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Comparative Study on Congestion Control Techniques in Wireless Sensor Networks

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ABSTRACT

Wireless networks are designed to consist of large number of cheaper, smaller nodes with sensing, data processing, and communication capabilities, run in unattended mode, are densely used and collaborate to achieve a common mission. Wireless networks go beyond computer networks, contributing to the possibility of connectivity "everywhere and every time." Depending on the application, the large amount of correlated synchronized impulses of data sends to a small number of nodes. This high generation of data packets is usually uncontrolled and results in network congestion. Network congestion leads to packet drops at the buffers, and requires retransmission, increases energy dissipation rates of sensor nodes, and degrade channel quality. Therefore, congestion control has become very crucial for prolong the lifetime time of sensor networks. In this paper we focus on various existing techniques for detecting and controlling congestion and making comparison between them.

Keywords: Wireless Sensor Networks, Congestion, Congestion Detection and Control.

INTRODUCTION

In recent developments in integrated circuits, a new generation of lightweight, cheap low-capacity sensors has been developed. Due to their economic and computation viability, a network of 100 000 sensors has the potential for various applications, including battle field control, protection and disaster management, both militarily and civilly. There are several obstacles to networking and management of such systems because of the vast amount of such devices and their ad-hoc implementation in the field of interest. In the coming age of general computing, sensor networks are expected to play an important role. Safety in hostile environments is crucial to such networks, and safety problems remain a significant obstacle to the widespread deployment of such wireless networks. Depending on the application the large, sudden, and correlated synchronized impulses of data sent to a small number of sinks or base station without significantly disrupting the performance (i.e., fidelity) of the sensing application. This high generation of data packets is usually uncontrolled and often leads to congestion.

During congestion, sensor nodes usually drop the overflowed packets. Dropped packets are a major handicap for these networks since they result in severe energy consumption. In worst situation if no countermeasures are taken, the power of congested nodes can be exhausted leading to the creation of “dead paths” in the network. Congestion may cause degradation of overall channel quality and increased loss rates, leads to buffer drops and enlarged delays, and tends to be disgustingly unfair toward nodes whose data has to traverse a larger number of hops. Provisioning a WSN such that congestion is an infrequent occasion is quite challenging task. There are numbers of techniques proposed in literature for congestion control in wireless sensor networks that prevents packet drops and network deadlock.

ARCHITECTURE OF 1HERARCHICAL SENSOR NETWORK

From an energy consumption perspective, the sensor network in Figure 1 is not efficient. Each sensor node in the network sends its data packet to a portal sensor node that transmits the data to the end user in turn. The sensor node of the gateway is located far away from the typically deployed area. Each sensor node spends power not only on data detection and transmission but also on the transmission of data from another sensor. Thus, nodes drain energy at different rates according to their roles. As shown in Figure 1, the node that is farther than the other nodes deduces its energy easily. This means that many sensor nodes cannot connect with the gateway and the network in organizational, becomes. To solve this problem, a hierarchical clustered sensor network is one of the solutions proposed.

The network architecture is shown in Figure 1. It consists of 3 different types of sensor nodes: 'Sensors Nodes (SN), 'Superior Nodes forwarding (FN),' 'Entry points' or 'Base Stations' (BS),' 'Base Stations'., small usable "Sensor Nodes (SN)" The SNs may be unique for use (e.g., temperature sensors, pressure sensors, video sensors, etc). They are deployed for tracking or monitoring applications in groups or clusters) in strategic locations. The SNs shall send the collected data to the local FNs. We assume that every SN contains the FN in its cluster directly. SNs therefore do not have the task of transmitting data.

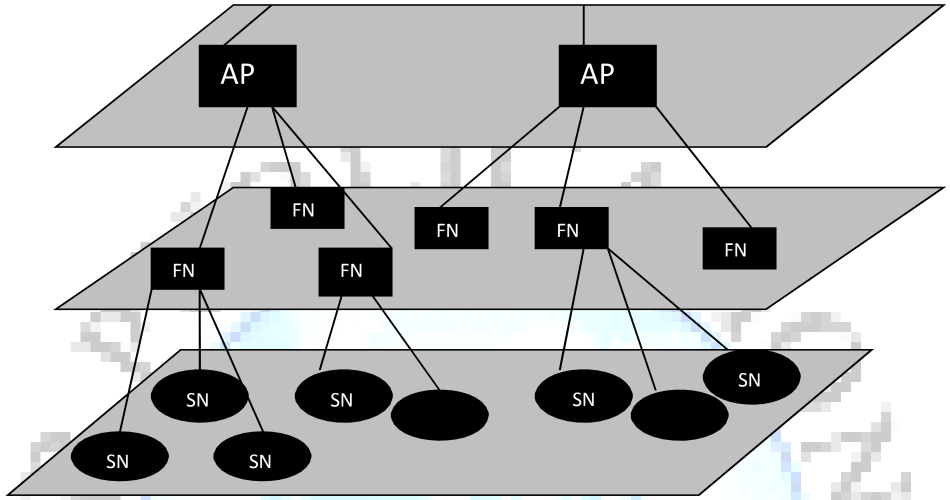

Figure 1 Sensor network architecture

"Forward Nodes (FNs)" higher energy that transmits data received from sensor nodes to top levels; The path data between the wireless networks and the wired infrastructure, "Access Points (AP)," or "Base Stations (BS)." Unlike sensor nodes in ad-hoc flat sensor networks, sensor nodes in this hierarchy network's lowest layer do not provide their neighbours with multihop routing capability. A number of SNs are arranged as a group with a higher layer node, the FN, in charge. Each sensor node therefore communicates only with its FN and supplies information like reading the sensor to its FN. FNs are located on the sensor node layer in the second layer top and provide multi-hop routing for SNs or other FNs.

FACTORS AFFECTING THE RELIABLE DATA TRANSFER IN WIRELESS SENSOR NETWORKS

The main factors that affect the RDT in WSNs are the following:

1. *Autonomous Maintenance:* The sensor nodes are randomly deployed and hence do no fit into any regular topology. Once deployed, they usually do not require human intervention. This implies that setup and maintenance need to be autonomous.

2. *Congestion Control Mechanism:* It includes the following congestion activities: detection, avoidance and correction. Congestion detection is the methodology in which that abnormality in the normal traffic is been made out. i.e. when a packet is been transferred from one node to other predicament events can happen. Congestion is controlled by various techniques. In this paper, we make highlight on different congestion control technique in Wireless Sensor Network which we will discuss later.

3. *Reduced number of retransmissions:* The transport protocol should implement a mechanism for packets loss recovery such as NACK, ACK, selective ACK or selective NACK. Concerning mechanisms designed for reducing the number of retransmissions, it is better to use NACK instead of ACK message in hop-by-hop, HBH,networks, such as WSNs.

4. *Reduced length of frame header:* In WSNs, contrary to TCP/IP based networks, the ratio between the payload and header length is small. So, during a design of WSNs protocol the primary goal is to reduce the header length.

5. *Short Range Transmission:* Long range communication is typically point to point and requires high transmission power, with the danger of being eavesdropped. So we should consider short range transmission to minimize the possibility of being eavesdropped.

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TECHNIQUES FOR DETECTING AND CONTROLLING CONGESTION

1. CODA (Congestion Detection and Avoidance)

CODA [1] is an upstream congestion mitigation strategy that consists of three elements: congestion detection, open-loop hop-by-hop backpressure, and closed-loop end-to-end multisource regulation. The queue length or buffer occupancy and channel load are used for detecting the congestion. If buffer occupancy or wireless channel load exceeds a threshold, it implies that congestion has occurred. The second prong of the CODA design is to use an open-loop broadcast of a backpressure message which is a fast and effective method when congestion occurs. When congestion is detected the receiver node where congestion occurred sends a message to all neighboring nodes to indicate that no more packets of data to send until they receive an indication to resend more data. The nodes send the message to next nodes to stop sending of data packets.

2. PSFQ (Pump Slowly, Fetch Quickly)

PSFQ [2] is designed to be scalable and energy efficient, trying to minimize the number of signaling messages and relying on multiple local timers. It addresses reliable communication from sink to sensors nodes (downstream). PSFQ consists of three “operations”: *pump, fetch,* and *report operations*. In pump operation, the sink slowly and periodically broadcasts packets to its neighbors until all data fragments have been sent out. In fetch operation, a sensor node goes into fetch mode once a sequence number gap in a file fragment is detected. It also sends a Negative ACK in reverse path to recover the missing fragment.

3. GARUDA

GARUDA constructs a two-tier topology and proposes two stage [3] loss recovery. It is designed to be operational in networks composed of sensor nodes (SNs) located at fixed locations. GARUDA belongs to downstream reliability guarantee. It solves the problem of reliable transport by transmitting a high-energy pulse, called WFP (Wait-for First-Packet), before transmitting the first packet. This pulse is almost immune to channel loss, and either idle SNs or sensors already receiving a data packet can hear it.

4. SenTCP

SenTCP [4] is an open-loop hop-by-hop congestion control with few special features. It jointly uses average local packet service time and average local packet inter-arrival time to estimate current local congestion degree in each intermediate node. In SenTCP, nodes avoid congestion by issuing periodic feedback signals to adjust the reporting rate of their upstream nodes depending on local buffer status. The use of hop-by-hop feedback control can remove congestion quickly and reduce packet dropping, which in turn conserves energy.

6. ART (Asymmetric and Reliable Transport)

ART addresses the reliability both in upstream and downstream directions. This is an event-based protocol that does not need to offer reliability at message level. In the upstream direction, ART assumes that the information from nearby SNs will be highly correlated, and proposes a scheme for event reliability. Consequently, it is not necessary to transport reliable all packets generated by SNs from event region. In opposite direction, it guaranties reliable messages reception from a subgroup of SNs that cover the entire area of interest, but not all located SNs in that area [5].

5. Comparison between various Congestion Control Techniques

In this section we make a comparison between the performances of the various congestion control techniques.

Congestion Control Techniques	PSFQ	GARUDA	SenTCP	ART
Loss Detection and Notification	NACK	NACK	ACK / Receiver NACK	NACK (queries) / ACK (events)
Direction	Downstream	Downstream	Upstream	Upstream (events) / Downstream (queries
Loss Recovery	Hop-by-hop	Two-tier two-stage	End-to-end	End-to-end
Type of Reliability	Packet Driven	Packetdriven / Destinationdriven	Eventdriven / Packetdriven	Packetdriven / Destinationdriven (queries)

CONCLUSION

Wireless sensor networking is an emerging technology that promises a wide range of potential applications in both civilian and military areas, and has therefore received tremendous attention from both academia and industry in recent years. Depending on the application, the large amount of correlated synchronized impulses of data sends to a small number of nodes. This high generation of data packets is usually uncontrolled and results in network congestion. In this paper, we presented a comprehensive survey of congestion control technique in wireless sensor network. They have the common objective of trying to prolong the lifetime of the wireless sensor networks. We also show the comparison between the performances of the various congestion control techniques that provides different reliability grades in order to suit the requirements of different applications regarding throughput, latency and energy consumption.

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