An Efficient Algorithm for Reliable Routing In-Network Aggregation in Wireless Sensor Network

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Abstract-- In advancing technology wireless sensor network have become popular. Wireless sensor networks consist of widely distributed sensor nodes. Sensor nodes have low energy because of its small battery size. This low energy in turn decreases the life span of network. The decreased lifespan of network may affect the application to run in-efficiently. For these reasons, many algorithms and protocols designed for wireless sensor networks which considered the energy consumption in their conception. Another main challenge in wireless sensor networks is to design the routing algorithms to guarantee the delivery of the sensed information properly to destination even in failure of nodes and interruptions in communications. The node failure becomes more critical when data aggregation is performed along routing paths as the data packets with aggregated data contain information from various sources and whenever one of these packets is lost a considerable amount of information will also be lost. In these contexts wireless sensor network should have data aggregation aware routing protocols that should provide increased aggregation rate, reliable transmission of sensed data and which uses reduced number of messages for setting up a shortest routing path towards the base station. In order to overcome these challenges, an efficient In-Network Data Aggregated Routing (INDAR) algorithm is proposed for Wireless Sensor Networks. The proposed algorithm is aimed to increase aggregation rate along the communication path in reliable way through a fault-tolerant routing mechanism.

Keywords—*Routing protocol, In-network aggregation, Wireless sensor networks*

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I. INTRODUCTION

Recent advances in wireless communication and electronics have enabled the development of low cost, low power multi-functional devices called sensor nodes. Wireless Sensor Networks consists of spatially distributed autonomous devices such as sensor nodes that cooperatively sense physical or environmental conditions such as temperature, pressure, sound, motion, vibration and pollutants at different locations. Wireless Sensor Networks are deployed for many applications such as homeland security, environmental monitoring, critical infrastructure systems communications, manufacturing and other applications that can be critical to save lives and assets.

A wireless sensor device has a battery-operated mechanism capacitated with sensing, processing and communicating capabilities. In addition, a power source supplies the energy needed by the device to perform the task that is programmed .This power source often consists of a battery with a limited energy budget. It could be also impossible or inconvenient to recharge the battery because nodes may be deployed in a hostile or unpredictable environment. On the other hand, the sensor network should have a lifetime long enough to full fill the application requirements. In many cases lifetime may be in the order of several months or even years are required. Therefore, the crucial question which arises is: "how to prolong the network lifetime to such a long time?" In few cases it is possible to scavenge energy from the external environment (e.g., by using solar cells as power source). However, external power supply sources often exhibit a non-continuous behaviour so that an energy buffer (a battery) is needed as well. In any case, energy is a very critical resource and must be used very sparingly. Therefore energy conservation is a key issue in the design of systems based on wireless sensor networks. Hence sensor nodes are energy-constrained devices and the energy consumption is generally associated with the amount of gathered data. Hence communication is often the most expensive activity in terms of energy.

The sensor network model depicted in Fig.1 consisting of one sink node (or base station) and a (large) number of sensor nodes deployed over a large geographic area (sensing field).Wireless Sensor Networks are data-driven networks that usually produce a large amount of information that needs to be routed, often in a multi-hop fashion towards a sink node, which works as a gateway to a monitoring centre (Fig.1).
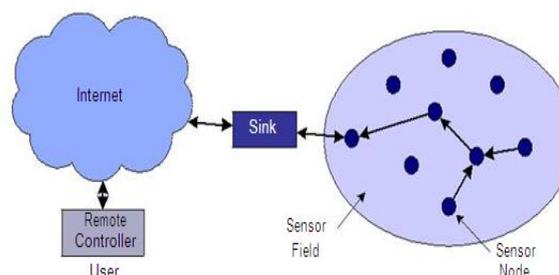

Fig. 1: Sensor network architecture.

The typical architecture of a wireless sensor node (Fig.2) consists of four main components:

(i) A sensing subsystem including one or more sensors (with associated analog-to-digital converters) for data acquisition.

(ii) A processing subsystem including a micro-controller and memory for local data processing.

(iii) A radio subsystem for wireless data communication.

(iv) A power supply unit.

Depending on the specific application, sensor nodes may also include additional components such as

➢ A location finding system to determine their position

➢ A mobilizer to change their location or configuration (e.g., antenna's orientation). However the latter components are optional.
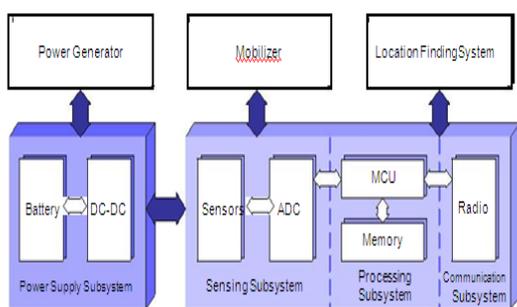
Fig. 2:
Architecture of typical wireless sensor node.

The power breakdown heavily depends on the specific node. However, the following remarks generally hold. The communication subsystem has much higher energy consumption than the computation subsystem. It has been seen that transmitting one bit may consume as much as executing a few thousands instructions. For this reason communication should be traded for computation.

• The radio energy consumption is of the same order in the reception, transmission and idle states. The power consumption drops of at least one order of magnitude in the sleep state. Hence the radio should be put to sleep (or turned off) whenever possible.

• Based on the specific application, the sensing subsystem might be another significant source of energy consumption, so its power consumption has to be reduced as well.

The rest of this paper is organized as follows. In Section II in-network aggregation is discussed. In Section III describes the t data aggregation survey. In Section IV the Proposed Architecture is discussed. In section V module description. Results in section VI and Conclusion and future work in Section VI.

II. IN-NETWORK DATA AGGREGATION

In order to conserve both energy and bandwidth, it is useful to move the integration and filtering of sensor data into the network itself. In-network aggregation is a mechanism for reducing the overall amount of power and bandwidth required to process the user's query by allowing sensor readings to be aggregated by intermediate nodes. A query requesting aggregate data is injected into the sensor network at a host node which is also known as a sink (Fig.3).
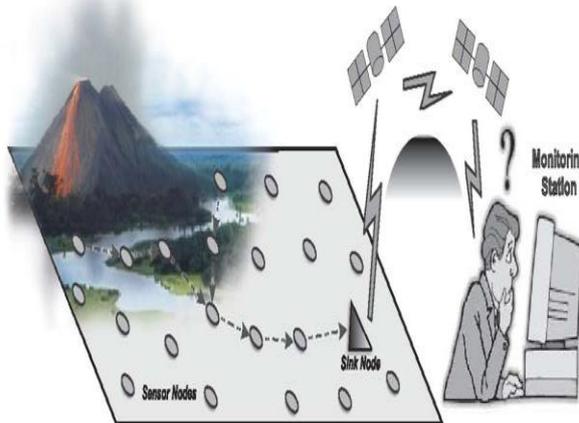

Fig. 3: Data aggregation aware routing, a key algorithm for data-driven WSNs

Definition

A possible strategy to optimize the routing task is to use the available processing capacity provided by the intermediate sensor nodes along the routing paths .This is known as data-centric routing or in-network data aggregation (Fig. 4).
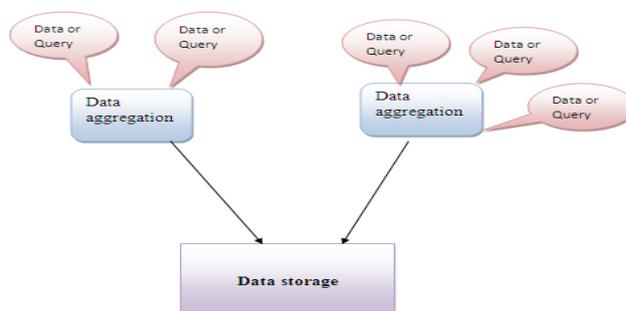

Fig. 4: Block diagram of in-network data aggregation.

Thus various algorithms have been proposed to provide data aggregation during the routing in WSNs. Some of them are tree-based approach and try to solve some variation of the Steiner tree problem; others are cluster-based algorithms while others are simply structure-less.

A. Tree-Based Approaches

Protocols here are usually based on a hierarchical organization of the nodes in the network. In these protocols, a tree structure is constructed first and then used later to either route the gathered data or respond to queries sent by the sink node. During the routing aggregation is performed. When two or more data packets arrive at the same node of the tree. Then the node aggregates all

1106

received d a t a with its own data and forwards only one packet t o its neighbour that is lower in the tree. Some of the tree based approaches are:

Shortest Path Tree (SPT): It is used to find the set of edges connecting all nodes such that the sum of edge lengths from root to each node is minimized. It is a very simple strategy to build a routing tree in a distributed fashion. In this method, every node that detects an event reports its collected information by using a shortest path to the sink node.

Greedy Incremental Tree (GIT): It is based on Directed Diffusion. The GIT algorithm establishes an energy efficient path a n d greedily attaches other sources onto the established path. When the first event is detected the nodes send their information as in the SPT algorithm and for every new event the information is routed using the shortest path to the current tree.

Centre at nearest algorithm (CNS): In this strategy, every node that detects an event sends its information to a specific node called aggregator by using a shortest path. The aggregator is the closest node to the sink (in hops) that detects an event.

Drawback for tree-based approaches: when a packet is lost at a certain level of the tree (e.g., due to channel impairments) data from the whole sub tree will be lost as well.

B. Cluster-Based Approaches

In these approaches, nodes are divided into clusters. Special nodes referred to as cluster-heads are elected to aggregate data locally and forward the result of such aggregation to the sink node.

Some of them are:

Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm: Clustered structures are exploited to perform data aggregation. In this strategy, cluster heads can act as aggregation points and they communicate directly to the sink node. In order to distribute energy consumption evenly among all the nodes , cluster-heads are randomly elected in each round.

Drawback: LEACH-based algorithms assume that the sink can be reached by any node in only one hop which limits the size of the network for which such protocols can be used.

Information Fusion-based Role Assignment (InFRA): This algorithm builds a cluster for each event including only those nodes that were able to detect it. Then the cluster-heads merge the data within the cluster and send the result toward the sink node. InFRA algorithm aims at building the shortest path tree that maximizes information fusion. Thus once the clusters are formed, cluster heads chooses the shortest path to the sink node

that also maximizes information fusion by using the aggregated coordinators- distance.

Drawback: InFRA algorithm is that for each new event that arises in the network, the information about the event must be flooded throughout the network to inform other nodes about its occurrence and to update the aggregated coordinators distance. This procedure increases the communication cost of the algorithm and thus limits its scalability.

C. Structure-Less Approaches

The Data-Aware Anycast (DAA) algorithm is a structure-less data aggregation algorithm which uses anycast to forward packets to one-hop neighbours that have packets for aggregation. It also have mechanisms for increasing the chance of packets meeting at the same node (spatial aggregation) and at the same time (temporal aggregation).

Drawback: Does not guarantee aggregation of all packets, the cost of transmitting packets with no aggregation increases in larger networks.

D. Drawbacks of Existing system

Does not guarantee the delivery of the sensed data even in the presence of nodes failures and whenever one of these packets is lost a considerable amount of information will also be lost.

III. PROPOSED ARCHITECTURE

The main goal of our proposed the INADR algorithm is to build a routing tree with the shortest paths that connect all source nodes to the sink while maximizing data aggregation. The proposed algorithm considers the following roles in the routing infrastructure creation are as follows (Fig.5):

- **Collaborator:** It is a node that detects an event and reports the gathered data to a coordinator node.
- **Coordinator:** It is a node that also detects an event and is responsible for gathering all the gathered data sent by collaborator nodes, aggregating them and sending the result toward the sink node.
- **Sink:** A node interested in receiving data from a set of coordinator and collaborator nodes.
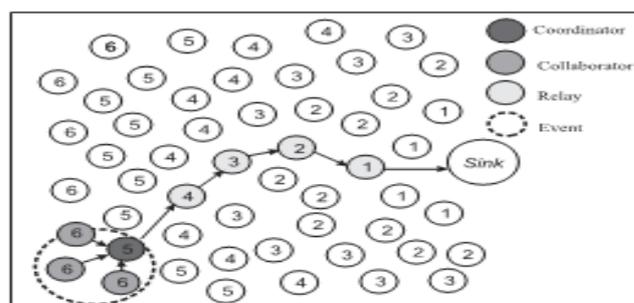- **Relay:** It is a node that forwards data toward the sink.

Fig. 5: Routing infrastructures.

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Outcomes of Proposed System

- It will be having reduced number of messages for setting up a routing tree from source to sink.
- Maximized number of overlapping routes, if there is more than one event.
- High aggregation rate is achieved
- A reliable data transmission.

IV. MODULE DISCRIPTION

Hop Tree Building

In this phase, the distance from the sink to each node is computed in hops. This phase is started by the sink node sending, by means of a flooding, the Hop Configuration Message (HCM) to all network nodes. The HCM message contains two fields: ID and HopToTree, where ID is node identifier that started or retransmitted the HCM message and HopToTree is the distance, in hops, by which an HCM message has passed.
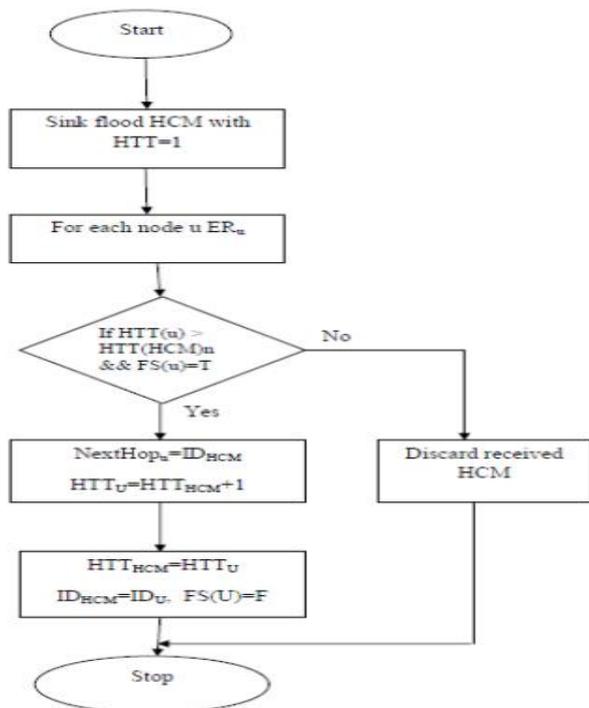
Fig. 6: Flow diagram of building hop tree.

The HopToTree value is started with value 1 at the sink, which forwards it to its neighbours (at the beginning, all nodes set the HopToTree as infinity). Each node, upon receiving the message HCM, verifies if the value of HopToTree in the HCM message is less than the value of HopToTree that it has stored and if the value of FirstSending is true.If that condition is true then the node updates the value of the NextHop variable with the value of the field ID of message HCM, as well as the value of the HopToTree variable, and the values in the fields ID and HopToTree of the HCM message. The node also relays the HCM message. Otherwise, if that condition is false, which means that the node already received the HCM by a shorted

distance, then the node discards the received HCM message. The steps described above occur repeatedly until the whole network is configured.

Before the first event takes place, there is no established route and the HopToTree variable stores the smallest distance to the sink. On the first event occurrence, HopToTree will still be the smallest distance; however,a new route will be established. After the first event, the HopToTree stores the smaller of two values: the distance to the sink or the distance to the closest already established route.

Cluster formation and leader selection

For the cluster formation & cluster head selection the following things must be known:

- Area of network.
- Number of sensor nodes.
- Sink and coordinators must be defined.
- How many clusters may be required must be defined.(Automatically formed when ever event occurs.

From the Fig. 7, first the nodes present on the center of each cluster get motivated. Cluster head is selected by comparing the hop to tree distance value between each node and the node with the lesser value will become cluster head. If the values of hop to tree distance of two nodes are same then the ID values are compared. The one with higher ID value will become cluster head. Another possibility is to use the energy level as a tiebreak criterion.
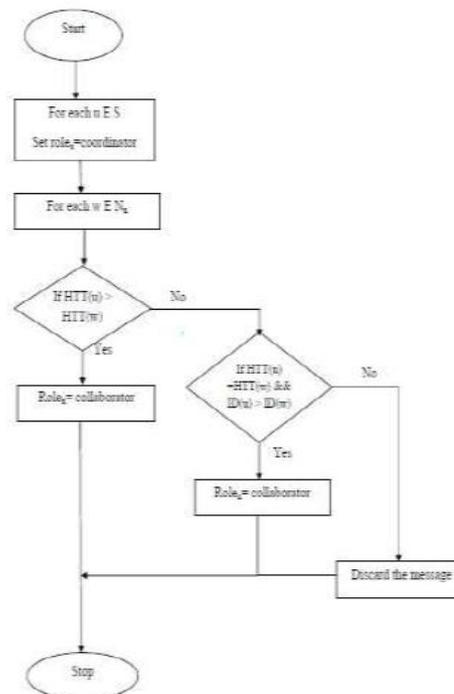

Fig. 7: Flow diagram of cluster formation and cluster head selection.

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Route establishment and Hop tree updation From the Fig. 8, the Coordinator sends a route establishment message to its NextHop node. The received route establishment message is retransmited the to its NextHop and starts the hop tree updation process. These steps are repeated until either the sink is reached or a node that is part of an a l r e a d y established route is found. The routes are formed by choosing the best neighbour at each hop. The choices for the best neighbour are in two folds: when the first event occur, the node that leads to the shortest path to the sink is chosen . After that when the subsequent events occur, the best neighbour is the one that leads to the closest node that is already part of an established route . This process tends to increase the aggregation points ensuring that they occur as close as possible to the events.
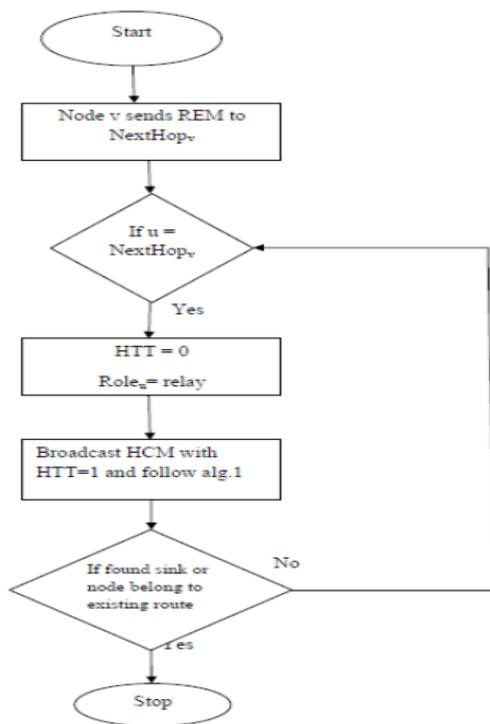
Fig. 8:Flow Chart for Route establishments

Route repair mechanism

The route used by the algorithm is unique for data transmission, which maximizes the data aggregation along with the overlapping routes. Any failure in one of its nodes will cause disruption, preventing the delivery of several gathered event data. In the conventional methods, flooding of the message is used for identifying the failure nodes. In our proposed method, ACK based repair mechanism is used to identify the node failure. When a node sends aggregated data packet to its NextHop, the receiver node should transmit an ACK to its sender. If the receiver does not receive the ACK, it has to find an alternate NextHop to forward the packet. Thus a new route will be established excluding the repaired node. This ensures the reliable data routing in the network. Examples are

shown below. A disrupted route is shown in Fig. 9(a). After applying the route repairing mechanism, a new partial path is reconstructed and is depicted as in Fig. 9(b).
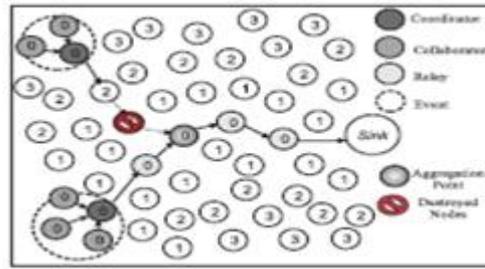
(a) Region with destroyed node.
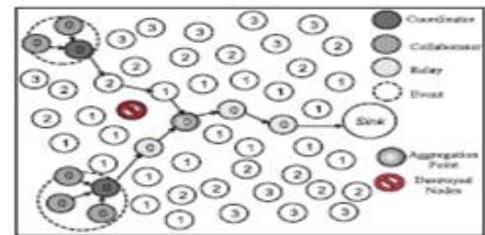
(b) Repaired path

Fig. 9: Example of path repair.

V. RESULTS

The performance evaluation of proposed system is compared with some other known solutions such as INFRA and SPT which has the same goal as that of proposed in routing the data. Performance is evaluated in different scenarios to find working capabilities and efficiency in various situations. It is done through MATLAB simulations.

1.
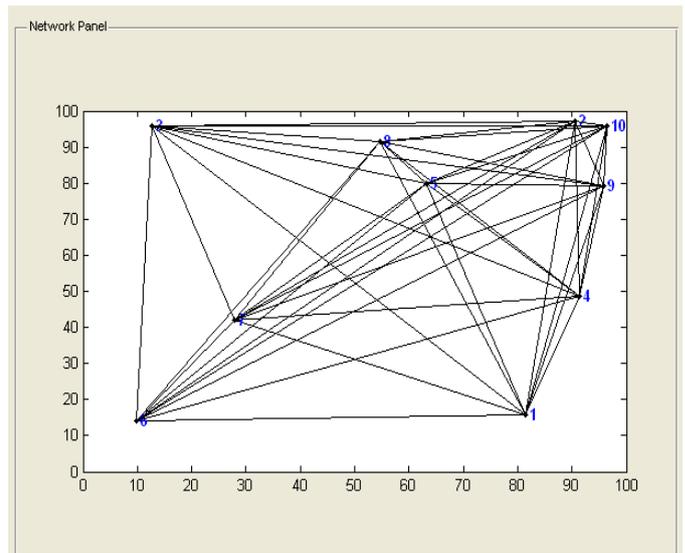
Window showing the deployement of nodes and sink. Where each nodes are connected and even network size are specified and shown.
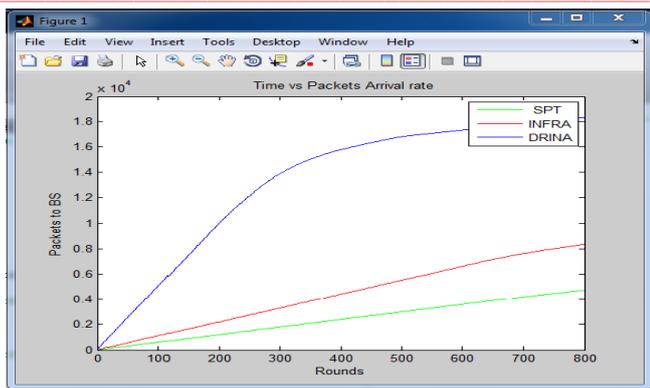
2.

Window showing data Packet arrival rate at cluster that are transferred in time during the time for different techniques. Number of packets that reach the cluster. This metric indicates the quality of the routing tree built by the algorithms and aggregation rate.
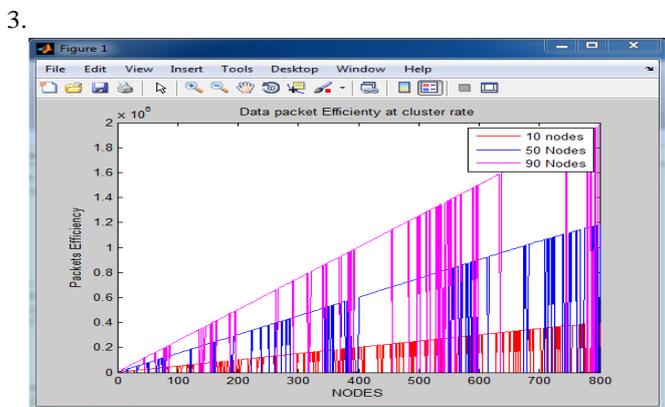
3.

Window showing data packet efficiency during cluster nodes or we can say energy consumed by Cluster nodes for set (10, 50, 90) Nodes. Efficiency is nothing but Packets per processed data. It is the rate between the total packets transmitted (data and control packets) and the number of data received by the cluster.
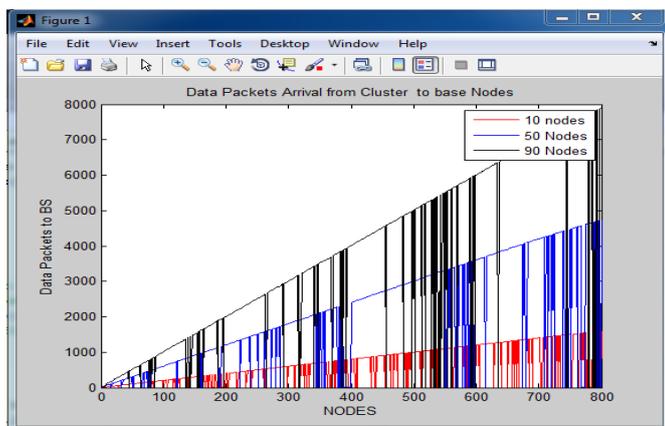
Window showing data packets received from Cluster to Base station for set of (10, 50, 90) Nodes here the data delivery rate are evaluated.

VI. CONCLUSION AND FUTURE WORK

In this paper, INADR algorithm is discussed. Aggregation aware routing algorithms play an important role in event-based wireless sensor networks. The proposed INDAR algorithm is an efficient and reliable Data Aggregation Aware Routing protocol for wireless sensor networks. By maximizing the aggregation points and offering a fault tolerant mechanism to improve delivery rate, INDAR will outperforms the existing systems. The proposed algorithm have some important key aspects required by wireless sensor networks for aggregation aware routing algorithms such as a reduced number of messages for setting up a routing tree, number of overlapping routes is maximised, high aggregation rate, reliable data aggregation and transmission.

As future work the proposed system can be modified which should also consider spatial correlation, waiting time of the aggregator nodes.

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