Proxy-based TCP-friendly streaming over mobile networks

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Outline

- **Introduction**
- **TCP Friendly Rate Control**
- **TCP Proxy**
- **Variable rate constraints and buffering delays**
- **Simulations**
- **Conclusion**

Introduction

- Streaming media becoming more important over wireless links
- Specialized requirements
  - Timely delivery for playback
  - Limited losses acceptable
  - Receiver buffer used to compensate for data rate fluctuations
- Initial buffering delay
  - needed to adjust for data rate changes
- Buffer Size Factors
  - Encoding of content
  - Available bandwidth during transmission

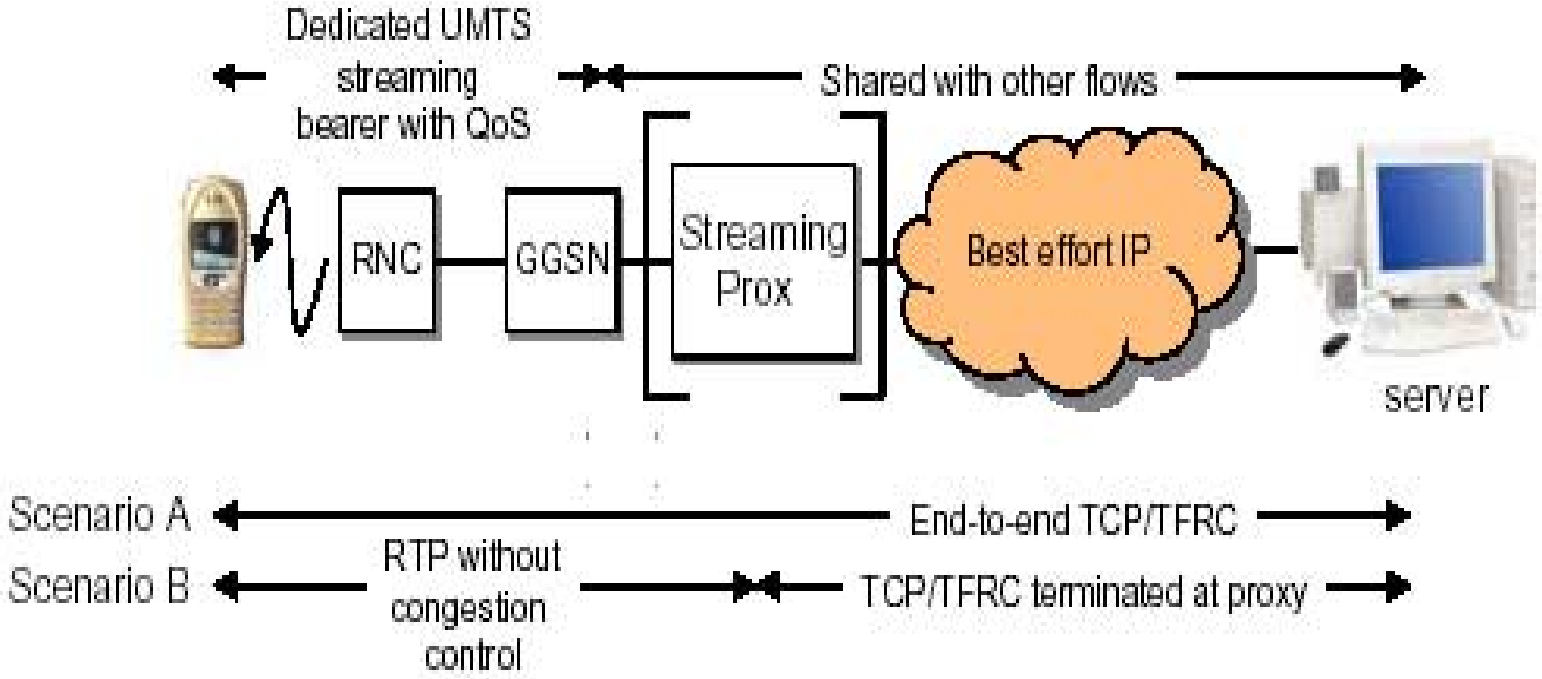
RTP Overview

- Internet-standard protocol for the transport of real-time data, including audio and video
- Data part of RTP is a thin protocol providing support for applications with real-time properties including timing reconstruction, loss detection, security and content identification
- UDP/IP is its initial target

WCMDA Overview

- (W-CDMA) Wideband Code-Division Multiple-Access implementation of third-generation (3G) cellular systems.
- Based on radio access technique proposed by ETSI Alpha group and the specifications was finalized 1999.
- W-CDMA link-level simulations are over 10 times more compute-intensive than current second-generation simulations.
- W-CDMA supports different users simultaneously transmitting at different data rates and data rates can even vary in time.

Two Scenarios – Proxy and End to End



TCP - Friendly Rate Control

- Goal – achieve fairness among TCP and non - TCP flows (improve utilization)
- Limit the drastic responses to congestion control for streaming
- Two major choices:
  - Mimic AIMD
  - Use throughput equation (less fluctuation)

TCP throughput Eq

- TCP throughput $= \dfrac{MTU}{RTT\sqrt{\dfrac{2p}{3}} + T_0\sqrt{\dfrac{27p}{8}}\,p(1+32p^2)}$

- Upper bound $\leq \dfrac{1.22MTU}{RTT\sqrt{p}}$

TFRC

$$t_{inter-packet} = \frac{s \text{ x } \sqrt{R_0}}{Throughput \text{ x } M}$$

- Equation-based congestion control
- Assigns network estimation to receiver
- Uses Weighting method to average p over number of loss intervals
- Uses EWMA (exponential weighted moving average) to calculate RTT
- Creates less fluctuation

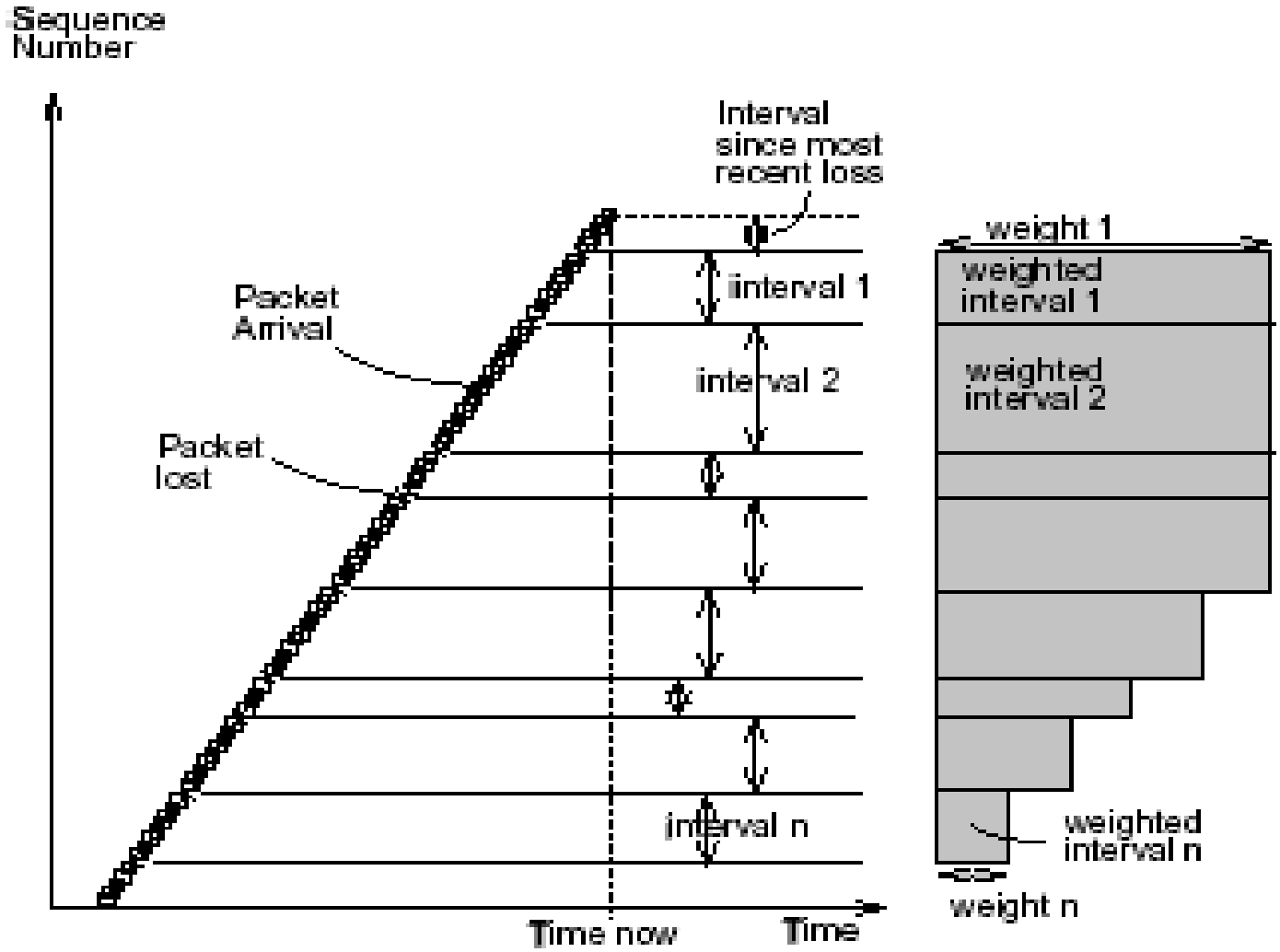


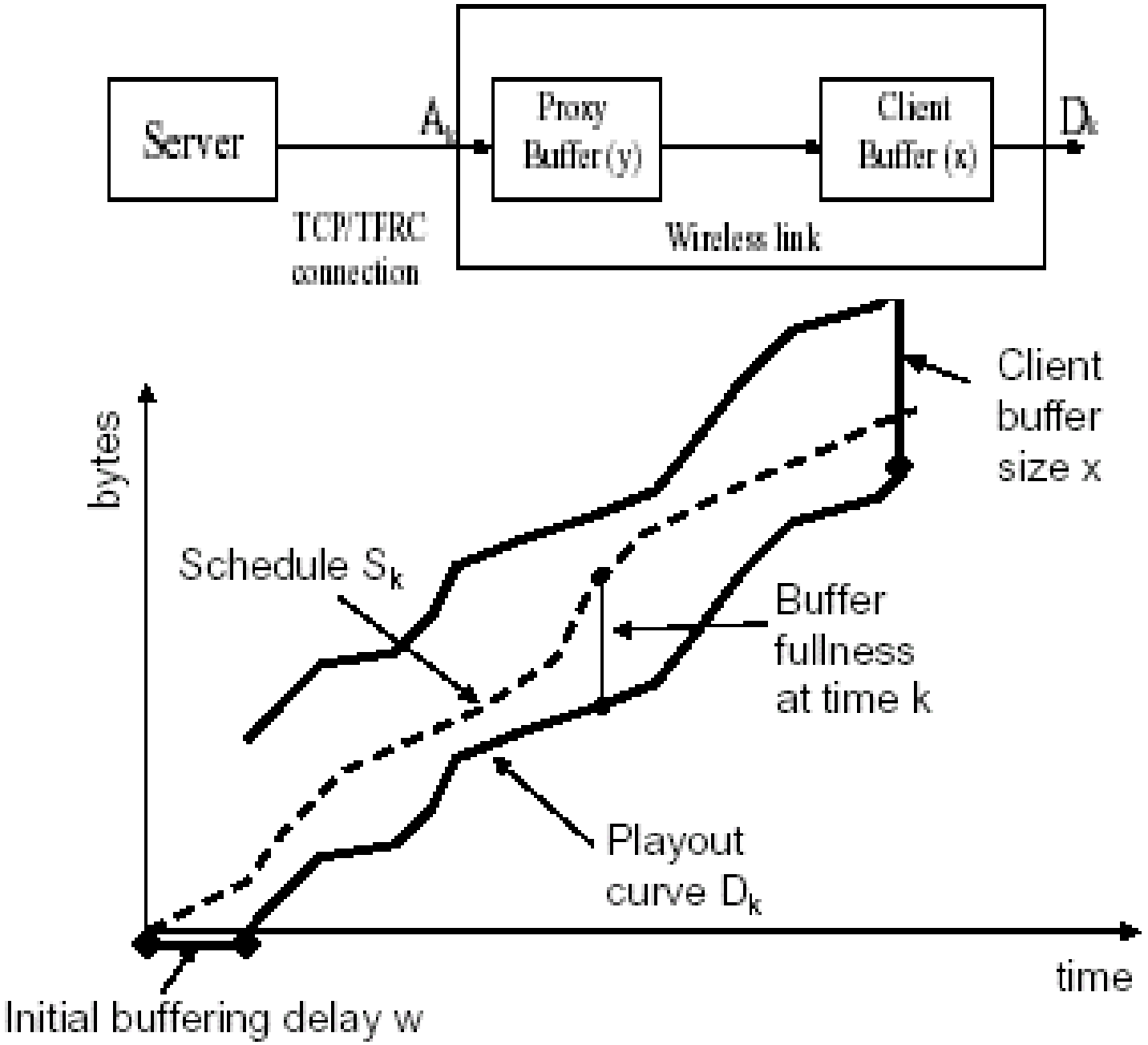
Figure 1: Weighted intervals between loss used to calculate loss probability.

TCP Proxy

- Needed because TCP has trouble fully utilizing mobile links
  - Large RTT
  - Non congestion packet loss
- Shields wireless link from Internet packet loss

Traffic Smoothing

- Video streaming uses constant quality encoding – results in variable rate streams
- To reduce fluctuations, server transmits frames into client playback buffer in advance of bursts
- Goal is to minimize required client buffer size and also don’t over or under fill buffer


Server
A_k
Proxy Buffer (y)
Client Buffer (x)
D_k
TCP/TFRC connection
Wireless link
bytes
Client buffer size x
Schedule S_k
Buffer fullness at time k
Playout curve D_k
time
Initial buffering delay w

Minimizing Initial Buffering Delay

$$S_k^{late} = \begin{cases} D_n \text{.....} (k=N) \\ \max\{S_{k+1}^{late} - R_k, D_k\} \text{.....} (k < N) \end{cases}$$

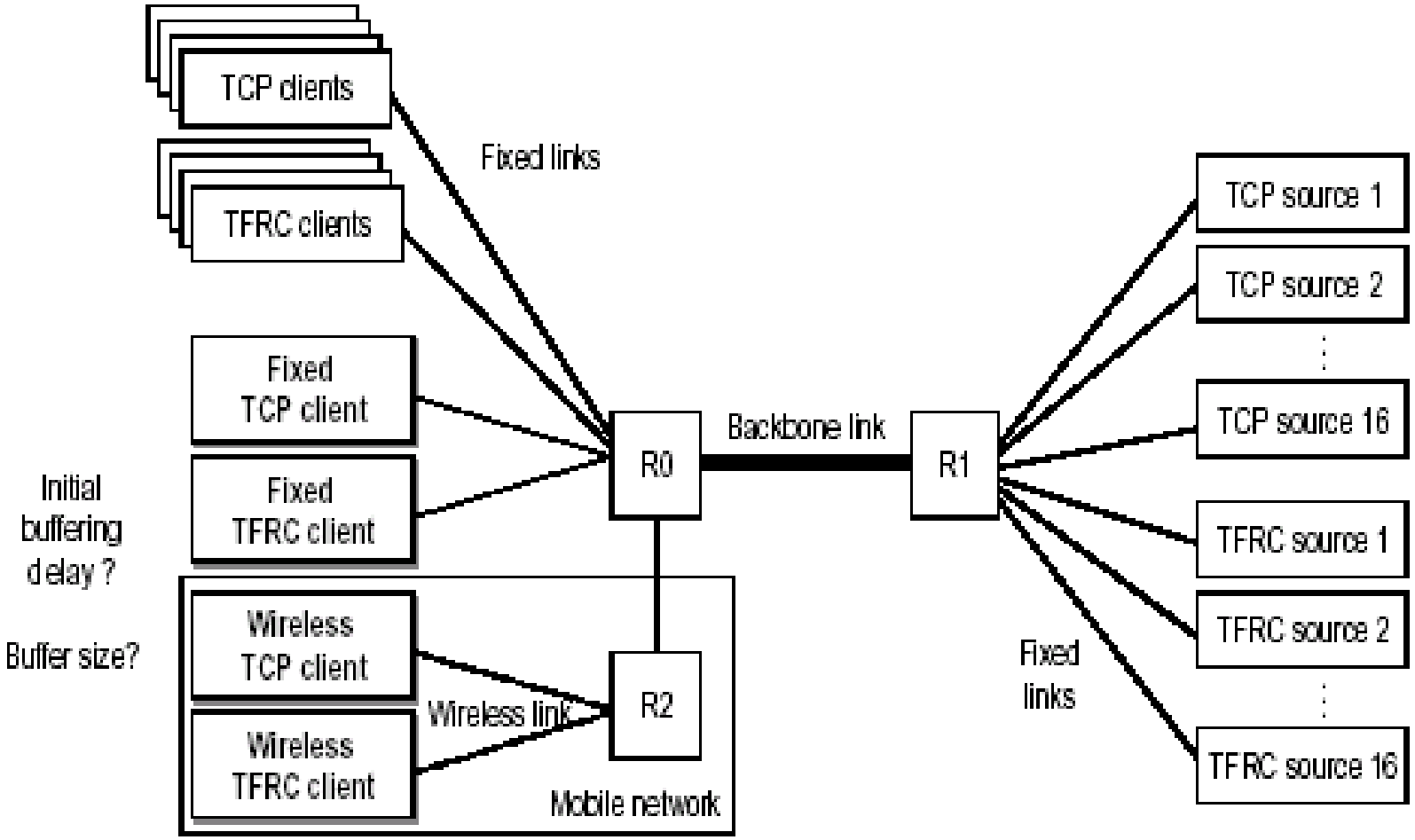
$$x^* = \max\{S_k^{late} - D_k\}$$

$$w^* = \min\{w \mid A_k - S_{k-w}^{late} \geq 0\}$$

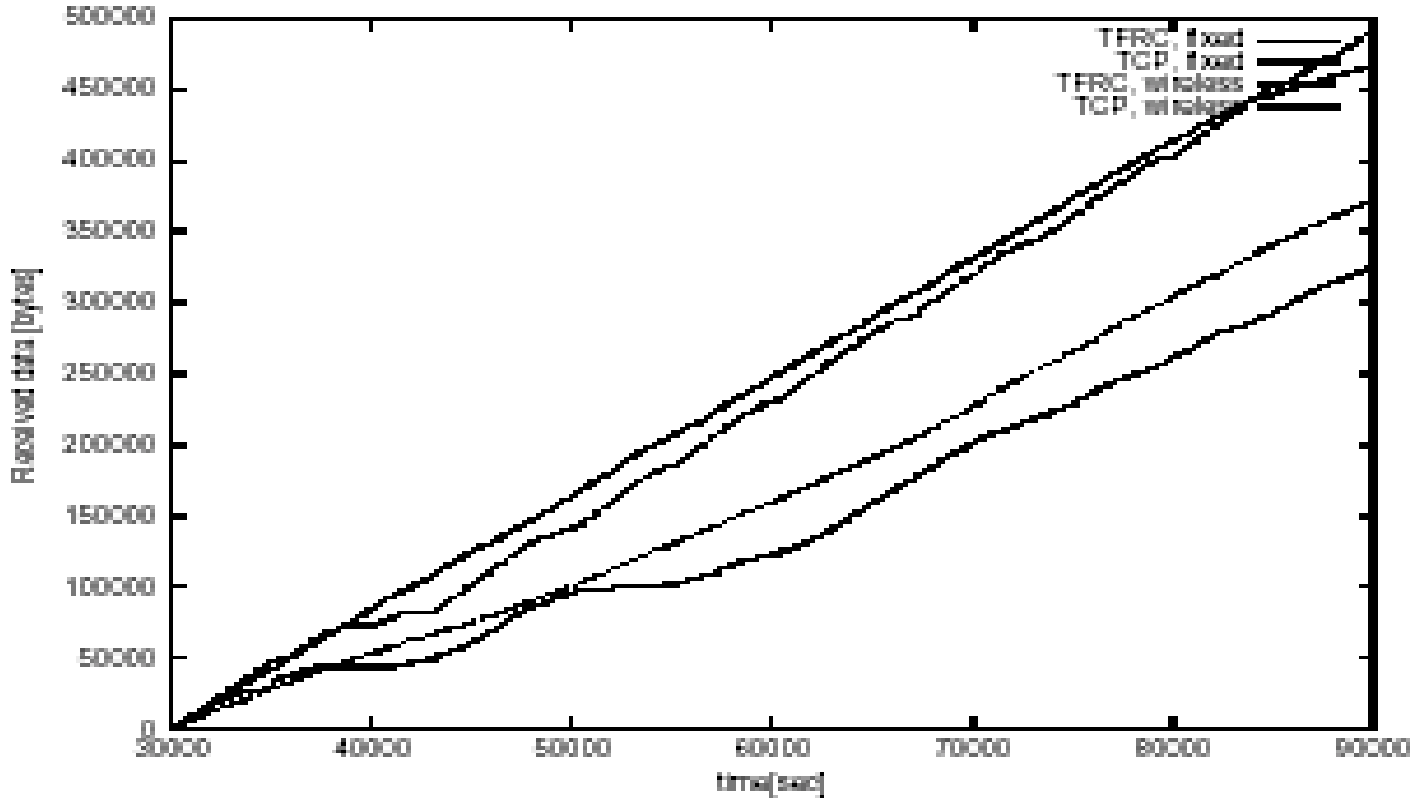
Minimizing Initial Buffering Delay
Proxy case

$$S_k^{early} = \begin{cases} 0 \text{.....} (k=0) \\ \max\{S_{k-1}^{early} + R_k, A_k\} \text{.....} (k > N) \end{cases}$$

Simulation

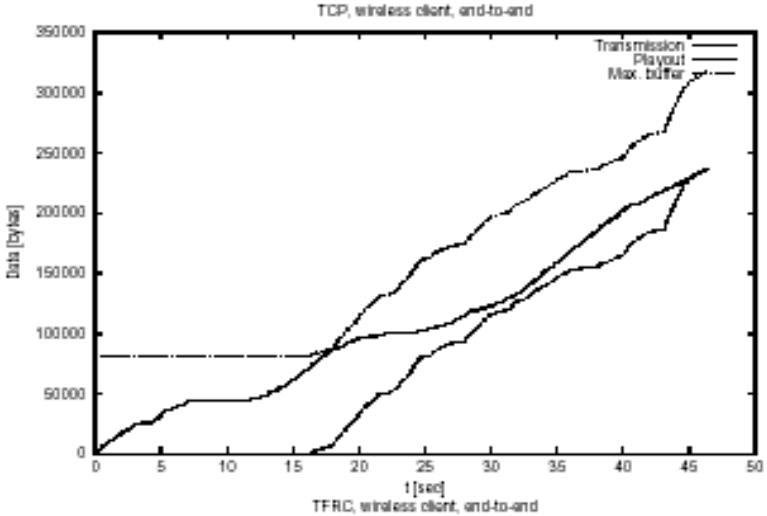

TCP clients
TFRC clients
Fixed links
Fixed
TCP client
Fixed
TFRC client
Initial
buffering
delay ?
Buffer size?
R0
Backbone link
R1
TCP source 1
TCP source 2
TCP source 16
TFRC source 1
TFRC source 2
TFRC source 16
Fixed
links
Wireless
TCP client
Wireless
TFRC client
Wireless link
R2
Mobile network

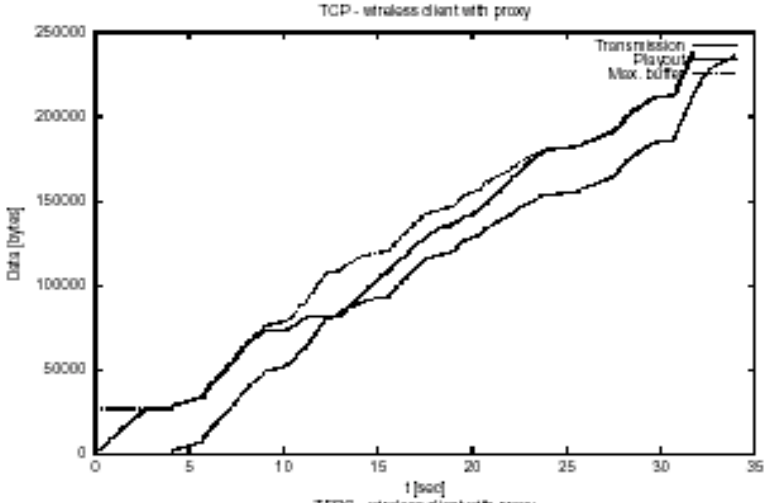
TCP TFRC Transmission behavior

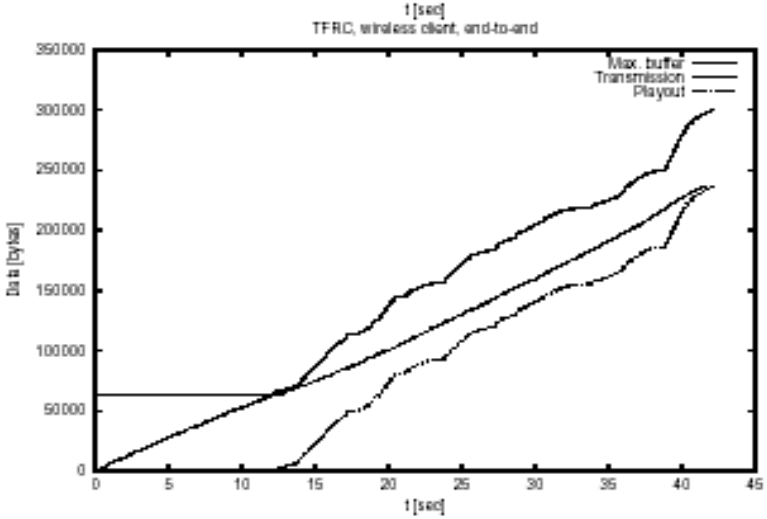


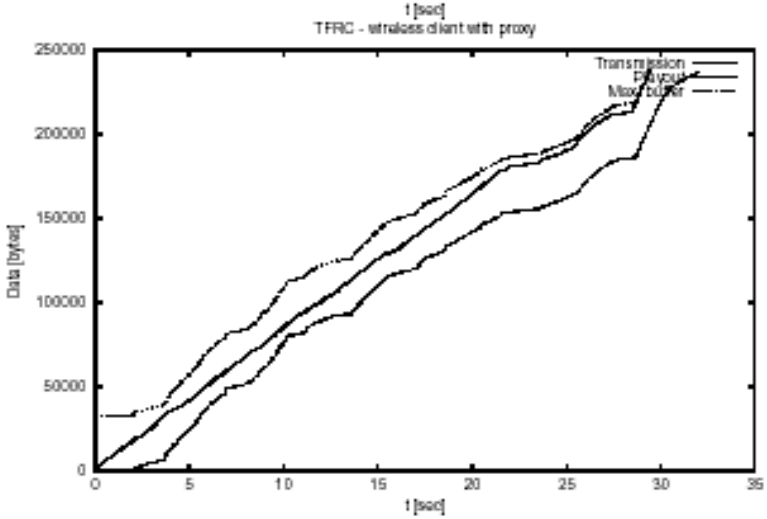
Simulation Results

Case	**R [kbps]**	***W* [sec]**	***X* [bytes]**
TCP, wired ?	65.6	1.7	26567
TFRC, wired ?	62.2	2.8	32016
TCP, wireless	43.3	13.9	76840
TFRC, wireless	49.7	9.0	58320


TCP, wireless client, end-to-end
Transmission
Playout
Max. buffer
Data [bytes]
t [sec]


TCP - wireless client with proxy
Transmission
Playout
Max. buffer
Data [bytes]
t [sec]


TFRC, wireless client, end-to-end
Max. buffer
Transmission
Playout
Data [bytes]
t [sec]


TFRC - wireless client with proxy
Transmission
Playout
Max. buffer
Data [bytes]
t [sec]

Simulation Results (Proxy)

Without proxy			
Case	**R [kbps]**	***W* [sec]**	***X* [bytes]**
TCP	16.5	81030	n.a.
TFRC	12.5	63833	n.a
With Proxy			
TCP	4.1	26924	26924
TFRC	2.2	26924	32602

Conclusions

- Use of Proxy resulted in decrease of initial delay buffer and decreased client size buffer
- Also showed increased utilization and average throughput
- Many aspects still to consider in the future

Questions?