Battling demons and vampires on your lunch break…

Switchboard: A Matchmaking System for Multiplayer Mobile Games

Justin Manweiler, Sharad Agarwal, Ming Zhang, Romit Roy Choudhury, Paramvir Bahl

ACM MobiSys 2011
Breakthrough of Mobile Gaming

Windows Phone 7
Top 10+ apps are games

iPhone App Store
350K applications
20% apps, 80% downloads

47% Time on Mobile Apps Spent Gaming

John Carmack (Wolfenstein 3D, Doom, Quake)…
“multiplayer in some form is where the breakthrough, platform-defining things are going to happen in the mobile space”
Mobile Games: *Now and Tomorrow*

**Increasing Interactivity**

- **Single-player Mobile**
  - (mobile today)

- **Multiplayer Turn-based**
  - (mobile today)

- **Multiplayer Fast-action**
  - (mobile soon)
Key Challenge

Bandwidth is fine: **250 kbps** to host 16-player Halo 3 game

**Delay bounds are much tighter**

Challenge: find groups of peers than can play well together

<table>
<thead>
<tr>
<th>Game Type</th>
<th>Latency Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-person, Racing</td>
<td>≈ 100 ms</td>
</tr>
<tr>
<td>Sports, Role-playing</td>
<td>≈ 500 ms</td>
</tr>
<tr>
<td>Real-time Strategy</td>
<td>≈ 1000 ms</td>
</tr>
</tbody>
</table>
The *Matchmaking* Problem

End-to-end Latency Threshold

Match to satisfy total delay bounds
Instability in a Static Environment

Due to instability, must consider latency distribution.
End-to-end Latency over 3G

Peer-to-peer reduces latency and is cost-effective.
The **Matchmaking** Problem

- **Targeting 3G:** *play anywhere*
- **Latency** not Bandwidth, *interactivity is key*
- **Measurement / Prediction** at game timescales

- **Link Performance**
- **Grouping**
- **P2P Scalability**
Requirements for 3G Matchmaking

- **Latency estimation has to be accurate**
  - Or games will be unplayable / fail

- **Grouping has to be fast**
  - Or impatient users will give up before a game is initiated

- **Matchmaking has to be scalable**
  - For game servers
  - For the cellular network
  - For user mobile devices
State of the Art

- **Latency estimation**
  - Pyxida, stable network coordinates; Ledlie et al. [NSDI 07]
  - Vivaldi, distributed latency est.; Dabek et al. [SIGCOMM 04]

- **Game matchmaking for wired networks**
  - Htrae, game matchmaking in wired networks; Agarwal et al. [SIGCOMM 09]

- **General 3G network performance**
  - 3GTest w/ 30K users; Huang et al. [MobiSys 2010]
  - Interactions with applications; Liu et al. [MobiCom 08]
  - Empirical 3G performance; Tan et al. [InfoCom 07]
  - TCP/IP over 3G; Chan & Ramjee [MobiCom 02]
A “Black Box” for Game Developers

End-to-end Performance
Crowdsourced Measurement

Link Performance (over time)
Crowdsourcing 3G over Time

Latency
Similarity
by Time

Time
Crowdsourcing 3G over Space

Latency Similarity by Distance
Can we *crowdsource* HSDPA 3G?

- **How does 3G performance vary over time?**
  - How quickly do old measurements “expire”?
  - How many measurements needed to characterize the latency distribution?

- **How does 3G performance vary over space?**
  - Signal strength? Mobility speed?
  - Phones under same cell tower?
  - Same part of the cellular network?
  - ...
Methodology

● **Platform**
  - Windows Mobile and Android phones
  - HSDPA 3G on AT&T and T-Mobile

● **Carefully deployed phones**
  - Continuous measurements
  - Simultaneous, synchronized traces at multiple sites

● **Several locations**
  - Princeville, Hawaii
  - Redmond and Seattle, Washington
  - Durham and Raleigh, North Carolina
  - Los Angeles, California
Stability over *Time* (in a Static Environment)

Redmond, AT&T, 15m Intervals

- **Empirical CDF**
  - RTT (Msec)

- **Black line** represents phone 1
  - **(all other lines phone 2)**

- **Live characterization is necessary and is feasible**
  - Performance drifts over longer time periods
  - Similar latencies under the same tower
Stability over Space (at the same time)

- Similarity at the same cell tower
- Substantial variation
- Divergence between nearby towers

Empirical CDF

RTT difference at 90th percentile (ms)
**Switchboard**: crowdsourced matchmaking

- **Phone Client**
  - Game
  - Network Testing Service

- **Switchboard Cloud Service on MSFT Azure**
  - Grouping Agent
  - Latency Data
  - Measurement Controller
  - Latency Estimator

- **Game Network Testing Service**
Scalability through *Reuse*…

- **Across Time**
  - Stable distribution over 15-minute time intervals

- **Across Space**
  - Phones can share probing tasks equitably for each tower

- **Across Games**
  - Shared cloud service for any interactive game
Client Matchmaking Delay

Switchboard clients benefit from deployment at scale.
Conclusion

- Latency: key challenge for fast-action multiplayer
- 3G latency variability makes prediction hard
- Crowdsourcing enables scalable 3G latency estimation
- Switchboard: crowdsourced matchmaking for 3G
k you!

cs.duke.edu/~jgm
jgm@cs.duke.edu