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Reliable Routing Protocols for Congestion Control in MANET

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ABSTRACT: In this paper, we consider the problem of congestion control in mobile ad-hoc networks(MANETs). A mobile ad-hoc network is a collection of mobile nodes forming an ad-hoc network without the assistance of any centralized structures. Due to link failure and node failure, packets can be loss. The nodes are limited to send and receive information but do not route anything across the network. To overcome these, we propose an adaptive reliable and congestion control routing protocol to resolve congestion and route errors in MANETs. The congestion is detected on the basis of utilization and capacity of link and paths. Also, destination node might be out of range of a source node transferring packets; so there is need of a routing procedure. This is always ready to find a path so as to forward the packets appropriately between the source and the destination. When a source node detects congestion on a link, it distributes traffic over alternative paths using a traffic splitting function. If a node cannot resolve the congestion, it signals its neighbours. By using simulation, we show that the proposed protocol is reliable and achieves more throughputs with reduced packet drops and overhead.

KEYWORDS: MANET; Routing Protocol; congestion; congestion control.

I. INTRODUCTION

Congestion refers to a network state where a node or link carries so much data that it may deteriorate network service quality, resulting in queuing delay, frame or data packet loss and the blocking of new connections. In a congested network, response time slows with reduced network throughput. Network congestion is the term where the source and destination nodes (source and destination computers for example) "over-pump", i.e. send and receive more data packets than they are supposed to. Data packets are forwarded from the source to the destination via routers and routers store the packets in buffers. Due to over pumping of packets, these buffers overflow which leads to packet loss. This can delay the delivery of other network packets. This phenomenon is called congestion.

1.1 Congestion control in MANET

In Ad-hoc networks, there is no fixed infrastructure and no separate network elements called as routers and so, the mobile nodes themselves act as the routers, that is, they are responsible for routing the packets.

1.2 Classification of Routing Protocols in MANETs

Types of routing protocols in MANET can be done in many different ways, but most of these are done depending on routing strategy as well as network structure. The protocols can be classified as flat routing; hierarchical routing and geographic position assisted routing depending on the network structure. According to the routing strategy protocols can be classified as Table-driven and source initiated. The classification is shown in the fig 1.1

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Classification of Routing Protocols

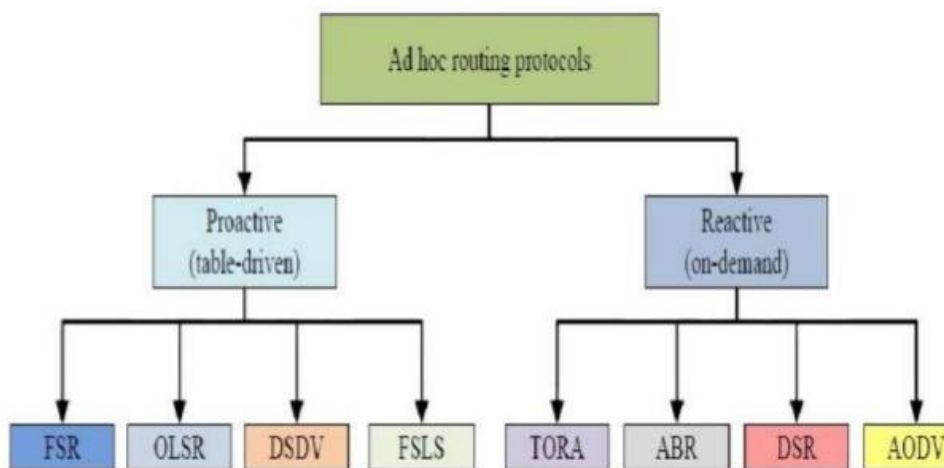


Figure.1.1 Classification of Routing Protocol

1.2.1 Pro-Active or Table Driven Protocols:

Proactive protocols are also called as table-driven protocols and will actively determine the layout of the n/w. And, hence, minimal delay in determining the route is to be taken. Proactive MANET protocols work better in networks that have low nodemobility or where the nodes transmit data frequently. Proactive Protocols are classified as:

- Optimized Link State Routing (OLSR)
- Fish-eye State Routing (FSR)
- Destination-Sequenced Distance Vector (DSDV)
- Cluster-head Gateway Switch Routing Protocol (CGSR)

1.2.2 Reactive i.e On Demand protocols:

Portable nodes- Notebooks, palmtops or even mobile phones usually consist of wireless ad-hoc networks. This brings a significant issue of mobility. The mobility causes the topology of the network to change constantly. On Demand protocols start to set up routes on-demand. This kind of routing protocols is usually based on flooding the network with Route Request (i.e. RREQ) and Route reply (RRP) messages. Such type of protocol is usually very effective on single-rate networks. It usually decreases the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path.

The different types of Reactive protocols are:

- Ad hoc On Demand Distance Vector (AODV)
- Dynamic Source routing protocol (DSR)
- Temporally ordered routing algorithm (TORA)
- Associativity based routing (ABR)
- Signal Stability-Based Adaptive Routing (SSA)
- Location-Aided Routing Protocol (LAR)

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Ad-hoc On-demand Distance-Vector Routing (i.e.AODV)

Ad hoc On Demand Distance Vector routing is a routing protocol for mobile ad-hoc networks and other wireless ad-hoc networks. It is developed in Nokia Research Centre of University of California, Santa Barbara and University of Cincinnati. Ad hoc On Demand Distance Vector has the ability of both unicast and multicast routing. Ad hoc On Demand Distance Vector mainly gives 3 types of control messages for route maintenance as follows:

RREQ-A route request message is transmitted by node requiring a route to node. As an optimization Ad hoc On Demand Distance Vector makes use of an expanding ring technique. Every route request carries a TTL value that states for how many hops message should be forwarded. Retransmission occurs if no replies are received. Data packets waiting to be.

RREP-A Route Reply message is unicast back to the originator of a route request, if the receiver is either the node using the requested address or it has a valid route to the requested address. The reason one can unicast such type of message back, is that every route forwarding a route request caches a route back to the originator.

RERR- Here, nodes look after the link status of next hops in active routes. When a link breakage in an active route is found, an error message is used to notify other nodes of the link. Instead of enabling this type of reporting mechanism, every node keeps a 'precursor-list' that contains the Internet Protocol address for each of its neighbours which are likely to use it as a next hop towards every destination.

1.2.3 Dynamic Source Routing (i.e. DSR)

Dynamic source routing protocol is on-demand, source routing protocol, where-by all the routing data is maintained (continuously updated) at mobile nodes. This type of protocol composes of 2 main mechanisms of 'Route Discovery' and 'Route Maintenance'. The major difference between this and the other on-demand routing protocols is that it is beaconless and hence, does not have necessity of periodic hello packet (beacon) transmissions, which are used by a node to inform its neighbours of its presence. The fundamental approach of this protocol during the route creation phase is to launch a route by flooding Route-Request packets in the network. The destination node, on getting a Route-Request packet, responds by transferring a Route-reply packet back to the source, that carries the route traversed by the Route-Request packet received.

A destination node, after receiving the first Route-Request packet, replies to the source node through the reverse path the Route-Request packet had traversed.

1.2.4 Destination Sequenced Distance Vector (i.e.DSDV)

Destination Sequenced Distance Vector is one of the most well-known table-driven routing algorithms for mobile networks. It comes under distance vector protocol. In distance vector protocols, each node i maintains for each destination x , a set of distances $\{d_{ij}(x)\}$ for each node j i.e. a neighbour of i . Node i treats neighbour k as a next hop for a packet destined to x if $d_{ik}(x)$ equals $\min_j\{d_{ij}(x)\}$. The distance vector algorithm described above is a classical Distributed Bellman-Ford algorithm.

II. RELATED WORK

In this paper [1], they have presented a Cluster Based Congestion Control (CBCC) protocol which consists of scalable and distributed cluster-based mechanisms for supporting congestion control in ad-hoc network, that is based on the self organization of the network into clusters. The protocol consists of clustering mechanism, traffic rate estimation and traffic rate adjustment. By extensive simulation, it showed that CBCC protocol is highly efficient in dealing multiple flows by achieving good delivery ratio and throughput with low delay.

In this paper [2], they proposed a spatial reusability-aware single-path routing (SASR) and any path routing (SAAR) protocols, and compare them with existing single-path routing and any-path routing protocols, respectively. Their

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results showed that the protocols they have used improve the end-to-end throughput compared with the existing protocols. For single-path routing, their median throughput gain is up to 60 percent and for any path, the maximum per-flow throughput gain is 71.6 percent.

In this paper [3], Congestion is detected according to the utilization and capacity of link and paths. When the link failure occurs, the upstream node with the cached data in its buffer can retransmit it through the next reliable link by using a bypass route. An adaptive reliable and congestion control routing protocol is proposed to resolve congestion and route errors using bypass route selection in MANETs and achieves more throughput with reduced packet drops.

In this paper [4], the problem of jointly performing scheduling and congestion control in mobile adhoc networks has been studied so that network queues remain bounded and the resulting flow rates satisfy an associated network utility maximization problem. Also, it addresses the issues of wireless Greedy Primal Dual (wGPD) algorithm for combined congestion control and its associated signaling with minimal disruption.

In this paper [5], the issue on a Stable Weight-Based on-demand Reliable Routing Method (WBRR) for MANETs have been discussed since, high mobility of mobile nodes is a major reason for link failures. The ability to increase packet delivery rate is defined and uses the weight-based route strategy to select a stable route in order to enhance system performance.

In this paper [6], Genetic Algorithm is used to determine the optimal multicast routing satisfying the quality of service requirements such as total delay, total delay jitter, packet loss and total bandwidth. A multi-constrained QoS multicast routing method is being proposed using the genetic algorithm.

III. PROPOSED WORK

Routing protocol using combined link stability estimation

3.1 Measuring the signal strength

The received signal strength in cross layer design can be calculated at the physical layer, and it is accessed at the top layers. The procedures at the physical layers have to be modified in order to reassign the measured value of received signal strength to the MAC layer along with the signal [10]. When a sending node transmits RTS (Ready to Send) packet, it attaches its transmission power level. The receiving node measures the signal strength received for free-space propagation model while receiving the RTS packet [10].

$$P_r = P_t (\lambda / 4\pi d)^2 G_t G_r \quad (1)$$

where k is the wavelength of carrier, d is distance between sender and receiver, P_r and P_t are the receiving power and transmitting power, respectively. G_t and G_r are unity gain of transmitting and receiving omni-directional antennas, respectively.

3.2 Route expiration time (RET)

The RET is the minimum time selected from a set of link expiration times (LETs) designed for the feasible path. LET [9] is the period of link connectivity between two nodes. So, the minimum value of LET is attained in each path and the maximum number of RET, which represents that the more reliable routing path, is selected.

$$RET_i = \text{Min}(LET_{si}) \quad (2)$$

Thus, the RET is the minimum value among LETs of the feasible path. The principle of LET is to estimate future disconnection time with the help of two neighbours in motion. This can be achieved by using the following method. A global positioning system (GPS) can determine the motion parameters of two neighbouring nodes. The following

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assumptions are made: a free space propagation model whose signal strength solely depends on the distance to the transmitter, and all nodes have their clocks synchronized using the GPS clock. Given a prediction T_p on the continuously available time for an active link between two nodes at time t_0 , the availability of this link, $L(T_p)$, is defined as

$$L(T_p) = P\{\text{to stay valid to } t_0 + T_p | \text{Available at } t_0\}$$

Indicating the probability that the link will be continuously available from time t_0 to T_p . The calculation of $L(T_p)$ can be divided into two parts:

the link availability when the velocities of the two nodes stayed unchanged between t_0 and $t_0 + T_p$, $L_1(T_p)$, and the one for the other cases, $L_2(T_p)$. That is,

$$L(T_p) = L_1(T_p) + L_2(T_p) \quad (3)$$

It is easy to calculate $L_1(T_p)$, which is equal to the probability that the epochs from t_0 onwards for the two nodes are longer than T_p , because T_p is an accurate prediction if the movements of the two nodes remain unchanged. Since nodes' movements are independent of each other, and the exponential distribution is 'memoryless,' $L_1(T_p)$ is given by

$$L_1(T_p) = [1 - E(T_p)]^2 e^{-2\lambda T_p} \quad (4)$$

However, it is difficult to give an accurate calculation for $L_2(T_p)$ because of the difficulties in learning about the changes in link status that are caused by changes in a node's movement.

3.3 Node's remaining energy

It is assumed that all nodes are equipped with a residual power detection device and know their physical node position. The transmitting energy for a packet can be computed as

$$Energy_{tx} = P_{size} * Power_{tx} / LBW \quad (5)$$

Where P_{size} is the data packet size, $Power_{tx}$ is the packet transmitting power, and LBW is the wireless link bandwidth. When a mobile node performs power control during packet transmission, the transmitting energy for one packet relative to the node distance is given as

$$Energy_{tx} = kd^\alpha \quad (6)$$

where k is the proportionality constant, d is the distance between the two neighbouring nodes, and α is a parameter that depends on the physical environment (generally between 2 and 4). For calculating the shorter distance between the transmitter and the receiver, the smaller amount of energy is required. At each node, the total required energy is given by

$$Energy_{tot} = p * (Energy_{tx} + Energy_{pro}) \quad (7)$$

where p is the number of packets. The energy required for packet processing ($Energy_{pro}$) is much smaller than that required for packet transmitting. The node remaining energy or the residual energy is the energy left after the packet transmission (i.e.) residual energy $Energy_{res}$ is given by

$$Energy_{res} = Energy_{initial} - Energy_{tot} \quad (8)$$

3.4 Node velocity

Consider a node N_1 which can always communicate with another node N_2 until it reaches position p_3 , which is at a distance R from N_1 , where R is the transmission range of each node. We also define $T_p = T_{p1p3}$, where T_{p1p3} is the

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time taken by node N1 to move from p_1 to p_3 . Knowing T_p , the probability that a link is available during the time period of T_p can be calculated. Assume that random walk-based mobility model defines the movement of a node. Thus, the epoch length of every node is exponentially disseminated with mean $k-1$. The route is evenly distributed over $[0, 2p]$ and the speed is also uniformly distributed in a known range. A conservative prediction of the link being available in the time period of T_p is given based on the assumptions above as in [7]

$$L_2(T_p) = 1 - e^{-2\lambda T_p} / 2\lambda T_p + \lambda T_p e^{-2\lambda T_p} / 2$$

A metric is needed to reflect this aspect and whose values should lie in the range $[0, 1]$ for accounting the reliability of a link while selecting routes. It is impossible to combine the $L(T_p)$ of each link along a path for estimating the path availability, because each link has a different T_p . The term $T_p * L(T_p)$ is used in the place of $L(T_p)$ which is an evaluation of average available time of a link. We can restrict our interest in the estimation within T_r , by assuming that estimation will be carried out regularly with period T_r . The ratio of $T_p * L(T_p)$ to T_r is very much concerned. A new routing metric is developed based on the above reasoning which is referred to as normalized link availability (LA_N). It can be defined as follows [7]:

$$LA_N = \min[T_p * L_2(T_p) / T_r, 1] \tag{10}$$

3.5 Combined metric

Finally, the combined metric for finding the link lifetime is given by

$$CRM = P_R + L_1(T_p) + Energy_{res} + LA_N \tag{11}$$

The node status is adaptively determined based on the value of CRM as given below.

Node status is Green, if $CRM_{min} < CRM < CRM_{max}$

Node status is yellow, if $CRM = CRM_{min}$

Node status is red, if $CRM < CRM_{min}$

where CRM_{min} and CRM_{max} are the maximum and minimum combined routing metric values. Then, Bypass Route Discovery is performed as described in our previous work [8].

IV. ALGORITHMS

4.1 Multipath construction:

Consider the network as a directed graph $G = (V, E)$, where V denotes the set of nodes and E represents the set of links or edges. In our technique, we propose to find multiple paths in terms of shortest and disjoint paths.

4.1.1 Shortest paths

The shortest path discovery algorithm discovers exclusive shortest paths from source S to destination D . Let sP_{sd} be the shortest paths between nodes S and D . Let N_s be the neighbour set of node S . Then, the alternative shortest paths can be estimated by using the formula,

$$sP_{sd}^{s-1} = \{S\} + sP_{s-1,d} \tag{12}$$

Where, $s-1$ is the neighbour node of S and $_$ stands for concatenation of two finite sub paths. The shortest paths $sP_{s-1,d}$ starts at node S and connects destination D through neighbour node $s-1$. However, this technique of finding alternate paths through neighbouring nodes may bring in the problem of routing loop. To ensure the constructed shortest routes are loop-free, sP_{sd} must guarantee that it does not contain S as an intermediate node. Thus, any shortest path must prove the condition given in Algorithm-1.

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Algorithm-1

Assumption: S and D as the source and destination nodes, respectively

sP_{sd} be the set of shortest paths between nodes S and D

1. If $S \in \text{nodes}(sP_{s-1,d})$ then

2. The alternate paths sP_{sd}^{s-1}

will be loop free

3. Else

4. The alternate path sP_{sd}^{s-1}

will be routing loop path

5. End if

The computed alternate paths from node S and D are kept in the set $A_{s,d}$. Paths that are included in set $A_{s,d}$ can be represented as,

$$A_{s,d} = \{sP_{sd}^{s-1} : s-1 \in N_S, S \in sP_{sd}^{s-1}\} \quad (13)$$

Thus, the set $A_{s,d}$ contains multiple alternate paths that connect S and D.

4.2 Disjoint paths

To make multipath routing efficient and consistent, it must satisfy the criteria of disjoint paths. In $A_{s,d}$, any two paths can be disjoint if and only if it solves the following conditions.

Algorithm-2

Assumption: Let S and D denotes the source and destination nodes respectively

Let sP_{sd}^{s-1} and sP_{sd}^{s-2} be two paths in the alternate path set $A_{s,d}$

1. Find common nodes in sP_{sd}^{s-1} and sP_{sd}^{s-2}

2. If the only common nodes are S and D then

3. The paths will be disjoint paths

4. Else if it has common nodes other than S and D then

5. The paths will be interconnected paths

6. End if

Thus, disjoint paths between S and D can be given as, $D_{s,d} = \{sP_{sd}\} \cup A_{s,d}$

4.3 Conjoint-c paths:

In this approach, multiple paths are generated by defining a set cP_{sd} . It includes the paths that contain more conjoint (common) links. Let P1 and P2 be two paths, these paths can be added to the set cP_{sd} if it satisfies the following condition,

$$|l(P1) \cap l(P2)| \leq c \quad (15)$$

Where l stands for links and c represents common links. We can define the set cP_{sd} at various levels,

At Conjoint level-0, the conjoint set cP_{sd} contains disjoint paths that connect S and D

At Conjoint level-1, cP_{sd} encompass paths that has at least a common link

At Conjoint level-c, cP_{sd} set contain paths with c common links

Finally, the conjoint property can be defined as,

$$cP_{sd}^{c=0} \subset cP_{sd}^{c=1} \subset \dots \subset cP_{sd}^{c=c} \subset cP_{sd} \quad (16)$$

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The algorithm for generating cP_{sd} set is given below in Algorithm-3

Algorithm-3

1. Initialize cP_{sd} to sP_{sd}
2. Paths in $A_{s,d}$ are arranged in ascending order of their path length
3. Further paths for the set Initialize cP_{sd} is selected from the set $A_{s,d}$
4. While ($A_{s,d} \neq 0$) do
5. Find out shortest path sp in $A_{s,d}$
6. Remove sp from $A_{s,d}$
7. Break
8. Check path sp against all paths in $A_{s,d}$
9. Check whether it satisfies conjoint condition (equation-15)
10. If sp satisfies condition (equation-15) for all paths in cP_{sd} then
11. Add sp to the set cP_{sd}
12. End

V. CONCLUSION

In this paper, techniques to resolve congestion have been proposed using route selection. When a node detects congestion on outgoing link L, it calculates the multipath routes to destinations. Traffic to the node is then shifted to alternative paths. The main aim is to minimize the utilization by shifting a portion of the traffic to the alternative paths. A node calculates a set of alternative paths and distributes the traffic. The proposed technique is reliable and achieves more throughput with reduced packet drop. TCP shows a consistent performance for all three routing protocols as an average. DSR is not good for high mobility and high number of nodes. We hope this will be of some use in future study in this area helping the growing interest and resulting in the required protocol for today's high demanding world.

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