STRATEGIES FOR OPTIMAL TRAFFIC FLOW IN MULTINODE AD-HOC WIRELESS SENSOR NETWORKS

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ABSTRACT

Due to heavy usage of data/voice transmission, the burstness in buffers and the packets dropout is a common problem in communication networks. To have an optimal utilization of resources and to improve the Quality of Service (QoS), the communication networks are to be designed with new strategies. Stochastic models provide the basic frame work for design and development of new communication networks. This paper addresses the problem of reducing burstness in buffers by introducing a communication network model with integration of three strategies of traffic flow transmission namely, dynamic bandwidth allocation (DBA), phase type transmission and direct arrivals to the multiple buffers. Here, the packet arrivals are characterized through compound Poisson Binomial process since the features of arrival of packets closely resembles by its characteristics. A mathematical model is developed and analyzed for a multi node Ad-hoc wireless communication system having dynamic bandwidth allocation (DBA) and phase type transmission with direct arrivals to the multiple buffers from outside resources in addition to the first buffer in bulk. The performance of the model is evaluated by deriving the system performance measures such as mean content of the buffers, mean delays in transmission, throughput of the buffers.

Keywords: *Wireless Communication Network, Phase type transmission, Dynamic bandwidth Allocation, direct arrivals to multiple buffers, compound Poisson binomial process.*

1. INTRODUCTION

A wireless communication network model is a representation of the physical phenomenon associated with a communication system. Due to unpredicted demand for transmission, congestion occurs in communication systems and burstness of buffers became a regular problem for service providers. Improvement of QoS is a prerequisite for efficient and effective operation of the communication systems. To improve the QoS and to reduce delay in transmission, packet switching is extensively used over message switching or circuit switching. The delay in packet switching can be further reduced by considering statistical multiplexing in communication networks much work has been reported in literature regarding integration of statistical multiplexing with dynamic engineering skills on reducing the burstness of buffers and efficient transmission. Mathematical models provide the necessary structure and frame work for design and development of efficient communication systems. Since conducting laboratory experiments with variable load condition and different transmission strategies is highly complicated and time consuming modelling the communication networks become a prerogative in designing new communication systems. Hence, different mathematical models for wireless communication networks have been developed and analyzed with various assumptions on arrivals and transmission processes.

Bit dropping and flow control mechanisms are highly used for the purpose of improving QoS. Later, dynamic bandwidth strategy in transmission is introduced and extensively used by considering utilizing the ideal bandwidth by adjusting the transmission rate depending on the content of the buffer connected to the transmitter. This strategy has reduced the burstness of buffers and delays in transmission.

2. QUEUING MODEL

Consider multi-transmitter wireless communication networks in which the messages arrive to the network are converted into a random number of packets. The arrival process of the messages is random and a number of packets (X) that a message can be converted follows a binomial distribution with parameters m_1, p_1 and m_2, p_2 and so on m_i,p_i i.e., the arrival modules follows a compound Poisson binomial process with composite arrival rate α_1. E(X) and α_2. E(X) and so on α_i. E(X). The probability mass function of the number of packets that a message can be converted is

$$C_{k_1} = \frac{{}^{m_1}C_{k_1} p_1^{k_1} (1-p_1)^{m_1-k_1}}{1-(1-p_1)^{m_1}};$$

$K_1=1,2,\ldots m_1$. $0<p_1<1$,

$$C_{k_2} = \frac{{}^{m_2}C_{k_2} p_2^{k_2} (1-p_2)^{m_2-k_2}}{1-(1-p_2)^{m_2}};$$

$K_2=1,2,\ldots m_2.\ 0<p_2<1$

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$$C_{k_j} = \frac{{}^{m_j}C_{k_j} p_j^{k_j} (1-p_j)^{m_j-k_j}}{1-(1-p_j)^{m_j}}; \quad K_j=1,2,\ldots m_j,\ 0<p_j$$

3. PERFORMANCE MEASURES OF THE NETWORK

In this section, we derive and analyze the performance measures of the communication network under transient condition. From the equations the joint probability generating function of the number of packets in the buffers.

The mean number of packets in the network is $L_N = L_1 + L_2$

where, L_1 is the mean number of packets in the first transmitter

L_2 is the mean number of packets in the second transmitter

4. PERFORMANCE EVALUATION OF THE NETWORK

In this section, the performance of the proposed network is discussed through numerical illustration. Different values of the parameters are considered for bandwidth allocation and arrival of packets. After interacting with the technical staff at the Internet providing station, it is considered that the message arrival rate (α_1 and α_2) varies from $1\text{x}10^4$ messages/sec to $4\text{x}10^4$ massages/sec. The number of packets that can be converted into a message varies from 1 to 30 depending on the length of the message. Hence, the number of arrivals of packets to the buffer are in batches of random size. The batch size is assumed to follow Binomial distribution with parameters (m, p). After transmitter 1, the packets are forwarded to the multiple buffers are connected to the multi transmitter, with forward transmission rate (β_1) varies from $1\text{x}10^4$ packets/sec to $5\text{x}10^4$ packets/sec. the packets leave the multiple transmitter with a transmission rate (β_2) which varies from $1\text{x}10^4$ packets/sec to $5\text{x}10^4$ packets/sec. In both the nodes, dynamic bandwidth allocation is considered i.e. the transmission rate of each packet depends on the number of packets in the buffer connected to it at the instant. Since performance characteristics of the communication network are highly sensitive with respect to time, the transient behaviour of the model is studied through computing the performance measures with the following set of values for the model parameters:

t = 0.1, 0.2, 0.3, 0.4 seconds

m_1 = 5, 6, 7, 8

m_2 = 4, 5, 6, 7

p_1 = 0.1, 0.2, 0.3, 0.4

p_2 = 0.2, 0.3, 0.4, 0.5

α_1 = 1, 2, 3, 4 (with multiplication of 10^4 messages/sec)

α_2 = 3, 4, 5, 6 (with multiplication of 10^4 messages/sec)

θ = 0.1, 0.3, 0.5, 0.7, 0.9

β_1 = 1, 2, 3, 5 (with multiplication of 10^4 packets/sec)

β_2 = 1, 2, 3, 5 (with multiplication of 10^4 packets/sec)

It is observed that the probability of emptiness of the communication network and the two buffers are highly sensitive with respect to changes in time. As time (t) varies from 0.1 to 0.4 second, the probability of emptiness in the network reduces from 0.761 to 0.025 when other parameters are fixed at (3, 2, 0.2, 0.1, 2, 3, 4, 8) for (m_1, m_2, p_1, p_2, α_1, α_2, β_1, β_2).

5. OPTIMAL POLICIES OF THE MODEL

In this section, we derive the optimal operating policies of the communication networks under study. Here, it is assumed that the service provider of the communication network is interested in maximization of the profit function at a given time t. Let the service provider gets an amount of R_i units per every unit of time of the system busy at i^{th} transmitter (i=1,2). In other words, he gets revenue of R_i units per every unit of throughput of the ith transmitter. Therefore, the total revenue of the communication network at time t is,

$$R(t) = R_1\beta_1(1-\exp)(\alpha\sum_{k=1}^{m}\sum_{r=1}^{k}\frac{{}^{m_1}C_{k_1}p_1^{k_1}(1-p_1)^{m_1-k_1}}{1-(1-p_1)^{m_1}}\,{}^{k}C_r(-1)^{3r}\frac{\left(1-e^{-r\beta_1 t}\right)}{r\beta_1})$$

$$+R_2\beta_2.1-\exp\left\{\left[\alpha_1\sum_{k_1=a_1}^{b_1}\sum_{r=1}^{k_1}\sum_{J=0}^{r}(-1)^{3r-J}\left(\frac{{}^{m_1}C_{k_1}p_1^{k_1}(1-p_1)^{m_1-k_1}}{1-(1-p_1)^{m_1}}\right)({}^{k_1}C_r)({}^{r}C_J)\left(\frac{\theta\beta_1}{\beta_2-\beta_1}\right)^{r}\left(\frac{1-e^{-[J\beta_2+(r-J)\beta_1]t}}{J\beta_2+(r-J)\beta_1}\right)\right]\right.$$

$$\left.+\alpha_2\left[\sum_{k_2=a_2}^{b_2}\sum_{s=1}^{k_2}\left(\frac{{}^{m_2}C_{k2}p_2^{k2}(1-p_2)^{m_2-k_2}}{1-(1-p_2)^{m_2}}\right)({}^{k_2}C_s)(-1)^{S}\left(\frac{1-e^{-\beta_2 st}}{\beta_2 s}\right)\right]\right\}$$

$R(t)=R_1$(Throughput of first transmitter) + R_2(Throughput of second transmitter)

6. CONCLUSION

This paper addresses the problem of reducing burstness of buffers and delays in transmission through integration of three optimal strategies of traffic flow control namely dynamic bandwidth allocation (DBA) phase type transmission and direct arrivals to the multiple buffers. Here, it is assumed that the arrival of packets in all the buffers are in bulk i.e. the messages at source are converted into a random number of packets and stored for forward transmission in buffers. This arrival process is characterised through compound Poisson binomial process. The performance of the model is evaluated by deriving the performance measures such as mean content of the buffers, mean delays in transmissions, throughput of the buffers, utilization of the transmitter. The sensitivity analysis of the model revealed that the integration of the three traffic flow control strategies can reduce the mean delays in transmission and burstness of buffers. By maximizing the revenue function, the optimal operating parameters of the model are derived using MathCAD code. It is observed that the optimal strategies are useful for monitoring the traffic flow of LAN, WAN, MAN and other internet service stations effectively. It is possible to extend this model with parallel and series communication networks having multiple nodes which will be taken up elsewhere.

8. REFERENCES

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