Final Report

01 August 1998 – 31 July 2005

NSF ANI-9730201

Certification

TransPAC Annual Report
01 August 2003 – 31 July 2005
NSF ANI-9730201

I certify that to the best of my knowledge, (1) the statements herein are true and complete, and (2) text in this report as well as in any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I understand that the willful provision of false information or concealing a material fact in this report(s) or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1011).

Michael A. McRobbie (Principal Investigator)
Vice President for Information Technology
and Chief Information Officer
Vice President for Research
Indiana University

Signature:

Date: 30 September 2005

Executive Summary

TransPAC was a high performance network connecting scientists in the United States with their counterparts in the Asia-Pacific region. TransPAC provided fundamental network infrastructure to support e-science collaborations between these researchers in a broad range of scientific disciplines including astronomy, molecular biology, high-energy physics, medicine, meteorology, visualization, and computational science.

Architecturally, TransPAC connected US national and international networks with the Asia-Pacific Advanced Network (APAN) in Tokyo, Japan. Indiana University provided technical and administrative support for TransPAC in the US. KDDI Corporation provided similar support for TransPAC in Japan.

TransPAC provided scientists worldwide with high performance access to data and computing resources located in Asia. In addition, TransPAC provided scientists with remote access to exceptional, world-class instruments such as electron microscopes, telescope arrays and satellite-based imaging devices.

As a vehicle for encouraging collaborations between groups in the US and the Asia-Pacific, TransPAC had notable success. By participating in and supporting the growth of new research communities such as Pacific Rim Applications and Grid Middleware Assembly (PRAGMA), Global Grid Forum and Asia-Pacific Grid (ApGrid), TransPAC was able to leverage the infrastructure investments made in the network. The idea that science depends on global collaborations and that these collaborations depend on international reliable high-speed networking and advanced networking services is borne out in the formation of communities such as PRAGMA and ApGrid.

TransPAC activities concluded in April 2005. At that point the new TransPAC2 project began. The network configuration when TransPAC2 concluded was one OC-48 circuit and one OC-192 circuit connecting researchers in Asia with collaborators in the United States. One of these connections (OC-48) landed in Los Angeles, where TransPAC connected directly to the Abilene network. The second connection (OC-192) landed in Chicago, where TransPAC connected to the StarLight facility.

It is noteworthy that over the course of the TransPAC project (1997-2005), the bandwidth between Asia and the US expanded from 35Mbps in 1997 to almost 15Gbps in 2005 with no increase in cost to the National Science Foundation. Some of this reflected economic issues within the telecommunications industry, but this was also the result of partnership development and careful negotiation on the part of the TransPAC team.

TransPAC played a pivotal role in strengthening the relationships between scientists and network engineers in Asia and the United States. This is demonstrated by the increasing role that TransPAC participants assumed in the Asia Pacific Advanced Network (APAN) meeting. See the presentations section of the report for further details.

Finally, TransPAC has laid the foundation for linking powerful Asian resources and economies into the rapidly developing cyberinfrastructure. Scientists and network engineers communicate daily regarding both operational concerns and future plans. These plans include linking the next phase of Asian networking to both the US and Europe, completing a true global network for support of global science.

The following report lists milestones, papers, and presentations in the life of the project; describes the TransPAC network and the status of the e-science applications supported by

TransPAC; and provides a summary of the primary accomplishments in the fifth year of funded activity under NSF Cooperative Agreement ANI-9730201, *TransPAC: A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)*. A brief overview of the plans for TransPAC2, the continuation of the TransPAC project, is also included.

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A. Introduction

TransPAC provides high performance international Internet service connecting the Asia-Pacific Advanced Network (APAN)[1] to the vBNS,[2] Abilene (an Internet2 backbone network),[3] and other global networks for the purpose of international collaborations in research and education. Ongoing TransPAC High performance International Internet Services (HPIIS) program objectives are:

Furnish, operate, and maintain a direct connection for high performance traffic between the Asia-Pacific and the US

Ensure, to the extent supportable by prudent application of networking technology, that only approved institutions' traffic is permitted to use the high performance connection

Monitor the performance and use of the TransPAC connection

Cooperate with the National Laboratory for Advanced Network Research (NLANR) Team (University of Illinois at Urbana [DAST], UCSD [MOAT] and Carnegie-Mellon University [NCNE]) to develop testbed implementations and, as appropriate, production implementations of new versions of Internet networking protocols

Maintain a publicly accessible TransPAC-HPIIS Web site containing information about the high performance connection and research and education collaborations that it enables

In concert with the methodologies developed by the NLANR Team, provide consultative user services supporting the use of TransPAC-HPIIS for high performance computing and communications applications; provide Web-based front-end tools and direct user support to enable direct access to differentiated network services

In addition to meeting the TransPAC program objectives, activities for FY 2003-2005 were centered in four areas:

1. Operation of fundamental TransPAC infrastructure, which remained unchanged through the Program Year

2. Expansion of TransPAC measurement infrastructure to provide a more detailed characterization of the network's performance

3. Continued support of Grid activities through active engagement with domain scientists and middleware developers both individually and collectively via the Global Grid Forum

4. Expansion of science activities supported reflecting the increase in global-scale research activities and the increase in Grid-enabled collaborations

A.1. Infrastructure

At the conclusion of the official TransPAC project, the TransPAC network was implemented as two circuits connecting Japan with the US: a "northern" OC-192 circuit to Chicago and a "southern" OC-48 circuit to Los Angeles.

The northern circuit is an OC-192 Packet-Over-SONET (POS) circuit from Tokyo to Chicago. In Chicago, this circuit terminates onto a Procket 8801 router located in the StarLight facility at 710

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[1] http://apan.net/home/index1.htm
[2] http://www.vbns.net/
[3] http://abilene.internet2.edu/

North Lakeshore Drive. This router maintains VLAN peering with US research and education networks across the StarLight Force10 Ethernet switch. In Tokyo, this circuit terminates onto a Procket 8812 router that maintains internal peering with the rest of the APAN Tokyo XP network.

The southern circuit is an OC-48 POS circuit from Tokyo to Los Angeles. In Los Angeles, the circuit terminates into an Internet2-owned Juniper T640 router that is part of the Abilene network. This T640 maintains peering with the rest of the Abilene backbone and transits US-domestic and international peer traffic to APAN. In Tokyo, this circuit is terminated on a Juniper M20 router that is connected to the rest of the Tokyo XP network via three link-aggregated Gigabit Ethernet (GigE) connections. This OC-48 circuit is the preferred circuit for US-Asia traffic.

This network configuration provides for physical redundancy; protection circuits are installed in the entire network path up to Los Angeles. For example, if there is an outage on the northern circuit, the southern circuit will be unaffected. However, the service from LA to Chicago for the northern circuit is an unprotected optical circuit.

A.2. Measurement

Developing new—and improving existing—measurement tools continues to be a focus of the TransPAC engineering staff. Measurement tools either used or developed by TransPAC include: Traceroute (from Chicago, Seattle, and Tokyo); Multi-Router Traffic Grapher (MRTG); the TransPAC animated traffic map; PingER (SLAC); Iperf; SNMP-based tools; Nagios; and Ganglia. Details about these tools can be found in *Progress in Performance Analysis and Measurement*.

Passive IPv4 header traces are currently being gathered from the StarLight facility in Chicago and the Pacific Northwest GigaPoP in Seattle. This data is available on a per-project basis for analyzing and debugging high performance network applications and network-related problems. TransPAC will continue to make this service available for research collaborations between the US and Asia-Pacific region.

Grid application measurement efforts have become increasingly important in the last year. The TransPAC engineering staff is working with the iVDGL (international Virtual Data Grid Laboratory) and other international Grid-related projects to provide a network- and end-systems monitoring infrastructure. TransPAC hopes to provide a better picture of the network requirements of Grid-related applications using the above set of monitoring tools.

A.3. Grid Activities

ApGrid

Asia-Pacific Grid (ApGrid)[4] is a partnership for Grid computing in the Asia-Pacific region, focusing on:

Sharing resources

Developing Grid technologies

Using technologies to create new applications

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[4] http://www.apgrid.org/

Collaboration within Asia and with the greater Grid community

TransPAC continues to be a key supporter of the ApGrid efforts and participated in ApGrid activities both at APAN meetings and SC2002.

PRAGMA

Pacific Rim Applications and Grid Middleware Assembly (PRAGMA) is a partnership between organizations in the Pacific Rim and the San Diego Supercomputer Center (SDSC) designed to encourage the development of Grid applications between the US and Asia.[5] TransPAC is also a key supporter of PRAGMA activities in Asia. TransPAC has participated in both the PRAGMA 3 and PRAGMA 4 meetings and has provided technical and organizational support for PRAGMA demonstrations. James Williams continues on the PRAGMA Executive Committee. The TransPAC and PRAGMA Web pages reference each organization and emphasize the importance of both applications and infrastructure.

Global Grid Forum

TransPAC was a 2003 Silver sponsor of the Global Grid Forum (GGF).[6] John Hicks and James Williams attended the GGF meeting in Tokyo. TransPAC had a sponsor booth in Tokyo to demonstrate how TransPAC infrastructure could facilitate US-Asia Grid activities.

A.4. Science

TransPAC continues to support research communities in a broad range of disciplines including biology, medicine, high energy physics, astronomy and space science, earth observation, and environmental science. In addition to collaborations between NASA and NASDA in space exploration and astronomy, a number of data and instrument grid projects between the US and APAN countries used TransPAC resources.

A particularly salient application of TransPAC—and advanced networking in general—occurred in April and May of 2003 during the outbreak of SARS in Taiwan. TransPAC cooperated with TANET2 and other international research and education networks to assist medical professionals in Taiwan. To provide for local and international medical consulting, National Center for High-performance Computing (NCHC) researchers quickly created the SARS Grid, a global-scale teleconferencing network that enabled physicians to communicate with one another and to share high-resolution X-rays, diagnoses, and treatment methods.[7] Participating physicians within Taiwan, from the US, and from other Pacific Rim countries could talk to each other face to face and to patients inside quarantined areas. This approach greatly reduced transmission of the disease by medical personnel and allowed medical researchers at remote locations immediate first-hand access to doctors and patients without the need for travel or risk of infection.

Other application highlights include a bandwidth-limited distributed analysis of the Large Hadron Collider Atlas detector events using the AIST Grid Datafarm storage technology, and a Japan-US-Netherlands multi-site demonstration of remote telemicroscopy and 3-D tomography reconstruction using the unique Osaka uHEVM and computing resources in the US.

A catalogue of science projects that TransPAC facilitates is available in *Appendix C*.

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[5] http://pragma.ucsd.edu/
[6] http://www.ggf.org/
[7] http://access.ncsa.uiuc.edu/Stories/SARS/

A.5. Summary

TransPAC continues to provide cost-effective network infrastructure for e-science between the Asia-Pacific region and the US. As a vehicle for encouraging collaborations between groups in the US and the Asia-Pacific, TransPAC has had notable successes. The TransPAC project continues to provide encouragement and support for furthering scientific collaborations between researchers in Asia and the US.

The US National Science Foundation and the Japanese Communications Research Laboratory agreed to fund the TransPAC project until April 2, 2005.

During the extension year, goals for TransPAC centered on increasing both production and experimental bandwidth from Asia to the US. Closer relationships were developed with international network research efforts such as PlanetLab.[8]

B. TransPAC Organization and Management Committee

The TransPAC Management Committee was co-chaired by the TransPAC Principal Investigator, Michael A. McRobbie, and Shigeki Goto, Professor at Waseda University and the former APAN Deputy Chair. This committee established policy and provided overall direction for the TransPAC Project. TransPAC Management Committee members for the reporting period included:

B.1. APAN

Australia

Robin Stanton (The Australian National University)
Markus Buchhorn (The Australian National University)

Japan

Shigeki Goto (Waseda University)
Kazunori Konishi (Kokusai Denshin Denwa, Co. Ltd.)

Korea

Yong-Jin Park (Hanyang University)
Seongjong Bong (Korea Telecom)

Singapore

Francis Lee (National Technological University)
Tham Chen Khong (National University of Singapore)

APAN Chair

Kilnam Chon (Korea Advanced Institute for Science and Technology)

Tokyo XP

Akira Kato (University of Tokyo)

Management Liaison

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[8] http://www.planet-lab.org/

Kunio Iijima (Japan Science and Technology Corporation)

B.2. United States

Indiana University

Michael McRobbie
Doug Pearson
Steve Wallace
James Williams
Rick McMullen
Dennis Gannon
Karen Adams

STAR TAP

Linda Winkler (Argonne National Laboratories)

Management Liaison

Tom Greene (National Science Foundation)

C. Major Milestones, August 1998 through July 2005

The following is a list of significant milestones spanning the entire history of the TransPAC project, from its inception in 1998 through its conclusion in 2005. A complete list of milestones for the most recent years—2003 through 2005—can be found in the *Section G: Complete Milestones* section of the Annual Report for FY03-05.

Complete milestones for earlier years of the project—1998 through 2003—are in *Appendix A*.

1998

July 30	ATM service established between the APAN Tokyo Exchange Point (XP) and STAR TAP
August 18	Cooperative Agreement for TransPAC signed
	Representatives of Indiana University and Japan Science and Technology Corporation sign MOU to establish link
	NSF TransPAC 5-year award to Indiana University formally announced in Washington, DC
October	24x7 IU TransPAC NOC operational
November	TransPAC-based iGrid demonstrations at SC'98

1999

March	JST funded TransPAC network upgrade to 73Mbps bandwidth completed
	TransPAC-based demonstrations at GOIN'99
April	First HPIIS Team Meeting in Chicago

November	TransPAC bandwidth increased to 70+30 Mbps (2 PVP circuits)

2000

July	iGrid2000 in conjunction with INET2000 in Yokohama Japan; TransPAC provides connectivity for iGrid
September	New TransPAC Web site
	TransPAC no cost upgrade to 155Mbps from 100Mbps
October	The TransPAC NOC is integrated into the Global NOC at Indiana University; current networks supported by the Global NOC are TransPAC, STAR TAP, AMPATH, Euro-Link, and MIRnet
	Indiana University Global Research Network Operations Center becomes production
June	TransPAC hosts the High Energy Physics/Nuclear Physics Networking Meeting in Indianapolis, Indiana
July	AMPATH network officially supported by the Global NOC at Indiana University
October	First TransPAC OC-12 connecting Tokyo to StarLight is active
	Second TransPAC OC-12 connecting Tokyo to Seattle is active
November	James Williams, Donald McMullen, Karen Adams, Dennis Gannon, and Michael McRobbie attend SC2001 in Denver; TransPAC provides Asia-US infrastructure

2002

May	TransPAC engineers assist in Global Terabit Research Network demo from Seattle to Brussels
	Teleglobe northern OC-12 services shut down permanently; TransPAC continues to operate on single OC-12 from Tokyo to Chicago
July	Taiwan begins routing across TransPAC
September	Network operations provided network support for the iGRID 2002 demonstrations
	Williams worked with Peter Aursberger on the PRAGMA governance structure and charter and participated in planning for the Miami Internet2 Joint Techs meeting
November	Williams and Hicks attended SC2002 in Baltimore, MD
	Network operations worked with all its partners to provide network support for SC2002
	TransPAC/Euro-Link coordination meeting held at SC2002

John Hicks worked with our Japanese TransPAC partners in the GFarm Project to set a new TransPAC utilization record at SC2002[9]

2003

March   John Hicks and James Williams attended GGF7 in Tokyo, Japan. TransPAC is a sponsor of GGF. Hicks and Williams provided handout materials about TransPAC at GGF7 and had many TransPAC-related discussions with GGF attendees.

A one-year TransPAC extension proposal was developed and submitted to the NSF for funding consideration.

August   Network operations completed work on a new internal database of global network contact information.

2004

January   TransPAC connection implemented as two OC-48 circuits, one routing through Chicago, the other through Los Angeles

August   The OC-192 circuit from Tokyo to Chicago became operational; the former OC-48 Circuit remained operational alongside the OC-192 for one month to ensure a smooth transition and network stability

September   Hicks Co-Chaired the seventh PRAGMA conference and workshop and gave the opening remarks for the conference

2005

January   Williams, Robb, Hicks, Dave Jent, and Doug Pearson all attended a JGN2/WIDE meeting hosted in Indianapolis to demonstrate the strength and value of Indiana University's information technology research, particularly the TransPAC connection and its relation to the research and education community. Possible collaborations between NICT/JGN2 and Indiana University were discussed and promoted.

February   Hicks attended the ESCC/Internet2 Joint Techs meeting in Salt Lake City, Utah.

April   Representatives of the TransPAC project attended a ceremony in Tokyo, Japan, to inaugurate the beginning of the TransPAC2 project, a 5-year continuation of the highly successful TransPAC project.

The original TransPAC project officially reaches its conclusion.

The TransPAC connection is upgraded to a single OC-192 SONET connection between Tokyo, Japan and Los Angeles, California.

June   A new TransPAC2 website was launched.[10]

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[9] http://datafarm.apgrid.org/
[10] http://www.transpac2.net/

D. Major Papers and Presentations, International Meetings and Conferences, August 1998 through July 2005

A complete list of meetings, papers, and presentations from these years is included in *Appendix B*. A complete list of meetings, papers, and presentations taking place from August 2003 to July 2005 is available in *Section G*.

1997, December 13-14
Indiana University; Bloomington, Indiana, USA
TransPAC All-Hands International Meeting

1998, April 9
Indiana University; Indianapolis, Indiana, USA
Internet2 and IU
Presentation: TransPAC - A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie

1998, July 21-24
Geneva, Switzerland
INET'98
Paper: A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie, et al
Presentation: A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie

1998, July 28-31
Chicago, Illinois, USA
7th International Symposium on High Performance Distributed Computing (HPDC-7 '98)
Paper: A High Performance Network for Research and Education Applications Between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie, et al

1998, August 29-30
Indiana University; Indianapolis, Indiana, USA
TransPAC Engineering Meeting
Doug Pearson

1998, September 24
Boulder, Colorado, USA
NASA-NASDA-APAN-TransPAC Technical Meeting
Presentation: TransPAC[11]
Doug Pearson

1998, September 26
San Francisco, California, USA
TransPAC Status Meeting

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[11] http://www.transpac.org/old-site/documents/980924_nasa_tech_dp.ppt

Presentation: Results of NASA-NSF-APAN-TransPAC Policy Meeting[12]
Doug Pearson
Presentation: Results of NASA-NASDA-APAN-TransPAC Technical Meeting[13]
Doug Pearson
Presentation: TransPAC-US Status Report[14]
Doug Pearson

1998, November 7-13
Orlando, Florida, USA
SuperComputing'98 and iGrid Demonstrations
Presentation: TransPAC Status Report[15]
Michael McRobbie

1999, February 17
Osaka University; Osaka, Japan
TransPAC Management Committee Meeting
Presentation: TransPAC Link Performance[16]
Linda Winkler
Presentation: TransPAC Status Report[17]
Doug Pearson

1999, April 28
Washington, DC, USA
Internet2 Member Meeting and Applications Demonstration

1999, May 17
Indiana University; Indianapolis, Indiana, USA
Meeting of Indiana University and members of Computer Network Information Center, Chinese Academy of Sciences
Presentation: TransPAC
Steve Wallace and Doug Pearson

2000, February 15-18
Tsukuba, Japan
IWS2000 and APAN Meetings

2000, April 20
Indianapolis, Indiana, USA
TransPAC/STAR TAP/Euro-Link NOC and Engineering Meeting

2000, June 14
Trondheim, Norway
Joint Meeting of the Association of European Universities and European Science Foundation
Presentation: Strategic Planning for IT & High Performance Networking in America

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[12] http://www.transpac.org/old-site/documents/980926_nasa_policy.ppt

[13] http://www.transpac.org/old-site/documents/980926_nasa_tech.ppt

[14] http://www.transpac.org/old-site/documents/980926_status_dp.ppt

[15] http://www.transpac.org/old-site/documents/981111_igrid_bof.ppt

[16] http://www.transpac.org/old-site/documents/990217_performance.ppt

[17] http://www.transpac.org/old-site/documents/990221_liaison_dp.ppt

Universities[18]
Michael McRobbie

2000, October 25
San Diego, California, USA
TransPAC HPIIS Performance Review
Presentation: TransPAC HPIIS Performance Review[19]
Michael A. McRobbie

2000, December 13
Indianapolis, Indiana, USA
TransPAC/STAR TAP/Euro-Link Engineering Meeting

2001, January 28-31
University of Hawaii; Honolulu, Hawaii, USA
APAN/TransPAC/NLANR/Internet2 Techs Workshop

2001, January 31
Honolulu, Hawaii, USA
NLANR/Internet2/APAN/TransPAC Joint Techs
NOC Best Practices BOF

2001, February 20
Tokyo, Japan
IWS2001
Keynote Presentation: Towards a Global Terabit Research Network
Michael A. McRobbie

2001, March 7-9
Washington, DC, USA
Internet2 Meeting
Presentation: Internet2 Measurement[20]
James Williams
Presentation: Internet2 Performance[21]
James Williams

2001, June 1-2
Indianapolis, Indiana, USA
High Energy Physics/Nuclear Physics Networking Meeting
Presentation: TransPAC and Global NOC Report[22]
James Williams

2001, August 20-22
Penang, Malaysia
APAN Meeting
Presentation: TransPAC Network Update[23]
Chris Robb

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[18] http://www.indiana.edu/%7Eovpit/presentations/trondheim/

[19] http://www.transpac.org/old-site/10-25_transpac_mcrobbie.ppt

[20] http://www.transpac.org/old-site/documents/i2_measurement_talk.ppt

[21] http://www.transpac.org/old-site/documents/i2_performance_talk.ppt

[22] http://www.transpac.org/old-site/documents/meetings/transpac-hep-talk.ppt

[23] http://www.transpac.org/old-site/documents/meetings/2001-08-20_penang_transpac-upgrade.ppt

Presentation: TransPAC Implementation of I2 Scavenger Service[24]
Chris Robb

2001, August 23-24
San Diego, CA, USA
HPISS 2001[25]
Presentation: TransPAC and Global NOC[26]
John Hicks

2001, October 22-24
Tokyo, Japan
Asia-Pacific Grid Workshop 2001, co-hosted by TransPAC
Presentation: High performance connectivity between the US and the Asia-Pacific Region[27]
James Williams

2002, January 8-10
Gainesville, FL, USA
International Virtual Data Grid, second meeting
James Williams represents TransPAC

2002, February 19-22
Hawaii, USA
Pacific Rim Networking, hosted by TransPAC
Presentation: Global Terabit Research Network: Building Global Cyber Infrastructure[28]
Michael McRobbie
Presentation: TransPAC - High performance connectivity between the US and the Asia-Pacific region[29]
James Williams

2002, May 5-9
Washington, DC, USA
Internet2 Member meeting
Presentation: Global Terabit Research Network[30]
Michael McRobbie
Presentation: Pacific Rim Networking Meeting Update[31]
James Williams
Presentation: Indiana University Animated Traffic Map Software[32]
Chris Robb

2002, August 27
Shanghai, China
APAN Meeting
Presentation: *TransPAC Update*

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[24] http://www.transpac.org/old-site/documents/meetings/2001-08-20_penang_qbss_scavenger-service.ppt

[25] http://moat.nlanr.net/Workshops/HPIIS-2001

[26] http://www.transpac.org/old-site/documents/hpiis-transpac-talk-v2.ppt

[27] http://www.transpac.org/old-site/documents/meetings/2001-10-23_transpac-tokyo-talk12.ppt

[28] http://noc.transpac.org/old-site/meeting/mcrobbie.ppt

[29] http://noc.transpac.org/old-site/meeting/transpac.ppt

[30] http://www.internet2.edu/presentations/spring02/20020507-Plenary-McRobbie.ppt

[31] http://www.internet2.edu/presentations/spring02/20020506-PacificRim-Williams.ppt

[32] http://www.internet2.edu/presentations/spring02/20020506-WeatherMap-Robb.ppt

John Hicks
Presentation: *Abilene Upgrade*
John Hicks
Presentation: *iVDGL Network Operations Center*
James Williams

2002, October 27
Los Angeles, CA, USA
Internet2 Meeting
Presentation: *iGOC Monitoring*
John Hicks
Presentation: *iGOC Update*[33]
James Williams

2003, January 23
Fukuoka, Japan
PRAGMA Workshop
Presentation: *Network Measurement*
John Hicks
Presentation: *TransPAC Update*
James Williams
Presentation: *Indiana University Global NOC Monitoring Infrastructure*
Chris Robb

2003, August 24 – 29
Busan, Korea
APAN Meeting
Jim Williams
Presentations: *TransPAC Development 2003 – 2004, PRAGMA*
Chris Robb
Presentations: *TransPAC Engineering 2003 – 2004, Abilene Observatory*

2003, September 9
Indianapolis, Indiana, USA
TransPAC Hosts the Vice Minister of Education from the People's Republic of China
Jim Williams
Chris Robb
John Hicks
Presentation: *Networking at Indiana University*

2003, October 14
Indianapolis, Indiana, USA
Fall Internet2 Meeting
Jim Williams
Presentation: *TransPAC Update*[34]
Chris Robb
John Hicks

[33] http://www.internet2.edu/presentations/fall02/20021027-HENP-Williams.ppt
[34] http://www.transpac.org/old-site/documents/meetings/2003-10-14_I2-talk.ppt

2003, October 22
Hainchu, Taiwan
John Hicks
Presentation: *TransPAC and Grid3 Update*[35]

2003, November 19
Phoenix, Arizona, USA
John Hicks

2004, January 25
Honolulu, Hawaii, USA
APAN Meeting/I2 Joint Techs
Jim Williams, Chair: Lambda International Networking Meeting
Presentation: *HOPI:* The Hybrid Packet and Optical Initiative as a Connectivity Solution
John Hicks
Presentations: *Grid2003 Report*[36]*, Status of Fast TCP and other TCP Alternatives*[37]
Chris Robb
Presentation: *Abilene Observatory*[38]

2004, April 19
Arlington, VA
I2 Member Meeting
Jim Williams
John Hicks
Chris Robb

2004, May 17
Beijing, PRC
Computer Network Information Center, Chinese Academy of Sciences
Pragma 6 Meeting
John Hicks
Presentation: *Grid3: Super Computing 2003 and Beyond*[39]

2004, September 16
San Diego, California, USA
Pragma 7 Meeting
John Hicks, Co-Chair
Presentation: *Pragma 7 Opening Remarks*[40]

2004, September 27
Austin, TX, USA
I2 Member Meeting
Jim Williams

2004, November 6
Pittsburgh, PA

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[35] http://www.transpac.org/old-site/documents/meetings/2003-10-22_PRAGMA-5-John-Hicks.pdf

[36] http://www.transpac.org/old-site/documents/meetings/2004-hawaii-jt-HOPI-Presentation-robb.ppt

[37] http://www.transpac.org/old-site/documents/meetings/2004-hawaii-jt-TCP-alternatives-hicks.ppt

[38] http://www.transpac.org/old-site/documents/meetings/2004-hawaii-jt-Abilene-Observatory3-robb.ppt

[39]http://pragma6.cnic.ac.cn/announce/ppt/Grid_experiences_and_applications/JohnHicks_Grid3%20SC2003%20and%20beyond.ppt

[40] http://www.pragma-grid.net/pragma7/presentations/MasonKatz.ppt

Supercomputing Conference 2004
John Hicks
Presentation: *PRAGMA Overview*[41]

2004, December 1
Miami, FL, USA
Chinese American Networking Symposium (CANS) 2004
Jim Williams
Presentation: *TransPAC2*[42]

2005, January 7
Indianapolis, Indiana, USA
JGN2 Meeting
Jim Williams
Presentation: *IU Research and the IRNC*[43]
Chris Robb
Presentation: *TransPAC2 Network Overview*[44]
John Hicks
Presentation: *TransPAC2 Measurement*[45]
Doug Pearson
Presentation: *Global Research NOC*[46]

2005, January 19
Bangkok, Thailand
19th APAN Meeting
Jim Williams
Presentation: *TransPAC Networking*
Chris Robb
Presentation: *TransPAC Engineering*
John Hicks
Doug Pearson

2005, July 18
Vancouver, BC, CA
Chris Robb
Presentation: *TransPAC2 Network Update*[47]

E. Final TransPAC Physical and Logical Network Topology

The following section details the physical attributes of the TransPAC connection as of April 1, 2005, before the inception of the TransPAC2 project. For a description of infrastructure changes planned as part of TransPAC2, refer to the *Future Plans* section.

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[41] http://www.pragma-grid.net/Presentations/SC2004/11_TransPAC_Hicks.ppt

[42] http://www.transpac.org/old-site/documents/meetings/tpac2-miami.ppt

[43] http://www.transpac.org/old-site/presentations/2005/2005-NICT-talk.ppt

[44] http://www.transpac.org/old-site/presentations/2005/2005-01-07-JGN2-Meeting.pdf

[45] http://www.transpac.org/old-site/presentations/2005/2005-JGN2-WIDE-measure.ppt

[46] http://www.transpac.org/old-site/presentations/2005/2005-noc_20050107f.ppt

[47] http://www.transpac.org/old-site/presentations/2005/20050718-Joint%20Techs%20v1.1.pdf

E.1. TransPAC Circuits

The final TransPAC network, as of April1, 2005, was implemented as two SONET circuits connecting Japan with the US: an OC-192 (10Gbps) northern circuit to Chicago, and an OC-48 southern circuit to Los Angeles. The northern circuit connected Tokyo with the StarLight facility in Chicago. The southern circuit connected Tokyo with the Abilene network in Los Angeles. Both of the TransPAC circuits traversed the same protected SONET service across the Pacific ocean, with the LA circuit using the work side and the Chicago circuit utilizing the protect side.
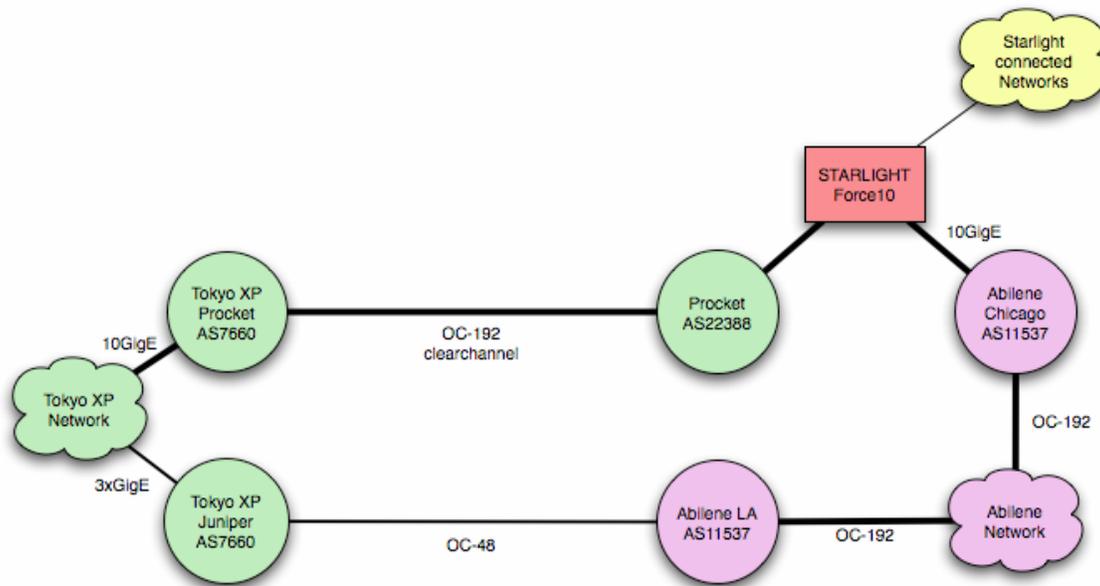
Figure 1: Final TransPAC Network Configuration

TransPAC circuit information is also discussed in *Progress in Network Infrastructure Development*.

E.2. Chicago Circuit

In the final two years of the TransPAC project, the Chicago circuit underwent two major topology changes. The following subsections describe the topology changes over this period.

E.2.1 Chicago Circuit - October 2003 through July 2004

During the period from October 2003 through July of 2004, the Chicago OC-48 circuit was provisioned on KDDI-A's trans-oceanic cable as the backup side of the protected OC-48 service between Tokyo and Los Angeles. From Los Angeles, the circuit continued to Chicago via an unprotected lambda provided to KDDI-A by Wiltel. KDDI-A, gave priority to the Los Angeles circuit with regard to trans-oceanic outages. That is, if there were an outage between Tokyo and Los Angeles, the TransPAC Los Angeles OC-48 would utilize the protect side of the trans-pacific portion of the network. The Chicago circuit would be down until the trans-pacific outage was resolved.

The OC-48 circuit to Chicago terminated on a Cisco 15454 SONET switch co-located at the Starlight facility. This optical switch, owned and operated by the TransPAC project, provided the capability to partition the OC-48 circuit into smaller sub-circuits.

In order to exploit this capability, the carrier must provide a circuit that has clear access to certain bytes in the SONET frame overhead. Unfortunately, KDDI-A lacked the capability to provide this clear-channel service at the time. That limitation constrained our ability to channelize the circuit into smaller sub-channels, though it did not hinder our ability to provide GigE service across the OC-48.

The OC-48 circuit was mapped to a single Gigabit Ethernet connection to the Force10 ethernet switch at Starlight. This effectively provided a GigE circuit between the Force10 switch and the Tokyo XP router.

The GigE circuit was operated in a manner consistent with other GigE circuits into the Starlight exchange point. Much like the previous Chicago TransPAC ATM circuit, the GigE circuit was divided into sub-channels- in this case, point to point VLANs. The APAN network in Tokyo maintained individual VLANs to peer networks in Chicago, including Abilene, ESNet and Starlight.
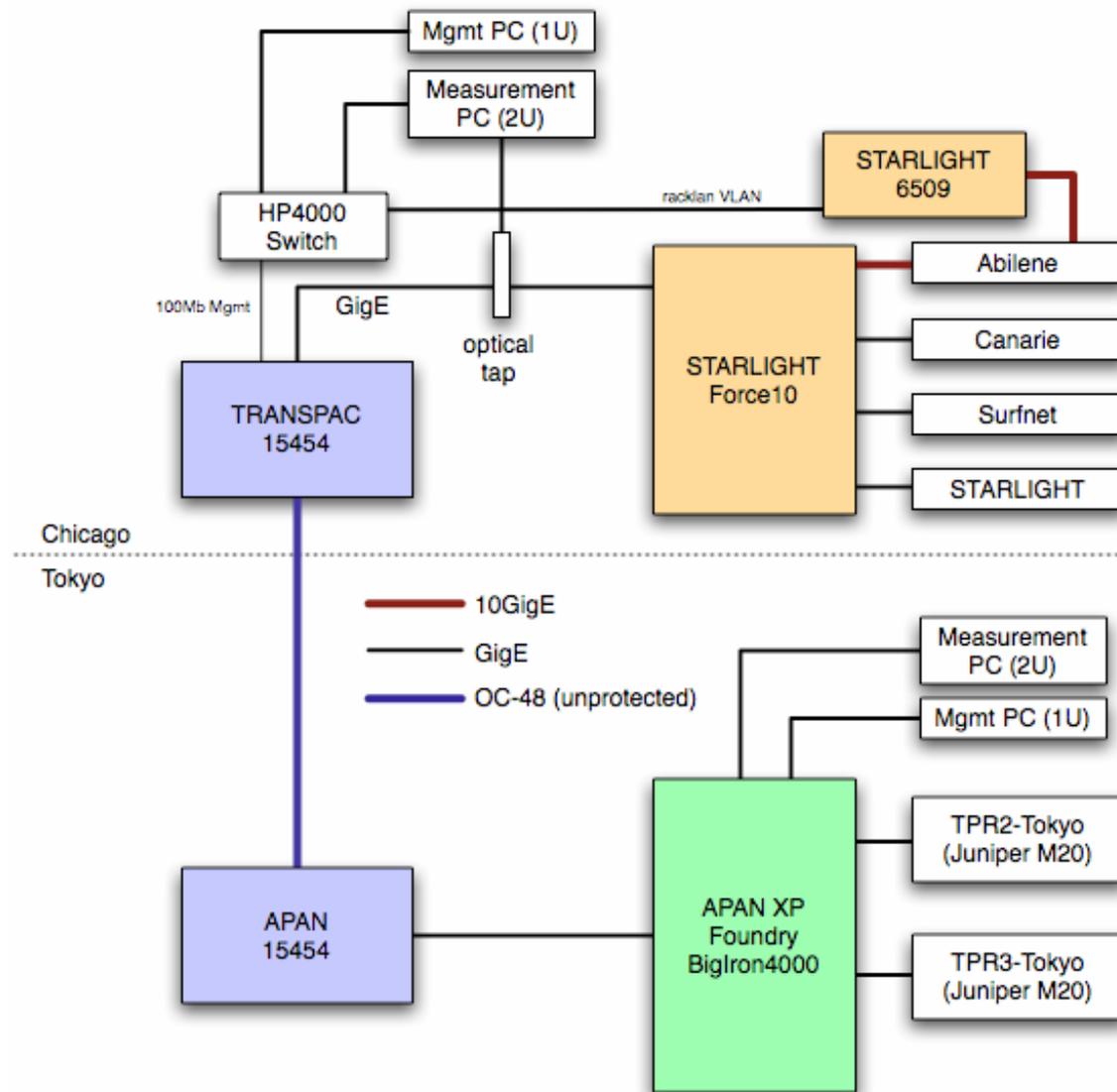
Figure 2: Chicago Topology (October 2003 – July 2004)

E.2.2 Chicago Circuit – August 2004 through March 2005

In the period from August 2004 through the end of the TransPAC project in March of 2005, the Chicago circuit was operated as an OC-192 POS circuit owned by the JGN2 network in Japan. This circuit, operated in cooperation with the TransPAC2 project in the United States connected Tokyo to Chicago by means of a Procket 8801 router co-located at the Starlight facility. The previous OC-48 circuit to Chicago was run in parallel for a month to ensure a complete transition of services to the new OC-192 circuit. The Los Angeles OC-48 remained a distinct and protected circuit after the Chicago circuit upgrade.

The Procket router in Chicago currently maintains a 10GigE connection to the Force10 ethernet switch at Starlight through which is obtains VLANs to US R&E networks. The router is placed in the TransPAC AS (22388) and is jointly managed by APAN and TransPAC engineering. The router and circuit are being monitored by the TransPAC NOC at Indiana University.
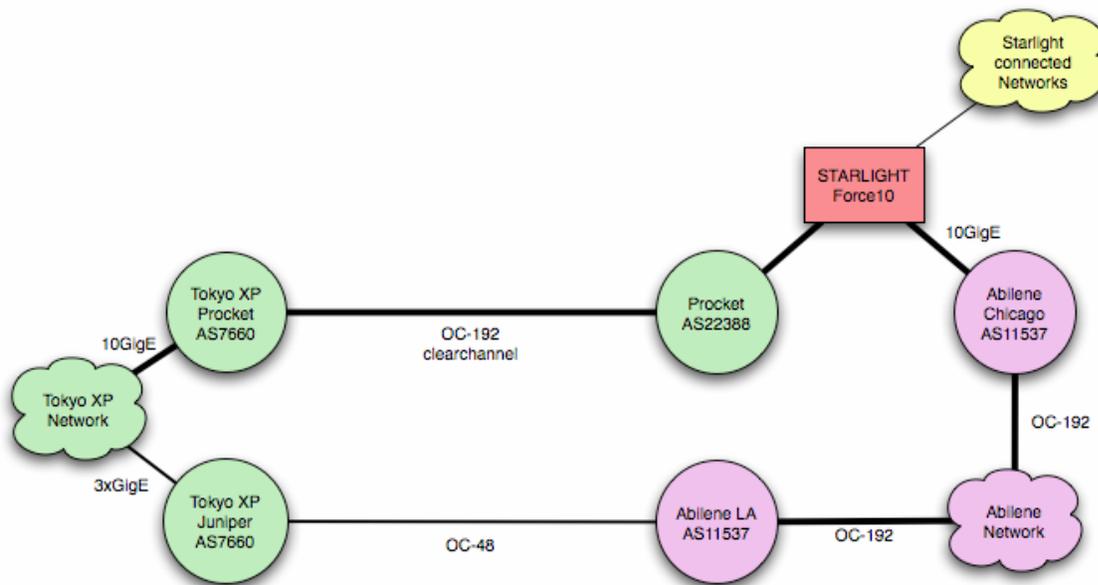
Figure 3: TransPAC network (August 2004 – March 2005)

Though Procket was acquired and dissolved by Cisco in mid 2004, the Procket router was acquired through a donation from Procket prior to the ownership change. Given the timing of the donation and the proximity to the conclusion of the TransPAC project, TransPAC and JGN2 engineers agreed that the router would perform adequately for the final six months of the project.

E.3 Los Angeles Circuit

The TransPAC circuit to Los Angeles retained a static configuration during the final two years of the project. As mentioned earlier, KDDI-A provided the Los Angeles and Chicago OC-48 circuits as the work and protect side of the same OC-48 service. KDDI-A, gave priority to the Los Angeles circuit with regard to trans-oceanic outages. That is, if there were an outage between Tokyo and Los Angeles, the TransPAC Los Angeles OC-48 would utilize the protect side of the trans-pacific portion of the network. The Chicago circuit would be down until the trans-pacific outage was resolved.
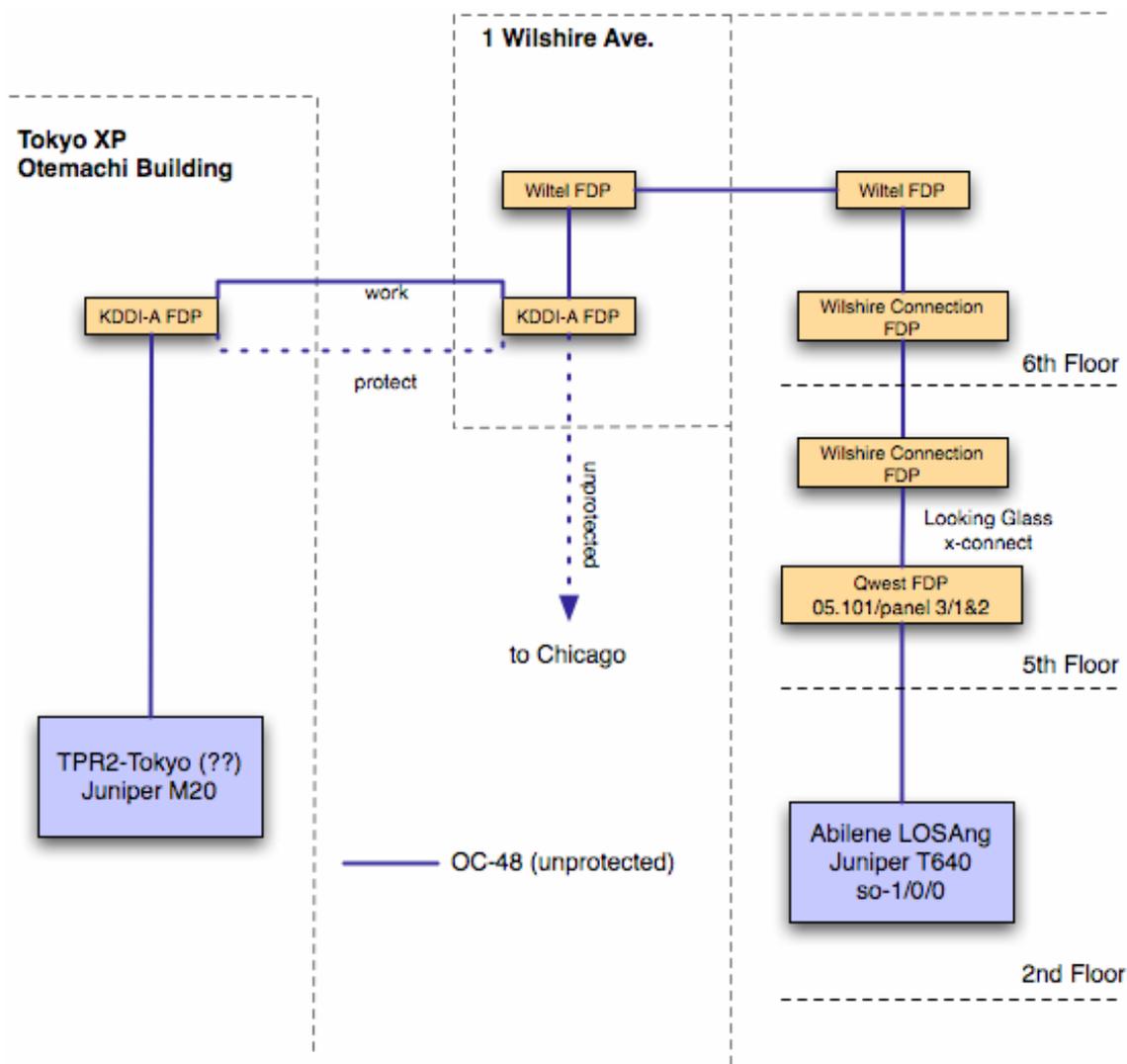
Figure 4: TransPAC Los Angeles circuit topology

The Los Angeles circuit, due to its higher priority in the network, is viewed as the primary ingress and egress point for US and Asian traffic exchanges. The Abilene network preferred APAN route advertisements via the LA circuit, as did APAN prefer Abilene route advertisements via the LA circuit.

E.3.1 Tokyo XP

In addition to providing distinct routers for the two TransPAC circuits, the Tokyo Exchange Point (Tokyo XP) provides connectivity to the entire APAN network. The Los Angeles circuit terminated on a Juniper M20 router during the final two years of the project. The Chicago circuit was initially terminated a Cisco 15454 from August 2003 through July 2004. The GigE channel that was mapped across the OC-48 terminated on a separate Juniper M20 router. Once the Procket router was installed in Chicago, the JGN2 OC-192 terminated on a Procket 8812 router.

In addition to providing separate Juniper M20 routers for the TransPAC circuits for redundancy, the Tokyo XP provides connectivity for the entire APAN network.
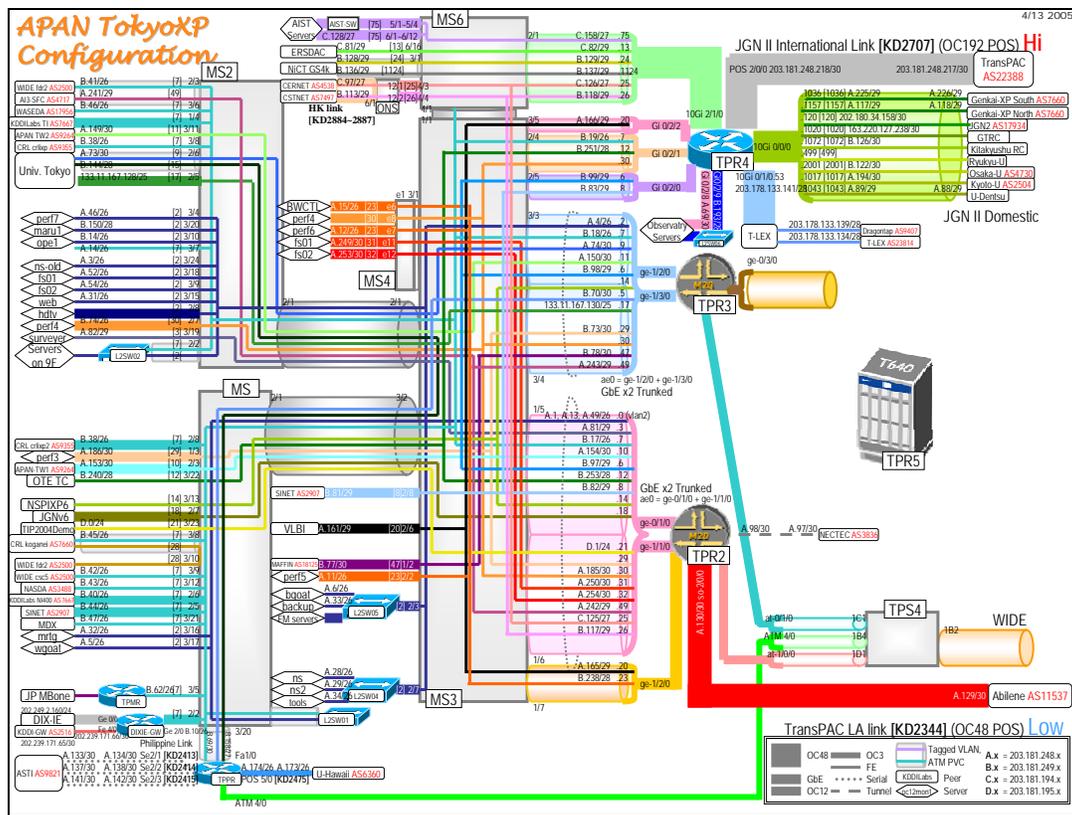
Figure 5: Tokyo XP Network Configuration

E.4. Future Plans

With the emergence of next-generation network technologies in the US, Asia and Europe, it is becoming increasingly important to provide an infrastructure that can meet the requirements of these new networks. With the impending completion of the National LambdaRail (NLR) facility in the US, any continuation of the TransPAC project needs to be flexible enough to participate in Layers 1 through 3 of the OSI protocol stack. This type of production experimentation needs to coexist with a set of production-level services that cannot be interrupted for the sake of next-generation technology experiments.

While the more experimental JGN2 Chicago circuit is already operating at OC-192 speeds, TransPAC management will look to upgrading the Los Angeles circuit to OC-192. This circuit will terminate into a TransPAC-owned router at the Pacific Wave facility in Los Angeles. This will give full access to US research, education, and federal networks on a much higher speed. This Los Angeles circuit will continue to remain the primary entry and exit point for APAN network traffic. As TransPAC becomes more involved in next-generation circuit switched architectures, and as transpacific bandwidth costs decrease, TransPAC engineers will look to the acquisition of more 10G links across the Pacific into much more sophisticated and service-enriched network devices.

Having multiple circuits into the United States allows for a much richer set of services and the necessary resources to participate in US, Asian, and European experiments without sacrificing the production services that the TransPAC project performed over the past seven years. In addition to TransPAC-managed services, the team needs to look at mutual backup services with fellow transpacific networks such as NII and WIDE.

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Though the Chicago JGN2 Procket router has performed well during the last six months of the project, The TransPAC team cannot continue to rely on donated equipment from a now-defunct vendor. This router will need to be replaced with a new piece of equipment in order to provide the set of services that TransPAC has striven to supply.

In addition to the traditional focus on the US-Asian interconnects, The TransPAC team plans to focus on intra-Asian connectivity to areas that traditionally have not been serviced by high-speed circuits. This includes, but is not limited to, Hong Kong, Singapore, and India.
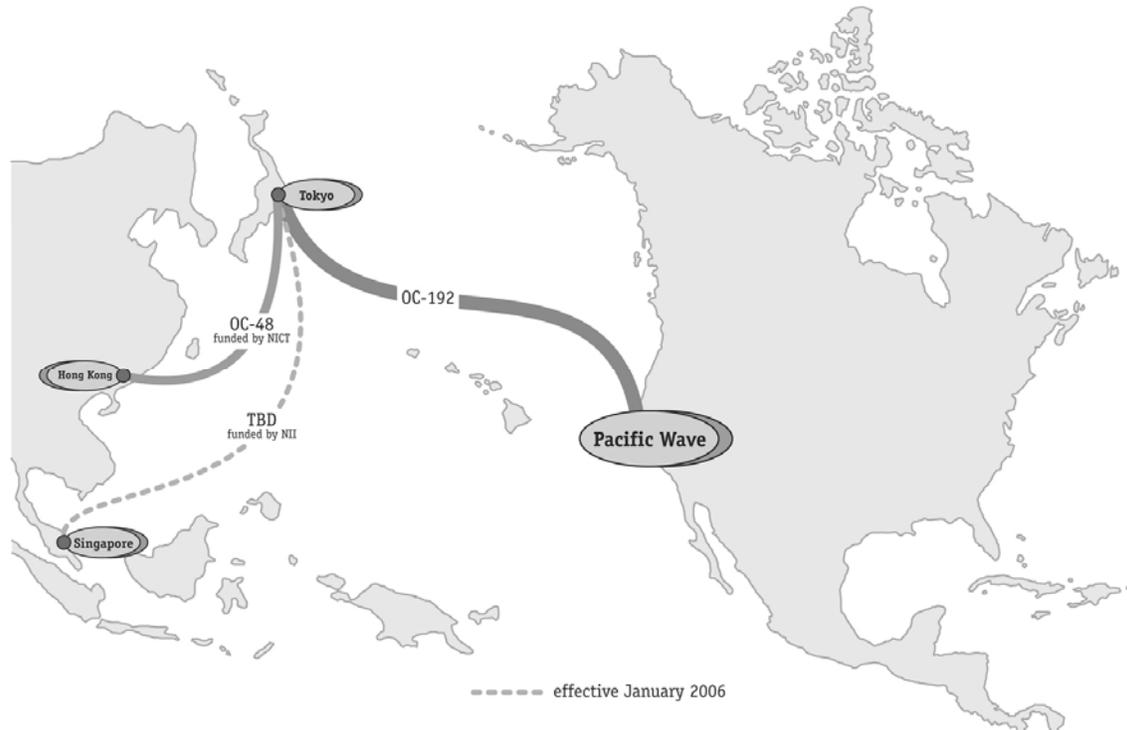
Figure 6: Proposed TransPAC2 Network

F. Application Status

In addition to applications already supported by TransPAC[48] considerable effort was placed into developing relationships with the PRAGMA[49] and ApGrid[50] organizations. These organizations

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[48] See *Appendix C*

[49] http://pragma-grid.net/. From the PRAGMA Web site: "PRAGMA has been founded as an open organization in which Pacific Rim institutions will collaborate more formally to develop grid-enabled applications and will deploy the needed infrastructure throughout the Pacific Region to allow data, computing, and other resource sharing. Based on current collaborations, PRAGMA will enhance these collaborations and connections among individual investigators by promoting visiting scholars' and engineers' programs, building new collaborations, formalizing resource-sharing agreements, and continuing transpacific network deployment. PRAGMA provides an opportunity for member institutions to work together to address applications and infrastructure research of common interest. PRAGMA is an open, international initiative to establish sustained collaborations and advance the use of the computational grid among a community of investigators at the leading research institutions around the Pacific Rim. PRAGMA is supported by the San Diego Supercomputer Center, the National Science Foundation, and participating institutions."

[50] http://www.apgrid.org/. From the AP-Grid Web site: "ApGrid is a partnership for Grid computing in the Asia Pacific region. ApGrid focuses on (1) sharing resources (2) developing Grid technologies (3) helping the use of our

act as focal points for US/Asia-Pacific collaboration in e-science (PRAGMA) and grid technology and infrastructure (ApGrid), and as such, provide a point of leverage for TransPAC to discover new projects with international connectivity needs and support them effectively. Conversely, each group's connection to TransPAC provides these communities with ready access to leading edge network capabilities for their constituent communities. TransPAC also provides network connectivity and operational support, through the iVDGL Grid Operations Center (iGOC),[51] for the International Virtual Data Grid Laboratory (iVDGL).[52] These three organizations in turn host a large number of international e-science efforts.

F.1. PRAGMA

TransPAC supports US connectivity by PRAGMA participants to a growing multi-national computing and storage test bed. Currently, this test bed consists of 24 Linux nodes at the University of Melbourne in Australia, 32 nodes at the San Diego Supercomputer Center (SDSC), 32 nodes at the National High Performance Computing Center in Taiwan, 80 nodes at the Korea Institute of Science and Technology Information, and 8 AIX nodes at the Chinese Academy of Sciences. Activities within PRAGMA are supported by a video network based on AccessGrid and commercial H.323 technologies. This test bed of computing and communications nodes supports international collaborations in the Asia-Pacific region in medicine, molecular biology, environmental science, astronomy, and materials science. PRAGMA also provides a real-science venue for development and evaluation of Grid middleware. Examples of TransPAC-supported efforts here include the NCHC volume segmentation tool,[53] which uses the SDSC Storage Resource Broker[54] to browse and render sections of a large 3-D volumetric data set; and the AIST Grid Datafarm, which provides distributed high performance storage for high energy physics experimental data. The latter project participated in the SC2002 bandwidth challenge, effectively using all TransPAC northern route bandwidth (and all available southern route bandwidth) to perform a distributed analysis of High Energy Physics (HEP) detector events.[55]

A particularly salient application of TransPAC—and advanced networking in general—occurred in April and May of 2003 during the outbreak of SARS in Taiwan. TransPAC cooperated with TANET2 and other international research and education networks to assist medical professionals in Taiwan. To provide for local and international medical consulting, National Center for High-performance Computing (NCHC) researchers quickly created the SARS Grid, a global-scale teleconferencing network that enabled physicians to communicate with one another and to share high-resolution X-rays, diagnoses, and treatment methods.[56] Participating physicians within Taiwan, from the US, and from other Pacific Rim countries could talk to each other face to face and to patients inside quarantined areas. This approach greatly reduced transmission of the disease by medical personnel and allowed medical researchers at remote locations immediate first-hand access to doctors and patients without the need for travel or risk of infection.

There is also a pressing need to develop tele-presence and tele-instrumentation standards for global sharing of specialized instrument resources. Within the context of PRAGMA and the NSF Middleware Initiative, a collaboration between the US and Australia was established to develop

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technologies in create new applications (4) building on each other work, etc., and ApGrid is not restricted to just a few developed countries, neither to a specific network nor its related group of researchers."

[51] http://igoc.iu.edu/

[52] http://www.ivdgl.org/

[53] http://www.pragma-grid.net/Presentations/UCSD/igrid2002_demo.ppt

[54] http://www.npaci.edu/DICE/SRB/

[55] http://www.gridtoday.com/02/1209/100843.html

[56] http://access.ncsa.uiuc.edu/Stories/SARS/

new approaches to tele-science and remote use of scientific instrumentation. This collaboration is expected to focus initially on electron microscopy and synchrotron-generated X-ray crystallography. The possibility of expanding the collaboration to include sensor nets for environmental monitoring is also being explored.

F.2. ApGrid

ApGrid is a partnership formed in 2001 for Grid computing in the Asia-Pacific region which focuses on sharing resources between institutions, developing Grid technologies and middleware, and promoting the development of new Grid-based applications. ApGrid provides resource sharing and monitoring middleware and has established a brokerage for Certificate Authorities for participating countries.

ApGrid is complementary to PRAGMA in many respects, but primarily in placing an emphasis on the development of Grid systems and middleware, and having a non-US core membership (primarily APAN countries). There is a natural synergy between PRAGMA, ApGrid, and TransPAC to provide, respectively, an application focus, a middleware focus, and network resources for US e-science collaborations in the Asia-Pacific region.

F.3. iVDGL and Global e-Science

The International Virtual Data Grid Laboratory (iVDGL) is a project funded by the National Science Foundation and designed to prepare an integrated data analysis environment for data-intensive science projects. The iVDGL is a consortium of 15 universities and four national laboratories. The iVDGL—to be constructed in partnership with the European Union, Japan, Australia, and other world regions—will form the world's first true global Grid and provide an integrated computational resource for major scientific experiments in physics, astronomy, biology, and engineering. The iVDGL will serve as a unique resource for scientific applications requiring access to Petabytes of data (one Petabyte equals one million Gigabytes) and beyond. In addition to supporting the iVDGL Grid Operations Center (iGOC), TransPAC has been active in installing and evaluating the WorldGrid toolkit at sites in the Asia-Pacific region. This is a prerequisite for institutional participation in iVDGL sub-projects (*e.g.* Atlas and GriPhyN).

TransPAC provides network connectivity to the Asia-Pacific components of the iVDGL. Indiana University, based on its experience in providing Global NOC services for the HPIIS projects such as TransPAC, is developing the iGOC for the iVDGL.[57]

G. Annual Report for Fiscal Years 2003-2005

The following sections include detailed information and events concerning the TransPAC project from the end of the previous Annual Report in July 2003, through the end of the TransPAC project.

G.1. Milestones, August 2003 through July 2005

2003

August	James Williams attended the CANS (Chinese American Network Society) meeting in Shanghai, China. Mr. Williams presented a paper.

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[57] http://igoc.iu.edu

James Williams and John Hicks attended the ApGrid and APAN meetings in Shanghai, China. James Williams presented a talk at the ApGrid meeting about the iVDGL Grid Operations Center. John Hicks presented a talk about measurement and presented the TransPAC update at the APAN meeting.

Network operations completed work on a new internal database of global network contact information.

October	James Williams and Chris Robb attended the Internet2 Members Meeting in Los Angeles. Both Williams and Robb presented papers.

Williams worked with Peter Aursberger on the PRAGMA governance structure and charter and participated in planning for the Miami Internet2 Joint Techs meeting.

Discussions were initiated in Los Angeles with our Japanese TransPAC partners regarding the characteristics of a post-HPIIS TransPAC Project.

November	TransPAC IPv4 peering was established with ESnet and DREN in Seattle.
December	NaukaNet (formerly MIRnet) peering was established with TransPAC.

2004

January	TransPAC connection implemented as two OC-48 circuits, one routing through Chicago, the other through Los Angeles.

Williams, Hicks and Robb attended the Internet2 Joint Techs meeting in Honolulu, HI. All gave presentations.

Williams, Hicks and Robb attended the Honolulu APAN conference. All gave presentations.

Hicks gave two presentations at the January 2004 APAN conference and I2 Joint Techs meetings: "Grid 2003," updating the international community on progress with the grid Datafarm and other grid computing projects; and "Fast TCP and other TCP Alternatives."

Robb presented at the January 2004 APAN conference and I2 Joint Techs meetings: "Abilene Observatory," updating the international community on the progress with this important project.

Williams presented at the January 2004 APAN conference and I2 Joint Techs meetings: updating on the "HOPI" project.

Williams Chaired the Lambda International Networking meeting during the January 2004 APAN conference.

April	Williams, Hicks and Robb attended the Internet 2 Member Meeting in Arlington, Virginia.
May	Hicks attended the sixth PRAGMA conference and workshop at the Computer Network Information Center of Chinese Academy of Sciences in Beijing, China. Hicks presented: "G3: Super Computing 2003 and Beyond," reflecting on the SC03 conference and presenting on the possibilities of further utilization of the Grid 3 project.

June	TransPAC engineers began talks with JGN2 regarding upgrading the Chicago circuit of the TransPAC connection from an OC-48 to an OC-192 circuit.
July	Work on upgrading the Chicago circuit began by installing a Procket 8801 router co-located at the StarLight facility in Chicago.
August	The OC-192 circuit from Tokyo to Chicago became operational. The former OC-48 Circuit remained operational alongside the OC-192 for one month to ensure a smooth transition and network stability.
September	Hicks Co-Chaired the seventh PRAGMA conference and workshop. He gave the opening remarks for the conference.
	Williams attended the Internet 2 Member Meeting in Austin, Texas.
October	The JGN2 OC-192's termination point at the Tokyo XP was upgraded from a Cisco 15454 to a Procket 8812 once the Procket router was installed in Chicago.
November	Hicks attended the SC04 conference in Pittsburgh, PA, and presented an overview of recent PRAGMA work.
December	Williams attended the Chinese American Networking Symposium (CANS), in Miama, FL. Williams presented an overview of plans for the TransPAC2 project.

2005

January	Williams, Robb, Hicks, Dave Jent, and Doug Pearson all attended a JGN2/WIDE meeting hosted in Indianapolis to demonstrate the strength and value of Indiana University's information technology research, particularly the TransPAC connection and its relation to the research and education community. Possible collaborations between NICT/JGN2 and Indiana University were discussed and promoted.
	Williams presented to the JGN2/WIDE meeting an overview of Indiana University research, particularly the NSF's International Research Network Connections (IRNC) program.
	Robb presented to the JGN2/WIDE meeting an overview of the TransPAC2 network.
	Hicks presented to the JGN2/WIDE meeting an overview of TransPAC2 measurement.
	Pearson presented to the JGN2/WIDE meeting an overview of the Indiana University Global Research Network Operations Center (Global NOC) in Indianapolis.
	Jent presented to the JGN2/WIDE meeting an overview of advanced network engineering at the Global NOC.
	Internet2 representatives were also present at the JGN2/WIDE conference. Heather Boyles presented an overview of collaborations and possible future collaborations between Indiana University, Internet2, and NICT/JGN2.

Williams, Hicks, Robb, and Pearson attended the 19th APAN meeting in Bangkok, Thailand. All presented presentations

February   Hicks attended the ESCC/Internet2 Joint Techs meeting in Salt Lake City, Utah.

April   Williams and McRobbie attended the official TransPAC2 signing ceremony in Tokyo, Japan. TransPAC officially concludes.

G.2. Papers and Presentations, International Meetings and Conferences, August 2003 though May 2005

2003, August, 24-29
APAN Meeting Pusan Korea
Presentation: TransPAC Development[58]
Presentation: PRAGMA[59]
Jim Williams

2003, September 9
TransPAC hosts Vice Minister of Education
from the Peoples Republic of China
Presentation: Vice Minister Talk[60]
Jim Williams
John Hicks
Chris Robb

2003, October 14
Fall Internet2 Meeting, Indianapolis
Presentation: TransPAC update[61]
Jim Williams

2003, October 22
PRAGMA-5 meeting Hsinchu, Taiwan
Presentation: TransPAC and Grid3 update[62]
John Hicks

2003, November 19
SC03, Phoenix
Presentation: TransPAC and Grid3 update[63]
John Hicks

2004, January 9
HPIIS Review, Washington DC

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[58] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-08-27_Busan_Talk.ppt

[59] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-08-27_PRAGMA-Williams.ppt

[60] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-9-9_Vice_Minister_talk.ppt

[61] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-10-14_I2-talk.ppt

[62] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-10-22_PRAGMA-5-John-Hicks.pdf

[63] http://transpac.org/old-site/documents/meetings/documents/meetings/2003-11-19_SC03-PRAGMA.ppt

Presentation: HPIIS Review DC Jan 2004[64]
Jim Williams

2004, January 25-30
Internet2 Joint Techs/APAN 2004, Hawaii
Presentation: HOPI[65]
Jim Williams
Presentation: Grid2003 update[66]
Presentation: TCP alternatives[67]
John Hicks
Presentation: Abilene Observatory[68]
Chris Robb

2004, August 31
GLIF meeting, Nottingham, UK

2004, September 16
PRAGMA, San Diego CA
TransPAC sponsored

2004, December
Chinese American Networking Symposium
Presentation: TransPAC2: Enhancing Production Science Networking between Asia and the United States[69]
Jim Williams

2005, January 7
JGN2 Meeting, Indianapolis
Presentation: Research at Indiana and the IRNC[70]
Jim Williams
Presentation: TransPAC2 Network Overview[71]
Chris Robb

2005, March 30
TransPAC2 Inauguration Ceremony Tokyo Japan[72] [73]

2005, May 2
Internet2 Spring Members Meeting, Arlington, VA

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[64] http://transpac.org/old-site/documents/meetings/2004-HPIIS%20Review%20DC%20Jan%202004.ppt

[65] http://transpac.org/old-site/documents/meetings/2004-hawaii-jt-HOPI-Presentation-robb.ppt

[66] http://transpac.org/old-site/documents/meetings/2004-hawaii-jt-HENP-Grid2003-hicks.ppt

[67] http://transpac.org/old-site/documents/meetings/2004-hawaii-jt-TCP-alternatives-hicks.ppt

[68] http://transpac.org/old-site/documents/meetings/documents/meetings/2004-hawaii-jt-Abilene-Observatory3-robb.ppt

[69] http://transpac.org/old-site/documents/meetings/tpac2-miami.ppt

[70] http://transpac.org/old-site/documents/meetings/nict-talk.ppt

[71] http://transpac.org/old-site/documents/meetings/tpac2-overview.pdf

[72] http://www.transpac2.net/

[73] http://www.nsftokyo.org/

Presentation: TransPAC2 Update[74] (First public TransPAC2 presentation)
Jim Williams

G.3 Progress Report for Fiscal Years 2003-2005

The following sections detail progress against the High Performance International Internet Services (HPIIS) program objectives and objectives set in the Program Plan of the previous TransPAC Annual Report. The TransPAC proposal listed six activities critical to meeting the HPIIS program objectives:

Furnish, operate, and maintain a direct connection for high performance traffic between the vBNS and APAN networks via the STAR TAP (Chicago)

Cooperate with STAR TAP and vBNS officials to ensure, to the extent supportable by prudent application of networking technology, that only approved institutions' traffic is permitted to use the high performance connection

Monitor the performance and use of the TransPAC connection

Cooperate with the vBNS and the National Laboratory for Advanced Network Research (NLANR) Team (University of Illinois at Urbana [DAST], UCSD [MOAT] and Carnegie-Mellon University [NCNE]) to develop testbed implementations and, as appropriate, production implementations of new versions of Internet networking protocols

Maintain a publicly accessible TransPAC-HPIIS Web site containing information about the APAN-vBNS high performance connection and research and education collaborations that it enables

In concert with the methodologies developed by the NLANR Team, provide consultative user services supporting the use of TransPAC-HPIIS for high performance computing and communications applications; provide Web-based front-end tools and direct user support to enable direct access to differentiated network services

In addition to these primary objectives, the previous program plan listed nine areas in which work was to be focused to further the primary objectives:

Network Infrastructure

Network Operations Center

User Services

Application Collaborations and Demonstrations

Advanced Application Services Testbeds (Middleware)

Advanced Network Services Testbeds (QoS, IPv6, and Web Cache)

Performance Analysis and Measurement

Web-based Information

HPIIS Team

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[74] http://transpac.org/old-site/documents/Internet2%20talk%20May%2005.ppt

Progress to date in each area against the global HPIIS goals and related elements in the statement of work in last year's annual report are discussed in detail in the sections that follow. Each section begins with the HPIIS objective for TransPAC and contains specific accomplishments against related goals set for this reporting period in sections labeled ***Progress in 'X' against FY03-04 Program Plan***.

G.3.1. Network Provisioning, Operation, and Management

"Furnish, operate, and maintain a direct connection for high performance traffic between the vBNS and APAN networks via the STAR TAP (Chicago)."

G.3.1.a. Progress in Network Infrastructure Development against FY03-04 Program Plan

Over the past two years, the TransPAC network underwent two significant infrastructure revisions. The first, occurring in FY03, involved the expected expansion of the network from a dual OC-12 architecture to a dual OC-48 architecture. This effectively quadrupled the bandwidth to an aggregate of 5Gbps (gigabits per second) of capacity between the United States and the Asia-Pacific region. The second change, occurring in FY04, involved the upgrade of one of the OC-48 circuits into an OC-192, effectively bringing the aggregate capacity up to 10.25Gbps. All of these upgrades were completed at no additional cost to the project.

The FY03-04 work plan called for the use of experimental services across the OC-48 circuit to Chicago. Specifically, it called for the implementation of two GigE channels within the OC-48 so that networks in Asia might experiment with US networks at Layer2 of the OSI protocol stack. Unfortunately, our international carrier, KDDI-A, was unable to provide the circuit engineering to make this possible. During the circuit procurement timeframe, US and Asian research and education network engineers had little experience in dealing with these types of SONET services. The TransPAC project was among the leaders of defining the requirements of next-generation services, thus paving the way for understanding of future networks such as NLR and HOPI.

G.3.1.b. Progress in Network Operations Center Development against FY03-04 Program Plan

TransPAC Network Operations Center (NOC) service was officially begun in October 1998. The TransPAC NOC is a continuing partnership between Indiana University (IU), the Asia-Pacific Advanced Network (APAN), and KDD (managers of the APAN Tokyo XP). The IU TransPAC NOC is physically located on the Indianapolis campus of Indiana University as part of the Global NOC.

The IU TransPAC NOC continues to work closely with the APAN TransPAC NOC to deliver a high-quality coordinated NOC service both to US and Asia-Pacific investigators.

The current set of NOC-deployed tools range from basic tools such as ping, netperf, Mping, mSD, PingER, pathchar, traceroute, and MRTG, and Round Robin Database (RRD) tool to more complex measurement tools such as OC12MON and Surveyor. DAG-based OC12MON tool development continues to be the focus of advanced network monitoring for the TransPAC NOC (DAG is a project of Waikato University, New Zealand).

The Indiana University Global Research Network Operations Center (Global NOC) provides operations and engineering services for TransPAC, the Abilene Internet2 network, STAR TAP, AMPATH (tier one services only), National LambdaRail (NLR), MAN LAN, IP Grid (Indiana

University/Purdue University connection to the TeraGrid project), Indiana GigaPoP, and the Indiana University network.[75] The IU Global NOC operational model is fully integrated within its existing 24/7 support structure. Designated NOC staff positions funded by these external networks comprise the primary support group for the various networks. Additional support is available from all NOC staff, regardless of network funding, as needed. Separate external identities, support mechanisms, and NOC Web pages are maintained for each network. The cross-functional nature of Global NOC services to TransPAC, Abilene, AMPATH, STAR TAP, NLR, etc., allows these services to be dynamic and efficient.

Housed at the Indianapolis campus, the IU Global NOC tier-one Service Desk is staffed by sixteen full-time employees. They work in conjunction with the IU engineering staff of nine full-time engineers and a team of three software and Web developers who work at the Bloomington or Indianapolis campuses.

The TransPAC NOC Service Desk provides the following general NOC services:

Problem Management (detection, tracking, and resolution of network problems)

Change Management (notification and control of changes to the network)

Performance Management (monitoring of network performance)

Configuration Management (hardware change monitoring)

Security Management (IU is a member of FIRST[76], the Forum of Incident Response Security Teams)

Quality Assurance

Reporting (regular reports supplied to all associated networks)

Documentation

Critical to the Service Desk's function is the ability to manage the problem resolution cycle in the event of a network outage. The steps of this process are:

Network alert (via monitoring tools or problem reporting mechanism)

Identification

Isolation

Troubleshooting

Escalation (to engineering staff, if necessary)

Documentation and tracking (via trouble ticket system)

Notification (to customer base)

Vendor contact (if necessary)

Continual tracking, documentation, notification, and assistance

Problem resolution

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[75] http://globalnoc.iu.edu
[76] http://www.first.org/

Reporting

The paragraphs following describe development projects, management and reporting tools that have been developed or refined as a portion of the work performed by the NOC in the FY's 03-04 and 04-05 reporting periods. These include:

Network management station

Animated traffic map

Network traffic statistics

Operational efficiencies

Revised Problem Escalation Procedures

Network monitoring system

AlertMon

New database

Trouble ticket system

Automated weekly reports

Research and Education Network - Information Sharing and Analysis Center (REN-ISAC)

iVDGL Grid Operations Center support

Network Management Station

Network management stations and OC12 passive monitoring machines are installed at the StarLight facility in Chicago and the Pacific Northwest GigaPoP (PNWG) facility in Seattle. The network management machines provide the Web services for various monitoring activity as well as a point of presence at StarLight and PNG. Accounts on these machines are given out on a per-project basis for testing network performance to and from the StarLight and PNG facilities. Web services include monitoring statistics, trace route services, and Ping statistics.

Animated Traffic Map

The TransPAC animated traffic map provides a pictorial overview of current network traffic and error rates.[77] NOC staff and network engineers use this service as a first-level network debugging tool. Traffic is displayed on a graphical map representing the topology of the network. Access to MRTG graphs on network traffic and error rates is available by clicking on the link. Utilizing historical data, one will also be able to view an animation of recent traffic patterns.

Network Traffic Statistics

DAG-based passive OC12MON monitoring tools are continually being developed for the TransPAC NOC and engineering staff. Tools such as Web-based monitoring are under investigation. IPv4 header trace files from the TransPAC network are also available on a per-project basis.

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[77] http://loadrunner.uits.iu.edu/weathermaps/transpac/

Operational Efficiencies

The Network Operations Center (NOC) Service Desk continues to improve its services by making additional changes and modifications to existing processes and procedures. Service Desk work flow is a task-driven environment across all the supported networks. All on-duty Service Desk technicians are directly responsible for the complete range of networks that the Global NOC supports. This is reflected in duties such as network outage/problem investigation and assessment, customer notification, and weekly reporting. Effective cross-training has been achieved, and this results in a more diversely trained support staff, ready to react to any situation for all networks.

Revised Problem Escalation Procedures

The Global NOC has implemented a revised version of its problem escalation procedures, including changes to the trouble ticket priority schema. This has placed a stronger emphasis on customer requests and related action items, and provides more in-house accountability.

Network Monitoring System

In December 2002, the NOC put the Nagios network monitoring system into production. Nagios is a host and service monitor designed to inform the NOC of network problems. When problems are encountered, the daemon sends notifications to the NOC in various ways (audible alert, page, e-mail). Current status information, historical logs, and reports can all be accessed via a Web browser. The Global NOC uses Nagios to monitor all of its supported networks.

AlertMon

AlertMon, an in-house developed system, provides a comprehensive view of active network alerts and serves as a portal to systems and documentation used in the problem management process. Alerts are passed to AlertMon from monitoring systems such as Nagios. AlertMon presents summary information of the alerts; provides direct link to incident records in the Footprints ticketing system; and most importantly, provides direct links to comprehensive information in the Global NOC Database. Linkages to information in the Global NOC database include problem management procedures for the network elements, technical information for the elements, contact information, and escalation procedures.

New Database

In the past year, a new TransPAC and Global NOC database was put into production. It contains a highly logical and hierarchical schema that documents network device inventory based on topology, inter-network connection dependencies, as well as contact information. An automated feature was built in that allows the NOC to routinely request contact information updates from network participants. This improvement will help expedite requests and collaboration between network participants and the NOC.

Trouble Ticket System

In spring 2004, the Global NOC upgraded its version of the Footprints trouble ticket system, utilizing a Sequel Server back-end. It has higher degrees of functionality and interoperability between the network monitoring systems, the NOC database, email systems, and reporting mechanisms.

Automated Weekly Reports

The Global NOC is in the process of instituting a new automated method of producing weekly network availability reports. Much of the same data presented in the older version of the report will still be available. However, the report will be modified to provide additional relevant information. The text will be drawn automatically from our trouble ticket and network monitoring systems The result will be an increased level of accuracy, and considerably fewer manual hours put into compiling and editing the report. Although still under development, it should be completed sometime in the next year Tied into this reporting process will be the development of an automated customer network notification tool that will provide greater accuracy, efficiency, and ease of use for the Service Desk staff.

REN-ISAC

The Global NOC provides support for the US-based Research and Education Network - Information Sharing and Analysis Center (REN-ISAC), housed at Indiana University. The REN-ISAC has a responsibility to receive and analyze operational, threat and warning, and actual attack information within research and education networking. By leveraging the REN-ISAC resources and information, TransPAC benefits from receiving the latest in international network security reports and recommended actions.

iVDGL Grid Operations Center Support

The Global NOC Service Desk staff has taken on the additional responsibility for the iVDGL Grid Operations Center (iGOC) to support Grid computing. Grid computing will be an essential part of the data traffic over the TransPAC network. By serving as the Grid Operations Center, the staff is closer to the actual science and services the network is used for. This can only benefit the overall NOC services the Global NOC provides for TransPAC. With the Global NOC continuing to develop the iGOC, support for grid computing to Asia will be enhanced. As networking moves step-by-step into optical switching, the TransPAC NOC will work with its APAN partners and other support contracts to help lead this effort.

National LambdaRail (NLR)

In the fall of 2003, the Global NOC began supporting the National LambdaRail (NLR) network. Engineering support for NLR Layer 2 & 3 networks is provided by the Global NOC Engineering group. Tier-one support for NLR is provided by the Global NOC Service Desk. National LambdaRail (NLR) is a major initiative of US research universities and private sector technology companies to provide a national scale infrastructure for research and experimentation in networking technologies and applications. NLR aims to catalyze innovative research and development into next generation network technologies, protocols, services and applications.

G.3.2. HPIIS Approved Institutions, Traffic Segregation, and AUP

"Cooperate with STAR TAP and vBNS officials to ensure, to the extent supportable by prudent application of networking technology, that only approved institutions' traffic is permitted to use the high performance connection."

The organizational and technical structures described in the previous TransPAC Annual Report remain in place and are functioning properly. New networks in both the Asia-Pacific region and the US continue to be added to the list of routable networks, consistent with the TransPAC-established routing and traffic segregation policies. The TransPAC Acceptable Use and

Authorization Policies remain as they were described in the 2002-2003 Annual Report. Networks that peer with TransPAC at STAR TAP include the vBNS, Abilene, NREN, NISN, and ESnet.

Because of changes in the TransPAC network structure in FY01-02, the routing plan for the northern route from Tokyo to Seattle was altered during the FY03-04 program year. Approval for TransPAC usage is still limited to research and education traffic only; however, approval is now granted at the institutional level rather than at the project level. This change has greatly simplified the TransPAC routing architecture in Tokyo and has led to increased usage of TransPAC by all parties. All routing policy is being enforced on the APAN routers in Tokyo. The network advertisements across the northern circuit are filtered on Autonomous System (AS) number, while the advertisements across the southern route continue to be subject to the same project-based filters as before.

To facilitate the use of TransPAC by APAN institutions that are on networks that contain a mix of authorized and unauthorized institutions, APAN utilizes a two-router infrastructure. Previous plans to consolidate the project-based routing to a single router have been abandoned as the project-based route filtering method has disappeared completely in favor of AS-based filtering.

G.3.3. Traffic and Performance Monitoring

"Monitor the performance and use of the TransPAC connection."

Progress in Performance Analysis and Measurement against FY03-04 Program Plan

Historically TransPAC employed traditional network measurement and monitoring techniques including SNMP base Multi-Router Traffic Grapher (MRTG), various Round Robin Database (RRD) tools, the locally developed weathermap, and other Global Research Network Operations Center (Global NOC) tools such as Nagios Alertmon. Passive monitoring hardware has been used in the past but is no longer cost effective due to constant changes in link technology and capacities.

Efforts to coordinate analogous monitoring and measurement facilities throughout APAN are important to TransPAC2. Takatoshi Ikeda from the KDDI APAN NOC visited Indiana University in December 2004 to work on Observatory code including bwclt, owamp, and netflow flow-tools. APAN donated four Unix servers to be used as measurement machines in Los Angeles, CA. Analogous Unix machines were deployed in the APAN NOC in Tokyo, Japan. Other Global NOC tools were deployed to support data collection and analysis from the TransPAC link.

TransPAC used both passive and active schemes as well as support from the Global NOC to monitor traffic and network devices.

Passive monitoring includes:

Multi-Router Traffic Grapher (MRTG)

Simple Network Management Protocol (SNMP)

Network Flow data

Animated Traffic Map

Visible backbone (JUNOS script)

Active monitoring includes:

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Internet2 piPEs project

- o BWCTL
- o OWANMP

Active Measurement Project (AMP)

Global NOC and other end system tools:

NDT (part of the Internet2 piPEs suite)

Alertmon (Nagios)

RANCID

Other Global NOC tools (24/7 support)

MRTG (SNMP)

MRTG, an open source tool developed by Tobias Oetiker,[78] uses the Simple Network Monitoring Protocol (SNMP) to report on the aggregated traffic utilization for the TransPAC network. MRTG statistics are gathered every five minutes. Daily, weekly, monthly, and yearly summaries are displayed on the TransPAC Web page.

An actual daily graph appears below. The time scale advances to the left as indicated by the red arrow. The solid green area represents input bits-per-second (traffic coming from APAN), while the blue line represents output bits-per-second (traffic headed toward APAN). On the yearly graph, the additional colors of dark green and magenta represent the maximal five minute input and output rates that occurred during the summarization period, and green and blue represent the average of the summarization period.
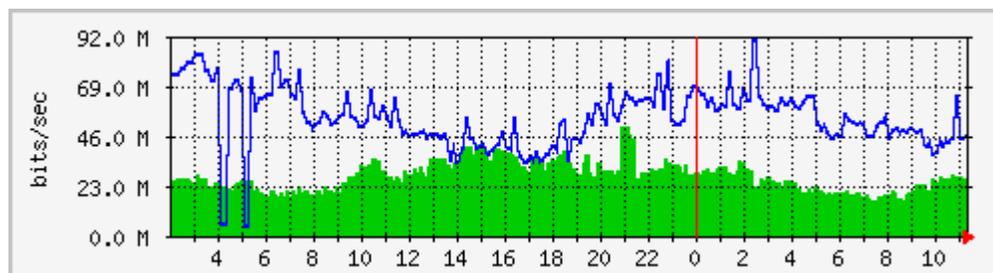
Figure 7: Example of Daily Traffic on TransPAC

While MRTG is an excellent tool to report on overall link utilization, it will soon be replaced with its successor, Round Robin Database Tool (RRDTool). This will enable us to keep more relevant daily statistics for longer periods of time.

SNAPP (SNMP Network Analysis and Presentation Package)

The SNAPP tool can measure any time-series statistics available though the Simple Network Management Protocol (SNMP). SNAPP was designed to allow collection of statistics with a fine degree of granularity, supporting very short intervals between data points. SNAPP was also designed with a flexible web based front-end to allow for easy and sophisticated presentation of data collected.

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[78] http://people.ee.ethz.ch/~oetiker/webtools/mrtg/

SNAPP consists of two pieces: a high-speed, multi-threaded application written in C to collect data; and a Web-based front-end system written in Perl. Data is stored in Tobi Oetiker's Round Robin Database (RRD) format.[79] SNAPP's front end allows users to easily view the data they wish to see, in a very flexible manner.

Users of SNAPP are able to tailor data presentation to a desired time period, down to the minute. They can also group graphs together into useful sets, and can review these sets of graphs each time they use the software.

SNAPP is currently being used for high-speed (one-minute averages) SNMP collection on the Abilene network. Using the Abilene Network Measurement Systems (NMS) infrastructure, a distributed version of SNAPP is collecting SNMP data at each Abilene PoP (point-of-presence) with 20-second granularity. The SNAPP data collector is also being used as the back end for the TransPAC animated traffic map.[80]

Network Flowdata

TransPAC uses Flow-tools and other locally developed tools to collect and analyze network flow data from the TransPAC router. Flow-tools is a collection of programs used to collect, send, process, and generate reports from NetFlow data. The tools can be used together on a single server or distributed to multiple servers for large deployments. The Flow-tools library provides an API for development of custom applications for NetFlow export.

Animated Traffic Map

The Animated Traffic Map software was developed at Indiana University and is used to view the current level of traffic on the Abilene and TransPAC networks as displayed on a map of the United States and Asia-Pacific region.[81,82] Current and historical traffic statistics on a link or at a core node are collected via SNAPP and displayed using RRD tool. The animated traffic map tool provides an excellent pictorial overview of aggregated traffic on the TransPAC network.

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[79] http://rrdtool.eu.org
[80] http://vabo1.jp.apan.net/cgi-bin/snapp/index.cgi
[81] http://loadrunner.uits.iu.edu/weathermaps/abilene/
[82] http://loadrunner.uits.iu.edu/weathermaps/transpac/
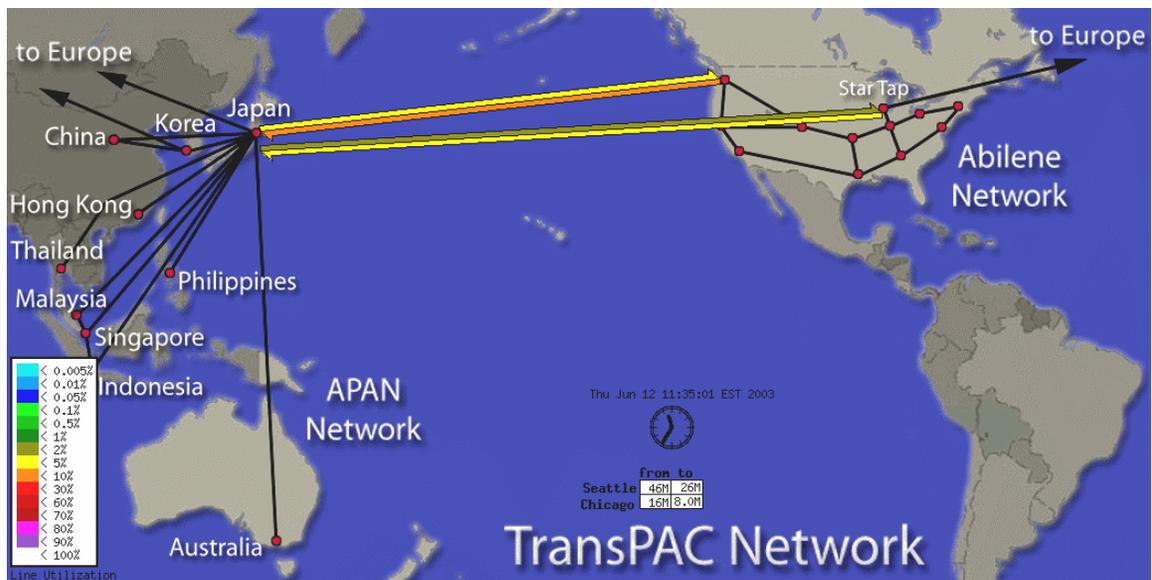
Figure 8: Example of TransPAC Animated Traffic Map

Visible backbone (JUNOS script)

The Visible backbone is a locally developed tool that uses JUNOS script and Perl to collect state information from Juniper routers via XML. The data is further processed through a collection of Perl scripts and published.

BWCTL

The BWCTL suite is a client and server application and scheduling and policy daemon that wraps Iperf. Currently BWCTL wraps Iperf by executing the Iperf command line program on the system. The BWCTL client application works by contacting a BWCTLD process on the two test endpoint systems. BWCTL will work as a third-party application. The client can arrange a test between two servers on two different systems.[83]

OWAMP

One-Way Active Measurement Protocol (OWAMP) is a command line client application and a policy daemon used to determine one-way latencies between hosts. Availability of the OWAMP will help network providers view the behavior of their networks and apply resources where appropriate.[84]

Active Measurement Project

Active Measurement Project (AMP) is a project of the Measurement and Network Analysis (NMA) group of the National Laboratory of Advanced Network Research (NLANR).[85] The AMP project provides round trip times, loss, topology, and on-demand throughput tests.

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[83] http://e2epi.internet2.edu/bwctl/

[84] http://e2epi.internet2.edu/owamp/

[85] http://moat.nlanr.net

NDT (part of the Internet2 piPEs suite)

The Network Diagnostic Tool (NDT) is a client/server program that provides network configuration and performance testing to a user's computer. The system is composed of a client program (command line or java applet) and a pair of server programs (a web server and a testing/analysis engine). Both command line and web-based clients communicate with a Web100-enhanced server to perform these diagnostic functions. Multi-level results allow novice and expert users to view and understand the test results.

Alertmon (Nagios)

Alertmon is a locally developed tool to view current Abilene alerts, built upon the Nagios software package. It includes audible alerts for each problem on the network. Nagios is an open-source host service and network-monitoring tool. It uses remote plug-ins to monitor system resources and report back to a central server. Nagios also has a facility for notification about changes in the network or host environment via email or pager.

RANCID

Using the RANCID system, the Global NOC monitors the TransPAC2 router's event logs. The RANCID system automatically emails appropriate engineers.[86]

Future Direction and Expansion of Services

TransPAC2 will work with Matthew Zekauskas of Internet2, principal investigator on the SGER: Network Measurement for International Connections (NSF Award Abstract - #0457404) and Matt Mathis, principal investigator on the related NSF SGER: Exploratory Research on Network Measurement for International Connections (NSF Award -# 0513437) to implement an IRNC-wide measurement environment. Working with the SGER projects and developing local data-mining and analysis techniques will provide unique insight into the global networking environment.

Education and Outreach

TransPAC2 will joint teach the Internet2 Network Performance Workshop at the 21st APAN meeting, held in Tokyo Japan, January 2006. This workshop covers detailed hands-on training for the Internet2 projects BWCTL, OWAMP, and NDT. This workshop will help stimulate interest in common measurement activities throughout the Asia Pacific region.[87]

G.3.4. Internet Protocol Development

"Cooperate with the vBNS and the National Laboratory for Advanced Network Research (NLANR) Team (University of Illinois at Urbana (DAST), UCSD (MOAT) and Carnegie-Mellon University (NCNE), to develop testbed implementations and, as appropriate, production implementations of new versions of Internet networking protocols."

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[86] http://www.shrubbery.net/rancid/
[87] http://e2epi.internet2.edu/ndt/

G.4.a. Progress in Advanced Application Services Testbeds against FY03-04 Program Plan

TransPAC continues to provide testing platforms for alternative TCP protocols like HighSpeed TCP, FAST TCP, and BICTCP. These facilities will resume production in the fall 2005. Interest in these services will determine the rate of development.

The TransPAC northern circuit was engineered with the Scavenger Service (less than best effort) active and available to researchers. However, with the dramatic increase in transpacific capacity, coupled with the increase in US domestic capacity via the Abilene upgrade to 10Gbps, overall interest in quality of service has waned in the past year. Analyses of the bandwidth requirements of the TransPAC circuit do not yield a requirement for further investigation into traffic prioritization and classification. TransPAC engineers continue to monitor the circuits for indications that quality of service is required.

TransPAC continues to be an active member of the iVDGL. The TransPAC network facilitates interactions between iVDGL institutions in the Asia-Pacific, the US, and the European Union. The Global NOC will continue to participate in the development of the iVDGL Grid Operations Center (iGOC). [88]

A new program in middleware for remote instrumentation funded by the NSF Middleware Initiative will use TransPAC to allow users of the Argonne synchrotron X-ray source in Australia to work with operators and technicians at APS beamlines.

G.4.b. Progress in Advanced Network Services Testbeds against FY03-04 Program Plan

QoS

Over the last two years of the project, there was little movement in the QoS community. TransPAC engineers continued to maintain membership and participation in the Internet2 Quality of Service working group.

IPv6

TransPAC continued to work with the IPv6 community to increase support and use of Internet Protocol version 6 (IPv6). The Los Angeles OC-48 circuit was configured with a native IPv6 BGP session between Abilene and APAN. Both configurations of the Chicago circuits had native IPv6 configured to Abilene. This provides a fully native and redundant IPv6 peering across both circuits connecting Tokyo with the United States.

Multicast

Multicast peering was established across both of OC-48 (later OC_192 on the Chicago route) circuits from Tokyo to the US. APAN continued to maintain a native multicast peering with Abilene across the southern OC-48 circuit as well as with the StarLight router in Chicago. Virtually all of the networks connected via STAR TAP and Abilene are multicast-enabled.

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[88] http://igoc.iu.edu

G.3.5. TransPAC Web Site and Online Documentation

"Maintain a publicly accessible TransPAC-HPIIS Web site containing information about the APAN-vBNS high performance connection and research and education collaborations that it enables."

Progress in Web-based Information against FY03-04 Program Plan

The TransPAC website has provided a means to present relevant application, conference, and workshop information as well as news and other information. TransPAC will continue to maintain its Web presence in the coming years.

TransPAC will also continue to provide electronic versions of presentations given throughout the year. TransPAC also continues to maintain application information through its online database.

In July 2005, a completely redesigned TransPAC website was launched as part of the TransPAC2 project.[89] The objective for the redesign was to make updating the website more streamlined, using new web server technologies.

TransPAC2 will also continue to provide electronic versions of presentations given throughout the year on this website, as well as provide a comprehensive archive of conferences and presentations given and in the past.

Although the TransPAC2 website is the official means through which the TransPAC team will provide information to the public from now on, the original TransPAC website is still available online for historical purposes.[90]

G.3.6. User Services and Training

"In concert with the methodologies developed by the NLANR Team, provide consultative user services supporting the use of TransPAC-HPIIS for high performance computing and communications applications. Provide Web-based front-end tools and direct user support to enable direct access to differentiated network services."

G.3.6.a. Progress in User Services and Training against FY03-04 Program Plan

James Williams continued to participate in the NLANR Joint Techs meetings as a member of the Program Committee. Williams also serves on the PRAGMA Advisory Board. PRAGMA events in Taiwan and Fukuoka, Japan were organized and supported by TransPAC, and TransPAC will continue to support Grid activities in the Asia-Pacific region both via the ApGrid forum and the PRAGMA project. As PRAGMA clarifies its mission and its relationships with ApGrid and TransPAC, a natural division of labor is foreseen in which PRAGMA handles application-level issues and TransPAC provides connectivity and NOC services.

G.3.6.b. Progress in Application Collaborations and Demonstrations against FY03-04 Program Plan

TransPAC continued support for Grid computing activities in the Asia-Pacific area includes support for ApGrid Workshops and for the PRAGMA program. TransPAC will continue its support of the iGrid activities, by providing network capacity and NOC support for special

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[89] http://www.transpac2.net/
[90] The original TransPAC website can be found at: http://www.transpac.org/old-site/

events and experiments. TransPAC will continue to support the High Energy Physics Nuclear Physics Working Group by providing both networking and NOC expertise.

FY2002-03 events supported by TransPAC include PRAGMA meetings in Taiwan and Japan, Global Grid Forum 7 in Tokyo, HPC-Asia, and SC03 in Baltimore. A major demonstration at SC03 was that of the Grid Data Farm, a distributed high performance storage system under development at the AIST in Tokyo.

G.3.6.c. Progress in Distributed HPIIS Team Development against FY03-04 Program Plan

There were several meetings between TransPAC team members and members of the Euro-Link and MIRnet team during the program year. The focus of these meetings was general information exchange. Topics discussed included the development of TransLight in Chicago, the progress of the GLORIAD initiative in Russia and the expansion plans for TransPAC.

The TransPAC, Euro-Link, and MIRnet teams met with the National Science Foundation on April 9, 2003 in Washington DC. Plans for further interactions between the HPIIS teams were discussed. The NSF actively sought HPIIS team input into the development of the next generation of international cyberinfrastructure as outlined in the Cyberinfrastructure Report.[91]

H. Reflections from the TransPAC Team

During the compilation of the final report on the TransPAC project, a series of interviews were conducted with those at Indiana University who have been most involved with the project.

The following excerpts from those interviews provide an appropriate portrayal of the history and intentions of the TransPAC project, from its conception in the mid-90s, to significant transformations in the goals of the project as it realigned to best serve the international research and education community, to the close and rewarding relationships formed between those involved on both sides of the connection, and how they will help to shape the face of Indiana University and the larger research and education community in the age of globalization.

Michael McRobbie
Principal Investigator TransPAC Project
Vice President for Research and Information Technology
Indiana University

On the origin of the TransPAC project, and what it means for the future:

> When I got [to Indiana University,] I knew that the NSF was talking about putting in an international program called the High Performance International Internet Services (HPIIS) program, and it seemed to me that I had unique connections in [the Asia-Pacific region.] And that would put us in great position to be the lead US institution for the proposal.

> …So I went on a trip with then-president Brand to the Asia-Pacific, and I stopped in to Tokyo and got support from the APAN people for us as the lead institution. And then, some time after that, we held a meeting in San Francisco where we all started to pull ideas together for the proposal that eventually became the TransPAC project.

> …The world is becoming very "global," and this has a significant impact on higher education in this country. And I think the universities in this country that are going to do

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[91] http://www.cise.nsf.gov/news/cybr/cybr.htm

the best in the future are those with strong, complex, multi-faceted relationships with the international community.

Jim Williams
Principle Investigator TransPAC2 Project
Director of International Networking
Indiana University

On the growth and flexibility of the TransPAC project:

> When the TransPAC project initially started, international telecommunications bandwidth was very expensive. As time progressed, bandwidth has become cheaper and cheaper. So, the focus of the project has changed, from using all of our resources to secure bandwidth to, now, concentrating more on facilitating the use of the bandwidth, and international collaborations in general.

> …Advancement in [international] applications parallels our ability to provide significantly more bandwidth between the US and Asia. So, as bandwidth prices decrease, the ability for people to do things like transfer large data sets, connect computing resources in the US to computing resources in Asia, and operate equipment and instruments remotely, has increased tremendously.

Chris Robb
Chief Network Engineer TransPAC and TransPAC2
Indiana University

On the value of international collaboration, on both a professional and a cultural level:

> The most interesting part [of working with the TransPAC team] is the interaction with the [international research and education] community. And, as someone who works on network infrastructure—especially between two large continents, with two somewhat disjointed research communities, where there isn't much communication—its very interesting because you get a bit of everything.

> …You get exposure to remote telemedicine, the Sloan Digital Sky Survey, astrophysics, the particle accelerator in CERN; so it's not that you get focused so much on one thing that's happening across the project or that you know the details, but you get the whole gamut of information. You get to work with people who are setting the agenda for science in the next century, so that's really rewarding in and of itself.

> …We do quite a bit of collaboration with the entire APAN community, we mingle, network, and maintain contacts at conferences; and I think that's fairly unique to the TransPAC network: the relationship that we form with the researchers themselves. And that's a very large aspect of what we'll become in the future.

I. Future Plans: TransPAC2

Though the original TransPAC project came to a conclusion on April 1, 2005, work continues on the transpacific connection, now officially called *TransPAC2*. The following information outlines the program plan for the TransPAC2 project during Fiscal Year 2005-2006, and beyond. The goal of the TransPAC2 team is to maintain the TransPAC connection as set forth in the original project, while continuing to explore ways to better serve and support the international research and education community, and cost-effectively expanding the connection's capabilities in the key areas of network infrastructure, network services, and user support services.

I.1. Network Infrastructure

With the emergence of next-generation network technologies in the US, Asia, and Europe, it is becoming increasingly important to provide an infrastructure that can meet the requirements of these new networks. With the impending completion of the National LambdaRail (NLR) facility in the US, any continuation of the TransPAC project needs to be flexible enough to participate in Layers 1 through 3 of the OSI protocol stack. This type of production experimentation needs to coexist with a set of production-level services that cannot be interrupted for the sake of next-generation technology experiments.

While the more experimental JGN2 Chicago circuit is already operating at OC-192 speeds, TransPAC management will look to upgrading the Los Angeles circuit to OC-192. This circuit will terminate into a TransPAC-owned router at the Pacific Wave facility in Los Angeles. This will give full access to US research, education, and federal networks on a much higher speed. This Los Angeles circuit will continue to remain the primary entry and exit point for APAN network traffic. As TransPAC becomes more involved in next-generation circuit-switched architectures, and as transpacific bandwidth costs decrease, TransPAC engineers will look to the acquisition of more 10G links across the Pacific into much more sophisticated and service-enriched network devices.

Having multiple circuits into the United States allows for a much richer set of services and the necessary resources to participate in US, Asian and European experiments without sacrificing the production services that the TransPAC project performed over the past seven years. In addition to TransPAC managed services, The TransPAC team need to look at mutual backup services with fellow transpacific networks such as NII and WIDE.

Though the Chicago JGN2 Procket router has performed well during the last six months of the project, The TransPAC team cannot continue to rely on donated equipment from a now-defunct vendor. This router will need to be replaced with a new piece of equipment in order to provide the set of services that TransPAC has striven to supply.

In addition to the traditional focus on the US-Asian interconnects, the TransPAC team plan to focus on intra-Asian connectivity to areas that traditionally have not been serviced by high-speed circuits. This includes, but is not limited to, Hong Kong, Singapore, and India.
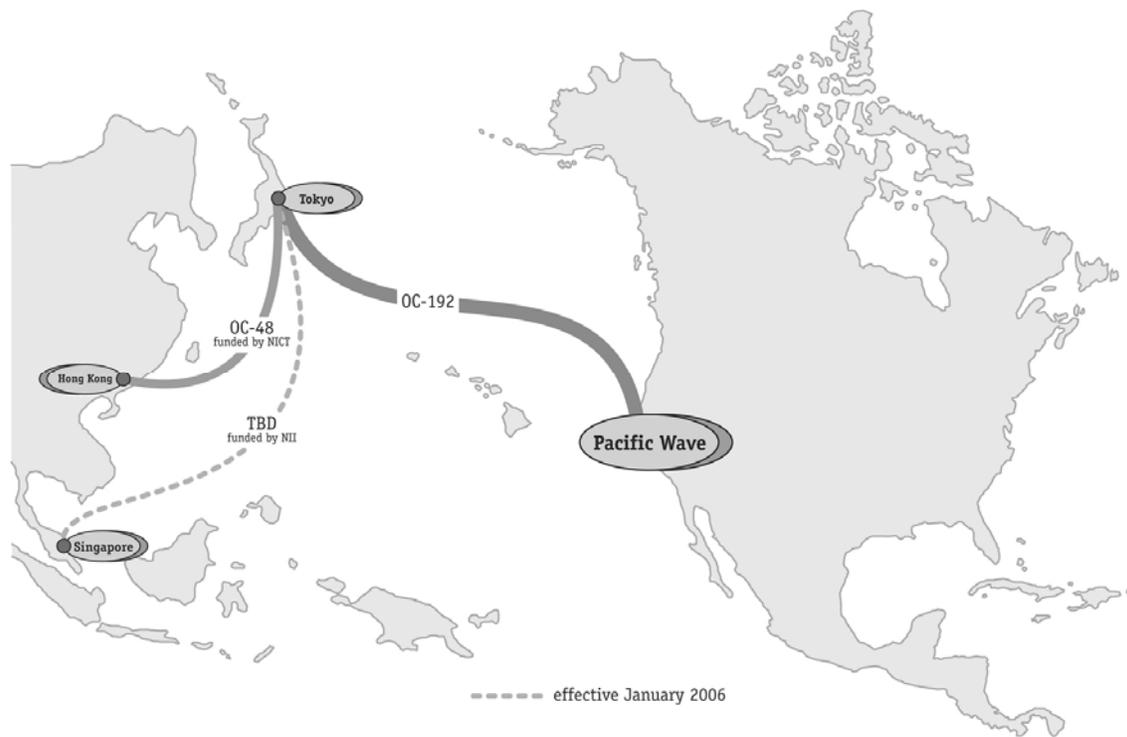
Figure 9: Proposed TransPAC2 Network

I.2. Network Operations Center

The Network Operations Center (NOC) will continue to make advancements that will improve service and support to the TransPAC network. In the coming program years, the Global NOC will continue to search for ways to improve its problem escalation procedures, including changes to the trouble ticket priority schema. This will place a stronger emphasis on customer requests and related action items.

The NOC will continue to develop the *Footprints* trouble-ticket system, utilizing a Sequel Server back-end. This will provide for greater interoperability between the network monitoring systems, the contact database, and reporting mechanisms. This development will allow the NOC to convert to a new automated network availability report and statistics system. The reporting tool is also dynamically tied in with an automated customer notification tool that will provide more accurate network maintenance and availability messages.

The NOC's network alert Web interface tool (AlertMon) will continue to be upgraded to provide more extensive and detailed links to the Global NOC's contact database, and will also include a database of NOC operator action items per each link monitored.

Over the course of the coming years, the Global NOC will continue to provide support for the US-based Research and Education Network - Information Sharing and Analysis Center (REN-ISAC), housed at Indiana University.[92] By leveraging the REN-ISAC resources and information, TransPAC will benefit from receiving the latest in international network security reports and recommended actions.

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[92] http://www.nipc.gov/pressroom/pressrel/NIPCandIU.htm

With the Global NOC continuing to develop the iVDGL Grid Operations Center (iGOC), support for grid computing to Asia will be enhanced. As networking moves step-by-step into optical switching, the TransPAC NOC will work with its APAN partners and other support contracts to help lead this effort. In the coming year, the TransPAC NOC will initiate a joint meeting with the APAN NOC to discuss distributed operations, as well as ways to more thoroughly integrate support.

I.3. Performance Analysis and Measurement

TransPAC engineers will continue to investigate the use of Juniper's Destination and Source Class Usage features to more clearly define TransPAC traffic sources and destinations. TransPAC engineers will work with vendors to further develop the IPv6 monitoring capabilities of the Network Operations Center. TransPAC engineers will continue to develop application and network passive monitoring tools. Tool development will focus on the analysis and debugging of international applications under various background conditions. TransPAC will provide an evaluation test bed for hardware and software developed by the NSF Strategic Technologies for the Internet grant titled *Network Management Tools for End-to-End Performance Measurement*.

I.4. Web-based Information

Application information will continue to be posted and maintained to the TransPAC Web site and links will continue to be provided to relevant Web-based resources.

TransPAC will continue to inform the community through further updates to the TransPAC Web site and to provide readers with news and information pertaining to TransPAC and to conferences and workshops related to international networking. As a part of event coverage, plans are to continue to post electronic versions of presentations for key events.

TransPAC staff will create a new "Tools" portion of the TransPAC network operations page with links to active instances of each tool as it is used on the TransPAC network. In addition, each tool will be made available for download, allowing APAN members to deploy them within their own networks.

I.5. HPIIS Team (IRNC team)

The TransPAC2 team at Indiana University will continue to work closely with the NSF and members of the IRNC project to ensure that international network connections are delivered in a reliable, efficient and effective manner.

I.6. Security

TransPAC will act as a coordinating agency between the APAN security working-group and the US Research and Education Network Information Sharing Analysis Center (REN-ISAC) housed at Indiana University to develop closer international cooperation on security issues.

The research arm of the REN-ISAC, housed in the Pervasive Technology Laboratory at Indiana University will work closely with TransPAC and APAN to collect and analyze Netflow data from TransPAC to identify, analyze, and mitigate network-based security attacks. Basic security plans as described in the official TransPAC2 work plan are as follows.

While providing high-performance resources for research and education experiments, these connections also have the potential to provide a high-performance access threat to US and global infrastructure. Given the high-speed nature of research and education networks, and their

common provision of 100 and 1000 Mbps connections to the desktop, the research and education end-user community is a prime target for network intrusions designed to gather "zombie" machines to participate in high-volume Distributed Denial of Service (DDoS) attacks. Increasingly, computer crackers in the US and abroad are
focusing their efforts on international connections because of lack of an effective international coordination and enforcement mechanism.

The two security areas that the TransPAC2 team will address throughout the duration of this project are protecting the network infrastructure itself and analyzing the data that transits our network. Protecting the network infrastructure is accomplished by packet filters applied to the control plane of the TransPAC2 router, keeping up to date on the vulnerabilities that effect network components, and monitoring device event logs. The Internet Security Systems product Internet scanner will accomplish security audits and port scanning of TransPAC network devices. Daily analysis of data that transits the TransPAC network is accomplished by providing NetFlow data to the Research and Education Networking - Information Sharing and Analysis Center (REN-ISAC).

The REN-ISAC is supported by Indiana University and works in concert with EDUCAUSE and Internet2. REN-ISAC is an integral part of the US higher education strategy to improve network security through information collection, analysis, dissemination, early warning, and response specifically designed to support the unique environment and needs of organizations connected to served higher education and research networks. In addition, the REN-ISAC supports efforts to protect the US national cyberinfrastructure by participating in the formal US ISAC structure.

Appendix A. Complete Milestones, July 1998 through July 2003

A.1. 1998

July 30	ATM service established between the APAN Tokyo Exchange Point (XP) and STAR TAP
August 18	IP routing between Kokusai Denshin Denwa and Indiana University via the vBNS at Downers Grove
September 8	Cooperative Agreement for TransPAC signed
September 21	Representatives of Indiana University and Japan Science and Technology Corporation sign MOU to establish link
September 21	NSF TransPAC 5-year award to Indiana University formally announced in Washington, DC
October 18	24x7 IU TransPAC NOC operational
October 23	APAN/vBNS peering
November 7-13	TransPAC-based iGrid demonstrations at SC'98
November 24	APAN/NREN peering
November 25	APAN/ESnet peering

A.2. 1999

March 14	JST funded TransPAC network upgrade to 73Mbps bandwidth completed
March 22-26	TransPAC-based demonstrations at GOIN'99
April 6	First HPIIS Team Meeting in Chicago
April 28	APAN, UCAID, and TransPAC representatives meet to discuss terms of APAN/UCAID Memorandum of Understanding (MOU) and establish outline for APAN/Abilene peering via TransPAC agreement
August 27	NORDUnet/APAN peering
September 21-24	APAN meeting in Canberra, Australia
October 3	IUCC (Israel)/APAN peering
October 4	SURFNET/APAN peering
October 10	TransPAC meeting in Seattle in conjunction with Internet 2
November	TransPAC bandwidth increased to 70+30 Mbps (2 PVP circuits)

A.3. 2000

February 14	TransPAC meeting in Tokyo in conjunction with APAN meeting and IWS2000
February 15-18	IWS2000 and APAN meetings in Tsukuba, Japan
March 17	OARnet/APAN peering
March 27	Informal TransPAC engineering meetings held at the Internet2 meeting in Washington, DC
April 11	iGrid2000 planning meeting in Chicago
April 20	TransPAC/STAR TAP/Euro-Link NOC and Engineering meeting in Indianapolis
May 16-17	TransPAC status report at NLANR Joint Techs meeting in Minneapolis and planning meeting for January 2001 NLANR Joint Techs meeting in Hawaii, co-sponsored by TransPAC and APAN
June 21	TransPAC 70Mbps and 30Mbps links merged in preparation for iGrid2000
July 18-21	iGrid2000 in conjunction with INET2000 in Yokohama Japan; TransPAC provides connectivity for iGrid
July 27	REUNA/APAN peering
August 22-25	APAN meeting in Beijing, China
September	New TransPAC Web site[93]
September 2	CERnet/APAN peering
September 18	TransPAC no cost upgrade to 155Mbps from 100Mbps
October 1	The TransPAC NOC is integrated into the Global NOC at Indiana University; current networks supported by the Global NOC are TransPAC, STAR TAP, AMPATH, Euro-Link, and MIRnet
October 16	Indiana University Global Research Network Operations Center becomes production
October 25	HPIIS Review in San Diego
November 1	TransPAC presentation at Internet2 meeting in Atlanta
December 12	A Juniper Networks-sponsored JUNOS class in Indianapolis in preparation for the deployment of a Juniper router at the STAR TAP
December 13	TransPAC, STAR TAP, Euro-Link Engineering meeting in Indianapolis

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[93] http://www.transpac.org

A.4. 2001

January 30-31	TransPAC co-hosts NLANR/Internet2 Joint Tech meeting in Hawaii; emphasis on technical cooperation and coordination between Asia-Pacific area and US
January 31	At the NLANR/Internet2/APAN/TransPAC Joint Techs in Honolulu, Hawaii, the Global NOC hosted a BOF session on NOC services and interaction between engineering staffs; also participating were the APAN and Canarie network NOCs
February 20	TransPAC Management Committee Meeting in conjunction with IWS2001 in Tokyo, Japan
February 19-23	Michael McRobbie, Donald McMullen, and James Williams and attended IWS2001 in Tokyo, Japan; Principal Investigator McRobbie delivered the keynote address
March 7-9	TransPAC presentations at Spring Internet2 meeting in Washington DC
May 15	Principle Investigator Michael McRobbie makes keynote presentation at TERENA conference in Antalya, Turkey
May 28	Cisco 7500 router replaced by Juniper M5 router at STAR TAP in Chicago
June 1-2	TransPAC hosts the High Energy Physics/Nuclear Physics Networking Meeting in Indianapolis, Indiana
June 5	James Williams represents TransPAC at the STAR TAP Advisory Committee Meeting in Stockholm, Sweden
June 8-9	James Williams represents TransPAC at the Coordinating Committee for Intercontinental Research Networking (CCIRN) meeting in Stockholm, Sweden
July 1	AMPATH network officially supported by the Global NOC at Indiana University
July	TransPAC trouble ticket updates available on the NOC Web page; report updated twice an hour
August 15-17	TransPAC participates in AMPATH meeting in Miami; Michael McRobbie, James Williams, and Brent Sweeny give presentations
August 20-24	Chris Robb represents TransPAC at APAN meeting in Penang, Malaysia
August 23-24	John Hicks attends the HPIIS 2001 workshop at the San Diego Supercomputer Center and presents on TransPAC[94]
October 15	First TransPAC OC-12 connecting Tokyo to StarLight is active
October 16-18	James Williams represents TransPAC at the kick-off meeting for the International Virtual Data Grid in California

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[94] http://moat.nlanr.net/Workshops/HPIIS-2001/

October 22	Second TransPAC OC-12 connecting Tokyo to Seattle is active
October 22-24	TransPAC co-hosts the First ApGrid Workshop in Tokyo; James Williams presents
November 12-14	James Williams, Donald McMullen, Karen Adams, Dennis Gannon, and Michael McRobbie attend SC2001 in Denver; TransPAC provides Asia-US infrastructure (see also Section G.6.b.)
December	NOC provides network-specific trouble ticket access for STAR TAP, TransPAC, and AMPATH engineers
December 11-12	TransPAC hosts NSF visit to Indianapolis to discuss international networking issues

A.5. 2002

January	Second iVDGL meeting in Gainesville; James Williams and John Hicks represent TransPAC
	Chris Robb represents TransPAC at Joint Techs meeting in Tempe
February	TransPAC hosts Pacific Rim Networking Meeting in Hawaii
March	Donald McMullen represents TransPAC at the First PRAGMA meeting in San Diego
	John Hicks attends the Passive and Active Measurement (PAM) workshop in Fort Collins, Colorado[95]
April	TransPAC hosts Spyros Konidaris in Bloomington
	James Williams presents at the Haystack Observatory in Nashua, NH
May	James Williams, Karen Adams, Chris Robb, Donald McMullen, and Michael McRobbie attend Internet2 meeting in Washington, DC; Williams, Robb, and McRobbie give presentations
	TransPAC co-sponsors the second ApGrid meeting in Taiwan; James Williams gives presentation
	TransPAC engineers assist in Global Terabit Research Network demo from Seattle to Brussels
	Teleglobe northern OC-12 services shut down permanently; TransPAC continues to operate on single OC-12 from Tokyo to Chicago
June	James Williams represents TransPAC at the CCIRN meeting in Washington, DC
	KDDI America replacement for Teleglobe circuit becomes active; TransPAC now functioning again with two OC-12 circuits
July	Native IPv6 enabled on TransPAC northern link

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[95] http://www.labs.agilent.com/pam2002/

	Donald McMullen represents TransPAC at the Second PRAGMA meeting in Seoul, Korea and at the Grid Forum Korea meeting following
	Taiwan begins routing across TransPAC
August	James Williams attended the CANS (Chinese American Network Society) meeting in Shanghai, China. Mr. Williams presented a paper.
	James Williams and John Hicks attended the ApGrid and APAN meetings in Shanghai, China. James Williams presented a talk at the ApGrid meeting about the iVDGL Grid Operations Center. John Hicks presented a talk about measurement and presented the TransPAC update at the APAN meeting.
	Network operations completed work on a new internal database of global network contact information.
September	James Williams attended iGrid2002 in Amsterdam and represented TransPAC during various experiments.
	Network operations provided network support for the iGRID 2002 demonstrations.
October	James Williams and Chris Robb attended the Internet2 Members Meeting in Los Angeles. Both Williams and Robb presented papers.
	Williams worked with Peter Aursberger on the PRAGMA governance structure and charter and participated in planning for the Miami Internet2 Joint Techs meeting.
	Discussions were initiated in Los Angeles with our Japanese TransPAC partners regarding the characteristics of a post-HPIIS TransPAC Project.
November	TransPAC IPv4 peering was established with ESnet and DREN in Seattle.
	Williams and Hicks attended SC2002 in Baltimore, MD.
	Network operations worked with all its partners to provide network support for SC2002.
	TransPAC/Euro-Link coordination meeting held at SC2002.
	John Hicks worked with our Japanese TransPAC partners in the GFarm Project to set a new TransPAC utilization record at SC2002.[96]
December	NaukaNet (formerly MIRnet) peering was established with TransPAC.

A.3. 2003

January	Williams, Hicks, and Robb attended the APAN/PRAGMA meeting in Fukuoka, Japan. A TransPAC meeting was held to discuss current operational status of the network and to plan for potential upgrades. Williams, Hicks, and Robb all presented talks about TransPAC.

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[96] http://datafarm.apgrid.org/

Indiana University hosted a visit from a Japanese delegation from the Communications Research Laboratory (CRL). Williams hosted the group in Bloomington and escorted them to Washington for a visit to the NSF.

The NSF asked TransPAC (and the other HPIIS projects) to prepare a supplemental funding request for a one-year extension to the TransPAC award. The IU TransPAC team and its Japanese partners worked on the specifics of a supplemental proposal.

February	Chris Robb worked with the APAN NOC to initiate BGP peering with ESnet in Seattle. Robb also worked with APAN engineers to pre-provision an HDTV demonstration between Osaka and the San Diego Supercomputer Center.
	TransPAC problem management system (*FootPrints*) was updated.
March	John Hicks and James Williams attended GGF7 in Tokyo, Japan. TransPAC is a sponsor of GGF. Hicks and Williams provided handout materials about TransPAC at GGF7 and had many TransPAC-related discussions with GGF attendees.
	A one-year TransPAC extension proposal was developed and submitted to the NSF for funding consideration.
April	John Hicks attended the PAM 2003 conference in San Diego.
	James Williams attended the Internet2 Member Meeting in Washington DC. TransPAC organized a luncheon in DC with officials from the NSF and other HPIIS projects. The impact of the Cyberinfrastructure Report on international networking was discussed.
	The NSF approved the TransPAC one-year extension.
May	James Williams met with NSF officials in Washington to discuss the Cyberinfrastructure Report and the future of international networking. One outcome of those discussions was beginning an investigation into the development of an international transit hub in Hawaii.
June	Indiana University hosted a meeting with our Japanese TransPAC partners in Bloomington, Indiana, to discuss engineering and policy issues related to the one-year TransPAC extension and the future on international networking.
	Chris Robb hosted a visit by our TransPAC Japanese partners to the StarLight facility in Chicago.
	James Williams met with KDDI America (the TransPAC circuit provider) to discuss an upgrade to the TransPAC service for the one-year extension period.
	James Williams participated in two NSF panels in Washington, DC.
July	TransPAC staff worked on Annual Report and Work Plan for the 2003-2004 extension year.

Appendix B. Complete Papers and Presentations, International Meetings and Conferences, December 1997 through July 2003

1997, December 13-14
Indiana University; Bloomington, Indiana, USA
TransPAC All-Hands International Meeting

1998, March 1
Tokyo, Japan
2nd Meeting of the TransPAC Consortium

1998, March 2
Tsukuba, Japan
APAN Committee and Working Group Meetings

1998, March 3-5
Tsukuba, Japan
Internet Workshop 1998 (IWS'98) and Worldwide Computing and Its Applications (WWCA'98)
Conferences
Presentation: (IWS'98) TransPAC - A High Performance Network Connection for Research and
Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Doug Pearson

1998, April 9
Indiana University; Indianapolis, Indiana, USA
Internet2 and IU
Presentation: TransPAC - A High Performance Network Connection for Research and Education
between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie

1998, June 23-24
Tokyo, Japan
Japan Science and Technology Corporation and Indiana University
Planning Meeting

1998, June 24-26
Tokyo, Japan
TransPAC-JP NOC Meeting

1998, June 30-July 2
Seoul, Korea
KRNET'98
Presentation: TransPAC – Policy-based Routing and Differentiated Services in TransPAC
Doug Pearson and Allen Robel

1998, July 1-3
Seoul, Korea
APAN Committee and Working Group Meetings

1998, July 21-24
Geneva, Switzerland
INET'98

Paper: A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie, et al
Presentation: A High Performance Network Connection for Research and Education between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie

1998, July 28-31
Chicago, Illinois, USA
7th International Symposium on High Performance Distributed Computing (HPDC-7 '98)
Paper: A High Performance Network for Research and Education Applications Between the vBNS and the Asia-Pacific Advanced Network (APAN)
Michael McRobbie, et al

1998, August 29-30
Indiana University; Indianapolis, Indiana, USA
TransPAC Engineering Meeting

1998, September 21
Washington DC, USA
NASA-NSF-APAN-TransPAC Policy Meeting
Presentation: TransPAC - Network Objectives and Policies[97]
Doug Pearson

1998, September 24
Boulder, Colorado, USA
NASA-NASDA-APAN-TransPAC Technical Meeting
Presentation: TransPAC[98]
Doug Pearson

1998 September 26-29
San Francisco, California, USA
Internet2 Project Meeting and Applications Demonstrations

1998, September 26
San Francisco, California, USA
TransPAC Status Meeting
Presentation: Results of NASA-NSF-APAN-TransPAC Policy Meeting[99]
Doug Pearson
Presentation: Results of NASA-NASDA-APAN-TransPAC Technical Meeting[100]
Doug Pearson
Presentation: TransPAC-US Status Report[101]
Doug Pearson

1998, November 7-13
Orlando, Florida, USA
SuperComputing'98 and iGrid Demonstrations

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[97] http://www.transpac.org/old-site/documents/980921_nasa_policy_dp.ppt

[98] http://www.transpac.org/old-site/documents/980924_nasa_tech_dp.ppt

[99] http://www.transpac.org/old-site/documents/980926_nasa_policy.ppt

[100] http://www.transpac.org/old-site/documents/980926_nasa_tech.ppt

[101] http://www.transpac.org/old-site/documents/980926_status_dp.ppt

Presentation: TransPAC Status Report[102]
Michael McRobbie

1998, December 7-11
Orlando, Florida, USA
IETF 43

1998, December 8
Orlando, Florida, USA
CCIRN QoS Working Group
Presentation: Proposed APAN I2 QBone Activities
Doug Pearson

1999, January 10-14
University of Maryland; College Park, Maryland, USA
Chinese-American Networking Symposium
 Presentation: Indiana University: From Intranet to TransPAC
Chris Peebles

1999, February 17
Osaka University; Osaka, Japan
TransPAC Management Committee Meeting
Presentation: TransPAC Link Performance[103]
Linda Winkler
Presentation: TransPAC Status Report[104]
Doug Pearson

1999, February 18-21
Osaka University; Osaka Japan
Internet Workshop 1999 (IWS'99)
Presentation: Internet2 and Other Research and Education Networks
Michael McRobbie

1999, March 22-25
Honolulu, Hawaii, USA
Global Observation Information Network'99 (GOIN'99) Conference

1999, April 6
Chicago, Illinois, USA
HPIIS Team Meeting

1999, April 28
Washington, DC, USA
Internet2 Member Meeting and Applications Demonstration

1999, May 17
Indiana University; Indianapolis, Indiana, USA
Meeting of Indiana University and members of Computer Network Information Center, Chinese
Academy of Sciences

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[102] http://www.transpac.org/old-site/documents/981111_igrid_bof.ppt

[103] http://www.transpac.org/old-site/documents/990217_performance.ppt

[104] http://www.transpac.org/old-site/documents/990221_liaison_dp.ppt

Presentation: TransPAC
Steve Wallace and Doug Pearson

1999, June 22
San Jose, California, USA
STAR TAP International Advisory Committee Meeting

1999, June 22
San Jose, California, USA
STAR TAP Technical Advisory Committee Meeting
Presentation: IU NOC
Doug Pearson

1999, June 22-25
San Jose, California, USA
INET'99 Conference
Joint Communications Research Laboratory, Japan, and Indiana University demonstration of
IEEE1394 Digital Video over IP

1999, October 10
Seattle, Washington, USA
Internet2 Meeting
TransPAC Management Committee Meeting
Presentation: TransPAC Status Report[105]
Doug Pearson

2000, February 14
Tokyo, Japan
TransPAC Management Committee Meeting

2000, February 15-18
Tsukuba, Japan
IWS2000 and APAN Meetings

2000, March 27-29
Washington, DC, USA
Internet2 Meeting
TransPAC Technical Meetings

2000, April 11
Chicago, Illinois, USA
iGrid2000 Planning Meeting

2000, April 20
Indianapolis, Indiana, USA
TransPAC/STAR TAP/Euro-Link NOC and Engineering Meeting

2000, May 16
Minneapolis, Minnesota, USA
Internet2/NLANR Joint Techs Meeting

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[105] http://www.transpac.org/old-site/documents/991010_status_dp.ppt

Presentation: TransPAC Infrastructure Update[106]
James Williams

2000, May 17
Minneapolis, Minnesota, USA
Internet2/NLANR Joint Techs Meeting
Planning for Joint Techs in Hawaii, jointly sponsored by APAN and TransPAC
James Williams on Program and Planning Committee

2000, May 18
San Diego, California, USA
CENIC 2000
Presentation: Internet2 and Global Development: Institutional Impact[107]
Michael McRobbie

2000, May 27
Beijing, China
Chinese-American Networking Symposium
Presentation: The Need for Global High Performance Networks[108]
Michael McRobbie

2000, June 14
Trondheim, Norway
Joint Meeting of the Association of European Universities and European Science Foundation
Presentation: Strategic Planning for IT & High Performance Networking in America Universities[109]
Michael McRobbie

2000, October 13
Atlanta, Georgia, USA
Presentation: TransPAC and the Global NOC: Present Status and Future Plans[110]
James Williams

2000, October 25
San Diego, California, USA
TransPAC HPIIS Performance Review
Presentation: TransPAC HPIIS Performance Review[111]
Michael A. McRobbie

2000, October
Beijing, China
Presentation: A TransPAC Update[112]
James Williams

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[106] http://www.transpac.org/old-site/NLANR.ppt

[107] http://www.indiana.edu/%7Eovpit/presentations/cenic2000/

[108] http://www.indiana.edu/%7Eovpit/presentations/beijing/

[109] http://www.indiana.edu/%7Eovpit/presentations/trondheim/

[110] http://www.transpac.org/old-site/1013_greg_atlanta.ppt

[111] http://www.transpac.org/old-site/10-25_transpac_mcrobbie.ppt

[112] http://www.transpac.org/old-site/documents/meetings/transpac-update.ppt

2000, December 13
Indianapolis, Indiana, USA
TransPAC/STAR TAP/Euro-Link Engineering Meeting

2001, January 28-31
University of Hawaii; Honolulu, Hawaii, USA
APAN/TransPAC/NLANR/Internet2 Techs Workshop

2001, January 31
Honolulu, Hawaii, USA
NLANR/Internet2/APAN/TransPAC Joint Techs
NOC Best Practices BOF

2001, February 20
Tokyo, Japan
IWS2001
Presentation: TransPAC Report[113]
James Williams
Presentation: STAR TAP Update[114]
James Williams and Linda Winkler

2001, February 20
Tokyo, Japan
IWS2001
Keynote Presentation: Towards a Global Terabit Research Network
Michael A. McRobbie

2001, March 7-9
Washington, DC, USA
Internet2 Meeting
Presentation: Internet2 Measurement[115]
James Williams
Presentation: Internet2 Performance[116]
James Williams

2001, March 15
Tsukuba, Japan
WAN Conference
Presentation: High Performance Networks[117]
James Williams and Donald McMullen

2001, May 14-17
Antalya, Turkey
TERENA Networking Conference 2001
Presentation: Towards a Global Terabit Research Network[118]
Michael A. McRobbie

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[113] http://www.transpac.org/old-site/documents/tokyo-feb-2001_v2.ppt

[114] http://www.transpac.org/old-site/documents/apan_2001_st-update.ppt

[115] http://www.transpac.org/old-site/documents/i2_measurement_talk.ppt

[116] http://www.transpac.org/old-site/documents/i2_performance_talk.ppt

[117] http://www.transpac.org/old-site/documents/meetings/t-sukuba-wan_03-15-01.ppt

[118] http://www.terena.nl/conf/tnc2001/proceedings/SlidesMcRobbie.ppt

2001, June 1-2
Indianapolis, Indiana, USA
High Energy Physics/Nuclear Physics Networking Meeting
Presentation: TransPAC and Global NOC Report[119]
James Williams

2001, June 5
Stockholm, Sweden
INET 2001
Presentation: Global Research NOC Update[120]
James Williams
Presentation: TransPAC Report[121]
James Williams

2001, June 8-9
Stockholm, Sweden
CCIRN meeting

2001, August 20-22
Penang, Malaysia
APAN Meeting
Presentation: TransPAC Network Update[122]
Chris Robb
Presentation: TransPAC Implementation of I2 Scavenger Service[123]
Chris Robb

2001, August 23-24
San Diego, CA, USA
HPISS 2001[124]
Presentation: TransPAC and Global NOC[125]
John Hicks

2001, October 2-5
Fall Internet2 Virtual Member Meeting
Internet2 QoS Working Group
Presentation: TransPAC QBSS Scavenger Service[126]
Chris Robb

2001, October 16-18
Los Angles, CA, USA
International Virtual Data Grid kickoff meeting
James Williams represents TransPAC

2001, October 22-24
Tokyo, Japan

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[119] http://www.transpac.org/old-site/documents/meetings/transpac-hep-talk.ppt

[120] http://www.transpac.org/old-site/documents/meetings/inet-2001-gnoc.ppt

[121] http://www.transpac.org/old-site/documents/meetings/transpac-inet-2001-talk.ppt

[122] http://www.transpac.org/old-site/documents/meetings/2001-08-20_penang_transpac-upgrade.ppt

[123] http://www.transpac.org/old-site/documents/meetings/2001-08-20_penang_qbss_scavenger-service.ppt

[124] http://moat.nlanr.net/Workshops/HPIIS-2001

[125] http://www.transpac.org/old-site/documents/hpiis-transpac-talk-v2.ppt

[126] http://www.internet2.edu/presentations/vimm/20011004-QoSWorkingGroup-Robb.ppt

Asia-Pacific Grid Workshop 2001, co-hosted by TransPAC
Presentation: High performance connectivity between the US and the Asia-Pacific Region[127]
James Williams

2002, January 8-10
Gainesville, FL, USA
International Virtual Data Grid, second meeting
James Williams represents TransPAC

2002, January 27-30
Tempe, AZ, USA
NLANR/Internet2 Joint Techs Workshop
Presentation: Indiana University Animated Traffic Map Software[128]
Chris Robb

2002, February 19-22
Hawaii, USA
Pacific Rim Networking, hosted by TransPAC
Presentation: Global Terabit Research Network: Building Global Cyber Infrastructure[129]
Michael McRobbie
Presentation: TransPAC - High performance connectivity between the US and the Asia-Pacific region[130]
James Williams

2002, April 7
Nashua, NH, USA
Connecting the Global VLBI Array in the New Era of High-Speed Networks
Presentation: International Connection Opportunities for VLBI[131]
James Williams

2002, May 5-9
Washington, DC, USA
Internet2 Member meeting
Presentation: Global Terabit Research Network[132]
Michael McRobbie
Presentation: Pacific Rim Networking Meeting Update[133]
James Williams
Presentation: Indiana University Animated Traffic Map Software[134]
Chris Robb

2002, May 13-15
Taipei, Taiwan
Second ApGrid Workshop, co-sponsored by TransPAC

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[127] http://www.transpac.org/old-site/documents/meetings/2001-10-23_transpac-tokyo-talk12.ppt

[128] http://www.internet2.edu/presentations/spring02/20020506-WeatherMap-Robb.ppt

[129] http://noc.transpac.org/old-site/meeting/mcrobbie.ppt

[130] http://noc.transpac.org/old-site/meeting/transpac.ppt

[131] http://www.transpac.org/old-site/documents/meetings/2002-04-07_vlbi-transpac(2).ppt

[132] http://www.internet2.edu/presentations/spring02/20020507-Plenary-McRobbie.ppt

[133] http://www.internet2.edu/presentations/spring02/20020506-PacificRim-Williams.ppt

[134] http://www.internet2.edu/presentations/spring02/20020506-WeatherMap-Robb.ppt

Presentation: Networking for International Grid Computing[135]
James Williams

2002, June 22
Washington, DC, USA
Coordinating Committee for Intercontinental Research Networking (CCIRN) forum
James Williams represents TransPAC

2002, July 10-14
Seoul, Korea
Second PRAGMA meeting
Grid Forum Korea
Donald McMullen represents TransPAC

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[135] http://www.transpac.org/old-site/documents/2002_ap-grid_presentation.ppt

Appendix C. Detail for New and Continuing TransPAC Projects

C.1. New Projects

C.1.a. Grid Datafarm

Collaborators

Japan: High Energy Accelerator Research Organization (KEK); National Institute of Advanced Industrial Science and Technology (AIST); the University of Tokyo; Tokyo Institute of Technology

USA: PRAGMA (San Diego Supercomputer Center)

Project Contacts

Dr. Osamu Tatebe (o.tatebe@aist.go.jp)

Project Web Site

http://datafarm.apgrid.org/

Project Description

Grid Datafarm is a Petascale data-intensive computing project initiated in Japan. The project is collaboration among High Energy Accelerator Research Organization (KEK), National Institute of Advanced Industrial Science and Technology (AIST), the University of Tokyo, and Tokyo Institute of Technology. The challenge involves construction of a Peta- to Exascale parallel filesystem exploiting local storage of PCs spread over the worldwide Grid.

C.2. Continuing Projects

C.2.a. PRAGMA

Collaborators

Australia: Australian Academic and Research Network (AARNET); Australian Partnership for Advanced Computing (APAC); Monash University (APAC); University of Sydney (APAC)

Singapore: Bioinformatics Institute

China: Chinese Academy of Sciences (CAS/CNIC); National Center for High performance Computing (NCHC); National Science Council (NSC)

Japan: Cybermedia Center, Osaka University; Global Scientific Information and Computing Center Tokyo Institute of Technology (TITECH); National Institute of Advanced Industrial Science and Technology (AIST); Osaka University Research Center for Ultra-High Voltage Electron Microscopy and the Cybermedia Center

Korea: Korea Institute for Science and Technology Information (KISTI); Kumoh National University of Technology

USA: National Science Foundation (NSF); Rutgers University; StarLight at University of Illinois at Chicago; Taipei Economic and Cultural Representative Office in the United States; Taipei Economic and Cultural Office in Los Angeles/Science Division; TransPAC at Indiana University; University of California, San Diego

Thailand: Thai Social/Scientific Academic and Research Network(ThaiSARN-3), National Electronics and Computer Technology Center; Thailand Embassy

India: University of Hyderabad

Malaysia: Universiti Sains Malaysia

Project Contacts

USA: Phil Papadopoulos (phil@sdsc.edu); Peter Arzberger (parzberg@ucsd.edu)

Project Web Site

http://pragma.ucsd.edu/index.html

Project Description

PRAGMA has been founded as an open organization in which Pacific Rim institutions will collaborate more formally to develop grid-enabled applications and will deploy the needed infrastructure throughout the Pacific Region to allow data, computing, and other resource sharing. Based on current collaborations, PRAGMA will enhance these collaborations and connections among individual investigators by promoting visiting scholars' and engineers' programs, building new collaborations, formalizing resource-sharing agreements, and continuing transpacific network deployment. PRAGMA provides an opportunity for member institutions to work together to address applications and infrastructure research of common interest.

C.2.b. ApGrid

Collaborators

Australia: Australian Partnership for Advanced Computing (APAC); The Australian National University; Monash University; University of Melbourne; Sydney VisLab; University of Adelaide; Griffith University

Canada: Canadian Embassy

China: ICT/CAS; CNC/CAS; SDB/CAS

India: Centre for Development of Advance Computing (CDAC)

Hong Kong: University of Hong Kong

Japan: AIST; TITECH; University of Tsukuba; RIKEN; KDDI; Osaka University; NAIST; Doshisha University

Malaysia: School of Computer Sciences Universiti Sains Malaysia; Universiti Teknologi Malaysia (UTM)

Singapore: iHPC; NUS; NTU; Sun Microsystems Inc.

South Korea: KISTI

Taiwan: NCHC; ASCC

Thailand: NECTEC; Kasetsart University; KMITNB

USA: Indiana University; SDSC

Vietnam: MOSTE; NCST

Project Contacts

National Institute of Advanced Industrial Science and Technology (AIST), Yoshio Tanaka (yoshio.tanaka@aist.go.jp)

Project Web Site

http://www.apgrid.org

Project Description

Computational Grid becomes an attractive platform for various kinds of HPC applications. Many Grid software systems have been designed and implemented, and nation-wide and world-wide Grid testbeds have been developed to investigate the performance, behavior, usability, and etc. of the softwares and applications on Computational Grid.

In 2000, Asia-Pacific Grid (ApGrid) was proposed to build Computational Grid around Asia-Pacific region. ApGrid is a partnership for Grid computing in the Asia-Pacific region. ApGrid focuses on (1) sharing resources (2) developing Grid technologies (3) helping the use of our technologies in create new applications (4) building on each other work, etc., and ApGrid is not restricted to just a few developed countries, neither to a specific network nor its related group of researchers.

The ApGrid objective is to develop a partnership among Asia-Pacific Communities to:

Share resources and knowledge

Share technologies

Collaborate and build on each others work

Encourage application community and assist them in using our technologies along with others

Build, nurture, and promote ApGrid technologies and applications

Provide a venue for sharing and exchanging ideas and help initiate new projects that benefit us

C.2.c. iVDGL

Collaborators

USA: GriPhyN; Particle Physics Data Grid

Europe: European Data Grid; GridPP Project

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International: Global Grid Forum

Project Contacts

USA: Paul Avery (avery@phys.ufl.edu); Ian Foster (foster@mcs.anl.gov); Carl Kesselman (carl@isi.edu); Harvey Newman (newman@hep.caltech.edu); Robert Gardner (rwg@indiana.edu); Alexander Szalay (szalay@jhu.edu); Albert Lazzarini (lazz@ligo.caltech.edu); Manuela Campanelli (manuela@utb1.utb.edu)

Europe: Fabrizio Gagliardi, Director, EU DataGrid (fabrizio.gagliardi@cern.ch); Mirco Mazzucato, Italian Grid project (mirco.mazzucato@pd.infn.it); Tony Hey, Director, e-Science Core Programme (tony.hey@epsrc.ac.uk); Neil Geddes, Director, PPARC e-Science (Neil.Geddes@pparc.ac.uk)

Project Web Site

http://www.ivdgl.org/

Project Description

The International Virtual Data Grid Laboratory 9iVDGL) is a consortium of 15 universities and four national laboratories to create the International Virtual Data Grid Laboratory (iVDGL). The iVDGL, to be constructed in partnership with the European Union, Japan, Australia and later other world regions, will form the world's first true "global Grid," providing an integrated computational resource for major scientific experiments in physics, astronomy, biology, and engineering. The iVDGL will serve as a unique resource for scientific applications requiring access to Petabytes of data (1 Petabyte = 1 million Gigabytes) and beyond.

The iVDGL will provide a global computing resource for several leading international experiments in physics and astronomy, including the Laser Interferometer Gravitational-wave Observatory (LIGO), the ATLAS and CMS experiments at CERN, the Sloan Digital Sky Survey (SDSS), and the proposed National Virtual Observatory (NVO). For these projects, particularly the CERN experiments whose members number in the thousands and whose data collections are expected to reach 100 Petabytes early in the next decade, the powerful global computing resources available through the iVDGL will enable new classes of data intensive algorithms that will lead to new scientific results. Other application groups affiliated with the NSF supercomputer centers and EU projects will also take advantage of its resources. Sites in Europe and the U.S. will be linked together by a multi-gigabit per second transatlantic link funded by a companion project in Europe.

C.2.d. GriPhyN

Collaborators

Many institutions conducting high energy research in the US and the A-P region

Project Contacts

USA: Dr. Fred Luehring and Dr. Harold Ogren, Indiana University

Japan: Dr. Satoshi Sekiguchi, AIST, Tsukuba Advanced Computing Center, METI

Project Web Site

http://www.griphyn.org

Project Description

GriPhyN is an NSF-funded global data storage and computing project for several experiments in high energy physics and cosmology (primarily the CERN Atlas project and the LIGO gravity wave observatory). Data production rates by these instruments has placed new requirements on both international bandwidth and services for managing bandwidth.

C.2.e. GRAPE-MD

Collaborators

Japan: University of Tokyo

USA: Many US researchers conducting n-body simulations

Project Contacts

USA: Dr. Piet Hut, Institute for Advanced Study, Princeton

Japan: Dr. Junichiro Makino, University of Tokyo

Project Web Site

http://grape.astron.s.u-tokyo.ac.jp/grape/

Project Description

The Gravity Pipe-Molecular Dynamics (GRAPE-MD) is a special purpose computer developed at the University of Tokyo for conducting n-body computations. The GRAPE-6 machine is expected to achieve 100TFLOPS and represents a global resource for conducting astronomical and molecular dynamics computations. TransPAC staff are working with researchers at the University of Tokyo to provide access to the GRAPE-MD to laboratories in the US.

C.2.f. Global Data and Software Library Sharing System

Collaborators

Japan: Electrotechnical Laboratory, Tokyo Institute of Technology, Real World Computing Partnership (RWCP)

USA: Argonne National Research Laboratory, Chicago University

Project Contacts

Dr. Satoshi Sekiguchi (sekiguchi@etl.go.jp)

Dr. Mitsuhisa Sato (msato@trc.rwcp.or.jp)

Professor Satoshi Matsuoka (matsu@is.titech.ac.jp)

Dr. Ian Foster (foster@mcs.anl.gov)

Project Web Site

None listed

Project Description

Experimental environment for globally distributed computing will be built on high-speed network. Target application is global astronomical observation. The system will support a large scale, globally distributed software library and database system using globally distributed software modules and hardware infrastructures. The system will feature both the repository of observed astronomical data and its usage from globally-distributed applications. The TransPAC team need a global high-speed, well controlled network circuit to test the systems.

C.2.g. Joint Program of Arctic Atmosphere Observations of GI/UAF and CRL/MPT

Collaborators

> Japan: CRL (Communications Research Laboratory)

> USA: University of Alaska Fairbanks - Geophysical Institute

Project Contacts

> Yasuhiro Murayama (murayama@crl.go.jp); International Arctic Environment Research Team, CRL, Tokyo, Japan

> Shun-ichi Akasofu (sakasofu@geewiz.gi.alaska.edu)

> Frank Williams

Project Web Site

> http://www.crl.go.jp/t/team5/ScienceplanE/

Project Description

The present plan was initiated in 1992 as an international cooperative research project with the US centering primarily on the University of Alaska Fairbanks within the framework of the Japan-US Science Technology Cooperation Agreement.

Communications Research Laboratory (CRL; formerly Radio Research Laboratories) has made many contribution to international science over the years in the use of radio and optical waves and through its studies of the ionosphere and atmosphere. CRL applies these advanced radio wave and optical technologies in the development of techniques for measuring scientific properties of the global environment and atmosphere. Just as importantly, CRL also seeks to advance atmospheric sciences by demonstrating the use of instrumentation developed and fabricated, as well as by conducting observational studies and thus contributing to the scientific understanding of and the approach to solution of the global environmental issues. The major target of the atmospheric observations associated with this plan is the middle atmosphere from the stratosphere to the lower thermosphere (10-100 km), above Alaska.

"Our data transfer experiment of [the] computer network … started together with a new connection of [the] Arctic Region Supercomputing Center of University of Alaska to [the] Seattle GigaPoP [in] October 1999. This enabled our middle and upper atmosphere observation instruments in Alaska to connect other states, and thus Japan, with [a] high-speed link, through

the APAN (Asia-Pacific Advanced Network) project. For the Joint program of Arctic atmosphere observations of GI/UAF and CRL/MPT, TransPAC is working well in collaboration with APAN (Asia-Pacific Advanced Network), to improve our connectivity of Alaska-Japan for our scientific experiments."[136]

C.2.h. MediaZine

Collaborators

Germany: Stefan Noll, Hartmut Chodura, Norbert Schiffner; Fraunhofer Institut Graphische Datenverarbeitung (IGD); Darmstadt, Germany

Singapore: Wolfgang Felger, Tony Chan, Law Yee Wei, Swee Eng Yeong; Centre for Advanced Media Technology (CAMTech)

Project Contacts

Stefan Noll (Stefan.noll@igd.fhg.de), Norbert Schiffner (norbert.Schiffner@igd.fhg.de); Fraunhofer Institut Graphische Datenverarbeitung (IGD); Germany

Project Web Site

http://www.igd.fhg.de/igd-a9/research/cve/

Project Description

This interactive multimedia magazine includes text, images, live audio, live video, animations, 3D computer graphics and embedded electronic commerce and communication functions. It represents all applications where the multimedia capacities of the Web could be combined with the immersive perception performances provided by streamed media.

C.2.The TransPAC team. Steering and Visualization of a Finite-Difference Code on a Computational Grid

Collaborators

USA: Arthurine Breckenridge, Rena Haynes, Sandia National Laboratories

Germany: Ulrich Lang, Uwe Woessner, Matthias Mueller, High Performance Computing Center Stuttgart (HLRS)

Project Contacts

USA: Arthurine Breckenridge (arbreck@sandia.gov), Rena Haynes (rahayne@sandia.gov), Sandia National Laboratories

Project Web Site

http://www.cs.sandia.gov/ilab/

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[136] Yasuihro Murayama, Communications Research Laboratory

Project Description

This application, demonstrated at iGrid2000 in Yokohama, Japan, emphasizes distributed parallel supercomputing and a collaborative virtual-reality computation steering environment applied to Grand Challenge problems.

C.2.j. Distributed Simulation Analysis among Scientists Located in Germany, the United States, and Japan

Collaborators

USA: Arthurine Breckenridge (arbreck@sandia.gov), Rena Haynes (rahayne@sandia.gov); Sandia National Laboratories

Germany: Ulrich Lang, Uwe Woessner, Matthias Mueller; High Performance Computing Center Stuttgart (HLRS)

Project Web Site

http://www.cs.sandia.gov/ilab

Project Description

This application emphasizes distributed parallel supercomputing and a collaborative virtual-reality computation steering environment applied to Grand Challenge problems.

C.2.k. Transoceanic Exploration of Cultural Heritage in Virtual Reality (EVL and the University of Tokyo)

Collaborators

USA: University of Illinois at Chicago, University of Missouri

Japan: The University of Tokyo , Telecommunications Advancement Organization, NTT

Project Contact

Jason Leigh (spiff@evl.uic.edu) Electronic Visualization Laboratory, University of Illinois at Chicago

Project Web Site

http://www.evl.uic.edu/cavern/lara

Project Description

Using cultural heritage as an application driver, the goal of the Networked Virtual Environments Collaborative Trans-Oceanic Research (N*VECTOR) project is to link EVL's CAVE and Tokyo's CABIN in order to better understand the requirements of multiple media flows among sophisticated virtual reality displays over great distances.

C.2.l. Global Internet Digital Video Network (GiDVN)

Collaborators

USA: International Center for Advanced Internet Research (iCAIR), Northwestern University

International: CANARIE Inc, CERN, APAN, KDD, APAN-KR, Seoul National University, SURFnet, DGSCA-UNAM, SingAREN, Royal Institute of Technology, Universitat Politecnica de Catalunya

Project Contact

Joe Mambretti (j-mambretti@nwu.edu); International Center for Advanced Internet Research (iCAIR), Northwestern University

Project Web Site

http://www.icair.org/inet2000

Project Description

GiDVN projects are enhancing media capabilities for the next-generation Internet, enabling new applications to interoperate. One general objective of the GiDVN project is to expand the capabilities of digital video from its current restricted usage on the Internet to allow it to be utilized more as a common data type, especially with regard to core architecture, access, integration with other applications, infrastructure scalability, differentiated services, quality of services, and interfaces with other Internet technology components. Eventually, advanced capabilities will be an integral part of an architecture that will provide a general, persistent digital video "dial tone."

C.2.m. High-quality Video Broadcast on High Performance Research and Education Networks (Indiana University)

Collaborators

Indiana University

IBM

Litton Network Access Systems

WireOne

Project Contacts

Doug Pearson (dodpears@indiana.edu)

Project Web Sites

http://www.indiana.edu/~video/igrid2000/

http://www.STAR TAP.net/PUBLICATIONS/news-igrid2000digvid.html

Project Description

iGrid2000 will highlight how scientific collaborators are now taking advantage of global connectivity to empower collaborative solutions to complex problems. Through advanced networking techniques, researchers can access distributed computing, remote storage, and visualization/virtual-reality display devices more efficiently than ever. Indiana University, in cooperation with corporate and university partners, is providing digital video services at iGrid2000 designed to facilitate researcher collaboration and provide global dissemination of the iGrid2000 demonstrations. IU is providing:

1. in cooperation with Wire One Inc; H.323 videoconferencing systems at the iGrid venue and to selected researchers at their home base to provide globally distributed researchers interactive access to their collaborators at the iGrid2000 site

2. in cooperation with Litton Network Access Systems and University of Washington; CAMVision-2 MPEG2 over IP codecs to provide broadcast-quality interactive and streaming video from the iGrid floor, including multicast to Internet2 sites that have the Litton equipment and the first live IP- based transpacific distribution to commercial cable reaching television audiences in the Seattle area and rebroadcast on the ResearchChannel reaching direct broadcast satellite viewers across the country

3. streaming video of the demonstrations, utilizing IBM Content Manager VideoCharger high-quality 1.5Mbps multicast MPEG1 and commodity-quality Webcast using Real technology; details regarding how to access the streaming video broadcasts are available at the Web site[137]

High-quality broadcast video delivered over high performance research and education networks serves an important role in the dissemination of information, education, and outreach regarding research activities. Interactive videoconferencing facilitates and unites the activities of geographically distributed research collaborations. Digital video services are a tool to empower the global research community.

C.2.n. Transpacific Telemicroscopy

Collaborators

Japan: Osaka University

USA: UCSD, SDSC

Project Contacts

Martin Hadida-Hassan (marty@sdsc.edu) - primary

Mark Ellisman (mark@alex.ucsd.edu)

Youki Kadobayashi (youki@center.osaka-u.ac.jp)

Project Web Sites

http://www-ncmir.ucsd.edu/CMDA/

http://www.uhvem.osaka-u.ac.jp/official/news.html

http://www.npaci.edu/online/v3.10/telemicroscopy.html

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[137] http://www.indiana.edu/~video/igrid2000/

Project Description

The National Center for Microscopy and Imaging Research (NCMIR) - an NIH-funded Resource - has been leading the efforts in the field of "Telemicroscopy" as part of an on-going research project started in 1992, the Collaboratory for Microscopic Digital Anatomy (CMDA). The CMDA contains a rich set of software tools that provide for remote operation of an electron microscope, the JEOL4000 IVEM, located at NCMIR in San Diego. Using CMDA tools, remote researchers can interactively steer this specialized microscope to investigate their specimens and collect high-resolution digital images of selected areas of the specimen. Additional CMDA tools allow for processing, analysis, and visualization of the acquired 2D and 3D datasets.

NCMIR has inspired similar efforts to be conducted by our collaborators at the Ultra-High Voltage Electron Microscopy (UHVEM) laboratory in Osaka University. The UHVEM laboratory has developed tools similar to the CMDA that provide for remote control of their unique electron microscope - the Hitachi H-3000, one of the most powerful electron microscopes in the world.

C.2.o. Asia-US-Australia Collaboration in the Silicon Vertex Detector Project for the BELLE High Energy Physics Experiment at KEK

Collaborators

> Japan: KEK (High Energy Accelerator Research Organization), Osaka University, Tokyo Metropolitan University, University of Tokyo, University of Tsukuba

> Australia: University of Melbourne, University of Sydney

> USA: University of Hawaii, Princeton University

Project Contacts

> Professor H. Aihara (aihara@phys.s.u-tokyo.ac.jp)

> Professor D. Marlow (marlow@puphep.princeton.edu)

Project Web Sites

> http://bsunsrv1.kek.jp/

> http://www.kek.jp

Project Description

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.

At the heart of the BELLE detector a high precision particle trajectory detection system consisting of silicon microstrip sensors will be installed. This silicon system contains about 100K channels to be read out by a high-speed online data-taking system. To achieve required precision all electronics channels must be constantly monitored and calibrated.

An international collaboration was formed to design and build the silicon vertex detector. In addition, the generated data will be jointly analyzed by the participating institutions to obtain physics results in a timely manner.

C.2.p. RHIC Pioneering High-Energy Nuclear Interaction Experiment (PHENIX) High-energy Heavy-ion experiment; Spin Physics Research with Relativistic Heavy Ion Collider (RHIC) at BNL; RHIC PHENIX Heavy Ion Collaboration

Collaborators

Japan: University of Tokyo

USA: Brookhaven National Laboratory

Project Contacts

Hideki Hamagaki (hamagaki@cns.s.u-tokyo.ac.jp); Center for Nuclear Study, University of Tokyo (CNS)

Sam Aronson (aronsons@bnl.gov); Brookhaven National Laboratory, Upton, NY

Project Web Site

http://www.phenix.bnl.gov/

Project Description

These general titles cover a number of physics experiments involving the Relativistic Heavy Ion Collider (RHIC) and Pioneering High-Energy Interaction Experiment linking numerous universities in Japan with Brookhaven National Laboratory in the United States.

The PHENIX experiment is one of the two major experiments in the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. It aims to detect the signatures of Quark Gluon Plasma (QGP) deconfined phase, which is thought to exist in the early universe. More than 400 physicists, engineers, and students from eleven countries are currently participating in the PHENIX experiment. The participating institutions from Japan are: University of Tokyo, CNS-Tokyo, KEK, Tsukuba, Waseda, Kyoto, Hiroshima, Nagasaki Institute for Applied Science, Tokyo Institute of Technology and RIKEN.

Example data regarding network performance can be found at:

http://ccjsun.riken.go.jp/ccj/present/CHEP2000/sld015.htm

C.2.q. Japan-US Collaboration on ICRF Heating and Current Drive Experiments and Modeling

Collaborators

Japan: University of Tokyo

USA: Massachusetts Institute of Technology

Project Contacts

Professor Y. Takase (takase@phys.s.u-tokyo.ac.jp)

Dr. M. Greenwald (g@psfc.mit.edu)

Project Web Site

http://www.psfc.mit.edu/cmod/

Project Description

The ICRF heating experiments on the Alcator C-Mod Tokamak at MIT has been highly successful. With the additional power and current drive capabilities currently being added in collaboration with PPPL (Princeton Plasma Physics Laboratory), the emphasis of research will shift toward steady-state advanced Tokamak experiments using current drive and profile control. MIT is already preparing the infrastructure necessary to support remote collaborators.

Participation in these experiments by the University of Tokyo group, including planning of experiments, real-time participation, and data analysis became possible with the increased bandwidth provided by APAN. The University of Tokyo group, in collaboration performed theoretical modeling of various heating and current drive scenarios in 1998 with MIT physicists. The results indicate potential usefulness of the high harmonic fast wave for current drive in both conventional and spherical tokamaks.

C.2.r. APBionet: Asia-Pacific Bioinformatics Network (genomic data, computation, and community support)

Collaborators

USA: Michigan State University

Japan: National Institute Genetics

Project Contacts

Prof. Hideaki SUGAWARA (hsugawar@genes.nig.ac.jp); Center for Information Biology, National Institute of Genetics

Prof. Herman D. Hughes (hughes@cps.msu.edu); Computer Science & Dir. of HSNP, Michigan State University

Prof. J. Tiedje (tiedjej@pilot.msu.edu); Center for Microbial Ecology, 540 Plant and Soil Sciences Building, Michigan State University

Project Web Site

http://rdp.cme.msu.edu/

Project Description

The APBionet was established to realize smooth information flow and sharing free from boundaries caused by physical distance, social system, technology, and culture. Broadband networks are indispensable to APBionet that consists of:

fast and robust networks of databases and applications

facilities for visualization of a large scale data and interactive simulation of life phenomena for the advanced study on life sciences and biotechnology

distant learning systems based on multi-media servers to foster bioinformatics experts in Asia-Pacific region

C.2.s. Bio-Mirror Public Service for High-speed Access to Biosequence Data

Collaborators

Singapore: National University of Singapore

USA: Indiana University

Project Contacts

Tan Tin Wee (tinwee@pobox.org.sg)

Don Gilbert (gilbertd@chipmunk.bio.indiana.edu)

Project Web Site

http://www.bio-mirror.net

Project Description

This is a worldwide bioinformatic 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, so much that distribution of them is hampered by existing Internet speeds. 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 infrastructure of the Very High Speed Backbone Service(vBNS), Abilene, TransPAC, and the Asia-Pacific Advanced Network (APAN).

Currently Available Servers

China
http://bio-mirror.cn.apan.net/
ftp://bio-mirror.cn.apan.net/

Japan
http://bio-mirror.jp.apan.net/
ftp://bio-mirror.jp.apan.net/pub/biomirror/

Korea
http://bio-mirror.kr.apan.net/
ftp://bio-mirror.kr.apan.net/pub/biomirror/

Singapore
http://bio-mirror.sg.apan.net/
ftp://bio-mirror.sg.apan.net/biomirrors/

Thailand
http://bio-mirror.ku.ac.th/

USA
http://www.bio-mirror.net/
ftp://bio-mirror.net/biomirror/

Current Data Sets

DNA biosequence data include GenBank, EMBL, and DDBJ. Protein biosequence data include SWISS-PROT*, TrEMBL, PIR. Other data include BLOCKS, ENZYME, PROSITE*, REBASE.

Data currently totals about 10 Gigabytes in compressed format, and are updated from the primary sources nightly. * Commercial restrictions on SWISS-PROT and PROSITE exist.

These servers are publicly available sites for high-speed access to up-to-date DNA/protein biological sequence databanks. High-speed access between the sites is provided by the network infrastructure developed by Very High Speed Backbone Service (vBNS), TransPAC, and Asia-Pacific Advanced Network (APAN), and these sites are well connected to national research and education networks within each country. DNA/protein biological sequence database is essential for advanced studies in genome research. These sequence data have been mutually collected between US, Japan and Europe since 1984.

Software search engines such as FASTA/BLAST are used to find homology sequences. These require huge local disks to store these databases. Some mirror servers have been developed to provide most recently updated data for DNA/protein biological sequence database. In present, however, these servers often fail due to the lack of existing network bandwidth. In this project, The TransPAC team will develop a reliable mirror server with high-speed data transfer over TransPAC.

In genome research the data of DNA database have been being increasing tremendously, including about 10% of Japanese contributions. However existing servers are mainly mirroring only US data to Japan. Therefore a bi-directional mirror server is to be helpful to update advanced data collected including in other countries and deliver them to researchers.

C.2.t. Japan-US Collaboration in Sloan Digital Sky Survey over the Network

Collaborators

    USA: Johns Hopkins University and seven other institutions

    Japan: University of Tokyo, Japan Promotion Group

Project Contacts

    Professor S. Okamura (okamura@astron.s.u-tokyo.ac.jp)

    Professor A. Szalay (szalay@tardis.pha.jhu.edu)

Project Web Site

    http://www.sdss.org

Project Description

Sloan Digital Sky Survey (SDSS) is a project to carry out both 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 as well as nearly the same number of stars. Among the extracted objects, about 1 million galaxies and 100 thousand quasars are selected, for which medium resolution spectra will be obtained.

The SDSS is a collaborative project between the US and Japan involving seven US institutions and the Japan Promotion Group JPG). The observation, The TransPAC team.e., data taking, will be carried out at the Apache Point Observatory, New Mexico, where some online data processing is performed. The bulk of the data reduction will be done at FNAL and the master database will be maintained there. The JPG will also maintain the whole set of the above data in Japan except for the raw data. The JPG is planning to produce the merged pixel map noted above from the flat-fielded data. The data processing to construct the merged pixel map involves reference to the raw data as well as the flat-fielded data.

Significant scientific analyses of these data will often produce the result whose amount is not much less than the input catalog itself. Accordingly, the network capable of transferring some 10GB in a day is of critical importance in order to promote active timely discussion between the JPG and US astronomers spread over several institutions. Similar imaging data taken with the Subaru Telescope will sometimes be useful to interpret the result of the SDSS data analysis.

C.2.u. Web Cache Meta Network

Collaborators

Japan: NTT, Keio University, Nihon University

Korea: KAIST

USA: NLANR

Another 30 APAN and US institutions

Project Contacts

Masaaki Nabeshima (nabe@slab.ntt.co.jp); NTT Labs

Kilnam Chon (chon@cosmos.kaist.ac.kr); KAIST

Duane Wessels (wessels@nlanr.net); NLANR

Project Web Sites

http://cache.jp.apan.net/

http://cache.kaist.kr.apan.net/

Project Description

To get high effectiveness of Web cache, cache servers and primary Web servers should exchange their status information and teach other (e.g. object update information from primary servers, load status information from cache servers.) The goal of this project is to make a network to exchange those Meta information. Currently The TransPAC team are experimenting with a hierarchical Web cache system between continents to get some operational data. NTT labs is developing a metadata exchange system (an alpha stage code is available).

As a step toward unified view of caching and replication, The TransPAC team are developing RepliCache (Large Object Cache) system. RepliCache will be located at GigaPOPs and it will serve large-bandwidth data (e.g., multimedia data) to users or collaborating caches. In the context of replication, resolution, and contents, The TransPAC team will cooperate with Internet 2 Distributed Storage Infrastructure project team.

C.2.v. CyberCAD: Internet Distributed Interactive Collaborative Design

Collaborators

USA: Indiana University

Singapore: National University of Singapore and Temasek Polytechnic

Project Contacts

Kim-Cheng Tan (kimcheng@tp.edu.sg); Temasek Polytechnic

Francis Eng-Hock Tay (mpetayeh@nus.edu.sg); National University of Singapore

Project Web Sites

http://eicu.tp.edu.sg/APAN-GDM/

http://ils.tp.edu.sg/apan/

Project Description

The goal of the Global Design Manufacturing Project (GDM) is to create a design and manufacturing hub in a global environment through Internet by sharing design and manufacturing tools among educational institutions and industry.

The CyberCAD software component of GDM has a controller-observer architecture to support reliable point-to-point synchronous portable Collaborative Computer Aided Design (COCAD). It allows geographically dispersed designers to work and communicate together synchronously on 3D design models, regardless of platform.

C.2.w. Data and Information Access Link (DIAL)

Collaborators

USA: NASA Goddard Space Flight Center (GSFC)

Japan: National Space Development Agency (NASDA)/RESTEC

Project Contact

Ramachandran Suresh (suresh@rattler.gsfc.nasa.gov); NASA ESDIS /RITSS, NASA Goddard Space Flight Center (GSFC), USA

Project Web Sites

http://dial.gsfc.nasa.gov

http://dial.eoc.nasda.go.jp

Project Description

DIAL is a Web-based distributed system to search, access and visualize satellite remote sensing data for Global Change research. It allows data providers to easily serve their Earth science data directly to their users. DIAL provides traditional catalog services like metadata search, while also providing extended interactive data services like browsing, subsetting, subsampling,

reformatting, and direct downloading. The power of DIAL has recently been enhanced by the addition of the EOSDIS "Version 0" protocol, which enables a project to set up a distributed system of DIAL servers.

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.

C.2.x. Development of Mirror Server by using High Speed Data Transfer in Genome Science

Collaborators

Japan: Ministry of Forestry and Fisheries

USA: Indiana University

Project Contacts

Yoshihiro Ugawa (ugawa@disc.dna.affrc.go.jp)

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Don Gilbert (gilbertd@chipmunk.bio.indiana.edu)

Project Web Site

None listed

Project Description

DNA/protein biological sequence database is essential for advanced studies in genome research. These sequence data have been mutually collected between US, Japan and Europe since 1984. Software search engines such as FASTA/BLAST are used to find homology sequences. These require huge local disks to store these databases.

Some mirror servers have been developed to provide most recently updated data for DNA/protein biological sequence database. At present, however, these servers often fail due to the lack of existing network bandwidth. In this project, The TransPAC team will develop a reliable mirror server with high-speed data transfer in HPIIS.

In genome research the data of DNA database have been being increasing tremendously, including about 10% of Japanese contributions. However existing servers are mainly mirroring only US data to Japan. Therefore a bi-directional mirror server is helpful to update advanced data collected including in other countries and deliver them to researchers. This mirror server could not be established without a high-speed and reliable connection.

C.2.y. Nucleic Acid Database

Collaborators

Japan: Japan Agency of Industrial Science

USA: Technology and Rutgers University

Project Contacts

Yoshikuni Okada (rdire@aist.go.jp), Director of RIPS center, Agency of Industrial Science and Technology

Prof. Helen M. Berman (berman@dnarna.rutgers.edu), Director Department of Chemistry, Rutgers, The State University of New Jersey

Project Web Site

http://ndbserver.rutgers.edu

Project Description

The Nucleic Acid Database (NDB) Project was established to serve as a resource for researchers who study the structure of nucleic acids. It provides a repository for the coordinates of oligonucleotide crystal structures. In addition, the NDB provides information of general interest to researchers in the field, and develops and distributes standard geometric information for use in molecular refinement and modeling programs.

This project is supported financially by the National Science Foundation and the Department of Energy. In Asia, the NDB WWW site is mirrored at the Structural Biology Center at AIST, Japan. For mirroring, The TransPAC team frequently needed to receive updates from NDB WWW site in US.

C.3. NASA Projects

C.3.a. Data Processing and Distribution of ASCA Data over the Network

Collaborators

USA: NASA

Japan: ISAS

Project Contacts

USA: N. White (white@lheavx.gsfc.nasa.gov), NASA

Japan: K. Mitsuda (mitsuda@astro.isas.ac.jp), M. Hoshino (hoshino@gtl.isas.ac.jp), ISAS

Project Web Site

http://heasarc.gsfc.nasa.gov/docs/asca/asca2.html

Project Description

Data processing and distribution of ASCA data over the network ASCA is the Japanese fourth X-ray astronomy satellite, and first to have major collaborations with the US. 65%, 15%, and 25 % of the total observation time are allocated for Japanese observers, US observers, and Japan-US collaboration, respectively. All the data, however, are made public to anyone in the world a certain time (1 or 1.5 years) after the observation is made. The telemetry data downlinked at the ISAS tracking station and NASA DSN (Deep Space Network) stations are first put together at ISAS (Sagamihara, Japan) and the first-stage data processing is made there. Then the data is sent to NASA/GSFC and the second-state data reduction is made there, and the product is sent back

to ISAS. The ASCA data processing and analysis software is developed and maintained by collaborations of ISAS and NASA/GSFC. Both the software and data products are distributed from ISAS and NASA/GSFC.

Three years have passed since the launch of ASCA. Although the data and software are extensively exchanged between the US and Japan, The TransPAC team rely on tape medium for the data exchange. There has always been a strong desire to use the network; however, because of limited bandwidth, The TransPAC team have not been able to afford it. The major advantages of using the network are:

Quick data transfer and quick response

Minimizing manpower and errors

Ease of maintenance

With the network, The TransPAC team can transfer data on a daily basis; on the other hand, The TransPAC team sends tapes of several days of observations at a time. Thus The TransPAC team can considerably speed up the data distribution. This is also important because The TransPAC team can check the data very quickly. Sometimes The TransPAC team need to iterate data exchanges several times, which would have required months to complete if The TransPAC team sends tapes.

C.3.b. Japan-US Collaborations in Developing ASTRO-E Science Instruments using the Network

Collaborators

USA: NASA, MIT

Japan: ISAS

Project Contacts

Japan: K. Mitsuda (mitsuda@astro.isas.ac.jp), M. Hoshino (hoshino@gtl.isas.ac.jp)

Project 2-1: R. Kelley (kelley@rosserv.gsfc.nasa.gov)

Project 2-2: P. Serlemitsos (serlemitsos@lheavx.gsfc.nasa.gov)

Project 2-3: G. Ricker (grr@space.mit.edu)

Project Web Site

http://heasarc.gsfc.nasa.gov/docs/astroe_lc/

Project Description

[Note: the ASTRO-E observer was lost and the project is no longer active. ASTRO-E will be replaced by another X-Ray observation platform in the future.]

Project 2-1 ASTRO-E XRS (X-ray spectrometer using micro calorie meter array)

Project 2-2 ASTRO-E XRT (X-ray telescope)

Project 2-3 ASTRO-E XIS (X-ray Imaging Spectrometer using X-ray CCD array)

ASTRO-E is the Japanese fifth X-ray astronomy satellite, scheduled to be put in orbit in early 2000. The TransPAC team have extensive collaborations with US scientists in three scientific subsystems. In these collaborations, components are first built, tested, and calibrated separately in Japan and in the US, then integrated, tested, and calibrated at ISAS. The instruments will be mounted on the spacecraft at ISAS and tested in the space craft integration test. In order to effectively proceed with the project, a high throughput network is essential, which the present network bandwidth does not allow. The TransPAC team would like to use [TransPAC] in the following ways:

1. Exchange online documents, design information (e.g., CAD data, Mechanical and Thermal mathematical models), test data/results, and software

2. Connect components of instruments or ground test equipments (GSE) developed separately in Japan and the US over the network and perform the end-to-end test

3. Monitor the spacecraft integration test from the US and respond as quickly as possible when any input from the US is necessary

Last year, The TransPAC team tried (2) using the proto-type model of XRS electronics which are working at ISAS and the GSE distributed at ISAS and at NASA/GSFC. However, because of limited bandwidth of Japan-US network, The TransPAC team could test only a small part of the functions.

C.3.c. Data Processing and Distribution of ASTRO-E Ground Test and Flight Data over the Network

Collaborators

USA: NASA

Japan: ISAS

Project Contacts

USA: N. White (white@lheavx.gsfc.nasa.gov)

Japan: K. Mitsuda (mitsuda@astro.isas.ac.jp), M. Hoshino (hoshino@gtl.isas.ac.jp)

Project Web Site

http://heasarc.gsfc.nasa.gov/docs/astroe_lc/

Project Description

ASTRO-E will produce 10 times larger amount of data than ASCA. The TransPAC team plan to have the Japan-US collaboration in data processing and distribution for ASTRO-E similar to that for ASCA. The data processing and distribution system is now being developed and will be tested in the spacecraft integration tests which will start in July 1998 at ISAS. During the ground test phase, The TransPAC team will use network for:

Development of software

Data processing of the spacecraft integration test data

After the satellite is put in orbit, The TransPAC team would like to use the network similar to our other projects. However, The TransPAC team will transfer about ten times larger amount of data via network.

C.3.d. The Geotail Data Analysis in Correlative Solar-Terrestrial Study

Collaborators

USA: NASA/GSFC

Japan: ISAS

Project Contacts

Japan: M. Hoshino (hoshino@gtl.isas.ac.jp)

USA: J. L. Green (green@nssdca.gsfc.nasa.gov)

Project Web Site

http://www-istp.gsfc.nasa.gov/istp/geotail/

Project Description

The key aim of the proposed research is to establish the global data analysis network links between US and Japan for the data exchange of the Geotail satellite, which is dedicated to the study of the solar-terrestrial physics.

The Geotail satellite was launched on July 1992 from Cape Canaveral, Florida, USA, by the Delta II launch vehicle. This is a joint program of the Institute of Space and Astronautical Science (ISAS) of Japan and the National Aeronautics and Space Administration (NASA) of the US. The main scientific objective is the study of the structure and dynamics of the Earth's magnetotail. The Geotail mission measures global energy flow and transformation in the magnetotail to increase understanding of fundamental magnetospheric processes such as the physics of the magnetic reconnection associated with substorms, the neutral line formation, and the plasma mixing and acceleration. Together with the WIND (NASA), POLAR (NASA), INTERBALL (IKI; the Russian Space Research Institute), and CULASTER (ESA; European Space Agency) projects, the Geotail takes part in the International Solar Terrestrial Physics (ISTP) program which aims at gaining improved understanding of the physics of the solar terrestrial relations. The ISTP program is organized by the Inter-Agency Consultative Group (IACG) which consists of ESA, IKI, NASA and ISAS.

Seven set of plasma scientific instrument such as magnetic field measurement, plasma particle detector, and plasma wave measurement, are on board GEOTAIL. About two thirds of the science instruments are provided by the Japanese Principal Investigators (PIs) and about one third of the science instruments are provided by the US PIs. In those Geotail data processing for the science data analysis, two databases, namely the Key Parameters and the Science Data Bases, are produced from experiments onboard GEOTAIL. The Key Parameters, which are used for obtaining overviews and identifying the times of interests, are produced at the Central DATA Handling Facility (CDHF) at GSFC/NASA. The Science Data Bases (SDB) is the standard material for data analysis. SDB is the calibrated and qualified database, and has finer time resolutions than the Key Parameters. The SDB data processing for seven set of scientific instruments on board GEOTAIL are mainly made by those Principal Investigators. Five years

has passed since the launch of GEOTAIL, and about 100GB of data has been obtained so far. For extensive studies, it is required to exchange a large amount of SDB data between the US and Japan, though the data exchange is now limited to only several events of interest through the tape medium and CD-ROM. The TransPAC team first proposed the data exchange between US and Japan through a high-speed network in the Geotail group.

It is highly recommended to exchange other ISTP satellite data as well as the Geotail data for further correlative solar-terrestrial data analysis. Many other international ground-based observations and theory efforts are also pursuing correlative solar-terrestrial research activities. The TransPAC team also propose an extensive data exchange via the network between NASA/USA and ISAS/Japan to make the magnetospheric physics a multi-discipline research field. The database centers at NASA and ISAS will play an important role on the data exchange.

To establish the above data analysis of global solar-terrestrial physics, it will be required to transmit at least about 100MB per day through the network, by taking into account that the data is sometimes revised or upgraded due to data calibration/correction. This proposal will be the milestone for further solar-terrestrial data analysis.

C.3.e. Data Processing of IRTS Data over the Network

Collaborators

USA: NASA/IPAC, NASA Ames, Caltech

Japan: ISAS

Project Contacts

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M. Hoshino (hoshino@gtl.isas.ac.jp)

C. Beichman (chas@ipac.caltech.edu), NASA/IPAC

T. Roellig (troellig@mail.arc.nasa.gov), NASA/ARC

A. Lange (ael@astro.caltech.edu), Caltech

Project Web Site

http://www.ir.isas.ac.jp/irts/irts_E.html

Project Description

The Infrared Telescope in Space (IRTS) is the first Japanese orbiting telescope dedicated to infrared astronomy. It is a cryogenically cooled 15 cm telescope onboard the Space Flyer Unit (SFU). The SFU (together with IRTS) was launched on March 18, 1995, and was retrieved by a Space Shuttle on January 13, 1996. The IRTS successfully performed an unbiased survey of 7% of the sky at a wide range of infrared radiation with wavelengths from 1.4 micron to 700 micron.

The IRTS is a joint project between the National Aeronautics and Space Administration (NASA) in the US and the Institute of Space and Astronautical Science (Japan), and the data were processed both in the US and in Japan in the following way:

1. All the data were first collected at ISAS (Japan) and the first-stage data processing is made

2. Most of the data were sent from ISAS (Japan) to each instrument team (both in US and in Japan), and each team analyzes the data and makes instrumental in-flight calibration

3. Part of the data were sent form ISAS (Japan) to the IPAC (USA), and the pointing-reconstruction is made

4. Pointing data are then distributed from IPAC (USA) to each instrument team (USA, Japan)

5. Each instrument team checks the pointing data, and repeat an iterative analysis (from 2 to 5), if required

6. Two years after the final pointing data were distributed, all the data are to be collected at IPAC (USA) and will be made available to the world-wide astronomical community

In summary, the data analysis is also a US-Japan collaborative project.

At the moment, The TransPAC team are at the stages between 2 and 5, in other words, are repeating iterative data analysis. The TransPAC team are now exchanging via tape medium. Hence it takes at least almost a month to find and correct very tiny mistakes. There has always been a strong desire to use the network; however, because of limited bandwidth, The TransPAC team were not [able to use] it.

[A] reliable network with sufficient bandwidth will considerably speed up data analysis. Moreover, the network will enable further detailed analysis, which will become possible only through frequent, and speedy exchange of data and information.

The IRTS data set is a unique tool to study the universe and the reliable network is indispensable to analyze this important data appropriately.

C.3.f. Exchange of Data between Infrared Astronomical Satellites

Collaborators

USA: NASA/IPAC

USA:NASA/GSFC

Japan: ISAS

Project Contacts

M. Hoshino

T. Nakagawa

Project Web Site

None listed

Project Description

The following three infrared astronomical satellites dedicated for survey have been so far launched.

1. IRAS (Infrared Astronomical Satellite) launched in 1983; joint project between USA, Netherlands, and UK

2. COBE (Cosmic Background Explorer) launched in 1989, USA

3. IRTS (Infrared Telescope in Space) launched in 1995; joint project between USA and Japan

Each satellite has its own characteristics, and each data set is complementary with each other. Moreover, the data analysis (especially for 2 and 3, and partly for 1) is still an on-going process. Hence The TransPAC team would like to exchange data and information very frequently.

Up to now, The TransPAC team have been using tapes to exchange data, since it is almost impossible to send any data larger than 50Kb via the network between USA and Japan. However, tapes are very inconvenient and inefficient ways of exchanging data. Moreover, tape drives are not necessarily compatible with each other. In other words, The TransPAC team frequently have problems with reading tapes written in other dives.

The reliable network with sufficient bandwidth will considerably speed up data exchanges, and will also make data exchanges more reliable. Frequent exchanges of data between three satellites with different characteristics will enable global studies of the infrared sky and will reveal many secrets in the universe.

C.3.g. Tropical Rainfall Measuring Mission (TRMM) Science Projects

Collaborators

USA: University of Washington, Florida State University, Texas A&M University, GSFC, NASA

Japan: Earth Observation Research Center (EORC), National Space Development Agency of Japan (NASDA)

Project Contacts

Kazuo Yoshida (yoshida@eorc.nasda.go.jp)

Seiichi Ueno

Kazuhiro Hiroshima

Dr. Robert Adler, University of Washington

Dr. Thomas T. Wilheit, Texas A&M University

Project Web Site

http://www.eorc.nasda.go.jp/TRMM/index_e.htm

Project Description

Tropical Rainfall Measuring Mission (TRMM) is the first artificial satellite that observes precipitation from space. The objectives of TRMM Science Projects are to understand the global energy and water cycles by providing quantitative measurement of rainfall in the tropics and determining how that rainfall may effect on global circulation, to predict global climate change, and to predict weather anomalies and natural disasters.

Appendix D. Research Experience for Undergraduates

During its tenure, the TransPAC project continuously made an effort to offer valuable experiences to undergraduate students from Indiana University, as interns under the National Science Foundation's Research Experience for Undergraduates (REU) program. Through the REU program, the TransPAC project was able to extend professional opportunities to students of widely varying academic disciplines, from advanced network analysis to web design and professional communications.

These experiences proved to be deeply enriching on both a personal and professional level, for the REU interns as well as the full-time members of the TransPAC staff.

The first REU internship took place in 2002, when undergraduate student Luke Fowler was invited to work with the TransPAC staff, developing measurement applications for network analysis and presentation. More specifically, Mr. Fowler worked primarily on a tool called SNAPP, or SNMP Network Analysis and Presentation Package. His personal summary of his experiences with the TransPAC project are presented later in this appendix, reprinted from a report sent to the National Science Foundation.

The experience of working with Mr. Fowler was such a positive one that it galvanized the TransPAC team to hire twice as many REU interns in the project's final year. Chad Kotil and Mark Casey were hired on to the TransPAC project in July of 2005, with each intern serving the project in a unique capacity, tailored to match both the needs of the TransPAC team, as well as their own interests and areas of expertise. Mr. Kotil and Mr. Casey's reports regarding their experiences with the project are reprinted below, after originally being sent to the National Science Foundation.

D.1 REU Interns' National Science Foundation Reports

D.1.a Chad Kotil's REU Report, 2005

Chad Kotil was hired on to the TransPAC team to design, develop and maintain a functional and user-friendly website for the TransPAC2 project. His position is a direct result of the lessons learned in the original TransPAC project, during which there was no one in charge of maintaining and updating the TransPAC website. After reviewing the state of the TransPAC website, the team decided that a new person needed to be hired dedicated to the maintenance of the website, in order to more adequately comply with the National Science Foundation's directive for maintaining an up-to-date public website for the project. Mr. Kotil will remain a member of the TransPAC team, maintaining the website, as long as he is able. He wrote the following reflections regarding his experiences and duties while working with the TransPAC team:

> My summer 2005 began with me having completed three quarters of my undergraduate collegiate career studying Business Informatics. A week after classes ended I went to visit my dad in Texas. I visit him every summer but usually not until the late summer months, just before classes resume. This year I decided to visit earlier so that I may find a good summer job that was related to Informatics. Informatics as I understand it to be is the application of internet technology to a specific industry or area of study. The Informatics homepage says "informatics is a bridge connecting IT to a particular field of

study such as biology, chemistry, fine arts, telecommunications, geography, business, economics, journalism, etc."

In Texas my dad had just started a new job in a new industry selling oil and natural gas drilling services and equipment. In the past my dad had worked selling bass boats and manufactured housing, and I always had a very good idea exactly what he did for a living. His new job would be no different, and I quickly learned exactly what his work entailed. I learned that his boss was interested in having a website for the business. So I offered to design it for him. I felt that even though I never received any formal training in web development I was experienced enough to undertake the task of designing a nice website for a company. I also felt that designing the company website would be good experience. For the rest of my time spent in Texas with my dad I was going to work with him and designing a website for his business. It was really great that I got the chance to work with my dad *and* design a website. The construction of the website[138] went smooth, and it was time for me to return to Cincinnati/Bloomington for the rest of the summer.

When I got back home from visiting my father, I had a website that I designed under my belt and I was looking to do freelance web design for the rest of the summer to save up money for school. To my good fortune I received an email from Becky Vianden in the Informatics school about a web developer position working with the TransPAC2 project. I contacted Jim Williams the project leader of the TransPAC2 project and eventually got the job as web developer for the TransPAC2 project.

Technology has always been a great interest of mine and the chance to work with a team of IT professionals who maintain a blazing fast research and educational internet2 link between Asia and America was a dream come true. I wasn't sure exactly what I was getting myself into, but I was confident that I could design a nice looking website that was easy to update. I learned a lot while developing the web site for Magnum Drilling Services, Inc. so the tools and methods that I would to use to design the new TransPAC2 website; CSS (cascaded style sheets), html, ssi (server side includes) I was familiar with. As I began work on the site design/redesign I rapidly learned more and more about what it takes to create a successful website. The website came along nicely and before long I had designed a website that I was happy with and my coworkers liked as well. Not everything went smooth however, I ran into a couple brick walls while trying to setup applications to enhance the website. I tried implementing a CMS (content management system) that can track articles submitted to the website either by TransPAC2 personnel, or by an internet user. The CMS would also provide blogging to the website and other neat features to enhance the site. The problem was that each CMS that I researched required a module that needed to be running on the web server in order for the CMS to function properly. I still plan on setting up a CMS for the TransPAC2 website. I think it would add a lot of functionality to the site.

One day in July, Jim Williams and I visited the Global NOC (Network Operations Center) located in the new Communications Technology Complex in Indianapolis, IN on the IUPUI campus. This also happens to be where the IUPUI Informatics building is located. While there I was shown how the Abilene network better known as Internet2 and other project networks are monitored for outages and problems. I saw how the ticketing system that is in place is used to efficiently report outages and problems to the proper personnel so that they can quickly be resolved. The NOC constantly has nice looking

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[138] http://www.magnumdrillingservices.com

charts and graphics showing the status of the network displayed on gorgeous big screen TV's/monitors.

Each summer job that I held while in college I enjoyed more than the job from the previous summer. Two summers ago I worked in a metal factory which was about the best motivation I could have ever received telling me to do well in school. Last summer I worked the grave yard shift as a janitor at a river boat casino, which was fun but I didn't enjoy the work. This summer I had a great job, with great people, doing work that I really enjoyed working on the TransPAC2 project. The experience gained is invaluable to me, and the work I was able to do is closely related to my Business Informatics undergraduate degree.

D.1.b Mark Casey's REU Report, 2005

Mark Casey concluded his time as a REU intern in the Fall 2005. During that time, he was responsible for the *2005 TransPAC Final Report.* The official TransPAC project concluded in April of 2005, and it was Mr. Casey's duty to report on the success and overall progress of the TransPAC project for the National Science Foundation, as well as to report on the plans for the TransPAC2 network, a continuation of the TransPAC project, already in progress at Indiana University. His report follows:

In the summer of 2005, I was given an incredible opportunity to work with the TransPAC project at Indiana University. My assignment was a huge undertaking—I was to compile, as best I could, the last eight years of research, engineering and development on the project into one large final report, to be turned in to the National Science Foundation. It was a chance to work in a highly specialized area—one in which I had little experience—and work independently on something that was sure to be lasting and valuable for the information technology community here at IU, and perhaps even the international community.

The project shifted several times from what I had originally planned, and gave me extremely valuable experience writing for deadlines, working with a tight-knit staff, writing professional business and technology communications, general writing and editing, as well as how to independently motivate myself and my team into getting necessary tasks done by certain deadlines.

As I said, high speed international networking wasn't an area in which I had a great deal of experience, and working with TransPAC as part of the Research Experience for Undergraduates program taught me more than I would ever have guessed about not only the nature of the international research and education community, but also how to quickly adapt and utilize new information, crafting it into unique and new output on the same subject matter.

The most important thing I learned as part of the TransPAC team was the emphasis on teamwork required in most professional environments. Too often, I feel that students are taught through their whole lives that they have to learn how to do everything themselves and for their career they have to be the best there is and not to expect anyone else's help. Working with TransPAC taught me how flawed this view is, and as I watched the team work together throughout the summer, as well as their interactions at the weekly team meetings, I learned that no one here—including me, my bosses and Chad Kotil, the other intern—would be able to effectively do our jobs without each other.

This summer I learned to tackle daunting goals in short amounts of time. I was expected to work independently, and I was trusted to do the job I was being paid to do without someone checking up on me every day. With all the emphasis on independent motivation, however, the ultimate message of working in a professional environment was never lost on me: you have to be able to depend on who you work with, as well as who you work for, or else you won't be able to do your own job as well as you can. I demonstrated this principle flawlessly nearly every day, and working with the project was the experience of a lifetime.

D.1.c Luke Fowler's REU Report, 2002

In the winter of 2002 Luke Fowler completed his time as a National Science Foundation Research Experience for Undergraduates (REU) intern on the TransPAC project at IU Bloomington. At the conclusion of his work on the TransPAC project, Mr. Fowler wrote the following about his experiences:

My experience in the REU position for the TransPAC project exceeded my expectations, affording me a wonderful opportunity to greatly expand my knowledge and skills pertaining to wide area computer networking. Most of my work involved data collection and presentation of time series network usage data.

My main project during the REU experience was the development of an application called SNAPP (SNMP Network Analysis and Presentation Package).[139] SNAPP is a tool that can be used to measure any time-series statistics available though the Simple Network Management Protocol (SNMP). SNAPP was designed to allow collection of statistics with a fine degree of granularity, supporting very short intervals between data points. SNAPP was also designed with a flexible Web-based front-end to allow for easy and sophisticated presentation of data collected. As part of my REU experience, I was able to attend an Internet2 Joint Tech's meeting in Boulder, Colorado where I made a presentation to the Measurement Working Group about this software.

SNAPP consists of two pieces: a high-speed, multi-threaded application written in C to collect data, and a Web-based front end system written in Perl. Data is stored in Tobi Oetiker's Round Robin Database format.[140] SNAPP's front end allows users to easily view the data they wish to see, in a very flexible manner. Users of SNAPP are able to tailor data presentation to a desired time period, down to the minute. They can also group graphs together into useful sets and review these sets of graphs each time they use the software.

Another project during my REU tenure was a modification of Indiana University's Animated Traffic Map software to support data storage via Tobi Oetiker's RRDtool software. This work was used to implement an animated traffic map for the TransPAC network.[141] This map uses the SNAPP data collector, with the Weathermap+RRD front end.

This animated traffic map software was also modified to allow for graphical display of the status of a set of clusters in a grid computing environment. Each of the cluster's computers is monitored by monitoring software known as Nagios. This Nagios monitoring data is used as input to the animated traffic map software. Each cluster in the

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[139] http://loadrunner.uits.iu.edu/dist/
[140] http://rrdtool.eu.org
[141] http://loadrunner.uits.iu.edu/weathermaps/transpac/

grid is represented as a dot on the animated traffic map. As individual computers in a cluster report problems (such as disk too full, CPU utilization too high, RAM usage too high, etc.) the color of the dot associated with the cluster changes. Problems are split into two categories: warnings and critical. The animated traffic map software can be configured to respond differently to a Nagios warning than to a Nagios critical. This map would allow NOC personnel to get an overview of the status of the entire grid through a single graphical representation. This software also supports viewing of a cluster's status over time, separated into total number of warning events and total number of critical events.

I also implemented a data collector and front-end for viewing data stored in Juniper Networks' *Destination Class Usage* MIB. *Destination Class Usage* can be used to attain separate packet/octet counters on a router based on their ingress and egress points. For example, I could get counters for all data traveling from network A to network B, network A to network C, and network A to network D. Using my software, all this data can be combined into a single meaningful graph. This software can access data both through the SNMP protocol and through Juniper's JunOScript XML/RPC interface.[142]

As part of my work experience, I was able to work with several excellent TransPAC engineers at Indiana University. My exposure to the TransPAC high-speed research network afforded valuable experiences which would be hard to attain in any other work environment. I have consistently been exposed to a variety of fascinating, cutting-edge networking technology.

D.2 Research Experience for Undergraduates: Program Conclusions

As is clearly evident from the collected NSF reports, the interns exceeded their mandates as students under the REU program by becoming productive members of the TransPAC staff. The REU program's flexibility allowed the TransPAC team to grant opportunities to students in more areas of experience than might originally be considered, prepared the students for their professional lives and even opened up entirely new possibilities for the TransPAC project itself.

The TransPAC team learned the extent of the REU program's possibilities after the conclusion of Mr. Fowler's term as an undergraduate intern. His performance far surpassed both his expectations and the expectations of those he worked with, and he was consequently hired in a more permanent capacity after his graduation in spring 2003. Due to the experiences he shared with the TransPAC project as part of the Research Experience for Undergraduates, he was able to find a comfortable place with the project upon entry into the workforce, and the project was able to hire someone trustworthy, with extensive experience regarding TransPAC and Global NOC procedures, duties and expectations.

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[142] http://trails.uits.indiana.edu/~traffic/gigapop/

Appendix E. Statistical Data for Global NOC and TransPAC Trouble Tickets

E.1. Global NOC Statistics

E.1.a. Distribution of Trouble Tickets

The Table and Figure below show the ticket distribution for all networks supported by the Global NOC.

Network	# of Tickets
STAR TAP	397
AMPATH	188
TransPAC	253
Total	838

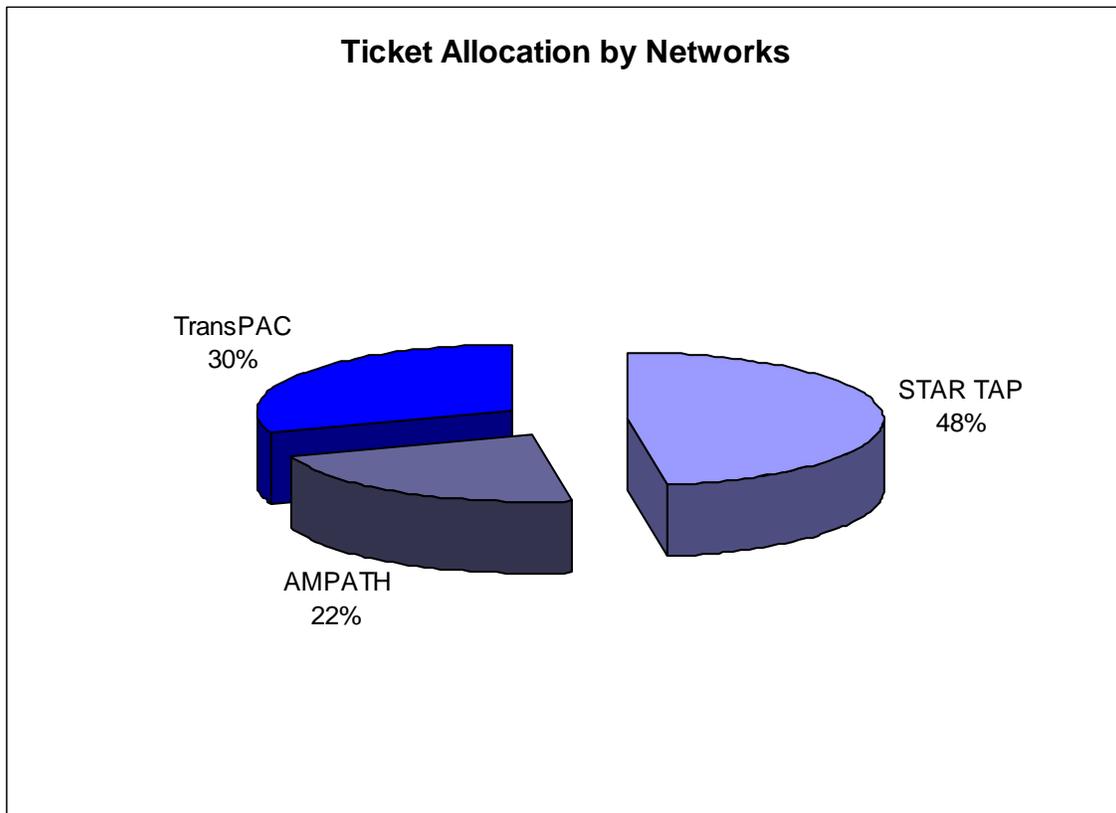**Table 1: Ticket Allocation by Networks**

Figure 10: Ticket Allocation by Networks

E.1.b. Unscheduled Outages

The Table and Figure below show the distribution of unscheduled outages for the networks supported by the Global NOC.

Network	# of Tickets
STAR TAP	120
AMPATH	101
TransPAC	62
Total	283

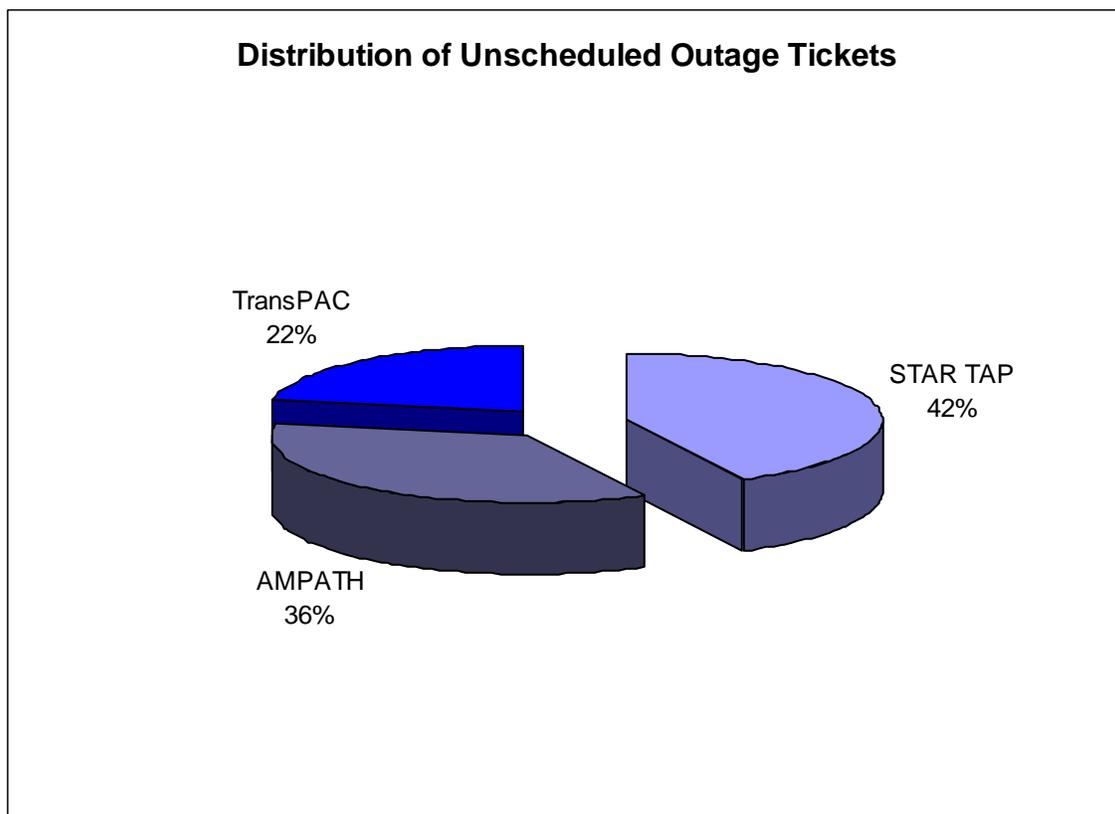**Table 2: Distribution of Unscheduled Tickets**

Figure 11: Distribution of Unscheduled Tickets

E.2. TransPAC Statistics

E.2.a. Distribution of TransPAC Trouble Tickets

The Table and Figure below show the distribution of TransPAC trouble tickets by type.

Type	# of Tickets
Problem	11
Request	8

Scheduled Maintenance	156
Tracking	16
Unscheduled Outage	62
Total	253

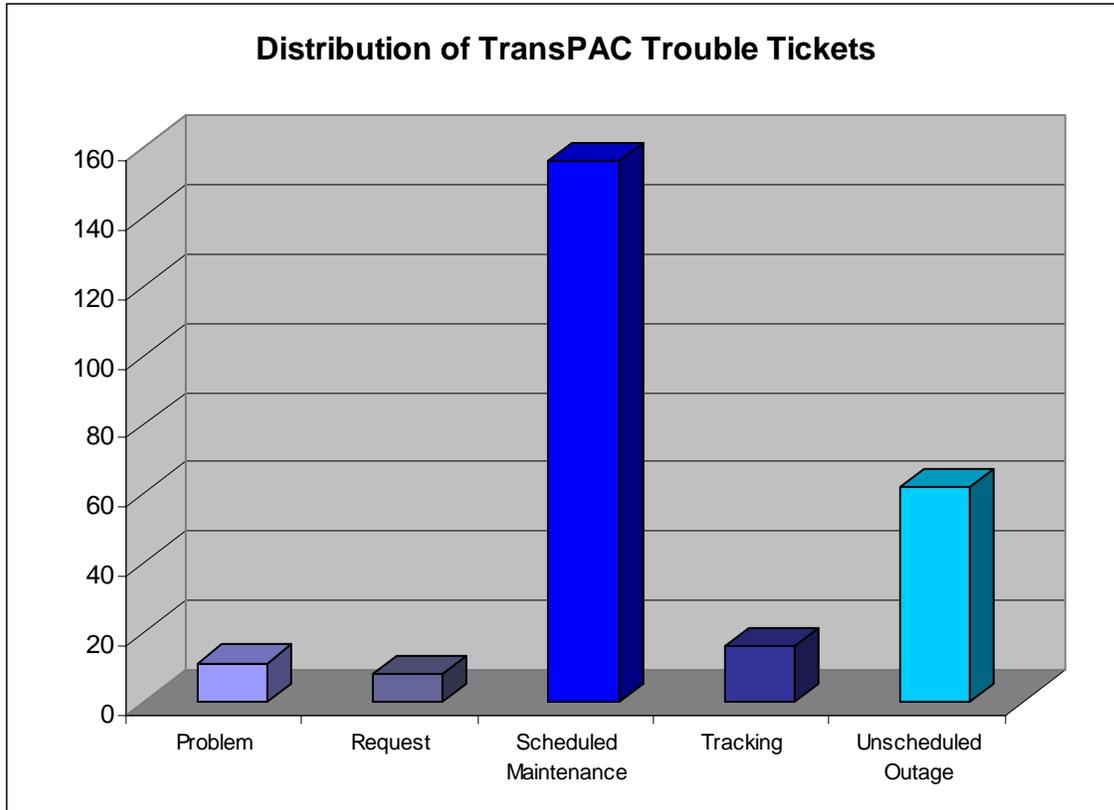**Table 3: Distribution of TransPAC Trouble Tickets**

Figure 12: Distribution of TransPAC Trouble Tickets

E.2.b. TransPAC Trouble Tickets by Reason

The Table and Figure below show the distribution of TransPAC tickets by reason.

Type	# of Tickets	% of Tickets
Circuit	23	37%
Hardware	6	10%
Software	4	6%
Undetermined	29	47%
Total	62	100%

Table 4: TransPAC Trouble Tickets by Reason

100

TransPAC Unscheduled Outage Tickets by Reason

Undetermined — 47%
Software — 6%
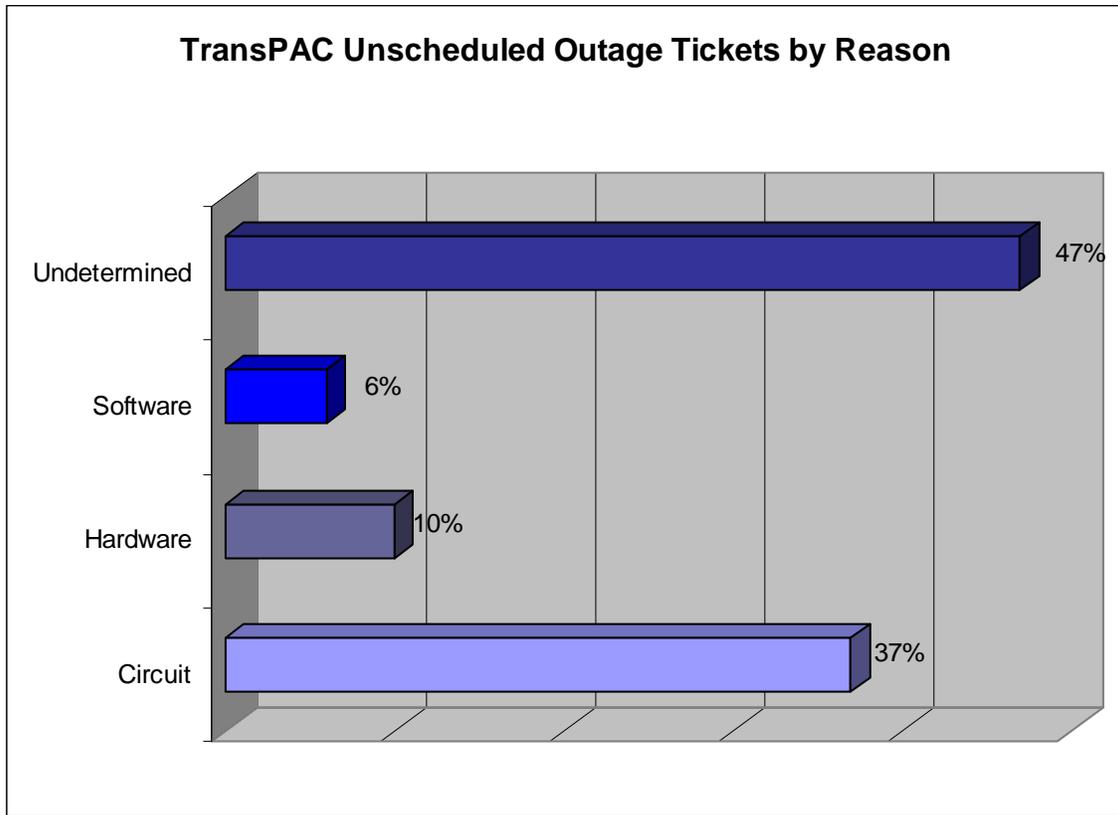Hardware — 10%
Circuit — 37%

Figure 13: TransPAC Trouble Tickets by Reason

E.2.c. TransPAC Unscheduled Outages

The Tables below show the breakdown of unscheduled outages reflecting downtime of the TransPAC network.

# of Outages in Minutes	TransPAC
10<	**30**
30<	**7**
60<	**3**
120<	**6**
240<	**9**
480<	**4**
960<	**2**
4800<	**1**
Total	**62**

Table 5: TransPAC Unscheduled Outages

Southern (TPR2)	1	13
TransPAC-Chicago OC-48	19	2628
JGN2-Chicago OC-192	20	5010
TransPAC-Los Angeles	17	665
TransPAC2-Los Angeles OC-192	3	732
Total	62	9059
Route	Occurrence	Total Downtimes (in Minutes)
Northern (TPR3)	9	1547
Southern (TPR2)	5	349
Total	14	1896

Table 6: By Northern and Southern Routes

Year	Unscheduled Outage Tickets	Total # of Tickets
2001	13	19
2002	19	66
2003	15	85
2004	22	118
2005	40	135

Table 7: Comparison by Year

Appendix F. Credits

Production

The 2005 TransPAC Final Report is produced by:
University Information Technology Services Communications and Planning Office
Office of the Vice President for Information Technology and CIO
Indiana University

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Illustrations

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Special thanks to STAR TAP, APAN, and Pacific Wave

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Funding

Intellectual Property