Packet loss in k-path routing and single shortest path routing in MANET

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Abstract—When we talk about ad hoc network, then it is quite obvious that nodes are not steady and there is no fixed static architecture. Routing is a very important factor in mobile ad hoc network which enables MANET not only to work well with a small size network, but also to work well with dynamically expanded huge network. This paper studies the possibility of packet loss and congestion in k- path routing and single shortest path routing in MANET.

Keywords-k-path routing, Congestion Control, packet loss probability.

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]. The movement of nodes is random in MANET. Therefore MANETs have a dynamic topology. There are lots of issues and challenges in designing a MANET network .In MANET each node acts as a trans-receiver, a router, which helps in forwarding packets from a source to destination. MANET nodes can be personal devices such as lap-top, mobile phones and personal digital assistant.MANET can change locations and configure itself. Mobile ad hoc networks are suited for use in situations where an infrastructure is unavailable .Application area of MANET includes military applications, at local level such as classrooms, conference, emergency operations, business applications and also used in VANET (Vehicular Ad hoc network)[3,4 and 5]. Figure 1.0 shows a simple mobile ad hoc network.

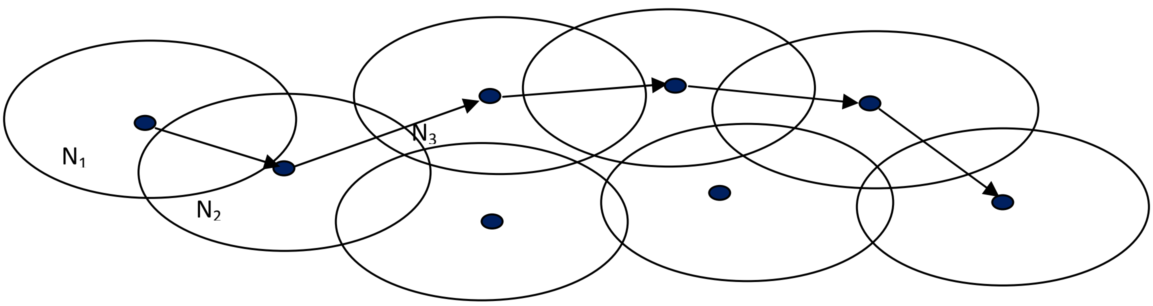


Figure 1.0 Simple Mobile ad-hoc network

1.1. Congestion in MANET:

Congestion is a situation in communication networks in which too many packets are present in a part of the subnet. Congestion may occur when number of packets send to the network is greater than the capacity of the network (number of packets a network can handle). Congestion leads to packet losses and bandwidth degradation and waste of time and energy .In Internet when congestion occurs it is normally concentrated on a single router, whereas, due to the shared medium of the MANET congestion will not over-load the mobile nodes but has an effect on the entire coverage area [6, 7].When the routing protocols in MANET are not conscious about the congestion, it results in the following issues

Long delay:This holds up the process of detecting the congestion. When the congestion is more rigorous, it is better to select an alternate path.

High overhead:More processing and communication attempts are required for a new route discovery. If the multipath routing is utilized, it needs additional effort for upholding the multipath regardless of the existence of alternate route.
Packet losses: The congestion control technique attempts to minimize the excess load in the network by either reducing the sending rate at the sender side or by dropping the packets at the intermediate nodes or by executing both the process. This causes increased packet loss rate or minimum throughput [8, 9 and 10]

II. PROBLEM DEFINITION:

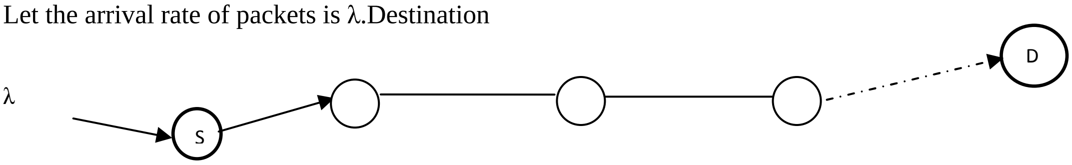
This paper compares both the scheme of single path routing and k path splittable routing in MANET. In MANETs communication between nodes is done through the wireless medium. Because nodes are mobile and may join or leave the network so MANET have a dynamic topology. Nodes that are in transmission range of each other are called neighbors. The neighbors can send data directly to each other however when a node needs to send data to another non neighboring node the data is routed through a sequence of multiple hops, with intermediate nodes acting as routers [11, 12]. As a result of these issues, MANETs are prone to numerous types of faults which includes

i) Transmission error ii) Node failures iii) Link failures iv) Route breakages v) Congested node

2.1Single shortest path routing:

In single shortest path routing only a single shortest route is used between source and destination node. In MANET, single shortest path routing is not an effective routing technique specially when there are many constraints. Single path routing sends entire traffic via a single route from source to destination. In MANET, the link capacity(bandwidth) ,the memory and processing power of the nodes are limited so that they cannot handle high amount of traffic, which generally leads to congestion ,packet loss , formation of hot spots in the network. As a consequences the end to end delay and unreliability of the network increases. In single path routing, if a link breaks or a node fails it leads to the network failure, i.e. no transmission occurs between source S and destination D. [13]

Let the arrival rate of packets is λ.Destination



Source Figure1.1: Single-path Routing

III. PACKET LOSS IN SINGLE SHORTEST -PATH ROUTING:

Packet losses are caused by either link errors or network congestion. First, letus derive the expression for packet loss due to link errors. Let the probability of packetloss on a link is p, the probability of successfully transmitting a packet on a link is (1−p). Apacket must be successfully transmitted over all N_l links along the route to reach thedestination. Therefore, the probability of successfully transmitting a packet over N_l links from the source to the destination is

$$p_{ssucc} = \{(1-p)\,.(1-p)\,.....(1-p)\}_{Nl\ times}$$ // using Multiplicative rule of Probability //

$$p_{ssucc} = (1-p)^{N_l} \quad \ldots (1.1)$$

Thus, the probability of packet loss on a route is:

$$P_{sloss} = 1-(1-p)^{N_l} \quad \ldots (1.2)$$

Let us now derive the formula for the probability of packet loss due to congestion. Let us assume that the queue length for a node in the network is Ql, for a $M\ /\ M\ /1:\ FIFO\ /\ Q_l\ /\ \infty$ queue.

The probability of having n packets in the queue is:

$$p_n = \frac{(1-\rho)\rho^n}{(1-\rho^{Ql+1})} \quad \ldots (1.3)$$

Where $\rho = \lambda / \mu$ is the traffic density,

Packets are dropped when the queue is full (n=Q_l). Therefore, the probability of a packet lossdue to congestion is:

$$p_{Ql} = \frac{(1-\rho)\rho^{Q_l}}{(1-\rho^{Ql_{+1}})} \quad \ldots (1.4)$$

Therefore, the net probability p_{snloss} of packet loss is:

$$p_{snloss} = p_{sloss} + p_{Ql}$$

$$p_{snloss} = 1-(1-p)^{Nl} + \frac{(1-\rho)\rho^{Ql}}{(1-\rho^{Ql+1})} \quad \ldots (1.5)$$

IV. K-PATH ROUTING IN MANET:

Splitting the traffic to different routes can provide better load balancing, fault tolerance and higher aggregate bandwidth. Splitting of the traffic can be helpful in reduction of congestion, bottle necks and minimization of the mean system delay; this also improves network resource utilization and bandwidth optimization [11, 13].

4.1 Network model for k-splittable routing:

The single-path model is considered as a multi-node $M / M / 1: FIFO / Q_l / \infty$ tandem network, and the k-path model as a set of k- parallel path. The proposed framework allows us to investigate issues such as optimal load distribution, end-to-end delay and k- path routing reliability in ad hoc networks. There are k node, link disjointed paths, which forms a sub graph in existing network. This sub graph is approximately a rectangular region, its size depend on source destination separation and the node density. To model each multi-hop path, a multi node $M / M / 1: FIFO / Q_l / \infty$ tandem network is considered [14, 15 and 16].

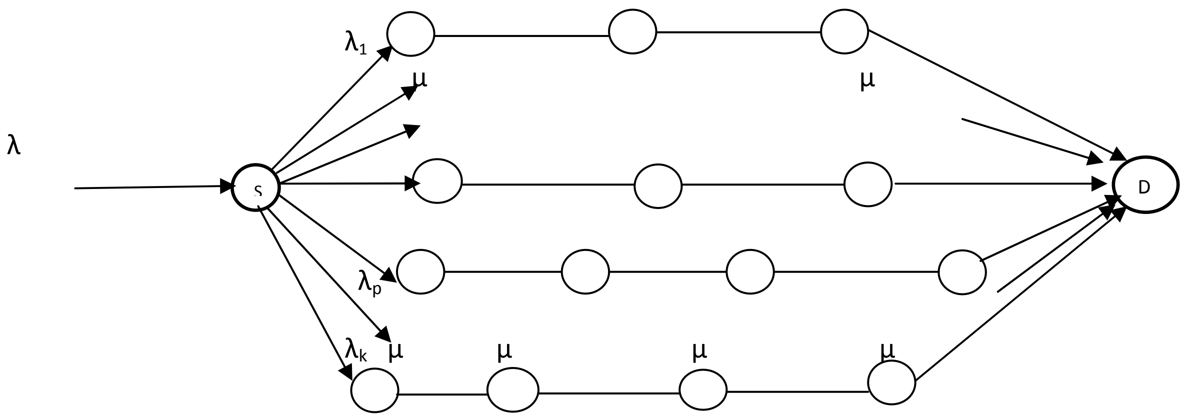


Figure 1.2: Multi-hop, M/M/1, with input arrivaland processing rate

Let there are k paths between source S and destination D, Assuming a path $p(p = 1,2--k)$ consists of I_p intermediate relaying node .the role of intermediate nodes is just to forward the traffic to the another node in the direction of destination.

Let μ is the processing power of each node. Since λ is the forwarding traffic therefore ignoring the mean system delay, all the divided traffic will reach to the destination at the same time.So the arrival rate at destination will remain λ.

Suppose a traffic flow with average passion arrival rate λ exist between source and destination, this traffic is then splitted in k-node disjointed paths, let the traffic along path p is $\lambda_{p}, \left(p = 1,2,---,k\right)$.

$\sum_{p=1}^{k} \lambda_{p} = \lambda$ … (1.6)

Each route will behave like a single path from source S to destination D.Thus probability of successful transmission of packet will be,

$p_{ksucc} = (1-p)^{Nl1}$, for route 1, $N_{l1}$are the number of links where p_{ksucc} is probability in case of successful transmission.

Since there are k routes thensimilarly we have

$p_{ksucc} = (1-p)^{Nl2}$,for route 2,---- , for route k, $p_{ksucc} = (1-p)^{Nlk}$

So probability of no link error on all the routes

$$= \{(1-p)^{Nl1}.(1-p)^{Nl2}.......(1-p)^{Nlk}\}$$

So probability of Packet loss due to link error

$$p_{klloss} = 1 - \{(1-p)^{Nl1}.(1-p)^{Nl2}.......(1-p)^{Nlk}\} = 1 - \prod_{i=1}^{k} (1-p)^{Nli} \quad \ldots (1.7)$$

Let us now derive the formula for the probability of packet loss due to congestion. Let usassume that the queue length for a node in the network is Q_l, for a $M/M/1: FIFO/Q_l/\infty$ queue

The probability of having n packets in the queue is:

$$p_n = \frac{(1-\rho)\rho^n}{(1-\rho^{Ql+1})} \quad \ldots (1.8)$$

Where, $\rho = \lambda / \mu$ is the traffic density.

Packets are dropped when the queue is full ($n = Q_l$). Therefore, the probability of a packet lostdue to congestion is:

$$p_{Ql} = \frac{(1-\rho)\rho^{Ql}}{(1-\rho^{Ql+1})} \quad \ldots (1.9)$$

Therefore, the net probability p_{knloss} of packet loss is:

$$p_{knloss} = p_{kloss} + p_{Ql}$$

$$p_{knloss} = \{1 - \prod_{i=1}^{k}(1-p)^{Nli}\} + \frac{(1-\rho)\rho^{Ql}}{(1-\rho^{Ql+1})} \quad \ldots (2.0)$$

V. ANALYSIS OF RESULTS:

The probability of packet loss in asingle shortest route and in ‘k’ disjointed multiple routes are given below

$$p_{snloss} = 1 - (1-p)^{Nl} + \frac{(1-\rho)\rho^{Ql}}{(1-\rho^{Ql+1})}, \qquad p_{knloss} = \{1 - \prod_{i=1}^{k}(1-p)^{Nli}\} + \frac{(1-\rho)\rho^{Ql}}{(1-\rho^{Ql+1})}$$

If we analyze these two, we get that only the first component is different in both the expressions i.e.

$(1-(1-p)^{N_l})$ And $(1-\prod_{i=1}^{k}(1-p)^{N_{l\,i}})$, certainly $N_l = N_{li}$ for some i $\in$(1, 2, --,k).

Thus clearly we have

$$(1-p)^{N_l} > \{(1-p)^{N_{l1}}.(1-p)^{N_{l2}}.......(1-p)^{N_{lk}}\} \text{ i.e. } (1-p)^{N_l} > \prod_{i=1}^{k}(1-p)^{N_{l\,i}}.$$

So we have $\{1-(1-p)^{N_l}\} < \{1-\prod_{i=1}^{k}(1-p)^{N_{l\,i}}\}$ which clearly shows that the packet loss in k-path routing is higher in comparison to single shortest path.

VI. Conclusion:

Splitting the traffic to k -different routes can provide better load balancing, fault tolerance and higher aggregate bandwidth. Splitting of the traffic can be helpful in reduction of congestion, bottle necks and in minimization of the mean system delay. This also improves network resource utilization and bandwidth optimization but in terms of packet loss the scheme does not seems better as in comparison to k-path routing the packet loss probability is less in single source shortest path routing.

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