# A review on taxonomy for congestion control and Congestion Avoidance approaches

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**Abstract**
A congestion avoidance and control scheme that monitors the incoming traffic to each destination and provides rate-based feedback information to the sources of burst traffic so that sources of traffic can adjust their packet rates to match the network capacity is described. The congestion avoidance mechanism at nodes on the periphery of the network controls incoming traffic so that it does not exceed the capacity of paths to different destinations. The congestion control mechanism at each node monitors the performance of adjacent links and generates rate control messages that warn the sources of traffic before congestion develops. Some existing schemes are reviewed, and the congestion avoidance and control scheme and its applicability to various transport protocols are discussed. Experiments show that the scheme is effective in preventing congestion inside the network and that it manages to restrict the traffic on any overloaded path to 80%-90% of its capacity.

***Keywords*** *- Analysis of CC strategy for WN, NDMWN, ATRED, Topology-Aware Resource Adaptation to Alleviate Congestion, CC Techniques in WSN, CC for High Speed wired network, Local cross layer CC, Receiver assisted CC.*

## I. Introduction

Network congestion in data networking and queueing theory is the reduced quality of service that occurs when a network node is carrying more data than it can handle. Typical effects include queueing delay, packet loss or the blocking of new connections. [1] Congestion is an important issue that can arise in packet switched network. Congestion is a situation in Communication Networks in which too many packets are present in a part of the subnet, performance degrades. Congestion in a network may occur when the load on the network *(i.e.* the number of packets sent to the network) is greater than the capacity of the network *(i.e.* the number of packets a network can handle.)[2]

## II. Causes of Congestion

Common reasons for congestion on router - Congestion can occur on a router when packets arrive at a greater rate than possible to forward. Congestion can be sporadic or long term. When congestion occurs, packets must be discarded by the router. Congestion occurs at a bottleneck when: [3]

- Packets arrive on several channels to be forwarded on a single channel.
- Incoming channel has a higher bandwidth than outgoing channel.
- Channel bandwidth is sufficient but router CPU processing is too slow to handle bookkeeping (queuing, routing table updates, etc).
- Router lacks sufficient memory buffer space.

Under an end-to-end reliable protocol (e.g. TCP), even with infinite memory, congestion can get worse because packets have timed out (e.g. moving from queue back to front on router or due to delay in acknowledging on a receiver) resulting in duplicates, adding to the congestion.[4]

## III. Taxonomy for congestion control and Congestion Avoidance approaches

### 1. Analysis of CC strategy for WN

For wireless networks, a congestion control mechanism based on bandwidth estimation and packet's arrival rate forecast is proposed in this paper. This mechanism estimates node's available bandwidth by monitoring the working state of node's wireless link in real-time and forecasts arrival rate of each packet by monitoring network traffic, then the node's congestion degree indicator can be obtained,[5] and congestion can be controlled in accordance with the type of packet. This mechanism reduces the overhead of the system, eases the congestion state of the wireless network, and improves network performance, and achieves good result in the aspect of ensuring stability and fairness of the queue length. This strategy is a completely non-state method, which can be achieved simply without setting complex configuration parameters, so it is easy to implement in wireless networks.[9]

- **WN CC algo based on adaptive QOS and wireless Bandwidth**
  To control wireless network congestion, an adaptive QoS and wireless bandwidth (adaptive-QWB) was designed in this paper. The adaptive-QWB algorithm seeks an active queue management for the optimal target queue according to the dynamic varying rate of current bandwidth.[6] The experiment results show that the varying-time of adaptive wireless bandwidth and the QoS guaranteed in transmission delay with the adaptive-QWB algorithm are superior to those of MADR algorithm and tuned-RED algorithm.[10]

- **Jointly optimal CC & Power Control for NDMWN**
  We formulate resource allocation in named-data multihop wireless network as a named-data network utility maximization problem with constraints arising from NDN's communication characteristic, whose objective is to maximize Data receiving rate related network utility minus weighted sum of links' transmission powers. By dual decomposition,[8] we derive a sub gradient algorithm that not only is distributed spatially, but also decomposes the named-data network utility maximization problem vertically into three protocol layers where congestion control, forwarding strategy and power control jointly solve the named-data network utility maximization problem.[10]

## 2. CC Techniques in WSN

Wireless Sensor Networks are event based systems that consists of a collection of autonomous sensor nodes that are spatially distributed and cooperatively monitor physical and environmental conditions. When an event has been detected these sensor nodes become active in transmitting the information and the load becomes heavy, increasing the data traffic and this might lead to congestion that results in packet drops, throughput reduction and degradation of channel quality which in turn decrease network performance. A congestion control scheme is necessary to monitor and regulate the traffic levels at an acceptable value.[7] This paper review various existing works used for detecting and controlling congestion. Different performance metrics that are used for measuring congestion was also surveyed. Finally a comparison of various performance measures was presented.[11]

### i Local cross layer CC

This method is based on buffer occupancy. Input to buffer is of two types:

a) Generated packets and b) Relay packets.

A sensor node has 2 duties a) Source duty and b) Router duty.

During source duty, the sensing unit of the node senses the event and generates packets to be transmitted. A node as a part of router duty receives packets from its neighbours to be forwarded to sink. It has two measures:

a) It explicitly controls the rate of generated packets in source duty.

b) It regulates the congestion in router duty based on current load on node.[12]

### ii Receiver assisted CC

In Receiver Assisted Congestion Control (RACC) method sender performs loss based control and receiver performs delay based control. Receiver maintains 2 timers, one for recording the packet interarrival time and other for measuring RTT. Sender uses this information from receiver to adjust the congestion window. The receiver can estimate the rate the sender should adapt to make best use of measured bandwidth based on packet interarrival timer. The RTT timer at receiver times the arrival of the next packet and detect packet drop if timeout occurs. Since receiver detects packet drop earlier than sender, it can send ACK to inform sender thereby reducing the waiting time of sender to retransmit a lost packet.[13]

### iii CC for self similar traffic in WSN

Congestion is caused due to several reasons, such as heavy traffic, link failure, node failure and many more. There are various techniques developed for combatting network congestion. In this paper, we have proposed a technique for prediction of the congestion before it happens and controlling the situation before it becomes worse. Congestion in the network is controlled by adjusting the traffic rate of sources. Source nodes change their transmission rate as soon as they receive the control signal. Further, the simulation results show that our algorithm outperforms other existing techniques in terms of packet delivery ratio and average number of packets dropped.

**iv CC in WSN using hybrid epidemic and DAIPAS approach**

Congestion in network creates additional load to the network. In Wireless Sensor Network (WSN) Congestion is one of the deemed challenge which reduces the resource and number of nodes deployed in the network. Congestion in WSN causes packet loss, delay, energy consumption in the network. In this research paper we proposed a Dynamic Alternative Path Selection Scheme for congestion control in WSN. For balanced transmission of data in the network binary tree network is formed for transmitting data from source to destination. For performance analysis of the created binary tree network, we use hybrid epidemic algorithm. For the created binary tree sensor network through hybrid DAIPaS congestion free paths are identified and updated in the routing table. Among the identified paths congested path has been made as dummy node in the routing table. Data will not be transmitted through that path in future. Through the proposed scheme it is expected that WSN network throughput has been increased with minimized delay, loss of packets in the WSN. In future congestion and collusion control has to be done by each node in a network for an efficient data transmission over the network. Further each node has to maintain a virtual routing table in order to maintain the path between the nodes. [13]

**v CC under traffic awareness in WSN**

A Distributed congestion control protocol, named TACCP was proposed for adaptively allocating an appropriate forwarding rate to potentially jammed sensors for mitigating the congestion load. TACCP can be used to avoid packet loss caused by traffic congestion reduce the power consumption of nodes, and improve the throughput of the entire network. We will consider the fairness of networks and the reliability and accuracy of the event detection in the fairness mechanism for the TACCP in WSN in the future.[15]

**vi Investigating network optimization approach in WSN**

More and more wireless mobile sensor networks are employed by robotics to perform harsh tasks such as disaster rescue, emission sources localization or hazardous contaminants localization. There are a lot of network optimization problems to be solved in the protocol design of wireless mobile sensor networks (WMSN), such as rate control, flow control, congestion control, medium access control, queue management, power control and topology control etc. These issues involve several layers of the network protocol stack so that it's quite difficult to consider every single optimization problem of them in a holistic view. The majority of contemporary research works mainly deal with one or some of them in terms of certain applications or objectives. However, most of the proposed protocols are based on simulations or experiments which lack of sufficient mathematical or theoretical analysis to fully understand the convergence or stability.[16]

**vii Priority based method for CC in WMSN**

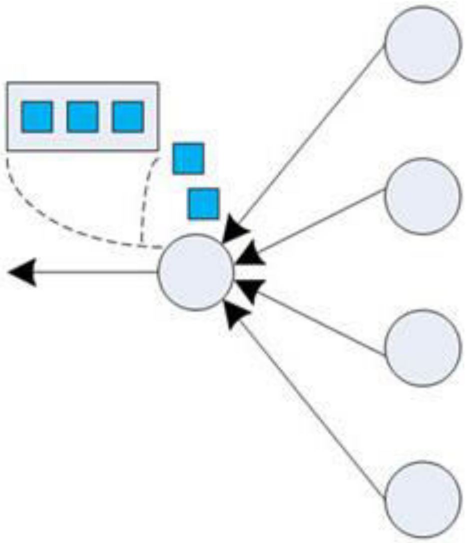
A new queue assisted protocol was proposed to congestion mitigation in WMSNs by considering zoning, the mobile sink, and optimal binary tree. The proposed method employs the three-level buffer and the defined threshold for them to detect and reduce congestion. A two part scheme was introduced in the proposed method. In first part, in each zone will be checked the Neighbourhood of two congested nodes then one of them, its request sends to the mobile sink and another, uses a Binary tree for congestion remedy. In second part, if two congested nodes don't have the Neighbourhood conditions then, solves their congestion by the Binary tree. This method is based on an event. Each event has the particular ID which keeps the quality of video data and increases a PSNR. We demonstrate the effectiveness of the proposed method by performing simulations and comparing the proposed method with three other protocols, DAlPaS, HTAP, and TARA. Simulation results show that in high data rate (for video packets) the network throughput, energy consumption, and hop-by-hop delay are better than other protocols. Also, simulation results shows if we increase number of zones then, the network delay and energy consumption reduces and throughput increases.[16]

**viii CC based on node and link in WSN**

A wireless sensor network (WSN) consists of distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. Due to the many-to-one characteristic of the sink node, the congestion problem is unavoidable in the wireless sensor network which leads to packets drops at the buffers, increased delays, wasted energy and requires retransmissions.

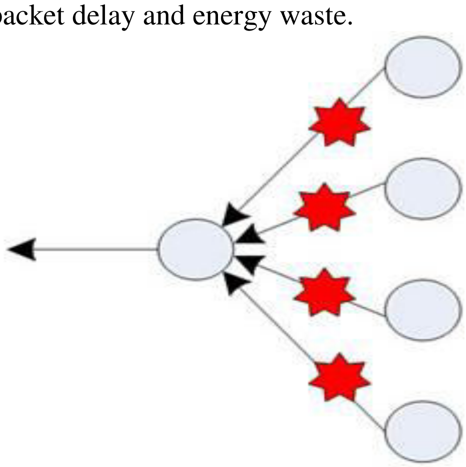
**Node-level congestion:**

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[4].



**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.



## ix CA & CC in WSN

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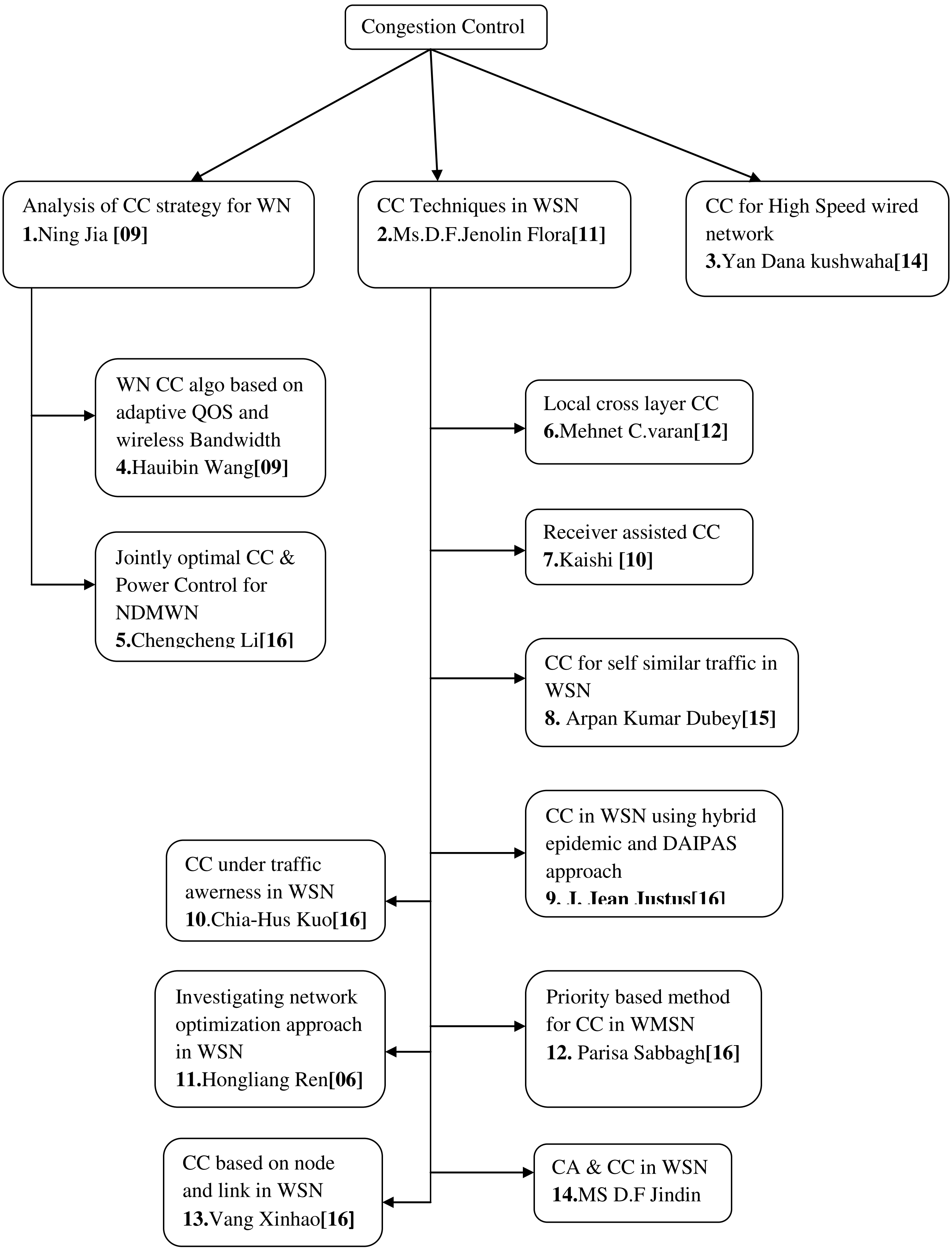
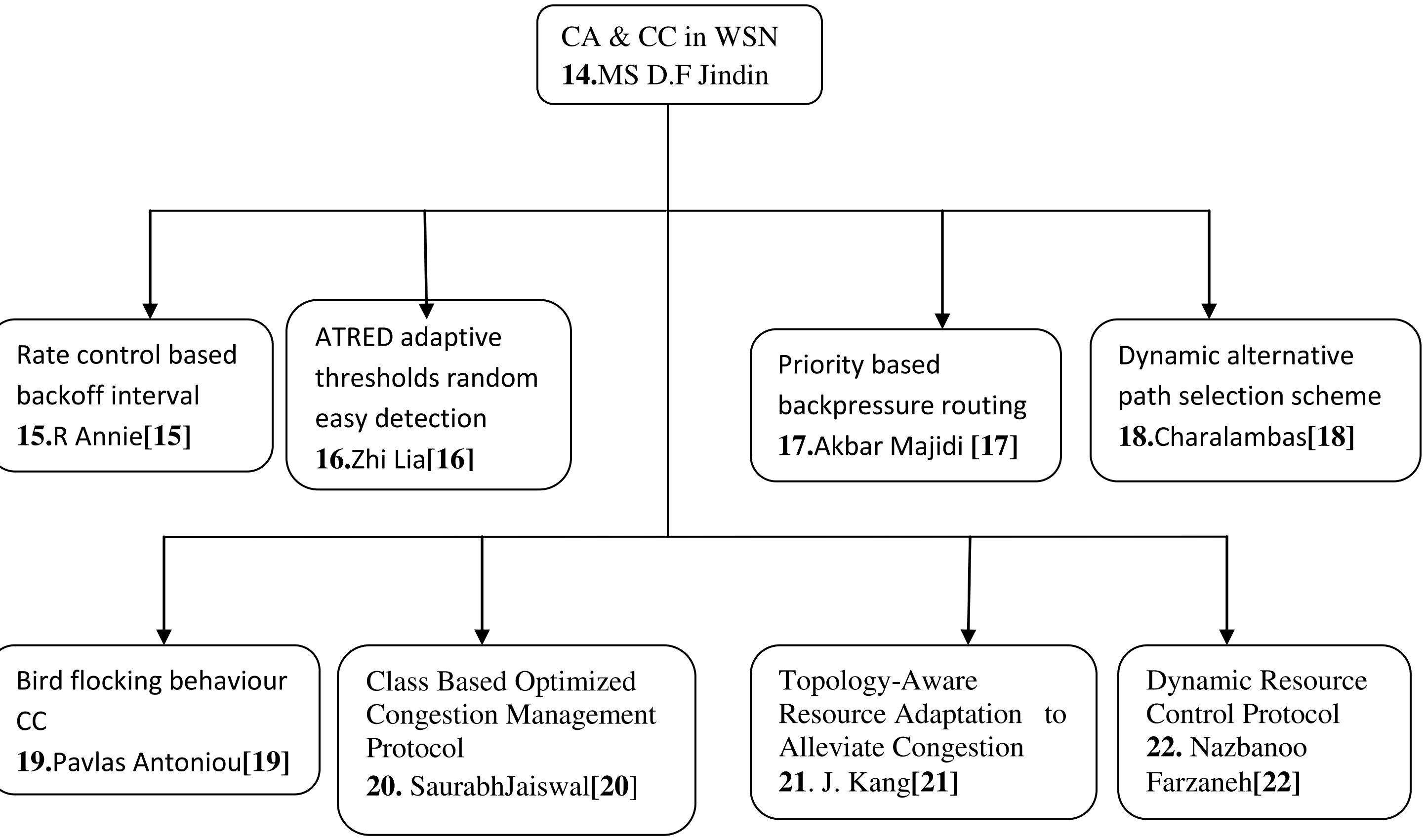
## 3. CC for High Speed wired network

Network is considered as a distributed system, any problem that arises in such a system requires a distributed solution. Thus for good congestion control in the network we also need a solution distributed at source as well as router ends. Braden et al. (1998) have commented that TCP congestion avoidance mechanisms, while necessary and powerful, are not sufficient to provide good service in all circumstances. There is a limit to how much control can be accomplished from the edges of the network. Some mechanisms are needed in the routers to complement the end point congestion avoidance mechanisms. Su and Hou (2000) found that congestion control is performed mainly by transport protocols at end hosts. However, as continuous media multicast applications (which usually do not deploy TCP for congestion control) become widely deployed on the internet, it becomes difficult to exclusively rely on end hosts to perform end-to-end congestion control. It has been agreed upon that the network itself must now participate in congestion control and resource management. The Internet Engineering Task Force (IETF) has advocated the deployment of active queue management mechanisms at routers to detect incipient congestion and to explicitly signal traffic sources before congestion actually occurs.

Low (2003) considered congestion control a distributed algorithm to share network resources (called “links”) among competing sources. It consists of two components: a source algorithm that dynamically adjusts rate (or window size) in response to congestion in its path, and a link algorithm that updates, implicitly or explicitly, a congestion measure and sends it back, implicitly or explicitly, to sources that use that link. On the current internet, the source algorithm is carried out by TCP, and the link algorithm is carried out by (active) queue management (AQM) schemes such as RED.[14]

## IV. Taxonomy for congestion control and Congestion Avoidance approaches






**WN-**Wireless Network
**WSN-** Wireless Sensor Network
**CC-**Congestion Control
**NDMWN-**Named data multihope wireless network
**WMSN-** Wireless Multimedia Sensor Network
**CA-** Congestion Avoidance

## V. Review of congestion avoidance protocols

| Sr. No. | Algorithms | Description |
|---|---|---|
| 1. | Back-off interval, Rate control | Per-node throughput is increased and the energy in the network is reduced by preventing packet drops. As the buffer occupancy is minimal, the rupture of data traffic is well maintained.<br><br>The state information after the transmission of packets, representing the real contention level is not maintained. |
| **2.** | ATRED congestion control<br><br>algorithm | Tuning difficulty of random early detection (RED) is decreased and has superior control on managing the queue, and attains much better performance.<br><br>RED algorithm leads to serious queue oscillation in the router and delay variation |
| **3.** | Backpressure routing and<br><br>dynamic prioritization for<br><br>congestion control (BDCC) | This algorithm does not pre-calculate routes and next step is selected dynamically.<br><br>Network should do most efforts to deliver data packets with instant or high priority. |
| **4.** | Dynamic Alternative Path<br><br>Selection Scheme | It is an easy and efficient approach for congestion control whereas the overhead is maintained as minimum.<br><br>The computational complexity is high and requires complete idea about network-wide per wavelength<br><br>link-state. |
| **5.** | Bird flocking behaviour | Robust way to avoid the congested area and dead node<br><br>zones.<br><br>Difficult to include power in the desirability function |
| **6.** | Class Based Optimized<br><br>Congestion Management<br><br>Protocol(COCM) | This algorithm is more efficient in terms of packet loss, energy efficiency, end-to-end delay and fairness.<br><br>Higher delays suffered by packets when they go through longer queues. |
| **7.** | Topology-Aware Resource<br><br>Adaptation to Alleviate<br><br>Congestion | Traffic control and resource Control<br><br>The congestion level-based avoidance is missing |
| **8.** | Dynamic Resource Control<br><br>Protocol (DRCP) | enhance throughput of the system and reduces packet drop, whereas energy saving.<br><br>The priority consideration of nodes are not considered. |

## VI. Conclusion

From the discussion, it was known that congestion control is one of the major as well as unpredictable events of the WSNs. The congestion in the network leads to energy waste, throughput reduction and number of packet loss results in network's performance degradation. In this paper a comprehensive survey of different congestion control strategies in wireless sensor network was carried out. Different performance metrics that are used for measuring congestion was also surveyed and a comparison between various techniques was presented. Although these congestion control techniques have been devised to monitor and regulate the traffic levels, still there are many challenges that need to be solved in wireless sensor network in this regard. We presented a comprehensive survey of congestion control technique in wireless sensor network. They have the common objective of trying to extend the lifetime of the wireless sensor networks. Different issues and challenges regarding the congestion control protocols were studied which will be useful for further research in this field.

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