Empirical QoE Study of In-Home Streaming of Online Games

Ivan Slivar, Mirko Suznjevic, Lea Skorin-Kapov, Maja Matijasevic

University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, Zagreb, Croatia
Problem - What, how and why?

- How does using in-home game streaming affect QoE when compared to “traditional” game clients for use in an online game?

- QoE measurements in which we compare playing sessions on a traditional and streaming game client for various Internet connection parameters.

- Basis for a QoE model for in-home cloud gaming taking into account not only the local network characteristics, but the whole household network.
Outline

- Problem
- Introduction
- Research assumptions and questions
- Methodology
- Results
- Conclusion

NetGames 2014, Nagoya, Japan
Introduction

- Cloud gaming - game logic and rendering is located on the server side and only the results are sent to the clients in a form of a video stream (most often) while the clients send the user input to the server
  - Reduces computing requirements of end user devices
  - Increases bandwidth and latency network requirements

- Server location:
  - Cloud gaming - game server in the cloud
    - OnLive
    - StreamMyGame
    - PlayStation Now
  - In-home game streaming - game server in local network
In-home game streaming

♦ Local network
  ■ Very high amount of bandwidth
  ■ Very low latency

♦ Local server
  ■ Relatively low computing capabilities
  ■ Usually 1:1 streaming capabilities

♦ Use cases
  ■ Playing on devices with lower hardware capabilities
  ■ Playing on devices with other operating systems
  ■ Use for games in education

♦ Exemplary services
  ■ Sony’s Remote Play service
  ■ Valve’s In-home streaming within Steam client
Research assumptions and questions

- **A:** Player’s incentive for using in-home streaming is usually more adequate position (e.g., playing in living room or in the bed)
- **Q:** How does the QoE degradation imposed by streaming client measure against such incentive? Do players still want to play under deteriorated conditions?
Reasarch assumptions and questions II

- **A:** Typical household has a wireless LAN with high bandwidth, low latency and packet loss, but has limited Internet connection (e.g., ADSL line) on which degradations can occur.
- **Q:** How do degradations appearing on the Internet link affect the QoE when playing?
A: Players’ resilience to latency in MMORPGs found in our previous studies is attributed to the masking effect of other degradations.

Q: Are players tolerance towards high latency values going to be the same in the case in which only latency is added?
Pre-survey

♦ Goal: To gather data about participant’s previous gaming experience, preferences, and self-assessed skill

♦ Test participants
  ■ 35 students
  ■ 7 experienced, 17 intermediate, and 11 novice players
  ■ 21 male and 14 female
  ■ Ages 22-28 with average of 23
  ■ Only several players actually had experience with the game under test - World of Warcraft

♦ Results of the pre-study were used to form balanced groups for subjective testing
  ■ Each group had 2 female players
  ■ Each group had one experienced and at least one novice player
Manipulated Internet network parameters on both uplink and downlink - 16 test scenarios
- Added delay of 75 ms, 150 ms and 225 ms (native around 40ms)
- Added loss of 3%, 5%, and 7% (manifesting as spikes of delay as WoW uses TCP)

Used cloud gaming platform: GamingAnywhere - open source cloud gaming solution
- Default settings - only 3 Mbit/s, 30 FPS
- Periodic mode - due to difficulties of running WoW in event driven mode

Each test scenario comprised of two phases
- 1. playing on the WoW client - players reported QoE (on a MOS scale 1-5)
- 2. playing on the GA client - players reported perceived degradation of the QoE (on a DMOS scale 1-5)
- Players also reported whether they would continue playing in the given conditions after each phase
Testbed

- Network parameters were simulated using IMUNES
- Players would swap between PCs for different experiment phases
Players show very high resilience to latency and loss!! Why?
- Is masking effect produced by a switch to GA client?
- Lack of experience with the game?

ANOVA applied to obtain the model

\[ MOS = 4.7059 - 0.00094 \times ND - 5.83444 \times PL \]
Results - Goodness of fit of the QoE model

- Reasonably good fit of the model
Results - degradation from switching to streaming client

- The switch between WoW client and GA client is always the same yet significant differences exist in the reported degradation!
- ANOVA applied to obtain the model

\[
DMOS = 3.5578 - 0.00081 \times ND - 5.4473 \times PL
\]
Results - Goodness of fit of the degradation model

- Slightly more dissipation when compared to a QoE model
Perceived degradation depends on the level of the degradation currently existing in the system!

IQX hypothesis: “change in QoE with respect to QoS degradation depends on the current QoE level”

\[ y = 0.3004x + 1.8954 \]
\[ R^2 = 0.99347 \]

Results - relation between existing degradation and newly introduced one II
Results - Players’ willingness to continue

- Online gaming
- In-home game streaming

Novice players | Intermediate players | Skilled players

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Conclusions & Future work

- QoE of the in-home cloud gaming for online games depends on the characteristics of the Internet connection (even if the cloud gaming stream does not go through it)

- MMORPG players without previous experience in the game are very tolerant to network latencies up to 450 ms
  - Should QoE studies only be done on the players who have experience with the game under test?

- Under testing conditions (which could be considered worst case) slightly less than 50% of players would continue playing on GA

- Future work
  - Tests with more bandwidth options
  - Testing newly available platforms (e.g., Steam)
  - Developing a QoE based bandwidth allocation strategy