Load-Aware Congestion Adaptive Multipath Multicasting

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Abstract

In recent years, all communication system becomes wireless due to vast development and advancements in wireless technology. Such network offers a platform to deploy a wide range of multimedia and other services with different data types. In mobile ad hoc networks one of the most prominent factors which affect the overall performance of the network is congestion. Congestion is one of the most misinterpreted concepts in the context of the wireless network. In general, excessive data traffic in the network referred to as congestion. However, in the wireless network, the congestion occurs due to unavailability of resources such as insufficient bandwidth, low battery power, and so on which leads to high packet losses, bandwidth reduction, and wastage of energy and time in recovering congestion. In addition to this, another factor which degrades the performance is improper load balancing due to certain routing metrics limitation. From the literature, it is observed that many of the existing solutions handle the above problems separately in a not-adaptive manner. However, addressing these issues together in an adaptive manner provides an effective solution to balance the load in the network as well as congestion. The proposed work addresses congestion and load balancing problems parallel with the aim to improve and enhance the overall network performance and lifetime. The proposed Load Aware Congestion Adaptive Multipath Multicast (LACAMM) routing approach adapt to current changes in the load and congestion level to find a suitable path even in the case of congestion scenario and node resource constraints. The proposed scheme measures the node resources such as residual bandwidth and the residual battery to predict the node stability. Redirects the data transmission under congested scenario from the congested node through the non-congested alternate path thereby improves the overall network performance. This work performs well under burst traffic with the harsh environment.

Keywords Multicasting, Congestion, Multipath, Adaptive routing

1 Introduction

A mobile ad hoc wireless network consists of a set of wireless mobile nodes shaped dynamically with none central administration or existing network infrastructure[1]. Every node in this network will act as a host and additionally as a router and contains a capability to move freely and at random in a direction at any speed. Owing to limitation of mobile nodes transmission varies the packets are forwarded to the destination during a multi-hop fashion with the assistance of intermediate nodes. One among the key problems in multihop mobile ad hoc network is congestion. The crucial factors that influence congestion throughout multi-hop relay are shared restricted wireless information measure, low device power, dynamically ever-changing configuration, and so on[2,3]. Congestion will cause packet loss, degradation of information measure, waste of resources on congestion recovery. It's troublesome to beat congestion problem however it's potential that the congestion is often avoided by adapting bound appropriate mechanism and rules for the flow. Normally routing algorithms in MANETs are generally classified into proactive and reactive routing. In proactive routing, the routes are established as like wired network approach and are updated either sporadically or on a progressive update fashion. This approach isn't appropriate once the network is just too massive and, therefore, the nodes are extremely mobile. In reactive routing, the routes are created as and once required and is a lot of economical than the proactive routing approach[4-7]. However, the matter is that the reactive routing protocol creates high management overhead just in case of frequent path breaks. This drawback is self-addressed by use of multipath routing approach. The routing protocols in MANETs are often classified in our own way as congestion-aware routing and congestion adaptive routing. Several existing solutions belong to congestion aware approach solely only a few are congestion adaptive. In congestion aware approach the congestion is taken into thought solely throughout route discovery and maintains a similar standing till the trail breaks. However in congestion adaptive routing the routes are adaptive to the present congestion standing of the network. Congestion non-adaptiveness can cause the following[8-9]:

Long delay: Congestion-aware routing takes long-standing to observe congestion. Upon congestion, it's quite essential to use a brand new route. But, the matter with congestion aware on demand routing protocol is that it takes long-standing to search out a much better non-engorged route this ends up in high delay.

High overhead: Upon congestion invoking re-route discovery involves with flooding of control packets to search out a brand new route to forward the information. The flooding of control packets creates high control overhead that degrades the performance of the network.

Many Packet Losses: As mentioned congestion could happen to any node at any time as a result of lack of resources that ends up in several packet losses. A typical congestion control try and scale back the traffic load, either by decreasing the rate at the sender or dropping packets at the intermediate nodes or doing each.

These problems become additional visible throughout transmission of enormous multimedia system applications during a large mobile accidental network and supply a negative impact on the network performance still as within the quality of service.

1.1 Congestion

Congestion may be a drawback that happens on shared networks, once multiple users access to constant resources (bandwidth, buffers, and queues). Once numbers of packets are present in a network is larger than the capacity of the network then this case is termed as congestion[10]. Congestion in a network could occur once the load on the network i.e. the amount of packets sent to the network is bigger than the capacity of network[6,11].

1.1.1 Congestion Control

Congestion control mechanism is performed once the network faces congestion. Congestion control mechanism sometimes enhances network overall performance based on the load condition of the network. The congestion control mechanism is completed through controlling the sending rate of information streams of every source and conjointly results in high utilization of the offered bandwidth. The most objective of congestion control is to attenuate the delay and buffer overflow caused by network congestion and, therefore, alter the network to perform higher. As congestion is directly associated with the problem of dropping the packet, it's needed that some technique is applied on the network so the drop of the packet can decrease. However to regulate on the quantity of dropping rate is tougher in MANETs as compared to the wired network due to the following characteristics [7,12-13].

A. Dynamic Topology

As in MANET, there's no central point or base station, to regulate the entire network. Each device will move freely in MANET, therefore, the topology of the network isn't mounted. Thus, it can't be expected whether or not a node that participates throughout some transmission can collaborate in the whole transmission or not[14]. A node will move any time instance thus a path detected by the source node to transfer its information will be a break at any time. If no path is found by the intermediate node to forward the information it'll begin to drop the packet once a while.

B. Multi-Hop Routing

Each node in MANET will receive and forward the data towards the destination nodes. However node forwarding capacity is restricted to its transmission range; it suggests that it will deliver the data packets to solely that node that come beneath its transmission range. If any 2 nodes that not come back beneath the transmission range of each other than the forwarding node depends on intermediate nodes to relay data in a multi-hop fashion[10, 12]. A route has been detected by a routing protocol then sender begins to transfer the data to a node that comes beneath its transmission range this node referred to as an intermediate node, every intermediate node further transmitted data to its neighbor node and this process is repeated till information reach to the destination. Arrival rate of packets at this specific node are often larger than its forwarding capacity so this node begins to drop the packet.

C. Heterogeneous Environment

In MANET, any device will participate if it's able to forward the data. These participating devices are totally different of various kind having a different storage capability and different resource. The transmission rate of every device could stay completely different. In MANET addition of recent device is extremely simple if it comes beneath the transmission range of different node it becomes the part of that network. Thus, it should be possible that a brand new device comes back and begin to transmit its own data on the route that is already detected by a different node. All devices taking part in communication are of various kinds and will become unavailable at any time that makes the period of communication not so long[5,15]. In such kind of condition, packets are dropped by the precursor node. Sometimes a particular node becomes the intermediate node between several nodes. A scenario will arise at this node that several of its neighbor nodes forward the data to that the same time, thus there'll be an excessive quantity of packets inward at these intermediate node. If the arrival rate of data on the nodes is bigger from its transmission rate node can begin to drop the packets.

D. Density of Node

The number of neighbor nodes of every node might also the reason in MANET, as a result of if a node cannot deliver the data on to the receiver node then use another intermediate node to forward the data packet. In MANET for every node, a lot of neighbor nodes mean a lot of link connections between the nodes and their neighbors. Itll become the rationale of a lot of arrival rate of packets at a specific node, therefore, a lot of neighbor node of any intermediate node become the rationale of coming significant load as compared to the node reception capacity. In such kind of condition, a node can begin to drop the packet[13,16].

E. Presence of Malicious Node

Reliability of the node is going to decrease as a result of the presence of malicious packet dropper node. In MANET participating devices have restricted resource sometimes routing protocol select the path within which packet dropper node work as an intermediate node. A Packet dropped node is self-seeking nodes that really not forward the data packets to next node however in place of this it simply drops the packet to save lots of the resources[3,17]. The presence of packet dropper node could be a severe downside in MANET and that they don't seem to be the sole reason for the massive delay, however additionally become the reason of heavy traffic load on the network because the sender might become involved in causing packets again and again if no acknowledgment is received from the receiver.

F. Absence of Physical Protection

In MANET it's impossible to guard a node type numerous kinds of threats because the node position isn't fixed, a node will move in any direction within the network[18]. The nodes will be attacked from any direction wherever fixed physical protection like firewall and gateways can't be applied. It means that for securing itself a node should be equipped to fulfill an offender directly or indirectly. However because of the absence of physical protection like in hard wired network, there's a lot of likelihood for a node to become unreliable, and begin to drop the packet.

1.1.2 Congestion Prevention

It is the mechanism to handle the network from congestion that involves play before network faces congestion. For this purpose nodes got to monitor their status and that they negotiate with the neighbor node within the network so no a lot of traffic than the required amount, the node will handle, are allowed to return to the network so no congestion can occur. Congestion affects the performance of the network. Therefore, some necessary congestion control technique is needed to stop the network from the congestion. Prevention from congestion in MANETs is far difficult as compared to wired networks because of its specific characteristics. The subsequent are a number of the most QoS provisioning and maintenance issues in MANETs[19].

A. Stable Route

To prevent the network from the congestion it's better to decide on a reliable path. For this purpose route are going to be analyzed so a perfect error free totally coverage path with high transmission delivery ratio is select. It needs data of the nodes which can be remain offered all the time, however because of the dynamic environment of MANET choice of such node isn't possible.

B. Reservation of Bandwidth

Bandwidth reservation is a technique to stop the network from congestion, during which nodes reserve bandwidth for future communication through negotiation between the neighbors nodes which come back among 2 to 3 hops. It needs communication, and exchanges of a message between them because the channel is shared between the nodes. In MANET environment, a node will moves from the reservation space of the node at any time even communication goes on. Thus, reservation of bandwidth means that additional overhead for communication and releasing messages. Therefore, bandwidth reservation isn't attainable in MANET.

C. Service Level Agreement (SLA)

In MANET, every participating node works as a host and as a router. Any node isn't responsible for performing some specific task. Since all the nodes within the network work to produce services, there's no clear definition of a Service Level Agreement (SLA). Whereas in, an infrastructure network the services to the users within the network are provisioned by one or additional service providers. Thus, estimation of the node behavior isn't possible that is needed for prevention from the congestion.

D. Channel Reliability

Since the wireless bandwidth and capacity in MANETs are suffering from interference, noise and multi-path attenuation, the channel isn't reliable. Moreover, the offered bandwidth at a node can't be estimated precisely as a result of it involves large variations based on the quality of the node and other wireless device transmission within the neighborhood etc.

E. Routing Difficulty

Routing is troublesome in MANET because link breakage occurs overtimes. Once any link of a path breaks, it got to find the other offered link or replaced with a new found path. This rerouting operation costs the scarce radio resource and battery power whereas rerouting additionally increase delay that additionally have an effect on quality of service of applications and degrade the network performance. Thus, the routing operation has got to take care of such variety of challenge that is tough to handle.

2 Previous Work

There are many congestion algorithms are proposed for mobile ad hoc networks some of them are explained below.

In [19] developed a method for detecting congestion well in advance in order to prevent the network from the congestion. Their work is based upon the calculation of approximate queue length in advance. For this purpose, they calculate the average queue length at the node level. Network characteristics like congestion and route failure need to be monitored and resolved with a reliable mechanism. To solve the congestion problem, a novel dynamic congestion estimation technique has proposed that could analyze the traffic fluctuation. By the assessment of average queue length, a node is able to find that there is some probability of congestion so it sends a warning message to its neighbors. Upon receiving the warning message they try to search some alternative congestion free path to the destination and resumes communication through an alternate path. So this dynamic congestion estimation procedure tries to provide a reliable communication within the MANETs by controlling upon the congestion in ad hoc networks.

In [20] a new technique to detect the packet dropper nodes in the network by using a reliability factor. In MANET each node has limited resources like limited battery power, a packet dropper node is that node in the network which may not cooperate properly in network operations as they not forward the coming data packets to the next node but instead of this they drop the data packet to save their resources. Such nodes are called selfish or misbehaving nodes and these nodes are also the reason of congestion. The dropping of data packet not only affects the network connectivity but also can widely waste the network resources. To handle this situation a scheme based on MAC-layer acknowledgments is used to detect the packet dropper nodes. To eliminate such nodes from the network its reliability is evaluated during the packet transformation. In this work the field of reliability factor is increased on the basis of acknowledgment received from the receiver, and all senders making the decision to send a packet to a node having higher reliability factor. The reliability factor identifies the packet dropper nodes based on the acknowledgment. Hence, on the basis of node reliability factor, a packet dropper node can be detected and also can be isolated from the network.

In [21], proposed congestion-aware routing (CARM) to adapt to the congestion. The high throughput non-congested routes to any node in the network are selected based on the weighted channel delay (WCD) value. Second, the proposed work adapts mismatched data-rate routes using effective link data-rate categories (ELDC). In general, the protocol tackles congestion by switching between the above-said approaches to compact congestion in the network and efficiently increases the overall network performance.

A method for reliability analysis for MANET is presented by Sreedhar and Damodaram[22]. They proposed that the node performance is also influenced by the number of neighbor nodes of that node. In their work effect of node mobility and reliability in a real MANET platform is proposed and analyzed. They proved that the wireless network has limited capacity, and the throughput of the wireless network granted to each user can be decreased to zero if the number of users increased. As the transmission capacity of the wireless network affect the throughput and it will affect the terminal reliability of MANET. Congestion means the arrival of an excessive amount of packets at a network which leads to many packet drops. A node can communicate with many nodes which are its neighbor nodes. As they come under the communication range of that node then there will always the chance that at the same time many neighbor nodes send their data packets to the same node, so there will be an excessive amount of packets arriving at these nodes become the reason of packets drop. Hence, congestion is related to the density of the node in some area, and it will influence the terminal reliability by reducing the intermediate node reliability. This work focuses on upon identifying the relationship between the number of link connections and the node reliability to reduce the congestion problem.

Type of Service Aware routing protocol (TSA) proposed in [23] is an improvement to AODV. This approach uses only a hop count as a metric for route selection. TSA is a cross-layer congestion-avoidance routing protocol in which the routes are used for extended periods of delay sensitive traffic. Avoiding busy nodes alleviates congestion, leads to fewer packets drop and in a short end-to-end delay. In addition, TSA distributes the load on a large area, so by increasing the spatial reuse. A simulation study reveals that TSA significantly improves the throughput and reduce packet delay during high congestion state.

To handle the network dynamics an optimized reliable ad-hoc on-demand distance vector (ORAODV) scheme proposed in [24]. The proposed protocol (O-RAODV) is meant for best route discovery and reliability of packet delivery. A new idea of blocking expanding Ring Search (Blocking-ERS) is employed in it to avoid network wide broadcasting. The Blocking-ERS doesn't begin its route search procedure from the source node whenever a broadcast is needed. The broadcast is initialized by any acceptable intermediate nodes on behalf of the source node that acts as a relay or an agent node.

3 Proposed LACAMM Approach

This work is adaptive to the current load and the tries to prevent congestion well in advance by warning its upstream and downstream forwarding group nodes. Each node on the primary path generates a warn message when it is prone to be congested. Upon receiving warn message the upstream node uses an alternate non-congested path along the primary path for avoiding the potential congestion area. Traffic is distributed eventually over the available routes, thus, efficiently decrease the chance of congestion. LACAMR is on-demand multipath multicast routing protocol which comprises the following components:

1.Resource monitoring
2.Congestion monitoring
3.Construction of resource full node list
4.Congestion free route primary route discovery
5.Congestion adaptively and traffic redistribution and
6.Route failure recovery

These components are explained in detail in the forth-coming subsections. Fig.1 depicts the proposed load aware congestion adaptive multipath multicasting approach.

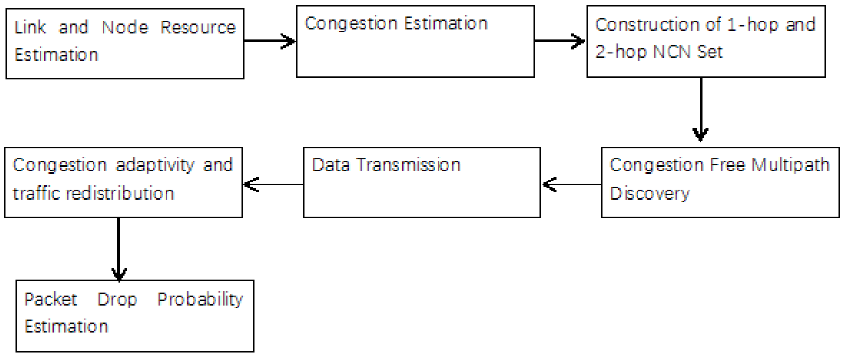

Fig. 1 Proposed LADAMR Approach

3.1 Resource Monitoring

3.1.1 Link Stability

In mobile ad hoc networks, the mobility induced by nodes as well as the propagation effects cause a packet to suffer fading effect. The link stability can be measured using signal-to-noise ratio (SNR) and can be determined with the help of hardware component. If the estimated SNR value is less than the threshold limits the packets will contain excessive errors due to high noise. This result in retransmission their by increases the overall delay thus degrades the performance significantly. The link stability can be estimated as follow using an equation (1).

$$BER = 0.5 * func(\sqrt{\frac{RSP * CB}{NP * BR}} \tag{1}$$

Where,
BER = Bit Error rate,
RSP = Received Signal Power,
CB = Channel Bandwidth,
NP = Noise Power and
BR = Bit Rate and
func = Error Function

The signal to noise ratio (SNR) for multiple packet transmission can be estimated using the equation (2) as:

$$SNR = 10log\frac{RSP}{NP + \sum_{i=1}^{n} RSP_i} \tag{2}$$

Where,$\sum_{i=1}^{n} RSP_i$is the signal strength of packets at the receiver.n is the number of packets received instantaneously. When a node is sending the data packet it appends its signal strength i.e., a transmitted power then the receiving nodes estimates the received signal strength using the free-space propagation model using the wavelength of the medium,the distance between the communicating nodes and unity gain of sending and receiving antennas as shown in equation (3).

$$RSS = TSS\left(\frac{\lambda}{4\pi d}\right)^2 G_s G_r \tag{3}$$

3.1.2 Available Bandwidth

The bandwidth availability is one of the very important factors which determine the connectivity of the network. In general, packet forwarding between the source and the destination follows a multi-hop communication. Hence, it is very much essential to ensure that whether the intermediate forwarding nodes have sufficient bandwidth to forward the data or not. The nodes in the wireless networks rely on the shared wireless links and the links are severely affected by fading, inference, and path loss[23].

It is estimated by measuring the idle periods of the wireless channel. Each node in the network listens to the channel and obtains the status to estimate the channel idle period using the channel observed time interval (CO_{ti}). Then the channel idle time (CI_i) can be estimated by increasing the count from the previous busy time to the start of the next busy time. Let us consider the total channel idle time consists of several channel idle slots, say n. Total channel idle time (CI_{ti}) is the sum of all n idle times. Thus, available bandwidth at a node is estimated using equation (4):

$$AB = \frac{\sum_{i=1}^{n} CI_i}{CO_{ti}} * BW_{total} \tag{4}$$

3.1.3 Estimation of Residual Battery

Battery Lifetime (BL_i) of a node i is estimated using the residual energy (RE_i) and new and old drain rate (DR) of a node i and is estimated as shown in equations (5) and (6):

$$BL_i = \frac{RE_i}{\propto *DR_{old}(j,k) + (1-\alpha)DR_{new}(j,k)} \tag{5}$$

$$DR_{new}(j,k) = \frac{E_{j,k}}{(1-p_{error})^n} \tag{6}$$

Where, DR_{old} and DR_{new} represents old and current calculated drain values and represents a constant value between 0 and 1. The number of neighbors of node says n is x_k where n knows its entire neighbors total current load, $TCL(i)$ then the probability of data forwarding can be computed as shown in equation (7):

$$P(n) = 1 - \left(\frac{TCL(n)_i}{MACQ_i(i)}\right) \tag{7}$$

3.2 Congestion Monitoring

Detecting congestion in a reactive manner will produce longer delay, high packet loss, and high control overhead. Unlike wired and high-speed networks congestion in MANET becomes more viable during transmission of large-scale multimedia data. Hence, eliminating congestion in such dynamic networks produce excessive overhead, delay, and a waste of resources. Many solutions have adapted active queue management strategies to eliminate the congestion problems. This work aims to propose an approach which is adaptive to the incoming traffic and anticipates congestion by redistributing the traffic along the available congestion free path.

Each node in the network estimates the incoming traffic and updates the same in the neighbor table periodically. This helps to find out the neighbor node current load status. The Current Data Traffic(CDT) is estimated to find out the congestion level of the node. Each node n_i samples the queue length in the MAC layer periodically.Suppose $Q_j(k)$ is the k^{th} sample value, and X is the overall sampling time period, then the current data traffic of node ni can be estimated using the equation (8).

$$CDT(i) = \frac{\sum_{k=1}^{X} Q_j(k)}{X} \tag{8}$$

The total length of the queue of node ni is the maximum capacity of the queue in the MAC layer is $MACQ_i(i)$; then the total current load is defined as follows using equation (9).

$$TCL(i) = \frac{CDT(i)}{MACQ_i(i)} \tag{9}$$

To monitor congestion well in advance, the average queue size is estimated by setting the static maximum and minimum threshold value for the queue length as $QMin_{th} = 0.25 * Size\_of\_Buffer$ and $QMax_{th} = 0.75 * Size\_of\_Buffer$ the current queue size can be estimated using equation (10) as:

$$Current_{AvgQSize}(i) = (1 - w_q) * AvgQold + TCL(i) * w_q \tag{10}$$

Where w_q is the queue weight, is a constant ($w_q = 0.002$) from RED queue results in Floyd, (1997). The current congestion status is computed as shown in equation (11).

$$Current_{cs}(i) = TCL(i) - Current_{AvgQSize}(i) \tag{11}$$

If the $Current_{cs}(i)$ is less than $QMin_{th}$,then the incoming data traffic is below the buffer size and hence, a node can handle the traffic. If $Current_{cs}(i) \leq$

$QMin_{th}$ and $\geq QMax_{th}$, then the buffer overflow likely to take place perform packet drop probability to avid the packet loss. Finally, if $Current_{cs}(i) \geq QMax_{th}$, then the node is congested, invoke redistribute the route through the available non-congested alternate path.

Table 1 List of symbolizations used in this work

Symbol	Description
RSP	Received signal power
CB	Channel bandwidth
NP	Bit rate
BR	Error function
$func$	Interference ranges of the nodes
SNR	Signal to Noise Ratio
RSS	Received signal strength
G_S	Sending antennas gain
G_r	Receiver antennas gain Propagation wavelength of the medium
TSS	Transmitted signal strength
d	Distance between any two communicating nodes
CO_{ti}	Channel utilized time interval
CI_i	Channel idle time
TCI_i	Total channel idles time
AB	Available bandwidth
BL_i	Battery lifetime of node i
DR_i	Drain rate of node i
RE_i	Residual energy of node i
xk	Set of neighbor nodes of k
TCL	Total current load
$p(n)$	The probability of data forwarding
CDT	The current data traffic
X	Overall sampling time
$MACQ_i(i)$	Current load on MAC layer of node i
$QMin_{th}$	The minimum queues threshold limit
$QMax_{th}$	The maximum queue threshold limit
W_q	The queue weight
$Current_{cs}$	The current congestion status of node
$Current_{AvgQSize}$	The current average queue size
RFN	The set of resource full node

3.3 Construction Of Resource Full Node (RFN) List

Fig.2 shows sample network scenario. Each node periodically updates its one-hop neighbor resource information. The periodic interval is set to 1sec. It helps each mobile node in the network to know about its one-hop neighbor resource information for constructing one-hop and two-hop congestion free resource-full node (RFN) list. After that, this set of congestion free (RFN) nodes will be used as a subset of a forwarding node to forward the datagram from the corresponding source to a destination.

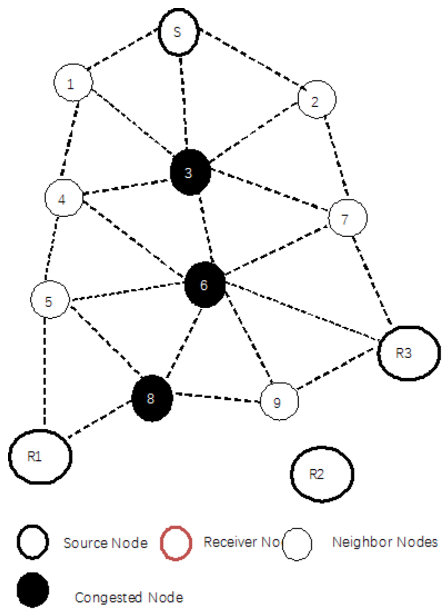

Fig. 2 Sample Network Scenario

Each mobile node updates its one-hop and two-hop neighbor list in its routing table and the same is used during the route discovery process to build congestion free primary path. The routing table contains the following fields information for each route entry:

$Multicast\_RT$ {

Src_Addr is the source mobile node address,

Dst_Addr is the destination node address,

Grp_Addr is the multicast group address,

Hop_Cnt is the number of intermediate hops i.e. hop count,

RFN_Node_Addr is the resource-full node address,

RFN_SET is the list of resource-full node set, and

Con_Status is the neighbors congestion status
}

Table 2 Resource full node list

Node Id	One-Hop Resource Full Node Id	Two-Hop Resource Full Node Id
S	1, 2	4, 7
1	S, 4	5, 7
2	S, 7	4, R3
4	1, 5	7, R3
5	4, R1	7, 9, R3
7	2, R3	5,9
9	R2, R3	R1
R1	5	9
R2	9	5
R3	7,9	4,5

3.4 Congestion Free Primary Route Discovery

LDAMM is an on-demand protocol initiates route discovery when a source mobile node has data to send. It first checks from its resource full node list whether the multicast receiver is in two-hop resource full node list or not. If the multicast receiver is in the two-hop resource full list, then it forwards the JRREQ using the existing path in its routing table. If not, then the source node initiates a route discovery process by just forwarding the JRREQ packet through its one-hop and two-hop resource full node set rather than flooding the JRREQ packet into the network. This procedure helps in minimizing the control overhead to a certain extent. Upon receiving this packet, the receiver node checks its two-hop resource full node list. If the multicast receiver found, then it forwards the JRREQ packet directly to it. The multicast receiver then responds to the first received JRREQ packet and sends back JRREP packet. If not found, it updates the received information and forwards JRREQ packet to its one-hop resource-full node. This process repeats until the multicast receiver node found. The first JRREP path considered as a primary path between the source and the multicast receiver. Finally, the source finds a resource full non-congested primary path to the destination. A primary route found in this case, are S→1→4→5→R1,S→2→7→R3,and S→2→7→R3→R2. These routes are used by the source to transmit a datagram towards the multicast receivers. Thus, the proposed work finds a resource full congested free primary path from source to destination with the help of resource full node list and controls the overhead by avoiding unnecessary flooding of packets. Table 3 describes the overall procedure involved in congestion free primary route discovery process after resource full node list selection.

Table 3 Procedure for congestion free primary route discovery process

Input: G= (V, E)
Output: The congestion free multicast tree
Begin
1) The source mobile node S checks its one-hop RFN list (1, 2) and a two-hop RFN list (4, 7) to find whether a multicast receiver is available or not.
2) If the multicast receiver nodes R1, R2, and R3 is not in one-hop and two-hop RFN list, then the source mobile node forwards JRREQ packet to its one-hop resource full nodes 1 and 2.
3) Now upon receiving JRREQ node 1 and node 2 will check its one and two hop RFN list to find whether R1, R2, and R3 is available or not. If not 1 and 2 forwards a JRREQ packet to its one-hop RFN nodes i.e.,(4, 7)
4) This process is repeated until JRREQ reaches a multicast receiver. In this case, node 2 and node 4 finds the multicast receivers is its two-hop resource full node list and forwards the JRREQ through intermediate nodes 5 and 7.
5) The multicast receiver node now sends a JRREP along the reverse path of the JRREQ to reach the source.
6) The source mobile node now fixes the first JRREP as a congestion free primary path and starts the transmission along this path.
End

3.5 Congestion Adaptive Alternate Route Discovery

Each node in the primary path periodically estimates and finds its congestion status. If it is likely to be congested then warns its upstream and downstream node by sending Congestion Warning Packet (CWP). Upon receiving this packet, the upstream node checks it updated Resource Full Node (RFN) list to find whether a multicast receiver is in it or not. If exists, exchange the new RFN list with its neighbors and resume the transmission along the newly available congestion free path. This new alternate route gets updated in its routing table. If not forwards the CWP to its previous node. If no RFN list found on the congestion free primary path, then the CWP, send to the source node. The source now assigns another alternate path if it is available otherwise initiates a new route discovery process to find a congestion free primary path.

This alternate path finding process does not incur any significant overhead, because of the availability of one-hop and two-hop resource full node list in each node. For example, if the resource-full node 9 detects the congestion, sends a CWP to its neighboring nodes on the primary path in this case R2 and R3 and updates the RFN list in the routing table. In response, the upstream node R3 checks its routing table new RFN list along the primary path. If exits, traffic will be resumed through the available RFN nodes otherwise it forwards the CWP to its previous node. In this case, there is no such alternate congestion free alternate path exists for node R2 it forwards towards its source node. The source node then initiates a new route discovery process. Table 4 presents the overall procedure involved in finding the congestion free alternate routes.

Table 4 Procedure for congestion free alternate route

Input: G=(V, E),multicast sessions.
Output: The congestion free of alternate route $V \in R_{ms}$
Begin
1) Initialize the current queue buffer size, average queue size new and old as 0.
2) Set minimum queue threshold limit to 0.25 * current queue buffer size and maximum queue threshold limit to 0.75 * current queue buffer size and queue utilization. Also, set queue weight as 0.002
3) Check if Current_Avg_Que Size is half of queue size.
4) For each arriving packet in queue increment the instantaneous queue size.
5) If it is a non-empty queue size, then apply the formula and if queue average new is less than queue minimum and queue average new together which is less then congestion warning limit, then set queue status as safe.
6) Else if Queue Average new is greater than queue minimum and queue average new put together which is less than queue maximum then set queue status as likely to be congested
7) if the instantaneous queue size is greater than queue maximum and alternate path be false together then update queue maximum.
8) Else queue status is congested
9) Update queue average old as queue average new and queue weight.
End

4 Results and Discussion

A comparison of LADAMM performance with that of MAODV is done for various network scenarios using the Network Simulator (NS2.34) . The observations are presented below

4.1 Simulation Configuration and Performance Metrics

The network consists of 100 nodes in a 1700 * 1700 m terrain size. The radio range is set to 250 m with bandwidth 2 Mbps. To detect the link breaks using feedback mechanism IEEE802.11 DCF is used. The channel propagation model used is Two-Way Ground Propagation model[24]. A queue size at each node is set to hold only 50 data packets and a routing buffer size is set to 64 data packets. The queue and buffer value is initially set to zero until the route discovery process.

The routing protocols used for performance analysis is MAODV. The data flow used constant bit rate (CBR), which varies from 1 packet/sec to 50 packets/sec. The mobility speed of the node is varied from 5m/s to 30 m/s and each scenario is simulated for 600 s. Table 5 describes a list of simulation configuration parameters used for performance analysis for various network scenarios.

Table 5 List of Simulation Parameters Used

Simulation Parameters	**Simulation Parameters**
Node Placement Scheme	Random
Propagation Model	Two-way ground propagation
Environment Size	1500mx1500 m
Number of Nodes	100
Transmitter Range	250m
Bandwidth	1Mbps
Simulation time	600s
Traffic Type	Constant Bit Rate (CBR)
Packet Size	512Bytes
Number of packets transmitted by sources	100
Mobility Model	Random way point Model
Packet rate	5-50packets/s

4.1.1 End-to-End Delay

The average end-to-end delay is a measure of time consumed to deliver a packet from the source to the destination due to buffering of packets, transmission, re-transmission and propagation delays.

4.1.2 Packet Delivery Ratio

Percentage of data packets received at the receivers out of the number of data packets generated by the CBR traffic sources.

$$PDR(\%) = \frac{Total\ number\ of\ packets\ received}{Total\ number\ of\ packets\ transmitted} * 100$$

4.1.3 Routing Control Overhead

Is the ratio of a total number of control packets received to the total number of control packets generated during the simulation time.

4.2 Overall Performance Evaluation

The simulated results discuss the different network scenarios. Various performance metrics such as end-to-end delay, packet delivery ratio, and control overhead are evaluated to facilitate the performance of the proposed LACAMM protocol.

4.2.1 Impact of LACAMM with MAODV

The end-to-end delay, packet delivery ratio and control overhead results with respect to varying CBR packet rates are shown below from Fig.3 to 5. These figures clearly show that the proposed LACAMM yields better results when compared to MAODV. Fig.3 represents the end-to-end delay for LACAMM and AODV with respect to varying the CBR packets rates from 5 packets/s to 55 packets/s. This figure shows that the end-to-end delay for proposed LACAMM is much smaller that of MAODV for all values of packet rates. The delay variation is LACAMM was less than that of MADOV enables the proposed work more suitable for real-time multimedia applications. Fig.4 shows the obtained packet delivery ratio with respect to varying the CBR packet rate is much higher than that of MAODV. This is because the proposed LACAMM has an ability to adapt to the load and congestion. But when the CBR packet rate increase MAODV fails to handle congestion and hence leads to poor packet delivery ratio. Fig.5 shows the routing control overhead for MAODV and LACAMM with respect to varying CBR packet rates. The figure reveals that proposed LACAMM has less routing control overhead that of MAODV. This is because LACAMM uses suppressed flooding concept during route discovery process with the help of RFN list and redistributes the traffic in case of congestion or route failure using an alternate congestion free path along the primary path. The re-route discovery takes place only if no alternate congestion free paths exists along the primary path and thus make the LACAMM superior to the MODAV.

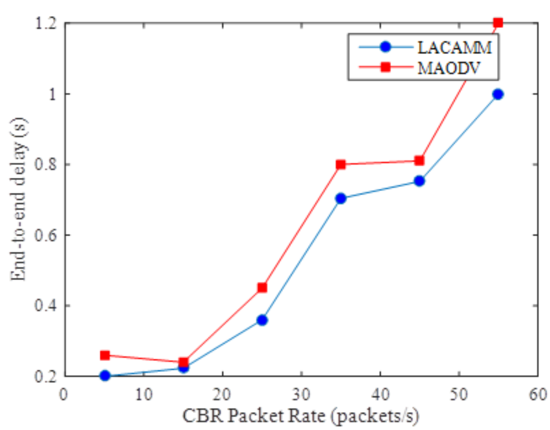

Fig. 3 Attained end-to-end delay with respect to various CBR packet rates

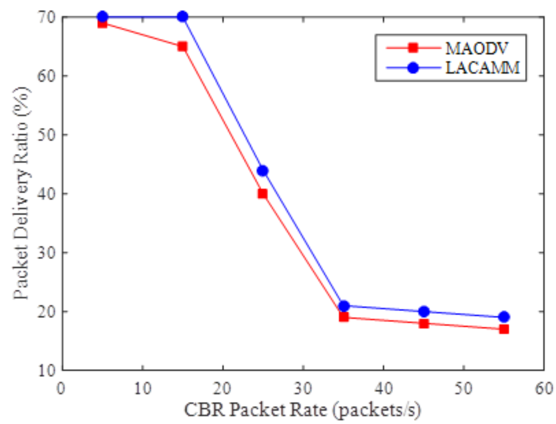

Fig. 4 Attained packet delivery ratio with respect to various CBR packet rates

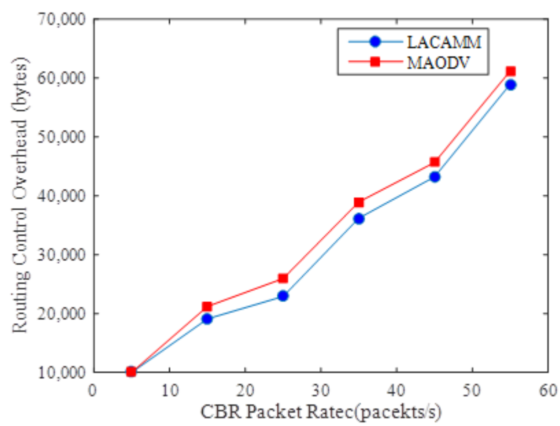

Fig. 5 Attained routing control overhead with respect to various CBR packet rates

4.2.2 Impact of LACAMM with EDAODV

Fig.6 to Fig.7 shows the results obtained for the end-to-end delay, packet delivery ratio and routing control overhead of the proposed LACAMM with EDAODV. Fig.6 shows the attained end-to-end delay for LACAMM and EDAODV with respect to varying the CBR packet rates. Both protocols attain somewhat same end-to-end delay when the data rate is between 5 packets/s to 15 packets/s but at higher data rates form 25 packets/s to 55 packets/s the proposed LACAMM attain lower delay that of EDAODV. This is because the availability of alternate congestion-free routes at each node along the primary path. Fig.7 show the attain packet delivery ratio for LACAMM and EDAODV with regard to the packet rates. The result reveals that for lower data rates 5 packets/s to 15 packets/s both protocols attain somewhat same packet delivery ratio but for higher data rates from 25 packets/s to 55 packets/s LACAMM improves the packet delivery ratio. Fig.8 shows the attained routing control overhead with respect to varying packet rates. From the figure, it is clearly understood that the proposed LACAMM has lower routing control overhead that of EDAOVD for all packet rates.

Thus, these results reveal that the proposed LACAMM achieves better result when compared with other two protocols MADOV and EDAODV improving network performance.

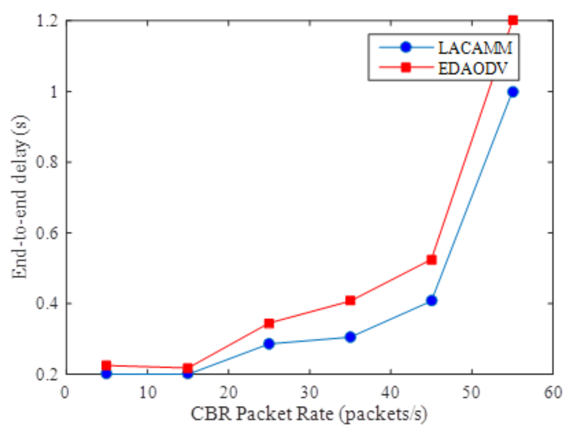

Fig. 6 Attained end-to-end delay with respect to various CBR packet rates

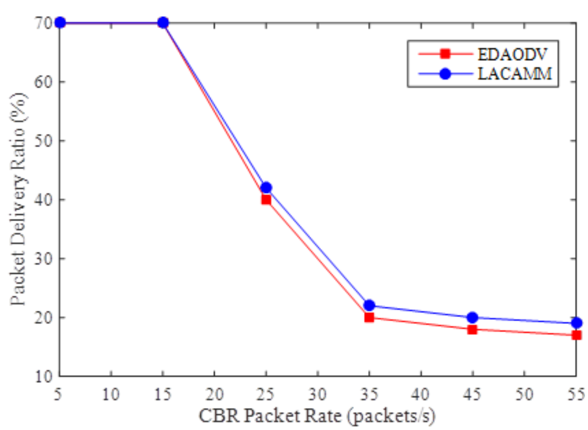

Fig. 7 Attained packet delivery ratio with respect to various CBR packet rates

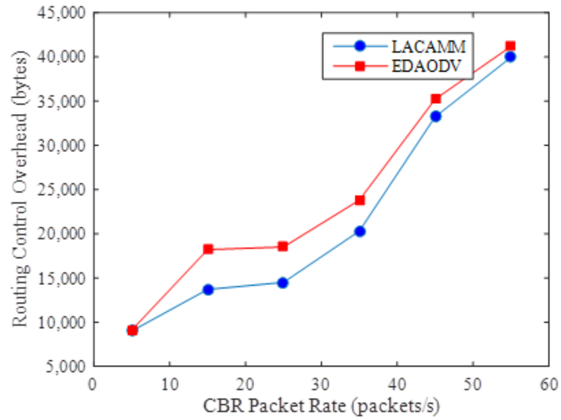

Fig. 8 Attained routing control overhead with respect to various CBR packet rates

5 Conclusion

Congestion control techniques have been specifically made for multimedia applications in MANETs. A suitable mechanism needs to be implemented such that network characteristics like congestion and route failure need to be found out and an apt solution needs to be supplied. The proposed approach could analyze the fluctuation in traffic and categorize the congestion status accurately to solve the congestion problem which is robust and dynamic in nature to estimate congestion. The LACAMM controls the congestion by using an alternative path after estimating the congestion status at the node levels along a path. The DCD-AMMRP algorithm shows considerable performance over the MAODV and EDAODV. The NS-2-based simulation confirms that the LACAMM outperforms in terms of delay, packet delivery ratio and routing overhead than that of MAODV and EDAODV.

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