International Journal of Computer Applications Technology and Research
Volume 4– Issue 7, 550 - 555, 2015, ISSN: 2319–8656

A Reliable Routing Technique for Wireless Sensor Networks

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Abstract: Wireless Sensor Network (WSN) consists of very large number of sensor nodes which are deployed close to the area which is to be monitored so as to sense various environmental conditions. WSN is a data-driven network which produces large amount of data and also sensor nodes are energy-limited devices and their energy consumption is mainly associated with data routing. Therefore it is necessary to perform redundant data aggregation so as to save energy. In this work data aggregation is achieved with the help of two key approaches namely Clustering approach and In-network data aggregation. These two approaches help to save energy and thereby increasing the lifetime of the network. The proposed work has some key features like reliable cluster formation, high data aggregation rate, priority of packets, minimized overhead, multiple routes, reduced energy consumption which enhance the network lifetime. The performance evaluation of the proposed approach is carried out using Network Simulator- version 2.

Keywords: sensor network; data routing; ns-2; sleep mode nodes; clustering; alternate path.

1. INTRODUCTION

The WSN is made up of very enormous number of wireless sensor nodes, which are deployed in space and capable of sensing the physical and environmental factors like pressure, vibration, temperature, heat content and sound close to the area where they are deployed. Wireless Sensor Network has become an important emerging area in wireless communication field. It is a very popular area for research, because of their vast usefulness in variety of applications[1].

Wireless sensor network (WSN) possess the ability of detecting (sense) the data, processing it and communicating the processed data, thereby enabling the connection of the physical word with the environment and many other inaccessible areas. The sensor nodes are placed close to the region, where the information has to be sensed. Each of these nodes senses the data which is required and forwards the data obtained after processing (if required) to other nodes to form the network [2].

The protocols and algorithms designed for wireless Sensor network must exhibit self-organizing capabilities which is one of the main requirements. The other special feature of WSNS is the co-operative operation exhibited by the sensor nodes. These nodes do not send the raw information instead, makes utilization of their dispensation abilities to perform simple computations required nearby and merely the necessary, important and moderately treated data will be transmitted to the destination.

The major limitations in the scenario of WSNs are limited capacity of the battery power source, physical size of the device, limited storage capacity, cost constraints, limitation of the processing capability of the sensors. Therefore the algorithms designed for WSNs must consider these key parameters as their main conception[3].

Figure 1 shows the routing of data in WSN

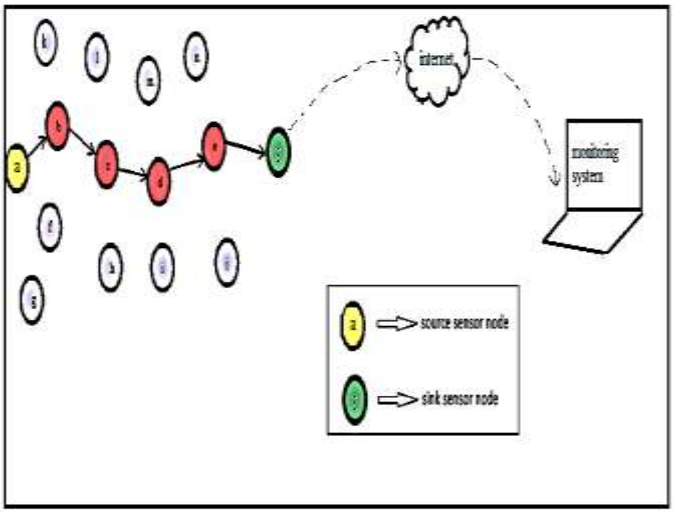


Figure 1: data routing in WSN

As presented in the above the nodes are placed close to area which is to be sensed. The deployment can follow any network topology as per the requirement. Here node named as ‘a’ is the source node as it senses the data in the first event. It processes the data being sensed and performs certain additional computations required. In the next step it stores the processed information if it is necessary for future references.

Now the processed data is ready to be communicated with the neighbor nodes. Source node finds the neighbor based on certain criteria and then forwards the processed data. The same procedure is continued unit the destination (sink node) is reached. From the sink node data can be obtained for further references [7].

2. RELATED WORK

The algorithms developed for routing data in WSN are mainly divided into three types. They are

- Tree based algorithms
- Structure less algorithms
- Cluster based algorithms

Tree based algorithms is based on hierarchical organization of the nodes in which a routing tree is build first and is used to route the data and also to aggregate the packets at intermediate nodes. The cluster-based approach is also similar but in this nodes are divided into groups called clusters. A special node called cluster-head is elected among the group members and this node performs aggregation of data locally and forwards the aggregated packet towards the sink node. Whereas in structure-less approach a random path will be chosen to route the data and here opportunistic aggregation of data occurs [3].

Few main approaches coming under the above algorithms are explained below.

2.1 Directed Diffusion

It comes under tree based approach. The Directed Diffusion [7] protocol is one of the most primitive characteristic based data transmitting approach. In this case, information fusion occurs opportunistically, that is only when the data packets meet at any intermediate nodes of the routing tree path.

2.2 Shortest Path Tree (SPT) algorithm

It comes under tree based approach, [5] wherein every node that detects an event reports its collected data by using a shortest path towards the sink node. The data aggregation occurs whenever routing paths overlap.

In tree based algorithm

- If at any movement, whenever a data is not found at a definite part of the routing path, say for example because of the damages present in the channel, data is vanished from the remaining whole part of the tree as well.

- A mechanism for fault tolerance is required for Tree-based algorithms in order to forward the aggregated information in a reliable manner.

2.3 Data-Aware Anycast (DAA) approach

It comes under the structure less algorithm [4]. This makes use of any of the path in order to route the data to its neighbor nodes which are at single hop from it and consists of data for information fusion. The main notion of this approach is, in place of developing a routing configuration in prior for fusion of information that is not possible lacking the knowledge of the topological configuration of the network, a self-governing group between the source nodes is designed. These sensors in the group play the lead as data fusion sockets.

The above algorithm is suitable only for event-based applications and these do not assure the fusion of every data.

2.4 LEACH algorithm

The important feature of Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol [2] is the inclusion of special node called as cluster head to condense the power charge of conveying data from normal sensing nodules to a monitoring Station which is far away. In this protocol, the sensor nodes themselves arrange into the group called as cluster.

Then any one of the members in the cluster becomes Cluster Head (CH). The main function of the CH node is to carry out aggregation of the data packets transmitted by members of the cluster and to route the gathered data towards sink.

Leach algorithm ascertain that the destination is reachable by just in single jump and which restricts the dimension of the system and for large areas the protocol is not applicable.
The proposed algorithm is also a cluster based approach and it overcomes the above disadvantages.

3 THE PROPOSED ALGORITHM

3.1 Objective

The main aim of the projected protocol is to establish a routing path which is shortest and which links all the source sensors to the destination sensor node, by using the shortest paths and also to increase the rate of aggregation of sensed data.

3.2 Key techniques

The key techniques used in the protocol

- Clustering process: sensor nodes which sense or detect the same kind of event are divided into groups and those groups are called as clusters. Each of these clusters is managed and leaded by a special type of node which is called by the name cluster head [3].
- In-network information fusion: the sensors are those devices with limited energy source and the most of the energy that is spent is mainly associated with data gathering process as well the data routing process.

A possible technique in order to optimize the way of performing the data forwarding job is 'in-network aggregation of data'. Here if the data packets from more than one sensor node arrives at any intermediate node (which is a part of any routing tree), then the data will be aggregated at the intermediate node, after aggregation a single data packet will be produced. This reduces the energy consumption and avoids the redundant data if present in the network.

4. MODULES OF THE PROJECT

In the algorithm considered, the different roles of the nodes are considered and they are

- **Collaborator (member of the cluster)**: A sensor node which is present in the cluster and which finds an event and informs about the collected information to the lead or controller.
- **Coordinator (head of the cluster)**: A sensor node which also detects an occasion and which is liable for collecting all the processed information transferred by collaborators, uniting them and forwarding the

aggregated summarized outcome towards the destination sensor or sink.

- **Relay (intermediate nodule)**: A node which forwards received information packets on the way to the destination node.
- **Sink node**: it is one which involved in accepting data from a clutch of collaborators and coordinator.

The projected algorithm is divided into five modules. They are:

Module 1: Constructing the hop distance from the sink: In this module [3] the distance of each of the nodes from the destination node is found in terms of hops. The phase is initiated by the sink node. Algorithm for this module is given below

```
step1. Consider N number of nodes. Sink is one among N nodes. Sink begins the hop tree
construction by broadcasting Hop Construction Message (Hop variable= 1), HCM into
the network,

Step 2. for n ∈ N (except sink) find

begin

If Hop value of n > Hop value of HCM, then

    Id of HCM→ next hop of n

Hop value of HCM + 1 → Hop value of n

// node n configures the HCM broadcasts it as follows

Step 3. Id of n→ Id of HCM

Hop value of n →Hop value of HCM

Else

n ignores the HCM received.

end
```

Module 2:cluster formation and lead selection:In this module, the nodes sensing the same event are grouped into cluster and the lead called as 'cluster head' is selected. this is shown in figure 2.

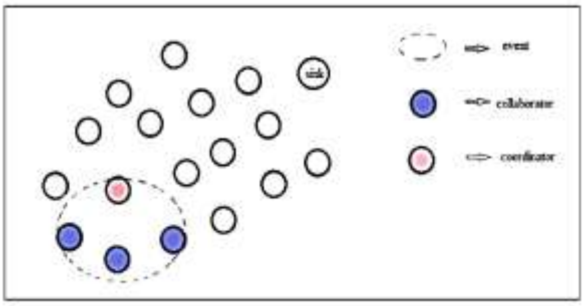


Figure 2: cluster formation

Module 3: **Route establishment**: In this module route is established from the cluster head to sink (BS-Base Station) via the relay(intermediate node) and then data transmission occurs. This module is shown in figure 3

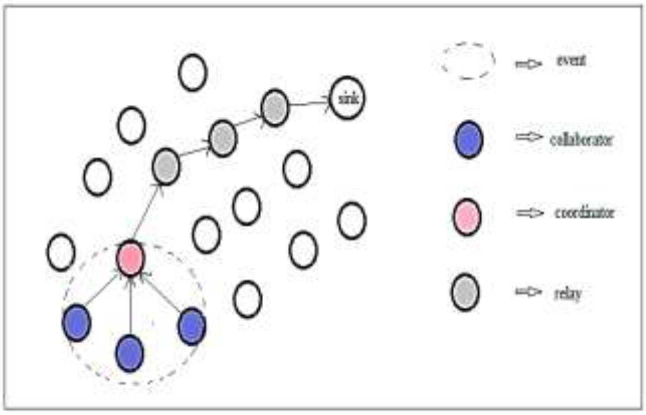


Figure 3: route establishment

Module 4: **Repairing of the failed routes**: The failure of the routes created may be caused due to less energy, communication failures, faulty nodes and physical destruction. To avoid such routes energy of the nodes will be checked regularly during data forwarding, if there is any reduction in energy or any other problem then the new nearest better node will be chosen and except the failed node the rest path is same as the previous route. This stage is presented in the figure 4 and figure 5.

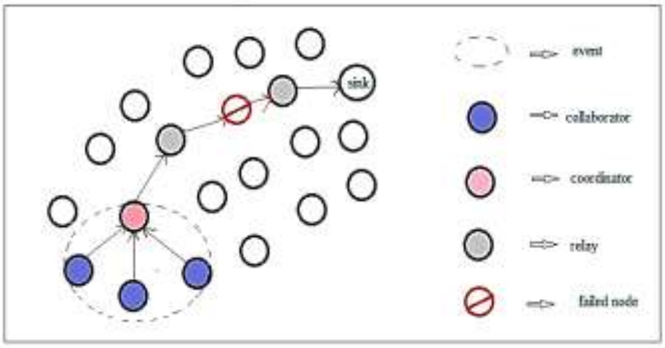


Figure 4. route failure

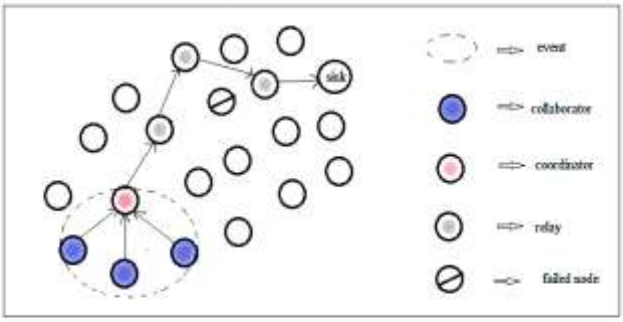


Figure 5. route repairing

Module 5: Scheduling the sleep and active duration and creating the alternate path to route the urgent data

Whenever any member of the cluster, sends the same data repeatedly for particular duration of time, then that particular node will be send to the sleep node for a while. This is done to conserve the energy and in doing so increasing the lifespan of the sensor node.

In some emergency situation it is necessary to collect the data as early as possible but the clustering and data gathering process introduces certain delay so in order to ensure the fast delivery of such urgent priority data packets a separate path will be created to route these packets whenever necessary thereby increasing the reliability. The alternate path is created in the same way as the route establishment process of module 3. The alternate route to route urgent data is shown below in figure 6.

The **module 5** is done as the part of enhancement work of the paper under consideration.

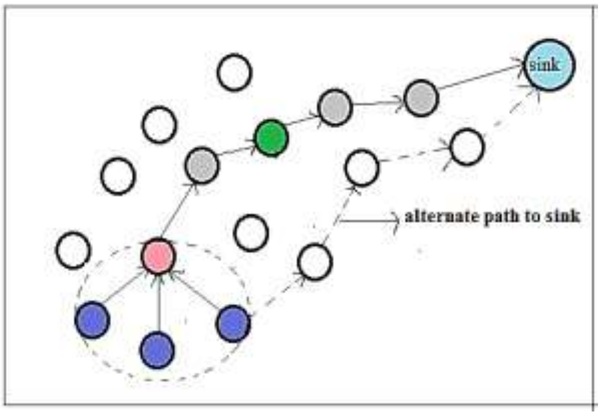


Figure 6: alternate path for routing urgent packets

4. RESULTS AND ANALYSIS

The performance evaluation of the approach under consideration is done using the network simulation tool (NS-2) and the results are compared with the basic communication network of the sensor nodes, in which the source nodule senses the information and route the processed data to the destination node without performing any data aggregation or cluster formation.

The evaluation of the performance of the projected algorithm is done under the following performance parameters:

Packet delivery ratio: It is defined as the ratio between the numbers of data packets received by the sink to the total number of data packets transmitted, in the overall simulation scenario. It signifies the efficiency of the algorithm. This is because lower the packet delivery ratio, higher will be the data aggregation rate.

Total hop counts: It is the entire figure of hops required for all the packets transmitted to go from source sensing devices to the destination sensor.

Average delay: It is the total average time involved for all the packets generated to move from source sensing devices to the destination sensor. Also the number of transmitted data packets and received data packets can be calculated.

4.1 The network animator outputs are shown below.

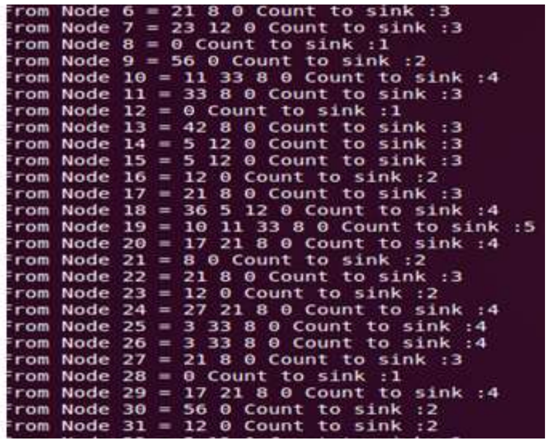

```
rom Node 6 = 21 8 0 Count to sink :3
rom Node 7 = 23 12 0 Count to sink :3
rom Node 8 = 0 Count to sink :1
rom Node 9 = 56 0 Count to sink :2
rom Node 10 = 11 33 8 0 Count to sink :4
rom Node 11 = 33 8 0 Count to sink :3
rom Node 12 = 0 Count to sink :1
rom Node 13 = 42 8 0 Count to sink :3
rom Node 14 = 5 12 0 Count to sink :3
rom Node 15 = 5 12 0 Count to sink :3
rom Node 16 = 12 0 Count to sink :2
rom Node 17 = 21 8 0 Count to sink :3
rom Node 18 = 36 5 12 0 Count to sink :4
rom Node 19 = 10 11 33 8 0 Count to sink :5
rom Node 20 = 17 21 8 0 Count to sink :4
rom Node 21 = 8 0 Count to sink :2
rom Node 22 = 21 8 0 Count to sink :3
rom Node 23 = 12 0 Count to sink :2
rom Node 24 = 27 21 8 0 Count to sink :4
rom Node 25 = 3 33 8 0 Count to sink :4
rom Node 26 = 3 33 8 0 Count to sink :4
rom Node 27 = 21 8 0 Count to sink :3
rom Node 28 = 0 Count to sink :1
rom Node 29 = 17 21 8 0 Count to sink :4
rom Node 30 = 56 0 Count to sink :2
rom Node 31 = 12 0 Count to sink :2
```

Figure 7: output of module 1(hop distance between every node to the sink node)

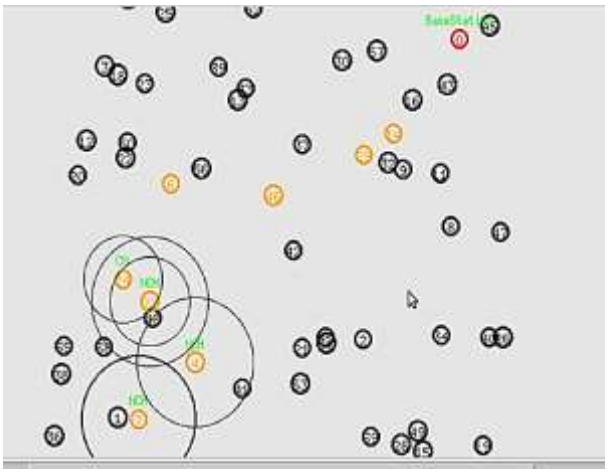


Figure 8: cluster formation and route building

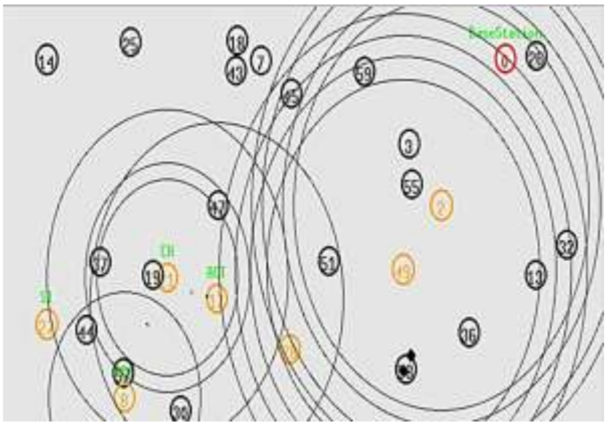


Figure 9: active and sleep mode scheduling (sl-sleep)

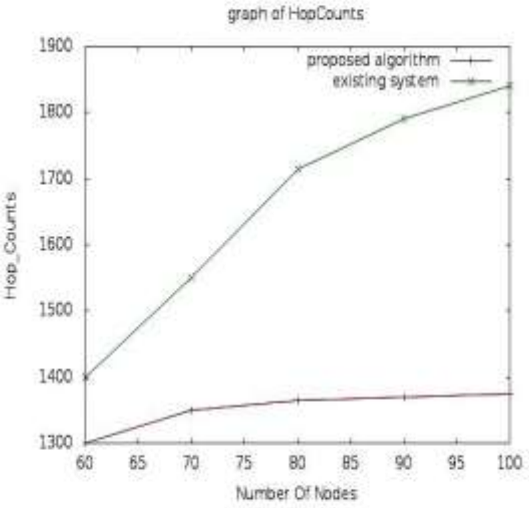
In figure 8 the route established is

24(CH) ⇒ 6 ⇒ 46 ⇒ 29 ⇒ 14 ⇒ 0(BS)

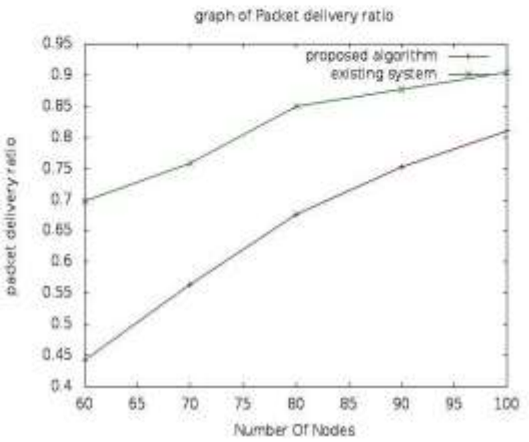
In figure 9 sl indicates the sleep status of the node. ACT indicates the active mode. In this scenario, the nodes 27, 8, 21, 17 form the cluster and 21 becomes CH. Here node number 27 is sending the same data for particular period, hence it is pushed to sleep mode. As we can notice from the figure node 27 is sending any data but the other members are sending data to CH.

4.2 Analysis of graphical results

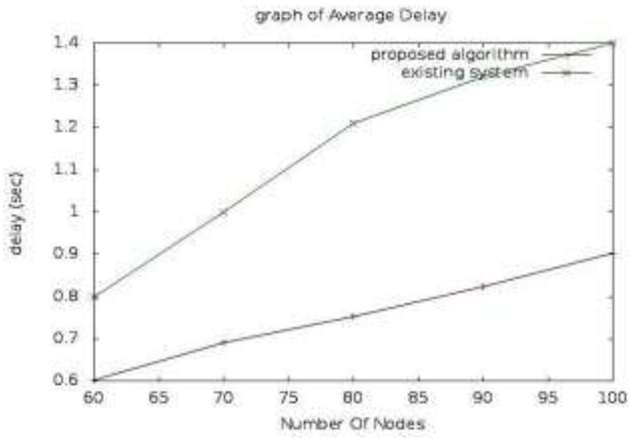
- **effect of the size of the network**



From the below graph we can infer that the total number of hop counts required increase as the number of nodes increases. This is obvious but we can notice that in case of the proposed algorithm the increase is very less when compared to the one without data fusion. This parameter is directly related with the energy, hence lesser number of hop counts indicates lesser energy intake and enhanced life time of the network.



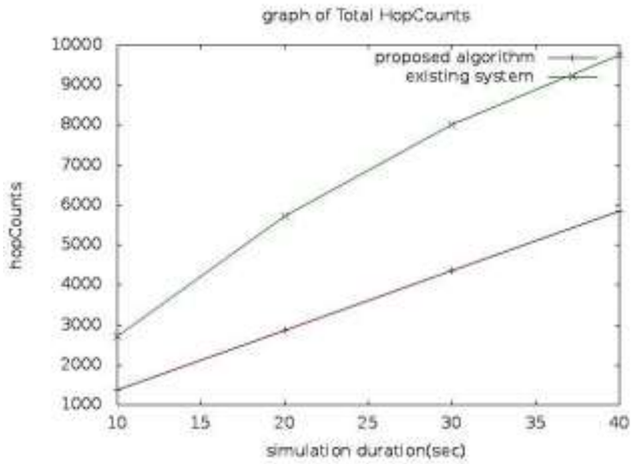
From the above graph we can notice that the packet delivery ratio increases with increase in the number of node for both the systems, but it is lesser for proposed system. This is because lower the packet delivery ratio, higher will be aggregation effect. Hence lower is the power intake.

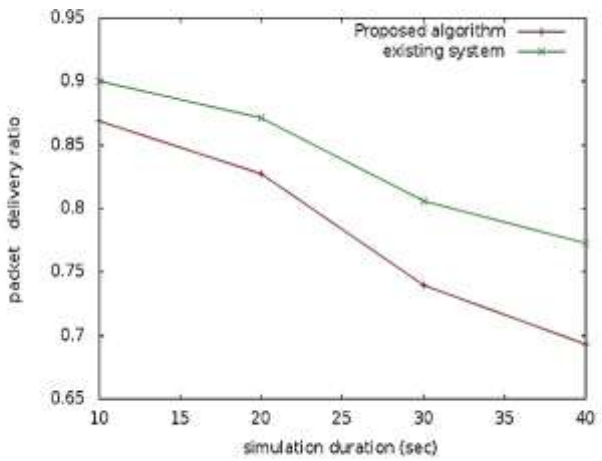


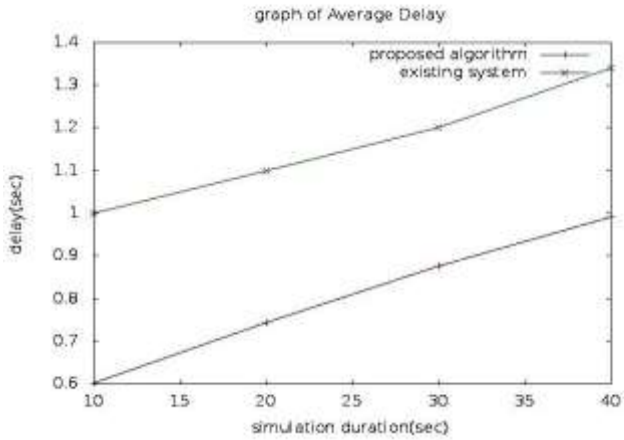
From the above graph, we can see that delay requirement is lower for the approach under consideration than that the approach without data aggregation.

- **Effect of the simulation time**

In WSN scenarios in order to verify the working of the approach under consideration, it is required to check the behavior under various simulation conditions. In the next part, we have considered the behavior with respect to simulation time. Under this situation the approach is giving the desired results as shown below.







5. CONCLUSION

The project presents a reliable and efficient approach for data routing in WSNs. The projected work is simulated and compared with the existing system with respect to different performance parameters.

The various simulation scenarios such as number of events, different simulation time and the different size of the network are considered. The obtained consequences show that the proposed work is performing better when compared the approach without data aggregation in all the scenarios and therefore this forms a reliable protocol to be used for WSNs.

As **future work**, different schemes may be designed in order to regulate the period of waiting of coordinator nodes on the basis of spatial and semantics event correlation. Along with this security can be included for the data that is being routed in the network

6. ACKNOWLEDGMENT

Our sincere thanks to everybody who have supported and encouraged towards the work we have done.

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