Three Node Tandem Communication Network Model with Duane Arrival Process having Phase Type Service

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ABSTRACT

This paper introduces a three node Tandem communication network model in which the arrival process follows a Duane process such that the inter arrival times follow Weibull distribution. In this model it is assumed that intermediator departures after transmission from first and second nodes are allowed it is further assumed that the inter transmission times in each node follow Poisson process and the transmission strategy is Dynamic bandwidth allocation. The network behavior is analyzed by deriving expressions for average number of packets in each Queue. The mean delays in transmission, the throughput of the nodes, the Utilization of the transmitters and the variability of the content of buffers. Through Sensitivity analysis it is observed that the arrival process has significant influence on network performance measures. The strategy of allowing inter mediatory departures reduce conjunction in buffers and mean delay of transmission of packets. This model also includes some of the earlier models as particular cases for specific limiting for specific values of the parameter. This model is useful for design and monitoring self-Similarity networks.

Keywords

Duane Arrival process, Communication network model, Sensitivity analysis, DBA

1. INTRODUCTION

William Cock and Charles Wheatstone [1] have pioneered the mathematical theory of communication. Thereafter in 1948 a tremendous revolution in communication network modeling is brought by Barden and Barttain. Later AT&T Bell labs, USA network group at MIT, IEEE communication society and other reputed organizations have put considerable efforts for invoking and designing efficient communication systems. (IEEE Communication Society, 2002). Conducting laboratory experiments under variable load conditions is highly complex and time consuming. Hence for efficient design and evaluation of communication networks, the network models are developed and analyzed with various assumptions on constituent processes of the model like arrival process, service process, flow control mechanisms, allocations, routing, etc. To improve Quality of Service, packet switching gives better utilization over circuit or message switching and yields relatively shorter delay in statistical multiplexing in communication network can reduce the delay in packet switching. Many of communication networks which support teleprocessing applications are mixed with dynamic engineering skills and statistical multiplexing [2], [3], [4]. To reduce the congestion in buffers the dynamic bandwidth allocation is evolved as an alternative and efficient control strategy over bit dropping or flow control strategies [5], [7], [8, 9]. In DBA, a large portion of the unutilized bandwidth is utilized by changing the transmission rate of packets depending on the content of the buffer connected to it. Much

work has been reported recently regarding communication network model with dynamic bandwidth [10]. In all these papers, the authors assumed that the arrival rate of packets is constant and follows a Poisson process.

But in many communication systems the assumption regarding Poisson process are seldom satisfied due to the time dependent nature of arrivals. Therefore, many phenomenon encountered in communication systems which reveal time dependent behavior of arrival process due to the factors like work load fluctuations, initiating, failures, congestion and flow control, overload peaks, reconfigurations, adaptive routing and others. So to have an efficient performance evaluation entities problem of communication systems like adaptive isolated routing and load balancing, evaluating alternative buffer of changed sharing schemes and effects and to study the effects of flow and control strategies it is needed to develop communication network models with time dependent arrivals. In addition to this [10] have showed that the packet arrival process of heavy tail distribution inter arrivals form a non homogeneous process and the mean packet arrival rate is not constant but it is time varying. This is also supported by the studies [18], who demonstrated the TCP connection arrival process is bursty and time dependent. Recently, much emphasis is given for modeling the arrival process of the communication networks using, Non-homogeneous Poisson Process with the assumption that the arrival rate is linearly dependent on time [9] [10], [11, 12]. In all these papers they assumed that the burstness of the traffic is either linearly increasing or decreasing depending on time, but in LAN, WAN, and MAN the traffic structure is quite different from the, arrival rates being linearly dependent function of time. This is also supported by [18] who have, modeled the packet arrivals as Log Normal distributions, since, the associated network traffic inter arrivals are distributed with heavy tail distributions. Feldmann [18] demonstrated that the Transport Control Protocol (TCP) connection arrival bursty and are characterized by heavy tail distributions such as Weibull distributions. Fisher et al [19], has analyzed a singer server queuing model with Weibull inter arrivals using simulations studied. Araik Tamazian and Mikhail Bogachev [17] have used Weibull distributions for inter arrival times in analyzing the performance of World Wide Web (WWW) servers. In these studies, they consider that the server is single and the queues are independent. But in LAN, WAN and MAN the output of one queue is an input to the other queue, and queues are not independent. No work has been reported in literature regarding Tandem communication network models with Weibull inter arrival times which model the LAN, WAN, MAN and other self-similarity network traffic with time dependent bursts, more close to the reality. This motivated to develop and analyze a two node tandem communication network model with Weibull inter arrival times having dynamic band width

allocation with modified phase type transmission. The Weibull distribution includes exponential distribution and several other skewed distributions as particular cases. Using the differential calculus, the explicit expressions for the network performance parameters such as mean number of packets in each buffer, mean delay in transmission, the throughput of the nodes, and the variability of the buffer content are derived. Through numerical analysis the performance of the communication network is evaluated with respect to the changes in input parameters. A comparative study of the proposed model with that of exponential inter arrival times is also carried.

2. COMMUNICATION NETWORK MODEL AND TRANSIENT SOLUTION

In this section, a communication network model having three nodes in tandem is studied. The arrivals to the buffer connected at node one is assumed to follow a Duane process with mean arrival rate as a function of time t. It is of the form $\lambda(t) = abt^{b-1}$. The transmission process from node one to node two follows a Poisson process with parameter µ1. It is also assumed that the packets arrive to the second buffer directly from outside of the network in a Poisson process with mean arrival rate ϵ. After getting transmitted from node one the packets are forwarded to the second buffer for transmission with probability θ or get terminated with probability π i.e., the packets arrived at second buffer contains the packets received from first node and directly from outside. After getting transmitted from second node the packet are forwarded to the third buffer for transmission with probability π or get terminated with probability (1- π). The transmission process of node two and three also follow Poisson process with parameters µ2 and µ3 respectively. The transmission rate of each packet is adjusted just before transmission depending on the content of the buffer connected to the transmitter. The packets are transmitted through the transmitters by the first in first out discipline. The schematic diagram representing the communication network model is shown in Figure 1.
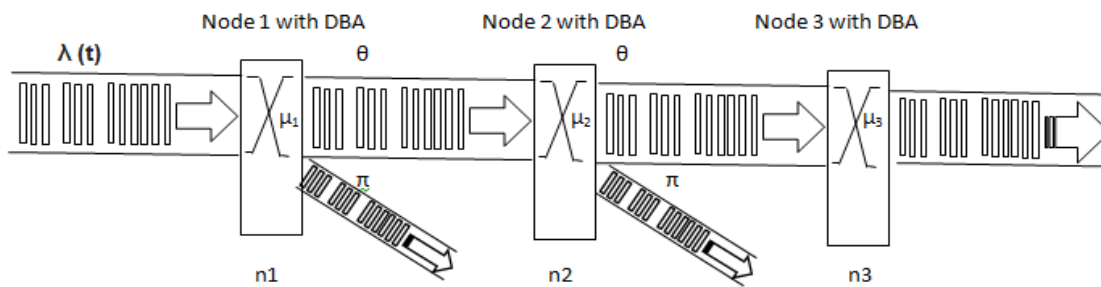

Figure 1: Schematic diagram of the CNM model with three stage arrival

Let P $n_1n_2n_3$ (t) be 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 the time t. with this structure, the difference –differential equations of the communication network are :

3. PERFORMANCE MEASURES OF THE NETWORK

The mean number of packets in the first buffer is

$$L_1(t) = E[N_1] = \sum_{n_1=0}^{\infty} n_1 P_{n_1}(t) = \left[ab \left[\left[e^{-\mu_1 t} \int_0^t e^{-\mu_1 v} v^{b-1} dv - \frac{e^{-\mu_1 t}}{\mu_1} \right] \right] \right]$$

The utilization of the first buffer is

$$U_1(t) = 1 - P_0(t)$$
$$= \left[1 - \exp\left[-ab\left[e^{-\mu_1 t} \int_0^t e^{-\mu_1 v} v^{b-1} dv - \frac{e^{-\mu_1 t}}{\mu_1} \right] \right] \right]$$

For computing the variability of the number of packets in first buffer is

$$E(N_1^2 - N_1) = ab\left[e^{-\mu_1 t} \int_0^t e^{-\mu_1 v} v^{b-1} dv - \frac{e^{-\mu_1 t}}{\mu_1} \right]^2$$

Therefore, the variance of the number of packets in the first buffer is

$$Var(N_1) = ab\left[e^{-\mu_1 t} \int_0^t e^{-\mu_1 v} v^{b-1} dv - \frac{e^{-\mu_1 t}}{\mu_1} \right]$$

In this section, the performance measures of the communication network under transient conditions are derived and analyzed. Expanding $P(s_1, s_2, s_3; t)$ given equation (16) and collecting the constant terms, the probability that the network is empty achieved as follows,

The throughput of the first transmitter is

$$Thp_1(t) = \mu_1 \left(1 - P_0(t)\right) = \mu_1 \left[1 - \exp\left[-ab\left[e^{-\mu_1 t} \int_0^t e^{-\mu_1 v} v^{b-1} dv - \frac{e^{-\mu_1 t}}{\mu_1} \right] \right] \right]$$

The mean delay in the first buffer size is

$$W_1(t) = \frac{L_1(t)}{Thp_1(t)}$$

Similarly, by substituting s_1=1, and s_3=1, s_1=1, and s_2=1, the probability generating function of the second buffer and third buffer size distributions are achieved and values are tabulated as follows,

4. PERFORMANCE EVALUATION OF THE NETWORK

In this section, the performance of the developed communication network is discussed through a numerical illustration. Different values of the parameters are considered for bandwidth allocation and arrival of packets. After interacting with the technical staff an internet providing station, is considered the packet arrival rate parameter "a" varies from 11 x10^4 packets/sec to 14x10^4 packets/sec, and 'b' varies from 1.25 to 2.5 with an average packet size of 52 bytes. After transmitting from node l, the forward

transmission rate 'μ₁' varies from 11×10^4 packets/sec to 14×10^4 packets/sec. The rate of transmission rate 'μ₂' varies from 26×10^4 packets/sec to 29×10^4 packets/sec. The rate of transmission rate 'μ₃' varies from 28×10^4 packets/sec to 31×10^4 packets/sec. In all these nodes, dynamic bandwidth allocation strategy is considered i.e., the transmission rate of each packet depends on the number of packets in the buffer connected to it at that instant.

Since performance characteristics of communication network are highly sensitive with respect to time, the transient behavior of the model is studied through computing the performance measures with the set of values for the model parameters as t = 0.8,0.9,1.0,1.1 seconds, a = 11,12,13,14 (with multiplication to 10×10^4 packets/sec) b=1.25,1.5,2,2.5 μ₁=11,12,13,14(10×10^4packets/sec), μ₂=26,27,28,29

(10×10^4packets/sec), μ3 =28,29,30,31(10×10^4 packets/sec), π = 0.4,0.3,0.2,0.1, θ = 0.6,0.7,0.8,0.9.

The probability of the network emptiness and buffer emptiness are computed for different values of t, a, b, μ₁, μ₂, μ₃, π, θ and presented in Table 1. The probability of network emptiness and different buffers emptiness with various parameters are represented graphically in Figure 2. From the Table 1 it is observed that the probability of emptiness in the entire communication network and in three buffers are highly sensitive with respect to changes in time. As time 't' varies from 0.8 seconds to 1.1 seconds, the probability of emptiness in the network reduces from 0.2261 to 0.0496 when other parameters are fixed at (10,3,10,25,30,0.5,0.5) for (a, b, μ₁, μ₂, μ₃, π, θ). Similarly, the probability for emptiness in three buffers vary from 0.2234 to 0.0483, 0.7649 to 0.5713and 0.9036 to 0.8042 for node l, node2 and node 3 respectively. The decrease in the node l is more rapid when compared to node 2, node 3. The influence of mean arrival rate of packets on the system emptiness is also studied. As the arrival rate parameters 'a' varies from 11×10^4 packets/sec to 14 x 10^4 packets/sec, the probability of emptiness of the network decreases from 0.1946 to 0.1242 when other parameters are fixed at (0.8,3,10,25,30,0.5,0.5) for (t, b, μ₁, μ₂, μ₃, π, θ). The same phenomenon is observed with respect to three nodes. This decrease is more in first node and moderate in second and third nodes.

Table 1: Values of network and buffer emptiness probability and utilization of the communication network with DBA*=seconds, \$= multiples of 1000 packets/seconds.

t*	a$	b	μ₁$	μ₂$	μ₃$	π	θ	$P_{0,0,0}(t)$	$P_{0,.,.}(t)$	$P_{.,0,.}(t)$	$P_{.,.,0}(t)$	$U_1(t)$	$U_2(t)$	$U_3(t)$
0.8	10	3	10	25	30	0.5	0.5	0.2261	0.2234	0.7649	0.9036	0.7766	0.2351	0.0962
0.9	10	3	10	25	30	0.5	0.5	0.1447	0.1423	0.7023	0.8735	0.8577	0.2977	0.1264
1.0	10	3	10	25	30	0.5	0.5	0.0872	0.0854	0.6372	0.8403	0.9146	0.3628	0.1597
1.1	10	3	10	25	30	0.5	0.5	0.0496	0.0483	0.5713	0.8042	0.9517	0.4287	0.1957
0.8	**11**	3	10	25	30	0.5	0.5	0.1946	0.1923	0.7447	0.8945	0.8077	0.2553	0.1053
0.8	**12**	3	10	25	30	0.5	0.5	0.1676	0.1655	0.725	0.8855	0.8345	0.275	0.1143
0.8	**13**	3	10	25	30	0.5	0.5	0.1442	0.1425	0.7058	0.8765	0.8575	0.2942	0.1232
0.8	**14**	3	10	25	30	0.5	0.5	0.1242	0.1226	0.6872	0.8677	0.8774	0.3128	0.1320
0.8	10	**1.25**	10	25	30	0.5	0.5	0.3281	0.3199	0.799	0.9119	0.6801	0.201	0.0881
0.8	10	**1.5**	10	25	30	0.5	0.5	0.293	0.2864	0.7846	0.9062	0.7136	0.2154	0.0937
0.8	10	**2**	10	25	30	0.5	0.5	0.2513	0.2467	0.7681	0.9008	0.7533	0.2319	0.0991
0.8	10	**2.5**	10	25	30	0.5	0.5	0.2322	0.2287	0.7629	0.9006	0.7713	0.2371	0.0992
0.8	10	3	**11**	25	30	0.5	0.5	0.2514	0.2482	0.7601	0.9014	0.7518	0.2399	0.0985
0.8	10	3	**12**	25	30	0.5	0.5	0.2757	0.2722	0.756	0.8995	0.7278	0.244	0.1004
0.8	10	3	**13**	25	30	0.5	0.5	0.2991	0.2952	0.7524	0.8979	0.7048	0.2476	0.1021
0.8	10	3	**14**	25	30	0.5	0.5	0.3214	0.3172	0.7494	0.8965	0.6828	0.2506	0.1035
0.8	10	3	10	**26**	30	0.5	0.5	0.2261	0.2234	0.772	0.9032	0.7766	0.228	0.0966
0.8	10	3	10	**27**	30	0.5	0.5	0.226	0.2234	0.7787	0.9028	0.7766	0.2213	0.097
0.8	10	3	10	**28**	30	0.5	0.5	0.2259	0.2234	0.7849	0.9025	0.7766	0.2151	0.0974
0.8	10	3	10	**29**	30	0.5	0.5	0.2259	0.2234	0.7909	0.9021	0.7766	0.2091	0.0977
0.8	10	3	10	25	**28**	0.5	0.5	0.2262	0.2234	0.7649	0.8978	0.7766	0.2351	0.102
0.8	10	3	10	25	**29**	0.5	0.5	0.2261	0.2234	0.7649	0.9036	0.7766	0.2351	0.0962
0.8	10	3	10	25	**30**	0.5	0.5	0.2261	0.2234	0.7649	0.9063	0.7766	0.2351	0.0935
0.8	10	3	10	25	**31**	0.5	0.5	0.2261	0.2234	0.7649	0.9063	0.7766	0.2351	0.0935
0.8	10	3	10	25	30	**0.4**	**0.6**	0.2257	0.2234	0.807	0.9073	0.7766	0.193	0.0925
0.8	10	3	10	25	30	**0.3**	**0.7**	0.2252	0.2234	0.8515	0.9184	0.7766	0.1485	0.0815
0.8	10	3	10	25	30	**0.2**	**0.8**	0.2246	0.2234	0.8984	0.9372	0.7766	0.1016	0.0627
0.8	10	3	10	25	30	**0.1**	**0.9**	0.224	0.2234	0.9478	0.9642	0.7766	0.0522	0.0358
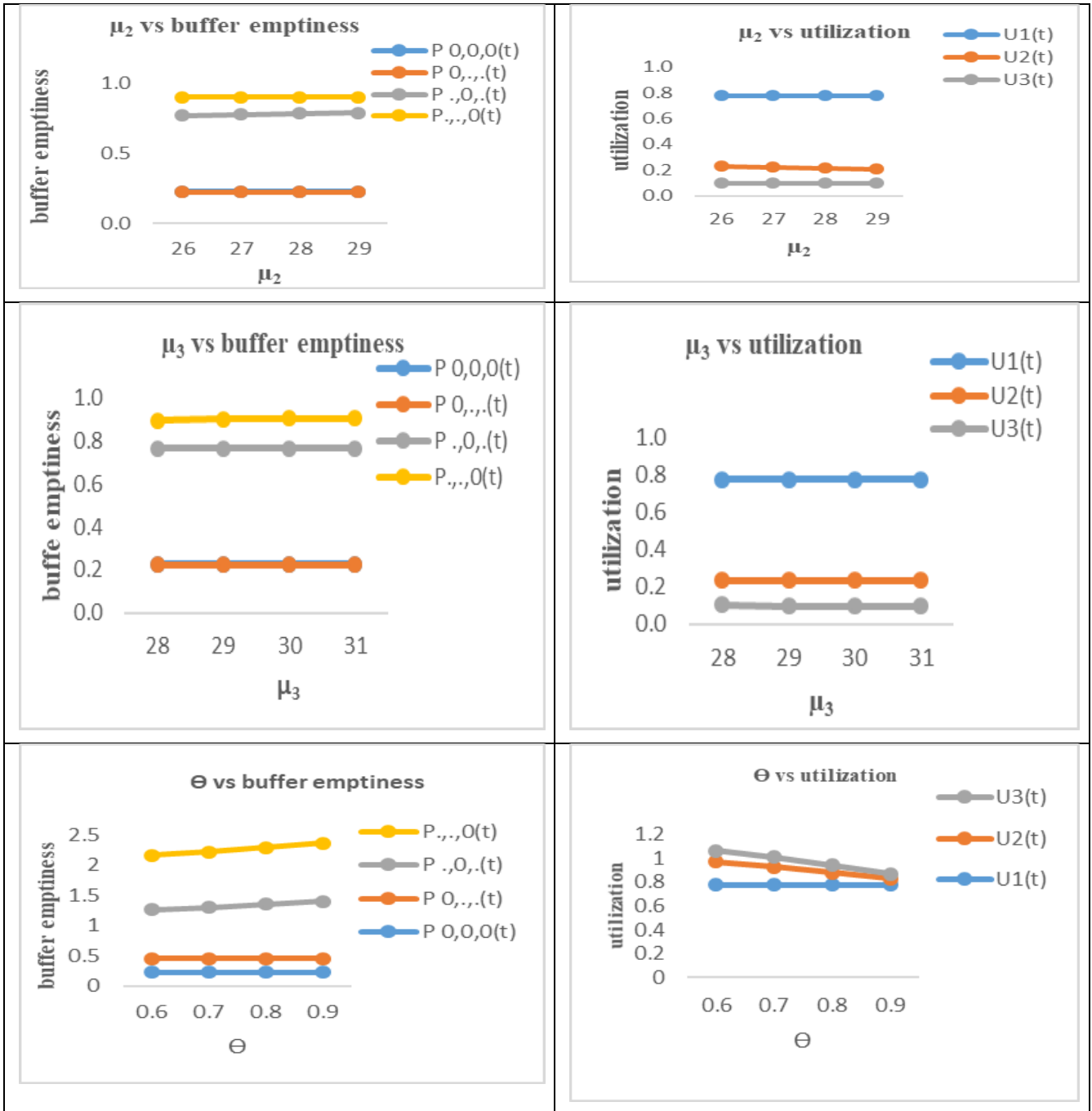
When the arrival rate parameter 'b' varies from 1.25 to 2.5, the probability of emptiness of the network decreases from 0.3281 to 0.2322 when the other parameters remain fixed. The same phenomenon is observed for three nodes. The decrease is faster in node 1 and moderate in the next two nodes.

When the transmission rate 'μ_1' of node 1 varies from 11 x10^4 packets/sec to 14 x 10^4 packets/sec the probability of emptiness in the network increase from 0.2514 to 0.3214 when the other parameters remain fixed. Similarly, the transmission rate 'μ_2' of node2 varies from 26 x 10^4 packets/sec to 29 x 10^4 packets/sec. The probability of emptiness of the network increases from 0.2261 to 0.2259 when the other parameters remain fixed. Similarly, the transmission rate 'μ_3' of node3 varies from 28 x 10^4 packets/sec to 31 x 10^4 packets/sec. The probability of emptiness in the network increases from 0.2262 to 0.2261

when the other parameters remain fixed. The same phenomenon is observed with respect to the emptiness of the three buffers.

When arrival rate Parameter 'θ' increases from 0.6 to 0.9, the probability of emptiness in the network decreases from 0.2257 to 0.224 when other parameter is remaining fixed. The utilization of transmitters of node 1, node 2 and node 3 for different parameters are computed and presented in Table 1 and the relationship with performance measures is shown in Figure 2. As time't' and arrival rate parameter 'a' increase the utilization of transmitters are increasing for fixed values of the other parameters. It is also observing that the as the arrival rate parameter 'a' increases the utilization of transmitters in three nodes are increasing for fixed values of the other parameters. As the transmission rate 'μ_1' increases, the utilization of the first node decreases. Similarly, as the

transmission rate 'μ_2' increases the utilization of the second node decreases when the other parameters remain fixed.

Similarly, as the transmission rate 'μ_3' increases the utilization of in third node decreases when the other parameters remain fixed.

The mean number of packets in the buffer and in the network, mean delays in transmission of both nodes are computed for different values are t, a, b, μ_1, μ_2, μ_3, π, θ and presented at Table 2. The relationship between the parameters and the performance measures are shown in the Figure 3.
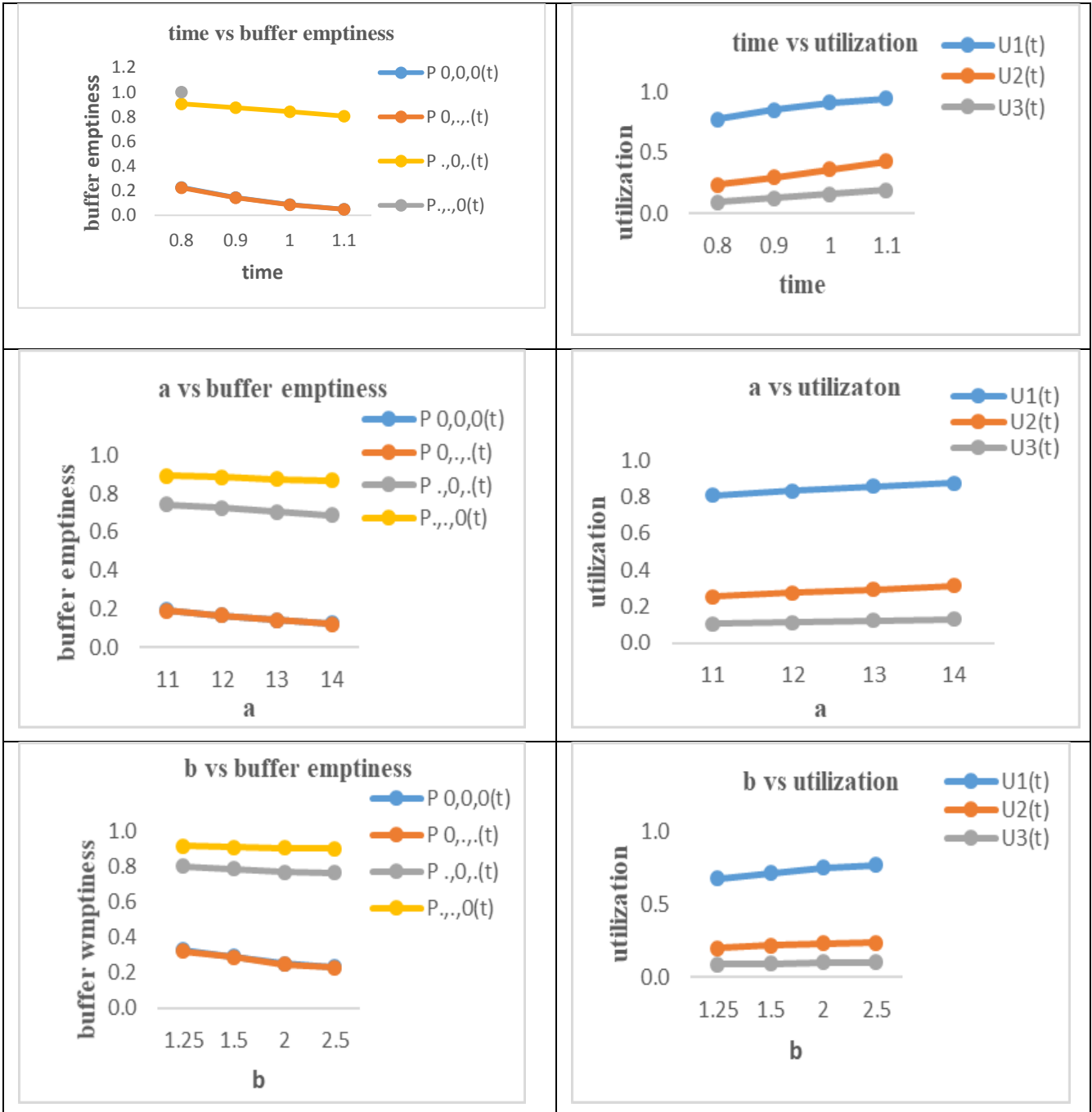
Table 2: Values of mean number of packets and mean delay of the communication network with DBA *=seconds, \$= multiples of 1000 packets/seconds

t*	a$	b	μ1$	μ2$	μ3$	π	θ	$L_1(t)$	$L_2(t)$	$L_3(t)$	$L_n(t)$	$W_1(t)$	$W_2(t)$	$W_3(t)$
0.8	10	3	10	25	30	0.5	0.5	1.4990	0.2680	0.1011	1.8681	0.1930	0.0456	0.0350
0.9	10	3	10	25	30	0.5	0.5	1.9496	0.3534	0.1351	2.4381	0.2273	0.0475	0.0356
1.0	10	3	10	25	30	0.5	0.5	2.4599	0.4507	0.1740	3.0845	0.2690	0.0497	0.0363
1.1	10	3	10	25	30	0.5	0.5	3.0299	0.5599	0.2178	3.8077	0.3184	0.0522	0.0371
0.8	**11**	3	10	25	30	0.5	0.5	1.6489	0.2948	0.1113	2.0549	0.2041	0.0462	0.0352
0.8	**12**	3	10	25	30	0.5	0.5	1.7988	0.3216	0.1214	2.2417	0.2156	0.0468	0.0354
0.8	**13**	3	10	25	30	0.5	0.5	1.9487	0.3484	0.1315	2.4285	0.2272	0.0474	0.0356
0.8	**14**	3	10	25	30	0.5	0.5	2.0986	0.3752	0.1416	2.6153	0.2392	0.0480	0.0357
0.8	10	**1.25**	10	25	30	0.5	0.5	1.1399	0.2244	0.0922	1.4565	0.1676	0.0447	0.0349
0.8	10	**1.5**	10	25	30	0.5	0.5	1.2504	0.2425	0.0983	1.5913	0.1752	0.045	0.035
0.8	10	**2**	10	25	30	0.5	0.5	1.3994	0.2638	0.1043	1.7675	0.1858	0.0455	0.0351
0.8	10	**2.5**	10	25	30	0.5	0.5	1.4753	0.2707	0.1045	1.8505	0.1913	0.0457	0.0351
0.8	10	3	**11**	25	30	0.5	0.5	1.3934	0.2744	0.1037	1.7715	0.1685	0.0457	0.0351
0.8	10	3	**12**	25	30	0.5	0.5	1.3012	0.2798	0.1058	1.6868	0.149	0.0459	0.0351
0.8	10	3	**13**	25	30	0.5	0.5	1.2201	0.2844	0.1077	1.6122	0.1332	0.046	0.0352
0.8	10	3	**14**	25	30	0.5	0.5	1.1484	0.2885	0.1093	1.5461	0.1201	0.046	0.0352
0.8	10	3	10	**26**	30	0.5	0.5	1.499	0.2588	0.1016	1.8594	0.193	0.0437	0.0351
0.8	10	3	10	**27**	30	0.5	0.5	1.499	0.2502	0.102	1.8512	0.193	0.0419	0.0351
0.8	10	3	10	**28**	30	0.5	0.5	1.499	0.2422	0.1024	1.8435	0.193	0.0402	0.0351
0.8	10	3	10	**29**	30	0.5	0.5	1.499	0.2346	0.1028	1.8364	0.193	0.0387	0.0351
0.8	10	3	10	25	**28**	0.5	0.5	1.499	0.268	0.1076	1.8746	0.193	0.0456	0.0377
0.8	10	3	10	25	**29**	0.5	0.5	1.499	0.268	0.1011	1.8681	0.193	0.0456	0.035
0.8	10	3	10	25	**30**	0.5	0.5	1.499	0.268	0.0982	1.8651	0.193	0.0456	0.0339
0.8	10	3	10	25	**31**	0.5	0.5	1.499	0.268	0.0982	1.8651	0.193	0.0456	0.0339
0.8	10	3	10	25	30	**0.4**	**0.6**	1.499	0.2144	0.0971	1.8105	0.193	0.0444	0.035
0.8	10	3	10	25	30	**0.3**	**0.7**	1.499	0.1608	0.085	1.7447	0.193	0.0433	0.0348
0.8	10	3	10	25	30	**0.2**	**0.8**	1.499	0.1072	0.0647	1.6709	0.193	0.0422	0.0344
0.8	10	3	10	25	30	**0.1**	**0.9**	1.499	0.0536	0.0364	1.589	0.193	0.0411	0.0339

It is observed that when time t=0.8 seconds the mean number of packets in the first buffer is 14990 packets after one seconds it is rapidly increases to 24599 packets, and at 1.1 seconds it becomes 30299 packets and there after its stabilizes. The mean number of packets in the second and third buffers in the network are increasing from 2680 packets to 5599 packets, from 1011 to 2178 packets when other parameters are fixed when the arrival rate parameter 'a' varies from 11 x10⁴ packets/sec to 14 x10⁴ packets/sec, the mean number of packets in the first, second and third buffers in the network are increasing from 16489 to 20986 packets, 2948 packets to 3752 packets 1113 packets to 1416 packets respectively. The parameter 'b' varies from 1.25 to 2.5 the mean number of packets in the first, second and third buffer in the network are increasing from 11399 packets to 14753

packets, 2244 packets to 2707packets, 0922 packets to 1402 packets respectively, when other parameters remain fixed.

The transmission parameter 'μ₁' varies from 11 x 10⁴ packets/sec to 14 x 10⁴ packets/sec, the mean number of packets in the first, second and third buffers are increasing from 13934 packets to 11484 packets, from

2744 packets to 2885 packets, from 1037 packets to 1093 packets respectively, when other parameters remain fixed.

Similarly, the transmission rate 'μ₂' varies from 26 x 10⁴ packets/sec to 29 x 10⁴ packets/sec, the mean number of packets in the first buffer remains at 14990 packets and the mean number of packets in the second and third buffers are

increasing from 2588 packets to 2346 packets, and 1016 packets to 1028 packets respectively when other parameters are remaining fixed. Similarly, the transmission parameter 'μ_3' varies from 28 x 10^4 packets/sec to 31 x 10^4 packets/sec, the mean number of packets in the first and second buffers remain constant at 14990 packets and 268 packets respectively. and third buffer decreases from 1076 to 0982 when other parameters remain fixe

It is observed that as time 't' and the arrival parameters 'a''b' are increasing the mean delay in buffers are increasing for fixed values of the other parameters. It

is also observed that as parameter 'θ' varies the mean delay in buffers are decreasing for fixed values of the other parameters.

The parameters π and, θ varies the mean delay in first buffer remain constant and in the second and third buffers its values are decreasing for fixed values of the other parameters. The variance of the number of packets in each buffer and in the network, throughput of each node are computed for different values of t, a, b, μ_1, μ_2,μ_3,π,θ are presented in Table 3. It is observed as time 't' increases, the throughput of first, second and third nodes are increasing from 77664 packets to 95168 packets, 58769 to 107184 packets and 28859 packets to 58725 packets respectively.

As the arrival parameter 'a' varies from 11 x10^4 packets/sec to 14 x 10^4 packets/sec, the throughput of the first, second and

third nodes are increasing from 80773 packets to 87737 packets, from 63825 to 78207 packets and from 31587 packets to 39609 packets. As the arrival parameter 'b' varies from 1.25 x10^4 packets/sec to 2.5 x 10^4 packets/sec, the throughput of the first, second and third nodes are increasing from 68015 packets to 77129 packets, from 50250 to 59284 packets and from 26419 packets to 29773packets.

When the transmission parameter "μ_1" varies from 11 x10^4 packets/sec to 14 x 10^4 packets/sec, the throughput of the first, second and third nodes are increasing from 82695 packets to 95598 packets, from 59986 to 62650 packets and from 29547 packets to 31054 packets when other parameters remain fixed. The transmission parameter "μ_2" varies from 26x10^4 packets/sec to 29 x 10^4 packets/sec, the throughput of the first node remain constant at 77664 packets, for the second and third nodes its values are increasing from packets to 59282packets top 60645 packets, and from 2893 packets to 29306 packets respectively when other parameters are remaining fixed. Similarly, the transmission parameter "μ_3" varies from 28 x10^4 packets/sec to 31 x 10^4 packets/sec, the throughput of the first and second nodes remain constant at 77664 packets and 58769 packets respectively and for third node it increases from 28565 packets to 28993 packets, respectively when other parameters are fixed. The graphical representation for the table 2 and table 3 are also calculated in thesimilarfashion.

Table 3: Effect of Various Parameters on Throughput and Variance under Transient State for Communication Network Model *=seconds, $= multiples of 1000 packets/seconds

t*	a$	b	μ1$	μ2$	μ3$	π	θ	Var(N₁)	Var(N₂)	Var(N₃)	Thp₁(t)	Thp₂(t)	Thp₃(t)
0.8	10	3	10	25	30	0.5	0.5	1.4990	0.2680	0.1011	7.7664	5.8769	2.8859
0.9	10	3	10	25	30	0.5	0.5	1.9496	0.3534	0.1351	8.5767	7.4425	3.7914
1.0	10	3	10	25	30	0.5	0.5	2.4599	0.4507	0.1740	9.1455	9.0700	4.7909
1.1	10	3	10	25	30	0.5	0.5	3.0299	0.5599	0.2178	9.5168	10.7184	5.8725
0.8	**11**	3	10	25	30	0.5	0.5	1.6489	0.2948	0.1113	8.0773	6.3825	3.1587
0.8	**12**	3	10	25	30	0.5	0.5	1.7988	0.3216	0.1214	8.3450	6.8748	3.4288
0.8	**13**	3	10	25	30	0.5	0.5	1.9487	0.3484	0.1315	8.5754	7.3541	3.6962
0.8	**14**	3	10	25	30	0.5	0.5	2.0986	0.3752	0.1416	8.7737	7.8207	3.9609
0.8	10	**1.25**	10	25	30	0.5	0.5	1.1399	0.2244	0.0922	6.8015	5.025	2.6419
0.8	10	**1.5**	10	25	30	0.5	0.5	1.2504	0.2425	0.0983	7.1362	5.3839	2.8096
0.8	10	**2**	10	25	30	0.5	0.5	1.3994	0.2638	0.1043	7.5325	5.7968	2.9719
0.8	10	**2.5**	10	25	30	0.5	0.5	1.4753	0.2707	0.1045	7.7129	5.9284	2.9773
0.8	10	3	**11**	25	30	0.5	0.5	1.3934	0.2744	0.1037	8.2695	5.9986	2.9547
0.8	10	3	**12**	25	30	0.5	0.5	1.3012	0.2798	0.1058	8.7336	6.1011	3.0126
0.8	10	3	**13**	25	30	0.5	0.5	1.2201	0.2844	0.1077	9.1625	6.1889	3.0623
0.8	10	3	**14**	25	30	0.5	0.5	1.1484	0.2885	0.1093	9.5598	6.265	3.1054
0.8	10	3	10	**26**	30	0.5	0.5	1.499	0.2588	0.1016	7.7664	5.9282	2.8983
0.8	10	3	10	**27**	30	0.5	0.5	1.499	0.2502	0.102	7.7664	5.9764	2.9098
0.8	10	3	10	**28**	30	0.5	0.5	1.499	0.2422	0.1024	7.7664	6.0218	2.9206
0.8	10	3	10	**29**	30	0.5	0.5	1.499	0.2346	0.1028	7.7664	6.0645	2.9306

0.8	10	3	10	25	**28**	0.5	0.5	1.499	0.268	0.1076	7.7664	5.8769	2.8565
0.8	10	3	10	25	**29**	0.5	0.5	1.499	0.268	0.1011	7.7664	5.8769	2.8859
0.8	10	3	10	25	**30**	0.5	0.5	1.499	0.268	0.0982	7.7664	5.8769	2.8993
0.8	10	3	10	25	**31**	0.5	0.5	1.499	0.268	0.0982	7.7664	5.8769	2.8993
0.8	10	3	10	25	30	**0.4**	**0.6**	1.499	0.2144	0.0971	7.7664	4.824	2.7759
0.8	10	3	10	25	30	**0.3**	**0.7**	1.499	0.1608	0.085	7.7664	3.7132	2.4435
0.8	10	3	10	25	30	**0.2**	**0.8**	1.499	0.1072	0.0647	7.7664	2.5412	1.8804
0.8	10	3	10	25	30	**0.1**	**0.9**	1.499	0.0536	0.0364	7.7664	1.3046	1.0727

If the variance of the number of packets in each buffer increases, then the burstness of the buffer will be high. Hence, the parameters are to be adjusted in such a way that the variance of the content of each buffer is become small. The coefficients of variation of the number of packets in each buffer is computed. To understand the consistency of the traffic flow. Its help us to control the smooth flow of packets in buffers. From this analysis it is observe that the dynamic bandwidth allocation strategy has significant influence on all

5. COMPARATIVE STUDY
The comparative study between the proposed communication network model with that of homogenous Poisson arrivals is presented in this section, the computed performance measure of both models are presented in the Table 5 for different values of t=0.8 ,0.9,1.0, 1.1.

performance measures of the network. It is further observed that the performance measures are highly sensitive towards smaller values of time. Hence, it is optimal to consider dynamic bandwidth allocation under and Duane arrival process and evaluate the performance under transient conditions. It is also to be observed that the congestion in buffer and delays in transmission got reduced to a minimum level by adopting dynamic bandwidth allocation. This phenomenon has a vital bearing on quantity of transmission.

As time t increases, the percentage variation of performance measures between the models are increasing. For the proposed models with non-homogenous Poisson arrivals having dynamic bandwidth allocation has more utilization compared to that of the model with Poisson arrivals under dynamic bandwidth allocation. From this analysis it is observed that the assumption of non-homogenous arrivals has a significant influence on all the performance measures of the network.

Table 4: Comparative study of models with homogeneous and Non-homogeneous Duane Arrivals

Time	Parameters	Poisson	Proposed model	Difference	Variance
0.8	$L_1(t)$	0.9993	1.499	0.4997	33.33555704
	$L_2(t)$	0.1998	0.268	0.0682	25.44776119
	$L_3(t)$	0.0832	0.1011	0.0179	17.70524233
	$U_1(t)$	0.6319	0.7766	0.1447	18.63250064
	$U_2(t)$	0.1811	0.2351	0.054	22.96894938
	$U_3(t)$	0.0798	0.0962	0.0164	17.04781705
	$Thp_1(t)$	6.3187	7.7664	1.4477	18.64055418
	$Thp_2(t$	4.5272	5.8769	1.3497	22.96618966
	$Thp_3(t)$	2.3948	2.8859	0.4911	17.01722166
	$W_1(t)$	0.1582	0.193	0.0348	18.03108808
	$W_2(t)$	0.0441	0.0456	0.0015	3.289473684
	$W_3(t)$	0.0347	0.035	0.0003	0.857142857
0.9	$L_1(t)$	0.9998	1.9496	0.9498	48.71769
	$L_2(t)$	0.1999	0.3534	0.1535	43.4352
	$L_3(t)$	0.0833	0.1351	0.0518	38.34197
	$U_1(t)$	0.632	0.8577	0.2257	26.31456
	$U_2(t)$	0.1812	0.2977	0.1165	39.13336
	$U_3(t)$	0.0799	0.1264	0.0465	36.78797
	$Thp_1(t)$	6.3203	8.5767	2.2564	26.30849

	$Thp_2(t$	4.53	7.4425	2.9125	39.13336
	$Thp_3(t)$	2.3972	3.7914	1.3942	36.7727
	$W_1(t)$	0.1582	0.2273	0.0691	30.40035
	$W_2(t)$	0.0441	0.0475	0.0034	7.157895
	$W_3(t)$	0.0347	0.0356	0.0009	2.52809
1	$L_1(t)$	0.9999	2.4599	1.46	59.35200618
	$L_2(t)$	0.2	0.4507	0.2507	55.62458398
	$L_3(t)$	0.0833	0.174	0.0907	52.12643678
	$U_1(t)$	0.6321	0.9146	0.2825	30.88781981
	$U_2(t)$	0.1812	0.3628	0.1816	50.05512679
	$U_3(t)$	0.0799	0.1597	0.0798	49.9686913
	$Thp_1(t)$	6.3209	9.1455	2.8246	30.88513477
	$Thp_2(t$	4.5311	9.07	4.5389	50.0429989
	$Thp_3(t)$	2.3981	4.7909	2.3928	49.9446868
	$W_1(t)$	0.1582	0.269	0.1108	41.18959108
	$W_2(t)$	0.0441	0.0497	0.0056	11.26760563
	$W_3(t)$	0.0347	0.0363	0.0016	4.407713499
1.1	$L1(t)$	1	3.0299	2.0299	66.99561042
	$L2(t)$	0.2	0.5599	0.3599	64.2793356
	$L3(t)$	0.0833	0.2178	0.1345	61.75390266
	$U1(t)$	0.6321	0.9517	0.3196	33.58201114
	$U2(t)$	0.1813	0.4287	0.2474	57.70935386
	$U3(t)$	0.0799	0.1957	0.1158	59.17220235
	$Thp1(t)$	6.3211	9.5168	3.1957	33.57956456
	$Thp2(t$	4.5315	10.7184	6.1869	57.72223466
	$Thp3(t)$	2.3985	5.8725	3.474	59.15708812
	$W1(t)$	0.1582	0.3184	0.1602	50.31407035
	$W2(t)$	0.0441	0.0522	0.0081	15.51724138
	$W3(t)$	0.0347	0.0371	0.0024	6.469002695

6. CONCLUSION

In this paper, a new and novel three nodes tandem communication network model with Duane arrival process having dynamic bandwidth allocation with phase type transmission was introduced. The arrival of packets in a network traffic is characterized through Weibull inter arrival time distribution which better represents the self-similarity network traffic having time dependent burstness. The Duane process is a generalization of Poisson process. Here it is, assumed that the three nodes are connected in tandem and the transmission processes follow Poisson. The transmission rate at every instant of packet transmission is adjusted depending on the content of the buffer connected to it. The explicit expressions for the performance measures of the communication network such as mean content of the buffers mean delays in transmission, the throughput of the nodes, utilization of the buffers are derived. The sensitivity of the model revealed that the inter arrival rate parameters has

significant influence on predicting the performance measures of the network more accurately. A comparative study of the proposed network with that of inter exponential transmission times shown that the proposed model outperforms the existing communication network model in scheduling self-similarity networks such as LAN, WAN and MAN. It is, also possible to derive the optimal operating policies of the networks with suitable cost consideration which will be taken elsewhere.

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