Correlating the Perceived Quality of Networked Games to Broadband Cable Network Design Parameters

Project Update: 11/01/2011

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School of Computing

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Jackson, Andrea Johnson, Phillip Hall, Marquita Frazier, Marvin Andujar, Pharen Johnson
Objective

- The objective of this project is to
  - Find the MOS utility functions for a set of Internet-based games; and
  - Correlate these functions to the design and optimization of modern DOCSIS-based cable networks.

- Procedure/methods
  - Phase 1: **Survey of relevant games and related work.** There are a tremendous number of games, some more relevant to that study than others. The objective of this phase is to develop a classification method (i.e., a taxonomy) that allows us to identify sets of games that are linked in meaningful ways. The output of this phase will be a brief survey paper that describes the taxonomy.
  - Phase 2: **Develop the study methodology.** This will involve the design and prototype of the cyberinfrastructure required to support a set of games that will be studied. The number of human subjects required for each game will be identified along with all details of the experimental design. A thorough ‘calibration’ phase is required.
  - Phase 3: **Conduct subject tests.**
  - Phase 4: **Analyze the results.**
  - Phase 5: **Develop the final paper.**
Progress to Date

- Phase 1: Survey of relevant games and relevant related work. There are a tremendous number of games, some more relevant to that study than others. The objective of this phase is to develop a classification method (i.e., a taxonomy) that allows us to identify sets of games that are linked in meaningful ways. The output of this phase will be a brief survey paper that describes the taxonomy.

- Phase 2: Develop the study methodology.
  - Infrastructure
  - Study design

- Phase 3: Conducting the tests. (At this step right now)
  - Dealing with Logistics
  - Gathering data

Important Message:
- Games under study: Call of Duty Modern Warfare II, World of Warcraft. Note: logistics might prevent all user studies from being carried out this semester.
- All discussion today is based on Call of Duty. There will likely be many changes to the study methodology when the second game is studied
- For Call of Duty, we are thinking of NOT having Voice active during the testing
Network Model

- This model is based on a session of Call of Duty Modern Warfare II.
Traceroute from our Network to Microsoft’s

[root@netlab-gw 6-23-2011]# traceroute -T 65.55.42.52
traceroute to 65.55.42.52 (65.55.42.52), 30 hops max, 40 byte packets
  1  cs-gateway.cs.clemson.edu (130.127.48.1)  3.588 ms  3.726 ms  3.945 ms
  2  130-127-1-29.generic.clemson.edu (130.127.1.29) 0.370 ms  0.500 ms  0.550 ms
  3  130.127.3.21 (130.127.3.21) 0.473 ms  0.489 ms  0.550 ms
  4  poole-border-01.clemson.edu (130.127.3.1) 1.257 ms  1.408 ms  1.149 ms
  6  205-186-63-2.generic.c-light.net (205.186.63.2) 3.917 ms  3.868 ms  3.835 ms
  7  nlr-to-slr.so.x.net (143.215.193.5) 91.287 ms  91.356 ms  91.290 ms
  8  216.24.186.55 (216.24.186.55) 85.897 ms  85.717 ms  85.732 ms
  9  216.24.186.78 (216.24.186.78) 85.842 ms  85.999 ms  85.882 ms
 10  216.24.186.77 (216.24.186.77) 86.250 ms  86.140 ms  86.154 ms
 11  216.24.186.80 (216.24.186.80) 86.108 ms  85.950 ms  86.001 ms
 12  216.24.186.70 (216.24.186.70) 86.054 ms  85.944 ms  85.916 ms
 13  216.24.186.68 (216.24.186.68) 85.750 ms  85.651 ms  85.558 ms
 14  microsoft-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.7) 85.895 ms  86.080 ms  86.205 ms
 15  ge-7-3-0-58.wst-64cb-1a.ntwk.msn.net (207.46.46.41) 85.988 ms  86.000 ms  86.073 ms
 16  ge-0-1-0-0.co1-64c-1a.ntwk.msn.net (207.46.43.162) 90.079 ms  89.997 ms  90.011 ms
 17  ge-2-3-0-0.co1-64c-1b.ntwk.msn.net (207.46.35.151) 90.766 ms  90.767 ms  89.871 ms
 18  ten9-1.co1-76e-1.ntwk.msn.net (207.46.47.189) 89.795 ms  89.907 ms  89.802 ms

Whois 65.55.42.52
Microsoft Corp MICROSOFT-1BLK (NET-65-52-0-0-0-1) 65.52.0.0 - 65.55.255.255
American Registry for Internet Numbers NET65 (NET-65-0-0-0-0) 65.0.0.0 - 65.255.255.255

Whois 207.46.43.162
Microsoft Corp MICROSOFT-GLOBAL-NET (NET-207-46-0-0-1) 207.46.0.0 - 207.46.255.255
American Registry for Internet Numbers NET207 (NET-207-0-0-0-0) 207.0.0.0 - 207.255.255.255
Network Testbed

- Broadband Access Network:
  - Downstream Rate: (1Gbps, 15 Mbps, 6 Mbps)
  - Upstream Rate: (1 Gbps, 2 Mbps, 1 Mbps)
- Summary of Experiments:
  - A group of 8 players
  - (2) Participants: Two users will play and provide their assessment
  - (6) Players: A small set of players who provide a consistent level of play (they will not be asked for their assessment)
Infrastructure Work: Finding the Right Emulation Settings

- Possible emulated network ‘environments’
  - ETHERNET: 1 Gbps Full-duplex link
  - BROADBAND High Speed: 20 Mbps Downlink, 2 Mbps Uplink
  - BROADBAND Medium Speed: 10 Mbps Downlink, 1 Mbps Uplink
  - BROADBAND High Speed With Background Traffic
  - Vary network delay and packet loss settings in uplink and/or downlink directions
  - Gather performance metrics of interest which include: Throughput, Latency, Jitter, Average Loss Rate, Measure of Level of Correlated Loss (Mean Burst Loss Length and Mean Inter Loss Distance, referred to as MBL, MILD)
  - We need a ‘calibration’ effort where we can fine tune and select the settings that will be used for the testing
Calibration studies

- Calibration
  - Make sure that the emulated environment with the specified congestion parameters works as expected

- Congestion Parameters studied
  - Constant Delay/Latency
  - Latency with Jitter
  - Independent Packet Loss
  - Correlated Packet Loss
Calibration Tools

- Iperf – TCP Throughput measurement
  - Window Size – 256 Kbyte (Maximum Allowed)
  - Duration – 1 minute (60 seconds)
  - Bidirectional Test – Uplink and Downlink
- VoIP Traffic Generator – Packet Latency, Loss, Jitter, MBL, MILD metrics
  - CBR Traffic – 100 byte packets
  - Throughput – 30 kbps (based on Gameplay TCPDump capture)
Calibration: Gaming Bandwidth Consumption

- **Settings:** Rate - 128 kbps Uplink, 128 kbps Downlink
  - Delay - 0 ms Uplink, 0 ms Downlink

- **Downlink Traffic:** ~30 kbps
- **Uplink Traffic:** ~15 kbps
- **Random Traffic:** ~ 0-5 kbps
Calibration Findings

- Latency, Jitter and Independent Packet Loss work as expected
- Correlated Packet Loss does not work
  - Decreases the average packet loss as correlation is increased
  - Any average packet loss rate under 50% will be affected by this incorrect implementation
- Based on these findings, we will focus on latency, jitter and uncorrelated packet loss for the pilot studies
  - Latency, Jitter (Experiments on Thursday)
  - Independent Packet Loss, Host Game on Congested Network (Experiments on Friday)
Pilot Study Experiment Setup

- Internet
- Linux Router
  - OS: CentOS
  - Netem Support
- Cisco Switch
- Xbox 360
  - Congested User
- LCD TV
- All other Gamers

Eth0: Uplink/Outgoing Packets Controlled
Eth1: Downlink/Incoming Packets Controlled
### Pilot Studies Congestion Settings

<table>
<thead>
<tr>
<th>Thursday’s Experiment Run Number</th>
<th>Latency (UL)</th>
<th>Latency (DL)</th>
<th>Jitter (UL)</th>
<th>Jitter (DL)</th>
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## Pilot Studies Congestion Settings

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<th>Latency(UL)</th>
<th>Latency(DL)</th>
<th>Jitter(UL)</th>
<th>Jitter(DL)</th>
<th>Host: Congested User</th>
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Experimental Components

- Flyer
- Study Parameter Matrix
- Explanation of Experiment
- Information Letter and Consent Letter
- Pre and Post Surveys
- Metrics
Clemson University
School of Computing
Human Centered Computing Division

Research Study Advertisement

Do you play video games such as Call of Duty??

Principal Investigator: Dr. Juan Gilbert, PhD

Who is conducting the study: Dr. Juan Gilbert, Dr. James Martin and their research assistants in the School of Computing

Purpose: To observe user satisfaction while playing online video games

Who can participate in the study: All individuals who are 18 years or older and are familiar with FPS games such as Call of Duty: Modern Warfare 2

Who do I contact if I have questions about participation in the study? If you would like to request further information about this study, you can contact France Jackson fjacks@clemson.edu, Andrea Johnson andrea5@clemson.edu, Marquita Frazier marquf@g.clemson.edu or Dr. Juan Gilbert juan@clemson.edu

This flyer will be posted around Clemson University’s campus and sent out via email blasts.
# Study Parameter Matrix

<table>
<thead>
<tr>
<th>Experimenter</th>
<th>Participant#</th>
<th>Pre Survey</th>
<th>Post Survey</th>
<th>Centralized Game Server</th>
<th>Peer Game Server</th>
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<td>Yes</td>
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<tr>
<th>Condition</th>
<th>Delay</th>
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<tr>
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<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
</tbody>
</table>
Explanation of Experiment

- There will be 2 sets of participants in this experiment:
  - 2 participants that will be playing on the congested network … referred to as “Participants”
  - 6 participants that will be playing from home to create a controlled background of competitors during each session… referred to as “Gamers”

- Each game session is approx. 10 minutes (not including pre and post surveys)

- Before beginning the experiment all participants and gamers must sign the information letter and consent form
Explanation of Experiment

- After the experiment is explained, the pre survey will be filled out by the “participants”.
- Gamers will wait to be invited to the session via Xbox Live and the game session will begin.
- Following the game the post survey will be completed by the “participants”.
Pre-Survey Questions

• Age: ____________________________

• Gender: Male  or Female  circle one

• How do you describe yourself?
  American Indian or Alaska Native
  Hawaiian or other Pacific Islander
  Asian or Asian American
  Black or African American
  Hispanic or Latino
  Non-Hispanic White

• How many hours a week do you play?
  (0-20) (21-40) (41-60) (61-80) (81+)

• What types of games do you play?
  MMOG  Sports  Racing  Shooter  Other
  If other,____________________________________
  Name the top 3 games that you play?

• What consoles do you play with?
  Xbox360  PS3  Wii  PSP  Nintendo DS  PC  Other
  If other____________________________________

• Which console do you play with the most?

• Do you use an Ethernet (wired) or wireless connection?

• Who is your cable provider?

• What is the speed of your connection?
  (Verizon high speed or Fios)
Post-Survey Questions

- How satisfied were you with your gameplay?
  Dissatisfied       somewhat satisfied    satisfied       very satisfied

- If not satisfied or somewhat satisfied, please explain why?

- Were you frustrated you during your gameplay?
  Yes or No

- If yes, rate your level of frustration
  Not frustrated       somewhat frustrated  frustrated   very frustrated

Two Additional questions:
1. Did you notice any delay while you were playing?
2. Do you think the delay impacted your performance?
What are we measuring?

- Once this study is complete we will be able to take the post survey and determine the overall user satisfaction as it relates to the delay participants actually experienced as well as the delay they “think” they experienced.
- We will also be able to look for a correlation between the amount of delay induced and the participant’s performance.
Pilot Studies Results - Latency

**Mean Opinion Score Scale 1**

<table>
<thead>
<tr>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: very satisfied, no frustration</td>
</tr>
<tr>
<td>3: satisfied, no frustration</td>
</tr>
<tr>
<td>2: satisfied, somewhat frustrated</td>
</tr>
<tr>
<td>1: somewhat satisfied, somewhat frustrated</td>
</tr>
<tr>
<td>0: dissatisfied, frustrated</td>
</tr>
</tbody>
</table>

**Mean Opinion Score Scale 2**

<table>
<thead>
<tr>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>3: very satisfied, no frustration</td>
</tr>
<tr>
<td>2: satisfied, no/somewhat frustrated</td>
</tr>
<tr>
<td>1: somewhat satisfied, somewhat frustrated</td>
</tr>
<tr>
<td>0: dissatisfied, frustrated</td>
</tr>
</tbody>
</table>

**Mean Opinion Score: Scale 1**

**Mean Opinion Score: Scale 2**
Pilot Studies Results – Jitter

### Mean Opinion Score Scale 1

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Score</th>
</tr>
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<tbody>
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<td>very satisfied, no frustration</td>
<td>4</td>
</tr>
<tr>
<td>satisfied, no frustration</td>
<td>3</td>
</tr>
<tr>
<td>satisfied, somewhat frustrated</td>
<td>2</td>
</tr>
<tr>
<td>somewhat satisfied, somewhat frustrated</td>
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<tr>
<td>dissatisfied, frustrated</td>
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### Mean Opinion Score Scale 2

<table>
<thead>
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<th>Feedback</th>
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<td>1</td>
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<tr>
<td>dissatisfied, frustrated</td>
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</tbody>
</table>

### Mean Opinion Score: Scale 1

- **Congested User**
- **Normal User**

### Mean Opinion Score: Scale 2

- **Congested User**
- **Normal User**
Mean Opinion Score: Scale 1

Mean Opinion Score: Scale 2

Packet Loss (Percentage)

MOS

Congested User

Normal User

Pilot Studies Results – Packet Loss

<table>
<thead>
<tr>
<th>Mean Opinion Score Scale 1</th>
<th>Feedback</th>
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<tbody>
<tr>
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<th>Mean Opinion Score Scale 2</th>
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<td>3</td>
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### Pilot Studies Results – Jitter with Congested User Host

#### Mean Opinion Score: Scale 1

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<th>MOS</th>
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#### Mean Opinion Score: Scale 2

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<th>MOS</th>
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<tr>
<td>0</td>
<td>dissatisfied, frustrated</td>
</tr>
</tbody>
</table>

- **Mean Opinion Score Scale 1**
  - **Congested User**: MOS decreases with increasing jitter, reaching a minimum at around 250 ms and then increases again. MOS is highest at 0 ms jitter. 
  - **Normal User**: MOS is consistently lower than the Congested User, indicating better performance.

- **Mean Opinion Score Scale 2**
  - **Congested User**: MOS decreases sharply with increasing jitter, reaching a minimum at around 200 ms and then increases again. MOS is highest at 0 ms jitter. 
  - **Normal User**: MOS is consistently lower than the Congested User, indicating better performance.
Pilot Studies Results – Correlation Between MOS and Game Scores

**Mean Opinion Score: Scale 1**

- Congested User
- Normal User

**Future Correlation Plot w/ Confidence Interval**

Game Host: Normal User

- Congested User
- Normal User 1
- Normal User 2
- Normal User 3
- Normal User 4
- Normal User 5

**Game Host: Normal User**

- Congested User
- Normal User 1
- Normal User 2
- Normal User 3
- Normal User 4
- Normal User 5

**Final Score**

- 0
- 200
- 400
- 600
- 800
- 1000
- 1200
- 1400
- 1600

**Delay (ms)**

- 0
- 100
- 200
- 300
- 400
- 500

**Kills/Deaths Ratio**

- 0
- 0.5
- 1
- 1.5
- 2
- 2.5
- 3

**Delay (ms)**

- 0
- 100
- 200
- 300
- 400
- 500
Pilot Studies Results – Correlation Between MOS and Game Scores

Mean Opinion Score: Scale 1

Game Host: Normal User

Game Host: Normal User

Kills/Deaths Ratio

Final Score

Jitter (ms)
Pilot Studies Results –
Correlation Between MOS and Game Scores

Mean Opinion Score: Scale 1

Game Host: Normal User 1

Game Host: Normal User 1
Pilot Studies Results – Correlation Between MOS and Game Scores

**Mean Opinion Score: Scale 1**

- **Congested User**
- **Normal User**

**Game Host: Congested User**

- **Congested User**
- **Normal User 1**
- **Normal User 2**
- **Normal User 3**
- **Normal User 4**
- **Normal User 5**

**Game Host: Congested User**

- **Congested User**
- **Normal User 1**
- **Normal User 2**
- **Normal User 3**
- **Normal User 4**
- **Normal User 5**