Factors Affecting Multiplexing Gain for VBR Voice

Jayaraman Iyer, Raj Jain and Sohail Munir
The Ohio State University
Contact: Jain@cis.ohio-state.edu
http://www.cis.ohio-state.edu/~jain/
Overview

- Summarize previous study
- Analyze effect of:
  - End to end delay threshold
  - Activity Factor
  - On and Off time duration
  - Link Capacity
  - Acceptable CLR
  - Compression
Conclusion of the Previous Study

Overbooking VBR voice causes queueing and performance becomes unacceptable.

Instead of overbooking, it is better to fill the leftover bandwidth by ABR or UBR.

Small buffering (1 or 2 cells per connection) is ok. Larger buffering makes delay unacceptable.

Its really the maxCTD that determines the buffering at the destination. CDV is not important.
For VBR voice, we need to specify Max CTD
Links between Switches = 1.544 Mbps (T1).

N multiplexed 64-kbps VBR voice sources
Silence suppression ⇒ VBR

Per-VC Queuing at the Switch
Simulation configuration

- Propagation delay: 24 ms
- Avg packetization delays: 6 ms + 6 ms (PCM)
- Assuming 5 switches on a typical path, delay variation allowed at each switch:
  \[ \frac{100 - 24 - 6 - 6}{5} = 12.8 \text{ ms} \]
- For single switch bottleneck case, End-to-end delay = 12.8 + 24 = 36.8 ms
- We used end-to-end network delay bound of 30 ms and 40 ms
Source Model

- 2-State Markov Model [Brady69]
- On-off times for silence and speech
- Exponential distribution for speech and silence state.
- Speech activity = 35.1%

\[ \mu = 352 \text{ ms} \quad \lambda = 650 \text{ ms} \]
Performance Metric

- Degradation in Voice Quality (DVQ) = Ratio of cells lost or delayed to total number of cells sent across.

- Cells lost or delayed = Cells dropped by switches + Cells arriving late
Parameters

- Allowed end-to-end delay = 30 ms
- Allowed degradation = $10^{-3}$
- Switch Buffers = 1 buffer/VC
- Average speech duration = 352 ms
- Average silence interval = 650 ms
  \[ \Rightarrow \text{Activity Factor} = \frac{352}{352+650} = 0.35 \]
- Link speed = 1.54 Mbps
- Voice rate = 64 kbps

In this contribution we study sensitivity to each of the above parameters.
Delay Thresholds and Buffers

- Given 1 buffer per VC, the delay cannot exceed a certain amount
  ⇒ Delay thresholds and buffering at switches are related (The factors interact)

- Conducted a 2×3 Full factorial experiment:
  Max allowable network delay = 30 ms or 60 ms
  Buffers per VC = 1, 2, or 4 cells

- Conclusion: Increasing the allowable delay or buffers increases the allowable multiplexing gain
Delay Thresholds and Buffers

Max Delay
= 30ms

Max Delay
= 60ms
DVQ = 0.001

Number of Connections

DVQ

0.005
0.004
0.003
0.002
0.001
0
0 10 20 30 40 50 60 70 80

DVQ30-1
DVQ30-2
DVQ30-4
DVQ60-1
DVQ60-2
DVQ60-4
Activity Factor

- Activity Factor = Speech / (Speech + silence)
- In the previous study:
  Activity factor = \( \frac{352}{352 + 650} = 0.35 \)
- In this analysis:
  - Silence Interval = 650 ms
  - Speech duration = 300, 400, 600, 650 ms
- Conclusion:
  Increase in the activity factor \( \Rightarrow \) Increase in load
  \( \Rightarrow \) Increases the CLR and DVQ
  \( \Rightarrow \) Decreases overall multiplexing gain
The diagram illustrates the relationship between the number of connections and the activity factor (DVQ). As the number of connections increases, the activity factor also increases. The diagram includes several curves labeled with specific DVQ values (300/650, 400/650, 600/650, 650/650). The DVQ value of 0.001 is highlighted, indicating the point where the activity factor starts increasing significantly with the number of connections.
Link Speed

- Parameter Values: 1.544 Mbps (default)
  - Tried 0.772, 1.544, and 3.088 Mbps

- Conclusion:
  - A larger pipe can buffer more source variations
  - The CLR and DVQ drop with a larger overall bandwidth
  - Increases the overall multiplexing gain
Link Speed

Number of Connections

DVQ

0.772 Mbps

1.544 Mbps

3.088 Mbps

DVQ = 0.001

The Ohio State University

Raj Jain
Goal: Increase speech bursts and silence intervals while keeping activity factor constant

Parameter Values: 352/650 ms (default), Tried 35/65, 175/325, 350/650

Conclusions: Longer speech burst

⇒ More burstiness
⇒ More cell loss
⇒ Larger DVQ
⇒ Lower multiplexing gain

Fluid approximation gives incorrect results
Speech/Silence Durations

Number of Connections

DVQ

DVQ = 0.001

35/65, 175/325, 350/650
Compression

- Higher compression ratio
  ⇒ Less bandwidth required per source
  Also, more packetization delay
  Also, acceptable cell loss ratio may be lower

- Parameter Values: 64 kbps (default)
  Tried 16 kbps, 32 kbps

- Conclusion: Compression does increase the multiplexing gain (assuming that the same CLR is acceptable)
Summary

- Multiplexing gain improves with
  - Increasing the link speed
  - Decreasing voice rate (compression)
  - Decreasing speech interval
- For the same activity factor, the duration of speech has a significant impact on multiplexing gain.
  ⇒ Fluid approximation does not give correct results.