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QoS of Internet Access with GPRS

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Overview

- Introduction
- Simulation model
  - traffic model
  - application specific protocols
  - core network model
  - GPRS model
- Numerical results
  - performance of GPRS
  - comparison to Internet access by modem
- Conclusion and outlook

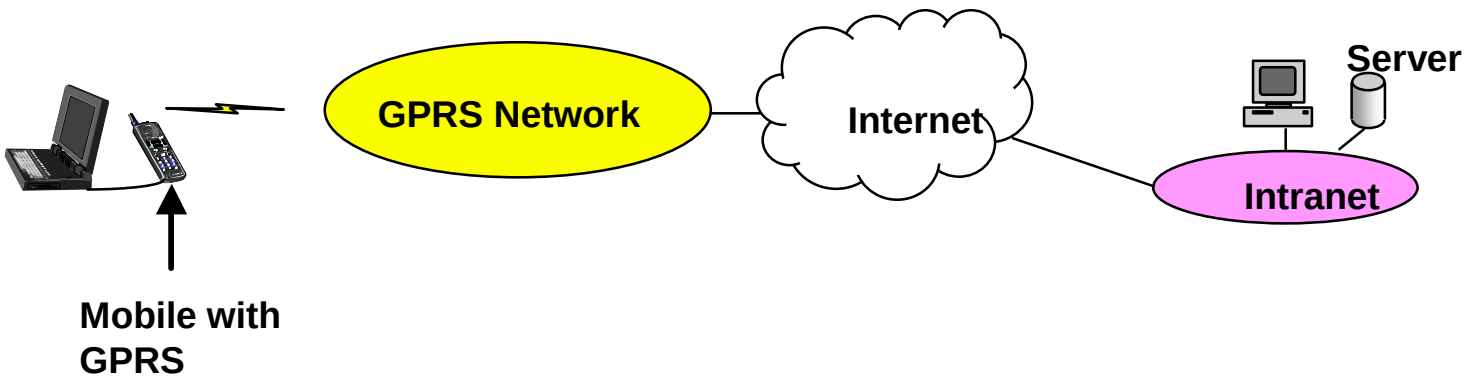
GPRS

GPRS extension of GSM to provide mobile Internet access

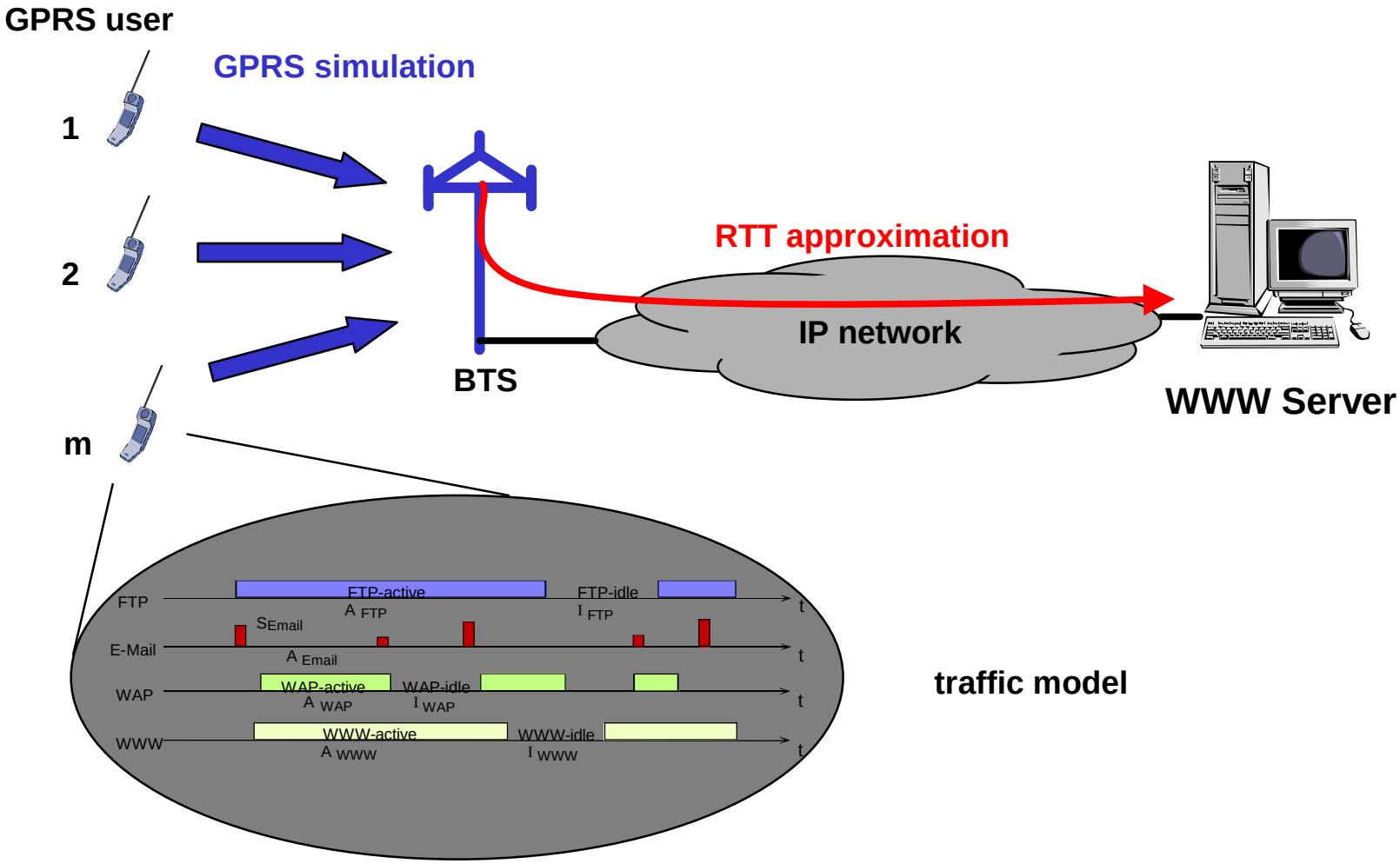
Higher bandwidth achieved by

- Usage of multiple channels (PDCHs)
- Coding schemes with higher data rate

Better usage of bandwidth by packet switching

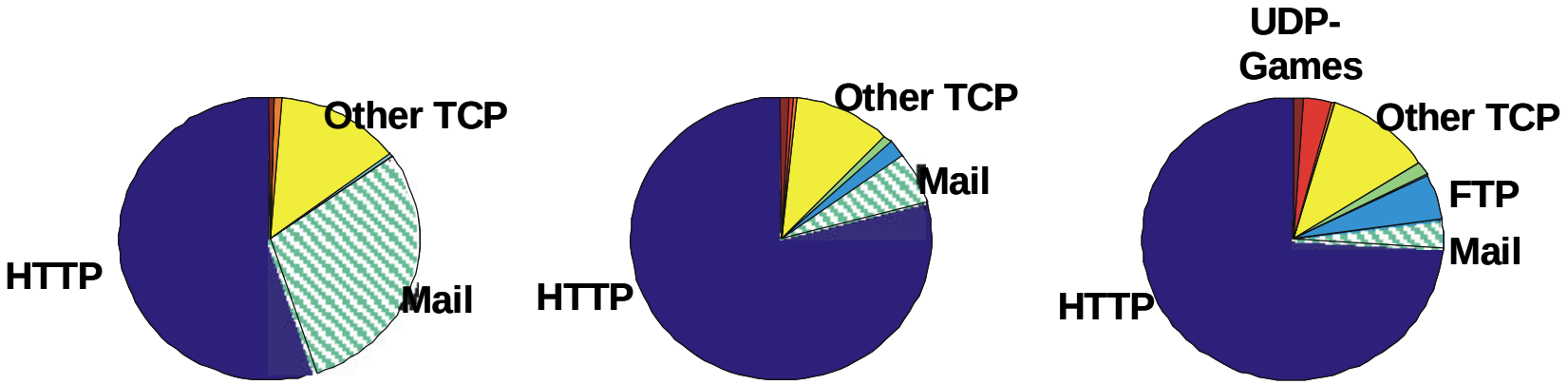


Simulation Concept



Major Applications

Measurements of the student modem access at the University of Würzburg



9.6kbps 33.6kbps 64kbps

Most important applications: WWW and Email

FTP no major application for GPRS

New applications arise (e.g. games, WAP)

Traffic Model

Applications

- WWW
- Email

Literature study of measurements in wired networks

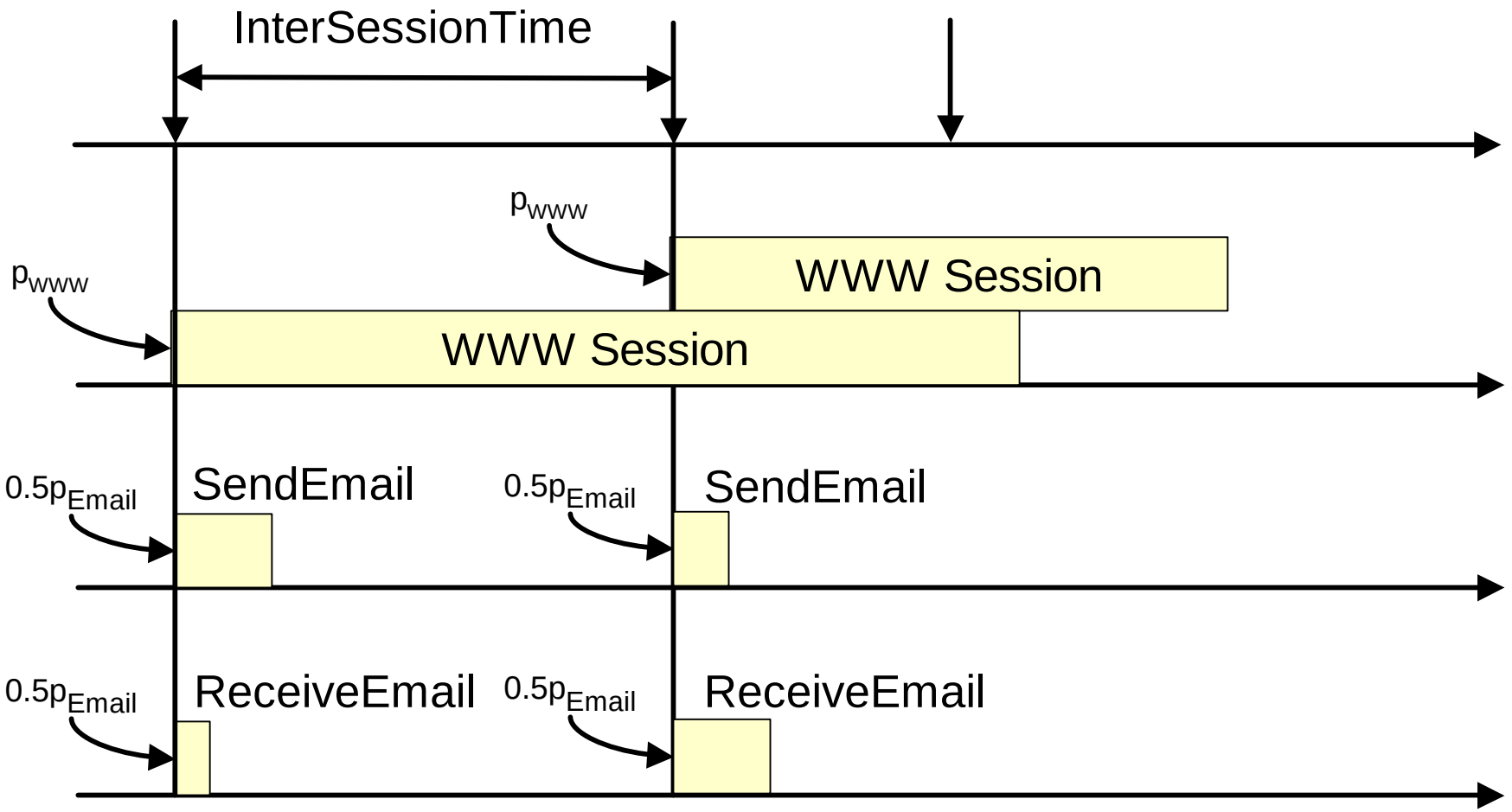
- H. Choi and J. Limb, Georgia Tech., 1999
- A. Reyes-Lecuona, et al, Universidad de Malaga, Spain, 1999
- N. Vicari, Universität Würzburg, 1997
- P. Barford and M. Crovella, Boston University, 1998

Own measurements

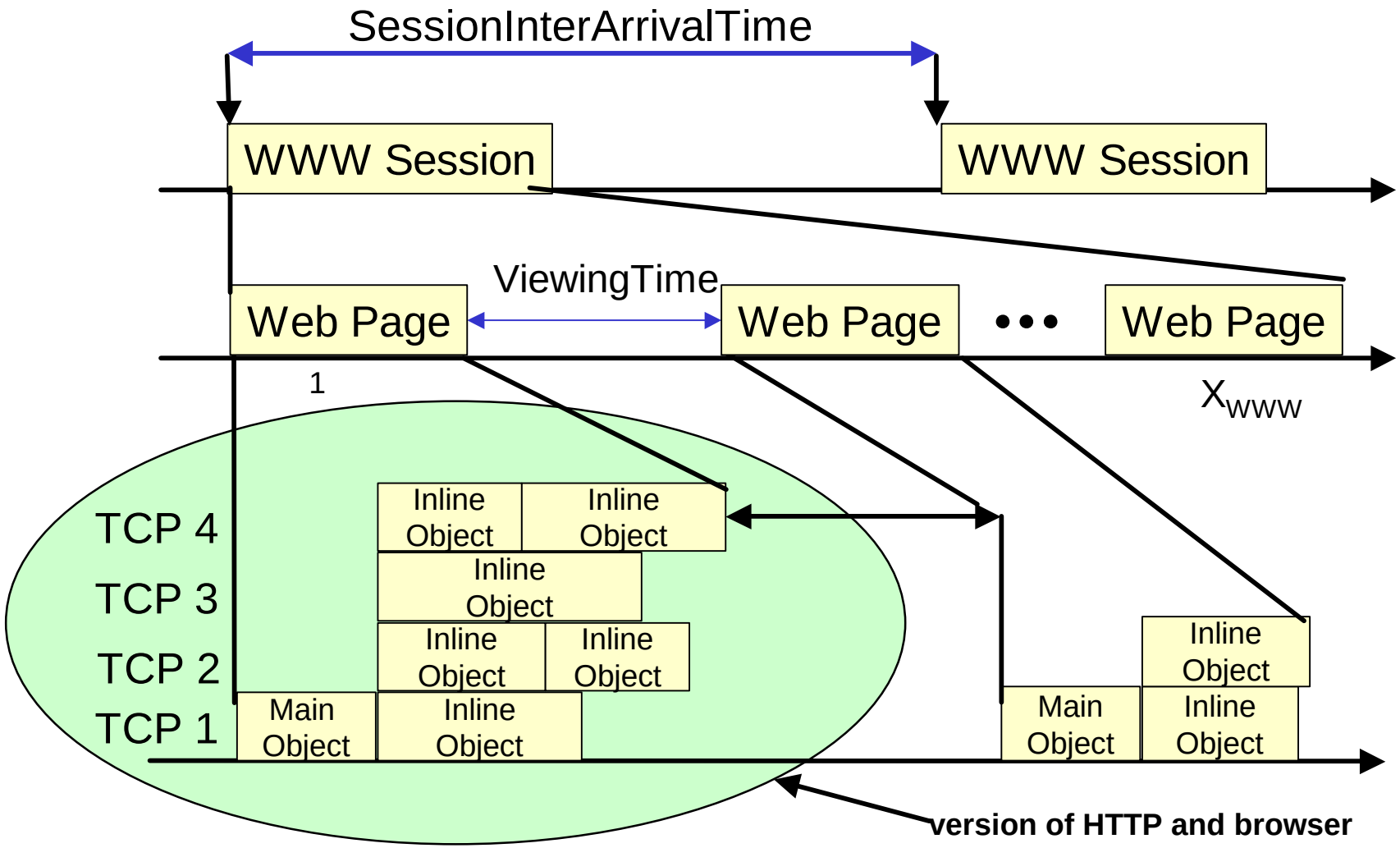
- Size of Emails

Development of a traffic generator for GPRS users

Arrival Process for WWW and Email



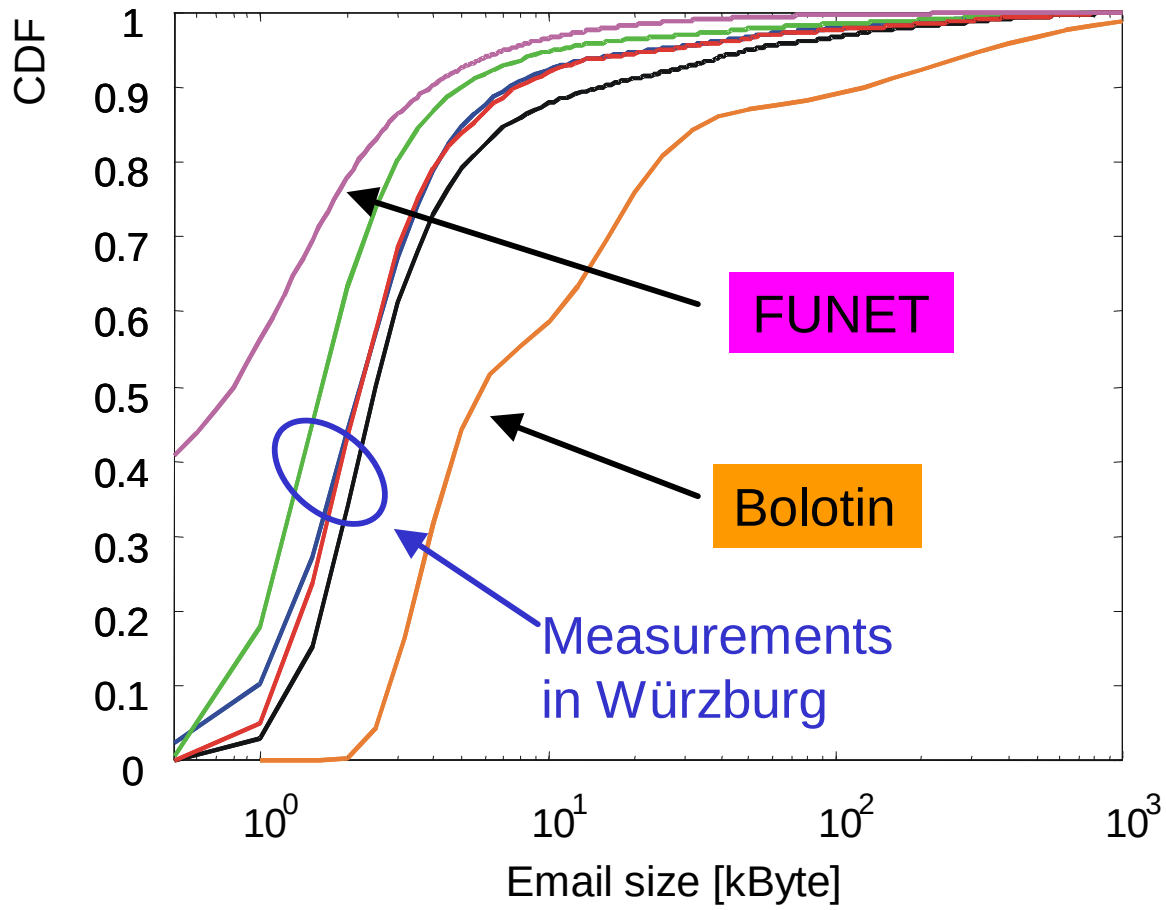
Web Session Model



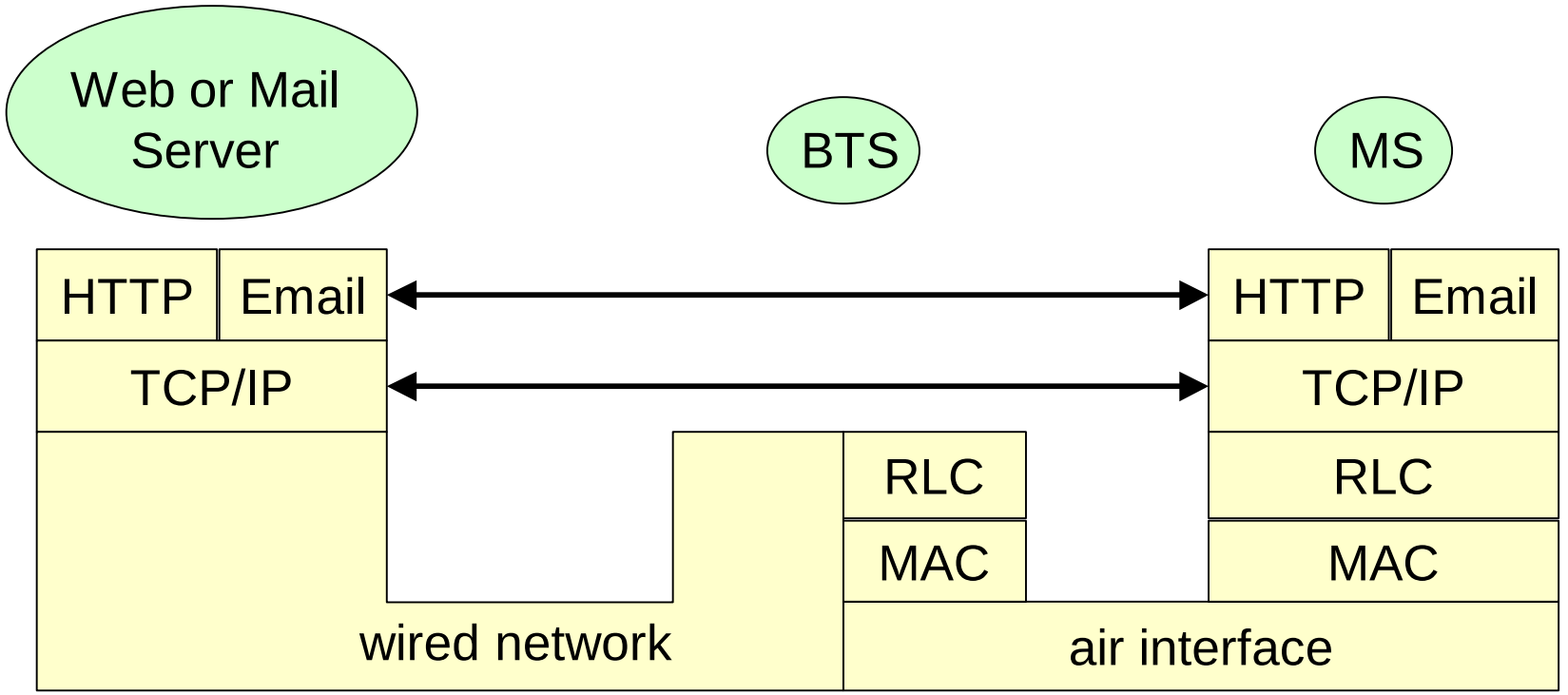
Parameter

Variable	Distribution	Mean	Standard deviation
Web request viewing time V_{www}	Weibull(a,b) truncated at a maximum of 15 min.	39.5 s	92.6 s
Number of inline objects N_{www}	Gamma(0.24, 23.42)	5.55	11.4
Size of main object M_{www}	Lognormal(1.31, 1.41)	10kB	25kB
Size of inline object O_{www}	Lognormal(-0.75, 2.36)	7.7kB	126kB
Size of GetRequest R_{www}	Lognormal(5.84, 0.29)	360B	106B
Number of web requests per WWW Session X_{www}	Lognormal(1.8, 1.68)	25	100

Email Model


CDF
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10^0
10^1
10^2
10^3
Email size [kByte]
FUNET
Bolotin
Measurements
in Würzburg

GPRS Simulation



Simulation Parameters und Results

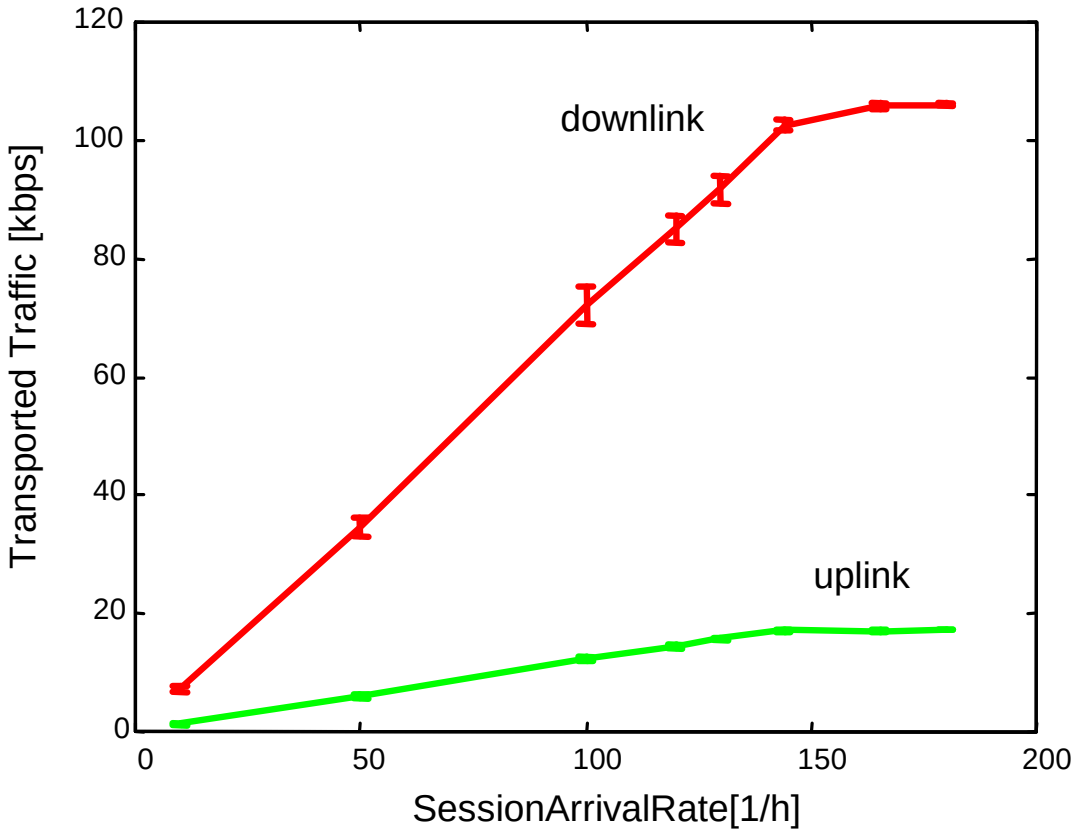
Simulated scenario:

- Base station with 3 frequencies
- Voice calls according to a blocking probability of 1%
- Coding scheme 2 with RLC block error rate: 7.5%
- Only *on-demand*, no *dedicated* PDCH
- Mobiles with 4 neighbored slots

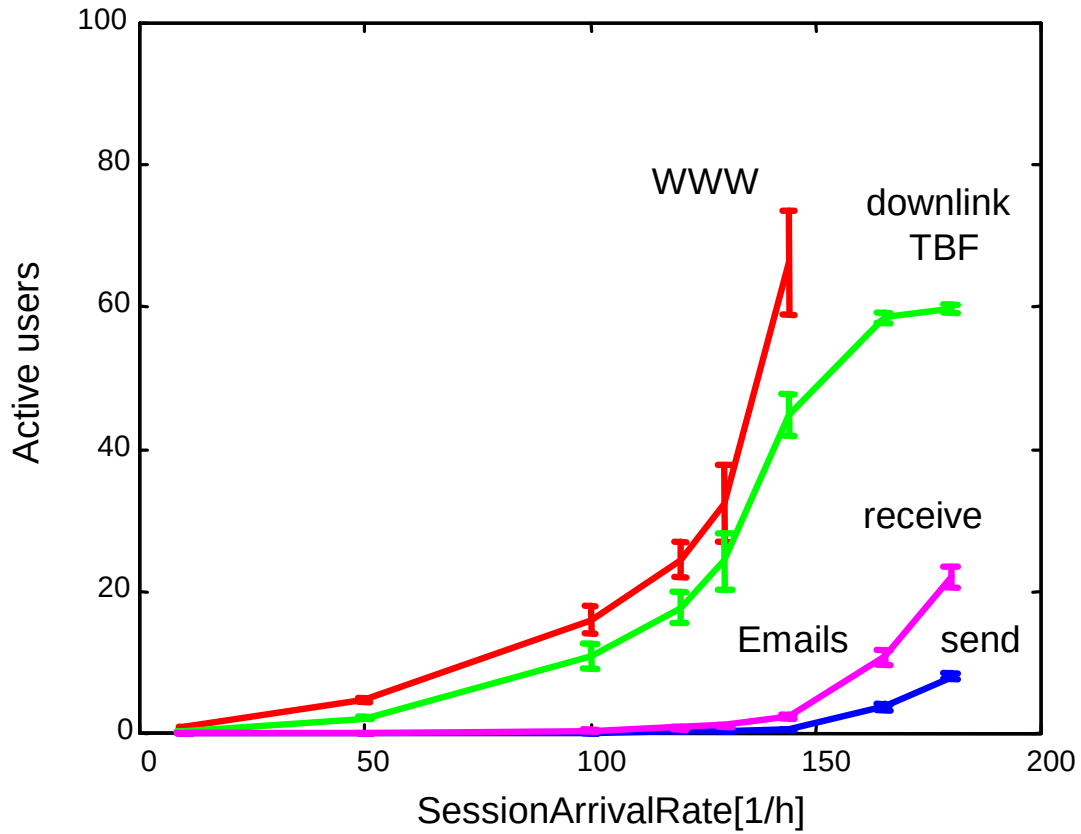
Results:

- QoS parameter depending on session arrival rate
  - Mean and median of the time to load a web page
  - Bandwidth of a TCP connection
  - Bandwidth of a TBF
- Comparison to modem Internet access

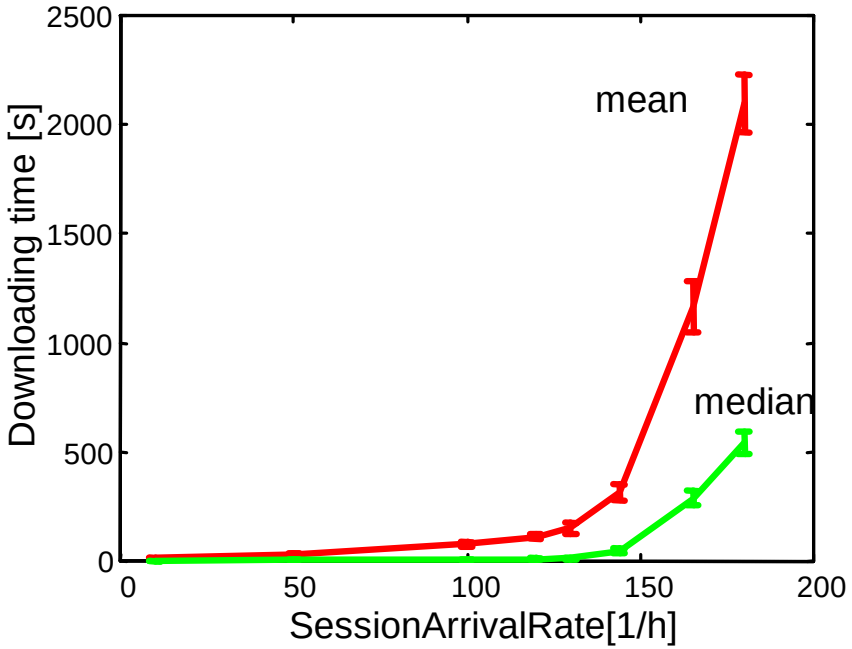
Data Flow on the Air Interface

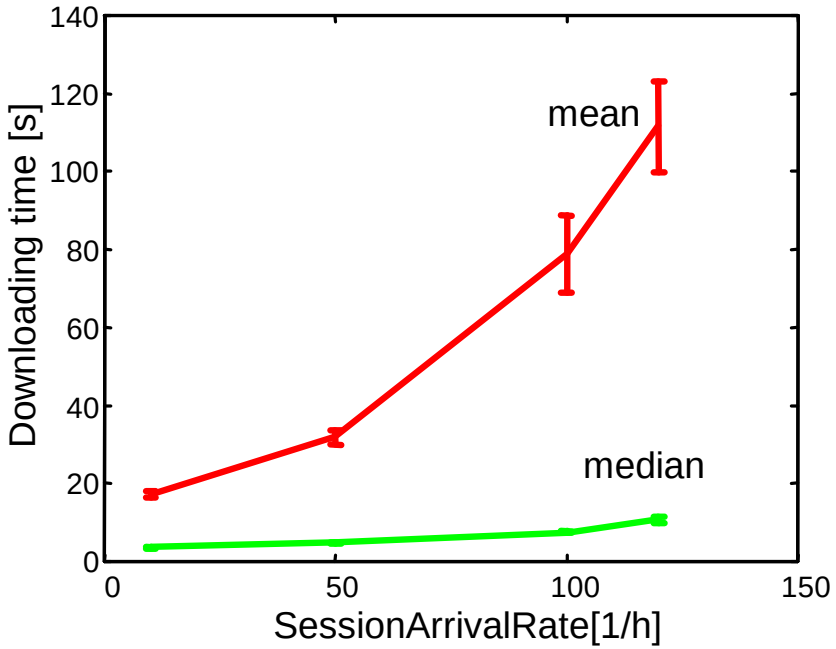


User Activity

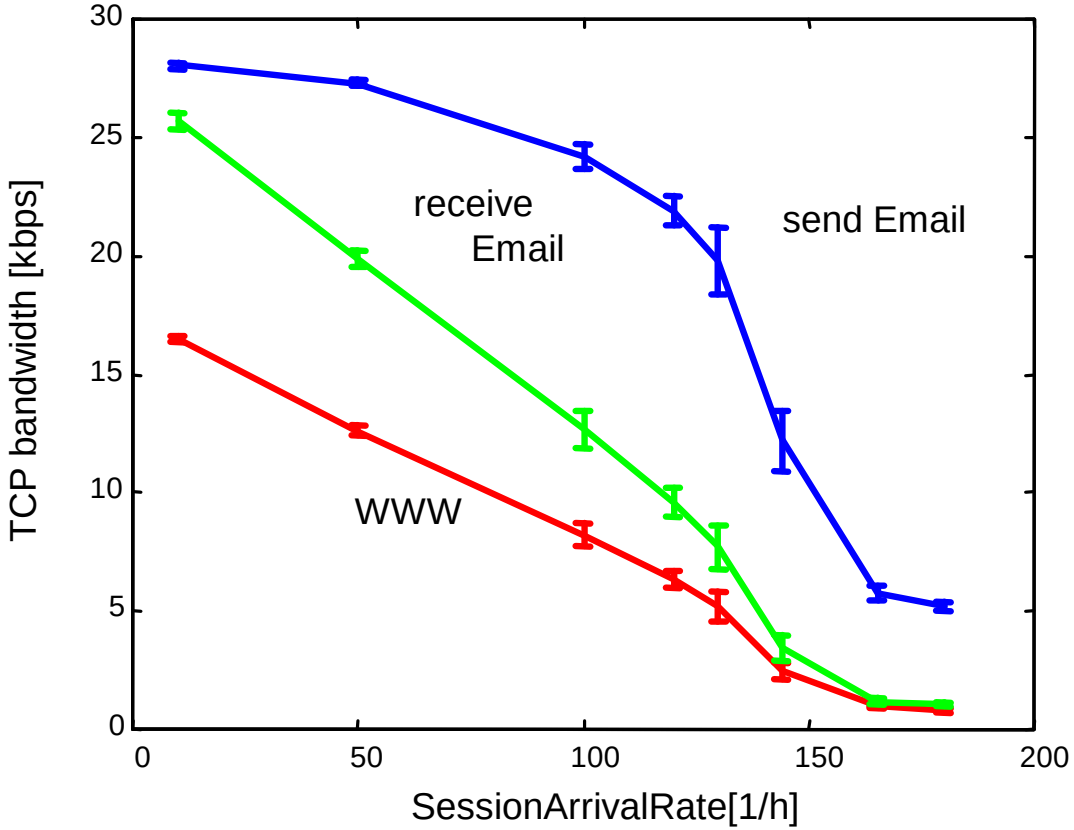


WWW Downloading Time

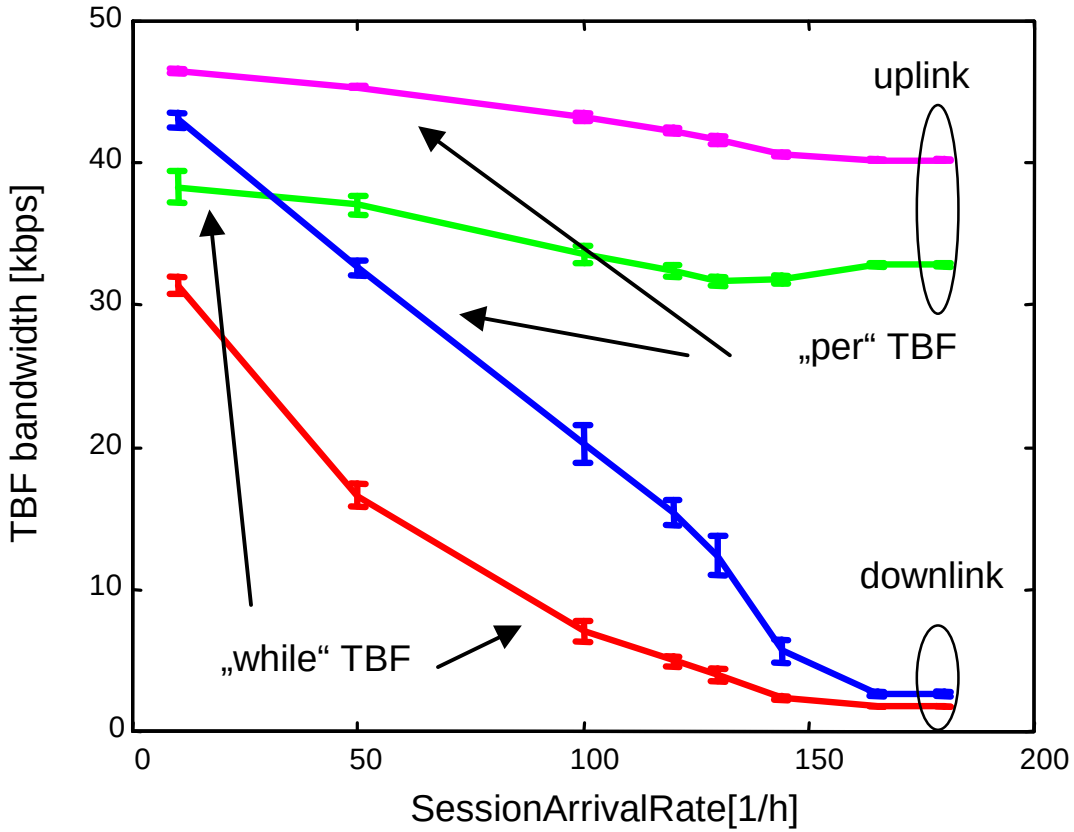




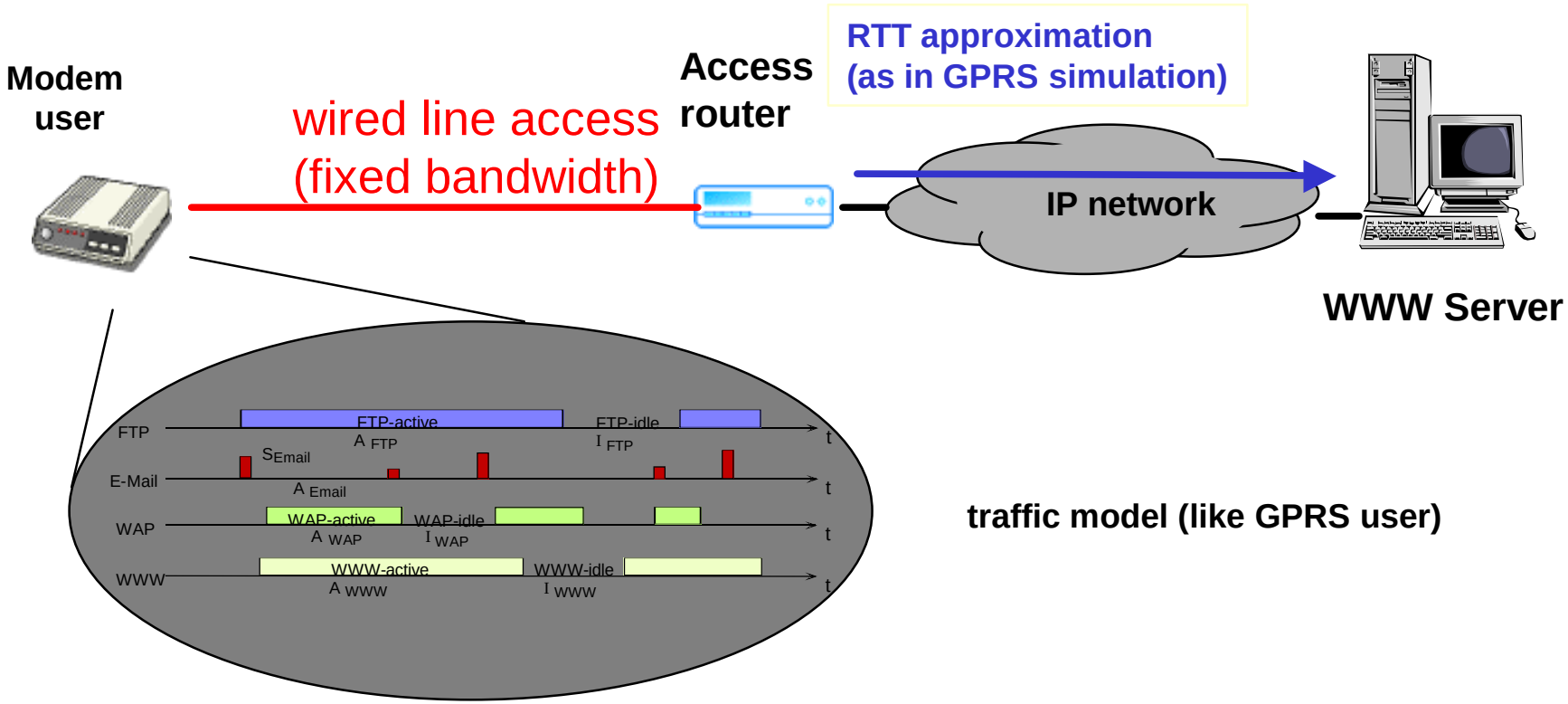
Bandwidth of TCP Connections



TBF Bandwidth

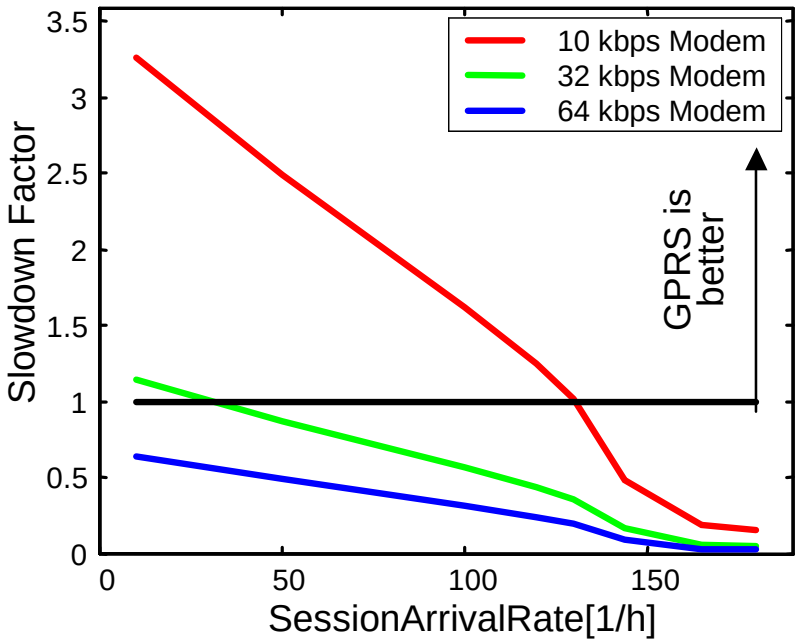


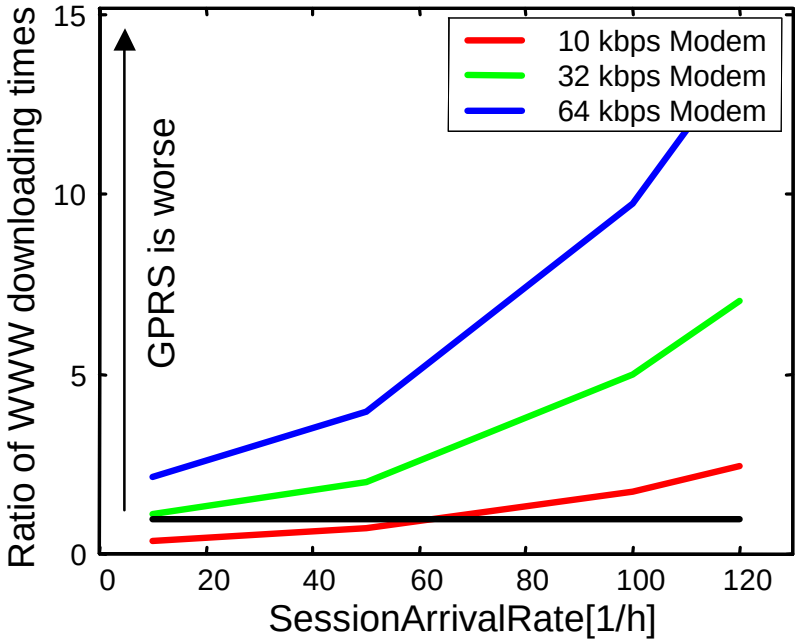
Simulation of Modem Internet Access



traffic model (like GPRS user)

GPRS vs. Modem Internet Access





$$\text{Slowdown Factor} = \frac{\text{TCP Bandwidth GPRS}}{\text{TCP Bandwidth Modem}}$$

Conclusion and Outlook

Conclusion

- Stochastic model for GPRS users based on wired network measurements
- Interaction of TCP and RLC works well
- RLC retransmissions do not cause TCP timeouts
- 4 slot mobiles achieve performance of 30kbps-modems for lightly to medium loaded cells

Outlook

- Investigation of Burst errors and Handover on TCP
- Extension of traffic model
  - WAP
  - Video/audio-streaming
- Simulation of the UMTS air interface