**International Journal of Academic Engineering Research (IJAER)**
**ISSN: 2000-001X**
**Vol. 2 Issue 8, August – 2018, Pages: 34-47**

# Performance Evaluation of Wireless Ad Hoc Networks For Three Zone Model Under Homogeneous Conditions

**[1]K Rajesh Yadav, [2]Dr. T Srinivasa Rao, [3]Sandhya Bathini**

[1]Department of CSE, GITAM University, Visakhapatnam, AndhraPradesh, India
k_rajesh_yadav@yahoo.co.in
[2]Department of CSE, GITAM University, Visakhapatnam, AndhraPradesh, India
tsr.etl@gmail.com
[3]IT Director , Appollidon Learning, Tampa, Florida 33626, USA
Sandyvirgo25@gmail.com

***Abstract:*** *Wireless ad hoc network is a collection of Wireless nodes which form a network without relying on any existing Centralized administration. Wireless networks, in particular ad hoc networks have revolutionized the field of Networking with increasing number of commercial and military applications. Establishing communication through portable devices without the dependence on or constraints of any central infrastructural id possible through ad hoc networks. Wireless ad hoc networks models play a predominant role in performance evaluation of many communication systems. In this paper we designed and developed a three zone (multi hop) wireless ad hoc network model with homogeneous Poisson arrivals of packets having dynamic bandwidth allocation the performance evaluation of model measured using various performance metrics like mean number of packets on buffer throughput, utilization and mean waiting time developed explicitly. This model shows better performance when compared with exiting models.*
.

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

## 1. INTRODUCTION

The demand for data wireless ad hoc networks is growing rapidly in many different fields. 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 bandwidth 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 (1997)). 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. Hence in this thesis we design and develop dynamic bandwidth allocation model for wireless ad hoc networks under 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 open queueing system or serial open queueing network. Several authors studied 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 paper we designed and developed a model for evaluation of the performance of a wireless ad hoc network with three zones each zone consists of one access points connected in tandem and each access point acts as a coordinator/ transmitter for that region.

We are considered a three zone multi hop wireless ad hoc network for transmission of packets from source to destination. For evaluating wireless ad hoc networks in commercial and business application, these models are utilized. Several researchers study performance evaluation of Wireless ad hoc network under various methods. Due to the difficulty of analyzing wireless ad hoc network models exactly, many studies on approximation techniques. The approximation techniques are largely complex and do not scale well. Some of these techniques are proposed without formal proofs. So in this paper, we developed and analyzed a wireless ad hoc network model for three zones for wireless communication systems in which the packets arrive to a buffer connected to the first node in zone 1 and after transmission to the first node the packet may routed to buffer 2 of node 2 in zone 2 with certain probability and after transmission to the second node the packet may routed to node 3 in zone 3. We also considered that Node1,Node2 and Node3 are connected in series to the serve the packet transmission from source to destination. The transient behaviour of this Wireless ad hoc network is analyzed by deriving the difference-diffential equations of the model. The Wireless ad hoc network performance is evaluated by obtaining explicitly expressions for the joint probability generating function of buffer size distributions, the probability of emptiness of buffers, the throughput of transmitters, the mean delays, the average content of the buffer etc,. This network model also includes the earlier models as particular cases for specific values of the parameters.

## 2. Wireless ad hoc networks for three zones under Homogeneous conditions

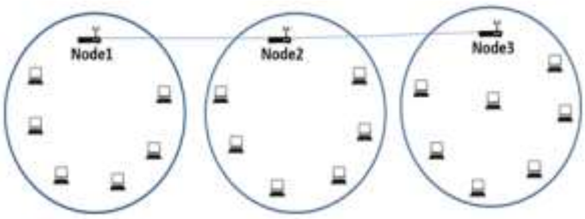
In this section we consider a Wireless ad hoc network with three zones connected in series and each zone consists of number of transmitting nodes/computers to transmit data from one zone to another. The arrival of packets to the buffer connected at node 1 in Zone1 are assumed to follow Homogeneous posisson process $\lambda$. 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 Node 2. Similarly zone 3 consists of node 3 (Access Point for Zone 3) acts as coordinator or transmitter to receive data from zone 2 and transmits data to the destination node/computer Node 1, 2 and 3 acts like router which consist of buffer and transmitter. Each 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 (1997) 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 three 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 and it is being transmitted through the third node to reach destination. All the

**International Journal of Academic Engineering Research (IJAER)**
**ISSN: 2000-001X**
**Vol. 2 Issue 8, August – 2018, Pages: 34-47**

three nodes the transmission is followed by 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).

Let n1, n2 and n3 denote the number of packets in the first buffer, second buffer and third buffer respectively.

The schematic diagram of Three Zone Wireless ad hoc network is shown in figure 2.1.




With this structure the postulates of the model are:

1. The occurrences of the events in non-overlapping intervals of time are statistically independent.
2. The probability that there is an arrival of one packet during a small interval of time h is [λ h + o(h)].
3. The probability that there is one packet transmission through first transmitter when there are $n_1$ packets in the first buffer during a small interval of time h is [$n_1$ $\mu_1$ h + o(h)]
4. The probability that there is one packet transmission through second transmitter when there are $n_2$ packets in the second buffer during a small interval of time h is [$n_2$ $\mu_2$ h + o(h)]
5. The probability that there is one packet transmission through third transmitter when there are $n_3$ packets in the third buffer during a small interval of time h is [$n_3$ $\mu_3$ h + o(h)]
6. The probability that other than the above events during a small interval of time h is [o(h)]
7. The probability that there is no arrival to the first buffer and no transmission in first, second and third nodes during a small interval of time h when there are $n_1$ packets in the first buffer and $n_2$ packets in the second buffer, $n_3$ packets in the third buffer is [1 – λ(t) h – $n_1$ $\mu_1$ h – $n_2$ $\mu_2$ h– $n_3$ $\mu_3$h + o(h)]

Let $P_{n_1,n_2,n_3}(t)$ denote the probability that there are $n_1$ packets in the first buffer and $n_2$ packets in the second buffer and $n_3$ packets in the third buffer at time t

The difference-differential equations of the network are

$$\frac{\partial P_{n_1,n_2,n_3}(t)}{\partial t} = -\left(\lambda + n_1\mu_1 + n_2\mu_2 + n_3\mu_3\right)P_{n_1,n_2,n_3}(t) + \lambda P_{n_1-1,n_2,n_3}(t) + (n_1+1)\mu_1 P_{n_1+1,n_2-1,n_3}(t) + (n_2+1)\mu_2 P_{n_1,n_2+1,n_3-1}(t) + (n_3+1)\mu_3 P_{n_1,n_2,n_3+1}(t)$$
$$n_1, n_2, n_3 > 0$$

$$\frac{\partial P_{0,n_2,n_3}(t)}{\partial t} = -\left(\lambda + n_2\mu_2 + n_3\mu_3\right)P_{0,n_2,n_3}(t) + \mu_1 P_{1,n_2-1,n_3}(t) + (n_2+1)\mu_2 P_{0,n_2+1,n_3-1}(t) + (n_3+1)\mu_3 P_{0,n_2,n_3+1}(t)$$
$$n_1 = 0, n_2, n_3 > 0$$

$$\frac{\partial P_{n_1,0,n_3}(t)}{\partial t} = -\left(\lambda + n_1\mu_1 + n_3\mu_3\right)P_{n_1,0,n_3}(t) + \lambda P_{n_1-1,0,n_3}(t) + \mu_2 P_{n_1,1,n_3-1}(t) + (n_3+1)\mu_3 P_{n_1,0,n_3+1}(t)$$
$$n_1 > 0, n_2 = 0, n_3 > 0$$

$$\frac{\partial P_{n_1,n_2,0}(t)}{\partial t} = -\left(\lambda + n_1\mu_1 + n_2\mu_2\right)P_{n_1,n_2,0}(t) + \lambda P_{n_1-1,n_2,0}(t) + (n_1+1)\mu_1 P_{n_1+1,n_2-1,0}(t) + \mu_3 P_{n_1,n_2,1}(t)$$
$$n_1, n_2 > 0, n_3 = 0$$

$$\frac{\partial P_{0,0,n_3}(t)}{\partial t} = -\left(\lambda + n_3\mu_3\right)P_{0,0,n_3}(t) + \mu_2 P_{0,1,n_3-1}(t) + (n_3+1)\mu_3 P_{0,0,n_3+1}(t) \qquad n_1 = 0, n_2 = 0, n_3 > 0$$

$$\frac{\partial P_{n_1,0,0}(t)}{\partial t} = -\left(\lambda + n_1\mu_1\right)P_{n_1,0,0}(t) + \lambda P_{n_1-1,0,0}(t) + \mu_3 P_{n_1,0,1}(t)$$
$$n_1 > 0, n_2 = 0, n_3 = 0$$

$$\frac{\partial P_{0,n_2,0}(t)}{\partial t} = -\left(\lambda + n_2\mu_2\right)P_{0,n_2,0}(t) + \mu_1 P_{1,n_2-1,0}(t) + \mu_3 P_{0,n_2,1}(t)$$
$$n_1 = 0, n_2 > 0, n_3 = 0$$

$$\frac{\partial P_{0,0,0}(t)}{\partial t} = -(\lambda)P_{0,0,0}(t) + \mu_3 P_{0,0,1}(t) \qquad n_1 = n_2 = n_3 = 0 \tag{2.1}$$

$$Let\ P(s_1, s_2, s_3, t) = \sum_{n_1=0}^{\infty}\sum_{n_2=0}^{\infty}\sum_{n_3=0}^{\infty} P_{n_1,n_2,n_3}(t) s_1^{n_1} s_2^{n_2} s_3^{n_3}$$

be the joint probability generating function of $P_{n_1,n_2,n_3}(t)$.

(2.2)

Multiplying the equation (2.1) with $s_1^{n_1}, s_2^{n_2}, s_3^{n_3}$ and summing over all $n_1$,$n_2$, and $n_3$ we get

International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47

$$\frac{dP}{dt}=-\lambda P+\lambda s_1 P-\mu_1 s_1\frac{\partial P}{\partial s_1}+\mu_1 s_2\frac{\partial P}{\partial s_1}-\mu_2 s_2\frac{\partial P}{\partial s_2}+\mu_2 s_3\frac{\partial P}{\partial s_2}-\mu_3 s_3\frac{\partial P}{\partial s_3}+\mu_3\frac{\partial P}{\partial s_3} \tag{2.3}$$

After simplifying, we get

$$\frac{\partial P}{\partial t}=\mu_1(s_2-s_1)\frac{\partial P}{\partial s_1}+\mu_2(s_3-s_2)\frac{\partial P}{\partial s_2}+\mu_3(1-s_3)\frac{\partial P}{\partial s_3}+\lambda P(s_1-1) \tag{2.4}$$

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

$$\frac{dt}{1}=\frac{ds_1}{\mu_1(s_1-s_2)}=\frac{ds_2}{\mu_2(s_2-s_3)}=\frac{ds_3}{\mu_2(s_3-1)}=\frac{dP}{\lambda P(s_1-1)} \tag{2.5}$$

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

$$a=(s_3-1)e^{-\mu_3 t} \tag{2.6a}$$

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

$$b=(s_2-1)e^{-\mu_2 t}+\frac{\mu_2}{\mu_3-\mu_2}(s_3-1)e^{-\mu_2 t} \tag{2.6b}$$

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

$$c=(s_1-1)e^{-\mu_1 t}+\frac{\mu_1}{\mu_2-\mu_1}(s_2-1)e^{-\mu_1 t}+\frac{\mu_1\mu_2}{(\mu_3-\mu_1)(\mu_2-\mu_1)}(s_3-1)e^{-\mu_1 t} \tag{2.6c}$$

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

$$d=P\exp\left[-\lambda\left[\frac{(s_1-1)}{\mu_1}+\frac{(s_2-1)}{\mu_2}+\frac{(s_3-1)}{\mu_3}\right]\right] \tag{2.6d}$$

where, a, b, c and d are arbitrary constants. Using the initial conditions $P_{000}(0)=1,\quad P_{000}(t)=0\quad \forall, t>0$

The general solution of (2.4) gives the probability generating function of the number of packets in the first, second and third buffers at time t, as $P(s_1,s_2,s_3,t)$.

Therefore

$$P(s_1,s_2,s_2,t)=\exp\left\{\lambda\left[\frac{(s_1-1)}{\mu_1}\left(1-e^{-\mu_1 t}\right)+\frac{(s_2-1)}{\mu_2}\left(1-e^{-\mu_2 t}\right)+\frac{(s_2-1)}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)+\frac{(s_3-1)}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{(s_3-1)}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)+(s_3-1)\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}+\frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right]\right\}$$

$$\lambda<\min\{\mu_1,\mu_2,\mu_3\} \tag{2.7}$$

## 3. PERFORMANCE MEASURE OF THE THREE ZONE MULTI HOP WIRELESS NETWORK:

Expanding $P(s_1,s_2,s_2,t)$ given in equation (2.7) and collecting the constant terms, we get the probability that the network is empty as

$$P_{000}(t)=\exp\left\{\lambda\left[\frac{(-1)}{\mu_1}\left(1-e^{-\mu_1 t}\right)+\frac{(-1)}{\mu_2}\left(1-e^{-\mu_2 t}\right)+\frac{(-1)}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)+\frac{(-1)}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{(-1)}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)+(-1)\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}+\frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right]\right\} \tag{3.1}$$

Taking $s_2 = 1$, $s_3 = 1$ we get the probability generating function of the first buffer size distribution as

$$P(s_1,t) = \exp\left\{ \frac{\lambda}{\mu_1}(s_1-1)\left(1-e^{-\mu_1 t}\right)\right\}, \qquad \lambda < \mu_1. \tag{3.2}$$

Expanding P( $s_1$,t) and collecting the constant terms, we get the probability that the first buffer is empty as

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

Similary $s_1 = 1$, $s_2 = 1$ we get the probability generating function of the second buffer size distribution as

$$P(s_2,t) = \exp\left\{ \lambda\left[\frac{(s_2-1)}{\mu_2}\left(1-e^{-\mu_2 t}\right)+\frac{(s_2-1)}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]\right\}$$

$$\lambda<\min\{\mu_1,\mu_2\} \tag{3.4}$$

Expanding $P(s_2,t)$ and collecting the constant terms, we get the probability that the second buffer is empty as

$$P_{.0.}(t) = \exp\left\{-\left[\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right)+\frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]\right\} \tag{3.5}$$

Similary $s_1 = 1$, $s_2 = 1$ we get the probability generating function of the third buffer size distribution as

$$P(s_3,t) = \exp\left\{\lambda\left[\frac{(s_3-1)}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{(s_3-1)}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right) + (s_3-1)\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)} + \frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)} + \frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right]\right\},$$

$$\lambda < \min\{\mu_1,\mu_2,\mu_3\} \tag{3.6}$$

Expanding P( $s_3$,t) and collecting the constant terms, we get the probability that the third buffer is empty as

$$P_{..0}(t) = \exp\left\{-\left[\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right) - \lambda\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)} + \frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)} + \frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right]\right\} \tag{3.7}$$

The mean number of packets in the first buffer is

$$L_1 = E[N_1] = \frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right) \tag{3.8}$$

The utilization of the first transmitter is

$$U_1 = 1-P_{0..}(t) = 1-\exp\left\{-\left[\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right]\right\} \tag{3.9}$$

The mean number of the packets in second buffer is

$$L_2 = E[N_2] = \frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) + \frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right) \tag{3.10}$$

The utilization of the second transmitter is

$$U_2 = 1-P_{.0.}(t) = 1-\exp\left\{\left[-\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) - \frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]\right\} \tag{3.11}$$

The mean number of the packets in third buffer is

$$L_3 = E[N_3] = \frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right) + \frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right) + \lambda\mu_2\left[\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)} + \frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)} + \frac{e^{-\mu_1 t}}{(\mu_2-\mu_1)(\mu_1-\mu_3)}\right]$$

(3.12)

The utilization of the third transmitter is

$$U_3 = 1 - P_{..0}(t) = 1-\exp\left\{-\left[\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right) + \frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right) + \lambda\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)} + \frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)} + \frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right]\right\}$$

(3.13)

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

$$\text{var}(N_1) = \frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right) \qquad (3.14)$$

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

var($N_2$)

$$= \frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) + \frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right) \qquad (3.15)$$

The variance of the number of packets in the third buffer is var($N_3$)

$$= \frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right) + \frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right) + \mu_2\left[\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)} + \frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)} + \frac{e^{-\mu_1 t}}{(\mu_2-\mu_1)(\mu_1-\mu_3)}\right]$$

( 3.16 )

The throughput of the first transmitter is

$$\mu_1\left(1-P_{0..}(t)\right) = \mu_1\left[1-\exp\left(-\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right)\right] \qquad (3.17)$$

The mean delay in the first buffer is

$W_1$=

$$\frac{L_1}{\mu_1\left(1-P_{0..}(t)\right)} = \frac{\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)}{\mu_1\left[1-\exp\left(-\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right)\right]} \qquad (3.18)$$

The throughput of the second transmitter is

$$\mu_2\left(1-P_{.0.}(t)\right) = \mu_2\left[1-\exp\left\{-\left[\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) + \frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]\right\}\right] \qquad (3.19)$$

The mean delay in the second buffer is

$$W_2 = \frac{L_2}{\mu_2\left(1-P_{.0}(t)\right)} = \frac{\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) - \frac{\lambda}{\mu_1-\mu_2}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)}{\mu_2\left[1-\exp\left\{-\left[\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right) + \frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\right]\right\}\right]} \qquad (3.20)$$

The throughput of the third transmitter is

**International Journal of Academic Engineering Research (IJAER)**
**ISSN: 2000-001X**
**Vol. 2 Issue 8, August – 2018, Pages: 34-47**

$$\mu_3\left(1-P_{..0}(t)\right)$$
$$=\mu_3\left[1-\exp\left\{-\left[\begin{array}{l}\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)\\+\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)\end{array}\right.\right.\right.$$
$$\left.\left.\left.+\lambda\mu_2\left(\begin{array}{l}\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}\\+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}\\+\frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\end{array}\right)\right]\right\}\right] \tag{3.21}$$

The mean delay in the third buffer is

$$W_3=\frac{L_3}{\mu_3\left(1-P_{..0}(t)\right)}$$

$$=\frac{\left(\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)+\lambda\mu_2\left[\begin{array}{l}\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}\\+\frac{e^{-\mu_1 t}}{(\mu_2-\mu_1)(\mu_1-\mu_3)}\end{array}\right]\right)}{\left(\mu_3\left[1-\exp\left\{-\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)-\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)-\lambda\mu_2\left(\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}+\frac{e^{-\mu_1 t}}{(\mu_1-\mu_3)(\mu_2-\mu_1)}\right)\right\}\right]\right)} \tag{3.22}$$

The mean number of packets in the entire network at time t is

$$L(t)=\left[\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right]+\left[\begin{array}{l}\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right)\\+\frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\end{array}\right]$$
$$+\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)$$
$$+\lambda\mu_2\left[\begin{array}{l}\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}\\+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}\\+\frac{e^{-\mu_1 t}}{(\mu_2-\mu_1)(\mu_1-\mu_3)}\end{array}\right] \tag{3.23}$$

The variability of the number of packets in the network is

$$\mathrm{var(N)}=\left[\frac{\lambda}{\mu_1}\left(1-e^{-\mu_1 t}\right)\right]+\left[\begin{array}{l}\frac{\lambda}{\mu_2}\left(1-e^{-\mu_2 t}\right)\\+\frac{\lambda}{\mu_2-\mu_1}\left(e^{-\mu_2 t}-e^{-\mu_1 t}\right)\end{array}\right]$$
$$+\frac{\lambda}{\mu_3}\left(1-e^{-\mu_3 t}\right)+\frac{\lambda}{\mu_3-\mu_2}\left(e^{-\mu_3 t}-e^{-\mu_2 t}\right)$$
$$+\lambda\mu_2\left[\begin{array}{l}\frac{e^{-\mu_3 t}}{(\mu_2-\mu_3)(\mu_3-\mu_1)}\\+\frac{e^{-\mu_2 t}}{(\mu_3-\mu_2)(\mu_2-\mu_1)}\\+\frac{e^{-\mu_1 t}}{(\mu_2-\mu_1)(\mu_1-\mu_3)}\end{array}\right] \tag{3.24}$$

For different values of t, λ, $\mu_1$, $\mu_2$ and $\mu_3$ the probability of the network is empty and the probabilities of emptiness of the three buffers, the mean number of packets in buffers, the utilization of transmitters, the variance of the content of buffers, throughput of transmitters and mean delay in the buffers are computed and given in Tables (3.1), (3.2) and (3.3).

Table 3.1: The values of $P_{000}(t)$, $L_1$,$P_{0..}(t)$, , $U_1$, var($N_1$), Throughput of first Transmitter, Mean delay in the first buffer for different values of t, λ, $\mu_1$ , $\mu_2$ and $\mu_3$ .

| t | λ | $\mu_1$ | $\mu_2$ | $\mu_3$ | $L_1$ | $P_{000}(t)$ | $P_{0..}(t)$ | $U_1$ | var($N_1$) | $Th_1$ | $W_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 25 | 30 | 0.633475 | 0.522443 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 2 | 2 | 3 | 25 | 30 | 0.665014 | 0.507393 | 0.514266 | 0.485734 | 0.665014 | 1.457201 | 0.456364 |
| 3 | 2 | 3 | 25 | 30 | 0.666584 | 0.506656 | 0.513459 | 0.486541 | 0.666584 | 1.459622 | 0.456683 |
| 5 | 2 | 3 | 25 | 30 | 0.666666 | 0.506617 | 0.513417 | 0.486583 | 0.666666 | 1.459748 | 0.4567 |
| 10 | 2 | 3 | 25 | 30 | 0.666667 | 0.506617 | 0.513417 | 0.486583 | 0.666667 | 1.459749 | 0.4567 |
| 15 | 2 | 3 | 25 | 30 | 0.666667 | 0.506617 | 0.513417 | 0.486583 | 0.666667 | 1.459749 | 0.4567 |
| | | | | | | | | | | | |
| 1 | 2 | 8 | 25 | 30 | 0.249916 | 0.768537 | 0.778866 | 0.221134 | 0.249916 | 1.769071 | 0.14127 |
| 1 | 3 | 8 | 25 | 30 | 0.374874 | 0.67374 | 0.687376 | 0.312624 | 0.374874 | 2.500994 | 0.14989 |
| 1 | 4 | 8 | 25 | 30 | 0.499832 | 0.590636 | 0.606632 | 0.393368 | 0.499832 | 3.146941 | 0.158831 |
| 1 | 5 | 8 | 25 | 30 | 0.62479 | 0.517783 | 0.535374 | 0.464626 | 0.62479 | 3.717011 | 0.168089 |
| 1 | 6 | 8 | 25 | 30 | 0.749748 | 0.453915 | 0.472485 | 0.527515 | 0.749748 | 4.220117 | 0.177661 |
| 1 | 7 | 8 | 25 | 30 | 0.874706 | 0.397926 | 0.416984 | 0.583016 | 0.874706 | 4.664125 | 0.187539 |
| | | | | | | | | | | | |
| 1 | 2 | 4 | 25 | 30 | 0.490842 | 0.603457 | 0.612111 | 0.387889 | 0.490842 | 1.551557 | 0.316355 |
| 1 | 2 | 8 | 25 | 30 | 0.249916 | 0.768537 | 0.778866 | 0.221134 | 0.249916 | 1.769071 | 0.14127 |
| 1 | 2 | 12 | 25 | 30 | 0.166666 | 0.835271 | 0.846483 | 0.153517 | 0.166666 | 1.842209 | 0.090471 |
| 1 | 2 | 16 | 25 | 30 | 0.125 | 0.870808 | 0.882497 | 0.117503 | 0.125 | 1.880049 | 0.066488 |
| 1 | 2 | 20 | 25 | 30 | 0.1 | 0.892853 | 0.904837 | 0.095163 | 0.1 | 1.903252 | 0.052542 |
| 1 | 2 | 24 | 25 | 30 | 0.083333 | 0.907859 | 0.920044 | 0.079956 | 0.083333 | 1.918934 | 0.043427 |
| | | | | | | | | | | | |
| 1 | 2 | 3 | 10 | 30 | 0.633475 | 0.459147 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 12 | 30 | 0.633475 | 0.476123 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 14 | 30 | 0.633475 | 0.488522 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 16 | 30 | 0.633475 | 0.497978 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 18 | 30 | 0.633475 | 0.50543 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 20 | 30 | 0.633475 | 0.511455 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| | | | | | | | | | | | |
| 1 | 2 | 3 | 25 | 26 | 0.633475 | 0.528021 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 25 | 30 | 0.633475 | 0.522443 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 25 | 35 | 0.633475 | 0.517322 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 25 | 40 | 0.633475 | 0.513517 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 25 | 45 | 0.633475 | 0.510579 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |
| 1 | 2 | 3 | 25 | 50 | 0.633475 | 0.508242 | 0.530744 | 0.469256 | 0.633475 | 1.407768 | 0.449986 |

Table 3.2: The values of $L_2$, $P_{.0.}(t)$, , $U_2$, var($N_2$), Throughput of second Transmitter, Mean delay in the second buffer for different values of t, λ, $\mu_1$ , $\mu_2$ and $\mu_3$.

| t | λ | $\mu_1$ | $\mu_2$ | $\mu_3$ | $L_2$ | $P_{.0.}(t)$ | $U_{2s}$ | var($N_2$) | $Th_2$ | $W_2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 25 | 30 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 2 | 2 | 3 | 25 | 30 | 0.079775 | 0.923324 | 0.076676 | 0.079775 | 1.91689 | 0.041617 |
| 3 | 2 | 3 | 25 | 30 | 0.079989 | 0.923127 | 0.076873 | 0.079989 | 1.921832 | 0.041621 |
| 5 | 2 | 3 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| 10 | 2 | 3 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| 15 | 2 | 3 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| | | | | | | | | | | |
| 1 | 2 | 8 | 25 | 30 | 0.079961 | 0.923153 | 0.076847 | 0.079961 | 1.921181 | 0.041621 |
| 1 | 3 | 8 | 25 | 30 | 0.119941 | 0.886973 | 0.113027 | 0.119941 | 2.825676 | 0.042447 |
| 1 | 4 | 8 | 25 | 30 | 0.159921 | 0.852211 | 0.147789 | 0.159921 | 3.694724 | 0.043284 |
| 1 | 5 | 8 | 25 | 30 | 0.199901 | 0.818812 | 0.181188 | 0.199901 | 4.529712 | 0.044131 |
| 1 | 6 | 8 | 25 | 30 | 0.239882 | 0.786721 | 0.213279 | 0.239882 | 5.331975 | 0.044989 |
| 1 | 7 | 8 | 25 | 30 | 0.279862 | 0.755888 | 0.244112 | 0.279862 | 6.102796 | 0.045858 |
| | | | | | | | | | | |
| 1 | 2 | 4 | 25 | 30 | 0.078256 | 0.924728 | 0.075272 | 0.078256 | 1.881800 | 0.041586 |
| 1 | 2 | 8 | 25 | 30 | 0.079961 | 0.923153 | 0.076847 | 0.079961 | 1.921181 | 0.041621 |

International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47

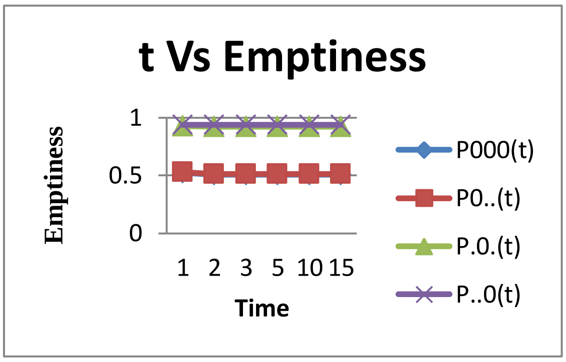
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 12 | 25 | 30 | 0.079999 | 0.923117 | 0.076883 | 0.079999 | 1.922070 | 0.041621 |
| 1 | 2 | 16 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| 1 | 2 | 20 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| 1 | 2 | 24 | 25 | 30 | 0.080000 | 0.923116 | 0.076884 | 0.080000 | 1.922091 | 0.041621 |
| | | | | | | | | | | |
| 1 | 2 | 3 | 10 | 30 | 0.185779 | 0.830457 | 0.169543 | 0.185779 | 1.695429 | 0.109576 |
| 1 | 2 | 3 | 12 | 30 | 0.155603 | 0.855899 | 0.144101 | 0.155603 | 1.729215 | 0.089985 |
| 1 | 2 | 3 | 14 | 30 | 0.133805 | 0.874761 | 0.125239 | 0.133805 | 1.753351 | 0.076314 |
| 1 | 2 | 3 | 16 | 30 | 0.11734 | 0.889282 | 0.110718 | 0.11734 | 1.771482 | 0.066239 |
| 1 | 2 | 3 | 18 | 30 | 0.104473 | 0.900799 | 0.099201 | 0.104473 | 1.785613 | 0.058508 |
| 1 | 2 | 3 | 20 | 30 | 0.094143 | 0.910153 | 0.089847 | 0.094143 | 1.796942 | 0.05239 |
| | | | | | | | | | | |
| 1 | 2 | 3 | 25 | 26 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 1 | 2 | 3 | 25 | 30 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 1 | 2 | 3 | 25 | 35 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 1 | 2 | 3 | 25 | 40 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 1 | 2 | 3 | 25 | 45 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |
| 1 | 2 | 3 | 25 | 50 | 0.075474 | 0.927304 | 0.072696 | 0.075474 | 1.817402 | 0.041528 |

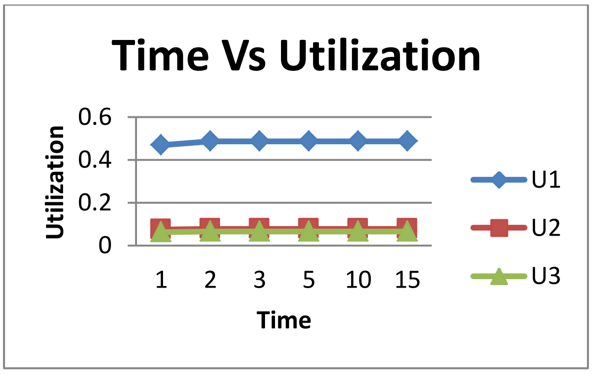
Table 3.3: The values of $L_3$, $P_{..0}(t)$, $U_3$, var($N_3$), Throughput of third Transmitter, Mean delay in the third buffer, L(t), var(N) for different values of t, λ, $\mu_1$, $\mu_2$ and $\mu_3$.

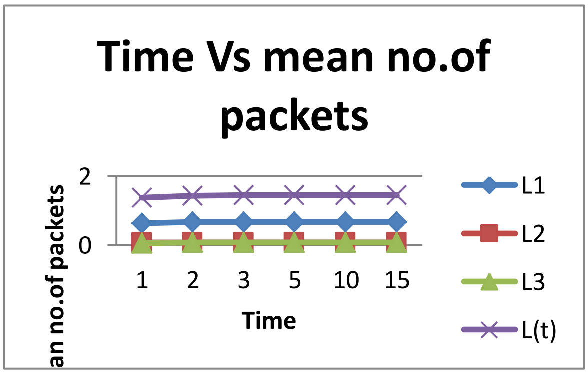
| t | λ | $\mu_1$ | $\mu_2$ | $\mu_3$ | $L_3$ | $P_{.0}(t)$ | $U_3$ | var($N_3$) | $Th_3$ | $W_3$ | L(t) | var(N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 25 | 30 | 0.064571 | 0.937469 | 0.062531 | 0.064571 | 1.875921 | 0.034421 | 1.378003 | 1.378003 |
| 2 | 2 | 3 | 25 | 30 | 0.066562 | 0.935605 | 0.064395 | 0.066562 | 1.931862 | 0.034455 | 1.438156 | 1.438156 |
| 3 | 2 | 3 | 25 | 30 | 0.066661 | 0.935512 | 0.064488 | 0.066661 | 1.934645 | 0.034457 | 1.441137 | 1.441137 |
| 5 | 2 | 3 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 1.441292 | 1.441292 |
| 10 | 2 | 3 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 1.441293 | 1.441293 |
| 15 | 2 | 3 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 1.441293 | 1.441293 |
| | | | | | | | | | | | | |
| 1 | 2 | 8 | 25 | 30 | 0.066644 | 0.935528 | 0.064472 | 0.066644 | 1.934161 | 0.034456 | 0.758974 | 0.758974 |
| 1 | 3 | 8 | 25 | 30 | 0.099978 | 0.904858 | 0.095142 | 0.099978 | 2.854269 | 0.035027 | 1.115586 | 1.115586 |
| 1 | 4 | 8 | 25 | 30 | 0.133311 | 0.875193 | 0.124807 | 0.133311 | 3.744212 | 0.035605 | 1.459028 | 1.459028 |
| 1 | 5 | 8 | 25 | 30 | 0.166644 | 0.846501 | 0.153499 | 0.166644 | 4.604979 | 0.036188 | 1.79065 | 1.79065 |
| 1 | 6 | 8 | 25 | 30 | 0.199978 | 0.818749 | 0.181251 | 0.199978 | 5.437527 | 0.036777 | 2.111652 | 2.111652 |
| 1 | 7 | 8 | 25 | 30 | 0.233311 | 0.791907 | 0.208093 | 0.233311 | 6.24278 | 0.037373 | 2.423099 | 2.423099 |
| | | | | | | | | | | | | |
| 1 | 2 | 4 | 25 | 30 | 0.065828 | 0.936292 | 0.063708 | 0.065828 | 1.911244 | 0.034443 | 1.161795 | 1.161795 |
| 1 | 2 | 8 | 25 | 30 | 0.066644 | 0.935528 | 0.064472 | 0.066644 | 1.934161 | 0.034456 | 0.758974 | 0.758974 |
| 1 | 2 | 12 | 25 | 30 | 0.066666 | 0.935508 | 0.064492 | 0.066666 | 1.934772 | 0.034457 | 0.608223 | 0.608223 |
| 1 | 2 | 16 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 0.530546 | 0.530546 |
| 1 | 2 | 20 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 0.483206 | 0.483206 |
| 1 | 2 | 24 | 25 | 30 | 0.066667 | 0.935507 | 0.064493 | 0.066667 | 1.93479 | 0.034457 | 0.451332 | 0.451332 |
| | | | | | | | | | | | | |
| 1 | 2 | 3 | 10 | 30 | 0.064031 | 0.937976 | 0.062024 | 0.064031 | 1.860726 | 0.034412 | 1.584108 | 1.584108 |
| 1 | 2 | 3 | 12 | 30 | 0.064208 | 0.93781 | 0.06219 | 0.064208 | 1.865697 | 0.034415 | 1.528833 | 1.528833 |
| 1 | 2 | 3 | 14 | 30 | 0.06432 | 0.937705 | 0.062295 | 0.06432 | 1.868847 | 0.034417 | 1.48839 | 1.48839 |
| 1 | 2 | 3 | 16 | 30 | 0.064397 | 0.937633 | 0.062367 | 0.064397 | 1.871024 | 0.034418 | 1.457554 | 1.457554 |
| 1 | 2 | 3 | 18 | 30 | 0.064454 | 0.937579 | 0.062421 | 0.064454 | 1.87262 | 0.034419 | 1.433279 | 1.433279 |
| 1 | 2 | 3 | 20 | 30 | 0.064497 | 0.937539 | 0.062461 | 0.064497 | 1.873841 | 0.03442 | 1.41368 | 1.41368 |
| | | | | | | | | | | | | |
| 1 | 2 | 3 | 25 | 26 | 0.074463 | 0.928242 | 0.071758 | 0.074463 | 1.865719 | 0.039911 | 1.397123 | 1.397123 |
| 1 | 2 | 3 | 25 | 30 | 0.064571 | 0.937469 | 0.062531 | 0.064571 | 1.875921 | 0.034421 | 1.378003 | 1.378003 |
| 1 | 2 | 3 | 25 | 35 | 0.055375 | 0.94613 | 0.05387 | 0.055375 | 1.885435 | 0.02937 | 1.360146 | 1.360146 |
| 1 | 2 | 3 | 25 | 40 | 0.048471 | 0.952685 | 0.047315 | 0.048471 | 1.892598 | 0.025611 | 1.346687 | 1.346687 |
| 1 | 2 | 3 | 25 | 45 | 0.043097 | 0.957818 | 0.042182 | 0.043097 | 1.898185 | 0.022705 | 1.33618 | 1.33618 |
| 1 | 2 | 3 | 25 | 50 | 0.038796 | 0.961947 | 0.038053 | 0.038796 | 1.902666 | 0.02039 | 1.327751 | 1.327751 |

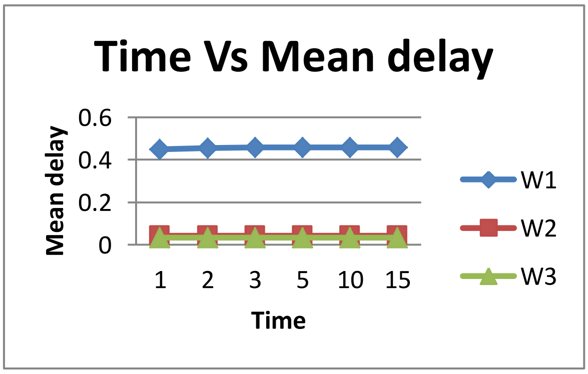
International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47

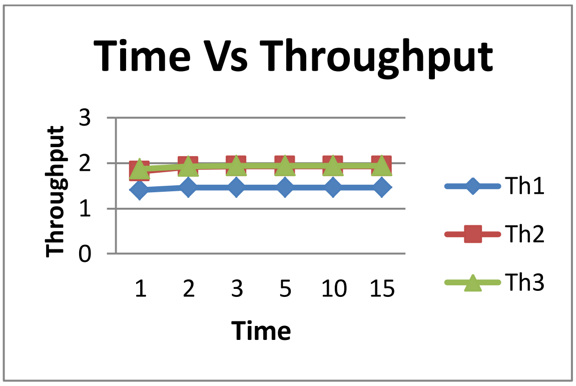
**Graph 3.1:** Showing the relation between performance measures and time

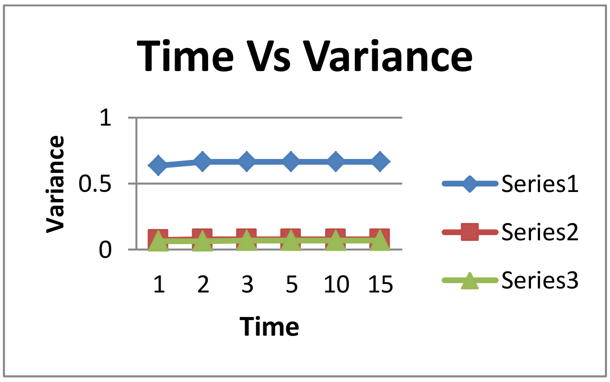


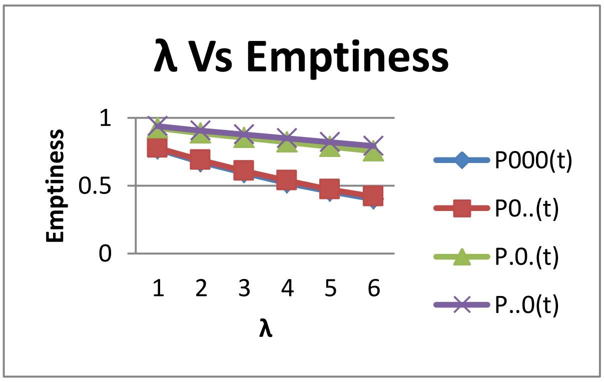



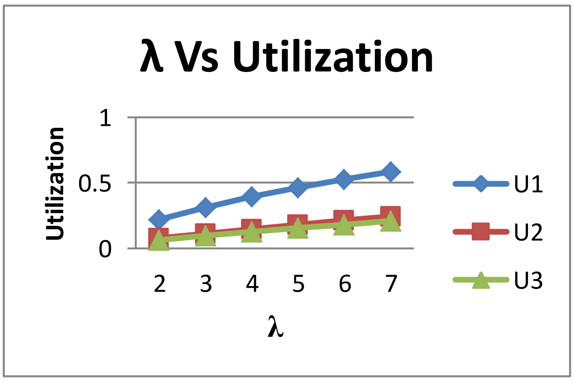



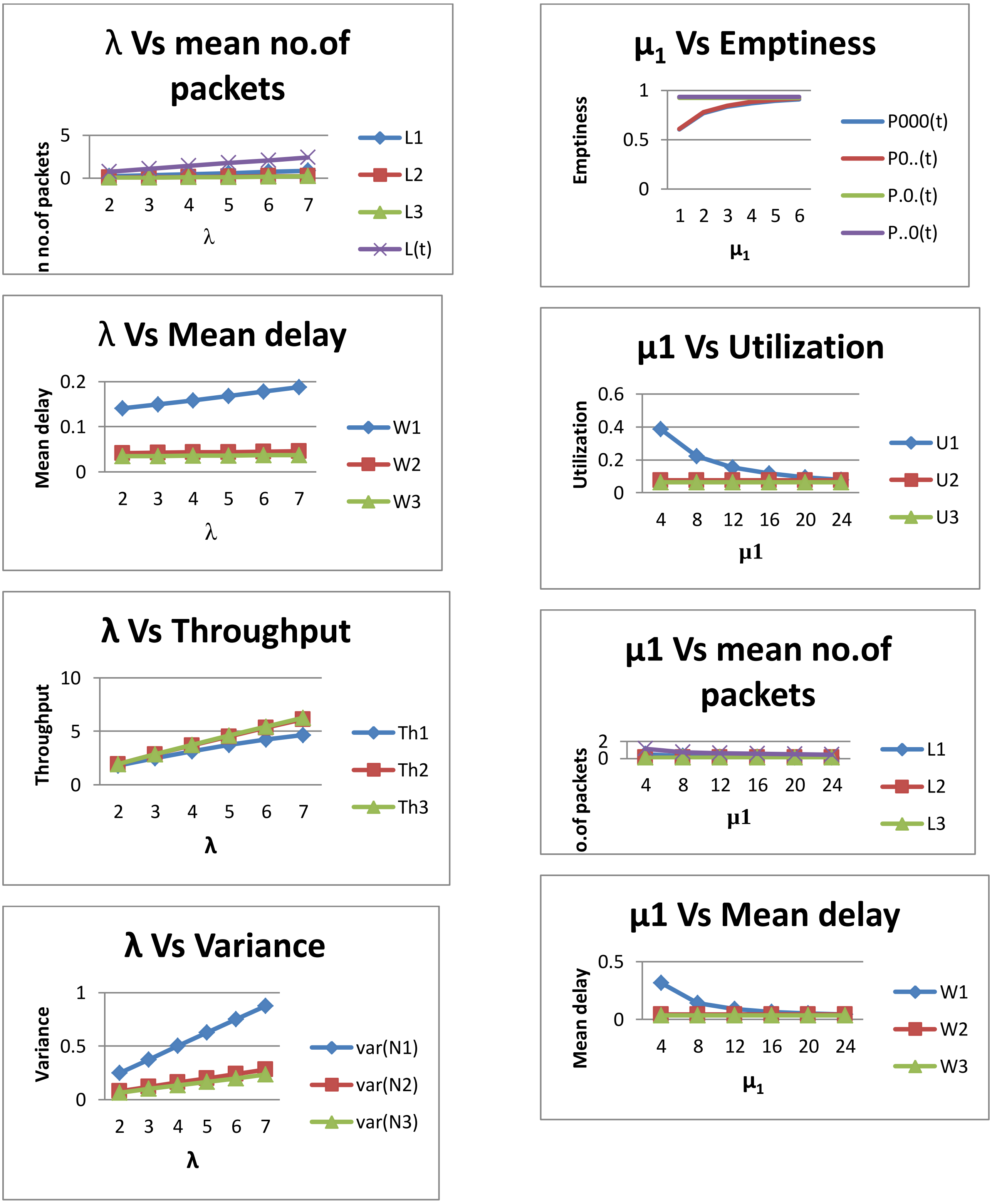




**Graph 3.2:** Showing the relation between performance measures and Mean Arrival Time



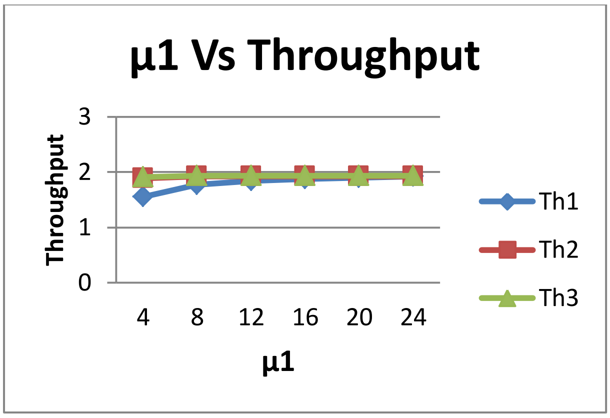



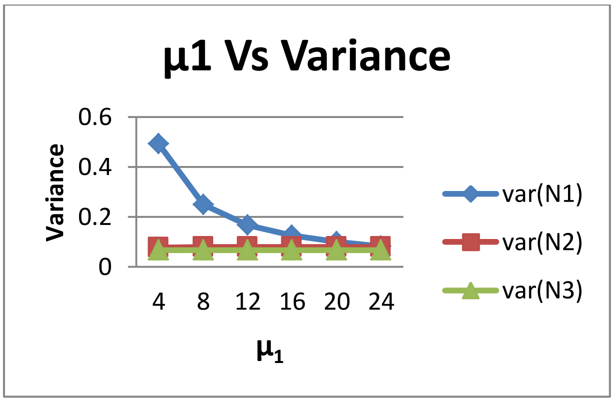
International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47



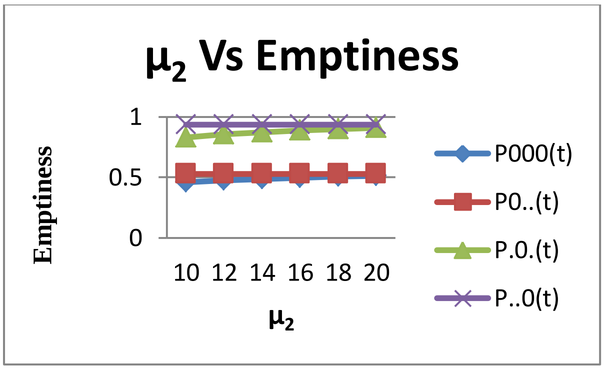

**Graph 3.3:** Showing the relation between performance measures and Transmission rate

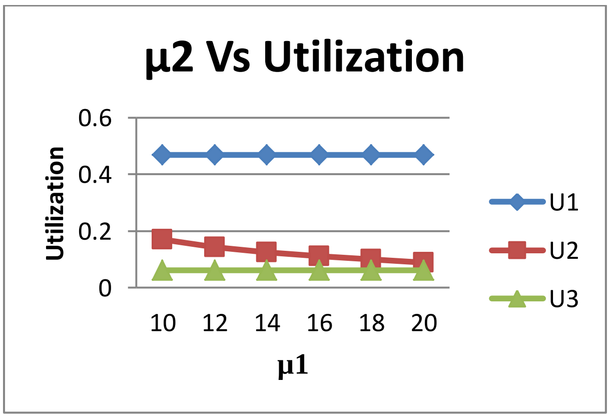
International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47

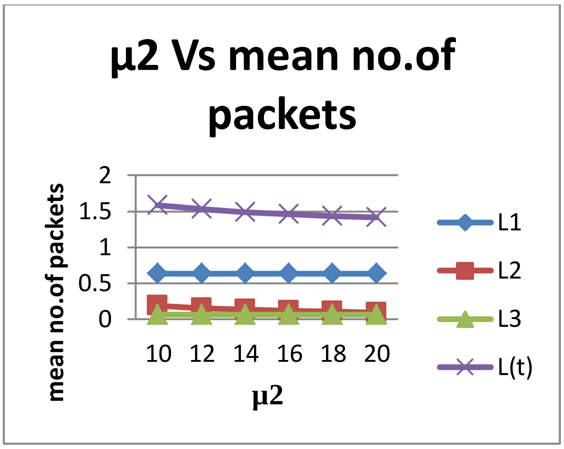


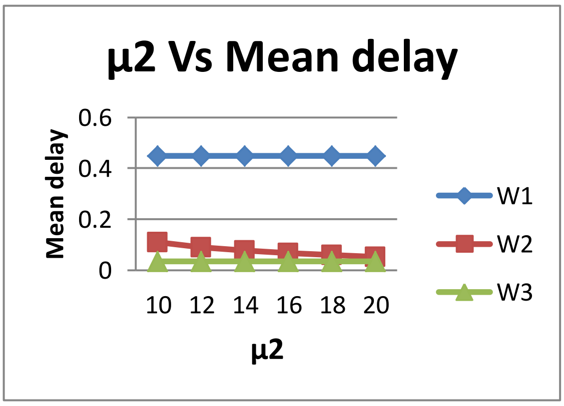



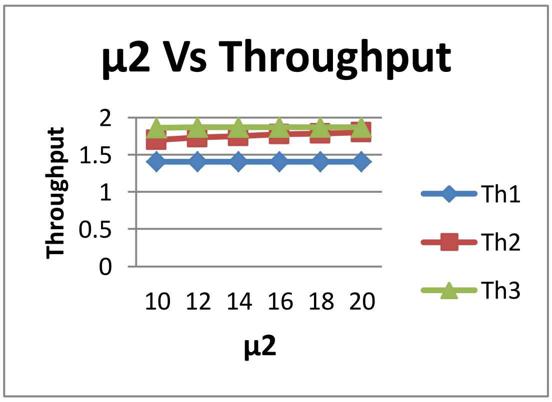

**Graph 3.4:** Showing the relation between performance measures and Mean Transmission Rate

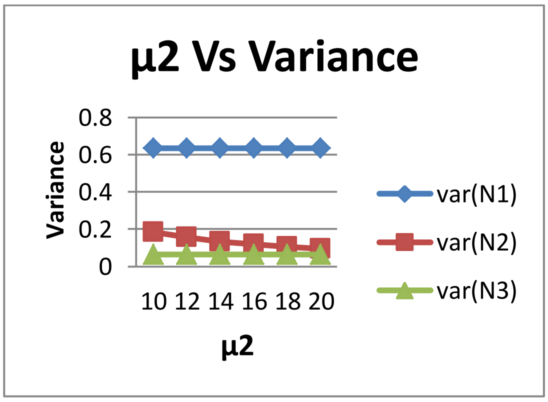


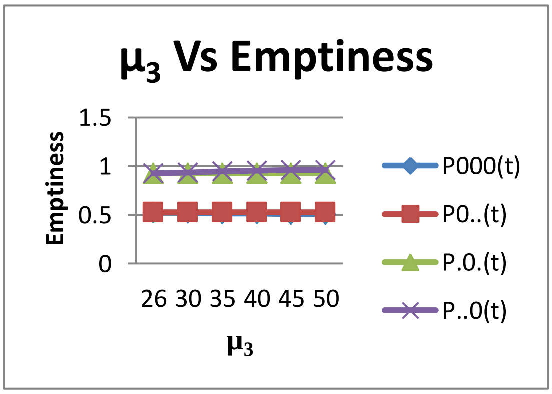



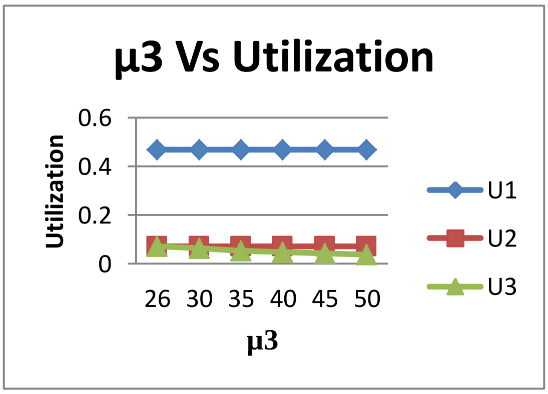



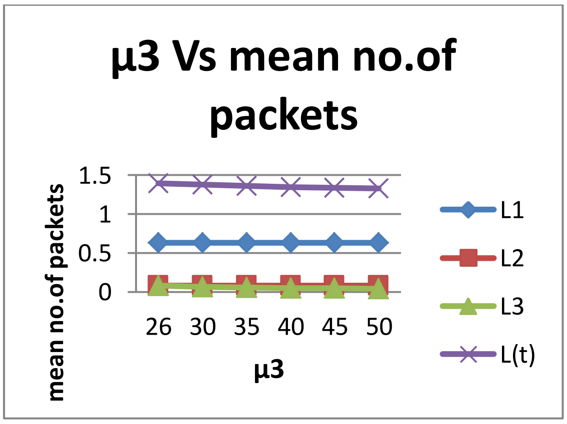



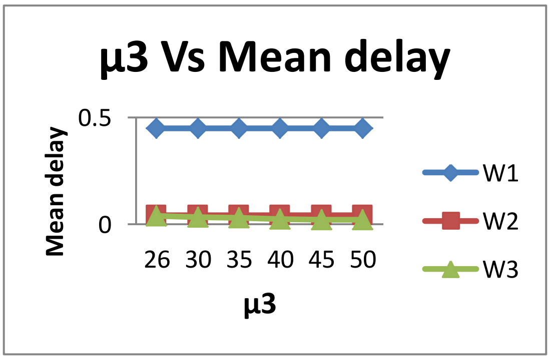
International Journal of Academic Engineering Research (IJAER)
ISSN: 2000-001X
Vol. 2 Issue 8, August – 2018, Pages: 34-47

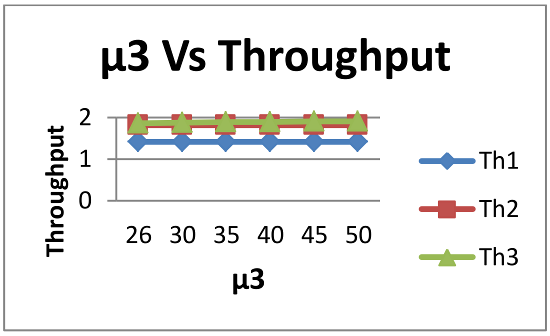
**Graph 3.5:** Showing the relation between performance measures and Mean Transmission Rate

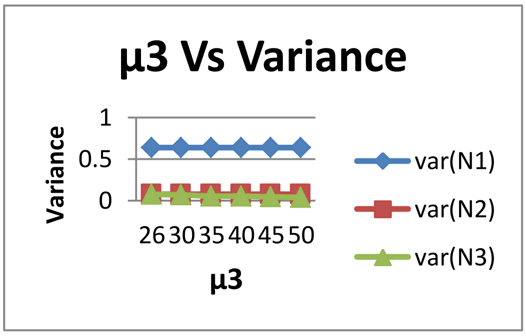



From the equations ( 3.1) to (3.24) , Tables (3.1), (3.2), (3.3) and graphs (3.1), (3.2), (3.3), (3.4), (3.5), it is observed that as the time increases the probability of the network emptiness and emptiness of the buffers are decreasing, the mean number of packets in the buffers are increasing up to a point thereafter stabilized, the utilization of transmitters are increasing, the mean number of packets in the network is increasing, the variance of the number of packets in the buffers are increasing, the throughput of the transmitters are increasing, the mean delay in the buffers are increasing, the total number of packets in the system is increasing, the variance of the number of packets in the network is increasing, when other parameters are fixed.

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

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

## 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. 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.

## References:

[1] Kin K.Leung (1997), Load-dependent service queues with application to congestion control in broadband networks, IEEE Global Telecommunications Conference, Vol.3,pp 1674 - 1679.

[2] Karanam,V.R., Sriram, K., and Bowker, D.O. (1988), Performance evaluation of variable bit rate voice in packet-switched networks. AT&T Technical Journal, Volume: 67, Issue: 5, pp. 57 – 71.

[3] Samarth H Shah, Kai Chen and Klara Nahrstedt (2003), Dyanamic Bandwidth Management for Single hop ad hoc wireless Networks, Proceeding of First IEEE International conference on Pervasive computing and communication, (PerCom'03), pp.1-9

[4] Ying Qiu and peter Marbach (2003), Bandwidth allocation in ah hoc networks: a price based approach, INFOCOM 2003, proceeding of the Twenty second annual joint conference of the IEEE computers and communications,pp797-807.

[5] Iftekhar Hussain, Zaved Iqubal Ahmed, Dilip kumar Saikia and Nityananda Sarme (2015) A QoS aware dynamic bandwidth allocation scheme for multi hop WiFi based long distance networks, EURASIP Journal on Wireless Communication and Networking.

[6] Amulya Sakhamuru, Varun Manchikalapudi (2015), Enhancement of fair distribution of Bandwidth over mobile ad hoc networks, International journal of Scienctific & Engineering Research, Vol.6, NO.5, pp. 1445-1449.

[7] Vivita Sherin B and Sugadev M, (2016), Optimization of Dynamic Channel allocation techniques in Mobile wireless sensor networks. ARPN Journal of Engineering and Applied Sciences, Vol.11, No.13, pp. 8221-8225.

[8] Seraphin B.Calo (1981), Message delays in repeated-service tandem connections, IEEE Transactions on Communications,Vol.COM-29,No.5. pp 670-678.

[9] Kotikalapudi Sriram, R.Scott McKinney, and Mostafa Hashem Sherif (1991), Voice packetisation and compression on broadband ATM networks, IEEE Journal of Selected Areas Communications, Vol.3, pp 294-304.