Switchboard: A Matchmaking System for Multiplayer Mobile Games

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Motivation

U.S. Mobile App Consumption, Time Spent per Category

- Games: 47%
- Social Networking: 32%
- News: 9%
- Entertainment: 7%
- Other: 5%

Source: Flurry Analytics, May 2011

• Infancy of mobile game
Challenge

• Estimation of network performance between players.
  – accurate and scalable

• Grouping players
  – Constraints
    • Network performance of players
    • Game characteristics
  – Quick

• Play well together
Matchmaking

End-to-end Latency Threshold

Connection Latency
Instability of 3G latency

[Graph showing the median latency over time from 9:36 AM to 12:00 PM.]
End-to-End latency over 3G

Empirical CDF

RTT (in ms)

AT&T to AT&T Direct
AT&T to AT&T via Bing
AT&T to AT&T via Duke
AT&T to AT&T via UW
Measurement of latency
Interval size

![Graph showing the relationship between Mean Sequential Difference and Interval Size (in minutes). The graph includes lines for 95th, 90th, 50th, and 25th percentiles.](image)
Frequency of measurements

Empirical CDF

RTT difference at 90th percentile (in ms)
Stability over time

Redmond, AT&T, 15m Intervals

Black line represents phone 1 (all other lines phone 2)
Stability over space

Empirical CDF

RTT difference at 90th percentile (ms)

Seattle Experiment

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End-to-End performance

Empirical CDF vs. RTT (ms)

- Durham FRH to San Antonio FRH
- Durham phone to FRH
- San Antonio phone to FRH
- Phone to phone
Switchboard
Switchboard

Phone Client

Game

Network Testing Service

Switchboard Cloud Service on MSFT Azure

Grouping Agent

Latency Data

Measurement Controller

Latency Estimator
ICMP Probes by Client Arrival Rate

Empirical CDF

ICMP Probes per Client

1 client/s
2 clients/s
5 clients/s
10 clients/s
Scalability by Client Arrival Rate

![Graph showing client-to-server traffic over time for different client arrival rates (1, 2, 5, and 10 clients per second). The y-axis represents client-to-server traffic in Kbps, and the x-axis represents time in minutes.]
Group Size by Client Arrival Rate

![Graph showing empirical CDF for different client arrival rates. The x-axis represents the size of the client group, and the y-axis represents the empirical CDF. The legend explains the lines as follows: 1 client/s (black solid), 2 clients/s (red dashed), 5 clients/s (blue dotted), and 10 clients/s (purple solid).]
Client Matchmaking Delay

![Empirical CDF of Time until placed in group (s)]

- Red line: Total 1 client/sec
- Blue line: Total 10 clients/s
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
Discussion

• Only for P2P?
  – Group more than 10 clients

• WiFi: what is going to be different under the WiFi environments?
  – Other factors interrupting communication
  – Different speed
Discussion (cont.)

• Under the dynamic environment?
  – If people move around, latency will differ.

• Hybrid with geography-base grouping
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