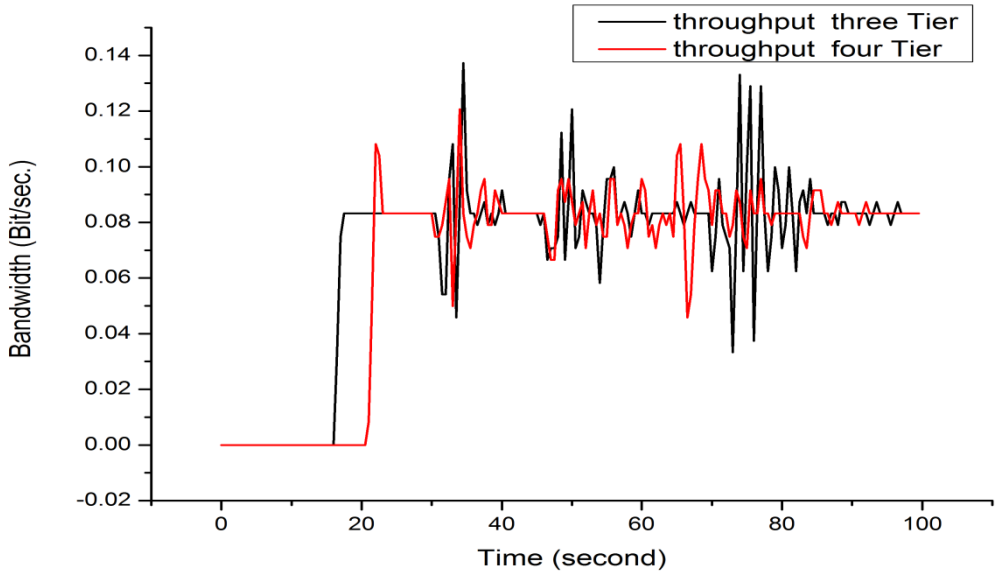

Figure 1.16: Three-tier and proposed architecture throughput comparison

In above graph, red line shows throughput of mobile agent based architecture and green line show throughput of CHs in three-tier architecture. Mobile Agent starts data transmission after 16 sec but CH starts after 21 second. Throughput of four tier architecture is high than three tier architecture in the period of 35 second to 65 second. Therefore Mobile Agent based architecture is better than three-tier.

Packet loss comparison between three tier and Mobile Agent based architecture of WSN

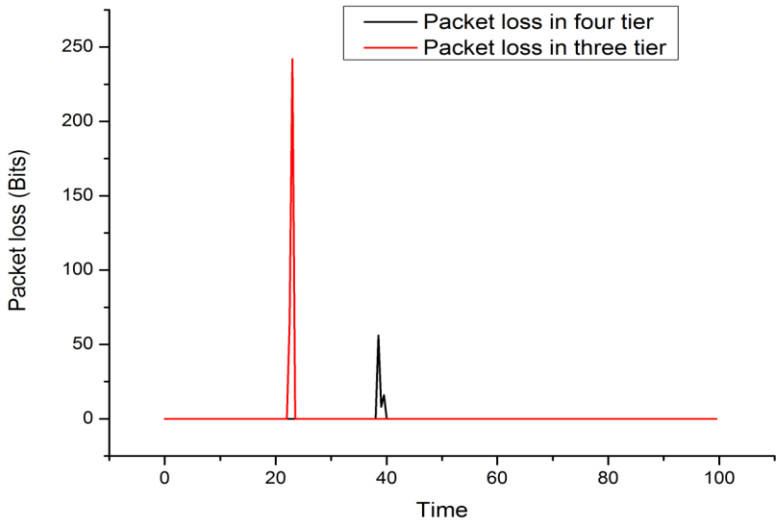

Figure 1.17: Three-tier and proposed architecture time packet loss comparison

In figure 1.17, red line show Packet loss of mobile agent based architecture and green line show Packet loss of three-tier architecture. Here we can see that using mobile agent technology packet loss reduced as compare to direct communication.

Time delay comparison between three tier and MA based four tier architecture of WSN

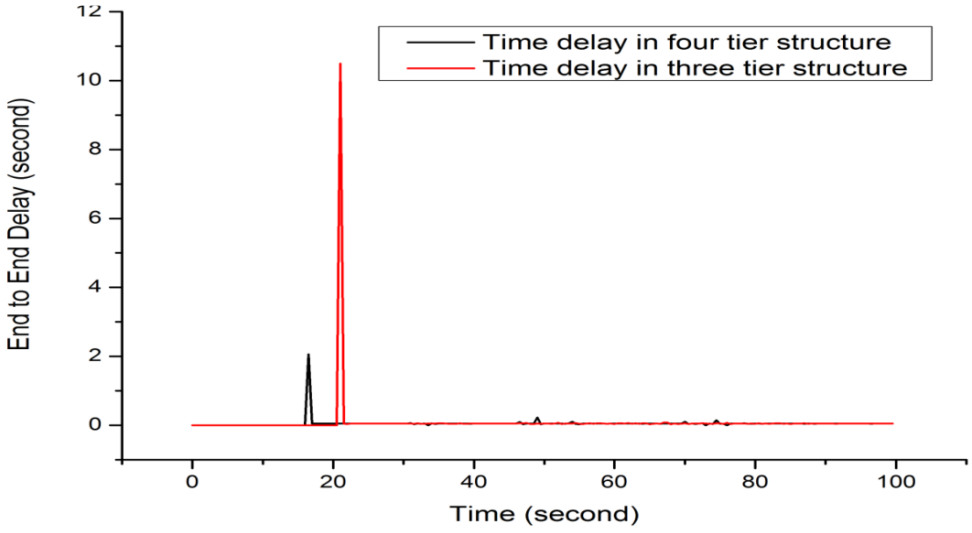

Figure 1.18: Three-tier and proposed architecture time delay comparison

In above graph, red line show delay time of mobile agent based architecture and green line show delay time of three-tier architecture. Here we can see that in three tier architecture has maximum time delay.

Conclusion:

The main focus of implemented work is to create mobile agent based wireless sensor network architecture to retrieve the information effectively. We

have implemented a four-tier mobile agent based hierarchical architecture of WSN and compare the performance with three-tier hierarchical architecture. In four-tier architecture cloud computing technology is integrated with mobile agent based three-tier architecture. All sensor nodes are scattered randomly in the field of wireless network. In our implemented work, data transmission is performed in four levels. At first level sensor members send data to the cluster head, at second level cluster heads store information in the clouds servers. In third level base station sends Mobile Agent to collect the information from the cloud servers. If the information is available in cloud servers, mobile agent will return and send information to the base station otherwise Mobile agents are migrated to the cluster heads. The number of sensor nodes and the sequence of sensor nodes that has to be visited by Mobile Agent are decided by base station. Cloud computing provide effective and fast response, accessibility and time saves. Therefore the combination of wireless sensor network with cloud computing technology can ease information sharing and analyzing,

This paper shows that Mobile agent approach is far better than traditional approach which increases the lifetime of network, better utilization of bandwidth, time reduction to complete a task and improve overall network performance.

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