Performance Study of Active Tracking in a Cellular Network

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Report from article

“Performance Study of Active Tracking in a Cellular Network Using a Modular Signaling Platform”

by Michal Ficek, Tomáš Pop, Petr Vláčil, Kateřina Dufková, Lukáš Kencl, Martin Tomek
What Will Be This Seminar About?

Performance analysis of system from telecommunication domain
Lets Start from the Very Beginning…

- ČVUT and RDC
  - [http://rdc.cz](http://rdc.cz)

- SS7Box:
  - Framework for prototyping

- SS7Tracker
  - LBS,
  - retrieving “position”
  - User tracking
What Is This Good For? Example: GMS Network Optimization

- Weak Location
- Approximate CR Boarder
- BTS Site Locations
Q: ”May be we would be interested in your system. Could you give us any assurance or at least estimation about minimal number of “position” queries per minute?“

A: ”Well,…, no.”
Background: SS7 and GSM Primer

- Cellular network
  - Base Transciver Stations, BSS, Cell-ID
  - switching subsystem,
    - Mobile Switching Center, Short Message SC
    - Home Location Register
    - Visitors Location Register
Background: Location Based Services

- Network does not know actual position of subscribed users
  - Location update
    - Device report position
  - Paging mechanism
    - Network wants to transfer data to device
    - Based on broadcasts in location areas

<table>
<thead>
<tr>
<th>Position Retrieval</th>
<th>Active (communicating devices)</th>
<th>Pasive (non-communicating devices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Based</td>
<td>Google Latitude</td>
<td>GPS</td>
</tr>
<tr>
<td>Network Based</td>
<td>SS7Tracker</td>
<td>VLR reading</td>
</tr>
</tbody>
</table>
How Does SS7Box Querying Cell-Id work?

- Key Idea: Force network to update VLR
- OK, but how?
- “Invisible” SMS
Performance Evaluation

• Possible bottlenecks
  • Hardware, Software architecture, network,…

• Tunable Parameters of the tracking

• Measure network behavior
  • i.e. distributions of service response times

• Simulation
  • To find best values for parameters

• Simulation verification

• Evaluation
Constraints – Network & Interconnection

- **GSM network**
  - Limited probably BTS air interface
    - ~60 SMS per minute for typical (12 channel) BTS

- **SMS Based tracking**
  - Minimal time between two consecutive queries

- **Interconnection**
  - E1 telephony line
    - ~ 64 kB/s
  - Link utilization
    - Operator policies
    - =>Bursts
Constraints – SS7Box

- **Hardware**
  - Memory, CPU
  - Signaling card
    - Max 4096 dialogs
- **Software**
  - Number of queues
  - Queue size
  - Message pool
Constraints – Impact on Tracked Device

- Invisible SMS has “no” effect
- What about battery consumption?
- How often have to be send?
Measuring Simulation Characteristics

- Service response times
  - Network: HLR, SMSC, VLR response times
  - Message delivery time
  - SS7Box working time
  - Message length
Measuring Simulation Characteristics

• Measurement
  • 500 users
  • 2 minutes tracking interval
  • 6 hours
  • 10 users *in burst*
• 700 000 messages
• Is 500 users adequate to obtain statistical analysis of mobile user population?
  • Yes for 95% confidence level and 5% confidence interval a population research was interested in.
• Is the selection representative?
  • ?
Measuring Simulation Characteristics

<table>
<thead>
<tr>
<th>Interval (service)</th>
<th>Time [s] median</th>
<th>Time [s] 95% quantile</th>
<th>msg len [B] req</th>
<th>msg len [B] res</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{SRI}$ (HLR)</td>
<td>0.3572</td>
<td>0.4910</td>
<td>107</td>
<td>121</td>
</tr>
<tr>
<td>$T_{SMS}$ (SMSC)</td>
<td>0.4384</td>
<td>0.5135</td>
<td>130</td>
<td>107</td>
</tr>
<tr>
<td>$T_{PSI}$ (VLR)</td>
<td>0.1392</td>
<td>0.1790</td>
<td>100</td>
<td>145</td>
</tr>
</tbody>
</table>

Table 5: Service response time distribution

<table>
<thead>
<tr>
<th>Interval</th>
<th>Time [s] median</th>
<th>Time [s] 95% quantile</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{SRLSMS}$</td>
<td>0.0769</td>
<td>0.1374</td>
</tr>
<tr>
<td>$T_{SMSPSI}$</td>
<td>9.0860</td>
<td>9.2074</td>
</tr>
<tr>
<td>$T_{PSLPSRI}$</td>
<td>119.8939</td>
<td>120.0146</td>
</tr>
</tbody>
</table>
Simulation Model

- Discrete time
  - G/G/1 model
    - literature
- Probabilistic
- Closed
  - New retrieval after previous finished
- Stable
Simulation Results – Number of Dialogs

![3D graph showing the number of TCAP dialogues against tracking interval and number of users. The graph indicates a pattern where the number of dialogues decreases as the tracking interval increases, for a fixed number of users.]
Simulation Results – Signaling Link Utilization

• Bust 5 vs. 15
• 1000 users
• ½ hour
• Int 90s
• T-SMS 10s
• 1s burs delay

• Bust size 5
• 1000 users
• 1 hour
• T-SMS 10s
• 1s burs delay
Simulation Results – Maximal Nr. SMS Sent

- 1000 users
- 1 hour
- T-SMS 10s
- 1s burs delay
Simulation Validation

- Validation values from simulation against measured values (link utilization)
  - Burst size 5
  - 500 users, 2 minute interval
  - 1 hour
  - T-SMS 10s
  - 1s burs delay
- Measured value is 3.39% higher than simulation results
  - Could be consequence of real user behavior
    - e.g. migration to rival networks
Q: “May be we would be interested your system. Could you give us any assurance or at least estimation about minimal number of “position” queries per minute?“

A: ”Yes, sure. Tracking 1000 people with 2 minute interval is OK. If you are interested in other parameters, we simulated it easily”
About The Article

• 16 pages, 6 authors
  • Many thanks to
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