DESIGNING SMART WSN: USING ADVANCEMENT IN THE FIELD OF OPTIMIZATION USED IN INTELLIGENT SOFTWARE AGENTS

Nisha A. Auti, Dr. Avnish R. Verma Dr. Biplab K. Sarkar

Research Scholar, Professor, Professor

Maharishi University of Information Technology, Lucknow, India,

Maharishi University of Information Technology, Lucknow, India,

P.V.P.I.T. Pune, India

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 called as Wireless Sensor Network (WSN). The applications like disaster monitoring, environment monitoring, weather monitoring, home automation, battlefield monitoring, etc. need the efficient functionality of WSNs deployed. Mostly, WSN deployed in remote resource-constrained areas. 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. There is need to deal with above-mentioned design issues and increase the usefulness of WSN. Hence, there is a need to design smart WSN by using the latest technologies.

I. 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 nodes in WSN are 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. 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.

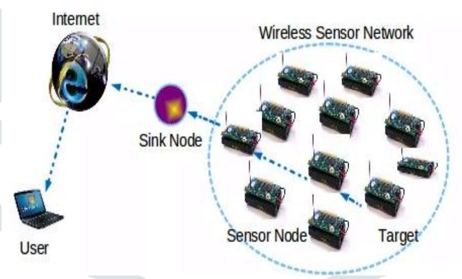

Figure 1.1: illustration of WSN application

From figure 1.1, it is showing that, in the sensor field, if sensor nodes detect an event, then its information is passing through sensor nodes towards the sink node. Sink node further communicates this information with a remote monitoring facility. The current technologies and methods enable researchers to design smart WSN with 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 [1]. The current sensor networks are introducing the improvement as compared to earlier sensor networks. The earlier sensors are deployed based on below listed approaches:

- The Sensors are located at a far distance from the actual sight. For this approach, the large number of sensors utilizes the complex methods which are required to differentiate the actual targets from the network noise.
- The deployment of many sensors is done in the network, which is only performing the task of sensing.
- It is required to design communication topology and sensors position very carefully, which is a time-consuming and manual task.

These all problems of earlier sensor networks are overcome by smart WSNs designs which are self-organized in all aspects, does not require any physical infrastructure.

Overall, WSN aims to perform the collection of data from the environment in which the WSN is deployed and forward it to the intended recipient to which data reporting is done.

However, as these sensor nodes are small and have less power, energy consumption is the main concern and deciding factor about overall network lifetime. Data collection, processing, sending, receiving, forwarding processes consumes more sensor node energy. In WSN, there are many factors based on which the energy efficiency of WSN determined like the architecture of WSN, topology design, routing protocol, MAC (medium access control) protocol, data aggregation schemes, etc. Topology control design methods are one of the critical areas which utilized for achieving the energy efficiency in WSNs. In this thesis, the work contribution and area of working on efficient topology control protocol design for WSNs. Before going for further discussion on energy efficiency, below are the formal understandings about energy efficiency, network lifetime, and other parameters used to claim the effectiveness of particular approach or method in WSN [2]. In the next section, the energy efficiency and network lifetime parameters discussed.

***Energy Efficiency**:* There is a need to extend the processing of WSN as much as possible. However, the topology control protocol is energy efficient if it can extend the overall network lifetime of WSNs. For every sensor node, energy consumption should be minimized.

Network lifetime: The term network lifetime is nothing but overall life in minutes till to the first sensor node in WSN dies.
Therefore, for WSNs, at present, energy consumption is the most important research problem considered while using topology control protocol. Why energy efficiency is necessary is explained as: 1) the single small radio sensor device has low power battery which is expected to operate many months after its deployment. 2) If WSN designed and deployed over the remote region, then it's required that all wireless sensor devices in such network utilize their batteries efficiently, so that network lifetime needs to be extended [3]. Therefore many researchers are focusing their interests on designing energy efficient approach.

II. COMPONENTS OF WSN

There are four essential components in any WSN as shown in Figure 1.2:

- a group of distributed sensor nodes;
- an interconnecting wireless network;
- a gathering-information base station(Sink);
- a set of computing devices at the base station (or beyond) required to interpret and analyze the received data from the nodes; sometimes the computing is done through the network itself.

Sensor nodes, as mention earlier, are low-cost and low-power devices used to accumulate the desired data and forward it to the base station. A sensor node is composed of four parts as shown in Figure 1.3; the nodes equipped with a sensing unit, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery, some sensor nodes have an additional memory component.

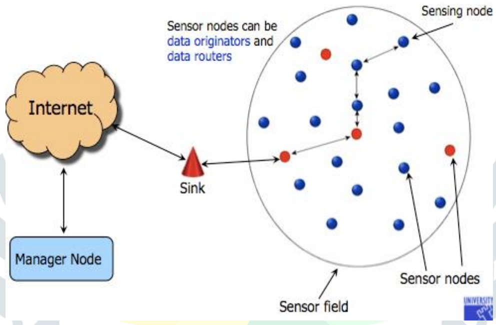

figure 1.2: Basic Sensor Network components

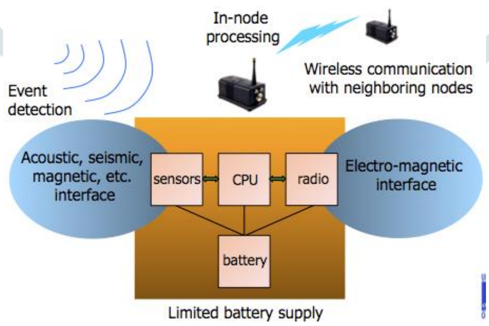

Figure 1.3: Sensor Node Architecture

The functionality of sensor nodes lies behind the ability of the node to either being the source of the data (i.e., senses the event) then transmits it, or just being a pure transceiver that received data from other sources then forwards it to other nodes to reach the base station. This functionality depends on the network architecture that depends in turn on the application.
The size of a single sensor node can vary from shoebox-sized nodes to the extent of dust. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few cents, depending on the size of the sensor network and the complexity of individual sensor nodes.
The WSN has many features helping the technology to be deployed in real life application as soon as possible even though these features differ depending on the technology, here is a list of them:

- A large number of nodes, often in the order of thousands
- Asymmetric flow of information, from sensor nodes to a command node
- Events trigger communications
- At each node, there is a limited amount of energy which in many applications is impossible to replace

- Low cost, size, and weight per node
- More use of broadcast communications instead of point-to-point
- Nodes do not have a global ID such as an IP number
- The security, both physical and at the communication level, is more limited than conventional wireless networks

The network architecture depends on the application of deploying WSN. For example, some nodes are connected directly to the sink without passing through other nodes (1-hop layer). Other layers might go through other nodes to forward the data to the sink.

III. WSN PROTOCOLS AND DESIGN ISSUES:

Sensor Node Protocol Stack

Generally, the WSNs deployed in resource-constrained environments where the longevity and sustenance of the WSN are dependent on the co-operation of all the nodes in the neighborhood as well as the different layers in the protocol stack of each sensor nodes as shown in figure 1.4. The protocol stack consists of the application layer, transport layer, network layer, data link layer, and physical layer. In conjunction with the various layers in WSNs, the sensor nodes use power management to use available power. Scheduling the sensing tasks to specific nodes within the site of occurrence is managed by Task management. Factors that influence task management include the status of varying power levels of nodes in the WSN so that not all sensor nodes in a given region are required to sense. Mobility management needed to detect and register the movement of sensor nodes, so that information of neighboring nodes is kept up-to-date. Networking within the umpteen sensor nodes is possible due to these management features incorporated within the WSN protocol stack that allows sensor nodes to work collaboratively, route data efficiently, and share the limited resources most optimally.

Based on the sensing application that the WSN is being deployed for, application software can be built and used for the application layer [4]. Based on the requirement of the sensing application/task, the transport layer provides reliable data from the transmitting node to the receiving node. The network layer is concerned with the routing of data from the transport layer, and the data link layer addresses methods on achieving a reliable, efficient communication between two communicating nodes. Factors such as propagation delay, energy awareness, medium access, and error control, managed within the data link layer. Finally, the physical layer addresses issues responsible for frequency selection, signal detection, modulation, and encryption.

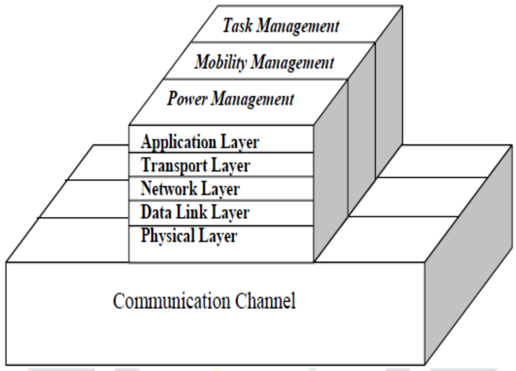

Figure 1.4: WSN protocol stack incorporated with task- mobility and power-management.

While most of the entities mentioned above would need to be handled seriously in existing networks, WSNs do not need to address all the attributes for their successful use. As traditional networks may aim to achieve high quality of service (QoS) provisions, sensor network protocols must focus primarily on power conservation due to limited, generally irreplaceable, power sources that can decide the longevity of the deployed WSN. Among the protocol layers discussed above the link-layer entities must sense the environment and signal it to the upper layer entities for appropriate adaptation to adjust for link availability, link capacity, latency, congestion status, and existing error conditions.

A few issues discussed here explain the importance of the need to design a robust data-link layer. When there is no event, the entire system, including the data link layer, should hibernate. The data link layer should use distributed methods so that clear and frequent communication across sites, achieving coordinated and standardized measures become possible [5]. Furthermore, a distributed network is more scalable and more robust because it has no infrastructure. Global synchronization not required in the data link layer. Since a large number of sensor nodes are deployed densely in a WSN, neighboring nodes stay very close to one another, making short distance one-hop communication a clear choice so that less power consumed. The limited bandwidth of wireless channels between nodes, low-power consumption requirements further aggravates the situation, as message overheads need to be kept at a minimum level over the single-hop communications. They must have inbuilt trade-off mechanisms that give the end user the option of prolonging network lifetime at the cost of lower throughput or higher transmission delay. Power is consumed only if a “data-centric” event occurs. Finally, the data link layer design needs to be robust and straightforward.

IV. RESEARCH MOTIVATION

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 [6]. The study shows that in the entire WSN designing process, the battery life of the sensor node is a critical resource. 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 considered as they 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 deployed randomly, and they form an ad hoc network. Nonetheless, various algorithms supporting the hierarchical clustering for adequate coverage and connectivity and information processing are available in the literature and 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 [6]. 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. However, this drifts necessaries sensor hubs to have different capacities to deal with various applications [7].

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) given by Chen et al. [8]. The work used these unique mobile entities in a planar WSN, where mobile operators 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 [9] 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 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.

V. PROBLEM STATEMENT

To improve the energy efficiency, since from last decade number of routing solution introduced based on clustering technique. The mobile agent based clustering shows the significant advantages for WSN applications. There are number of concerns while using the mobile agents based clustering such as 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 imperilled by mobile agents. From the literature survey, it is noticed that such difficulties that need to consider while planning the directing conventions for smart WSNs. Thus the main research problem is to design novel secure mobile agents based clustering protocol to address the challenges of secure communications, efficient clustering, and data aggregation for smart WSNs.

VI. RESEARCH OBJECTIVES

The main aim of this research work is to propose a novel clustering algorithm for a wireless sensor network to improve the network lifetime, security, and QoS performances.

- To present a review of various clustering methods for energy efficiency in smart WSNs.
- To study the importance, applications, and challenges of mobile agent based clustering in smart WSNs
- To design new mobile agents based clustering algorithm using the advance optimization algorithm.
- To develop a lightweight security protocol for mobile agent based communications.
- To present practical analysis and performance evaluation

VII. RESEARCH CONTRIBUTIONS

The current cluster based routing methods having drawbacks as 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 the limitation of energy consumption as mobile agents are also battery operated as well as mobile agents lead the problem of security. These problems can be overcome by first proposing the optimized mobile agent based clustering method to achieve both load balancing and energy efficiency. The optimization performed by using the optimization methods such as Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) or many more depending on the application. To provide data security, the work evaluates the trust of mobile agents as the trust-based approach limits the overhead and energy consumption. The key contributions of the research work on designing smart WSN are:

Mobile Agents based clustering: There is need to propose, mobile agent based clustering protocols using efficient optimization techniques called PSO. Particle swarm optimization (PSO) is feasible for the localization problem because of its fast convergence and moderate demand for computing resources in wireless sensor networks. However, existing PSO has below limitations: Less efficiency for nodes deployment, less precision, unbalanced energy consumption and management for clustering in WSNs, and convergence issues with PSO. Hence, the work has proposed the modified PSO method to solve the problem of unbalanced energy consumption as well as improving efficiency while deploying the sensor nodes. After the sensors deployment and clustering using modified PSO, the said work has implemented the mobile agents to collect the data from the Cluster heads (CHs) in the network and send it to the sink nodes efficiently.

Secure Mobile Agent based clustering: To address the challenges of unreliable mobile agents based data collection and transmission, the said work present the trust-based solution which evaluates the trust score of each mobile agent before involving in the process of communications with CHs in the network using different sensor nodes parameters. This can improve the QoS of the network as well as network lifetime as the reliable mobile agents limit the re-transmissions in the network.

The proposed protocol is called Secure Mobile Agent-based Clustering using modified PSO (SMACP) protocol.

VIII. CONCLUSION AND FUTURE WORK

The main objective of the research work was to propose a novel secure mobile agent based clustering protocol for smart WSNs to improve energy efficiency as well as QoS performance using latest optimization techniques. 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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