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Enhancement of Routing Performance for Energy Efficiency and Critical Event Monitoring in Wireless Sensor Network

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Abstract: *In Wireless Sensor Network, because of limitation on sensor node energy, the energy efficiency is a major concern which should be deliberated while planning to design a protocol. To overcome this conflict, data grouping and accumulation should be done in this issue to decrease consumption of sensor node energy and cost of communication by aggregating data redundancy at intermediate sensor nodes to reduce number and size of alarming messages in critical event monitoring. The network for design is Ad-Hoc network. In this paper we proposed an improved algorithm Improved-Data Routing for In-Network Aggregation Data (I-DRINA) whose results are compared with existing known protocols as Data Routing for In-Network Aggregation (DRINA) and Low Energy Adaptive Clustering Hierarchy (LEACH). The proposed protocol has designed for improvement in path routing in network and stables the energy consumption in the wireless network to prolong the existence of network for monitoring of an event. The simulation of this project work has been done on NS2 platform for WSNs. The simulation results of proposed I-DRINA algorithm gives better improvement in results than the results of existing DRINA and LEACH algorithms for various performance parameters and different nodal scenarios in WSN.*
Keywords: *Broadcasting delay, Critical event monitoring, Energy efficiency, Wireless sensor network.*

I. INTRODUCTION

Wireless Sensor Network (WSN) consisting of the spatially distribution of independent sensor nodes that co-operatively senses the physical conditions such as temperature, pressure, sound, level etc. and sends the effective data towards the distant site through the wireless network. The WSN consists of a large number of sensor nodes which are mostly battery powered or solar powered. Hence saving of energy for these nodes is a significant issue in WSN. As the sensor nodes in network must have to work for a long time without recharging or changing the batteries [1][2]. Hence the improvement in energy efficient algorithm is very much required in WSN.

Also in WSN, many times a small message packets are required to broadcast as they are only to inform the remote server regarding the environmental situations. Such environmental situations called as the critical events. Hence while handling the critical event situations, the end to end delay required to transmit the alarming message is less enough in the WSN to wake-up network. As the broadcasting delay occurs due to sleep scheduling because of the sensing or relay node have to wait till the receiver nodes are active and ready to receive that message. Therefore broadcasting delay is also important parameter while designing the protocols for the WSN. This overall information is routed in the network in multipath manner towards the sink node. Hence data gathering at specific nodes also gives effective way to reduce broadcasting delay in the network [3][4].

To improve performance of network by considering the energy efficiency and broadcasting delay, it is necessary to improve the routing algorithms in WSN which is a challenging task. The routing performance will be enhanced with improvement in the AODV algorithm. Therefore in this project work, we have proposed the innovative approach Improved-Data Routing In Network Aggregation (I-DRINA). In this algorithm, improvement in routing algorithm to that of existing algorithm Data Routing In Network Aggregation (DRINA). This paper gives the comparative study of simulation results of existing algorithms as Low Energy Adaptive Clustering Hierarchy (LEACH), (DRINA) and proposed algorithm (I-DRINA) [1][2][8].

II. COMPARATIVE STUDY OF PROTOCOLS

In this section, we will see the overview of existing algorithms for clustering, scheduling and data aggregation which aims for energy efficiency and least broadcasting delay:

2.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

In WSNs, LEACH plays an important role to form clusters for given nodes in the network. LEACH is an AdHoc based routing protocol. In this algorithm, the clusters are formed based on the percentage of cluster heads in the given WSNs. The LEACH protocol is divided in to two phases such as Cluster Formation and Data Routing [3].

2.1.1 Cluster Formation

In this phase, the clusters are formed with following equation:

$$t(n)=\begin{cases}\frac{P}{1-p\left[r^{*}\bmod\left(\frac{1}{p}\right)\right]}, & \text{if } n\in G\\ 0, & \text{if } n\notin G\end{cases} \quad (1)$$

The cluster and cluster head is formed based on the rounds. In this one of node in the network is picks up a random value between 0 to 1. This value is compared with the threshold value T(n) for equation (1). If the randomly selected value is less than that of the threshold value T(n), then that node is selected as a cluster head in the respective round.

For the equation (1), 'n' denotes the present node. 'P' denotes the required percentage of cluster head in the network. 'r' denotes the present round for selection of cluster head. 'G' denotes the nodes which are not selected as a cluster head in (1/p) of previous rounds [1][2][3].

2.1.2 Data Routing

After the formation of clusters and selection of cluster heads in the above phase, the actual data transferred through the network. In this, if one or multiple nodes in the network detect a critical event, then that node must have to send that data to the cluster head as early as possible to the cluster head situated at remote place to wake-up overall network. The data is transferred in two phases as uplink and downlink [5][6].

2.1.2.1 Uplink

In this Phase, after detecting a critical event in the network; that node sends an alarming message to the cluster head and cluster head to remote server for further processing in the network in multi hop fashion.

2.1.2.2 Downlink

After getting the alarming message by cluster head to wake-up overall network, the cluster head broadcasts the alarming message to the entire network quickly [7].

2.2 Data Routing In Network Aggregation (DRINA)

The main aim of DRINA algorithm is to improve routing performance in the network by implementing a routing tree with shortest paths which connects overall sensor nodes to the server nodes or cluster head nodes in the network. Also the data has been aggregated in this protocol to reduce the redundancy of data [8]-[12].

The DRINA protocol divides the nodes in to following four types.

- **Collaborator:** A node which identifies an event and collectively sends data to the coordinator.
- **Coordinator:** A node which also identifies an event. That node collects data sent by collaborator nodes and sends to sink node.
- **Sink:** A node which accepts data from the collaborators and coordinator nodes.
- **Relay:** Nodes which are intermediate between the routing paths and forwards data to the sink node.

This protocol has distributed into three phases 1.Hop tree Formation 2. Cluster Formation and Leader Election 3.Establishment of Route and Hop Tree Update.

2.2.1 Hop Tree Formation

In this phase, the routing distance has been calculated in the form of hops by sending HCM (Hop Configuration Message) message starting from sink node to overall network. The HCM message has distributed in two fields: ID and HopToTree. The ID field gives the information about identifier which is started from sink node and HopToTree contains the shortest routing distance of each node from the sink node shown in Fig. 1.

The HopToTree field started by 1 at sink node and overall nodes in the network set the HopToTree field to infinity. After receiving the HCM message by node in the network; it checks the value of HopToTree in the HCM message with the HopToTree value in the nodes which is stored previously. If the value is less, then that node updates the value of NextHop variable with values in the ID and HopToTree Fields. If HCM message again received by the same node, then that message is discarded by the same node as it has already acquired the shortest distance from sink node [8]-[12].

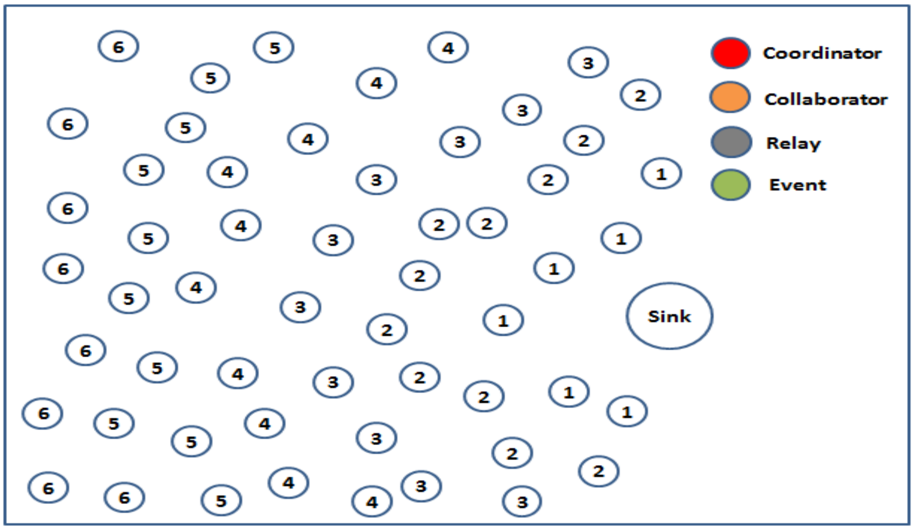

Fig. 1 Hop Tree Configuration

2.2.2 Cluster Formation and Leader Election

In this phase, if one or multiple nodes detect an event, this algorithm forms cluster of that event detected nodes. If this event is detected first round, then the node will be selected as a coordinator or leader node which is closest to that of sink node shown in Fig. 2. Otherwise the coordinator node is close to the already established routing path. If in case of tie that is two or more number of nodes are at the same distance from the sink node then coordinator node will be that node which has minimum ID in HCM. The coordinator further collects the information and sends towards the sink node with minimum hop distance [8]-[12].

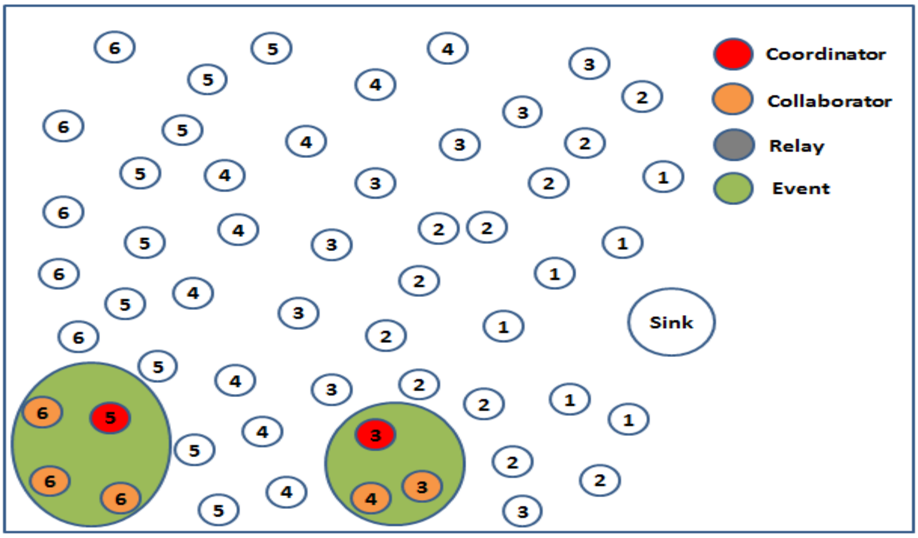

Fig. 2 Cluster Formation and Leader Election

2.2.3 Establishment of Route and Hop Tree Update

In this phase, the route is established between the coordinator nodes and sink node with the help of Route Establishment Message (REM). The coordinator nodes firstly send REM to the NextHop neighboring nodes. As the NextHop nodes get the REM message, it further retransmits to the NexHop nodes to those nodes with route table update process in the network. In this way, the Hop Updating process continues to the sink node gets the REM message or a relay node which is the part of previously established tree path towards sink node. This routing path is determined on the best suitable shortest route at each hop [8]-[12].

The Fig. 3 shows shortest possible path towards the sink node. If the event detected in the network firstly, then the path is established with shortest distance with broadcasting HCM message as shown in Fig. 4. The events detected afterwards at any nodes or clusters, they will firstly find the pre-established path as shown in Fig. 5. This method gives the aggregation of the data in the network.

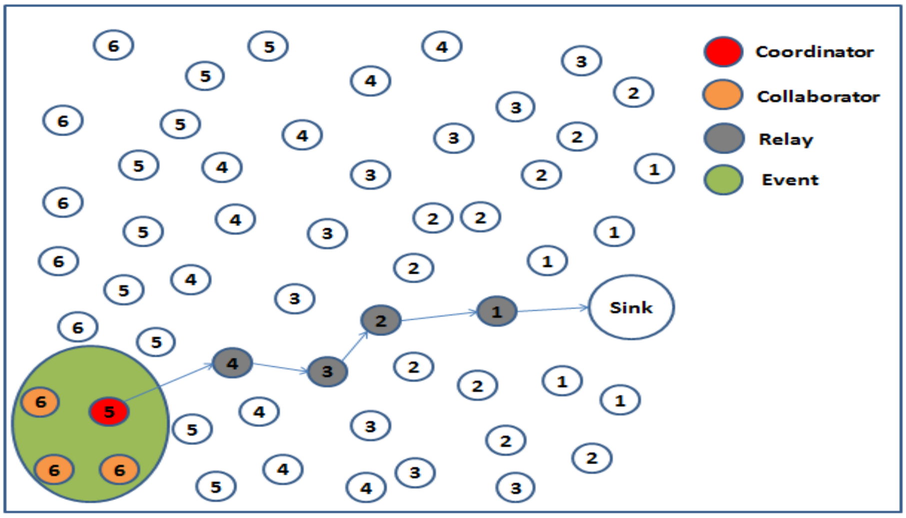

Fig. 3 Establishment of Route

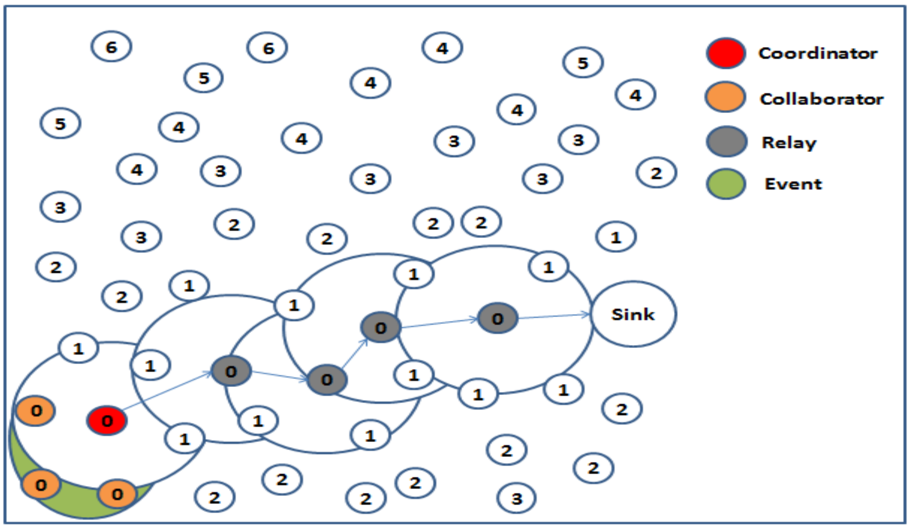

Fig. 4 Hop Tree Updatation

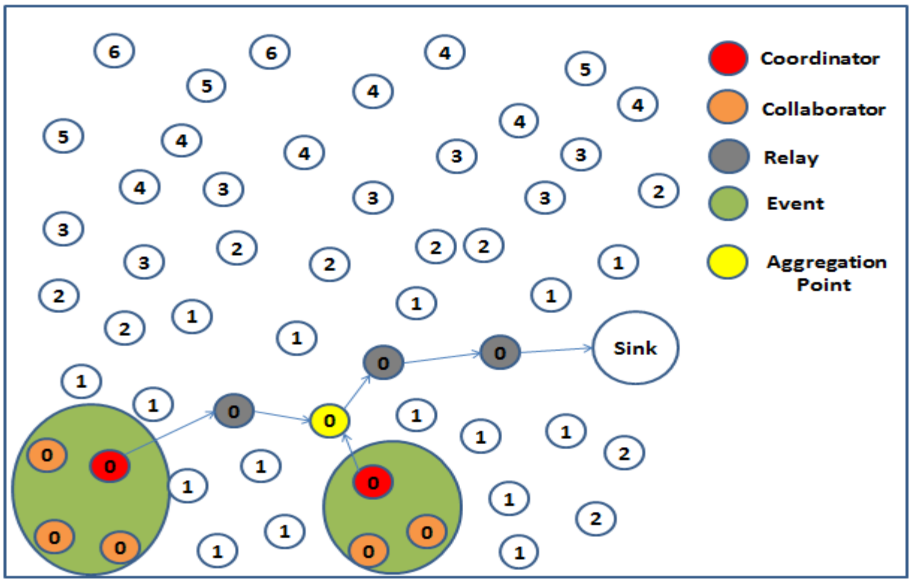

Fig. 5 Establishment of Route and Hop Tree Update

III. PROPOSED METHODOLOGY

In the section, the I-DRINA protocol is improved with routing performance by considering the energy. Energy is most crucial parameter in WSNs as it has to utilize in effective manner. Hence in proposed protocol work, we have implemented the energy conscious routing algorithm. This algorithm maintains stability in the network traffic which is intermediate between the source to destination nodes.

Consider the nodes in fig. 6(a) are intermediate nodes in the path of source to destination and the path A-B-C-D is a shortest path from source to the destination node. But in this route path, the relay nodes B and C remains as intermediate nodes. Therefore those nodes may blows down after some time due remaining energy at those nodes. Therefore the proposed protocol works well at this situation by routing the path through neighbor nodes by comparing the remaining energy of those nodes. In Fig. 6(b), the path is routed via node E and F substituting to node B with route from source to A-E-F-C-D to destination. In Fig. 6(c), path is redirected via nodes E-F-G substituting node C with route A-E-F-G-D to destination node. This path routing is done by comparing the remaining energy of present relay nodes and the neighboring nodes which overhear the REM message while route establishment phase.

Hence, the proposed protocol I-DRINA which is improvement to that of DRINA, gives the energy efficient environment in WSNs in which the intermediate relay nodes are protected from getting blows down due to energy remaining at those nodes. Also due to this sometime the routing may minimizes the broadcasting delay in the network.

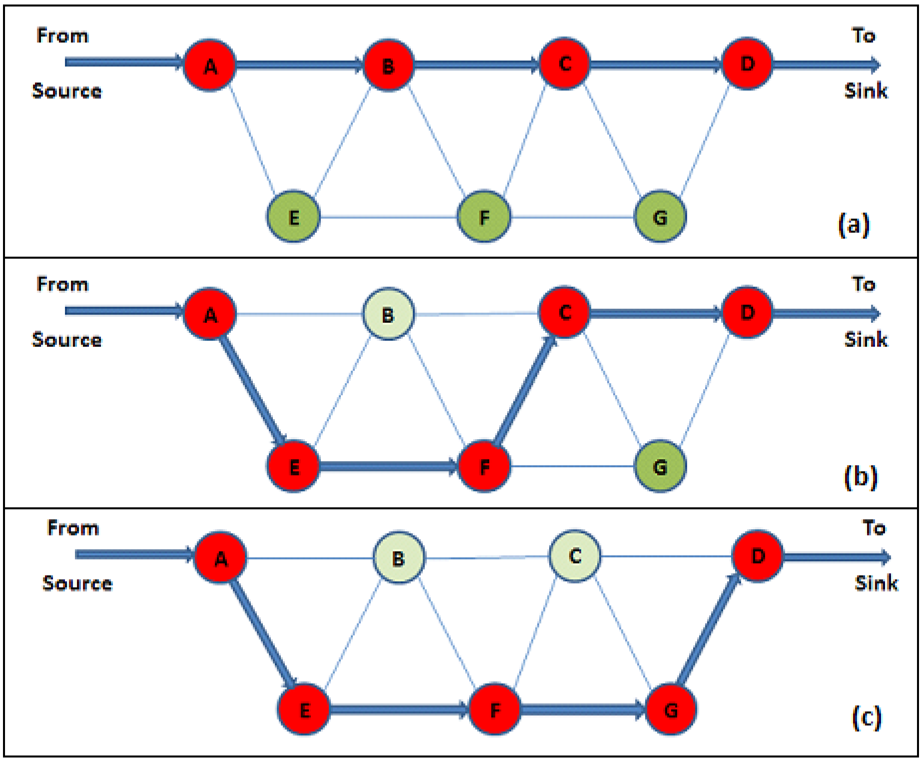

Fig. 6 Establishment of Energy Concious Route and Updatation of Hop Table

IV. PERFORMANCE EVALUATION

In this section, the results of proposed protocol I-DRINA has compared with the existing protocols as LEACH and DRINA which are related to that of routing protocols in the network. The comparative study of results with following performance parameters:

- Average Energy Consumption
- End to End Transmission Delay
- Average Throughput
- Normalized Routing Load
- Packet Delivery Ratio

4.1 Simulation Environment

In this project work, we have performed the experiments for the simulation results on Network Simulator-2 which is simulation software for WSNs. The simulation has done for different nodal configuration with area of 1000X1000 sq. meters. Assumption is that nodes have not mobility in the network. The simulation model parameters required to perform experiment given in table 1.

Table: 1 Simulation Parameters

Simulation Parameters	
Parameters	**Values**
Simulation tool	NS-2
Propagation	Two Ray Ground
Channel used	Wireless
Initial energy	100 Joules for each node
Network area	1000m X 1000m
Number of nodes	100,150,200,250,300
Number of clusters	2
Antenna type	Omni-Directional
Routing MAC protocol	AODV
Data packet length in queue	50

4.2 Simulation Result Analysis

In this experimental work for given protocols, the network has implemented on different scenario with 100, 150, 200, 250, 300. The analysis of result with different performance parameters are as follows:

4.2.1 Average Energy Consumption

In WSNs, sensor nodes mostly battery powered. So energy consumption must have to put as minimum as possible. The main sources of consumption of energy in WSNs are sensing, routing or communicating and computational work.

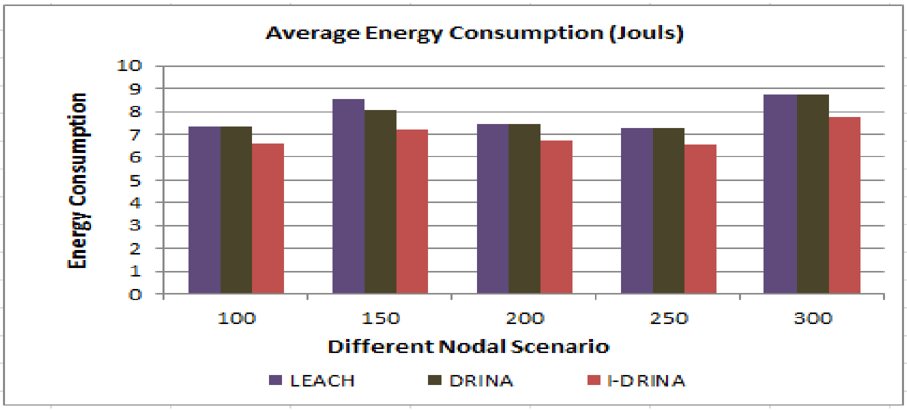

Fig. 7 Average Enegy Consumption

Results in Fig. 7 shows that the Average Energy Consumed by proposed I-DRINA protocol is minimized compared to that of existing protocols.

4.2.2 End to End Transmission Delay

End to End Delay is the time required to transmit message packet from source node to destination node successfully. It may contains all probable types of delays as queuing in the transmission path, buffering at routers, acknowledgement delay, packet retransmission in case of packet failure, time for message coding.

Fig. 8 shows that the end to end delay in the proposed protocol I-DRINA is less than that of two known protocols as LEACH and DRINA.

4.2.3 Average Throughput

Average Throughput is ratio of difference between number of data packets received at destination node and number of data packets lost in between to the total time required from first data packet to last data packet. The unit of throughput is bits/sec. Throughput in the network plays an important role as it is totally related to the data packet loss and broadcasting delay in WSNs. In Fig. 9, the average throughput of I-DRINA is improved compared to LEACH and DRINA effectively. The performance is incresed due to improvement in the routing for the I-DRNA over the DRINA.

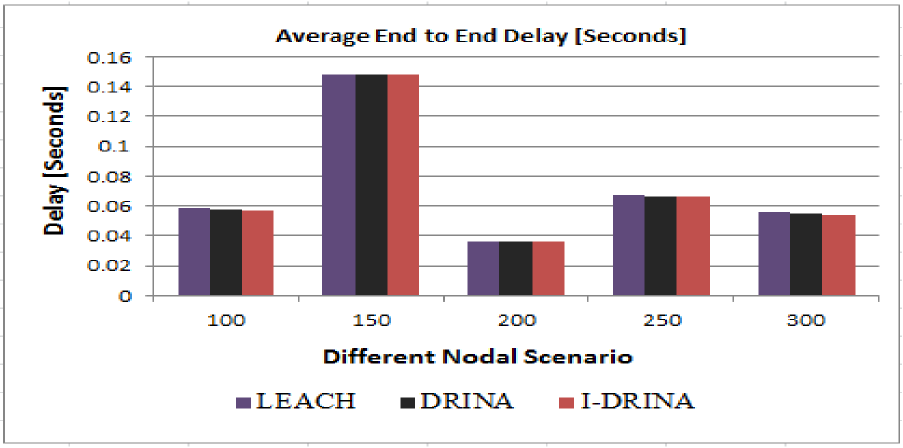

Fig. 8 Average End to end Delay

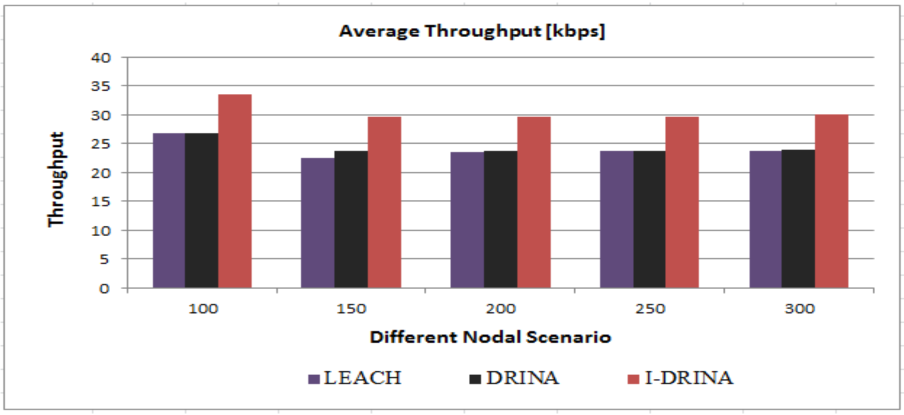

Fig. 9 Average Throughput

4.2.4 Normalized Routing Load

Routing Load is the ratio of number of routing packets to the number of data packets. The routing load determines the network effectiveness. As the network must have minimum routing packets and maximun number of data packets.

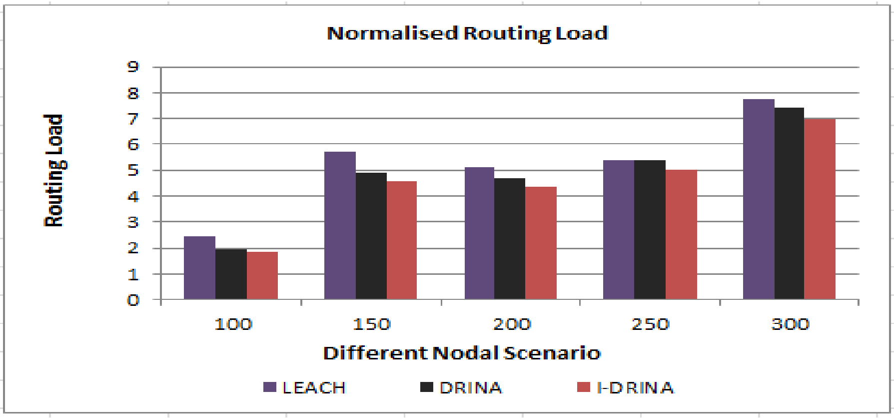

Fig. 10 Normalized Routing Load

Fig. 10 gives the copararison of result in which gives the idea about I-DRINA improved the routing load by minimizing the routing packets in the network with effectively increase in number of data packets.

4.2.5 Packet Delivery Ratio

It is a ratio of number of received packets by destination nodes effectively to the number of packet generated by the source node. This ratio must be high enough that is signifies the network performance affecting due to packet loss in WSNs. The Packet Delivery Ratio is measured in the percentage form.

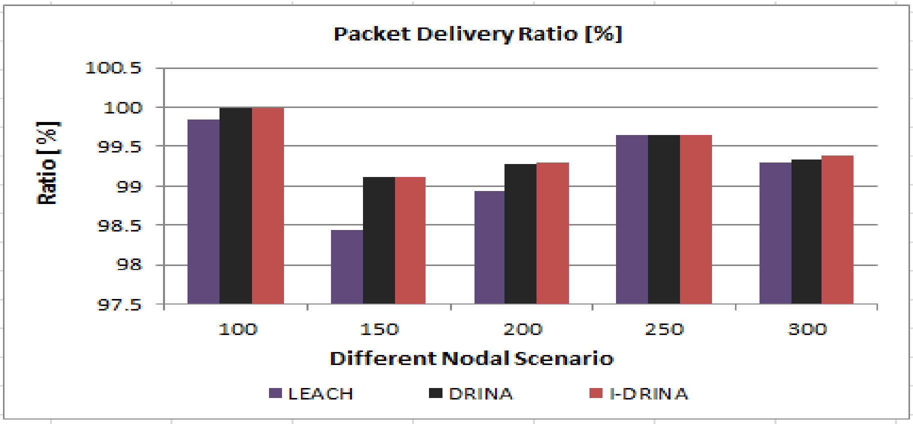

Fig. 11 Packet Delivery Ratio

In Fig. 11, proposed I-DRINA protocol gives the improvement in the Packet Delivery over the existing protocol.

V. CONCLUSION

In this project work, we have improved the routing performance of the proposed protocol I-DRINA. The improvement has done by considering the energy efficiency with data aggregation in event monitoring in WSNs. The dynamic routing in the network gives the better results to the network. The proposed protocol has compared with energy consumption, broadcasting delay, throughput, routing load and packet delivery type of performance parameters of the network. For these simulation results considering as a reference, the proposed protocol I-DRINA protocol gives improvement in the overall performance parameters over existing LEACH and DRINA protocols.

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