Enhancement of Energy Performance in Sensor Networks

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Abstract- In order to eradicate Congestion problem an Enhanced version of congestion Control is proposed called ECODA (Enhanced Congestion Detection and avoidance for Multiple Class of Traffic in Sensor Networks).Using three mechanisms which uses dual buffer Thresholds/Weighted buffer difference, Flexible Queue Scheduler and bottleneck based Control Schemes. ECODA effectively Controls Congestion problems for different class of traffic using MAC layer. ECODA has a flexible queue scheduler and packets are scheduled according to their priority. Many applications would require fast data transfer in high-speed wireless networks nowadays. However, due to its conservative congestion control algorithm, Transmission Control Protocol (TCP) cannot effectively utilize the network capacity in lossy wireless networks. In this paper, we propose a receiver-assisted congestion control mechanism (RACC) in which the sender performs loss-based control, while the receiver is performing delay-based control. The receiver measures the network bandwidth based on the packet inter-arrival interval and uses it to compute a congestion window size deemed appropriate for the sender. After receiving the advertised value feedback from the receiver, the sender then uses the additive increase and multiplicative decrease (AIMD) mechanism to compute the correct congestion window size to be used. Our mechanism can mitigate the effect of wireless losses, alleviate the timeout effect, and therefore make better use of network bandwidth and also our mechanism can outperform conventional TCP in high-speed and lossy wireless environments. It can reduce packet loss, improve efficiency and lower delay.

Index Terms— Bottleneck ,Congestion, Dual buffer thresholds, Energy Efficiency, Flexible queue scheduler and weighted fairness, Sensor Networks, Quality of Service.

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1 INTRODUCTION

THE wireless sensor networks (WSNs) are different from established wireless networks in many aspects and it has been extensively used in many fields like habitat monitoring, real-time target tracking, environment surveillance and healthcare, etc. Generally, sensor nodes are restricted in computation, storage, communication bandwidth, and energy supply. Many research studies have been carried out on the physical layer [1], the media access control (MAC) layer [2], the network layer [3] and transport layer [4] in WSNs.

The WSNs leads to unpredictable network load in event-driven nature. It operates under idle or light load and then suddenly become active in response to a detected event. The information in transfer is a very important criterion when the events were detected. The congestion in the networks is caused by the busty traffic that results from the detected events. The network throughput and coverage fidelity are reprimanded during congestion. Hence, in sensor networks, congestion control is a serious issue. This congestion control is classified into end-to-end congestion control and hop-by-hop congestion control. In the first control, it performs exact rate adjustment at source and intermediate nodes according to current Quality of Service level at sink node. At the same time, the problem of end-to-end congestion control is that it heavily relies on round-trip time (RTT), which results in slow response and low convergence. In contrast, hop-by-hop congestion control provides faster response.

Many works have been carried out on congestion control such as transport protocols that provides end-to-end reliability without congestion control [5], protocols with centralized congestion control scheme [6], protocols with distributed congestion control scheme [7] and energy efficient congestion control scheme (ECODA) [8]. These existing works have different Quality of Service requirements and should be serviced accordingly. Thus, the issue for packets with different importance is to be considered. Hence, in this paper, an improved ECODA method for detection and avoidance of congestion in sensor networks is proposed. In this proposed method, the given procedure is followed. For,

1. Congestion detection: Dual buffer thresholds and weighted buffer difference by using accept state, filter state and reject state.

2. Flexible queue scheduler and weighted fairness: Dynamically select the next packet to send based on the Round Robin algorithm.

3. Congestion detection and avoidance: Bottleneck node based source sending rate control which includes determination of rooting path status from a source to sink and bottleneck node detection and data sending rate control.

The step 1, 2 and 3 are done based on [8]. In addition to this, if the energy level is reduced to the particular child node during transmission of packets, it informs the parent node to change the transmission to another child node which is nearest to it for preventing the packet drop.

2 PROPOSED SYSTEM

2.1 Congestion Detection

The dual buffer thresholds and weighted buffer difference are used to detect the congestion. The Fig.1 shows the details of buffer state such as "accept state ($0 - Q_{min}$)", "filter state ($Q_{min} - Q_{max}$)" and "reject state ($Q_{max} - Q$)". The different buffer states are reflected different channel loading which is used to accept or reject packets in different states.

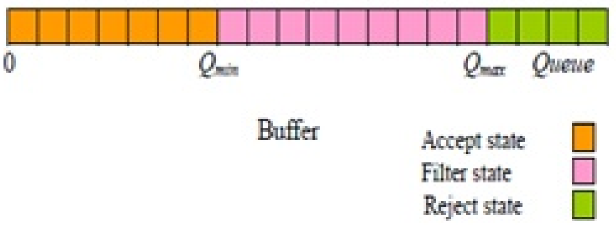

Fig. 1. Buffer state

The packet at each node has to send for buffer monitoring and piggybacks its weighted buffer changing rate *(WR)* and weighted queue length *(WQ)* with outgoing packets. The corresponding congestion level bit in the outgoing packet header is set if a node's buffer occupancy exceeds a certain threshold and its packets has higher priority among neighborhood. The weighted buffer with length WQ(t) after Δt and the weighted buffer difference at time
t + Δt are calculated as,

$$WQ(t+\Delta t) = WQ(t) + WR * \Delta t \qquad (1)$$

$$WQD_{nodei}(t+\Delta t) = \sum_{j=1}^{N} DP(packet_j) - Max(WQ_k(t+\Delta t)) \qquad (2)$$

Where $k\in$ neighbor (nodei) and N is the total number of packets in the buffer. If $WQD_{nodei}(t+\Delta t) \geq 0$, the data of node i is the most important among its neighbors. If congestion happens, other nodes should lower down their data sending rate to mitigate node's congestion.

2.2 FLEXIBLE QUEUE SCHEDULER AND WEIGHTED FAIRNESS

The Flexible Queue Scheduler is used to drop a low priority packet rather than the high priority packet when a high priority packet arrives if the queue in a sensor node is nearly full and dominated with low priority packets. At the same time, the high priority packet may be dropped due to queue overflow with tail-dropping. The packets are sorted by their dynamic priority from high to low for every source. A round robin algorithm is taken when sending next packet. The algorithm scans the route-through traffic queue from head to tail to ensure fairness.
If Q is the total buffer size of a node, the dynamic priorities of packets are denoted as

$$DP1, DP2\ldots DPn \qquad (3)$$

in the queue, where n is the total number of priorities. Therefore, the total numbers of packets are

$$N=NDP1+NDP2+NDP3\ldots\ldots+NDPn \qquad (4)$$

For handling packets with different strategy, two thresholds are used such as Q_{min} and Q_{max}. The Flexible Queue Scheduler is performed based on the following steps and shown in Fig.2.
1) If $0\leq N\leq Qmin$, all incoming packets are buffered, because queue utilization is low.
2) If $Qmin\leq N\leq Qmax$, some packets with low dynamic priority are dropped or overwritten by subsequent packets with high dynamic priority.
3) If $Qmax\leq N\leq Q$, some packets with high dynamic priority is dropped or overwritten, then the expected average buffer length increases at a rate of two variables that can be tuned to achieve optimal system performance.

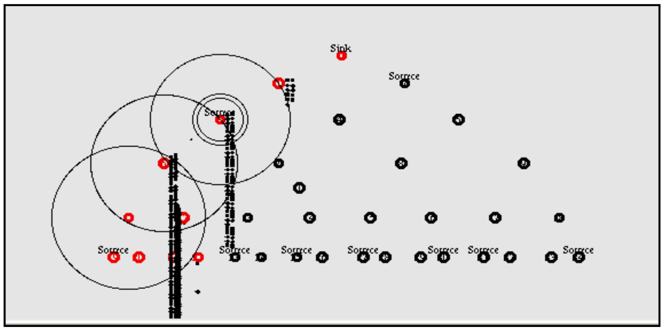

Fig. 2. Performance of Flexible Queue Scheduler

2.3 BOTTLENECK NODE BASED SOURCE DATA SENDING RATE CONTROL

The bottleneck node based source data sending rate control consists of the determination of routing path status from a certain node to sink and the bottleneck node detection and source data sending rate control. For determination of routing path status from a certain node to sink, its data forwarding delay is piggybacked in the data packets' header for node *i* whose next hop is sink. Its child node overhears this information and compares its own forwarding delay *D* (*i*) with its parent *p*'s data forwarding delay *D* (*p*) and does the following calculation:

$$D_{max}(i) = MAX\{D(p),D(i)\} \qquad (5)$$

Next time, when this child has data to send, $D_{max}(i)$ will be piggybacked in the packet header, $D_{max}(i)$ is the path status from node *i* to sink. This process is recursively computed up to the final source node.
Similarly, for the bottleneck node detection and data sending rate control, it extracts the delay information piggybacked in the data packets when source node s overhears data from its parent *p* and set its data sending rate *Gs* as:

$$Gs = 1/D_{max}(p) \qquad (6)$$

The source node or forward node decreases its data sending rate or adjusts data sending rate for different paths if multiple paths exist based on receiving a backpressure message. However, if no backpressure message is received, the source node doesn't increase its data sending rate additively. The outcome of the method is shown in Fig.3. From the figure, it is clear that the packets are transferred without packet drop.

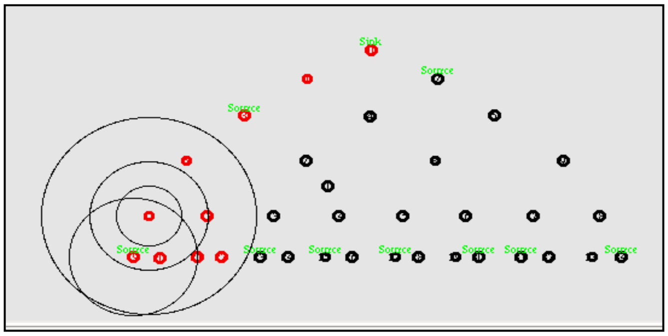

Fig. 3. Performance of Bottleneck method

3 SIMULATION RESULTS

The improved ECODA method has three components such as dual buffer thresholds and weighted buffer difference for congestion detection, Flexible Queue Scheduler for packet scheduling, and Bottleneck node based source data sending rate control. Hence the proposed method is compared with CODA [9] since it is widely accepted congestion control schemes. The simulations runs are carried out with NS2 and its parameters which are specified in Table 1. The parameters are set according to mica2 mote, which is most common sensor network developing environment. The topology used for simulation is shown in Fig.4, which is a tree structure, sink is the root, and this is agreed with the sensor network topology pattern.

TABLE 1
NS-2 SIMULATION PARAMETERS

Channel type	Wireless
Radio propagation model	2 ray ground
Interface queue type	Drop tail/Pri-queue
Antenna model	Omni Antenna
Maximum packet in IFQ	100
No. of mobile nodes	35
Routing protocol	DSDV
X-axis distance	1200
Y-axis distance	700
Transmission model	Radio
Initial energy (joules)	100

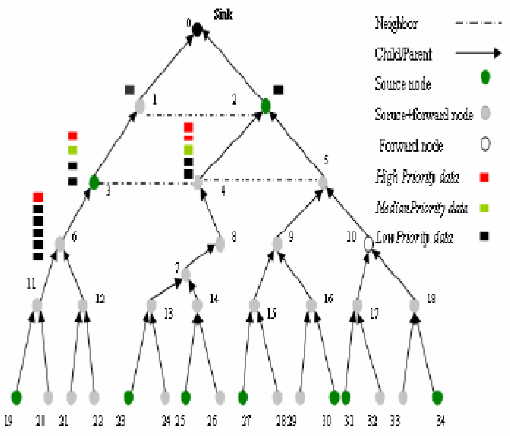

Fig.4. Simulated network structure

The Topology is made using NS2 simulator which is used to measure the throughput, drop and energy which are shown in Fig.5, 6 and 7 respectively.

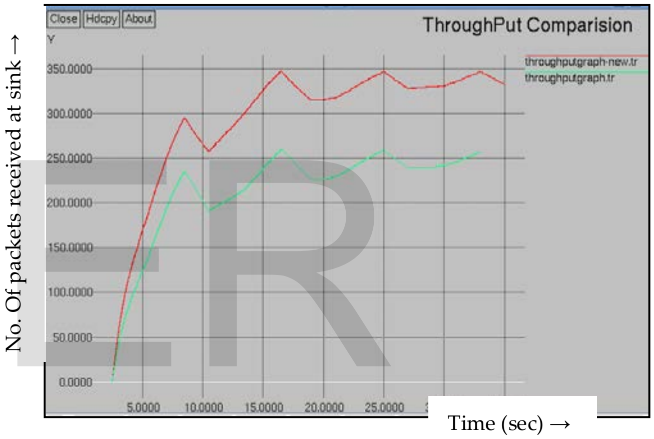

Fig. 5. Throughput comparision

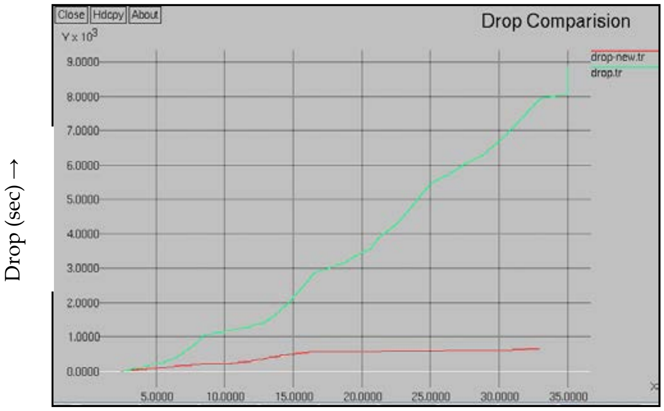

Fig. 6. Drop comparison

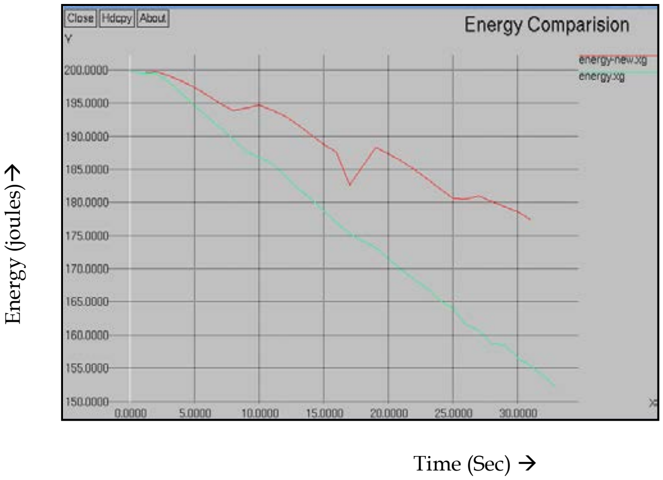

Fig. 7. Energy comparison

The figures show Throughput comparison, Drop comparison and Energy comparison between existing systems (CODA) with proposed system (Improved ECODA). Maximized Throughput, Reduced packet drop and improved energy are achieved through the proposed system than the existing system.

4 CONCLUSION

The improved congestion control protocol (ECODA) method is proposed in this paper. In addition, it has a flexible queue scheduler with packets and Bottleneck node based source data sending rate control. It is overcome the drawbacks of packet drop and improves the energy efficiency as well as, if the energy level is reduced to the particular child node during transmission of packets, it informs the parent node to change the transmission to another child node which is nearest to it for preventing the packet drop. From the results it was observed that it can reduce packet loss, improve energy efficiency and lower delay than the existing technique.

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