Carrying Wireless Traffic over IP Using Realtime Transport Protocol Multiplexing

Michael Menth
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)
An Example of the Markov Model

Packet Size

N₀ Arrivals

TCU

I(N₀)

A₈

B₈

M(N₁)

W(N₁, S₀₁)

Loss(N₂, S₀₂)

L(N₀)

S₀₁

Q(S₀₁)

Sₘₐₓ

Spacer
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

\[ f^0 \quad \text{Input: } X^0 = (S^0), \; Y^0 = (N,L(N)) \]
\[ S' = \max(S^0 - \text{TCU} \cdot C, 0) \]
\[ \text{if } (S' + L(N) \leq S_{\text{max}}) \]
\[ S^I = S' + L(N) \]
\[ \text{else} \]
\[ S^I = S' \]
\[ N^I = N \]
\[ \text{Output: } X^I = (S^I, N^I) \]

\[ f^I \quad \text{Input: } X^I = (S^I, N^I), \; Y^I = (I(N^I)) \]
\[ S^0 = \max(S^I - I(N^I) \cdot C, 0) \]
\[ \text{Output: } X^0 = (S^0) \]

\[ f = f^I \circ f^0 \]
# Required Random Variables

### RTP Multiplexing

- **Number of VS in an IP packet**
  \[
  \left( \sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j \right) \land (N = i)
  \]
  \[N = 1\]

- **Length of an IP packet L(N)**
  \[L(N = i) = \sum_{j=1}^{i} B_j + 2 \cdot i + 12 + 8 + 20\]
  \[L(N = 1) = B + 12 + 8 + 20\]

- **Intermultiplex time I(N)**
  \[
  \left( \sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j \right) \land \left( I(N = i) = \sum_{j=1}^{i} A_j - TCU \right)
  \]
  \[I(N) = A\]

- **Multiplexing time M(N)**
  \[
  \left( \sum_{j=1}^{i-1} A_j \leq TCU < \sum_{j=1}^{i} A_j \right) \land (0 \leq k < i) \land \left( M(N = i) = TCU - \sum_{j=1}^{k} A_j \right)
  \]
  \[M(N) = 0\]
QoS Behavior

![Graph showing QoS behavior with offered load on the x-axis and voice sample mean waiting time on the y-axis. The graph includes three lines representing different probability distributions.](image-url)
Comparison – Critical Load

![Graph showing the comparison of critical load against bandwidth for different configurations.](image-url)
Comparison – Overhead

![Graph comparing overhead with bandwidth]

- Mux-2-12
- Mux-3-0
- Mux-3-12
- Mux-12-12
- IP/UDP
- IP/UDP/RTP

Bandwidth C [Mbps]
Comparison – Number of Users

Bandwidth C [Mbps]

Number of Users

- Mux-2-12
- Mux-3-0
- Mux-3-12
- Mux-12-12
- IP/UDP
- IP/UDP/RTP
Optimum Timer Value

![Graph showing the relationship between TCU (msec) and Critical Load for different values of \( c \) and a link capacity of 8 Mbps.]

- \( c \) values: 0.5, 1.0, 2.0
- Link capacity: 8 Mbps
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)