International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 3, May-Jun-2023, ISSN (Online): 2395-566X

Impact of Self-Organizing Map (SOM) Clustering on Energy Consumption and Communication Overhead in Wireless Sensor Networks (WSNs)

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Abstract- Wireless Sensor Networks (WSNs) have gained significant attention in various applications, including environmental monitoring, healthcare, and industrial automation. However, the limited energy resources of sensor nodes pose significant challenges to the network's overall performance and lifetime. In this study, we investigate the impact of Self-Organizing Map (SOM) clustering techniques on energy consumption and communication overhead in WSNs. SOM clustering offers an efficient approach to organize sensor nodes into clusters, enabling localized data processing and reduced communication requirements. We analyse and compare the performance metrics of energy consumption and communication overhead for WSNs employing SOM clustering techniques against traditional approaches.

Keywords- Communication Overhead (CN), Node, Cluster, Energy Consumption (EC), Wireless Sensor Networks (WSN), SOM, Fuzzy Logy.

I. INTRODUCTION

Wireless Sensor Network (WSN) is a network infrastructure composed of small autonomous devices, called sensor nodes that are capable of sensing and collecting data from the surrounding environment [1-2]. These sensor nodes are equipped with sensing, processing, and wireless communication capabilities, allowing them to monitor various physical or environmental conditions, such as temperature, humidity, light, and sound.

WSNs are commonly used in applications where traditional wired networks are impractical or expensive, such as environmental monitoring, surveillance, precision agriculture, healthcare, and industrial automation. The sensor nodes in a WSN are typically deployed in large numbers and are distributed over a wide area, forming a network that can efficiently collect and transmit data to a central base station or sink node.

The communication in a WSN is usually achieved through wireless protocols, such as Zigbee, Bluetooth Low Energy (BLE), or IEEE 802.15.4 [1-5]. These protocols are designed to be energy-efficient, as the sensor nodes are typically powered by batteries or energy harvesting mechanisms, and prolonging the network's lifetime is a critical concern.

The collected data from sensor nodes can be processed locally or transmitted to a central node for further analysis. In some cases, sensor nodes can collaborate and form clusters using clustering algorithms, such as SOM (Self-Organizing Map), to optimize energy consumption and communication overhead. Clustering helps in reducing the number of transmissions required and enables localized processing, thus conserving energy and increasing network efficiency.

WSNs present unique challenges due to their limited resources, including energy, computational capabilities, and memory. Therefore, optimizing energy consumption, communication overhead, and network lifetime are crucial aspects in WSN design and performance analysis.

Researchers and practitioners are continuously exploring new algorithms, protocols, and techniques to improve the performance of WSNs, considering factors such as energy efficiency, scalability, robustness, and security. Performance analysis studies provide valuable insights into understanding the behavior of WSNs, optimizing their operation, and addressing the specific requirements of different applications.

It is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or Environmental conditions [6-8]. A WSN system incorporates a gateway that provides wireless. connectivity back to the wired world and distributed nodes. The wireless protocol you select depends on your application requirements. Some of the available standards include 2.4 GHz radios based on either IEEE 802.15.4 or IEEE 802.11 (Wi-Fi) standards or proprietary.radios, which are usually 900 MHz [11].

A WSN can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links [9-12]. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks like wireless Ethernet.WSN is a wireless network that consists of base stations & numbers of nodes. These networks are used to monitor physical or environmental conditions like temperature, sound, pressure, & co-operatively pass data through the network to a main location as shown in the figure 1.1.

Fig 1. Wireless Sensor Networks (WSN).

II. WIRELESS SENSOR NETWORK (WSN)

Network to a main location or sink where the data can be observed and analyzed. One can be retrieve required information from the network by injecting queries and gathering results from the sink. The sensor nodes can communicate among themselves using radio signals [10]. For typically a wireless sensor network contains hundreds of thousands of sensor nodes. It have individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, communication bandwidth and storage capacity [12-15]. After the sensor nodes are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication. Wireless sensor devices in respond to queries sent from a "control site" to perform specific instructions or provide sensing. The working mode of the sensor nodes may be either continuous or event driven. Wireless sensor devices can be equipped with actuators to "act" upon certain conditions.

Wireless sensor network (WSN) is an ad-hoc network technology comprising even thousands of autonomic and self-organizing nodes that combine environmental sensing, data processing, and wireless networking. The applications for sensor networks range from home and industrial environments to military uses. Unlike the traditional computer networks, a WSN is application-oriented and deployed for a specific task. WSNs are data centric, which means that messages are not send to individual nodes but to geographical locations or regions based on the data content. A WSN node is typically battery powered and characterized by extremely small size and low cost.

It is wireless network sometimes more specifically referred as Wireless Sensor and Actuator Networks as described in a Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints [14-18]. Wireless sensor network are using Global Positioning System (GPS) and local positioning algorithms can be used to positioning information and obtain location. The requirement for low device complexity together with low energy consumption, a proper balance between communication and signal/data processing capabilities must be found. This is motivates a huge effort in research activities, industrial investments and standardization process on this field since the last decade. At present time, most of the research on WSNs has concentrated on the design of energy- and computationally efficient algorithms and protocols; the application domain has been restricted to simple data-oriented monitoring and reporting applications [17-20].

That authors in propose a Cable Mode Transition algorithm, in which determines the minimal number of active sensors to maintain K-coverage of a terrain as well as K-connectivity of the network. Specifically, it is allocates periods of inactivity for cable sensors without affecting the coverage and connectivity requirements of the network based only on local information schemes. In a delay-aware data collection network structure for wireless sensor networks is proposed in the objective of the proposed network structure is to minimize delays in the data collection processes of wireless sensor networks which extends the lifetime of the network.

The network geometric deficiencies and used Particle Swarm Optimization (PSO) based algorithms to locate the optimal sink location with respect to those relay nodes to overcome the lifetime challenge Sensor-actuator networks can provide the ability to continuously monitor the integrity of structures in real-time, and detect damage at an early stage, and provide robustness in case of catastrophic failures [12-13].

III. SENSOR NETWORK

A Sensor is a device that responds and detects some type of input from both the physical or environmental conditions, such as heat, light, pressure etc. The output of the sensor is generally an electrical signal that is transmitted to a controller for further processing. A wireless sensor network consists of autonomous sensors scattered in an environment where they monitor conditions such as temperature, sound, and pressure. Because of the huge size of this forest, changes in the forest affect not only the local environment but also global climate by altering wind and ocean current patterns.

IV. SIMULATION PERFORMANCE PARAMETER

The simulation analysis we are considering following parameters as shown in the table 1.

Table 1. Simulation parameter in WSN.

S. No.	Parameter	Value
1.	Clustering technique	Fuzzy Logy and SOM
2.	No. of node	200, 300 and 400
3.	No. of cluster	5
4.	Update time	10 sec
5.	Update distance	50 m.
6.	Sink velocity	50-300 m/s.
7.	Network length	1000 × 1000 m2

V. ENERGY CONSUMPTION

Energy consumption is easily one of the most fundamental but crucial factor determining the success of the deployment of sensors and wireless sensor networks (WSNs) due to many severe constraints such as the size of sensors, the unavailability of a power source, and inaccessibility of the location and hence no further handling of sensor devices once they are deployed.

The generic goal here is to reduce the amount of energy consumption of some components of the application as much as possible by reducing the tasks that have to be performed by the sensors and the associated networks yet still fulfill the goal of the intended application. We consider 5 access points with different clustering techniques K-means, Fuzzy and SOM for 50, 100 and 150 Nodes as shown in figure 2 and 3 respectively.

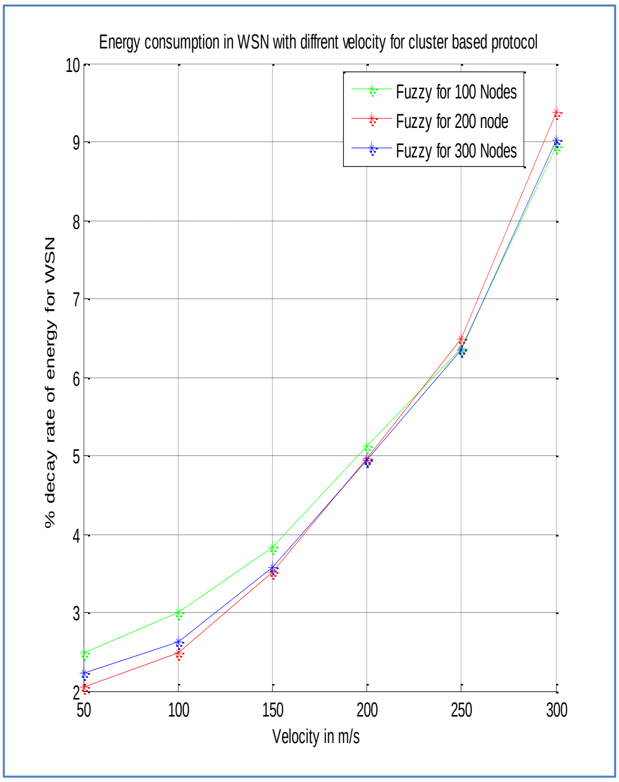

Fig 2. Energy Consumption in WSN for 100, 200 and 300 Nodes using Fuzzy logy.

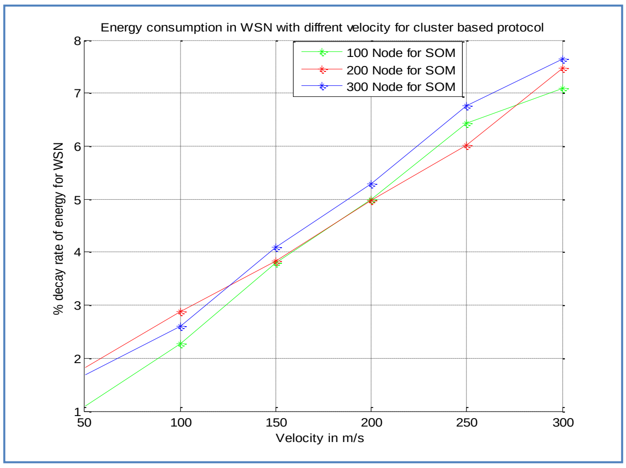

Fig 3. Performance of Energy consumption in WSN for 100, 200 and 300 Nodes using SOM.

1. Result Analysis:

In above simulation, consider different numbers of node with five cluster using fuzzy and SOM clustering techniques, in this performance we analysis % decay rate of energy consumption for 100 node 2.2%, 200 node 2.6% and 300 node 2.8% at constant velocity of 100m/s. So that minimum decay at 100 nodes is beater 0.4% as compared to 200 nodes in figure 3.

VI. COMMUNICATION OVERHEAD FOR FUZZY LOGY

The comparative evaluation of communication overhead due to sink mobility with speed variations, the effect of update time variation the effect of number of nodes used in the wireless sensor networks is carried out. It has been observed that communication overheads increase significantly when sink mobility is high. The communication overheads can be reduced by increasing update time. We consider 5 access points with different clustering techniques Fuzzy and SOM for 100, 200 and 300 Nodes as shown in figure 4 and5 respectively.

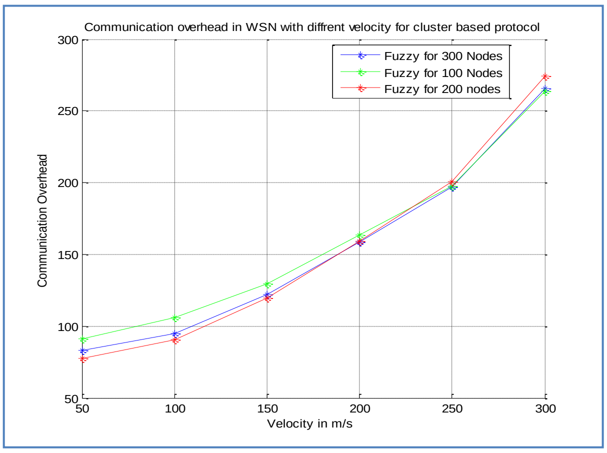

Fig 4. Performance of communication overhead in WSN for 100, 200 and 300 Nodes using fuzzy logy.

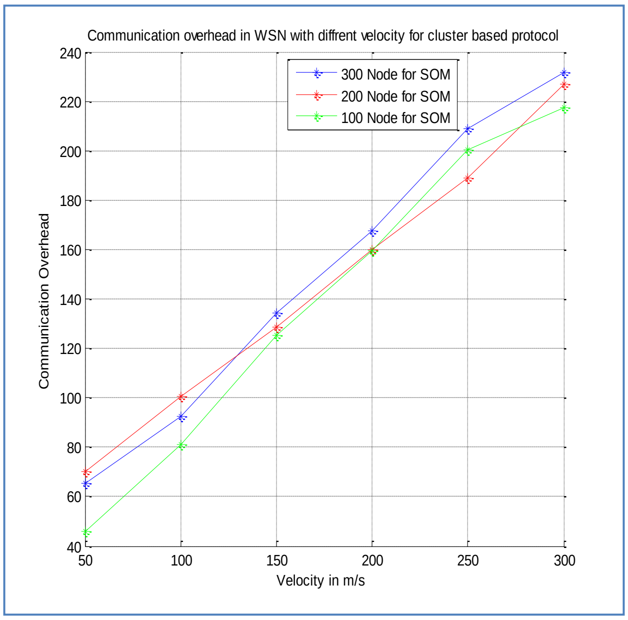

Fig 5. Performance of communication overhead in WSN for 100, 200 and 300 Nodes using SOM.

1. Result Analysis:

In above simulation figure 5, consider 100, 200 and 300 nodes with five cluster using fuzzy and SOM clustering techniques, in this performance we analysis % communication overhead for 100 node 80, 200 node 100 and 300 node 92 at constant velocity of 100m/s in figure 5.

VII. CONCLUSION AND FUTURE WORK

Efforts have been made to minimize the energy consumption of wireless sensor networks and lengthen their useful lifetime at different levels and approaches. Some approaches aim to minimize the energy consumption of sensor itself at its operating level, some aim at minimizing the energy spent in the input/output operations at data transmission levels and others target the formulation of sensor networks in terms of their topology and related routing mechanisms.

For the future works, we will further improve our algorithm aiming at security routing problems to try to establish the trust evaluation model by SOM evidence theory to defend the attacks from the malicious nodes in the network.

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