Near-Optimal Voice-Data Integration over Third Generation Wireless TDMA Channels

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Abstract
A new multiple access control (MAC) protocol for mobile wireless communications is presented and investigated. We explore, via an extensive simulation study, the performance of the protocol when integrating voice and data traffic over two wireless TDMA channels.

1. System Model, Actions of Terminals, and Base Station (BS) Scheduling

The uplink channel time is divided into time frames of equal length. The frame duration is selected such that a voice terminal in talkspurt generates exactly one ATM size packet per frame [1]. Each frame consists of three *types* of intervals, the *voice request* intervals, the *data request* intervals and the *information* intervals. All request intervals are subdivided into an equal number of minislots (6) and each minislot accommodates exactly one, fixed length, request packet. The data request intervals are distributed uniformly within the frame.
We allow certain data request (Rd) slots to be ″transformed″ into voice request (Rv) slots, to accelerate the termination of the voice request contention period.
The concept of reserving a minimum bandwidth for both voice and data terminals to make reservations helps to keep the access delay within relatively low limits and gives clearly better performance than the PRMA [3] and quite a few PRMA-like algorithms (e.g., [5]).
Also, the voice and data terminals do not exhaust their attempts for a reservation within the request intervals. Any other free, at the time, information slot of the frame can be temporarily used as an extra request slot (ER slots) [2], with priority given to the voice terminals, the codec rate of which is assumed 32 Kbps.
Upon successfully transmitting a request packet the terminal waits <u>until the end of the frame</u> to learn of its reservation slot (or slots). A terminal with a reservation transmits freely within its reserved slot. Generally, a terminal that fails to transmit a request tries again in successive frames until it succeeds. However, since voice packets that age beyond the voice delay limit (24ms = 2 channel frames) are dropped, a voice terminal may stop transmitting requests without ever succeeding.
We assume that the BS always allocates the earliest available information slot within the frame, and that it services every outstanding voice request before servicing any data requests. Voice traffic is offered priority over the data traffic, due to its more stringent quality of service requirements.
Finally, *we apply the following low-voice-load mechanism to our scheme*. We define the *frame voice occupancy* as the ratio of {(voice reservations + voice requests) / number of information slots in the frame}. This ratio is calculated by the BS immediately after the end of the voice request slots of <u>each frame</u>. If the ratio is lower than a set limit (50%), we allow data terminals with requests to acquire up to 8 slots in the current frame (average data message length = 8 packets). Still, only the first allocated slot is guaranteed to data terminals with reservations in subsequent frames. The selection of the *low frame voice occupancy limit* and of the *maximum number of slots that can be allocated to data terminals within a frame* (<u>the two parameters of our low-load mechanism</u>) must be done carefully, so that even in the case of low voice load enough information slots will still remain available in the next frame for voice terminals who enter talkspurt to use as ER slots.

2 Voice-Data Integration in a 1.8 Mbps Medium Capacity Channel (VDI-MCC)

We compare our scheme with two previously proposed efficient schemes for voice-data integration, IPRMA [6] and RRA [1,4]. The comparison proves our scheme's significantly better performance for a wide range of data message arrivals (between 25 and 330 Kbps), in terms of mean data access and message delays and voice capacity (maximum number of voice terminals subject to voice packet dropping probability less than 1% and mean data message delay smaller than 200 msecs). The channel throughput (used fraction of the total number of information slots within the frame) is in our scheme at minimum 3% larger than in RRA for very high voice and data loads and up to 50% larger than in RRA for low voice loads and high data loads.

3. Voice-Data Integration in a 9.045 Mbps High Capacity Channel (VDI-HCC)

In this case, our scheme achieves a near-optimal voice multiplexing gain (<u>2.16</u>), whereas the optimal (however, impossible to achieve in practice) multiplexing gain is equal to <u>2.26</u>. Also, the constant surpassing of 96% channel throughput for all the data message arrival rates we have examined (between 100 Kbps and 2.56 Mbps) and the achievement of a throughput as high as 98.4% for very high data message arrival rates indicates the high efficiency of the proposed multiplexing mechanism.

4. Future Work

After achieving very encouraging results due to the introduction of our two novel ideas, the next step of our research will be the introduction of variable bit rate compressed video sources into the high capacity channel system and the efficient multiplexing of all three diverse types of traffic.

REFERENCES

1. A. C. Cleary, ″Voice-Data Channel Access Integration in Third Generation Microcellular Wireless Networks: Design and Performance Evaluation″, *Ph.D. Disseration, CIS Dept., University of Delaware*, 1997.
2. N. M. Mitrou, Th. D. Orinos and E. N. Protonotarios, ″A Reservation Multiple Access Protocol for Microcellular Mobile-Communication Systems″, *IEEE Transactions on Veh. Technology*, Vol. 39, No. 4, Nov. 1990, pp. 340-351.
3. S. Nanda, D. J. Goodman and U. Timor, ″Performance of PRMA: A packet voice protocol for cellular systems″, *IEEE Transactions on Veh. Technology*, Vol. 40, pp. 584-598, 1991.
4. A. C. Cleary and M. Paterakis, ″Design and Performance Evaluation of an RRA Scheme for Voice-Data Channel Access in Outdoor Microcellular Wireless Environments″ *Mobile Networks and Applications* (*MONET) Journal, ACM and Baltzer Science Publishers*, Vol. 2, No. 1, 1997, pp. 31-43.
5. D. A. Dyson and Z. J. Haas, ″A Dynamic Packet Reservation Multiple Access Scheme for Wireless ATM″, *IEEE MILCOM'97*.
6. W. C. Wong and D. J. Goodman, ″A packet reservation multiple access protocol for integrated speech and data transmission″, *IEE Proceedings-1*, Vol. 139, Dec. 1992, pp. 607-612