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An Improved Precipitate Energy Balanced Routing Method for Wireless Sensor Networks

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***Abstract*--Wireless Sensor Networks (WSNs) are one of the types of Wireless Networks consists of collection of light-weight sensors which are battery powered majorly used for monitoring purposes. In these sensor networks,lots of energy sensor nodes arepresented as virtualin a particular network coverage area. Efficiency of energy, Limited storage capacity and computing capability, high data error rates, scalability in processing with a large number of sensor nodes, Survivability in harsh environments, experimental time are some of the issues of Wireless Sensor Networks. To overcome these issues, many researchers have been developed various routing protocols for Wireless Sensor Networks. With the aim of increasing the network performance into some extent, Improved Precipitate Energy Balanced Routing Method (IPEBRM) is proposed in this paper and the performance of proposed method is compared with the existing methods like LEACH, EBRMFAF using NS-2 Simulator in terms of performance metrics such as Throughput, Packet Delivery Ratio, Packet Loss Rate and End-to-End Delay.**

***Keywords*-- Energy *Balance*, LEACH, EBRM-FAF, NS-2 Simulator and Wireless Sensor Networks (WSNs).**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) is the active and emerging research area in the field of Wireless Networks over the last two decades [1] [2]. It is also considered as effective medium for integrating physical world and information world of Industrial Applications (IAs).

The sensor nodes of this network work with each other for sensing some physical phenomenon and the information gathered through them is processed as well as analyzed for getting relevant results. Number of algorithms and their respective protocols with self-organizing capabilities play a significant and vital role in Wireless Sensor Networks [3] [4].

The topology of each node and network has the high impact in minimizing some tasks of Wireless Sensor Networks such as energy limitation, network latency, computational resource disaster and the quality of accessing data communication. Security routing, low access control, coverage area problem, less efficiency of energy and security are the major issues of WSNs. Expanding the lifetime of the sensor networks and preserving a balanced energy expenditure of nodes are still the very challenging issues of Wireless Sensor Networks [5] [6].

To overcome these issues and improve the network performance into some extent, researchers concentrate on routing methods at present era. To achieve this goal also, LEACH and Energy Balanced Routing Method on Forward Aware Factor (EBRM-FAF) are proposed by Degan Zhang et al in February 2014[7].

It balances the energy into some extent. Avoiding the unwanted nodes which affects the system performance is not clearly discussed in that method. To address this issue, the method IPEBRM is proposed in this paperand its detailed description is given in Section 3.IPEBRM balances the energy consumption and increases the lifetime of the network and also reduces the process time.

1.1 Overview of the proposed model

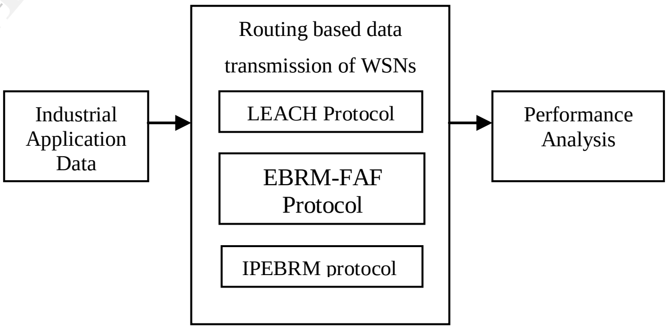

Fig.1.Block Diagram of the proposed system

An overview of the proposed system is given in Fig.1. The routing based data transmission of Industrial application data for existing LEACH, EBRM-FAF and proposed IPEBRM methods are tested in the Wireless Sensor Networks to analyze their performance using performance metrics Throughput, Packet Delivery Ratio, Packet Loss Rate and End to End delay.

II. IMPROVED PRECIPITATE ENERGY BALANCED ROUTING METHOD (IPEBRM) PROTOCOL

The main goal of the proposed protocol is to decrease the data loss in Wireless Sensor Network, and reducing unnecessarydata transmissions for avoiding the redundancy. By implementing this protocol, WSNs frequently updates its neighbors (sensor nodes which are in direct transmission range). If WSN finds a sensor node within its transmission range, it would check the node ID to identify the group of the nodes. After identifying the particular group or cluster, the sink node transmits the message to the respective group of sensor nodes that are distributed in a uniform manner. By using the IPEBRM protocol, number of sensor nodes are accessing the same content of Wireless Sensor Network is decreased exponentially in some complex scenarios of WSNs such as low distance between two neighbor sensor nodes and more sensor nodes density. This functionality of IPEBRMprotocol significantly reduces redundant broadcasts within the WSNs coverage area.

The IPEBRM protocol in sensor nodes decides whether or not to accept the content from the sink node in broadcast communication. The advantage of Improved Precipitate Energy Balanced Routing Method (IPEBRM) protocol is the size of the data packet which is not increased while adding the list of forwarding neighbors. The main challenge in the design of IPEBRM protocol for sensor nodes is to find out whether the received message from Sink node is to be the broadcast or not. The step by step process of IPEBRM protocol is shown below.

Step 1: Build an Wireless Sensor Network by creating sink source sensor node to neighbor sensor node distance within the range of 200 meters using Distance = square root ((x1-x2)^2- (y1-y2)^2) in which x1 and y1 mention x axis and y axis positions of source node and x2 and y2 point out x axis and y axis positions of each node.

Step 2: Wireless Sensor nodes are partitioned into different group (clusters) of sensor nodes such as c1, c2, c3 and c4.

Step3: Store the details such as Time, source, Neighbor sensor node and Neighbor node count in a separate file similar to the neighbor details.

Step 4: Store neighborhood forwarding sensor nodes in a file separately which contains Group name, the node ID, neighbor node ID, X position of node, Y position of node, distance between node and Neighbor node using “proc” command.

Step 5: one sensor Node to other sensor node relationship is carried out to find the shortest path for transmitting content using the source to node distance calculation file.

Step 6: Neighbor sensor node information are updated for each time for effective data Transmission in a routing method.

Step 7: Sink node take individual group as a input for which message is transmitted and repeated through steps 1 to 3.

Step 8: Broadcast transmission occurs if WSN finds sensor nodes within the coverage area at particular time interval.
Attime’t’, if Neighbor_count has distinct values, transmit the message to Neighbors.

Step 9: A particular sensor node can avoid broadcasting of data if its neighbor sensor has already received the same content from Sink or it finds another stranger sensor node closer to its neighbor sensor nodes that has the same content.

Step 10: After certain time duration (approximately 0.4 seconds), stop the transmission and read the next neighbor sensor node information from the file.

A cluster head sensor node can broadcast content to its neighboring sensor nodes (atleast one sensor node) which have not received within a particular defer time interval. The IPEBRM protocol clearly determines that whether the broadcast process is redundant or not. If access time (communication time between sink and destination) of a particular sensor node (X) is low compared to the maximum access time of another sensor node (Y) in the same group, then X will communicate with Y for accessing the data. However, the broadcast gets redundant if all such neighbor sensor nodes receive the message from other sensor nodes even though time interval is expired. The proposed protocol reduces the redundant broadcasts without changing the access time design of MAC-layer. It reduces the computational complexity by selecting maximum number of forwarding neighborhood sensing nodes for the sensor nodes to improve the overall network performance. The IPEBRM protocol helps the nodes to utilize the resources effectively within the WSNs coverage area. So it leads to build an efficient Wireless Sensor network.

III.EXPERIMENTAL RESULTS

The performance of LEACH, EBRM-FAF and IPEBRM methods are analyzed in non real time environment by using NS2simulator. The NS-2 is an acronym for Network Simulator version 2. It is a discrete event simulator and is a standard experiment environment for the research community in networking. It is used to build non real time vehicular ad-hoc environment at low cost. It works at packet level and provides support to simulate group of protocols like TCP, UDP, FTP and HTTP. It also simulates for wired and wireless networks. The simulation area or open area topology of NS-2 execution is 1000 meters x 1000 meters by means of 4m/s node velocity. Simulation path is used to indicate the source to destination connections. Different performance metrics have been chosen to evaluate different techniques or different protocols. AODV is used for basic route discovery and maintenance operations.

The parameters such as Throughput, Packet Delivery Ratio, Packet Loss Rate and End-to-End Delay are used to evaluate the performance of the proposed method for data transmission in routing and compared to others. The performance metrics are shown with their formulae in Table 1.

Table 1: Parameters with its Formulae

PERFORMANCE METRICS	FORMULAE
Throughput	$\frac{\text{No of received packets x packet size}}{\text{Transmission Time}}$
Packet Delivery Ratio (PDR)	$\frac{\sum \text{No of packets received}}{\sum \text{No of packets sent}} \times 100$
Packet Loss Rate (PLR)	(No. of packet sent – No. of packet received)
End-to-End Delay	$\frac{\text{Simulation processing time}}{\text{Overall transmission time}}$

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The amount of work that is successfully done by a WSN within a particular amount of time is called as throughput. It measures the effectiveness of routing methods. The routing based transmission approach IPEBRM achieves high throughput when compared to LEACH and EBRM-FAF methods. The throughput values governed by these methods for various sensor nodes in different transmission times 60s, 120s, 180s, 240s, and 300s are tabulated in Table 2 and its graphical representation is given in Fig.2.

Table 2: Average Throughput (bps) of routing methods

Transmission time (sec)	Routing Methods		
	LEACH	EBRM-FAF	IPEBRM
60	6553	7099	7645
120	3686	4164	4437
180	2776	3094	3322
240	2389	2525	2696
300	2048	2157	2348

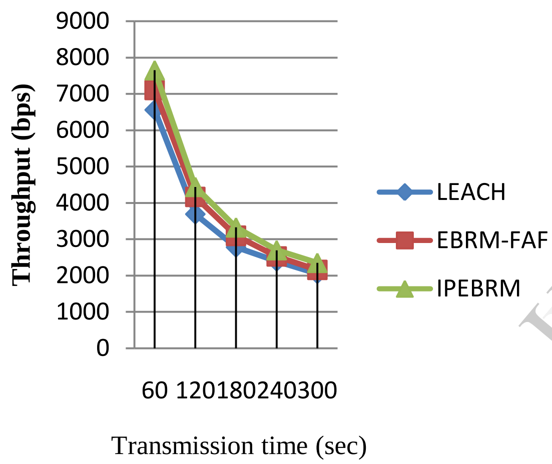

Fig. 2. Average Throughput of Routing Methods for 40 nodes

From the simulation results, it is noted that the LEACH protocol or method achieves low throughput values compared to EBRM-FAF and IPEBRM. Its values are get decreased when transmission time increases. The same result is reflectedfor EBRM-FAF and IPEBRM. But they achieve high throughput values than LEACH. Among these three methods, proposed IPEBRM achieves high throughput values.

Packet Delivery Ratio (PDR) is the ratio of the number of packets received successfully and the total number of packets transmitted by the source. It is the ratio between sum of total number of packets received by sensor nodes and sum of total number of packets sent by the source. It measures the data loss rate of the data transmission approaches and also used to find out efficiency, completeness and scalability of the approaches used in WSNs. The average Packet Delivery Ratio (PDR) values earned by these approaches for various sensor nodes in different transmission times 60s, 120s, 180s, 240s, and 300s are tabulated in Table 3 and the graphical representation of the same is given in Fig 3.

Table 3: Average Packet Delivery Ratio (PDR) (%) of routing methods

Transmission time (sec)	Routing Methods		
	LEACH	EBRM-FAF	IPEBRM
60	48	52	56
120	54	61	65
180	61	68	73
240	70	74	79
300	75	79	86

According to the simulation results, the PDR values of proposed IPEBRM are high compared to LEACH and EBRM-FAF whereas LEACH has low PDR values. EBRM-FAF provides high PDR values than LEACH and less PDR values than IPEBRM. For the three methods, the Packet Delivery Ratio (PDR) values are getting increased while the transmission time increases.

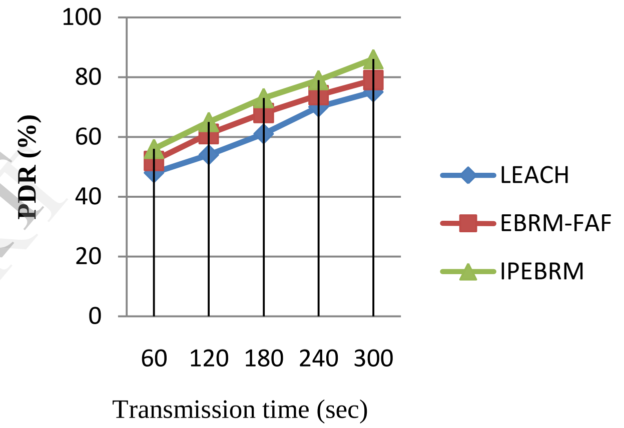

Fig. 3.Average PDR of Routing Methods for 40 nodes

Packet Lost Rate (PLR) is the total number of packets dropped during the Simulation is called as Packet loss rate which is used to find the inefficiency of particular method or protocol in NS 2. Packet Loss Rate (PLR) is the difference between number of sent packets and received packets by the SINK node and DESTINATION sensor nodes respectively. It is used to calculate how many packets are missing during the transmission, and it also helps to analyze the routing methods. The average Packet Delivery Ratio (PDR) values earned by these methods for various sensor nodes in different transmission times 60s, 120s, 180s, 240s, and 300s are tabulated in Table 4 and the graphical representation of the same table is given in Fig 4.

Table 4: Average PLR (%) of routing methods

Transmission time (sec)	Routing Methods		
	LEACH	EBRM-FAF	IPEBRM
60	52	48	36
120	46	39	29
180	39	32	20
240	30	26	14
300	25	21	8

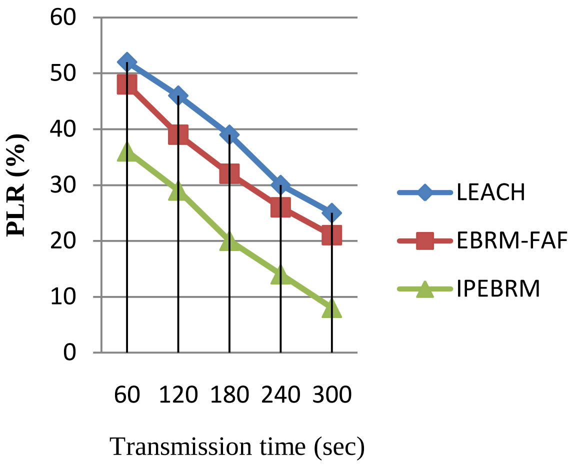

Fig. 4. Average PLR of Routing Methods for 40 nodes

From the simulation results, it is revealed that Proposed IPEBRM method achieves low PLR values than LEACH and EBRM-FAF. The PLR values are getting decreased while the transmission time increases.

The ratio between the processing simulation time and overall simulation time is called as End-to-End Delay. It is used to identify which routing method is best. The average End-to-End Delay values obtained by these methods for various sensor nodes in different transmission time 60s, 120s, 180s, 240s, and 300s are tabulated in Table 5 and the graphical representation of the same is represented in Fig 5.

Table 5: End-to-End Delay (ms) of routing methods

Transmission time (sec)	Routing Methods		
	LEACH	EBRM-FAF	IPEBRM
60	2.3	1.6	1.1
120	3.4	2.7	1.9
180	4.5	3.2	2.6
240	5.2	4.1	3.3
300	7.1	6.3	4.8

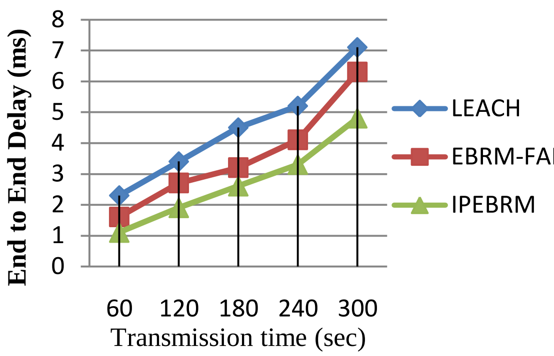

Fig. 5. Average End-End Delay of Routing Methods for 40 nodes

The proposed IPEBRM method achieves very low delay times compared to existing methods. For the increasing transmission times, the value of delay also increases. The same is also repeated in LEACH and EBRM-FAF also. But comparing them, IPEBRM is a better routing method. The overall performance of all the routing methods are tabulated in the following table 6 and their pictorial representation to understand easily is given in Fig 6.

Table 5: Overall performance of All Routing Protocols

Performance Metrics	LEACH	EBRM-FAF	IPEBRM
Throughput	63%	71%	82%
Packet Delivery Ratio	56%	64%	76%
Packet Loss ratio	55%	45%	33%
End to End delay	24%	15%	11%

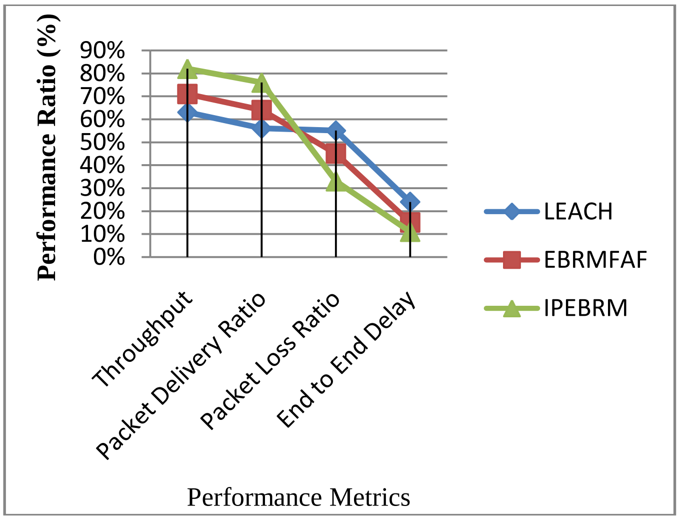

Fig. 6.Overall performance of routing methods

As illustrated in Fig 6, LEACH routing method and its respective protocol achieves fewer throughputs whereas EBRM-FAF and proposed IPEBRM method achieved 8% and 11% increased throughput than LEACH. Analyzing the overall Packet Delivery Ratio values, proposed method achieves 20% higher throughput than LEACH and 8% than EBRM-FAF method. According to the Packet Loss Ratio values achieved by these methods, proposed IPEBRM only achieved less PLR values. It has 22% less PLR values than LEACH and 12% less than EBRM. At last, by evaluating the delay values LEACH method and EBRMFAF method have 24% and 15% delays. Proposed IPEBRM achieves 13% less delay values than LEACH and 4% fewer delays than EBRM method.

As per the Experimental Results and Analysis, it is revealed that the proposed routing method IPEBRM achieves high throughput, high Packet Delivery Ratio, Less Packet Loss Rate and low End to End Delay and so it is clearly declared that Proposed IPEBRM is the better routing method, while comparing it with LEACH and EBRM-FAF.

IV. CONCLUSION

The performance of routing based data transmission methods or protocols such as LEACH, EBRM-FAF and also IPEBRM are analyzed in Wireless Sensor Networks using NS-2 simulator. Results revealed that the proposed IPEBRM method provides better results for efficient data transmission routing from sink node of WSN to destination sensor nodes by improving the Packet Delivery Ratio, dropping the unwanted neighboring forward nodes, providing direct power for Sink node with network monitoring compared to existing LEACH and EBRM-FAF. The proposed method is very useful to sensor nodes for accessing Industrial Application Data like temperature of electronic devices etc. In future, researchers may concentrate on routing methods to facilitate high throughput, high Packet Delivery Ratio (PDR), low Packet Loss Rate (PLR) and Less Delay even though complex scenarios will occur in Wireless Sensor Networks such as increased transmission time and more sensor nodes density.

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