ISSN:2229-6093

G.Vijaya Lakshmi et al, Int. J. Comp. Tech. Appl., Vol 2 (4), 750-760

CONGESTION CONTROL AVOIDANCE IN ADHOC NETWORK USING QUEUING MODEL

G.Vijaya Lakshmi

Research Scholar, Dept of CSE
JNTUA College of Engineering
Anantapur-515001, INDIA
vijayalakshmi.treasury@gmail.com

Dr. C.Shoba Bindhu

Associate Professor, Dept of CSE
JNTUA College of Engineering
Anantapur-515001,INDIA
shobabindhu@gmail.com

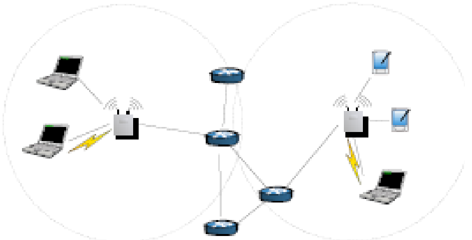
ABSTRACT

Mobile adhoc network is an emerging standard or wireless communication. Due to the impendence in infrastructure dependencies these networks are rapidly emerging. These networks are since evolving has to develop methodologies for the compatibility of current services in such an environment. Various services compatibilities were studied and methodologies were proposed for the same. One basic problem observed during the incorporation of services in adhoc network is the traffic flow, and its proper modeling. As the demanded service increases the variability in the links increases. Due to the dynamicity of the link factors there are various issues been observed, in which congestion is one of the problem. Congestion is caused when the offered load to the network is more than the available resources. To overcome the congestion problem in mobile adhoc network a queuing model is suggested in the current work. The queuing mechanism is developed based on the probability distribution in different range of communication. The queuing mechanism hence improves the network metrics such as overall network throughput, reduces the route delay, overhead and traffic blockage probability. The approach is generated over a routing scheme in adhoc network. A Matlab simulation is developed for the suggested approach and evaluated for multiple network environments to evaluate the system performance.

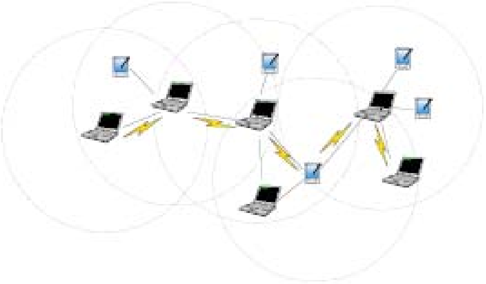
Keywords: Manets, Queuing theory, WNCS, State dependent models.

I. INTRODUCTION

With the increasing widespread use of wireless technologies, Quality of service (QoS) provisioning in ad hoc networks remains a Challenging task. Good scalability of the QoS architecture is necessary, as the size of the ad hoc networks is huge. A Networked Control System traditionally consists of a wired based communication medium, either direct connections between the plant and controller using dedicated cables or by employing a bus based technology such as token ring or Ethernet. Recent research has investigated using wireless networks between the plant and a backbone wired network technology such as Ethernet to the controller [1][4]. This paper investigates using a wireless network that does not rely on any wired infrastructure as the communication medium and for the purpose of controlling congestion which happens due to heavy traffic is overcome by queuing models. Mobile Ad Hoc Networks (MANETs) are dynamic infrastructure less wireless networks where each node within the network is required to forward and route packets, nodes can also leave and enter the network in real time due to their mobility. In this work we consider the problem of congestion control in mobile ad-hoc networks (MANETs) and overcome the problems by applying queuing models. In most wireless networking environments in productive use today the users' devices communicate either via some networking infrastructure in the form of base stations and a backbone network, examples are WLANs, GSM/UMTS, and 4G Networks (see Figure 1(a)), or directly with their intended communication partner, e.g. using 802.11 in ad-hoc mode



(a) Infrastructure-based wireless network.



(b) Mobile ad-hoc network.

Fig.1. Comparison of wireless network architectures.

In contrast a mobile adhoc network does not have an infrastructure and still the devices do not need to be within each other's communication range to communicate. Instead, the end-users' (mobile) devices also act as routers, and data packets are forwarded by intermediate nodes to their final destination (see Figure 1(b)). MANETs are applicable in situations where no infrastructure is available; a common example is a disaster relief scenario. They are also the foundation for vehicular ad-hoc networks, where communication between cars is used to increase vehicle safety and driving comfort. There are also related multihop wireless networks, e. g. wireless mesh networks or wireless sensor networks. These networks share some of the congestion control related problems with MANETs. Much research effort has been put into the MANET area.

II CONGESTION PROBLEM

In a network with shared resources, where multiple senders compete for link bandwidth, it is necessary to adjust the data rate used by each sender in order not to overload the network. Packets that arrive at a router and cannot be forwarded are dropped, consequently an excessive amount of packets arriving at a network bottleneck leads to many packet drops. These dropped packets might already have travelled a long way in the network and thus consumed significant resources. Additionally, the lost packets often trigger retransmissions, which mean that even more packets are sent into the network. Thus network congestion can severely deteriorate network throughput. If no appropriate congestion control is performed this can lead to a congestion collapse of the network, where almost no data is successfully delivered.

a) Priority of Traffic

Generally in QoS provisioning, the bandwidth is allocated first to the higher priority traffic in preference and then allocated to the lower priority traffic. The lower priority traffic can utilize the bandwidth only after the utilization of the higher priority traffic. If a high priority flow's traffic pattern satisfies the behavior described in the service agreement, its packets should be delivered in preference to other packets with lower priorities. On the other hand, flows with lower priorities should use as much bandwidth as possible after the transmission requirements of higher priority flows

b) QoS Provisioning Challenges in MANETs

Due to several problems, QoS provisioning in MANETs is much complicated when compared to wired networks. The following are some of the main QoS provisioning and maintenance problems in MANETs.

- It requires knowledge of the available bandwidth, which is difficult to be accurately estimated in a dynamic environment.
- Bandwidth reservation has to be made through negotiation between neighbors within two to three hops other than only the direct neighbors sharing the same channel, and this needs signaling message exchanges between them. Moreover, when the neighbor moves out of the reservation area of the node, the reserved bandwidth in a neighbor should be released through some mechanism. Hence, an extra control overhead will be introduced by these signaling messages and consumes limited bandwidth and energy.

- The reserved bandwidth over the entire duration of an active session cannot be guaranteed. Some of the reserved bandwidth might be stolen by the oncoming node, if a communicating node moves towards a node which has reserved some bandwidth for flow(s). The reserved bandwidth over the link between them might be unavailable or the link might be broken, if two nodes on the end of a link move away from each other.
- In MANETs, due to the dynamic topology, there is no clear definition of what is core, ingress or egress router. Since all the nodes in the network cooperate to provide services, there is no clear definition of a Service Level Agreement (SLA). On the other hand, an infrastructure network where the services to the users in the network are provisioned by one or more service providers .
- Since the wireless bandwidth and capacity in MANETs are affected by interference, noise and multi-path fading, it is limited and the channel is not reliable. Moreover, the available bandwidth at a node cannot be estimated exactly because it involves in a large variations based on the mobility of the node and other wireless device transmitting in the vicinity etc [5]

III QUEUING SYSTEMS

A queuing system consists of one or more servers that provide service of some sort to arriving customers. Customers who arrive to find all servers busy generally join one or more queues (lines) in front of the servers, hence the name **queuing systems**. There are several everyday examples that can be described as queuing systems [7], such as bank-teller service, computer systems, manufacturing systems, maintenance systems, communications systems and so on.

Components of a Queuing System: A queuing system is characterized by three components:

Arrival process - Service mechanism - Queue discipline.

a)Arrival Process

Arrivals may originate from one or several sources referred to as the **calling population**. The calling population can be limited or 'unlimited'. An example of a limited calling population may be that of a fixed number of machines that fail randomly. The arrival process consists of describing how customers arrive to the system. If A_i is the inter-arrival time between the arrivals of the (i-1)th and ith customers, we shall denote the mean (or expected) inter-arrival time by E(A) and call it **(λ);** = 1/(E(A) the arrival frequency.

b) Service Mechanism

The service mechanism of a queuing system is specified by the number of servers (denoted by s), each server having its own queue or a common queue and the probability distribution of customer's service time. let S_i be the service time of the ith customer, we shall denote the mean service time of a customer by E(S) and **μ** = 1/(E(S) the service rate of a server.

c) Queue Discipline

Discipline of a queuing system means the rule that a server uses to choose the next customer from the queue (if any) when the server completes the service of the current customer. Commonly used queue disciplines are:

FIFO - Customers are served on a first-in first-out basis. LIFO - Customers are served in a last-in first-out manner. Priority - Customers are served in order of their importance on the basis of their service requirements.

d) Measures of Performance for Queuing Systems:

There are many possible measures of performance for queuing systems. Only some of these will be discussed here.

Let, D_i be the delay in queue of the ith customer W_i be the waiting time in the system of the ith customer = $D_i + S_i$ Q(t) be the number of customers in queue at time t L(t) be the number of customers in the system at time t = Q(t) + No. of customers being served at t

Then the measures,

$$d = \lim_{n \to \infty} \frac{\sum_{i=1}^{i=n} D_i}{n} \quad \text{and}$$

$$w = \lim_{n \to \infty} \frac{\sum_{i=1}^{i=n} W_i}{n} \qquad \text{Eq(1)}$$

(if they exist) are called the **steady state average delay** and the **steady state average waiting time in the system**. Similarly, the measures,

$$Q = \lim_{T \to \infty} \frac{1}{T} \int_0^T Q(t).dt \quad \text{and}$$
$$L = \lim_{T \to \infty} \frac{1}{T} \int_0^T L(t).dt \qquad \text{Eq (2)}$$

(if they exist) are called the **steady state time average number in queue** and the **steady state time average number in the system.** Among the most general and useful results of a queuing system are the **conservation equations**:

$$Q = (\lambda)\, d \text{ and } L = (\lambda)\, w \qquad \text{Eq (3)}$$

These equations hold for every queuing system for which d and w exist. Another equation of considerable practical value is given by,

$$w = d + E(S) \qquad \text{Eq (4)}$$

Other performance measures are:

the probability that any delay will occur. - the probability that the total delay will be greater than some pre-determined value - that probability that all service facilities will be idle. - the expected idle time of the total facility. - the probability of turn-aways, due to insufficient waiting accommodation.

e) Notation for Queues.
Since all queues are characterized by arrival, service and queue and its discipline, the queue system is usually described in shorten form by using these characteristics. The general notation is:

[A/B/s]:{d/e/f}
Where,
A = Probability distribution of the arrivals
B = Probability distribution of the departures
s = Number of servers (channels)
d = The capacity of the queue(s)
e = The size of the calling population
f = Queue ranking rule (Ordering of the queue)
There are some special notation that has been developed for various probability distributions describing the arrivals and departures. Some examples are,

M = Arrival or departure distribution that is a Poisson process

E = Erlang distribution

G = General distribution

GI = General independent distribution

Thus for example, the **[M/M/1]:{infinity/infinity/FCFS}** system is one where the arrivals and departures are a Poisson distribution with a single server, infinite queue length, calling population infinite and the queue discipline is FCFS. This is the simplest queue system that can be studied mathematically. This queue system is also simply referred to as the M/M/1 queue.

IV SYSTEM MODEL REQUIREMENTS (MARKOVIAN SYSTEM)

The common characteristic of all markovian systems is that all interesting distributions, namely the distribution of the interarrival times and the distribution of the service times are exponential distributions and thus exhibit the markov (memoryless) property. From this property we have two important conclusions:

- The state of the system can be summarized in a single variable, namely the number of customers in the system. (If the service time distribution is not memoryless, this is not longer true, since not only the number of customers in the system is needed, but also the remaining service time of the customer in service.)
- Markovian systems can be directly mapped to a *continuous time markov chain* (CTMC) which can then be solved.

A. The M/M/1-Queue

The M/M/1 Queue has iid interarrival times, which are exponentially distributed with specified parameters and also iid service times with exponential distribution. The system has only a single server and uses the FIFO service discipline. The waiting line is of infinite size. It is easy to find the underlying markov chain. As the system state we use the number of customers in the system. The M/M/1 system is a pure birth-/death system, where at any point in time at most one event occurs, with an event either being the arrival of a new customer or the completion of a customer's service. What makes the M/M/1 system really simple is that the arrival rate and the service rate are not state-dependent.

Steady-State Probabilities

We denote the steady state probability that the system is in state k(k€N) by pk, which is defined by

$$p_k := \lim_{t\to\infty} P_k(t) \qquad \text{Eq (5)}$$

Pk(t) Where pk(t)) denotes the (time-dependent) probability that there are k customers in the system at time t. Please note that the steady state probability pk does not dependent on t. We focus on a fixed state k and look at the *flows* into the state and out of the state. The state k can be reached from state k-11 and from state k+1 1 with the respective rates $\lambda P_{k-1}(t)$ (t) (the system is with probability $P_{k-1}(t)$ (t) in the state k-1 at time t t and goes with the rate λ from the predecessor state k-11 to state k) and $\mu P_{k+1}(t)$ (the same from state k+1). The total flow into the state k is then simply $\lambda P_{k-1}(t) + \mu P_{k+1}(t)$. The State k is left with the rate $\lambda P_k(t)$) to the state k+1 and with the rate $\mu P_k(t)$ (t) to the state k-1 (for k=0 there is only a flow coming from or going to state 1). The total flow out of that state is then given by $\lambda P_k(t) + \mu P_k(t)$. The total rate of change of the flow into state k is then given by the difference of the flow into that state and the flow out of that state:

$$\frac{dP_k(t)}{dt} = (\lambda P_{k-1}(t) + \mu P_{k+1}(t)) - (\lambda P_k(t) + \mu P_k(t)) \qquad \text{Eq (6)}$$

Furthermore, since the pk are probabilities, the *normalization condition*

$$\sum_{k=0}^{\infty} p_k = 1 \qquad \text{Eq (7)}$$

B. M/M/m-Queue

The M/M/m-Queue (m > 1) has the same interarrival time and service time distributions as the M/M/1 queue, however, there are m servers in the system and the waiting line is infinitely long. As in the M/M/1 case a complete description of the system state is given by the number of customers in the system (due to the memoryless property). The M/M/m system is also a pure birth-death system.

C. M/M/1/K-Queue

The M/M/1/K-Queue has exponential interarrival time and service time distributions, each with the respective parameters λ and μ. The customers are served in FIFO-Order, there is a single server but the system can only hold up to K customers. If a new customer arrives and there are already K customers in the system the new customer is considered lost, i.e. it drops from the system and never comes back. This is often referred to as *blocking*. This behavior is necessary, since otherwise (e.g. when the customer is waiting outside until there is a free place) the arrival process will be no longer markovian. As in the M/M/1 case a complete description of the system state is given by the number of customers in the system (due to the memoryless property). The M/M/1/K system is also a pure birth-death system. This system is better suited to approximate "real systems" (like e.g. routers) since buffer space is always finite.

V COMPARISION OF DIFFERENT QUEING MODELS

In this section we want to compare three different systems in terms of mean response time (mean delay) vs. offered load: a single M/M/1 server with the service rate mμ, a M/M/m system and a system where m queues of M/M/1 type with service rate μ are in parallel, such that every customer enters each system with the same probability. The answer to this question can give some hints on proper decisions in scenarios like the following: given a computer with a processor of type X and given a set of users with long-running number cruncher programs. These users are all angry because they need to wait so long for their results. So the management decides that the computer should be upgraded. There are three possible options:

- buy n-1 additional processors of type X and plug these into the single machine, thus yielding
  a multiprocessor computer
- buy a new processor of type Y, which is n times stronger than processor X and replacing it, and
  let all users work on that machine
- provide each user with a separate machine carrying a processor of type X, without allowing
  other users to work on this machine

We show that the second solution yields the best results (smallest mean delays), followed by the first solution, while the last one is the worst solution. The first system corresponds to an M/M/m system, where each server has the service rate μ and the arrival rate to the system is λ The second system corresponds to an M/M/1 system with arrival rate λ and service rate m.μ. And, from the view of a single user, the last system corresponds to an M/M/1 system with arrival rate λ/k and service rate μ. In this work we have to visualize variety of queuing models and check the network parameters. Defined queuing models are analyzed and used for reliable communication in manets without congestion. Once the congestion is controlled and route overhead is also less we can have a good communication system. The M/M/1 queuing model (exponential arrival and service rates) is considered as a base case, but due to its specific assumptions regarding the arrival and service processes, it is not useful to describe real-life situations. Relaxing the specifications for the service process, leads to the M/G/1 queuing model (generally distributed service rates). Relaxing both assumptions for the arrival and service processes results in the G/G/k queuing model. We are designing a system which will speak about three queuing models on different environments. We have considered topologies like static, random and clustered topology where congestion is introduced and checked on these environments. The considered parameters are delay time, network overhead, throughput etc.,. the proposed method is been tested on all kinds of networks using queuing models.

VI. RESULTS AND OBSERVATIONS

CASE STUDY 1: STATIC TOPOLOGY

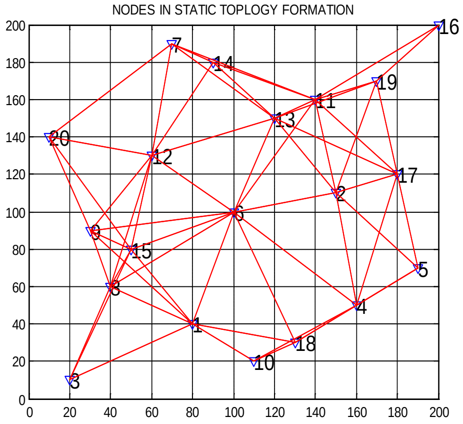


Fig 2: nodes in topology formation

Fig 2 illustrates about how the assigned nodes are established as a network. By applying the routing method we have got all the possible links in between the nodes. Whenever a node has to deliver packets to the destination from the source it has to follow the shortest path and reliable path to travel. This is done by the routing methodology.

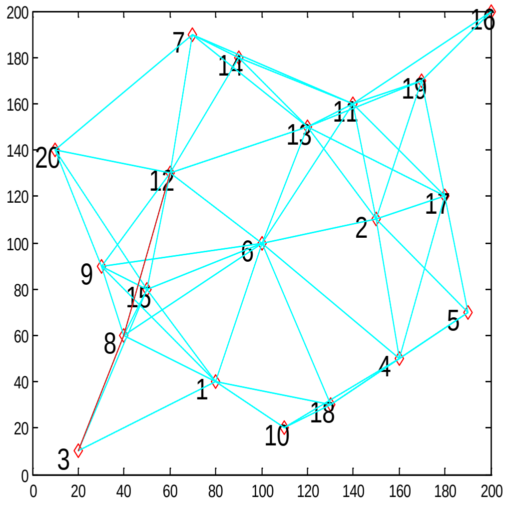


Fig 3: Link Probability

It is observed from the figure 3 that the reliable path is chosen and the data is passed through that path. It is represented by red dotted lines. After calculation of reliable path the data packets has to travel to destination in communication phase. The setup phase finds out which are all the possible paths shown in above figure.

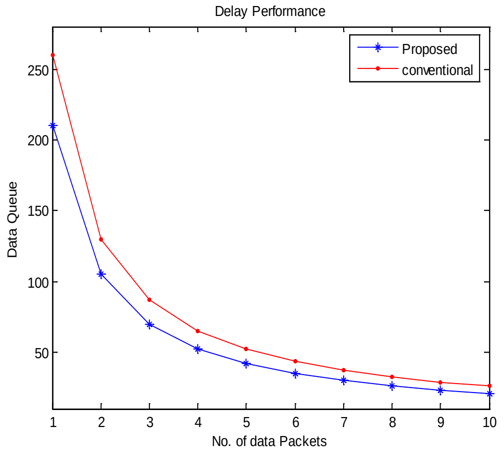


Fig 4: Delay Performance

Fig 4 plot is between number of data packets and data queue. Its been observed that delay performance is better in proposed system when compared to conventional systems. In proposed model we are using queing methods to overcome the delay. Its clearly observed that as the number of data packets are increasing the queue management is good in the proposed work.

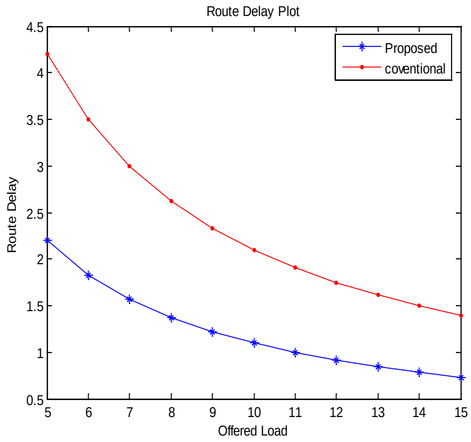


Fig 5: Route Delay Plot

Usually when the offered load is more the route delay will be there. The load is more means obviously the traffic and due to traffic congestion also will be more. Inorder to overcome the congestion in the network due to heavy traffic queing models are used. The above plot mentions how the route delay varies when the offered load is increased. For the proposed method route delay is less when compared to the convention method.

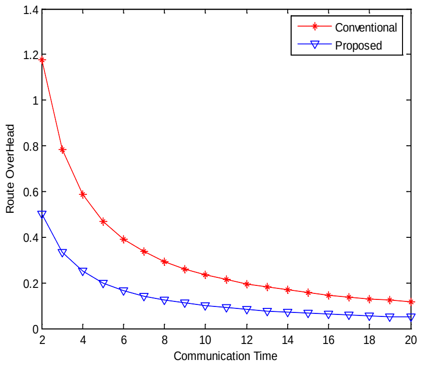


Fig 6: Route Overhead

Due to route delay the route overhead will increase. It leads to failure in data packets arrival. Chance of data packet loss will be there. Hence by applying queing model the problem is clearly solved. It's observed that even increase in communication time the route overhead is less in proposed methodology when compared to conventional method.

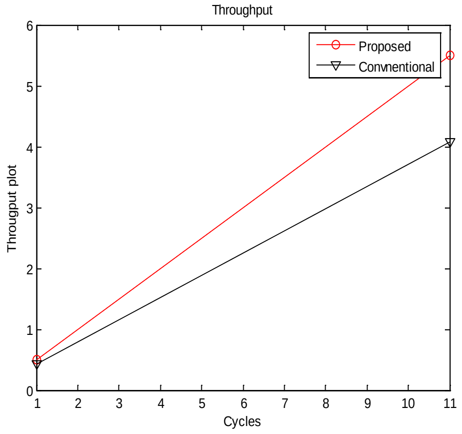


Fig 7: Throughput Plot

For any system throughput is the main parameter to be concentrated on. Fig 7 gives idea that the routing system which is used without any queing model has got less throughput when compared to the reliable model which we have proposed. The throughput is comparatively high when compared to the conventional method.

CASE STUDY 2
RANDOM TOPOLOGY

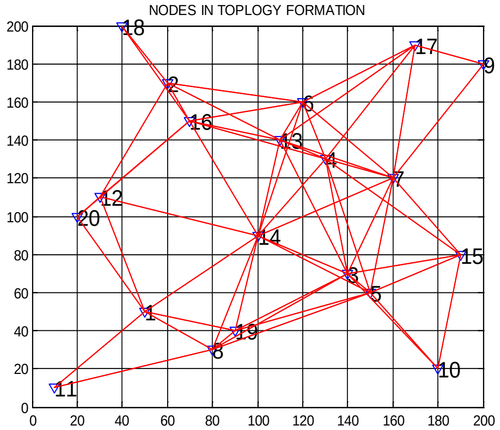


Fig 8: Nodes In Topology Formation

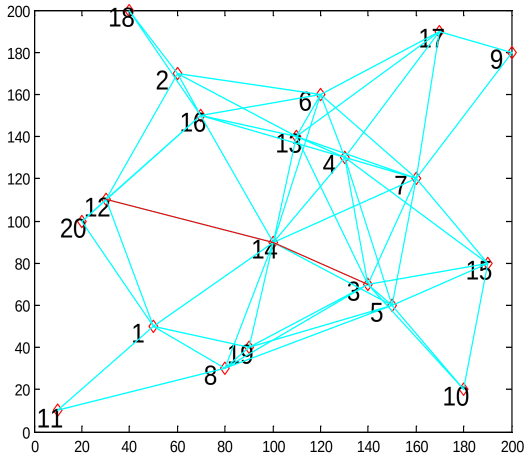


Fig 9: Link Probability

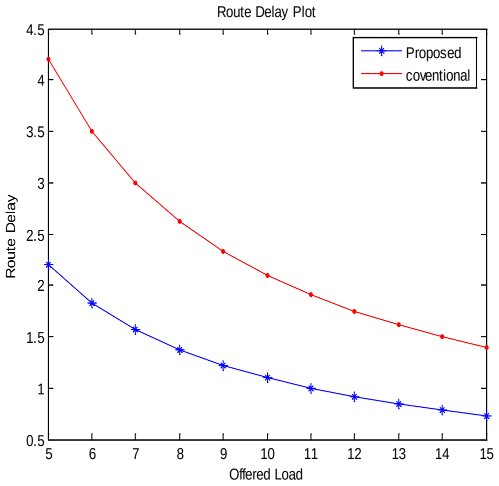


Fig 10: Route Delay Plot

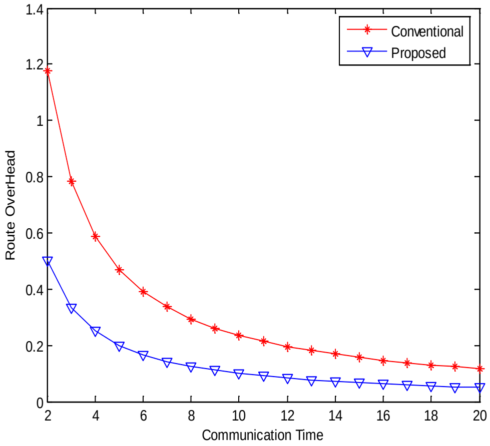


Fig 11: Route overhead

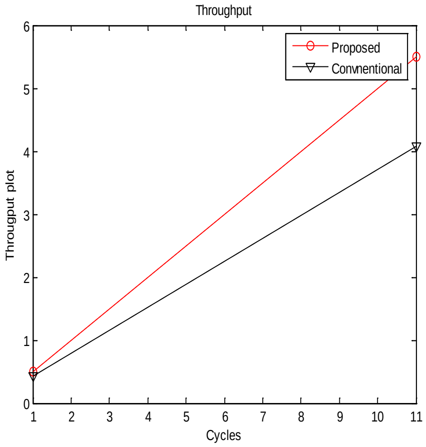


Fig 12: Throughput Plot

CASE STUDY 3
CLUSTERED TOPOLOGY

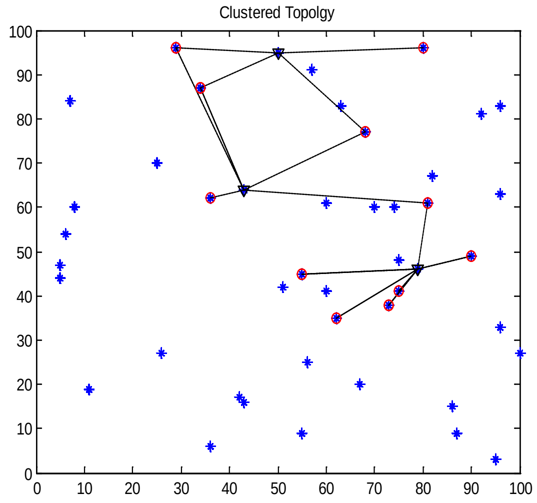


Fig 13: Nodes Formation in clustered topology

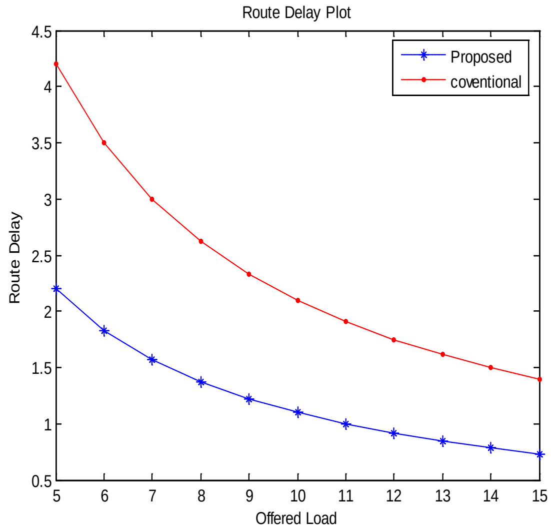


Fig 15: Route Delay Plot

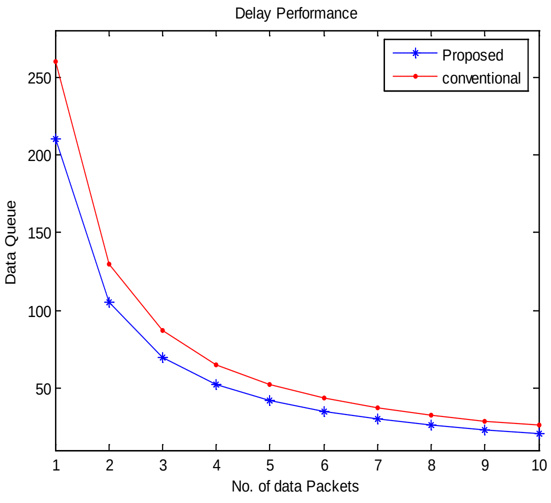


Fig 14: Delay Performance

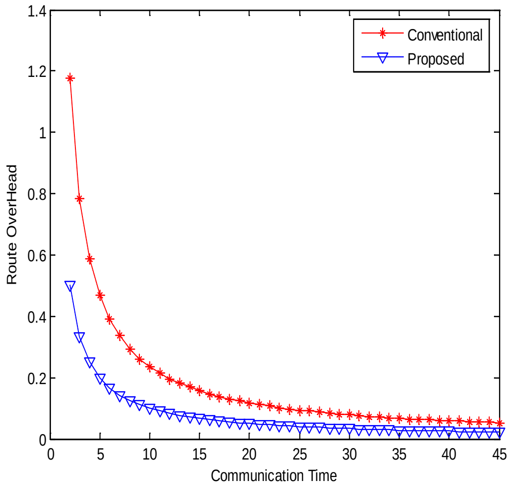


Fig 16: Route Overhead

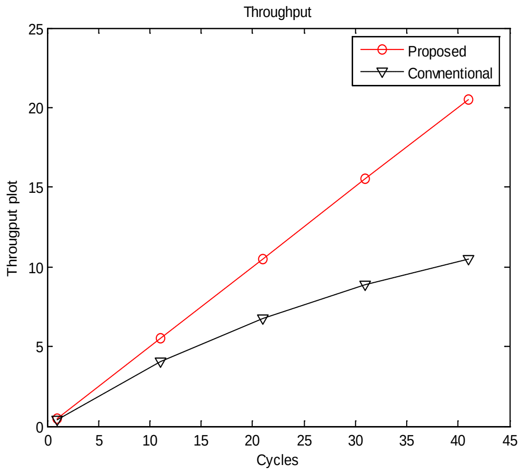


Fig 17: Throughput plot

VII CONCLUSION

Congestion and finite capacity queuing systems are probably one of the most prevalent facts of modern life. Congestion usually leads to a decrease in the systems service rates and finite capacity impedes overall system throughput. Using a wireless network that does not rely on any wired infrastructure as the communication medium and for the purpose of controlling congestion which happens due to heavy traffic is overcomed by queuing models. Mobile Ad Hoc Networks (MANETs) are dynamic infrastructure less wireless networks where each node within the network is required to forward and route packets, nodes can also leave and enter the network in real time due to their mobility In this work a queuing model is developed for congestion control in mobile adhoc network. The system is checked on three environments viz., static, random and clustered topology. We have seen the variation in system's performance through the above comparison plots. Parameters like network overhead, delay are decreased. It is visualized that more number of load can be controlled without any congestion using the queuing models

VIII REFERENCES

[1] C. A. Harding, H. Yu and A. L. Griffiths, "Delay Algorithm for WNCS over MANETs in MATLAB and SIMULINK", Chinese Automation and Computing Society Conference, Loughborough University, UK. September 2006.

[2] E. Cinlar, "Superposition of Point Processes," Stochastic Point Processes (P. A. W. Lewis ed.) Wiley, 1972, pp. 549- 606

[3] A. E. Eckberg, "The Single Server Queue with Periodic Arrival Process and Deterministic Service Times", IEEE Transactions on Communications (pre-1998). Vol. 27. Issue 3. March 1979.

[4] V. S. Frost and B. Melamed, "Traffic Modelling For Telecommunications Networks", Communication Magazine, March 1994, Vol. 32, Issue 3.

[5] T. Bially, B. Gold, and S. Seneff, "A Technique for Adaptive Voice Flow Control in Integrated Packet Networks", IEEE Transactions on Communications. March 1980. Vol. 28, Issue 3.

[6] C. Weinstein, "Fractional Speech and Talker Activity Model for TASI and for Packet-Switched Speech", IEEE Transactions on Communication. August 1978. Vol. 28. Issue 8.

[7] Arnold O. Allen. *Probability, Statistics, and Queuing Theory – With Computer Science Applications*. Computer Science and Applied Mathematics. Academic Press, New York, 1978.

[8] Gunter Bolch. *Leistungsbewertung von Rechensystemen-mittelsanalytischerWarteschlangenmodelle*. B. G. Teubner, Stuttgart, 1989.

[9] Gunter Bolch, Stefan Greiner, Hermann de Meer, and Kishor S. Trivedi. *Queueing Networks and Markov Chains – Modeling and Performance Evaluation with Computer Science Applications*. John Wiley and Sons, New York, 1998.

[10] Christos G. Cassandras. *Discrete Event Systems – Modeling and Performance Analysis*. Aksen Associates, Boston, 1993.

[11] William Feller. *An Introduction to Probability Theory and Its Applications - Volume II*. John Wiley, New York, second edition, 1968.

[12] William Feller. *An Introduction to Probability Theory and Its Applications - Volume I*. John Wiley, New York, third edition, 1968.

[13] Boudewijn R. Haverkort. *Performance of Computer Communication Systems – A Model Based Approach*. John Wiley and Sons, Chichester / New York, 1998.

[14] Leonard Kleinrock. *Queueing Systems – Volume 1: Theory*, volume 1. John Wiley and Sons, New York, 1975.

[15] Leonard Kleinrock. *Queueing Systems – Volume 2: Computer Applications*, volume 2. John Wiley and Sons, New York, 1976.

[16] Randolph Nelson. *Probability, Stochastic Processes, and Queueing Theory – The Mathematics of Computer Performance Modeling*. Springer Verlag, New York, 1995.

[17] Thomas G. Robertazzi. *Computer Networks and Systems – Queueing Theory and Performance Evaluation*. Springer Verlag, New York, 1994.

[18] K. Xu, K. Tang, R. Bagrodia, M. Gerla, and M. Bereschinsky, "Adaptive Bandwidth Management and QoS Provisioning in Large Scale Ad Hoc Networks," Proc. Military Comm. Conf. (MILCOM '03), Oct. 2003

[19] Xue, J. Stuedi, P. Alonso, G.,"ASAP: an adaptive QoS protocol for mobile ad hoc networks",14th IEEE proceedings on Personal, Indoo r and Mobile Radio Communications, 2003. PIMRC 2003.

[20] T. Bonald, M. May and J. Bolot, "Analytic Performance of RED Performance", Ninetieth Annual Joint Conference of the IEE Computer and Communication Societies. Vol. 3, March 2000.

[21] A. L. Griffiths and R. Carrasco, "IP Multiple Access between 3G/4G Mobile Radio and Fixed Packet Switched Networks", PhD Thesis, Staffordshire University, 2004

[22] M. S. Hasan, C. A. Harding, H. Yu and A. L. Griffiths, "Modelling delay and packet drop in networked control systems using network simulator NS2", International Journal of Automation and Computing, vol 2. 2005. pp 187-194.