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무선 ATM 액세스 전달구조에서 VBR 트래픽에 대한 셀 스케일과 호 접속레벨간의 관계

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The Relation of Cell Scale and Call Connection Level for the VBR Traffic in the Wireless ATM Access Transport

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ABSTRACT

In this paper it is focused on the relation between CLR(Cell Loss Ratio) and blocking probability in the wireless ATM access transport. Traffic model of wireless ATM access transport is based on the cell scale, burst scale and call connection level. The CLR due to buffer overflow for wireless access node is derived for VBR traffic. The CLR due to transmission errors for wireless channel is derived. Using the CLR for both access node and wireless channel, the CLR of wireless ATM access transport is derived. The relation between CLR and blocking probability is analyzed for VBR traffic to evaluate performance of wireless ATM access transport.

Key Words : ATM, CLR, VBR, Blocking probability

Ⅰ. Introduction

ATM network will have an important role in the future evolution of global communication networks. Wireless ATM access transport is considered as a wireless access network to interconnect the mobile users to the ATM network. In other words, wireless ATM access network architectures focus on the wireless extension of the B-ISDN terminals for seamless ATM connection.

In this paper it is focused on the relation analysis between CLR and blocking probability in the wireless ATM access transport which consists of access node and wireless channel. Wireless ATM access transport and its traffic model are surveyed in section 2. In section 3, the CLR due to buffer overflow of wireless access node is derived for VBR traffic and the CLR due to transmission errors for wireless channel is derived. Also, using the CLR equation for both the access node and the wireless channel, the CLR of wireless ATM access transport is derived and finally the relation between CLR and blocking probability is analyzed. and the paper closes with the remarks in section 4.

Ⅱ. Wireless ATM access transport and traffic model

2.1 Wireless ATM access transport

Wireless ATM access transport is considered as a wireless access network to interconnect the mobile users to the ATM network. But there are some problems about packet mode information transport in the wireless environment, which is characterized by unreliable sharing access with

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finite resource and mobility. So modified or enhanced functionalities of the B-ISDN UNI, such as ATM and AAL layer protocols, are suggested to improve the wireless connectivity, which includes error control to improve the error performance and mobility support. Convolutional channel coding scheme is particularly considered to meet service requirements as shown in table 1[1]. The ATM Forum Wireless ATM group has proposed a WATM system reference model[2,3]. This model specifies the signalling interfaces among the mobile terminal, wireless terminal adapter, wireless radio port, mobile ATM switch and non-mobile ATM switch. It also specifies protocol layering architecture of the user and control planes.

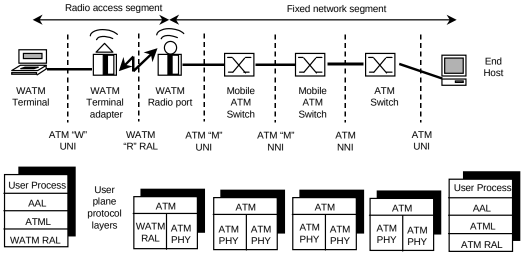


Figure 1. The reference configuration of wireless ATM network.

Table 1. CLR performance requirements for ATM traffic.

Items	ITU-T I.356 (end-to-end cell transfer performance)	Akira paper (wireless access link)
Bit rate (Mbit/s)	all bit rates	all bit rates
CLR	3×10^{-7}	1.5×10^{-8}

2.2 Traffic model of access node

We can extend the flow of calls in a circuit switched network to consider the flow of cells through an ATM buffer. The time between arrivals (calls or cells) is given by a negative exponential distribution, that is to say, arrivals form a Poisson process. But, although the same source model is used, different types of behaviour are being modelled. In a ATM network, the focus is at the level below the call time scale, the characteristic behaviour of the service as a flow of cells. So three different time scales of activity are considered. That is, cell scale, burst scale and call connection level must be considered in a ATM switched network[4]. Cell scale is focused on the behavior of cell generation at the lowest level and concerned with the time interval between cell arrivals. Burst scale is focused on the behavior of a transmitting user, characterized as a cell flow rate, over an interval during which that rate is assumed constant. In the connection level, set-up and clear events delimit the connection duration, which is typically in the range 100-1000 seconds. table 2 shows three time scale levels.

In ATM not only do connections contest, and may be made to queue, but each accepted connection consists of a stream of cells and these also must queue at the nodes as they traverse the network. we will use a queue then as a mathematical expression of the idea of resource contention in figure 2. There are two elements of queueing behavior in the performance analysis of ATM networks : the cell scale and burst scale components.

Table 2. Time scale level

Levels of traffic behaviour	Stochastic phenomenon	Stochastic model	Traffic loss
Cell scale	Statistical cell multiplexing generated from various source	Queue and population model	Cell loss
Burst scale	Statistical multiplexing of a packet or packet group	Queue and population model	Cell loss
Call connection scale	Call connection	Population model (Erlang)	Call blocking

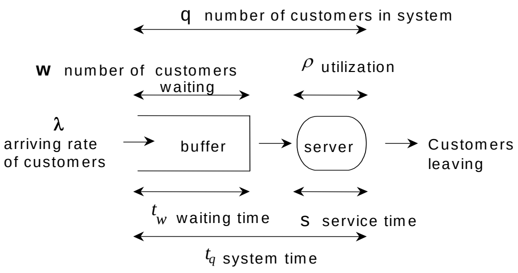
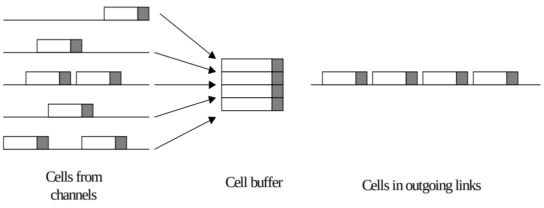
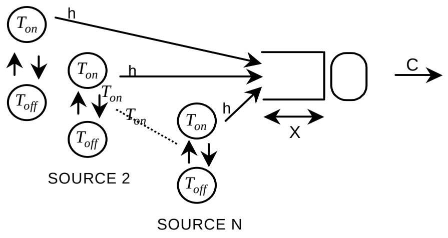


Figure 2. Queueing system.



(a) Modeling of cell scale queueing



(b) Modeling of burst scale queueing

Figure 3. Queueing model of VBR traffic in the access node

Cell scale and burst scale queueing occurs with VBR traffic when two or more cells arrive during a time slot. Cell scale queueing analysis quantifies the effect of having simultaneous arrivals according to the relative phasing of the CBR streams, so we define simultaneity as being within the period of one cell slot. Burst scale queueing is that the total input rate of simultaneous bursts exceed the cell slot rate of the ATM buffer. Principle and modeling of VBR traffic are shown on fig. 3.

We consider two major systems, LCC (Lost Call Cleared) systems and LCD (Lost Call Delayed) systems for connection performance evaluation. In LCC systems which can be applied to ATM networks as shown in fig. 4, queueing is not provided for call requests, calls are assumed to arrive with a Poission distribution, and it is further assumed that there are a nearly infinite number of users. The Erlang B formula describes the GoS as the probability that an arbitrary user will experience a blocked call in a LCC system. It is assumed that all blocked calls are instantly returned to an infinite user pool, and may be retried at any time in the future. The time between successive calls by a blocked user is a random process and is assumed to be Poisson distributed[4]. LCC system model with infinite input can be described by a Markov chain representation of a system with s channels. The number of busy channels is equal to the number of busy users, and the probability of blocking is given as

$$B(s,a) = \frac{\frac{a^s}{s!}}{\sum_{k=0}^{s} \frac{a^k}{k!}} \qquad (1)$$

where s is the number of channels, and a is the total offered load to the system[4,11].

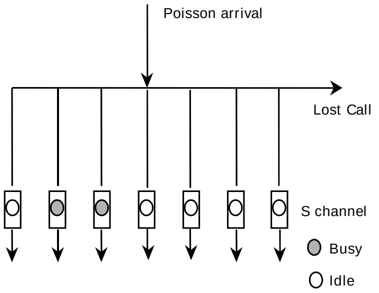


Figure 4. LCC system model with infinite input

2.3 Performance improvement of wireless channel environments

The purpose of this section is to investigate error control issues encountered in using ATM over wireless data links. ATM must be made to perform satisfactorily over wireless data links if certain error control measures are used to insure that RF link characteristics do not impair ATM operation. Forward error correction (FEC) and data link layer automatic repeat request (ARQ) are conventionally used to improve error performance. There are a number of tradeoffs that can be made in optimizing performance, considering error rate and throughput as tradeoff factors. Since the wireless environment can vary widely, the choices made will be strongly influenced by the wireless channel characteristics. Therefore, there will be variations in the appropriate choices of parameters for different channels. Several variations on this architecture may be more suitable depending upon channel conditions. Interleaver/deinterleaver is needed only for burst noise channels. This interleaver is not needed for channels which have not significant burst noise problem. The best choice of interleaver for traffic requiring reliable delivery may be too long for delay sensitive traffic. The solution for this situation is to introduce the mux/demux function. This will allow delay sensitive traffic to have a different interleaver length and a different FEC approach if desired.

Thus, delay sensitive traffic can use a shorter interleaver length to keep the delay small, and the rest of the traffic can use a longer interleaver to minimize BER. In conclusion, for nonreal time VBR(nrt-VBR) services which require high reliability, ARQ is needed, but FEC cab be used to reduce the number of retransmissions, known as the Hybrid ARQ scheme(6). Recommended error control architecture is shown in figure 5(9).

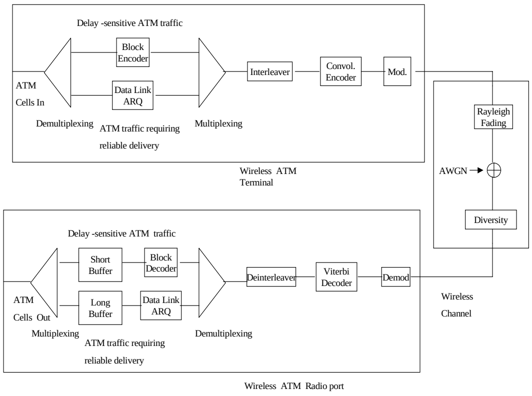


Figure 5. Recommended error control architecture

Ⅲ. The CLR and blocking probability in the wireless ATM access transport

3.1 The CLR of wireless ATM access transport

The CLR of wireless ATM access transport (CLR_T) is related to the CLR due to buffer overflow (CLRo) and the CLR due to the non-ideal physical channel (CLRc). The CLR_T can be estimated as CLR_T = CLRo + (1-CLRo)CLRc. The cell loss ratio resulting from buffer overflow and the cell loss ratio resulting from bit error rate of physical layer are two independent processes. The CLR performance of wireless ATM access transport using Type I Hybrid ARQ scheme with two- code is represented as CLR(x, ρ, γ), where x is the cell buffer capacity, N_o is the ratio of service capacity to peak rate $(\frac{C}{h})$, $\lfloor N_o \rfloor$ take the first integer below N_o, b is the average burst length, γ is the ratio of bit energy to the power spectral density, ρ is utilization and p is the bit error rate at the output of demodulator[5,6]. The Type I Hybrid ARQ protocol is the simplest of the hybrid protocols. Each packet is encoded for both error detection and error correction. These protocols can be implemented using either one-code or two-code system and two code system is used in this section as shown in Fig. 6.

$$CLR(x, \rho, \gamma) = CLR_O + (1 - CLR_O)CLR_C \quad (2)$$

$$CLR_c = \frac{P_{de}P_e}{1 - P_{de}P_r}$$

$$CLRo = CLR_{cs} + CLR_{bsl}CLR_{bsd}$$

$$= \exp\left[-2x\left(\frac{1-\rho}{\rho}\right)\right] +$$

$$\exp\left[-N_0\frac{x}{b}\frac{(1-\rho)^3}{4\rho+1}\right] \times$$

$$\frac{1}{(1-\rho)^2 N_0}\frac{(\rho N_0)^{\lfloor N_0 \rfloor}}{\lfloor N_0 \rfloor !}e^{-\rho N_0}$$

P_e is the probability that a received packet contains an undetectable error pattern and satisfies the equation $P_e \le 2^{-(n_1-k)}[1+(1-2p_{be})^{n_1} - 2(1-p_{be})^{n_1}]$.

P_r is the probability that a received packet contains a detectable error pattern and thus causes the generation of a retransmission request, satisfies the equation $P_r = 1 - P_c - P_e$. P_c is the probability that a received packet is error-free and satisfies the equation $P_c \ge (1-p_{be})^{n_1}$. p_{be} is the bit error rate at the output of viterbi decoder and satisfies the equation $p_{be}(M=4) \le 1/2(7D^7+39D^8+104D^9+352D^{10})$, $D=2\sqrt{\frac{p(1-p)}{M-1}} + \left[\frac{M-2}{M-1}\right]p$[5,7,8,9]. p is the bit error rate at the output of demodulator such as $p = \frac{1}{2}\left[1 - \frac{1}{\sqrt{1+\frac{n_2}{k\gamma}}}\right]$. P_{de} is the probability of FEC decoder error and satisfies $P_{de} \le 1 - P_c$.

n_1 is the total length of error detection code(16 bit + 6 bit). n_2 is the total length of FEC code(code rate = 1/2, constraint length = 7, length = 22 bit + 22 bit). k is the information bit length(16 bit).

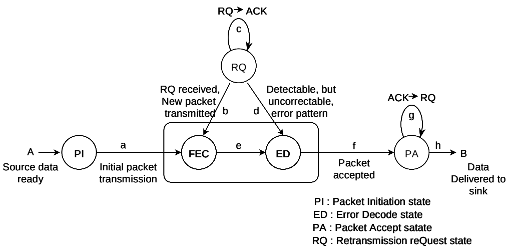


Figure 6. State diagram for a Type-I Hybrid ARQ protocol based on two codes

3.2 The blocking probability of wireless ATM access transport

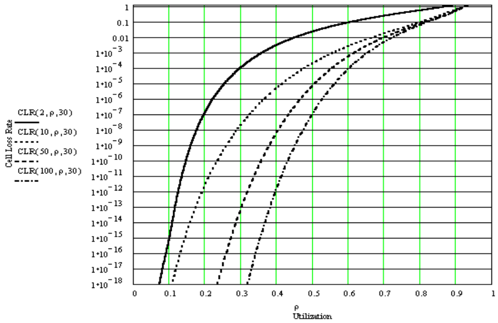
Another GoS parameter, in addition to cell loss, is the probability of a connection being blocked. This is very much dependent on the CAC algorithm and the characteristics of the offered traffic types. If we restrict the CAC algorithm to one that is based on limiting the number of connections admitted, then we can apply Erlang's lost call formula to the situation as shown in (1).

3.3 Relation analysis between CLR and blocking probability

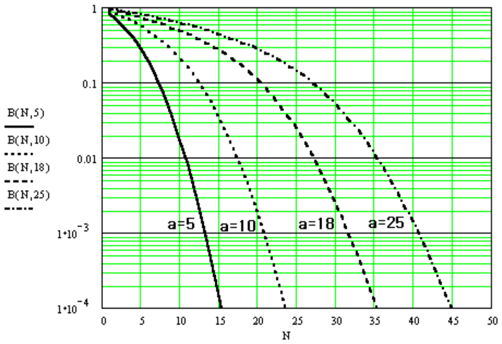
CLR(x, ρ, γ) curve shows how the cell loss ratio varies with the buffer size for different utilization as shown in Figure 7(a). B(N, a) curve shows how the connection blocking probability varies with the maximum number of connections for different offered traffic intensities as shown in Figure 7(b). From the two curves described in Figure 7, the relation between CLR and blocking probability is derived for the following parameter.

- cell slot rate(C) : 4,528 cell/sec
- mean cell rate(m) : 20 cell/sec
- average number of cells per burst(b) : 10 cells
- peak cell rate(h) : 226 cell/sec
- the ratio of the cell slot rate to the peak cell rate (N_0) : 20.04
- the code rate of 4-ary(M=4) convolutional code(r) : 1/2
- constraint length of 4-ary convolutional code (ν) : 7

requirements of 10^{-7} are reached under a certain circumstances. In other words, when a CLR is 10^{-7} with the signal to noise ratio(γ) curve of 30 dB, the maximum number of connections is near 74. Now that we have a figure for the maximum number of connections, we can calculate the offered traffic at the connection level for a given probability of blocking. From Figure 7(b), we find that for 74 maximum connections and a connection blocking probability of 0.03, the offered traffic intensity is 63 Erlangs. Note that the mean number of connections in progress is numerically equal to the offered traffic, i.e. 63 connections. The cell loss probability for this number of connections can be found from Figure 7(a). It is below the CLR requirements of 10^{-7}. In conclusion, we have seen



(a) CLR of Wireless ATM access network with Type I Hybrid ARQ Scheme



(b) Blocking probability, given maximum connections and offered traffic

Figure 7. The relation between blocking probability and CLR

that the relation between cell scale level and call connection level can be derived. we have also seen that when the connection blocking probability requirements are taken into account, the actual cell loss probability can be rather lower than that for the maximum allowed number of connections[10,11].

Ⅳ. Conclusion

In this paper we have seen the relation between CLR and blocking probability in the wireless ATM access transport. VBR traffic model of wireless ATM access transport is based on the cell scale, burst scale and call connection level. In other words, the cell scale, burst scale and call connection level are considered for a mix of VBR traffic. The CLR equation due to buffer overflow for wireless access node was derived for VBR traffic and the CLR equation due to burst errors for wireless channel was derived. Using the CLR equation for both access node and wireless channel, the CLR equation of wireless ATM access transport was derived. And finally the relation between CLR and blocking probability was analyzed for the VBR traffic in the wireless ATM access transport. These results can be utilized for designing the practical wireless ATM access networks.

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