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Novel Cluster Based Energy Proficient Data Aggregation in Wireless Sensor Networks

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Abstract: Sensor nodes in the network continuously sense the physical phenomenon of the environment and transfers to the base station. To reduce the energy consumption and to avoid the redundant information a novel cluster based energy capable data aggregation technique is implemented. Here, the cluster node in the network is selected based on higher residual energy. The member nodes in the cluster send the collected information through high link connectivity nodes to the Data Depositor (DD) present near the Cluster Head (CH). The DD analyses the aggregated information, updates the repositories without redundant information. This collected information is then transferred via. stable routing to the destination. The performance of this proposed protocol is implemented using network simulator tool.

Key words: Routing, data depositor, data aggregation, clustering, wireless sensor networks, protocol

INTRODUCTION

In wireless sensor network, the sensors are used to collect the information from the environment and forwards to the base station via. single hop or multi-hop communication. Multifunctional wireless sensor nodes are used for several applications and it is developed by recent advancements in wireless communications and electronic devices. These sensor nodes unrestrictedly communicate with its neighbour nodes and the features of theses nodes are sensing, processing and forwarding the data.

Several routing protocols for network topology management have been proposed effectively to perform data collection or aggregation. Topology management plays an important role in reducing different constraints such as limited energy, delay, node failure, long range communication within a network, communication failure, etc. Selection of effective topology helps to increase the network performance, lifetime and QoS. To extend the lifetime of the network, energy consumption is the challenging factor in order to guarantee the connectivity of the network.

Clustering is a technique used for energy preservation in wireless sensor networks. Cluster based communication is an advanced approach used to conserve energy of all sensor nodes present in the network and some of the higher energy nodes called cluster heads are only able to communicate with the destination node or base station. By grouping the nodes into cluster and applying data aggregation technique to that will greatly reduces the energy consumption and increases the throughput of the network.

Literature review: Different approaches have been released to obtain energy efficient data collection in wirelessly sensor nodes. Several clustering mechanisms have been proposed based on system level design and routing consideration using energy prediction (Vaidyanathan *et al*., 2004). Grid based data aggregation and network based data aggregation are the two data aggregation schemes was proposed data aggregator is fixed in each grid to aggregate data from all sensors within the grid. Here, the signal strength is measured and the highest signal strength node is selected as data aggregator. Network flow data aggregation involves energy constraints to optimize the network lifetime by applying approximation algorithm based on heuristics such as distance, hop-count and residual energy (Chong *et al*., 2007). A data collection method was proposed based on careful analysis of the surveillance information delivered by the sensors. To dynamically reduce the workload of sensors spatial correlation is used, here, sensors are partitioned into clusters and the cluster is managed efficiently for energy constraint. By aggregating the data, the relay nodes reduce the number of transmissions compared to the usual number of transmissions. Randomized intra-cluster scheduling method is used to balance the workload among all the sensor nodes without introducing communication overhead (Jeong *et al*., 2016). Adaptive data aggregation scheme was proposed for energy harvesting in wireless sensor nodes. The aggregated data received from the other nodes and the sensed data by the node are all aggregated together and transmitted to the other node at appropriate times. This scheme periodically gathers the

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sensed information and occasionally transmits the aggregated data based on the residual energy of the corresponding node. If the node has high residual energy, the node transmits the aggregated data by using its extra energy and if the residual energy is lesser, then node is set to sleep state and disconnected from the routing path (Zhang *et al*., 2017).

To obtain optimal data gathering scheme Distributed Data Gathering Approach (DDGA) was proposed. Here, a Rechargeable Sensor Node (RSN) with a mobile sink which travels in a pre-defined path is used to collect the data in their surrounding environment. All the sensor nodes needs to transmit their sensory data to the mobile sink and each sensor can vary its transmission range by adjusting its transmission power. Solar cells are used to power up the rechargeable sensors. The network utility maximisation problem is transformed into an approximate solution by shifting energy consumption conservation by analysing necessary conditions for optimal solutions (Kawamoto *et al*., 2015). For each location in the network the environmental condition is different, hence, an efficient data collection method was proposed in this scheme. The dynamic adjustments to the network and the users were made based on the CSMA/CA scheme. The list of ambient information is collected and transmitted according to the user requirements in the determined time period and the algorithm was proposed to accommodate the changes occurred in the network condition dynamically (Zhao *et al*., 2008). Mobile data gathering with space-division multiple access technique was proposed to optimise the system performance. A mobile data collector called sencar deployed in the WSN to collect the data from the sensors. Each sensor directly sends the information to the sencar without any relay, so that, the sensor lifetime gets prolonged. SDMA was used to reduce the total data gathering time, i.e., the data uploading time and moving time. Minimum Covering Spanning Tree (MCST) algorithm named greedy algorithm was used to find out the minimum average cost of the polling points (Zhou *et al*., 2015). Both data routing and data aggregation are considered to improve the energy efficiency for data gathering in WSN. Three aggregation methods such as full aggregation, non-aggregation and a hybrid partial aggregation using compressive sensing are used. Mixed-Integer linear Programming (MIP) was proposed, here, optimal data-gathering tree with the maximum network lifetime was found for each and every node present in the network. The sink node S collects the data from all the nodes a-f, a and b are the intermediate nodes collect the data from the nodes c and d as well as e and f and adds its own data into the data unit, then all the information in the data unit is sent to the S node (Fig. 1) (Pacharaney and Gupta, 2016).

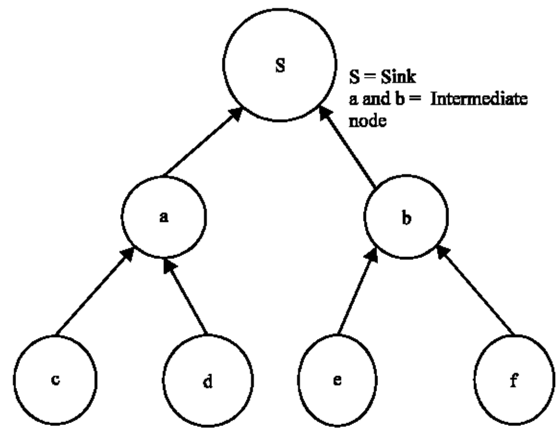

Fig. 1: Tree based data collection

The data sensed from the high density nodes have more redundancies and the energy conservation will be higher. To provide high reliability in terms of connectivity and coverage area of the network restructuring a hexagonal clustering topology is proposed. Attenuated disk model is used to determine the Euclidean distance between the sensors. The significant amount of energy consumed by the sensor nodes during sensing and communicating describes sensing energy cost. Active/sleep scheduling algorithm is used for sensor nodes for power management in order to prolong the network lifetime.

MATERIALS AND METHODS

In wireless sensor networks, sending the data to the base station requires more accuracy because sensed data used for several critical and real time applications. The information should be passed via. stable routing with high energy efficient sensor nodes. The energy efficient sensor nodes are identified by forming clusters in the network. The BS collects the information of nodes position and their energy levels during the setup phase. Based on the collected information, the node with higher energy is selected as the cluster head. The CH gathers and analyses the information received from the MN. The link stability is calculated among the cluster heads present in the network.

Connectivity link between member nodes in the cluster: The wireless sensor network is partitioned in to group of clusters and each cluster consists of certain Member Nodes (MN) in them. The nodes with the higher energy are selected as Cluster Head (CH). The connectivity link between the member nodes should be maintained in order to collect the information continuously. The link between

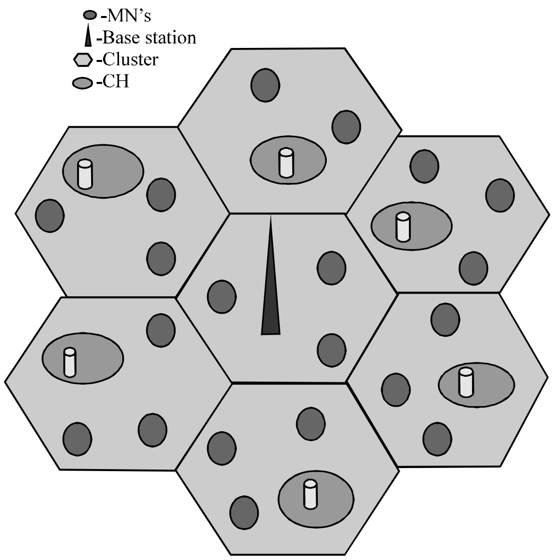

Fig. 2: Cluster based data collection scenario

the nodes is determined by using received signal strength. The highly stabled link nodes are selected for optimal routing. The sensed information from the member nodes are aggregated in the Data Depositor (DD) node and transmitted to the CH through stable link.

Connectivity between CH and BS: The CH consists of data depositor in which the data collected from all the sensor nodes are fused together. The data analyser is used to analyse the ambient information collected from the member nodes in which the redundant information's are removed and data's are updated. The CH contains the analysed data in the DD is transferred to the base station. The link between the CH's should be stable and shortest path is selected for data transfer in order to reduce energy conservation. The link between the nodes or cluster heads is determined by the Received Signal Strength Indicator (RSSI). It involves transmitted power, received power and distance between the nodes. Based on the power present in the received signal, the link between the nodes is constructed.

Figure 2 shows the each cluster consists of some number of MN's and these MN's are used to sense the information from the environment and passed to the CH. The CH is selected in the cluster based on the residual energy of the node. The CH consists of DD, here, the data is analysed using data analyser in a timely fashion, so that, the redundancies present in the collective information is removed and only the required data is transferred to the BS effectively through high stability link (Algorithm 1).

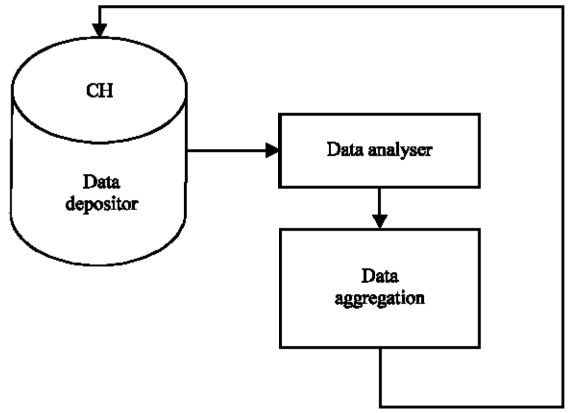

Fig. 3: Data aggregation

Algorithm 1; Data transfer through stability link:

A0-setup phase:
  BS-collects node information
  Cluster formation
  Calculate energy level of each node
  Select higher energy node
  Set as CH
A1-data collective phase:
  Src broadcasts RREQ
  Dstn send RREP
  Grouping sensed data through DD
  Processing data for redundancies
  CH sends processed data to DSTN

The CH consists of data depositor which gathers information from all the nodes and process the information for efficient output. This DD consists of data analyser and data aggregation mechanism in order to process the sensed information. The data aggregation is the technique used to remove the unnecessary or some redundant data to reduce the energy consumption for data communication (Fig. 3). This aggregated data is sent to the BS or to the next cluster head based on efficient routing path to the destination.

RESULTS AND DISCUSSION

The simulation analysis is done for the proposed protocol and the performance is analyzed by using the Network Simulator (NS2) tool. NS2 is a discrete event time driven simulator which is used to mainly model the network protocols. The NS2 is an open source programming language uses C++ in back-end and OTCL (Object Oriented Tool Command Language) in front-end. The nodes are distributed in the simulation environment. The parameters used for the simulation of the proposed scheme are tabulated in Table 1.

The simulation of the proposed scheme has 50 nodes deployed in the simulation area 1000×1500. The traffic rate

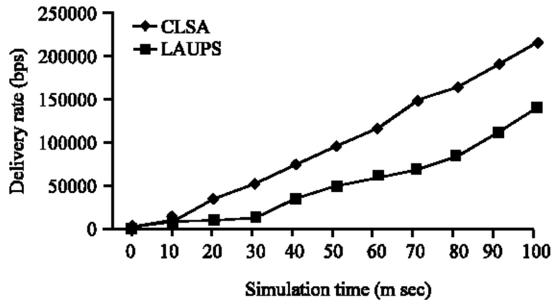

Fig. 4: Packet delivery rate

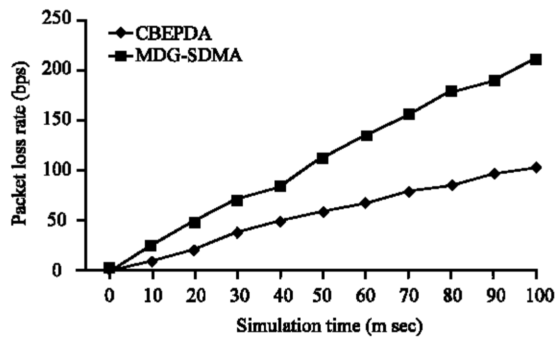

Fig. 5: Packet lost rate

Table 1: Simulation metrics

Parameters	Values
No. of nodes	50
Routing scheme	CBEDA
Traffic model	VBR
Simulation area	850×850
Channel	Wireless medium
Transmission range	250 m
Communication	TCP
Antenna	Omni antenna

of the network is handled using the Variable Bit Rate (VBR). All the nodes receive the signal from all direction by using the Omni directional antenna.

Packet delivery rate: The number of packets or data that are successfully delivered to the receiver is said to be packet delivery rate. Figure 4 shows the delivery rate for the proposed scheme and existing scheme. It is clearly shown that, the delivery rate of proposed method has higher rate than the existing method MDG-SDMA. The greater value of PDR means better performance of the protocol.

Packet loss rate: PLR is the packet loss rate that can be termed as total number of packets lost during the data transmission. The PLR of the proposed scheme is lower than the existing scheme as shown in Fig. 5. Lower the PLR indicates the higher performance of the network.

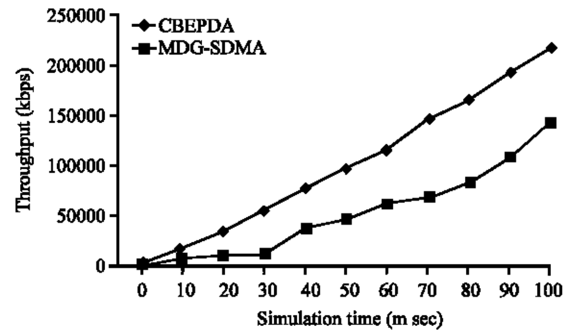

Fig. 6: Throughput

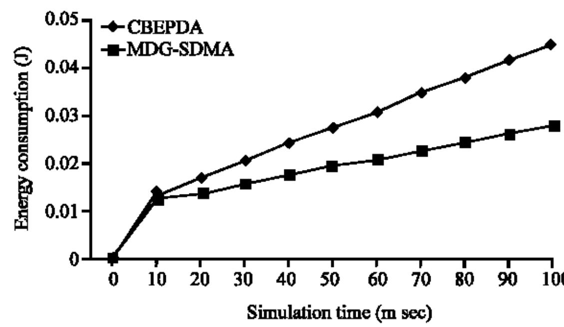

Fig. 7: Energy consumption

Throughput: The average of successful messages distributed to the destination is defined as the throughput of the network. The average throughput is approximately derived by using the given Eq. 1:

$$\text{Throughput} = \frac{\sum_0^n \text{Packets received(n)} \times \text{Packet size}}{1000} \quad (1)$$

Figure 6 shows that proposed scheme has greater average throughput when compared to the existing scheme.

Energy consumption: The amount of energy consumed by a node for the data transmission at current instance of time is defined as energy consumption. The energy efficiency is exposed in Fig. 7. The energy consumption ratio for the proposed scheme is lower compared to the proposed scheme since the data is aggregated using clustering model.

CONCLUSION

A novel cluster based energy capable data aggregation technique is implemented. Here, the cluster node in the network is selected based on higher residual energy. The member nodes in the cluster send the collected information through high link connectivity nodes to the data depositor present near the CH. The data depositor analyses the aggregated information and updates the repositories without redundant information. This collected information is then transferred via. stable routing to the destination. The performance of the proposed system is analysed and the results were discussed.

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