# Integrated Voice/Data Transmission in a High Speed Common Channel Using Demand Assigned Movable–Boundary TDMA Multiplexer[1]

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## ABSTRACT

The paper proposes and evaluates a protocol which combines the ideas of demand assignment and movable boundary for integrating voice and data traffic in a high speed common channel. Each multiplexer serves a group of voice users plus a data user. The common channel is shared by a number of groups or multiplexers using distributive demand assigned TDMA. Within each group time slots are shared between voice and data users through movable boundary. Since voice has real–time constraint, it is given higher priority in the use of channel resource. Blocked calls are assumed lost. In this paper, mathemetical expressions of several key performance measures are derived. Numerical examples are used to demonstrate the performance of this protocol and computer simulations are also conducted to verify the the results.

## I. Introduction

The integration of voice and data has become a trend especially with the coming of the age of ISDN. It is a well–known fact that voice traffic has more severe time constraint but is less vulnerable to packet loss. On the contrary data traffic can tolerate longer delay but has a more stringent constraint on packet loss. Integrated voice and data communication has in the past received considerable attention from researchers.

In this paper, we combine the ideas of movable boundary and demand assignment to propose a protocol for a high speed backbone channel such as FDDI, see Fig. 1. Connnected to the backbone are $N$ multiplexers each of which concentrates the traffics generated from local voice and data users. In other words, movable boundary protocol shall be implemented in concentrating local traffics. Demand assigned TDMA described above is next used to integrate the traffics from these multiplexers.

## II. Protocol and Assumptions

In our proposed demand assigned movable–boundary (DAMB) TDMA protocol, the channel time is organized into, now called, superframes to fit our consideration of using high speed backbone. The slot structure of a superframe is sketched in Fig. 2(a). Each superframe contains three parts: reservation frame, fixed frame, and variable frame. The users, voice or data, connected to a multiplexer are said to belong to the same group. Each group has a vector in the reservation frame to issue requests from its members. Each group also has one time slot in the fixed frame and upto $c$ slots in the variable

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[1] The work reported in this paper is supported jointly by the National Science Council under Grant NSC80–0404–E002–16 and Telecommunication Lab, Directorate General of Telecom., Ministry of Communications under Grant TL–NSC–80–2101 of the Republic of China

[2] Also with Institute of Information Science, Academia Sinica,

frame. This explains why in Fig. 2(a) the superframe can have a maximum of $N(c+1)$ slots in the fixed plus variable frame. The actual number of slots assigned to a group is determined by the requests recorded in the reservation vector.

Consider slots occupied by users of a specific group in the fixed and variable frame in Fig. 2(a) and put them together as the subframe sketched in Fig. 2(b). Clearly the subframe of Fig. 2(b) contains at least one but no more than $c+1$ slots of which the first slot is taken from the fixed frame of Fig. 2(a). The slots in Fig. 2(b) are assigned to users in the group via the method movable boundary.

We can now with no difficulty see that demand assignment of the protocol is designed for the multiplexers or groups connected to the backbone and built in the reservation frame. In other words each group can reserve a certain number of slots in each superframe and the slots claimed by a group are then assigned to its affliated users through movable boundary. Each voice user can use only one slot in each superframe and the real–time requirement of voice communication is realized by proper selection of $c$ so that $N(c+1)$ slots do not consume too much time. Let each group have $m_v$ voice users plus one data user. The voice users are served on the basis blocked calls get discarded. Upto $c$ voice calls can be served in each superframe. In other words each group has one slot reserved for data transmission in each superframe. But slots not used by voice users can be allocated to transmit more data packets. The data user is equipped with an infinite queue since data integrity is the major concern. At the beginning of each superframe each multiplexer determines the number of active voice users, examines the contents of data queue, and requests the amount of slots he desires using his reservation vector.

The following assumptions are adopted in this paper.

1) Voice calls are packetized;

2) A voice user is said to be active if he has a call to deliver. An active user, once accepted by the system, will be given one slot in each superframe till the call is completed. A voice user is said to be inactive or idle if he does not have a call to deliver. Clearly, a voice user alternates between active and idle state. If a voice user is active in a superframe we assume that the voice user will continue to be active in the next superframe with probability $p$. On the contrary if a voice user is idle in a superframe we assume that the voice user will become active in the next superframe with probability $1-q$.

3) A voice user changing his state from idle to active shall be blocked if his affliated multiplexer has already accepted $c$ previous calls for service.

4) The arrival process to the input of a data queue is assumed to be Bernoulli. The probability of receiving a packet per slot is $\delta$.

5) As compare to the fixed frame, the reservation frame is much shorter so that its length can be ignored. The length of the fixed frame needs to be longer than the round–trip signal propagation delay so that the contents of the reservation frame can be made known to everyone before the reservation frame ends.

## III. Analysis

Define

$s_{j,i}(v,d)$:probability of having $v$ active voice users and $d$ data packets in group $i$ when the $j$th superframe begins.

$s_i(v,d)=\lim_{j\to\infty} s_{j,i}(v,d)$, i.e. the value of $s_{j,i}(v,d)$ at steady state.

In [1] we have derived recursive expression of the PGF of $s_i(v,d)$ based on which performance measures such as average queue length, and average frame size can be obtained. We have also obtained the blocking probability of a blocked call and mean packet delay. Consult [1] for details.

## IV. Numerical Examples and Discussions

Throughout the following examples we consider a homogeneous system with $m_v=10$, $c=5$, $N=5$. In this paper the curves are traced from numerical calculations while the simulated results are marked by triangles. We indeed observe good agreement between calculations and simulations. Fig. 3 is used to demonstrate the variation of average superframe length versus $p$ under $\delta=0.04$ for $q=0.85$, 0.90, and 0.95. Under a given $p$ larger $q$ means longer idle period which in turn implies less number of active voice users and then shorter superframe length on the average. We do observe such reasonable trend in Fig. 3. Now let us vary $p$ under a given value of $q$, say, 0.90. We observe that as $p$ increases the average superframe length also increases. This phenomenon is also reasonable. It can be concluded from Fig. 3 that larger $p$ and smaller $q$ together create longer length.

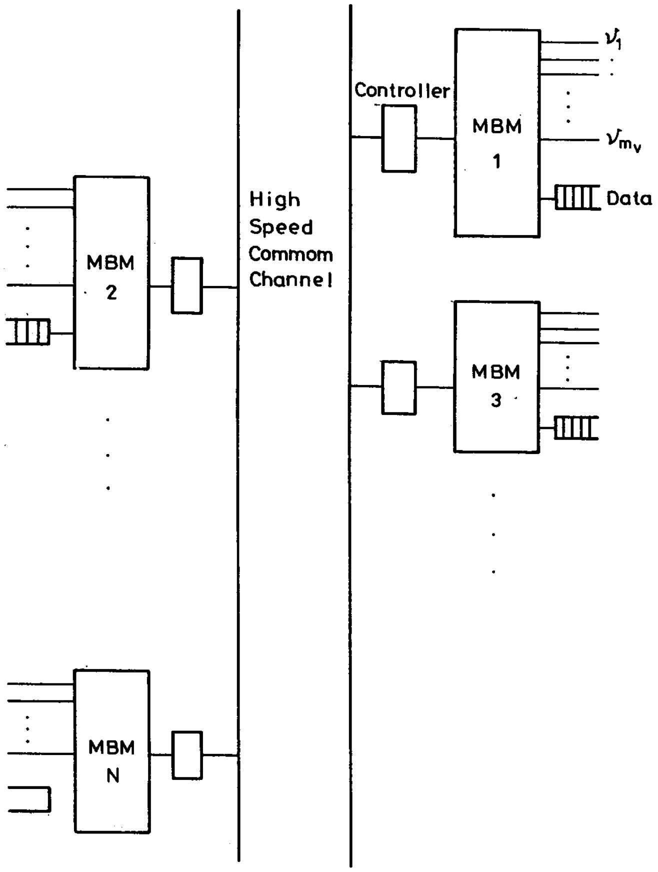
Fig. 4 shows the behavior of data user. In Fig. 4 we plot $\overline{Q}_{d_i}$ versus $p$ under $q=0.85$, 0.90, 0.95. Since larger $p$ and $q$ imply more frequent occurrence of voice communications. We observe the reasonable trend that larger $p$ and smaller $q$ give us larger queue length in the data queue. Similar to Fig. 3 we observe that under a fixed $p$ and $\delta$, smaller $q$ creates longer queue length.

Fig. 5 demonstrates the delay behavior of data packets. The behavior is consistent with what we observe in Fig.. 4.

Finally in Fig. 6 we examine the blocking probability of a voice call. Again in Fig. 6 we use $q$ as parameter. The trend is consistent with that observed in Fig. 3.

## REFERENCES

[1] L. P. Chin and J. F. Chang,"Integrated Voice/Data Transmission in a High Speed Common Channel Using Demand Assigned Movable Boundary TDMA Multiplexer," research notes, Department of Electrical Engineering National Taiwan University, Taipei, Taiwan, December 1990.



MBM: Movable Boundary Multiplexer

Fig. 1

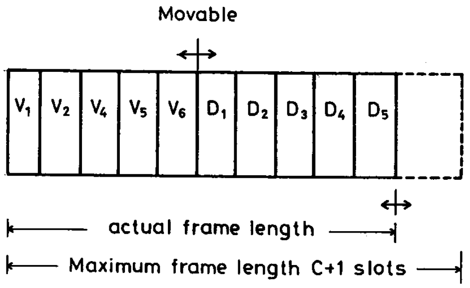


Fig. 2(b)

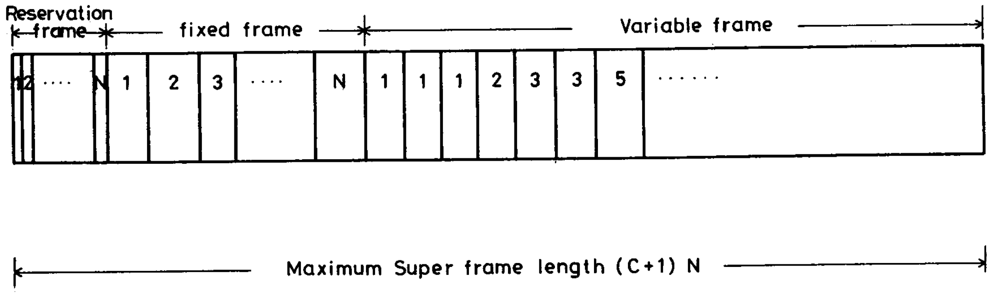


Fig. 2(a)

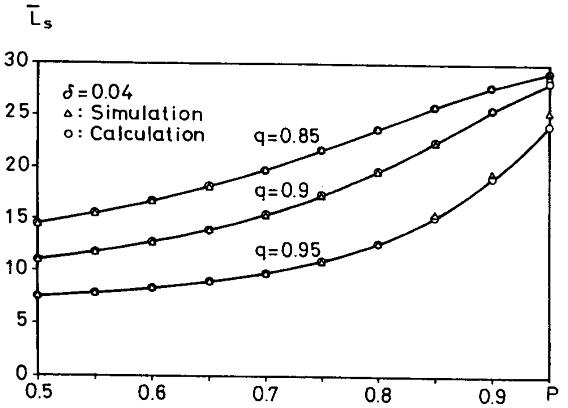


Fig.3

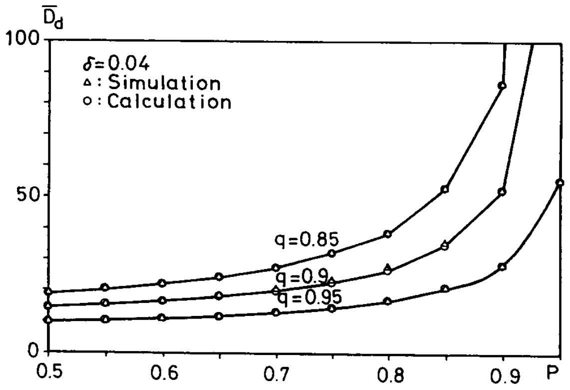


Fig.5

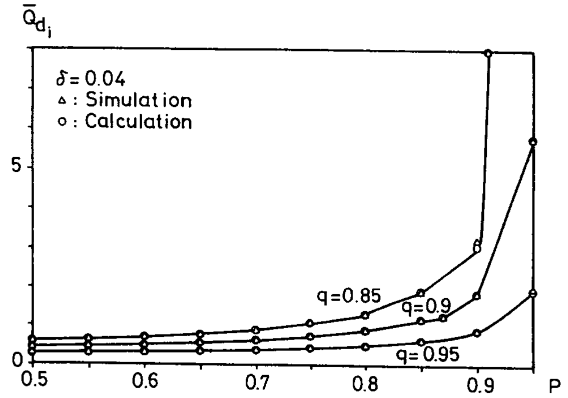


Fig.4

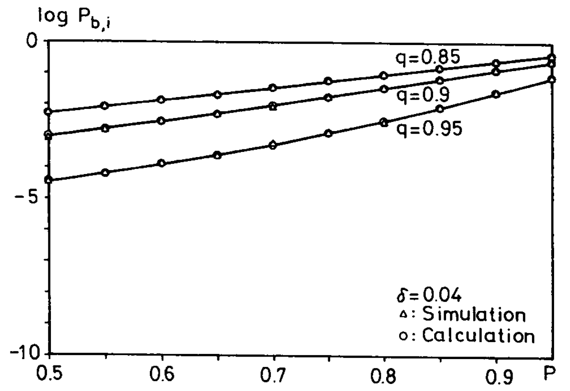


Fig.6