An Efficient and Load Balancing Scheme in WSN

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Abstract

The group of tiny and battery constrained small wireless sensor devices deployed randomly for monitoring, detecting, localizing, capturing, etc. on-field information across the different real-time applications in Wireless Sensor Network (WSN). The main concern of WSN is network lifetime and Quality of Service (QoS) enhancement as the sensor nodes are having limited processing and battery capabilities. Several routing protocols designed from the last two decades to address the energy efficiency challenges. In this paper, clustering-based methods show better performance compared to non-clustering methods, but cluster heads (CHs) suffered from the excessive load, which leads to more energy consumption of sensor nodes that becomes the CH in each interval. This problem can solve by using the mobile agents in WSN clustering to optimize the energy efficiency and load balancing in the network.

Keywords: WSN, QoS, Cluster Heads (CHs), Load Balancing, Efficiency, Real Time Applications.

1. Introduction

The sensor networks are nothing but a group of nodes with tasks of sensing, data collection, and processing, transmitting data over a wireless medium which are deployed densely within the sight or very near to it. Every sensor node in WSN is collecting information and sending back this collected information to the sink node in the network. WSN must have the capability of self-organization as the location of sensor nodes are not fixed and predefined [1]. Therefore, efficient positioning of sensor nodes yields the improved WSN performance as this kind of network is heavily depends on cooperation between sensor nodes to disseminate the collected information to the intended recipient in the network. The current technologies and methods for MEMS (micro electro mechanical systems), digital electronics as well as wireless communications enable researchers to design the less power, less cost, and multifunctional sensor devices which freely communicate in limited distances and having small size. Such small sensor nodes composed of processes such as sensing, communication, information processing, data aggregation, data dissemination, etc. based on collaborative communication among the large number sensor nodes as shown in figure 1 [2].

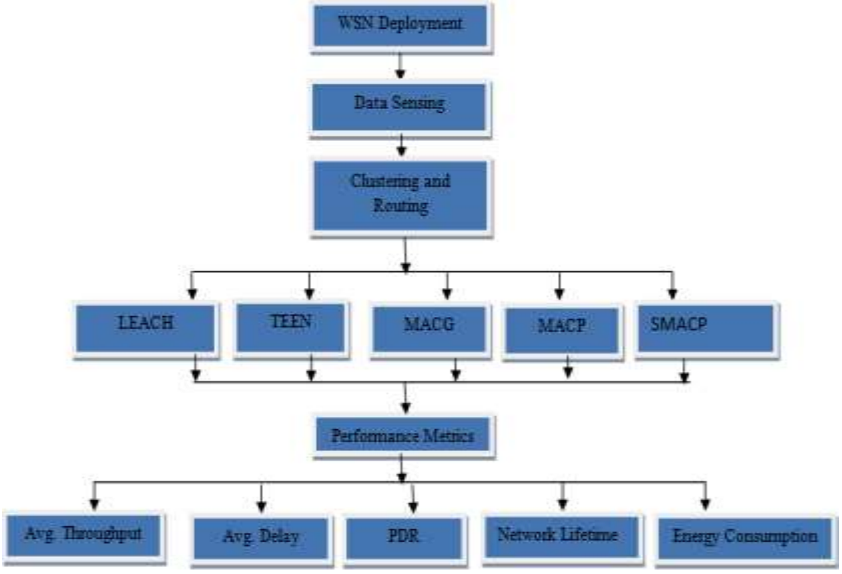

Figure 1: Evaluation of architecture

2. Background of research work

Considering the various applications of WSN using mobile agents in various domains, many load balancing scheme are developed which we have discussed here [3-5].

Chen et al. [6-7] gave one of the initial work in which mobile agents used for dissemination. The authors also gave various design issues for using mobile agents in WSN. After that, the research community exploited these distributed autonomous mobile entities for aggregation in addition to data dissemination [8]. Over the years, mobile agents have been used for energy balancing, extending the lifetime of the network, etc. The use of mobile agents for one or the other tasks as mentioned earlier in WSN also depends upon the application. mobile agent technology was thus found to be a promising solution to the resource- constrained network of wireless sensors, especially when deployed in a non- deterministic environment. The main factor which encourages the integration of mobile agents with wireless sensors in a given network is that they reduce communication cost. Mobile agents have increased flexibility provided by mobility, and the agent itself sent to the server for direct computation. A large amount of raw information transferred to determine their relevance can be very time consuming and clog of the networks. Mobile agent approach trades server computation and costs for savings in network bandwidth and client computation. Extensive simulation-based comparisons between Mobile agent based WSN (MAWSN) [9] and client/server-based WSN (CSWSN) has revealed that, depending on the parameters, MAWSN considerably reduces the energy consumption while conditionally improving the end-to-end delay. Majority of the work exploited the ability of mobile agents (MA) to carry processing codes that allow the computation and communication resources at the sensor nodes harnessed efficiently in an undefined area. These intelligent units are capable of adjusting their behaviors depending on quality of service needs (e.g. data delivery latency) and the network characteristics to increase network lifetime while still meeting those quality of service needs.

Owing to the high cost of deploying hundreds and thousands of sensor nodes in any non- deterministic environment (like dense forests, undersea etc.) the deployment done to achieve the trend of “One deployment, multiple applications” [10,11]. Authors [12-13] have devised UbiMASS, a mobile agent system for dynamic service distribution. In UbiMASS, mobile agents offering services are loaded on sensor nodes dynamically, and hence a single node could serve a variety of applications.

The standard Particle swarm optimization (PSO) is feasible for the clustering and localization problem because of its quick convergence and moderate demand for computing resources in wireless sensor networks. The standard PSO is easy to implement, less overhead, low algorithmic complexity, however, suffered from several challenges as well, such as:

- Less efficiency for nodes deployment
- Less precision
- Unbalanced energy consumption and management for clustering in WSNS.
- Easily trapped in local optimum, which leads to premature convergence.
- Some particles may fly far away from the search region.

3. WSN Model Analysis

3.1 Mobile Agents based Clustering using Modified PSO

Before performing the clustering process, first broadcasting performed after the network deployment [14-16]. The WSN setup performed in three phases, such as broadcasting, clustering, and routing. In the broadcasting phase, all the sensor nodes and mobile agents allocate unique ID. The mobile agents collect sensor nodes IDs and other mobile agents in network and then complete local information shared with BS. After receiving the information at the BS node, the clustering and routing process initiated. The clustering is performed by using the modified PSO here. The algorithm of clustering described in below steps:

Algorithm 1: Clustering using Modified PSO

Inputs

N: number of sensor nodes
d: dimensions of particle (d=N)
: predefined size of particles

Pbest: Personal best

Gbest: global vest

I: number of iterations

Output

Gbest: final clustering solution

Particles Initialization: Let, P_i =[$Y_{i,1}$, $Y_{i,2}$, $Y_{i,3}$, …, $Y_{i,N}$] be the ith particle of the population where each component, $Y_{i,d}$,maps the assignment of the sensor node s_d to a mobile agent.

While (*I*)

3.2 Components initialization:

Initialize each component with a randomly generated uniformly distributed number Rand (0,1).

The random number is generated independently for each component. 3.3. The component of the dth dimension of this particle i.e. $Y_{i,d}$ = rand (0,1)

maps mobile agent to which the sensor node s_d is assigned.

The mapping is done as follows:

The particle representation is a part of the clustering algorithm. As mentioned above that the dimension of each particle is equal to the number of the sensor nodes. Therefore, addition/deletion of any sensor node would change the particle dimension and require re-clustering.

Update Velocity and Position: the velocity and the position are updated in each iteration using applying equations (3.3) and (3.4)

Update $Pbest_i$ and *Gbest* using equations (3.12) and (3.13) respectively

End While

Return *Gbest*

Stop

3.2 Trust based Routing

After the clustering process, the process of data aggregation and dissemination performed by computing the trust score of mobile agents or sensor nodes in the network. It computes the trust score of each node that involves in the process of sending data from the source sensor node to BS using the parameters like network lifetime, average distance, and packet delivery probability. The parameters network lifetime and average distance are computed for each node similar ways as described above

Algorithm 2: Secure Communication
Inputs *S*: Source Node *BS:* Sink

1. *S* initiates the route discovery
2. *S* finds one-hop neighbouring nodes *n*
3. *S* broadcast RREQ's to *n*
4. Put all *n* in sleep mode
5. Upon receiving RREQ at each $I \in n$
   5.1.Network lifetime computing using Eq. (3.7)
   5.2.Average distance computation using Eq. (3.9)
   5.3.Packet delivery probability using Eq. (3.14)-(3.16)
6. Compute the trust using eq. (3.17)
7. Select *intermediate node I* with maximum value T^I among all *n*
8. Update routing table
9. If (I == D)
10. Active all nodes in path
11. *I* sends RREP to *S*
12. *S* starts data transmission
13. Else
14. Repeat *S* = *I*
15. End If

4. Simulation using NS2

As per the dictionary, the Simulation can be defined as ―reproduction of essential functions of something is an aid to learn or training." In simple words, the process where one can construct one model of mathematics is called simulation in order to solve the system problem. Such a process frequently uses to reproduce the characteristics of the complex work.

4.1 Energy Analysis through Trace Files: It added energy breakdown in each state in the traces to support detailed energy analysis. In addition to the total energy, now users will be able to see the energy consumption in different states at a given time. Following is an example from a trace file on energy.

[energy 979.917000 ei 20.074 es 0.000 et 0.003 er 0.006]

The meaning of each item is as follows:

energy: total remaining energy

ei: energy consumption in IDLE state es: energy

consumption in SLEEP state

et: energy consumed in transmitting packets

4.2 Setting Mobile Node Movements

The mobile node is intended to maneuver during a three-dimensional topology. But the dimension (Z) isn't used. That's the mobile node assumed to proceed forever on a flat tract with Z forever adequate zero.

Therefore, the mobile node has X, Y, Z (=0) coordinates that are frequently adjusted because the node moves. There are two mechanisms to induce movement in mobile nodes. Within the initial methodology, the beginning position of the node and its future destinations could also expressly. These directives are usually enclosed during a separate movement situation file. However, the situation can even be outlined manually within the program. The start-position and future destinations for a mobile node could also be set by victimization the subsequent APIs:

```
$node set X_ <x1>
$node set Y_ <y1>
$node set Z_ <z1>
$ns at $time $node setdest<x2><y2><speed>
```

At $time sec, the node would start moving from its initial position of (x1,y1) towards a destination (x2,y2) at the defined speed. In this method, the node-movement-updates triggered whenever the position of the node at a given time is required to be known. This may be triggered by a query from a neighboring node seeking to know the distance between them, or the set dest directive described above that changes the direction and speed of the node.

4.3 Network Design Parameters

To evaluate the effectiveness of proposed SMACP protocol with similar methods, we designed networks with a large number of sensor nodes. Thus one can design the wireless sensor networks using the NS2 simulator with the presence of mobile agents. The designed WSNs is having the varying number of sensor nodes such as 200 to 700 with total 60 mobile agents to perform the tasks of data collection and aggregation to achieve the load balancing and energy efficiency in the network. The routing protocols designed are MAPA and CM2SV2 in NS2 as per their algorithms given by the said authors. The network parameters presented in table 1 used to configure the WSNs.

Table 1: Simulation parameters for similar methods evaluation

Number of sensor nodes	200-700
Simulation Time	100 second
Mobile Agents (MAs)	30
Mobility of MAs	10 m/s
Routing Protocols	MAPA & CM2SV2
MAC	IEEE 802.11
Propagation Model	Two-Ray Ground
Mobile Agents	60
CBR Connections	05

5. Results and analysis

Before presenting the performance evaluations, we described the visualization outcomes of NS2. In this section, we investigate the results of non-mobile agent based clustering protocols LEACH and TEEN. The results analysis of LEACH and TEEN with mobile agent based clustering protocols MACG and proposed MACP. Finally, the secure MACP evaluated with LEACH, TEEN, MACG, and MACP to demonstrate the impact of adding trust based data transmission. [17-18]

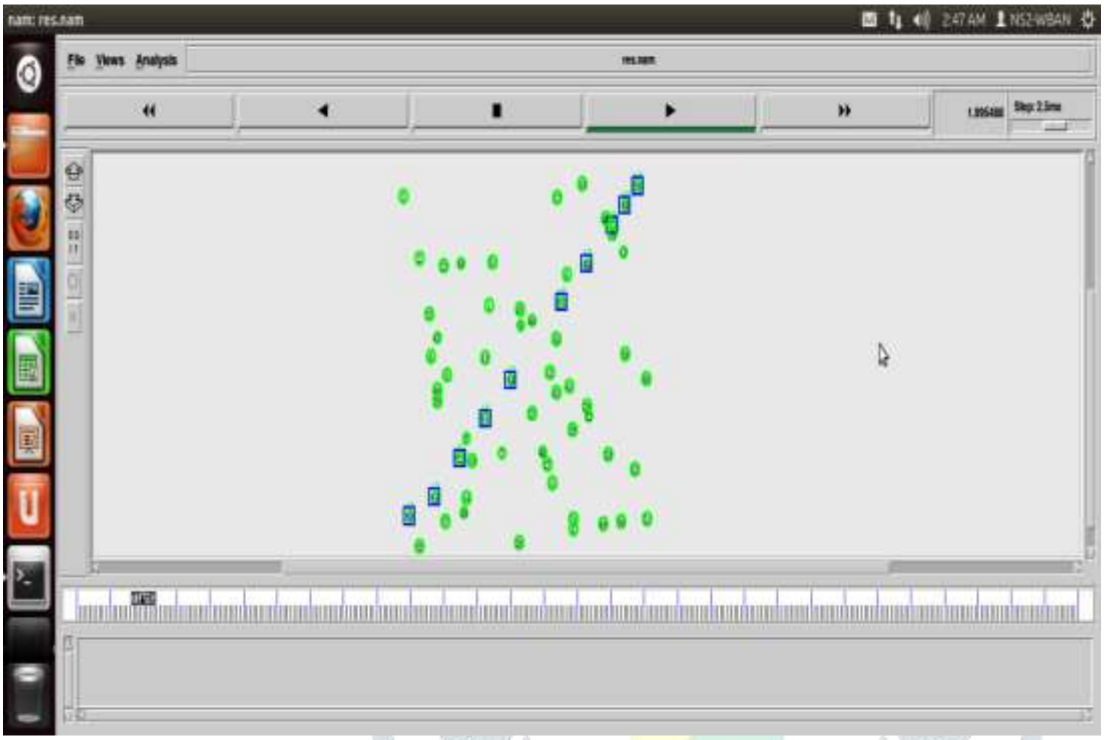

Figure 2: WSNs deployment

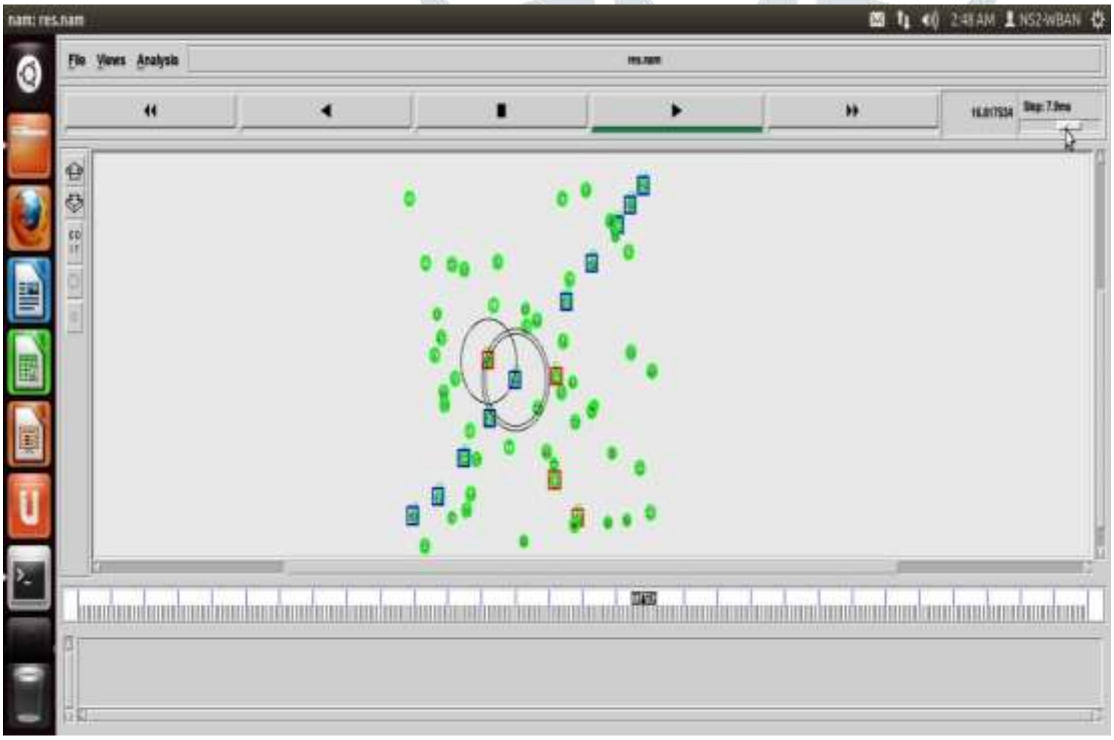

Figure 3: Process of data aggregation and dissemination

The NAM results do not give us the performance of the simulated network. Therefore we must use the trace files to measure the various performance metrics. Figure 4.4 demonstrates the 30 sensor nodes networks visualization.

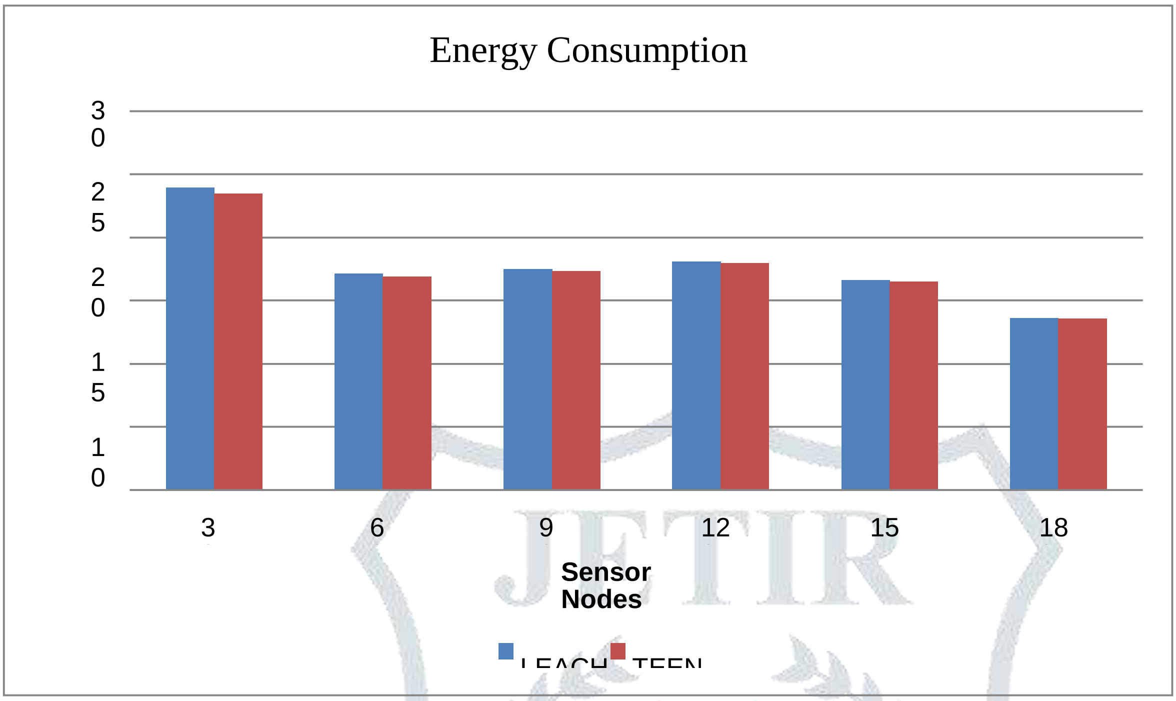

Figure 4: Investigation of average energy consumption for LEACH and TEEN

This section presents the performance analysis of LEACH and TEEN protocols with two mobile agent based clustering methods MACG and MACP. The MACG designed using the Genetic Algorithm (GA) for mobile agent based clustering. The MACP is our first contribution in this research where we used the modified PSO in place of basic PSO and GA algorithms to improve performances.

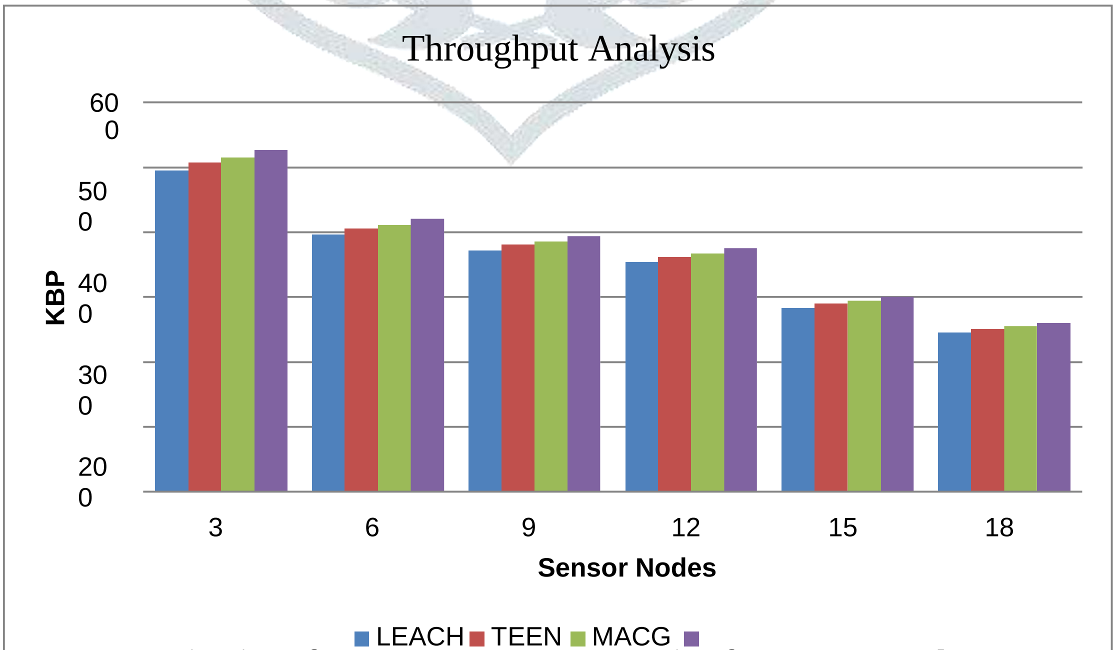

Figure 5: Investigation of average energy consumption for LEACH and TEEN

As observed in figure, LEACH protocol shows the worst throughput performance and proposed MACP protocol shows the best throughput performance for all networks. The mobile agent-based methods show the significant throughput and PDR (figure 4.12 and table 4.7) as compared to LEACH and TEEN. Due to mobile agents, the process of data aggregation and dissemination effectively optimized in protocols MACP and MACG. The MACP shows better QoS performance compared to MACG due to the use of the modified PSO algorithm for the clustering purpose.

demonstrates the outcomes of energy efficiency performances of SMACP with both recent clustering methods investigated. The results show that as the number of sensor nodes increases, the energy consumption in network increases as well and hence leads to lower network lifetime. The performance of CM2SV2 method shows better energy efficiency performance as compared to MAPE technique method mainly designed to solve the imbalanced energy problem in which the mobile sinks are used as MAs to overcome the problem of an energy hole. However, the key problem with this method is there is manually required to adjust the speed of mobile sinks in various zones in order to balance the energy consumption of Cluster heads (CHs). The problems with CM2SV2 and MAPE protocols addressed by proposed SMACP, which improves the performance of energy efficiency compared to both protocols as the efficient PSO algorithm used for clustering and trust ware data communications

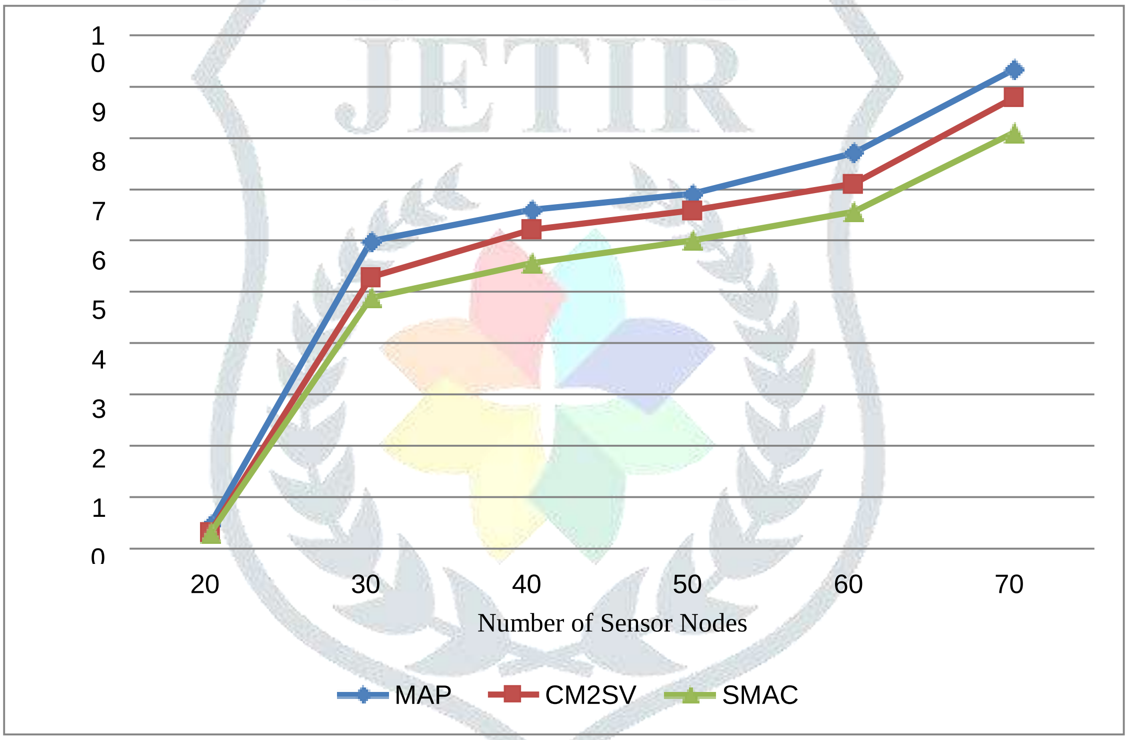

Figure 6: Average energy consumption analysis

6. Conclusion

In this research, the main objective was to propose a novel secure mobile agent based clustering protocol for WSNs to improve energy efficiency as well as QoS performance. The literature conducted on different clustering based protocols and mobile agents based on clustering protocols. The literature claims that mobile agents would move data processing to sensed location resulting in the conservation of bandwidth, which otherwise would consume a lot of energy of sensor nodes. Secondly, mobile agents facilitate collaborative signal and information processing resulting in the flexibility of data. Thus interestingly mobile agent based clustering becomes strong research for energy efficiency in WSNs. However, the mobile agent is a new computing paradigm that offers data and code mobility. A mobile agent visits the network either periodically or on demand and performs data processing autonomously

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