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CONGESTION BASED ROUTE RECOVERY TECHNIQUE FOR MANET

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ABSTRACT

In mobile adhoc network (MANET), the previous work of the authors considered route recovery technique based on route failures alone and doesn't consider the packet drops due to congestion. The congestion is likely to occur when incoming traffic exceeds the network capacity which results in increased delay and packet loss. In order to overcome these issues, in this paper, congestion detection and recovery technique is proposed in mobile ad hoc network. In this technique, each node estimates the parameters such as queue length, data rate, and medium access control (MAC) contention. The upper and lower limit of these parameters is compared and node is marked with the congestion status such as normal, medium or high level. When data is to be transmitted from the source to destination, the intermediate nodes along the path verify its congestion status. If the congestion status of any one node is high or congestion status of more than one node is medium, a warning message will be sent to the source. The source then selects the alternate congestion free path for data transmission. By simulation results, it is estimated that the proposed technique reduces the packet drop due to congestion and increases the packet delivery ratio.

Keywords: *Mobile Ad Hoc Network (MANET), Medium Access Control (MAC), Congestion Detection, Route Recovery Technique*

1. INTRODUCTION

1.1 Congestion Detection in MANET

A Mobile Ad-Hoc Network (MANET) is a temporary network; the mobile devices in an ad-hoc network are communicating through wireless links without any pre-existing infrastructure. The one major problem of this network is network congestion; it may take place at any intermediate nodes when data packets are traveling from source to destination. The congestion occurs in mobile ad hoc networks due to limited availability of resources. In such networks, packet transmissions suffer from interference and fading, due to the shared wireless channel and dynamic topology. Transmission errors also cause burden on the network due to retransmissions of packets in the network. Recently, there has been increasing demand for support of multimedia communications in MANETs. The large amount of real-time traffic tends to be in bursts, is bandwidth intensive and liable to congestion. Congestion in a network may occur at interval time when the incoming traffic is larger than the capacity of the network. The major problems of congestion are high data loss, increasing End to End and retransmission packets which affect the overall network performance. Congestion leads to packet losses and bandwidth degradation, and wastes time and energy on congestion recovery. To minimize congestion in a network different routing algorithms have been used [1, 4]

Congestion can be classified into four different types:-

- Instantaneous Congestion
- Baseline Congestion
- Flash Congestion
- Spiky Delay

Instantaneous congestion is caused by mild bursts, created naturally by burstiness of IP traffic.

Baseline congestion appears to be caused by systematic under-engineering of network or hop capacity (or alternatively due to simple source overflow described earlier).

Flash congestion suggests frequent but momentary periods of overload in a highly utilized

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network, where bursts from individual sources add up to create significant packet loss hills.

Spiky delay is a condition where no packets are transferred for a long duration of time - the transit delay of packets shoots up from few milliseconds to tens of seconds during this period.

1.2 Congestion Problem

In a network with shared resources, where multiple senders compete for link bandwidth, it is necessary to adjust the data rate used by each sender in order not to overload the network. Packets that arrive at a router and cannot be forwarded are dropped, consequently an excessive amount of packets arriving at a network bottleneck leads to many packet drops. These dropped packets might already have travelled a long way in the network and thus consumed significant resources. Additionally, the lost packets often trigger retransmissions, which mean that even more packets are sent into the network. Thus network congestion can severely deteriorate network throughput. If no appropriate congestion control is performed, this can lead to a congestion collapse of the network, where almost no data is successfully delivered.[6]

1.3 Congestion Detection

Accurate and efficient congestion detection plays an important role in congestion control of sensor networks. There is a need for new congestion detection techniques that incur low cost in terms of energy and computation complexity. Several techniques are possible. [9]

Buffer Queue Length

Queue management is often used in traditional data networks for congestion detection. However, without link-layer acknowledgments (some applications might not require this and hence would omit it to save the overhead) buffer occupancy or queue length cannot be used as an indication of congestion. It is difficult to quantify a level of congestion or infer congestion solely based on buffer occupancy. This bimodal effect is not responsive enough and too coarse to provide smooth and efficient congestion control.[9]

Channel Loading

Channel loading gives accurate information about how busy the surrounding network is but it is inherently a local mitigation mechanism. It has limited effect, for example, in detecting large-scale congestion caused by data impulses from sparsely located sources that generate high-rate traffic. Listening to the channel consumes a significant portion of energy in a node.[9]

Report Rate/Fidelity Measurement

For typical applications in sensor networks, the sinks expect a certain sampling rate or reporting rate coming from the sources. This rate is highly application-specific, and can be seen as an indication of event fidelity; that is, the reporting rate from the source with respect to certain phenomenon should be high enough to satisfy the applications' desired accuracy. When a sink consistently receives a less than desired reporting rate, it can be inferred that packets are being dropped along the path, most probably due to congestion. [9]

1.4 Problem Identification

In paper [14], a fuzzy based route recovery technique consists of two phases, Proactive failure discovery, and Route failure recovery. Initially, nodes in the network estimate their status using the following metrics Link Expiration Time (LET), Link Received Signal Strength (LRSS), Available Band Width (ABW) and Residual Energy (RE). These values are fuzzified and fuzzy rules are formed to decide the type of node whether it is a weak, normal or strong node. This information is exchanged among all the nodes. The status of the node is verified before data transmission. If the successor node is weak, route recovery warning (RRW) message is sent to all the neighboring nodes. Then local route recovery process is initiated by changing the route to the strong nodes

This paper addresses route recovery based on failures alone and didn't take packet drop due to congestion into consideration. As an extension to this approach, in this paper, congestion detection and recovery technique is proposed in mobile ad hoc network.

2. LITERATURE REVIEW

K. Srinivas et.al [2] have proposed A MAC layer level congestion detection mechanism, that includes energy efficient congestion detection, Zone level Congestion Evaluation Algorithm [ZCEA] and Zone level Egress Regularization Algorithm [ZERA], which is a hierarchical cross layer based congestion detection and control model in short we refer this protocol as ECDC(Energy Efficient Congestion Detection and Control). ECDC derived a cross layered congestion detection mechanism with energy efficiency as primary criteria that included as congestion detection mechanism to "Two step cross layer congestion routing". The proposed algorithm aims to deliver an energy efficient mechanism to quantify the degree of congestion at victim node with maximal

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accuracy. Packet loss in network routing is primarily due to link failure and congestion. Most of the existing congestion control solutions do not possess the ability to distinguish between packet loss due to link failure and packet loss due to congestion.

T. Senthil kumaran et.al [3] have proposed an early congestion detection and optimal control routing in MANET called as EDOCR. Initially EDOCR segregates network in to spares and dense region by using mean of neighbors. After segregation of networks, it initiates an optimal route discovery process to find a route to destination. This optimal route discovery is reducing the RREQ overhead during the route discovery operation. All the primary path nodes periodically calculate its queue status at node level. While using early congestion detection technique, node detects congestion that is likely to happen and sends warning message to Neighbors. Now EDOCR utilizes the non-congested predecessor node of a congested node and initiates optimal route discovery process to find an alternate non-congested path for a destination. Thus, EDOCR improves performance in terms of reducing delay, routing overhead and increases packet delivery ratio without incurring any significant additional cost. The performance of EDOCR was compared with EDAODV, EDCSCAODV and AODV using the Ns-2 simulator. The result reveals significant improvement over EDAODV, EDCSCAODV and AODV routing schemes.

Yanyong Zhang et.al [7] have proposed new a two-level congestion detection scheme that provides an accurate node-level and flow-level congestion measurements in an energy-efficient way in ad hoc networks. Simulation results show the node-level congestion measurement, which uses the set of buffer occupancy, packet drop rate, and channel loading as an indication of congestion, accurately portrays the congestion level by decoupling the measurement from various MAC protocol characteristics. The flow-level congestion measurement based on the node-level congestion measurement provides sfined-grained congestion information in the network. For energy-efficiency, the lazy channel loading measurement saves a lot of energy needed to accurately measure the channel loading while maintaining the same level of accuracy as synchronous measurements. Simulation results show the proposed mechanism significantly cut down the energy needed to accurately measure congestion while maintaining high level of accuracy needed for timely congestion control.

Mr.S.A.Jain et.al [10] have proposed Ant Colony algorithm which has been used in Mobile Network since long because of isomorphism between them In MANET, routes may fail due to failure of links that may be caused by movement of nodes. In addition when mobility speed is high, link failures occur more causing delivery ratio to decrease. So the problem of packet losses and delays can be solved to a certain extent by detecting the link failures.Packet delivery failures due to wireless link collisions may incur unnecessary route reestablishments from the source node. Thus this type of route reestablishment can be prevented if there exists a mechanism different mechanisms for the link failure detection by using alternate route finding from the nearer of the faulty node resulting into improvement in throughput, and end to end delay parameters. Thus performance of MANET will be significantly increased, along with TCP throughput.

Xiaoqin Chen et.al [11] have proposed congestion-aware routing (CARM). CARM utilizes two mechanisms to improve the routing protocol adaptability to congestion. Firstly, the weighted channel delay (WCD) is used to select high throughput routes with low congestion. The second mechanism that CARM employs is the avoidance of mismatched link data-rate routes via the use of effective link data-rate categories (ELDCs). In short, the protocol tackles congestion via several approaches, taking into account causes, indicators and effects. The decisions made by CARM are performed locally.The simulation results demonstrate that CARM outperforms DSR due to its adaptability to congestion protocol for mobile ad hoc networks which uses a metric incorporating data-rate, MAC overhead, and buffer delay to combat congestion.

Consolee Mbarushimana et.al [12] have proposed a Type of Service Aware routing protocol (TSA), an enhancement to AODV, which uses both the ToS and traditional hop count as route selection metrics.TSA is a cross-layer congestion-avoidance routing protocol in which the routes through nodes engaged with delay sensitive traffic for extended periods are only selected as the last resort, even when they are shorter. Avoiding busy nodes alleviates congestion, results in less packets drop and in a short end-to-end delay. In addition, TSA distributes the load on a large area, thus increasing the spatial reuse. Simulation study reveals that TSA considerably improves the throughput and packet delay of both low and high prior.

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Kazuya NISHIMURA et.al [13] have proposed a routing protocol that reduces network congestion for MANET using multi-agents. MANET is a multihop wireless network in which the network components such as PC, PDA and mobile phones are mobile. The components can communicate with each other without going through a server. Two kinds of agents are engaged in routing. One is a Routing Agent that collects information about network congestion as well as link failure. The other is a Message Agent that uses this information to get to their destination nodes. MAs correspond to data packets and determine their direction autonomously using an evaluation function.

3. PROPOSED SOLUTION

3.1. Overview

In this paper, the network characteristics like congestion need to be detected and remedied with a reliable mechanism. The CBRRT have analyzed the traffic fluctuation and categorized the congestion status perfectly. After estimating the congestion status at the node level along a path, the CBRRT controls the congestion by using an alternative path. The proposed congestion based route recovery technique minimizes the packet drop and delay while increasing the packet delivery ratio.

3.2. Estimation of Metrics

3.2.1. Estimation of Average Queue Length (L_q)

The average queue length aims at gathering the entire traffic fluctuations and follows the enduring variations of the instant queue that duplicates the stable network congestion. The equation (1) is average queue length (L_q) it is defined as

$$L_q = (1-W_q) * L_q + L_{iq} * W_q$$

Where, L_{iq} = Instantaneous queue length
W_q = weight factor that helps in regulating the congestion in the network.

The weight factor W_q regulates the network congestion. If the W_q is too tiny, the average length of the queue does not clutch the extensive range congestion, which might result in ineffective Congestion Detection Technique. If W_q is an outsized, the average queue length follows the instant queue, which corrupts the performance of the Congestion Estimation Technique. Therefore, the value of W_q should be communicated to the traffic smoothing in the queue. Hence should be chosen such that it acts as the good traffic smoothing factor in the queue. [4]

3.2.2. Estimation of MAC Contention (T_{MAC})

The standard packet sequence of medium access control that includes the distributed coordination function (DCF) is request-to-send (RTS), clear-to-send (CTS) and data acknowledgement (ACK). The time taken between the receipt of one packet and transmission of the next packet is termed as short interframe space (SIFS). Hence the minimum channel occupation (T_{min}) owing to the MAC overhead is defined as follows.

$$T_{min} = T_R + T_C + 3T_S + T_A \quad (2)$$

Where T_R = Time consumed on RTS
T_C = time consumed on CTS
T_S = SIFS period
T_A = time consumed on data acknowledgement

Thus the MAC overhead is computed by including the time taken owing to contention for the channel using the following equation.

$$T_{MAC} = T_{min} + T_{ac} \quad (3)$$

Where, T_{ac} is the time taken due to access contention [11]

3.2.3. Estimation of Incoming data rate (R_{in})

In a given route, the throughput is mainly based on minimum data rate of its entire links. There is a possibility that routes with various data rates exist in the network. If a node with high data rate transmits more traffic to a low data rate node, then the congestion occurs which in turn results in long queuing delay. [1] As effective bandwidth of a link is minimized by the congestion, the data rate of a link (R_{in}) is estimated using the following equation

$$R_{in} = z / D \quad (4)$$

Where, z = data size.
D = channel delay (1)
D is estimated using the following equation

$$D = T_{MAC} + T_d \quad (5)$$

T_d = data transmission time

3.3. Congestion Detection Technique

The congestion in a network is likely to occur when the number of packets arriving at node exceeds its queue length. The congestion status of the node can be categorized into following three states

- Normal (N)
- Medium(M)
- High (H)

When the node becomes congested, it starts losing the data packets. In the proposed technique, the following three parameters are used to monitor congestion of the node.

- Average Queue Length (L_q)

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- Incoming Data Rate (R_{in})
- MAC Contention (T_{MAC})

Each of the above factors has two limits such as Upper Limit (UL) and Lower Limit (LL). By comparing each factor with these two limits, the congestion status of the path can be estimated.

The following table estimates the congestion status of the node considering the parameters in individual manner.

Table 1: Congestion Status Of The Node

Factors	Condition	Congestion Status
Queue Length	$L_q \leq LL$	N_1
	$LL < L_q \leq UL$	M_1
	$L_{q>}$ UL	H_1
Data Rate	$R_{in} \leq LL$	N_2
	$LL < R_{in} \leq UL$	M_2
	$R_{in>}$ UL	H_2
MAC contention	$T_{MAC} \leq UL$	N_3
	$T_{MAC} > UL$	H_3

In table 1, N_1, M_1 and H_1 represent the normal, medium and high level congestion status of the node with respect to queue length. Similarly N_2, M_2 and H_2 represent the normal, medium and high level congestion status of the node with respect to incoming data rate. And N_3, H_3 represents the normal and high level congestion status of the node with respect to MAC contention.

Based on the above estimated congestion status of node, following rules are framed.

Rule (1)

If node possess (N_1, N_2 & N_3)
Then
Node is congestion free (i.e. **Normal** status of the node).
End if

Rule (2)

The node while possessing the following combination of the congestion status (shown in table 1) is said to possess **medium** level congestion.

1. N_1, M_2 & N_3
2. M_1, N_2 & N_3
3. M_1, M_2 & N_3
4. H_1, N_2 & N_3
5. H_1, M_2 & N_3

Rule (3)

The node while possessing the following combination of the congestion status (shown in table 1) is said to possess **High** level congestion.

1. M_1,N_2, & H_3
2. M_1, M_2 & H_3
3. M_1, H_2 & H_3
4. H_1, N_2 & N_3
5. H_1, N_2 & H_3
6. H_1, M_2 & H_3
7. H_1, H_2 & H_3

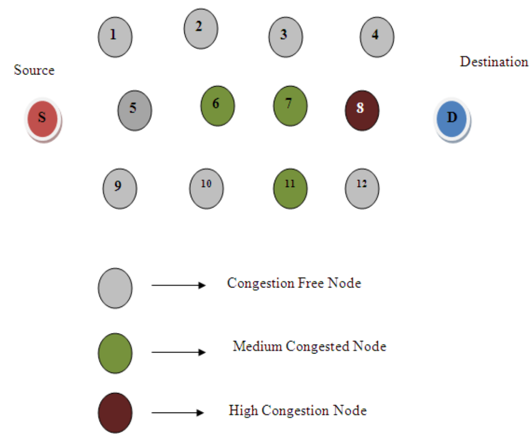

Figure 1 Congestion Status of the Node

3.4. Congestion Recovery Technique

Let S and D be the source and destination nodes, respectively.

Let N_{i1}, Ni2 and N_{i3}, be the intermediate nodes along the path.

Let $C(N_{i1})$, $C(N_{i2})$ *and* $C(N_{i3})$ be the congestion status of the nodes N_{i1}, N_{i2} *and* N_{i3}, respectively.

When S wants to transmit the data to D, it initially estimates the congestion status of the nodes using the rules described in the section 3.3.2.

If (one C (N_{i1}) = H) OR (C(N_{i2}) = M and C(N_{i3}) = M)
Then

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$$N_{int} \xrightarrow{CWM} S$$

Alternate congestion free path is chosen for the data transmission.

End if

If the congestion status of any one N_{int} is high or congestion status of more than one N_{int} node is medium, a congestion warning message (CWM) will be sent to S. S then selects the alternate congestion free path.

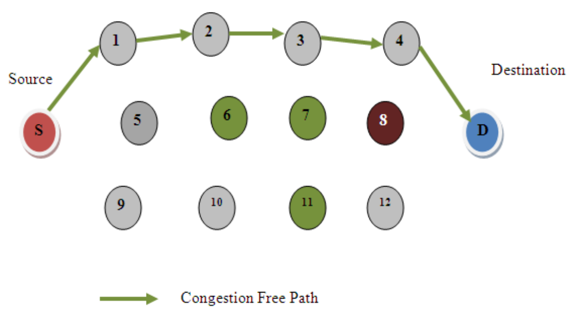

Figure 2 Selection of Congestion Free Path

Fig 2 demonstrates the selection of congestion free path. As the path with nodes N_6 and N_7 are in medium congestion level and N_8 is with high congestion level, the path is said to be congested. Then these intermediate nodes transmit a CWM to S. S then transmit the data through the alternate congestion free path where the nodes N_1, N_2, N_3, N_4 are normal nodes i.e. congestion free nodes.

4. SIMULATION RESULTS

The performance of congestion based route recovery technique (CBRRT) is evaluated through NS2 [15] simulator. A random network deployed in an area of 1000 X 1000 m is considered. Initially 50 sensor nodes are placed in square grid area by placing each sensor in a 50x50 grid cell. The sink is assumed to be situated 100 meters away from the above specified area. In this simulation, the channel capacity of mobile hosts is set to 2 Mbps. The simulated traffic is CBR with UDP source and sink. The number of sources is varied as 2, 4, 6 and 8, 10

Table 2: Simulation Parameters

No. of Nodes	100
Area Size	1000 X 1000
Mac	802.11
Routing protocol	CBRRT
Simulation Time	50 sec
Traffic Source	CBR
Pause time	5 seconds
Rate	250kb
Transmission Range	150m
Speed of events	5 m/s
Transmit Power	0.395 w
Receiving power	0.660 w
Idle power	0.035 w
Initial Energy	10.1 Joules
Packet Size	250,500,750,1000 and 1250 Bits/Sec
Flows	2,4,6, 8 and 10

4.1. Performance Metrics

The performance of CBRRT technique is compared with the TSA [12]. The performance is evaluated using to the following metrics.

- **Average Packet Delivery Ratio:** It is the ratio of the number .of packets received successfully and the total number of packets transmitted.
- **Throughput:** It is the number of packets received during the transmission.
- **Energy:** It is the average energy consumed for the data transmission.

4.2. Results

The simulation results are based on flows and packet size. In both parameters are compared with delay, delivery ratio, packet drop and energy of the nodes. The flow of traffic is vary the number from 2, 4, 6 and 8, 10 and based on packet size to vary as 250,500,750, 1000 and 1250 Bits/Sec.

A. Based on Flows

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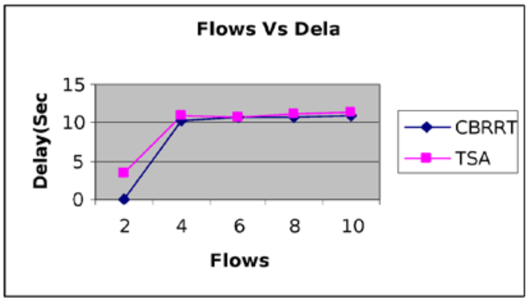

Fig 3: Flows Vs Delay

Fig 3 shows the delay occurred for both the techniques when the number of traffic flows is increased from 2 to 10. From the fig, the delay steeply increases when the flow is increased from 2 to 4. Since CBRRT predicts congestion more accurately than TSA, the delay is less.

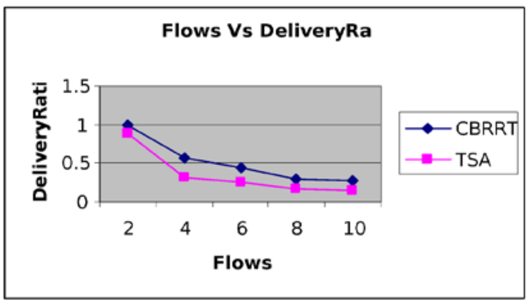

Fig 4: Flows Vs Delivery Ratio

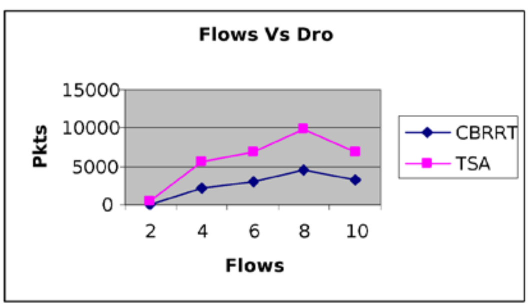

Fig 5: Flows Vs Drop

The delivery ratio and packet drop for both CBRRT and TSA are depicted in Fig 4 and 5, respectively. As the traffic flows are increasing, congestion will be triggered and results in more packet loss. Hence the packet drop increases and delivery ratio gradually decreases, when the number of flows is increased from 2 to 10. However, CBRRT has reduced packet drops, when compared to TSA, since it not only considers congestion status, but also the failure status of nodes also. Hence the packet delivery ratio of CBRRT is higher than TSA.

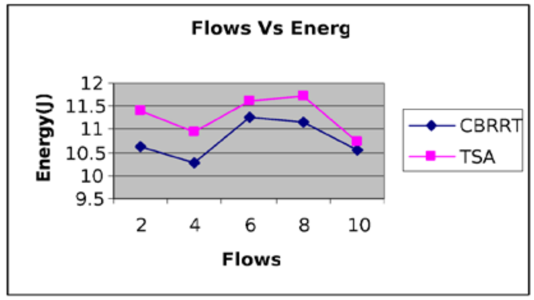

Fig 6: Flows Vs Energy

Fig 6 shows the energy consumed for both the techniques when the flows are increased from 2 to 10. It can be seen that CBRRT consumes less energy when compared to TSA, since it considers residual energy as one parameter for node status.

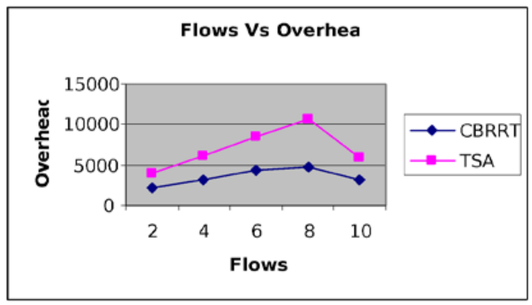

Fig 7: Flows Vs Overhead

The overhead occurred during the routing process is depicted in fig 7. When the number of traffic flow is increased, it results in congestion and hence alternate routing will be triggered. So the overhead is increasing linearly as shown in the fig. But CBRRT has significantly lower overhead when compared to TSA, since TSA stores the queue status all traffic classes.

A. Based on Packet Size

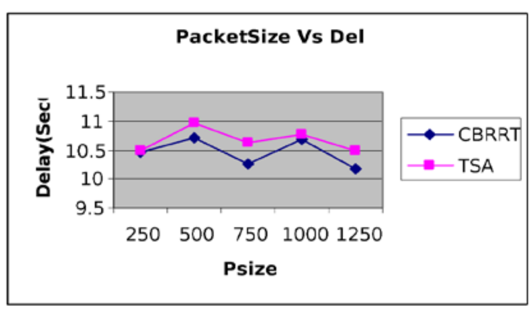

Fig 8: Packet Size Vs Delay

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Fig 8 shows the delay occurred for both the techniques when the packet size is increased from 250 to 1250 bytes. Since CBRRT predicts congestion more accurately than TSA, the delay is less.

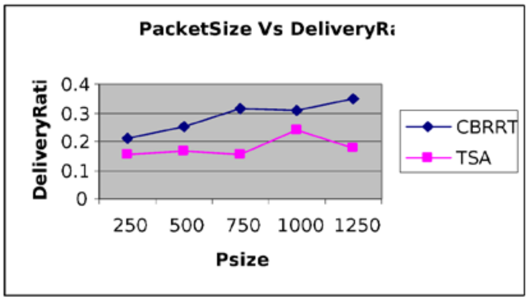

Fig 9: Packet Size Vs Delivery Ratio

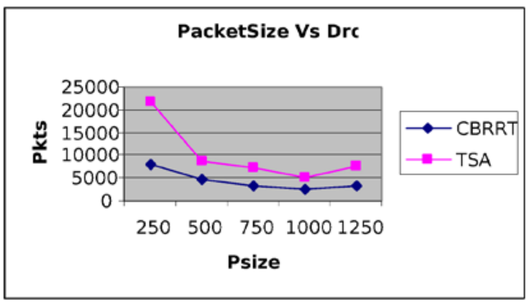

Fig 10: Packet Size Vs Drop

The packet drop and delivery ratio for both CBRRT and TSA are depicted in Fig 10 and 9, respectively. As the packet size is increasing, the data sending rate will be reduced and results in reduced packet loss. Hence the packet drop decreases and delivery ratio gradually increases, when the packet size is increased. However, CBRRT has reduced packet drops, when compared to TSA, since it not only considers congestion status, but also the failure status of nodes also. Hence the packet delivery ratio of CBRRT is higher than TSA.

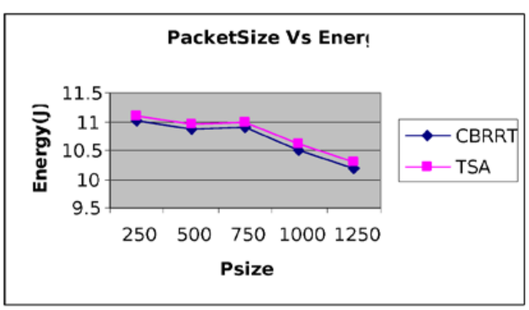

Fig 11: Packet Size Vs Energy

Fig 11 shows the energy consumed for both the techniques when the packet size is increased from 250 to 1250 bytes. It can be seen that CBRRT consumes less energy when compared to TSA, since it considers residual energy as one parameter for node status.

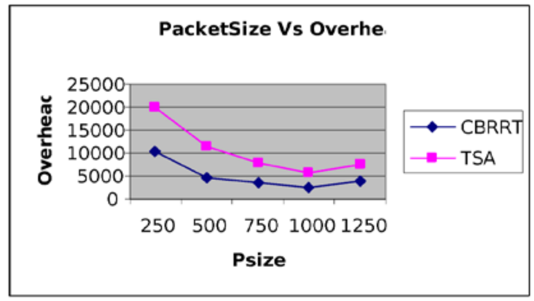

Fig 12: Packet Size Vs Overhead

The overhead occurred during the routing process is depicted in fig 12. When the packet size is increased, it results in reduced congestion and hence alternate routing will not be triggered often. So the overhead is decreasing linearly as shown in the fig. But CBRRT has significantly lower overhead when compared to TSA, since TSA stores the queue status all traffic classes.

5. CONCLUSION

In this paper, congestion detection and recovery technique is proposed in mobile ad hoc network. The congestion status of the nodes by using the parameters such as queue length, data rate, and medium access control (MAC) contention and it is compared with the upper and lower limit of these parameters and the node is congestion status that normal, medium or high level. When data is to be transmitted from the source to destination, the intermediate nodes along the path verify its congestion status. If the congestion status of any one node is high or congestion status of more than one node is medium, a warning message will be sent to the source. The source then selects the alternate congestion free path for data transmission. By using network simulator -2 results, it is estimated that the proposed congestion detection based route recovery technique minimizes the packet drop and delay while increasing the packet delivery ratio in presence of high traffic loads.

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REFERENCES

[1] Laxmi Shrivastava, G.S.Tomar and Sarita S. Bhadauria," A Survey on Congestion Adaptive Routing Protocols for Mobile Ad-Hoc Networks", *International Journal of Computer Theory and Engineering*, Vol. 3, No. 2, April 2011.

[2]K. Srinivas and A. A. Chari," ECDC: Energy Efficient Cross Layered Congestion Detection and Control Routing", *International Journal of Soft Computing and Engineering (IJSCE)* ISSN: 2231-2307, Volume-2, Issue-2, May 2012.

[3]T.Senthil kumaran and V.Sankaranarayanan," Early Congestion Detection and Optimal Control Routing in Manet", *European Journal of Scientific Research* ISSN 1450-216X Vol.63 No.1 (2011), pp. 15-31.

[4]Senthil Kumaran, T. and V. Sankaranarayanan," Congestion Free Routing in Adhoc Networks", *Journal of Computer Science* 8 (6): 971-977, 2012.

[5]Duc A. Tran and Harish Raghavendra," Routing with Congestion Awareness and Adaptively in Mobile Ad hoc Networks", 2005.

[6]Prof.K.Srinivas and Prof.A.A.Chari," Cross Layer Congestion Control in MANETs and Current State of Art", *International Journal of Computer Applications* (0975 – 8887) Volume 29– No.6, September 2011.

[7]Jaewon Kang Yanyong Zhang and Badri Nath," Accurate and Energy-efficient Congestion Level Measurement in Ad Hoc Networks", 2006.

[8]R. Bhuvaneshwari and P. Veena," Congestion Avoidance by Early Detection in Wireless Sensor Networks", *Bonfring International Journal of Research in Communication Engineering*, Vol. 2, Special Issue 1, Part 4, February 2012.

[9]Chieh-Yih Wan, Shane B. Eisenman and Andrew T. Campbell," CODA: Congestion Detection and Avoidance in Sensor Networks", 2006.

[10]Mr.S.A.Jain and Ms Aruna.A, Kadam," A Study of Congestion Control Mechanism Using Link Failure Detection in MANET", *International Journal of Engineering Research and Applications (IJERA)* ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 1, Jan-Feb 2012, pp.1009-1012.

[11]Xiaoqin Chen∗, Haley M. Jones *and* A .D .S. Jay lath," Congestion-Aware Routing Protocol for Mobile Ad Hoc Networks",2006.

[12]Consolee Mbarushimana and Ali Shahrabi," Congestion Avoidance Routing Protocol for Qos-Aware MANETs", 2008.

[13]Kazuya NISHIMURA and Kazuko TAKAHASHI," A Multi-Agent Routing Protocol with Congestion Control for MANET", 2006

[14]Devi M and V. Rhymend Uthariaraj "Fuzzy Based Route Recovery Technique for Mobile Ad hoc Networks", *European Journal of Scientific Research* ISSN 1450-216X Vol.83 No.1 (2012), pp.129-143

[15]Network Simulator: http:///www.isi.edu/nsnam/ns