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Dynamic bandwidth Management for wireless ad hoc networks for two zones under Non-Homogeneous conditions

K.Rajesh Yadav, Dr. T Srinivasa Rao, Dr. P Suresh Varma, N.Mahendra,
Department of CSE,
[1,2] GITAM University, [3] Adikavi Nannaya Universities, [4]WISTAM,
[1, 2, 4,] Visakhapatnam, [3] Rajahmundry, AP,
[1] k_rajesh_yadav@yahoo.co.in, [2]tsr.etl@gmail.com, [3] vermaps@yahoo.com, [4]narla.mahendra@gmail.com

ABSTRACT

Recently wireless ad hoc networks are continuing to attract the attention for their potential use in several fields. Most of the work has been done in modeling and simulation, because conducting experimentation is complex and time consuming. Wireless ad hoc network models play a predominant role in performance evaluation of may communication systems. In this paper we proposed Wireless ad hoc network model for zones under non-homogeneous conditions. In this paper we considered arrival of packets follows non-homogenous nature having dynamic bandwidth allocation is introduced for performance evaluation and monitoring of wireless ad hoc networks. It is further assumed that transmission time required by each packet at each node is dependent on the content of the buffer connected to it. The transient behavior of the network model is analyzed by the system performance measures like mean number of packets in each buffer, mean delay in transmission, the throughput of the nodes, utilization of transmitters etc,. The non-homogeneous Poisson arrivals and dynamic bandwidth allocation strategy can reduce burstness in buffer and improve quality of service.

Keywords
Wireless ad hoc networks, performance evaluation,dynamic bandwidth allocation.

1. INTRODUCTION

A Wireless ad hoc network consists of a collection of wireless node without a fixed infrastructure. The shared medium multi-hop nature of wireless ad hoc network poses fundamental challenges to the design of an effective resource allocation to maximize performance. To satisfy this rapidly growing demand by many users, various kinds of effective Wireless ad hoc networks have been developed for this purpose. With the development of sophisticated technological innovations in recent years, a wide variety of Wireless ad hoc networks are designed and analyzed with effective bandwidth allocation techniques. In general a realistic and high speed transmission of a data or voice over wireless transmission lines is a major issue of the Wireless systems. It is generally known that the Wireless ad hoc networks gives better performance over traditions networking and yields relatively short network delay.

The statistical multiplexing in Wireless system has a tremendous influence in utilizing channel capacities efficiently. Many of the wireless ad hoc networks which support the Voice, Data and teleprocessing applications are often mixed with statistical techniques and dynamic engineering skills. Due to the unpredicted nature of demands at wireless transmission lines, congestion occurs in Wireless systems. Generally the analysis in a Wireless system is mainly concerned with the problems of allocation and distribution of data/voice packetization, statistical multiplexing, flow control, bit-dropping, link capacity assignment, delays and routing, etc., for efficient utilization of the resources.

For efficient utilization of resources, it is needed to analyze the statistically multiplexing of data/voice transmission through congestion control strategies. Usually bit dropping method is employed for congestion control. The idea of bit dropping is to discard certain portion of the traffic, such as least significant bits in order to reduce the transmission time, while maintaining satisfactory quality of service as perceived by the end user, whenever there is congestion in buffers. Bit dropping method can be classified as input bit dropping (IBD) and output bit dropping (OBD) respectively (Kin K.Leung (2002)). In IBD bits may be dropped when the packets are placed in the queue waiting for transmission. In contrast bits are possibly discarding in OBD only from a packet being transmitted over the channel. This implies fluctuations in voice quality due to dynamically varying bit rate during a cell transmission (Karanam, V.R., Sriram, K. and Bowker, D.O. (1988)). To maintain the voice quality another approach is to consider dynamical bandwidth allocation in the transmitter through utilizing the vacant bandwidth available in the router for the cells which are dropped from the packet under transmission. For evaluating the performance of transmitter under following conditions: (1) at a fixed load when instantaneous fluctuations occur and (2) under variable load when variations occur due to bit dropping or dynamic allocation of bandwidth.

Samarth H Shah et al (2003) proposed an admission control and dynamic bandwidth management scheme which provides fair scheduling. Ying Qiu and peter Marbach (2003) proposed an iterative price and rate adaption algorithm. This algorithm converges to a socially optimal bandwidth allocation. Iftekhar Hussain et al (2015) proposed a QoS aware dynamic bandwidth allocation sheme to mitigate congestion problem in gateway based multi hop WiFi based long distance networks and thereby enhance QoS guarantees for real time traffic, Amulya Sakhamuru, Varun Manchikalaudi (2015) presented fair share algorithm in which bandwidth is fairly distributed in order to avoid the packet losses in terms of data transfer in the channel dynamic allocation. Efficiency affected by some factors like throughput, packet transmission and latency. Due to fair distribution of bandwidth in the network, efficient transfer of packets can be achieved. Vivita Sherin B and Sugadev M (2016) presented a novel algorithm for the optimization of the dynamic channel allocation for a CBR(Cluster based routing) called Mobile cluster based relay reconfiguration (MCRR) where the cluster head is chosen considering the energy of the all nodes in the cluster. This approach is used for increasing the performance by optimization in terms of throughput, energy consumption, packet loss and bandwidth for mobility mobile nodes.

In the review of literature very little work is reporting regarding dynamic bandwidth allocation in Wireless ad hoc networks and no one is reported under homogeneous and non homogeneous conditions. The author already designed and developed dynamic bandwidth allocation model for wireless ad hoc network under homogenous conditions. Hence in this thesis we design and develop dynamic bandwidth allocation models for wireless ad hoc networks under non-homogenous conditions.

It is generally difficult to perform laboratory experiments that capture dynamic bandwidth allocation (i.e. changing the bandwidth just before transmitting the packet) effect on packetized voice transmission under a wide variety of traffic conditions. In addition to these complexities in empirical analysis usually the transmitters are connected in tandem with at least two nodes. Therefore to study the performance evaluation of dynamic bandwidth allocation through load dependent strategy, we develop markovian model (using queueing analogy). The Wireless systems are typically modeled as networks of interconnected nodes/queues by viewing the messages as customers, communication buffer as waiting line and all activities in necessary transmission of the messages as services. This representation is most natural with respect to actual operation of such systems. This sort of synchronization has an advantage of conceptual simplicity and great generality. This leads a wireless network to view as a tandem queueing system or serial queueing network. Several authors have studied the Wireless ad hoc network as a tandem network. They have considered the independent assumption among the service and arrival processes (Seraphin B.Calo, (1981)). Also very little work has been reported in literature regarding Transient Analysis of Wireless ad hoc Networks which are very useful for accurate predictions of the performance measures.

In this chapter we designed and developed a model for evaluation of the performance of a wireless ad hoc network with two access points connected in tandem and each access point acts as a coordinator/ transmitter for that region.

2. Load dependent Dynamic allocation of bandwidth for wireless ad hoc networks for two zones under Non-Homogeneous conditions

In this section we consider a Wireless ad hoc network with two zones each zone consists of number of transmitting nodes/computers to transmit data from one zone to another. The arrival of packets to the buffer connected at node 1 in Zone1 are assumed to follow non-homogeneous posisson process with mean arrival rate as a function of t. it is of the form λ (t) = $\lambda+\alpha t$. The Zone 1 consists of node 1 (Access Point for Zone 1) which acts as coordinator of transmitter to transmit data from zone 1 to another. Similarly zone 2 consists of node 2 (Access Point for Zone 2) acts as coordinator or transmitter to receive data from zone 1 and transmits data to the destination node/computer. Node 1 and 2 acts like router which consist of buffer and transmitter. Buffer connected to the transmitter stores incoming packets and forward to the next node based on load dependent dynamic bandwidth allocation strategy which is shown in figure 2.1. This idea used for better Broadband utilization with bit dropping congestion control scheme. The idea is to reduce packet (cell) transmission time in case of congestion, while maintaining satisfactory quality of service. Kotikalapudi Sriram et al (1991) have developed the bit dropping method as a congestion control in Broadband network. They utilized simulation studies for analyzing the performance of the network. Kin K.Leung (2002) has studied the performance evaluation of congestion control in Broadband networks through load dependent queues. He considered single node network, by utilizing the Laguerre’s function techniques. However, in wireless ad hoc networks the packets are transmitted through two access points’ nodes. It is assumed that the message are packetized at source and stored in buffer for transmission. After being transmitted in the first node, it is being transmitted through the second node. In both the nodes the transmission is carried with load dependent strategy. In load dependent strategy the transmission rate is a linear function of number of packets in the buffer (Depending on the size of the buffer content the transmission time of the packet is fixed with dynamic allocation of bandwidth in the router).

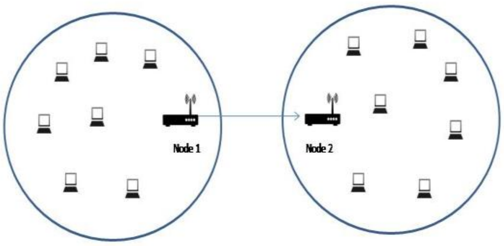


Figure 2.1 Two region wireless ad hoc network with two nodes/access points

Here we assume that the arrival of packets follows a poisson process with parameter λ and the number of transmissions at both the nodes follows poisson processes with parameters μ_1 and μ_2 respectively depending on the number of packets in the buffers. The packets are transmitted through the nodes by first in first out principle. With this structure the postulates of the wireless ad hoc networks are

i) The occurrence of the events in non-overlapping time intervals of time are statistically independent

ii) The probability that there is arrival of one packet in the first buffer connected to node 1 during small interval of time h is [$\lambda(t)h + o(h)$] where $\lambda(t) = \lambda+\alpha t$

iii) The probability that there is one packet transmission through first node, when there are n_1 packets in the first buffer during connected to node 1 small interval of time h is [$n_1\mu_1 h + o(h)$]

iv) The probability that there is one packet transmission through node 1 when there are n_2 packets in the second buffer connected to node 2 during small interval of time h is [$n_2\mu_2 h + o(h)$]

v) The probability that other than above events during small interval of time h is [o(h)]

vi) The probability that there is no arrival in the first buffer connected to node 1 and no transmission through first or second nodes during small interval of time h when there are n_1 packets in the first buffer connected to node 1 and n_2 packets in the second buffer connected to node 2 is [$1 - \lambda(t)h - n_1\mu_1 h - n_2\mu_2 h + o(h)$]

Let $P_{n_1,n_2}(t)$ denote the probability that there are n_1 packets in the first buffer connected to node 1 and n_2 packets in the second buffer connected to node 2 at time t

The difference differential equations of the wireless ad hoc network are

$$\frac{\partial P_{n_1,n_2}(t)}{\partial t} = -(\lambda(t)+n_1\mu_1+n_2\mu_2)P_{n_1n_2}(t)+\lambda(t)P_{n_1-1,n_2}(t)+(n_1+1)\mu_1P_{n_1+1,n_2-1}(t)+(n_2+1)\mu_2P_{n_1,n_2+1}(t) \qquad n_1,n_2>0$$

$$\frac{\partial P_{n_1,0}(t)}{\partial t} = -(\lambda(t)+n_1\mu_1)P_{n_1,0}(t)+\lambda(t)P_{n_1-1,0}(t)+\mu_2P_{n_1,1}(t) \qquad n_1>0, n_2=0$$

$$\frac{\partial P_{0,n_2}(t)}{\partial t} = -(\lambda(t)+n_2\mu_2)P_{0,n_2}+\mu_1P_{1,n_2-1}(t)+(n_2+1)\mu_2P_{0,n_2+1}(t) \qquad n_1=0, n_2>0$$

$$\frac{\partial P_{0,0}(t)}{\partial t} = -\lambda(t)P_{0,0}(t)+\mu_2P_{0,1}(t) \qquad n_1=0, n_2=0$$

(2.1)

Let $P(s_1,s_2,t)=\sum_{n_1=0}^{\infty}\sum_{n_2=0}^{\infty}P_{n_1,n_2}(t)s_1{}^{n_1},s_2{}^{n_2}$ be the joint probability generating function of $P_{n_1n_2}(t)$.

(2.2)

Multiplying the equation (2.1) with $s_1{}^{n_1},s_2{}^{n_2}$ and summing over all n1, n2, we get

$$\frac{dP}{dt} = -\lambda(t)P+\lambda(t)\sum_{n_1=0}^{\infty}\sum_{n_2=0}^{\infty}P_{n_1n_2}(t)s_1^{n_1+1}s_2^{n_2}-\mu_1s_1\frac{\partial P}{\partial s_1}+\mu_1\sum_{n_1=1}^{\infty}\sum_{n_2=0}^{\infty}n_1P_{n_1n_2}(t)s_1^{n_1-1}s_2^{n_2+`}-\mu_2s_2\frac{\partial P}{\partial s_2}$$

$$+\mu_2\sum_{n_1=0}^{\infty}\sum_{n_2=2}^{\infty}n_2P_{n_1n_2}(t)s_1^{n_1}s_2^{n_2-1}+\mu_2\sum_{n_1=0}^{\infty}P_{n_1,1}(t)s_1^{n_1}$$

(2.3)

After simplifying, we get

$$\frac{\partial P}{\partial t} = \mu_1(s_2-s_1)\frac{\partial P}{\partial s_1}+\mu_2(1-s_2)\frac{\partial P}{\partial s_2}-\lambda(t)P(1-s_1)$$

(2.4)

Solving the equation (2.4) by Lagrangian's method, the auxiliary equations are

$$\frac{dt}{1} = -\frac{ds_1}{\mu_1(s_2-s_1)} = -\frac{ds_2}{\mu_2(1-s_2)} = \frac{dP}{\lambda(t)P(s_1-1)}$$

(2.5)

Solving the first and third terms in equation (2.5), we get

$$a = (s_2 - 1)e^{-\mu_2 t}$$

Solving the first and second terms in equation (2.5), we get

$$b = (s_1 - 1)e^{-\mu_1 t} + \frac{\mu_1}{\mu_2 - \mu_1}(s_2 - 1)e^{-\mu_1 t}$$

Solving the first and fourth terms in equation (2.5), we get

$$c = P\exp\left[-\lambda(t)\left[\frac{(s_2 - 1)}{\mu_2} + \frac{(s_1 - 1)}{\mu_1}\right]\right] \tag{2.6}$$

Where, a, b and c are arbitrary constants. Using the initial conditions

$$P_{00}(0) = 1, \qquad P_{00}(t) = 0 \quad \forall,\ t > 0$$

The general solution of (2.4) gives the probability generating function of the number of packets in the first buffer and the number of packets in the second buffer at time t, as P(s1,s2,t).

Therefore

$$P(s_1, s_2, t) = \exp\left\{\begin{bmatrix} \dfrac{(s_1 - 1)}{\mu_1}\left(1 - e^{-\mu_1 t}\right)\left(\lambda - \dfrac{\alpha}{\mu_1}\right) + \dfrac{(s_1 - 1)\alpha t}{\mu_1} \\ + \dfrac{(s_2 - 1)}{\mu_2}\left(1 - e^{-\mu_2 t}\right)\left(\lambda - \alpha\left(\dfrac{1}{\mu_2} + \dfrac{1}{\mu_1}\right)\right) + \\ \dfrac{(s_2 - 1)\alpha t}{\mu_2} + \dfrac{(s_2 - 1)}{\mu_2 - \mu_1}\left(e^{-\mu_2 t} - e^{-\mu_1 t}\right)\left(\lambda - \dfrac{\alpha}{\mu_1}\right) \end{bmatrix}\right\}$$

$\lambda < \min\{\mu_1, \mu_2\}$ (2.7)

3. PERFORMANCE MEASURE OF THE WIRELESS AD HOC NETWORK:

Expanding P (s1, s2, t) given in equation (2.7) and collecting the constant terms, we get the probability that the network is empty as

$$P_{00}(t) = \exp\begin{bmatrix} -\dfrac{1}{\mu_1}\left(1 - e^{-\mu_1 t}\right)\left(\lambda - \dfrac{\alpha}{\mu_1}\right) \\ + \dfrac{\alpha t}{\mu_1} - \dfrac{1}{\mu_2}\left(1 - e^{-\mu_2 t}\right) \\ \left(\lambda - \alpha\left(\dfrac{1}{\mu_2} + \dfrac{1}{\mu_1}\right)\right) \\ + \dfrac{\alpha t}{\mu_2} - \dfrac{1}{\mu_2 - \mu_1}\left(e^{-\mu_2 t} - e^{-\mu_1 t}\right) \\ \left(\lambda - \dfrac{\alpha}{\mu_1}\right) \end{bmatrix} \tag{3.1}$$

Taking s2 = 1, we get the probability generating function of the first buffer size distribution as

$$P(s_1, t) = \exp\left\{\frac{1}{\mu_1}(s_1 - 1)\left(1 - e^{-\mu_1 t}\right)\left(\lambda - \frac{\alpha}{\mu_1}\right)\right\}$$

$,\lambda < \mu_1$. (3.2)

Expanding P (s1, t) and collecting the constant terms, we get the probability that the first buffer is empty as

$$P_{0.}(t) = \exp\left\{-\left[\frac{1}{\mu_1}\left(1 - e^{-\mu_1 t}\right)\left(\lambda - \frac{\alpha}{\mu_1}\right) + \frac{\alpha t}{\mu_1}\right]\right\} \tag{3.3}$$

Similarly s1 = 1, we get the probability generating function of the second buffer size distribution as

$$P(s_2, t) = \exp\left\{\begin{bmatrix} \dfrac{(s_2 - 1)}{\mu_2}\left(1 - e^{-\mu_2 t}\right)\left(\lambda - \alpha\left(\dfrac{1}{\mu_2} + \dfrac{1}{\mu_1}\right)\right) \\ + \dfrac{(s_2 - 1)\alpha t}{\mu_2} + \dfrac{(s_2 - 1)}{\mu_2 - \mu_1}\left(e^{-\mu_2 t} - e^{-\mu_1 t}\right) \\ \left(\lambda - \dfrac{\alpha}{\mu_1}\right) \end{bmatrix}\right\}$$

$$\lambda<\min\{\mu 1, \mu 2\} \qquad (3.4)$$

Expanding P (s2, t) and collecting the constant terms, we get the probability that the second buffer is empty as

$$P_{.0}(t)=\exp\left\{-\left[\begin{array}{l}\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)+\frac{\alpha t}{\mu_2}\\ +\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)\end{array}\right]\right\}$$

(3.5)

The mean number of packets in the first buffer is

$$L_1=E[N_1]=\frac{1}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)+\frac{\alpha t}{\mu_1}$$

(3.6)

The utilization of the first transmitter is

$$U_1=1-P_{0.}(t)=1-\exp\left\{-\left[\frac{1}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)+\frac{\alpha t}{\mu_1}\right]\right\}$$

(3.7)

The mean number of the packets in second buffer is

$$L_2=E[N_2]=\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)$$
$$+\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)$$

(3.8)

The utilization of the second transmitter is

$$U_2=1-P_{.0}(t)$$
$$=1-\exp\left\{-\left[\begin{array}{l}\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)\\ +\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)+\left(\lambda-\frac{\alpha}{\mu_1}\right)\end{array}\right]\right\}$$

(3.9)

The variance of the number of packets in the first buffer is

Var (N1)
$$=\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)+\frac{\alpha t}{\mu_1}$$

(3.10)

The variance of the number of packets in the second buffer is

var(N2)

$$=\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)$$
$$+\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)$$

(3.11)

The throughput of the first transmitter is

$$\mu_1\left(1-P_{0.}(t)\right)=\mu_1\left[1+\exp\left(\frac{1}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)\right)+\frac{\alpha t}{\mu_1}\right]$$

(3.12)

The mean delay in the first buffer is

W1=
$$\frac{L_1}{\mu_1\left(1-P_{0.}(t)\right)}=$$
$$\frac{\frac{1}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)+\frac{\alpha t}{\mu_1}}{\mu_1\left[1+\exp\left(\frac{1}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)\right)+\frac{\alpha t}{\mu_1}\right]}$$

(3.13)

The throughput of the second transmitter is

$$\mu_2\left(1-P_{.0}(t)\right)$$

$$=\mu_2\left[1+\exp\left\{\left[\begin{array}{l}\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\\ \left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)\\ +\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)\end{array}\right]\right\}\right]$$

(3.14)

The mean delay in the second buffer is

$$W2=\frac{L_2}{\mu_2\left(1-P_{.0}(t)\right)}$$

$$=\frac{\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)+\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)}{\mu_2\left[1+\exp\left\{\left[\begin{array}{l}\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\\ \left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)+\frac{\alpha t}{\mu_2}\\ +\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)\end{array}\right]\right\}\right]}$$

(3.15)

The mean number of packets in the entire network at time t is, L(t) and L(t) = E(N1) + E(N2) for all t, then the mean number of packets in the network is

$$L(t)=\left[\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right]+\left[\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right)+\frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]$$

(3.16)

The variability of the number of packets in the network is

Var (N) = var (N1) + var (N2) + 2 cov (N1, N2)

$$=\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)+\frac{\alpha t}{\mu_1}+\frac{1}{\mu_2}\left(1-e^{-\mu_2 t}\right)\left(\lambda-\alpha\left(\frac{1}{\mu_2}+\frac{1}{\mu_1}\right)\right)$$
$$+\frac{\alpha t}{\mu_2}+\frac{1}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\left(\lambda-\frac{\alpha}{\mu_1}\right)$$

(3.17)

For different values of t, λ, μ1, μ2 the probability of the network emptiness, the probability of emptiness of each buffer, the mean number of packets in each buffer, the utilization of both transmitters are computed and given in Table (3.1).

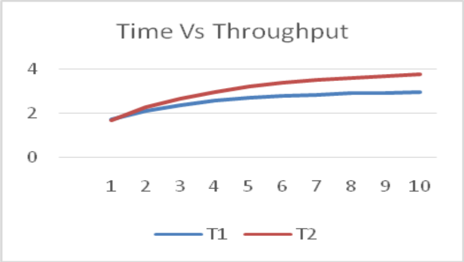
Table 4.3.1: The values of $P_{00}(t)$, $P_{0.}(t)$,$P_{.0}(t)$, L_1, L_2, var(N_1), var(N_2), U_1, U_2 for different values of t, λ, μ_1, μ_2 .

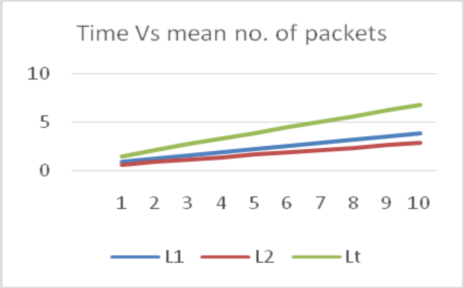
t	λ	α	μ1	μ2	$P_{00}(t)$	$P_{0.}$ (t)	$P_{.0}$ (t)	L_1= E[n_1]	U_1	L_2=E[n_2]	U_2	var(n_1)	var(n_2)
1	2	1	3	4	0.4714	0.4226	0.5797	0.8612	0.5774	0.5452	0.4203	0.8612	0.5452
2	2	1	3	4	0.2454	0.2950	0.4272	1.2208	0.7050	0.8505	0.5728	1.2208	0.8505
3	2	1	3	4	0.1363	0.2111	0.3316	1.5555	0.7889	1.1040	0.6684	1.5555	1.1040
4	2	1	3	4	0.0760	0.1512	0.2582	1.8889	0.8488	1.3542	0.7418	1.8889	1.3542
5	2	1	3	4	0.0424	0.1084	0.2011	2.2222	0.8916	1.6042	0.7989	2.2222	1.6042
6	2	1	3	4	0.0237	0.0776	0.1566	2.5556	0.9224	1.8542	0.8434	2.5556	1.8542
7	2	1	3	4	0.0132	0.0556	0.1219	2.8889	0.9444	2.1042	0.8781	2.8889	2.1042
8	2	1	3	4	0.0074	0.0399	0.0950	3.2222	0.9601	2.3542	0.9050	3.2222	2.3542
9	2	1	3	4	0.0041	0.0286	0.0740	3.5556	0.9714	2.6042	0.9260	3.5556	2.6042
10	2	1	3	4	0.0023	0.0205	0.0576	3.8889	0.9795	2.8542	0.9424	3.8889	2.8542
2	1	1	3	4	0.4384	0.4113	0.5473	0.8883	0.5887	0.6027	0.4527	0.8883	0.6027
2	2	1	3	4	0.2454	0.2950	0.4272	1.2208	0.7050	0.8505	0.5728	1.2208	0.8505
2	3	1	3	4	0.1374	0.2115	0.3335	1.5534	0.7885	1.0982	0.6665	1.5534	1.0982
2	4	1	3	4	0.0769	0.1517	0.2603	1.8859	0.8483	1.3460	0.7397	1.8859	1.3460
2	5	1	3	4	0.0430	0.1088	0.2032	2.2184	0.8912	1.5938	0.7968	2.2184	1.5938
2	2	1	2	5	0.1240	0.1762	0.5216	1.7363	0.8238	0.6509	0.4784	1.7363	0.6509
2	2	1	4	5	0.4078	0.3917	0.4919	0.9374	0.6083	0.7095	0.5081	0.9374	0.7095
2	2	1	6	5	0.8197	0.5279	0.4836	0.6389	0.4721	0.7266	0.5164	0.6389	0.7266
2	2	1	8	5	1.4270	0.6161	0.4795	0.4844	0.3839	0.7350	0.5205	0.4844	0.7350
2	2	1	10	5	2.3395	0.6771	0.4771	0.3900	0.3229	0.7400	0.5229	0.3900	0.7400
2	2	1	3	2	0.2327	0.2950	0.2130	1.2208	0.7050	1.5463	0.7870	1.2208	1.5463
2	2	1	3	4	0.2454	0.2950	0.4272	1.2208	0.7050	0.8505	0.5728	1.2208	0.8505
2	2	1	3	6	0.2571	0.2950	0.5588	1.2208	0.7050	0.5820	0.4412	1.2208	0.5820
2	2	1	3	8	0.2646	0.2950	0.6428	1.2208	0.7050	0.4419	0.3572	1.2208	0.4419
2	2	1	3	10	0.2698	0.2950	0.7004	1.2208	0.7050	0.3561	0.2996	1.2208	0.3561
2	2	-1	3	4	0.4000	0.8966	0.8688	0.1092	0.1034	0.1406	0.1312	0.1092	0.1406
2	2	-0.5	3	4	0.3540	0.6790	0.7275	0.3871	0.3210	0.3181	0.2725	0.3871	0.3181
2	2	0	3	4	0.3133	0.5143	0.6092	0.6650	0.4857	0.4955	0.3908	0.6650	0.4955
2	2	0.5	3	4	0.2773	0.3895	0.5102	0.9429	0.6105	0.6730	0.4898	0.9429	0.6730
2	2	1	3	4	0.2454	0.2950	0.4272	1.2208	0.7050	0.8505	0.5728	1.2208	0.8505

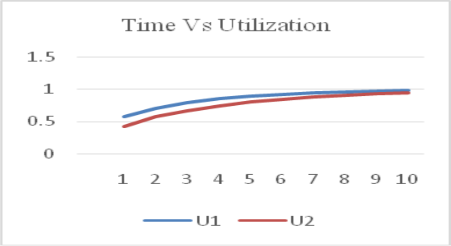
Table 4.3.2: The values of Throughput1, Throughput$_2$, W [n_1], W [n_2], var((t) for different values of t, λ, $\mu_{1,}$ $\mu_{2,}$ α .

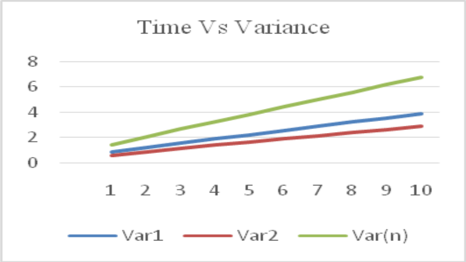
t	λ	α	μ_1	μ_2	Th_1	Th_2	$W[n_1]$	$W[n_2]$	E[L(t)]	var(L(t))
1	2	1	3	4	1.7321	1.6812	0.4972	0.3243	1.4065	1.4065
2	2	1	3	4	2.1151	2.2912	0.5772	0.3712	2.0713	2.0713
3	2	1	3	4	2.3667	2.6738	0.6572	0.4129	2.6595	2.6595
4	2	1	3	4	2.5463	2.9673	0.7418	0.4564	3.2430	3.2430
5	2	1	3	4	2.6749	3.1958	0.8308	0.5020	3.8264	3.8264
6	2	1	3	4	2.7671	3.3737	0.9236	0.5496	4.4097	4.4097
7	2	1	3	4	2.8331	3.5122	1.0197	0.5991	4.9931	4.9931
8	2	1	3	4	2.8804	3.6201	1.1187	0.6503	5.5764	5.5764
9	2	1	3	4	2.9143	3.7041	1.2200	0.7030	6.1597	6.1597
10	2	1	3	4	2.9386	3.7696	1.3234	0.7572	6.7431	6.7431
2	1	1	3	4	1.7660	1.8107	0.5030	0.3329	1.4910	1.4910
2	2	1	3	4	2.1151	2.2912	0.5772	0.3712	2.0713	2.0713
2	3	1	3	4	2.3654	2.6662	0.6567	0.4119	2.6516	2.6516
2	4	1	3	4	2.5449	2.9589	0.7410	0.4549	3.2319	3.2319
2	5	1	3	4	2.6736	3.1874	0.8297	0.5000	3.8122	3.8122
2	2	1	2	5	1.6476	2.3920	1.0538	0.2721	2.3871	2.3871
2	2	1	4	5	2.4333	2.5405	0.3852	0.2793	1.6468	1.6468
2	2	1	6	5	2.8327	2.5822	0.2255	0.2814	1.3655	1.3655
2	2	1	8	5	3.0713	2.6024	0.1577	0.2824	1.2193	1.2193
2	2	1	10	5	3.2294	2.6144	0.1208	0.2830	1.1300	1.1300
2	2	1	3	2	2.1151	1.5739	0.5772	0.9824	2.7671	2.7671
2	2	1	3	4	2.1151	2.2912	0.5772	0.3712	2.0713	2.0713
2	2	1	3	6	2.1151	2.6472	0.5772	0.2198	1.8028	1.8028
2	2	1	3	8	2.1151	2.8574	0.5772	0.1546	1.6627	1.6627
2	2	1	3	10	2.1151	2.9958	0.5772	0.1189	1.5769	1.5769
2	2	-1	3	4	0.3103	0.5247	0.3519	0.2680	0.2498	0.2498
2	2	-0.5	3	4	0.9629	1.0898	0.4020	0.2919	0.7052	0.7052
2	2	0	3	4	1.4572	1.5630	0.4564	0.3170	1.1606	1.1606
2	2	0.5	3	4	1.8315	1.9593	0.5148	0.3435	1.6159	1.6159
2	2	1	3	4	2.1151	2.2912	0.5772	0.3712	2.0713	2.0713

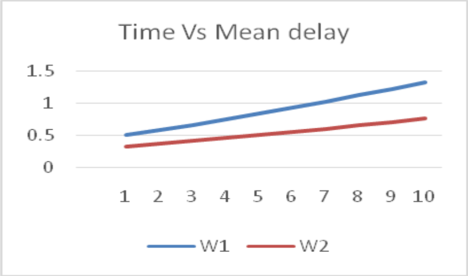
Graph 3.1: Showing the relation between performance measures and time



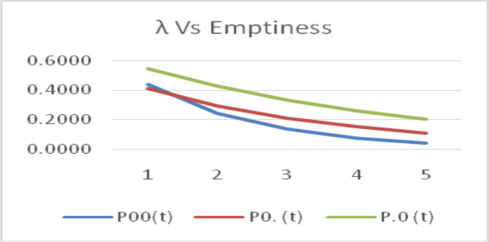


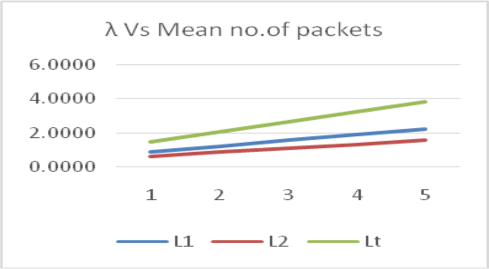


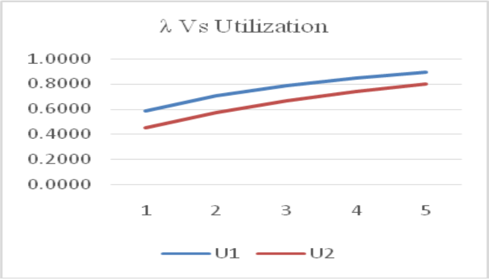


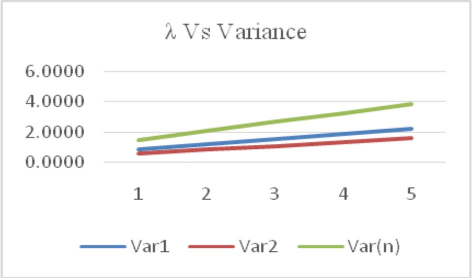


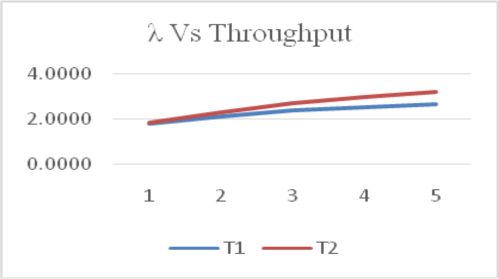
Graph 3.2: Showing the relation between performance measures and Mean Arrival Time

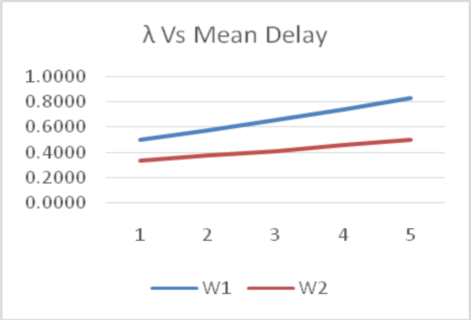




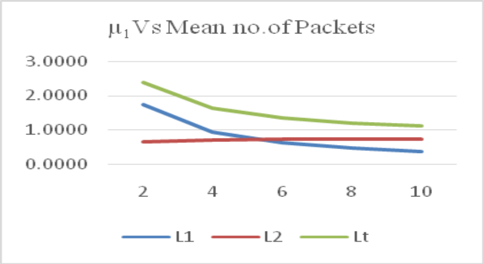


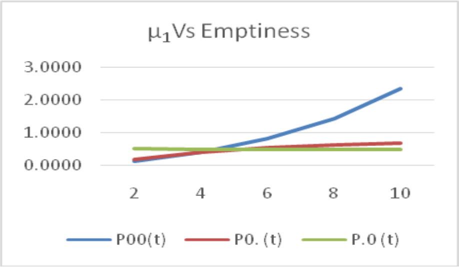


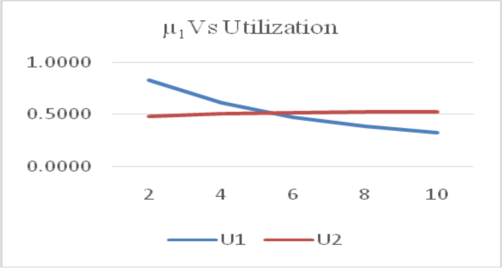


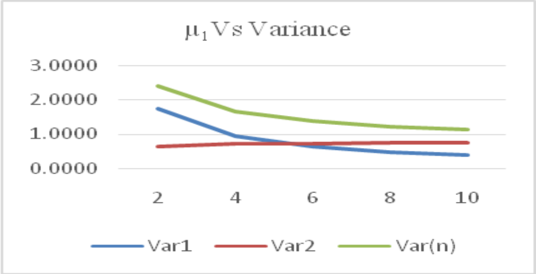


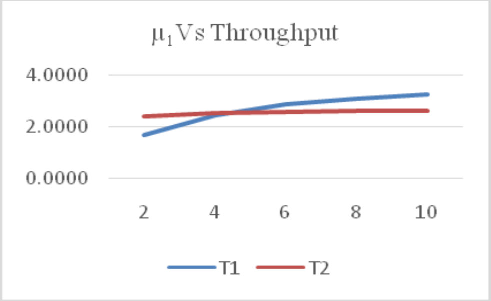
Graph 3.3: Showing the relation between performance measures and Transmission rate

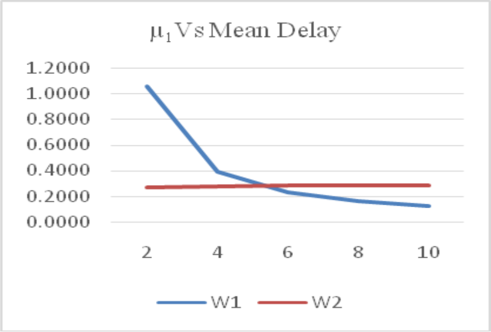




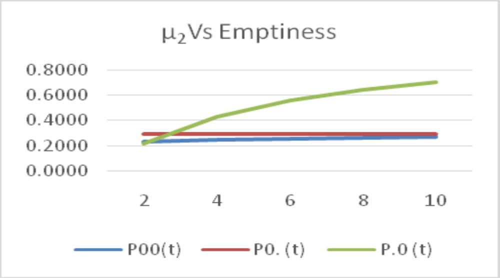


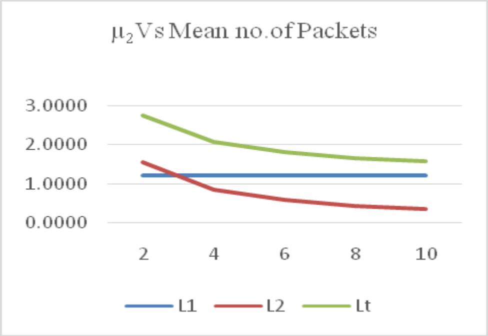


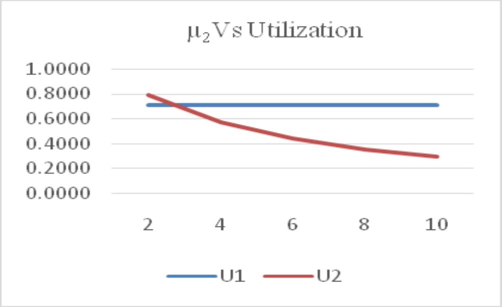


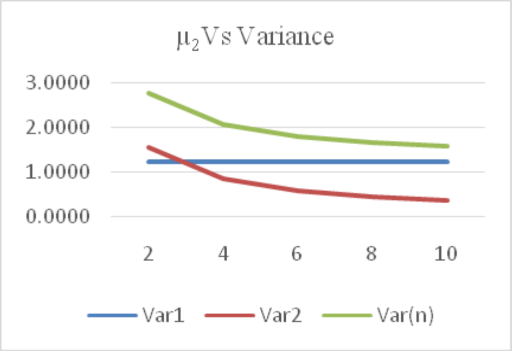


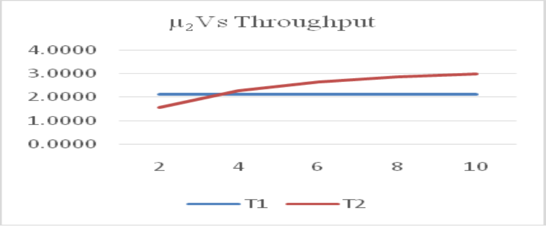
Graph 3.4: Showing the relation between performance measures and Mean Transmission rate

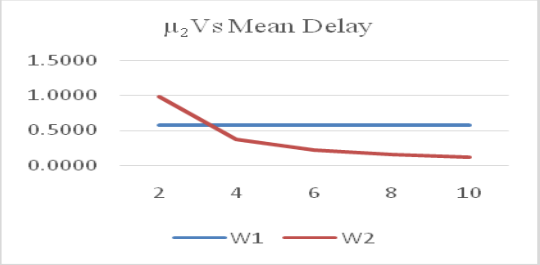












From the equations (3.1) to (3.17), Table (3.1), Table (3.2) and graphs (3.1) to graphs (3.4) it is observed that as the time increases the probability of the wireless network emptiness and buffers emptiness are decreasing, the mean number of packets in each buffer increases, the utilization of transmitters are increasing. the throughput of the first and second transmitters are increasing, the mean delay in the first and second buffers are increasing, the mean number of packets in the network increasing, when other parameters are fixed

It is also observed that as the mean arrival rate increases, the probability of the network emptiness and probability of emptiness of the buffers are decreasing. As the mean numbers of packets in each buffer are increasing, the utilization of the transmitters are also increasing, the throughput of the first transmitter increases, the throughput of the second transmitter increases, the mean delay in the first buffer increases, the mean delay in the second buffer increases, the mean number of packets in the network increases, when other parameters are fixed

It is also observed that as the transmission rate of the first transmitter increases, the probability of the network emptiness and the probability of the first buffer emptiness are increasing, the probability of second buffer emptiness is decreasing, the mean number of packets in the first buffer decreases, the mean number of packets in the second buffer increases, the utilization of the first transmitter decreases, the utilization of second transmitter increases and variance of the first buffer decreases, the throughput of the first transmitter increases, the throughput of the second transmitter increases, the mean delay in the first buffer decreases, the mean delay in the second buffer increases, the mean number of packets in the network decreasing when other parameters are fixed.

It is also observed that as the transmission rate of the second transmitter increases, the probability of the network emptiness increases, the probability of the first buffer empty is unchanged, the probability of second buffer empty increases, the mean number of packets in the first buffer is unchanged, the mean number of packets in the second buffer decreases, the utilization of the first transmitter is unchanged, the utilization of second transmitter decreases and the variance of the first buffer is unchanged, the throughput of the first

4. CONCLUSION:

In this paper a novel and new wireless ad hoc network model developed and analyzed the wireless ad hoc systems more effectively and efficiently. The work presented in this paper focus on the improvement of allocation of bandwidth dynamically using load dependent strategy under non-homogeneous conditions. This shows that dynamic allocation of bandwidth can reduce mean delay and mean service time. The developed network performs faster than the traditional network without load dependence.

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Authors Profile

Dr T Srinivasa Rao received the **B,Tech.** degree from GITAM ,Andhra University, Visakhapatnam, Andhra Pradesh, India. Received the **M.Tech.** degree in Andhra University, Visakhapatnam, Andhra Pradesh, India. Received the **Ph.D.** degree in Andhra University, Visakhapatnam, Andhra Pradesh, India.Present working as Associate Professor , Department of CSE, Gitam Institute of Technology ,Gitam University, Visakhapatnam. His research interest includes wireless communication (**WiFi,WiMax**), Mobile Ad hoc networks ,Sensor Networks ,Neural Networks and fuzzy logic, Communication networks, Data mining, softwareengineering, Machine learning.

Dr. P suresh Varma is a Professor in the Department of Computer Science, Adikavi Nannaya University, and Rajahmundry, India. He published several research papers in national and international journals and presented papers at various conferences, seminars and workshops. His current research interests are Communication Networks, Data Mining and Cloud Computing.

N.Mahendra received the **M.C.A.** degree in Birla Institute Of Technology, Ranchi, India, in 2002. Received the **M.Tech.** Degree in Andhra University in 2005 , India.

His research interest includes wireless communication (**WiFi,WiMax**), Mobile Ad hoc networks ,Sensor Networks, Communication networks.

K.Rajesh Yadav received the **MSc.** degree in computer science from the Andhra University, Visakhapatnam, Andhra Pradesh, India. Received the **M.Tech.** degree in computer science from the Gitam University, Visakhapatnam, Andhra Pradesh, India. His research interest includes wireless communication (**WiFi,WiMax**), Mobile Ad hoc networks ,Sensor Networks, Neural Networks and fuzzy logic, Communication networks.