Data Aware Routing in Wireless Sensor Networks

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Abstract — The wireless sensor network (WSN) has set of wireless intelligent sensor nodes with high speed network. Nodes are deployed randomly in a surge of unanticipated applications. The routing is one of the most important challenges in WSNs for data transmission over the sensor nodes. The paper proposes the data aware routing in WSNs, which incorporates energy efficient routing of data. The objective of the proposed work is to improve the performance of network in terms of energy consumption and throughput. The simulation results show that the proposed approach perform better in-terms of utilization of minimum energy, efficient for cluster formation, and reduce communication overhead in WSNs.

Keywords — *Wireless Sensor Network, Cluster Head, Energy Aware Routing, Sensor Node, Sink Node.*

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I. Introduction

The wireless sensor network (WSN) composed of intelligent wireless sensor nodes. These nodes are connected with smart intelligent networks. There are many set of unforeseen applications in WSNs. The diversity of evolving applications represents the great success of WSNs in real world environment. Application specific WSN consists of hundreds to thousands of multi-functioning sensor nodes, operating in an unattended or hostile environment with limited computational and sensing capabilities. Realization of sensor network applications requires wireless networking techniques [1]. WSNs are used in wide range of applications in areas like health, military, home, context aware, and commercial industries in our day to day life. Sensor nodes are densely deployed in an unattended environment with the capabilities of sensing, wireless communications and computations. These spatially distributed autonomous devices cooperatively monitor physical and environmental conditions.

The prime purpose of such sensor networks is to gather information about the environment or data they are sensing and send the information back to end-users. WSN protocol design is influenced by many factors such as hardware constraints, network topology, and power consumption. In most WSN applications the power unit of sensor node is not replaceable [2] [3]. Limited energy becomes one of the biggest challenges in WSN design. Indeed, the protocol is used in WSN by writing queries and gathering results from the base station, which behave as an interface between users and the network. In this way, WSNs can be considered as a distributed database. It is also envisioned that sensor network will ultimately be connected to the internet, through which global information becomes feasible.

Maximizing the lifetime of individual nodes on a sensor network is a key consideration in deployment of WSNs. Power limitations in sensor networks makes routing of traffic a critical issue, since a congested node relaying a high volume of packet will soon exhaust its battery and fail. Moreover, a bottleneck node will cause packets to experience longer delays, possibly missing their deadlines which would be disastrous for real time traffic routing. Therefore, in order to prolong the lifetime of the sensor nodes, there is a need to develop a mechanism of managing power consumption at the forwarding nodes as real time and non real time traffic are routed through them. The energy consumption and packet losses are problems that must be addressed in the design of WSNs. In order to collect reliable information, sensor network should be operative for a long time and minimize network traffic loss. It is challenging task to check inward network working status and get continuous information from sensors [4].

The rest of the paper is organized as follows: Section 2 presents an overview of related works. Section 3 discusses the proposed work for data aware routing scheme. Simulation and results analysis are presented in Section 4, and finally conclude the proposed work in Section 5.

II. Related Work

The work given in [5] presents an effective uses of various protocols on multipath routing in WSN. It has supported the multipath routing information, which is stored in the form of tabular representation for future references for routing. The work given in [6] presents an energy efficient routing algorithm for WSNs. The selection of cluster heads by the sink node in the network based on the following parameters like residual energy and node localization. Cluster head selects the shortest path to sink node for data transmission or routing of data. The proposed scheme shows the better energy and network lifetime.

The survey of QoS aware routing protocols with the performance issues and the design challenges for WSN is presented in [7]. The work given in [8] discusses on data centric routing in WSN by using energy aware. The proposed scheme shows the effective usage of network performance parameters in terms of energy consumption, network lifetime, packet transmission, and throughput. The proposed work is simulated by using NS-2 simulator. The routing is presented in WSN based on MAC aware [9]. In which the next hop decisions are made based on the TDMA scheduling and the two-hop neighbourhood knowledge. Coherent decisions in space, taken by the routing protocol, with those taken by the MAC protocol, in time, prove to be efficient against several metrics: delay, energy consumption and hop number. The simulation results show good performance of our strategy in medium and high density networks compared to the state of the art.

The work given in [10] proposes delay and energy aware routing in WSN. This scheme aims to construct the trade-off between energy consumption and delay for transmitting data from sensor nodes to sink node in the network. The work given in [11] presents distance based energy aware routing algorithm for WSNs. In this paper, a distance based energy aware routing (DEAR) algorithm is proposed to ensure energy efficiency and energy balancing based on theoretical analysis of different energy and traffic models. The context aware routing for data gathering and dissemination in distributed sensor networks is presented in [12]. In this work, identifies four different contexts in DSN by considering the scenario of forest environment such as: temperature context, air pressure context, energy aware context, and object aware context. The two levels of data aggregation processes (Cluster Head node and Sink node levels) are considered for minimizing the redundant data for transmission. Finally, they have evaluated the performance parameters for the proposed scheme. Some of the related works are given in [13, 14, 15, 16, 17, 18, 19, and 20].

Previous researches do not consider the clusters for the data aware routing in the WSN. The number of nodes increases in the network, the data transmission or traffic congestion increases. In this regard, the network required for cluster formation among the nodes. The clusters are used to provide the following advantages: load balancing, decrease the traffic congestion, scalability, flexibility, and better throughput in the network. In the proposed work, the network is split into number of clusters, each cluster has cluster head (CH) node. The election of CH node is based on highest energy among the nodes in the clusters. Once CH elected in all the clusters, the remaining nodes are associated with respective CHs. Finally the proposed data aware routing performs the better network lifetime and efficient energy consumption. An objective of the proposed work is as follows: (1) to provide energy efficient routing over the CHs; (2) to minimize the traffic congestion; (3) to provide efficient load balancing and data aggregation over the CHs; (4) to increase the throughput of the network.

III. Proposed Work

The proposed system architecture, topology control, and functioning scheme are described in this section.

A. System Architecture

The following essential assumptions were made in the proposed scheme: (1) All the sensor nodes are static and deployed randomly; (2) Nodes in WSN are initializing with GPS for tracking location. During set-up phase all nodes inform its location to CH node; (3) all the sensor nodes sense the data periodically and send it to the respective CH node through single-hop, CH node forwards the sensed data to sink node/base station using data aware routing (DAR) inspired routing protocol.

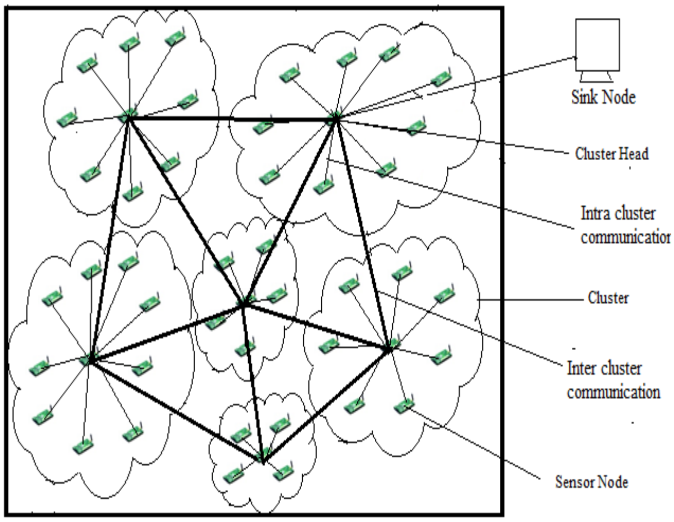

Fig.1. System Architecture.

The proposed system architecture consists of set of sensor nodes $S_i = \{S_1, S_2, S_3, S_4, \text{---} Sn\}$, which are deployed randomly as shown in fig.1. The network is divided into clusters, each cluster has CH node. In each cluster, the highest energy of node is elected as a CH node. The remaining active nodes are considered to be cluster member nodes of respective CHs of the network. The CH node collects the data from its member nodes, transmits the data to sink node over the CHs in the network. The sink node stores the data/information about each clusters of the network like CH_id, #active nodes, and bandwidth of the cluster. All active nodes in each cluster communicate with CH node periodically single-hop communications. In each round, whenever energy drops below among active nodes in each cluster, one of the nodes will be elected as a Ch node. Finally, sink node performs the operation upon receiving the data form sensor nodes in the network. Some of the notations used in the proposed scheme are as shown in table I.

TABLE I. Notations

Notations	Descriptions
$S_i = \{S_1, S_2, S_3,$ --------- $Sn\}$	Number of sensor nodes
CH_i	Cluster Head Node
E_S	Energy required for sensing
E_T	Energy required for transmission
C_i	Clusters
T_{Ei}	Total Energy of sensor node
B_i	Bandwidth
P_k	Number of Packets
l	Length (meter)
b	Breadth (meter)
Th_E	Threshold level energy
ES_i	Energy of sensor nodes
RSEi	Residual energy of sensor energy
N_S	Sink node
AC_i	Active Nodes
Sln_i	Sleep Node
Rc	Transmission range
di	Distance

B. Functioning Scheme

1. Algorithm for Data Aware Routing.

Begin

1. Deploy the number of nodes randomly with initial configuration of sensor nodes in the network;
2. To identify number of possible cluster is as follows:

   Number of Clusters = Number of Nodes / Minimum number of nodes in each cluster ≤ 50.

3. To select the CH in each cluster based on the localization and highest energy randomly;
4. Selected CH node broadcast the message to its all nodes;
5. Each node receives the CH information within the communication range;
6. CH form the cluster with its active nodes (member nodes) in the network;
7. CH node transmit the information to sink node periodically over the CHs is as follows:
   if (Data = = TRUE) {
   CH Aggregate the cluster member's data and send the data to sink node;
   Else

End

IV. SIMULATION

The proposed work is simulated by using MATLAB programming language. The scheme of the proposed work has been simulated in various network scenarios with random number for 100 iterations. This section presents the simulation model, simulation procedure, performance parameters, and results and discussions.

A. Simulation Model

The proposed simulation model consists of 'S_i' number of sensor nodes are deployed randomly in a WSN. The proposed scheme associates with CHs for data transmission and data aggregation. It's considered an area of l * b square meters for WSN environment. Each experiment corresponds to a random placement of sensors in a fixed network area and performs the data aware routing in WSN. Sensor nodes are used to generate variable size of data packets. S-MAC protocol [21] is used for media access in WSN. The transmission of packets is assumed to occur in discrete time. A node receives all packets heading to it during receiving interval unless the sender node is in 'non-active' state. For simplicity,

Each sensor has a battery with finite, non-replenish able energy, which was set to an initial energy in joules. Whenever a sensor transmits or receives a data packet, it consumes some amount of energy. The energy model for the sensors is based on the first order radio model for calculation of the energy dissipation for sensing and receiving, transmission as well as finding fault tolerance of the network. The radio can perform the power control and hence use the minimum required energy to reach the fault tolerance criteria. It is assumed that at any given time, the value of energy required for transmitted (ET) and sensing (ES) for 'k' bit packet to another node'd' meters is 'EN' Joules for node.

Total Energy (T_E) = E_S*P_k/Bits+E_T*P_k/Bits*d_i (1)

Where,

P_k = Size of packets in terms of bits

B. Simulation Procedure

To illustrate some of the results of simulation, we have considered the following variables: S_i=100–600 wireless sensor nodes, Number of sink nodes (N_S) = 1, Energy of each nodes (ES_i) = 2 J, Size of the network = 1000 × 1000 m, Transmission range (Rc) = 100 to 200 m, Energy required for sensing of each node (E_S) = 50 nJ/Bit, Energy required for transmission of data (E_T) = 50 nJ/Bit, Packets (P) = 64, 128, 512, 1024 Bits and so on, and Threshold Energy (Th_E) = 0.05J, and transmission of data = bits/s.

Begin

1. The number of sensor nodes placed randomly;
2. The network is associated with number of clusters;
3. Configure the CHs node in each clusters;
4. Apply the proposed scheme for data routing over the CHs;
5. Evaluate the performance parameters against existing algorithms.

End

C. Performance Parameters

The following are the performance parameters for the proposed scheme s:

1) *Energy Consumption*: The number of active nodes increases, the increase in the energy consumption of sensor nodes in the networks. The energy consumption of nodes is measured in terms of mJoules.
2) *Throughput*: It measures the number of sent and received packets successfully through communication channel within specified time of the network

D. Results and Discussions

Fig.2 describes the number of nodes increases in the WSNs, there is increase the energy consumption among the number of sensor nodes with respect to various data rates. The proposed data aware routing (DAR) algorithm achieves the better energy consumption for routing from source node to sink node. Initial deployment of sensor nodes are assumed to be good number of active nodes in all three data rates, as the percentage of data rates increases for data processing, gradually increases the energy consumption of sensor nodes in the WSN environment.

The fig.3 depicts the throughput of the network with the number of nodes. As the number of node increases, the decrease in the throughput of the network with respect to different data rates. The proposed DAR algorithm achieved better throughput as compared with routing algorithms. The number of nodes can be rigorously and aggressively switched to sleep mode so that packet dropping is more and also congestion is more, whenever number of nodes increase. The proposed DAR performs better throughput of the network because the CH node always monitors the status of active nodes in terms of energy, bandwidth, and link efficiency.

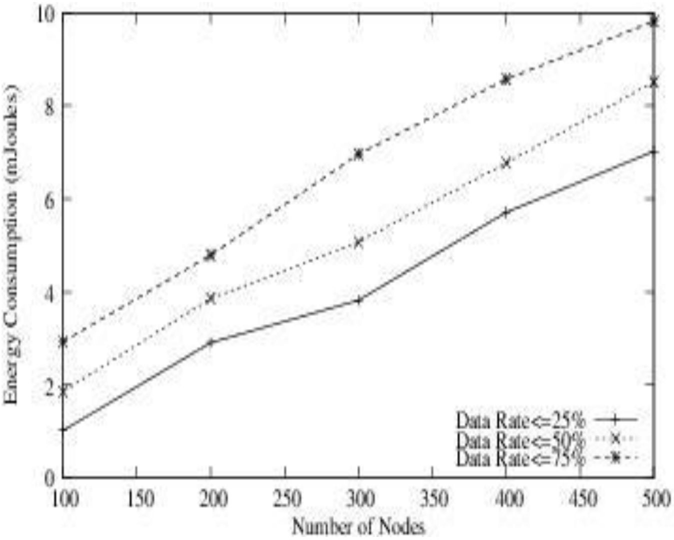

Fig.2. Number of Nodes vs. Energy Consumption.

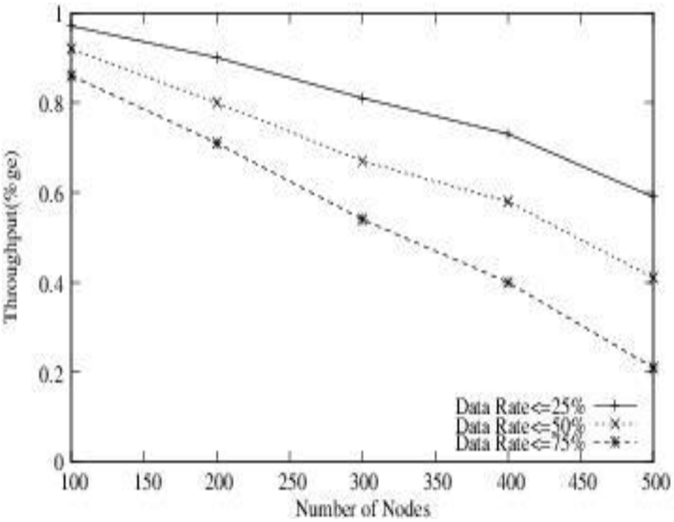

Fig.3. Number of Nodes vs. Throughput.

V. CONCLUSION

The proposed data aware routing algorithm is energy efficient for data processing in the network. Compared to other algorithms, proposed protocol (DAR) gives less delay, minimum packet loss, relatively better throughput. In this work, the performance parameters analyzed in terms of number of energy consumption and throughput. Simulation result shows that the proposed protocol is much better than other protocols.

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