# Queue Management Scheme to Control Congestion in A Vehicular Based Sensor Network

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*Abstract*— **Vehicular Ad-Hoc Networks (VANET) is subsumed class of Wireless Networks. Sensors are utilised in vehicles for monitoring physical variables or environmental conditions with ease. The main task of each sensor incorporated is to acquire respective data from the surroundings. The unit (node) which collects the data from the sensor processes it into meaningful information. In a vehicular network such information is sent to other nearby vehicles for various purposes, such as indication of very close vehicles. The ability to route the packet to the next node is the foremost requirements of such vehicular networks. One of the main issues to be addressed in VANET is congestion. When a sudden burst of traffic is detected, the nodes need to forward it towards the destination. The node that is forwarding may also have some packets to be delivered from it. The outgoing packets and transitory packets lead to buffer overflows at a node which in turn lead to packet drops and finally degrades the overall network performance. Congestion control schemes are essential in such situations to increase network performance and ensure a fair use of the resources. This paper proposes a congestion control scheme distributed across the transport, network and MAC layers that can detect and avoid congestion in the network. It provides priority based traffic scheduling with a dual queue scheduler whichfavours transitory packets. When congestion is detected based on the buffer occupancy, source sending rate is updated by the sink periodically with the help of dual queues and route the packets through less congested paths.**

***Keywords- VANET,congestion, cross-layer optimization, networks, routing.***

## I. INTRODUCTION

VANETcomprises of a gathering of self-ruling nodes that are spatially differentiated and are integrated with sensors that helpfully monitor physical and natural conditions. Such systems find expanding utilization in assorted territories like over-taking, speed control and so forth. A local VANET may comprise of tens or hundredsof nodes scattered in an area. When an event is detected, there is a sudden outburst of data .The data generated by the nodes increases and the offered load exceeds available capacity and the network becomes congested. Congestion inthe network can be transitory (link level congestion) or persistent(node level congestion). Transitory congestion is mainlydue toover flow of a link,as a result of the burst of packets arriving at the switch or router buffer. It occursas a result of link variations. Persistent or sustained congestion happens when the long term arrival rate at a link exceeds its capacity. This happens when data sending rate from the source increases and the buffer over flows whereas, transient congestion solely introduces a delay in data transmission, and persistent congestion leads to data loss.

Congestion ends up in packet dropping, delays, exaggerated throughput, and wastage of communication resources, power, and eventually decreases the life span of the network. Congestion control involves several strategies for monitoring and regulating the quantity of data entering the network to keep traffic levels at a suitable level. In VANET, congestion control has anaffluent history of algorithm development and theoreticalstudy. Varied schemes for congestion control have been projected and enforced over the years. The existing works differ in the algorithms they use for adjusting the sending rate from source and techniques to deal with transient congestion like dropping packets or using back pressure mechanism that mitigates the rate of links feeding the congested buffer. They areclassified based on whether to follow a traditional stratified approach or cross layer approach.

Considering the limited energy and dispensation resources of VANETs, optimization and design of network layers arise as the most promising alternative to stratified approach. Network layers can be jointly optimized to maximize overall network performance while minimizing the energy spent. Knowledge has to be shared among all layers to obtain highest possible adaptability.

## II. RELATED WORK

In recent years, various routing protocols have been analysed for Vehicular Ad-hoc Networksand their performance is widely compared [1],[2]. Various congestion control techniques [3] have been suggested for the Wireless Networks, including VANET.The existing works can be classified in several ways. In general, transitory congestion in VANET is effectively dealt with using buffers at the links and dropping the excess packets, whereas sustained congestion is mitigated by transport protocols which scale back the transmission rate of a source when its packets are dropped or marked. Some mechanisms for congestion control operate at a specific layer like network, Medium Access Control (MAC)[4] or transport layers whereas others are distributed among various layers involving sharing of knowledge across layers. The latter is the Cross Layer Approach. The works [5],[6],[7] have dealt with layered approach .The works of Mehmet C. Vuran[8] , and Yu Xie[9] are examples of cross layered approach.

Most of the protocolsare following the layered approach of designing protocols to overcome congestion[10].It has been proved through various works that a cross layer design of protocols for communication which involve joint participation of network, MAC or transport layers can enhance the network performance and minimize energy expenditure[11], [12].

Previously works were focused on energy efficient congestion control scheme called Congestion Detection and Avoidance(CODA) [13],[14], [15] which deals with three mechanisms distributed across the network and MAC layer. It handles both persistent and transient congestion, but does not give differentiated services to multiple class of traffic. Event-to-Sink Reliable Transport (ESRT)[16]that equips itself with a transport protocol for wireless has an exact congestion notification mechanism whichpermits the sink to manage the sending rate of sources.A source sets the congestion bit in its outgoing packets when its buffer overflows. However ESRT uses high energy signals to broadcast network state to nodes at regular intervals,which consumes a lot of energy. Also in the event of congestion it regulates sending rate of all sources irrespective of where the congestion hotspot is present. However there is a need to support heterogeneous sources and regulate only the source which is responsible for congestion. There have been considerable efforts in developing congestion control schemes that give importance to high priority data or data with specific delay or Quality of Service(QoS) requirements in the event of congestion. In a workof Li Qang Tao[17] data is classified according to the static priority of sources and dual queues are introduced for the source and transit traffic. In a later work Enhanced Congestion Detection and Avoidance(ECODA)[18] introduces three mechanisms to detect and control persistent and transient congestion. It uses the novel concept of dual buffer threshold. However to deal with persistent congestion it uses a technique based on overhearing which is coarse and unreliable. In the event of maximum congestion,no priority is given to the transit packets. Everynode has the additional overhead of calculating the weighted buffer difference in order to identify high priority data that is expensive considering the limited power of the node. LaterCOngestionALleviation and Avoidance(COALA) [19] presented a novel protocol, which aims to act both proactively, in order to avoid the creation of congestion in WSNs, and reactively, so as to mitigate the diffusion of upcoming congestion through alternative path routing [20]. However, does not give enough insight about the difference between the energy loss of transit and generated packet drops.

## III. PROPOSED SYSTEM

The proposed system focuses at developing an efficient congestion management protocol for Wireless Sensor Networks(WSN) using cross layer approach. The architecture of the system is as shown in Fig.1. Source has sensors and forwards the sensed data towards the sink. Intermediate nodes have congestion control mechanisms to boost the network performance. The proposed congestion control scheme is distributed across the network, MAC and transport layers.It has a Link level back pressure technique to deal with transient congestion, Transport layer algorithm to adaptively control the source sending rate and intelligent dynamic routing at the Network Layer.

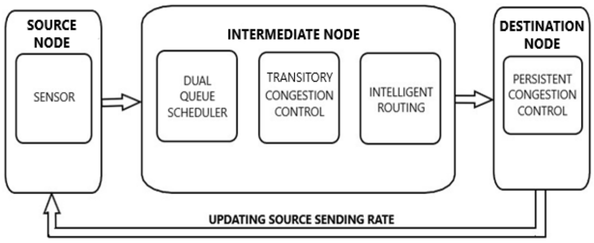


Fig.1.Overall Architecture

All the three techniques at each layer are not independent and work in a distributed cross layer fashion. At link level implicit hop by hop back pressure is used to alleviate transient congestion. At the transport layer,the sink periodically updates the sending rates of sources according to the delay incurred by the packets from various sources in reaching the sink. Accordingly different sources are assigned different sending rates. When the control packets flow from the sink to sources periodically, each node on its way piggybacks the buffer occupancy status in the control packets which can be used by the routing algorithms to choose best paths.Even if at times the link varies dynamically for a short time and the data contained in control packets for routing might mislead, the first mechanism of proposed system at link level will take care of such sudden congestion in network.

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Algorithm: Determination of the queue of incoming packet

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The steps followed in the proposed algorithm are as follows.

**Min** is considered as half of the entire queue length:

Min = ½ Queue Length

**Max** is considered as three-fourth of the entire queue length:

Max = ¾ Queue Length

1: A packet reaches the router.
2: Generated and Transit Queue usage is calculated.
3: Header is identified from the packet to get the source and time to live for classification.
4: **if** (Generated) **then**
5: Route it into the generated packet queue.
6: **else if** (Transitory) **then**
7: **if** (**Min** not reached) **then**
8: Route the packet into the transit packet queue.
9: **else if** (**Min** reached) **then**
10: **if** (High priority) **then**
11: Route the packet into the transit packet queue.
12: **if** (Low priority) **then**
13: Route the packet into the generated packet queue.
14: **elseif** (**Max** reached) **then**

Drop all the generated packets from the generated packet queue.
Route the packet into the transit packet queue.
Update Generated and Transit queue usage.

## IV. Implementation Of The Proposed Scheme

The proposed system implements an efficient congestion control scheme for WSN. It has different mechanisms distributed across the Link layer, Network layer and Transport layer.

### *A. Queue Scheduler*

The node in WSN can act as both source and forwarder. Based on this function there are two types of data namely locally generated data and transit data. The data generated from any source node is called locally generated data. The data at any source node can be differentiated into transit data, which it receives from a downstream node and generated data, which is its own sensed data. In a multi-hop network, the sensed data has to travel many hops to reach the sink. Hence dropping of such transit data leads to more energy wastage. Also the TTL (Time To Live) of packets is small in networks, so it is necessary to route the transit packets immediately when compared with generated packets at a node.

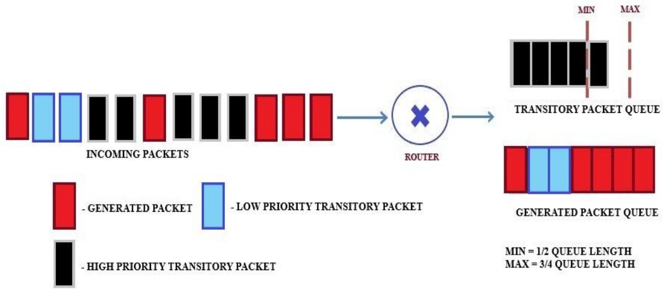



Fig.2 Dual Queue Scheduler

A flexible queue scheduler as shown in Fig.2 is employed at the interface of network and MAC layers at every node.It is brought about as a dual queue during which the generated traffic at the nodes and transit traffic are queued separately.Both queues are of the similar length. It is considered that dropping of transit traffic results to more energy wastage and within the event of buffer overflows the packets from generated traffic queue is dropped to make space for the transit traffic. The transit packet queue as shown in Fig.2 has twin thresholds. Buffer occupancy on top of the minimum threshold, signals onset of congestion and incoming packets from different nodes are queued in the generated queue. This is carried out to make room for transit traffic that are having high priority. When the buffer occupancy crosses the maximum threshold the two queues are utilized for storing transit packets and all the generated packets are dropped. As the congestion is eased off by the back pressure messages propagated to downstream nodes, the transit queue occupancy falls down and the queues are used in normal way. The minimum threshold is set to half of the queue length and the maximum threshold is set to three fourth of the queue length. These values are considered optimal as the congestion control schemes won't be initiated either too early leading to excessive drop of generated packets or too late causing the drop of transit packets.

### *B. Transitory Congestion Control*

Transitory congestion occurs due to temporary oversubscription of a selected link and ends up in buffer over flow at the routers. Hop by Hop back pressure is used to control transitory congestion. In the proposed system the transit queue occupancy is used to trigger back pressure messages.If the transit queue is occupied on the far side the minimum threshold back pressure is set towards downstream nodes. On receiving the back pressure messages the node reduces its forwarding rate,and based on its queue occupancy decides whether to propagate the backpressure further downstream.A node receiving back pressure can select alternate paths to route its outgoing packets. When the transit queue occupancy falls back to normal, the node will stop propagating back pressure messages and sets the normal sending rate again.

### *C. Persistent Congestion Control*

Persistent or unrelenting congestion arises, when the long term arrival rate at a link exceeds its capacity. This happens when the data sending rate from source increases and the buffer over flows. While transient congestion solely introduces a delay in data transmission, persistent congestion leads to data loss. In order to avoid persistent congestion the sink node observes the incoming packets from every source for the delay they took in reaching the sink. The sending rate for every source is set as the reciprocal of maximum delay that a packet from that source took to reach the sink. This is estimated sporadically and sends to the sources through control messages. In Fig.3, The red lines from the destination car indicate the control messages towards sources.

These control messages can also contain the buffer occupancy status of each node on its way to the source, which can be used for an intelligent routing at network layer.

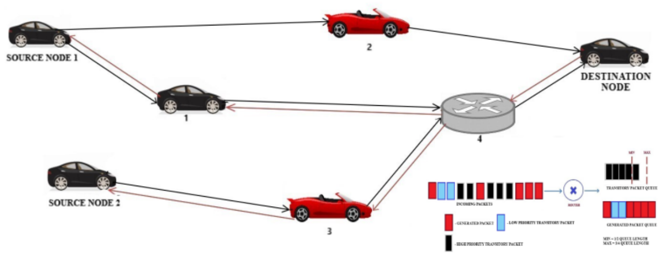



Fig.3 Rate control of sources

### *D. Routing Scheme*

Congestion in WSN and VANET may lead to packet loss or delayed delivery of important information rendering the WSN-based monitoring or control system useless. A dynamic routing scheme that works in concert with the congestion control mechanism to forward the packets through less congested nodes can reduce transient congestions and also improve overall network performance.The sink can periodically updates the sending rate for each source by sending control messages.These control messages piggyback the buffer occupancy at each node on their way to the sources information can be intelligently used for routing purpose.A node filled beyond minimum threshold can be purposefully avoided and another node in the transmission range can be chosen for next hop of a packet.

## V. SIMULATION RESULTS

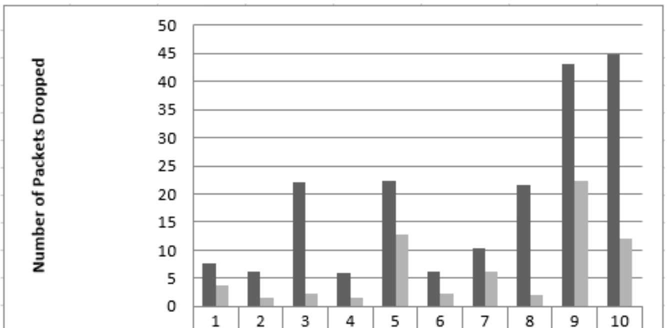
Fig.4.General Congestion Scenario

In the Fig.4, a common congestion scenario is shown.

As the fundamental step towards the implementation of the congestion control protocol,the interface queue between the Network and the MAC layers arechanged.The queue offers priority to transit packets and in the event of congestion, the generated packets are dropped grantingroom for the transit packets. The simulation scenario is performed with regular drop tail queue and with the modified queue and the results are analysed. The regular queue is used as the interface queue in the initial simulation .The queue enqueues all incoming packets at its tail and drops packet from tailwhenever the maximum limit is exceeded.

The regular queue is modified to perform differentiated service. It will ensure that during overflow, incoming transit packets are transmitted and the generated packets are dropped. The transit packets are enqueued at the head of the generated packet queue after queue is filled beyond the minimum threshold.Hence, during dropping at the tail the transit packets are saved to an extent, though during heavy congestion transit packets might also be dropped.

The simulation was performed for various scenarios, with the sources positioned differently and also by altering the source sending rates. The scenarios were simulated both using the regular queue and the improved queue. In all the cases, there was significant decrease in the transit packet drop when the improved queue is used.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Generated Queue | 7.55 | 6.06 | 22.03 | 5.94 | 22.4 | 6.06 | 10.27 | 21.66 | 43.07 | 44.8 |
| Transitory Queue | 3.71 | 1.61 | 2.35 | 1.61 | 12.75 | 2.35 | 6.19 | 2.1 | 22.28 | 12 |

Fig.5. Performance Analysis

Fig.5 shows the performance analysis of various scenarios.It clearly depicts the performance advantage gained through the improved queue. In all the cases, the numbers of generated packets that are dropped are significantly higher than the number of transitory packets that are dropped. Since the number of generated packets dropped is greater and the number of transient packets dropped is reduced, energy expenditure is also reduced. The algorithm is substantiated by the results obtained.

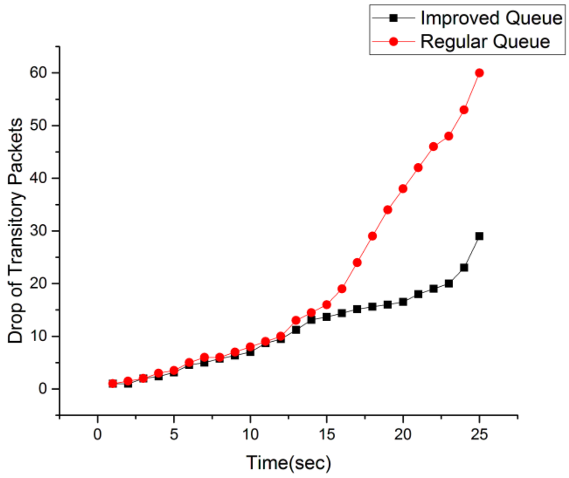



Fig.6.Comparison of Performance with and without Improved Queue

In Fig.6, the graphillustrates the performance of regular queue and improved queuefor one of the variouscongestion scenarios. It can be inferred that the improved queue nearly drops only half of the transitory packets when compared to the regular queue. Thus the improved queue contributes greatly to the energy reduction.

## VI. CONCLUSION

A cross-layered congestion control algorithm for VANET is proposed. It enables joint optimization of different layers and is more advantageous compared to the traditional layered approach. Concentration is majorly on congestion control. Here congestion can be detected using the buffer occupancy in dual queue. During congestion more priority is given to the transit packet than generated packet.

One of the common situations where this approach would make a difference is in the vehicular overtaking scenarios. When a speeding vehicular node is overtaking another node, the vehicles further ahead also need to be made aware of the overtaking. Such communication would prevent accidents from taking place because, the speed of the vehicle can be overwhelming and time taken for the generated packets to reach the appropriate nodes may be large. Another compelling scenario is when vehicles are forced to enable sudden brakes. In such a case informing the vehicles following behind the given vehicle will help these vehicles to not engage in series of rear-to-head collisions.Hence, the VANET can be enhanced by prioritising transitory packets over the generated packets.

Simulation has been carried out to demonstrate the effect of the improved queue and the results show that the proposed queue model significantly brings down the drop rate of transit packets. Hence, an overall improvement of energy consumption and throughput is achieved.

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