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Smart Routing for WSN for the Energy Balanced Routing over Hierarchical Deployments

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Abstract— the data aggregation is the method of combining the data streams coming from multiple nodes. The data aggregation methods reduce the routing decision cost implied by the routers or nodes in the path. The data aggregation can be proven to be efficient in the terms of energy efficiency or transmission efficiency. The proposed model is entirely based upon the data aggregation and data forwarding technique. In this research project, we have tried to develop the new era aggregation model for the wireless sensor networks. The proposed model is intended to enhance the energy efficiency by improving the aggregation model for the sensor networks to enable the efficient delivery mechanism for the data. The WSNs are the directed graph networks, where the data is being sent into the similar direction of base transceiver station (BTS). Because the data in the directed graph networks flow in a particular direction, it always made the aggregation method efficient. The proposed model aggregation model is based upon the smart amalgamation of heuristic and greedy algorithm based aggregation. The greedy allows the algorithm to cover any number of data streams for the aggregation, whereas heuristic is responsible for the group formation before going for the aggregation. The multiple aggregation groups are produced by using the heuristic approach in the proposed model. So in this thesis, we have proposed and implemented the smart heuristic and greedy based hybrid aggregation and data transmission algorithm. The proposed model has shown its effectiveness in the case of aggregation and data transmission. The proposed model has proved its efficiency in the form of network load, route persistence, energy consumption and latency. The proposed model has proved it better than the previous approaches on the basis of the above listed performance parameters.

Keywords— data aggregation, energy efficient WSN, wireless sensor network, minimum latency, route adequacy.

I. INTRODUCTION

A wireless sensor network is a collection of sensor nodes which co-operatively send sensed data to base station. Wireless sensor nodes are very small in size and have limited processing capability very low battery power. Each of these nodes collected data and its purpose is to route this information back to a sink. All the sensor nodes are interacting with each other or intermediate sensor nodes. In wireless sensor network source node is the node which will send the requested data. Similarly sink node is the node which will send the request for the data. A sensor nodes that generates data, based on its sensing mechanisms observations and transmit sensed data packet to the base stations. The base station is act as a gateway between sensor nodes and end users. The base station will also used for aggregation of data between the nodes.

This process needs more energy to transmit data when base station is located very far away from sensor nodes so that better technique is have fewer nodes sends data to base station. Theses nodes called aggregated nodes and processes called data aggregation in wireless sensor network. Data aggregation is the process of compressing the correlated data of neighboring nodes locally before transmitting them to their destination. The main goal of data aggregation algorithms is to gather and aggregate data in an energy efficient manner so that lifetime of network is increased. With aggregation, packet loss become more destructive because the loss of one packet may cause the loss of information aggregated from a number of nodes. So robustness is crucial issue for data aggregation. The major challenges of data aggregation for event detection lie in dynamics of data traffic. The existing data aggregation methods based on continuous sensing in which sensor nodes follows a predefined schedule so sensor nodes will waste time and energy to listen even if there is no event at all. A new MAC protocol, DA-MAC is formed which provide direct support from data aggregation. To achieve both robustness and dynamic data aggregation simultaneously a cross-layer approach is used. DA-MAC protocol provides channel contention information that channel is busy or not. Based on channel content status, the MAC protocol helps a sensor node determine when and where to aggregate and send out data.

The proposed model is based upon the amalgamation of the tree-based routing with the energy-based and energy-balanced routing to elongate the WSN lifetime. The proposed model is intended to utilize and combine the most efficient protocols to offer the best performance of the WSNs. We have amalgamated the hybrid routing mechanisms with the data aggregation method to minimize the routing decision overhead to make the whole system efficient.

II. RELATED WORK

Kiran Maraiya et al. [1] which explained that due to data aggregation we reduce the energy consumption by eliminating redundancy. In wireless sensor network all nodes are resource constraints. With the help of data aggregation life time of network will increased. They describe the architectural based efficient data aggregation and protocol based network architecture. **Weigang Wu et al. [6]** which states that a cross-layer approach to realize robust and dynamic data aggregation by use of direct support from MAC layer. A new MAC protocol, DA-MAC gives the channel content information. Based on this information a node can dynamically check when and where to do aggregation. To tolerate packet losses, used a virtual overlay, Rings to forward one packet to multiple nodes. This approach can handle both traffic dynamics and packet losses, with less cost. **Hamed Yousefi et al. [7]** which explained that a structure-free Real-time data Aggregation protocol, RAG. In this they use a new method combining temporal and spatial convergence of packets using judiciously Waiting policy and Real-time Data-aware any casting policy. They gain performance improvement in terms of energy consumption, miss ratio, aggregation gain and end-to-end delay for wireless sensor networks.

Delaney et al presented their own routing framework for tree-based Routing Protocol for Low power and Lossy networks (RPL) in WSN. This framework aimed at tackling the problem of instability caused due to frequently changing transmission routes. The said problem was tackled with the introduction of neighbourhood heuristics (NHs) which included the combination of current sensor's routing metric as well as of its neighbors to identify the link quality of present route and other alternatives, so that an effective decision can be taken to select the routes that add to the stability of the network along with maintaining a single best path. This route stability framework not just gives the best single path but also leads to best alternatives routes in case of primary link failure. Bechkit et al provided a new weighted Shortest Path Tree (SPT) routing algorithm to overcome the drawbacks of existing SPT algorithm for many-to-one WSN link structure. In existing SPT algorithm the path from source node to sink was calculated on the basis of costs of the links making up the path with all links within that path having same weight. As a result the nodes closer to the sink faced heavy load rather than those being far and exhausted early in terms of energy. In the new weighted SPT algorithm, all the links are assigned with the decreasing weights based on their level of presence within the network, aiming at reducing communication overheads and increasing the lifetime of the network. Musznicki et al introduced the concept of Dijkastra-based Localized Energy-Management Algorithm (DLEMA) for reducing the load on bandwidth and preserving the energy to increase the overall network lifetime. This algorithm was introduced keeping in mind the energy requirements of sensor nodes deployed in remote areas with no human reach to replace or recharge the batteries. DLEMA calculates only the lowest cost path from the present node to the destination node in a one-to-many network tree as a result, there are lowest delays and the network lasts longer.

III. EXPERIMENTAL DESIGN

The neighbour formation is the process of initial stage connectivity between the wireless sensor nodes. The neighbor formation process is based upon the coordinate information sharing and distance based calculation. The nodes within the one hop distance and transmission radius are marked as the immediate neighbor for the nodes. The Pythagorean formula has been used for the purpose of distance calculation in the three dimensional environment. The formula is as following:

$$Di = (x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2$$

The neighbor formation is the fundamental process for the wireless sensor network connectivity. The neighbor formation process is the initial stage sensor node connectivity process initiated using the hello sharing and then followed by sharing the node location coordinates. Wireless sensor network Localization is the process of creating the inter-connections between the sensor nodes. The sensor node localization process connects the nodes with other nodes within the transmission range of each node. The nodes maintain the neighbor table for the shortlisted nodes. The neighboring nodes are further connected and grouped in the groups in order to facilitate the flexible and easy management of the nodes in near connections. The localization process further enables the other processes as routing, clustering, etc.

Algorithm 2: Localization Group Formation

1. Power up the sensor nodes in the WSN cluster.
2. The nodes begin the data transmission broadcasts towards the neighbor nodes (specifically the nodes located on the one hop distance)

   When R is given 250 meters, denotes the transmission range of the sensors.

3. A sensor only shares its GPS coordinates obtained via internet source or GPS source with the nodes in the transmission range.

   Di (i,j) = $\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} + (z_i - z_j)^2$ (1)

   $\int_0^N \boldsymbol{transmit(x,y) \rightarrow i} \quad , \boldsymbol{if\ Di < R}$ **(2)**

4. The neighbor node replies with its GPS position details to the requesting node.
5. The sensor node builds the whole information at a single place in the shape of an information array which contains several neighbor attributes information such as distance

   Distance (i,j) using (1)

6. The neighbor formation process takes place once the initial information broadcast is finished with the nodes within transmission range

   Nodes (j) = $\int_0^N \sum_{n=j}^{di<R} fn\ (\ x_j\ ,\ y_j\ ,\ d_{ij}\ )$ (3)

   Where, Nodes (j) denotes Neighbor Table array for node i.

   $x_j$denote x coordinate andy_j denote y coordinate.

7. Neighbor table on the sensor is updated with all essential neighborship details after completion of the neighboring process and the anchor node selection procedure begins.
8. Anchor nodes are selected randomly in the given topology which helps in forming the clusters in the WSN network.
9. The nodes connect themselves to the anchor node on the minimum distance to form the location based WSN clusters.
10. In the final step, the anchor node will release and relay its role to other node with highest degree of connections on the distance of one –hop.

Aggregation Decision

After the completion of the localization process the final step comes to aggregate the data on the local anchor nodes, which are managing the small groups within in the WSN cluster. The aggregator nodes are capable analyzing the traffic coming from the slave nodes of the anchor nodes. The anchor node analyzes the ingress data, aggregates it and forwards it to the cluster center or the sink, whatever is in the direct transmission range of the anchor nodes. The local aggregators, also called anchor nodes use the following method to aggregate the data to convert them from several node data to one stream towards the sink or the cluster head:

Algorithm 3: Aggregation Process

1. The anchor node analyzes the ingress data comings from the local or slave nodes.
2. The nodes sending the similar types and sizes of data are grouped in the several network sub-groups on the regional aggregator node, called anchor node.
3. The local aggregator node aggregate the data into different streams according to the packet size, data volume and ingress data rate.
4. The aggregated data header includes the detailed information of the source nodes in the aggregation header.
5. The active slave nodes are changed from one aggregate stream to another, if they changes the data volume, data rate or packet size.

IV. RESULT ANALYSIS

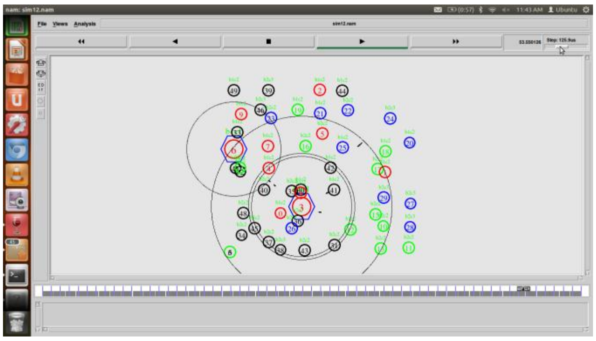

Fig 13: The route forwarding scheme on the run

The proposed model has been well tested under various situations in the sensor network simulation. The proposed energy based routing protocol on sensor network has been well tested for the performance parameters of delay, throughput, and network load. The nodes in the proposed model simulation have performed well in terms of all of the above parameters. The network load, throughput, and throughput has been recorded lesser than the ordinary sensor networks with mobility or stationary positioning under the similar situations.

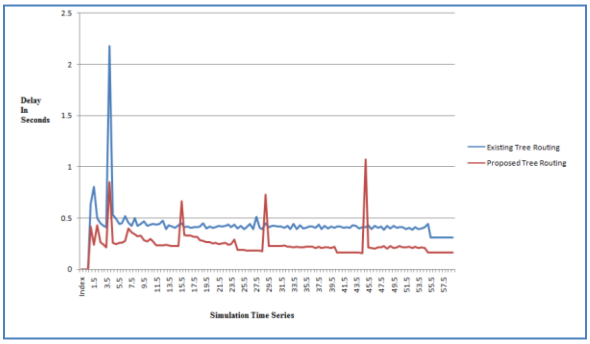

Fig 14: The delay obtained from the various groups of nodes in the topology

The maximum delay recorded in the simulation is ranging between 0.5 and 1 milliseconds. (Figure 14) The delay is the parameter represents latency of a packet when it was being sent between two nodes. The time taken for a packet to reach the destination from the source is called the total delay. The improvement of almost 20%-30% has been recorded in the proposed model in comparison with the existing model.

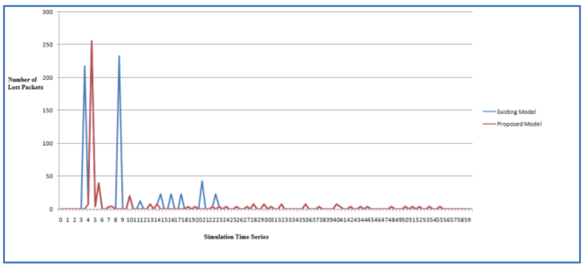

Fig 15: The graph of lost data across the groups of nodes in the given cluster

The lost data rate is the parameter which shows the data drop due to link overloading or resource occupancy during the runtime. The proposed mode has been well tested for the data rates on the different times in the simulation, which has directly affected packet loss. The proposed model has been found showing the minimum lost at 0 percentage resource usage and maximum lost at 250 packets, where the sensor network is over-flown with the data, because a number of nodes are transmitting the heavier amount of data towards the sink nodes. The lost in the earlier stage is little higher in the case of proposed model, where the network convergence due to mobility is the major reason, whereas afterwards the lost data rate comes to the normal levels. There is almost 2-3% improvement recoded in the proposed system.

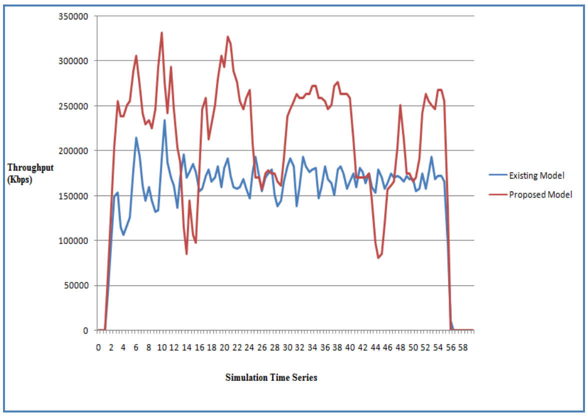

Fig 16: The graph of throughput obtained from different groups in the given topology

The throughput (Figure 16) is the parameter represents the capacity of a node or a network to send the data per second. The throughput of the sensor network using our proposed energy aware tree based routing protocol has been recorded between 80 and 350 Kbps in proposed system and 100 to 230 kbps in the existing system. The 0 kpbs is the value recorded when no data is being sent between the nodes in the initial stages. Once the data transfers start, the throughput starts going up. The maximum limit of the throughput is 160 Kbps. The proposed system shows the improvement of almost 15-20% in the throughput.

V. CONCLUSIONS

The proposed model is the combination of the tree-based routing with the energy-based routing for the WSN cluster lifetime elongation. The major goal of the proposed model is to overcome the routing overhead problems and the problems related to the energy efficiency. The proposed model has been designed to minimize the transmission delay and load, whereas improving the throughput and packet delivery ratio. The proposed model has been evaluated on all of the essential parameters at multiple times to evaluate the performance of the proposed model. The proposed model has been found highly efficient and flexible in order to provide the best delivery of the data.

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