TransPAC4
Award #1450904
Year 5 Quarter 2
1 Mar 2019 through 31 May 2019

Jennifer M. Schopf, Hans Addleman – Principal Investigators

Summary
The TransPAC project supports circuits and services for the use of 100G networks between the US and Asia, with a focus on measurement and end user support. Year 5 Quarter 1 highlights include signing an MOU with the Academica Sinica Grid Computing Centre (ASGC), putting in place an LHCONE Virtual Routing and Forwarding (VRF) in Hong Kong to better support high energy physics, using the NetSage tool for our flow reporting, and additional science engagement based on our MOUs.

1. TransPAC Overview
The TransPAC project supports three circuits and their associated network services between the US and Asia. The TransPAC-PacWave 100G circuit is a 100 Gbps link between Seattle, Washington, and Tokyo, Japan. This circuit has been in production since February 2016 and is the primary project circuit for production traffic for TransPAC4. This link is fully supported by NSF and is managed in cooperation with Pacific Wave and Pacific Northwest GigaPop (PNWGP). We also support two 10 Gbps circuits between Guam and Hong Kong that have been in production operation since September 2018.

The TransPAC circuits are used to support a wide variety of science applications and demonstrations of advanced networking technologies. In addition, the TransPAC award supports science engagement, experimental network research, measurement deployments, and security activities.

2. Staffing
At the beginning of Year 5 Quarter 2, project staff included:

- Jennifer Schopf, IN@IU Director, TransPAC4 PI
- Andrew Lee, Network Analysis, TransPAC4 co-PI
- Hans Addleman, Primary TransPAC Network Engineer
- Edward Moynihan, Science Engagement Specialist
- Scott Chevalier, perfSONAR and Training
- Doug Southworth, perfSONAR and Training
- Heather Hubbard, Project Support

During this quarter, Lee decided to pursue a network engineering job with the GlobalNOC. When he left the IN@IU team, he also stepped down as the co-PI for TransPAC4. We are in the process of making Addleman the new co-PI. Chevalier will be picking up some of the coordination work previously performed by Lee. In Quarter 3, Southworth will begin to extend the analysis work that Lee previously started. This quarter we also funded Antoine Delvaux as a consultant for perfSONAR training in Laos.

3. Conference and Workshop Travel

TransPAC staff participated in various meetings to support their role in collaborations in Asia. Some of these trips were funded by sources other than TransPAC. The travel for Quarter 2 included:

- Schopf attended the Internet2 Global Summit, Washington DC, March 5-8, https://www2.internet2.edu/e/66332/l-66332-2018-11-01-blhxn4/blhzx2/366390041. Schopf spoke as part of the Global 100G infrastructure session and also attended the IRNC PI meeting.
- Chevalier, Delvaux, and Southworth led a 3-day perfSONAR workshop, March 6-8, with host National University of Laos (NOUL), Vientiane, Laos, sponsored by Asi@Connect, http://www.tein.asia/sub/index.php?page=1&mc=6030&idx=2290&a=view. In total there were 22 participants representing NRENs and Universities from Laos, Cambodia, Thailand, and Vietnam.
- Schopf attended the Coalition for Network Information (CNI) Spring Meeting and Campus Research Computing Consortium(CARCC) workshop, St. Louis MO, April 8-10 https://www.cni.org/event/cni-spring-2019-membership-meeting. While there, she met with current ESIP president, Dr. Karl Benedict, to discuss collaborations for earth sciences in Asia.
- Chevalier and Southworth attended the Spring perfSONAR Developer Face-to-Face Meeting in Bloomington, IN, May 20-22. It is during these twice-yearly meetings where the perfSONAR development team plans for the year ahead in development.

Presentations this quarter included:

- Schopf, Jennifer, “TransPAC and the Asia Pacific Ring”, Invited Panel Presentation, Internet2 Global Summit, March 7, 2019. Session webcast available at https://meetings.internet2.edu/2019-global-summit/detail/10005421/
- Chevalier, Scott, Southworth, Doug, and Trocha, Szymon, “perfSONAR Training and Documentation”, presentation at the perfSONAR Spring Face-to-Face Meeting, Bloomington, IN May 20-22, 2019, available online at https://docs.google.com/presentation/d/1X4NApyHdJomURja5v9vjSjZvyTgmIAoaKLFZoQCAw6g/edit#slide=id.p1

4. Collaborative Activities

4.A Collaborations with IRNC Partners

Collaboration with the IRNC AMIS awardee, NetSage, continued. NetSage is currently capturing ongoing NetFlow, SNMP, and perfSONAR data for TransPAC. Live network statistics from TransPAC can be viewed on the NetSage portal at https://portal.netsage.global/grafana/dashboard/db/bandwidth-dashboard?refresh=1d&orgId=2. We are now using the NetSage dashboards for our reporting tables and graphs, as well as for part of our analysis work.

In Quarter 2, we continued working with the NetSage staff to populate the Science Registry with flows tagged by science domain, project, location, and educational institution endpoints, focusing on the TransPAC Top Ten Talkers list. In Quarter 2, the collection threshold for flow data in NetSage was lowered to 1M and the data used in this and future quarterly reports will reflect that change.

We maintained a close collaboration with Pacific Wave, not only through our joint support of the TransPAC-PacWave 100G circuit but also through bi-weekly calls to coordinate activities to ensure that our services and resources are complementary. This collaboration in part has also led to additional engagement between our group and the Pacific Research Platform (PRP) and ESnet. During Quarter 2, we started to plan for SC19 and how best to use and configure the 100G circuit for the proposed experiments from NICT and SINET.

At the Trans-Pacific R&E (TPRE) Network meeting in January, the Guam Open Exchange, GOREX, announced a potential downtime this summer during a possible site move. This has now been pushed to the end of 2019.

The IRNC NOC provides Tier 1 support services including monitoring the state of the trans-Pacific circuits and the equipment installed in Seattle and Hong Kong. TransPAC contracts with the IU GlobalNOC to supply Tier 2 and Tier 3 services.

4.B Collaborations with Asian Partners

We continue to build valuable collaborations with international partner organizations around the world. In Quarter 2, this included:

- **Academica Sinica (ASGC):** On April 29th, we signed an MoU with Academica Sinica Grid Computing Centre (ASGC) that formalizes our partnership and lays out areas of future collaboration, including partnering on application support and science engagement.
- **China Education and Research Network (CERNET)**: We continued discussions with CERNET to resolve the routing issue found last quarter where traffic between China and Korea is directed through the US. We worked with CERNET and the University of Hawaii to allow routing changes based on BGP community strings. A deeper investigation of the routes also showed AS path padding as an issue. Addleman will continue to work with CERNET in the next quarter to try to get these issues resolved.

- **Philippine Research, Education, and Government Information Network (PREGINET):** We established a new IPv4 peering with PREGINET in Hong Kong. They are not interested in IPv6 peering at this time.
- **Collaboration Asia Europe-1 (CAE-1):** CAE-1 is a consortium of six research and education (R&E) networks: AARNet (Australia), GÉANT (Europe), NORDUnet (European Nordics), SingAREN (Singapore), SURF (Netherlands) and TEIN*CC/Asi@Connect (Asia-Pacific). They have collaborated to funds and support a 100G circuit from Singapore to London that went live in May. The official launch event will be held next quarter at the TNC19 conference.
- **Kenjiro Yamanaka, National Institute of Informatics (NII):** Yamanaka is preparing a MMCFTP demonstration for TNC19 next month. This experiment will use multiple international links to showcase the performance of the new protocol in an ultra-long latency environment. Preparatory discussions to determine the best network path took place on the ANA engineering call and the Pacific Wave coordination calls. It is expected that Yamanaka will perform a similar demonstration for SC'19.
- **Global Lambda Integrated Facility (GLIF):** International Networks at Indiana University is a sponsor of GLIF. We also participate in the Global Network Architecture Technical Working Group (GNA-Tech). Discussions continued in Quarter 2 on how to successfully merge these two groups. A face-to-face meeting is planned for June 2019 in conjunction with TNC19.

In Year 4, we received partial funding from Asi@Connect (operated by TEIN*CC) to oversee two perfSONAR Training Workshops for participants from the TEIN-defined "Lower Middle Income Countries" that have not previously had access to dedicated perfSONAR training. These workshops are important to US researchers collaborating in these regions, as we will have better information about the state of the networks and will be able to troubleshoot both network and file transfer issues more effectively. The funding from Asi@Connect supports in-region participants to travel to the workshop sites, local workshop expenses, and a small amount of equipment. The first workshop took place in Laos on March 6-8. The second one is scheduled for July 8-10 in India. This work is detailed in Section 6.C.2.

4.C Science Engagement

4.C.1 High Energy Physics

We continue to participate in the LHCONE overlay network in support of LHC-related computing centers in the US and Asia. For the last year, TransPAC has provided the connectivity from Tokyo to Seattle to close the loop from NICT's LHCONE VRF in Hong Kong (which runs via the NICT funded 100G from Hong Kong to Tokyo) to ESnet's LHCONE VRF in Seattle.

In Quarter 2, we began the process of turning up our own LHCONE VRF to extend the LHCONE over our two Guam-Hong Kong 10G circuits and then on to CONUS via PIREN. We also began working on adding a new peering with ESnet in Los Angeles (via

Guam) and on adding a peering with TEIN in Hong Kong. The VRF turn-up and new peering arrangements will be completed in early Quarter 3.

With the addition of the new LHCONE VRF, IN@IU will transition from being a LHCONE transit provider to being an official LHCONE Network Service Provider (NSP). This process included working with the community of LHCONE engineers to agree to adhere to the AUP for LHCONE NSPs (available online at: https://twiki.cern.ch/twiki/bin/view/ LHCONE/LhcOneAup) as well as the policies for filtering routes and packets for the directly connected compute centers (available online at: https://twiki.cern.ch/twiki/bin/view/LHCONE/LhcOneHowToConnect). Official administrative and technical contacts for all LHCONE-related issues were submitted as well. Our LHCONE VRF application was formally approved by the LHCONE community and our VRF information is now part of the LHCONE wiki (available online at: https://twiki.cern.ch/twiki/bin/view/LHCONE/LhcOneVRF).

LHCONE traffic that is part of a VLAN or VRF is included in the SNMP data (detailed in Section 6.A) but not included in the flow data graphs (shown in Section 6.B), as we do not collect flow data on VLANs. The energy science-related traffic shown in the flow data graphs is being transported outside of the LHCONE VLAN or VRF.

Our partners at NICT currently provide us with usage statistics for the Hong Kong - Seattle LHCONE VLAN, which is shown in Figures 1 and 2. There was an outage on the Hong Kong-Tokyo 100G link that is part of this VLAN starting on May 5 (Week 19), so NICT supplied us with two graphs, one showing the standard route and one showing the detoured route during this frame, although collected with a slightly different tool so that the axis are labeled differently. We do not currently have a way of collecting per VLAN data for the Guam-Hong Kong circuits, but we are working with our partners to identify a way to measure this traffic as well.

We also continue to participate in discussions within the LHCONE community on a proposal that would allow the Belle-II experiment in Japan to use the LHCOPN and LHCONE networks to transfer data. These discussions will continue at the upcoming LHCONE meeting in June.

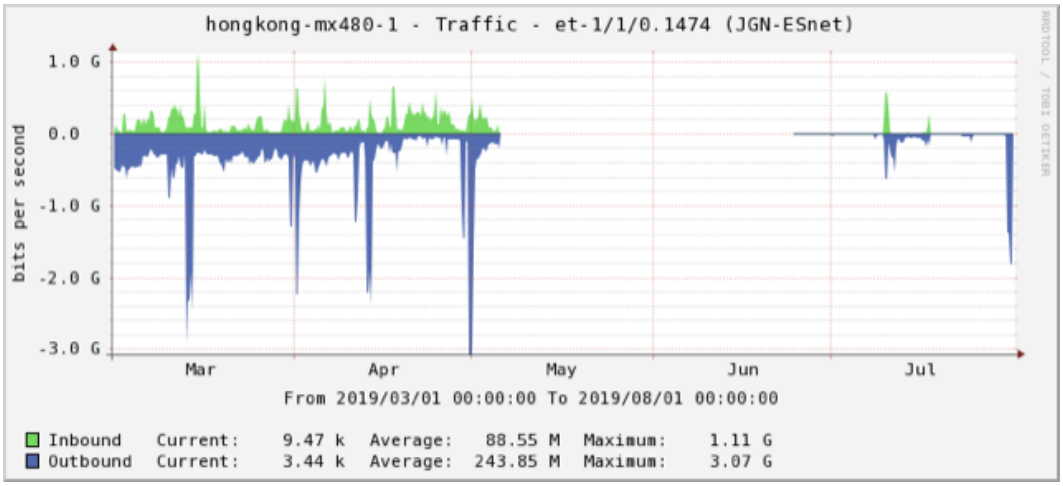

Figure 1: Use of the LHCONE VLAN that includes the TransPAC-PacWave 100G circuit. There was an outage on the Hong Kong-Tokyo 100G link that is part of this VLAN starting on May 5, so the VLAN was remapped until that link became operational again in June.

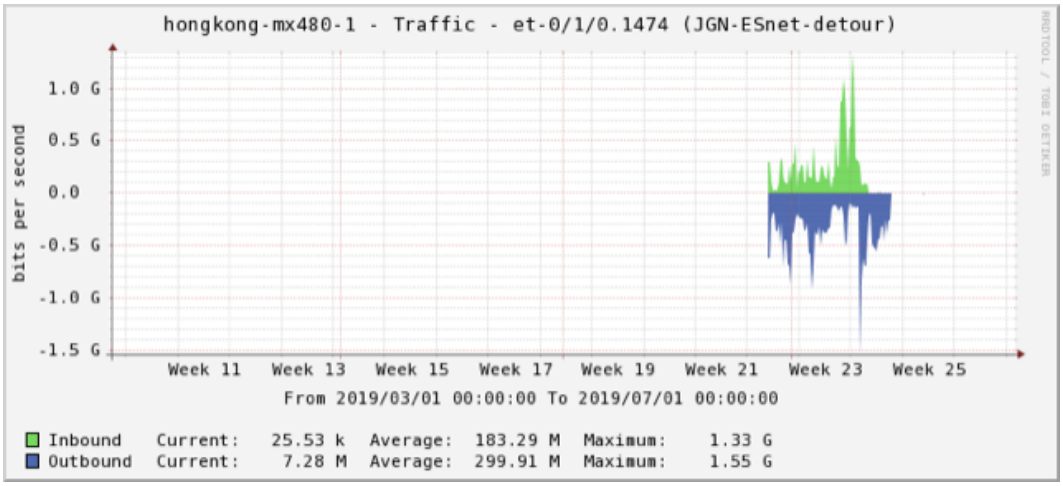

Figure 2: Use of the LHCONE VLAN that includes the TransPAC-PacWave 100G circuit during the outage of the standard mapping of the VLAN (shown in Figure 1).

4.C.2 Geoscience/Climate

We continued our efforts in Quarter 2 to target the US geoscience community. We worked with NASA representatives to identify atmospheric science traffic on TransPAC and to tag these flows in the NetSage Science Registry. Schopf met with Benedict, ESIP president, in April to discuss ongoing collaborations. TransPAC staff worked with the Engagement and Performance Operations Center (EPOC) to follow-up on engagements from the Earth Science Information Partners meeting in Quarter 1, including reaching out to Yunsoo Choi from the University of Houston to invite him to an EPOC deep-dive workshop hosted by the Lonestar Education and Research Network (LEARN). Finally, we continued our collaboration with Dr. Tho Nguyen from the University of Virginia (UVA) and Dr. Richard Keim from Louisiana State University (LSU) in support of data sharing between US and Vietnamese water and water-related research collaborations in the Lower Mekong region.

4.C.3 Other Science Engagement

In Quarter 2, we worked with many of our MoU partners to try to accelerate our science engagement efforts. These included:

- **Buseung Cho (KISTI):** A discussion was had to share potential engagement outreach targets, including a genomics collaboration Cho believes is sending large amounts of data to the US. We are working with KISTI and using NetSage tools to try to find out more about this collaboration.
- **Jennifer An (CERNET):** We discussed renewing our efforts to work together with the Bioinformatics community on a future workshop. These conversations will continue in Quarter 3.
- **Justin Yung Kwok (JUCC):** Kwok contacted us about the Hong Kong University of Science and Technology (HKUST)-MIT Research Alliance Consortium (http://hkust-mit.consortium.ust.hk/). One of the teams in this consortium is researching distributed Internet of Things sensors and is looking to improve the latency on their current connections between Hong Kong and Boston. We are working with JUCC and using NetSage to determine if we carry any of their data and determine if there's anything we can do to help them.
- **Guam EPSCOR researchers and GOREX:** The University of Guam (UG) is interested in hosting a Science Engagement Deep Dive workshop. We began planning this workshop in Year 4 but determined with UG that more participation would be likely if we moved the workshop to a later date. We are currently working with UG to determine next steps. The former CIO leaving Guam this past spring has complicated this situation. Follow-ups from these discussions and further researcher engagement efforts will take place in Quarter 3.

We continued our participation in several international science engagement and coordination projects including GEANT's Task Force on Researcher Engagement, the Pacific Research Platform, PRAGMA, the perfSONAR consortium, and the Joint Engineering Team (JET).

Finally, in Quarter 2 we began a more targeted and domain specific approach to our science engagement efforts by looking more closely at astronomy traffic on the TransPAC circuits. Working with NetSage tools, we looked at top talkers sending Astronomy data across our circuits and at network performance for these endpoints. We will use this information to inform our future outreach efforts and to gain greater insight into how the astronomy community is using IN@IU resources.

5. Circuit Deployments and Technical Updates

5.A Technical Updates for the TransPAC-PacWave 100G Circuit

No technical or engineering work was performed on the 100G circuit this quarter.

Prior to this Quarter, the NetSage project discovered that the Tstat TCP analysis software package they had been using to collect unsampled flow data on the TransPAC-PacWave 100G circuit could not collect any data traffic with asymmetric routes, which meant the bulk of the traffic on the circuit was not included. Because of this, we are in the planning

process to remove the Tstat server that is deployed in Seattle to return it to IU for repurposing.

5.B Technical Updates for the Guam-Hong Kong Circuits

During this quarter, the IPv4 peering with the Philippine Research, Education, and Government Information Network (PREGINET) was completed. They declined at this time to setup an IPv6 peering. Work continued with the China Education and Research Network (CERNET) to improve their routing policy to enable Hong Kong traffic to Asian endpoints stay within Asia instead of transiting to the United States and back. We also started engineering work to extend the LHCONE VRF instance to the TransPAC Hong Kong router.

6. Circuit Status and Performance

For both the TransPAC-PacWave 100G circuit and the two 10G circuits between Guam and Hong Kong, we currently collect sampled flow data, SNMP data, and perfSONAR data.

6.A. SNMP Traffic Graphs

Figures 3 and 4 show the SNMP data for the traffic on the TransPAC-PacWave 100G Circuit during Quarter 1. The consistent, large spikes seen in Figure 3 and 4 outbound (orange) are ongoing Very Long Baseline Interferometry (VLBI) data from Italy to Japan. Smaller spikes are mostly ongoing data transfers between the Atacama Large Millimeter Array (Chile) and the National Astronomical Observatory of Japan (NAOJ) via WIDE. Figures 5 and 6 show the SNMP data for the traffic on the two Guam-Hong Kong 10G circuits. They show a pronounced dip in traffic from April 3-11, which was the result of an outage of a HKOX VLAN that transits the HK-Guam TransPAC link. Table 1 shows that almost 3 petabytes of data were transferred over the TransPAC-PacWave 100G and the two 10G Guam-Hong Kong links during Quarter 2.

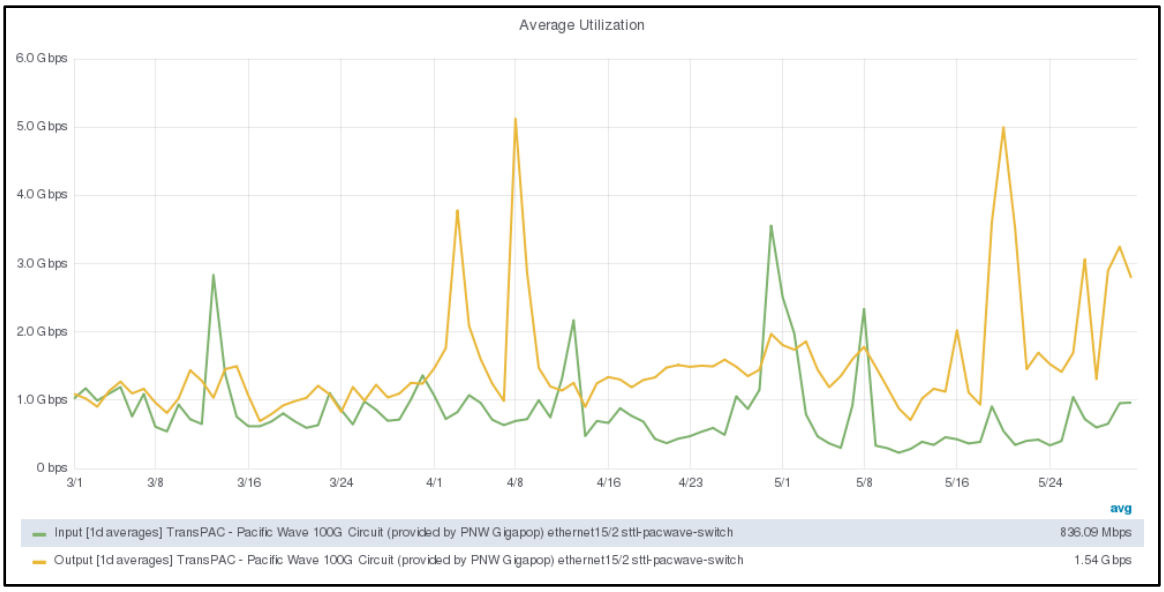

Figure 3: TransPAC-PacWave 100G circuit traffic using smoothed daily averages.

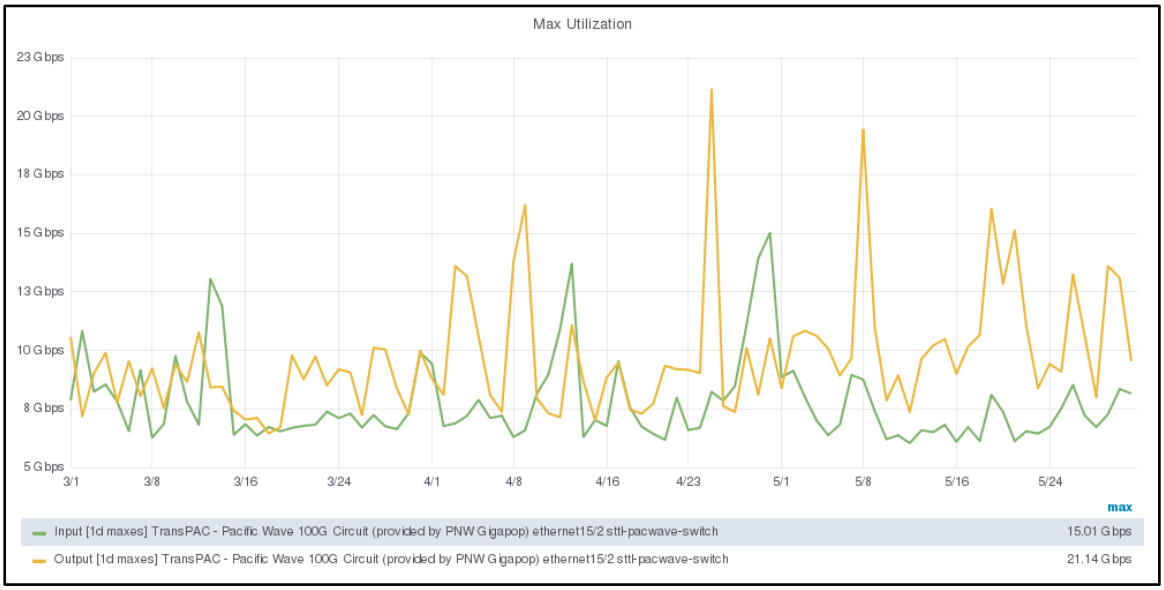

Figure 4: TransPAC-PacWave 100G circuit traffic using maximum daily averages.

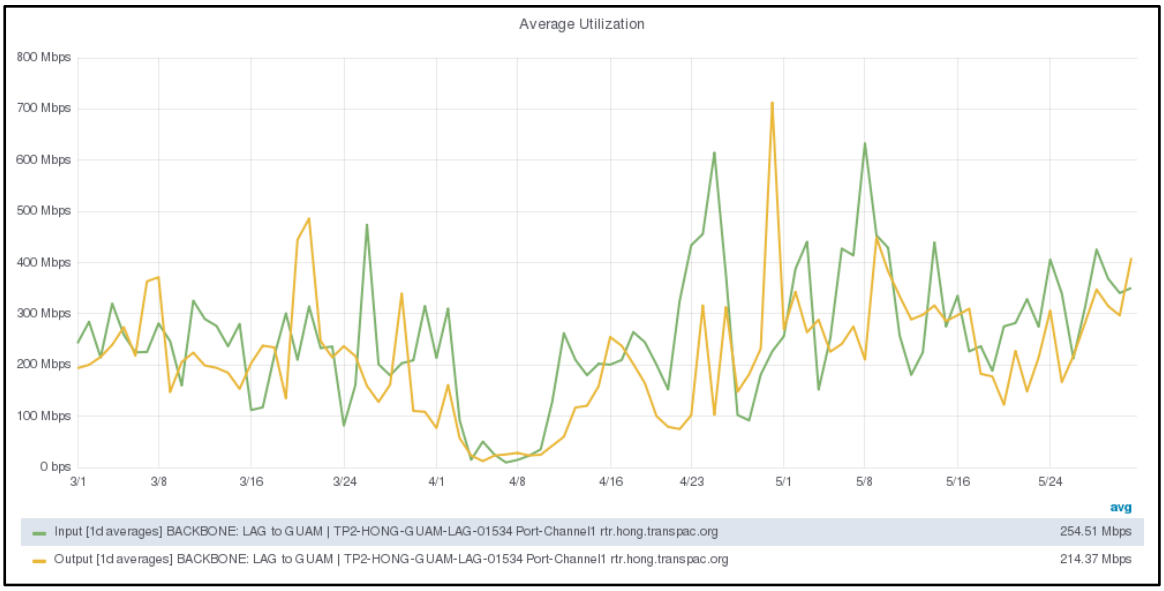

Figure 5: Traffic using smoothed daily averages for the two TransPAC Guam-Hong Kong 10G circuits.

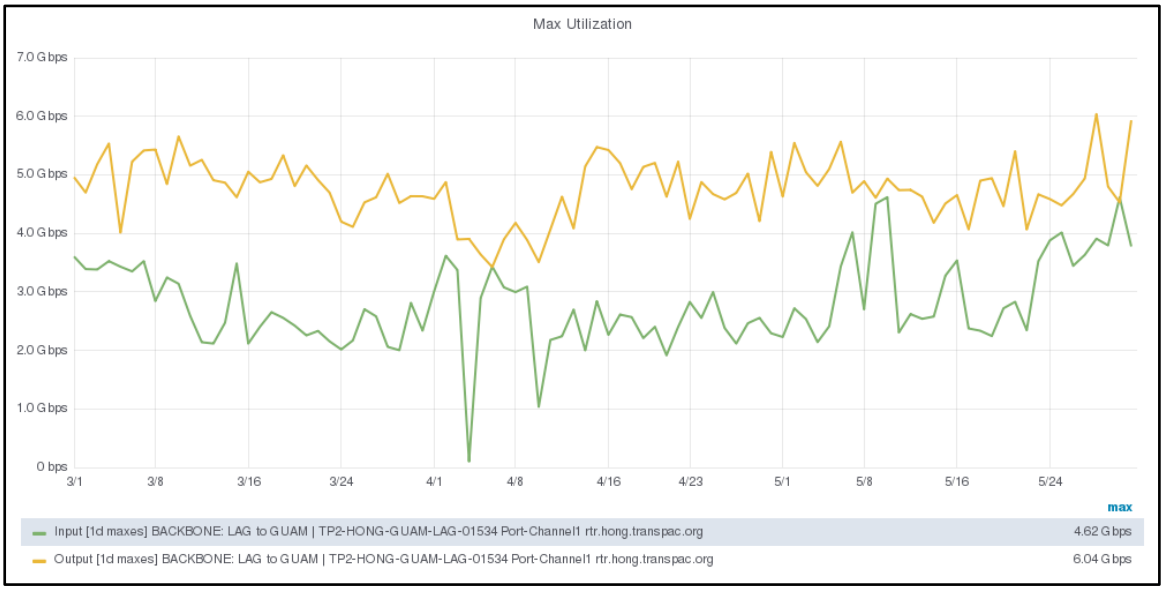

Figure 6: Traffic using maximum daily averages for the two TransPAC Guam-Hong Kong 10G circuits.

Table 1: Traffic in terabytes transferred over TransPAC links, March 1, 2019 - May 31, 2019.

Source-Destination	March	April	May	**Total**
Tokyo-Seattle	309.37	289.26	232.11	**830.74**
Seattle-Tokyo	365.66	539.06	622.51	**1,527.23**
Guam-Hong Kong	76.15	45.09	91.76	**213.00**
Hong Kong-Guam	80.30	63.21	109.37	**252.88**
Total	**831.48**	**936.62**	**1,055.75**	**2,823.85**

6.B Flow Data

Both the TransPAC-PacWave 100G circuit and the two 10G circuits between Guam and Hong Kong collect sampled flow data. De-identified versions of this data are also shared with the IRNC NetSage project.

Figure 7 and Table 2 show the Top 10 Talkers by source and Figure 8 and Table 3 show this data by destination for the TransPAC-PacWave 100G circuit. Table 4 shows the Top Talker pairs. Outbound from the US this quarter, VLBI data including the ongoing transfers between Italy and Japan continued to be the largest source of traffic. We also see significant transfers from ALMA in Chile to the National Astronomical Observatory of Japan (NAOJ) via WIDE. ALMA is one of the key sites in the Earth Horizon Telescope (EHT) international collaboration and has the largest collection area in the EHT collaboration that can generate up to 64 Gigabits/sec of data. Stanford University sent a large amount of data to a number of universities in China and Hong Kong, including the Hong Kong University of Science and Technology, the University of Hong

Kong, and the Chinese University of Hong Kong, many of which are aggregated under the China Education and Research Network Center (CERNET).

Inbound to the US this quarter, there were two Japanese institutions sending data to NASA that topped the list - the Earth Observation Research Center at the Japan Aerospace Exploration Agency and the Japanese National Institute of Informatics. Other inbound traffic and transit traffic to Europe mirrors outbound with a large amount of VLBI traffic. TransPAC staff is reaching out in the next quarter to discuss performance and offer assistance to VLBI end points. Also of note is an increase in the amount of traffic to Microsoft Corporation, specifically to their Azure Cloud platform, primarily from a set of universities in Indonesia. While traffic to Azure is normally present on TransPAC, this represents a considerable increase in transfers during Q2. We will be contacting staff at the Indonesia Research and Education Network (IDREN) to make sure they are aware that their universities are working with a cloud based in the US and not one in Asia.

Figure 9, Table 5, Figure 10 and Table 6 show the Top Talkers by source and destination, for the two TransPAC Guam-Hong Kong 10G circuits. Table 7 shows the Top Talker pairs. The top source of traffic this quarter was the Chinese University of Hong Kong, which had multiple large transfers with institutions including the University of Chicago, Brookhaven National Laboratory, Simon Fraser University, and Deutsches Elektronen-Synchrotron (DESY), so this is likely related to energy science research. Other notable sources of traffic are the University of Hawaii and NASA, which reflect the recent overall surge in astronomy and astrophysics traffic that tends to be the dominant traffic driver across Pacific and Atlantic R&E links. The traffic labeled Indiana University is related to the perfSONAR deployment in Hong Kong that uses the IU IP space, so NetSage maps that traffic source to the Indiana University ASN. Likewise, some of the University of Hawai'i traffic is to perfSONAR nodes in Guam. These tests give us proactive insights into the state of our network, but do not reflect traffic flowing from the state of Indiana through Hong Kong to the state of Hawai'i.

Top destinations on the Guam-Hong Kong circuits include Hong Kong University of Science and Technology and the University of Hong Kong, which show almost 500TB of data transferred, primarily in the astronomy and biomedical science disciplines. There were also significant transfers between universities in China and Hong Kong to several United Kingdom R&E institutions that are aggregated under JISC, as seen in Table 6.

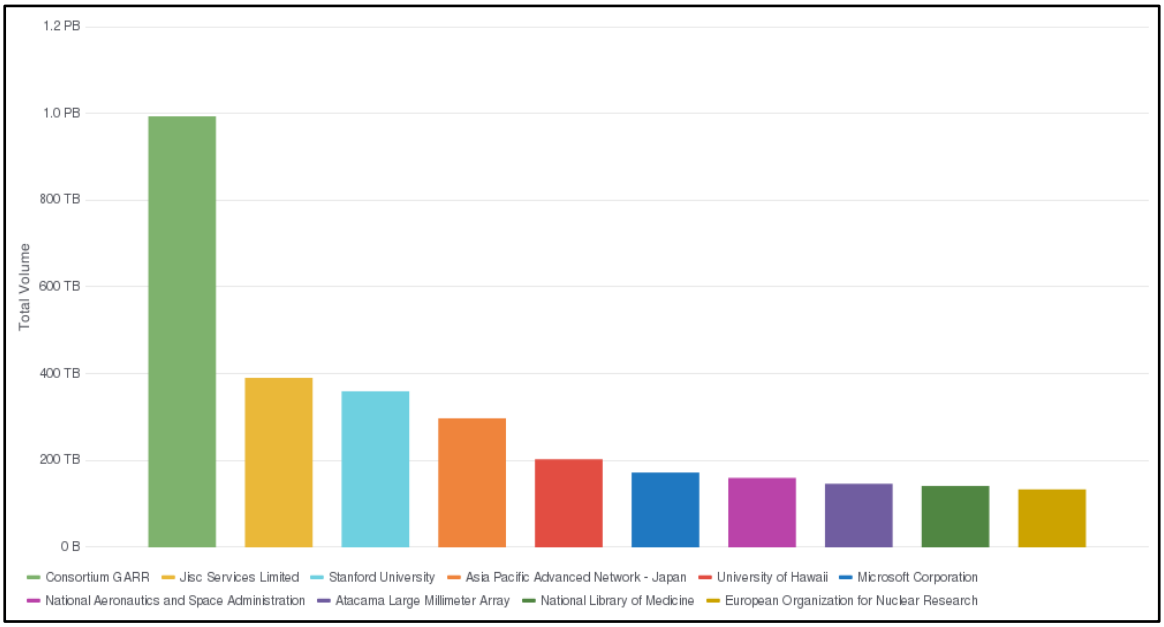

Figure 7: Top Ten Sources on TransPAC-PacWave 100G circuits, March 1, 2019 through May 31, 2019.

Table 2: Top Ten Sources on TransPAC-PacWave 100G circuits, March 1, 2019 through May 31, 2019.

Source	Total Vol.	Largest Flow	# Flows
Consortium GARR (IT)	993.3 TB	156.4 GB	369.2 K
JISC (UK)	390.5 TB	30.2 GB	3.0 Mil
Stanford University (US)	359.7 TB	16.4 GB	3.0 Mil
Asia Pacific Advanced Network (JP)	297.4 TB	24.7 GB	441.5 K
University of Hawaii (US)	203.0 TB	38.4 GB	68.6 K
Microsoft Corporation (US)	172.4 TB	8.7 GB	9.0 Mil
NASA (US)	160.0 TB	16.6 GB	1.2 Mil
Atacama Large Millimeter Array (CL)	146.4 TB	93.3 GB	1.2 Mil
National Library of Medicine (US)	141.3 TB	79.3 GB	1.1 Mil
European Organization for Nuclear Research (CERN)	133.5 TB	4.1 GB	1.6 Mil

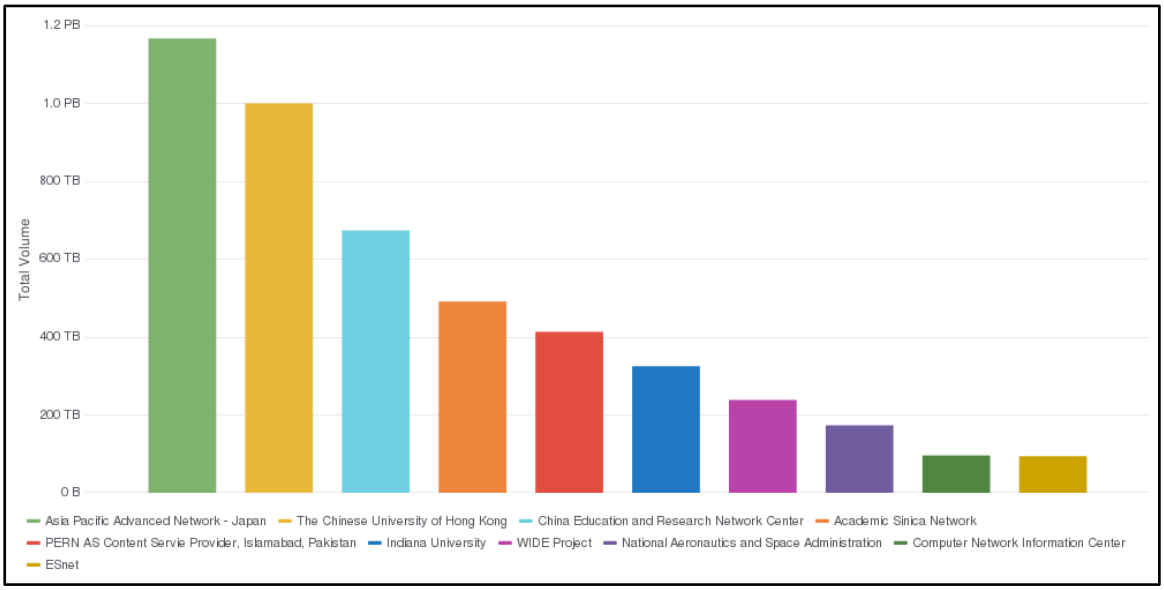

Figure 8: Top 10 Destinations on TransPAC-PacWave 100Gcircuits, March 1, 2019 through May 31, 2019.

Table 3: Top 10 Destinations on TransPAC-PacWave 100G circuits, March 1, 2019 through May 31, 2019.

Destination	Total Volume	Largest Flow	# Flows
Asia Pacific Advanced Network (JP)	1.2 PB	156.4 GB	589.1 K
Chinese University of Hong Kong (UK)	1.0 PB	37.2 GB	7.8 Mil
China Education and Research Network (CN)	673.5 TB	12.8 GB	7.4 Mil
Academica Sinica Network (TW)	491.3 TB	79.3 GB	4.0 Mil
PERN AS Content Service Provider (PK)	413.4 TB	7.6 GB	6.8 Mil
Indiana University (US)	325.0 TB	38.4 GB	70.7 K
WIDE Project (JP)	238.5 TB	93.3 GB	2.2 Mil
NASA (US)	173.3 TB	40.0 GB	1.6 Mil
Computer Network Information Center (KR)	96.0 TB	67.5 GB	323.5 K
ESnet (US)	94.0 TB	24.7 GB	23.4 K

Table 4: Top 10 Flow Pairs on TransPAC-PacWave 100G circuits, March 1, 2019 through May 31, 2019.

Source	Destination	Total Volume	Largest Flow	# Flows
Consortium GARR (IT)	Asia Pacific Advanced Network (JP)	952.1 TB	156.4 GB	34,112
Stanford University (US)	China Education & Research Network (CN)	271.0 TB	11.7 GB	2,356,224
JISC (UK)	Academic Sinica (TW)	198.7 TB	30.2 GB	1,118,030
University of Hawaii (US)	Indiana University (US)	178.5 TB	38.4 GB	20,594
Atacama Large Millimeter Array (CL)	WIDE Project (JP)	153.1 TB	93.3 GB	1,240,473
JISC (UK)	Chinese University of Hong Kong (HK)	153.1 TB	5.2 GB	1,389,864
European Organization for Nuclear Research (CERN)	Chinese University of Hong Kong (HK)	136.6 TB	4.2 GB	1,673,779
National Institute of Informatics (JP)	NASA (US)	111.0 TB	40.0 GB	588,518
Fermi National Accelerator Laboratory (US)	PERN AS Content Service Provider (PK)	110.7 TB	5.8 GB	580,320
NASA (US)	Asia Pacific Advanced Network (JP)	106.3 TB	5.7 GB	366,944

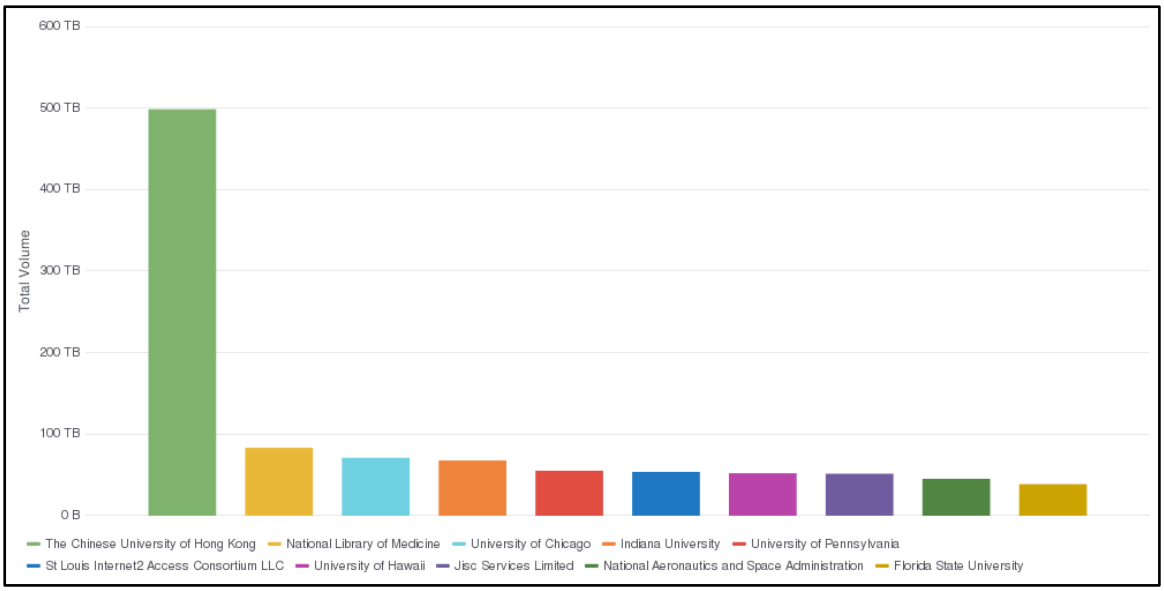

Figure 9: Top 10 Sources on TransPAC Guam-Hong Kong 10G circuits, March 1, 2019 through May 31, 2019.

Table 5: Top 10 Sources on TransPAC Guam-Hong Kong 10G circuits, March 1, 2019 through May 31, 2019.

Source	Total Volume	Largest Flow	# Flows
Chinese University of Hong Kong (HK)	498.5 TB	44.4 GB	1.8 Mil
National Library of Medicine (US)	83.4 TB	35.2 GB	275.0 K
University of Chicago (US)	71.1 TB	2.3 GB	240.1 K
Indiana University (US)	67.8 TB	13.7 GB	27.7 K
University of Pennsylvania (US)	55.2 TB	11.1 GB	122.5 K
St Louis Internet2 Access Consortium LLC (US)	53.8 TB	45.6 GB	4.0 K
University of Hawaii (US)	52.2 TB	12.0 GB	281.3 K
JISC (UK)	51.6 TB	32.6 GB	205.7 K
NASA (US)	45.3 TB	7.1 GB	489.0 K
Florida State University (US)	38.8 TB	3.0 GB	557.4 K

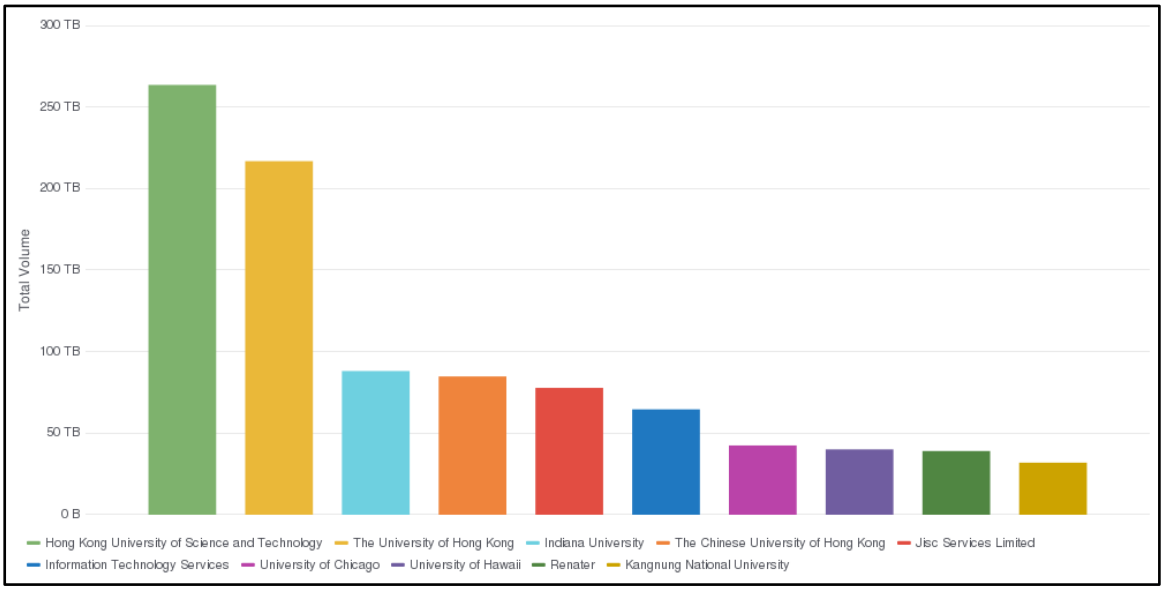

Figure 10: Top 10 Destinations on TransPAC Guam-Hong Kong 10G circuits, March 1, 2019 through May 31, 2019.

Table 6: Top 10 Destinations on TransPAC Guam-Hong Kong 10G circuits, March 1, 2019 through May 31, 2019.

Destination	Total Volume	Largest Flow	# Flows
Hong Kong University of Science and Technology (HK)	263.6 TB	32.6 GB	1.7 Mil
University of Hong Kong (HK)	216.8 TB	45.6 GB	930.2 K
Indiana University (US)	88.1 TB	18.5 GB	21.1 K
Chinese University of Hong Kong (HK)	84.8 TB	7.8 GB	284.6 M
JISC (UK)	77.8 TB	14.7 GB	275.2 K
Information Technology Services (HK)	64.6 TB	17.2 GB	495.4 K
University of Chicago (US)	42.5 TB	10.7 GB	248.4 K
University of Hawaii (US)	40.1 TB	12.2 GB	10.8 K
RENATER (FR)	39.1 TB	6.0 GB	136.4 K
Kangnung National University (KR)	31.9 TB	7.1 GB	114.0 K

Table 7: Top 10 Flow Pairs on TransPAC circuits, March 1, 2019 through May 31, 2019.

Source	Destination	Total Volume	Largest Flow	# Flows
Chinese University of Hong Kong (HK)	JISC (UK)	76.0 TB	14.7 GB	216,478
University of Chicago (US)	Hong Kong University of Science and Technology (HK)	70.7 TB	2.0 GB	235,593
National Library of Medicine (US)	University of Hong Kong (HK)	56.6 TB	35.2 GB	183,246
St Louis Internet2 Access Consortium LLC (US)	University of Hong Kong (HK)	53.8 TB	45.6 GB	4,029
The Chinese University of Hong Kong (HK)	University of Chicago (US)	40.9 TB	10.7 GB	137,852
Indiana University (US)	University of Hawaii (US)	40.0 TB	12.2 GB	9,220
Florida State University (US)	Hong Kong University of Science and Technology (HK)	38.4 TB	266.5 MB	555,834
University of Hawaii (US)	Indiana University (US)	38.3 TB	12.0 GB	7,977
Chinese University of Hong Kong (HK)	RENATER (FR)	36.4 TB	6.0 GB	95,684
Brookhaven National Laboratory (US)	Chinese University of Hong Kong (HK)	36.0 TB	3.6 GB	163,667

6.C PerfSONAR

6.C.1 Deployments

The TransPAC project supports perfSONAR servers in Hong Kong and Seattle that provide periodic testing between several US and Asian sites. TransPAC participates in the IRNC mesh available at http://data.ctc.transpac.org/maddash-webui/index.cgi?dashboard=IRNC%20Mesh. We also participate in the APAN testing matrix, http://ps2.jp.apan.net/maddash-webui/.

6.C.2 Training

TransPAC funding supports training activities in the region. Chevalier, Delvaux, and Southworth led a 3-day perfSONAR workshop with host National University of Laos (NOUL) that was partially funded by Asi@Connect/TEIN*CC. The goal of the workshop was to provide training and small nodes so that the APAN perfSONAR mesh could be expanded to include Lower Middle Income Countries that had not previously been involved. In expanding the testing mesh, collaborations between Asia and the US can be better supported in terms of understanding their data movement needs.

In total there were 22 participants representing NRENs, government organizations, and universities from Laos, Cambodia, Thailand, and Vietnam. Invitations were also extended for participants in Myanmar but they were unable to attend. Small nodes were distributed to each participant and post-workshop contact was made between the participants and the APAN MaDDash administrator for continued perfSONAR support.

Twelve participants completed the post-workshop survey. Of those responding, seven attendees identified as Engineers while the remaining respondents identified as managers, IT security, Network Architects, or Managers. Ten of the twelve respondents said they were "Very Satisfied" with the workshop. Comments from the survey included that it was very well organized and executed, that it was especially informative and relevant to network development (as seen in their community), and that the facilitators did an excellent job. Additional information from the survey is included in Table 8.

Table 8: Results from post-workshop survey for Laos perfSONAR Training Workshop.

Subject Matter	**Prior to Workshop** Somewhat/Very Knowledgeable	**After Workshop** Somewhat/Very Knowledgeable
Measurement and Monitoring	7	11
perfSONAR	3	10
pSConfig / MaDDash	3	10
Science Engagement	3	9
Science DMZ / Data Transfer	3	9

Planning continued for the second perfSONAR workshop jointly supported by Asi@Connect. It will be held in July at the IU Global Gateway office in New Delhi, India. This workshop will support attendees from India, Afghanistan, Nepal, Bhutan, Bangladesh, and Sri Lanka.

6.C.3 General Support

Chevalier is helping APAN staff to monitor and support the APAN MaDDash. This quarter, he worked with local administrators to resolve three problems with the mesh: the nodes in Korea and the Philippines were both unresponsive, and the node in Bangladesh was inaccessible due to the permissions of a firewall being set incorrectly and blocking test access.

We are currently planning to host a perfSONAR Troubleshooting Workshop at APAN 48 in July to address additional problems with the APAN MaDDash. This full-day workshop will include a session to introduce perfSONAR and then three open sessions to work through issues on the MaDDash with attending perfSONAR administrators.

Chevalier and Southworth attended the Spring perfSONAR Developer Face-to-Face Meeting. These twice-yearly meetings enable the perfSONAR development team to set their plans for the year ahead. As head of the Training team, Chevalier lead the discussion on how training materials and documentation would be updated, and worked with other consortium members to evaluate upcoming training sessions.

6.D Trouble Tickets

During Year 5 Quarter 2, there no scheduled maintenances and seven unscheduled outages, as shown in Table 9.

Table 9: Unscheduled Outages for TransPAC equipment and circuits, March 1, 2019 - May 31, 2019.

Incident Number	Cust Impact	Ntwk Impact	Title	Outage Type	Source Impact	Current State	Start Time (UTC)	End Time (UTC)	Duration
INC0030449	4 - Low	2 - High	Brief Outage - TP SEAT-SEAT	Undet.	Vendor	Closed	2019-03-13 23:21:17	2019-03-13 23:21:18	0 days 0 hr 0 min
INC0030475	4 - Low	2 - High	Brief Outage - TP HONG-GUAM	Undet.	Vendor	Closed	2019-03-14 08:43:00	2019-03-14 08:44:00	0 days 0 hr 1 min
INC0030691	2 - High	2 - High	Instability Resolved - TP HONG-GUAM	Hardware	Vendor	Closed	2019-03-17 08:42:56	2019-03-17 19:12:00	0 days 10 hr 29 min
INC0031136	2 - High	2 - High	Outage Resolved - TP HONG-GUAM	Undet.	Vendor	Closed	2019-03-23 15:16:27	2019-03-28 04:48:38	4 days 13 hr 32 min
INC0032793	4 - Low	2 - High	Outage Resolved - TP HONG-GUAM	Unann. Maint.	Vendor	Closed	2019-04-17 18:01:53	2019-04-17 18:18:14	0 days 0 hr 16 min
INC0035277	2 - High	2 - High	Outage Resolved - TP SEAT-TOKY	Unann. Maint.	Vendor	Closed	2019-05-28 15:05:37	2019-05-28 16:25:45	0 days 1 hr 20 min
INC0033973	2 - High	2 - High	Outage Resolved - TP HONG-GUAM	Circuit - Damaged Fiber	Vendor	Closed	2019-05-05 08:15:57 2019-06-16 12:35:17	2019-06-15 21:28:07 2019-06-16 17:14:08	41 days 13 hr 12 min 0 days 4 hr 38 min

6.E Downtime and Availability

The core nodes for the project did not experience any down time during Project Year 5 Quarter 2. Table 10 lists the overall downtime for the project circuits. Due to the redundancy offered by the two circuits between Guam and Hong Kong, no downtime for the system was experienced.

Table 10: Downtime and availability for TransPAC circuits.

TransPAC Backbone Circuits	Down Time	Reporting Period Availability	52 Week Availability
TP2-SEAT-TP-TOKY-100GE-01522 (100G TransPAC-PacWave circuit)	01 hr 20 min	99.94%	99.97%
TP2-SEAT-TP-SEAT-TP-100GE-01523 (Cross Connect between TP and Pacific Wave)	00 hr 00 min	100%	100%
TP2-HONG-GUAM-10GE-01527 (Telstra Hong Kong-Guam 10G)	11 dy 13 hr 55 min	87.41%	96.68%
TP2-HONG-GUAM-10GE-01528 (AT&T Hong Kong-Guam 10G)	04 dy 13 hr 32 min	95.04%	98.74%
TP2-HONG-GUAM-LAG-01534 (20G combined Hong Kong-Guam circuit)	00 hr 00 min	100%	100%
TP2-HONG-HONG-10GE-01525 (10G Connection to HKOX)	00 hr 00 min	100%	100%
TP2-HONG-HONG-10GE-01526 (10G Connection to HKIX-RE)	00 hr 00 min	100%	99.99%

7. Software and Systems Work

Addleman has been investigating methodologies for DDOS detection that, if successful, will allow TransPAC to track DDOS traffic on its international links. The project is still waiting on a stable release of Nozzle, the plug-in needed to interface to the Faucet OpenFlow controller. Addleman has been in contact with the developers and anticipates release in shortly to allow this research to continue. If Nozzle is not released in the next quarter we will begin to explore other options for addressing DDOS detection.

8. Security Events and Activities

Basic security measures were maintained throughout Quarter 2 and there were no security incidents to report. All TransPAC network and server hardware is managed by the GlobalNOC and are in compliance with the all IU policies. IN@IU security documents can be found online at https://internationalnetworks.iu.edu/about/policies.html. These documents are revised and updated as needed.

Indiana University is currently reviewing the IU Cyber Risk Mitigation Responsibilities policy (IT-28) as it pertains to the deployed TransPAC equipment. More information on this can be found at https://kb.iu.edu/d/bdls. We continue to work closely with the GlobalNOC systems team to be in full compliance with this policy.

9. Milestones and Progress

1. Planning / Coordination

1. Planning / Coordination

1.2.1 Evaluate circuit capacity and community needs. Negotiate with vendors and partners for new circuits as capacity demands grow.

- ONGOING - We continue to track needed capacity by the community, but do not expect addition circuit deployments through the end of this award. See Section 5.

1.2.2 Finish partner MOU process - Contact partners and start the process of signing Memorandum of Understandings with each.

- COMPLETED - A final MOU was signed this quarter with Taiwan's Academica Sinica Grid Computing Centre (ASGC). We do not expect to sign additional MOUs during the project. See Section 4.B.

1.3.1 Evolve network architecture - New network designs over the evolution of the 5-year award. This will include 100G circuit speeds, software defined networking/ exchanges, possible new peering points, and greater than 10G flows.

- ONGOING - We continue to expand our peering partners. See Section 5.

1.3.2 Coordinate with IRNC:NOC winner - Coordinate with the IRNC:NOC awardee to ensure they have a sufficient and appropriate level of access to all of the TransPAC4 equipment supporting international activities. This includes appropriate logs, SNMP access, portal or login access to obtain data not available via SNMP, etc.

- ONGOING - The TransPAC project continues close coordination with the IRNC NOC. See Section 4.A

1.3.3 Coordinate with IRNC:AMI winner - Coordinate with the IRNC:AMI awardee for the appropriate distribution of flow data, per our own security and data policies, SNMP and other access as appropriate.

- ONGOING - TransPAC shares measurement data, specifically SNMP, perfSONAR, and flow data, with NetSage. TransPAC continues to work closely with NetSage for the Science Registry and development and use of the dashboards. See Section 4.A

1.3.4 Overall Management of the project

- ONGOING - Meetings continue more than quarterly with project partners at conferences including APAN, TNC, SC, and Internet2's Global Summit and TechX. See Section 3 and 4.B

1.3.5 Project Reporting - Report generation for the life of the project

- ONGOING - Reporting infrastructure is in place for up to date reporting; WBS update as part of this report.

1.3.6 Documentation and dissemination

- ONGOING - Both private and public facing documentation continues to be updated.

2. Outreach

2.2.1 Analyze usage data to identify geoscience/bioinformatics researchers. Leverage our TransPAC4 partners to provide support and if possible, connectivity for these researchers.

- ONGOING - See Section 4.B and 4.C

2.3.2 Analyze current network traffic and reach out to possible new network users

- ONGOING - See Section 6.B

2.6.1 Attend domestic and international conferences for application identification and relationship maintenance

- ONGOING - See Section 3 and 4

2.6.2 Coordinate connectivity with existing and new TransPAC Partners

- ONGOING – We will continue to hold meetings at APAN, TNC, and Internet2 Conferences with our partners. See Section 3.

2.6.3 Ensure connectivity in support of the Large Hadron Collider

- ONGOING - We continue our support of the Large Hadron Collider through our efforts in the LHCONE community. See Section 4.C

2.6.4 Ensure connectivity in support of Belle-II

- ONGOING - See Section 4.C

2.6.5 Coordinate with network partners and researchers to support large flows

- ONGOING – We will continue to develop new flow analysis tools that will assist us in identifying appropriate researchers. See Section 6.B

2.6.6 Explore additional application communities

- ONGOING – We continue to look through flow data and discuss with our partners what application communities would most benefit from more intentional engagement. See Section 4.C and 6.B

3. Operations

3.2.2 Deploy SDN DDOS Solution Deploy the SDN based DDOS mitigation solution.

- DELAYED - This work continues, see Section 7.

3.2.3 Evaluate and update existing POPs and equipment. Evaluate and install new points of presence and equipment as community demands expands and changes.

- ONGOING - We continue to track needed capacity by the community, but do not expect addition circuit deployments through the end of this award. See Section 5

3.5.1 Refine network measurement and monitoring data. Refine and make network telemetry useful to researchers and the IRNC:NOC. This will include creating public web pages and repositories that provide easy access to data

- ONGOING - We continue to work with IRNC NOC.

3.5.2 Tune and support large flows Monitor large flows across the network and work with researchers to fine tune the end points and entire path. Work with researchers to ensure performance is as expected.

- ONGOING - We continue to work closely with network researchers to support both large-scale demos and day-to-day activities to ensure effective network performance. See Section 6.B

3.5.3 Deploy support and telemetry for large flows. Work with partners to configure and allow for large flows across the TransPAC4 network. Work with systems to deploy monitoring solutions for large flows.

- ONGOING - The tools we have developed support collection of data for large flows and we will continue to improve them as well as work with our partners to ensure effective network performance. See Section 6.B

3.5.4 Operate Infrastructure; Pay for circuit, port, maintenance, and hardware costs.

- ONGOING

4. Research / Experimentation

4.1.1 SDN for DDOS mitigation - Research the feasibility of using SDN technologies for detection and mitigation of DDOS attacks on the TransPAC network.

- DELAYED - See Section 7.

4.2.1 Test larger than 10G flows Test network equipment, configuration, and support for greater than 10G flows.

- DELAYED - Delayed until network experimenters express a concerted interest in such activity.

4.3.3 Evaluate routing issues using Flow data

- ONGOING - See Section 6.C.

10. Financial Reporting Details Year 5 Quarter 2

Table 11 shows the expenses for Year 5 Quarter 2. Note that due to a change over in the IU travel system, several trips from several months ago are only showing up as charges this quarter, even though the trips took place some time ago. These have all been verified as valid expenses.

Table 11: Year 5 Quarter 2 expenditures.

Description	Mar-19	Apr-19	May-19	TOTAL
Schopf, Jennifer (PI)	1,864	1,864	1,864	**5,592**
Andrew Lee	3,745	2,553	0	**6,298**
Hans Addleman	7,556	7,556	7,556	**22,668**
Doug Southworth	1,208	1,208	1,208	**3,624**
Scott Chevalier	1,106	1,106	1,106	**3,318**
Ed Moynihan	1,174	1,174	1,174	**3,522**
Heather Hubbard	975	975	1,463	**3,413**
Support- Global NOC Systems	5,935	5,944	2,074	**13,953**
Support- Global NOC Network Eng	1,721	1,729	1,747	**5,197**
F&A on Compensation 32%	8,091	7,715	5,821	**21,627**
Subtotal Compensation	**33,375**	**31,824**	**24,013**	**89,212**
Travel - Lee - Nordunet DK Aug'18		2,446		**2,446**
Travel - Addleman- Security Oct 2018			665	**665**
Travel-Addleman APAN NZ Aug 2018			584	**584**
Travel-Schlemmer Install HK Aug'18			2,618	**2,618**
Travel - Addleman - SC18 TX Nov 2018			376	**376**
Travel- Schopf PTC HI Jan'19	325			**325**
Delvaux Training Consult	5,113	3,510		**8,623**
TP domain renewal	40			**40**
Travel - Chevalier - PS LA Mar'19		4979	331	**5,310**
Travel - Addleman - APAN KR Feb'19		3,403		**3,403**
Travel - Schopf - APAN KR Feb'19		2,335	526	**2,861**
Travel - Lee - APAN KR Feb'19		2593		**2,593**
Travel - Southworth - LA Mar'19		3,451		**3,451**
FedEx MOU to ASGC			28	**28**
Wire Transfer Fees	20			**20**
F&A on Other Expense 32%	1,759	7,269	1,641	**10,670**
Subtotal Other Expenses	**7,257**	**29,986**	**6,769**	**44,013**
Seattle-Tokyo co-lo (PNWGP)		3000	1500	**4,500**
Telstra - Guam-HK 10G	13,359	13,359	13,359	**40,077**
ATT - Guam-HK 10G	12,223	24,828	12,153	**49,204**
iAdvantage - Hong Kong Co-lo	8534	4069	4069	**16,672**
Laos PS WS Equipment and shipping		1726		**1,726**
Wire Transfer Fees	60	20	20	**100**
Subtotal Circuit Expense	34,176	47,002	31,101	**112,279**
Grand Total	**74,808**	**108,812**	**61,883**	**245,504**