Lessons learnt from distributing video over an HLA backbone

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Distributing and capture video over an HLA backbone

- Why capture video in a simulator?
- Why capture video digitally?
- Why distribute and capture video over HLA?
- Direct video streaming performance
- HLA video streaming performance
- HLA video recording performance
- Conclusions
Why capture video in a simulator?

• Easy way of making student stations screens, live cameras monitoring student performance and simulator out the window view available for live monitoring and After Action Review.
• If the simulator isn’t designed for recording of all states and being able to replay those states.
• Add After Action Review capability to a system where no other software can be installed due to security restrictions. (capture on the HDMI/DVI display signal)
• No need for any simulator specific solution.
Why capture video digitally?

- Easier to make sure everything is synchronized.
  - Video
  - Simulation data
  - Radio communication
- Easier to make backups and keep track on recordings.
- More reliable and less expensive hardware
- Todays computer hardware and storage is very capable in terms of both capacity and speed.
Why distribute and capture video over HLA?

• Advanced filtering mechanisms in HLA can help reducing bandwidth problems.
  ▪ Publish/Subscribe
  ▪ DDM

• Can be distributed over WAN if needed.

• Possibilities to filter with already accredited Cross Domain Security (CDS) solutions.

• Capture video streams in sync with other simulation data and audio streams with a COTS HLA Recorder.
Example of HLA video and simulation architecture

- **Video Source:** Student screen or similar
- **ffmpeg, HW capture or similar**
- **IOS Station for DAAR**
- **ffplay or similar player**
- **HLA Media Streamer Federate**
- **HLA Radio**
- **HLA Media Streamer Federate**
- **HLA Recorder**
- **SQL**
- **HLA Recorder**
- **ffplay or similar player**
- **IOS Station for AAR**
- **HLA Media Streamer Federate**
- **HLA Federation Live**
- **HLA Federation AAR**
Direct video streaming setup

Computer 1 & 2
- Video Source: Student screen or similar
- ffmpeg, HW capture or similar

Computer 3
- ffplay or similar player

1Gbit network
Direct video streaming performance

- Video streaming directly from ffmpeg to ffplay
  - 1Gb network.
  - Two computers used for streaming data.
  - 4k 60Hz, 32Mbit/s per movie.
  - One computer receiving all data and displaying one of the 4k-videos.
  - Windows UDP buffers has been tweaked.
  - 30 movies @ 4k 60Hz 32Mbit/s could be streamed.
  - 960Mbit/s in total.
  - No artefacts in the videos.
  - Streaming can be done until the network gets saturated.
HLA video streaming setup

**Computer 1 & 2**
- Video Source: Student screen or similar
- ffmpeg, HW capture or similar
- HLA Media Streamer Federate

**Computer 3**
- ffplay or similar player
- HLA Media Streamer Federate

**1Gbit network**
HLA video streaming performance - Unoptimized

- HLA video streaming performance - Unoptimized
  - Same setup as before, 4k 60Hz, 32Mbit/s per movie.
  - Streaming ffmpeg → HLA federate → HLA federate → ffplay.
  - Default packet-size for ffmpeg (1360bytes/packet)
  - One HLA interaction per ffmpeg UDP packet.
  - Video can be streamed up to 20 movies and a total of 640 Mbit/s.
  - After that, the computer receiving the HLA interactions starts to get overloaded, especially when it needs to show one of the 4k-movies at the same time.
  - Without showing the 4k-movie, up to 28 movies and a total of 896Mbit/s can be streamed.
HLA video streaming performance - Unoptimized

- Bitrates and callback-rates for 28 movies and 1360 bytes per packet:

![Graph showing Ethernet throughput](image-url)
HLA video streaming performance - Optimized

- Changes to ffmpeg to use larger packet size of 52kB gave less callbacks and much higher performance.
- 30 movies @ 4k 60Hz 32Mbit/s could be streamed.
- 960Mbit/s in total.
- CPU-usage was low for the receiving federate.
- Callback queue was empty.
- Streaming can be done until the network gets saturated.
**HLA video recording setup**

**Computer 1 & 2**
- Video Source: Student screen or similar
- ffmpeg, HW capture or similar
- HLA Media Streamer Federate

**Computer 3**
- HLA Recorder
- SQL

**1Gbit network**
HLA video recording performance

- Recording of the HLA video and simulation data can be done to a SQL server for After Action Review.
- The SQL server's single session performance is what's currently limits the bitrate that can be recorded.
- Fast SSD-drives and CPU:s can help recording speed.
- Multiple Recorders can be used for increasing recording speed using multiple SQL sessions.
Video recording performance

• Up to 1Gbit/s of video data have been recorded to a single SQL-server using 4 Recorders.

Disk recording with up to 270MB/s
Conclusions

• Direct video streaming can be done over a 1Gb network up to the full capacity of the network.
• HLA video streaming can be done over 1Gb network up to the full capacity of the network.
• HLA has no negative effect on video streaming performance.
• In our tests we have recorded 1Gbit/s of HLA video data to a SQL server.
• Tuning of the various components is required in order to get high performance for both direct and HLA video streaming.
• We can distribute and record synchronized video-, simulation- and radio-data over HLA for After Action Review applications.
  ▪ Audio data and simulation data is not affected by video streaming when bandwidth is available
QUESTIONS