Optimization Technique for Approximate High Impact of Node Density for Two Hop Relay Manets

Meerasharif Sheik, Bobba Basaveswara Rao

Abstract: ***Networking system is fast growing field in the world. Daily lot of changes, improving and sophisticated devices are invented. Investigation on impact of node density on the two Hop Relay Mobile Ad Hoc Networks performance under limited buffer constraint is improved. To achieve this objective per node throughput and end to end delay are considered as performance metrics. The optimal parameters of packet generating probability, source buffer, relay buffer and routing control parameter are considered to study the dynamic nature of node density for fixed area of a MANET. The optimal node density is calibrated numerically when the throughput is maximized. The supporting experimentation is presented and drawn conclusions. The optimization technique will reveal the impact of node density for two hop relay MANETs and also identifies the dynamic behavior of the system for better performance of the network. The Strong recommendation of the technique is to strengthen the system.***

Index Terms: 2HR, Source Buffer, Relay Buffer, Node Density, Throughputs.

I. INTRODUCTION

MANET is self-autonomous mobility of nodes, network parameters and the nodes communicate with each other straightly or indirectly using hop by hop without backbone network .The MANETs provide an efficient and low cost methodology which is infrastructure-less accompanied by high degree of flexibility. The classical Internet world is typically analyzed with the help of different QoS metrics wherein performance assumptions and degree of network usage increases year on year. The goal of any wireless network is maximum throughput along with desired quantization values are materialized with high effective parameters. The source node sends a packet to destination either directly from SOURCE to DESINATION or indirectly (SOURCE-RELAY-DESTINATION) the source nodes sends to the relay node and relay node to finally destination node.

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throughput but no center of interest on node density and the factors involved in it. LakshmanNaik.L et al[12] have analyzed the node density and pause time effects with respect to protocols and their evolutions only, but not concentrated on general perspective. Jiajia Liu et al [13] have generalized two hop relay for delay control but not identified the impact of node density on the network delay.

Tran The Son et al [7] have investigated the impact of hop count and node density on MANETs performance by observing the nodes increasing from 25 to 200 in a fixed area but not generalized for the networks. Mohammed A. Mahdi et al [19] have evaluated the performance of MANETs routing protocols with non-uniform node density topology, as these are simulated with different protocols but not generalized. B.BasaveswaraRao et al [20] have generalized the per node throughput exact equations but not identified the impact of node density on the performance metrics. All these studies have not exposed the inter relationship factor between throughput and delay with consideration of dynamic changes in the node density in a fixed area of MANET. So there is a need to study the impact of node density on MANETs Performance under limited buffer constraints.

This paper makes an attempt to analyze the factor of influence of node density on throughput and End to End delay. To do this a two Hop Relay MANETs for fixed rectangular area is being considered.

The main objectives and contributions of this paper are as follows:

- To investigate the impact of node density under general limited buffer constraints.
- To identify the impact of the node density on throughput T*.
- Identifying the impact of node density on end to end delay D*.
- To identify the relationship between the throughput T* & End to End Delay D*.
- The numerical illustration is presented for strong support of the process and obtained ideal node density for different input parameters.

The remaining part of the paper is organized as follows. Section 2 discusses about the related work on node density with general limited buffer constraints. Section 3 identifies the preliminaries and methodology of node density. Section 4 presents effect of node density on throughput and End to End Delay. Section 5 identifies the relationship between the throughput and End to End Delay. In Section 6 numerical illustration with result analysis are presented. Finally the conclusions and future scope of the work are presented in section7.

II. RELATED WORK

This section introduced the previous work on node density of ad hoc networks. To improve the performance of a typical MANET, there is a need to study the node density factor on ad hoc network. For brevity only selected set of related work that is indicative of range of approaches used for improving and analyzing MANET routing performance on node density is reported in this section.

Elizabeth et al [1] have explored the analysis of the optimum node density for MANETs under transmission power tradeoff for delivering the maximum number of data packets and stated that the node density should increase as rate of node movement increases. Jia- Chun Kuo et al [2] have identified the impact of node density on throughput and delay scaling in multi hops wireless networks. They developed a tradeoff mechanism in a significant way that states that large node density experiences linear degradation in throughput. EssamNatsheh et al [3] have presented the node density and broadcast management in heterogeneous environments of MANETs. They determined that the broadcast probability is based on the density and connectivity and not just the number of nodes. N Adam et al [4] have identified the effect of node density on performance of routing protocols AODV, DSR and TORA using OPNET simulator. They compared these protocols in terms of performance metrics and determined that the AODV exhibits best in performance. Nurul I. Sarkar et al [5] have conducted a study combining the node density, packet length and mobility of MANET routing protocols (OLSR, AODV, DSR and TORA).They combined all the performance metrics for these four routing protocols using OPNET simulator and stated that the node density and mobility has a significant impact on these protocols. G. Jisha and Philip Samuel [6] have identified the impact of node density on node connectivity in MANET routing protocols AODV and DSDV. They evaluated and compared these protocols in NS2 simulator with performance metrics and stated that these protocols perform identical in all conditions with a proportionate increase in node density and connectivity. Tran The Son et al [7] have investigated the impact of Hop-Count and Node density on MANETs performance and they simulated the performance metrics through ns3 simulator in terms of throughput and end to end delay, finally found the degradation of throughput when increasing the hop count and node density. Golnar K et al [9] have estimated the node density in VANETS using received power signal with a physical layer based model, the work provides with two equations they are Received signal strength versus simultaneously transmitting nodes and simultaneously transmitting nodes versus node density. MeenaRao et al [10] have evaluated the performance of AODV nth BR Routing protocol under node density and mobility for MANETs and they observed that the route after link breakage is found to be best with AODV nth BR protocol.

Jia Liu et al [11] have been modeled a buffer limited MANETs for End to End Delay using a theoretical framework and generated exact expressions for delay based on modeling of both packet queuing and delivery delay. Jia Liu et al [13] have optimized the throughput in buffer limited mobile ad hoc networks using a golden section search algorithm and then the joint optimization algorithm outputs the optimized values. Jia Liu et al [14] have been modeled a buffer limited MANETs for performance model using a theoretical framework and generated exact expressions for throughput, throughput capacity and expected end to end delay. B. Basaveswara Rao et al [15] have performed a comparison between the routing protocols of two different types as proactive and reactive, and then identified the best performing protocol using a limited buffer at a random value through simulation. SK Meera Sharief et al [16] have identified the impact between the routing protocols using buffer considering the buffer as finite and infinite through simulation for different network parameters.

Ako Muhammad Abdullah et al [18] have investigated the impact of mobility models (FCM, SCM, RWM and HWM) on MANET routing protocols (AODV, OLSR and GRP). The performance metrics are varied with speed, pause time and node parameters such as data drop rate, average end-to-end delay, media access delay, network load, retransmission attempts and throughput. They stated that OLSR protocol provides better performance than others. Mohammed A. Mahdi et al [19] have studied and evaluated the performance of MANETs routing protocols (AODV, DSR and CBRP) in Non-uniform Node density topology using NS2 simulator. They stated that the CBRP outperformed in terms of routing load and AODV outperforms in terms of average delay. B Basaveswara Rao et al [20] have been maximized the per node throughput using NSC Algorithm and identified the optimal source buffer, optimal relay buffer, optimal routing control parameter value, and the maximized throughput values for given number of nodes, MANET area size, packet generating probability.

After examine these studies to arrive an idea there is research gap to identify the influence of node density over the inversely proportional performance metrics throughput and delay. The next section and other remaining sections are studied and draw conclusions to fulfill this research gap.

III. PRELIMINARIES

In this section the necessary notations are given below for analyzing the behavior of performance metrics through adoption of B/B/1/K queuing model for two hop relay MANETs.

Node density (n):- The total number of nodes per square area of the network.

Packet Generating Probability (λs):- The probability of the Packet generated at source node

Packet Transmission Probability (μs):- The probability of the packet transmission at source node

Area of the Network (m):- The total square area of the torus network, which is equally partitioned with a total of m2 cells.

HOP Count: - It is node count per each partitioned cell, which is considered as 2HR count (two hop relay), i.e. the maximum number of nodes per cell is permissible up to three and minimum of number of nodes is zero. The nodes in the cell are named as source node, relay node and destination node.

Buffer (B):- It is the size of the buffer that should be maintained at each node.

Source Buffer Bs: - It is the size of the buffer that should be maintained at source node.

Relay Buffer Br: - It is the size of the buffer that should be maintained at relay node.

Queuing Model(B/B/1/K):-

This is the model used for constructing the working system. The Bernoulli queuing model is used as a queuing model in this paper i.e. B/B/1/K model where a service may or may not happen as Boolean values with Bernoulli process and generation with single server and each node maintains a buffer K.

Psd: It is the probability of that a node gets the chance to transmit the packet from source to destination as

$$P_{sd}=\frac{m^2}{n}-\frac{m^2-1}{n-1}+\frac{m^2-1}{n(n-1)}\left(1-\frac{1}{m^2}\right)^{n-1} \quad (1)$$

Psr: Probability that a node gets the chance to transmit the packet from source to relay as

$$P_{sr}=\alpha\left\{\frac{m^2-1}{n-1}-\frac{m^2}{n-1}\left(1-\frac{1}{m^2}\right)^{n}-\left(1-\frac{1}{m^2}\right)^{n-1}\right\} \quad (2)$$

Where α is routing control parameter.

Prd: Probability that a node gets the chance to transmit the packet from relay to destination as

$$P_{rd}=(1-\alpha)\left\{\frac{m^2-1}{n-1}-\frac{m^2}{n-1}\left(1-\frac{1}{m^2}\right)^{n}-\left(1-\frac{1}{m^2}\right)^{n-1}\right\} \quad (3)$$

IV. EFFECT OF NODE DENSITY

The area wise MANET performance is mainly depends up on the number of active nodes. From time to time the number of nodes that are active is volatile. Because of this volatile property the behavior of performance metrics like per node throughput (T) and end to end delay (D) play a crucial role in packet transmission process. To explore the node density influence on MANTES the research carried out by [13] are taken as basis in the context of notations for this work. They derived the following equations for per node throughput and end to end delay for given values of m, n, λs. If the node density increases then it creates a volatile impact on the performance of throughput and end to end delay. The reason why it creates impact on these factors is if the number of nodes increases the throughput directly decreases as these are inversely proportional and the end to end delay may increase as it is directly proportional to n in the below equations.

$$T=P_{sd}(1-\pi_s(0)) + P_{sr}(1-\pi_s(0)(1-\pi_r(B_r)) \quad (4)$$

$$D=\frac{1+L_s}{\mu_s}+\frac{(n-2+L_r)(1-\pi_r(B_r))}{p_{sd}+p_{sr}(1-\pi_r(B_r))} \quad (5)$$

Where L_s, L_r, θ, $\pi_r(i)$, $\pi_s(0)$ given as follows

$$L_s=\frac{\theta-B_s\cdot\theta^{B_s}+(B_s-1)\theta^{B_s+1}}{(1-\theta)(1-\theta^{B_s})}$$

$$where,\theta=\frac{\lambda_s(1-\mu_s)}{\mu_s(1-\lambda_s)}$$

$$L_r=\frac{1}{(1-\pi_r(B_r))}\sum_{i=0}^{B_r-1} i\bullet\pi_r(i)$$

$$\pi_r(i)=\frac{C_i(1-\pi_s(0))^i\beta^i}{\sum_{k=0}^{B_r}C_k(1-\pi_s(0))^k\beta^k}$$

$$\pi_s(o)=\frac{\mu_s-\lambda_s}{\mu_s-\lambda_s.\theta^{Bs}}$$

The maximization of per node throughput T* is calculated with the optimal values of Bs*, α*, Br*, the optimal values are derived through combination of partial derivation and linear search methods in [13].

$$T^*=P_{sd}(1-\pi_s*(0))+P_{sr}*(1-\pi_s*(0)(1-\pi_r(B_r*)) \quad (6)$$

and

$$D^*=\frac{1+L_s*}{\mu_s*}+\frac{(n-2+L_r*)(1-\pi_r(B_r*))}{p_{sd}+p_{sr}*(1-\pi_r(B_r*))} \quad (7)$$

To investigate impact of node density on these performance measures T* and D* with λs for various values of m. The next section explores the relationship between these metrics.

RELATIONSHIP BETWEEN DELAY AND THROUGHPUT

The relationship between the delay and the throughput is derived from the equations (6) & (7),and then the relation expression is given in (8).

$$D^*=\frac{1+L_s*}{\mu_s*}+\frac{(n-2+L_r*)(1-\pi_r(B_r*))}{p_{sd}+p_{sr}*(1-\pi_r(B_r*))}$$

$$D^*=\frac{1+L_s*}{\mu_s*}+\frac{(n-2+L_r*)(1-\pi_r(B_r*))(1-\pi_s*(0))}{(p_{sd}+p_{sr}*(1-\pi_r(B_r*)))(1-\pi_s*(0))}$$

$$D^*=\frac{1+L_s*}{\mu_s*}+\frac{(n-2+L_r*)(1-\pi_r(B_r*))(1-\pi_s*(0))}{(p_{sd}(1-\pi_s*(0))+p_{sr}*(1-\pi_r(B_r*))(1-\pi_s*(0)))}$$

Substitute the equation (6) in the above will get the relation expression (8) as

$$D^*=\frac{1+L_s*}{\mu_s*}+\frac{(n-2+L_r*)(1-\pi_r(B_r*))(1-\pi_s*(0))}{T^*} \quad (8)$$

$$D^* = x + y\left(T^*\right)^{-1}$$

where

$$x = \frac{1+L_s^*}{\mu_s^*}$$

$$y = \left(n-2+L_r^*\right)\left(1-\pi_r(B_r^*)\right)\left(1-\pi_s^*(0)\right)$$

One can observe inversely proportional relation between D* and T* from equation (8).

The next section supports with numerical illustration to identify the dynamic behavior of T* and D* for various values of n, and λs in a fixed area of m sq.mts. of a MANET.

V. Numerical Illustration

The Numerical illustrations are drawn between the node density and all the important parameters like throughput, control parameter, packet transmission probability, size of source buffer, size of relay buffer, and end to end delay for different packet generating probabilities. The node density values are varied from 0 to 150, λs varied from 0.05 to 0.15 and m is varied from 4 to 8 Sq.mts. From these contributing parameters the optimized values of throughput, end to end delay, source buffer size, relay buffer size, transmission probability and routing control parameter are computed from the afore mentioned equations. These parameters are selected because of the significance of the node density as a parameter while maximizing the throughput and minimizing the end to end delay. The ideal values are selected from the [13] where each values of source buffer size, relay buffer size and control parameter values are generated from the Enhanced NSC algorithm [20]. In each iteration, the values are evaluated for optimized parameter values and finally the throughput and end to end delay are obtained. The relation between the throughput and delay share an inherent inversely proportional relation and hence the graphs are being obtained in the same classic way. The study of node density as a factor is being segmented into three different scenarios namely low, medium and high density. The following graphs are drawn to illustrate the diversified relation between different combinationsof optimized parameters against node density.

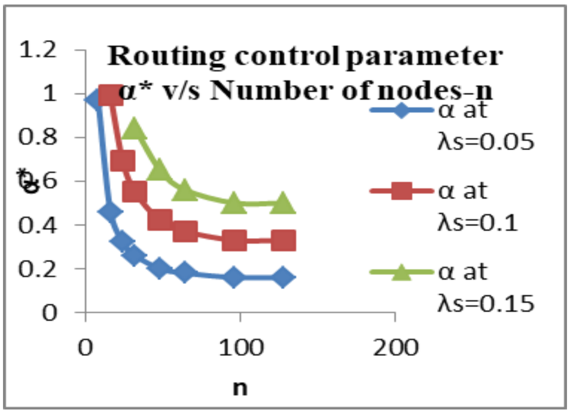

Fig 1- Effect of α* for fixed area and varied n, λs

By observing the above graph, it clearly touches the minimum ideal value of control parameter at n=72, 98, 128 for λ=0.05, 0.10, 0.15 respectively and then the graph falls down to reach its ideal value. The upper bound and lower bound values depend on the packet generating probability.

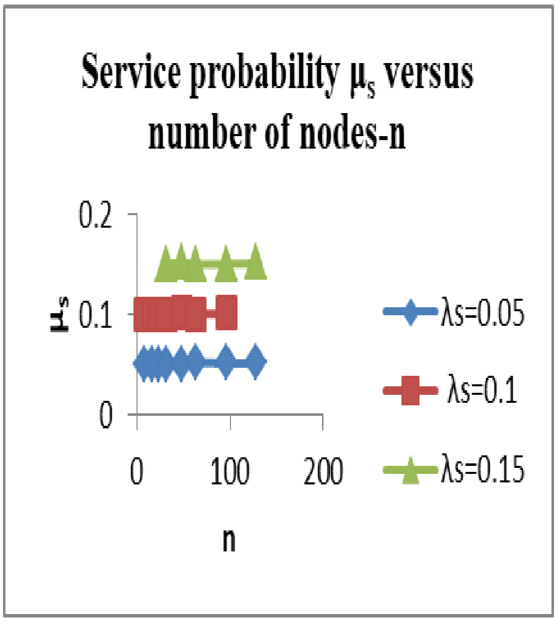

Fig 2 - Effect of μs for fixed area and varied n, λs

The above graph illustrates Transmission Probability is in line with the packet generating probability while the number of nodes are increased.

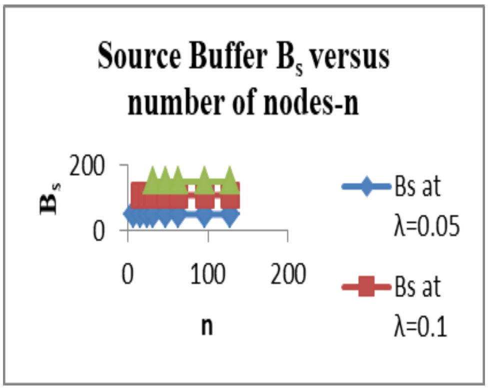

Fig 3 - Effect of Bs for fixed area and varied n, λs

From the above graph, Source Buffer size remains at the same levels irrespective of change in number of nodes for various values of λs.

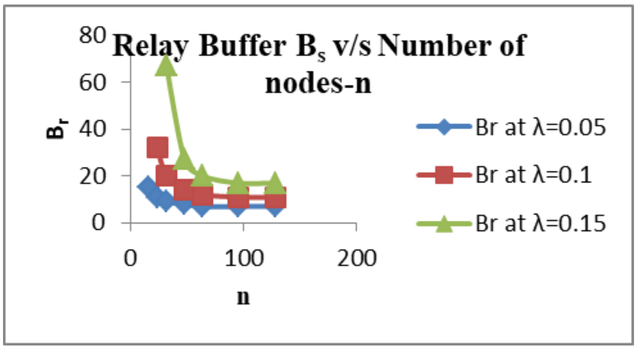

Fig 4 - Effect of Br for fixed area and varied n, λs

The above graph indicates that the Relay buffer size is decreasing while there is an increase in the number of nodes and stabilizes at n=72 and further this doesn't have any bearing with different values of λs.

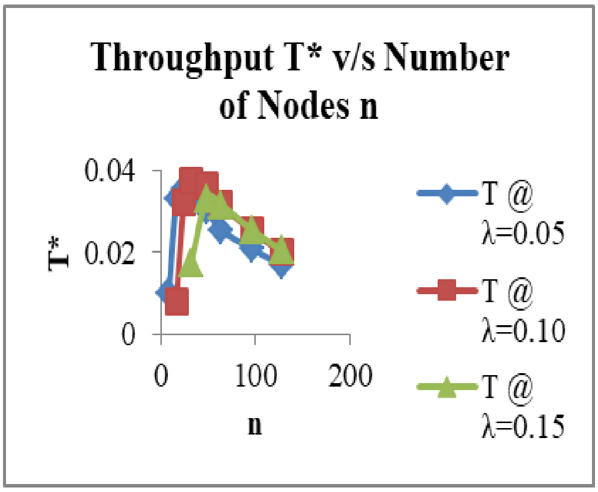

Fig 5- Effect of T* for fixed area and varied n, λs

This graph depicts the relationship between throughput and number of nodes which has the potential to have a clear assessment about the number of nodes where throughput is Maximum. It clearly indicates that the maximum value of throughput is at n=24, 32, 48 for λ=0.05, 0.10, 0.15 respectively.

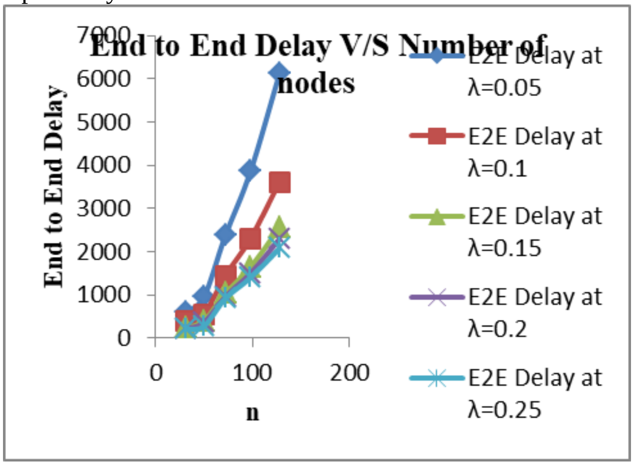

Fig 6 - Effect of E2E Delay for fixed m and varied n, λs

As a natural phenomenon there is an increase in the end to end delay with the increase in number of nodes for various values of λs .

From the above numerical results and the relationship of throughput and end to end delay the following relationship is established between λs, n, throughput and end to end delay for given values of m which is as follows:

Table 1: Effect of node density for T* and D* of the given values of m, n, λs

m	λs	n	D*	T*
5	0.05	50	955.7086473	0.030957847
	0.10		554.7392332	0.027864722
	0.15		399.4999938	0.025760455
	0.05	72	726.2949152	0.025760455
	0.10		330.3910436	0.021735845
	0.15		214.5090062	0.016862696
	0.05		590.8404118	0.025489
	0.10	98	387.2192758	0.021736
	0.15		241.0947646	0.016863
6	0.05	50	955.7086473	0.030957847
	0.10		554.7392332	0.027579772
	0.15		399.4999938	0.023486096
	0.05	72	959.9020072	0.027579772
	0.10		473.4495917	0.02407814
	0.15		296.0930379	0.021735845
	0.05	98	726.2949153	0.027864722
	0.10		330.3910436	0.02407814
	0.15		214.5090062	0.019322397
7	0.05	50	2370.94019	0.02576
	0.10		1446.20498	0.021736
	0.15		1032.868061	0.016863
	0.05	72	1266.630737	0.030958
	0.10		644.6479371	0.02758
	0.15		413.0385844	0.023486
	0.05	98	288.3491137	0.016862696
	0.10		144.5060677	0.023486096
	0.15		190.7929702	0.019322397

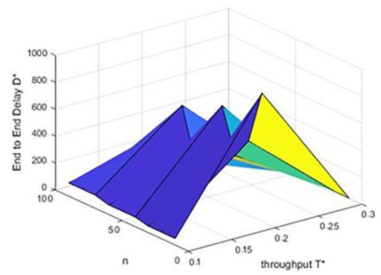

Fig 7: Effect of Node Density on Throughput T* & End to End Delay D* at m=5

The above three dimensional graph illustrates the relation between Node density, End to End Delay and throughput. Here the throughput increases to a certain point and falls linearly thereof.This graph obeys the general inverse relationship between Throughput and End to End delay. No matter the area of MANET.

VI. CONCLUSION

In this paper to study the impact of node density on the two hops relay (2HR) MANET performance in terms of per node throughput and the end to end delay. The analytical results are calculated based on the earlier works of [14, 20] under limited buffer constraints. The point when throughput reaches its peak could be considered as the ideal node density for given MANET size and packet generating probability. The both performance metrics are inversely proportional to each other and are shown for different sizes of MANET area. When the node density increases the throughput decreases considerably if the node density is increased then the end to end delay increases gradually. This phenomenon is observed for all the values of packet generating probability. The MANET designer may take this as a guide line in terms of fixing the size of the MANET, corresponding buffer sizes so that the maximum throughput can be experienced by all the active nodes. This work may be extended as a future study to implement this analysis for multi-hop MANETs and study in a real time scenario also may be simulated.

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