CCE-OLMRP: Congestion and Contention Endurance Outflow Load-balancing Multicast Routing Protocol

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Abstract: In this paper we explain a congestion and contention endurance approach for OLMRP (Outflow Load Balancing Multicast Routing Protocol). The OLMRP, designed earlier, is a multicast routing protocol and the congestion endurance model we designed now is twofold, one dealing with congestion at Mac level and other is cross layered routing level model which enables congestion state tolerance by switching to a reserve path and using Mac level multicast routing with MALMR (Medium Access Level Multicast Routing) along with OLMRP, Multicast Mobile Ad hoc routing congestion is avoided and contention endurance state is achieved.

Keywords: multicast, on-demand routing, congestion control, ad hoc network, ODMRP, OLMRP, MGCA, MGOL, Mobile Ad Hoc Networks,, Quality of Service, Shortest Multiple Path Multicast Routing Topology

1. INTRODUCTION

As described in [2], [3], the primary function of a multicast protocol is to transfer packets from a source to the destination points of a multicast group with a desirable quality of service (QoS). QoS depends on the performance provided by the network in general [1]. Particularly, QoS in voice communications requires 1.To maintain a high packet delivery ratio (PDR), 2. Low Packet delay 3.Restricting the Jitter in packet arrival time to minimum. Thus, the aim in QoS provisioning is to Achieve a more deterministic network behavior termed as bounded delay, jitter, and PDR is a key factor for QoS provisioning [1]. The simple group communication algorithm called Flooding, though not ideal for multicast routing due to excessive use of available bandwidth, is enough to attain high PDR as long as the network is not congested due to high data traffic and/or node density. Thus, the secondary function of a multicast routing protocol is to utilize the bandwidth efficiently, which is directly proportional with the number of retransmissions required to deliver generated data packets to all members of a multicast group with a maximum PDR. The later focus of a multicast topology is to reduce the power dissipation of the network. Although cross-layer design which optimizes the performance of a wireless communication system is a better option, several researchers have argued that such cross-layer design is not the best choice in the long run as it loses modularity and could lead to unintended cross-layer interactions as described in [6] [19]. However, by stringently adhering to standard hierarchy, we could miss performance enhancements offered through exploitation of less restricted cross-layer design. Therefore, in this paper, we suggest a multicasting architecture that provides successful congestion control mechanism. Although there are several protocols for multicasting in mobile ad hoc networks [4], [5], [7], [8], [9], to the best of our vision, there is no such protocol which can handle congestion to improve QoS with a cross model for tree and mesh based architecture. Thus, in this paper, we suggest a distributed architecture multicast ad-hoc routing that handles the congestion with hierarchical outflow load balancing.

2. RELATED WORK:

In the research domain, ‘Congestion awareness and control in networks’ is a subject that attains reasonable attention. Xiaoqin Chen et al[2] describes congestion aware routing that handles congestion by selective metrics used to assess data-rate, MAC overhead and buffer delay, which helps to identify and deal the congestion contention in the network. Hongqiang Zhai et al[3]proposed a solution with an argument that congestion and severe medium contention is interrelated. Yung Yi et al[4]proposed a hop level congestion control approach. Tom Goff, Nael [5] explored a set of algorithms that initiates alternative path usage when the quality of a path in use becomes suspect. Xuyang et al[6] present a cross-layer hop-by-hop congestion control scheme designed to improve TCP performance in multi hop wireless networks. The impact of congestion on transport layer degrading the performance was described in [7]. Duc et al[8] argued that current designs for routing are not congestion adaptive.

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Depending on the research in [6] [5], a loss-event centered disconnection timer of ADMR is stated to be difficult when used as a mobility indicator, since it triggers a source node to initiate a time limited data flood into the congested networks. The authors specifically remarked the setbacks of Receiver join issues and ACK implosions of ADMR under high-density scenarios based on a static exhibition model. Both the issues are resolved by setting up a predefined minimum limit for Join, Repair, and Explicit ACK timers to allow data packets to be transmitted [5]. However, fixed timeout value is sensitive to the protocol performance since using a large value for the Repair Wait Time can degrade ADMR efficiency under high mobility networks while a large value of Ack Wait Time can result in low throughput and excessive pruning. Moreover, the solutions are scenario specific as they are designed for single-group based multicast where all receivers are one step away from the source and need to send explicit ACKs to maintain forwarding status. Although network congestion is the dominant reason for packet loss, very little effort is being made to address the issue from a routing perspective as shown in [8], [9] and [10]. In [8], the idea of exploiting congestion information in networks, a higher layer protocol is used for uni cast routing by focusing on enhancement of the dynamic source routing (DSR) protocol. This evaluation demonstrates comprehensive performance enhancement in terms of scalability, routing overhead and packet delivery ratio. A congestion-adaptive routing protocol (CRP) [10] is another unicast routing protocol using congestion information to maximize its effectiveness and efficiency. Based on a bypass routing concept, CRP provides better performance in terms of delay variation in intensely loaded networks as compared to other outstanding on demand unicast routing protocols.

Most of the existing models are targeted at determining congestion through packet loss. Frequent packet loss can impact disconnection in routing path. Hence, attempting to control packet loss that occurs due to link failure by controlling the outflow load balancing is an ineffective effort. By regularizing the egress at all nodes which take part in routing, is an expensive approach. In general it is possible to control the congestion at hop level [4][15]. Hence egress regularization at each node of the network would be an expensive in resource utilization. Here in this paper we argue that it is an essential requirement to identify the reason for packet loss. Hence, efforts need to be put in to establish the routing path again to solve link failure conditions. Furthermore, we also put forward the argument that hop level congestion control is not sufficient due to inability of hop level nodes to balance the outflow load to control the congestion and leftovers from resource usage would be same as those in source level egress regularization models. Hence, from our earlier work, we propose a Multicast ad hoc routing that controls the congestion through stratified egress tuning approach that referred as Hierarchical Outflow Load-balancing multicast routing protocol shown in [16]. As OLMRP model is aimed to control congestion, it was built on packet transmission strategy at MAC layer called Group Level Multicast (GLM) packet transmission. Previously, we had proposed MAC level routing strategy, which is a Medium Access Level Multicast Routing protocol that tolerates congestion and contention at MAC level. From the knowledge of experiments and qualitative analysis carried out previously, we propose a novel congestion and contention endurance strategy for OLMRP.

3. CONGESTION AND CONTENTION ENDURANCE OUTFLOW LOAD-BALANCING MULTICAST ROUTING PROTOCOL

3.1 Congestion Control Strategy in OLMRP

A hierarchical order is used to handle the congestion state as follows

- The Status of congestion within Multicast Group
- The status of congestion between Multicast Groups

This helps in minimizing of source level outflow regulation cost and balances the power consumption.

i. Network and Node activities under proposed protocol:

The network is to be split into Multicast groups with respect to nodes participating in multicast such that multicast nodes as multicast group heads

For each multicast group i where $i = 1..|MG|$; ($|MG|$ is the total number of multicast groups)

Find transmission load threshold ζ_n for each multicast group i

By using ζ_n of each multicast group Transmission load threshold for entire network can be measured .

ii. Information sharing within Multicast Group [between Node and multicast group head]

Each node n that belongs to multicast group MG_i verifies the outflow load and shares degree of outflow load $d(ol)_n$ with multicast group head. Once $nd(ol)_k$ received from each node k of the multicast group MG_i, the multicast group head $MG_i(h)$ calculates the degree of outflow load $mgd(ol)_{MG_i}$ at Multicast Group MG_i.

$$mgd(ol)_{MG_i} = \frac{\sum_{k=1}^{|MG_i|} nd(ol)_k}{|MG_i|}$$

iii. *Multicast Group Congestion Assessment(MGCA) Algorithm*

Multicast Group congestion assessment (MGCA) algorithm is presented in this section. MGCA helps in locating the state of packet dropping due to congestion. This evaluation occurs under Mac layer. The algorithm MGCA follows

Algorithm:

```
At an event of inflow loads at node $i$ :
Updating Inflow load:
$if\ ((\gamma_t - \gamma_T) < 0) do$
    $\sigma' := 0.5 \times \left( \frac{il_{cr} - il_{\gamma_T}}{\gamma_t} \right) + 0.5 \times (\sigma')$
    $il_{\gamma_T} := il_{cr} \left( \frac{\gamma_t}{\gamma_T} \right) + il_{\gamma T} \left( \frac{\gamma_T - \gamma_t}{\gamma_T} \right)$
$endif$
$if\ ((\gamma_t - \gamma_T) \geq 0) do$
    $\sigma' := \frac{il_{cr} - il_{\gamma_T}}{\gamma_t}$
    $il_{\gamma_T} := il_{cr}$
$endif$
```

Here in the above conditional statement

γ_t :Time between last two transmissions of hop level connected nodes in routing path

γ_T : Time between two transmissions of hop level connected nodes in routing path

σ' : Average slop threshold of the inflow load

il_{cr} : Current inflow load ratio

il_{γ_T} : Average inflow load threshold observed for predefined interval γ_T

il_{cr} : Current inflow load ratio

il_r : Inflow load ratio

il_{ce} : Expected inflow load threshold at current interval

Detecting packet drop at the Mac layer level:

```
$il_{ce} = il_{\gamma_T} + \sigma' \gamma_{et}$
$if\ (il_{ce} < il_r) do$
    $packet$ loss due to $link\ failure$
$else$
    $packet$ loss due to $congestion$
$endif$
```

Multicast Group Outflow Load-balancing (MGOL) Algorithm

If congestion is found at node i in routing path, MGOL is initiated. On receiving congestion alerts from Mac layer, the routing protocol initiates MGOL. If node i affected by congestion, MGOL alerts node s as it is the node that transmits data to hop level node i. Upon receiving alerts about the congestion at hop level target node i, s evaluates '$nd(ol)_s > mgd(ol)_{MG_c}$', and if found true, verifies if $(nd(ol)_s - mgd(ol)_{MG_c})$ is greater than or equal to ε_s is true or not. If true, the node s balances its outflow load so that $nd(ol)_s$ is not less than $mgd(ol)_{MG_c}$

Here in the above description ε_s is outflow threshold at node s, MG_c is the current multicast group as $s \in MG_c$

The node s balances its outflow load by increasing packet so that $nd(ol)_s$ is greater or equal to $mgd(ol)_{MG_c} + \varepsilon_{MG_c}$

$$\varepsilon_{MG_c} = \frac{\sum_{k=1}^{|MG_c|} mgd(ol)_{MG_c} - nd(ol)_k \{k \in MG_c \text{ and k is a node}\}}{|MG_c|}$$

If '$(nd(ol)_s \leq mgd(ol)_{MG_c}) or\ ((nd(ol)_s - mgd(ol)_{MG_c}) < \varepsilon_s)$' node s avoids balancing the outflow load and alerts the $MG_c(h)$ (multicast group head of the MG_c, $s \in MG_c$). Then $MG_c(h)$ alerts all connected unicast nodes to the node s of the group MG_c. Upon receiving alerts from $MG_c(h)$ all connected unicasting nodes attempt to balance their outflow to that of node s and updates their '$nd(ol)$'. As unicasting node updates its '$nd(ol)$' and alerts $MG_c(h)$, the $MG_c(h)$ estimates $mgd(ol)_{MG_c}$ and checks the same with $d(ol)$ as follows

$mgd(ol)_{MG_c} \geq d(ol) + \bar{\varepsilon}$ is true or not.

Here in this equation $d(ol)$ the routing path level degree of outflow load and $\bar{\varepsilon}$ is outflow load threshold is measured at path level.

If given conditions are true, MGOL process ends and if not true, $MG_c(h)$ alerts $MG_p(h)$ and MGOL is initiated at multicast group MG_p, which is an adjacent upstream multicast group to MG_c. The MGOL process at MG_p is as follows:

Upon receiving the alert from $MG_c(h)$, the $MG_p(h)$ alerts all connected unicasting nodes of node 's', which belongs to multicast group 'MG_p'. Then upstream unicasting nodes of the group 'MG_p', which are upstream nodes connected to node s balance their outflow load and define $nd(ol)$ and inform the same to $MG_p(h)$. Later, $MG_p(h)$ measures $mgd(ol)_{MG_p}$ and verifies it as follows:

$$mgd(ol)_{MG_p} \ge d(ol) + \bar{\varepsilon}$$

If above equation is true, MGOL process ends at MG_p, and if not, continues to next multicast group in the upstream level of **the** MG_p

This process continues till victim node i is free from congestion or if MGOL is applied at all upstream multicast groups of the 'MG_c'.

The above process is described as an attempt to avoid the congestion by balancing the outflow load between multicast groups and can be referred as **M**ulticast Group level **O**utflow **L**oad-balancing (MGOL).

Once the MGOL ends, the source multicast group evaluates the $d(ol)$.Based on this '$d(ol)$' value, the transmission source node balances its outflow load.

Multicast Group Outflow Load-balancing (MGOL) Algorithm

P1:

$$\varepsilon_{MG_C} = \frac{\sum_{k=1}^{|MG_C|} mgd(ol)_{MG_C} - d(ol)_k}{|MG_C|}$$

If $nd(ol)_S > mgd(ol)_{MG_C}$ and $nd(ol)_S - mgd(ol)_{MG_C} \ge \varepsilon_{MG_C}$ begin

$$D_t(s) = D_t(s) + bt$$

Here $D_t(s)$ *is delay time at the node* s

bt *is buffering time threshold*

Value of buffering time threshold bt *should be decided such that* $d(ol)_S \ge mgd(ol)_{MG_C} + \varepsilon_{MG_C}$

Return.
Endif

P2:

Node s alerts multicast group head $MG_c(h)$ about the congestion state of the node i.

$MG_c(h)$ Alerts all upstream unicasting nodes to node s nodes, which belongs to multicast group MG_c

Each node of $\{n_{u1}, n_{u2}, \ldots, n_{uk}\}_{MG_C}$ updates their '$ndol$' and alerts about the same to $MG_C(h)$

$MG_c(h)$ Measures $mgd(ol)_{MG_C}$ by the subsequent equation:

$$mgd(ol)_{MG_C} = \frac{\sum_{k=1}^{|MG_C|} nd(ol)_k}{|MG_C|}$$

If $mgd(ol)_{MG_C} > dol$ and $(mgd(ol)_{MG_C} - dol) \ge \bar{\varepsilon}$ begin

Alert: The victim node i is freed from congestion state

Return.
Endif

P3: $MG_c(h)$ Alerts $MG_p(h)$

$MG_p(h)$ Alerts all unicasting upstream nodes to node s, which are belongs to multicast group MG_p

For each upstream unicasting node $\{n \mid n \in MG_p\}$ begin

If $nd(ol)_n > mgd(ol)_{MG_p}$ and $nd(ol)_n - mgd(ol)_{Mg_p} \ge \varepsilon_{MG_p}$ begin

$$d_t(n) = d_t(n) + bt$$

The Value of buffer threshold bt *should be decided such that* $nd(ol)_n \ge mgd(ol)_{MG_p} + \varepsilon_{MG_p}$

Endif

Find $nd(ol)_n$ *and send the same to* $MG_p(h)$

End-of-for each

Then $MG_p(h)$ measures $mgd(ol)_{MG_p}$

if $mgd(ol)_{MG_p} - d(ol) \ge \bar{\varepsilon}$ and $\bar{\varepsilon} > 0$

Alert: Balancing Outflow load at multicast group MG_p removed congestion state at node i.

Return;
Endif

For each upstream multicast group in sequence
Begin

Consider MG_p as MG_c

Consider immediate upstream multicast group $MG_{p'}$ to multicast group MG_p as MG_p

```
Go to P1
End-of-foreach
$\{MG_1 \mid \text{transmissioninitiation node is src and src} \in MG_1\}$
```

Measures $d(ol)$ as

$$d(ol) = \frac{\sum_{i=1}^{|MG|} mgd(ol)_{MG_i}}{|MG|}$$

The transmission initiated node 'src' that belongs to multicast group 'MG_1', balances the outflow load such that congestion state will be avoided.

3.2 Routing path Level Congestion Endurance in OLMRP

We also alter the actual proactive approach of the OLMRP for route discovery. The source node n_s finds the path to the destination node n_d in a broadcasting manner. The broadcasted route requests $rreq$ packet to carry the relay node information to all the nodes in routing path. During the transmission of the route request from $rreq$ packets, the transport layer identifies the overhearing nodes of each relay node and updates application layer which then will be carried by route request $rreq$. Once the destination node receives the route request $rreq$ it prepares a route response $rrep$ packet which contains a list of relay nodes and their over hearing nodes. Upon receiving a route response packet, each relay node updates its routing table with successor and predecessor node information and the list of overhearing nodes of that node and successor node in the routing path. Once the route response $rrep$ packet is received by source node n_s, optimal path is selected. Later, the source node n_s sends relay node identity acknowledgement $ack(pn)_i$ to each relay node pn_i of opted routing path. On receiving relay node identity acknowledgement $ack(pn)_i$, relay node pn_i attempts to identify optimal paths between relay node pn_i and two hop level successor relay node pn_{i+2}, in this phase relay node pn_i sends a route request $rreq$ to pn_{i+2}. This route request $rreq$ broadcasts only through overhearing nodes of the relay node pn_i and relay node pn_{i+1}. On receiving the route request from pn_i, pn_{i+2} prepares route response $rrep$ and transmits to pn_i via the path opted by $rreq$. Hence upon receiving route response $rrep$, pn_i selects an optimal path between relay nodes pn_i and pn_{i+2} ,finally stores in the routing table. The selected optimal path will be used for path restoration between nodes pn_i and pn_{i+2}, if congestion found at pn_{i+1} and if unable to control, path restoration occurs between pn_i and pn_{i+2}.

i. The Route Discovery for congestion endurance in OLMRP

1. n_s Prepares $rreq$ and broadcast it to neighbor nodes
2. Upon receiving $rreq_i$ a hop level node n_i verifies that rebroadcasting of $rreq_i$ already done by itself or not.
3. If rebroadcasting done already then discards the $rreq_i$, if not n_i collects details of overhearing nodes from the transport layer and adds its identity and details of its overhearing nodes to '$rreq_i$', then rebroadcasts . This process is recursive till $rreq$ received by the destination node n_d .
4. Then destination node n_d prepares a route response packet $rrep_i$ that contains the details of the nodes exist in the path, through which the route request $rreq_i$ traversed to reach n_d and their over hearing nodes. The route response packet $rrep_i$ transmits back to the source node n_s through the path opted by route request packet $rreq_i$.
5. Each intermediate node pn_i of the path that used route response packet $rrep_i$ collects details about its predecessor node pn_{i-1} in the routing path, successor node pn_{i+1} and overhearing nodes of current relay node pn_i and successor relay node pn_{i+1}
6. Relay node pn_i updates its routing table with the details obtained in the previous step.
7. The steps 6 and 7 recurrent till response packet received by the source node n_s
8. Source node n_s finds the optimal path that contains cells with dense with nodes.
9. For each relay node 1 to 'n' of the path selected, n_s sends $ack(pn)_i$ for $i = 1..n$.
10. Upon receiving $ack(pn)_i$, pn_i start finding alternative path between pn_i and pn_{i+2}, such that the alternative path must use only overhearing nodes of the 'pn_i' and 'pn_{i+1}'.

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11. $pn_i$ Then stores alternative path between $pn_i$ and $pn_{i+2}$ at routing cache.
12. The steps 3 to 11 are applied to multiple destinations of the multicast rout discovery of OLMRP.
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3.3 Congestion and Contention Endurance at Medium Access Level in OLMRP

OLMRP utilizes MALMR as the underlying MAC layer, which intern used as underlying MAC protocol for multicast to achieve congestion endurance. Since Multicast packets are dispatched blindly in OLMRP, there is probability of packet lost due to channel congestion or receive-buffer excess flow. But retransmission does not occur to the lost packets in OLMRP. However by using MALMR, even in network congestion delivery of packets having multicast is ensured. MALMR effectively manages the congestion by adapting "first sequence ordered" to cast the packet to all target nodes in broadcast manner.

i. MALMR Algorithm[17]

Description of the notations

I. nm ←Node participating in multicasting
II. nu ←Node participating in one of the unicasting path of nm
III. TNL ←Target Node List
IV. bp_{nm} ←Buffer of Packets to multicast at nm
V. FS_{nm} ← Buffer of Frames already sent by nm
VI. FR_{tn} ←Buffer of frames received by target node tn that listed in TNL
VII. cs ← Boolean flag

Input:

TNL, bp_{nm}, $cs \leftarrow true$

Algorithm:

```
1. Begin
2. Fetch $\{tn_i \mid tn_i \in TNL\}$ that fetched in ordered first manner for $i = 1....|TNL|$
3.   Fetch sequence numbers range $fo,....fl$ of the frames such that $fj \in FS$ for each $j = 0,...l$
4.   If $bp_{nm}$ is not empty
5.   Begin
6.     Set $cs \leftarrow false$
7.     Pick next sequence number $sn$ of the packet to be multicast.
8.     Send sequence numbers range $\{fo,...fl,sn\}$ to $tn_i$ and wait for response from $tn_i$
9.     Receive the sequence number $rsn$ of the frame from $tn_i$
10.    If $rsn \cong sn$
11.    Begin
12.      Multicast new packet from $bp_{nm}$ and wait for acknowledgement from $tn_i$
13.    End of block Started at line 3
14.    Else if $rsn \in \{f0,...fl\}$
15.    Begin
16.      Multicast cached frames of range $\{rsn,....fl\}$ in a sequence. And then multicast new data packet from $bp_{nm}$ with sequence number $sn$
17.    End of block Started at line 4
18. End of block Started at line 2
19.   Else if $bp_{nm}$ is empty and $cs \neq true$
20.   Begin
21.     Set $cs \leftarrow true$
22.     Fetch $\{tn_k \mid tn_k \in TNL\}$ that fetched in ordered first manner for $k = i....|TNL|$
23.     Begin
24.       Fetch sequence numbers range $fo,....fl$ of the frames such that $fj \in FS$ for each $j = 0,...l$
25.       Send sequence numbers range $\{fo,...fl\}$ to $tn_k$ and wait for response from $tn_k$
26.       Receive the sequence number $rsn$ of the frame from $tn_k$
27.       If $rsn \in \{fo....fl\}$
28.       Begin
29.         Multicast cached frames of range $\{rsn,....fl\}$ in a sequence.
30.       End of block Started at line 7
31.     End of block Started at line 6
32.     Set $i \leftarrow k$
33.   End of block Started at line 5
34.   Else if $bp_{nm}$ is empty
35.   Halt a time interval $ti$ and go to step 1
36. End of block Started at line 1
```

In step 12, 16 and 29 all nodes of list TNL also receives those frames and according their respective FR status they update FR, that is if the nodes not found that frame in their respective FR then updates otherwise discards.

In step 12 and 16, if acknowledgement received from target node tn_i then the node nm updates it's FS_{nm} by adding new sequence number to FS_{nm}

4. SIMULATIONS AND RESULTS DISCUSSION

In this section we gaze at the simulations led by using Ns-2 simulator [16]. We accomplished performance assessment using ns-2 with considerations described in table 1.

No of Hops:	225
Approximate Hop distance	300 meters
Approximate total network	1000X1000 meters
Approximate Cell Radious	100X100 meters
Physical channel bandwidth	2mbps
Mac Layer:	802.11 DCF with the option of handshaking prier to data transferring
Physical layer representation	802:11B
Performance Index	Outlet directive cost and end-to-end throughput
Max simulation time	150 sec

Table 1: parameters used in NS-2 for performance analysis

We performed simulations on three different routes, that are varied in length as the number of hops.

Paths and their lengths are

1. A path that contains 15 nodes
2. A path contains 40 nodes
3. A path that contains 81 nodes

All the three paths are loaded equally with a standard interval of 10 sec. Loads given in bytes can be seen in Fig 1. The Fig 2furnish the throughput observed for the proposed CCE-OLMRP. The congestion control cost observed for CCE-OLMRP is in Fig 3.

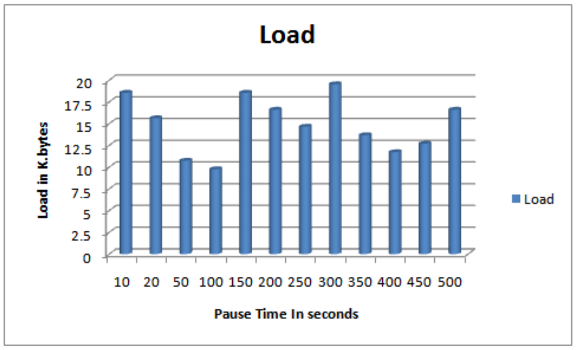

Fig 1: Data size in k.bytes is sent to destination node from the source node

The procedure of measuring jamming control fallows:

Based on available resources, bandwidth and liveliness for individual transaction threshold value between 0 and 1 is assigned. In the process of congestion evaluation and control, total cost is measured by adding the cost of each event involved. Fig 8 represents comparison between congestion cost for CRT and congestion and contention control model [15].

$$ccc = \sum_{e=1}^{E} ct_e$$

If ccc is the cost of a congestion control, E is the total number of events involved. ct_e is cost of an event e. The event examples are the "cost of communication between Mac, physical and application layers ", "alert from Mac to victim source node", "outlet cost of the participating groups", and "packet inlet estimation and packet outlet directive".

The packet delivery fraction (PDF) can be expressed as:

$$P' = \sum_{f=1}^{e} \frac{R_f}{N_f}$$

$$P = \frac{1}{c} * P'$$

- P is the fraction of successfully delivered packets,
- c is the total number of flow or connections,
- f is the unique flow id serving as index,
- R_f is the count of packets received from flow f
- N_f is the count of packets transmitted to flow f.

The fig 2 indicates the advantage of CCE-OLMRP over OLMRP [16], because of path restoration strategy introduced under congestion tolerance activity. Figure 3 to 6 reveals the advantage of the CCE-OLMRP over ODMRP, identical to the performance of OLMRP [16]. The figure 6 indicates the advantage of CCE-OLMRP over OLMRP in terms of Packet delivery fraction achieved due to root discovery strategy which is introduced under the concept of path restoration for congestion and link failure tolerance.

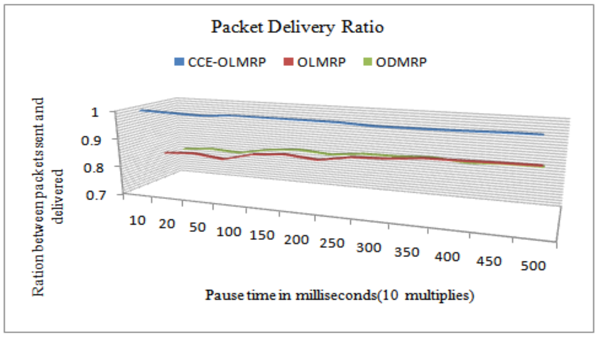

Fig 2: PDR advantage of CCE-OLMRP over OLMRP and cross layer ODMRP

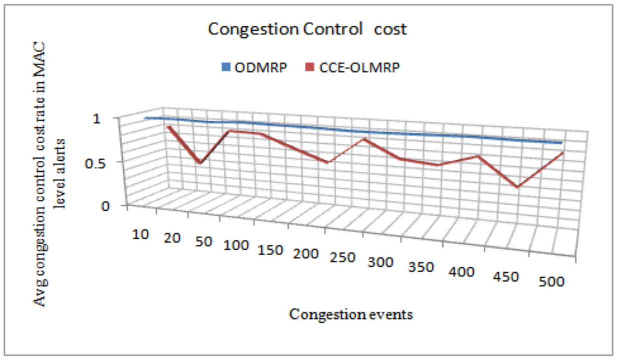

Fig 3: The advantage of CCE-OLMRP to minimize the control congestion cost over ODMRP

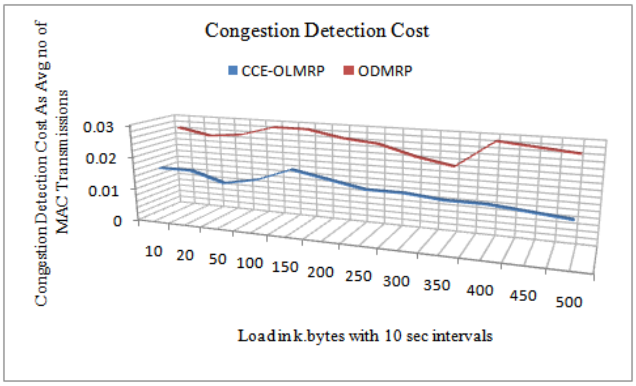

Fig 4: The advantage of CCE-OLMRP to minimize the cost for detecting congestion over ODMRP

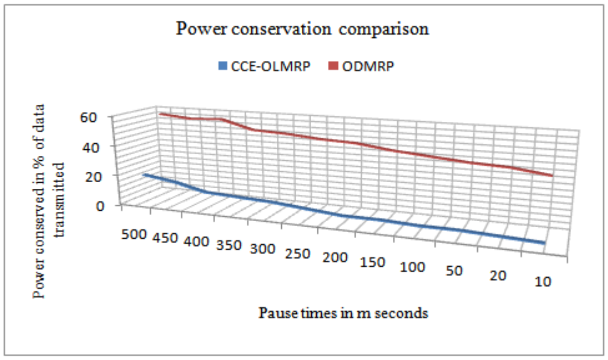

Fig 5: The Advantage of CCE-OLMRP over CRT in power conservation for data transmission

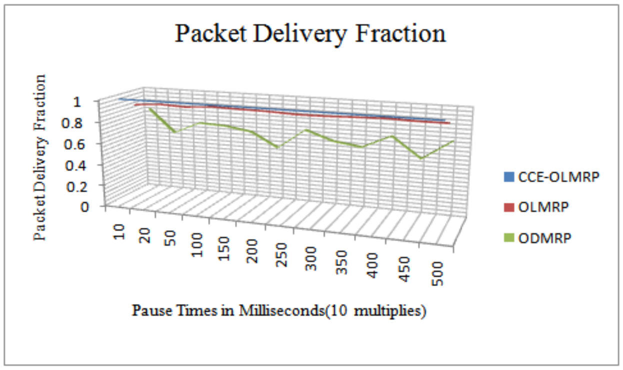

Fig 6: Packet Delivery Fraction advantage of CCE-OLMRP with congestion tolerance strategy over OLMRP.

5. CONCLUSION:

In multicast mobile ad hoc networks, jamming is a common issue. Because of shared wireless channel and dynamic topology packet transmissions experience noise and network drop frequently. In multicast mobile ad hoc network, output through a given route depends on the bare minimum data rate of its total links. A route of links with different data rates, has a potential of congestion if, a higher data rate node passes more traffic to a lower data rate node and leads to long queue and delays on such routes. The conventional hop count routing does not adapt well to mobile nodes. The transmission capability, reliability and congestion around a link are included in a congestion-aware routing for mobile ad hoc networks. Numerous solutions are mentioned in writing along with our proposed models MALMR[17] and OLMRP [16] to handle congestion situations. If overwhelming congestion happens under extreme circumstances, no routing topology can handle the congestion. Therefore, in this chapter we put forth a proposal for a Congestion and Contention Endurance Outflow Load-balancing Multicast Routing Protocol for congestion control and manage mobile ad hoc networks. This model is an extension of OLMRP and is referred as CCE-

OLMRP. A path restoration strategy is used to manage the congestion.

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