

# **CIREN Final Report May 1, 2005 - 30-September-2010**

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CIREN/TransPAC2 (SCI-0441096)**

## **Final Report Description**

This Final Report is divided into five parts:

1. Summary of CIREN project activity, including a year by year break down.
2. Major Accomplishments, including a more detailed year-by-year summary.
3. Meetings and Presentations, including a year by year outline of CIREN staff activities
4. Specific project activities. These include:

US-Pakistan network development

IRNC GENI related activities

Supported science activities

Dynamic Circuit Network (DCN) activities

Measurement activities

SuperComputing activities

Security activities

5. Special added reports. These include:

Intern reports

EU trans-Atlantic networking report

GENI reports

Pakistan reports

Each of these five sections has a description of the section preceding the section itself.

## Summary of CIREN Project activity

This section contains a high-level year by year description of the CIREN project, also known as TransPAC2. A more detailed description of project activity is discussed in the Major Accomplishments section.

### Project Summary: Year One

The TransPAC2 Project began with an official signing ceremony in Japan on April 1, 2005. One month later the Project technically went online and became fully functional. The initial network consisted of a 10G link from the Pacific Wave facility in Los Angeles to the APAN facility in Tokyo, Japan. From Tokyo, APAN provides connectivity to Asia broadly.

In October 2005 the network extended to Hong Kong to provide access for traffic from China (CERNET and CSTNET). Our partners NICT – Japan is the link owner for this circuit.

In January 2006 TransPAC2 connectivity extended to Singapore across a new OC-12 funded by NII from Tokyo. This circuit immediately allowed for an alternate path to Europe via the TEIN2 Singapore link. Further connectivity to local Singapore and nearby Asian resources is expected within the next six months.

Concurrent with the Singapore connectivity detailed above, the TransPAC2 network began receiving TEIN2 routes from APAN in late December. TransPAC2 provides the primary transit between the US and TEIN2 member countries.

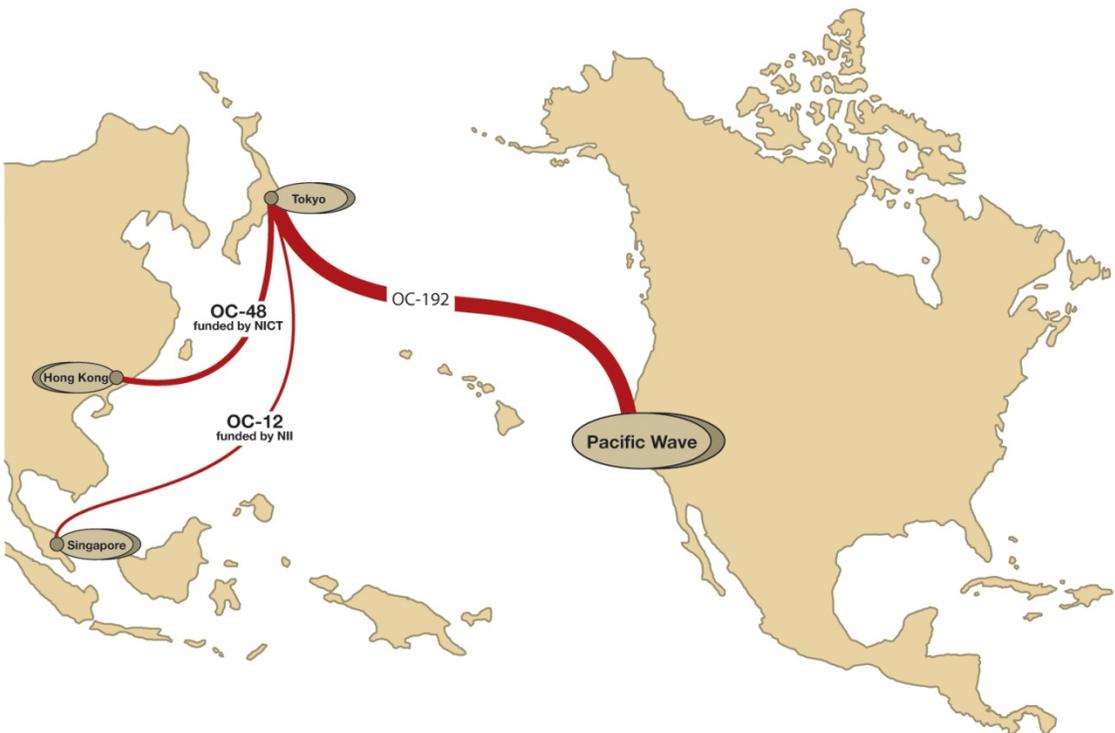


Figure 1: TransPAC2 Topology as of January 30<sup>th</sup>, 2006

## **Project Summary: Year Two**

TransPAC2 is an infrastructure project organized around four key components: engineering, measurement, applications and security. These components are developed as Work Plans and posted on the TransPAC2 web site, [www.transpac2.net](http://www.transpac2.net). Please refer to the TransPAC2 web site at [www.transpac2.net](http://www.transpac2.net) for complete details and further documentation.

The IRNC Review was held in Washington, DC in October 2006. The TransPAC2 presentation to the review committee is available on the TransPAC2 web site ([www.transpac2.net](http://www.transpac2.net)). The results of this review spawned a new TransPAC2 Workplan (IRNC Review WorkPlan) are attached in the "reports" section.

## **Project Summary: Year Three**

Principle Investigator, James Williams, worked with Heather Boyles of Internet2 and others to develop Research and Education Networking in South Asia at the workshop held at the Spring Internet2 Member Meeting in DC. Presentations from this workshop are available on the Indiana University South Asia page at <http://southasia.indiana.edu>. Williams is the chairman of the South Asia SIG.

TransPAC2 developed and submitted a funding request to the NSF to provide a network connection between the U.S. and Pakistan. Details of this connection are presented later in this report's Pakistan section.

The project installed PerfSONAR tools on the TP2 node in LA and on the APAN node in Tokyo (partially installed as of 31-December). Further details can be found in this report's Measurement section.

Williams attended the First GENI Engineering meeting in Minneapolis and prepared a GENI funding proposal to define the interface between the U.S. and international network research test beds.

Interested service providers received an RFP for the final two years of the TransPAC2 project.

## **Project Summary: Year Four**

Circuit RFP decided in favor of continuing the KDDI-A-provisioned circuit, therefore reducing costs by approximately 10%.

TransPAC2 staff made presentations throughout the year at various events including the Internet2 Joint Techs/APAN meetings, the Internet2 members meetings, the APAN meetings, as well as other meetings outlined in more detail in the Presentations section.

Brent Sweeney began working as the TransPAC2 engineer, replacing Chris Robb. Chris Robb moved away from the TransPAC2 project in order to take on new responsibilities with Internet2.

TransPAC2 engineers worked with Internet2 and CENIC to arrange for access to the Dynamic Circuit Network (DCN). This activity is detailed in the Dynamic Circuit section of this report.

## **Project Summary: Year Five**

Chinese American Network Symposium (CANS) was held in Indianapolis and co-hosted by TransPAC2. This meeting provided a venue for exchange of information between networking experts from the U.S. (broadly based including Internet2, ESnet and other university networking experts). The workshop agenda and presentations are located at: <http://www.indiana.edu/~uits/cans2008/program.html>.

The Dynamic Circuit Network implementation was completed in October, allowing native layer2 connectivity between users in the APAN region with the U.S. It demonstrated successfully in November at SC08 and is now a supported service across TransPAC2.

Williams was elected to Internet2 External Research Advisory Committee (ERAC) and appointed to the Internet2 Standing Committee on International Strategy (SCIS).

Williams continues to serve as the Sub-group Chair of the Emerging NREN South Asia Special Interest Group for Internet2.

Williams also received an NSF award to hold a workshop in India. He will work to develop this in conjunction with Greg Cole and the NSF funded GLORIAD/Taj Project.

In addition to his TransPAC2 duties, Sweeny became the acknowledged expert in implementing a Cisco Telepresence Exchange in the R&E domain as he implemented an international TP Exchange on behalf of National LambdaRail. This exchange has seen huge growth during 2009 while working with the Interconnect University Cisco TP systems throughout the United States and in Australia, the Middle East, and Europe, with Asian systems coming into the exchange very soon. He will also be leading an effort to establish similar TP exchanges in other regions, especially Asia and Europe.

## **Project Summary: Year Six**

A significant accomplishment during this period was the development of the TransPAC3 IRNC2 proposal, which built on and improved upon the successful TransPAC2 project. Considerable work during this year was dedicated to the anticipation of the actual inauguration of TransPAC3 and its smooth transition from TransPAC2. At the end of this period in August-September 2010, we issued an RFP for circuit services for TransPAC3, evaluated responses, and made an award with planned TransPAC3 rollout in January 2011.

Brent Sweeny and John Hicks participated in support of the SuperComputing '09 Conference and Exposition in Portland, Oregon in November 2009. Hicks was a member of the measurement and monitoring team, and Sweeny a member of the routing team. A number of APAN-related projects participated in SC09 as well. Sweeny also helped coordinate, provide, and support the extensive use of NLR for SC09 support.

Cisco Telepresence among universities and others institutions in the research and education community continues to expand, both domestically and internationally, Sweeny works with regional and international networks to support and coordinate these connections through the R&E Telepresence exchange. This R&E Telepresence exchange is the first of its kind to connect with commercial Telepresence exchanges.

During this time planning continued for the NSF sponsored India Workshop.

International Networking at Indiana University (IN@IU) developed a new website, located at: <http://internationalnetworking.indiana.edu/>.

Williams continues with his duties as a member of the Internet2 External Research Advisory Council (ERAC) and the South Asia Special Interest Group (SA-SIG), remains the co-Chair of the GENI Campus Operations Monitoring Information and Security (COMIS) Working Group, and participated in the U.S.-India Joint Committee meeting on Science and Technology Collaboration.

Williams participated as a Working Group Leader in the development of the US-Pakistan Joint Committee Meeting on Science and Technology Collaboration. This activity is discussed in detail in the Pakistan Section of this report.

## **Summary of milestones and accomplishments**

This section of the CIREN Final Report presents in more detail the year by year activities and accomplishments outlined in general terms in the previous section.

### **Significant Milestones and Accomplishments for Project Year One**

#### **April 2005**

TransPAC2 hosted a “signing ceremony” in Tokyo where Memorandums of Understanding were signed between TransPAC2 and the National Institute of Informatics of Japan (NII), TransPAC2 and the National Institute of Information and Communications Technology of Japan (NICT) and TransPAC2 and the Asia Pacific Advanced Network (APAN). This marked the formal beginning of the TransPAC2 Project. Peter Freeman of the NSF participated in the event and delivered a commemorative speech. See [www.transpac2.net](http://www.transpac2.net) and <http://www.nsftokyo.org/> for more details.

#### **May 2005**

TransPAC2 OC-192 connection between the US and Asia (APAN facility in Tokyo) became officially active. The TransPAC2 circuit terminates on a Juniper T320 router, which was installed in KDDI-A co-location space in Los Angeles in late April 2005. The T320 maintains an additional 10GigE connection to a TransPAC2 Hewlett Packard Ethernet switch. From there, a KDDI-A-provided metro 10GigE circuit interconnected the TransPAC2 Ethernet switch and the Pacific Wave Ethernet facility in Los Angeles. An initial BGP peering with Abilene was established on Day 1.

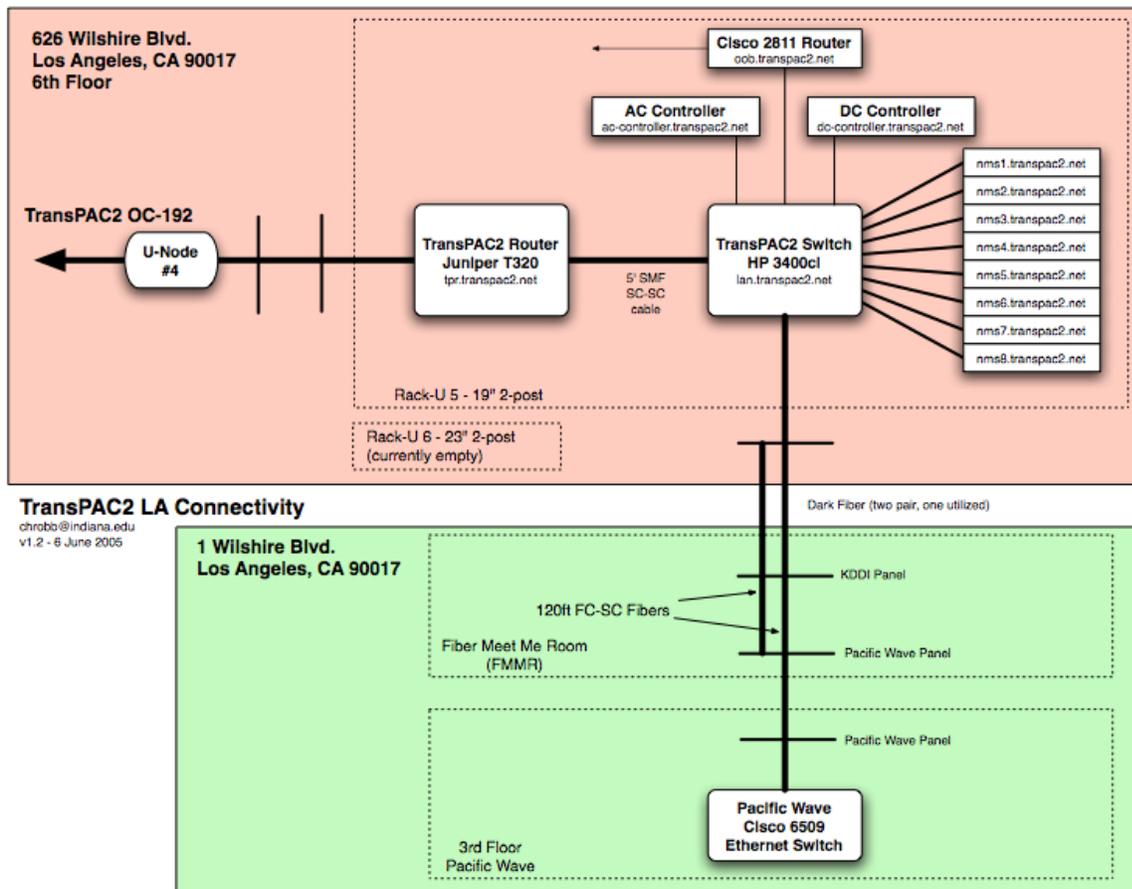


Figure 2: TransPAC2 Los Angeles Topology as of May 1<sup>st</sup>, 2005

As an interesting side note, PacificWave bought Juniper T320 as a part of a larger purchase. TransPAC2 then repurchased the T320 from PacificWave. This saved TransPAC2 significant funds and is an illustration of the TransPAC2-PacificWave partnership.

JGN2 and SINET agreed upon a secure and tested backup plan in the case of potential problems with the TransPAC2 project. JGN2 is the primary backup, therefore providing parallel backup if a circuit problem arises within the terrestrial part of TransPAC2. At the same time, SINET provides secondary backup services for more serious circuit problems within the oceanic part of TransPAC2 and JGN2.

In addition the project moved forward with developing and engineering measurement and security workplans. These workplans are available in current and archived format on the TransPAC2 web site. They represent the planning and progress of the TransPAC2 Project toward specific goals in engineering, measurement and security.

## September 2005

TransPAC2 engineers worked with APAN's engineering on iGrid-specific configuration tasks.

Examples of supported applications involved in iGrid activities are:

- Data Reservoir on IPv6: 10Gb Disk Service in a Box
- E-VLBI
  - Very-Long-Baseline Interferometry (VLBI) is one of the most powerful techniques available for the high-resolution imaging of distant radio sources in the universe and for making accurate measurements of the motion of the earth in space. Multiple radio telescopes scattered over the surface of the earth simultaneously record data from a radio source at streaming data rates as high as 1 Gbps for a 24-hour period.
- Sloan Digital Sky Survey
  - Sloan Digital Sky Survey (SDSS) is a project to carry out imaging and spectroscopic surveys of half the northern sky using a dedicated, wide-field, 2.5-m telescope. The imaging survey with a large mosaic CCD camera produce digital photometric maps of the sky in five color bands. These maps are used to extract the position and various photometric parameters of about 100 million galaxies and close to the same number of stars. The SDSS is a collaborative project between the U.S. and Japan involving seven U.S. institutions and the Japan Promotion Group (JPG).
- IVDGL (GriPHyn) – now Open Science Grid (OSG) activities
  - The iVDGL is a global data grid that serves forefront experiments in physics and astronomy. Its computing, storage and networking resources in the U.S., Europe, Asia and South America provide a unique laboratory that will test and validate grid technologies at international and global scales. Sites in Europe and the U.S. will be linked by a multi-gigabit per second transatlantic link funded by the European DataTAG project.

## October 2005

The Transpac2 router fully incorporated into the Arbor Networks Peakflow SP product (<http://www.arbornetworks.com/>) used by the REN-ISAC. The SP system collects, analyzes, and manages Netflow, SNMP, and BGP data to provide a comprehensive view into traffic traversing the Transpac2 network. See this report's Security Section following for further details.

## November,2005

TransPAC2 engineers attended Supercomputing 2005 in Seattle Washington. Event details can be found at: [http://sc05.supercomputing.org/schedule/event\\_detail](http://sc05.supercomputing.org/schedule/event_detail). Examples of supported applications are listed below.

- The Grid Datafarm team participated in the SC|05 StorCloud Challenge and won the "Most Innovative Use of Storage In Support of Science" award. Gfarm file system is a next-generation network shared file system, which will meet a demand for much larger, reliable, and faster file system. This will be an alternative solution for the NFS. TransPAC2 provided some of the overall bandwidth for this StorCloud Challenge. <http://datafarm.apgrid.org/software/>
- TransPAC2 was the primary trans-Pacific network link used for this Band Width Challenge entry by Ehime University and NICT. Abstract: A Challenge to Real-time Visualization for 3D Computer Simulations and Satellite Observations for Space Weather
- TransPAC2 and JGN2 were used for this Band Width Challenge by the NCDM team. Abstract: High Performance Mining of Streaming Data.

- The Open Science Grid (OSG) is a global Data Grid that will serve forefront experiments in physics and astronomy. OSG's computing, storage, and networking resources in the U.S., Europe, Asia and South America provide a unique laboratory that will test and validate Grid technologies at international and global scales. The OSG demonstrated the capabilities with U.S, European, and Asia counterparts. The OSG and the OSG grid operations center (GOC) are supported by Indiana University. TransPAC2 is used as a primary network link to connect the US with the APAN region.
- AIST used TransPAC2 to transfer large amounts of data for their demo from Tokyo to Seattle.

## **October 2005**

TransPAC2 connections extended to Hong Kong (CERNET and CSTNET China traffic). TransPAC2 router began seeing CERNET and CSTNET routes, with NICT – Japan as the link owner. OC-48 is split into 2 x 1Gbps at the Hong Kong location to pick up both CSTNET and CERNET traffic.

## **Significant Milestones and Accomplishments for Project Year Two**

### **January 2006**

TransPAC2 connectivity extended to Singapore across a new OC-12 funded by NII from Tokyo. This circuit immediately allowed for an alternate path to Europe via the TEIN2 Singapore link and will provide connectivity to local Singapore and nearby Asian. Concurrent with the Singapore connectivity detailed above, the TransPAC2 network began receiving TEIN2 routes from APAN. TransPAC2 began providing primary transit between the U.S. and TEIN2 member countries.

The 21<sup>st</sup> APAN meeting held in Tokyo 1/22-1/27 provided an opportunity for TransPAC2 engineers and Matt Zekauskas from Internet2 to conduct the Internet2 E2E network performance workshop. There were approximately 25 people in attendance including representatives from Japan, Korea, China, Hong Kong, Taiwan, Thailand, Malaysia, and the US. There were presentations from experts in security, measurement, high performance networking, and the medical application space (remote surgery).

### **February 2006**

TransPAC2 established a physical interconnect with the JGN2 network in Los Angeles. JGN2 engineering split their Tokyo to Chicago circuit in Los Angeles and installed a JGN2-managed Force10 Ethernet switch. TransPAC2 added a 6-port 10GigE Hewlett Packard Ethernet switch and established a 10GigE cross-connect to the JGN2 Force10. This enabled TransPAC2 to create a supplementary peering with Tokyo across a redundant circuit path. The diagram below illustrates the TransPAC2 topology in Los Angeles as of March 1<sup>st</sup>, 2006.

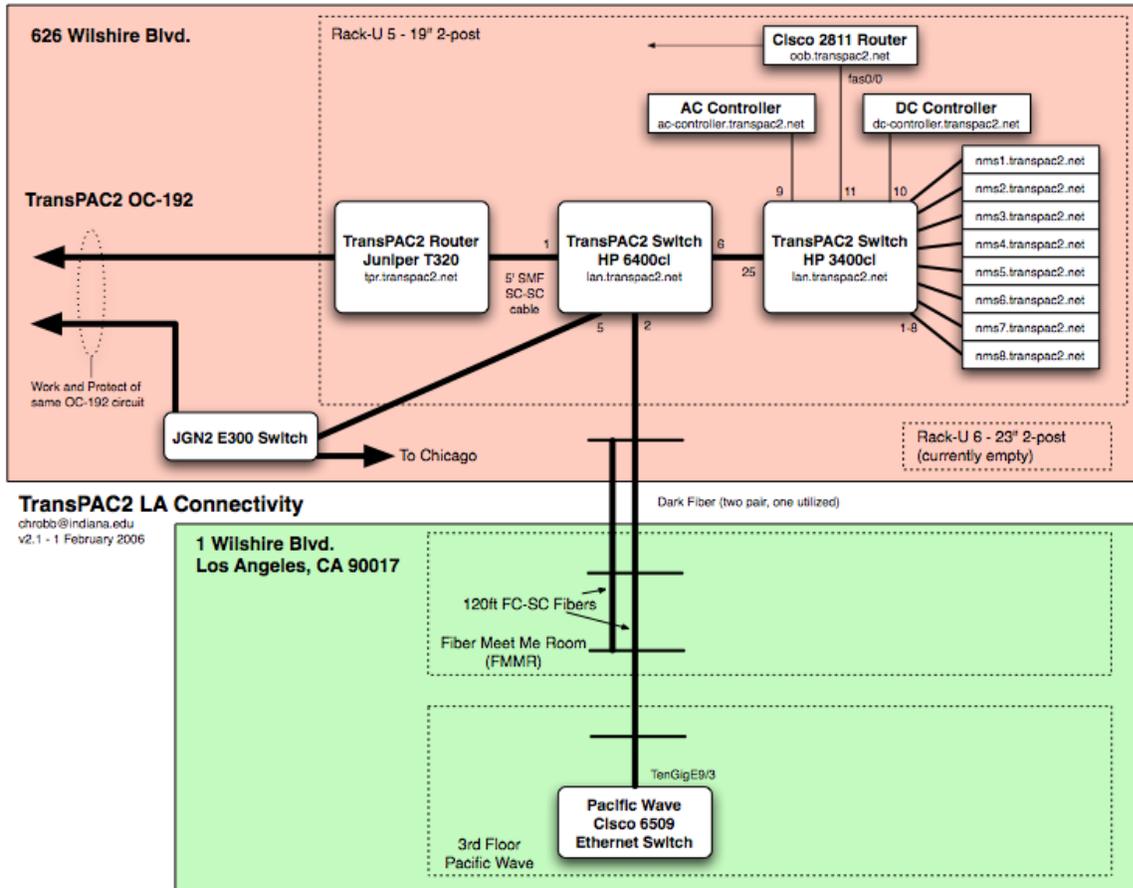


Figure 3: TransPAC2 Los Angeles topology as of March 1<sup>st</sup>, 2006

## April 2006

Chris Robb gave several presentations at the Spring Internet2 Member Meeting in Washington DC (4/24-4/26) on the routing challenges posed by the proliferations of international research and education interconnects<sup>1</sup>. The resulting discussion generated interest in the formation of a Research and Education focused Network Operators group, or RENOG. TransPAC2, in collaboration with Internet2, instantiated the RENOG organization and mailing list in the weeks following the meeting.

<sup>1</sup> <http://transpac.org/presentations/2006/International%20R&E%20Peering%20v1.1.pdf>

## **July 2006**

Williams and Hicks attended the APAN meeting in Singapore. Hicks gave presentations concerning TransPAC2 measurement and security (See <http://www.transpac2.net/presentations.php>) while Williams chaired a session in the Network Engineering track and discussed the RENOG efforts.

A 10G measurement PC was installed on TransPAC2 in Los Angeles. Along with the 8 machines already deployed, this machine provides a new level of high performance network testing and application support.

TransPAC2 completed a public version of security gateway by using Peakflow SP WSDL/SOAP API to access security incidents on the TransPAC2 network (same access information and measurement gateway).

## **August 2006**

A web services interface was installed on the TransPAC2 web page to access security and measurement information provided by Arbor Networks Peakflow SP (see <http://www.transpac2.net/stats.php>). Development of these services is inline with our mission to provide better security and usage information.

## **September 2006**

John Hicks attended the first Immersive Medical Telepresence (IMT) conference held in Phoenix, AZ and co-sponsored by Internet2. This is a significant step towards connecting tele-medical groups in the U.S. and APAN region. A follow-on meeting was held during the fall Internet2 Members Meeting in Chicago. We continue to support future activities involving the I2 IMT and the APAN Medical WG.

TransPAC2 engineer Chris Robb began work as the primary project leader on the Internet2 network upgrade. This collaboration with Internet2 will help TransPAC2 engineers to more easily make a determination on future equipment purchases that will enable Asian Pacific network interoperability with the future Internet2 architecture.

## **October 2006**

Hicks attended the Arbor Summit in Toronto, Canada. This meeting provided an opportunity to meet directly with Arbor Networks developers and Japanese colleagues from the Tokyo XP.

TransPAC2 engineers initiated MOU discussions with National Lambda Rail (NLR) management regarding the exchange of routes via NLR's interconnect to Pacific Wave in Seattle. Due to concerns regarding international routing paths, TransPAC2 asked NLR to not transit TransPAC2-preferred routes to its peer network. This new peering interconnects TransPAC2 to NLR customer networks, though the Internet2 Abilene network remains the primary method of U.S. domestic transit.

## **November 2006**

Hicks attended Supercomputing 2006 in Tampa, FL and met with PRAGMA, APAN, and other researchers concerning TransPAC2. TransPAC2 presentations were given at the IU and PRAGMA Booth.

## **December 2006**

TransPAC2 engineers initiated discussions with KDDI-America regarding the network topology plans for the next year. The discussion contained two components: 1) feasibility of extending the existing TransPAC2 circuit contract past the existing termination date, and 2) future technical requirements for a possible circuit-based interconnect to the Internet2 network in Los Angeles.

## **Significant Milestones and Accomplishments for Project Year Three**

### **January 2007**

TransPAC2 participated in the APAN 23 meeting in Manila. Jim Williams and John Hicks gave various presentations and chaired a session in the Network Engineering program. See presentations at <http://www.transpac2.net/presentations.php>

Williams worked with Heather Boyles of Internet2 and others to develop a R/E Networking in South Asia Workshop to be held at the Spring Internet2 Member Meeting in DC.

### **February 2007**

Williams attended the NSF Security Summit in Washington on February 22-23.

### **April 2007**

TransPAC2 staff (Williams, Hicks and Robb) attended the Internet2 meeting in Washington, DC

Williams worked with Heather Boyles of Internet2 and Michael Foley of the World Bank and others to present a R/E Networking in South Asia Workshop at the Spring Internet2 Member Meeting in DC. One outcome of this meeting was the formation of a South Asia Special Interest Group (SA-SIG). Williams is the chair of this group. See the website at: <http://southasia.indiana.edu>.

Robb and Williams met with representatives from PERN2 (Pakistan Education and Research Network) at the Internet2 meeting in Washington DC. Based on this and other discussions, Williams developed a proposal to extend the IRNC program to Pakistan. This proposal, which has complete Pakistan support, was submitted to the NSF in July, 2007.

### **July 2007**

Williams attended the DICE consortium in Berkeley, CA, July 10-13 during which he discussed The development of inter-network NOC and measurement services.

### **August 2007**

Williams attended the CCIRN meeting in Xi'an, China. Williams and Hicks attended the CANS 2007 meeting in Xi'an, China where Hicks presented a talk on network security. Both also attended the APAN

meeting in Xi'an China, immediately following the CANS meeting where Hicks presented a talk on TransPAC2 and Internet2 perfSONAR activities.

Williams attended a NSF sponsored meeting in Beijing preceding the Xi'an meetings with representatives of other Asian networks and other U.S. and NSF representatives. During the meeting Williams gave a short presentation about TransPAC2.

### **September 2007**

Williams and Hicks attended the PRAGMA meeting at the University of Illinois.

TransPAC2 began discussions with the National Institute of Informatics in Japan regarding TransPAC2 hosting an NII engineer for several weeks in 2008. Details will be finalized in early 2008.

A Supplemental Funding Request to provide an IRNC extension from Singapore to Karachi, Pakistan was completed and sent to the NSF for review and possible funding.

### **October 2007**

Williams attended the GENI Workshop in Minneapolis and the IRCN Workshop in Washington.

Hicks attended the Internet2 fall members meeting in San Diego and also chaired the TransPAC2 and SouthAsia SIG meetings. In addition he took notes at the RENOG BOF and met with Japanese colleagues to discuss a possible visit from NII to Indiana University in Spring 2008.

Hicks traveled to LA with Japanese colleagues after the fall members meeting to tour the KDDI America, PacWave, and SINET collocation facilities. Plans for Supercomputing 2008 and other future activities were discussed.

Through the TransPAC2 network, PerfSONAR resources were deployed (SNMP, OWMP, and BWCTL) in LA and partially deployed (SNMP) in Tokyo.

The NSF approved funding to provide a network connection to Pakistan. TransPAC2 worked hard to make the connection live by the first quarter of 2008.

### **November 2007**

Robb and Williams created and issued a RFP to continue TransPAC2 network services past the currently contracted service termination date of April 1<sup>st</sup>, 2008. RFP results were due by December 21 and a provider selection was made early in 2008.

### **December 2007**

TransPAC2 RFP responses were due on December 21. A decision on a carrier for the final two years of TP2 was made in January 2008.

## **Significant Milestones and Accomplishments for Project Year Four**

### **January 2008**

Indiana University began preparation for development of a GENI solicitation response.

Williams attended a State Department briefing about the IRNC programs and presented about TransPAC2 and connections with Pakistan.

Work began to prepare for the Chinese American Networking Symposium to be held in Indianapolis.

Williams, Sweeny and Hicks attended the Joint techs – APAN meeting in Hawaii and presented a variety of papers and reports.

### **February 2008**

Williams worked with the Advanced Network Management Laboratory to prepare a submission for funding from the Cybertrust solicitation.

The GENI proposal was completed and submitted to the GENI Project Office.

Daniel Doyle (Summer REU) interviewed and was hired for part-time employment until summer. Daniel's final intern report is included at the end of this Final Report.

### **March 2008**

Williams and other IU staff members attended the Second GENI Engineering Conference in Arlington, VA.

Prep work for CANS meeting continued.

Engineering discussions began with Pacific-Wave regarding DCN implementation from the U.S. to Japan (and into APAN generally).

### **April 2008**

Williams traveled to Pakistan to present a series of lectures about international networking and the Pakistan-U.S. network connection. A complete description of the trip and the talks given at various universities is available at <http://pakistan.indiana.edu>.

Williams, Sweeny, Peck and Hicks attended the Spring Internet2 meeting in Arlington, VA and presented a variety of papers and reports.

### **May 2008**

Williams attended the NSF Cybersecurity Summit in Washington, DC.

**June 2008**

Williams traveled to New York City to meet with new KDDI-America President to discuss advancing the TransPAC2 and KDDI-A relationship.

Hicks and Sweeny host an engineer from SINET for several weeks.

**July 2008**

Williams, Hicks, Peck and Sweeny attended the Internet2 Joint Techs meeting in Lincoln, Nebraska, where Sweeny participated on a DCN panel. Sweeny also met with a group in Lincoln after Joint Techs tasked with redesigning the Internet2 ipv6 hands-on workshops.

Williams presented a talk at the Bloomington Chamber of Commerce about International Networking @ IU, specifically related to Pakistan.

**August 2008**

As Sub-Group Chair, Williams traveled to Nepal for meetings with the Internet2 South Asia Special Interest Group and a variety of other discussions and presentations.

Pakistan connection (Karachi-Singapore) is officially deployed and active.

Hicks and Sweeny made a number of presentations at the 26<sup>th</sup> APAN meeting in Queenstown, New Zealand. During this meeting a joint TransPAC2/Internet2 PerfSONAR workshop was held. Sweeny met with the chief APAN engineer to work out technical details and to schedule the Internet2-TransPAC2-APAN DCN implementation.

**September 2008**

Hicks traveled to Ann Arbor, MI for a PerfSONAR Developers' workshop and DICE meeting.

Engineering implementation began for the DCN implementation over TransPAC2.

**October 2008**

Williams, Sweeny, Peck and Hicks attended the Fall Internet2 meeting in New Orleans to participate in and present on a number of topics. During this meeting a DVTS tele-medical video demonstration was held between the conference venue, Indiana University, and Stanford University. The video demonstration was part of TransPAC2's ongoing support of tele-medicine within APAN and provided an opportunity for U.S. physicians to participate in a DVTS session.

Project developers completed the DCN implementation over TransPAC2.

Sweeny helped setup the SC08 supercomputing conference network in Austin, TX.

The CANS 2008 conference was held in Indianapolis, IN.

TransPAC2 officially announced Pakistan connection.

### **November 2008**

Williams gave a remote presentation for the HONET meeting in Malaysia.

Sweeny and Hicks worked on the routing and measurement teams in support of the SC08 supercomputing conference in Austin, TX.

DCN tests were conducted over the APAN and TransPAC2 networks. DCN tests end successfully across the APAN, TransPAC2, and Internet2 domains into the SC08 show as part of a NICT/JGN2 LIGO demonstration.

### **Significant Milestones and Accomplishments for Project Year Five (October and November 2008 are both mentioned twice- what is the rationale behind this?)**

#### **October 2008**

Indiana University was awarded a GENI grant for development of the GENI Meta Operations Center (GMOC). This will provide strong linkage between the operations research efforts of GENI and the production operations of TransPAC2. For more details see <http://gmoc.grnoc.iu.edu/>.

Sweeny helped setup the SC08 supercomputing conference network in Austin, TX.

TransPAC2 co-hosts the Chinese American Network Symposium (CANS) in Indianapolis. This meeting provided a venue for the exchange of information between networking experts from the U.S. (broadly based including Internet2, ESnet and other university networking experts). For more details visit <http://www.canscouncil.net/cans2008/CANS2008-Announcement.english.pdf>

Hicks facilitated a telemedical demo between Indiana University and I2 Members Meeting in New Orleans

#### **November 2008**

The Dynamic Circuit Network implementation, allowing native layer2 connectivity between users in the APAN region with the US, was completed in October. It demonstrated successfully in November at SC08 and is now a supported service across TransPAC2.

DCN is used successfully across the APAN, TransPAC2, and Internet2 domains into the SC08 show as part of a NICT/JGN2 LIGO demonstration.

Greg Cole visited Bloomington to discuss possible GLORAID-TransPAC2 cooperation.

Hicks was a member of the SC08 measurement team, providing network monitoring and measurement support to the entire supercomputing conference. Hicks also worked with APAN engineers to display a TransPAC2 PerfSONAR weather map at the SCinet NOC and around the show floor.

#### **February 2009**

Williams travels to New York City to meet with KDDI-America (the TP2 circuit supplier).

Williams begins discussions with NSF regarding possible US-India Cyberinfrastructure Workshop.

Thomas Wang from the NOC attended the Joint Techs in College Station, TX.

Hicks attended APAN meeting in Taiwan and conducted a PerfSONAR follow-on workshop

Sweeny attended and presented at Joint Techs meeting in College Station, TX

Sweeny attended and presented at APAN meeting in Kaohsiung, Taiwan

### **March 2009**

Hicks conducted a PerfSONAR follow-on workshop at the 27th APAN Meeting, Kaohsiung, Taiwan (the same thing is mentioned under February- which month did this occur?)

Peck, Williams and Sweeny attended the NLR all-hands meeting in San Diego, CA in March.

Williams attended the GEC4 GENI Engineering Conference in Miami, FL.

Williams was elected to the Internet2 External Research Advisory Committee (ERAC) and appointed to the Internet2 Standing Committee on International Strategy (SCIS).

Williams worked with representatives of ETRI and KISTI, (Korean research organizations) to prepare and submit a GENI proposal for establishment of linkage between GENI and ETRI/KISTI-Korea for international federation.

### **April 2009**

Nizar Louly met with Badr Hubais from the ANKABUT network. They discussed issues relating to network management and how Indiana University might be able to assist ANKABUT as they assume the role of a regional NREN in the U.A.E.

Williams attended Internet2 Spring Members Meeting. Williams participated in ERAC and SCIS meeting while in Washington D.C.

Williams chaired a meeting for the South Asia SIG at the Internet2 meeting in Washington.

Williams attended the Science, Technology and Innovation Policy Workshop at Harvard.

Sweeny attended and presented updates to JET meetings during the quarter.

Nizar Louly and Terry Broadstreet from the Service Desk attended the Internet2 Members Meeting in Arlington, VA. Louly participated in a number of international networking events, while Broadstreet met with the engineering group for MAX GigaPoP, a new network the GRNOC is supporting.

### **May 2009**

Williams attended and presented at the Advanced International Conference on Telecommunications in Venice. His presentation was titled, "The GENI Project and the GMOC: Federated Management Infrastructure and Implications beyond GENI" He was part of a panel on the future of the Internet.

The GlobalNOC Service Desk re-organized its staff resources to provide greater focus on significant areas. The first action was to create "Specialized Support Technicians (SSTs)" for specific network area support. At this time, Alice Jackson was appointed as the administrator for external contacts and customers (or SST) for TransPAC2 and AMPATH.

### **June 2009**

The GlobalNOC Service Desk completed a major facility renovation, including installing a more functional "video wall," and replacing all of the glass surrounding the facility. A picture follows at the end of this section. The GlobalNOC Service Desk now hosts a new Cisco Telepresence site for use by networking and service desk staff. It is expected that this telepresence unit will be helpful for internal and external NOC interactions, for disaster recovery planning, and for troubleshooting of GRNOC networks.

### **July 2009**

As part of the Internet2 Joint Techs Conference, the Service Desk at the GlobalNOC hosted a series of tours of its renovated facilities and the new Cisco Telepresence site now operating at the Service Desk. GRNOC Systems Engineering group created a three dimensional, touch screen, Atlas Maps application to display real time utilization of all GRNOC Networks. Both the TransPAC2 circuits and the Pakistan backhaul circuit to Asia via TransPAC2 are currently displayed.

Hicks upgraded the TransPAC2 Peakflow SP security system to 5.0.

Williams attended the APAN29 meeting in Kuala Lumpur, Malaysia and held a TransPAC2 planning meeting.

### **August 2009**

Hicks helped coordinate the annual maintenance contract on the Arbor Peakflow SP system with Internet2 and Indiana University/TransPAC2.

Sweeny and Hicks attended and participated in the Joint Techs meeting held in Indianapolis. The GlobalNOC hosted a number of tours for this meeting.

Sweeny attended and presented TransPAC2 activities and updates to JET meetings during the quarter.

Indiana University and a variety of its partners prepared and submitted two responses to the NSF IRNC solicitation.

Jim Williams won an NSF award to hold a workshop in India. He will work to develop this in conjunction with Greg Cole and the NSF funded GLORIAD/Taj Project.

## September 2009

Hicks worked with GRNOC engineers and Li Zhoungui (CERNET2) to gather SNMP data from the TEIN2 router in Singapore and implemented the Singapore to Pakistan link on the TransPAC2 Atlas. For more details see [http://atlas.GlobalNOC.iu.edu/atlas.cgi?map\\_name=TransPAC2](http://atlas.GlobalNOC.iu.edu/atlas.cgi?map_name=TransPAC2).

To see the Pakistan backhaul circuit to Asia via TransPAC2 , TP2-KAR-SING-0192-01517, displayed in real time on GRNOC Atlas Maps [http://atlas.grnoc.iu.edu/atlas.cgi?map\\_name=TransPAC2](http://atlas.grnoc.iu.edu/atlas.cgi?map_name=TransPAC2) . Although the circuit was implemented in late 2008, monitoring access was negotiated and worked out during the first half of 2009.

The GlobalNOC began supporting FutureGrid, a project funded by the NSF to develop a high-performance grid test bed for the development and testing of parallel, grid, and cloud computing. FutureGrid will be developed through a partnership of IU, Purdue University, the University of California - San Diego, the University of Chicago/Argonne National Labs, the University of Florida, the University of Southern California, the University of Texas, and the Center for Information Services and High Performance Computing at Technische Universität

Comment



## **Significant Milestones and Accomplishments for Project Year Six**

Due to worked funded by this award, Williams was invited to participate and lead the Broadband Working Group in the Department of State Joint Commission Meeting on Science and Technology between the US and Pakistan. The report from that Working Group is attached to this report.

October 2009

Williams attended the Internet2 Fall Member meeting in San Antonio, Texas. He participates in the ERAC meetings and chairs the SA-SIG meeting. Details of the SA-SIG meeting can be found at: <https://wiki.internet2.edu/confluence/display/emergingren/Agenda+for+Monday+5+October%2C+2009>

Williams participated in an NSF evaluation panel in Washington, DC.

### **November 2009**

Summer intern (Brandon Williams) was hired to produce a report on "How International Networks can connect to GENI". A copy of this document is attached to this report.

Williams participated in GEC5 at the University of Utah and co-chairs the COMIS Working Group.

Williams co-hosted a visit from a group of Pakistan universities to Indiana University.

Sweeny and Hicks participated in support of the Supercomputing '09 conference and exposition in Portland, Oregon in November 2009. Hicks was a member of the measurement and monitoring team, and Sweeny a member of the routing team. Sweeny also helped coordinate, provide, and support the extensive use of NLR for SC09 support. This was the culmination of a year of preparation and consulting with end-users on needed functions, and with the SCinet teams to coordinate, design, create, and operate the conference network and all its supporting functions. A number of APAN-related projects participated in SC09. Research organizations from the APAN region are prominent and demanding users (and testers) of the SCinet network.

### **December 2009**

The Global NOC began support of the Mid-Atlantic Crossroads (MAX) GigaPoP, located in the Washington D.C. area. This network plays a significant role in international networking by supporting the NGIX East international peering point with numerous European and international networks landing and peering at this location.

The GlobalNOC Service Desk completed an audit of all TransPAC2 NOC documentation. New documentation was created as needed, while also updating existing documentation. The GlobalNOC continued to evaluate documentation environments that would combine both network tools and documentation layouts, as well as communication platforms for a more robust troubleshooting environment.

Greg Cole visited IU-Bloomington for discussions about how our IRNC projects can better support each other.

## **January 2010**

The GlobalNOC Service Desk opened a second office on the Indiana University, Bloomington Campus. The new Bloomington office enhances the Service Desk operational model by its support of specific GlobalNOC and IU networks. The new office also provides the primary Indianapolis based Service Desk with a “hot” backup facility as part of the GlobalNOC’s larger business continuity efforts. In the event one of the Service Desk locations is adversely impacted by a major environmental event (tornado strike, ice storm, etc), all essential Service Desk resources remain available by redundancy and mobility, with a trained staff able to perform its duties at more than one location.

Williams participated on the search committee for the new Internet2 International Activities Director.

Sweeny participated in the Internet2/ESCC Joint Techs meeting in Salt Lake City, UT.

JGN2+, one of our most important network partners in Japan and provider of the complementary backup connection for TransPAC2, relocated its network termination in Los Angeles. This move required extensive coordination among JGN, APAN, JGN’s new and old providers, and TransPAC2 and went very smoothly.

## **February 2010**

In February 2010 Sweeny met with officials from the Australian Ministry of Finance in Canberra after the APAN meeting in Sydney to discuss Cisco Telepresence deployment and technical issues. The U.S.-lead Research and Education Telepresence Exchange, built on the groundbreaking efforts of the NLR Telepresence Exchange, is the world leader in Telepresence implementation in the R&E networks. Because of this, its advice and input are sought by technologists inside and outside Cisco. In addition to rapid growth of the Telepresence-using R&E community, its connectivity to the commercial Telepresence world increased markedly during this past year.

The GlobalNOC added a new PMI certified project manager to its staff. The project management process assured consistent quality across projects as well as appropriate allocation of resources to incoming business. IRNC supported networks benefit through added assistance with scheduling resources and project reporting.

Williams, Hicks, and Sweeny attended the APAN 29 meeting in Sydney, Australia. Williams co-chaired the Future Internet Testbed Working Group, while Hicks chaired perfSONAR workshop and Sweeny spoke on Telepresence and worked on engineering coordination with APAN partners in planning for IRNC2 proposals.

## **March 2010**

The GlobalNOC signed a contract to support the new network for U.S. governmental agency National Oceanic and Atmospheric Administration (NOAA). Support included GlobalNOC engineering, Service Desk functions, and systems engineering support for its new research network N-Wave. N-Wave was initially used to support its R&D HPCS program, connecting 17 NOAA sites to the network. Due to his routing expertise. Sweeny provided support to this project as well.

Williams participated in the U.S.-Pakistan JCM in Washington DC. Further details are located in the Pakistan section of this report.

Hicks attended PRAGMA 18 in San Diego, CA and discussed grid application and possible collaboration with the DLT project.

#### **April 2010**

Williams and Sweeny participated in the Spring Internet2 meeting in Washington, DC. Williams chaired the SA-SIG Working group and participated in the ERAC discussions. IRNC-2 awards were announced at this meeting.

#### **May 2010**

Sweeny participated in and presented at the NLR All-Hands Meeting.

Hicks attended the Internet2 MM in Arlington, VA and discussed The Dynamic Gateways for International Research (DyGIR) project and IRIS: International Research Instrumentation System projects with International partners and Internet2.

#### **June 2010**

The GlobalNOC began support of the new FutureGrid network, a project funded by the NSF to develop a high-performance grid test bed for the development and testing of parallel, grid, and cloud computing.

Williams participated in the TERENA meeting (TNC2010) in Vilnius, Lithuania. From the U.S. Sweeny remotely presented a plan for European R&E Telepresence exchanges as part of global R&E Telepresence architecture. Williams participated in the EU sponsored discussion of EU-U.S. networking issues while in Vilnius. Report from the European Commission is attached to this report.

Williams participated in the U.S.-India Joint Committee Meeting on Science and Technology Cooperation in Washington, DC.

Sweeny attended and presented at the CIC all-hands meeting in Chicago.

#### **July 2010**

In conjunction with its partners the PAC-WAVE network, the GlobalNOC began support of the newly merged U.S. national R&E commercial peering service, Internet2 TR-CPS. This merged service combined Internet2's previous CPS service with the other national R&E peering service, Transit-Rail.

Indiana University, with funding from the NSF, sponsors the INRC Kickoff in Washington, DC. For more details visit <http://irncworkshop.indiana.edu/>

Hicks attended the NSF/Internet2 sponsored perfSONAR workshop in Arlington, VA and discussed DyGIR and IRIS with Internet2.

Hicks and Sweeny attended the Internet2 Joint Techs in Columbus, OH and finalized plans to test the DLT on TransPAC2.

### **August 2010**

Formal announcement of the Indiana University ACE and TP3 awards.  
See announcement at <http://internationalnetworking.indiana.edu/>

Williams traveled to Vietnam for the APAN meeting. Sweeny also attended the APAN meeting in Hanoi, moderating one of the Network Engineering sessions and delivering Jim Williams' presentation on ACE and TransPAC3.

### **September 2010**

The GlobalNOC completed a new GlobalNOC Change Management System. The system is a series of updated procedures and guidelines, along with a new web-form tool developed and incorporated into the GlobalNOC's ticketing system. Upon final approval of this system, network engineers may now quickly submit a change request adhering to pre-defined guidelines and scheduling timeframes. The new process ensures smooth and prepared changes, as well as allows proper notification, pre-planning, and approval of any network changes.

TransPAC2 staff attended the DICE meeting in Ottawa. The principals met with technical representatives and discussed compatibility issues between perfSONAR PS and MDM as well as dynamic circuit compatibility between Asia, the US and Europe. The DICE perfSONAR WG goals included; defining what and how to deploy resources, what data to make available, integration, support and scalability. We supported these goals by working in concert with the DICE community and contributing to policy documents concerning perfSONAR and dynamic circuit software integration.

Hicks attended the SC10 measurement install fest in Ann Arbor, MI and discussed DyGIR and IRIS with Internet2.

Sweeny participated in the NOAA all-hands meeting.

## Year by Year Meetings and Presentations

This section of the CIREN Final Report provides detailed information about presentations made by CIREN staff during the period of the award.

### Project Year One

Robb, Hicks and Williams attended the ESnet/Internet2 Joint Techs in Vancouver, July 18-20, 2005.

- a. John Hicks attended the Internet2 E2E piPES performance workshop at the Joint Techs meeting in Vancouver. He discussed teaching the workshop at the January APAN meeting in Tokyo with Internet2 staff. This was a joint Internet2, APAN, TransPAC2 workshop open to all APAN members.
- b. Chris Robb provided a TransPAC2 update and had engineering discussions with Pacific Wave.

Williams attended APAN20 in Taipei, July 23-27, 2005.

- a. John Hicks gave a remote presentation at the APAN Taipei NOC session concerning TransPAC2 security and measurement efforts.
- b. Williams gave a presentation about NOC-NOC cooperation.
- c. Presentations are available at [www.apan.net](http://www.apan.net)

Williams spoke remotely at APII workshop in Seoul, September 5-6, 2005 about NOC-NOC cooperation.

Williams attended the NSF Cybersecurity Summit in Washington, DC. Problematic activity from Asia was a significant issue/problem that was mentioned by many attendees. It was not clear exactly where this activity originated (R/E networks or commercial networks). After completing preliminary investigations TransPAC2 planned to increase its security activities.

John Hicks attended SC05 and gave TransPAC2 presentations concerning measurement at the IU booth and PRAGMA booth. TransPAC2 participated in a number of SC05 demonstrations. See both the Performance and Applications sections below.

Williams, Hicks and Robb attended the APAN21 meeting in Tokyo. Williams made a presentation about the recent Internet2 Security Exercise. Robb made a presentation about US R/E Infrastructure. See [www.apan.net](http://www.apan.net) for presentation details.

Williams, Hicks and Robb attended the Internet2 meeting in Arlington, VA. Robb gave a keynote talk about International Routing, while Williams provided a TransPAC2 update. See [www.internet2.edu](http://www.internet2.edu) for presentation details. Also see [www.renog.org](http://www.renog.org) for a downloadable version of the Chris Robb presentation.

Robb attended the ESnet/Internet2 Joint Techs conference in Madison, WI (7/16-7/20).

Robb met with SONET vendors to discuss possible future equipment and topologies.

Robb, Williams and Hicks attended the NSF IRNC Program Review in October. The TransPAC2 presentation to the review committee and the committee's findings and feedback are available on the TransPAC2 web site.

TransPAC2/Force-10 held security discussions at the I2 meeting in DC and continued to work on the security proposal.

Williams and Hicks attended APAN meeting in Singapore and gave presentations concerning TransPAC2 measurement and security (See <http://www.transpac2.net/presentations.php>) and chaired a session in the network Engineering track.

John Hicks attended the first Immersive Medical Telepresence (IMT) conference held in Phoenix, AZ and co-sponsored by Internet2. A follow on meeting was held during the fall Internet2 Members Meeting in Chicago.

Hicks attended the Arbor Summit in Toronto, Canada. This meeting provided an opportunity to meet directly with Arbor Networks developers and Japanese colleagues from the Tokyo XP.

Hicks attended Supercomputing 2006 in Tampa FL and met with PRAGMA, APAN, and other researchers concerning TransPAC2. . TransPAC2 presentations were given at the IU and PRAGMA booth.

Williams, Hicks, Robb, and Kotil, attended the Internet2 Fall Members Meeting in Chicago, IL (12/4-12/7). Williams mediated a discussion about provisioning dynamic circuits between countries. Attendees included TransPAC2, Geant2, APAN, ESNET, and Internet2.

## **Project Year Two**

Williams, Hicks and Robb attended the APAN21 meeting in Tokyo. Williams made a presentation about the recent Internet2 Security Exercise. Robb made a presentation about US R/E Infrastructure. Williams chaired a session in the Network Engineering track. See [www.apan.net](http://www.apan.net) for presentation details.

Williams, Hicks and Robb attended the Internet2 meeting in Arlington, VA. Robb gave a keynote talk about International Routing, while Williams provided a TransPAC2 update. See [www.internet2.edu](http://www.internet2.edu) for presentation details. Also see [www.renog.org](http://www.renog.org) for a downloadable version of the Chris Robb presentation.

Robb met with APAN engineers to discuss TransPAC2 futures and also worked with Internet2 staff and APAN staff to determine future network connectivity options for TransPAC2.

## **Project Year Three**

John Hicks met with the Immersive Medical Technology Group, Arbor Networks, and our APAN security collaborators.

Williams and Hicks attended APAN23 in Manila. Presentations are available on the APAN web site (<http://www.apan.net>) and the TransPAC2 web site (<http://www.transpac2.net> )

Williams attended the NSF Large Systems Security meeting in Washington, DC. See the following recommendation:

**“(5) Develop an agenda for increasing international security cooperation to support international science.**

International science collaborations such as ITER and the HDC project require a tremendous degree of cooperation between the involved organizations. While organizational cooperation between the different research branches has advanced steadily, there has been little or no improvement in communications between the security groups of these different organizations.

An example of this is that security data from events at CERN tend to propagate to U.S .computational facilities via high-energy physics mailing lists. While this is useful, it would be much more efficient to have tools and agreements in place so that the computer security groups could exchange information without worrying about (for example) local privacy rule violations.

We propose that a workshop be funded that addresses the impact of security issues on global science. It would not only be designed to answer basic questions regarding how to respond to international security issues but also would be a platform to develop better relations and communications between the different organizations involved in these collaborative efforts.

Given the cross-departmental nature of this research, we suggest involvement by Internet2, ESnet, FIRST and their EU counterparts, and the OSG/HEP community, which seems to be grappling with many of these issues already."

Williams presented remotely at the Korean APII meeting March 20-23 in Seoul. The presentation is available on the TP2 website at <http://www.transpac2.net>.

Williams, Hicks and Robb participated in an IRNC investigators meeting in DC, April 12-13.

Williams, Hicks and Robb participated in the Internet2 Spring Member Meeting in DC (April 23-26) and the follow-on South Asia Special Interest Group meeting (April 27).

See <http://transpac2.net> and <http://southasia.indiana.edu> for complete details and presentations.

**Project Year Four**

Williams participated in the DICE meeting in Berkeley, CA July 10-13.

Williams participated in an NSF IRNC planning meeting at the NSF office in Beijing on August 23.

Williams and Hicks participated in CANS 2007 and the CCIRN meeting in Xi'an, China on August 25-26. Williams and Hicks participated in APAN27 in Xi'an China.

Williams and Hicks attended the PRAGMA meeting at UIUC in Urbana, Illinois on September 24-25.

Hicks participated in the Internet2 Fall Member Meeting in San Diego on October 8-11. See the TransPAC2 web site <http://www.transpac2.net> for presentation details.

Williams participated in the first GENI Engineering meeting in Minneapolis, MN on October 8-10.

Williams attended and participated in the NSF IRNC planning workshop in Washington, DC on October 23-26.

Williams, Sweeny and Hicks attended the Joint techs – APAN meeting in Hawaii and presented a variety of papers and reports. Presentations are available on the APAN web site (<http://www.apan.net>) and the TransPAC2 web site (<http://www.transpac2.net> )

Presentations by TransPAC2 at the Joint Techs/APAN meeting in Hawaii included:

- Sweeny: Gigapop Geeks BOF <http://events.internet2.edu/2008/jt-hawaii/sessionDetails.cfm?session=3584&event=278>
- Sweeny: BGP path-hinting <http://events.internet2.edu/2008/jt-hawaii/sessionDetails.cfm?session=3608&event=278>
- Sweeny: presentations on TransPAC2 engineering, including new DCN functions for APAN and path-hinting, at APAN meeting

Williams briefed the U.S. State Department about TransPAC2 and Pakistan.  
<http://www.transpac2.net/presentations/2008/State%20Dept%20TP2%20Briefing.ppt>

See <http://pakistan.indiana.edu> for a complete list of Williams' talks and presentations in Pakistan.

Presentations by TransPAC2 at the Internet2 Member Meeting in Arlington:

- Sweeny: TransPAC2 update for APAN group; update on path-hinting at RENOG

### **Project Year Five**

Williams KDDI-America presentation in NYC.  
<http://www.transpac2.net/presentations/2008/KDDI%20talk.ppt>

Williams and Sweeny presented at the Nebraska Joint Techs meeting:

- Sweeny: Gigapop Geeks BOF (ipv6 deployment) <http://events.internet2.edu/2008/jt-lincoln/sessionDetails.cfm?session=10000089&event=281>
- Sweeny: DCN implementation panel discussion <http://events.internet2.edu/2008/jt-lincoln/sessionDetails.cfm?session=10000083&event=281>
- Williams: Inter-Agency Communication and International Projects  
<http://events.internet2.edu/2008/jt-lincoln/sessionDetails.cfm?session=10000134&event=281>

See Williams' presentation at the Bloomington Chamber of Commerce at  
<http://www.transpac2.net/presentations/2008/Bloomington%20talk.ppt>

See <http://southasia.indiana.edu> for a list of presentations in the last year (some by Williams) focused around South Asia.

Presentations by TransPAC2 at the Internet2 Member Meeting in New Orleans:

- Sweeny: TransPAC2 update for APAN group

Sweeny's routing presentations in support of the SC08 supercomputing conference in Austin, Texas.  
<http://www.transpac2.net/presentations/2008/SC08-Routing-PresentationV2.ppt>

TransPAC2 co-hosted the Chinese American Network Symposium (CANS) in Indianapolis. This meeting provided a venue for exchange of information between networking experts from the US (broadly based including Internet2, ESnet and other university networking experts).

See: <http://www.indiana.edu/~uits/cans2008/>

Program: <http://www.indiana.edu/~uits/cans2008/program.html>

There was a TransPAC2 planning meeting in New Orleans and various presentations by TransPAC2 staff.

Williams remote presentation for the HONET meeting in Malaysia.

<http://www.transPAC2.net/presentations/2008/Internet2%20and%20NRENS%20in%20South%20East%20Asia.ppt>

Hicks attended Supercomputing 2008 and worked as a member of the SCinet measurement team.

Thomas Wang for the NOC attended the Joint Techs in College Station, Texas. Sweeny spoke on BGP path-hinting on Feb 3 at the same Texas Joint Techs meeting

<http://www.internet2.edu/presentations/jt2009feb/20090203-It-sweeny.pdf>

Peck, Williams and Sweeny attended the NLR all-hands meeting in San Diego. Sweeny gave presentations on implementing Cisco Telepresence on university campuses, on Telepresence architecture, and on the NLR Telepresence Exchange. See <http://www.nlr.net/events/200903-AllHands/>

Hicks attended APAN meeting in Taiwan and conducted a perfSONAR follow-on workshop as part of the Internet2 measurement team. Sweeny attended the APAN meeting in Kaohsiung, Taiwan and spoke about the BGP path-hinting protocol and status update "Using a new BGP path-hinting protocol to signal routing requests" For more details view <http://www.jp.apan.net/meetings/0903-TW/brent2.pdf> and "TransPAC2 engineering update: dynamic circuits from Internet2 to the APAN region"

<http://www.jp.apan.net/meetings/0903-TW/brent.pdf>

Nizar Louly, and Terry Broadstreet from the Service Desk attended the Internet2 Members Meeting in Washington D.C. Hicks and Williams attended Internet2 Spring Members Meeting. Williams participated in ERAC and SCIS meetings while in DC.

## **Program Year Six**

Hicks attended and participated in the Joint Techs meeting in Indianapolis. While there Hicks prepared an affidavit and testified as an expert witness in the United States District Court Southern District of Indiana concerning commercial international networking and domain registrant responsibilities. While not directly involving science this input from the TransPAC2 program may have an effect on clarifying a small part of the Internet-legal system interaction.

Sweeny participated in the Internet2 Joint Techs meetings in Indianapolis. With Dan Magorian, he led the "Gigapop Geeks BOF" and several discussion topics:

<http://www.internet2.edu/presentations/jt2009jul/20090719-magorian-sweeny.pdf>

The Quilt organization conducted a workshop for current and prospective users of Telepresence on September 14-15 at the University of Kansas in Kansas City, where Sweeny was one of the program committee and spoke on a number of topics.

Steve Peck and Terry Broadstreet from the Service Desk attended the Fall Internet2 Members Meeting in San Antonio, TX.

Brent Sweeny and John Hicks participated in support of the Supercomputing '09 conference and exposition in Portland, Oregon in November 2009. Hicks worked as a member of the measurement and monitoring team, and Sweeny as a member of the routing team. A number of APAN-related projects participated in SC09. Sweeny also helped coordinate, provide, and support the extensive use of NLR for SC09 support.

Steve Peck and Mathew Hoffman from the Service Desk attended the Winter Internet2 Joint Techs conference in Salt Lake City, UT.

Hicks attended APAN 29 in Sydney and chaired perfSONAR workshop.

Williams participates in the US-Pakistan JCM in Washington DC. The written report for this group accompanies this report.

Hicks attended PRAGMA 18 in San Diego

Mathew Hoffman and Eldar Urumbaev from the Service Desk attended the Fall Internet2 Members Meeting in Arlington, VA.

The Global NOC hosts the National LambdaRail All-Hands meeting in Indianapolis, IN. Steve Peck and Ty Bell from the Service Desk attend. Peck presents an operational report for the past 12 months.

Hicks attended the Internet2 MM in Arlington VA.

Steve Peck, Mathew Hoffman and Eldar Urumbaev from the Service Desk attended the Summer Internet2 Joint Techs conference in Columbus, OH. Hicks attended the Internet2 Joint Techs in Columbus OH

Hicks attended the NSF/Internet2 sponsored perfSONAR workshop in Arlington VA.

GlobalNOC hosted the first NOAA N-Wave All-Hands meeting in Indianapolis, IN. NOAA & Global NOC staff, network engineers and management met with representatives from NOAA project offices, regional optical and state networks, and network contractors/vendors to discuss coordinated activities related to the N-Wave Project. Steve Peck and Eldar Urumbaev from the Service Desk attend, with both collaborating on a presentation on operational issues and best practices.

Hicks and Williams attended the DICE meeting in Ottawa.

Hicks attended the SC10 measurement install fest in Ann Arbor



## Specific project activities

This section of the Final Report focuses on specific activities that represent significant project contributions in areas of interest to the NSF such as HR development, contributions in new areas for the project (Pakistan, GENI) or significant efforts outside the defined project scope (SuperComputing).

### **US-Pakistan Connectivity – See: <http://pakistan.indiana.edu>**

In January 2007, in preparation for the United States-Pakistan First Joint Committee on Science and Technology (Feb 13-14, 2007) Williams prepared a briefing on internal networking in Pakistan and the possibilities of a US-Pakistan network connection. Among the recommendations of the FJC report was... “an introduction of high speed connectivity between the two countries”. With the assistance of Internet2, a cooperative project between TransPAC2 (US-IRNC initiative) and PERN2 (Pakistan-HEC initiative) was begun to develop this high speed connectivity.

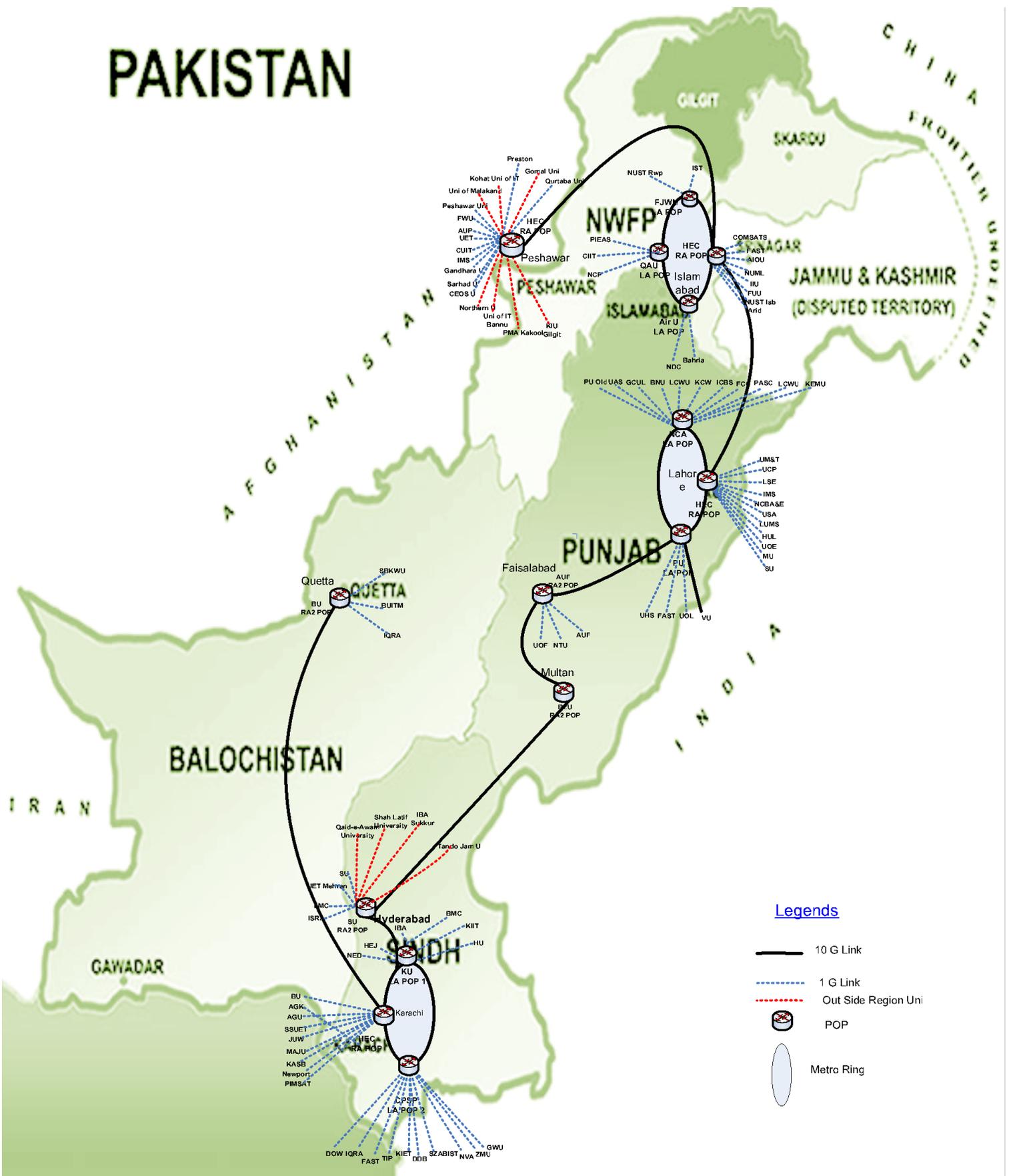
A funding request was submitted to the NSF and funds allocated for US half of the project. A similar funding process was undertaken in Pakistan and the Pakistan-HEC approved and allocated funding for Pakistan half of the project. Some technical details within Pakistan remain to be worked out. However, these are expected to be completed around 1/1/2008 and the connection completed in 1st Quarter 2008.

Technically the connection will be from Singapore to Karachi where it will connect to the PERN2 network. The connection will share the EU TEIN2 POP in Singapore. Pakistan and the US will split costs of the “wet” segment between Singapore-Karachi. Pakistan will be responsible for all networking costs within Pakistan.

Both NSF and NIH investigators have expressed direct interest in this connection. There is a planned US-Pakistan joint science meeting to be held in the US in 2008.

The following diagram outlines the PERN2 network in Pakistan. This network is expected to be completed in 2009.

# PAKISTAN



- Legends**
-  10 G Link
  -  1 G Link
  -  Out Side Region Uni
  -  POP
  -  Metro Ring

Williams visited Pakistan in early April 2008. He met with officials from the Pakistan Higher Education Commission (HEC). He visited a number of universities in Islamabad and in the area around Islamabad. He led a seminar and training program on high performance networking for the HEC. He also met with officials from the HEC and the Pakistan Telecommunications Company Limited to discuss details of the US-Pakistan network connection. This connection will be made from the TransPAC2 point of presence in Singapore to Karachi, Pakistan where it will connect to the PERN/PERN2 network.

The connection became active on 14-August, 2008. There was considerable work to be done on routing issues.

This project was made possible by close cooperation between the HEC in Pakistan, the TEIN2 project of the European Commission and the US National Science Foundation. Official publicity for the launch of the Pakistan network can be found at:

NSF: [http://nsf.gov/news/news\\_summ.jsp?cntn\\_id=112503&org=NSF&from=news](http://nsf.gov/news/news_summ.jsp?cntn_id=112503&org=NSF&from=news)

Indiana University: <http://uitspress.iu.edu/news/page/normal/9124.html>

European Commission:

<http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1590&format=HTML&aged=0&language=EN&guiLanguage=de>.

In the fourth quarter of 2008 and through 2009, Sweeny worked with network engineers in Singapore, China, Japan, and Pakistan to help support the PERN connection that was new in 2008. There were a number of issues to work out to optimize and adjust their routing, and in early 2009 the Singapore TEIN POP relocated and we helped to make sure that the change went as smoothly as possible. The PERN connection continues to be used successfully and productively by Pakistani and US researchers.

The unsettled political situation in Pakistan makes onsite visits to researchers difficult and the time differential makes VC connections inconvenient. Indiana University made a strong effort to organize Pakistan researchers and submit a proposal for a Bioinformatics and Genomics Center in Pakistan. But, ultimately, this effort was unsuccessful and no proposal was submitted. Other applications will be investigated as the situation in Pakistan permits.

Sweeny worked with network engineers at TEIN3 and PERN to help ensure continued functional operation. The PERN connection continues to operate as planned to provide relatively high-speed networking to the R&E community in Pakistan and to bring them more closely into the community of international researchers.

The US-Pakistan link usage has been quite high over the past 3 months as Pakistan is receiving data from Caltech (and other physics sites) related to the LHC experiments in CERN.

Williams was a group lead for the Broadband Applications Working Group, charged by the Department of State to help prepare for the Pakistan JCM. The JCM was held at the NSF and chaired by Dr. Arden Bement, Director NSF. The report is attached at the end of this Final Report.

## **IRNC GENI activities**

Williams attended the second GENI Engineering Meeting in Washington, DC. Although there was some detailed discussion of some GENI engineering areas, this was still a fairly introductory meeting. There was an International luncheon that Williams attended. There was a very large group at this meeting from Japan and a presentation about the Japanese Akira Project. There is also interest in GENI activities from Korea and Europe. Over the next year, TransPAC2 will try to coordinate some of this international interest in GENI. Regarding Indiana University specific efforts:

Indiana University has been awarded a GENI grant to develop a GENI Meta Network Operations Center (GMOC).

From the GENI Press Release:

**[GMOC].** "Global Research NOC at Indiana University – GENI Meta Operations Center". PI is Jon-Paul Herron at Indiana Univ. The scope of work on this project is to facilitate the sharing of operational and experimental information among GENI experimental components. This effort has both technical development and operational requirements. Technically, the GENI Meta Operations Center (GMOC) would require a well-defined protocol to help generalize the operational details of GENI prototypes and for the providers of prototypes to send those details to an operational data repository.

These requirements suggest a modular approach, with a generalized protocol rather than a restricted set of hardware and software that GENI prototype participants would be required to run. In other words, it would be largely up to the GENI Spiral 1 project investigators to decide what data to share and how to collect this data from their prototype infrastructure. The GMOC would provide the standardized format for this data and the systems required to share, monitor, display, and act on this data. In addition, the GMOC could be used to help provide a repository for data collections passing into and out of GENI prototypes for the purpose of discovering and isolating prototypes that have caused problems. This might require additional instrumentation at the connection points and substrate elements between prototypes. This would be accomplished with the help of the other prototypes that are part of GENI Spiral 1.

The GMOC will work with these other projects to develop the operational data formats, processes, and systems needed for a consistent and useful suite of GENI infrastructures. During the project, participants will investigate how a Meta Operations Center might interact with various prototype participants to accomplish operations functions.

We expect the close interaction between the GENI project efforts described above and the ongoing TransPAC2 NOC efforts to assist the TransPAC2 NOC (and all IRNC NOCs) in developing tools to interact with and participate in the GENI activities.

Williams worked with representatives of ETRI and KISTI, (Korean research organizations) to prepare and submit a GENI proposal for establishment of linkage between GENI and ETRI/KISTI-Korea for international federation. This proposal has been funded by the GPO-NSF and work will begin in 2010. This proposal has the beneficial side effect of bringing together the TP2 and GLORAID projects as the dvNOC and Korea are a key component of GLORAID. This is the K-GENI proposal described below.

A short description from the K-GENI proposal:

"We will provision a dedicated international connection between Korea and Indiana University in the US to facilitate an investigation into international federation strategies for operations between the GENI Meta-Operations Center, at Indiana University, and ETRI/KISTI-Korea. GMOC engineers and ETRI/KISTI engineers will use this connection to support tests for methods of interoperability between GMOC1 and the dvNOC2 system. The dvNOC is being developed as a part of the GLORIAD-KR project funded by Korean government and is in use by ETRI/KISTI. Examples would include testing a data stream of "externally significant" operational data between GMOC and dvNOC, including things like outage information and maintenance notification."

The K-GENI Project, described in the previous AR has been completed. A copy of the project final report accompanies this report.

## Science collaboration highlights

"The primary goal of TransPAC2 is to increase research and educational (R/E) collaboration between the United States and Asia. To increase R/E collaboration, TransPAC2 will deploy a secure, production-quality high-performance network infrastructure between Asia and the US and will assist our Asian partners in the deployment of high-performance infrastructure within Asia. TransPAC2 will enhance collaborations between US researchers and governments and Asian researchers and governments. TransPAC2 will also provide technical support for collaboration activities where requested."

### iGrid (<http://www.igrid.com/igrid/>)

TransPAC2 engineers worked with APAN engineering on iGrid-specific configuration tasks. Examples of TransPAC2 supported applications involved in iGrid activities are:

- Data Reservoir on IPv6: 10Gb Disk Service in a Box
- E-VLBI
  - Very-Long-Baseline Interferometry (VLBI) is one of the most powerful techniques available for the high-resolution imaging of distant radio sources in the universe and for making accurate measurements of the motion of the earth in space. Multiple radio telescopes scattered over the surface of the earth simultaneously record data from a radio source at streaming data rates as high as 1 Gbps for a 24-hour period;
- Sloan Digital Sky Survey
  - Sloan Digital Sky Survey (SDSS) is a project to carry out imaging and spectroscopic surveys of half the northern sky using a dedicated, wide-field, 2.5-m telescope. The imaging survey with a large mosaic CCD camera will produce digital photometric maps of the sky in five color bands. These maps will be used to extract the position and various photometric parameters of about 100 million galaxies and close to the same number of stars. The SDSS is a collaborative project between the US and Japan involving seven US institutions and the Japan Promotion group (JPG). IVDGL (GriPHyn) – now Open Science Grid (OSG) activities
  - The iVDGL is a global Data Grid that will serve forefront experiments in physics and astronomy. Its computing, storage and networking resources in the U.S., Europe, Asia and South America provide a unique laboratory that will test and validate Grid technologies at international and global scales. Sites in Europe and the U.S. will be linked by a multi-gigabit per second transatlantic link funded by the European DataTAG project.
- PRAGMA – Pacific Rim Application Grid Middleware Assembly
  - The Pacific Rim Application and Grid Middleware Assembly (PRAGMA) was formed to establish sustained collaborations and advance the use of grid technologies in applications among a community of investigators working with leading institutions around the Pacific Rim.

## Remote medical activity in Asia-Pacific

The Digital Video Transfer System (DVTS, see Figure 7) is used in the Asia-Pacific area since 2003 to transmit high quality moving images for international telemedicine. The high quality imaging provides viewing of live operating procedures including external and internal views of the patient. Remote locations are able to interact with the surgical team in real time. There have been more than 46 telemedical events

in Japan, Korea, China, Taiwan, Thailand, US, and Australia since 2005. More events are planned for Singapore, Malaysia, and the Philippines. This project promotes the exchange and standardization of medical techniques, social medical systems, and medical education.

TransPAC2 provides networking infrastructure and support for the use of DVTS and other medical applications. TransPAC2 can support multiple DVTS channels from the US to the Asian-Pacific region.

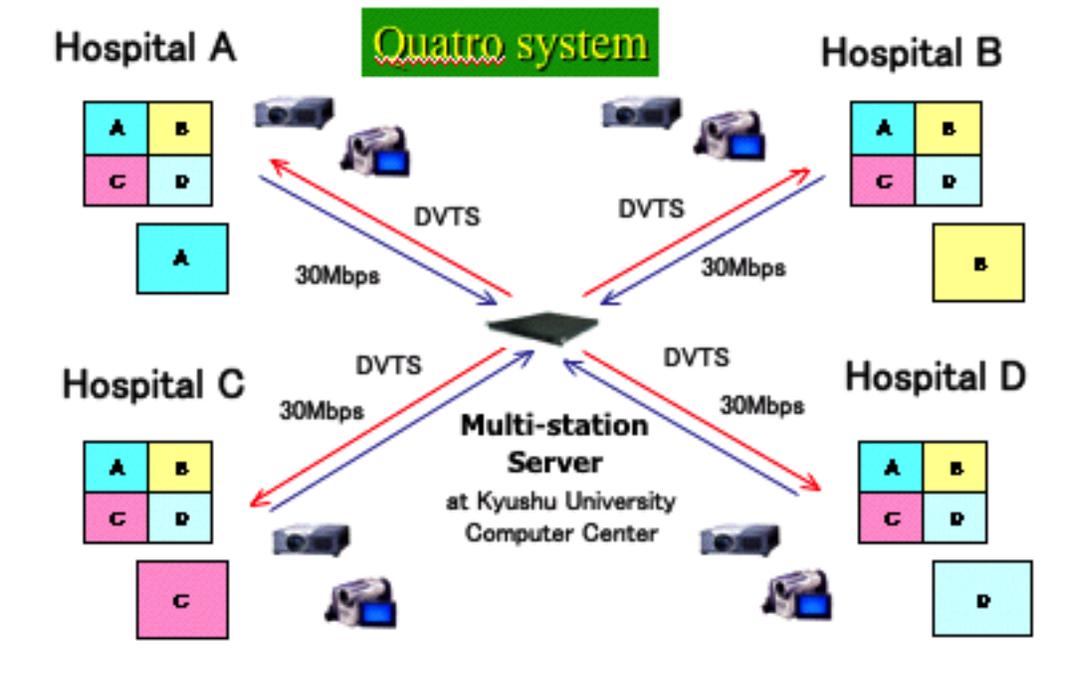


Diagram of DVTS connecting four hospitals for a telemedical event

Information provided by Dr. Shuji Shimizu, MD, PhD

Email: [shimizu@surg1.med.kyushu-u.ac.jp](mailto:shimizu@surg1.med.kyushu-u.ac.jp)

Bio-Mirror public service for high-speed access to biosequence data



<http://bio-mirror.net/>

Don Gilbert - Department of Biology, Indiana University, Bloomington, IN 47405, USA

Summary: Timely worldwide distribution of biosequence and bioinformatics data depends on high performance networking and advances in Internet transport methods. The Bio-Mirror project focuses on providing up-to-date distribution of this rapidly growing and changing data. It offers FTP, Web and Rsync access to many high-volume databanks from several sites around the world. Experiments with data grids and other methods offer future improvements in biology data distribution.

This is a world-wide bioinformatics public service for high-speed access to up-to-date DNA/protein biological sequence databanks. In genome research, these databanks have been being growing tremendously. There is over 495 Gigabytes (compressed) total data. The Bio-Mirror project is devoted to facilitate timely access to important large data sets for this research. High speed access is provided by Internet2, TransPAC2, the Australian Academic Research Network (AARNet) and the Asia-Pacific Advanced Network (APAN). Bio-mirror has resources available in the following countries: Australia, Austria, China, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Taiwan, Thailand, USA.

The following applications regularly benefit from the TransPAC2 networks:

### **Astronomy**

Very-Long-Baseline Interferometry (VLBI) is one of the most powerful techniques available for the high-resolution imaging of distant radio sources in the universe and for making accurate measurements of the motion of the earth in space. Multiple radio telescopes scattered over the surface of the earth simultaneously record data from a radio source at streaming data rates as high as 1 Gbps for a 24-hour period. TransPAC2 provides high-performance network access to the VLBI facility in Kashima Japan.

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

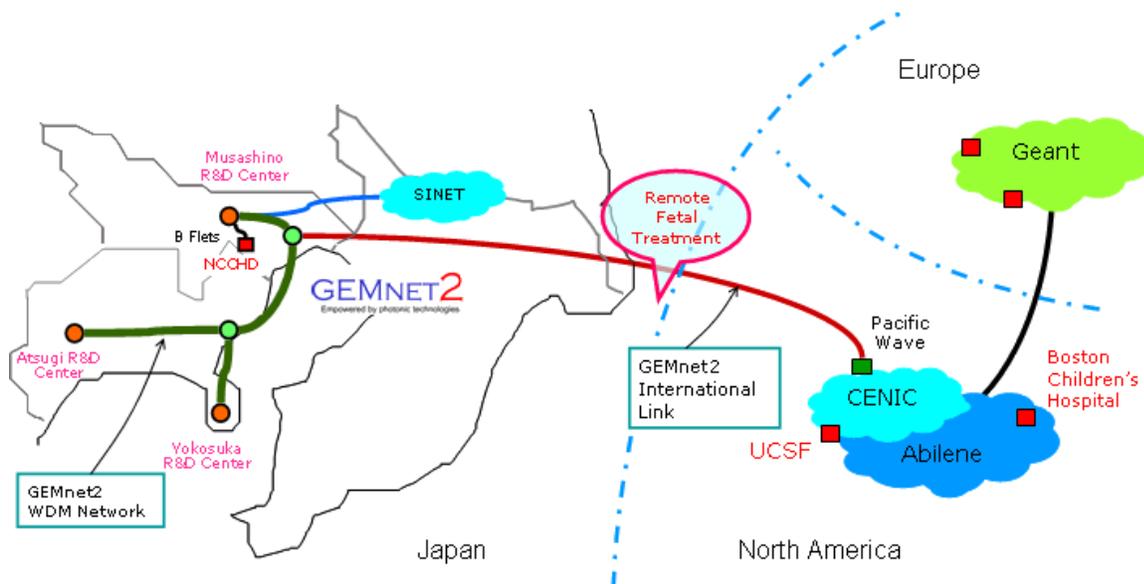
e-VLBI won the [Internet2 IDEA award, 2006](#)

For more information about e-VLBI see: [Internet2 e-VLBI](#)

## Tele-medicine

### US-Japan Telepresence and telemedicine in fetal care management

Nippon Telegraph and Telephone Corporation (NTT, headquarters: Chiyoda-ku, Tokyo) and the National Center for Child Health and Development (NCCHD, Setagaya-ku, Tokyo) tested the feasibility of transmitting digitalized fetal medical images (including 3-dimensional ultrasound as well as fetoscopic images) between the US and Japan. The purpose is to implement the telediagnosis and prospective telesurgical treatment of fetal diseases on a global scale. These feasibility studies are to be conducted using ultrahigh-speed network technologies through interconnections of the GEMnet2 ultrahigh-speed experimental network operated by NTT Laboratories with overseas research and education (R&E) networks from March 1, 2006 through March 31, 2007.



This application is an example of the type of telemedical activities going on between the U.S. and Asia. TransPAC2 is in a prime position to provide networking connectivity and support to these kinds of applications. TransPAC2 is currently working with the Barrow Neurological Institute, Internet2, and the APAN medical application group to use the TransPAC2 network to support this type of applications. Other applications include viewing remote surgical and diagnostic procedures. These applications are valuable teaching tools that connect experts to remote location. The goal is to move electrons not atoms. In these virtual classrooms, surgeons and OR staff can see and interact with an entire classroom of students as if they are there in the operating room. TransPAC2 will continue work with these groups to bridge the gap in the medical application space between the U.S. and the AP Region.

Information courtesy of Dr. Hisao Uose ([uose.hisao@lab.ntt.co.jp](mailto:uose.hisao@lab.ntt.co.jp)) of NTT laboratories.

## PRAGMA

The Pacific Rim Application and Grid Middleware Assembly (PRAGMA) was formed in 2002 to establish sustained collaborations and advance the use of grid technologies in applications among a community of investigators working with leading institutions around the Pacific Rim. Currently there are 29 institutions in PRAGMA, who meet twice a year at PRAGMA Workshops. In PRAGMA, applications are the key, integrating focus that brings together the necessary infrastructure and middleware to advance the application's goals. Working groups focus our activities. PRAGMA is governed by a Steering Committee.

TransPAC2 serves on the Steering Committee and supports PRAMGA applications using the TransPAC2 network connection.

For more information about PRAGMA see: [PRAGMA Home](#)

This section describes general, reoccurring activities that TransPAC2 is involved in and/or groups that benefit from TransPAC2.

### Earth Science

- DIAL is a web-based distributed system to search, access and visualize satellite remote sensing data for Global Change research. In collaboration with NASDA and other institutions, NASA has DIAL servers set up to distribute satellite remote sensing data. NASA and NASDA also collaborate on the Tropical Rainfall Measurement Mission (TRMM); 3D data is transferred from NASA to NASDA using TransPAC/APAN, processed and visualized for the web.

- In 1993, the US/Japan Common Agenda for Cooperation in Global Perspective was established to facilitate cooperation in addressing pressing global problems, including natural hazards. In 1998, a new joint earthquake research program, called the US/Japan Cooperative Research in Urban Earthquake Disaster Mitigation, emerged out of this broad agreement. Under this five-year program, NSF provides funding for U.S. researchers, while collaborating Japanese researchers are being supported principally by the Japanese Ministry of Education, Science, Sports and Culture.

- The Space Physics and Aeronomy Research Collaboratory (SPARC) is an NSF-sponsored community resource for the upper atmospheric and space sciences; operating 24 hours a day for scientific collaboration and access to real-time and archival data.

### High Energy Physics

- The BELLE detector is the state-of-the-art detector to investigate CP violating phenomena with unprecedented precision at the KEK B meson factory. The CP (C=Charge conjugation, P=Parity) violation is a key to explain why the universe is dominated by the matter, not by the anti-matter. The primary goal of the BELLE detector is to identify the origin of the CP violation. The BELLE collaboration consists of more than 40 institutions from Japan, Korea, China, Taiwan, India, Russia, USA, Australia, and Europe.

- The **GriPhyN (Grid Physics Network)** collaboration is a team of experimental physicists and information technology (IT) researchers who plan to implement the first Petabyte-scale computational environments for data intensive science in the 21st century.

- ATLAS is a general-purpose experiment for recording proton-proton collisions at LHC. The ATLAS collaboration consists of 144 participating institutions (June 1998) with more than 1750 physicists and engineers (700 from non-Member States). The detector design has been optimized to cover the largest possible range of LHC physics: searches for Higgs bosons and alternative schemes for the spontaneous symmetry-breaking mechanism; searches for supersymmetric particles, new gauge bosons, leptoquarks, and quark and lepton compositeness indicating extensions to the Standard Model and new physics beyond it.

### **Life Sciences**

- DNA data has accumulated more rapidly than compute power so researchers must often exclude potentially informative data to make statistical analysis practical. Utilizing the computationally intensive maximum-likelihood method of phylogenetic inference in a globally distributed collection of computational nodes, Indiana University, National University of Singapore and ACSys CRC in Australia have analyzed the DNA of cytoplasmic coat proteins, micro-sporidia, and cyanobacteria.

### **Astronomy and Space Science**

- Sloan Digital Sky Survey (SDSS) is a project to carry out imaging and spectroscopic surveys of half the northern sky using a dedicated, wide-field, 2.5-m telescope. The imaging survey with a large mosaic CCD camera will produce digital photometric maps of the sky in five color bands. These maps will be used to extract the position and various photometric parameters of about 100 million galaxies and close to the same number of stars. The SDSS is a collaborative project between the US and Japan involving seven US institutions and the Japan Promotion group (JPG).
- The LIGO Scientific Collaboration (LSC) is a forum for organizing technical and scientific research in LIGO. Its mission is to insure equal scientific opportunity for individual participants and institutions by organizing research, publications, and all other scientific activities. It includes scientists from the LIGO Laboratory as well as collaborating institutions.

### **Tele-Sciences**

- Scientists at the Osaka University Research Center for Ultra High Voltage Electron Microscopy (UHVEM) and University of California San Diego National Center for Microscopy and Imaging Research (NCMIR) successfully use international advanced research networks to couple the world's largest and most powerful (3 million volt) transmission electron microscope at UHVEM to a remote-use computer pavilion set up at NCMIR.

### **Phoebus**

Dr. Martin Swany – University of Delaware

The Phoebus project seeks to encourage a paradigm shift in the way traditional edge and backbone networks are utilized in order to improve end-to-end throughput over long distances. By augmenting the

current Internet model with an additional service layer, Phoebus embeds "intelligence" in the network that allows a connection to become articulated and adapt to the environment on a segment by segment basis. The system includes a protocol and software infrastructure that addresses many of the fundamental issues in long distance data movement and allows the Internet infrastructure to evolve.

- Allows existing applications to utilize dynamic circuit allocation with no changes.
- Allows adaptation to segment-specific transport protocols.
- Automatically improves end-to-end performance without extensive host tuning.

We also work with our partners at the University of Delaware and user communities to deploy the Data Logistics Toolkit (DLT). The DLT is a software package of integrated storage and networking technologies for creating WAN-aware storage nodes, or depot pools. By deploying depot pools at disparate sites, research communities can create a general facility for data intensive, global collaboration — a global drop box with advanced capabilities —that can significantly improve the utilization of wide area links. The DLT combines technologies for shared storage, network monitoring and dynamic network provisioning to optimize the rapid movement and timely placement of data through policy-controlled data sharing, replication, caching and overlay multi-cast. DLT-enabled infrastructure can address a wide variety of application specific data logistics scenarios, and the package includes client libraries and tools that make it easy for traditional applications to use its capabilities. The DLT team has committed to work with us (see letter) to ensure that their software helps our user communities maximize the value they receive from our network.

## **Dynamic Circuit Network (DCN) Activities**

A significant engineering goal for the TransPAC2 project in 2008 was to provide dynamic layer2 (Ethernet-like) circuit-provisioning and -switching capabilities through the TransPAC2 network, enabling the APAN community to participate in the Internet2-ESnet-European "DCN" dynamic circuit project and to extend its functions and reach through the APAN region. Accordingly, TransPAC2 has been in close discussions with Internet2 regarding connectivity to the DCN network and has worked through the year to achieve this goal. Physical connectivity to DCN was finally achieved when Internet2 extended a 10 Gigabit DCN connection to the PacificWave exchange point in Los Angeles, which we can reach through our existing 10GE connection to PacificWave there (see the Los Angeles topology drawing for details). We were also able to extend the layer2 tagging across the SONET link to Tokyo using MPLS L2VPN technology and connect seamlessly to native Ethernet resources in the APAN region.

In spite of a number of technical challenges, TransPAC2 was able to accomplish this goal with no additional cost to the project and to provide DCN connectivity through the network so that APAN partners could use it to bring content successfully to Supercomputing 08 in November. This was a huge success and the APAN participants are very happy with the results.

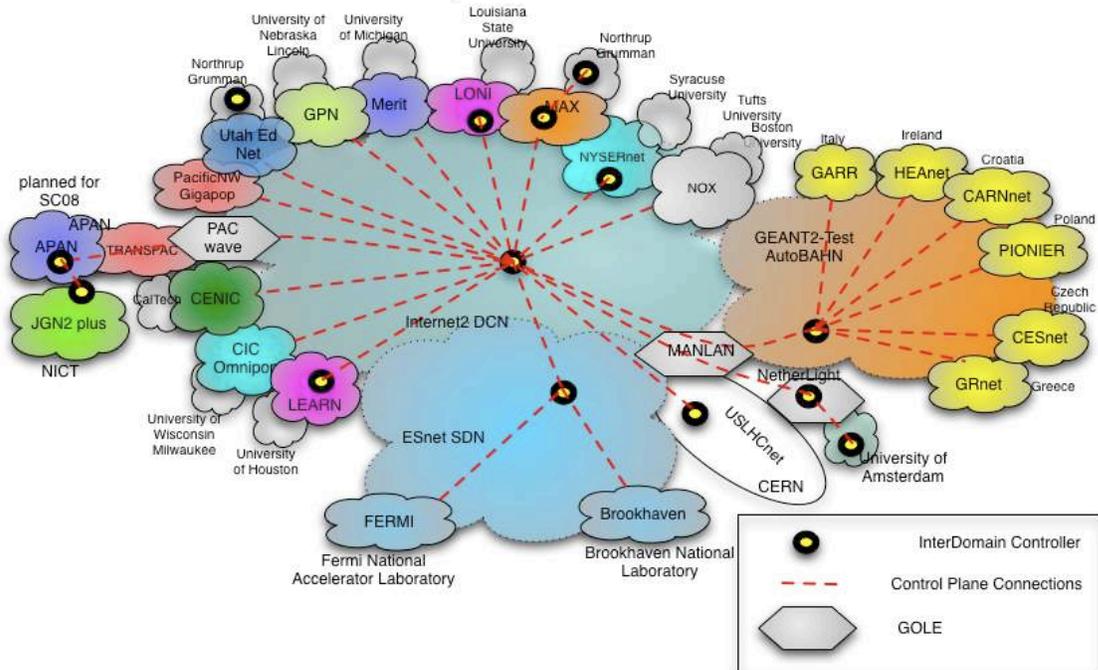
The most significant engineering addition has been the DCN capability, the implementation of which is discussed at greater length below. It was able to be accomplished at no additional cost to the project. As explained above, this allows TransPAC2 to extend the dynamic circuit-switching capabilities of the jointly-developed Internet2-ESnet-Canarie-DANTE dynamic circuit network to our APAN partners, functionally extending the Internet2 DCN network into many parts of the Asian research community. This capability was used successfully by JGN2/NICT and others at the November 2008 Supercomputing conference to bring LIGO data over this layer2 network from Tokyo and elsewhere to a correlator on the SC08 show floor. See below [Figure 5, "Global Dynamic Circuit Network"] for a map showing some of the regions accessible through DCN, including APAN.

A summary of the tasks related to the TransPAC2 DCN implementation includes these considerations:

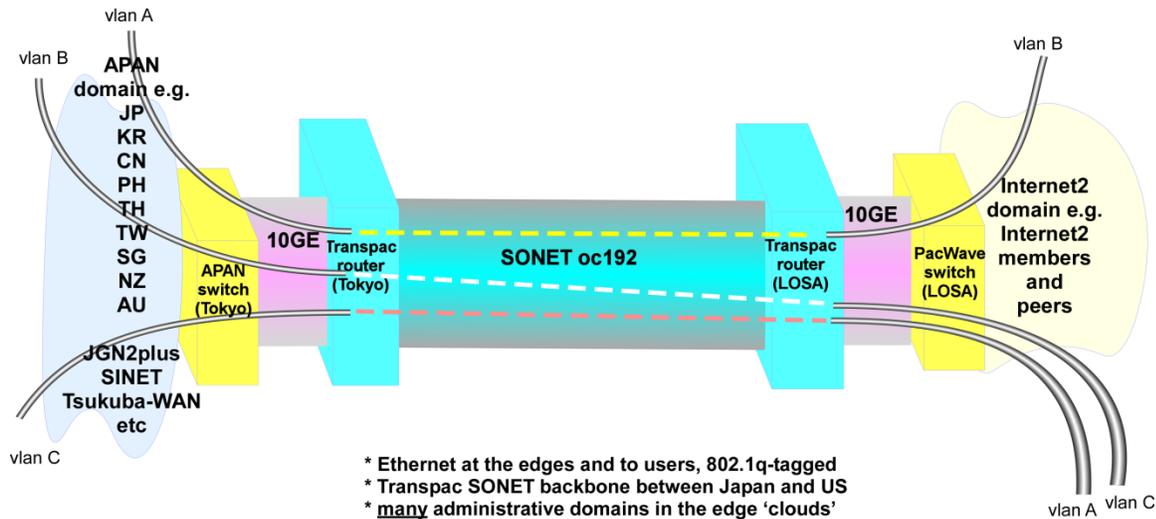
- We worked with Internet2 to make sure physical connectivity would be established from I2 to the PacWave exchange point in Los Angeles where we also connect and that TransPAC should have access to it. This connection was established in the first half of the year and we worked with PacWave to ensure we would share access to DCN on it.
- Since the SONET circuit between the USA and Tokyo is not channelized, one of the most difficult tasks was to identify and implement a technology that could accept layer2-tagged frames from the DCN Ethernet network, carry the tagged information across the SONET network, and deliver them on the other end again as tagged Ethernet frames, as if it was Ethernet all the way—without disrupting the production routed traffic occupying most of the same OC192. Our goal was to identify the most straightforward and simple technology that would accomplish this. In the second quarter we narrowed the technology choices down to two and Sweeny and Tanaka from APAN each investigated them and presented a plan at the APAN meeting in August. Tanaka tested them further in a Juniper lab Tokyo and Sweeny eliminated a simpler JunOS option. These discussions and tests continued in August with Tanaka, Sweeny, and a Juniper engineer meeting to discuss technical options, finally selecting MPLS L2VPN as the most appropriate technology for our needs. (See a diagram [Figure 6, “APAN-TransPAC-Internet2 DCN”] below showing logically how the vlans enter, traverse, and exit the SONET link.)
- Concurrently, in July-September APAN engineers identified Japanese users who could fruitfully first use DCN to collaborate with colleagues in the US and worked to confirm DCN capability through their region to those users. APAN and TransPAC2 also worked to implement their own IDCs (inter-domain controller, the server which communicates with domain controllers in other domains. Each administrative domain e.g. Internet2, TransPAC, APAN, NYSERNET, etc each have their own IDC) to negotiate DCN characteristics and configure the path through our domain.
- In October, the TransPAC and APAN engineers reconfigured the TransPAC OC192 to enable carrying layer2-over-SONET framing. When this was completed, there was a complete layer2 path from Internet2 across TransPAC to the users of the APAN region.
- Since all of the above technology choices require CCC on the Juniper core routers to encapsulate the layer2 frames across the SONET network between the US and Japan, and since CCC requires 802.1q VLAN-ids to be less than 512 and PacWave VLAN-ids are all greater than 512, we must provide VLAN translation. The current TransPAC switch cannot do this, so TransPAC worked during the 2<sup>nd</sup> and 3<sup>rd</sup> quarters with CENIC to provide VLAN translation for all PacWave VLANs coming to the TransPAC router in Los Angeles.
- The TransPAC2 DCN control-plane technology has initially been simple statically-configured VLANs. IDCs will be added in Los Angeles and Tokyo to provide true inter-domain dynamic control for the TransPAC and APAN domains.
- TransPAC has requested that Internet2 designate a set of “static” VLANs (dynamically configured over DCN but fixed across the TransPAC routed circuit) for use in the TransPAC DCN trial. When the TransPAC IDC is complete the static VLANs will no longer be needed in the switched portions of the TransPAC-APAN networks, though the nature of the L2VPN configuration requires a block of static VLANs across that part of the network which can be dynamically used by the IDCs, and TransPAC can use the IDC to dynamically allocate, assign, and program VLANs as needed.
- Sweeny presented engineering updates on TransPAC DCN implementation progress, capabilities, and plans at the APAN meeting in August.
- APAN and TransPAC engineers tested the DCN capability end-to-end through the APAN, TransPAC, and Internet2 networks in October and November to ensure proper function including jumbo frames and acceptably high levels of throughput.

- APAN/NICT/JGN2 demonstrated the DCN functionality from Tokyo across all three networks to the SC08 show floor. They were very pleased with the results.
- Sweeny is an active member of the Internet2 DCN Working Group, who are tasked with representing members' technical, functional, operational, and business requirements to the DCN developers and providers.

## Global Dynamic Circuit Network



# APAN-TransPAC-Internet2 DCN



The Dynamic Circuit Network implementation, allowing native layer2 connectivity between users in the APAN region with the US, was completed in October 2008 and demonstrated successfully in November at SC08 and is now a supported service across TransPAC2. It was used by APAN researchers during the year, and extensively for SC09 and subsequently.

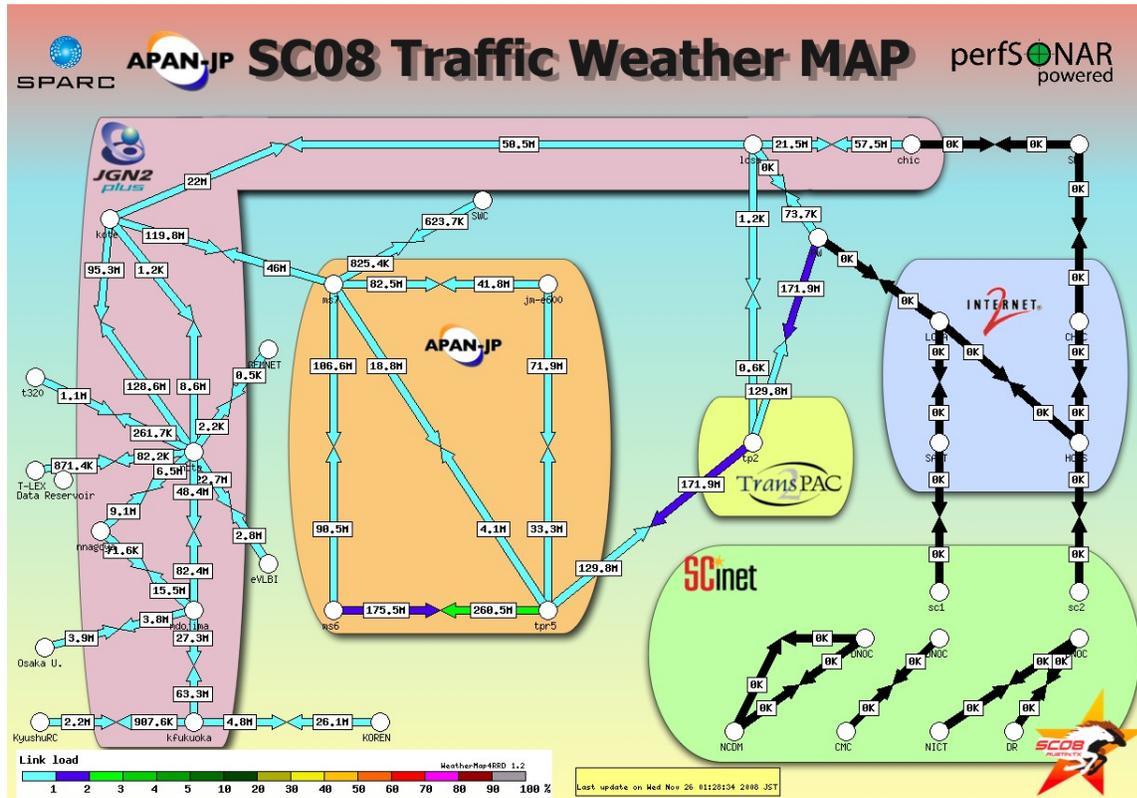
## Measurement activities

The TransPAC2 project is fully integrated into the Internet2 perfSONAR (PS-PS) infrastructure. John Hicks joined the PS-PS development team and attends the development conference calls and attended the face-to-face meeting in Ann Arbor in September 2008. All currently available PS-PS services are deployed on TransPAC2 in Los Angeles and Tokyo. A PS-PS powered weather map describing the TransPAC2 and JGN2 topology was used at SC08 in the AIST, NICT, and SCInet booths (See below). TransPAC2, Internet2, and DANTE held a perfSONAR workshop this year at the 26th APAN meeting in Queenstown, New Zealand. The workshop covered a high level overview of the project down to detailed installation instruction geared toward the APAN community. TransPAC2 provides perfSONAR support to other organizations including CSTNET, KOREN, and KAREN.

### Measurement workshop in Tokyo - 2006

TransPAC2, APAN and Internet2 jointly held a Network Performance Workshop in conjunction with the APAN meeting in Tokyo in January 2006. The Network Performance Workshop (January, 22-23, 2006), sponsored by APAN/Internet2/TransPac2, was offered at the recent 21<sup>st</sup> APAN meeting in Tokyo (Jan. 22-26). This workshop provided hands-on training in the installation and use of several tools used by the Abilene network. This workshop was developed by Internet2's End-to-End Performance Initiative (E2Epi) and consists of 1.5 days of installation and configuration instructions for bwctl, owamp, and NDT. Speakers from the US and AP region presented material related to current measurement topics and initiatives for the remaining .5 day of the workshop. Over 40 measurement experts from the US and AP-region registered for the workshop. Feedback from the workshop participants was all positive and

encouraging. There were approximately 25 people in attendance including representatives from Japan, Korea, China, Hong Kong, Taiwan, Thailand, Malaysia, and the US. There were presentations from experts in security, measurement, high performance networking, and the medical application space (remote surgery).



The TransPAC2 project is fully integrated into the Internet2 perfSONAR (PS-PS) infrastructure. All currently available PS-PS services are deployed on TransPAC2 in Los Angeles and Tokyo. TransPAC2 BWCTL, OWAMP, SNMP, and PingER data are available from Los Angeles and Tokyo. .

TransPAC2 measurement data can be viewed with early tools like perfADMIN (Internet2) and perfSONARUI (GEANT2-JRA1). We will continue to work with Internet2 and the DICE consortium to deploy perfSONAR resources and publish TransPAC2 performance data when available. PerfSONAR is rapidly becoming the infrastructure of choice to discover measurement resources and gather data available in the REN community. TransPAC2 is taking advantage of this momentum by becoming an early adopter and advocate of perfSONAR with deployment strategies and outreach.

TransPAC2 has deployed the latest version of perfSONAR in Los Angeles and Tokyo, publishing data with the following tools:

- perfSONAR-PS Lookup Service (LS) – Providing resource discovery through LS
- perfSONAR-PS SNMP MA - Exposing interface usage data of network equipment through SNMP
- perfSONAR-BUOY
- Throughput - Exposing throughput data on TransPAC2 and to other key locations using bwctl
- Delay - Exposing delay data from owamp
- perfSONAR-PingER MA – Expose pingER data

TransPAC2 has presented material related to the development of perfSONAR at APAN conferences dating back to January 2007. At the last APAN meeting in New Zealand, a joint Internet2 and TransPAC2 workshop was conducted dedicated entirely to perfSONAR. The workshop was well received based on the feedback and inquiries. The JP NOC staff announced a deployment scheduled consisting of four locations (Kyushu, Tokyo, Osaka, Kashima) in Japan with data from Slnet, JGN2, and TransPAC2. Other organizations including CERNET, AARNET, and KOREN have also expressed interest in a perfSONAR deployment strategy. A comprehensive installation document geared toward the AP Region was developed in collaboration with the JP NOC and Internet2 staff for this workshop. This working document serves as a step-by-step guide to getting started with perfSONAR-PS in the AP Region. The evolution of this document continues to reflect changes and updates to the perfSONAR-PS measurement software suite.

A new 4rrd-based TransPAC2 weather-map was developed with data collection through perfSONAR. The new TP2 Weather-map was displayed at SuperComputing 2008.

In the past year we have seen remarkable progress concerning perfSONAR. The product itself has gone through a number changes and the deployment footprint continues to grow. The US based perfSONAR-PS (PS-PS) version 3.1 and GEANT2 perfSONAR MDM (PS-MDM) 3.2 are currently available for download. Internet2, ESnet, and APAN-JP have continued deployments and increased the available number of circuits monitored by perfSONAR. The Joint Engineering Team (JET), DICE and other organizations have adopted perfSONAR as their measurement platform. PerfSONAR is becoming the infrastructure of choice to discover measurement resources and gather data available in the REN community. TransPAC2 has implemented both the PS-PS and PS-MDM versions of perfSONAR in order to test interoperability with GEANT2 and TEIN2. All tests were successful and the PS version remains in production on the TransPAC2 network.

TransPAC2 has adopted a NOC services model for perfSONAR resources through collaborative efforts with DANTE/GEANT2. The goal is to offer NOC supported measurement services to ensure the reliable availability of network measurement resources and data. The GRNOC will provide 24x7 monitoring of measurement hosts and services. Both perfSONAR PS and perfSONAR MDM will be supported. Status weather map with drilldown node information provides a public view of available network information. These 'weather maps' provide a comprehensive view of global networking infrastructure and

application support. We will offer end-to-end monitoring software for trouble shooting and application optimization.

TransPAC2, APAN, and Internet2 conducted a follow-on perfSONAR workshop during the 27th APAN meeting in Kaohsiung, Taiwan. We heard updates and presentations from Korea, Japan, Taiwan, Singapore, and Thailand. Korea reports initial deployments on the KREONET2/KiSTi link through the APAN-JP peering in Hong Kong. Japan is well connected on APAN-JP and has resources in four locations (Kyushu, Tokyo, Osaka, Kashima). Taiwan has good connectivity through TWAREN to NCHC. Early work publishing data on TL1 interfaces and monitoring their international links continues. Exposing data on the Pakistan link and from ThaiREN remains a possibility through NICT (Japan) PS efforts.

TransPAC2 and the APAN-JP NOC have continued to work on a perfSONAR installation guide for both the PS and MDM versions. This working document serves as a step-by-step guide to getting started with perfSONAR-PS in the AP Region. The evolution of this document continues to reflect changes and updates to the perfSONAR measurement software suite.

Concerns about perfSONAR from the AP region include:

- Privacy issues
- Deployable AA architecture
- Limited use with DCN
- Limited Measurement Archive (MA) tool set

All presentations are online here: <http://www.jp.apan.net/meetings/0903-TW/>

Tools like perfADMIN (Internet2) and perfSONARUI (GEANT2-JRA1) continue their popularity as early GUI interfaces to view perfSONAR data. Other efforts include a 4rrd-based weather map displayed at SC08 and collaborations with the GRNOC systems engineering on the ATLAS weather map. Efforts are under way to build a perfSONAR flash based ATLAS tool to discover topology services from lookup services (LS) along an application path and dynamically build a geographic view with drill down data exploration. The GRNOC ATLAS code was recently released under the GENI open software agreement. We will continue to build and support these tools for other NOCs and organizations in the REN community. Example applications for this open service include incorporating perfSONAR into OSG GOC and other grid monitoring services.

## SuperComputing activities

Hicks with APAN engineers on SuperComputing bandwidth challenge demo schedule and configuration. Hicks attended SuperComputing 2005 (SC05) and gave TransPAC2 presentations at the IU booth and PRAGMA booth concerning measurement.

### SC05 specific TransPAC2 related activities:

- The Grid Datafarm team participated in the [SC|05 StorCloud Challenge](#) and [won the "Most Innovative Use of Storage In Support of Science" award!](#) Gfarm file system is a next-generation network shared file system, which will be an alternative solution of NFS, and will meet a demand for much larger, much reliable, and much faster file system. TransPAC2 provided some of the overall bandwidth for this StorCloud Challenge. <http://datafarm.apgrid.org/software/>
- TransPAC2 was the primary trans-pacific network link used for this Band Width Challenge entry by Ehime University and NICT. Abstract: [A Challenge to Real-time Visualization for 3D Computer Simulations and Satellite Observations for Space Weather](#)
- TransPAC2 and JGN2 were used for this Band Width Challenge by the NCDM team. Abstract: [High Performance Mining of Streaming Data](#).
- The Open Science Grid (OSG) is a global Data Grid that will serve forefront experiments in physics and astronomy. OSG's computing, storage, and networking resources in the U.S., Europe, Asia and South America provide a unique laboratory that will test and validate Grid technologies on international and global scales. The OSG demonstrated the capabilities with U.S, European, and Asia counterparts. The OSG and the OSG grid operations center (GOC) are supported by Indiana University. TransPAC2 is used as a primary network link to connect the US with the AP-region. <https://www.opensciencegrid.org/bin/view>
- AIST used TransPAC2 to transfer large amounts of data for their demo from Tokyo to Seattle.

In November, at the SC08 SuperComputing conference in Austin, Texas, the APAN-TransPAC2-Internet2 DCN implementation was used with great success by LIGO (Physics) researchers in Japan and the United States, with both end sites feeding data across DCN to a correlator on the show floor. All participants were pleased with the performance of the connections and with the versatility DCN provided them. After that late-2008 demonstration of DCN, its use has increased during 2009 and where it was a new and experimental offering for SC08, its availability is assumed and crucial during 2009 and for SC09 plans, where it was used again with great success. The drawing below illustrates how layer2 vlans on the APAN and US sides of the TransPAC2 SONET circuit can transparently interconnect. The layer2 information is carried across the SONET circuit and passed out the other side with the identical layer2 framing.

The next year, at the SC09 SuperComputing conference in November, in Portland, Oregon, TransPAC2 again played a crucial role in carrying high-performance research and demonstration traffic between the APAN region and the SC09 resources. The use of TransPAC2 demonstrated how production high-performance networks play a vital role in the real work of scientific computing. Bandwidth-challenge winning entries also came from the APAN region, with KREOnet working with Cal Tech in the bulk-bandwidth category, and the University of Tokyo also winning. NICT and JGN2 and others also used the dynamic-circuit capability implemented for SC08 and now used fairly routinely by APAN researchers with American and European colleagues. Sweeny provided considerable support especially for Korean and Japanese research groups over TransPAC, NLR, and Internet2 into the SCinet network, using network technologies including v4, v6, native (layer2 end-to-end) Ethernet, and dynamic circuits.

Brent Sweeny and John Hicks participated in support of the SuperComputing '09. Hicks was a member of the measurement and monitoring team, and Sweeny a member of the routing team. A number of APAN-related projects participated in SC09. Sweeny also helped coordinate, provide, and support the extensive use of NLR for SC09 support.

Sweeny and Hicks worked with virtually all of the APAN-region participants in the network, helping with planning for, provisioning, building, and supporting the layer2 and layer3 network connections across the WANs and the show floor. For both SC09 and CCinet, Hicks worked to bring WANS, including Transpac2 into the conference and coordinate the delivery of those network connections to the actual participants. Sweeny was in charge of one of the core routers for the network and worked with the team on all other aspects of the SC09 network.

## **Security activities**

TransPAC2 is using the statistics and reporting capabilities of the Arbor Peakflow SP System to publish Netflow and BGP analysis. The Peakflow SP system has a rich set of statistics capability that provides detailed analysis for TransPAC2 traffic. The SP system implementation is made possible through the REN-ISAC also supported by Indiana University. Currently a manual process, an automated SOAP interface (under development) will provide updates to the TransPAC2 statistics web page (<http://www.transpac2.net/stats.php>). The report format will be consistent with the Peakflow SP security reports concerning TransPAC2 traffic. Custom traffic reports are available upon request. Figures 5 and 6 show examples of TransPAC2 traffic reported by the Arbor Peakflow SP system from Monday May 8 through Tuesday May 9 2006.

TransPAC2 engineers met with APAN and GEANT NOC engineers to discuss adopting the Security Event System (SES) proposal along with the REN-ISAC and Internet2. We hope to establish goals and a roadmap for cooperation on the development of operational protocols for exchanging security event information – information that can be applied within respective communities for protection against malicious actors. The Security Event System (SES) is being developed by REN-ISAC, in cooperation with Internet2, and funded by a Department of Justice grant.

Within SES, event data, normalized in standards-based data structures, is received from participating sites and external information sharing relationships. Correlation is performed on the data, identifying “bad actors”, and developing “confidence”. The resulting high-confidence bad actor information is fed back to the participating sites, for application in local protections, such as IDS, blocks, and sinkholes. A SES implementation within a federation is illustrated in Figure 1. Examples of SES within a participating site are illustrated in Figure 2. In addition, SES is designed to support multiple federations, sharing information across policy borders. Figure 3 illustrates the U.S. research and education community, represented by REN-ISAC, sharing with three other federations.

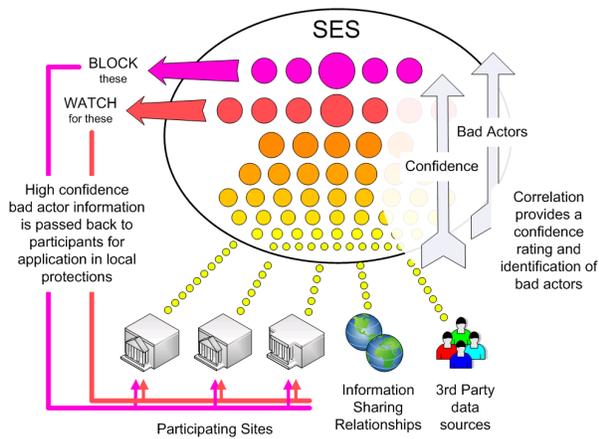


Figure 1 – A SES Federation

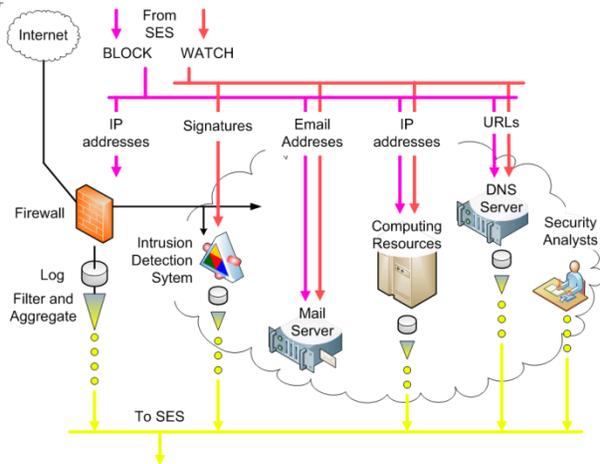


Figure 2 – Within a Participating Site

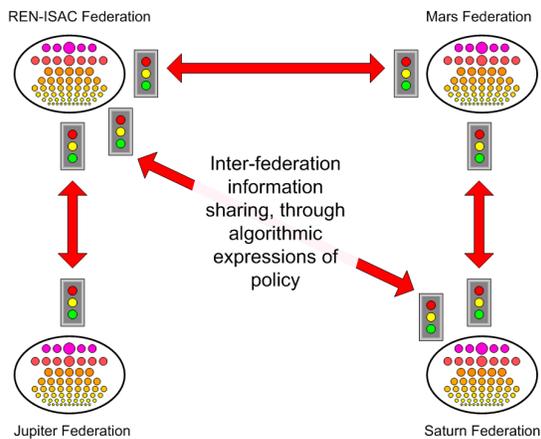


Figure 3 – Inter-Federation Sharing



### **Additional attached reports**

This section of the Final Report contains documents generated during the project from a variety of sources. A list follows:

1. IRNC review TP2 Workplan – generated from the October 2006 IRNC review
2. Daniel Doyle – TP2 Summer intern Final Report - 2009
3. US-Pakistan Broadband Applications Group Report - 2010
4. Brandon Williams Summer intern report on GENI – 2010
5. K-GENI Final Report – 2010
6. Transatlantic networking workshop Vilnius - 2010

## **IRNC Review – TransPAC2 Workplan Issues**

**Prepared by James Williams – Principal Investigator**

Following are eight issues raised directly in the TransPAC2 portion of the IRNC Review. While other issues in the review require IRNC wide action, these issues are related specifically to TransPAC2. As such, the issues will be addressed via an IRNC Review Workplan. The Workplan will be updated regularly, in a manner similar to the other TransPAC2 Workplans.

1. Work with our partners in Asia to develop a deeper view into and understanding of routing issues and traffic load across the existing multiple trans-Pacific links.

Routing within the Asia-Pacific area is complex, made more so by the new activity caused by the TEIN2 network. TransPAC2 is involved in two activities focused on developing a better understanding of AP routing and R/E routing in general. The Research and Education Network Operators Group (RENOG) has met on 4 occasions (at both Internet2 meetings and APAN meetings). Presentations from these meetings are available on the RENOg web site (<http://www.renog.org>). See in particular the presentation by Akiro Kato regarding the December 26, 2006 earthquake in Asia. In addition to the RENOg activities, the APAN meetings have held sessions within the Network Engineering section relating to international routing. APAN presentations are available at: <http://www.apan.net>. This activity is ongoing.

2. Work with our partners at the APAN NOC to deploy perfSONAR in the spring of 2007.

The TransPAC2 LA node is a full participant in perfSONAR. The TransPAC2 Tokyo node is also a full participant in perfSONAR. While development and enhancement of perfSONAR capabilities will continue, this activity is complete.

3. Work closely with the Internet2 Telemedicine Group and the APAN Telemedicine Group to encourage and assist their activities.

TransPAC2 will continue to keep abreast of the activities of both the Internet2 and APAN telemedicine group by attending meetings and receiving correspondence through the relevant email lists. Every effort will be made to disseminate information to each group where appropriate and encourage the use of the TransPAC2 network. Discussions concerning US and APAN Telemedicine groups were held during the APAN conference in Manila. Further discussions are between US and Asian researchers are scheduled for the Spring Internet2 members meeting 2007. TransPAC2 will participate in the South Asia medical forum scheduled for the Internet2 Member Meeting.

4. Work more closely with PRAGMA to assist in their Grid related efforts.

TransPAC2 will continue to provide guidance and support of PRAGMA activities as an active member of the steering committee. Both Williams and Hicks attended the recent PRAGMA meeting at NCSA.

5. Work closely with KDDI-America (and possibly other vendors) to deploy Layer2 services across TransPAC2.

Layer 2 services will be included in the next TransPAC2 RFP for circuit services, to be released in December 2007. APAN has purchased the necessary equipment to provision Layer 2 services across TransPAC2. TransPAC2 will also make appropriate equipment purchases. We expect Layer 2 services to be implemented across TransPAC2 for the final two years of the IRNC award.

6. Develop a better understanding of network usage.

TransPAC2 unveiled a new measurement website, <http://globalnoc.iu.edu/transpac2/measurement.html>, in an effort to consolidate our efforts and make our resources more available. This site changes frequently as resources become available. More detailed traffic reports are now included in the quarterly report. Quarterly and annual usage graphs for peer, tcp, and udp traffic as well as a histogram of the number of bgp routes are included. This list will grow with time.

7. Using Arbor PeakFlow tools to set autoblocks.

It is our experience that the auto-blocking capabilities of the Peakflow system be used as a guide or indication that some action should be taken. There should always be a human in the decision making process, based on available resources. TransPAC2 utilizes the front line and engineering staff of the Global Research NOC to monitor the link 24x7x365. When a network anomaly is detected there are qualified personnel to take appropriate actions. TransPAC2 understands that this does not apply to other networks with limited resources. There is a danger with any auto-mitigation scheme of exploiting blocking rules and creating a denial of service at the network level. Another concern is that Peakflow uses sampled netflow and even a highly tuned system will have false positives. Finer grained data and deeper packet inspection is required to determine the true nature of traffic on the link. Requiring a human in the mitigation process helps to reduce errors in anomaly detection and action required to combat network threats. We will continue to work with Arbor Systems to refine their autoblock capability.

8. Investigate implementing VCs to LHC sites served by TransPAC2.

Investigation into the specific needs of LHC communities will be accomplished in conjunction with work with PRAGMA, Open Science Grid (OSG), and other grid related organization like the OpenGridForum.

TransPAC2 is currently an IP packet based network and therefore does not provide direct support for virtual circuits, however TransPAC2, in its current configuration, could be used to provide MPLS services across the Pacific connecting say the Internet2 network to networks in APAN. As TransPAC2 evolves and Layer 2 capabilities are available, direct VCs will be investigated. See item #5 above.

# Indiana University Summer REU Program Report

Dan Doyle

“If GM had kept up with technology like the computer industry has, we would

all be driving \$25 cars that got 1000 MPG” - Bill Gates

My name is Daniel Doyle and I am a junior in Computer Science at Indiana University. When I signed on for the Summer International Research Connections Undergraduate Internship at Wrubel Computing Center, I did not have any real experience with designing and maintaining webpages and CGI scripts, nor did I have any hands-on knowledge of how to set up and interact with databases. The things they teach you in classes only extend so far into the real world once you have a project and deadlines. What I did have, however, was a host of helpful coworkers and a drive to learn and do the best that I could.

The outline of the project that Jim Williams gave to me was fairly straightforward – create a tool that could gather and parse relevant path data from the standard *traceroute* command line tool, and then make this tool accessible through a web interface. I opted to write in my scripting language of choice, Python, and utilized a multi-threaded approach where each request got its own thread of control so that many multiple requests could be handled without anything depending on or interfering with anything else.

The basic way that it worked was as follows – every X hours for Y days, as specified by the user when the request was made, the tool would run the *traceroute* command and store the results of whatever came back in a flat file, with the results of each trace being appended to the end, delimited by a newline. At the end of this time period, the tool would go through the file it had created and figure out two things. The first of these was a simple comparison, using the first as the basis, of the hops each trace took, noting where they differed or if the size differed, which would indicate a wholly different path. The second was more interesting and useful, and as such was the one that got further developed. It looked at the data and created a table that showed every hop possible taken, as well as how many times that node appeared in the data set. By examining the results of this, one could see a path trend emerge or see outlying nodes.

After the basic tool had been written and debugged, it was time to create the web interface. I had done a couple of “Hello World” type things in HTML before, but that was the extent of my web coding. As such, this particular aspect of the project was both the most frustrating and the most rewarding. I originally decided to jump right into the deep end and try to implement AJAX in the interface to allow for real-time information to be represented on the page for the user. Unfortunately, starting a potentially month or year long data collection tool via AJAX proved to be impossible to the best of my understanding, as it would time out and kill the process after about ten or so minutes. Therefore, the AJAX portion of the interface was ultimately scrapped.

What I did learn and kept from this particular mishap, though, was the Javascript I had written to validate user input before it was passed to the tool. By doing error-checking on the front-side, it was possible to alert the user immediately if there was some sort of issue with the data they had entered, rather than them waiting for the entire duration to expire and realize that nothing had actually been working. There is still some error-checking within the tool itself just in case, but the web interface was designed to catch any erroneous information.

Furthermore, Jim felt that it would be useful to have the tool be able to email the parsed results to the user when the request finished, rather than them having to come check in on the status. This ultimately proved to be fairly easy, given Python's extensive support on MIME and SMTP libraries, though as with just about everything else on this project it was a learning experience. As of this writing, the current implementation is using the IU SMTP server to send out emails with the results as an attachment, though this is changeable through the configuration file.

Also around this time Jim felt that there was the need to move from simple ASCII representations of data to a more aesthetically pleasing to the user. After a bit of trial and error with various applications, I settled on using GraphViz, an open source application that takes files in a particular format and generates a visual tree of them. Support in the CGI script was added for this, as well as additional support for condensing the trees – that is to say that there is only one edge from one given node to another.

At this point, I met with Jason Zurawski and Jeff Boote of Internet2 to see if there was some way to incorporate the data being generated by this tool into their perfSONAR utilities. They asked me to set up an SQL database and provided a schema for the data that they wanted collected and stored. Also at this point John Hicks set up a server running at IUPUI to allow the tool to run from a set location and to be accessible from the outside world instead of just running from my local machine. This ended up being a touch of serendipity as it allowed me to set up, test, and run a full production MySQL server instead of SQLite.

The original storage schema called for storing IP addresses as a charvar, or essentially a block of text. While this was extremely human readable, it proved to be the slowest possible method of storage when it came to searching / indexing. As such, Jason suggested that I look into another way of storing it. After researching a number of message boards and SQL forums, it was decided that the optimal way was to use the built-in SQL *INET\_ATON* to convert a standard IP address (ie, 192.168.0.1) into an unsigned integer, which would be markedly faster to search and take up less space when storing, though sacrificing human readability.

While this worked, there was unfortunately one additional problem – it did not support IPv6 addresses. Jeff Boote suggested that to remedy this solution, we ought to create another table that mapped a simple integer key to the string representing the address and use that key in all of the other tables in place of the IP address. In this way we kept the power of searching and storing via integers, as well as maintaining human readability and IPv4 and IPv6 capabilities. As of the time of this writing, this is the current implementation of the storage.

Jim Williams set up a meeting for me with himself and several other engineers working at WCC to gauge how the project was moving along and to offer suggestions or criticisms. At the end of this

meeting, I had another couple of ideas on how to advance the project, including a login system, a periodic update system, and the ability to check on your data at any time.

The first part of these new ideas that I chose to tackle was the ability to check the data at any given time. By supplying the same title and email address given when the request was initially made, the script would immediately parse and email the results of whatever amount of traces had been finished. This part was easy enough.

However, once I set about creating a login system it became apparent that the "Evaluate Now" feature would be better merged into this login system. The login system is written as a CGI script entirely in Python and uses the standard username and password scheme, with these being stored in a database on the server. The passwords are stored as hashes as a measure of security. As of the current implementation, when a user logs into the system they are presented with a drop menu containing all of the files that are currently being processed under their name. By simply selecting one of these, the same effect is achieved as the original evaluation system but without the need for the user to remember titles, as well as keeping each user's trace requests separate.

At this point, Jim set up another meeting with the software development team so that they could see how the tool was progressing as well as to make further suggestions. Aside from some minor aesthetic things and a few interface tweaks, such as adding relevant time information, the major focus of this meeting was to add functionality for the jobs to be restarted automatically in the event of a server crash or reboot. Since the purpose of this tool was to run tests potentially spanning months, this seemed like a very important idea.

I had never attempted something like this before, so I spent a fair deal reading about the task and asking several of my coworkers for suggestions. I ultimately developed a system wherein each trace job would write out the current state it was in to a flat file uniquely associated with it after every trace it performed and before it entered the long sleep cycle until the next trace. Upon execution of the restart script, all of the state files would be read and the processes essentially restarted using that information.

At this point I met with Chad Kotil, a previous summer REU, to discuss sprucing up the web interface. We talked about a couple of ideas and ultimately settled on the one that is on the web page now. The interface in total went through three separate phases which I guess are somewhat indicative of the complexity of web programming as I was learning. The first was simple black text on a white background with no real organization. The second featured a basic table with some background coloring. And lastly, the third and, at least currently, final version featured full blown CSS with no tables.

Also, an interesting utility called *tcptraceroute* was brought to my attention by Jim. Normally, *traceroute* sends out ICMP echo requests with increasing TTLs, causing a stream of undeliverable messages to be returned which indicate the path the packets are taking. Unfortunately, these types of packets often end up being blocked by firewalls and as such we end up at some point with an unfinished

trace. *Tcptraceroute* fixes this for the most part by using TCP packets, like those used in web browsers, which are almost never blocked. As such, we are now able to build a complete picture of previously hidden nodes.

Unfortunately, *tcptraceroute* does not support IPv6 addresses, so upon moving the tool to using that we ended up losing the ability to use these addresses. The fix was fairly easy, however. Now when an address is submitted it checks to see whether or not it is an IPv6 address – if it is then it reverts back to using normal *traceroute*, otherwise it goes forward with *tcptraceroute*. The authors of *tcptraceroute* kept its output almost entirely identical to that of normal *traceroute*, so the changes made to the parser were extremely minimal.

As the summer began to wind down, I really felt like I had accomplished a lot. Prior to coming here, I had no real work dealing with CSS, databases, subprocesses, email systems, and automatic process restarts. Yet at the close of the project, I had researched, tested, and ultimately implemented them all successfully. I had also gained some valuable insight into the world of the computing business and gained an understanding for the way that things worked. All in all, I was able to produce a tool that was deemed useful, learned a lot in the process, made numerous contacts, and I was able to keep a roof over my head – a successful and enjoyable summer.

**Pakistan-U.S. Joint Committee Meeting**  
**19-May-2010**

**Report from the Broadband Applications Working Group**

**Recommendations for the S&T Working Group of the Pakistan-US Strategic Dialogue**

**Part I**

**Top Priority: Increased broadband connectivity at all levels in Pakistan**

The Broadband Applications Working Group (BAWG) agrees that to meet the challenges of increased research and educational collaboration and widespread access to global information stores, broadband communications within Pakistan needs to be enhanced. This recommendation has three sub-parts.

1. Enhancement of international broadband connectivity. Increased international broadband connectivity will be a fundamental building block for new research and education partnerships (e.g. access to large data sources; distance learning activities). Current broadband connectivity in Pakistan is provided by a strong and novel partnership between Pakistan, the US and the European Union. This well-functioning international partnership should be employed to increase international broadband connectivity as required.
2. The PERN/PERN2 broadband network must be extended to all research and education institutions at high speed as soon as possible. Institutional access to broadband resources is required for participation in global research and education.
3. Individual workgroups within institutions must have access to the institutional broadband at high speed. Work groups must be able to access broadband resources to participate in global research and education.

The three parts of this recommendation are obviously connected. This problem must be attacked as three parts of a whole. Improvement in one area without attention to the other will yield unsatisfactory results.

**Additional critical concerns:**

**Increased attention to human capacity building (HCB) in technical areas**

HCB is critical for the development and maintenance of the required broadband connectivity outlined above. We strongly support the HCB recommendations put forward by the other two Working Groups. These HCB recommendations must be extended to the academic disciplines that support broadband technology (Computer Engineering and Computer Science; Electrical and Electronic Engineering). In addition, increased funding and emphasis must be directed to the technology training needed to operate and maintain broadband technology. A suitably designed and funded collaboration between engineering institutions in Pakistan and the US should be formed to address this currently unmet need.

## **Increase emphasis on Entrepreneurship and Commercialization**

By its nature, there is a close relationship between commercial organizations and broadband deployment. This provides an ideal opportunity for university-industry partnerships in many aspects of broadband development (hardware, software, operational tools). It is in the best interests of industry to work with universities in product development, refinement and deployment. This model has been quite effective in the US (Stanford University is a case in point) benefitting both sides of the partnership. With appropriate training (as described above) and government support, as thoroughly described by the S&T Research Cooperation Working Group, beneficial industry-academic partnerships can be formed. The benefits of these partnerships are not only in product development, but in better industry relationships, better access to high-quality training materials and state-of-the-art technical expertise.

## **Increased emphasis on information infrastructure**

Broadband is critical infrastructure for information. Information is critical for the development of research and education. Many quality-of-life improvements can be made through improved management of, and access to, scientific databases, medical databases and geospatial information (irrigation, weather, seismicity, crop yields). Increased broadband capacity will enable researchers and clinicians to have full access to the institutional foundations of 21<sup>st</sup> century science and medicine – MEDLINE, the largest biomedical database in the world, comprising more than 19 million citations; GenBank, an annotated collection of all publicly available nucleotide sequences and their protein translations; PubMed Central, an archive for literature from life sciences journals; ClinicalTrials.gov, an international registry of over 90,000 trials in 172 countries. Increased access to broadband infrastructure providing full access to information, will enable US and Pakistan partners to take advantage of and contribute to the scientific community on a daily basis. This dual infrastructure of technology and information, will allow Pakistan to participate fully in the world of research and practice.

## **Part II**

### **Areas benefitting from expansion of Pakistan broadband infrastructure**

The BAWG discussed many research and education opportunities enabled by improved broadband infrastructure ranging from fundamental optical network research to geo-science and agricultural applications. Following are two areas discussed by the Working Group in some detail.

Bioinformatics/genomics/cheminformatics – The BAWG and the S&T Research Cooperation Working Group both feel that there are significant opportunities for intellectual collaborations and strong possibilities for commercialization in the development of a stronger, more globally connected bioinformatics and genomics environment in Pakistan. The Pakistan Higher Education Commission (HEC) can play a strong role in guiding this effort and integrating it into the existing Pakistan bioinformatics/genomic/cheminformatics efforts.

Distance Learning –In many disciplines, distance learning will be the preferred mechanism for the spread of knowledge and the enhancement of collaboration. The BAWG strongly supports the recommendations of the S&T Research Cooperation Working Group and the Nursing Workforce focus Group. These recommendations should be extended to include the use of distance learning as a tool in the development of technical HCB.

Respectfully submitted,

Naveed Malik  
Rector  
Virtual University of Pakistan

James Williams  
Director – International Networking  
Indiana University

# **My Summer Intern Experience**

**Brandon Williams**

**Indiana University**

**16 August 2010**

## **About me**

I am a sophomore at Indiana University. I am majoring in Informatics and minoring in Cognitive Science. I would like to be a computer programmer after I finish my degree.

## **About my summer**

My summer internship gave me great experience in the computer field. I learned many things during this internship. I learned things such as how parts of a network function, what submarine cables do, rules of conduct for researchers, and a few major international networks.

## **Learning about networking**

I knew almost nothing at all about networking when I started this internship. I now know how some parts of a network operate. I learned about IP addresses, switches, routers, and more. Every computer that communicates over the Internet is assigned an individual IP address that identifies the device and distinguishes it from other computers on the Internet. The physical address is the MAC address of the adapter chosen by the program. The IP address is the logical address assigned to your connection by your ISP or network administrator. Switches are used to send information from one computer to the next computer. Switches check what the hardware address for a packet is, and then the information is sent to the device.

A router is used to connect multiple networks. A router checks where the information is supposed to be sent based on a packet's IP address. If the information is intended to go to another network, the router sends it to another router, then that router continues to send the information. If the information is intended to stay in the same network, the router sends the information to its destination.

### **Learning about submarine cables**

I also learned what submarine cables do. I learned what causes submarine cables to break, how cables are fixed after they break, how Ethernet stretches far and a few other things about submarine cables. Cables can be broken by fishing trawlers, anchors, earthquakes, undersea avalanches, and even shark bites. Based on surveying breaks in the Atlantic Ocean and the Caribbean Sea, less than 9% of breaks between 1959 and 1996 were due to natural events. Cable breaks are common. There are more than 50 repairs a year in the Atlantic alone.

To repair cables, breaks are reported by shore stations that can pinpoint the location of the break quite accurately by means of electrical measurements. A repair ship will be sent to this location and drop a marker buoy that designates a likely proximity to the break. Several types of grapples are used depending on the situation. If the sea bed in question is sandy, a grapple with rigid prongs is used to plough under the surface and catch the cable. If the cable is on a rocky sea surface, the grapple is more flexible, with hooks along its length so that it can adjust to the changing surface. In especially deep water, the cable may not be strong enough to lift as a single unit, so a special grapple that cuts the cable soon after it has been hooked is used and only one length of cable is brought to the surface at a time, whereupon a new section is spliced in.

Fiber optic cables are able to travel long distances by using repeaters. Modern optical fiber repeaters use a solid-state optical amplifier, usually an Erbium-doped fiber amplifier. A solid-state laser transfers the signal into the next length of fiber. The solid-state laser excites a short length of doped fiber that itself acts as a laser amplifier. As the light passes through the fiber, it is amplified. The optic fiber used in undersea cables is chosen for its exceptional clarity, permitting runs of more than 100 kilometers between repeaters to minimize the number of amplifiers and the distortion they cause.

With my co-intern I gave a presentation to the group of IU networking interns about submarine cable systems and answered questions.

### **Learning about research ethics**

As part of a program sponsored by the Office of Research Administration at Indiana University I also learned rules of conduct for researchers. If there is a conflict of interest because money is involved, then you should state that money was involved in the research. Authors should cite the work of others. A whistleblower is someone who goes out of normal channels in an organization to warn of serious wrongdoing to come or to report serious wrongdoing already done. A whistleblower must be absolutely sure that they are doing the right thing before they blow the whistle. Research misconduct weakens the relationship between the public and the researchers. A weakened relationship between the public and researchers means that there would be fewer investments in research.

### **Learning about networks**

I also learned a few major international research and education networks. Internet2, National Lambda Rail (NLR), and the Global Environment for Network Innovations (GENI) are the networks I learned about.

Internet2 was created in 1996. It is composed of research and education communities. Internet2 is a high speed network that research and education communities can connect to. Internet2's purpose is not to replace the commercial Internet, instead it is providing resources where new technologies can be created. Internet2 members create open-source tools that give existing network infrastructures more capabilities. Many technologies that were previously made in the Internet2 community are part of today's Internet.

National LambdaRail (NLR) was formed in May 2003 and launched in September 2003. The NLR Network Operations Center (NOC) is located at Indiana University's Global Research NOC. NLR is owned by the research and education community and represents the common interests of the nation's higher education and academic research communities in achieving robust, high capacity, experimental communications services.

The Global Environment for Network Innovations (GENI), a project sponsored by the National Science Foundation, is a virtual laboratory at the frontiers of network science and engineering for exploring future internets at scale. GENI supports at-scale experimentation on shared, heterogeneous, highly instrumented infrastructure. GENI provides collaborative and exploratory environments for academia, industry, and the public to speed up major discoveries and innovation in global networks. GENI has two parts to its mission. The first part of the mission is to open the way for transformative research at the frontiers of network science and engineering. The second part of the mission is to inspire and accelerate the potential for groundbreaking innovations of significant socio-economic impact.

## **Summary**

I gained experience in the computer field by meeting people that work in it. I worked under a network manager and was able to talk and listen to other networking engineers while I worked. I learned a lot from the experienced engineers. I met some other networking interns and worked with one of them to do a submarine cable presentation. I learned how to do a small collaboration from the presentation. I learned things during this summer internship that I will be able to use later in my career.

## **K-GENI: establishment of operational linkage between GENI and ETRI/KISTI-Korea for international federation**

James G. Williams – Principal Investigator

Myung Ki Shin – ETRI

Dongkyun Kim - KISTI

Period: January 1, 2010 – March 31, 2010

### I. Major accomplishments

Network connection between the GMOC project located in Bloomington/Indianapolis Indiana and ETRI/KISTI in Korea was engineered, tested and put into research production.

#### A. Milestones achieved

Milestone 1 - Identify a PoC for response and escalation: Done. For the initial research portion of this activity with PoC will remain the PI, James Williams. In the longer term, as the connection moves toward production, the PoC will shift to the GlobalNOC.

Milestone 2 – Select network for connection between ETRI –Korea and IU: Done. NLR (and some IU university-owned networking) provide the required network connection.

Milestone 3 – Network connection goes live. Done. The network connection actually went live on/around April 15, 2010. There is a demo planned for GEC8.

Milestone 4 – Playbook version 1.0. This portion of the project has been delayed due to difficulties in hiring an appropriately skilled undergraduate researcher. We have an undergraduate researcher on board now and expect the project to move forward with the same estimated completion date.

## B. Deliverables made

Network between ETRI and IU designed, configured and made operational. Demonstration planned for GEC8.

Student hired to begin Playbook development.

## II. Description of work performed during last quarter

### A. Activities and finding

Network connection between ETRI-Korea and Indiana University put into place.

Undergraduate researcher hired to develop International Connections Playbook.

### B. Project participants

Brandon Williams – undergraduate student in Informatics will be developing the International Connections Playbook.

### C. Publications (individual and organizational)

None.

### D. Outreach activities

None.

### E. Collaborations

Planned collaboration with ETRI/KISTI is proceeding without problems. Joint IU-ETRI demonstration planned for GEC 8.

### F. Other Contributions

None.

## Summary Report of the Transatlantic Workshop held in Vilnius on 2<sup>nd</sup> June 2010

### **Attendance:**

**US:** Alan Blateky (NSF), Vince Datoria (DOE, Remotely), Steve Cotter (ESNET) Bill Johnston (ESNET), Doug Van Houweling (Internet2), Jim Williams (ACE)

**Canada:** H el ene Joncas (Canarie CSO)

**Europe:** Dai Davies (DANTE), Klaus Ullman (DFN, DANTE Chairman, GN3 Exec Chairman), Vasilis Maglaris (NTUA, NREN PC Chairman), Enzo Valente (GARR CEO), Erik-Jan Bos (Surfnet CTO), Jerry Sobiesky (GLORIAD, NORDUnet), Huib Van Langevelde JIVE Institute) Charles Yun (JIVE Institute), Ralph Niederberger (Juelich Supercomputer Centre), Paul Flicek (EBI) Carmela Asero (EC), Jean-Luc Dorel (EC)

**Rapporteur:** Robin Arak

### **1.0 Introduction**

This report summarises the responses to the set of questions posed to the participants in the Transatlantic Workshop which was held at the TERENA Networking Conference in Vilnius on 2<sup>nd</sup> June 2010. The report covers the key points made in the presentations given and also covers some of the discussions that were conducted at the workshop, highlighting the key issues raised.

The report is not intended to give a comprehensive account of the full responses received but aims to highlight the key issues that need to be addressed for transatlantic connectivity. In each of the sections the original questions posed are given with summary responses as given at the workshop.

### **2.0 Funding Agencies**

**1. What is your strategy for addressing connectivity needs within the US/Europe and globally? How about transatlantic links in particular?**

## **Department of Energy (US)**

Provide network infrastructure needed to support DOE science mission:

- IP layer peering with US and International R&E networks
- Circuit level interconnections with peer networks
- Multiple peering points with major science partner networks (i.e., GÉANT, USLHCnet)
- Direct peering in Europe with GÉANT

Support globally distributed science communities with leadership class compute resources and unique scientific instruments

## **Canarie (Canada)**

Canarie has a 10Gbps circuit extending the network from New-York City to Amsterdam. With the assistance of SURFNET, CANARIE also acquired 10Gbps of capacity to extend the network from Amsterdam to Geneva (required to support LHC). The CANARIE network has a point of presence in New-York City.

A 4Gbps link from Halifax to Copenhagen has been acquired in partnership with NORDUnet.

The government of Canada turns to CANARIE for transatlantic connectivity needs and implementations.

## **European Commission**

The model in Europe is based on a federated model with each country connecting their NREN to the GÉANT backbone. The funding is based on 50% being provided by the European Commission and 50% by the NRENs. The European backbone is procured by DANTE who operate the backbone. 93M Euros was provided over 4 years. The cost sharing model reduces the digital divide. The project as well as funding the network and operations also funds joint research activities to test ideas that may then be made into services. Dissemination is also funded so that the various communities in Europe and beyond are made aware of GÉANT.

For global connectivity the principle of reciprocity is used. Inter-continental projects to connect Latin America and Asia have been funded. Connectivity to the Black Sea area , India and Africa is being funded.

Peering arrangements are also in place.

## **2. What are your recent funding decisions with regard to networking infrastructures?**

### **Department of Energy (US)**

Upgrades to national backbone:

- IP and dynamic circuit network infrastructure
- Upgrade portions of the backbone to 100 Gbps
- Dedicated testbed to support research

Accelerate adoption of 100 Gbps network technologies:

- Deployment over US continental backbone
- Peering with national and international peers

### **Canarie (Canada)**

Funding of around 0.5 billion dollars has been provided over the years. Various projects have been funded as well as network infrastructure:

- *CBRAIN*: platform for processing and sharing brain imaging data
- *Health Services Virtual Organization*: platform for ICT-based health services
- *Science Studio*: management system for remote control of projects at Canadian Light Source
- *Netpune* – Ocean Management

### **European Commission**

Recent funding decisions are GN3. For user funding NEXPRES for eVLBI will be funded. Also projects such as 6DEPLOY have been funded to help with the deployment of IPv6.

## **3. What are your plans for the future? Is research connectivity high in the political agenda? Where will the budgets come from?**

## **Department of Energy (US)**

DoE has funded a US R&E network (ESnet) for the past 2 decades and will continue to support science:

- Connections to labs, unique science instruments, and supercomputers.
- Peering relationships with Academic and other R&E networks.

DoE Office of Science is the largest sponsor of basic research in the US.

Congressional support is strong for continued funding.

## **Canarie (Canada)**

Several plans are in place including green projects and plans for exploring tighter integration of the network, computing facilities, middleware, applications, data storage and virtual collaboration tools.

## **European Commission**

Key issues in Europe are to deploy services for scientific communities (incl. those of the ESFRI-roadmap), understand and face up to the challenge of huge data volumes.

Research and education networks will be a leverage for innovation (e.g. future internet PPP);

Making decisions on the base of user requirements and technology trends; a high level expert group will look at all aspects of research and education networks in FP8.

In the future the development of the future internet will be carried out with industry. There will be calls for projects to support this. GÉANT will play a role in this. There will be support for clouds and virtualization through the FEDERICA project.

Global policies will support AfricaConnect, Alice, EUMEDCONNECT

### **3.0 Network Users**

#### **1. What are your requirements in terms of capacity for transatlantic connectivity for the short (1-2 years)/mid (3-5 years) /long (greater than 5 years) term? Same for global requirements. How specific/generic they are?**

The capacity requirements are going to increase considerably over the next 5 years with the demand potentially reaching 1 Tbps by 2015. The traffic in many cases will require dynamic allocation, guaranteed bandwidth and performance and traffic isolation. The sections below summarise the requirements.

#### **Short term (1-2 years)**

End to end 10Gbps wavelength (Super computing)

Multiple 1+ Gbps (eVLBI) (1 Gbps per telescope)

80 Gbps guaranteed dynamically allocated isolated traffic (LHC)

Large data transfers -Multiple flows of traffic for file transfer (Climate research)

Large data transfers 200TBytes per day (DNA sequencing)

#### **Medium term (3-5 years)**

40Gbps or multiple 10Gbps channels (Super computing)

Multiple 4Gbps (eVLBI) (4 Gbps per telescope)

280 Gbps guaranteed dynamically allocated isolated traffic (LHC)

Large data transfers -Multiple flows of traffic for file transfer (5-15 PBytes) (Climate research)

Very large data transfers from multiple sites potentially 50x 200TBytes per day (DNA sequencing)

#### **Long term (5+ years)**

100Gbps (Super computing)

Multiple 10 Gbps (eVLBI) (e.g. 17 x 10Gbps to North America) (10+ Gbps per telescope)

400+ Gbps guaranteed dynamically allocated isolated traffic (LHC)

30-40Gbps (ITER – Magnetic fusion)

Very large data transfers from multiple sites with faster sequencing machines could be 1-10Pbytes of data per day from each site. (DNA sequencing)

**2. What services and support do you need? Some details are: how many users, institutions, localisations, load, timing etc. This could also include backbone or inter-domain services depending on the architecture.**

The service requirements vary depending on the user communities but several challenges will be faced by the operators in order to provide the services and support that users will need in order to carry out their day to day research/science activities. These are:

Dynamic Lightpaths on a shared infrastructure (across multiple operation domains).

Ability for lightpaths to reach the edges of the network.

Dynamic line speed shared storage and shared data archives.

Dynamic Grid (shared computing infrastructure).

Cloud computing.

Hotline for solving problems and getting all the necessary partners together.

One stop shop support.

Effective and quick problem and performance problem resolution.

Network tools that work and experts who can help users meet their requirements.

Very large data transfers from multiple sites around the world for mirroring archiving and disaster recovery of large DNA data sets.

### **3. What do you expect from research and education networks?**

Expectations from users of research and education networks are high. In general there seems to be a problem of services not being transparent and a lot of expertise being required to use high performance networks. These issues need to be tackled. A summary of expectations is given below:

- Provide new and up-to-date services.
- Test new developments with user involvement using real applications.
- Educate the users about using networks.
- Provide fast, reliable and low cost networks.
- Last mile connectivity (at high bandwidth).
- Access to other communities with similar needs and skills.
- Less pain and effort to achieve the desired network performance.
- Transparent network utility – connect up and it works without having to understand how.
- Functional tools that “normal” users can use and understand.
- Easy transfer of large data sets 1TB to 200TB by users without network expertise.
- Tools that work with the network. (Network users have to be aware of what is needed when procuring equipment.)
- More working together (users, institutions, network providers/operators).
- Support to identify bottlenecks of connectivity as soon as possible.

### **4. What is your view on how costs are/should be covered?**

In Europe the non alignment of different costing models in different National Research and Education Networks (NRENS) causes problems when working on Pan-European projects. New costing and financing models are required to simplify things for users. This has to be addressed on a global (or at least European/transatlantic basis).

There is a preference by users for government institutions to cover the costs but it is recognised that this is unrealistic to have all network costs free at the point of use.

Users recognise that network costs have to be paid by users but fair costing models have to be developed. These costing models should recognise user views which are:

- Institutions of research users are expected to cover costs.
- There are different cost models in different countries.
- Developers of novel services should be fully subsidized.
- Researchers are against per bit pricing.
- Costing based on network access bandwidth is not fair if the full access bandwidth being funded cannot be fully guaranteed and used.
- Costing models should reflect real costs.
- Research projects should get bandwidth free.
- Concern that costs to data generators will be used as an argument to not submit and share data. This will reduce research collaboration.
- More transparency on costs to data users.

In the US the costing models are different depending on the network. ESnet is funded centrally by the DoE and the users of the network (laboratories, unique science instruments and supercomputers) do not have to directly pay for the use and development of the network. Internet2 is a membership organisation and is funded by its members who connect to the network.

In Canada, Canarie is funded primarily by the Canadian government, although there are some nominal membership fees but no charges are made to regional networks or institutions.

## **5. What changes in your field could significantly affect your needs / usage of capacity?**

The main changes which will affect network usage and requirements are:

### **Increasing network usage**

- The increasing size and complexity of scientific instruments will increase network bandwidth requirements.
- Changes in the way that science is carried out with scientists conducting science remotely from their scientific instruments. E.g. LHC, ITER, Telescopes.

- Changes in the compute model which may not optimise/minimise network utilisation. E.g. if a cloud model is used network traffic is more likely to traverse the network more often to different facilities such as storage, computation, archive storage, visualisation.
- Significant drops in the cost of large volume storage will allow analysis of remote datasets by large numbers of users.
- Multiple deployments of large network attached computing resources.
- Increasing rate at which DNA sequencing can be carried out and decreasing costs of sequencing machines will increase the data rate but also increase the number of data flows and paths.

### **Decreasing network usage**

- Significant drops in the cost of large volume storage will allow large data storage and slow forwarding.
- Changing charging to a per bit basis will drive traffic off the network.
- Large costs for network upgrades.

## **6. Other Issues raised and emphasized by user communities**

### **eVLBI**

Other issues are that for eVLBI image quality is important and this requires high bandwidth real time data traffic. In the long term the Square km array which will include 1000's of telescopes will require very high bandwidth.

Challenges are that a global structure for dynamic allocation of network storage and computing facilities needs to be developed, with dynamic lightpaths being an essential development to support eVLBI. Data storage is also important so that raw data can be re-analysed.

Radio telescopes are generally in remote areas so the last mile connections at high bandwidth are important. NRENs have to be able to provide these connections. The "last mile" high bandwidth connections are therefore important and often cost is an issue for providing the last mile connections from NRENs.

Funding issues are that an operational budget for networking is required, however R&D activities should remain fully subsidised to allow for innovation.

The development of a technical skills collaboration model will be important to support science that uses networking.

### **SuperComputing**

There is a large demand for Supercomputing facilities e.g. 200 million of CPU hours was bid for in a recent DEISA call for projects (120 responses were received) and only one fifth of this is available. Typical projects include life sciences, climate research and fusion research.

The data has to be provided to the Supercomputers using the network. The data rate is not constant but is sporadic and repeated, therefore on cost grounds it is not sensible to have high bandwidth network connections available all the time. What is required is bandwidth on demand so a reservation system for the network is required. A meta-scheduler which deals with the reservation of all the various resources is needed. Ideally optically protected wavelengths on demand are required and the ability to aggregate wavelengths to 100 Gbps.

The expectations are that fast, reliable, protected, easy to use and low cost services should be provided.

Problems with the current system are that there are no standard hot lines to resolve problems and it is hard to trace and sort out connectivity and performance problems. Issues such as standardisation of trouble ticketing need to be addressed and site support from a person who can answer queries is important. There needs to be more active monitoring of the network and more support from the network operator. One suggestion is that comprehensive perfSONAR monitoring and testing should be implemented so that end to end performance issues can be more easily resolved. One example of a performance problem was given: A 10 Gbps circuit was provided with an expectation that nearly 10 Gbps data transfer could be achieved but only 1 Gbps was achieved.

### **DNA Sequencing**

Over the last few years there has been a change in the way that DNA sequencing is carried out with the development of much faster and cheaper sequencing machines. It is likely that the speed of sequencing could increase by two orders of magnitude over the next five years. Currently sequencing can be carried

out at 10T Bases a day where each base is represented by 10 bytes. So current transfer of data for one sequencing machine would be 100Tbytes per day at present.

New low cost sequencing machines at around \$50,000 mean that machines will be purchased by individual university departments. In order to share data there needs to be multiple data flows to a central or several central aggregation/mirroring sites where data can be analysed, archived and made available.

The main issues are that the network should not prevent data transfer otherwise this will discourage the sharing of data and reduce research collaboration and security of data for some projects will be important. The cost of network services should not discourage the transfer of data. Providing the data is reliably transferred in a reasonable time the time sensitivity is not important.

There is a large DNA sequencing centre in China so links to this centre will be important.

### **Biological Imaging**

The transfer of high resolution biological images will require high network bandwidth but will also require infrastructure for storing sharing and archiving image data which is not currently available.

### **Cloud Computing**

The development of open source cloud computing could have a large impact on the support of mid range computing users who may not have access to Supercomputers. Clouds may displace departmental and university facilities.

### **High-End Users (HPC, CERN, ITER,...)**

High end users require a stable network and computing platform which will involve:

- Provisioning 10-40-100 Gbps networks (DWDM over dark fiber, leased  $\lambda$ )
- Meeting robustness, reliability and security requirements
- Enabling multi-domain e2e monitoring & on-demand hybrid resource allocation
- Managing converging e-infrastructures as a High Performance Computing & Networking (HPCN) Cloud.

All of these requirements will define the Future Internet Services & Applications

## **Future Internet Development to Support Users**

The development of the future internet will affect the services that can be offered to users. In developing the future internet the requirements are: Sharing optical backbones & housing for future internet experiments, emulating real-world conditions in isolation from production traffic (slicing, virtualization), advanced interconnection of local testbeds (e.g. wireless labs)

In Europe NRENs and GEANT can act as infrastructure providers and innovation brokers. They can also leverage from the experience of closely related European Future Internet initiatives (e.g. FEDERICA, Menticore, Phosphorous, NOVI) and related experimental facilities in the US (e.g. GENI experimental platforms over substrate R&E providers like Internet2, NLPR, ESnet and RON facilities Internet2 and NLR).

## **DoE funded projects**

The Office of Science Labs typically depend on ESnet for all of their network service, including commodity Internet and R&E networking. The scientific user population of the 10 Office of Science labs is probably 30-50% of the total population, which is of order 50,000.

Users are asked how they conduct science and the changes in the way they conduct science determines the requirements for bandwidth and other services. The drivers are major science projects e.g. LHC ITER, Chilean observatory, climate science, cloud computing.

## **Climate Research**

Climate researchers are scattered across many end points throughout the US and Europe. It is estimated that there will be 5 to 15 PBytes of data which could be transferred to multiple locations.

There are two data movement needs in the Climate Science community. The first involves the movement of large data sets between major institutions. The second involves the distribution of observational data, model data, and derived data sets to a broad and diverse set of consumers, including scientists, policymakers, and the general public.

In the first case, climate sciences will need to transfer approximately 1.2 petabytes of data between the US and each of several sites in Europe and Asia beginning in the next few months and ending in late

2011. After that is done, the data movement between large Climate Science institutions is likely to be characterized by periodic updates to those data sets rather than steady-state load since constant data transfers do not appear to be part of the climate computational model (they seem to move data once and then run analysis codes against it, rather than constantly refreshing a local cache from a distant data repository the way HEP does).

In the second case, the data will be downloaded in smaller transactions (varying in size from megabytes up to a few terabytes in some cases) by tens of thousands of users scattered around the world. This will be a broad, diffuse load, more akin to the traffic profile of a large content distribution site and different from the large-scale movement of massive data sets characterized by the first case.

### **High Energy Physics**

The close collaboration between HEP sites in the U.S. and in Europe means that special consideration must be given to transatlantic network connectivity and bandwidth capacity. The LHC will be a heavy user of transatlantic bandwidth over the next few years, but several other HEP projects rely on transatlantic networking as well, including BaBar and the Tevatron, and also including upcoming collaborations such as Super-B.

### **Cloud Computing**

The DOE is exploring the cloud concept with its federal partners to identify opportunities to provide better service at lower cost through cloud services.

The DOE National Laboratories are exploring the use of cloud services for scientific computing. They are also developing high bandwidth networking to transport the high volumes of data between DOE and cloud service providers required by scientific computing.

The Magellan project (\$32 million) will examine cloud computing as a cost-effective and energy-efficient computing paradigm for scientists to accelerate discoveries in a variety of disciplines, including analysis of scientific data sets in biology, climate change and physics.

One of the goals of the Magellan project is to explore whether cloud computing can help meet the overwhelming demand for scientific computing. Although computation is an increasingly important tool for scientific discovery, not all research applications require massive computing power. The number of scientists who would benefit from mid-range computing far exceeds the amount of available resources.

### **Canarie (Canada user projects)**

There are several projects in Canada being funded by the Canadian government through Canarie. These all have different network requirements which are assessed on a case by case basis:

- *CBRAIN*: platform for processing and sharing brain imaging data
- *Health Services Virtual Organization*: platform for ICT-based health services
- *Science Studio*: management system for remote control of projects at Canadian Light Source
- *Netpune* – Ocean Management

Development of the standardisation of middleware is key to achieving the objectives of integrating the applications with the network. Tighter integration of the network, computing facilities, middleware, applications, data storage and virtual collaboration tools is being explored and there is a proposal for virtual centre for innovation which will involve the slicing, partitioning of resources for users, including resources such as cloud computing, wireless networks, security facilities etc.

#### 4.0 Network Operators

##### 1. What are your existing and planned capabilities for transatlantic connectivity?

The table below gives a brief summary of the existing and planned capability based on the responses of the operators.

<b>Organisation/Project</b>	<b>Current capability</b>	<b>Planned capability</b>
ACE		Multiple 10 Gbps
CANARIE	10 Gbps + 2 Gbps	Depends on usage
DANTE/GÉANT	20 Gbps	Multiple 10 Gbps and 40 Gbps wavelengths
ESnet	2 X 20 long-term OSCARS circuits *	PerfSONAR for diagnosing poor end-end throughput
GLORIAD - NORDUnet	10 Gbps + 2.5 Gbps	2 x 10Gbps
GLORIAD - SURFnet	Multiple 10 Gbps	
GLORIAD - Russia	622 Mbps	Multiple 10 Gbps
Internet2	Dozens of circuits to internet international exchange point in New York  10 Gbps to GÉANT  5 international links  Commercial peering 32Gbps	perfSONAR site deployment.

\* On-Demand Secure Circuits and Advance Reservation System (OSCARS)

## **2. What is your existing and planned portfolio of services and support e.g. core, inter-domain, end-to end, etc.**

Operators still will continue to support IP services and some will support additional services such as identity management, grid, mobility, monitoring tools, development tools for collaborative research etc.

There is a strong move towards more support for end-to-end lightpaths and in particular dynamically allocated lightpaths. Operators have developed and are developing services which will guarantee bandwidth, performance and security.

A summary of the responses is given below.

### **ACE**

End-to-end services with reliable performance.

Dynamic circuit services

Planning to install 10 Gbps towards GÉANT in the next 5 years.

Concerned about security in particular denial of service attacks.

### **CANARIE**

IP services including IPv4 & IPv6 unicast and multicast. Federated access projects supported, grid middleware data repositories, sensor grids and remote equipment control, development tools for collaborative research, identity services (Shibboleth, eduroam)

End-to-end Lightpath services. Circuits shaped to demand over SONET, Gigabit Ethernet and 10 Gigabit Ethernet.

### **DANTE/GÉANT**

IP services, end-to-end services , monitoring services

**Planning:** Bandwidth on demand, mobility services, identity management and management tools.

## **ESnet**

Ability to guarantee bandwidth

Guarantee of security

## **GLORIAD**

Each partner provides their own set of services based on the communities they support.

Activities between partners are coordinated to provide the widest possible set of services on a common platform that meet community needs.

## **Internet2**

Classic IP services including IPv4, IPv6, multicast , commercial peering.

Dynamic circuits 50 Mbps to 10 Gbps

L1 waves and L2 circuits among 50 add/drop points

**Planning:** End-to-end performance service, support for cloud computing pilots, identity management and security, certificate service to U.S H.E. community.

Rolling out of perfSONAR for monitoring.

Moving towards at least 40Gbps wavelengths across the Atlantic and preferably 100Gbps.

Looking at moving further up the protocol stack to support storage and compute resources on the network.

Various programs to explore community opportunities to leverage network, middleware and licensing capabilities with cloud service providers

### **3. How do you support innovation whilst ensuring that operationally stable, reliable and cost effective services are provided?**

Operators mainly support innovation by some form of segmentation of their networks, isolating experiments from the general production network. This is approached in several different ways including the use of VLANs, dedicated lightpaths, etc. Testbeds are also used for experimentation. Different management models exist within different communities for the testing on networks. Some are informal, whilst others are becoming more formalized. A summary of the responses is given below.

#### **ACE**

Careful segmentation and separation of production services from non destructive experimental services over the same infrastructure.

#### **CANARIE**

Implementation of network and application innovations through the allocation of network resources on the base CANARIE network services. Each innovation project can submit a request for resources allocation off the CANARIE network. Projects can request any type of resources from wavelength to VLAN. Special requests, are evaluated for the risk they pose to the reliability of the CANARIE services. When the projects pose risks outside of their own allocated resources, appropriate resources are deployed to ensure that experiments do not over run outside of the allocated service.

#### **DANTE/GN3**

The project development activities are organised into two groups. The first group is more research oriented. They are then matched by a companion set of activities, which are more service oriented. There are three themes represented in these coupled activities. These are Connectivity services, Network Performance Services and End-user oriented services. The whole process for service introduction is much more formalised than in the past. There is a transition to service process. The organisational split between service oriented and developmental activities reflects the differing approaches needed to achieve service innovation. Business case methodology is and will be used to examine the cost effectiveness of new innovative services.

## **ESnet**

Configurations are tested in realistic testbeds with configurations that are as close as possible to the production network before being introduced into the production environment. Once in the production network, to the extent that it is possible, new devices and services will exist along side of existing services for at-scale testing.

## **GLORIAD**

Innovation is supported at various levels by working with innovative partners around the world and collaboratively deploying a shared network platform supporting both production and experimental services based on the GLIF model of open exchange points and community-shared links and services. Each partner has it's own focus/specialty/interest supported by a wide diversity of funding models. The GLORIAD-US team opted to apply for NSF IRNC ProNet funding to maintain US support for production services – including a flexible “hybrid” network platform with which the US community can continue to push boundaries and work productively with innovators globally.

## **Internet2**

Internet2 invests in R&D of new services using member and connectivity fees collected from its membership. All activities are governed by a community governance process that has to balance the level of fees it can afford to contribute with the depth of R&D and the stability of the operational support for production services.

## **4. What is your view on how costs are/should be covered?**

There are many different costing models deployed in operational networks ranging from entirely centrally government agency funded to individual user groups providing funding when they require services. Similarly the funding of transatlantic links varies. The opinions on how the costs should be covered vary . Some think an agreed model would be appropriate whilst others think that no standard model should be adopted. There is some support for the principle of reciprocity (cost sharing) for transatlantic traffic and also for other intercontinental traffic. A summary of the responses is given below.

## **ACE**

Between “strong partners” such as the US-EU cooperative sharing of costs should be the model. If the one of the partners is not “strong”, such as in the developing world, then other arrangements must be made. The more specific financial details (level of governmental involvement) are specific to each project/relationship.

## **CANARIE**

CANARIE is funded by the government of Canada to design and operate the Canadian research network. As such, CANARIE works with the Canadian research community to ensure that the network resources will be in place to ensure that their needs are met. CANARIE’s policy is one of cost recovery. For example applicants are responsible for the incremental infrastructure costs associated with the provisioning of lightpaths across the CANARIE Network. Also, long-term lightpaths for which the two end points are outside CANADA require the upfront payment of the costs incurred through the utilization of the CANARIE network.

## **DANTE/GÉANT**

The principal of reciprocity is important in any arrangement with respect to global access to GÉANT infrastructure i.e., in order to allow access to GÉANT infrastructure we expect to receive equivalent access to interconnected infrastructure. In a global interconnection we generally expect that costs should lie where they fall, thus GÉANT and NREN costs should be absorbed by GÉANT partners and funded according to their relevant cost recovery mechanisms. We expect similar arrangements to apply with interconnect partners. We believe that the costs of interconnection should be shared approximately equally. The precise mechanism for sharing i.e., joint funding or reciprocal provision is less important.

## **ESnet**

ESnet is centrally funded as a facility supporting the Office of Science science mission, programs, and Labs.

## **GLORIAD**

For such international efforts, we resist – first and foremost – any imposition of uniform model and approach towards financing links and services – each economy and community involved is different – those differences must be acknowledged and respected.

GLORIAD operates on strong belief that costs should be shared. Having every partner contribute materially leads to a true sense of ownership (each pays some part of the bill). This provides "power of many" to achieve what is difficult or impossible to achieve centrally. While powerful, it is also very complicated – requiring much coordination, consensus building, innovative contracting mechanisms, etc.

We operate on assumption that international networking must be a public/private partnership. We don't treat international carriers as simple "service providers" but as integral partners who need to understand the R&E community's advanced requirements and who work with us to extend/expand access and services globally.

## **Internet2**

Costs for transatlantic services which are shared broadly among national, regional and pan-continental users ideally would be funded by federal agencies in the U.S. and by the E.U in Europe in a reciprocal balanced way.

Internet2 believes that it does not make sense to have a single network operator collect fees from its members for costs that may be broadly shared or be of benefit beyond that membership.

## **5. Should there be and what could be the engagement rules for users with specific transatlantic requirements?**

The individual operators handle engagement with users in different ways, but in-common is the assessment of requirements and their impact on the network. Some engagement is informal whilst others have processes for dealing with and satisfying requests. There are differing views on whether standard processes should be used. The responses are given below.

## **ACE**

Operators (and funders) must be prepared to develop infrastructure and services to meet specific science demands (within a set of reasonable constraints). Users with specific requirements should be prepared to supplement "standard funding" to have those requirement met.

## **CANARIE**

Every network resource request on the CANARIE network is evaluated for research impact and the resources needed. On project approval, CANARIE proceed to resources allocation or procurement depending on the solution designed. CANARIE does not treat transatlantic resources and domestic resources differently.

## **DANTE/GÉANT**

The issue of engagement rules is very dependant on the requirements of transatlantic users. In particular, if the requirement is for simple IP services, this will be limited to mutual support for performance issues. If the requirements extend to quasi- dedicated or dedicated resources the challenge is more complex. Within Europe we have developed the concept of the “Lead NREN whereby, DANTE as the GÉANT co-ordinating partner and an NREN which represents the centre of gravity of a European project will co-operate, involving other NREN’s as appropriate to offer a pan-European solution to networking needs. The question of how this approach might operate between Europe and North America has, to date been dealt with on an individual basis.

## **ESnet**

At the moment engagement is happening but it is largely ad-hoc. ESnet would like to solicit ideas for setting up some common set of rules/procedures for addressing transatlantic requirements, as requests will come from different communities of users in different countries/continents.

## **GLORIAD**

Rules should not be imposed on “users” but rather on operators and service providers. If we cannot deliver what users request, we must “get out of their way” and facilitate/help find others who can deliver.

National and regional service partners should, first, know their users; they should be “user-driven” and have mechanisms in place for having those needs easily communicated.

Focus must turn upside-down – from emphasis on “network operations” and “link reliability” to customer-focused, flow-based performance.

To facilitate above, we must develop decentralized service delivery systems; like GOLEs and distributed operations centers (like dvNOC), where there are minimal rules (and fees) and a lot of freedom as to how/when/where/what. We recognize the historical fact that centralization of communications services severely limits innovation (and ultimately fails at maintaining control).

## Internet2

The transatlantic component of US<->Europe end-to-end network paths are unique in that most users can reach any of the US exchange points (e.g. MAN LAN, Starlight, NGIX- East) with equal ease and likewise reach any of the European exchange points with equal ease, but the total amount of transatlantic connectivity is quite finite. Moreover, most of the transatlantic links are owned and operated by different entities and some are restricted to particular types of traffic (e.g. LHC).

As the network needs of users with specific transatlantic requirements continues to increase, and as those needs emerge from international collaborations among researchers, the operators of transatlantic network connectivity should begin joint engagement with those user communities to map out network needs going forward, much like ESnet does within the US today through a series of annual workshops.

Practical steps being taken are:

- Agreements between Internet2 and international networking partners offer interoperability and access
- Promote the collaboration between U.S. researchers and overseas counterparts
- Create bridges for virtual collaboration between R & E communities and over 100 international R & E networks

## **6. What inter-domain coordination is required and how could it be provided? (e.g. strategy and operational coordination)**

At present the inter-domain coordination varies. Some operators participate in the DICE operations group (DANTE Internet2, CANARIE, ESnet operations group) which coordinates the delivery of transatlantic services and sets operational goals, as well as being involved in piloting services such as bandwidth on demand. The Internet2 representative stated that the DICE group was not closed to others attending providing they were willing to commit resources to work on initiatives to achieve practical goals which will improve cross-domain co-operation and services. The GLORIAD community also establish cooperation by adopting standards but do not use formal agreements. Some of the operators actively participate in GLIF (Global Lambda Integrated Facility) as well as NRENS throughout the world participating, whilst others do not. It is clear that there are several forums for collaboration which promote cooperation when planning and delivering inter-domain services. These forums have different constituents and different goals but there does not seem to be any overall coordination between these different forums.

A summary of the responses is given below.

## **ACE**

Security coordination is critical and possibly quite difficult inter-domain service to deliver. Without security coordination the entire activity is put in danger. Measurement and dynamic circuit provisioning are also extremely important. Key mechanisms are standardization (via standards bodies) and developing venues (meetings) for advancement of required coordination.

## **CANARIE**

The present, inter-domain coordination is done at the network operation level. Each project is analyzed and each solution is hand designed through one of the country's leadership and participation of other national network. Strategically, there could be energy saved and faster service provisioning if there was:

- A central repository of network resources availability across all networks, providing solution designers with the necessary background to discuss solutions.
- A base level and standardized service definition for the easy implementation of cross-domain services.
- A minimum amount of resources available across all networks to permit for rapid turn-up of new inter-domain services.
- A coherent policy for the sharing short-term and long-term services across domain in order to help evaluate potential costs for solutions.

## **DANTE/GÉANT**

Apart from IP, where there are always performance issues, the question of mutual support for advanced connectivity and other services requires a more extensive co-ordination. These services require access to other domains resources and the ability to manage such resources at some level. This in turn implies bilateral agreements as well as common operational procedures. Integration of operations centres is also vital for the support of users. The European experience is that such services are operationally complicated and require a high level of technical support as well as an agreed policy framework and a common approach to security. To further the implementation of such services GÉANT has been co-operating with North America via the DICE initiative involving Canarie, ESNET, and I2 on the North American side. DICE has, in March 2010 set a number of challenging service-oriented goals to be achieved within the next 12 months including a common monitoring framework as well as piloting bandwidth on demand.

## **ESnet**

There are several, independently funded network paths across the Atlantic serving the general R&E environment and so various sorts of coordination is definitely necessary in order to better utilize that available bandwidth. Currently informal coordination is happening through the DICE Operations Group. This should probably be replaced by a more transparent mechanism.

## **GLORIAD**

Establishing consensus on simple, “lightweight” standards that meet minimal and broadly acceptable requirements is the focus of GLORIAD community coordination.

Good standards and models of interoperability and coordination exist today; innovative, flexible partners cooperate globally towards informal, effective shared operations. New links and services are established, shared and cooperatively managed – typically without formal agreements or MOUs. (if MOUs are required, we have failed as a community)

GLORIAD’s emphasis is on distributed, decentralized sharing of resources and coordination of services to establish an enabling platform for users - and avoiding creation of confining, limiting structures and procedures. We are “operationalizing” this in open-source, standards-based software tools (dvNOC).

## **Internet2**

Significant inter-domain coordination is required. Currently, all the R&E network operators are working collaboratively through the DICE partnership to shape the overall set of transatlantic network bandwidth and services on a voluntary basis. One might argue that all future funding of transatlantic connectivity from both the US and Europe should be determined in the context of the existing overall connectivity picture and a mutually-agreed-to strategy for going forward.

## **7. What are the top 3 technology innovations you expect to change operations in the coming years?**

There is a lot of agreement about the technology innovations that are likely to change network operations in the coming years. In particular the move to 40/100 Gbps networking is one innovation which will require the use of dynamic circuit allocation, QoS to partition and control the bandwidth. There will be a move towards end-to-end inter-domain automated dynamic circuit/bandwidth reservation and monitoring across heterogeneous network environments. There is also likely to be a move toward virtualised network management. All of these developments would have the aim of providing more reliable, diverse, secure, guaranteed services on an end-to-end basis. A summary of the responses is given below, along with other issues raised in the discussions.

## **ACE**

Deployment of 40/100G networking has the potential to change everything. If 40/100G networking develops quickly in the terrestrial environment but not in the trans-Atlantic market, there will be serious capacity issues that must be dealt with via some service development (dynamic circuits, QoS or such...). If 40/100G trans-Atlantic capacity is available and affordable, then this service development becomes more problematic (perhaps useful for other reasons). Regardless, security remains a critical topic for discussion.

Standardization (and acceptance) of deployment and support of dynamic circuits combined with standardization and support of end-to-end measurement will allow network users to easily see/verify the bandwidth commitment network operators have made. This reverses the existing network model of operators supplying a largely unknown and unmeasured service to users who have little ability to determine the specific details of the quality of that service.

The development of services will rely on standardization (through standards bodies) and through meetings required for coordination.

## **CANARIE**

- 1) Inter-Domain dynamic circuit configuration
- 2) End-to-end Inter-Domain circuit monitoring
- 3) Carrier Ethernet or related technology.

Issues are also costing models, performance analysis and provision of bandwidth on demand.

## **DANTE/GÉANT**

- 1) 100Gbps transmission technology.
- 2) Multi-domain automated bandwidth reservation, provisioning and monitoring.
- 3) User-controlled virtualized Network on Demand (Future Internet) services across a shared connectivity platform.

There were concerns that resilience is a major issue which needs to be tackled by better coordination between stakeholders.

## **ESnet**

- 1) Introduction of 40G and 100G waves.
- 2) More comprehensive use of virtual circuit management tools (a la the DICE collaboration).
- 3) More comprehensive perfSONAR monitoring and network deployment.

There are concerns about the engagement rules for cooperation between networks. Today the model is ad hoc with each network and groups of users making their own plans without any structured approach to planning.

## **GLORIAD**

- 1) Inter-domain Dynamic Provisioning (VLAN with committed bandwidth and/or others)
- 2) Distributed, decentralized Virtual operational services (dvNOC)
- 3) Network virtualization and integration with other IT resources
- 4) Improved end-to-end performance monitoring (know that customer has a problem before they can pick up the phone to report it!)

GLORIAD were concerned that rules may hamper developments and different multiple funding sources would imply that no single cost model could be adopted.

## **Internet2**

Internet2 would like to see tighter integration of middleware and trust services in to bandwidth provisioning and utilization tracking to better profile the needs and uses of limited resources like transatlantic connectivity. This capability should not be used to create or change any particular financial model, but instead could provide a much richer set of reservation and quality assurance guarantees to scientists attempting global collaborations.

Internet2 would also like to see significant enhancement of transatlantic capabilities from bundles of 10G links to bundles of 100G links, with attention paid to ensuring path diversity, maintaining services

in the presence of specific link outages, and coordination with the growth of end user capabilities.

The main trends are: 100Gbps, federations, dynamic performance management, integration of middleware and trust services and cloud computing.

## **5.0 Issues raised by the participants and observations made**

The workshop comprised of presentations and discussions about the issues raised during the presentations. The responses to the questions and subsequent discussions have highlighted some issues that should be addressed. Some of important issues are:

1. Planned capacity building of transatlantic services in the next five years which will move towards the provision of capacity in the order of 1 Tbps based on user predictions.
2. The current and planned level of investments from agencies seems to be sufficient to cover this requirement although this needs to be continuously and cooperatively monitored together with technology trends amongst agencies.
3. Planning end-to-end services requires strong cooperation and coordination between all transatlantic stakeholders with a particular emphasis on user requirements in the planning process.
4. It is clear that there are several forums for collaboration which promote cooperation when planning and delivering inter-domain services. These forums have different constituents and different goals but there does not seem to be any overall coordination between these different forums.
5. Better coordination is required when building resilient transatlantic capacity by all stakeholders including IRCN awardees and GLIF, agreeing about the choice of routes to ensure optimal diversity to achieve maximum resilience.
6. The DICE group was recognized as a privileged gathering for discussing transatlantic inter-domain operations such as perfSONAR, trouble-ticketing etc. It was argued that critical factors to its future success imply commitment, inclusiveness and openness of its activities. Lowering the barrier to deploy solutions should be sought by making it user friendly.
7. The development and use a set of interoperable standards and services for dynamic allocation of bandwidth across multiple domains. A first step should include definition of the services based on user requirements.
8. The need to roll out perfSONAR widely so that end-to-end services across multiple domains can be monitored and to ease performance troubleshooting. A critical success factor is to make perfSONAR monitoring information visible across all domains so that an operator in one domain can monitor performance in another domain which is not under their management control. (This will allow performance troubleshooting to be more easily carried out.) This implies a true shared

responsibility for performance monitoring and troubleshooting by operators across multiple operation domains.

9. Develop interoperable security operation and standards so that security can operate across multiple network domains.
10. Consideration should be given to provide 24/7 NOC user support.
11. Understand and agree on the way forward with costing models including the application of the principle of reciprocity. Provide more transparency about network costing/charging for end user communities.
12. The bringing together of user communities so that one-stop shop user support can be better coordinated and so that user needs are better understood and defined.

## **6.0 Conclusions**

A constructive dialogue between all interested parties including users is key for future planning, funding, operations and support of transatlantic networking services. The transatlantic workshop was a step towards identifying some of the issues that will need to be tackled if end-to-end services across multiple domains are going to be quickly set up and reliably delivered and supported.

As scientific endeavors are increasingly becoming global no single network operator can be responsible for end-to-end delivery of services across multiple domains. This means that successful user support requires cooperative development and operations amongst network operators.

Failing to reach sufficient collaboration will lead to user dissatisfaction, an increased risk of losing time and money and a lower adoption rate of new innovations. There may also be a duplication of investment of public funds if several different solutions are developed by different stakeholders.

Agencies should closely follow the evolution of requirements and standard solutions and services through continuous transatlantic dialogue.

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