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Post-graduate course in Radio Communications
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Analysis Methods for Combined Voice and Data

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Why to integrate voice and data

- Save money
  - the cost of packet voice is currently estimated to be only 20 to 50 percent of the cost of a traditional circuit-based voice network.
- More efficiently used band
- gain increased user productivity
  - integrate computers with PBXs to provide applications such as advanced call center features

Difficulties in combining voice and data

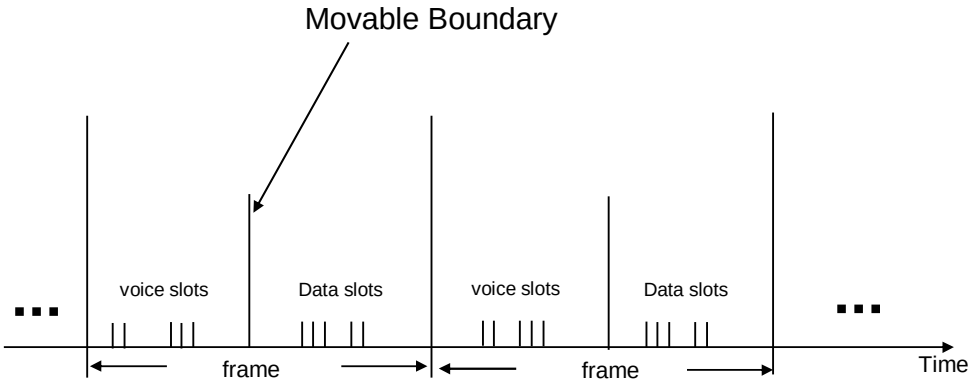
- Voice is sensitive to delay, but can tolerate errors and even packet loss, a loss of 1-2% of voice packets has insignificant effect on the perceived quality of reconstructed voice.
- Whereas, data packets are sensitive to loss and errors but can generally tolerate delays.

Multiuser access

- A key technical problem to be dealt with in integration of voice and data.
  - Contention-based packet communications protocols (ALOHA, CSMA)
  - Fixed access methods (FDMA, TDMA)
  - CDMA

Movable boundary TDMA with silence detection

- Frame structure in a movable-boundary frame-polling system.



Packet reservation multiple access

- Variable mixture of voice packets and data packets
- PRMA system is closely related to reservation-ALOHA, merges characteristics of slotted ALOHA and TDMA protocols.
- Terminals can send two types of information, referred to as periodic and random.

Analysis methods 1 (M/D/1)

- Approximate the system by a fixed-foundary TDMA system (Voice packets always occupy the N1 available slots)
- One-dimensional M/D/1 (Markov arrival, definite service time and single server) queuing model.
- The queuing delay: $$Q_d = \frac{\lambda_d}{2\mu_d^2(N-N1)^2(1-\rho_d)}$$

Where $$\rho_d = \frac{\lambda_d}{\mu_d(N-N1)}$$

N is the number of slots in a frame

λ_d is the arrival rate of the data packets

Analysis method 2 (M/G/1)

- This method assumes a variable service rate and depends upon the probability of voice occupancy of the slot.
- The queuing delay: $Q_d = \lambda_d \frac{\overline{\chi^2}}{2(1-\lambda_d \overline{\chi})}$

Where $\overline{x^2} = \sum_{i=0}^{N1} \mathrm{P}(i)\chi_i^2$

$\overline{x} = \sum_{i=0}^{N1} \mathrm{P}(i)\chi_i$

Here xi=1/(μd(N-i)) is the service time for N-I slots of data, and P(I) is the probability that the voice traffic would require I slots for transmission.

- One dimensional M/G/1 (Markov arrival, general service time, and single server) queuing model.

Analysis Method 3 (recursive method analyzed)

- Two-dimensional Markov chain to model the voice and data traffic
- Recursive method analyzed
- Results obtained by this analytical method lie closest to the results of simulations.
- The queuing delay is: $Q_d = Tr[R(I-R)^{-1}\pi]$

Where Tr[ ] is thr trace operator, which sums all elements of a vector, R is an (N1+1)X(N1+1)matrix, I is the identity matrix, and ♉ is a vector of length N+1.

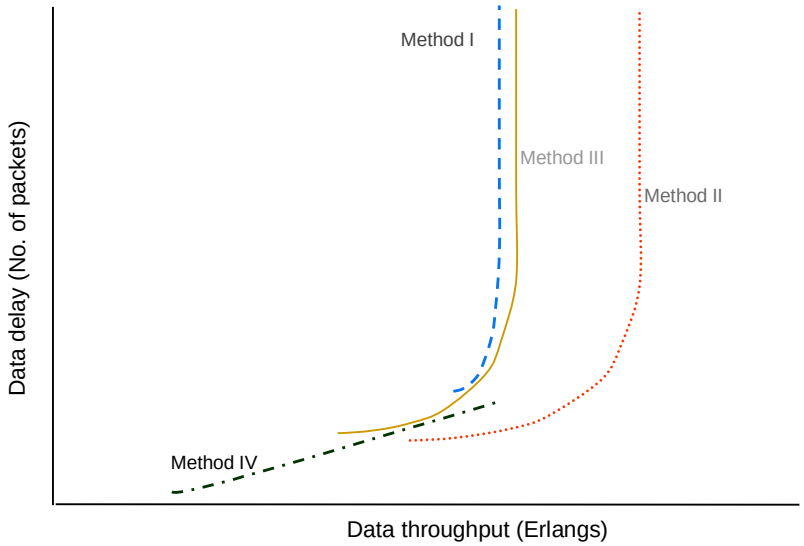
Analysis method 4

- An approximate analysis of the underload region in which the data throughput is smaller than the number of slots left in the frame after voice transmission.
- The average delay is:

$$Q_d = \sum_{i=0}^{N1} P(i) Q_{d,(\overline{N}-i)} \approx \frac{\rho \sum_{i=0}^{N1} P(i) P_{d,N-i(\rho_d)}}{a}$$

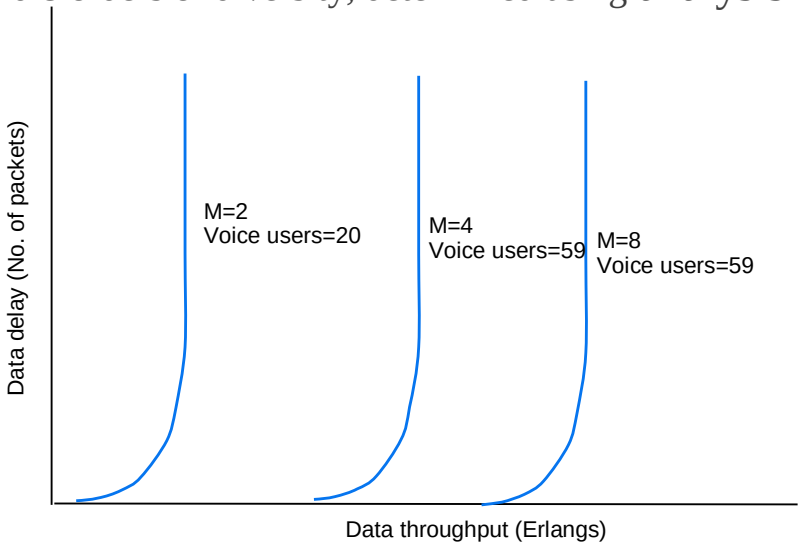
Comparison of performance assessment methods (1)

• Delay versus throughput for a dual-rate syestem with dual diversity. Diversity (M)=2, voice users=59.



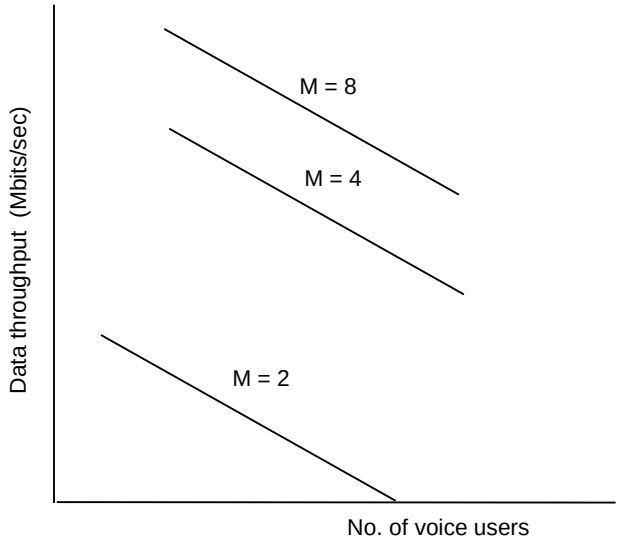
Comparison of performance assessment methods (2)

• Delay versus throughput for a single-rate movable-boundary TDMA system with M=2,4,and 8 orders of diversity, determined using analysis method III.



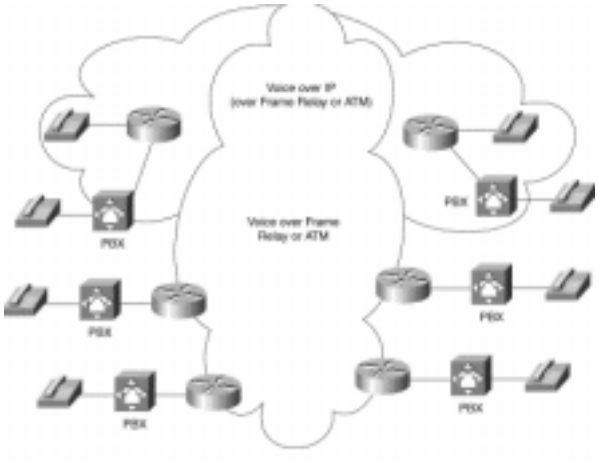
Comparison of performance assessment methods 3

• Throughput for a single-rate system versus number of voice users for data delay less than 10 msec with diversity M=2,4 and 8.



Voice/Data integration technologies

- Voice over ATM
- Voice over frame relay
- Voice over IP



Summary

- Integrate voice and data can save money and make efficient use of bandwidth
- 4 different methods could be used to analyze the combination of voice and data

Reference

- Book 3: Wireless Informations Networks, Chapter 11, Kaveh Pahlavan & Allen H. Levesque, John Wiley & Sons, inc 1995.
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Homework

- Give a general description of the different analyze methods of combining voice and data.