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Enhance QoS of Lossy Wireless Sensor Network by In-Network Data Aggregation

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Abstract: ***In lossy wireless sensor network, packet loss due to buffer overflow of sensor nodes and the delay caused due to retransmission of that lost packet is a major problem. So improving the delay performance along with reliability of WSN is a big challenge. The goal of the proposed system is to broadcast sensed data to focus on delay performance. Also congestion at collector node due to duplicate sensed data in network is reduced by data aggregation, for this we compute a function at the collector node from the information gathered by spatially distributed sensor nodes. Because wireless sensor network applications require various levels of communication reliability (CR), the data transmission should satisfy the desired CR of the applications. Here, we propose a flexible loss recovery mechanism (called Active Caching) for sensor network applications with various CRs. The proposed system caches data packets at intermediate nodes in routing path which are computed by CR to retransmit lost packets during multi-hop transmissions.***

Keywords: WSN, CH, Data Aggregation, CR and TDMA

1. Introduction

A multidisciplinary research area such as wireless sensor networks where close collaboration between users, application domain experts, hardware designers, and software developers is needed to implement efficient systems. Data aggregation is the process of collecting and aggregating the useful data. In WSN, data aggregation is an effective way to save the limited resources. Data coming from multiple sensor nodes is aggregated as if they are about the same attribute of the phenomenon when they reach the same routing node on the way back to the sink. While collecting information, in-network computation at intermediate forwarding nodes can substantially increase network efficiency by reducing the number of transmissions.

On the other hand, it also increases the amount of the information contained in a single packet and makes the system vulnerable to packet loss. Instead of retransmitting lost packet, which incurs additional delay, wireless broadcasting is an effective strategy to improve delay performance while satisfying reliability constraint.

Due to the high packet loss rate in wireless sensor networks, more reliable data transmission is desirable. Because wireless sensor network applications require various levels of communication reliability (CR), we propose a flexible loss recovery for sensor network applications with various CRs. This scheme caches data packets at intermediate nodes over routing paths computed by CR to retransmit lost packets during multi-hop transmissions. The rest of this paper is organized as follows: Section 2 presents literature review about WSN and data aggregation, Section 3 describes the proposed model. Section 4 shows the implementation results and analysis. Finally, the conclusion is presented in Section 5.

2. Literature Review

First, a survey of challenges in wireless sensor network is done. Since the Wireless Sensor Network consists of tremendous sensors and have limited power source, they face the problem of energy depletion. Apart from this Wireless Sensor Network faces the problem of Congestion, Unbalanced Energy Distribution, Routing, Security, Node Redundancy and Data-logging [2], [11].

Activating the hot spot problem gives the unbalanced energy distribution. In WSN, there unbalanced power consumption exists, that is, nodes near the data sink or base station , called hot spots, have a high probability of forwarding a high amount of packets and die early. These hot spots consume more power in WSN. Here further study includes sensor nodes that need to be deployed very densely and in a random fashion. They should be able to operate without human intervention. Clustering is a technique employed to increase the various capabilities of a sensor network [3].

Cluster-based communication has been addressed for these networks for various reasons such as scalability and energy efficiency. The problem of adding security to cluster based communication protocols for homogeneous wireless sensor networks consisting of sensor nodes with severely limited resources [4].

Energy Efficient Clustering Scheme for Data Aggregation proposes a comprehensive energy consumption model for multi-tier clustered sensor networks in which all the energy consumptions not only in the phase of data transmissions but also in the phase of cluster head rotations are taken into account. But mobility of nodes is also a considerable issue [5].

Another one technique of data aggregation called Redundancy Elimination for Accurate Data Aggregation (READA) has been proposed. By exploiting the rang of spatial correlations of data in the network, READA applies a grouping and compression mechanism to remove duplicate data in the aggregated set of data to be sent to the base station without largely losing the accuracy of the final aggregated data. But even after compression of data, data duplication at some level exists [6].

Spatial and temporal multiple aggregation (STMA) scheme has been proposed to minimize energy consumption and traffic load when a single or multiple users gather state based sensor data from various sub-areas through multi-hop paths. The performance of STMA has been evaluated in terms of energy consumption and area-to-sink delay [7].

A flexible loss recovery mechanism called Active Caching, caches data packets at intermediate nodes over routing paths computed by CR to retransmit lost packets during multi-hop transmissions. Because the Active caching presents a tradeoff between end-to-end delays and memory requirements dependent on CR, it can be used flexibly in various sensor network applications. This mechanism can overcome the problem of data loss due to buffer overflow at each node; we are going to do implement it in proposed system [8].

3. Proposed Model

The proposed system consists of the hierarchical network where each node have some parent sensor node/nodes, which sense the event and transmit the data packet to the respective parent, parent node will gather all the information and hop by hop send it to the special node called sink.

3.1 System Architecture

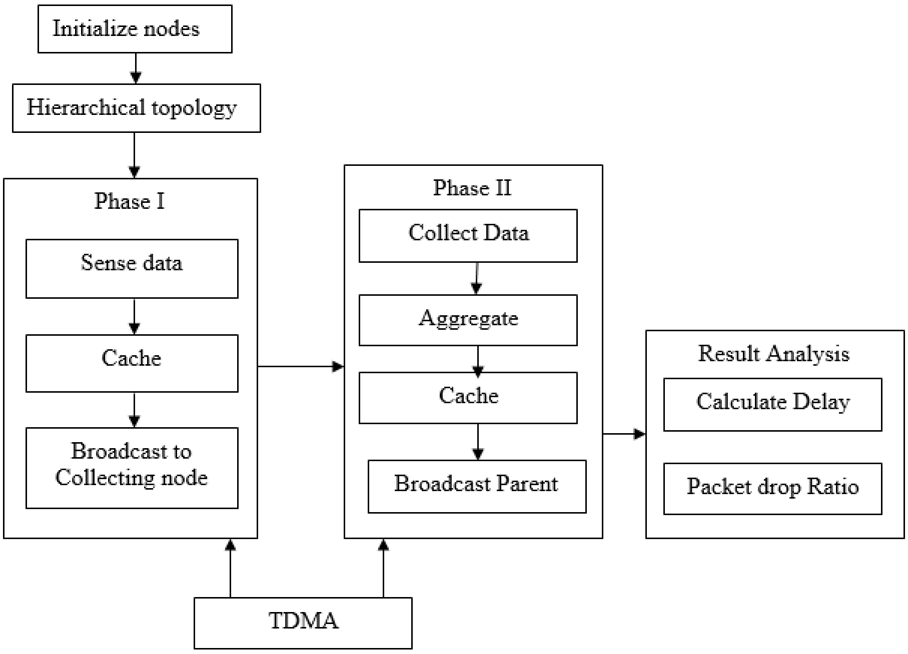

Figure 1: Tired Structure Architecture

Here first step is to initialize all the nodes in the network. Then design and implement the hierarchical topology. In this, sensor nodes are divided into layers, and for each sensor node, there is a list of its parent nodes from inner layer, these parent nodes aggregates all the data and sends that data to other collector node close to the sink.

3.1.1 *Phase I:* In first phase, Sensor node senses the data from environment and sends it to collecting node through wireless broadcast. It uses TDMA for broadcasting.

If the buffer of sensor node is full and the data is going to be lost, then there is a caching mechanism with which we are going to cache this data and after some time transmit it within the network with higher priority.

3.1.2 Phase II: In second phase, Collector node collects all the data from different sensor nodes. Aggregation function is computed to remove the duplicate data. Again this aggregated packet is broadcasted to send it to sink node. It also uses TDMA for broadcasting.

At collector node also caching mechanism is attached to handle the buffer overflow.

3.1.3 *Phase III (Result Analysis):* Delay calculation and packet drop ratio are calculated with the help of trace file data. The information in the trace file includes all data about every packet which will be further used to generate graphs of comparison.

4. Performance Evaluation

We verify our analysis results and evaluate performance of proposed Tired Structure Data Aggregation Model. Here we consider

4.1 Experimental Setup

Table 1 gives the detailed information about all the experimental setup used for the implementation of proposed model and its result analysis.

Table 1: Experimental Setup

Parameter	*Value*
Area of Sensor Field	500 * 500
Topology	Mesh
No. of Nodes	50
No. of Sink Node	1
Circular Layers	7
Packet Size	Variable
MAC Layer Protocol	802.11(b)
Routing Protocol	AODV
Frequency of Packet Generation (1/Time Interval) : Reporting Rate	Used different frequency rate for analysis
Source Nodes	All common sensor nodes within network

4.2 Quality of Service Parameters

We will evaluate the QoS of proposed Tired Structure Data Aggregation Model on the basis of following parameters:

1. Packet Delivery Ratio

Fig. 2 shows the result for packet delivery ratio as a NS3 generated graph. Here packet size is constant 64 bytes and the graph shows that, as the time increases there is increase in PDR also. Up to first 7 seconds the increase rate in high but after that there is small increase in PDR which is almost stable after that.

Here the result shows that, for constant packet size of 64 bytes and variable Reporting Rate (RR) there is increase in PDR. For low RR value i.e. 100 packets/second the rate is low than RR 150 and for 200 RR even though there is more data in network, PDR value is greater than other RR values. From this we can say that for increasing RR value this model is working fine.

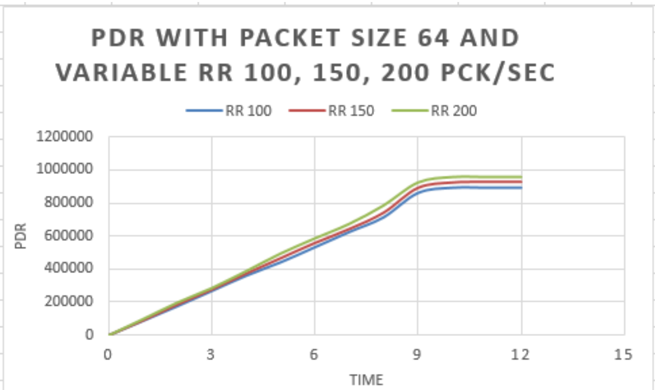

Figure 2: Packet Delivery Ratio

2. Throughput

Fig 3 shows the NS3 generated results for Throughput of the network for packet size 128 bytes. From the graph it is clear that with simulation time throughput of the network also increases to a great extent due to less packet drop and E2E delay.

Fig 3 gives throughput results for constant RR value of 150 and variable packet sizes of 64, 128 and 256 respectively. For low packet size of 64 bytes there is slight low throughput which goes on increasing for packet size 128 bytes and throughput is maximum for 256 bytes. From this it is clear that for any packet size this model is working fine.

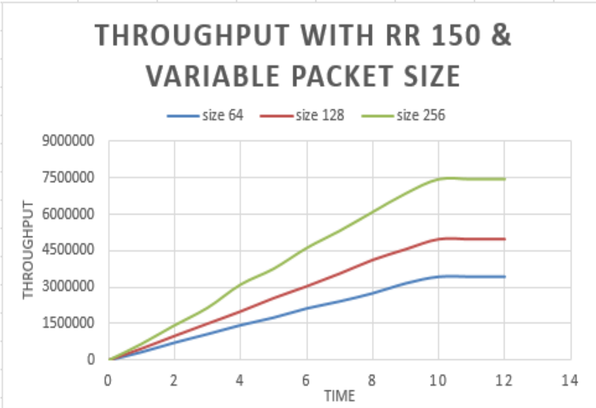

Figure 2: Throughput

3. End to End Delay

Fig 4 gives a tracemetrics (NS3) generated graph of End to End Delay for individual stream. Graph shows that as time passes the end to end delay remains low, either it will decrease or remains constantly low. For all the variations in packet size and RR values the delay remains low and model gives its optimum result. This will result in increased throughput and QoS of the network.

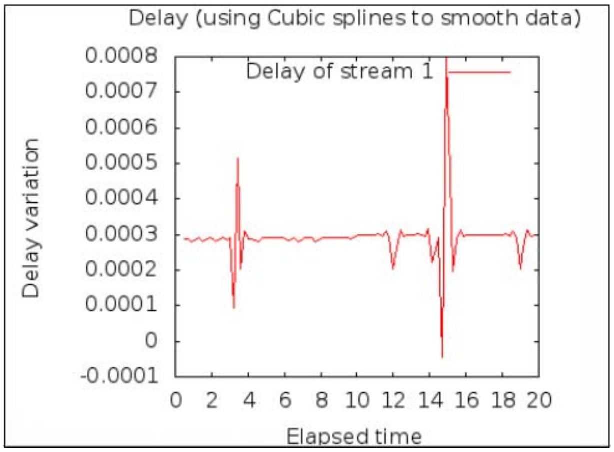

Figure 2: End to End Delay

5. Conclusion

In this paper we are concentrating upon the area of WSN where actually event takes place i.e. we can say leaf nodes of the tree, which have low memory. And this area have more chances to drop packets due to congestion which lead to effect reliability and overall QoS of sensor network. But using our proposed model we will reduce data loss by caching the incoming data and hence improving the reliability. Another one achievement is over congestion problem at collector node due to duplicate data, due to this the collector nodes will consume more energy and die early. But our model will aggregate the data at collector node to remove data duplication and send this data to the sink, ultimately this will increase the reliability and network lifetime. Third point is that retransmission of lost data in multihop network will take more time, so the proposed model includes data broadcasting technique which reduces end-to-end delay in the network. And effect of all these is overall improved QoS of wireless sensor network.

In future we will try to check security of the network and data. Also there is need to check an intermediate node or source node is really a part of our network (A security challenge).

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Author Profile

Harshada Kupade received the BE degree in Information Technology from Government College of Engineering Karad and ME degree in Computer Engineering from Jaywantrao Sawant College of Engineering in 2013 and 2015, respectively. During 2013-2015, studied the Wireless Sensor Network and recent issues with it, also briefly reviewed intrusion detection in WSN and how to recover from this.

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