97-0858R1: Factors Affecting Multiplexing Gain for VBR Voice

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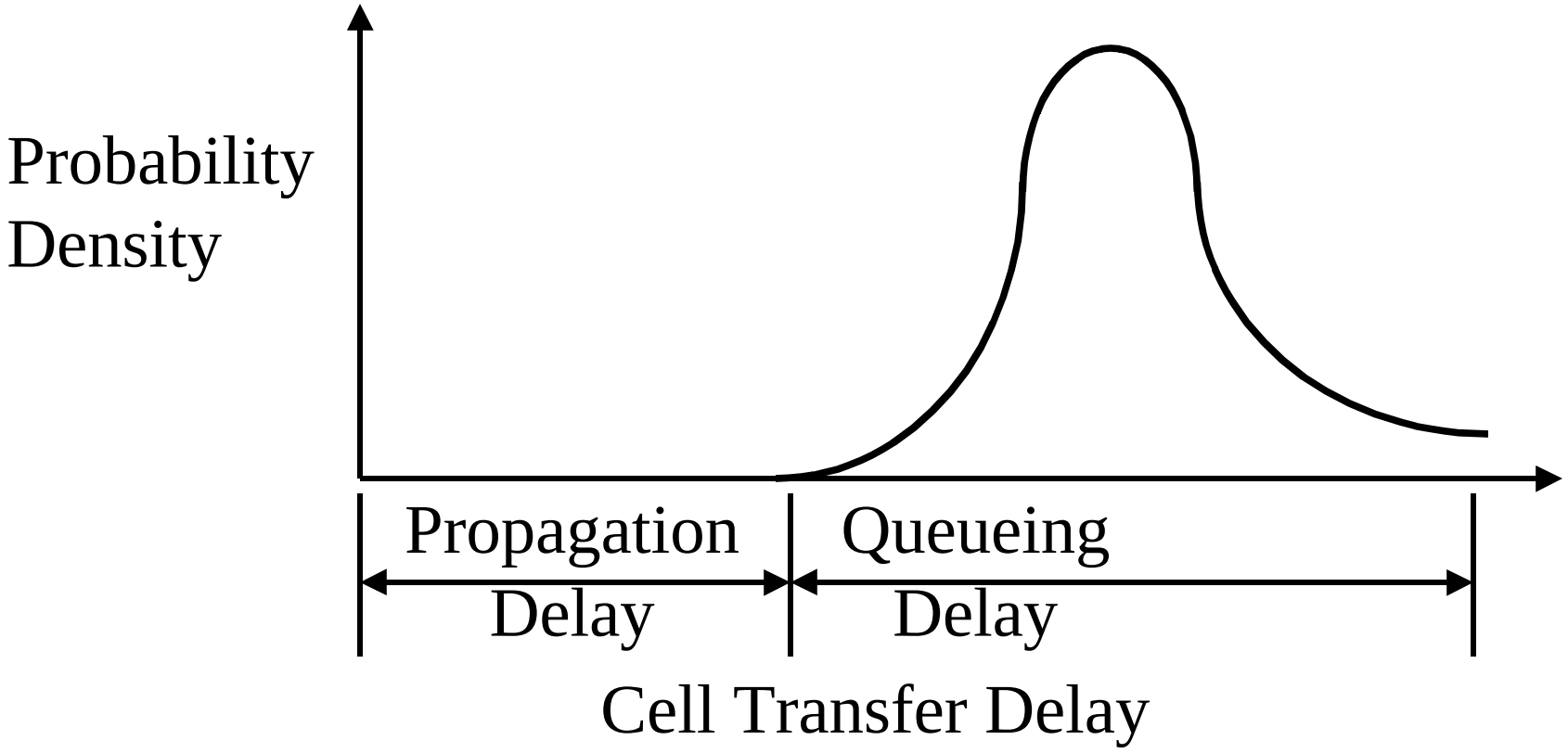
Overview

- 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 [97-0608]

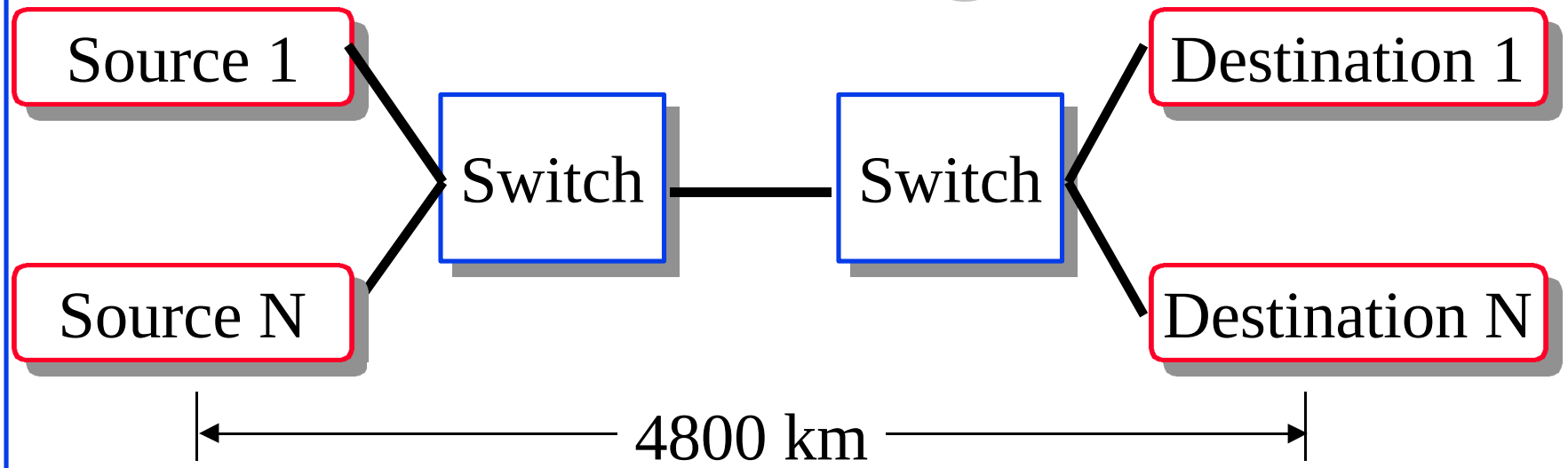
- Overbooking VBR voice causes queueing and performance becomes unacceptable.
- Instead of overbooking, it is better to fill the left-over bandwidth by ABR or UBR.
- Small buffering (1 or 2 cells per connection) is ok. Larger buffering makes delay unacceptable.
- Its really the maxCTD that determines the buffering at the destination. CDV is not important.

CDV



- For VBR voice, we need to specify Max CTD

N-Source Configuration



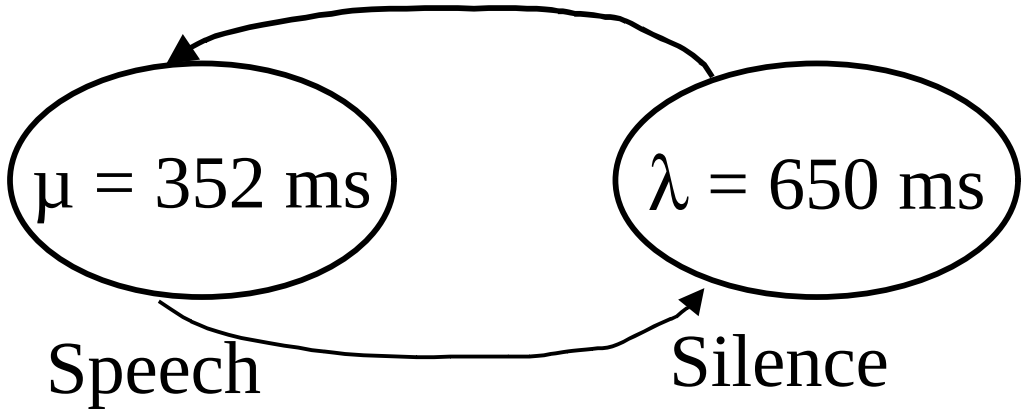
- Links between Switches = 1.544 Mbps (T1).
- N multiplexed 64-kbps VBR voice sources
  Silence suppression ⇒ VBR
- Per-VC Queuing at the Switch

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
  = (100 - 24 - 6 - 6)/5 = 12.8 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%



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

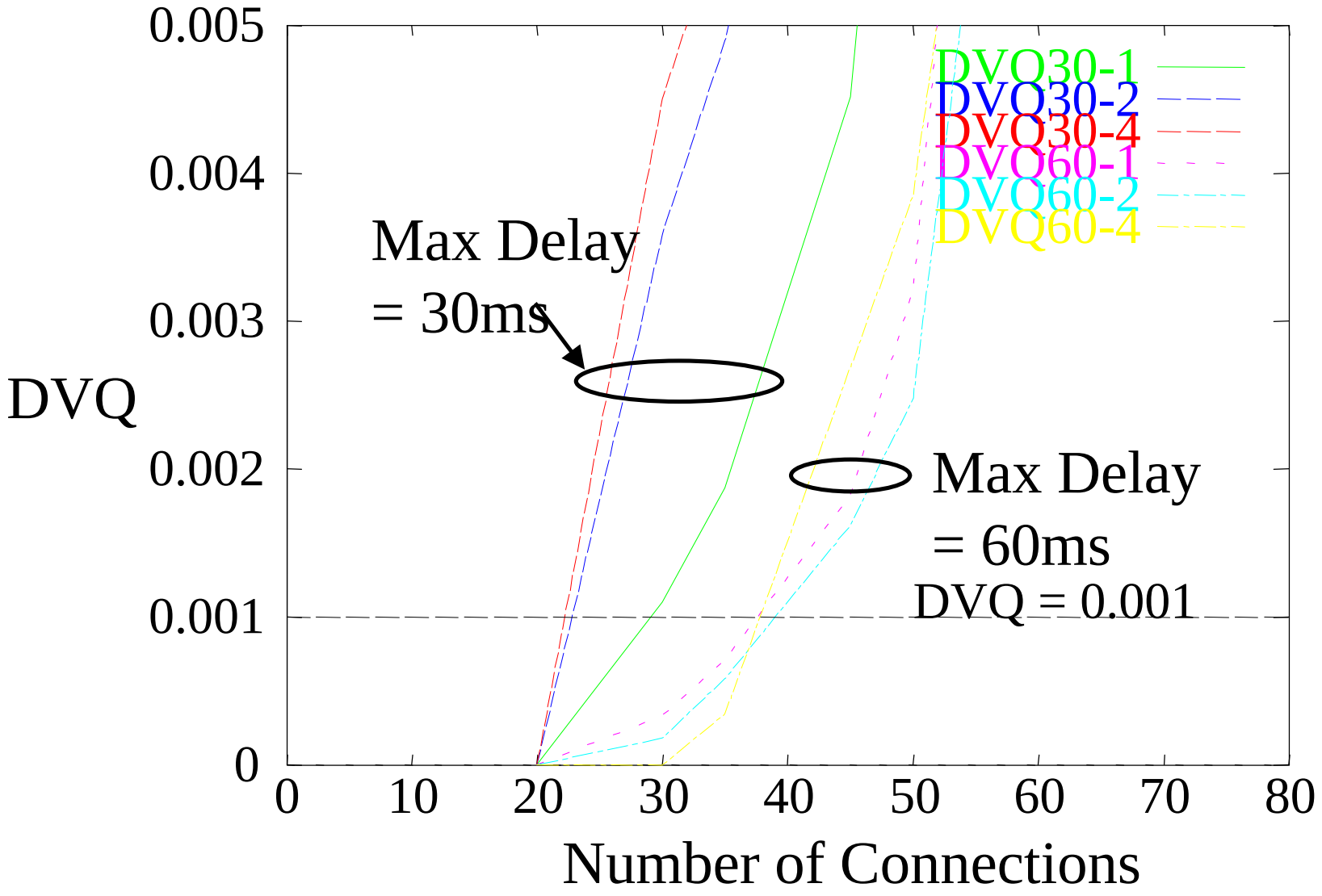
- Allowed end-to-end delay = 30 ms
- Allowed degradation = 10^{-3}
- Switch Buffers = 1 buffer/VC
- Average speech duration = 352 ms
- Average silence interval = 650 ms
  $\Rightarrow$ Activity Factor = 352/(352+650) = 0.35
- Link speed = 1.54 Mbps
- Voice rate = 64 kbps

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
  $\Rightarrow$ 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

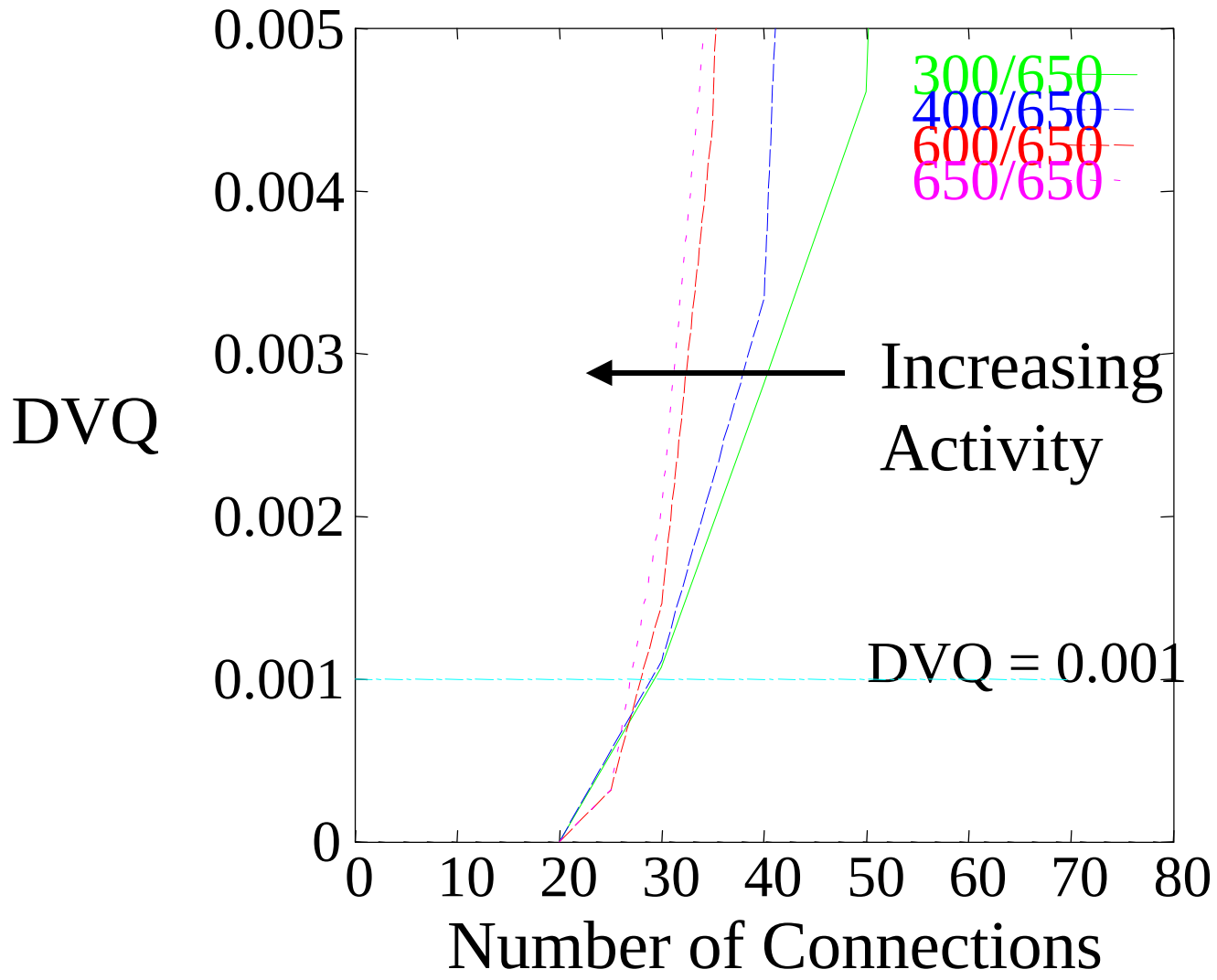
Delay Thresholds and Buffers



Activity Factor

- Activity Factor = Speech /(Speech+silence)
- In the previous study:
  Activity factor = 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 ⇒ Increase in load
  ⇒ Increases the CLR and DVQ
  ⇒ Decreases overall multiplexing gain

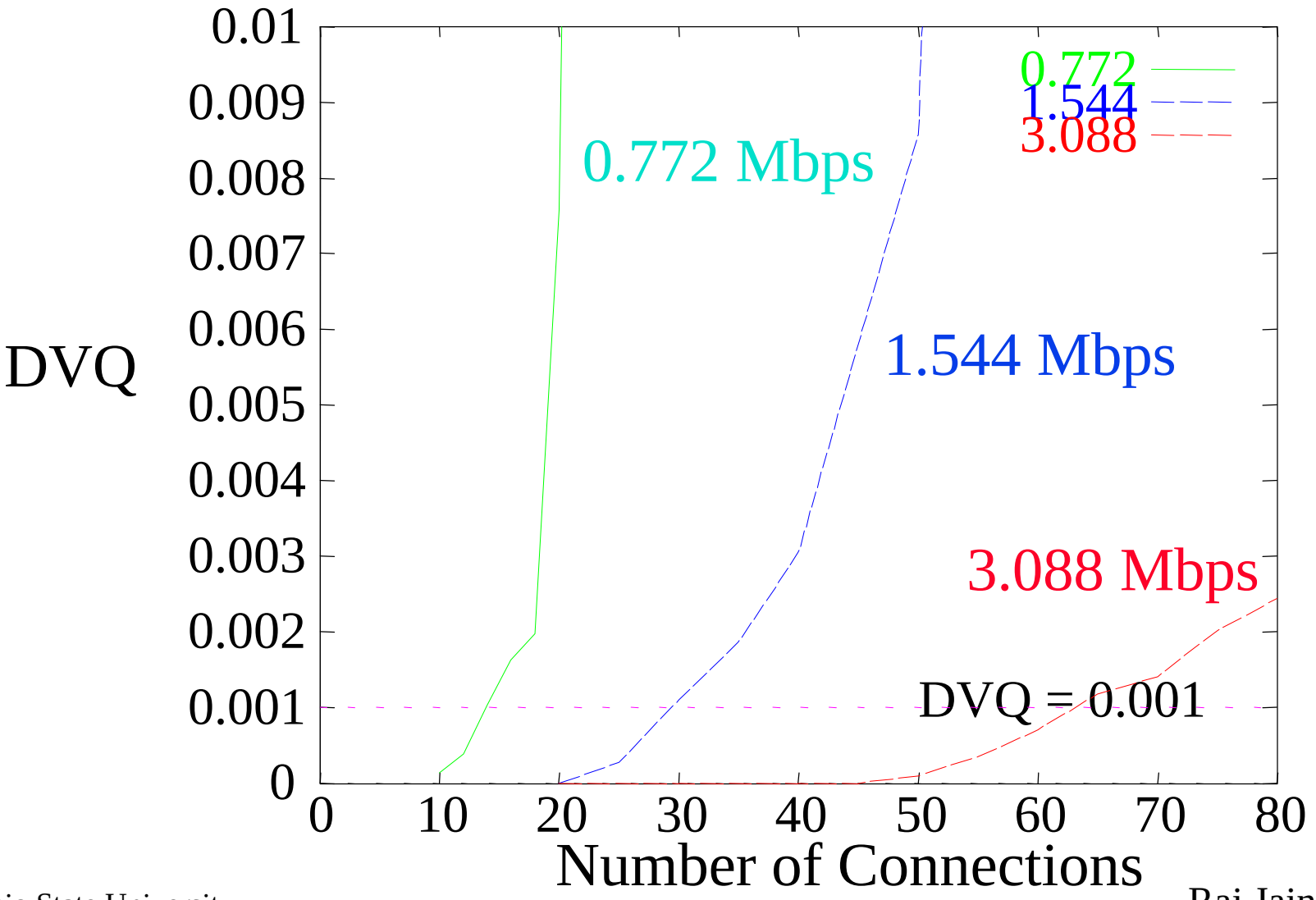
Activity Factor



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
    $\Rightarrow$ Increases the overall multiplexing gain

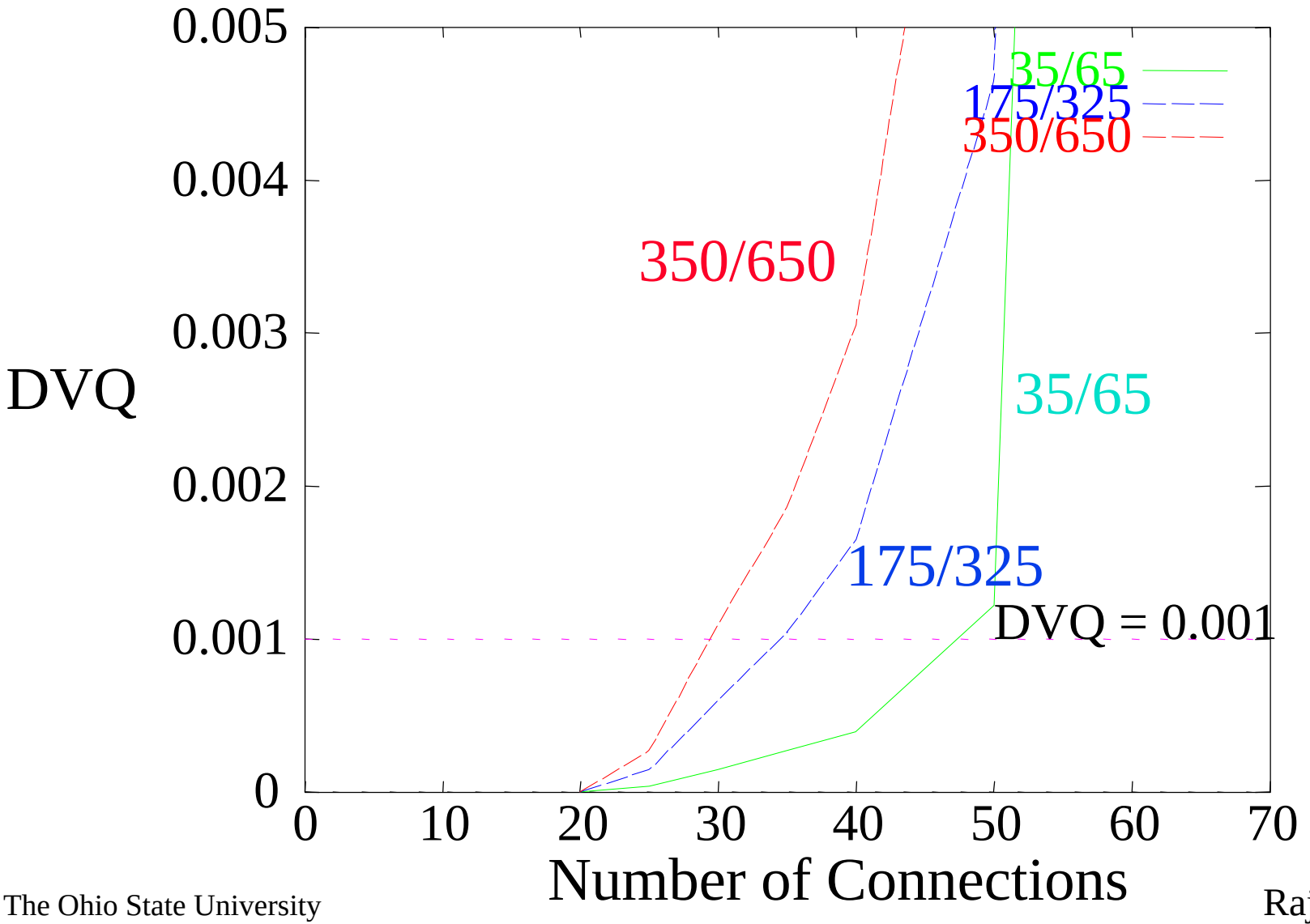
Link Speed


DVQ
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
10
20
30
40
50
60
70
80
Number of Connections
0.772
1.544
3.088
0.772 Mbps
1.544 Mbps
3.088 Mbps
DVQ = 0.001

Speech/Silence Durations

- 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

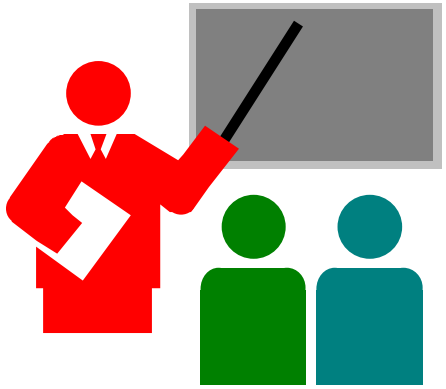
Speech/Silence Durations



Compression

- Higher compression ratio
  $\Rightarrow$ 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.
  $\Rightarrow$ Fluid approximation does not give correct results.