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The mobile data collectors have high energy resources

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***Abstract*---**Most of Energy is saved due to the introduction of mobile nodes for data collection. Apart from this, we are reducing the load for mobile data collectors also. In general, mobile data collectors have high energy resources. But it is not possible in all terrains. This FERP gives better results in military and plateaus, and irregular terrains where multihop communication is complex. This work is further enhanced by Trust node based routing to improve the lifetime of the network. Mobile Node-based routing is an efficient routing technique compared to traditional approaches. Due to this FERP majorly data isolation is provided for sensor nodes, and the network is more energy efficient. The Mobile data collector collects data from only Family heads and forwards to the cluster head. The Node level energy saving scheme is proposed in this work. The performance of this routing protocol is assessed based on Energy consumption, Throughput, Lifetime, Packet Delivery Ratio, Energy efficiency.

***Keywords*---**Energy, Network, Efficient, Communication, Mobile.

Introduction

WSN is an arrangement of a group of sensor nodes, which can communicate through wireless links and can work together to detect the physical environment. These physical things and convert them into equivalent electrical quantities. This WSN transforms gross mechanical actions into subtle sensory responses. The data gathered from various sensor nodes are aggregated and send to the base station (BS). The sensor node is equipped with five modules, which are memory unit, processor, power unit, group of sensors, and Transceiver. The processor has a command control among these modules. The major challenge of WSN is giving high throughput with limited resources like processing power, limited bandwidth, and storage space. Clustering is an effective way that makes the network consume a low amount of energy, so the network will be more energy efficient. Clustering is nothing but the arrangement of sensor nodes into several groups, and every group is allotted with a cluster head to communicate with the base

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station. The interference reduction, low energy consumption, and lifetime improvement are the major advantages of clustering. Sensor nodes sense the physical state of the target area, process, and transmit information. The application of WSNs includes a microelectromechanical system, low power digital electronics, and low power radio frequency design systems. Sensor nodes consist of transceivers, power Source, microcontroller, and external memory. Since sensor nodes do not need manual maintenance, their Energy resources follow the scavenging principle.

Technological improvements in wireless sensor networks cause drastic changes in every field. WSN introduces so many developments in the fields of environmental monitoring, medical, industrial, military, and social, habitat monitoring, surveillance [1], etc. Many sensor nodes in a cluster can forward their sensed data to the cluster head. The cluster head can forward the data after data gathering, to the base station (BS). For this data gathering, several tree-structured techniques [2] are proposed in conventional protocols. The redundant data can be eliminated in Data Gathering Trees [DGT] by aggregating sensed data of the sensor node with child nodes data of a particular sensor node, before forwarding to the parent nodes [3]. The malicious node identification is also one of the major challenges for WSN [4]. The malicious behavior of the node degrades the performance of the network, reduces QOS, fault data transmission, unnecessary energy wastage, etc. There are several approaches present in recent days to identify malicious node identification along with lifetime improvement [5]. The trust value of the node can be calculated from its residual energy and its trustiness of data sensing. If its trust value is less than the predefined minimum acceptable value of trust, then it is called an entrusted node [6].

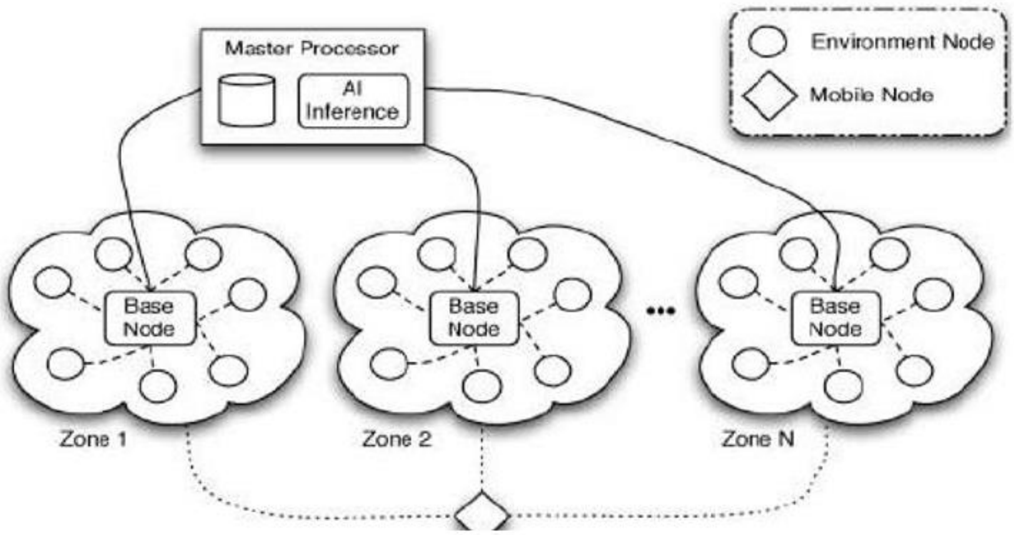

Fig .1 General scenario of WSN

The motivation of the Paper

Most of the terrains are not uniform and deployment of sensors in those terrains is a complex challenge because random deployment is not giving good results. Some terrains like military areas and plateaus have different terrain structures and those structures have several issues from deployment to lifetime.

1) Traditional clustering methods are not giving better results in plateaus.
2) Introducing Mobile Data Collectors in Sub Clusters for Data isolation among nodes.
3) Reducing overhead and delay of the Network.
4) Providing long life for Mobile Data Collectors for High throughput and better QOS.

Contributions of the Paper

Apart from traditional approaches in WSN, we are following cluster-based routing and apply this CBR to Sub clusters for reducing the delay, and energy consumption of the network. In this Family-based Efficient Routing Protocol, Each sub-cluster is assigned with at least one mobile node for data gathering. The mobile node collects data from each node in the sub-cluster individually and forwards to the cluster head. The major contributions of the paper are:

1) Divide Clusters into Sub clusters for Efficient Distributed Clustering
2) Each sub-cluster is divided into various families according to their residual energy and distance.
3) Each Sub-cluster is assigned with at least one mobile node for data gathering
4) Each Mobile node is collecting data From the Family head node and report it to the cluster Head.

Related Work

WSNs can extant the distinctive benefits and suppleness with respect to low-power and economical fast deployment for several applications. The sensor arrangement is a critical issue for some important objectives in WSNs like coverage, lifetime, and connectivity. Deployment of tactic was based on potential field theory to deploy the mobile sensor nodes in an unknown environment to enhance the network coverage [8]. Numerous energy-efficient schemes are defined as a cluster-based routing is found to be a more energy-efficient and ascendable way to form sensor nodes [9]. As the shortest path spanning trees instinctively have a short delay, it is extremely significant to find an energy-efficient shortest-path tree for time-critical applications [10]. Hybrid Energy-Efficient Distributed Clustering (HEED) was reported which is a multi-hop clustering algorithm for WSN. HEED contains distributing energy consumption to prolong the network lifetime, reducing energy consumption during the CH selection phase, and reduce the control overhead of the network [11]. Efficient Sleep Awake Aware (EESAA) is an intelligent routing protocol for WSNs which introduced a technique of pairing among nodes. Among these pairs, just a single member node awakes in each round to forward sensed data while the other member node stays in sleep mode to save the energy resources [12]. Deployment of relay nodes results in fault-tolerance in heterogeneous WSN with higher network connectivity. Heterogeneous

WSN contains sensor nodes with unlike transmission radius. Further relay node proved more advantages when deployed in clustered sensor networks [13]. Chuanhe et al., (2007) [14] was introduced a reputation-based trust management scheme using a stimulus mechanism. Trust management scheme encourages packet forwarding and discourages selfish behaviors based on quantified objective measures and reputation propagation by a one-way hash chain based authentication. The performance of this scheme in the malicious nodes, as may be expected in a hostile environment has not been investigated.

Trust and Energy-aware Routing Protocol were proposed for WSNs and it aims to address the energy limitations. By keeping the resource-constrained characteristics of WSNs in mind, the design of Trust and Energy-aware Routing Protocol is centered on trustworthiness and energy efficiency. Routing Protocol is capable of dynamically sensing and segregate misbehave nodes during the trust assessment phase while the energy awareness feature was incorporated in the route setup phase which helps in improved load balancing among trust nodes [15]. The hierarchical trust management for WSNs performs multipath routing when intrusion is detected in wireless sensor networks. It evaluates the trustworthiness of the node using a subjective trust (performance at running time) and objective trust (node status) [16]. High consumption of energy during data collection and distribution process is decreased using a clustering method; hierarchical routing capitalizes upon these benefits by the division of nodes into clusters. The clustering method generally selects the node with more energy as Cluster Head (CH), which collects the information and transmitted through lower-energy nodes by clustering method [17].

Methodology

In a Wireless sensor network, the Deployment of sensor nodes is uneven due to its terrain structure. These sensor nodes form as groups, and each group is assigned with a head node. This group is called Cluster, and the Head node is called Cluster Head. The CH should be in the middle of the sensing region to get effective results with limited energy. In this type of Mobile-based data collection method, at least one or two mobile nodes are assigned for each cluster. Here all nodes are assigned with uniform energy and assigned with a number called Member ID.

1) The sensor nodes are deployed randomly in a distributed fashion and static.
2) The sensor nodes can communicate with neighbors and they can send their sensed information to Cluster Head.
3) Each node is assigned with high energy, and a unique ID is allotted to each node to avoid redundant packets from sensor nodes.
4) The node has to use power level dynamically for Transmission when equipped with a low amount of energy
5) Node position should be calculated based on Residual signal strength.

1. Energy Consumption Model:

In the network, If a sensor node is placed in a location L, and it has to transmit a message of K bits of Data to a distanced, then E (Trans)k,d =

$$\begin{cases} k \times E(elec) + d \times\propto (fs) \times d^2\,, & d < d(0) \\ k \times E(elec) + d \times\propto (mp) \times d^2\,, & d \geq d(0) \end{cases} \quad (1)$$

The amount of energy utilized to receive k-bit message for a sensor node in a network is

$$E\ (rec)_{\mathbf{k}} = k\times E(elec) \quad (2)$$

The total Amount of energy consumed to aggregate P messages with k-bit each is computed as,

$$E(agg)_{\mathbf{p,k}} = k \times P \times E(da) \quad (3)$$

Where

E (da) is the amount of energy dissipated per a single bit to aggregate message signal.

E (elec) is the energy consumed by the sensor node for a bit of data transmission.

In J round, the energy consumed by Cluster Head is given in equation 1.

$$Residual\ Energy = RE + S(i) * E \quad (4)$$

The average residual energy (ARE) is calculated by using following equation,

$$ARE(Round + 1) = \frac{RE(Round+1)}{2} \quad (5)$$

The Total Energy Consumption (TEC) on each rounds are calculated using the following equation.

$$TEC(Round + 1) = E_0 * n - RE(Round + 1) \quad (6)$$

In case are 'H' layers available in the network, the average energy consumption of node can be defined as

$$AEC(Round + 1) = \frac{TEC(Round+1)}{H} \quad (7)$$

2. Proposed Method

2.1. Problem Statement

Wireless sensor networks suffer from energy limitations and a lack of lifetime improvisation techniques. The traditional approaches do not give uniform results for all types of terrains. According to nature, all terrains are not uniform, and flat.

Some important geographical areas like the military and plateaus suffer from irregular terrains. Uneven deployment is also one of the major problems in WSN. Introducing mobile nodes among clusters is an efficient technique and it gives good results for WSN compared to other protocols. Depends on the type of application various routing protocols are proposed. A single protocol is unable to give good results in all-terrain structures. For plateaus, we are proposing a new form of Clusterbased Routing which gives several advantages compared to traditional approaches.

2.2. Family Based Efficient Routing Protocol

The Family-based efficient Routing protocol is implemented in Wireless Sensor Networks to improve the energy efficiency of the network. The major parameters Lifetime, throughput, quality of service are dependent on energy efficiency. SO if we can make network energy efficient, automatically remain parameters like a lifetime, QOS, throughput increases automatically. The Design flow of FERP is discussed in this section. In Distributed sensor networks, organize sensor nodes into clusters, and these clusters are divided into sub-clusters, and each sub-cluster is assigned with a mobile node for data collection. This Mobile node-based data collection is an efficient technique than traditional approaches. In the proposed system, we are assigning a mobile data collector for each sub-cluster, and divide sub-cluster nodes into various families, according to their residual energy as shown in Figure 2.

Phase 1: During the initial phase, sensor nodes identify their neighbors and compare their residual energy with their neighbors. The highest node elected as Family Head, and the maximum numbers of nodes per family are based on nodes density in the sub-cluster. If heavily loaded sub-cluster can form more number of families, and nodes per family would be also more.

*Phase 2***:** The family head nodes give an Intimation message to the mobile node, about their position, residual energy value, and Family Head number with their respective ID. The family head node aggregates the data from its family members and gives it to the Mobile node.

Phase 3: For every five rounds of data collection, the family nodes again compare their Residual energy with neighbors, and again families are reformed based on residual energy. After FH is re-elected, again family heads have to give intimation about their location to the mobile node.

2.3. Objectives and Advantages of Proposed Aggregation Algorithm

The main advantages of the proposed algorithm, compared to conventional algorithms are listed below:

1) Conventional Cluster-based routings and data aggregation algorithms are unsuccessful to give optimum results in plateaus and military applications. But this algorithm gives better results in Network Loss, Lifetime, and Energy efficiency.

2) Data isolation is provided by introducing mobile nodes as data collectors. Due to Mobile node data collection, neighbor node interferences are greatly reduced.
3) Dynamic Energy saving is possible due to Family-based Routing
4) Less loaded and heavily loaded sub-clusters can take decisions dynamically to share the mobile node energy resources.
5) Less Overhead, High QOS, large throughput, and more lifetime of the network are achieved by using this protocol.

2.4. Energy Consumption Model for Proposed Algorithm

The Energy consumed by mobile data collector to collect data from each sensor node with a message bit length 'k' is given as

$$E_{(MDC)} = k \times E_{elec} + k \times E_{s} \times r_{h(\ )}^2 \quad (\ ) \qquad (8)$$

Where E $_{(MDC)}$ is the Energy consumed by Mobile data collector node, and r_h is the average distance between mobile data collector and cluster head.

$$r_h^2 = \frac{L^2}{2\pi K} \qquad (9)$$

RE is the residual energy consumed by the cluster head for R bits of data transmission in particular round, and it is expressed as

$$RE = \left(\frac{T}{f} - 1\right) \times k \times E_{(elec)} + \frac{T}{f} \times k \times E_{(d)} + k \times E_{(elec)} + \propto (fs) \times r_d \quad (10)$$

Where,
T is the number of nodes equally dispersed over the square area L $\times$L.
E $_{(d)}$ is the energy consumed per bit report to the base station, and r_d is the distance between cluster head to the base station.

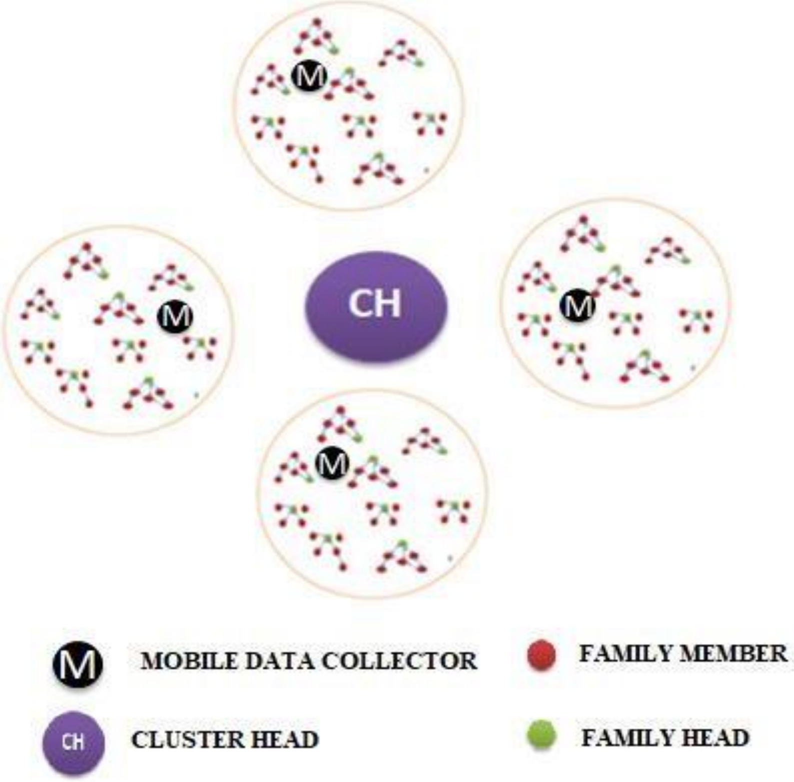

Figure 2. Design structure of FERP in WSN

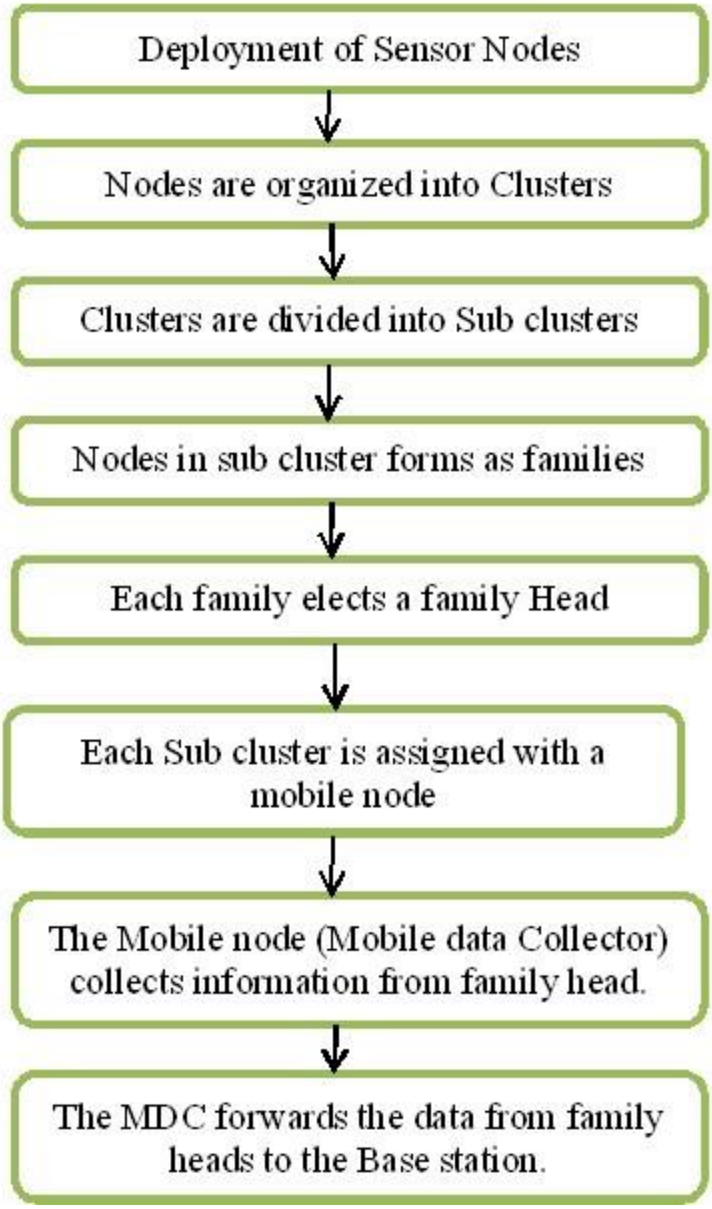

Figure 3. Design Flow of FERP in WSN

Performance Analysis

A family-based efficient routing protocol is different from other protocols in data collection, and routing techniques. In previous works, the authors proposed a mobile data collector among clusters, and further, it can be improved by assigning mobile nodes to sub-clusters for data collection. In this protocol, we are saving the energy consumption of the network at the node level. The election of family head is based on residual energy. By simulating the network by applying this FERP algorithm, we have several advantages by comparing the results with existed works. This FERP algorithm is compared with NBBTE (Node Behavioral Strategies Banding Trust Evaluation Algorithm), and SNIDP (Suspicious node information dissemination protocol), GLBD, MLPA techniques. The FERP performance is evaluated under the following metrics: (i) Energy efficiency (ii) Energy Consumption (iii) Throughput, (iv) lifetime of the network.

Results and Discussions

The results of conventional algorithms MLPA, GLBD, NBBTE, and SNDP are compared with the proposed algorithm FERP. The simulation of the proposed work is performed and simulated using the ns2 simulator. The FERP protocol is implemented with a number of nodes 50, and these sensor nodes are randomly deployed in the area of 1320*1032 m with in the field of coverage. The base station is located inside the sensing field i.e. at the centre of the sensing area. This base station is also called a sink.

Table-1
Simulation parameters

Parameters	Values
Simulation Period	100ms
Coverage Area	1320*1032
No of Nodes	51
No of sink node	1
No of mobile node	5
No of Sub cluster	5
No of Cluster Head	1
Traffic Type	CBR
Agent Type	UDP
Routing protocol	AODV
Initial power	100 J
Transmission Power	1 J
Receiving Power	1 J
Queue Type	Drop-Tail

Network Lifetime

The network lifetime depends on the number of data gathering rounds that those sensor nodes can withstand with minimum residual energy. Lifetime is the key parameter that decides throughput and robustness of the network. The lifetime of the node depends on the energy consumption of the sensor node and remaining residual energy of the node. The figure shows lifetime comparison graphs of various protocols. The lifetime of FERP protocol is 1494 and the other NBBTE algorithm is 1265, SNDP is 969, GLBD is 1165, and MLPA is 1389.

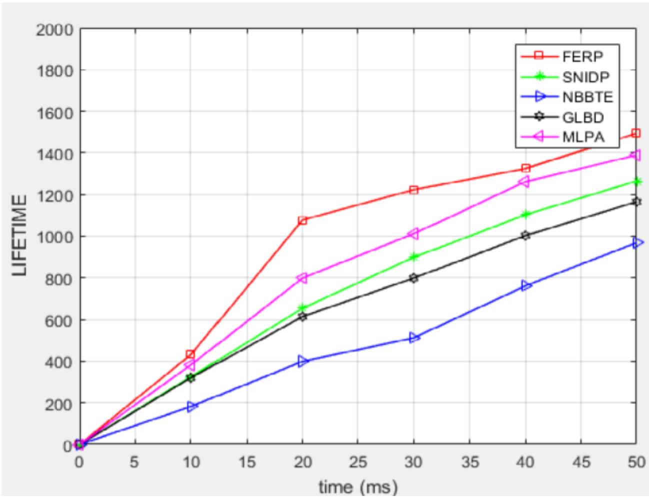

Fig. 4 Network lifetime comparison with existing systems

Energy Efficiency

Energy efficiency and lifetime improvement have a linear relationship. Energy efficiency depends on the energy consumption of the network and other parameters like the number of nodes, the average energy of the network, etc.

$$Energy\ Efficiency = \sum_{i=1}^{n} E_i$$

The figure shows lifetime comparison graphs of various protocols. The energy efficiency of the FERP protocol is 57 and the other NBBTE algorithm is 54, SNDP is 52, GLBD is 56, and MLPA is 35.

Energy Consumption

The Energy consumption of the network includes energy consumed by the sensor nodes, transceiver, processor, and memory unit. Energy consumption and lifetime improvement have a linear relationship. The figure shows the energy consumption comparison graphs of various protocols. The energy consumption of FERP protocol is 40 and the other NBBTE algorithm is 46, SNDP is 48, GLBD is 44, and MLPA is 65.

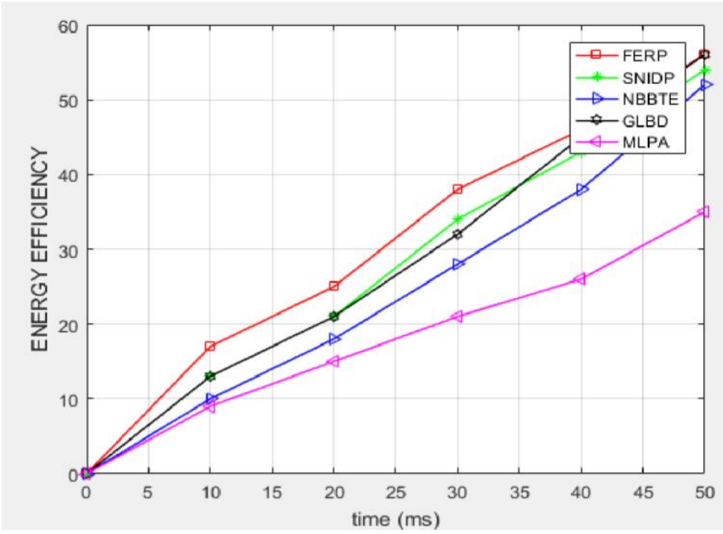

Figure 5 Energy Efficiency comparison graph with existing system

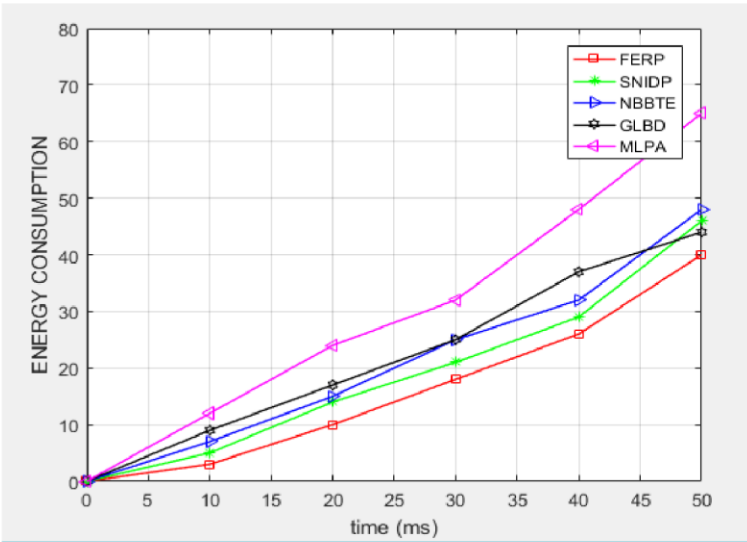

Figure 6 Energy consumption comparison graph with existing system

Network Throughput

The network throughput depends on the number of packets forwarded by the non-base station and the number of packets received by the base station. The throughput of the FERP algorithm is 1526 KBPS, and the other NBBTE algorithm is 969, SNDP is 1265, GLBD is 886, and MLPA is 542.

Packet Delivery Ratio

The packet delivery ratio is the ratio between the numbers of packets initiated by the source in the network to the number of packets received by the sinks in the network. The PDR of the FERP algorithm is 97.040, and the other NBBTE algorithm is 97.02, SNDP is 97.69, GLBD is 91.77, and MLPA is 77.

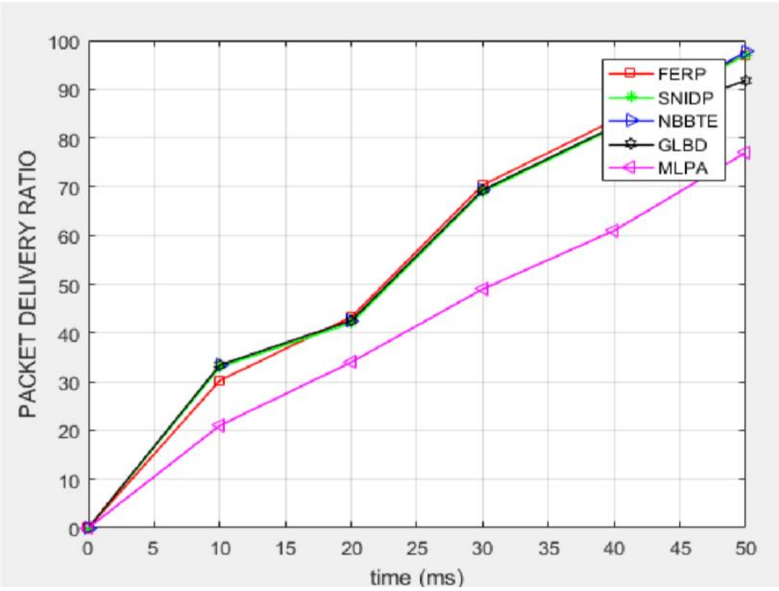

Figure 8: Packet delivery ratio comparison graphs with existing system

Table-2

Comparison between existing and proposed load balancing algorithms

PARAMETER	NBBTE	SNIDP	FERP (proposed)
Packet delivery rate	77%	72%	97.12%
Control overhead	1265 packets	1564 ackets	952 packets
Energy Consumption	65%	80%	42%
Energy efficiency	35%	20%	56%
Throughput	542 Kbps	244 Kbps	1526 Kbps
Loss	432 packets	564 packets	164 packets
Lifetime	35%	20%	59% (1400 Rounds)

Conclusion

Mobile Node-based routing is an efficient routing technique compared to traditional approaches. Due to this FERP majorly data isolation is provided for sensor nodes, and the network is more energy efficient. The Mobile data collector collects data from only Family heads and forwards to the cluster head. The Node level energy saving scheme is proposed in this work. The performance of this routing protocol is assessed based on Energy consumption, Throughput, Lifetime, Packet Delivery Ratio, Energy efficiency. Most of the Energy is saved due to the introducing of mobile nodes for data collection. Apart from this, we are reducing the load for mobile data collectors also. In general, mobile data collectors have high energy resources. But it is not possible in all terrains. This FERP gives better results in military and plateaus, and irregular terrains where multihop communication is complex. This work is further enhanced by Trust node based routing to improve the lifetime of the network.

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