COLLABORATIVE TRIALS OF INTERNET2 AND NTT
Past and latest works

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Joint collaborative trials of Internet2 and NTT

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History of the collaborations between Internet2 and NTT
History of the collaborations

- 1998  NTT’s first participation to Internet2 meeting
- 1999  NTT has become an Internet2 corporate member
- 2001  GEMnet Connected to Internet2 network in San Jose (then moved to Seattle)
- 2001  Remote monitoring of ASTE/ALMA radio telescope in Chile
- 2003  International e-VLBI observation between MIT Haystack and CRL Kashima
- 2006  Uncompressed HDTV tele-conference between Tampa and Tokyo at SC06
- 2007  Uncompressed HDTV transmission from Boston to Osaka for a live broadcast
- 2011  Global distributed video production trial using SDN at SC11
- 2012  Super Hi-Vision (8K) video transmission trial from London to Tokyo
- 2014  Super Hi-Vision (8K) video transmission trial from Rio de Janeiro to Tokyo
- 2016  Immersive video viewing trial of Kabuki performance (traditional Japanese theatrical play) between Las Vegas and Tokyo
Super Hi-Vision (8K) video transmission from London to seven cities in UK, US and Japan

- In collaboration with Internet2, JANET, GÉANT and SINET4, NTT has created a high performance experimental network connecting UK, US and Japan for a global SHV (8K) video transmission. It was used for the public viewing of a big sporting event held in London in 2012.
Super Hi-Vision (8K) video transmission from Brazil to Japan

- NTT has created an extremely reliable experimental network with RNP, Internet2 and other partners using a highly redundant IP network configuration and efficient FEC technology between Brazil and Japan. It was used for the SHV (8K) public viewing of a big sporting event in Brazil in 2014.
GEMNET2: R&D NETWORK TESTBED OF NTT
Features of GEMnet2

- GEMnet2 (Global Enhanced Multifunctional Network 2) is owned and operated by NTT’s laboratories for their research and development.
- The network has connections with research and education (R&E) networks and other research organizations in Japan and other countries to enable the testing of ultra high-speed applications and other experiments.
- While GEMnet2 is mainly used for the internal R&D activities within NTT, we are also actively promoting experiments with other organizations.
GEMnet2 Overview

- GEMnet2 connects three NTT R&D centers in metropolitan Tokyo area by optical fibers.
- Three R&D centers are equipped with ROADM and WDM, which constitute a trunk network with a capacity of several tens of gigabits per second.
LATEST TRIAL: IMMERSIVE VIDEO VIEWING TRIAL OF KABUKI PERFORMANCE (TRADITIONAL JAPANESE THEATRICAL PLAY) BETWEEN LAS VEGAS AND TOKYO

- Overview of the trial
- Experiments of remote ultra-high-presence live viewing
- Requirements for trial network
- Network diagram
- Summary
Overview of the trial

- Nippon Telegraph and Telephone Corporation (NTT) and Shochiku Co., Ltd (Shochiku) started joint experiments to create a new way of appreciating a kabuki performance.

- On May 7, 2016, NTT and Shochiku conducted the first experiment of the project, Ultra-high-presence video live viewing of KABUKI LION SHI-SHI-O' Las Vegas Performance produced by Shochiku.
Experiments of remote ultra-high-presence live viewing

- Remote greeting on a stage with a quasi-3D video produced using Kirari!
- Space reproduction using multiple 4K screens
- Live high-quality delivery of a 4K spherical video to a mobile terminal
Requirements for trial network

• Short period of time to construct the network: we had only 3 months to establish the network between the theater in Las Vegas and the site in Tokyo.
  – We had to combine multiple links separately procured for a limited period of time.

• Conditions for video transmission
  – Total bandwidth 750 Mbps (13 video streams for 4K multi screens (up to 50 Mbps) and 100Mbps for HMD demonstration)
  – Keep the rates of packet losses below the level which the FEC function can correct.
  – Prepare for two network paths with physically different routes
Network diagram
Locations of network testers

Musashino
- SW NX7004
- SW Cat6509
- Test Center

Otemachi
- SW NX7004
- AQ1200

Seattle
- SW Cat6504
- Accedian
- AQ1300

Las Vegas
- SW LAS-SW12
- SW LAS-SW11
- Test Center
- AQ1300

Video equipment
- GEMnet2 equipment
- Video equipment
- Network testers
Summary

• Results of the latest trial
  – We could construct two paths combining various network services both commercial and academic networks.
  – Each path was guaranteed for 1 Gbps bandwidth.
    • Internet2’s AL2S was very reliable.
    • The overall latency was small and stable.
    • Packet losses were small enough for the correction by the FEC function during the performance.

• Conclusion
  – NTT has been able to conduct a number of global scale network trials in collaboration with Internet2 and they were all very successful.
  – Internet2 has provided us a nice community in which we could collaborate with other R&E network partners worldwide as well as the latest network resources.
  – We are looking forward to the continual collaboration with Internet2.
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