

A Survey on Traffic Aware Congestion Control Techniques in Wireless Sensor Network

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ABSTRACT: Wireless sensor network composed of one or more sink and ten or thousands of sensor nodes scattered in physical space. Congestion occurs in wireless sensor network when the numbers of packet being transmitted through the network approaches the packet handling capacity of network. Congestion in wireless sensor network affects the continuous flow of data, loss of information, delay and reduces the energy of nodes due to overhead of retransmission. It also decrease overall throughput of system. Therefore congestion needs to be control in wireless sensor network in order to prolong system lifetime, improve fairness and quality of service and to achieve high energy efficiency. There are various techniques available which control the congestion. This paper presents different techniques for congestion control in wireless sensor network and also includes comparison of the techniques based on various parameters like throughput, delay and energy consumption.

KEYWORDS: Wireless sensor network, Congestion, Congestion control techniques

I. INTRODUCTION

In wireless sensor network there is large of number of sensor nodes which are deployed in sensor field for monitoring and recording the physical condition of environment such as temperature, pressure, humidity, sound, vibration and wind speed. Wireless sensor network widely applied to applications such as environmental monitoring, target tracking, habitat monitoring, healthcare, telecommunication monitoring, military surveillance and factory monitoring.

Congestion in wireless sensor network occur when traffic load exceed the available capacity of network. Wireless sensor network leads to unpredictable network load because of the event-driven nature. Wireless sensor network operate under idle or light load and then suddenly become active in response to a detected event so whenever an event has been detected, the information in transit is of great importance. However, the busy traffic that results from the detected events can easily cause congestion in the networks[1].

Congestion in WSN can be transient congestion and persistent congestion. Transient congestion is caused by link variation and persistent congestion is caused by source data sending rate. Congestion in wireless sensor network classify as node level congestion and link level congestion. Fig. 1 shows the types of congestion in wireless sensor network. As shown in Fig. 1 node level congestion caused by buffer overflows and results in packet loss and increasing queuing delay while the link level congestion caused by link collision. Link level congestion occurs when the channel is accessed by multiple sensor nodes at the same time which result in decrease link utilization and overall throughput while increasing packet delay and energy waste.

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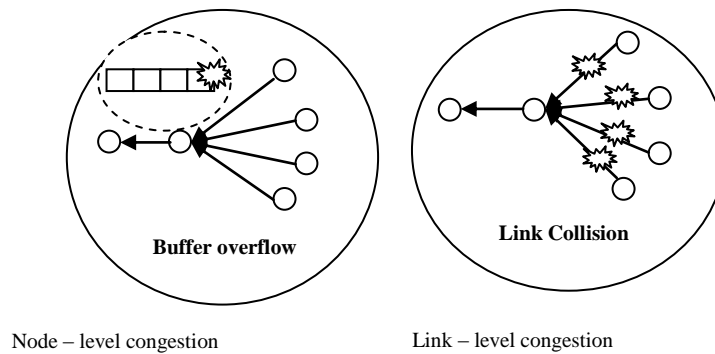


Fig. 1. Congestion types in WSN [2]

In wireless sensor network when large no. of node transmit information at the intermediate nodes there flows will be cross and this high no. of node increase the congestion but also they improve the reliability. Congestion decrease network performance and cause packet loss and energy waste. When congestion happens the network throughput and coverage fidelity are penalized so congestion control is critical issue in sensor network [1].

Congestion control techniques in wireless sensor network classified in to hop-by-hop congestion control and end-to-end congestion control. In end-to-end congestion control techniques it is responsibility of end sink to detect congestion. Once the sink receives the congestion identification it performs exact rate adjustment at each source and it is responsible for both congestion detection and control. End- to-end congestion control techniques rely on round-trip time (RTT), which results in slow response and low convergence. In hop-by-hop congestion control techniques, congestion is detected by intermediate nodes.

Based on control policy protocols divided into traffic control and resource control. Traffic control protocols are either reactive or preventive (avoiding). Resource control protocols are classified according to the type of resource to be tuned. Upon congestion detection and depending on the application strategy, either traffic control is applied by throttling or resource control is used by exploring idle resource, There are various congestion control techniques available like CODA, ECODA, EECC, UHCC, HCCP, FACC, PCCP, etc.

II. RELATED WORK

In this section several congestion control techniques are introduce such as Congestion Detection and Avoidance (CODA), Enhanced Congestion Detection and Avoidance (ECODA) and Energy Efficient Congestion Control (EECC).

A. Congestion Detection and Avoidance (CODA) [3]

Congestion Detection and Avoidance (CODA) use present and past channel load condition, and the level of current buffer state at each receiver for congestion identification The goal of CODA is to maintain low cost or no cost operation during normal condition, but be responsive enough to quickly mitigate congestion around hotspot once it is detected[CODA]. CODA handles both persistent and transient congestion. Congestion Detection and Avoidance (CODA) comprise 3 mechanisms: receiver-based congestion detection, open loop hop-by-hop backpressure, closed-loop end-to-end multi-source regulation.

1. Receiver-based congestion detection:

There are many good indicator of congestion such as nearly overflowing queue and measured channel load higher than fraction of the optimal utilization. Listening to channel for measuring the channel loading or to acquire signalling information for collision detection provide good indication of congestion but it cause high energy cost if performed all time. Proper time for activation of detection mechanism is when node buffer is not empty.

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Node broadcast suppression message when it detect congestion based on channel loading and buffer occupancy. Node continues to broadcast this message up to certain max no. of time with minimum separation as long as congestion persists. The suppression message provide basis for open loop backpressure mechanism.

2. Open loop hop-by-hop backpressure:

Once congestion is detected node broadcast backpressure message and this message propagate towards the source. Whenever nodes receive this backpressure message they throttle their sending rate or drop the packet based on local congestion policy (e.g. AIMD). Whenever upstream node receive backpressure message it determine whether or not further propagating the backpressure signal to upstream based on its local network condition.

The term depth of congestion used to indicate number of hops that backpressure message has travel before non-congested node encountered. This term used by routing protocol and local packet dropping policy to help balance the energy consumption during congestion across different paths.

3. Closed-loop end-to-end multi-source regulation:

The cost of closed loop flow control is high compared to open loop flow control because it required feedback signalling. In closed-loop end-to-end multi-source regulation a new approach proposed is proposed that would dynamically regulate all source associated with particular data event. The source regulates themselves at predefined rates under normal condition without involvement of closed loop sink regulation. The source enters in sink regulation only if the threshold is exceeding at this point source require constant feedback from sink to maintain its rate and sink sends a stream of ACKs to control the transmission rate of sources if congestion is detected.

B. Enhanced Congestion Detection and Avoidance (ECODA)[1][4]

Enhanced Congestion Detection and Avoidance (ECODA) have distributed mechanism operating at both MAC layer and network layer. Fig. 2. shows the block diagram of Enhanced Congestion Detection and Avoidance (ECODA). Enhanced Congestion Detection and Avoidance (ECODA) comprise 3 mechanisms: (1) Use dual buffer thresholds and weighted buffer difference for congestion detection (2) Use flexible Queue Scheduler for packets scheduling (3) A bottleneck-node-based source sending rate control scheme.

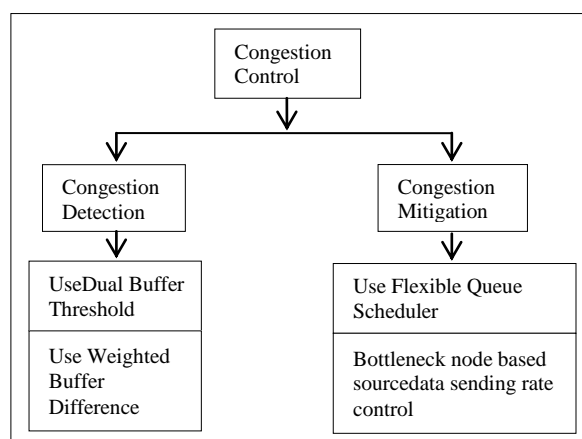


Fig. 2. Block diagram[6]

1. Congestion detection:

To measure local congestion level at each node dual buffer threshold and weighted buffer difference use for congestion detection. Buffer states define as accept state, filter state and reject state. Fig. 3 shows to border different buffer states 2

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thresholds Q_{min} and Q_{max} are used. Different buffer states have different channel loadings and to accept or reject packets in different states corresponding strategy is adopted.

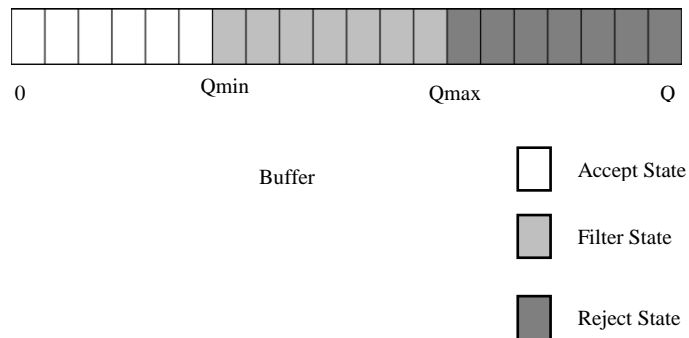


Fig. 3. Buffer state [1]

Every node which has data to send monitors its buffer and piggybacks its weighted buffer changing rate (WR) and weighted queue length (WQ) in its outgoing packets. The corresponding congestion level bit in the outgoing packet header is set when node buffer occupancy exceeds a certain threshold and its data has higher priority among neighbourhood.

2. Flexible queue scheduler and weighted fairness:

Nodes that are near to sink have more priority to send their own generated data while node that are far from sink have to send their packet through many hops and experience long delay. To solve this unfairness problem flexible queue scheduler is used. This scheduler differentiates locally generated traffic and route through traffic for which it uses 2 sub queues. In route through traffic queue packets are grouped by sources and every packet is sorted by their dynamic priority from high to low. For selecting next packet scheduler uses robin algorithm and this algorithm scans route-through traffic queue from head to tail to ensure fairness. One packet is sent from one source from route through traffic queue and then local generated packet is sent.

3. A bottleneck-node-based source sending rate control scheme

Both transient and persistent congestion are handled by ECODA. It makes use of hop-by-hop backpressure mechanism to handle transient congestion. It uses bottleneck node based source sending rate control and multipath load balancing to handle persistent congestion. This mechanism does not require explicit ACK from sink, every node determines routing path status from sink and forwarder finds better path to forward data. Bottleneck node is identified and source data sending rate adjusts more accurately using this mechanism.

C. Energy Efficient Congestion Control (EECC)[5]

In this technique congestion control mechanism is designed at source which reacts based on sum of node weight at each node. Every node calculates its weight which is the product of channel busy ratio and buffer occupancy. After calculating weight every node passes it to upstream node. Upstream node adds this weight to weight of downstream node if there is no congestion and passes this information towards upstream node. Once source node receives the sum of all weight information from downstream nodes it uses this information for controlling rate.

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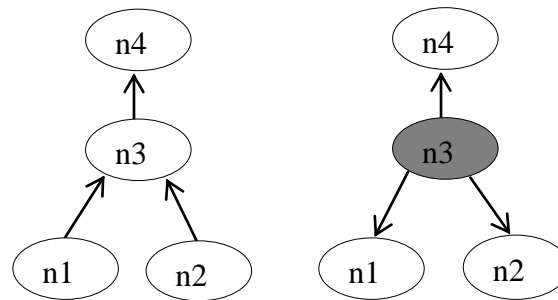


Fig. 4(a). Node weight propagation [5] Fig. 4(b). New rate propagation[5]

In Fig.4 shows that the node weight at n1 and n2 is passed to the upstream node n3. Node n3 computes its local weight and adds it to the weight obtained from nodes n1 and n2 if there is no congestion at n3. When there is congestion at n3, a new transmission rate is calculated by node n3 and its broadcast this new rate to its downstream nodes n1 and n2. On receiving this, n1 and n2 adjust their transmission rate based on new rate as shown in figure. Energy efficient congestion control (EECC) adopts method of explicit congestion with some modification. Once buffer size and channel busyness ratio reach their higher threshold, the congestion notification bit sets by node in every data packet it sent. When parent receive this notification it calculates the new rate and informs its children nodes.

After enough data collect by sink it uses a clustering algorithm to partition nodes according to the sending rates and similarity of data obtained. Sensor nodes within the same cluster work alternatively to save energy so sink broadcast scheduling and cluster information to all sensor nodes. Whenever node within a cluster receives this broadcast information it enters in to energy saving mode according to schedule.

III. COMPARATIVE ANALYSIS

A comparative analysis of the CODA, ECODA and EECC is based on parameters like throughput, delay and energy consumption of sensor nodes is shown in the table 1.

Throughput: The throughput of node i is denoted as the ratio of its total received packets over time Δt .

Delay: Delay refers to the time taken for a packet to be transmitted across a network from source to destination.

Energy Consumption: The energy consumption denote as energy consume by node in sending and receiving packet.

CODA consumes extra energy because it needs feedback from sink to maintain sending rate when persistent congestion happen. CODA cannot deal with the situation that several buffers exceed threshold simultaneously, packet experience long delay in CODA than ECODA. ECODA use bottleneck node based source reporting control scheme and it costs no extra energy and robust than CODA' closed loop multi source regulation scheme. EECC make the use of energy efficient scheduling so it consumes less energy compared to CODA.

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Table 1. Comparison of congestion control techniques

Parameter	Congestion Control Techniques		
	CODA	EECC	ECODA
Throughput	Less than EECC & CODA	Higher than CODA	Higher than CODA
Delay	More delay	-	Less delay than CODA
Energy Consumption	Consume more energy than EECC & ECODA	Consume less energy than CODA	Consume less energy than CODA

IV. CONCLUSION

There are several transport layer protocols for congestion control in wireless sensor network. This paper present overview of several congestion control techniques like CODA, ECODA and EECC. Also the comparative analysis of congestion control techniques is presented using several parameters like throughput, delay and energy consumption which shows among the 3 techniques Enhanced Congestion Detection and Avoidance (ECODA) is best for congestion control as it achieve high throughput, less delay & less consumption of energy compare to other techniques.

V. FUTURE SCOPE

The limitation of ECODA is that if the buffer is in the reject state, there is a possibility of dropping high priority data packet which can be improved in future.

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