



MIAMI FL



SEPTEMBER 25-28

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



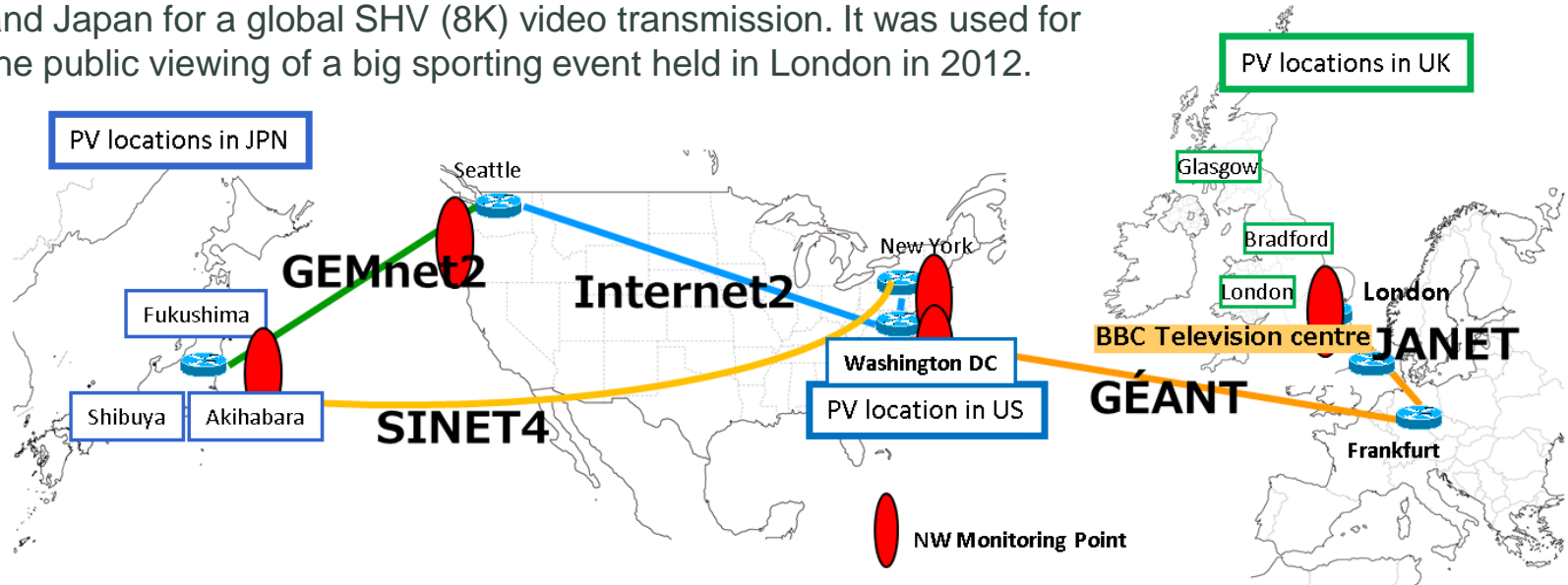
History of the collaborations

- 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



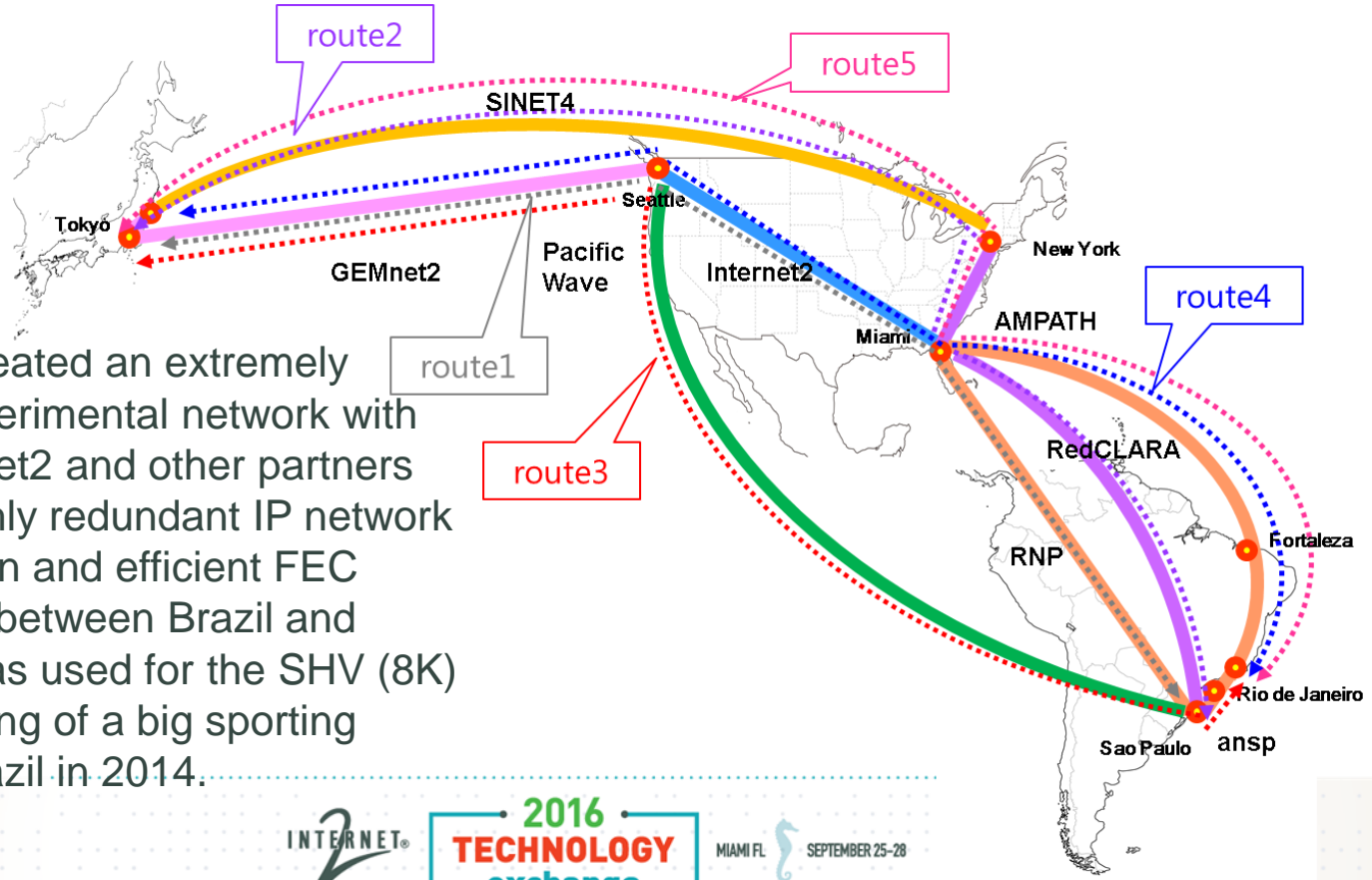
Super Hi-Vision (8K) video transmission from London to seven cities in UK, US and Japan

- 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



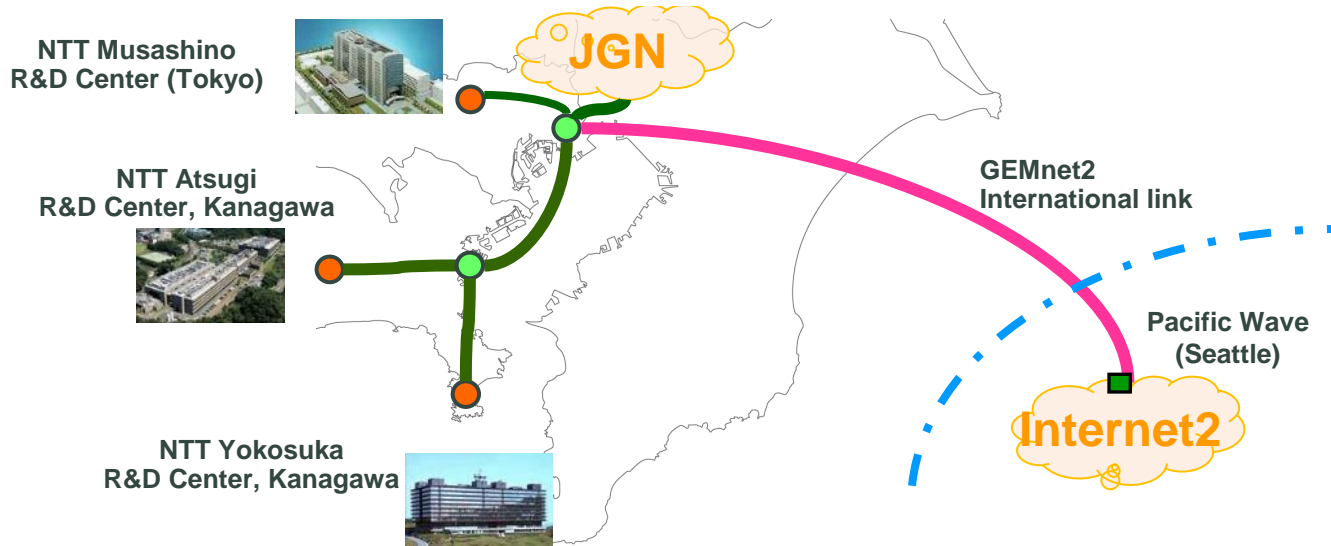
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Features of GEMnet2

- 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.



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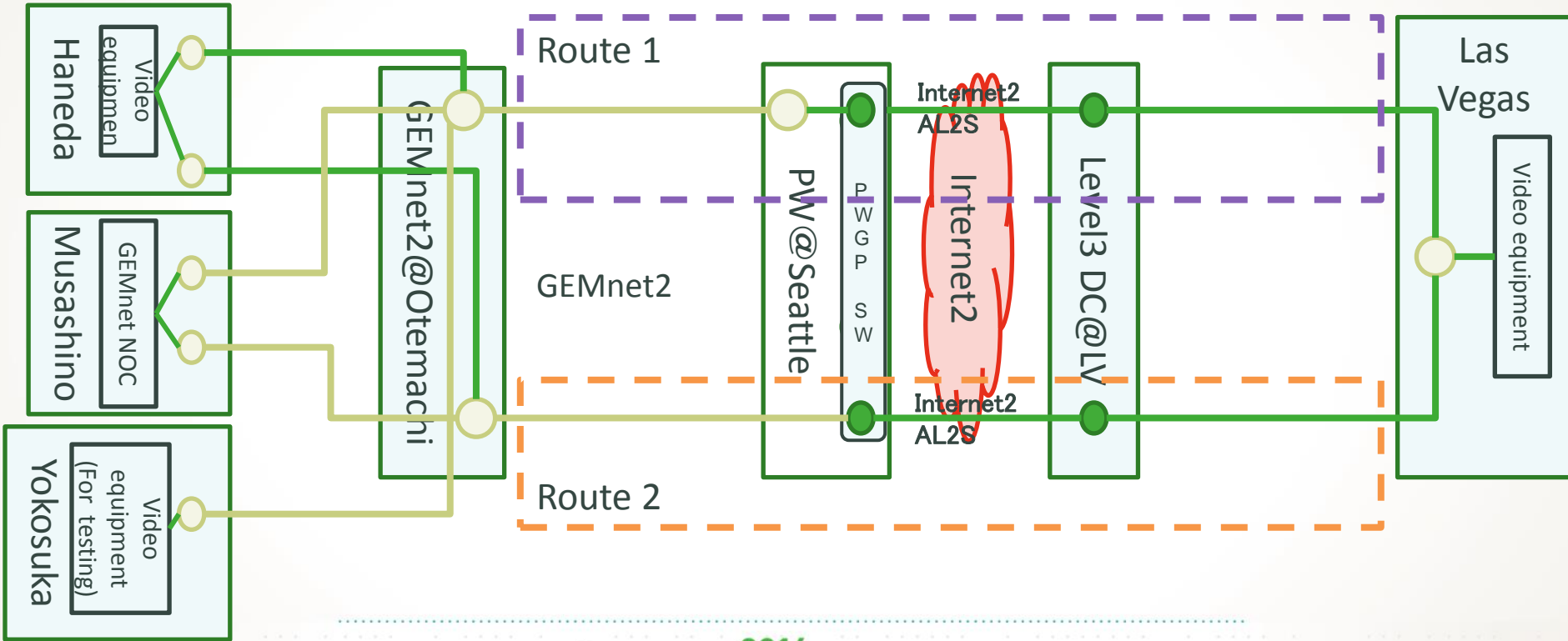
Experiments of remote ultra-high-presence live viewing

- 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

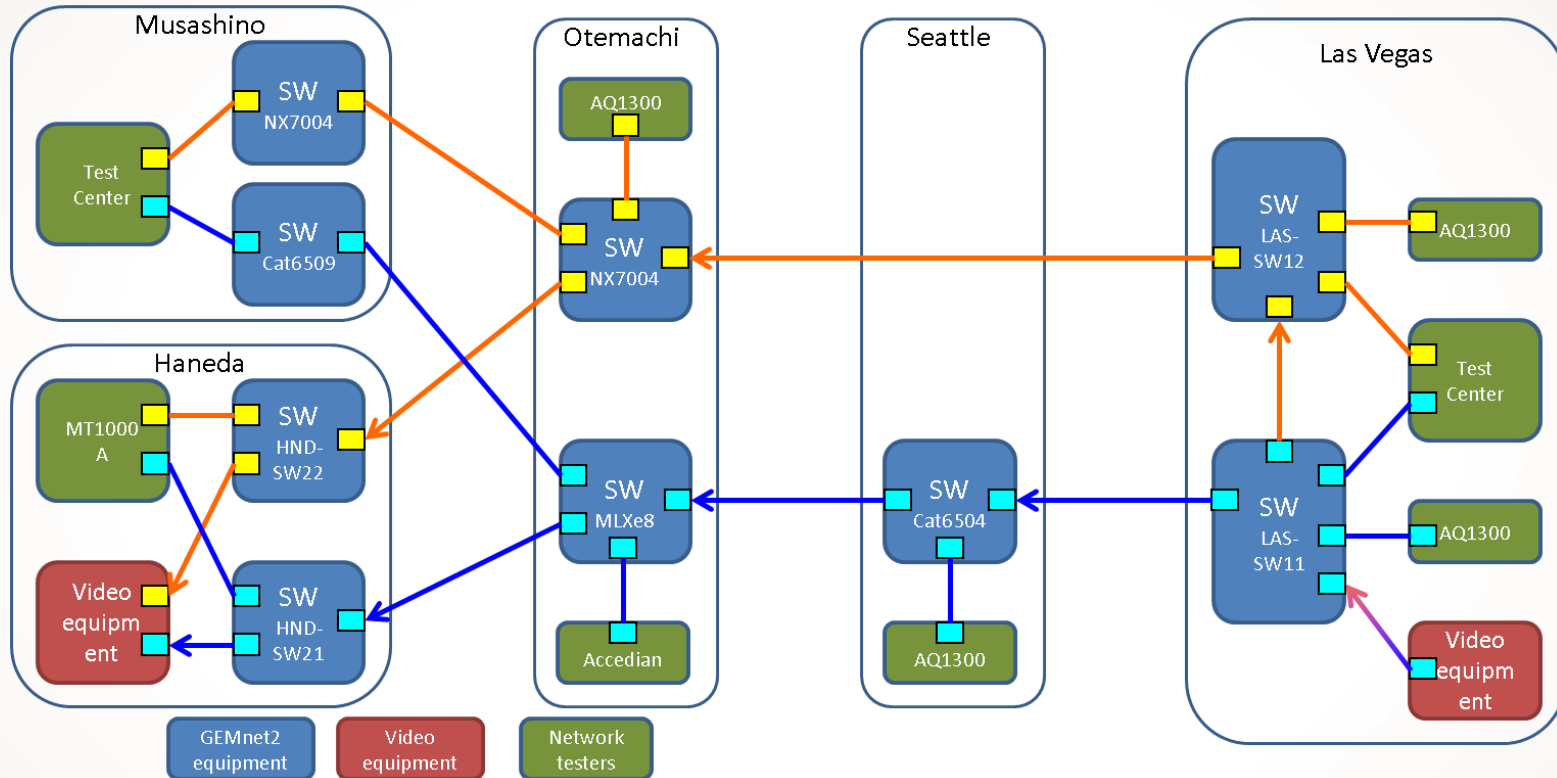
Requirements for trial network

- 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



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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