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General Self-Organizing Tree-Based Energy Balance Routing Protocol with Clustering for Wireless Sensor Network

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Abstract: A Wireless Sensor Network (WSN) forms of a huge number of wireless sensor nodes which are deployed randomly and densely in a targeted region. The networks work properly till it is having sufficient battery power.To optimize battery power, energy efficient routing protocols should be employed such as General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB), Hybrid Energy-Efficient, Distributed clustering approach (HEED) and Power Efficient Gathering in Sensor Information Systems (PEGASIS).GSTEB can be employed to reduce energy consumption. It constructs a routing tree for each round. BS allocates a root node and delivers information about location awareness to all sensor nodes and it automatically organizes nodes when any node in tree has low battery power. This protocol prolongs network lifetime. Among these protocols GSTEB provides high throughput, packet delivery ratio and having longer battery time compared to HEED and PEGASIS. The disadvantage of GSTEB is that the average packet drop is slightly high with respect to time. So GSTEB is modified with clustering mechanism to reduce packet dropping. This provides less average drop and less energy consumption.

Key words: Wireless sensor network, routing protocols, lifetime, energy consumption, automatically

INTRODUCTION

A Wireless Sensor Network (WSN) is begun to be deployed at an accelerated pace. It is reasonable to expect that whole world will be covered through the WSN in 10-15 year and access to them through internet. It provides thousands of such nodes to communicate through wireless channels for information sharing as well as cooperative processing. The new technologies are exciting with unlimited potential for numerous application areas including environmental, medical, military, transportation, entertainment and smart spaces.

A wireless sensor network is a collection of nodes organized into a concerted network. The sensor nodes are deployed randomly and densely in a targeted region. After the initial deployment of the network, sensor nodes are responsible for self-organizing an appropriate network infrastructure with multi-hop connections between sensor nodes.

A wireless sensor node composes of sensing, computing, communication, actuation and power components. These components are integrated on a single or multiple boards and packaged in a small number of cubic inches. The sensing unit is consisted of sensors and Analog to Digital Converters (ADC) which are used to collect and spread environmental data. The processing unit comprises of microprocessor and small memory storage used to store temporary data during processing. For commercial purpose, each node has a range between 2 and 512 kbs of RAM. The transceiver unit is used for sending and receiving data through a wireless channel. All these units are powered by batteries within the power unit.

Architecture of WSN is shown in Fig. 1. Wireless sensor network consists of number of sensor nodes. Target node sends data to internet through sink node. This will broadcast to user. WSNs are very useful and can be deployed for support variety of applications. These are based on growing technologies like wireless communication technology, information technology, semiconductors, MEMS, micro systems technology and micro-sensors, military application, Warehouse management, health monitoring and temperature monitoring, checking the concentration of chemicals and gases.

Many energy efficient protocols are available for reducing energy consumption and to maximize the lifetime of network. Protocols are classified into three types based on routing. There are node-centric routing, data-centric routing, QoS based routing.

In node centric routing, node centric communication is not a commonly expected

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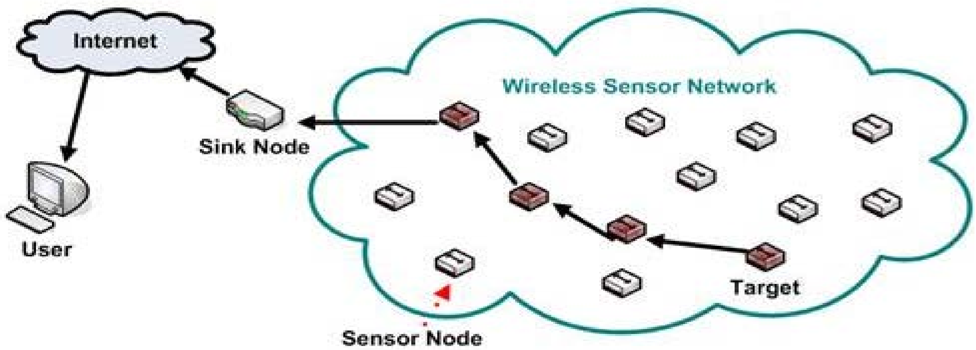

Fig. 1: Architecture of WSN

communication type. Therefore, routing protocols designed for WSNs are more data-centric or geocentric.

In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data. Here, data is usually transmitted from every sensor node within the deployment region with significant redundancy. In location aware routing nodes know where they are in a geographical region. Location information can be used to improve the performance of routing and to provide new types of services.

In QoS based routing, protocols data delivery ratio, latency and energy consumption are mainly considered. To get a good QoS (Quality of Service), the routing protocols must possess more data delivery ratio, less latency and less energy consumption. In this study, GSTEB with clustering is proposed for wireless sensor network. In this protocol, sensor nodes are divided into number of clusters. This protocol reducesdistance between BS and sensor nodes. It reduces energy consumption and increases lifetime of sensor nodes.

Literature review: The main purpose of WSN is to gather information and send it to the BS. If a BS placed faraway from sensor nodes it would be consume more energy. So many protocols have been proposed for reducing the energy consumption such as LEACH, HEED, PEGASIS, TBC, GSTEB and etc.

Recentrouting protocols for sensor networks and presented a classification for the various approaches pursued. The three main categories explored in this study were data-centric, hierarchical and location-based. In this study the design issues considered are: network dynamics, energy considerations, data delivery models, node capabilities and data aggregation/fusion (Akkaya and Younis, 2005). This research highlights the design tradeoff between energy and communication overhead savings in some of the routing paradigm as well as the advantages and disadvantages of each routing technique.Although many of these routing techniques look promising, there are still many challenges that need to be solved in the sensor networks.

Low-Energy Adaptive Clustering Hierarchy (LEACH) is based on clustering and it combined with energy-efficient cluster-based routing application-specific data aggregation to achieve good performance in terms of system lifetime, latency and application-perceived quality (Xiangning and Yulin, 2007). LEACH included a new distributed cluster formation technique that enabled self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes and techniques to enable distributed signal processing to save communication resources. Their results showed that LEACH can improve system lifetime by an order of magnitude compared with general-purpose multi hop approaches.

HEED is a multi-hop wireless sensor network clustering algorithm that brought an energy-efficient clustering routing which is different from LEACH in the way of selecting the Cluster Head (CH) and which was selected based on the hybrid combination of the two parameters. The first parameter depends on the residual energy of the node and the second parameter was the cost of communications within the intra-cluster. The communication cost was the minimum power levels required by all nodes within the cluster range to reach the cluster head. In HEED protocol each node can join only to one CH with one hop only. After a cluster formation, each node can be either elected to become a CH due to a probability or join a cluster according to CH messages. It gave more life time of sensor nodes than PEGASIS. But it had a disadvantage of loss transmission and decreases energy level in CH when CH was far away from the BS (Younis and Fahmy, 2004). PEGASIS is the improvement of LEACH protocol. It makes the chain formation of nodes instead of making clusters. The farther node will transmit the data via its neighbor node and in this way chain was created. The last node in the chain called as leader node which will transmit all the data to sink node. Compared to LEACH protocol PEGASIS had been shown performance of about 100-300% for different network topologies in WSN. PEGASIS will dissipate less energy because only leader node in chain will actively take part in data aggregation and data fusion. In PEGASIS each node should be aware of the remaining energy status of its neighbors. Node far away from the leader node will forward the data many times by the chain which causes long time delay. So there was a problem of time delay in PEGASIS protocol which should be improved (Lindsey and Raghavendra, 2002).

Concept of sensor networks which had been made viable by the convergence of micro electro-mechanical systems technology, wireless communications and digital electronics. The sensing tasks and the potential sensor networks applications were explored and a review of factors influencing the design of sensor networks provided (Akyildiz *et al*., 2002). Then, the communication architecture for sensor networks is outlined and the algorithms and protocols developed for each layer in the literature are explored. Open research issues for the realization of sensor networks were discussed.

New Tree Based Routing Protocol (TBRP) improves network lifetime of the sensor nodes. TBRP accomplished with a better performance in lifetime by balancing the energy load with respect to all the nodes. TBRP presented a new clustering factor for cluster head election which can efficient to handle the heterogeneous energy capacities. It also introduced a fuzzy spanning tree for sending aggregated data to the base station (Liu *et al*., 2009).

Twonew algorithms under name PEDAP (Power Efficient Data gathering and Aggregation Protocol) which were near optimal minimum spanning tree based routing schemes where one of them was the power-aware version of the other. The algorithms performed well both in systems where base station was far away from and where it was in the center of the field (Karl and Willig, 2005). PEDAP achieved improvement between 4-20× in network lifetime compared with LEACH and about three times improvement compared with PEGASIS.

GSTEB is used to reduce energy consumption. It has number of rounds. It builds a routing tree for each round. BS assigns a root node and broadcasts information about location awareness to all sensor nodes and it automatically organizes nodes when any node in tree has low battery power. It consists of four phases for each round. The four phases are initial phase, tree constructing phase, self-organized data collecting and transmitting phase, information exchanging phase. This protocol prolongs network lifetime. Among these protocols GSTEB provides high throughput, packet delivery ratio and having high remaining energy compared to HEED and PEGASIS. But one of the demerits in GSTEB has an average drop high when time increase (Han *et al*., 2014).

MATERIALS AND METHODS

To prolong network lifetime and minimize the highest energy consumption, modified GSTEB is used. The proposed work is that the GSTEB is modified by using clustering which is called clusteredGSTEB protocol (Han *et al*., 2014). This GSTEB protocol is based on tree structure. It is a self organizing network that the sensor nodes are automatically organized according to the energy. This clustered GSTEB provides less energy consumption, less packet drops and high throughput.

Architecture for proposed GSTEB protocol is shown in Fig. 2. It consists of six steps. There are Initialization phase, splitting into number of clusters, choose the cluster head, tree constructing phase, self organizing data

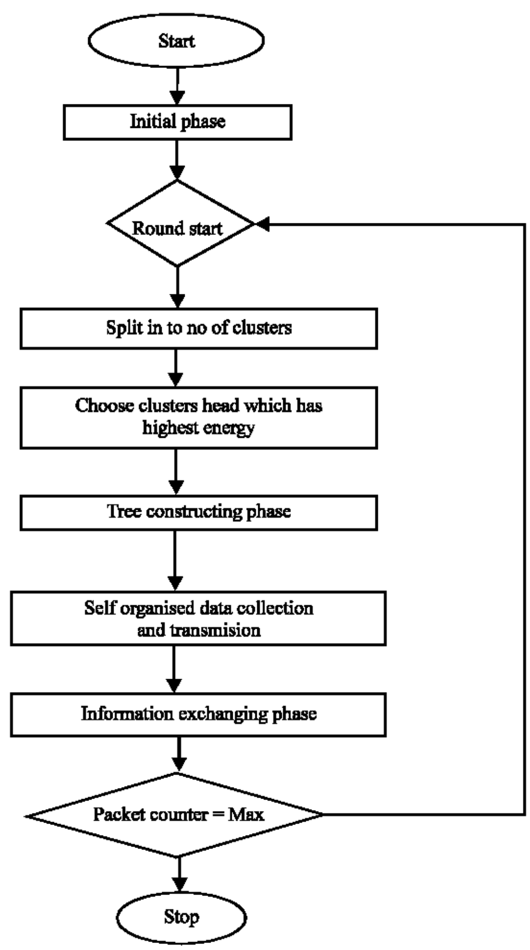

Fig. 2: Architecture for clustered GSTEB protocol

collection and transmission and information exchanging phase. These steps are used to construct protocol.

Initialization phase: The parameters of network are introduced in this phase. To consider parameters i.e., required area, number of nodes, initial energy, radio model, packet size, maximum packet size, routing protocol and so on. After these assumptions, Base Station (BS) sends a packet to all sensor nodes in specific area to inform them of starting time. Each sensor nodes send its location awareness to all sensor nodes i.e., in the specific radius circle. This packet consists of node ID, Energy Level (EL) and distance of nearest nodes (Han *et al*., 2014).

Splitting into number of clusters: All sensor nodes are splitting in to number of clusters. Merit of this step is that the data packets send within cluster. So, energy consuming will be reduced.

Choosing the cluster head: Cluster head is chosen according to the EL in this step. All nodes in the cluster send data packet to the cluster head. That CH node sends packet to sink node or BS (Younis and Fahmy, 2004).

Tree constructing phase: In tree constructing phase, each node elect parent node from its neighbors according to Energy Level (EL) and every node records its neighbors' neighbors' information. The parent node is selected within the cluster by using EL. Lowest energy level nodes are acting as child nodes. These child nodes send packets to their parent node (Han *et al*., 2014). That parent nodes send packet to their respective CH. CH sends the packets to BS. So distance will be reduced. EL should not be suddenly decreased.

Self-organized data collection and transmitting phase: After construction of tree, each node gathers information and it will produce data packet.The data packet of child node sends to CH through parent node. CH sends packet to base station. Nodes are self organized with respect to the EL.

Information exchanging phase: In this phase, parent node is exchanged when node exhausts its energy. After recognition of EL reduced, the parent node is exchanged in the next round of this phase. All nodes are monitoring the neighbouring nodes. Automatically nodes are updating changes. All packets are sent then it will move to next round.

RESULTS AND DISCUSSION

The simulation has been carried out to analyze the performance of clusteredGSTEB, GSTEB, HEED and PEGASIS protocols using NS2. The comparison of all protocols is done by parameters of throughput, energy consumption, packet drop and packet delivery ratio (Table 1).

Node generation: The clustered GSTEB, GSTEB, HEED and PEGASIS protocols are simulated and it will be shown in the NAM window by following figures.

Figure 3 shows the NAM output for Clustered GSTEB in NAM window. In this, clusters are represented by using various colors like blue, orange and black, yellow, pink and etc. Red color node is represented as sink node. Figure 4 shows the execution of GSTEB Protocol. In this figure, Red color node represents the BS. Violet color nodes and orange color node represent the root nodes, parent nodes and child node. Figure 5 shows the execution of PEGASIS protocol. Blue color node represents BS. Black color node act as a leader node. Green color and violet color nodes are used to form a chain. Figure 6 shows the execution of HEED protocol. In which combination of red color and blue color node is BS. Green color nodes are forming a cluster. Red color node sends the data packets BS. This node is cluster head.

Comparison of protocols: Throughput is defined as a total number of packets delivered over the total simulation time. This parameter is more important to analyze the performance of all sensor networks. The performance of all protocols isanalyzed by throughput.

Figure 7 shows throughput comparison of GSTEB, HEED, PEGASIS and clustered GSTEB Protocol. It shows that clustered GSTEB has the highest throughput compared to others because ofdata packets transmitting through the CH to sink node.

Figure 8 shows a comparison of energy consumption GSTEB, HEED, PEGASIS and Clustered GSTEB. It shows that Clustered GSTEB has lowest energy consumption compared to others because of cluster formation. Figure 9 shows a comparison of packet dropping ratio GSTEB, HEED, PEGASIS and clustered GSTEB. It shows

Table 1: Simulation parameters

Parameters	Values
Number of nodes	40
Area size	1000×1000 m
Simulation time	30ms
Packet size	100 bytes
Maximum number of packets	300
Routing protocol	DSDV
Initial energy	100J
Model	Two ray model

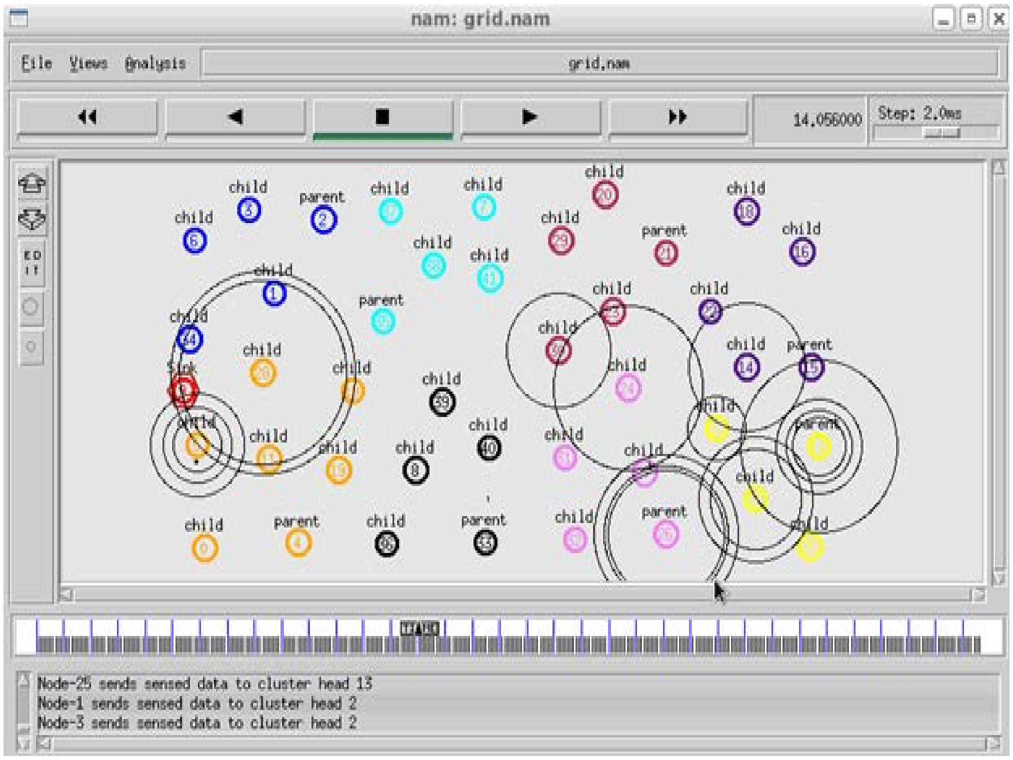

Fig. 3: Execution of ClusteredGSTEB in NAM window

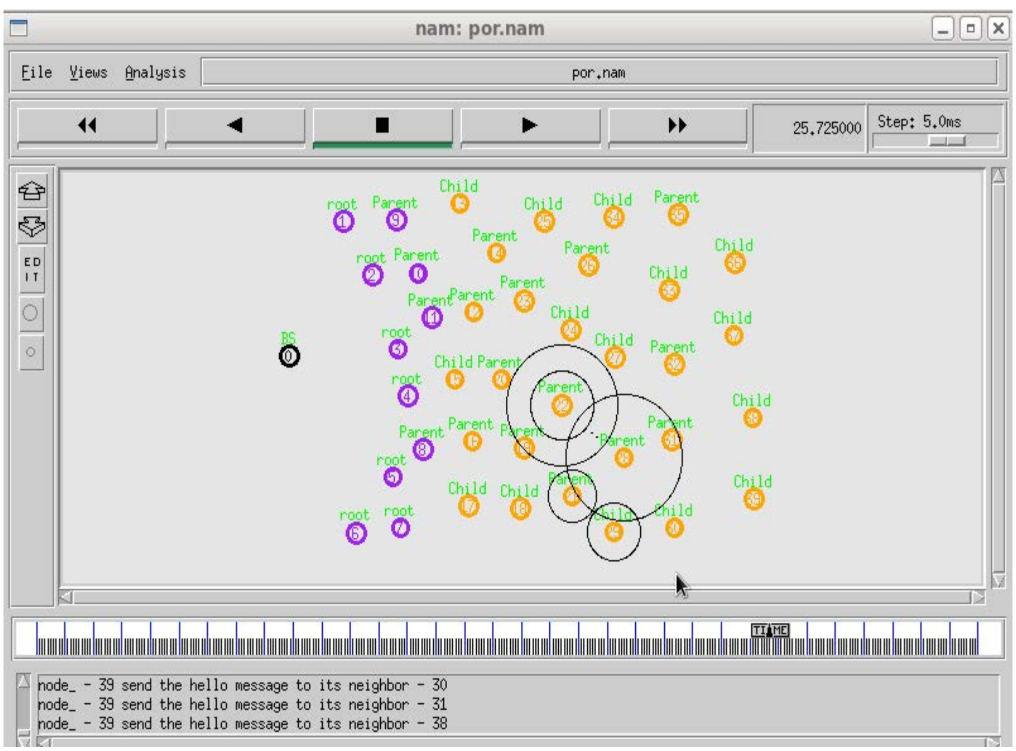

Fig. 4: Execution of GSTEB in NAM window

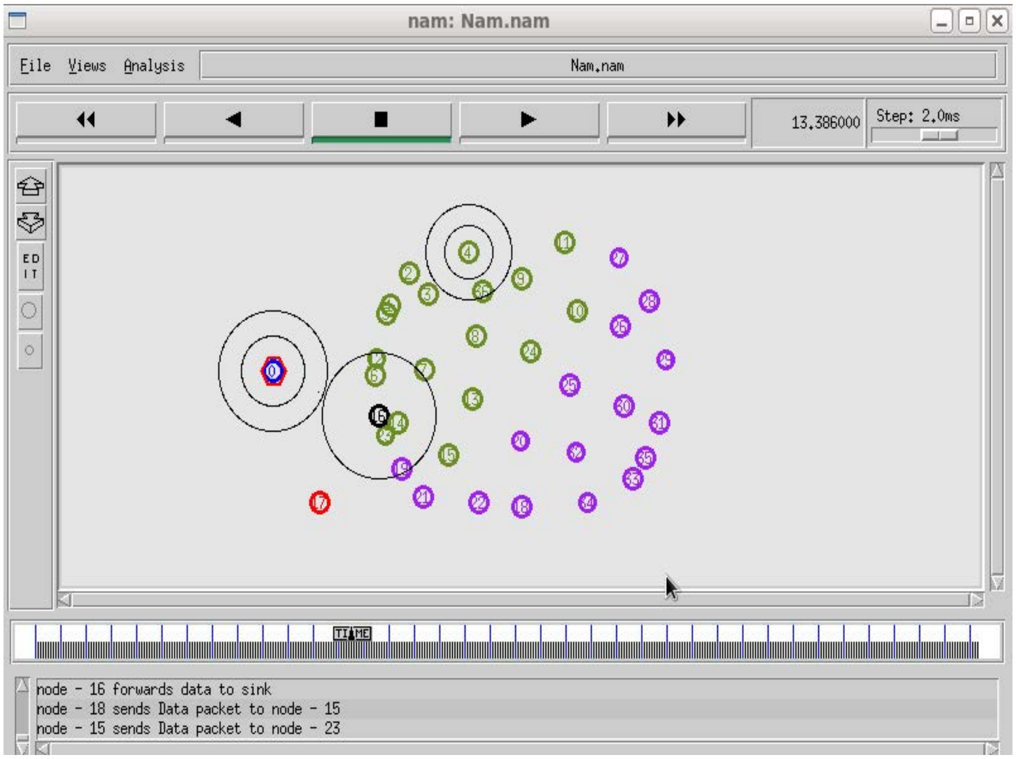

Fig. 5: Execution of PEGASIS in NAM window

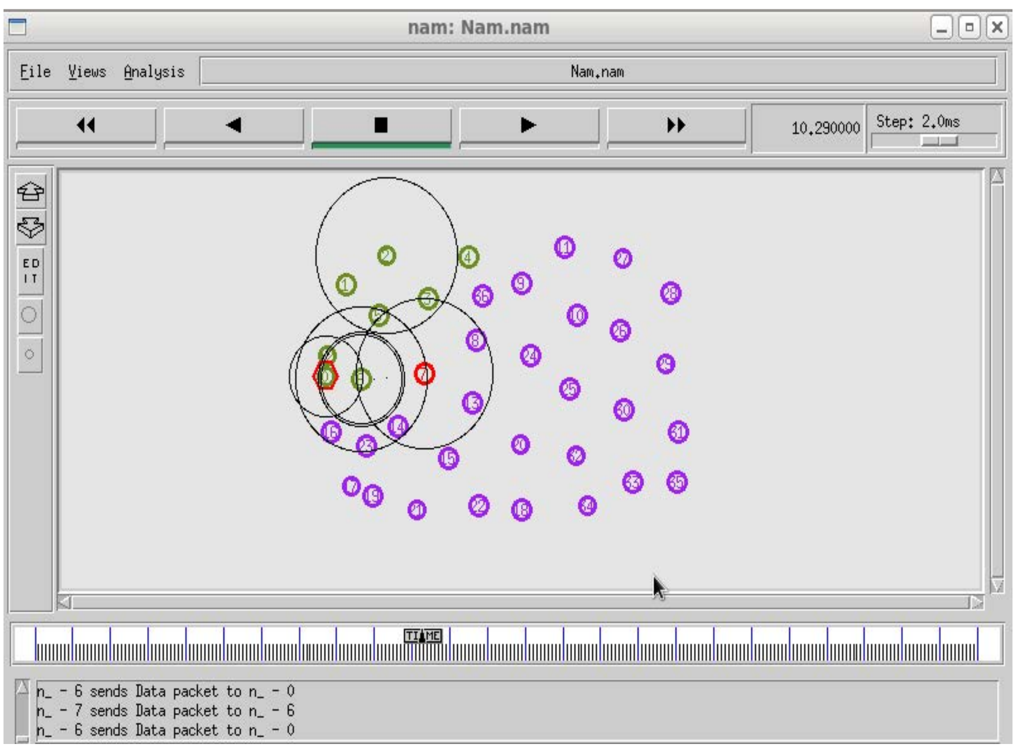

Fig. 6: Execution of HEED in NAM window

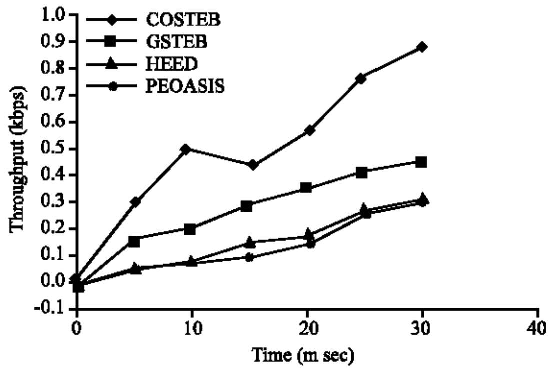

Fig. 7: Comparison of throughput-GSTEB HEED, PEGASIS and clustered GSTEB

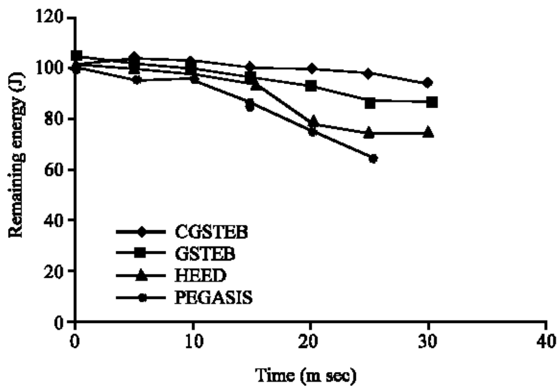

Fig. 8: Comparison of energy consumption-GSTEB HEED, PEGASIS and Clustered GSTEB

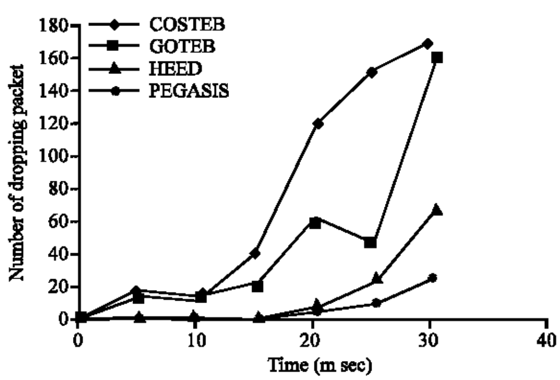

Fig. 9: Comparison of packet dropping ratio-GSTEB HEED, PEGASIS and clustered GSTEB

that clustered GSTEB has least packet dropping ratio compared to others. Because of GSTEB protocol is modified with clustering. Figure 10 shows a comparison of packet delivery ratio-GSTEB, HEED, PEGASIS and Clustered GSTEB. It shows that Clustered GSTEB has highest packet delivery ratio compared to all other protocols because of cluster and tree formation.

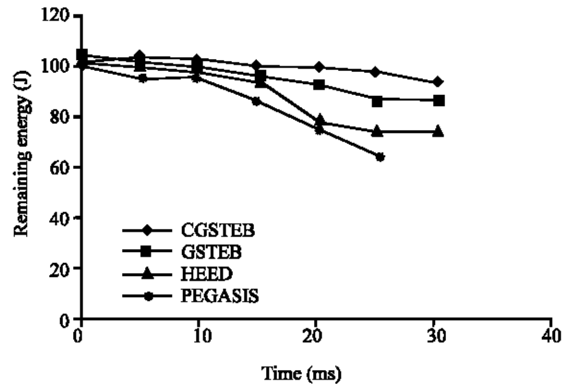

Fig. 10: Comparison of packet delivery ratio-GSTEB, HEED, PEGASIS and clustered GSTEB

CONCLUSION

GSTEB protocol is modified with clustering structure. The performance of clustered GSTEB protocol compared with other three routing protocols (GSTEB, HEED and PEGASIS) parameters like throughput, energy consumption, Packet dropping ratio and Packet delivery ratio. From the results obtained it is examined that clustered GSTEB provides better performance interms of throughput, energy consumption and packet dropping ratio. Clustered GSTEB minimizes energy consumption compared to other two protocols.

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