

# Agent-based Clustering Routing Protocol for Wireless Sensor Networks

Nisha A. Auti, Avnish R. Verma, Bipalab K. Sarkar, Aparna Junnarkar

**Abstract:** *The Wireless Sensor Network (WSN) is the group of tiny several sensor devices deployed randomly for the monitoring tasks according to the need of society such as environment monitoring, military services, etc. The widely studied problem of WSN is the energy efficiency of sensor nodes as the sensor nodes are having limited processing and battery capabilities. The literature study revealed that several routing protocols, data aggregation methods, and system designs proposed to address the energy efficiency. Mainly, the energy efficiency is dependent on the efficient design of WSN routing protocol. However, there are very few works attempted for exploiting the mobile agents in WSN clustering to optimize the energy efficiency performance further. In this paper, the concept of a mobile agent in clustering and the recent works proposed for WSN is presented. The proposed mobile agent based clustering methods for WSNs are discussed and experimental evaluation in the form of energy utilization, network lifetime, and throughput performances are considered. The outcome of this experimental analysis is the current challenges and future directions for optimizing the mobile agents based clustering protocol.*

**Index Terms:** Routing Protocol, Mobile Agent, NS2, Wireless Sensor Network

## I. INTRODUCTION

Wireless sensor networks have seen the exponential growth and have also received considerable attention [1] as these small and inexpensive entities can sense the environment, process data and help scientists to take decisions based on the inputs [2]. WSNs have been applicable in various sensitive domains such as target detection, surveillance and environmental monitoring. Exponential developments towards reducing the size of motes and improvements in technical designs including hardware and software have led to advancements in this domain. It is evident from the architecture of the sensor node that the lifetime of a network is primarily dependent on the battery of the node [3]. Hence, it is of utmost importance to employ energy efficient protocols for primary tasks i.e. sensing, networking, and communication. In the light of the current body of research, sensors have been considered to be deployed in the non-deterministic area; hence the

deployment, networking, and communication shall be carried out efficiently.

An in-depth study of the literature revealed that lot many system architectures, communication protocols, and data aggregation algorithms are available addressing the need for energy efficiency. In a non-deterministic environment, wireless sensors are deployed randomly and they form an ad hoc network. Nonetheless, various algorithms supporting the hierarchical clustering for efficient coverage and connectivity and information processing are available in the literature and are being discussed in the upcoming sections. However, very few researchers have thought of employing mobile agents to improve the efficiency of these highly useful tiny motes [4].

Although mobile agents have gained a lot of attention in the late nineties very few proposals are available exploiting their capabilities in wireless sensor networks. Owing to the high cost of deploying hundreds and thousands of sensor nodes in any non-deterministic environment (like dense forests, , etc.) the deployment is done with an aim to achieve the trend of "One deployment, multiple applications". However, this drifts necessities sensor hubs to have different capacities to deal with various applications. In any case, it is difficult to store the programs required to run each conceivable application in the nearby memory of installed sensors, as this device, for the most part, have firm memory limitations [5] [6]. Because of this reason, the utilization of mobile representative to dynamically deploy a new type of applications in WSNs appears to be an efficient approach to address this challenge.

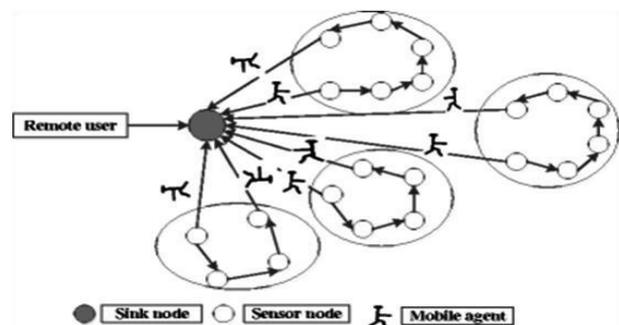


Fig.1. Structure of Mobile Agent-based Clustering

Earlier work which used mobile agents in the field of WSN dates back to the year 2005 when the first architecture of Mobile Agent-Based Wireless Sensor Network(MAWSN) was given by Chen et al. Fig. 1 shows the general structure of mobile agent based clustering protocol.

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The work used these special mobile entities in a planar WSN, where mobile operators were misused at three levels (i.e. hub level, undertaking level, and consolidated errand level). The system utilizes the mobile specialist's capacity to convey preparing codes that permit the calculation and discussion assets at the sensor hubs to be effectively outfitted in an application particular design. Inferable from their inbuilt features, mobile specialists alter their practices relying upon nature of administration needs (e.g. information conveyance, latency) and the system attributes to expand organize lifetime while as yet meeting those nature of service needs. The authors in their subsequent works [7] have also highlighted different kinds of applications and design difficulties for using mobile agents in wireless sensor networks. Authors identify that mobile agents in WSN offer twin-fold advantages.

First of all, mobile agents would move data processing to sensed location resulting into 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 into the flexibility of data. Thus interestingly mobile agent based clustering becomes strong research for energy efficiency in WSNs. The current cluster based routing methods having drawbacks like cluster heads suffered from excessive energy consumption due to all loads on it, therefore this can be later overcome by placing the mobile agents in WSNs which can acts cluster head with more energy sources in it. However with use mobile agents with clustering again imposing a limitation of energy consumption as mobile agents are also battery operated as well as mobile agents lead the problem of security. To overcome these problems, first proposed the optimized mobile agent based clustering method in order to achieve both load balancing and energy efficiency. The optimization performed by using the optimization methods such as Genetic Algorithm (GA), PSO, ABC, etc. To provide data security, the trust of mobile agents is evaluated as the trust-based approach limits the overhead and energy consumption.

Thus interestingly mobile agent based clustering becomes strong research for energy efficiency in WSNs. The work discussed here is the study on mobile agent based routing methods first, and then design recent mobile agent based clustering protocols in NS2 for the evaluation purpose. The comparative study and research gaps observed from the simulation outcomes. In section II, the brief discussions on agent-based routing protocols presented. In section III, the WSN design parameters and performance metrics discussed. In section IV, the simulation results and discussion presented. Finally, in section V, the conclusion and future work are presented.

## II. RELATED WORK

A number of research on mobile agent based routing protocols reported since from last decade for the wireless network communication. The study on such protocols is presented in this section.

Shah et al. [4] used the concept of mobile agents also known as the mobile sink in a sparse sensor network. These mobile sinks are also called as "information mules" and used for data collection from sensors deployed and nearby

wireless access points in the network. The authors have introduced the concept of mules who takes a self-assertive walk around the sensor network to collect the information from the sensor nodes deployed in the network, forward that information, they drop off the information at some ways. Since the hub's data transmission extent is short, their energy usage can be unfathomably diminished.

Wang et al. [5] proposed an energy efficient data dissemination algorithm which is based on the main objective to improve the network lifetime called as Mobility Based Information Accumulation Algorithm. The proposed system has various network zones with an indirect shape with mobile agents called mobile sinks in the network. These mobile sinks are working in the forward and in the reverse development in the edges of the circle to prolong the network lifetime.

Wang et al. [6] proposed a mobile sink based algorithm with a specific true objective to improve the performance of the clever home network by using efficient clustering algorithm and mobile sink hub game plan procedure. They considered the substitute number of mobile sinks in the network as one of the unmistakable conditions. The authors in their work initially used a single mobile sink which has a circuitous moment in the said substitute radius of the network. Then after, they have used multiple mobile sinks to find the accurate number of mobile sinks in a roundabout zone. In their work, they have assumed that the mobile sinks deployed in the network are moving with steady speed.

Ma et.al [7] the authors in their work mainly focused on to the important design issue in mobility based sink is the speed with which the mobile sink moves in the network and it has been reduced to guarantee message conveyance in the wireless sensor network. Probably this arrangement could enhance the network lifetime utilizing limited sensors energy efficiently and achieve a high parcel conveyance proportion by using different mobile sinks with a some settled speed.

As of late Alyaa Amer Ayman et.al [8] proposed anchored clustered mobile operator based directing convention. Harmony used for securing investigating open keys in a clustered mobile specialist WSN to shield sensor hubs from malicious administrators. Cluster heads go about as a conveyed key storing and query office molding a ring overlay network. D. Sheela et.al [9] proposed another security mindful mobile specialist based directing convention. Creator concentrated on making a joined security game plan which uses mobile administrators. The proposed security plan using mobile administrators is to give fundamental security benefits and to ensure against seven attacks, for instance, Denial of Service attack, Hello flooding attack, Traffic examination, Cloning attack, Sinkhole attack, Black gap attack and Specific sending attack with the energy overhead of keeping an eye on a solitary attack. Rupali Rohankar et.al [10] proposed the specialist based data collection algorithm for remote networks. Creator mimicked the operator based predictive data collection algorithm (PLA) and contrasted and ordinary pioneering directing convention.

Mohamed El Moussaoui et.al [11] proposed a new agenda masterminding algorithm for Mobile Agents (MAs) in light of cluster heads (CHs). As opposed to orchestrating plan among all sensor nodes (SNs), maker organized the calendar just among CHs. In any case, they bundle SNs in bunches in perspective of the thickness of SNs by then select a couple of SNs as CHs. Second, they plan plans for MAs just among CHs in light of minimum spanning over tree algorithm (MST). Finally, maker dispatches a perfect number of MAs for information accumulation and get-together from CHs.

Niayesh Gharaei et.al [12] proposed system is based on the important objective of using clustering in a wireless sensor network is to efficiently use limited energies of the nodes by using the mobile sink as one of the mobile agents for the energy consumption of WSN. The authors proposed a Varied Velocity Algorithm (CM2SV2) in which the circular movement of Mobile-Sink is considered to manage the energy use extent of cluster heads (CH). The perfect cluster estimation is one of the important objective of the said work and the authors considered the very important parameter of the hub is their energy use to estimate the same. In the said work two stages of Genetic Algorithm (GA) is effectively used to choose the perfect between the angle of cluster measure and get the right and incentive from the interval.

However new research going on the overall effectiveness change utilizing the mobile agents for WSNs. There are a number of concerns while misusing the mobile agents for clustering activities, data accumulation, data combination and so forth in sensor networks, for example, unwavering quality of data transmission, stack adjusting, adaptability, energy effectiveness at both sensor nodes and mobile agents, most imperative is security that may be imperiled by mobile agents. From the writing survey, we watched such difficulties that need to consider while planning the directing conventions for WSNs.

**III. WSN WITH MOBILE AGENT DESIGN**

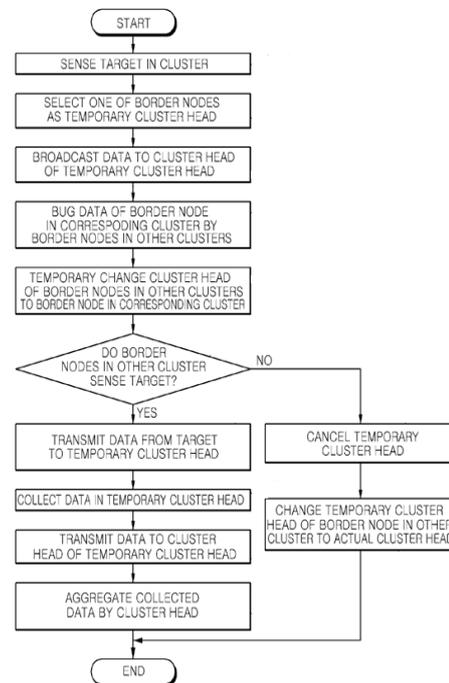
The main objective of this work is to evaluate the recent mobile agents' based methods on wireless sensor networks. Thus one can design the wireless sensor networks using the NS2 simulator with the presence of mobile agents.

Figure 2 is a flowchart showing an operational flow for a method for cluster-based data transmission in wireless sensor networks. The designed WSNs is having a varying number of sensor nodes such as 200 to 700 with total 30 mobile agents to perform the tasks of data collection and aggregation to achieve the load balancing and energy efficiency in the network. These designed networks are evaluated using two recent methods reported in [11] and [12]. The routing protocols designed are MAPE [11] and CM2SV2 [12] 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**

Number of sensor nodes	200-700
Simulation Time	100 second
Mobile Agents (MAs)	30

Mobility of MAs	10 m/s
Routing Protocols	MAPE & CM2SV2
MAC	IEEE 802.11
Propagation Model	Two-Ray Ground
Mobility	the random waypoint mobility model
Antenna	Omni Antenna
CBR Connections	5
Network size	500 x 500
Packet size	512
Initial energy (SNs & MNs)	0.5nJ/bit



**Fig 2 Flowchart showing the operational flow of a method for cluster-based data transmission in WSN**

**IV. SIMULATION RESULT**

The working of both evaluated methods using the mobile agents is different for clustering as well as data aggregation. For any routing protocol in WSNs, the key performance metrics are related to energy efficiency as well as QoS parameters.



Figure 3 and 4 demonstrate the outcomes of energy efficiency performances using both recent clustering methods investigated in this paper using the 30 MAs. 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 the better energy efficiency performance as compared to MAPE technique. The CM2SV2 method mainly designed to solve the energy imbalanced problem in which the mobile sinks are used as MAs to overcome the problem of the 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 efficiently use the energy utilization of Cluster heads (CHs). Thus this can affect the QoS performance; the results showing in figure 5 demonstrate the QoS analysis.

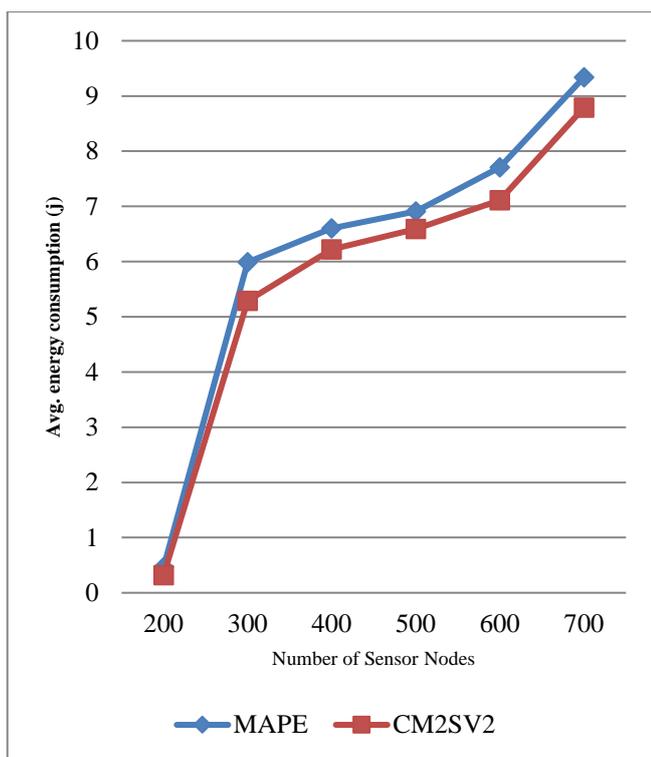


Fig.3. Average energy consumption analysis

The throughput performance of the MAPE algorithm shows the better improvement as compared CM2SV2 algorithm, as the MAPE designed for efficient data aggregation using the MAs in clustering.

The outcomes of both methods are contradictory; it means they failed to achieve the trade-offs between the energy and QoS efficiency for the sensor networks.

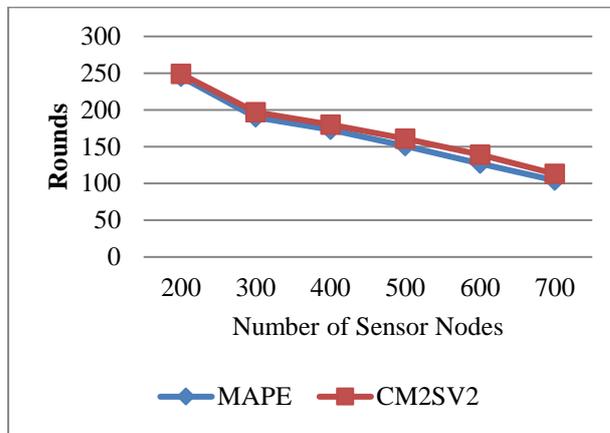


Fig.4. Network lifetime analysis

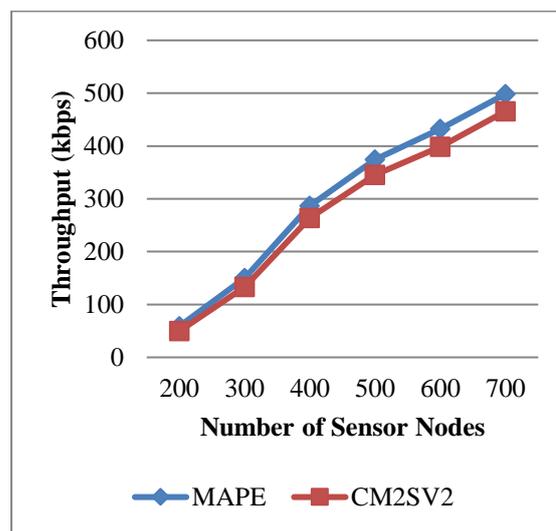


Fig.4. Average throughput performance analysis

### V. SIMULATION RESULTS

This paper has first presented the literature study that clearly advocates deploying mobile agents for efficient processing in sensor networks. It is evident from the works already available that in client/server-based sensor network, sensors only gather information and send to a sink node. 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. On contrary to various advantages that a mobile agent based sensor network offer, it also contributes certain disadvantages such as code caching, safety, and security. Mobile agents are making their space in e-commerce, military situation awareness, just to list a few. Recent studies indicate that scientists have been using mobile agents for data fusion in distributed sensor networks. In this paper, experimental evaluation of two recent MA-based clustering methods for WSNs is presented. The outcomes are not fruitful for the WSNs. There are several directions to work on MAs in WSNs such as tradeoffs between energy and QoS efficiency, security from the MAs, evaluation of other QoS parameters such as delay and routing overhead.



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