WIRELESS ATM NETWORKING THROUH CHANNELS

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ABSTRACT

Asynchronous Transfer mode (ATM) has proved its utility in the multimedia network by virtue of its transport Mechanism. Fading becomes a dominent factor in realization of wireless ATM connectivity. Due to fading characteristics the transmitter power needs to fluctuate within some pre specified range in order to keep the probability of error within tolerable limits. In this paper we consider some suitable model for delay sensitive and loss sensitive traffics of ATM. The relevant queueing theoretic approach has been analyzed for randomized service time distribution that comes from the information theoretic limit of the channel characteristics. A combination of queueing theory and information theory has produced more useful performance analysis for the throughput and delay characteristics.

1. INTRODUCTION

Asynchronous Transfer mode is a connection oriented, cell based communication protocol. It is a communication transport system which can transport virtually all services, both legacy and new. The legacy system is defined as those that predate the current generation of investment computing assets. The word was initially coined as a polite euphemism for absolute and described assets that predated client server computing such as mainframes and proprietary microcomputer systems. Such systems are regarded as part of an organizations computing heritage. They continue to serve a vital role in many enterprise computing infrastructure and web services can help to enhance their contribution by making their resources available in new and more flexible ways. ATM offers an integrated, scalable, multi-service platform with a defined quality of service on an individual connection basis. The quality of service (QOS) achievable is such that low latency, low jitter applications, such as interactive video can be supported. Operationally it is a high speed connection oriented packet like multiplexing and switching technique that provides flexibility of network access, dynamic bandwidth allocation on demand, and flexible bearer capacity allocation [1]-[2]. The arrival process from the users is random, but a suitable usage parameter control algorithm for worst case analysis may make the arrival process to the first-in-first-out (FIFO) buffer deterministic.[3].

Considerable amount of analysis on multi-access communication model over additive gaussian noise channel has been reported in the literature [4]. Queuing theoretic approach analyzes a random arrival of messages and for randomized service time distribution, which comes from the information theoretic limit of the channel characteristics [5]-[7].

Multi-access communication system consists of a set of users sending respective information to a single channel. Each transmitter generates a sequence of messages constituted by random data of certain length. The receiver finds out transmitted information from a Poisson distributed model for traffic at its input. Multi-access environment includes additive Gaussian noise channel with noise density N_0 and transmission bandwidth W. All the transmitters are considered to have equal power P. There are N active transmitters at a given time. Signal-to-noise ratio (SNR) for any of these active transmitters has been shown in [8] and given by P/ {(N-1) P+N_0 W}.

The decoder, thus, has a total information resolving power of nW ln [1+P/{(N-1) P+N_0 W}] nats/unit-time. This resolution it shares equally along the active transmitters.

2. QUEUEING MODEL FOR ATM TRAFFIC

In broadband networks based on ATM, the CBR traffic from fixed rate voice, video or circuit emulation is characterized by virtual circuits with almost periodic cell arrivals. In this paper, the infinite buffer is considered for queue length distribution for each ATM switch whose output port carry CBR traffic at single rate. The problems that more than one cell may be destined for the same output line within the same time slot is referred to as output contention and queuing occurs as a result. A single server rate λ fewer Queues are fed by K independent sources with period n. It is assumed that arrival times of the K circuits are independent and uniformly distributed over all n slots within a period. From Little's Theorem we know that an M/M/1 queue is built with the arrival rate less than that of the service rate μ to give total number of packets waiting N', in terms of ρ defined as λ/μ, equal to $\rho/1-\rho$. The service rate in the case of wireless ATM is bounded by a channel capacity which is dependent upon a signal to noise ratio parameter. A channel condition produces a wide fluctuation in a signal power and thereby the service rate is affected considerably. In order to tackle such a situation we are required to adjust the transmitter in a suitable way. Changing the power level is one such alternative, while decreasing the transmission rate is another suitable option. It is assumed in all such discussions that the channel information is made available to the transmitter by receiver feedback mechanism. In certain cases the effect of multipath may reach a significant level such that by merely enhancing power level may not bring the probability of error to a constrained limit. In such a case a second option of reducing the transmission rate appears a better one. However, the adjustment of transmission rate may complicate the synchronization at the receiver.

In most of the models consider for ATM switching network is assumed that the several virtual connections (vc) share a link such that the link capacity is not exceeded by the equivalent bandwidth. The traffic arrival is simply averaged out in such cases. In wireless ATM network, however, the delay variation is very critical and the packet or cell buffering becomes a bottleneck. Therefore, the cell burst may cause buffer overflow. The desired packet is selected from a set of received once for forwarding to the outgoing link. First-in-first-out (FIFO) queueing policy is easier to implement. Andrews and his colleagues investigated the stability of first-in-first-out discipline and shows that the queue length grows to infinity if FIFO is applied at the nodes [9]. Chlamtac et al [10] have replaced the flow condition of ATM network by a source rate condition based on the root system parameter and the delay and buffer size bound have been obtained therein.

In this paper we analyzed the deterministic approached of Chlamtac [10] by combining the queueing behaviour with the information theoretic approach. We assume indirectly that there exists a super chain (v_1:p$\rightarrow q_1$), (v_2:$q_1\rightarrow q_2$),……, (v_n :$q_{n-1}\rightarrow q_n$), (v_{n+1}: $q_n \rightarrow$ p') from p to p'; where q_j represents j^{th} packet. Queue. Let us take the packet with the earliest critical time in this chain. Here (v_1:a$\rightarrow$ b) denotes the event that packets a and b are in the same delay chain on the outgoing link of node v on the path P, and packet a left earlier than b. For the ease of notation, we set q_0=p, q_{n+1}=p', v_0=A (the source node). Let $d(v_i,v_{i+1})(q)$ be the total queueing delay that a packet q suffers on the subpath from v_i to v_{i+1}, including the node v_{i+1} but not including v_i. The notations $d[v_i,v_{i+1}](q)$ and $d(v_i,v_{i+1})(q)$ similarly have meaning with the obvious differences concerning the inclusion of the endpoints v_i but not v_{i+1} and both of the nodes v_i & v_{i+1} respectively in the subpath.

Further, $d_{vi}(q)$ is the queueing delay suffered by q at node v_i. We denote by x_{vi}, i=1,2…n+1 the number of packets transmitted between q_{i-1} and q_i from node v_i on the path. These packets, together with q_i, i=1,2…n, are called intermediate packets. Let $s(q_0)$,$s(q_{n+1})$ be the starting time of $q_0=p$ and $q_{n+1}=p'$, respectively at the source node. With these notations it has been proved that the following condition holds [10]:

$$\sum_{i=0}^{n} d_{(vi,vi+1)}(q_i) + \sum_{i=1}^{n+1} x_v + n \geq s(q_{n+1})-s(q_0) \quad (1)$$

In equation (1) above the term x_{vi} depends upon the channel conditions. The service rate of the path for a wireless channel cannot be always one. Therefore, the number of packets transmitted between the packet q_{i-1} and q_i from node v_i is expected to vary by significant amount. Teletar model [8] has considered a case for n active transmitters at a given time and found that the decoder at the receiving node can resolve a transmission rate W ln[1+p/{(n-1)p+N_0W}] nats/unit-time which it shares equally among the active transmitters. In this paper we have analyzed the effect of SNR variations on the queueing delay. Average over all the possible paths between two adjacent nodes in a chain of ATM virtual path links has been considered a suitable parameter for performance analysis.

3. Simulation Results

In the simulation study we consider the variations in channel behaviour getting effectively transformed into channel capacity variations. For this purpose the randomness is incorporated in service time variations. Simulation of Poisson distributed arrival time is explored in Fig.1 where the number of packets generated by a particular user, (say user 1) is shown to vary at different instants but for the same time interval of one second. The axis of Y represents the number of packets generated during respective seconds. In other words the average arrival rate is 39 packets/second. In our study, the packet duration is considered to be 20millisecond. The communication medium in normal conditions can transmit at a rate of 500 packets/second. Considerable volume of results is available in literature for the throughput and/or delay performance analysis of multi-access networks with respect to the network load variations. Our result represents a verification of a particular case of 0.78 load on the network because the network in consideration consists of 10 nodes with the above cited traffic distribution. The throughput and delay value for our simulation turns to have a variance of 1% from the theoretical value of throughput and 1.5% from that of the delay [11].

In Fig.2 the axis of X represents signal power and Y represents the service rate variations. The service rate in the case of wireless ATM is bounded by a channel capacity which is dependent upon a signal to noise ratio parameter. The performance curves for SNR values and the transmitted power, ranging from 0 dB to 50 dB, in increments of 10 dB. The service rate for 10 nodes considered in the network is seen to vary between 400 packets/second to 580 packets/second in an exponential manner. Fig.3 shows average delay as a function of traffic load and SNR variation on the network. The SNR variation is reflected in variable channel capacity and thereby, suitable changes in the service rate.

Queueing behaviour of wireless ATM as represented by equation (1) is studied in Fig.4. The effect of multi-access interference is included in the variations of x_{v_i}. For the Poisson distributed traffic of Fig.1 and consideration of 10 active users sharing the channel, the service rate, which is the channel capacity, is obtained from the Telatar model [8] and affects the number of packets transmitted from the node v_i between the packets q_{j-1} and q_j. For various values of j, the x_{v_i} has been computed by simulation. It can be observed that for increasing the additive noise variance in the channel causes almost linear decrement in the number of packets passing over the path during transmission of two successive local packets at the node in consideration. Also, the trend can further be generalized that such a number x_{v_i} for j^{th} node approaches a constant value when the steady state condition is reached. In our case the almost steady state condition is reached after transmission of about 50 local packets from the node.

4. CONCLUSION

We have studied the queueing behaviour of the wireless ATM network involving 10 nodes in a multi-access environment. Congestion behaviour of a link using deterministic algorithm has been observed with respect to changes in the channel behaviour represented by channel capacity.

5. REFERENCES

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The SNR and the curves Representing corresponding performance results:

0 db	-------------
10 db	---o---o-----
20 db	---x---x-----
30 db	---□---□-----
40 db	---\----\------
50 db	---Δ---Δ------

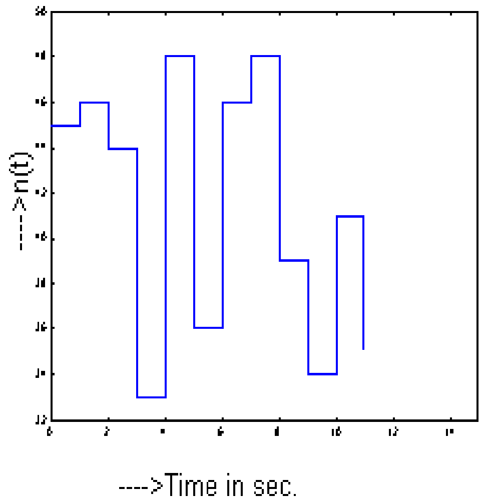

Fig.1.Traffic arrival at a node

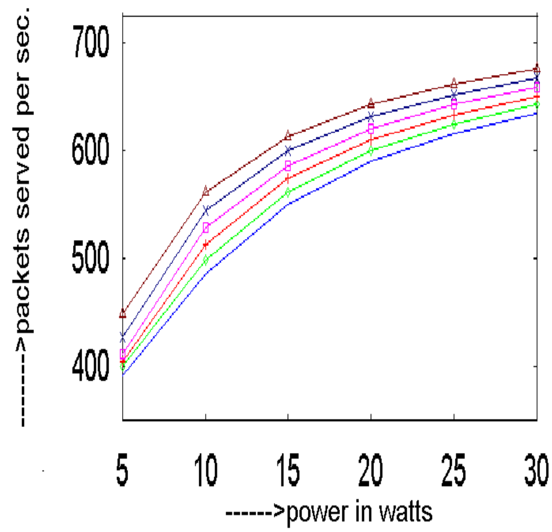

Fig.2:-> Service Rate Variation

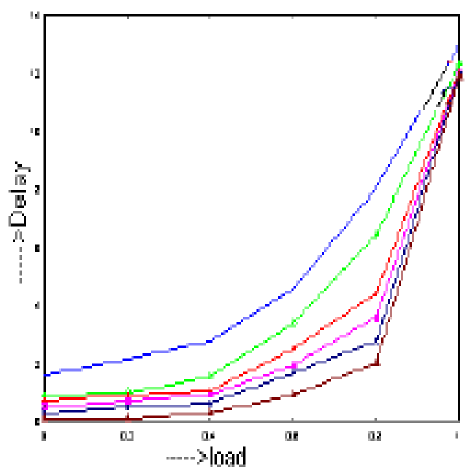

Fig.3.Packet delay in packet units versus offered load on the link

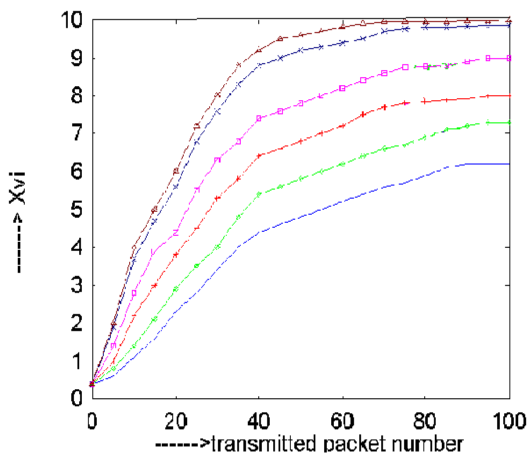

Fig.4.Number of packets passing through a link between two successive local packet transmissions versus duration number