International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

Enhanced Throughput Using BWDN For Wireless Sensor Networks

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Abstract

WSNs leads to unpredictable network load. Congestion in a Wireless Sensor Network (WSN) can cause missing packets, low energy efficiency, and long delay. When congestion happens, the network throughput and coverage fidelity are penalized. So, congestion control is a critical issue in sensor networks. To address this challenge, we propose BWDN for Wireless Sensor Networks. It has three techniques: 1) Network based congestion avoidance 2) Flexible Queue Scheduler 3) Balancing the work of dead nodes.

Index Terms - congestion; delay.

1. Introduction

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, enabling also to control the activity of the sensors. Wireless sensor networks (WSNs) have been widely applied to habitat monitoring, real-time target tracking, environment surveillance and healthcare, etc. They are different from traditional wireless networks in several aspects. Commonly, sensor nodes are restricted in computation, storage, communication bandwidth, and most importantly, energy supply. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth.

Extensive studies have been carried out in recent years on the physical layer, the media access control (MAC) layer, the network layer and transport layer in WSNs. Typically, WSNs operate under idle or light load and then suddenly become active in response to a detected event. When the events have been detected, the information in transit is of great importance. However, the busty traffic that results from the detected events can easily cause congestion in the networks.

In WSNs, congestion can be divided into transient congestion and persistent congestion. Transient congestion is caused by link variations, and persistent congestion is caused by source data sending rate. Congestion control mechanism can be classified into end-to-end congestion control and hop-by-hop congestion control. End-to-end congestion control performs exact rate adjustment at source and intermediate nodes according to current QoS level at sink node. The drawback of end-to-end congestion control mechanism 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 has faster response. Currently, there are extensive studies to address congestion problems in WSNs. Some papers provide reliable end-to-end data delivery from every sensor to a sink and hop by hop congestion control at every intermediate node on the path from source to sink.

As sensor network software and hardware mature, applications which transfer image, video, and structure monitoring data in WSNs are becoming increasingly possible. These applications have different QoS requirements and should be serviced accordingly. We need to consider the fairness issue for packets with different importance. In this paper, we propose BWDN protocol for Wireless Sensor Networks for achieving throughput.

2. Related work

In the literature, many works have been conducted on congestion control, congestion mitigation, and reliable transmission in WSNs. Existing works can generally be classified into three categories.

The first category consists of protocols with centralized congestion control schemes. ESRT [1] classifies a network into five regions. It adjusts source packet data sending rate such that network stays in a state where sufficient number of packets arrive at a sink without producing congestion. ESRT's rate allocation is centrally computed i.e., the base station periodically counts the number of received sensor readings and retasks the sensors by broadcasting a new transmission rate. Due to the drawbacks of centralized scheme, ESRT cannot deal with transient congestion efficiently. RCRT [4] is another centralized transport protocol in which all functionalities including congestion detection, rate adaptation, and rate allocation are implemented at sink node. Although RCRT's performance is good, it can't differentiate flows unconstrained in bottleneck regions. Also, RCRT's convergence is too slow when the network has highly varying RTTs.

The second category consists of protocols with distributed congestion control schemes. Fusion uses hop-by-hop flow control, rate limiting, and prioritized MAC to alleviate congestion. With this combination, Fusion achieves higher goodput and better fairness with heavy loads than previous schemes. Congestion detection and avoidance (CODA) [2] in sensor networks is another congestion mitigation strategy, it provides a comprehensive discussion on congestion control and proposes an open-loop hop-by-hop backpressure mechanism and closed-loop multi-source regulation scheme. For transient congestion, each sensor monitors channel utilization and buffer occupancy level to detect congestion. For persistent congestion, source requires sink's feedback to maintain its data rate. IFRC [9] and CCF [10] are both congestion control protocols to ensure fairness. In IFRC, every node adopts multi-level buffer thresholds. When a node's buffer exceeds the threshold, it asks its neighbors to decrease data sending rate and maintain its buffer utilization less than a predefined level. In CCF, two schemes are proposed to ensure fairness: probabilistic selection and epoch based proportional selection. However, IFRC and CCF both try to ensure absolute fairness among every node.

The third category ECODA [5], consists of following key ideas: 1) ECODA adopts a technique to measure congestion, which uses dual buffer thresholds and weighted buffer difference for congestion detection. The method is different from traditional single buffer threshold method, it could differentiate congestion level and dealt with them correspondingly. 2) The flexible queue scheduler can dynamically select the next packet to send. Moreover, it adopts a novel method to filter packets according to channel loading and packets priority when congestion happens. 3) Transient congestion and persistent congestion are differentiated and are dealt with differently. For transient congestion, hop-by-hop implicit backpressure manner is used. For persistent congestion, bottleneck node based source sending rate control and multi-path loading balancing are proposed. Unlike, this method does not need explicit ACK from sink. Using the method, bottleneck nodes can be identified and source sending rate can be dynamically adjusted more accurately.

3. Protocol overview

3.1. Network based congestion avoidance

Congestion is said to occur in the network when the resource demands exceed the capacity and packets are lost due to too much queuing in the network.

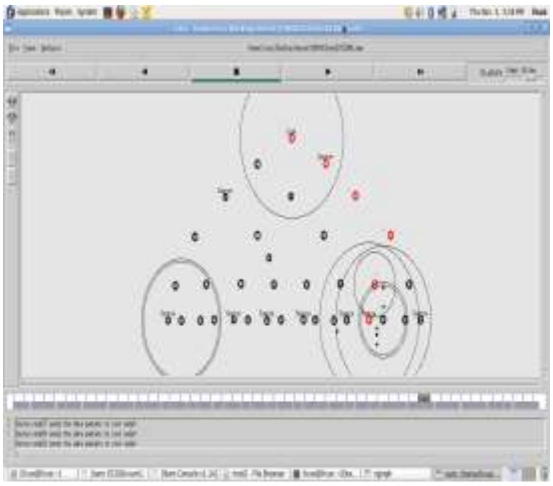

Figure 1 Congestion detection.

ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

During congestion, the network throughput may drop to zero and the path delay may become very high. In this scheme, a router detects that congestion may occur and attempts to slow down senders before queues become full.

3.2. Flexible Queue Scheduler

While nodes far from the sink have to send their packets through many hops and experience a long delay. To resolve unfairness problem, we propose a Flexible Queue Scheduler. Every packet has two kinds of priorities: static priority and dynamic priority, which will be defined shortly. Packet static priority is represented as an integer and the lowest static priority *SP* (packet) =0. Dynamic priority changes with the number of hops and delay. In this approach which packet has high dynamic priority that is called high priority packet. If the queue in a sensor node is nearly full and dominated with low priority packets, when a high priority packet arrives, it is better to drop a low priority packet rather than the high priority packet. Two parameters α and β are used for tuning the system performance.

$$\text{DP (packet)} = \frac{\alpha*\text{hop}+\text{SP (packet)}}{1+\beta*\text{delay}}$$

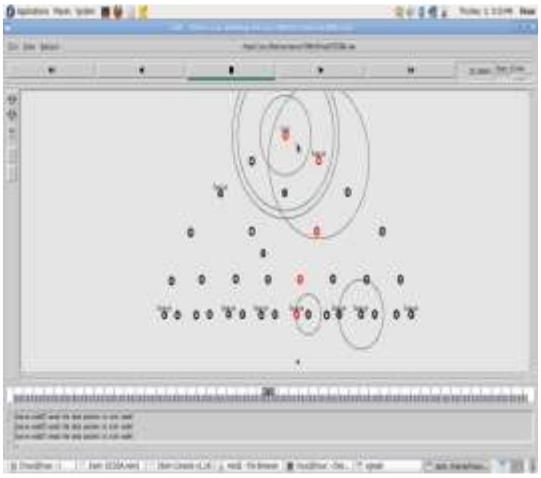

Figure 2 Flexible Queue Scheduler

3.3. Balancing the work of dead nodes

Using the method of Balancing the work of dead nodes, the node enter into the dead state because of low energy. This child node conveys this low energy information to that parent node. So the parent node send request to their another child node for do the work of dead node. i.e., parent node send move & cover details to another child node. So another child node covers the area of dead node and balancing the work of dead nodes.

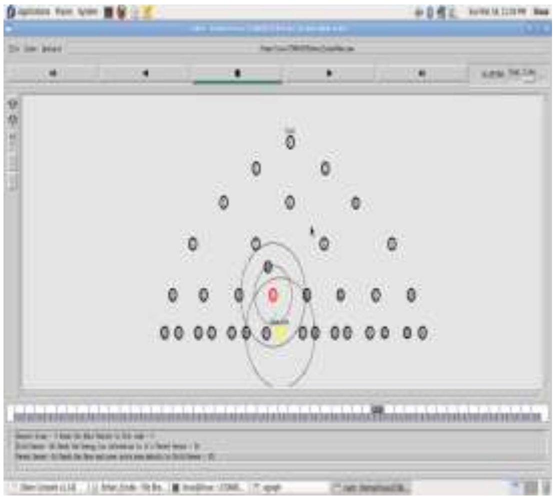

Figure 3 Balancing the work of dead nodes.

4. Evaluation & comparison

4.1 Throughput and end-to-end delay

Throughput and delay are simulated and one can see that BWDN for Wireless Sensor Networks has higher throughput than other previous techniques using the module of balancing the work of dead nodes.

5. Conclusion

In this paper, BWDN for Wireless Sensor Networks is proposed. It avoids congestion using Network based congestion avoidance and Wireless Sensor Networks has a flexible queue scheduler and packets are scheduled according to their priority. It deals with transient congestion and persistent congestion efficiently. Simulations show that BWDN for Wireless Sensor Networks achieves high throughput, high link utilization and flexible fairness. It can reduce packet loss, and lower delay.

6. References

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