

A Slotted CDMA Protocol with BER Scheduling for Wireless Multimedia Networks

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Motivations

- To support different QoS requirements of several traffic classes in CDMA wireless multimedia services
 - maximum BER
 - maximum transmission rate
 - maximum timeout



Goals

- Maximize Throughput
- Minimize Packet Losses



Assumptions

- Based on MC DS-SS-CDMA.
- Allow mobile to transmit simultaneously up to m packets using m orthogonal codes.
- There are q multimedia traffic classes.
- Use one power level for each slot since each packet is classified into different slot based on its BER requirement.

Assumptions

- A mobile terminal with packets to transmit must request for admission and transmission from a base station using a Request slot or piggyback with a data slot
- Prioritization and allocation of packets are processed at the base station
- A base station provide acceptance notification to mobile terminals on a Control slot on the downlink.
- A maximum number of packets for a specific BER allowed to transmit in a slot is known priori.

Packet Prioritization

- Packets are grouped in batch.
- Each batch has different priority proportional to the remaining packets left and inversely proportional to the timeout -- minimizing the packet losses.
- M_q = maximum transmission rate (# of packets) in a slot of a mobile for service class q
- R_b = remaining packets in batch b , T_b = time out for batch b , then the priority of batch $b - P_b$ is,

Packet Prioritization

$$P_b = \begin{cases} \lceil R_b / M_q \rceil / T_b, & \text{if } < N_p \\ N_p & \text{(# of slots in a frame)} \end{cases}$$

- To maximize throughput, the maximum number of packets of batch b allowed to transmit in a frame is,

$$N_b = \begin{cases} \lceil P_b \rceil \cdot M_q, & \text{if } < R_b \\ R_b & \end{cases}$$

- It is better that a mobile sends packets as many as possible in a same slot rather than distributed in different slots (due to code orthogonality)

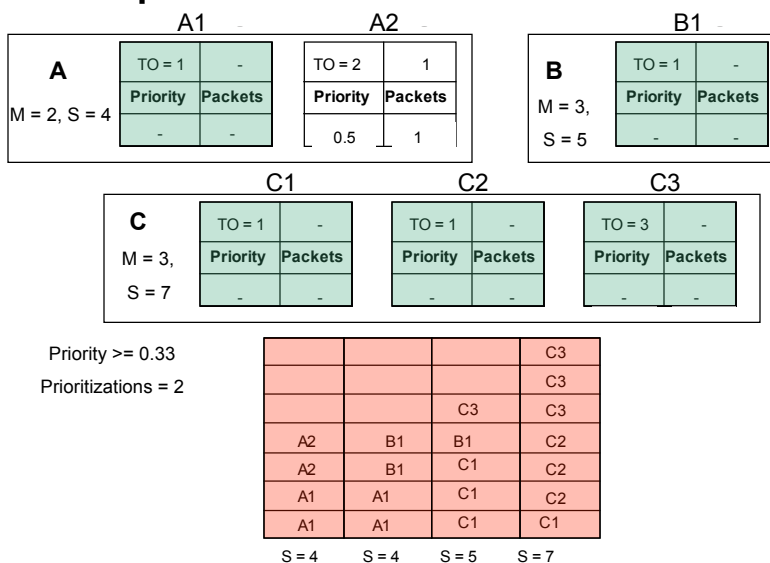
Packet Usher

- The base station keeps q records; each record contains priority of packets of each batch waiting for transmission.
- Packets with the highest priority get to transmit first by searching all the records in round robin fashion.
- Slot allocation is determined by Packet Allocator based on the value of N_b and BER_q .
- After the first search, if there are remaining packets and there are some space left in slots, the remaining packets with the next highest priority of all records get to transmit through slot allocation again and so on.

Packet Allocator

- To maximize the number of packets in a frame.
- Accommodation in empty slots or in slots that have packets with the same traffic class.
- Accommodation in slots that have packets with more stringent BER requirements.
- Accommodation in slots that have packets with more relaxed BER requirements.

Example



Simulation Models

- Voice
- CBR video traffic
- VBR video traffic
- CBR digital audio traffic
- ABR computer data traffic
- ABR e-mail traffic

Voice Traffic Model

TABLE I
NUMERICAL VALUES FOR THE SPEECH ACTIVITY MODEL

Condition	Average Duration (s)
Conversation Length	180.0
Principal Talkspurt	1.000
Principal Gap	1.350
Minispurt	0.275
Minigap	0.050

CBR Video Traffic Model

- Transmission time is exponentially distributed with a mean equal to 180 s.
- Bit rate = 220 kb/s

VBR Video Traffic Model

TABLE II
NUMERICAL VALUES FOR THE VBR VIDEO MODEL

Parameter	Value
Mean Video Transmission Time	180×10^3 msec
Mean State Holding Time	160 msec
Minimum Bit Rate	120 Kbps
Maximum Bit Rate	420 Kbps
Mean Bit Rate	239 Kbps

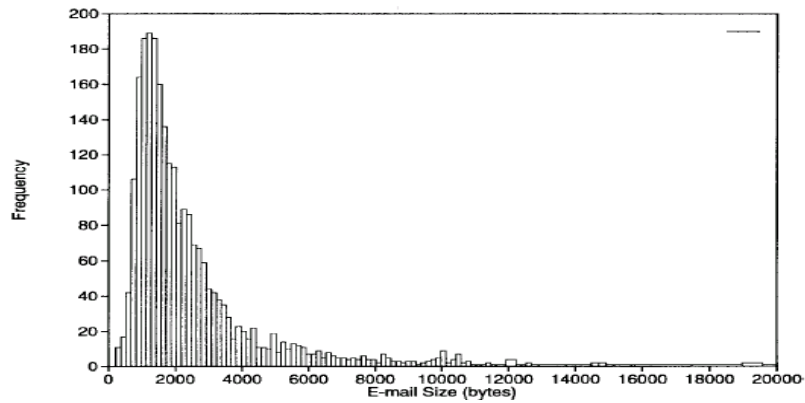
CBR Digital Audio Traffic Model

- Represent a continuous bit stream of digital FM stereo audio.
- Constant bit rate = 128 kb/s
- Exponential Holding Time = 360 s.

ABR Computer Data Traffic Model

- Data Message Length is exponentially distributed.
- Mean size = 30 kbytes.

Email Traffic Model



Traffic Distribution

TABLE IV
RELATIVE ARRIVAL RATES OF MOBILES TRANSMITTING
THE DIFFERENT TRAFFIC CLASSES

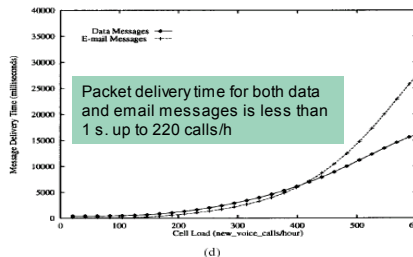
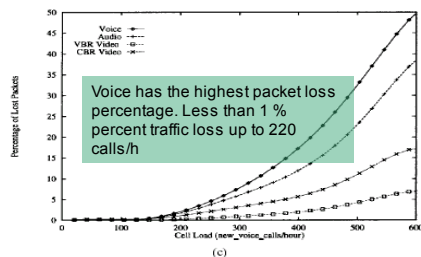
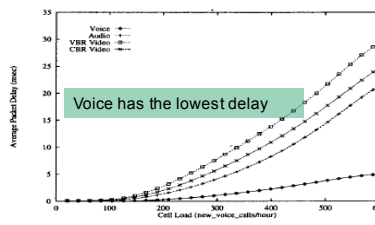
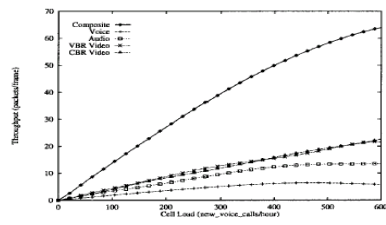
Traffic Class	Percentage
Voice Traffic	70 %
CBR Audio Traffic	3 %
CBR Video Traffic	4 %
VBR Video Traffic	4 %
Data Traffic	15 %
E-mail Traffic	4 %

System Parameters

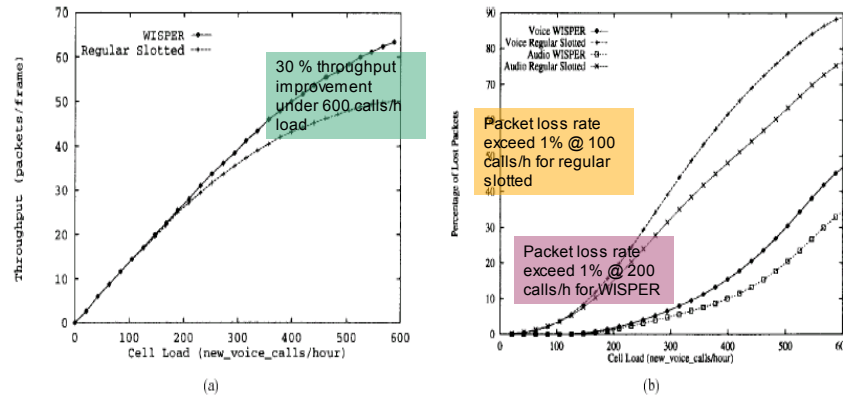
TABLE III
SIMULATION ASSUMPTIONS AND SYSTEM PARAMETERS

Parameter		Value
Frame Size		16 msec
Number of Packet Slots per Frame N_p		10
Number of (Raw) Information Bits per Slot		264
Simulation Time (per point)		108,000 sec
Simulation Cycles (per point)		6.75×10^6
Voice Traffic	Maximum Tolerable BER	10^{-3}
	Maximum Number of Packets per Slot S	15
	Packet Time out Value	2 frames
CBR Digital Audio Traffic	Maximum Transmission Rate Capability	1 packet/slot
	Maximum Tolerable BER	10^{-4}
	Maximum Number of Packets per Slot S	10
CBR Video Traffic	Packet Time out Value	6 frames
	Maximum Transmission Rate Capability	6 packets/slot
	Maximum Tolerable BER	10^{-5}
VBR Video Traffic	Maximum Number of Packets per Slot S	8
	Packet Time out Value	3 frames
	Maximum Transmission Rate Capability	4 packets/slot
Computer Data Traffic	Maximum Tolerable BER	10^{-9}
	Maximum Number of Packets per Slot S	4
	Packet Time out Value	$[2 \times \text{total_packets}]$ frames
E-mail Traffic	Maximum Transmission Rate Capability	4 packets/slot
	Maximum Tolerable BER	10^{-5}
	Maximum Number of Packets per Slot S	4
E-mail Traffic	Packet Time out Value	$[50 \times \text{total_packets}]$ frames
	Maximum Transmission Rate Capability	1 packets/slot

Simulation Results



Simulation Results



Regular Slotted mode uses different power control levels for different traffic types based on their BER targets and employs the basic FCFS service discipline without BER scheduling to allocate slots for transmission of packets.

Conclusions

- WISPER maximizes throughput and minimizes packet losses using packet user and packet allocator based on different BERs of different traffic types.
- The protocol is simple to implement since only one power level is used in the same slot (one BER traffic in a slot – **not always holds**).
- Using single power level in a slot, however, lower throughput since it increases capacity consumption in the slot.
- Power levels are not minimized.