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Congestion Based Load Balancing Using Mulipath Routing In Mobile Adhoc Network

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ABSTRACT
Mobile ad hoc networks (MANETs) comprises of a set of wireless nodes which are mobile in nature. These mobile nodes dynamically communicate among each otherby relaying data from one node to another. There is no fixed base station or a wired backbone network available in the network i.e. it does not require any infrastructure. MANET nodes differ from other type of nodes by their limited battery power, memory, processing capacity, and as well as high range of mobility. In these types of networks, the mobile wireless nodes can change their position dynamically and they may enter or leave the network frequently. As their transmission range is limited, they require multiple-hops to exchange information between them in the network. Therefore routing becomes a major issue during the design of a MANET. In this paper,load balancing in multipath routing in MANETs is specifically examined. Multipath routing provides multiple paths between a sending and destination node. The proposed routing protocol increases the reliability of data transmission and provides load balancing. Since the bandwidth available is very limited, Load balancing is given a special importance in MANETs.

keywords: MANET, Load Balancing, Multipath Routing, fault tolerence.

1. INTRODUCTION

A (MANET) is a wireless network which consists of mobile nodes and data is transferred between them in multi-hop basis. MANET does not require any pre-installed infrastructure. The topology of the MANET's can change dynamically as the nodes poses an un-controlled mobility.They utilize a common wireless communication medium for data transmission which is shared between all the nodes. The wireless nodes present in MANET have a restricted battery power. Designing a dynamic and efficient routing protocol in MANET is really a challenging issue. The routing overhead of the designed protocols should be less.During the past two decades on-demand routing protocols like Dynamic Source Routing (DSR) [1,2], TORA [3], Ad-hoc Ondemand Distance Vector (AODV) [4]) for MANET has been developed. For data transmission these protocols select the shortest path with minimum hop count. The congestion or the huge traffic in thenetwork is not taken in to consideration by these protocols. This degrades the overall performance of the networkTherefore changes should be made in the design of the routing protocol to select routes between sending and receiving node in a way such that the traffic load on the entire MANET is evenly distributed. Efficient load balancing algorithm will alleviate the congestion and will increase the network performance. This paper proposes a load-balancing algorithm which is congestion based and utilizes a Multipath routing mechanism.

If thedata traffic is not distributedevenly in each path of the network, the congestion in the network is increased which parallel increases the end to end delay in the network.Thus distributing the data traffic along multiple paths can lower congestion in some paths and other problems like overall packet delay in transmission and node early dying due to overloading. The load balanced multipath routing protocols can be classified in to two types. The first type utilizes labelling or source routing mechanisms whereas the second family makes use of hop by hop routing protocols.The AOMDV which uses a hop-by-hop routing approach is used as the base routing protocol in this paper.The AOMDV [5] protocol is an extension of AODV which differs from AODV by its multipath routing approach. In AOMDV the sending node receives and saves multiple Route Reply messages (RREPs) coming from destination and intermediate nodes. The traditional route selection procedure of AOMDV cannot handle the sudden changes in the network due to congestion which is caused by transmitting data traffic through a particular path or a node.

In this paper, the problems of the AOMDV routing protocol are addressed and an efficient method for AOMDV with support for multiple route selection based on the congestion in the selected route is proposed. In the proposed method the source node maintains a set of multiple disjoint routes to the destination and monitors the quality of the routes by measuring the congestion. Ifthe performance of the selected pathfalls below a thresholdlevel, the source node will select another path from the already discovered paths.

The rest of this paper is organized as follows. In Section 2, we briefly analyze the previous ad-hoc multi path routing protocols with support for load balancing. In Section 3,the proposed scheme, modified AOMDV, is presented. To show the effectiveness of the proposed method, the performance of the proposed methodis analyzed and evaluatedby various parameters like throughput and delay in Sections 4. This paper is concluded in Section 5.

2. RELATED WORKS

The QoS requirements for a realtime application have compelledthe researchers to focusin the field of load balancing in MANETs.Variousresearchers have discussed and proposed solutions for the load balancing problem in MANETs. In [6] the authors have proposed a QoS aware routing protocol based multi path routing approach is proposed using the intermediate nodes with high bandwidth availability, processing capacity, remaining energy in the node etc. The proposed method utilizes the available bandwidth in the networkefficiently by distributing traffic load across multiple paths in the network. A congestion controlled adaptive multi-path routing protocol is proposed in [12] which supports load balancing and avoid congestion in in the network. The protocol finds fail-safe multiple paths, which provideseach intermediate node on the selected primary path with multiple paths to destination.

By considering the energy aware routing protocols and load balancing techniques the MANET routing protocols' energy efficiency is increased in [7]. Adaptive load balancing technique with node caching enhancement is adopted in the proposed work. A new routing algorithm with distributed load is proposed in [8] to establish the best routing paths. In this algorithmthe multimedia data is given high priority and its routing is done over the lightly loaded linksand also it is ensured that the resources are shared among the high and low priority traffic. The lightly loaded path is utilized by general datawhen the multimedia traffic is not present.

A gossiping mechanism is used to develop a novel adaptive load balancing routing protocol for MANET[9]. The forwarding probability of the routing messages is adjusted adaptively as per the traffic load and position of the nodes during route discovery. With an objective to use the ant based algorithm for load balancing, a routing protocol is proposed in [10]. Using a threshold valuethe number of ants that has been sent is controlled. The work presented a new dynamic and adaptive routing algorithm for MANETs inspired by the ant colony paradigm. A load-balancing algorithm that drives the traffic farther from the center of the network is proposed in [11]. A routing metric which considers a node's degree of centrality is used and this approach improved the load distribution and increased the network performances in terms of average end-to-end delay and network reliability. But one major drawback with this method is that it uses only single path routingwhich causes extra overhead when the nodesare highly mobile. A multipath routing scheme was proposed in [13] which increased the throughput by alleviating congestion in network employing shortest route. Its major drawback is that it detects the congestion based on current load in the node and does not consider its bandwidth or residual energy.

3. PROPOSED ROUTING PROTOCOL - LOAD BALANCED AOMDV

To provide multipath routing capability, for each destination the AOMDV contains a set of routes in the route tables. All the routes to a particular destination node will have the same destination sequence number. If a route advertisement with a higher sequence number arrive a node then it removes the older routes. In this paper, an extension to AOMDV protocol is proposed which utilizes certain procedures and techniques for improvingthe performance of the network. AOMDV findsmore than one routes between sender and receiverwhen the sender node wants to transmit data. It discovers multiple paths during the route discovery process but it selects only one path for data transmission.

When the sender receives one or moreRoute Reply (RREP) packets from one or more intermediate node through various disjoint paths, it decides:

- If one RREP packet arrive the sending node then it selects the available one route and sends data packets from source to destination through the path.
- If many RREP arrives the sending, the source selects the route with less "hopcount". The other route information's are stored in a temporary buffer and if a RERR packet arrives indicating the failure of the primary selected route, the next best route from alternate routes is utilized for data transmission. The routing selection procedure is as follow:

Algorithm : Conventional Route Selection Procedure in AOMDV

If (source don't have route to receiver) {
Route discovery – Source Broadcasts RREQ}
If (Source has one route) {
Send data to destination through particular route}
Else {
Send data packets through best route}

To use multiple routes from source to destination and to distribute the data traffic evenly throughout the network by providingload balance in the network the following changes are carried out in the basic Route selection procedure of the AOMDV routing protocol.

Algorithm : Proposed Route Selection Procedure in AOMDV

If (no route to receiver) {
Broadcast RREQ packets as in AOMDV}
If (Sender has a path) {
Forward data packets throughthe particularpath}
Else if (N paths are available from sender to receiver) {
Transmit data packet through less congested routes}

Always the AOMDV routing protocol sends the data through the route with the leasthopcount.But if the less congestion routesare considered for data transmission, they can givelow endtoend delay when compared to routes with lower hopcount.

To select the less congested routes, a new method which allows the sending node to select the less congestedpath must be developed. So in this research a new metric to achieve load balancing between the selected routes is proposed. This takes the number of active paths through each node for consideration.The congestion is estimated based on the queue length and arrival rate. If the queue length and arrival rates are low, then the congestion will be less otherwise the congestion will be more. Normally in AOMDV the RREP packet contains information like HOP Count, Sequence number, etc., but in our modified AOMDV to better distribute the traffic load evenly, two more information are added to it. They are

Arrival rate and Aggregate Interface Queue length in the route path. The additional information are stored and updated in the routing table.

When the RREQ arrive at a node and if it is the destination node then it adds Queue length and Arrival rate along with other information and then forwards the RREP to the next intermediate node in the reverse path. When the RREP packets reach the intermediate nodes it sums up their Arrival rate and queue length in the respective fields of RREP packet. Finally when the RREP packet reaches the source node it contains the sum of the arrival rate and the total data packets waiting in the queue of the intermediate nodes along the route path in which the RREP packets arrived the source node.

When the intermediate node receives the RREQ packet from a source and if it has the route information for the respective destination node it sends the RREP packet to the source node along with the additional information such as arrival rate and queue length.

The Source node receives multiple route replies which are sent by the destination and intermediate nodes. The source node selects 'M' number of paths and starts forwarding the data packets through multiple paths. The packets sent by source node are scheduled according to Round-Robin (RR) algorithm [14].

Transmitting data through multiple paths can achieve load balancing in the network and can provide fault-toleranceand highaggregate bandwidth in the network. Load balancing is achieved by distributingthe data along multiple routes. This can reduce congestion and alleviates other bottlenecks in the network.The aggregate bandwidth of the paths has to fulfill the required bandwidth of the application. As more bandwidth is available, the end toendpacket delay will reduced to a great extent.

When a sender node begins transmitting data through multiple paths, one or many of the paths may fail due to mobility of the node and/or due to the failure of the link and node. When there is route failure route maintenance has to be followed as it is done in uni-path routing. The route discovery has to be initiated once when there is a route or path failure. When multiple routes are utilized for data transmission, route discovery can be initiated when a single route fails or all the routes fail. If a fresh route discovery is initiated after all the selected routes failure, then there will be a delay in data transfer before new routes are available. The delay will degrade the QoS requirement of the application. Also initiating a fresh route discovery after failure of each node will also degrade the overall performance of the network. So it is better to initiate route discovery when N number of routes fail and the value of$N$ is less than total available paths. This option will bring a tradeoff between the two fore mentioned conditions.

4. SIMULATION AND RESULTS FOR LOAD BALANCED AOMDV

For evaluating the performance of the Modified AOMDV simulations are performed using Network Simulator (NS2). The simulation scenarios are modeled with network parameters which represents the real time implementation. During all the simulations the network parameters are kept constant but only the size of the network (i.e) the number of nodes are alone changed to better evaluate the performance of the proposed algorithm. The throughput, packet loss, packet delivery ratio and routing load are taken as performance metrics. During each simulation the trace file is generated and using *'perl'* scripts the values are calculated. The throughput is calculated by finding the ratio between the volumes of data travelled during the simulation period and the duration of the simulation and is expressed in kilo bytes per second (kbps). The packet loss which reflects the real performance of the routing algorithm is calculated by finding the difference between the number packets originating from the source node and the number of data packets reaching the destination. The packet delivery ratio is the ratio between the numbers of packets sent to the number of packets received. The routing load is the ratio between the numbers of routing packets sent to the total number of the sent packets. The routing load depicts the impact of the additional load put over the network by the routing packets. The following parameters were used to build the simulation environment the MAC layer is modeled using IEEE 802.11 standard and the physical layer is implemented with the wireless physical channel.

The Droptail queue method with Priority management is utilized to manage the waiting and incoming data packets at the intermediate nodes. The size of the data packets transmitted during the simulation is chosen to be 512bytes. If larger the size of the data packets then the amount of energy spent to transmit the data packets will be higher so a moderate size of the data

During all the simulations the constant bit rate type of traffic is used and random way point movement is used for the node movement. At the starting of the simulation mobile nodes are distributed randomly on 500m x 500m a square field. Each nodeselects its receiving node in the field randomly, and a velocity of 10 m/s id fixed for all the mobile nodes. All the node are not constantly moving inside the field, every node moves to a new position after waiting for a specific period of time termed as Pause time. By this model of node movement, the current position and velocity of the node does not have any relationship with the next movement of the node.

Table 1. Simulation Parameters

Parameter	Value
Simulation Time	200
No. of Nodes	Varied Between 20 to 60
Traffic Type	Constant Bit Rate
Pause Time	10 Sec
Topology Area	500 X 500
Packet Size	512 bytes
MAC Protocol	IEEE 802.11
Mobility Model	Random Way Point
Wireless Channel	Physical Wireless
Antenna Type	Omni Directional
Queue Type	Drop Tail

The simulations were performed with 20, 30, 50 and 60 numbers of nodes using both AOMDV and Modified AOMDV and the results are tabulated below. The results indicate that the Modified AOMDV outperforms the AOMDV by all the metrics. The packet loss is greatly reduced in the Modified AOMDV when compared to AOMDV in all the simulation scenarios and also PDR of Modified AOMDV is higher when compared to AOMDV. The throughput is increased which represents that the modified algorithm is performing better with varying network size. The multipath nature of the proposed routing algorithm guarantees the delivery of the data packets originating from the source node therefore the Packet loss is reduced even when the network size is increasing.

The proposed routing protocol, modified multipath AOMDV, is also compared with AODV routing protocol which exhibits lesser performance when compared to the proposed protocol. The modified multipath AOMDVand the conventional AODV protocols differ in their strengths and weaknesses. As the topology of the wireless network is getting changed dynamically the path breaks in on-going sessions are frequent in MANET. When there is a path failure new route discovery has to be initiated. Alwaysthe modified multipathAOMDV have up-to-date information about alternate pathsapart from the primary route.

In conditions when the network traffic is irregular in nature the modified multipathAOMDVgives less routing overhead as the routes are found proactively. But in case of AODV a route has to be discovered before the actual data transfer is started. High routing load plays a major role in deciding the overall performance in wireless networks with low bandwidth.The route information gained during the route discovery process is not cached by the AODV routing protocol, and so it faces the problem of high routing load. Modified AOMDV utilizes multiple paths which are discovered the process of route request broadcast. The multiple routes help to lower the routing load and also the packet delay is reduced without modifying the basic structure of the protocol.

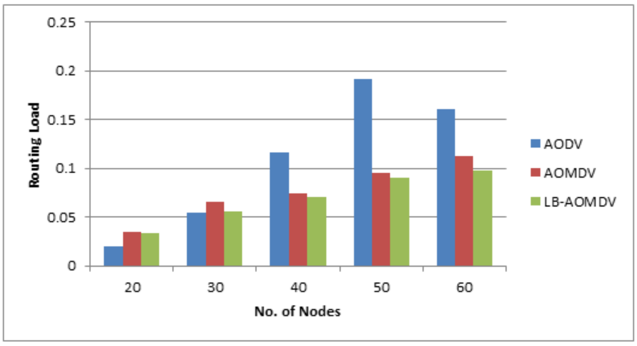

Fig. 1. Comparison of Routing Overhead of the Protocols

Packet loss is a more complicated problem that has to be addressed in MANET,as wireless links are subjected to transmission errors and the topology of the network is changed dynamically. The packet loss occurs due to any of the following conditions such as transmission errors, congestion, and un-availability of route to the receiver, broken links, etc. The aggregate packet loss for AODV is 10 to 20% higher than that of Modified AOMDV irrespectiveof the number of nodes.

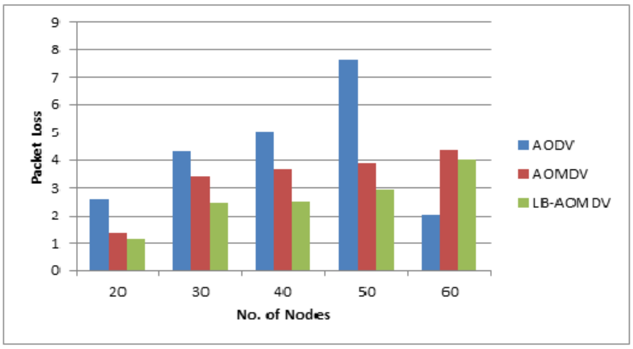

Fig. 2. Comparison of Packet Loss of the Protocols

The multipath AOMDV performed particularly well, as it delivers over 95% of the data packets irrespective of the number of nodes. But AODV fails when the node density increases. The performance of the Modified AOMDVis consistent.

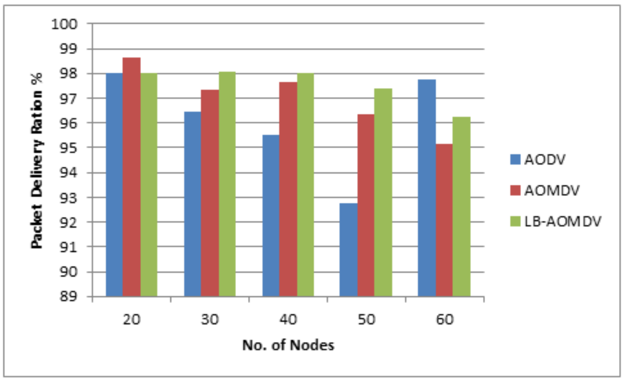

Fig. 3. Comparison of Packet Delivery Ratio of the Protocols

The Fig above highlights the relative performance of the three routing protocols. Both the AODV and modified AOMDV protocols deliver a greater percentage of the originated data packets when there is little node, converging to 100% delivery when there is more number of node. AOMDV has a slightly better delivery ratio (about 1.5%) than Modified AOMDV only when the number of node is 20. This is because when more than one path is utilized for transmitting data packets, the probability of collision at the MAC layer is higher. The interference between paths can be avoided by utilizing multiple channels for data transmission, which different frequency band can be provided for each path. In our simulation and experiments, only one channel used, so Modified AOMDV shows high packets loss due to the collision at the MAC layer. This problem get reduces as the number of nodes increases, the links become more unstable, and there are also more loops in the network. The packet delivery rate of AOMDV then decreases swiftly and Modified AOMDVperforms better thanAOMDV.

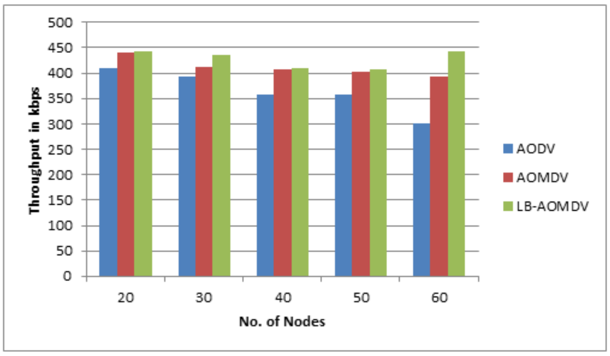

Fig. 4. Comparison of Throughput of the Protocols

The Throughput of the network is considered as main parameter for the analytical comparison of the performance of the protocols. The Figure shows the throughput of the network in all three protocols for 20, 30 and 60 number of nodes. The comparison shows that AODV performed least in case of throughput too. Throughput of AOMDV is little higher than that of AODV and it is less than that of proposed protocol. The reason behind the reduce throughput is the high routing overhead generated by AODV. The throughput of the AODV is better when the number of nodes is less. An optimal route might be discovered by the AODV during the route discovery as it finds multiple routes to a destination. Modified AOMDV performed better than AODV and AOMDV in case of throughput too. This is due to the proactive nature of protocol.

5. CONCLUSION

In this paper, load balanced multipath routing in MANETsis presented which deals the network layer issues. The proposed multipath routing does not interact with the transport layer.The majorproblem to which a best solutionhas to be given with at the transport layer is the outoforder data packets. The packets received at the destination will not be in orderif multiple pathsare utilized to transfer data in a round-robin fashion. The next major problem that must be addressed lies at the link layer. When multiple paths are used to attain higher bandwidth, the problem starts at the link layer which is not common in wired networks. As the nodes in the MANET communicate with each otherthrough the wireless medium, which is shared between the wireless nodes,packet loss due to radio interference must be addressed. The throughput will be limited as the data transmissions from a node through a path may interfere with transmissions from another source node along another path.These issues will be taken for consideration in our future work but however thesimulations &results exhibits that the proposed multipath routing with load balancing produces better results than using uni-path routing in higher density networks.

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