Dimensioning GPRS Networks for Coexisting Applications based on WAP and Conventional Internet Protocols

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Structure

- motivation
- traffic models for mobile services and applications
- WAP traffic model
- performance analysis of WAP over GPRS
- conclusions
Motivation

- Radio network dimensioning demands the relationship between
  - offered traffic predicted by operator
  - QoS desired by operator for his clients
  - radio resources needed (number of PDCHs and TRX)

- GPRS traffic offered by
  - conventional Internet applications (laptop computers or enhanced PDA)
  - WAP-based applications running on smart phones and PDAs

- Aims of this research
  - simulation results for a predicted traffic mix of WAP, WWW and e-mail
  - the effect of traffic generated by conventional Internet applications on the WAP performance and vice versa
Internet and Multimedia traffic modelling

- **aim**
  - definition of user profiles
  - characterization of sessions

- **predicted applications for mobile (E)GPRS users**
  - WWW, e-mail, file transfer over TCP/IP
  - Wireless Application Protocol (WAP)
  - Streaming
  - Video-Conferencing, VoIP

- **methodology**
  - use measurement results for fixed Internet from the literature
  - perform own measurements
  - use standardized models (e.g. UMTS 30.03)
  - use market prediction studies
Example: WWW session

WWW session

page 1

object 1

object 2

object m

page 2

size m

$t_{\text{read}}$

$t_{\text{object}}$
### Internet model

(source: HTTP: UMTS 30.03, SMTP, FTP: Paxson, Floyd)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Distribution</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP parameter (WWW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pages per session</td>
<td>geometric</td>
<td>5.0</td>
</tr>
<tr>
<td>pause between pages [s]</td>
<td>exponential</td>
<td>12.0</td>
</tr>
<tr>
<td>objects per page</td>
<td>geometric</td>
<td>2.5</td>
</tr>
<tr>
<td>object size [byte]</td>
<td>(\log_2)-Erlang-k</td>
<td>3700</td>
</tr>
<tr>
<td>SMTP parameter (e-mail)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e-mail size [byte]</td>
<td>(\log_2)-normal</td>
<td>10000</td>
</tr>
<tr>
<td>FTP parameter (file transfer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>amount of data per session [byte]</td>
<td>(\log_2)-normal</td>
<td>32000</td>
</tr>
<tr>
<td>amount of data per file [byte]</td>
<td>(\log_2)-normal</td>
<td>3000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internet Client</th>
<th>Internet Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP</td>
<td>HTTP</td>
</tr>
<tr>
<td>FTP</td>
<td>FTP</td>
</tr>
<tr>
<td>SMTP</td>
<td>SMTP</td>
</tr>
<tr>
<td>TCP</td>
<td>TCP</td>
</tr>
<tr>
<td>IP</td>
<td>IP</td>
</tr>
</tbody>
</table>

GPRS Bearer

P. Stuckmann, C. Hoymann

FFV 2002
Wireless Application Protocol (WAP 1.x)

- protocol architecture optimized for the wireless environment
- use of Wireless Markup Language (WML) as a description conform with the Extensible Markup Language (XML)
- session is composed of requests for WAP decks composed of several cards
- WAP deck has maximal size (no heavy-tailed distribution like in the WWW)
- architecture is based on a proxy concept (use of WAP gateways) for the conversion of Internet stack to WAP stack
- use of UDP instead of TCP
WAP protocol architecture

- WAP Terminal
  - WAE
  - WSP
  - WTP
  - (WTLS)
  - WDP
  - Wireless

- WAP Gateway
  - WSP
  - WTP
  - (WTLS)
  - WDP
  - Wireless
  - HTTP
  - (SSL)
  - TCP
  - IP
  - Wireline

- Web Server
  - WAE
  - HTTP
  - (SSL)
  - TCP
  - IP
  - Wireline
Wireless Application Protocol (WAP 2.0)

- Convergence with widely used Internet protocols like TCP and HTTP
- Mobile profile of TCP for wireless links based on IETF work (fully interoperable with today´s TCP)
- No WAP proxy required (HTTP 1.1)
- WAP 2.0 specifications finished 2001
- First WAP 2.0 phones expected on the market in 2003
- WAP 1.x protocol stacks will still be used in the mobile terminals in the next years
- Only WAP 1.x regarded in this work
A WAP session is uniquely defined by:

- size of uplink and downlink packets $x$ and $y$
- response time of the network $t_{\text{Response}}$ (not dependent on user or application)
- reading time of the user taken between two WAP decks $t_{\text{Read}}$
- number of WAP deck requests $n$
Measurement test bed

measurement of packet sizes and arrival times
→ parameterization of the model
# WAP model in comparison to WWW model

(source: Stuckmann, Finck, Bahls)

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</tr>
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<td><strong>HTTP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pages per session</td>
<td>geometric</td>
<td>5</td>
</tr>
<tr>
<td>reading time between pages</td>
<td>exponential</td>
<td>12 s</td>
</tr>
<tr>
<td>objects per page</td>
<td>geometric</td>
<td>2.5</td>
</tr>
<tr>
<td>object size</td>
<td>log2-Erlang-k</td>
<td>3700 byte</td>
</tr>
<tr>
<td><strong>WAP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>decks per session</td>
<td>geometric</td>
<td>19</td>
</tr>
<tr>
<td>reading time between decks</td>
<td>exponential</td>
<td>14 s</td>
</tr>
<tr>
<td>packet size in UL (request)</td>
<td>log2-normal</td>
<td>108 byte</td>
</tr>
<tr>
<td>packet size in DL (deck size)</td>
<td>log2-normal</td>
<td>511 byte</td>
</tr>
</tbody>
</table>
Simulation Environment (E)GPRSim
# Simulation parameters

<table>
<thead>
<tr>
<th>parameter</th>
<th>value / mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of mobile stations</td>
<td>1-30</td>
</tr>
<tr>
<td>multislot cap. (DL/UL)</td>
<td>4/1, 1/1</td>
</tr>
<tr>
<td>coding scheme</td>
<td>CS-2</td>
</tr>
<tr>
<td>PDCHs fixed</td>
<td>1-4</td>
</tr>
<tr>
<td>PDCHs on-demand</td>
<td>0</td>
</tr>
<tr>
<td>C/I [dB]</td>
<td>12 (BLER = 13.5 %)</td>
</tr>
<tr>
<td>session inter-arrival time [s]</td>
<td>12</td>
</tr>
<tr>
<td>session prob. WAP / WWW / e-mail</td>
<td>pure or 60 / 12 / 28</td>
</tr>
</tbody>
</table>
Performance and system measures

- application response time
  - for each received file (WAP deck, e-mail or WWW page) the difference between the date of request from the client (GET request) and the date of reception at the client is calculated
  - from these values the mean value is calculated

- downlink IP throughput per user
  - during an ongoing transmission the downlink IP throughput for each user is calculated for each TDMA frame
  - from these values the mean value is calculated

- downlink IP system throughput per radio cell
  - the quotient of the total amount of received IP bytes in one radio cell divided by the regarded time period
  - equals the offered IP traffic (loss-free system)

- downlink PDCH utilization
  - the quotient of the number of transmitted radio blocks containing data or control information divided by the total number of transmitted radio blocks
Application Response Time

Application response time (pure)

Application response time (traffic mix)
PDCH Utilization

Downlink PDCH utilization (pure)

Downlink PDCH utilization (traffic mix)
Downlink IP Throughput per User

Throughput Performance (pure)

Throughput Performance (traffic mix)

DL IP throughput [kbit/s]

Number of MS

0 5 10 15 20

DL IP throughput [kbit/s]

Number of MS

0 5 10 15 20

WWW 4 PDCH
WAP 4 PDCH
e-mail 4 PDCH
Conclusions

- nearly constant WAP deck response time of ca. 2 seconds even for 20 active WAP users and 4 available PDCHs.
- With only 1 PDCH WAP response time increases to more than 10 seconds for 20 WAP users in the radio cell.
- Web page response time passes 20 seconds already with 10 active WWW users.
- In traffic mix scenarios WWW and e-mail performance not strongly affected by WAP traffic
- WAP response time increases slightly from 1.2 seconds for pure WAP traffic to 2.1 seconds for the traffic mix scenario.