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An Improvement in Congestion Control Using Multipath Routing in Manet

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GJCST-E Classification : C.2.2

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An Improvement in Congestion Control Using Multipath Routing in Manet

Mr. Abhishek Bande [α] & Mr. Gaurav Deshmukh [σ]

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I. Introduction

Mobile Ad hoc network is a self configuring, self organizing and self maintaining dynamic network. A mobile ad hoc network (MANET) is a network consisting of a set of mobile nodes with no centralized administration [1,2]. In mobile ad hoc network nodes are in movable format means they can form any topology as they change their position so by considering nodes are movable we are currently having many protocols for routing in multipath. The main objective of multipath routing protocols is to provide reliable communication and to ensure load balancing ad to improve quality of service of MANETs. These multipath protocols are broadly classified into five categories to improve delay, provide reliability, reduce overhead, maximize network life and hybrid routing. In multipath routing protocols have issues for multiple paths discovery and maintaining these paths. Issues, objectives, performances, advantages and disadvantages of these protocols are summarized. In MANETs each mobile node has limited resources such as battery, processing power, and on-board memory (i.e., RAM). In MANETs, mobile nodes communicate with each other in a multi-hop fashion. That means a mobile node sends a packet to a destination via intermediate nodes. Hence, the availability of each node is equally important in MANETs. Otherwise, overall performance of the network may be affected by single intermediate node. In order to meet these characteristics and design constraints, an efficient routing protocol is essential for MANET. Designing an efficient routing protocol for MANETs is a very challenging task to achieve. Many routing protocols have been proposed and these protocols can be classified as proactive and reactive. In proactive routing protocols like destination sequence distance vector (DSDV) mobile nodes update their routing tables by periodically exchanging routing information among themselves. Proactive routing protocol generates large number of control messages in the network due to periodic information exchanges. Hence, proactive routing protocols are not considered suitable for MANET. To overcome the limitations of proactive routing protocols [3], reactive routing protocols like dynamic source routing (DSR) and ad hoc on-demand distance vector routing (AODV) protocols have been proposed for MANET. In reactive routing protocol, a route is discovered when it is required. Reactive routing protocol consists of two main mechanisms: (a) route discovery and (b) route maintenance. A source node discovers a route to a destination by using the route discovery mechanism. On the other hand, a source node detects any topology change in the network by using the route maintenance mechanism. In route discover procedure Once all paths have been discovered [4], a source node chooses a path, which is the shortest and stores remaining paths in database. When the shortest path algorithm is used, nodes which is located around the center of a network may carry more traffic compared to other nodes that are located at the other or boundary of the same network. When multiple connections are setup in a network, the wireless links located at the center of the network carry more traffic and can, therefore network gets congested. This type of congestion problem may affect the performance of a network in terms of delay, throughput and reliability. If source node chooses shortest path then it may break due to node movement as nodes are movable. Moreover, communication through a wireless medium is inherently unreliable and is also subjected to link errors like UDP.

Multipath routing protocols proposed for MANET can be broadly classified as [5] (a) delay aware multipath routing protocols, (b) reliable multipath routing

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protocols, (c) minimum overhead multipath routing protocols,(d) energy efficient multipath routing protocols and(e) hybrid multipath routing protocols. In this paper we are covering all the protocols which are for multipath based on congestion control.

II. Literacher Servey

a) Computer Network

A Network is defined as the group of people or systems or organizations who want to share their information collectively for their business purpose. In Computer terminology the definition for networks is similar as a group of computers logically connected for the sharing of information or services (like print services, multi-tasking etc.). These networks may be fixed (cabled, permanent) or temporary.

Types of Computer Network: There are mainly two types of computer networks a) Wired Network b) Wireless Network

i. *Wired Network*

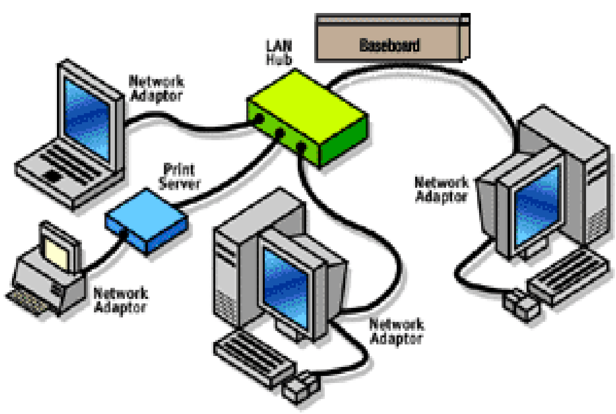

Fig. (a) : Wired Network

The wired networks are generally connected with the help of wires and cables means there exist a physical connection between two computers. Generally the cables being used in this type of networks are CAT5 or CAT6 cables. The connection is usually established with the help of physical devices like Switches and Hubs in between to increase the strength of the connection. In wired network there is a reliability of data to be reached at destination. Following are some advantages of wired network.

Advantages:

A wired network offer connection speeds of 100Mbps to 1000Mbps. Physical, fixed wired connections are not prone to interference and fluctuations in available bandwidth, which can affect some wireless networking connections.

Disadvantages:

Wired networks are expensive to maintain the network due to many cables between computer systems and even if a failure in the cables occur then it will be very hard to replace that particular cable as it involved more and more costs.

When using a laptop which is required to be connected to the network, a wired network will limit the logical reason of purchasing a laptop in the first place.

ii. *Wireless Network*

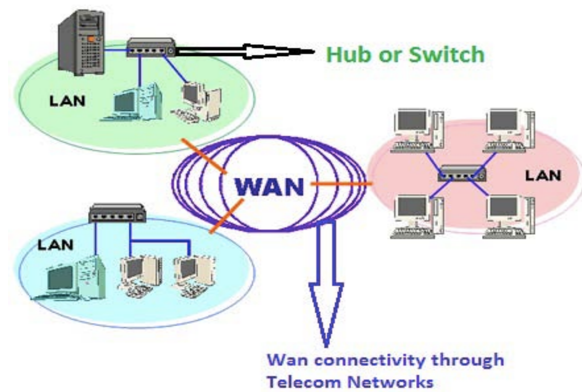

Fig. (b) : Wireless Network

In Wireless networks there is no physical existence of cable between two computers. It use some sort of radio frequencies in air to transmit and receive data instead of using some physical cables. The Wireless network eliminates the disadvantage of wired networks and it also eliminates cable cost.

Advantages:

Mobile users are provided with access to real-time information even when they are away from their home or office. Network can be extended to places which cannot be wired. Wireless networks offer more flexibility and adapt easily to changes in the configuration of the network.

Disadvantages:

Interference due to weather, other radio frequency devices, or obstructions like walls. The total Throughput is affected when multiple connections exists.

In Wireless network there is no guarantee of data to reach at destination.

b) Routing

Routing is the process of selecting paths in a network along which to send network traffic. It is an act of moving information across an inter-network from a source to destination.

Routing is mainly classified into

a) Static Routing b) Dynamic Routing

i. *Static Routing*

Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator.

The routing table doesn't depend on the state of the network status, i.e. whether the destination is active or not. Static routing doesn't depend on availability of destination node.

ii. *Dynamic Routing*

Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing mainly depends on the state of the network i.e. the routing table is affected by the activeness of the destination.

c) Mobile Ad-Hoc Network

A wireless mobile ad hoc network [6] is usually defined as a set of wireless mobile nodes dynamically self-organizing a temporary network without any central administration or existing network infrastructure. Since the nodes in wireless ad hoc networks can serve as routers, they are movable so they can form any type of topology. They forward packets for other nodes if they are on the route from source to the destination (like intermediate node. Besides other issues, routing is an important problem in need of a solution that not only works well with a small network, but also sustains scalability as the network gets expanded and the application data gets transmitted in larger volume. Since mobile nodes have limited transmission capacity, they mostly intercommunicate by multi hop relay. Multi hop routing is challenged by limited wireless bandwidth, low device power, dynamically changing network topology, and high vulnerability to failure, to name just a few. To answer those challenges, many routing algorithms in MANETs [6] were proposed. There are different dimensions to categorize them: proactive routing versus on-demand routing, or single-path routing versus multipath routing. In proactive protocols, routes between every two nodes are established in advance even though no transmission is in Demand and in reactive routing routes between every two nodes are established when needed.

Our motivation is that congestion is a cause for packet loss in MANETs [6]; mostly packets will loss cause of congestion only. Our aim is to control congestion in MANETs [6]. Typically, reducing packet loss involves congestion control. Congestion in routing in MANETs [6] may lead to the following problems:

1. *Long delay:* It takes time for a congestion to be detected by the congestion control mechanism. In severe congestion situations, it may be better to use a new route. The problem with an on-demand routing protocol is the delay it takes to search for the new route.
2. *High overhead:* In case a new route is needed, it takes processing and communication effort to discover it. If multipath routing is used, though an alternate route is readily found, it takes effort to maintain multiple paths.
3. *Many Packet Losses:* Many packets may have already been lost by the time congestion is occurred or detected. A typical congestion control solution will try to reduce the traffic load, either by decreasing the sending rate at the sender or dropping packets at the intermediate nodes or doing both. The result is a high packet loss rate or a small throughput at the receiver.

III. Classification of the Routing Protocols in ad Hoc Network

a) Delay Aware

i. FZR (Fresnel Zone Routing)

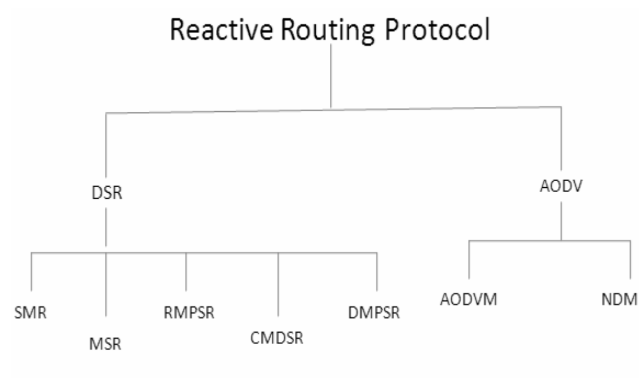

Fig. (c) : Reactive Routing Protocol Taxonomy

ii. AODVM-PSP (Multipath Ad-Hoc on Demand Distance Vector Protocol with Path Selection Probability)

iii. BGR (Biased Geographical Routing Protocol)

b) Reliable

a) Multipath Routing Protocol for Changing Topology
b) End-to-End Estimation Based Fault Tolerant
c) NTBR (Neighbor Table Based Multipath Routing)
d) CHAMP (Caching And Multipath Routing)

c) Minimum Overhead

a) SMR (Split Multipath Routing)
b) MDSR (Multipath Dynamic Source Routing)
c) ADOVM (Multipath AODV)

d) Energy Efficient

a) MDR (Multipath on Demand Routing)
b) EM-GMR (Energy and Mobility Aware Geographical Multipath Routing)

e) Hybrid

a) MSR (Multipath Source Routing)
b) RMPSR (Robust Multipath Source Routing)

f) Congestion

Congestion is a problem that occurs on shared networks, when multiple users access to the same resources (bandwidth, buffers, and queues). When number of packets are present in a network is greater than capacity of network then this situation is called as congestion. Congestion in a network may occur when the load on the network i.e. the number of packets sent to the network is greater than the capacity of network.

Congestion Control Mechanisms:

i. *End-system flow control:* This is not a congestion control mechanism scheme, but it is a way to prevent the sender in network from overflow the buffers of the receiver.

ii. *Network congestion control:* In this scheme, end systems choke back in order to avoid congesting the network. The mechanism is similar to end-to-end flow controls, but the main intention is to reduce congestion in the network, not the receiver.

iii. *Network-based congestion avoidance:* In this scheme, a router detects that congestion may occur and attempts to slow down senders before queues become full.

iv. *Resource allocation:* This technique involves scheduling the use of physical circuits or other resources, for a specific time period. A virtual circuit, built across a series switches with a guaranteed bandwidth is a form of resource allocation. This technique is difficult, but can eliminate network congestion by blocking traffic that is in excess of the network capacity.

g) Multipath Routing Protocols

Taxonomy of multipath routing protocol based on congestion control

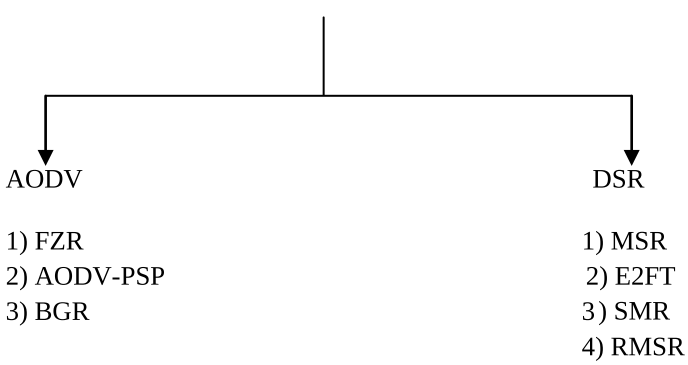

Fig. (d) : Taxonomy of MRP based on congestion control

1) FZR: (Fresnel Zone Routing.)
2) AODV-PSP: (Multipath Ad-Hoc On Demand Distance Vector Protocol With Path Selection Probability)
3) BGR: (Biased Geographical Routing Protocol.)
4) MSR: (Multipath Source Routing)
5) E2FT: (End 2 End Estimation based fault tolerant)
6) SMR: (Split Multipath Routing)
7) RMSR: (Robust Multipath Source Routing)

i. *AODV (Ad hoc On-Demand Distance Vector)*

a. *AODV description*

The AODV protocol [1] is a reactive routing protocol it is also called as a pure on-demand routing protocol because a mobile node does not have to maintain any routing information if it is not located in an active path. Like DSR, the AODV protocol also consists of two main mechanisms a route discovery and a route maintenance mechanism. But the route request packet (RREQ) structure of the AODV protocol is different from that of the DSR protocol. To detect a fresh or new route from an old route, each node maintains two counters such as node sequence ID and broadcast ID. Each route request (RREQ) packet contains information about the destination sequence number which is used for distinguish from remaining node and the source sequence number in addition to source address and destination address. The sequence numbers are used to indicate the freshness and newness of a route in network. Each neighbor node either sends a reply message called as RREP to a source or it rebroadcasts a request message RREQ to its neighbors depending on whether it is the destination or not. If a node is not the destination, it needs to keep track of a request packet to set up a reverse path as well as a forward path. When a destination replies back to a source, it uses the reverse path. Mobile nodes can determine whether a route is a current one or an old one by comparing the destination sequence number in the RREQ packet with that of the sequence number stored in the route cache. If the route request sequence number is greater than the recorded one, it does not send a reply to the source. Instead, it re-broadcasts that request message. An intermediate node only replies from its route cache if the route request sequence number is less than or equal to the sequence number stored in the route cache. If a node does have a current route, it sends a reply using a unicast route reply packet (RREP). The reply packet travels along the reverse path, which was set up previously. When a reply packet travels back through the reverse path, each intermediate node sets up a forward path to the node from which it receives this reply. When a route reply packet reaches the source, the source starts sending data packets to the destination using the discovered path. If that source learns more routes later on, it updates its route cache accordingly.

b. *AODV Properties*

- Floods RREQs with unique IDs so duplicates can be discarded.
- Each node maintains backup route(s) in alternative route table.
- Distance-vector protocol so only destination, next hop and number of hops known.
- Alternative route (backup) route(s) or other routes which are discovered while route discovery used when primary fails.

- No multiple complete routes available.
- Alternative route(s) determined in RREP phase.
- Alternative route(s) by overhearing RREPs to other nodes.
- No complete route(s) information known at source.

ii. *Fresnel zone routing (FZR)*

FZR is a multipath routing protocol which supports congestion control. It classifies intermediate nodes according to their capacity and efficiency in forwarding packets. FZR protocol is a combination of both proactive and reactive routing protocols. FZR [10] can lighten congestion at an intermediate node and achieve better transport layer throughput. In FZR path hop count which is nothing but the shorter distance traveled by the packet so the hop count is used for zone construction. In FZR [10], each node maintains a distance table; the table consists of the fields: destination address, sequence number and hop distance. To construct and maintain these tables, a mobile node broadcasts Hello messages. Upon receiving a Hello message, a node updates its own table. When a distance table is propagated throughout the network, each node updates its distance table and the first order paths are discovered. FZR [10] discovers alternate second order path with an on-demand approach. A source node or an intermediate node located in the first zone initiates the route discovery process. When a neighbor located in the second zone receives a request packet, it sends a reply message to the originating node via the upstream neighbors. The upstream nodes then record the forward path in the table and forward the reply messages to the originator. Upon receiving a reply massage, the originator records the path in the forward path table and this procedure repeats itself until message packet received at destination. Then data is transferred on this path.

iii. *Ad hoc On-demand Multipath Distance Vector routing (AOMDV)*

a. *AOMDV description*

The AOMDV uses the basic AODV route construction process. In this case, some extensions are made to create multiple link-disjoint paths. The main idea in AOMDV is to compute multiple paths during route discovery. It consists of two components:

- A route update rule to establish and maintain multiple loop-free paths at each node.
- A distributed protocol to find link-disjoint paths.

Before describing AOMDV [8], we first discuss AODV, from which it is derived. In AODV, when a source needs a route to a destination, it initiates a route discovery process by flooding a RREQ for destination throughout the network. RREQs should be uniquely identified by a sequence number so that duplicates can be recognized and discarded. Upon receiving a non-duplicate RREQ, an intermediate node records previous hop and checks whether there is a valid and fresh route entry to the destination in routing table. If such entry is found, the node sends back a RREP to the source; if not it rebroadcasts the RREQ message. A node updates its routing information and propagates the RREP upon receiving further RREPs only if a RREP contains either a larger destination sequence number or a shorter route found.

In AOMDV [8] each RREQ, respectively RREP arriving at a node defines an alternate path to the source or destination. Just accepting all such copies will lead to the formation of routing loops. In order to eliminate any possibility of loops, the "advertised hop count" is introduced. The *advertised hopcount* of a node *i* for a destination node *d* represents the maximum hopcount of the multiple paths for node *d* available at *i*. The protocol only accepts alternate routes with hopcount lower than the advertised hop count, alternate routes with higher or the same hopcount are discarded. The advertised hop count mechanism establishes multiple loop-free paths at every node. These paths still need to be disjoint. For this we use the following:

When a node *S* floods a RREQ packet in the network, each RREQ arriving at node *I* via a different neighbor of *S,* or *S* itself, defines a node-disjoint path from *I* to *S*.

In AOMDV this is used at the intermediate nodes. Duplicate copies of a RREQ are not immediately discarded. Each packet is examined to see if it provides a node-disjoint path to the source. For node-disjoint paths all RREQs need to arrive via different neighbors of the source. This is verified with the *first hop* field in the RREQ packet and the *firsthop_list* for the RREQ packets at the node.

At the destination a slightly different approach is used, the paths determined there are link-disjoint, not node-disjoint. In order to do this, the destination replies up to k copies of the RREQ, regardless of the firsthops. The RREQs only need to arrive via unique neighbors.

AOMDV properties

- Extension of AODV.
- RREQs from different neighbors of the source are accepted at intermediate nodes.
- Multiple link-disjoint routes are created (with modification at the destination they can be node-disjoint).
- Maximum hop count to each destination ("advertised hop count") is used to avoid loops.
- Multiple routes are established in single route discovery process.
- Nodes maintain next-hop info for destinations (multiple next-hops possible).

iv. *Multipath AODV with Path Selection Probability (AODV-PSP)*

a. *AODV-PSP description*

The AODVM-PSP protocol is an extension of AODVM protocol discussed earlier. The route discovery mechanism of AODVM-PSP [11] is similar to that of the AODV protocol. The multiple paths are set up in a similar manner as that of the AODVM protocol.

The main difference between AODVM-PSP and AODVM [11] is that AODV-PSP considers delays along a path while making a routing decision. When a node sends a packet to a destination, the packet includes information as to what time (concept of timestamp) it was transmitted. An intermediate node or a destination node can estimate the delay based on the information included in the packet. The AODVM-PSP does not especially find link- disjointed paths unlike the AODVM [11] protocol. The AODVM-PSP [11] does not use keep alive packet like the AODVM protocol to avoid the congestion. The RSR protocol is based on a disparity routing scheme. In a disparity routing scheme, a message is partitioned or divided in small parts and sent over different paths. The idea is that if a path fails, there is still a chance for other paths to send a packet successfully to a destination. Disparity routing can be broadly classified into two types:

Non-redundant and redundant. In non-redundant disparity routing, a message is divided into sub-messages and these sub-messages are routed through different paths. In redundant disparity routing, a message is also divided into sub-messages, but the number of sub-messages is less than the number of discovered paths that the routing protocol uses. The traffic dispersion on different paths is done in a round-robin fashion where each path has a constant weight of one packet. If no other alternate path is available, RSR performs similarly as DSR. In the destination node, RSR has an agent named duplicate packet filter (DPF) at the destination r. The function of DPF is to filter out the duplicate packets. Moreover, when there is no intermediate node between a source and a destination, PDA does not duplicate a message. PDA also does not duplicate a packet if there is only one route available between a source and a destination.

v. *Biased geographical routing (BGR) protocol*

The BGR [11] protocol improves the delay performance of a network by using the congestion in formation of a network. The main idea behind the BGR protocol is to insert a bias angle in each packet. This bias angle determines the route of a path towards a destination. The BGR protocol uses two congestion control algorithms, namely in-network packet splitter (IPS) and end-to-end packet scatter (EPS). The IPS splits traffic flows to avoid congestion. Congestion arises when too many connections are set up through a certain section of a network (i.e. hot-spot). In order to avoid a hot-spot, the IPS splits the traffic flow just before the hot-spot. The IPS requires periodic information (congestion information) exchanges among neighbors. If IPS fails to reduce congestion, the EPS algorithm is activated. In the case of EPS algorithm, a source splits traffic flows among multiple paths, therefore, reduces congestion.

IV. Conclusion

Multipath routing can improve network performance in terms of delay, throughput and reliability. Multi path routing protocols also improve load distribution, reliability, delay and energy efficiency. AODVM-PSP (Ad hoc on demand distance vector routing with path selection probability) considers delays along the path while making routing decision. The ability to forward traffic on multiple paths would be useful for customizing paths for different applications, improving reliability, and balancing load. Due to scalability and economic.

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