Experiences with uncompressed high-definition internet TV for advanced collaboration

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GLORIAD-KR HDTV Group
One-way delay vs., user perception

- Will not need echo cancellation
- Will not notice the delay
- Will notice slight hesitation
- The delay is obvious to all users

Recommended upper E2E delay limit

- 20ms
- 100ms
- 150ms
- 200ms
- 300ms

- Domestic (Korea)
- East Asia
- North America
- Russia
- Europe
- Middle East
- Latin America
- Etc.

Round-trip-time/2 delay (including Encoding/decoding delay)

May 2006. Based on PingER history. ping from the east Asia to the world

http://www.gloriad-kr.org/hdtv
# Networked HDTV

<table>
<thead>
<tr>
<th></th>
<th>Compressed</th>
<th>Uncompressed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Res.</strong></td>
<td></td>
<td>Up to 1920x1080</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>19.2Mbps</td>
<td>1.485Gbps</td>
</tr>
<tr>
<td><strong>CODEC</strong></td>
<td>MPEG2</td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>Handle one stream with</td>
<td>Handle one stream with</td>
</tr>
<tr>
<td></td>
<td>high performance server</td>
<td>high performance server</td>
</tr>
<tr>
<td></td>
<td>(Single CPU)</td>
<td>(Dual CPUs)</td>
</tr>
<tr>
<td><strong>Delay</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>En/Decoding</td>
<td>1~2 seconds</td>
<td>0</td>
</tr>
<tr>
<td>Buffering</td>
<td>dependent on policy</td>
<td>Ideally, 0~5 frames</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0ms~166ms)</td>
</tr>
<tr>
<td><strong>Advantage</strong></td>
<td>- Low cost</td>
<td>- Low delay</td>
</tr>
<tr>
<td></td>
<td>- Low bandwidth</td>
<td>- Ultra-high quality</td>
</tr>
<tr>
<td></td>
<td>consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- high quality</td>
<td></td>
</tr>
<tr>
<td><strong>Disadvantage</strong></td>
<td>- High delay</td>
<td>- High cost</td>
</tr>
<tr>
<td></td>
<td>- sensitive to packet</td>
<td>- Large bandwidth</td>
</tr>
<tr>
<td></td>
<td>losses</td>
<td>consumption</td>
</tr>
<tr>
<td></td>
<td>- not fit into</td>
<td></td>
</tr>
<tr>
<td></td>
<td>interactive applications</td>
<td></td>
</tr>
<tr>
<td><strong>Killer apps.</strong></td>
<td>IPTV</td>
<td>Broadcasting</td>
</tr>
</tbody>
</table>

http://www.gloriad-kr.org/hdtv
Advantages of Streamed Uncompressed HDTV over Broadcast-style

1. Extremely low processing delay (No CODEC)
   - ideally, zero
2. Ultra-high presentation quality (No error propagation)
   - no temporal dependency
3. Accessibility to middleware technologies and network infra.
   - easy to apply it to numerous applications like education, entertainment, medical, and so forth.
4. Easy to merge and transport other types of media
5. Interactivity
   - support 1:1, 1:N, and limited N:N

http://www.gloriad-kr.org/hdtv
**Uncompressed HDTV in the World**

<table>
<thead>
<tr>
<th></th>
<th>USC/ISI</th>
<th>Research Channel</th>
<th>NTT</th>
<th>GLORIAD-KR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scanning</strong></td>
<td>720p</td>
<td>1080i</td>
<td>?</td>
<td>1080i</td>
</tr>
<tr>
<td><strong>In/Output</strong></td>
<td>SMPTE292M</td>
<td>SMPTE292M</td>
<td>SMPTE292M</td>
<td>SMPTE292M</td>
</tr>
<tr>
<td><strong>HD-SDI</strong></td>
<td>DVS</td>
<td>DeckLink AJA</td>
<td>Own</td>
<td>AJA</td>
</tr>
<tr>
<td><strong>SMPTE292M over IP</strong></td>
<td>No, but Possible</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Active samples over IP</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Dual-channel</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Hardware audio</strong></td>
<td>No</td>
<td>Embedded</td>
<td>Embedded</td>
<td>Internal</td>
</tr>
<tr>
<td><strong>Software video</strong></td>
<td>xVideo, SDL</td>
<td>?</td>
<td>?</td>
<td>xVideo</td>
</tr>
<tr>
<td><strong>Software audio</strong></td>
<td>RAT</td>
<td>?</td>
<td>?</td>
<td>Yes (Linux ALSA)</td>
</tr>
<tr>
<td><strong>Capture from disk</strong></td>
<td>No</td>
<td>?</td>
<td>?</td>
<td>No</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td>UltraGrid 0.4.1</td>
<td>iHD1500</td>
<td>Own</td>
<td>UltraGrid 0.3.1 modfy.</td>
</tr>
<tr>
<td><strong>Etc.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GLORIAD-KR version of UltraGrid

1. Cost-effective system integration and development
   - Adopt low-cost HD-SDI Interface (AJA’s OEM_HS)
   - Add internal 24-bit 48KHz HW audio to the system: audio capture, separate audio RTP stream, audio playout
   - Support dual-port streaming with software packet-stripping
   - SW-based multi-channel audio playout (PC sound card)

2. System Specification
   - Linux (Mandrake, Suse, Fedora Core 5)
   - EM64T dual Xeon (at least 2 PCI-X)
   - Dual-port 1 Gbps or 10 Gbps network interface
Partners

5 Sites are using GLORIAD-KR version of UltraGrid in the Globe
### Cost-effectiveness

50% off over USC/ISI’s UltraGrid

<table>
<thead>
<tr>
<th></th>
<th>DVS</th>
<th>OEM_HS</th>
<th>Software A/V playout</th>
<th>Dual-port support</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDV Cam.</td>
<td>$4,500</td>
<td>$4,500</td>
<td>$4,500</td>
<td>$4,500</td>
</tr>
<tr>
<td>1 HD-SDI converter</td>
<td>$1,600</td>
<td>$1,600</td>
<td>$1,600</td>
<td>$1,600</td>
</tr>
<tr>
<td>2 Servers</td>
<td>$4,800</td>
<td>$4,800</td>
<td>~ $4,800</td>
<td>~ $4,800</td>
</tr>
<tr>
<td>2 10 G NIC</td>
<td>$2,600</td>
<td>$2,600</td>
<td>$2,600</td>
<td>$0</td>
</tr>
<tr>
<td>2 Frame grabber</td>
<td>$14,000</td>
<td>$3,400</td>
<td>$1,700</td>
<td>$1,700</td>
</tr>
<tr>
<td>1 HDSDI converter</td>
<td>$770</td>
<td>$770</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>2 Audio A/D Converter</td>
<td>$900</td>
<td>$900</td>
<td>$400</td>
<td>$400</td>
</tr>
<tr>
<td>Display</td>
<td>$2,400</td>
<td>$2,400</td>
<td>$2,400</td>
<td>$2,400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$31,570</strong></td>
<td><strong>$20,970</strong></td>
<td><strong>~ $18,000</strong></td>
<td><strong>~ $15,400</strong></td>
</tr>
</tbody>
</table>
Global Ring Network for Advanced applications Development (GLORIAD)

- The first round-the-world high-performance networks jointly established by Korea, China, Unite States, Russia, Canada and Netherlands
- Improve networked collaboration with e-Science and Grid applications like HEP, Astronomy, Fusion, Geosciences, Medical sciences, and so forth.

Grand Opening for Big GLORIAD(05.9.5)
Uncompressed HDTV Transport System:
GLORIAD-KR (HW-based HDTV-OUT)

Sony HVR-Z1N

HD-SDI converter

6-channel audio

Audio embedder

HD-SDI signal converter

HD display

Speakers

A/V transport over IP networks

http://www.gloriad-kr.org/hdtv
Uncompressed HDTV Transport System:
GLORIAD-KR (SW-based PC-OUT)

Sony HVR-Z1N
HD-SDI converter
Audio embedder

6-channel audio

PC monitor
Speakers

A/V transport over IP networks

http://www.gloriad-kr.org/hdtv
Uncompressed 720p HDTV: application technology in UltraGrid (UCS/ISI)

Ladan Gharai, “Putting the “Ultra” in UltraGrid: Full rate Uncompressed HDTV Video Conferencing”,

http://www.gloriad-kr.org/hdtv
Uncompressed 1080i HDTV: application technology in GLORIAD-KR

Play

- A/V synchronization
  - Video Playout Buffer
  - Audio Playout Buffer
  - RTP/RTCP
  - Sequencing
  - Network Intf.

Grabber

- Video Packetization
  - RTP/RTCP
- Audio Packetization
  - RTP/RTCP
  - Network Intf.

http://www.gloriad-kr.org/hdtv
Demonstrations and Experiments with GLORIAD-KR Version

- **iGrid 2005**, Interactive 3D HD Video Transport and Collaborative Data Analysis for e-Science over UCLP. KISTI, GIST
- **C-K Experiments**, First C-K Uncompressed HD experiment exploiting GLORIAD network. KISTI, GIST, KAIST, TsingHua Univ, CNIC
- **DancingQ 2006**, The First Real-time Commercial Culture Event over R&E Network. ANF, KISTI, CRC, i2Cat
- **SC 2006**, Software-based A/V play with a low-cost uncompressed internet HDTV. KISTI, GIST
Demonstrations and Experiments

http://www.gloriad-kr.org/hdtv
DancingQ 2006

- **DancingQ 2006 (L2+L3)**, The First Real-time Commercial Culture Event over R&E Network.
  - Bound two lightpaths with port-based VLAN (L2)
  - Add L3 multicast service
  - Jumbo frame support
  - 1 Gbps E2E network bandwidth
  - ANF, KISTI, i2Cat, CRC, KAIST, GIST
• DancingQ 2006 (L2+L3)

KREONet2, KISTI, Korea

Daejeon #1
(Cisco ONS 15600)
Daejeon #2

Seoul #1

Seoul #2

Seoul (Korea)
Cisco  C3570G
1GigE/UTP

HD Camera
HD Sender

CRC /Ottawa (Canada)

Catalyst 6509

HD Receiver

HD Sender

HD Receiver

DancingQ 2006 (L2+L3)

CA.net 4, CANARIE, Canada

Seattle
Cisco ONS

Calgary
Nortel OME

Toronto
Nortel OME

Thunder Bay
Cisco ONS

?New York
Nortel OME

Ottawa
Cisco ONS

New York, US

Toronto
Cisco ONS

CESCA, Spain
Barcelona

RedIRIS, Spain
Barcelona

L2 Light Path I

L2 Light Path II

L3 IP Multicast

GEANT2, Europe

New York
Nortel OME

Toronto
Cisco ONS

CESCA, Spain
Barcelona

RedIRIS, Spain
Barcelona

http://www.gloriad-kr.org/hdtv
ELSA 2006 Pre-congress

- **ELSA 2006 (short-haul L3)**, Live Uncompressed HD broadcast of Laparoscopic Liver Surgery
  - Local network
  - No *jumbo frame* support
    (Endpoint Fragmentation and Reassembly)
  - 1 Gbps E2E network bandwidth
  - KISTI, Sony, Olympus, SNU Bundang Hospital.
• ELSA 2006 (short-haul L3)

B2F Network system room
Private network
Fiber 1G
HD SDI Sending Machine server 61.252.62.55
UTP 1G

SONY HDC –X300
SONY Anycast Station HD-A/V mixer
Olympus EXERA 2 – HD laparoscope camera

B1F Auditorium Room
Uncompressed HD
Analog Audio
HD SDI Video

Sony HD Cine-projector SRX-R110
HD- SDI Receiving Machine server 61.252.62.56
D/A audio converter
Audio Mixer

Powerpoint
A/D audio converter
VGA/HD graphic converter

http://www.gloriad-kr.org/hdtv
SC 2006 Demonstrations

- **SC 2006 (long-haul L3)**, 8-bit 1080i video & multi-channel 24-bit audio playout with low-cost graphic and sound card
  - No QoS guarantee
  - Jumbo frame support
  - KISTI, GIST

![Diagram showing components of SC 2006 Demonstrations](http://www.gloriad-kr.org/hdtv)
How to apply it to Access Grid

- Already have AG module
- Many-to-many?
  - One-to-one or **One-to-many visual sharing**
  - A one-to-many shared application
- Visual sharing with uncompressed HDTV
- Interactive conference with compressed HDV (VLC, DVTS) or AG