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A SURVEY OF COMPARISON ON VARIOUS CONGESTION CONTROL PROTOCOLS FOR WIRELESS SENSOR NETWORKS

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Abstract-Wireless sensor networks (WSNs) are an emerging class of networks with a wide variety of potential applications in the fields of health, military, environmental monitoring and soon. It is typically composed of multiple tiny devices equipped with limited sensing, computing and wireless communication capabilities There has been an increased focus towards developing transport protocols for WSNs in the research community. Congestion Control concentrates on enabling the network to recover from packet loss, congestion avoidance detects incipient congestion and prevents its occurrence. We provide a summary and comparison of existing congestion control protocols
Keywords- wireless sensor networks, transport protocols, congestion control, congestion avoidance

I.INTRODUCTION

A Wireless Sensor Network (WSN) is a highly distributed network consisting of a large number of tiny, low cost, lightweight wireless nodes deployed to monitor an environment or system These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user. Wireless Sensor Networks (WSNs) are used in many applications in military, ecological, and health related areas[1][2]. These applications often include the monitoring of sensitive information such as enemy movement on the battlefield or the location of personnel in a building.

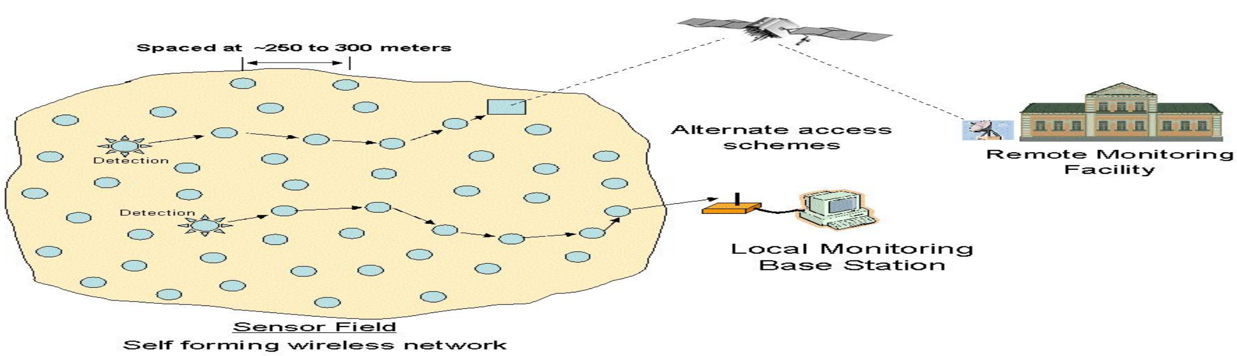

Figure 1.Illustrates an example for WSN.

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A WSN may also have some interesting features including self-organization, dynamic network topology, and multi-hop routing, which are important for many real world applications. Wireless sensor network differ from other wireless ad hoc network in the sense that they are resource limited viz. power restrictions, memory, often prone to failure, densely deployed, topology changes, remotely managed. These are the constraints that make WSN a challenge.

Congestion control in WSNs has been largely implemented by using rate based approaches with the sources controlling the rate of the packets forwarded towards the sink. Periodic packet generation by the sources allow rate based congestion control as it enables an end-to end adaptation which has been successful in developing the internet architecture. However, nodes are not as relatively far apart from each other in WSNs (as in wired networks) with radio interference playing a major role in decreasing the successful packet delivery probabilities. An increase in the traffic generation leads to degraded channel quality with corresponding increases in the loss rates experienced by the nodes.

Transport protocols for WSNs should provide end-to-end reliability and end-to-end QOS in an energy efficient way. The performance of a transport protocol for WSNs can be evaluated using metrics including: energy-efficiency, reliability, QOS metrics such as packet loss ratio, packet delivery latency, and fairness.

II.CONGESTION IN WIRELESS SENSOR NETWORKS

There are mainly two causes for congestion in WSNs. The first is due to packet arrival rate exceeding packet service rate. This more likely occurs at sensor nodes close to the sink as they usually have more combined upstream relay traffic. The second is influenced by the link level performance such as contention, interference and bit error. This type of congestion occurs on the link. Congestion in WSNs has a direct impact on energy-efficiency and application's QOS. First, the congestion can cause buffer overflow and furthermore lead to longer queuing time and more packet loss. Not only can the packet loss degrade reliability and application's QOS, but also wastes limited energy and lowers energy-efficiency. Second, the congestion can still degrade link utilization third, the link-level congestion usually results in transmission collisions if contention based link protocols, for example CSMA (Carrier Sense Multiple Access), are used to share radio resources. The transmission collision in turn will increase packet service time and waste additional energy. Therefore congestion in WSNs must be efficiently controlled, either to avoid it or mitigate it. Usually there are three mechanisms that can deal with this problem: *congestion detection*, *congestion notification*, and *rate adjustment*.

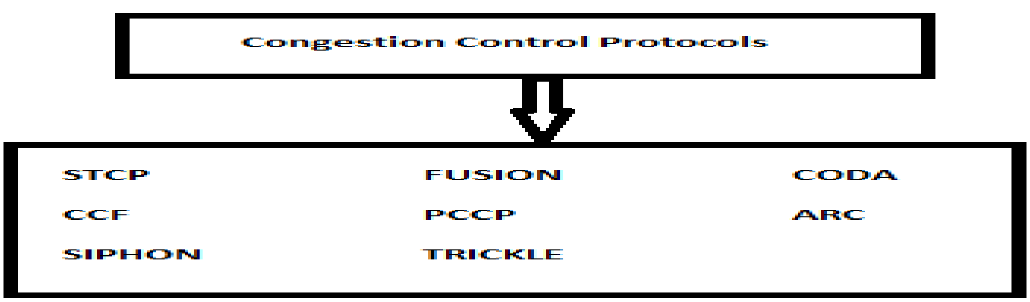
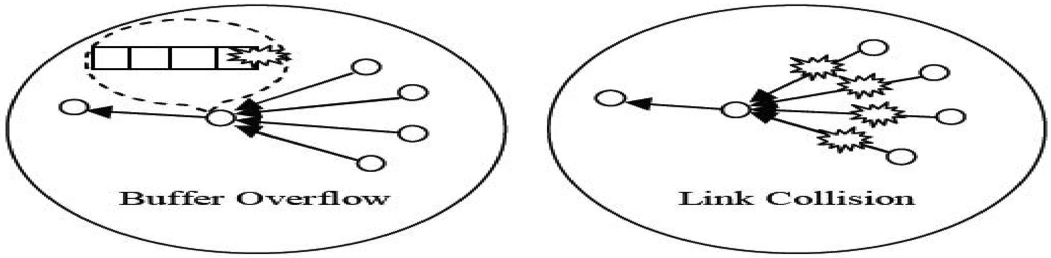


Figure 2.Congestion Control Protocols in Wireless Sensor Networks

A.Congestion types in Wireless Sensor Networks

1. Node-level congestion: The node-level congestion that is common in conventional networks. It is caused by buffer overflow in the node and can result in packet loss, and increased queuing delay.
2. Link-level congestion: In a particular area, severe collisions could occur when multiple active sensor nodes within range of one another attempt to transmit at the same time. Packets that leave the buffer might fail to reach the next hop as a result of collision. This type of congestion decreases both link utilization and overall throughput, while increasing both packet delay and energy waste.



1- Node-level congestion 2 - Link-level congestion

Figure 3. Congestion types in WSNS

III. CONGESTION CONTROL PROTOCOLS IN WSN

A.*Sensor Transmission Control Protocol (STCP)-*

STCP is a generic, scalable and reliable transport layer protocol where a majority of the functionalities are implemented at the base station, thereby saving considerable energy at the sensor nodes[3]. STCP offers controlled variable reliability, congestion detection and avoidance, and supports multiple applications in the same network**.** Data flows generated by sensors were classified as continuous and event-driven. Based on flow characteristics, rate of transmission and required reliability, STCP adapts itself to maximize throughput in an energy efficient manner.

B.Data Fusion-

Data fusion is generally defined as the use of techniques that combine data from multiple sources and gather this information in order to achieve inferences, which will be more efficient and potentially more accurate than if they were achieved by means of a single source[4]. The term efficient, in this case, can mean more reliable delivery of accurate information, more complete,
and more dependable. The data fusion can be implemented in both centralized and distributed systems. In a centralized system, all raw sensor data would be sent to one node, and the data fusion would all occur at the same location. In a distributed system, the different fusion modules would be implemented on distributed components. Data fusion occurs at each node using its own data and data from the neighbors. Fusion, integrates three techniques: hop-by-hop flow control, rate limiting, and a prioritized MAC.

C. Congestion Detection and Avoidance (CODA)-

This is a energy efficient congestion control scheme for sensor networks called CODA (Congestion Detection and Avoidance)[5]. This comprises three mechanisms: (i) receiver-based congestion detection; (ii) open-loop hop-by-hop backpressure and (iii) closed-loop multi-source regulation.

D.Trickle-

Trickle’s basic primitive is simple: every so often, a mote transmits code metadata if it has not heard a few other motes transmit the same thing[6]. This allows Trickle to scale to thousand-fold variations in network density, quickly propagate updates, distribute transmission load evenly, be robust to transient disconnections, handle network repopulations, and impose a maintenance overhead on the order of a few packets per hour per mote. Trickle sends all messages to the local broadcast address. There are two possible results to a Trickle broadcast: either every mote that hears the message is up to date, or a recipient detects the need for an update. Detection can be the result of either an out-of-date mote hearing someone has new code, or an updated mote hearing someone has old code. As long as every mote communicates somehow – either receives or transmits – the need for an update will be detected.

E.Siphon-

Siphon, a set of fully distributed algorithms that support virtual sink discovery and selection, congestion detection, and traffic redirection in sensor networks[7]. Siphon is based on a Star gate implementation of virtual sinks that uses a separate longer-range radio network (based on IEEE 802.11) to siphon events to one or more physical sinks, and a short-range mote radio to interact with the sensor field at siphon points.

F.PCCP-

PCCP, node priority index is introduced to reflect the importance of each node. PCCP uses packet inter arrival time along with packet service time to measure a parameter defined as congestion degree and further more imposes hop-by-hop control based on the measured congestion degree as well as the node priority index[8]. PCCP controls congestion faster and
more energy efficiently than other known techniques. PCCP tries to avoid/reduce packet loss while guaranteeing weighted fairness and supporting multipath routing with lower control overhead. PCCP consists of three components: intelligent congestion detection (ICD), implicit congestion notification (ICN), and priority-based rate adjustment (PRA).

G.Congestion Control and Fairness (CCF)-

CCF is a distributed congestion control algorithm for tree based communications in wireless sensor networks, that seeks to adaptively assign a fair and efficient transmission rate to each node [9]. Based on the difference of the two, a node then decides either to increase or decrease the bandwidth allocable to a flow originating from itself and to those being routed through it. Since the application requirements in sensor network follows no common trait, our design abstracts the notion of fairness, allowing for the development of a generic utility controlling module. Such separation of the utility and fairness controlling modules enables each one to use a separate control law, thereby portraying a more flexible design. The working of congestion control is independent of the underlying routing algorithm and is designed to adapt to changes in the underlying routing topology.

Congestion control in WSN have actually benefited from upstream traffic direction flow. Congestion control such as ECODA, PHTCCP, FUSION, ARC, CODA, Trickle, SIPHON, PCCP, and CCF have been well accounted for in identifying new congestion mitigation techniques that would enable efficient design for energy efficiency in WSN.

FEATURE PROTOCOL	CONGESTION DISCOVERY (CD)	IMPLICIT CONGESTION NOTIFICATION (ICN)	EXPLICIT CONGESTION NOTIFICATION (ECN)	CONGESTION AVOIDANCE (CA)	RELIABILITY DIRECTION (RD)	LOSS RECOVERY (LR)	LOSS DETECTION & NOTIFICATION (LDN)	ENERGY EFFICEINCY (EE)	RELIABILITY PRESENCE (RP)
ECODA	QUEUING & PACKET CONDITION	NO	YES	RATE-ADJUSTMENT ENHANCED-PACKET DROP	UPSTREAM	--	ACK	GOOD	PACKET-SELECTION
PHTCCP	PACKET-SERVICERATIO	YES	NO	RATE-ADJUSTMENT	--	--	--	--	PACKET
FUSION	QUEUE-OCCUPANCY CHANNEL-SAMPLING	YES	NO	PRIORITORIZED-ACCESS LOCATION	--	H-B-H	--	NONE	--
ARC	QUEUE-OCCUPANCY	IMPLICIT	NO	RATE-ADJUSTMENT FUNCTION	--	--	--	--	--
FACC	PACKET DROP-RATE AT THE SINK	NO	YES	RATE-ADJUSTMENT	--	H-B-H	--	--	PACKET
CODA	BUFFER-OCCUPANCY, CHANNEL-LOAD	NO	YES	RATE-ADJUSTMENT	--	--	ACK	GOOD	PACKET
TRCKLE	--	NO	NO	POLITE GOSIP	DOWNSTREAM	H-B-H	--	--	--
SIPHON	APPLICATION-FIDELITY	NO	NO	TRAFFIC-REDIRECTION OPERATING-SCOPE CONTROL	--	H-B-H, E-T-E	--	NONE	PACKET
PCCP	PACKET-INTERVAL DURATION PACKET-SERVICE DURATION	NO	NO	WEIGHTED-FAIRNESS	--	--	--	ENERGY	--
CCF	QUEUE-OCCUPANCY PACKET FLOW	YES	NO	RATE-ADJUSTMENT	--	--	--	ENERGY	--

Table.1 Comparison in Congestion Control Protocols for WSN

IV. CONCLUSION

In this paper, we gave a brief introduction about Wireless Sensor Networks, and congestion control in wireless sensor network. A survey of various protocols used for congestion control (CC) in Wireless Sensor Networks is presented. Finally we give comparison of various congestion control protocol for WSN .So through this survey we can conclude that congestion control protocol is a matter of great concern and should be dealt effectively. Thus, it can be concluded that till date many effective protocols have been proposed to detect and control congestion in transport layer for WSN. Nevertheless, there is still scope for developing more effective protocols using artificial intelligence, cross layer technique etc.

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