MATHEMATICAL MODEL TO CONTROL CONGESTION IN MANETS

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ABSTRACT

The Performance of Mobile Ad Hoc Network (MANET) depends upon Routing Protocols and mobility model used. TCP Variants was investigated in order to evaluate the performance of Routing Protocols. TCP Vegas from the variants gives best results. TCP works on transport layer so it is needed to be adapted to specific properties of MANET. End to end throughput was the performance parameter used to evaluate the mathematical model. Congestion in MANET is the new era problem. Here, depending upon the use of routing protocols and the mobility way a mathematical model is made and analysed.

***Keywords*: MANET, TCP Variants, Routing Protocols, Mobility Models.**

I INTRODUCTION

Routing is the task of finding and using paths to direct data flows through a network while optimizing one or more performance measures. This often comes down to a problem of finding minimum cost paths between pairs of source and destination nodes in the network.

Routing protocols have been classified as

- Proactive (Table-driven routing or Source Routing)
- Reactive (On demand or Distributed routing)
- Hybrid schemes (or Hierarchical routing).

1.1 MANET Routing Protocols

Reactive protocols send less control packets than proactive ones when the network topology changes as in MANETs. In Dynamic Source Routing (DSR), each packet transmitted by the source includes the complete path to the destination. Ad hoc on-demand distance vector (AODV) protocol uses a routing table and performs better than DSR, but is more difficult to implement because it uses advanced features like timers, sequence numbers, and promiscuous-mode listening. The dynamic MANET on demand (DYMO) protocol is a considered best as it lies between the low complexity of DSR and the higher performance of AODV.

PROACTIVE (Table Driven)	REACTIVE (On Demand)	HYBRID
DSDV	AODV	ZRP
WRP	DSR	HSR
CGSR	TORA	LANMAR
STAR	ABR	
	CBRP	
	RDMAR	

Table1:MANET Routing Protocols

Note: In all these protocols the adopted metric is the number of hops which are needed to reach the destination node; it is a network layer metric.

II TCP VEGAS

It is proposed by Brakmo and Peterson in 1995. It is a Congestion control algorithm which uses RTT time to measure the network situation. It basically compares the expected efficiency and actual efficiency to decide whether increasing or decreasing the cwnd value.

Vegas use following three modified mechanism to increase delivery throughput and decrease packet loss. [4]

- Modified Slow-Start Mechanism
- New Congestion Avoidance Mechanism
- New Retransmission Mechanism

(a) Modified Slow Start Mechanism

Limited Slow-Start Mechanism.

- To be able to detect and avoid congestion during slow-start, TCP Vegas reduce the increasing rate of cwnd.
- Cwnd is allowed exponential growth only every other RTT. (Doubles the size of cwnd every 2 RTT time while there are no losses).
- In between, the cwnd stayed fixed so a valid comparison of the expected and actual rate can be made.

- When the actual rate falls below the expected rate by a certain amount (γ threshold) – TCP Vegas changes from slow-start mode to linear increase/decrease mode.

- By limiting the maximum increase in the cwnd in a round-trip time, Limited Slow-Start can reduce the number of drops during slow-start, and improve the performance of TCP connections with large congestion windows.

- When Vegas detect there is queuing in network , the queue length exceeds the threshold, γ,and the actual rate falls below the expected rate, TCP Vegas change its state from slow-start mode to congestion avoidance mode, and set cwnd to 7/8 of current value.

(b) Modified Congestion AvoidanceTCP Vegas has another New Congestion Avoidance Mechanism to control the size of cwnd by observing the variation of RTT.

When the sender receives an ACK, Vegas calculate the difference between the expect send rate and the actual send rate.

- Vegas defines two thresholds, α and β, and
  - Diff = Expected sending rate – Actual sending rate.
- where Expected send rate= Window size / Base RTT.
- Actual send rate= (the bytes transmitted between the time that the segment is sent and its ACK is received) / (the Segment's RTT).
- Base RTT is the minimum of all measured RTT, that is updated if the Diff < 0.
- When Diff < α, Vegas increase the cwnd linearly during next RTT, and
- And when Diff > β, Vegas decrease the cwnd linearly during the next RTT.
- But TCP Vegas leaves the cwnd unchanged when α < Diff < β.
- The default value of (α=1 and β=3).

(c) New Retransmission Mechanism

- TCP Vegas improved the Fast retransmit mechanism in order to detect packet loss earlier and retransmit immediately.

- When a duplicate-ACK is received, Vegas checks if the RTT time, which is the difference of the current time and the timestamp recorded for the relevant segment, is greater than the timeout value. If it is, Vegas retransmit the segment immediately without 3 duplicate-ACKs.

- When a non-duplicate ACK is received, if it is the first second one after a transmission, TCP Vegas again checks if the time interval, since the segment was sent is larger, than the time out value. If so, it retransmit the segment.

- TCP Vegas decrease the cwnd if the retransmitted segment was previously sent after the last decrease.

III MANET MOBILITY MODELS

MANET uses these Entity mobility models:

1) Random Walk:-

In this mobility model, Mobile node moves from its current location to a new location by randomly choosing a direction and speed in which to travel.

2) Random Waypoint:-

The Random Waypoint Mobility Model includes pause times between changes in direction and speed. A Mobile node begins by staying in one location for a certain period of time (i.e., a pause time).

Group mobility models for ad hoc networks are:

1) Pursue Mobility Model:-

Given mobility model simulates a moving pattern, in which all the nodes are following the movement pattern of one node.

2) Pursue Smart Mobility Model:-

Pursue Smart Mobility Model is an optimization of Pursue Mobility Model. In Pursue Mobility Model, all the nodes except the pioneer node have to start from the same point from where the pioneer node has started. But in Pursue Smart Mobility Model, all nodes will start from their nearest segment when the pioneer node reached to the segment.

3) Reference Point Group Mobility Model

The Reference Point Group Mobility model represents the random motion of a group of mobile nodes as well as the random motion of each individual MN within the group. Group movements are based upon the path travelled by a logical centre for the group.

IV THE CONGESTION MODEL

Analyzing ad hoc network of n nodes.

Sample space, $a_n=(a_i * a_j)^n$

where: a_i= location of single network node.

a_j= whether node is in range or out of range.

But the two parameters which will remain always random in nature:

- No. of nodes presently connected with network.
- Distance between 2 nodes.

EV ,event, is a subset of sample space a_n.

MEV is subset of $a_{n.}$

Event of MANET can have 2 stages i.e. particular device can be switched ON or switched OFF.

Location of any single network node can be defined as $a_i=[0,t]$.

$a_n= [0,t]^n$.

μ_a is probability of distribution of node.

Because MANET is multi-hop connection (many to many relationship)

$d.\mu_{(0)}$ node= probability of distribution of 1st node.

$d.\mu_{(1)}$ node= probability of distribution of 2nd node.

$d.\mu_{(2)}$ node= probability of distribution of 3rd node.

$d.\mu_{(3)}$ node= probability of distribution of 4th node.

And so on…

Therefore, Mathematical behavior of System is obtained as: $d.\mu_{(n)} = t^{-n}.d^n x$.

r=range of network signal, $r>|x_i-x_j|$

Connectivity of particular device is directly proportional to range, r, but it is inversely proportional to location of network node.

In MANET all nodes are considered equally without any particular node having higher priority over any other node so mathematically it is represented as:

E[A]= (n factorial)* summation of permutation of all devices.

$$E[A]= n! \int_0^1 dx1 \int_{x1}^{1} dx2...... \int_{xn-1}^{1} dxn.F(x); \text{------}\mathbf{\{1\}}$$

4.1 Influence of Interference factor

Two main parameters to evaluate interference are:

(a) Spectral efficiency.(Modulation technique used).

(b) Multiple access technique.

For the clear communication S/N ratio is the judging factor.

But, mathematically, $P_f = S / 1 + N_S$ is determined by modulation technique used.

Where: P_f = performance factor (very good signal)

S= Signal, N_S = Noise

Congestion model is based on:

(a) Geographical Position: Geographical factor of Sender and Receiver is main issue. Mobility model plays the important role.

(b) Statistical Factors:

Here, propagation factors like fading and shadowing are the main issue.

Both these factors are important and affect simultaneously in an uncorrelated manner.

While Fading uses Rayleigh distribution, Shadowing uses normal distribution as signal may be blocked by large hills, mountains and other obstacles.

Mathematically, suppose the signal amplitude is as[without congestion] and signal amplitude is ac[near to congestion].

R=range of network. We need to calculate probability when as will be greater than ac.

Signal strength at non-congested state can be calculated as follows:

Consider a variable y which is Rayleigh distribution with modal value, sigma.

Probability Density Function of this distribution is:

$$P(\gamma) = \left(\frac{\gamma}{\sigma^2}\right) \exp\left(\frac{-\gamma^2}{2\sigma^2}\right) \quad \text{---\{2\}}$$

The probability, P1, such that $a_s >= r_{ac}$ at a given a_c is:

$$P_1 = \int_{ra_c}^{\infty} p(\gamma_s) d\gamma_s \quad \text{------\{3\}}$$

$$P_1 = \exp\left(\frac{-r^2 . \gamma_c{}^2}{2\sigma_s{}^2}\right) \quad \text{-----\{4\}}$$

To obtain probability P2 such that $a_s > r\gamma_c$

For all γ_c, it is essential that we integrate this function over all γ_c, thus

$$P_2 = \int_0^{\sigma} P_1 \underline{p(\gamma_c) dy_c} \quad \text{------\{5\}}$$

Put the value of equations 2,3 and 4 in equation 5 we get,

$$P_2 = \int_0^{\alpha} \left[\exp\left(\frac{-r^2 . y_c{}^2}{2\sigma_s{}^2} \right) \times \right] \left[\left(\frac{\gamma_c}{\sigma_c{}^2} \right) \exp\left(\frac{-\gamma_c{}^2}{2\sigma_c{}^2} \right) \right] dy_1 \qquad \text{---\{6\}}$$

$$= \int_0^{\alpha} \left(\frac{\gamma_c}{\sigma_c{}^2} \right) \exp\left[\left(\frac{-\gamma_c{}^2}{2\sigma_x{}^2} \right) \left[\left(\frac{r^2}{\sigma_s{}^2} \right) + \left(\frac{1}{\sigma_c{}^2} \right) \right] \right] dy_1 \qquad \text{----\{7\}}$$

$$P_2 = \frac{\sigma_s{}^2}{r^2 \sigma_c{}^2 + \sigma_s{}^2} \qquad \text{------\{8\}}$$

REFERENCES

[1] D. Cavin, Y. Sasson, and A. Schieper "*On the accuracy of MANET simulators*" In *Proc. ACM Workshop on Principle of Mobile Computing 02,* pp. 38–43. 2002.

[2] M. Jehan,G.Radhamani T.Kalakumari "*VEGAS: Better Performance Than Other TCP Congestion Control Algorithms on MANETs*" International Journal of Computer Networks (IJCN), Volume (3), Issue (2) , June 2011.

[3] National Tsing hua University,"*wireless ad hoc and sensor networking technologies*", Programme for improving academic excellence of universities.

[4] P. Gupta and P. R. Kumar. *The capacity of wireless networks*. IEEE Trans. Information Theory, 46:, pp 8–404, 2000.

[5] P. Santi and D. M. Blough "*An evaluation of connectivity in mobile wireless ad hoc networks*. In *Proc. IEEE DSN 2002*, pp. 89–98. 2002.

[6] P. Santi and D. M. Blough "*The critical transmitting range for connectivity in sparse wireless ad hoc networks"* IEEE Trans. Mobile Computing, 2: pp 25–39,2003.

[7] P. Santi, D. M. Blough, and F. Vainstein. "*A probabilistic analysis for the range assignment problem in ad hoc networks*", In *Proc. ACM MobiHoc 01*, pp.212–220. 2001.

[8] S. R. Biradar, Subir Kumar Sarkar , Puttama dappa C "A Comparison of the TCP Variants Performance over different Routing Protocols on Mobile Ad Hoc Networks" *(IJCSE) International Journal on Computer Science and Engineering* Vol. 02, pp 340-344, 2010.

[9] T. Camp, J. Boleng, and V. Davies," *A survey of mobility models for ad hocnetwork research*". Wireless Communication in Mobile. Computing, 2(5):pp.483–502, 2002.