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Distributed Systems
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Carrying Wireless Traffic over IP Using Realtime Transport Protocol Multiplexing

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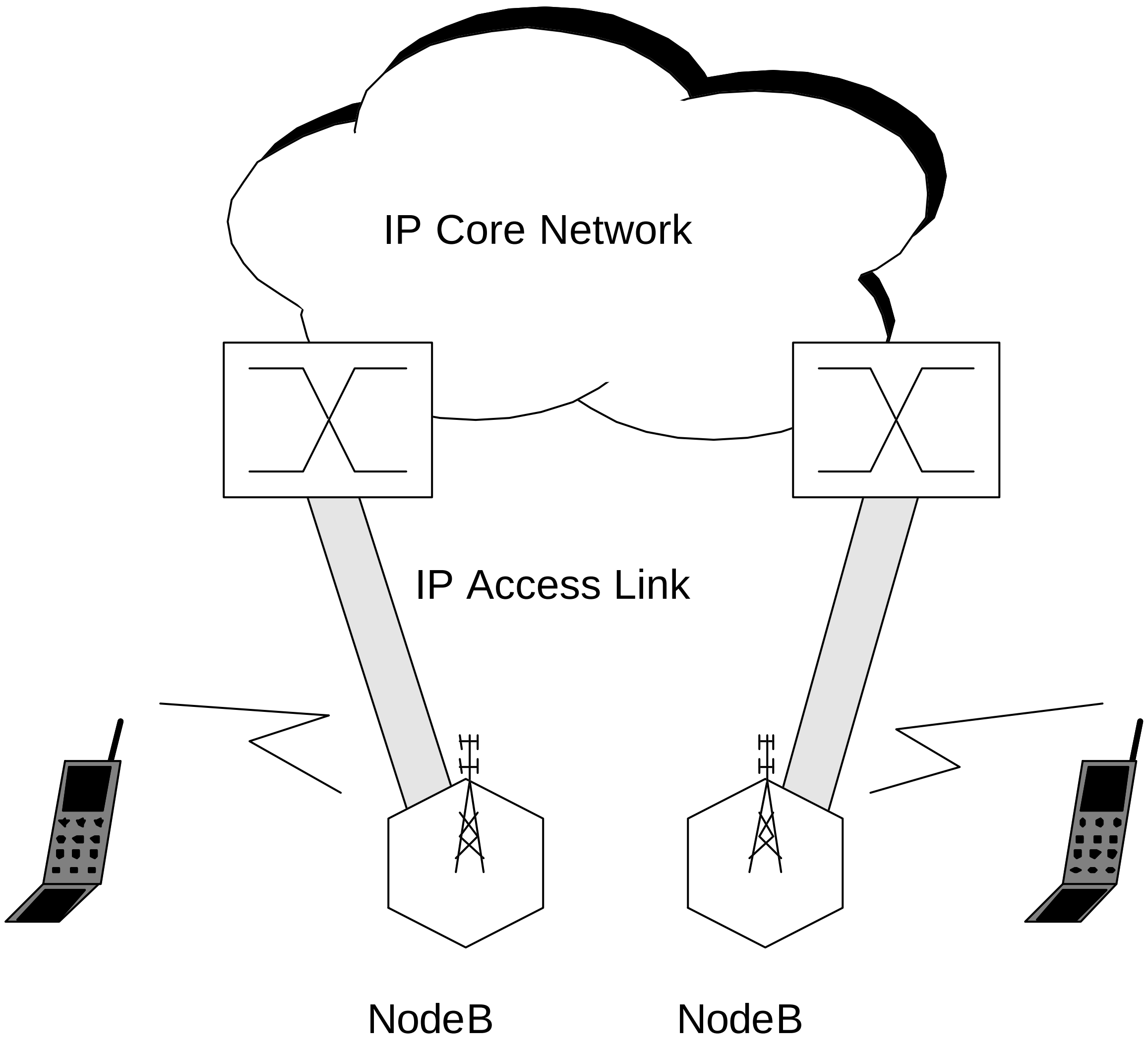
Overview

- ▷ Scenario
- ▷ Multiplexing voice in IP and ATM
- ▷ Analytic model of RTP multiplexing
- ▷ Numerical results
- ▷ Summary

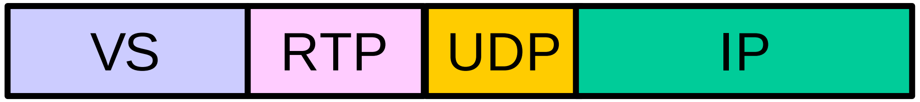
UMTS Network Architecture

- ▷ Technologies
  - IntServ
  - DiffServ
- ▷ QoS
  - Loss
  - Delay
- ▷ Traffic
  - Voice
  - Data



RTP Multiplexing

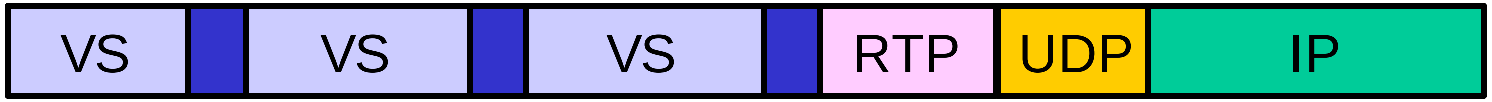
▷ Tunneling voice samples (VS)



- RTP/UDP/IP protocol header suite
- **Problem**: short packets ⇒ high protocol overhead
- Several flows share a link ⇒ multiplexing possible

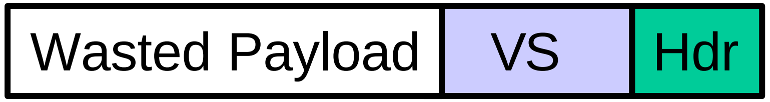
▷ RTP multiplexing

- Mini/RTP/UDP/IP protocol header suite



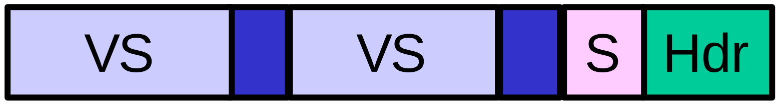
ATM Adaptation Layer Type 2

▷ Similar problem in ATM

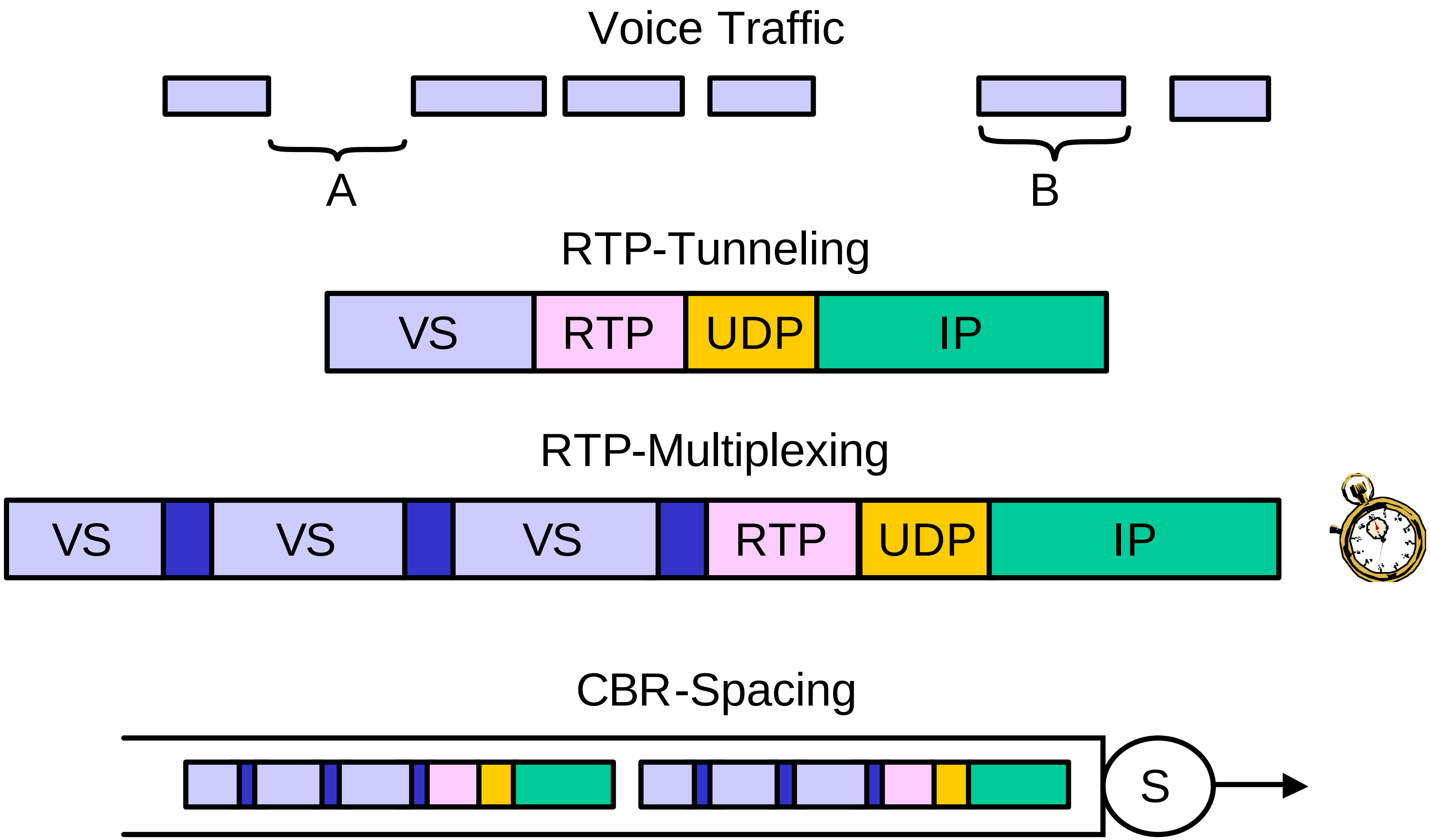


- **Problem**: Short packets ⇒ wasted payload
- Several flows share a link ⇒ multiplexing possible

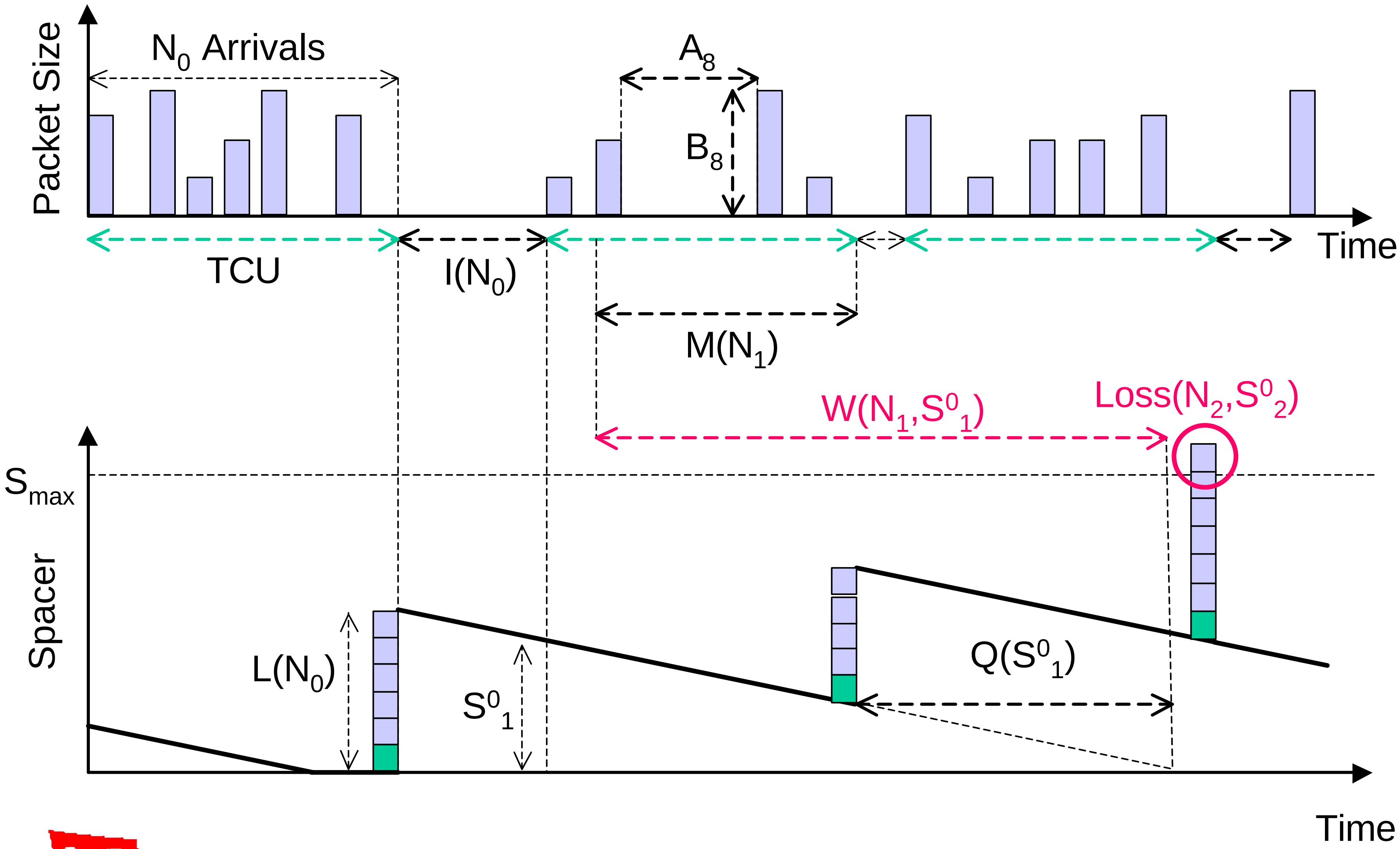
▷ AAL-2 (simplified)



Model

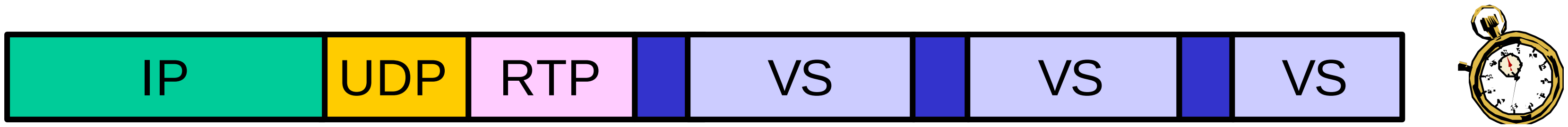

Voice Traffic
A
B
RTP-Tunneling
VS
RTP
UDP
IP
RTP-Multiplexing
VS
VS
VS
RTP
UDP
IP
CBR-Spacing
S

An Example of the Markov Model

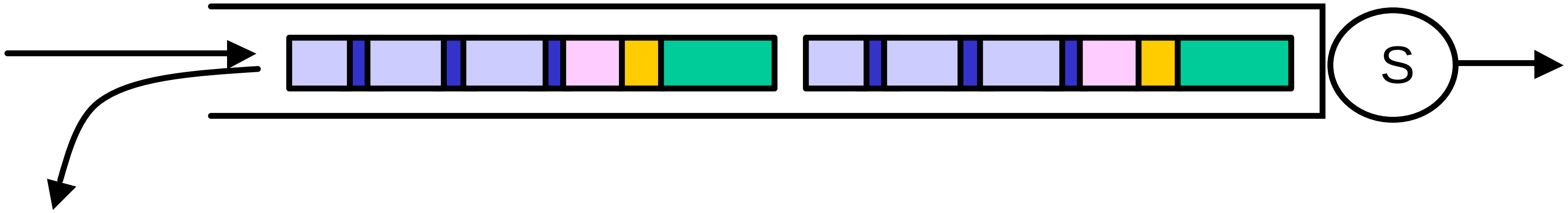


Performance Measures

- Voice sample loss probability $(< 10^{-6})$
- Overhead = header size / payload size
- Multiplexing time M



- Queuing time $Q = S / C$

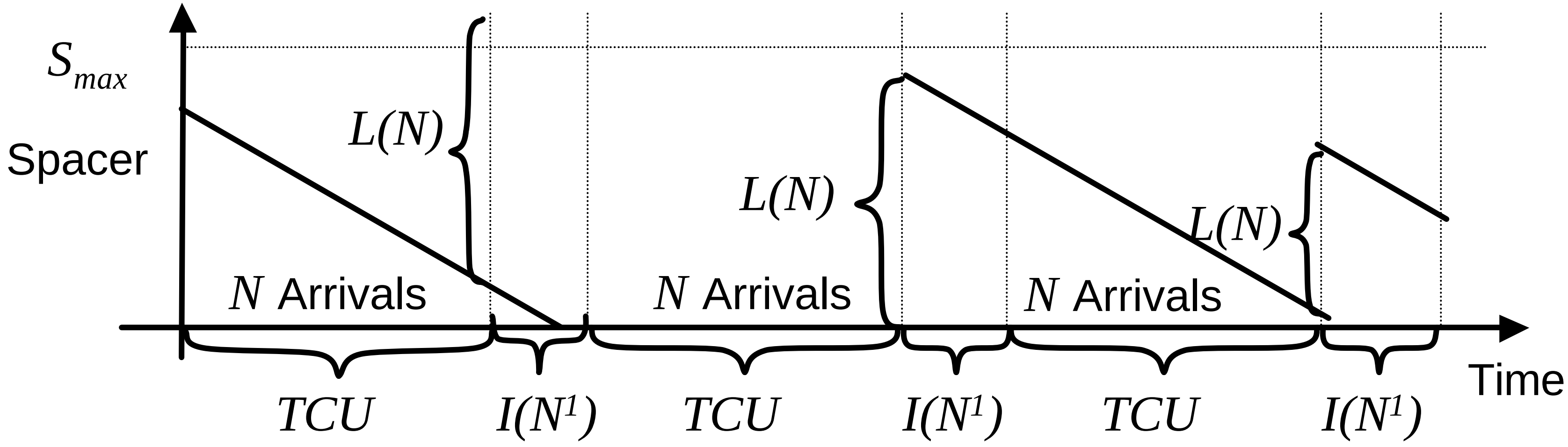


- Waiting time $W = M + Q$
- Excess of delay budget $(Prob(W > 1 \text{ msec}) < 10^{-4})$
- Critical load is maximum offered load where QoS is met.

Markov Model Specification

- ▷ State transition functions $f = f^0 \circ f^1$
- ▷ Renewal points
  - Before multiplexing, f^0: multiplex time
  - After multiplexing, f^1: intermultiplex time
- ▷ States
  - $X^0=(S^0)$: spacer
  - $X^1=(S^1,N^1)$: spacer and number of VS in last IP packet
- ▷ Factors
  - $Y^0=(N,L(N))$: number of VS in IP packet, IP packet length
  - $Y^1=(I(N^1))$: intermultiplex time

State Transition Function



f^0 **Input:** $X^0 = (S^0),\ Y^0 = (N, L(N))$

$S' = \max(S^0 - TCU \cdot C, 0)$

if ($S' + L(N) \leqq S_{max}$)

$S^1 = S' + L(N)$

else

$S^1 = S'$

$N^1 = N$

Output: $X^1 = (S^1, N^1)$

f^1 **Input:** $X^1 = (S^1, N^1),\ Y^1 = (I(N^1))$

$S^0 = \max(S^1 - I(N^1) \cdot C, 0)$

Output: $X^0 = (S^0)$

$f = f^1 \circ f^0$

Required Random Variables

RTP Multiplexing

- Number of VS in an IP packet

$$\left(\sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j\right) \wedge (N = i)$$

- Length of an IP packet L(N)

$$L(N = i) = \sum_{j=1}^{i} B_j + 2 \cdot i + 12 + 8 + 20$$

- Intermultiplex time I(N)

$$\left(\sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j\right) \wedge \left(I(N = i) = \sum_{j=1}^{i} A_j - TCU\right)$$

- Multiplexing time M(N)

$$\left(\sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j\right) \wedge (0 \leq k < i) \wedge \left(M(N = i) = TCU - \sum_{j=1}^{k} A_j\right)$$

RTP Tunneling

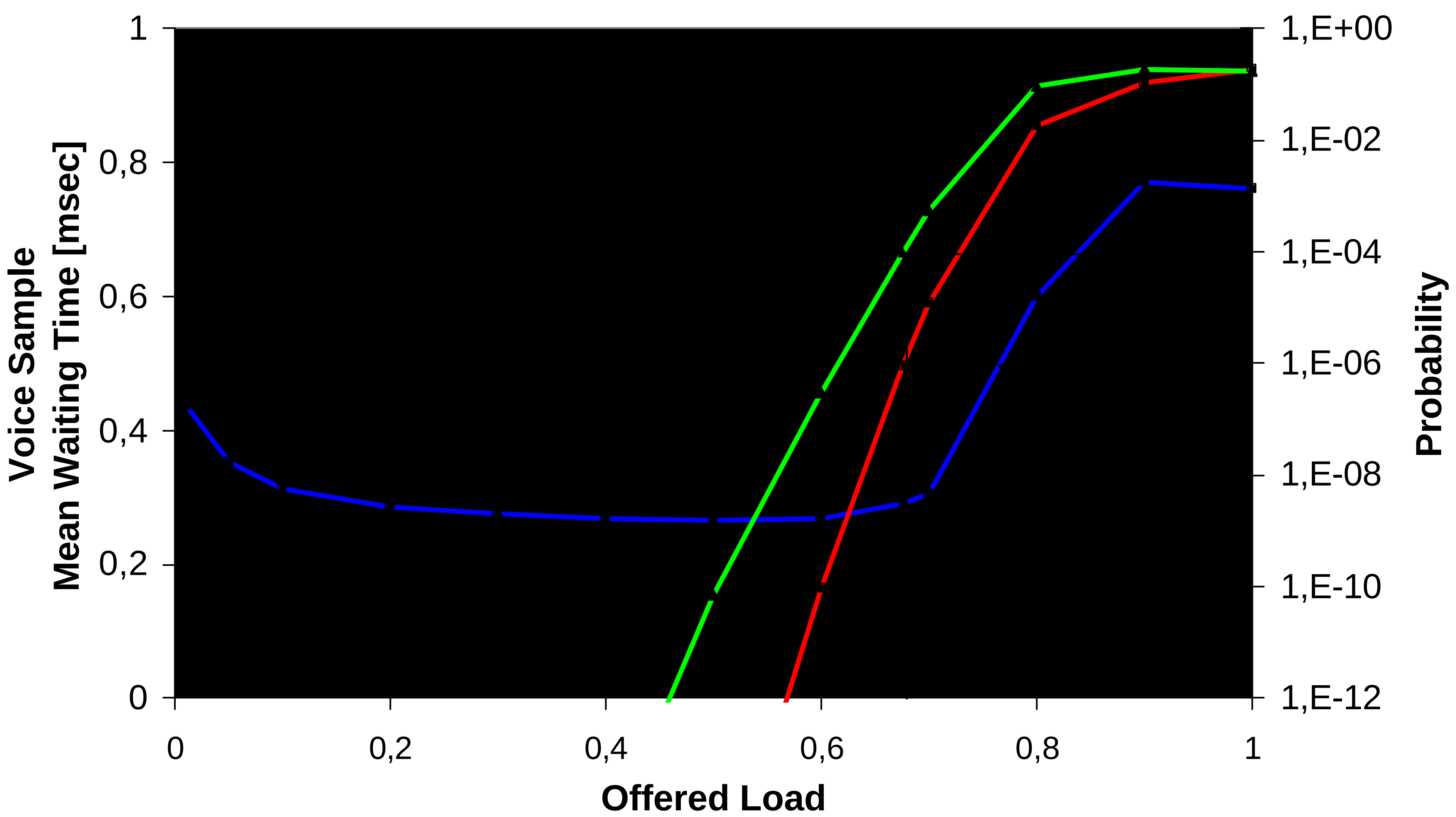
$$N = 1$$

$$L(N = 1) = B + 12 + 8 + 20$$

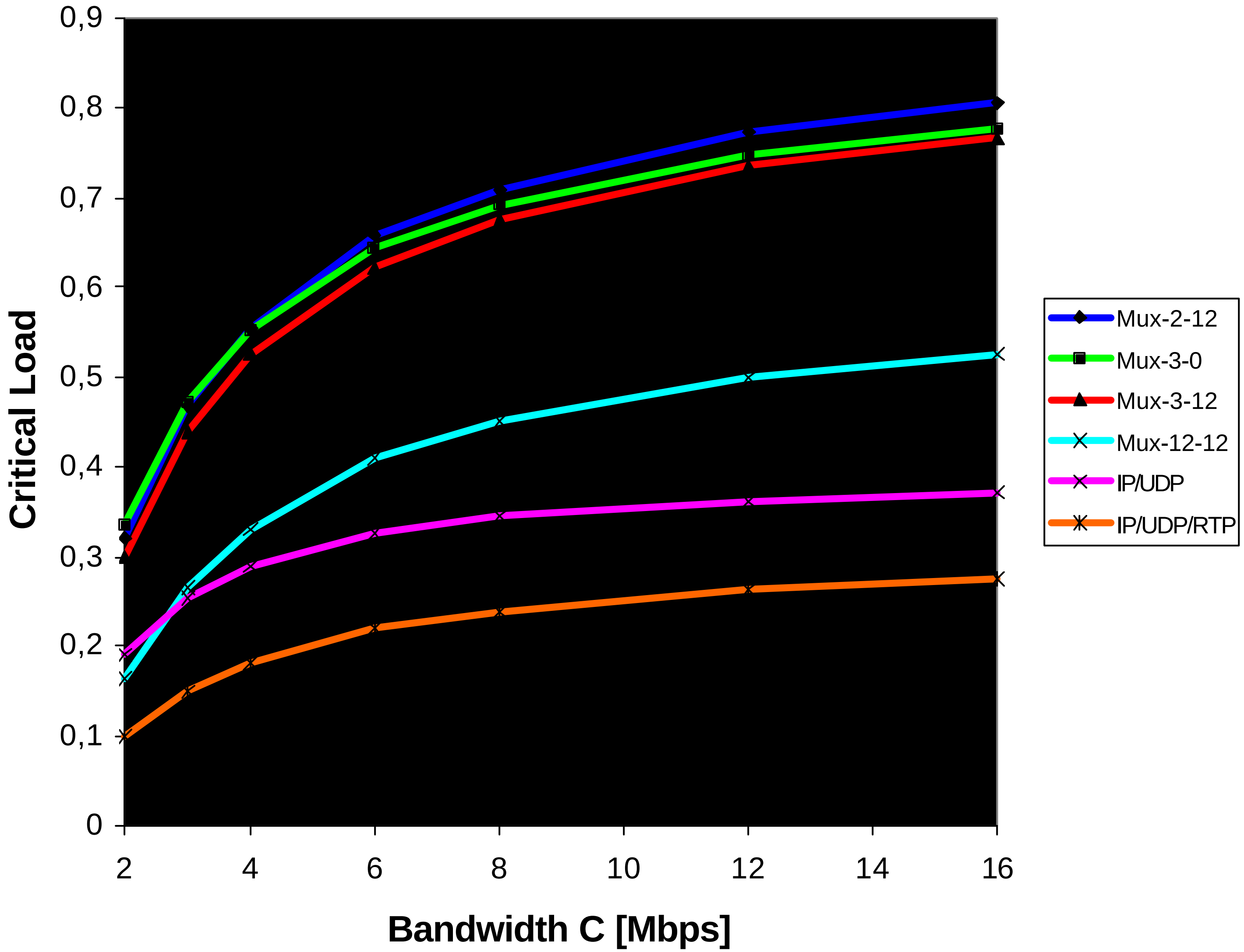
$$I(N) = A$$

$$M(N) = 0$$

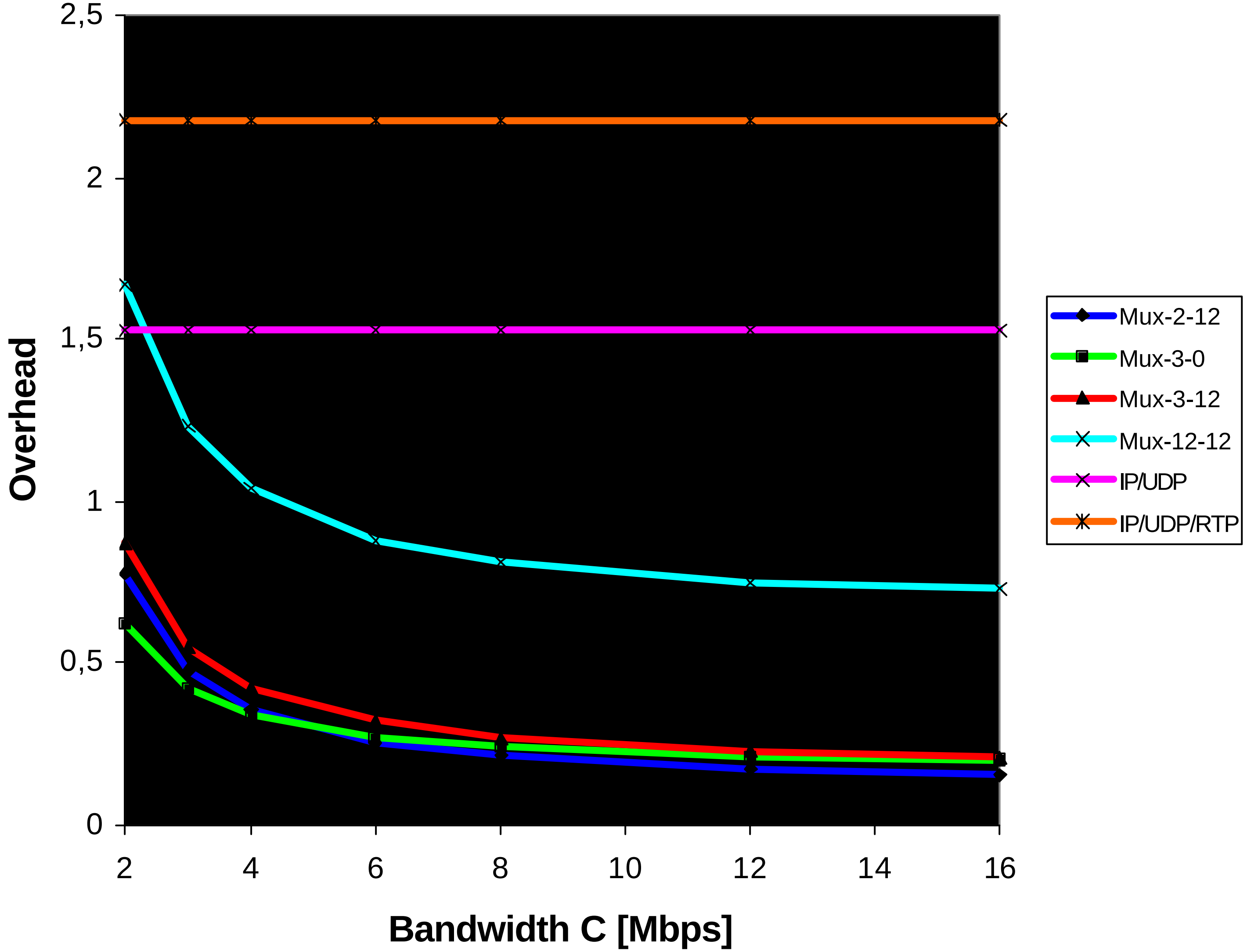
QoS Behavior



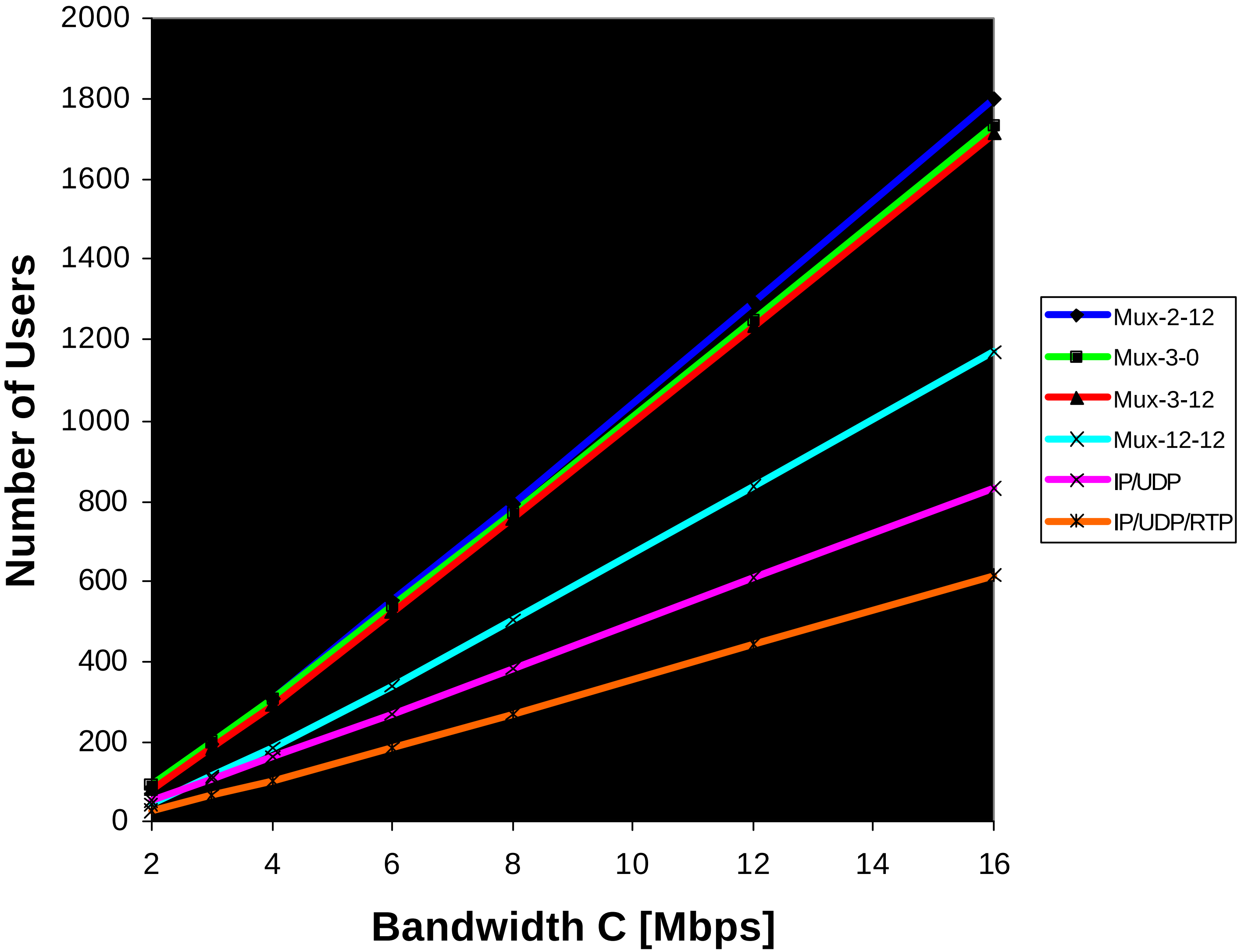
Comparison – Critical Load



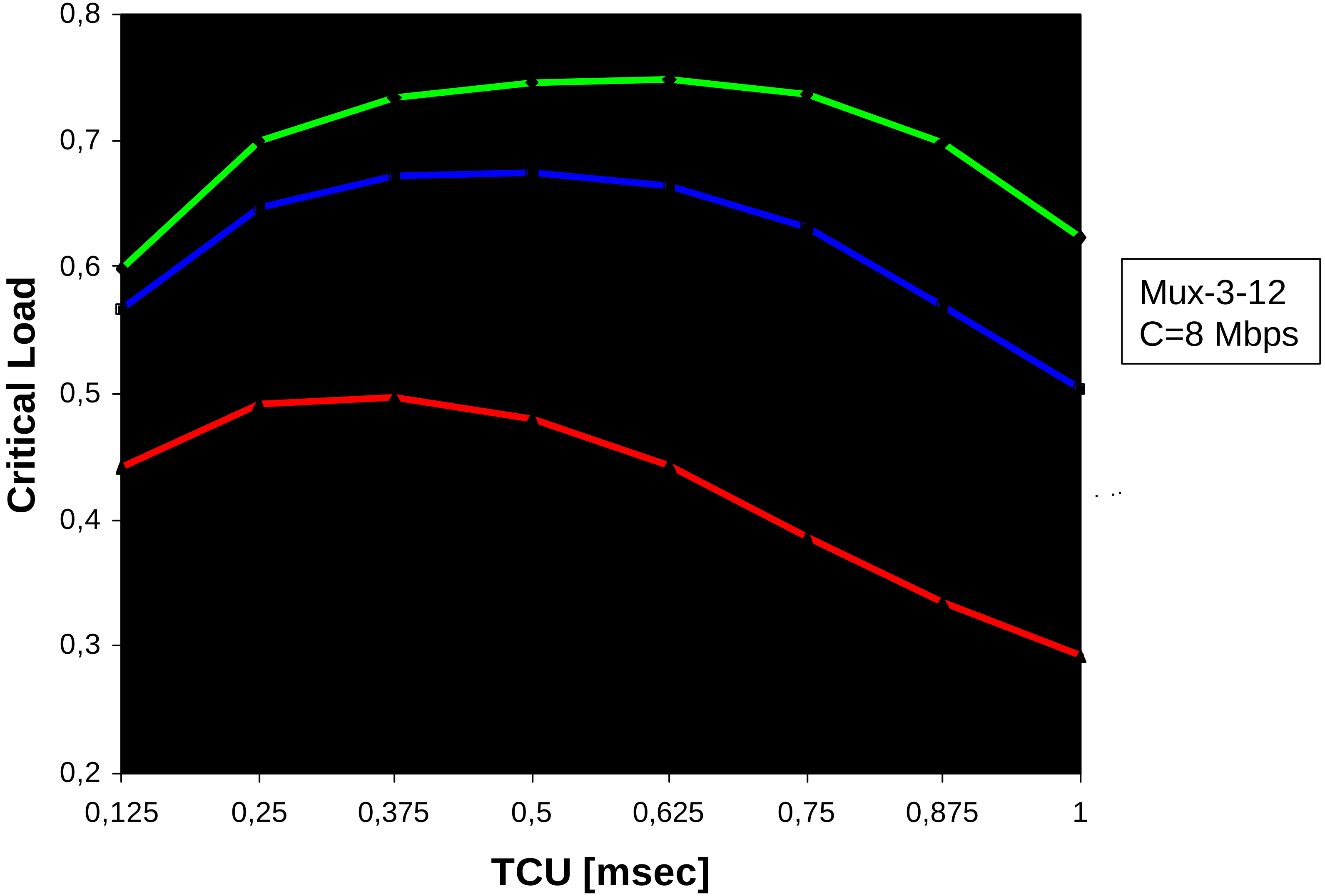
Comparison – Overhead



Comparison – Number of Users



Optimum Timer Value



Summary

- ▷ RTP multiplexing of voice traffic in IP networks
- ▷ Markov model and application to numerical framework
- ▷ Computation of QoS performance measures (loss, delay)
- ▷ Numerical results:
  - 50% bandwidth savings with RTP multiplexing
  - Existence of optimum timer value
- ▷ Acceptance of RTP depends on tradeoff between:
  - Increased router complexity and delay
  - Bandwidth savings
- ▷ Extension to QoS of packet and circuit switched data traffic in UMTS terrestrial radio access network (UTRAN)