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RELIABLITY CONTROL USING LOSS RECOVERY RATIO IN WIRELESS SENSOR NETWORK

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Abstract- In Wireless Sensor Network congestion leads to the degradation of communication links that result in the decreased the reliability and waste of energy which one of the scarcest resources of sensor network. In cluster based environment each sensor senses the information and forwarded to its cluster head and cluster head will forward that data packet towards the sink. But the cluster heads are one hop from sink node so that they acts as intermediate nodes and hence there are more chances of congestion and leads to packet drop i.e. nothing but data loss. In my model I recover this data loss by using my loss recovery model where I attach the database to the cluster heads and those packets which are drop at cluster head due to congestion are push into the database and re-transmitted to the sink with high priority.

Keywords- *Wireless Sensor Network, Reliability, Network Simulator*

I. INTRODUCTION

Wireless Sensor Network consists of small micro-controller fitted with sensors and some means of communication radios. They are distributed over wide area and transmit gathered data to one or many central nodes called as Sink or also known as base station [1].

The sensor nodes are used to detect, measure, and record physical event/properties like temperature, moisture, motion, pressure, vibration, sound, light, radiation, image, chemical changes etc. Usually, sensor nodes senses physical data and transmit the gathered information to base station or sink node.

The applications of wireless sensor network can be categories as remote environmental monitoring and target tracking. The monitoring applications includes physical or environmental event monitoring at indoor/outdoor locations, factory monitoring, process automation monitoring, health and wellness monitoring, power monitoring, inventory monitoring, structural monitoring etc. The tracking applications include military tracking applications, objects tracking, animals tracking, humans tracking, and vehicles tracking etc [2].

There are many problems to be solved in wireless sensor network, such as congestion control, rate control, flow control, medium access control, queue management, power control and topology control.

In a Wireless sensor network a large amount of data flows from sensors to sink. When large numbers of sensor nodes are transmitting the data packets, the load becomes heavy and data traffic also increases and this might lead to congestion situation. Congestion in a wireless sensor network may leads to problems like data packet loss, delay of critical information, wastage of resources, buffer overflow. In wireless sensor network application packet loss occurs at different levels. The packet loss may occur due to overflow of buffer capacity, congestion situation, packet collision, poor radio communication, and failure of node. The packet loss results in wasted energy and degraded quality of service [3].

In a wireless sensor networks one common critical service is data collection, where sensed data are continuously collected by sensor nodes and forwarded to a central base station for further processing. The detection of packet loss and correctly recovering missing packets is important factor to be considered. Wireless sensor networks need to be overcome problems like congestion control, reliable data collection or dissemination, energy conservation etc. Some mechanism should be implemented to avoid data packet loss in congestion situations.

The current work concentrates on improving data collection at sink node. It focuses data packets storage mechanism as primary task in a wireless sensor network to achieve reliable data collection in wireless sensor network. The packet loss is minimized by retransmitting the dropped packets to sink. The dropped packets are recovered from attached database file. This technique improves data collection by avoiding congestion situations in the wireless sensor network.

A. Important Units

1) Sink Nodes

In WSN architecture, the sink is a special node which function is to gather the collected data and send it outside the network. Thus, each node transfers the data to the sink node.

2) Sensor Nodes

A sensor node in a wireless sensor network is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

B. Characteristics of wireless sensor networks

The wireless sensor network system should have following characteristics: fault tolerant, scalable, long life, programmable, and secure.

1) Fault Tolerant

The system should be robust against node failure (running out of energy, physical destruction, hardware, software issues etc). Some mechanism should be incorporated to indicate that the node is not functioning properly.

2) Scalable

The system should support large number of sensor nodes to cater for different applications.

3) Long life

The sensor node should be power efficient. It is difficult to replace or recharge thousands of nodes. The node’s communication, computing, sensing and actuating operations should be energy efficient too.

4) Programmable

The reprogramming of sensor nodes in the field might be necessary to improve flexibility.

5) Secure

The system should be secure enough to prevent unauthorized access to node information.

C. Applications

Sensor networks are the key to gathering the information needed by smart environments, whether in buildings, utilities, industrial, home, shipboard, transportation systems automation, or elsewhere.

1) Military

Wireless sensor networks can be an integral part of military command, control, communications, computing, intelligence, surveillance, reconnaissance and targeting systems.

2) Health

Sensor networks are also widely used in health care area. In some modern hospital sensor networks are constructed to monitor patient physiological data, to control the drug administration track and monitor patients and doctors and inside a hospital.

D. Motivation

WSN is emerging research area with lot off distinctive application that has specific requirement for particular application. WSNs have many resource constraints. To manage reliable and congestion free traffic one should carefully design protocol stack of WSN, in which transport layer provide as important role with the help of lower layer services. Existing TCP and UDP protocols are not suitable for WSNs because of distinctive Features of WSNs. Also some existing WSN transport layer protocols are provides limited functionality like some provide only reliability; some provide only congestion detection and avoidance.

II. LITERATURE SURVEY

The architecture of computer and communication networks is often structured in layers: physical, data link, network (or internetworking), transport, and other higher layers, including session, presentation, and application. Each lower layer acts as a service provider to its immediate upper layer, which is a service user. Interactions between neighboring layers occur through service access points (SAPs).

Feasibility of Using TCP or UDP for WSNs Although TCP and UDP are popular transport protocols and deployed widely in the Internet, neither may be a good choice for WSNs. For the most part, there is no interaction between TCP or UDP and the lower-layer protocols. In wireless sensor networks, the lower layers can provide rich and helpful information to the transport layer and enhance the badly needed system performance.

Akan et al. presented a new reliable transport scheme for wireless sensor network, the ESRT (Event-Sink Reliable Transport) protocol. ESRT is an end-to-end technique. The ESRT protocol achieves reliability and also conserves energy by help of congestion control component [4].

Pump Slowly Fetch Quickly is a simple transport protocol. It uses hop-by-hop error recovery technique. In this case intermediate nodes also perform loss detection and recovery. In this protocol the data distributed from a source node with slow speed (pump slowly), but the nodes which finds data loss are allowed to fetch (i.e. recover) any missing data from immediate neighbors quickly [5].

Khan et al. presents in-network storage model for data persistence under congestion in wireless sensor network. This model is built with dense clustered sensor field. Here, the routing nodes act as data buffers during congestion periods in order to avoid data loss [6].

An idea of enhancing reliability on wireless sensor network by AODV-ER routing protocol implemented in [7]. The proposed protocol finds the route which has the highest end-to-end reliability from the source to the destination based on the hop-by-hop packet reception probability.

A reliable transport protocol proposed for wireless sensor networks in [8]. The model uses the hop-by-hop technique. Each intermediate node has two types of buffer, the receive buffer and retransmission buffer respectively. All the received packets are placed in the receive buffer also copy of each received packet is saved in a cache memory. When a node receives the ACK of its already sent packet, it removes the packet from its local cache. Packets which are received with negative ACK are forwarded to the retransmission buffer.

III. PROPOSED WORK

In wireless sensor networks sensor nodes senses physical parameters data and transmit the gathered information to base station. The source node will generate events as per the frequency provided to that source node. If all source nodes forward there packets towards the sink the possibility of congestion is more since each node will process these packets in hop by hop data dissemination. The nodes near to the sink operate as intermediate node, there energy will consume more so, they dead early and further data packets transmission from source nodes to sink clogged that leads to congestion situation in network. Congestion in wireless sensor network may leads to higher packets drop, lower throughput and increased delay.

To evade packet loss persistent data storage needed at intermediate nodes, so that sink can retrieve the dropped packets from stored database file.

A. Principles for the Design of a virtual cluster based WSN

We generally envision all deployed sensors self-organizing into a single logical virtual cluster network, transferring data (unicast or multicast) along the edges of the virtual cluster network using underlying unicast transport services. For unicast, all the sensors in the network form a single virtual cluster so that any sensor can deliver messages to any other sensor via the edges of the virtual cluster network. Upon individual sensor's failures, the virtual cluster network can self-recover quickly and using only local information. Once the virtual cluster is built, any sensor can deliver messages to any other sensor without the need of an additional virtual cluster routing protocol.

The route between any two sensors is automatically determined by compass routing in a proactive way. Since sensors only need to communicate with virtual cluster neighbors, each sensor only needs to maintain routing tables to virtual cluster neighbors, offering a potential memory advantage over conventional (non-virtual cluster) routing schemes .

For multicast, sensors in a virtual cluster based network are able to deliver messages to all other members using the forwarding tree implied by the Delaunay triangulation.

I propose two architectures for measuring reliability in data collection. The first architecture is hierarchical cluster based architecture is shown in Fig. 1. In this architecture a cluster of few nodes formed in hierarchical manner all source nodes in that cluster will sense parameter data values and forward data packets towards the sink through their respective cluster head node.

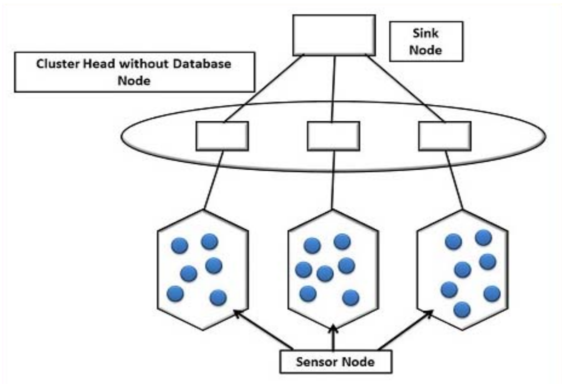

Fig 1: Hierarchical cluster based architecture (Cluster head without database)

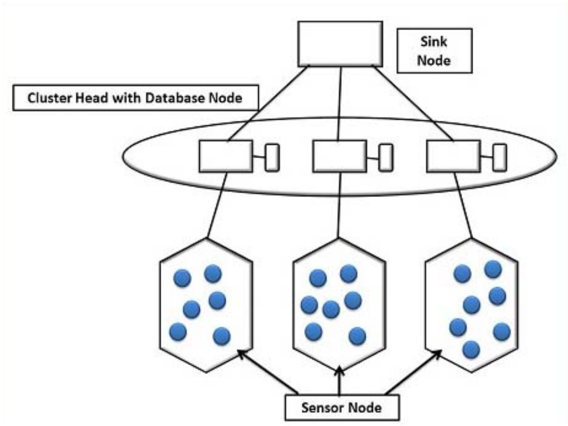

Fig 2: Virtual cluster based architecture (Cluster head with database)

The second architecture is hierarchical virtual cluster based architecture is shown in Fig. 2. This architecture is similar as first hierarchical cluster based architecture, in addition to that, each cluster head act as storage node that attached with database file. The source nodes forward sensed data packets towards their cluster head which will further transmits packets to the sink. The dropped data packets are stored in database file attached to cluster head automatically in background. The packets which are dropped in between cluster head and sink during transmission will be identified by cluster head on getting negative acknowledgement from sink node. These packets will be sent back to the sink by cluster head node after recovering dropped packets from database file. So, packet loss is minimized and reliable data collection can be achieved at sink node.

B. Scope

Here I evaluate performance of MAC protocol (MAC 802.11) with AODV Protocol and analyze the results which achieved the reliability using the virtual cluster based network with database node.

IV. IMPLEMENTATION

I have implemented both architecture models using NS-2 based simulation, both architecture models looks same but in case of hierarchical virtual cluster based model database file is attached to cluster head nodes. The packets storage work will perform automatically in background. The actual implementation of both architecture using NS-2 simulations looks same as shown in Fig. 3, but in case of hierarchical virtual cluster based second architecture, I have attached database file to the cluster head nodes. The details of both architectures are explained below.

A. Hierarchical cluster based architecture (Cluster head without database)

The NS-2 simulation implemented architecture is shown in Figure 3. Initially, the source node will generate events as per the frequency provided to that source node. All source nodes forward there packets towards to the sink (node 0) through cluster head (node 1&2). Here in this case no database file attached to cluster head node. Cluster head only performs normal packet transmission from source node to sink. Due to limited or insufficient buffer size at cluster node there is more packets drop while transmission of packets from source node to sink. So, this architecture suffers from the lower packet delivery ratio. To overcome the packet drop issues I implemented another model i.e. virtual cluster based hierarchical model where I have attached database file to cluster head nodes. This model results with lower packet delivery ratio, more end-to-end delay, more packet drop, less received packets compare with virtual cluster based architecture where database attached to the cluster head.

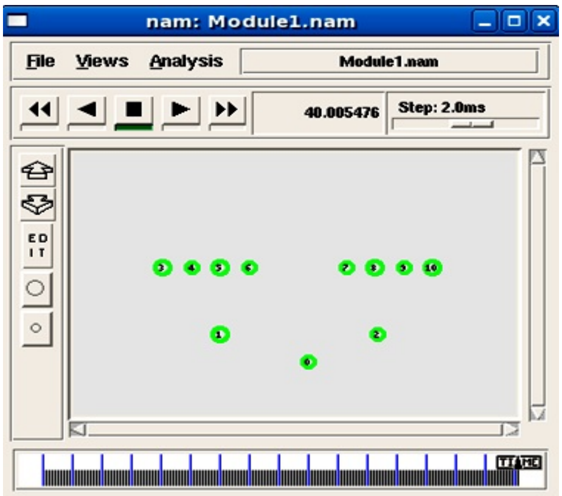

Fig. 3: NS-2 simulations for both hierarchical architectures

B. 0Hierarchical virtual cluster based architecture (Cluster head attached with database file)

The NS-2 simulation implemented architecture is shown in Fig. 3. This architecture model looks same as cluster based architecture in simulation but attached with database file in background. Initially, the source node will generate events as per the frequency provided to that source node. All source nodes forward there packets towards to the sink through cluster head. Here in this case database file attached to cluster head node. The cluster head (node 1 & 2) collects incoming data packets from source node and simultaneously forwards it to sink (node 0). The packets which are discarded or dropped while transmission from cluster head node to sink node will be pushed into attached database file automatically. When cluster head will get negative acknowledgement from sink node, it will recollect drop packets from database file and resent those data packets to the sink node. Hence, by using this architecture I reduce the congestion and increase the reliable data collection at sink node.

In NS-2 we can create simulation using number of nodes with variety of topologies. Each node has associated with queue of user defined length to store data packets (IFQ length value). During the transmission of packets when this queue full with adequate number of packets further incoming packets will be dropped as no sufficient space. The dropped packets could not be easily recovered. A certain data packet recovery mechanism needed, I have implemented that using a database file. The database file is created using C++ and TCL scripting. The packets which are dropped while transmission from cluster head node to sink will be marked as discard. All the discarded packets are automatically push into database file. When packet drops the negative acknowledgement will be received by cluster head node from sink. The cluster head node then recollects dropped packet from attached database file and retransmits data packets to sink node. The database file is dynamic in size, it can accommodate as many as numbers of packets. This architecture model results with improved packet delivery ratio, more number of received packets, less number of dropped packets as well as minimized end-to-end delay compare with previous hierarchical cluster based architecture. The overhead on architecture is energy consumption issues of nodes. The energy consumption is greater in hierarchical virtual cluster based database attached model because of frequent storage and retransmissions for dropped packets. The simulation parameters for implementation are given in Table I below.

Area of sensor field	1000 * 1000 m
Topology Used	Hierarchical
Packet length	512 bytes
IFQ Length	100 Packets

Transmission range	200 m
Interference range	550 m
Initial Energy	100 Joules
Mac layer protocol	802.11
Routing Protocol	AODV
Frequency of packet generation	(1/Time interval)
Number of sensor nodes	11
Source node numbers	4,5,8,9
Cluster Head Numbers	1,2
Sink node numbers	0

Table I: NS-2 Simulation Parameters

V. PERFORMANCE ANALYSIS

In performance analysis I have compared above two models i.e. hierarchical cluster based architecture based architecture (cluster head without database) and virtual cluster based model (cluster head attached with database). For performance analysis I have considered packet size as 512 bytes, reporting rate (1/interval time) of 10, routing protocol AODV, MAC protocol 802.11 and initial energy of 100 Joules. I have compared these two models on basis of packet delivery ratio, received packets, drop packets, end-to-end delay. The graphs shown below illustrate comparative analysis of both models. Overall the hierarchical virtual cluster based model (database attached model) will give better results.

A. Packet Delivery Ratio

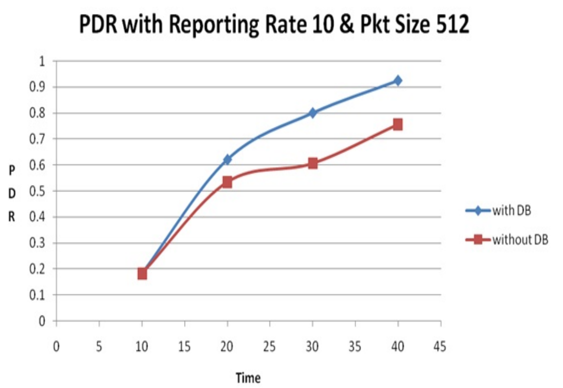

Fig. 4: Comparative graph for Packet Delivery Ratio

The graph shows the Packet Delivery Ratio (PDR) comparison for with Database and without Database model. Here I take RR 10 and Packet size 512, the graph shows that the PDR for Database (DB) model is high as compare to without DB model because the drop packet retransmitted and due to that PDR will increases for DB model.

B. Drop Packet

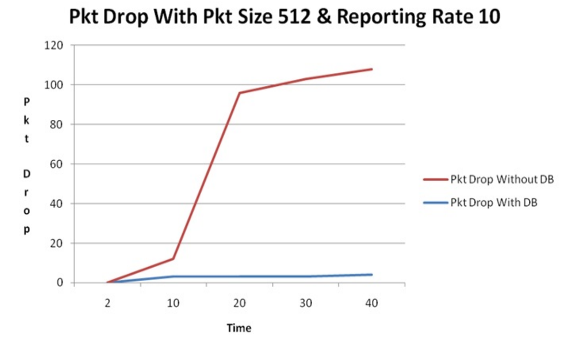

Fig. 5: Comparative graph for Drop Packet

The Graph shows the packet drop comparison for with DB model and without DB model here I take packet size 512 byte and reporting rate 10 after simulation I observe that packet drop with DB model is very less as compare to without DB model because the cluster head Maintains the database so that packet drop in our model is very less.

C. Received Packet

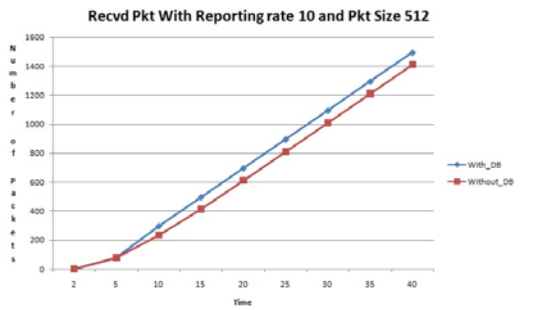

Fig. 6: Comparative graph for Received Packet

The graph shows the received packets by both the model with DB and Without DB. Here packet received packet by DB model is more as compared to Without DB model because the congestion occurs in the network and due to that packets are drop but in DB model we maintain the database at cluster head and due to that reliability will be maintain drop packet will be retransmitted.

D. End-to-End Delay

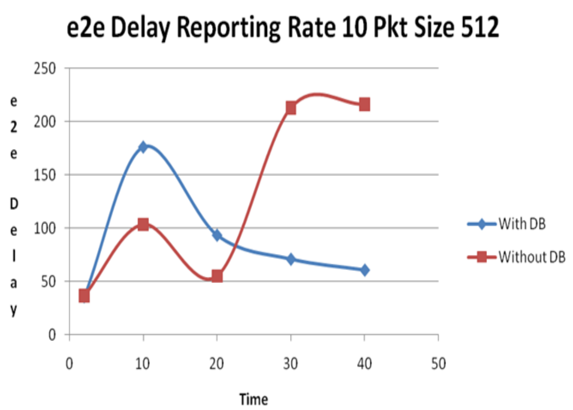

Fig. 7: Comparative graph for End-to-End Delay

The graph shows the End-to-End (E2E) delay for the hierarchical architecture with database and without database. Here the standard reporting rate is 10 and packet size 512 with these parameters we will observe that for the time 0 to 20 both architectures e2e delay will increase and at 20 it will decreases, but after 20 sec without DB will increases continuously because the congestion occurs in network due to that packets are drop and e2e delay will increases. But with DB architecture it will be reverse its e2e delay will decreases it gives better result. So after analyzing above graph I will prove that my architecture will give minimum end-to-end delay.

E. Energy Consumption

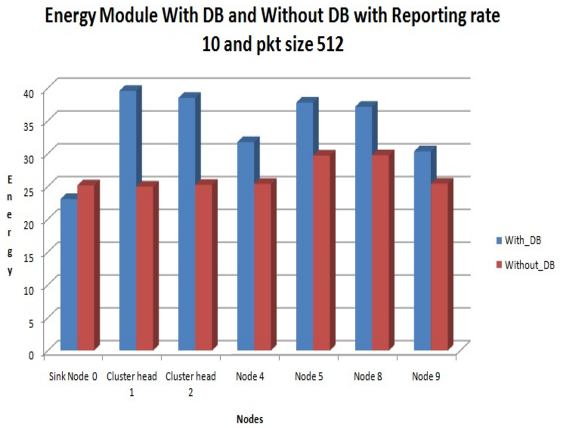

Fig. 8: Comparative graph for Energy Consumption

The graph shows the energy consumed by all nodes for the hierarchical architecture with database and without database. In this graph for all nodes we take initial energy 100 joules after simulation we will take average energy of all nodes and we find that energy consumed by database model will more than without database model. The database model consumes more energy because they have to retransmit packet which are drop between cluster heads and sink node.

VI. CONCLUSION AND FUTURE WORK

The data which flows from the wireless sensor network has higher impact on the link load. Working on this data against the congestion, its reliability, and loss recovery understanding regarding the traffic dynamics within WSNs provides a basis for further works on network optimization. In these applications, many low power and inexpensive sensor nodes are deployed in a vast space to cooperate as a network. It is suggested that WSN applications can be categorized as event-driven or periodic data generation. For periodic data generation scenarios, constant bit rate (CBR) can be used to model the data traffic arrival process when the bit rate is constant.

In most wireless sensor network maintaining reliability is the challenging issue, but using virtual cluster based data collection architecture with database nodes, can minimizes the congestion and improves the reliability of network.

Still some issues are left un-answered:

1. If the cluster head will dead early then will the packet are transfer throw other cluster head.
2. If the acknowledgement packet is lost then will that packet is retransmitted.

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