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Energy Efficient Routing Protocol based on QoS using Multi-Sensor radio transmission

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Abstract*: Wireless Sensor Networks (WSNs) has foreseen big changes in data gathering, processing and disseminating for monitoring specific applications such as emergency services, disaster management, and military applications etc. Wireless sensor network can be classified into Wireless sensor network with multiple sensing unit (WSN) and Wireless heterogeneous sensor network with multiple sensing units (WHSN). In Wireless heterogeneous sensor networks with multiple sensing units, the sensor nodes have different sensing units in a sensor node. These sensors collect information of the environment on the bases of task or node scheduling. In Wireless sensor nodes with multiple sensing units, the sensor nodes have multiple sensing units collecting the different information from the environment and schedule the sensing unit during deployment, after that send the data to base station save the energy.In this paper proposed Energy Efficient Routing Protocol based on QoS using Multi-Sensor radio transmission with multi sensing units. The proposed protocol was simulated using OMNET++4.0 simulator. The performance of proposed protocol is EERPQM was compared with distributed cluster head scheduling (DCHS) protocols. The results show that EERPQM is more energy efficient than DCHS.*
.***Keywords:*** *WSN, Routing protocol, QoS, heterogeneous WSN, multi sensor, radio transmission*

1. INTRODUCTION

A wireless sensor network consists of a large number of such sensor nodes which are densely deployed in wide area of network. Wireless sensor networks can give us with fine-granular observations about the physical world where we are living [1]. Sensor nodes are capable of gathering information, processing and communication. Information gathering is done by actual sensors. A WSN consists of spatially distributed autonomous sensors to monitor physical or environmental condition such as measuring the temperature, sound, pressure, air pollution and chemical composition etc. some supporting functionalities such as power supplies, are required to build a complete sensor node. Some modern network are bi-directional which are work in the both direction also enabling a complete sensor activity. WSN was motivated by military application such as battlefield, surveillance. Today such sensor networks are used in industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring and so on.

2. LITERATURE REVIEW

Routing protocols for Wireless Sensor Networks are basically divided into two categories: Network Structure Based protocols and Protocol Operation Based protocols. These network structure based protocols are divided into three categories: flat routing protocols, Hierarchical routing protocols, and Location based routing protocols. Protocol operation based protocols are divided into five categories: Negotiation based routing protocol; Multi-path based routing protocol, Query-based routing protocol, Qos-based routing protocol, and Coherent-based routing protocol [2].

2.2.1 Flat routing protocols

Flooding and gossiping [3] are not based on any routing algorithms. In Flooding, each sensor node will broadcast its information, until the message reaches the sink node. Gossiping is an alternative of Flooding. Both of these protocols suffer from resource blindness. **SPIN** protocol saves a significant energy [4]. There is the less knowledge of the nodes awareness of the network. In comparison to flooding SPIN halves the redundant data. But this broadcasting mechanism does not guarantee the delivery of packet. **Directed Diffusion [5]** sink broadcasts the "interest" message to the all sensor nodes. This routing algorithm is not suitable for that application which needs continuous data delivery to the sink since it is based on query-driven data delivery model.

2.3.2 Hierarchical Routing Protocols

LEACH, Low Energy Adaptive Clustering Hierarchy [6] is based on clustering. LEACH is an energy conserving communication protocol where all the nodes in the network are uniform and energy constrained. LEACH is based on the completely distributed approach and it's no global knowledge. The cluster head selection is performed randomly, in order to balance the energy of the network. **PEGASIS [7]** is an improvement to LEACH. It forms chains of sensor nodes. One of the nodes routes the aggregated data to the sink. The drawback is that it introduces excessive delay for distant nodes. **Hierarchical-PEGASIS [8]** is an extension of PEGASIS. Their **hierarchical-PEGASIS has been designed to** decrease the delay. Two different solutions were proposed to avoid collisions of simultaneous transmissions: First, employs signal coding CDMA. Second, allows simultaneous transmission only for spatially separated nodes. **TEEN and APTEEN**, **[9]** and **[10]**, have been defined for time-critical applications. These protocols are based on the working of abrupt changes in event attribute values which is measured by the sensors. This protocol implements a very complex query system. The main drawbacks of TEEN and APTEEN are overhead and complexity of forming clusters in multiple levels. Therefore, it treat with attribute based naming of queries and implementing threshold-based functions.

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2.3.3 Network Flow and QoS-Aware Routing Protocols

SPEED [11] is an adaptive, location-based real-time routing protocol that aims to reduce the end-to-end, deadline-miss ratio in a sensor network. It supports soft communication based on feedback control and stateless algorithms. It also specifies three types of real time communication services: unicast, multicast, and any cast. **MMSPEED (*Multi-Path and Multi-SPEED Routing Protocol*) [12]** has a novel packet delivery mechanism for wireless sensor networks to grant service differentiation and probabilistic QoS guarantees in timeliness and reliability domains. The reliability is obtained by multi-path routing. This mean the number of paths that looks on the required degree of reliability for the traffic flows. The QoS guarantees in timeliness method are guarantees the packet delivery speed.

2.3.4 Task scheduling algorithm for WSN with multi sensor unit

Divisible Load Theory (DLT) [13] schedules workload for WSN. This approach is providing optimization strategies of sensing workload scheduling. So there is two representative network models are presented such as single-hop multi-source sensor network model (SHMS) and Two-level hierarchical model (TLH). These two model is contributions include as first derive a optimal solutions of the workload scheduling to minimize the finish time of a sensing task in two different network models [13]. **Multiple Sensing Unit Scheduling Algorithms (MSUS)** [14] minimize the event-misses and saving energy in wireless sensor network. It focuses on event-driven task scheduling algorithm, called MSUS (multiple sensing unit scheduling). This algorithm is explained a best power state based on the priority and timing requirements. There are some advantages as: First, the scheduling of task is based on the priority and timing requirements to minimize the event-misses. Second, the scheduling of task in sensor node from multiple sensing units by choosing best power states resulting in minimum energy consumption. But it does not talk about the routing node and how the data is transmitted in a network. **Energy efficient distributed cluster head scheduling scheme for two tiered wireless sensor network [15]**, optimization and load balancing of network resources are critical concern to provide the intelligence for long duration. The major novelty of this work is that the network is divided into primary and secondary tiers based on received signal strength indication of sensor nodes from the base station. The proposed DCHS supports for two tier WSN architecture and gives suggestion to elect the cluster head nodes and gateway nodes for both primary and secondary tiers. The DCHS mechanism satisfies an ideal distribution of the cluster head among the sensor nodes and avoids frequent selection of cluster head, based on Received Signal Strength Indication (RSSI) and residual energy level of the sensor nodes. Drawback such as: firstly the network lifetime decreases with the increase of the number of targets and attributes. Secondary, this is not talk about data redundancy and the type of data processed in the network.

3. PROPOSED PROTOCOL

The algorithm has been designed for Energy Efficient Routing Protocol based on QoS using Multi-Sensor radio transmission called EERPQM for providing QoS for wireless multi sensor networks. The EERPQM has been designed for sensor nodes having multi sensing unit and two transmitters. The proposed protocol is used to reduce the energy consumption as heterogeneous sensor consume more energy. The proposed algorithm has been designed for applications where there is a rate guaranteed service for the transmission of data of one sensor while it is a best effort service for the data of the other sensor in a node. The data of one sensor (rate guaranteed service) uses a high power radio for transmission while for best effort transmission (data of other sensor) a low power radio is used. The sensor nodes coordinate the transmission of data in timely manner and achieve load balancing among the sensor network. This protocol overcomes the problem related to event capturing and real time data transfer as compared to the WHSN. In WHSN the existence of multiple sensing units modifies the large amount of data which is aggregated and transmitted by the sensor node, thereby increasing the energy consumption.

This scheme is based on the cluster based approach where each sensor is detecting the event and sends aggregated data to its cluster head. The cluster head then directs data packets towards the sink. This protocol assumes the existence of multi sensors (S1,S2,S3….so on) and two transmitters (R1 and R2) for sensor nodes. All the sensor nodes are assumed to be identical and have different types of sensing unit and transmitting unit. The sensing unit say SU1 senses the event and sends data to the cluster head through low power radio (Rx_1), at the same time sensing unit say SU2 also senses the event and sends data to the cluster head through high power radio (Rx_2) and as so on. The sensor nodes should be able to transfer data to the sink in real time. The EERPQM protocol is focused on the data delivery aspect of real time data. The advantages of EERPQM protocol is real time event capturing and real time data transfer and avoids redundant data generation or transmission.

Let us assume one sensing unit senses the room temperature at the same time the other sensing unit senses the humidity data. The temperature data is most critical data; it urgently sends data when event is detected. The temperature data is based on rate guaranteed service for the transmission of data. Other sensor senses the humidity data and the best effort transmission of data. The proposed protocol considers packet deadline, energy of the forwarding nodes and congestion at intermediate nodes to deliver real-time traffic and best effort traffic. It also decreases data redundancy (**duplicate data packets)** at the source node to increases reliability.

3.1 Working of EERPQM protocol

3.1.1 Event Assignment

Let us consider a cluster based wireless sensor network, a cluster approach is used to identify the packet delivery. The sensor node architecture, all sensor nodes know its location and sends data to its parent node or cluster head. Let us

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assume all sensor nodes know predefine range. All nodes communicate to each other within its range. The child node sends the data to cluster head which is most nearest to sink.
Sensor SU1, SU2… and SU10 sense the event and send to the cluster head(CH) and base station (BS) in data packet format.

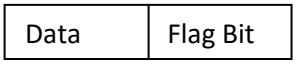

Figure 3.1 Data packet

Flag bit = 0, temperature
= 1, humidity

The entire node maintains a routing table to exchange beacon messages (HELLO) and forward a data packet based on the routing table as

< Id, x, y, e, T, flag_bit >

The HELLO packet contains unique Id for node identification, geographic location (x, y) of the node, e denote the energy of the node, T originating timestamp of the packet and flag_bit which is identified as the coming packet is SU1 packet or SU2 packet or SU10 packet. All nodes are known as there neighboring node location and form an aggregating cluster.

3.1.2 Data transmission

The main issue is how to remove redundant data in a network. So there is introducing a concept of MAC layer which is overcome the delay and remove the packet redundancy in a network. The MAC layer is subsequently transmitting each queued packet one at a time. It differentiated the services as real time traffic and best effort traffic. MAC layer also eliminates a more accurate data packet or lesser critical data packet and blocks the other packet with more aggressive deadline. The aggregation is as in each sensor is collect the reading in its queue is for SU1, SU2, SU3…SU10. The reading is stored in buffer is check if the reading is same as the pervious reading then it discard this packet and again take a new reading. This new data or reading is send by Rx_1 of SU1 and Rx_2 of SU2 and so on. The transmission of data is depend on which sensor is sense most critical data and these data is transmitted by two transmitter or radio. There the Rx_1 is working as low power radio for best effort services and Rx_2 is working as high power radio for rate guaranteed service for transmission.

3.1.3 EERPQM Algorithm

The proposed algorithm is based on rate guaranteed service and best effort service. The sensing unit SU1 is detect the event and check the reading, if new reading (N) is not equal to previous reading(P) then the SU1 is transmit data through low power radio to the cluster head. But the new reading is same as previous reading then discard this data and turn off the sensing unit SU1, this approach is apply for each sensor in a node. In parallel the sensing unit SU2 is sense the event, check the new reading is not equal to previous reading. Then SU2 is sending the data to the cluster head through the high power radio. The transmission depends application specific value and can be adjusted according to the application. The value can be adjusted according to the application to ensure a minimum or maximum rate guaranteed for different sensor readings.

Table 3.1: EERPQM algorithm

Node Scheduler Algorithm:

While (event is detected in child node = true)
Sensor SU1, SU2… and SU10 is sensing the environment
if (S1 is ON) && (P! = N) && (Rx_1 is ON)
Get readings of Sensor with sensing unit SU1
P=N
Transmit the data of S1 through Rx_1 to the parent node i.e. $Data_{S1}$
else
Discard the data i.e. P=N // remove the redundant sensing data//
Turn off sensor S1
end if
If (S2 is ON) && (P! = N) && (Rx_2 is ON)
for (t=10; t>0; t--) //10 is application specific value
Get readings of Sensor with sensing unit SU2
P=N
Transmit the data of SU2 through Rx_2 to the parent node at t i.e. $Data_{S2}$
else if (SU2 is ON) && (P! = N) && (Tx_2 is ON) && (t=0)
Discard the data i.e. P=N
Turn OFF sensor S2
Turn OFF Rx_1
Transmit the data of SU1 or SU3…SU10 through Rx_2 to the parent node at t i.e. $Data_{S1}$
else
After time t Turn ON sensor S2
else if
end if
end while

Message Sending by Cluster (CH):- Algorithm:

1. If CH = 0 (free) then
2. Message is send directly to the CH.
3. Else CH = 1 (busy in receiving packet data from other node) then
4. CH is checked after regular intervals by member node, want to send the data to the CH, for sending its aggregated data.
5. When CH becomes free then
6. Data is send to the cluster head (CH).

The CH further sends the data to the Base Station.

The SU2, SU3…SU10 is turned off, the transmission of best effort service data via a high power radio and sensing unit SU1 sends data thought high power radio (Rx_2) to the cluster head. The cluster head is sent the aggregated data to the sink. The cluster head uses the average function for aggregation. The cluster head sends the aggregated data to the base station. In Table 3.1 shows the proposed protocol (EERPQM protocol).

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4. SIMULATION RESULTS & DISCUSSION

Omnet++ an open source simulator was used for simulation of EERPQM protocols. The simulation model used for simulating these proposed protocols is as presented here. The graph is plotted between Total energy consumed by the nodes vs. Number of nodes for EERPQM protocol (as proposed) as shown in figure 4.1. The energy consume in the proposed protocol is less compare to DCHS & LEACH protocols. There the proposed protocol is more energy efficient as compared to the other two protocols.

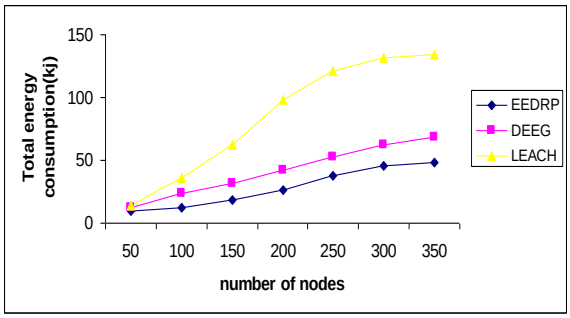

Figure 4.1: Num of Nodes Vs. Total energy consumption

5. CONCLUSIONS AND FUTURE WORK

In proposed work, it is tried to minimize the energy used by the hybrid heterogeneous networks. Also traffic is minimized. In this paper, we take two attributes for a sensing device to improve the working and other attributes (e.g. energy used, traffic etc) of a sensor node. Initially all the sensing devices send the "hello" message to other sensor nodes. The message also consists of the energy of the sensor node. The message is broadcasted to all other member nodes and the sensing node with higher energy is selected as the Cluster Head (CH). Then all other member nodes sense the locality for any change in the event. If there is any change then the changed data is send to the cluster head through transceiver. Then the cluster head send the sensed data to the BS. In previous papers a single node is used for a single attribute but we have taken two attributes in a sensor node. This improves energy efficiency, less data lost and it is real time based. In proposed algorithm the number of attributes can increases as to improve energy efficiency, data traffic and avoid replicated data. The replicated data causes traffic and energy loss in the routing protocol.

The future work may involves the heterogeneous sensor node sensing more than two attributes at a time to save energy, to lower traffic congestion and better quality data.

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