Interactive 3D Services over Windows Azure

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Agenda

- Objectives
- Interactive 3D platforms in Windows Azure
  - 3D shop – single user
  - 3D teapot – multi-user
- Demo
- Performance
- Lessons learned & future work
- Shameless advert
Principal Questions

- How to create and distribute 3D interactive environments over the cloud?
- How to enable their creation for 3rd parties?
- How to do it on Windows Azure?
Inspiration: (own, past) 3D Mobile Internet Project

- Interactive 3D client-server solutions
  - 3D Mobile Talking Head
  - 3D e-Shop
- Technology
  - VRML, Server scripts
  - Standalone application or 3D-viewer plugin
  - Server-based speech recognition and synthesis
- internet3d.rdc.cz
- Best Paper Award, Danihelka, Hak, Kencl, Zara. 3D Talking-Head Interface to Voice-Interactive Services on Mobile Phones. SiMPE Workshop at MobileHCI 2010
- Android and iPhone licenses sold commercially
- Careful considerations of functionality distribution
Long-term project big picture: 3D Interactive Cloud Services

- Natural interaction: speech, 3D environment, real-time, multi-user
- Architecture: new graphics technologies together with cloud scalability & functions
- Fast creation & deployment of cloud-based 3D apps (e-Shops, Games, Education, etc)
- Early prototypes:
  - client-side rendering of a talking-head interface on desktop Windows using Silverlight;
  - client-cloud virtual shop with 3D content using Windows Azure;
  - Shared 3D teapot using Silverlight, Azure and various clients.
Related work

- Second Life
  closed server infrastructure

- RuneScape
  cloud MMORPG (Amazon)

- Social games in Azure (turn based)

- Tankster

- Vampire Legacy

- Is Azure good for this?
Prototype I: Single-user 3D shop with Talking Head on Azure

**Client** (MS Silverlight5 in browser)
- 3D Store content (3D models, textures)
- XNA drawing surface
- Virtual 3D Store app (.xap file)
- MS Silverlight runtime plugin 5
- Web browser (IE, Firefox, Chrome)
- Windows OS (later also Linux and Mac)
- Graphics accelerated hardware

**Cloud** (Windows Azure)
- Content data files
- Virtual 3D Store (.xap file)
- Azure Storage
- Windows Azure
- Microsoft datacenter

1. request
2. .xap
3. request
4. .obj, .jpg

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Prototype II: 3D Teapot - Multi-user interaction with a shared 3D object

Silverlight browser client

XNA mobile app

<table>
<thead>
<tr>
<th>pitch</th>
<th>yaw</th>
<th>color</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30.5</td>
<td>34.5</td>
<td>#FFAC58</td>
</tr>
</tbody>
</table>

Represented by a simple, shared state
Client Software Architecture

XNA Rendering code

XNA based 3D

XNA Framework 4.0

XNA Interface (shaders, rendering context)

Silverlight application

Silverlight 5 Runtime

Windows Phone 7.5 Silverlight application

Windows Phone 7.5 Silverlight
Detailed architecture – browser client

1. http request
2. download SL 5 page
3. SOAP communication with web synchronization service using Windows Communication Foundation library (WCF)
4. store state to database using SQL queries and Entity Framework

- Azure Storage (Europe)
- Azure Compute (West USA)
- SQL Azure Server (South-Central USA)

Web Role

Client with web browser

pitch | yaw | color
---|---|---
-30.5 | 34.5 | #FFAC58
Detailed interconnection – mobile XNA client

1. download request

2. download application

3. SOAP communication with web synchronization service using Windows Communication Foundation library (WCF)

WP7 Marketplace (operated by Microsoft)

Application
SL 4 + XNA

Web Role

Azure Compute (West USA)

SQL Azure Server (South-Central USA)

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Windows Phone 7.5 Mango

Application
SL 4 + XNA
Teapot state synchronization protocol

**GetState**
- returns all fields of current state
- server does not maintain sessions

<table>
<thead>
<tr>
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<th>Yaw</th>
<th>R</th>
<th>G</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>158</td>
<td>68</td>
<td>45</td>
<td>200</td>
<td>150</td>
</tr>
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</table>

**UpdateState**
- sends relative change on client to server
- only changed fields sent
- client must track changes (maintain session)

<table>
<thead>
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<th>Pitch delta</th>
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<th>R</th>
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<th>B</th>
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</thead>
<tbody>
<tr>
<td>+15</td>
<td>-7</td>
<td>null</td>
<td>null</td>
<td>null</td>
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</table>

SL 5
– or –
SL 4 + XNA application
Measurement setup

- Configurable auto-movement of teapot
- Logging latency of `GetState` & `UpdateState` operations
- 2 scenarios:
  - 24 simultaneous instances at university classroom
    - Incrementally increasing # of instances
    - Excellent network connectivity
    - 2 instances per machine
  - 2 simultaneous instances at a public café (Starbucks, Prague center)
    - Typical use case
    - WiFi connectivity
# Measurements - Latency

## Classroom
- 24 instances

<table>
<thead>
<tr>
<th>Latency (ms)</th>
<th>Classroom</th>
<th>Starbucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>91.40</td>
<td>204.38</td>
</tr>
<tr>
<td>St Dev</td>
<td>165.86</td>
<td>100.95</td>
</tr>
<tr>
<td>Median</td>
<td>63</td>
<td>195</td>
</tr>
<tr>
<td>Min</td>
<td>46</td>
<td>78</td>
</tr>
<tr>
<td>Max</td>
<td>8078</td>
<td>2101</td>
</tr>
</tbody>
</table>

## Starbucks
- 2 instances

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Measurements - Latency

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<td>78.00</td>
<td>2101.00</td>
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</tbody>
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24 instances vs. 2 instances
Lessons Learned & Future Work

- **Azure lessons**
  - Carefully consider data-center and geographic distribution
    - SQL processing elsewhere?
  - Atomicity of SQL operations would be nice
  - Shared state closer to web/worker roles
  - UDP vs TCP
  - Latency large – cloudlets or CDNs

- **Further Work**
  - Much more measurements
  - Sharing state by other means?
  - Prototype 3: Multi-user seeing each other
  - Integrate with speech recognition and synthesis
  - Open platform for rapid 3\(^{rd}\) party configuration
  - Dynamic workload migration between client and cloud based on immediate conditions and context
  - Geographic distribution
Thank you! Q&A

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URLs:
www.rdc.cz
danihelka.blob.core.windows.net/sync/usa/index.html
danihelka.blob.core.windows.net/world//index.html
IFIP Networking 2012
Conference @ CTU, Prague

- May 21-25, 2012
- networking2012.cvut.cz/
- Renowned networking research conference
- Network Architecture, Applications and Services, Wireless and Sensor Networks, Network Science
- 64 papers, 28% acceptance rate, ~120 worldwide attendees
- 2012: IFIP TC6 40-year anniversary
- Keynotes by Vint Cerf (Google), Jon Crowcroft (Cambridge University), Pablo Rodriguez (Director, Telefonica R&D), Dina Katabi (MIT) and many others
- MSR sponsored – thank you!