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Performance Evaluation of Wireless Sensor Networks' Communication Overhead and Energy Consumption using the Self-Organizing Map Method

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ABSTRACT

Powerful actors and resource-constrained sensors are joined in wireless networks to form Wireless Sensor and Actor Networks (WSANs). The lifespan of a sensor network may be effectively increased by clustering. The method of clustering involves breaking up sensor networks into smaller, more nimble groups of individuals with a cluster head. In hierarchically organised wireless sensor networks, clustering algorithms must choose the ideal number of clusters. In this study, we examine the effectiveness of cluster-based wireless sensor networks for various wireless sensor network communication patterns (WSNs). By utilising the self-organizing map (SOM) based clustering approach, we concentrate on their performances in terms of Communication overhead and Energy consumption in WSN with varied velocities for the cluster based protocol.

KEYWORDS: *Wireless sensor networks, Self-organizing map, Clustering protocols, sensor*

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1. INTRODUCTION

Wireless sensor networks are spatially distributed autonomous sensor network systems that are used for monitoring the environment, maintaining human health, keeping tabs on soldiers, controlling traffic lights, and monitoring the health of various machines [1]. They are made up of a number of wireless sensor motes that gather data from their environment and send it to a base station, also known as a sink. The sensor network is divided into distinct, regionally focused groups, or clusters, via clustering techniques [2–6]. Cluster heads and member nodes are the two different categories of sensor nodes that make up the network. Data from the surrounding area is gathered by the member nodes and sent to the cluster head. The cluster heads do data compression because localised information might cause the data from the same cluster to have significant levels of redundancy. Data aggregation is the procedure in question.

Wireless sensor networks (WSNs) have been viewed as a particular use of ad hoc networks. A WSN has more potential than a MANET to be deployed in many emerging areas because it can include hundreds of low cost, small-sized, battery-operated sensor nodes. Many ad hoc routing protocols that were created specifically for mobile wireless ad hoc networks (MANETs), such as AODV, DSR, DSDR, TORA, and OLSR, worked well on MANETs. According to research, these ad-hoc routing protocols are effective for MANETs with a variety of features and needs. It can also be divided into mobile ad hoc networks and static ad hoc networks (MANET). Static WAHN refers to wireless nodes that are stationary.

The energy used by the sensors determines how long an application will last, and dead nodes might have an impact on data dependability, device compatibility, and accuracy. However, a sensor node is normally made up of four basic units: the processing unit, the sensing/identification unit, the communication unit, and the power supply unit [8, 9]. The following work is contributed in this paper.

- Analyze and improve the energy usage for employing different nodes 125, 150, and 175 using the SOM method with five clusters in order to lengthen the network's life.
- To assess and contrast the performance of communication overhead and energy consumption in WSN for various nodes (125, 150, and 175) on SOM using Matlab R2013a Simulation tools.

2. WSN IN IOT CHALLENGES AND APPLICATIONS

The complexity of IoT is achieved by many heterogeneous artefacts being shown and communicating in various contexts, which also complicates the implementation of security measures. Existing WSN security research mostly addresses arbitrary problems without considering the implications of the IoT concepts and characteristics as they are covered in this article [10]. Real time management, Security and privacy, Security, Quality of service, Configuration, Availability, Data integrity, Confidentiality.

Many various types of sensors, including seismic, low sample rate magnetic, thermal, visual, infrared, acoustic, and radar, may be included in wireless sensor networks. They can keep an eye on a wide range of environmental factors, such as temperature, humidity, vehicle movement, lightning conditions, pressure, soil composition, noise levels, the presence or absence of specific objects, the mechanical stress levels on attached objects, and the current characteristics of an object, such as its speed, direction, and size. The following categories can be used to categorise WSN applications: Applications in the following categories: a. military; b. environmental; c. healthcare; d. domestic; e. traffic control. The various Applications of WSN as shown in figure 1.

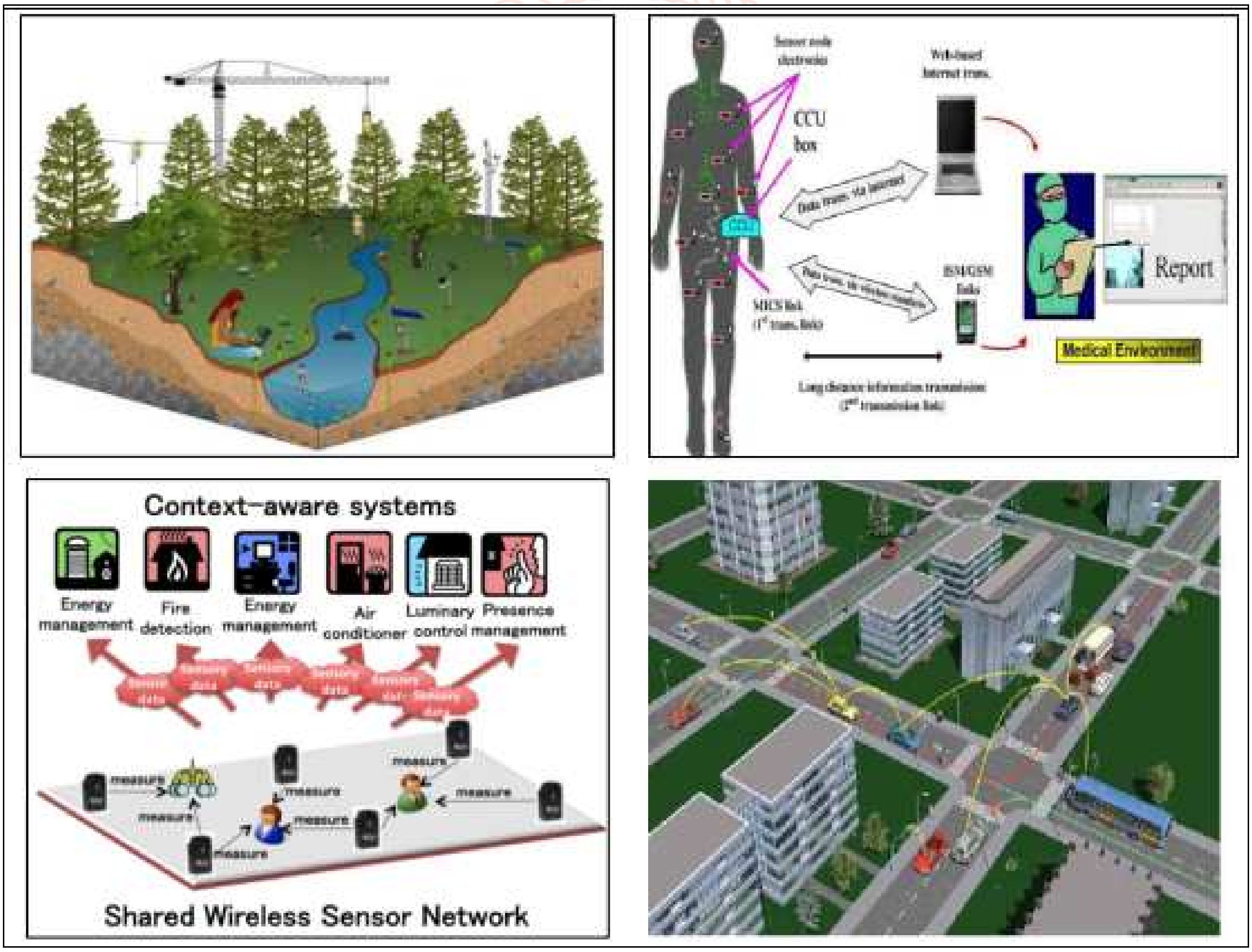

Fig.1: Applications of WSN [11, 12]

3. SENSOR NODES ARCHITECTURE

A sensor network is made up of several sensor nodes, which are compact, lightweight, and portable detecting stations. Each sensor node has a microcontroller, a transducer, a transceiver, a power supply, and other components. Based on physical occurrences and effects received by the transducer, electrical signals are generated. The data from the sensor output is processed by the microprocessor and stored. A central computer issues orders to the transceiver, which then sends data to that computer system. Each sensor node is powered by its own battery. The Sensor Nodes Architecture has been presented in figure 2.

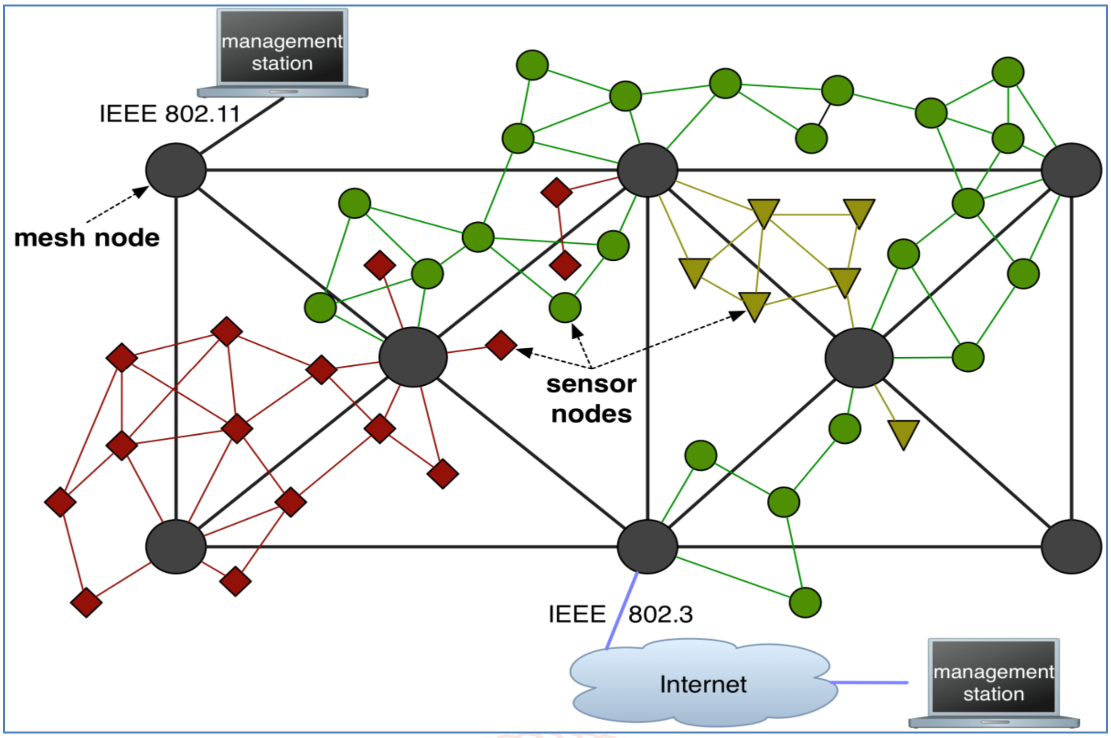

Fig. 2: Sensor Nodes Architecture

4. SOM-BASED CLUSTERING METHOD

An essential tool in the exploratory stage of data analysis and mining is the self-organizing map (SOM). It is input space on low-dimensional regular grid prototypes that may be used to examine and investigate data characteristics. When there are many SOM units, it is necessary to group, or cluster, comparable units in order to simplify quantitative analysis of the map and the data. Unsupervised approaches are therefore particularly appealing for data analysis, and the Kohonen algorithm in particular is currently commonly employed in this context. It succeeds in both "projection" and classification tasks.

4.1. Cluster based approach for 5 access points of SOM technique for different Nodes

Let's review this algorithm's definition, which is also known as SOM (Self-Organizing Map). In its truest form, it handles real-valued, quantitative data where each observation is represented by a real vector. Quantitative variables, for instance, can be indices, ratios, quantities, and measurements that are coded using real numbers. We don't now take into account the qualitative characteristics that may exist in the database. For 125, 150, and 175 Nodes, respectively, we take into account 5 access points of the SOM approach, as seen in figures 3, 4, and 5.

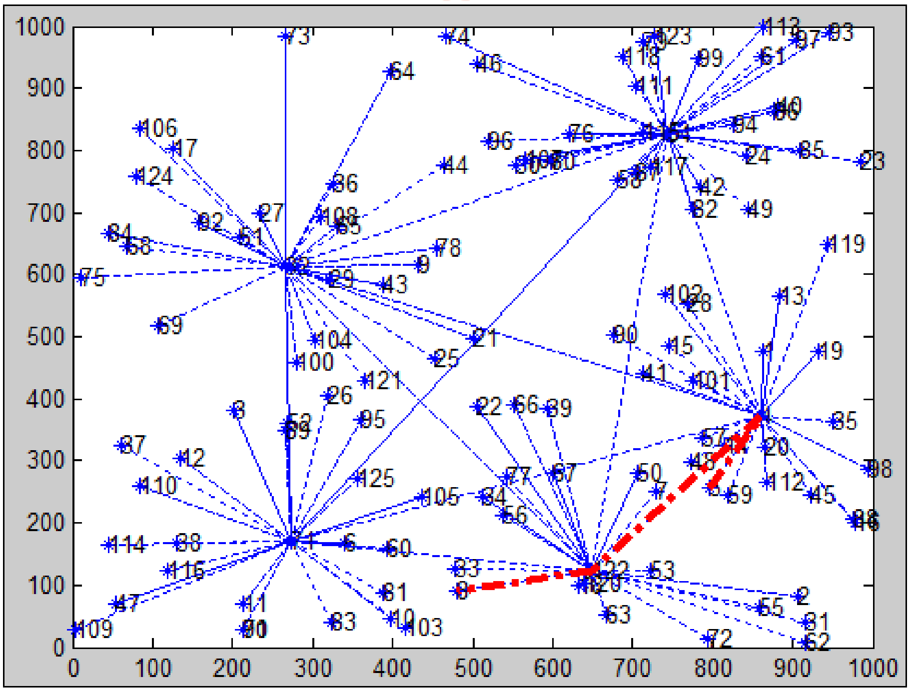

Fig.3: Performance of SOM clustering for 125 Nodes

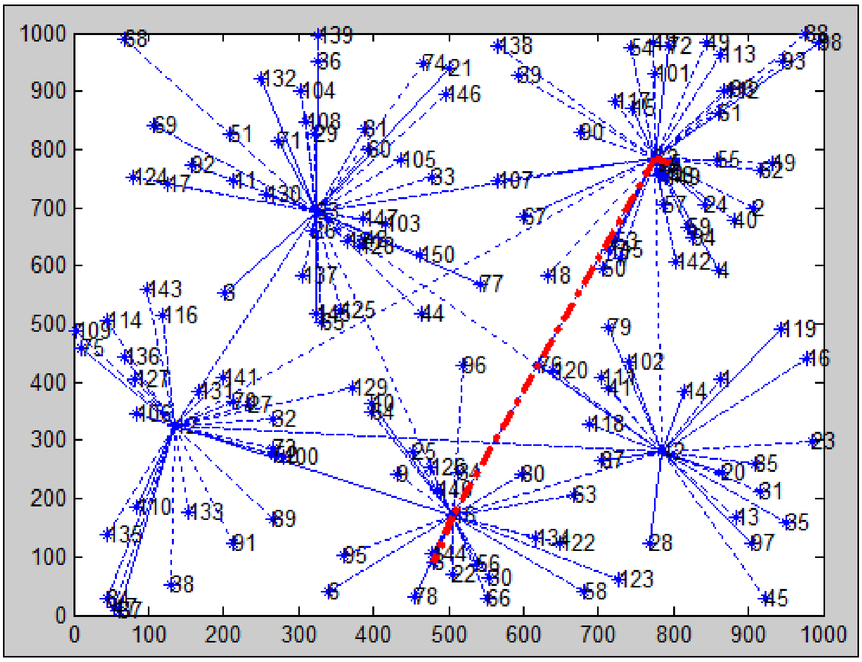

Fig.4: Performance of SOM clustering for 150 Nodes

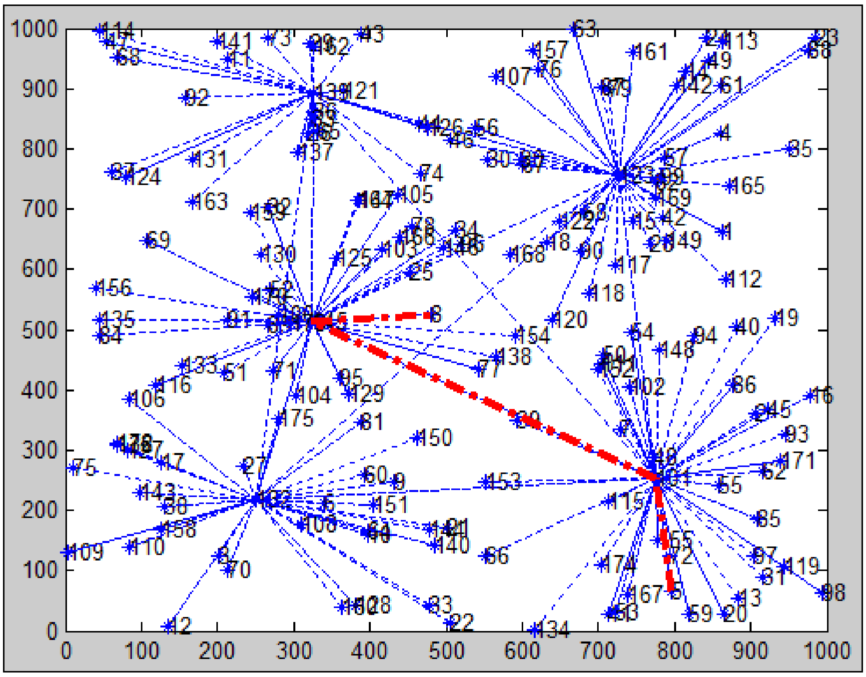

Fig.5: Performance of SOM clustering for 175 Nodes

Wireless Sensor Network (WSN) plays an extremely significant role in usual lives. Wireless Networks in provisions of constraints of their resources. The energy consumption is the principal concern in Wireless Sensor Network (WSN). Therefore, a numerous researchers focused on energy efficient algorithms in WSNs for extending the life time of sensors. These differ depending on the deployment of node, the network design, the characteristics of the cluster head nodes and the network operation. Energy is proficient of save by grouping nodes as clusters.

5. RESULTS AND COMPARISONS

Each node in the wireless sensor network determines its likelihood of becoming a candidate cluster head using the formula [14], assuming that nodes in the network have access control. Due to the fact that many applications are being built utilising these networks technology, it is a fascinating network to examine. The sort of WSN that is being studied here is made up of a number of sensors and nodes connected via a wireless network.

The primary clustering techniques used in the simulation results include SOM different-different numbers of nodes with 125, 150, and 175 nodes in 5 clusters. Analysis of the simulation's performance is based on a comparison of communication overhead and typical energy use. The result shown between communications overhead versus velocity (m/s) and percentage decay rate of energy for WSN versus Velocity in (m/s). The simulation is analysis done on MATLAB R2013a [15, 16].

5.1. Energy consumption

Due to numerous severe constraints, including the size of the sensors, the lack of a power source, and the location's inaccessibility, which results in no further handling of the sensor devices once they are deployed, energy consumption is unquestionably one of the most fundamental but crucial factors determining the success of the deployment of sensors and wireless sensor networks (WSNs). We take into account 5 access points using SOM clustering approaches, and the network nodes we take into account are 125, 150, and 175 as shown in figure 5.8 and the corresponding table 5.3, respectively.

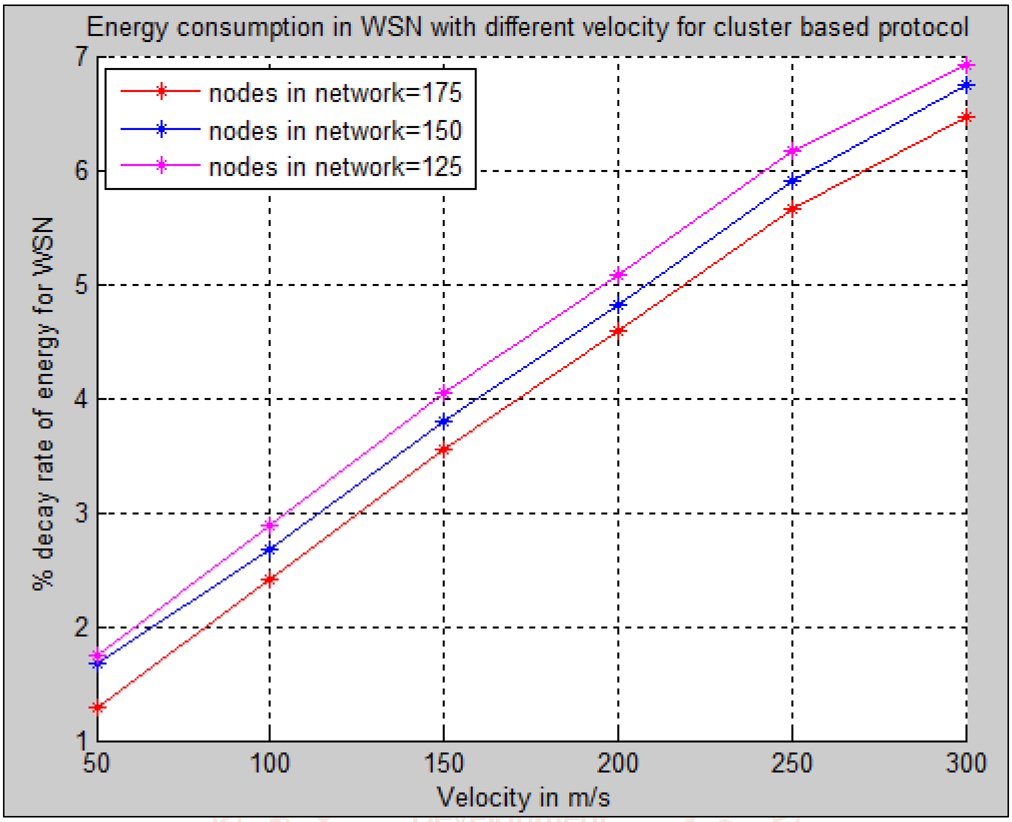

Fig.6 Energy consumption in WSN with different velocity for cluster based protocol

Table 1: Energy consumption analysis for different number of network nodes

Used technology	Number of nodes in network	125	150	175
	Velocity in m/s	(%) Average Energy consumption		
SOM	100	2.85%	2.60%	2.40%
	150	4.05%	3.80%	3.50%
	200	5.01%	4.82%	4.50%
	250	6.12%	5.89%	5.60%
	300	6.97%	6.62%	6.40%

5.2. Communication overhead

In wireless sensor networks, the comparative evaluation of the communication overhead caused by sink mobility with speed changes, the effect of update time variation, and the influence of node count is carried out. It has been shown that when sink mobility is high, communication overheads dramatically rise. By lengthening the update time, the communication overheads can be decreased. We take into account 5 access points using SOM clustering approaches, and the network nodes we take into account are 125, 150, and 175 as shown in figure 7 and the corresponding table 8, respectively.

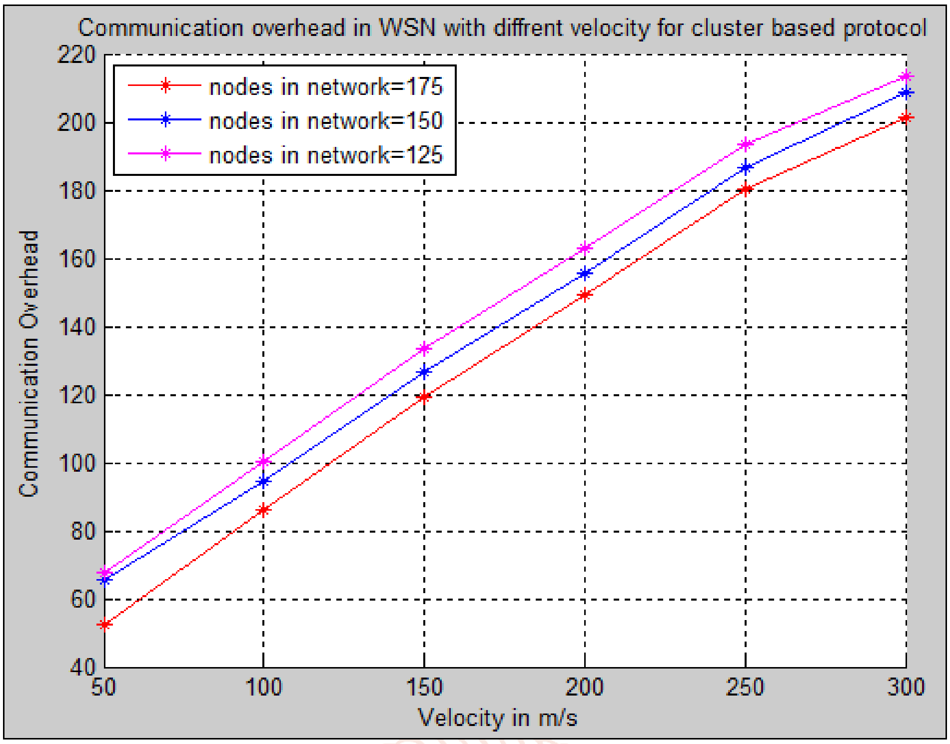

Fig. 7: Communication overhead in WSN with different velocity for cluster based protocol

Table 2: Communication overhead analysis for different number of network nodes

Used technology	Number of nodes in network	125	150	175
	Velocity in m/s	Communication overhead		
SOM	100	100	91	86
	150	137	127	120
	200	163	156	149
	250	195	187	180
	300	214	211	201

The Energy consumption and Communication overhead analysis for different number of network nodes are report in table 1 and table 2 respectively. We have also examined the average distance travelled and the link distance travelled in WSNs with various speeds for cluster-based protocols employing network nodes with 125, 150, and 175 nodes, respectively. The results are shown in figures 8 and 9, respectively.

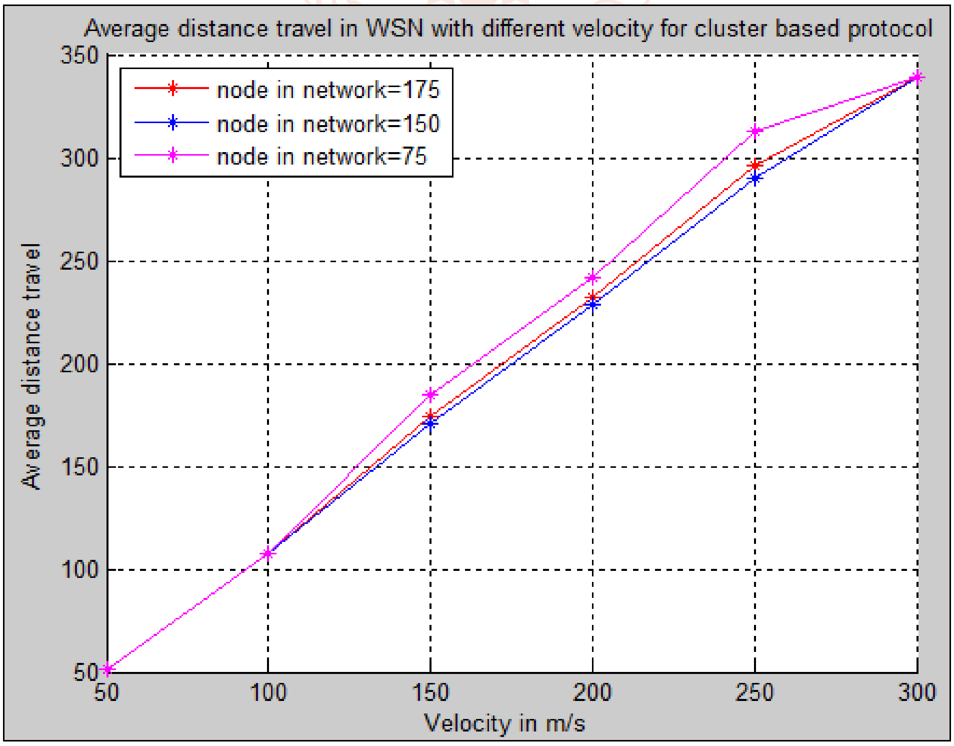

Fig.8: Average distance travel in WSN with different velocity for cluster based protocol

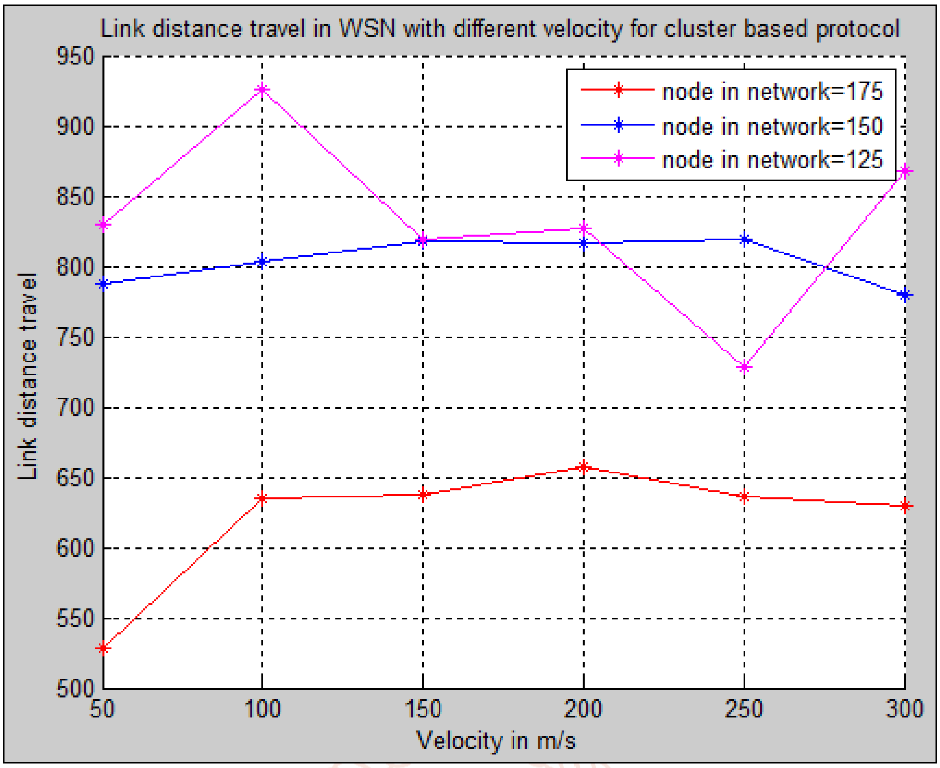

Fig.9: Link distance travel in WSN with different velocity for cluster based protocol

6. CONCLUSION

WSNs have been heavily utilised in many facets of human existence. The development of WSNs, which constantly detect the necessary parameters, has been facilitated by advances in computer technology. In recent years, the IoT-based WSN systems have attracted a lot of interest. Any sensor node may communicate and react to the many qualities thanks to the sensing technology. This article provides an overview of several WSN-related topics.

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