S9156: STREAMING VR CONTENT FROM THE CLOUD

Rouslan Dimitrov, NVIDIA
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Workstation Graphics For Low-Power Devices
VR STREAMING TO ANY DEVICE
The Project’s Vision

Content → Cloud Servers → Internet → Clients
ARCHITECTURE

Cloud Server to HMD

VR App
- OpenVR Runtime
  - Virtual HMD Driver
  - Video Encoder
  - Virtual Audio Driver
  - Audio Encoder

GeForce Now
  - Driver

Internet

HMD
- Late & Lens Warp
- VR Runtime
  - Video Decoder
  - Audio Decoder

GeForce Now
  - App
QOS
Reliability & Resilience

Relevant Internet problems:

- Jitter
- Missed packets
- Bandwidth variation
QOS

Need to dynamically adjust:

• Jitter absorption queue size (for jitter)
• Forward error correction strength (for dropped packets)
• Video compression rate (for bandwidth variation)
LATENCY

Button to Photons

Using:

• HelloVR sample modified to change color on button press
• Latency meter (instrumented switch + photodiode)
• Local Cloud with Client on WiFi (average ping time 4 ms)
LATENCY

Button to Photons

Results:

<table>
<thead>
<tr>
<th></th>
<th>Latency [ms]</th>
<th>Stdev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local VR</td>
<td>38.3</td>
<td>3.4</td>
</tr>
<tr>
<td>CloudVR</td>
<td>81.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Diff</td>
<td>43.3</td>
<td>-0.1</td>
</tr>
<tr>
<td>Jitter FIFO + Ping</td>
<td>31.2</td>
<td></td>
</tr>
<tr>
<td>Diff – Above</td>
<td>12.1</td>
<td></td>
</tr>
</tbody>
</table>

Server Driver + Client App latency = 12.1 ms.

The Jitter FIFO can be downsized at the cost of occasional missed frames.

*Average of 40 clicks*
LATENCY

WIN SERVER

VR App

VR Runtime

Video Params (e.g. ROI, optional)

OpenVR Interfaces < 0.5 ms

RGFrame

Sensor & input data

Encode 3-10 ms

Frame Pacing

Decode 3-10 ms

Video / Audio / Data (sensors, inputs, QoS)

NVSS 1 ms

Audio Capture / Encode

NVSC

Install

CLIENT

Display

Controller & inputs

HMD

VR Runtime

Jitter FIFO

RGB Frame

Lens Warp

OpenVR Interaces (e.g., OpenVR)

Time Warp

10-50 ms (depending on network)

1-3 ms

Audio Playback

Audio / Video / Data (sensors, inputs, QoS)
DELIVERED FRAMES
No Motion, 1440x1600x2 @ 50 Mbps
DELIVERED FRAMES
No Motion, 1440x1600x2 @ 10 Mbps
DELIVERED FRAMES

Fast Motion, 1440x1600x2 @ 50 Mbps
DELIVERED FRAMES

Fast Motion, 1440x1600x2 @ 10 Mbps
See More VR on the Exhibition Floor

Expo Hall 3, Concourse Level

VR VILLAGE
Explore the VR Village to get hands-on with the latest advances in virtual reality (including Cloud VR Streaming)

VR THEATER
Go to the VR Theater to see and experience narrated VR demos built by our partners

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VR VILLAGE HOURS
Tuesday: 12:00pm - 7:00pm  Wednesday: 12:00pm - 7:00pm  Thursday: 11:00am - 2:00pm