TransPAC4
Award #1450904
Year 5 Quarter 3
1 June 2019 through 31 August 2019

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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 3 highlights include multiple meetings with partners at APAN 48, final details for an LHCONE Virtual Routing and Forwarding (VRF) in Hong Kong to better support high energy physics, moving forward on an approach for DDoS detection on the TransPAC 100G link, and planning in support for SC'19 demonstrations.

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 3, project staff included:

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

No staffing changes took place during Quarter 3.

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 3 included:

- Moynihan attended the LHCOne meeting, Umea, Sweden, June 4-5, 2019, https://indico.cern.ch/event/772031/. Moynihan provided updates on IN@IU and our efforts to support LHCOne traffic, presented on engagement efforts using NetSage to understand international traffic flows, and met with representatives from ESnet to finalize the set-up of a VLAN across the Hong Kong - Guam circuit.
- Schopf and Moynihan attended TNC19, Tallinn, Estonia June 16-20, 2019, https://tnc19.geant.org/. Schopf and Moynihan met with multiple TransPAC partners to discuss Science Engagement and future infrastructure planning.
- Chevalier and Delvaux led training at the Asi@Connect perfSONAR Workshop in New Delhi, India, July 10-12, 2019, https://global.iu.edu/presence/gateways/india/news-events/events/index.html. The training consisted of 22 participants from India (NKN), Afghanistan, Bangladesh, Bhutan, Nepal, and Sri Lanka at the IU Gateway in New Delhi.
- Moynihan attended the Earth Science Information Partners (ESIP) summer meeting in Tacoma, WA July 16-19, 2019, https://2019esipsummermeeting.sched.com/info. Moynihan presented a poster on Science Engagement and our efforts to support US researchers collaborating internationally.
- Addleman and Chevalier attended APAN 48 in Putrajaya, Malaysia, July 21-26, 2019, https://apan48.my/. Chevalier led a full day session that focused on debugging the APAN perfSONAR MaDDash. He also presented a recap of the Asi@Connect perfSONAR Workshops as part of the Network Engineering Workshop and gave one of the closing keynotes. Addleman presented a TransPAC update. Addleman and Chevalier also met with many partners in the region to discuss ongoing objectives and developing stronger support and relations. Special efforts were made in Malaysia to introduce Chevalier to our partners in his new capacity as Asia Coordinator. Our poster for the Engagement Performance Operations Center (EPOC) was accepted and displayed at the conference for its duration.

Presentations this quarter included:

- Moynihan, Edward, "International Networks at Indiana University, 2019 Overview", invited presentation, LHCONE meeting, Umea, Sweden, June 4, 2019. Presentation slides available online at: https://indico.cern.ch/event/772031/contributions/3416875/attachments/1855781/3048036/LHCONE_INIU_overview_.pdf
- Moynihan, Edward, "Helping Researchers Collaborate More Effectively with Improved Data Transfers" accepted poster submission, Earth Science Information Partners (ESIP) summer meeting, Tacoma, WA July 16-19, 2019. Poster available online at:

https://drive.google.com/file/d/1E6SKhKgy1RtDLcf8T5k9AjQhe4CH5_NA/view?usp=sharing

- Chevalier, Scott, "Helping Researchers Collaborate More Effectively with Improved Data Transfers", accepted poster submission, APAN 48 Conference, Putrajaya, Malaysia, July 22, 2019. Poster available online at: https://drive.google.com/open?id=1E6SKhKgy1RtDLcf8T5k9AjQhe4CH5_NA
- Addleman, Hans, "TransPAC, Performance Engagement, and Workshops", invited presentation, APAN 48, Putrajaya, Malaysia, July 25, 2019. Presentation slides available online at: https://drive.google.com/file/d/1arSMkqYlkhdVito_Ffq2uKhsLvZYG6lE/view?usp=sharing.
- Chevalier, Scott, "Asi@Connect perfSONAR Workshops-Laos and India", closing keynote, APAN 48, Putrajaya, Malaysia, July 26, 2019. Presentation slides available online at: https://drive.google.com/file/d/1Hv6lVbjZHe-WUpJf1842-9iSiTA4DCnA/view?usp=sharing.

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 3, 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. We also began investigating the use of NetSage for possible detection of DDoS attacks on the TransPAC links.

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 3, we continued to plan for SC19 and how best to use and configure the 100G circuit for the proposed experiments from NICT and SINET.

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 3, this included:

- **Australia's Academic and Research Network (AARNET):** We met with AARNET staff at TNC to discuss multiple items. AARNET is considering adding connectivity to Guam, possibly in 2020, and wanted to know more about our plans for connectivity at GOREX. We also spoke about their plans for supporting research in Antarctica. They are beginning to look at options for expanding satellite connectivity in support of Australian research stations. Finally we spoke to them about their potential interest in contributing to the Science Registry.
- **China Education and Research Network (CERNET)**: We completed work with CERNET to resolve the routing issue found Y5Q2 where traffic between China and Korea was being directed through the US. We worked with CERNET and the University of Hawaii, including GOREX, to allow routing changes based on BGP community strings. A deeper investigation of the routes at that time also showed AS path padding as an issue. This has been resolved by CERNET. At TNC, we also spoke with Jennifer An about the possibility of renewing annual meetings of the US and China Research and Education Networking communities. An believes there is interest on both sides to pursue a meeting or workshop similar to the previous China-American Networking Symposiums. We will continue to track this and have further conversations with CERNET in Quarter 4.
- **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 fund and support a 100G circuit from Singapore to London that went live in May, 2019. The official launch event was held at TNC19. At APAN, Addleman spoke with partners about current and future usage of the circuit. Currently, the link is only being used for demos and experiments. SingAREN will put production traffic on it next year after their planned Data Mover Challenge award ceremony in February 2020. We will continue to track routes and usage in the region as our partners ramp up usage of the link.
- **Global Network Architecture Group (GNA-G):** In Quarter 3, the GNA-G was created as a result of the merger of the Global Network Architecture (GNA) Technical Working Group and the Global Lamba Integrated Facilities (GLIF) group. We participated in the first face-to-face meeting of the GNA-G at TNC19 and are helping define the future of this group and what role IN@IU can play in it.
- **National Institute of Informatics, Japan (NII):** Kenjiro Yamanaka completed the Massively Multi-Connection File Transfer Protocol (MMCFTP) demonstration at TNC19 in June. This experiment used four 100G international links including the TransPAC-Pacific Wave 100G circuit to showcase the performance of the new protocol in an ultra-long latency environment between Japan and Europe (https://indico.geant.org/event/1/timetable/?print=1&view=nicecompact). The experiment was able to achieve 321Gbps across the links between Europe and

Japan. It is expected that Yamanaka will perform a similar demonstration for SC'19 in Denver, CO, using five 100G international links, including TransPAC.

- **National Institute of Information and Communications Technology, Japan (NICT):** In Quarter 3 TransPAC engineers started discussion with NICT around SC19 and demonstrations that will take place during the conference. We have started discussions about moving production traffic to another international link during SC19.
- **Philippine Research, Education, and Government Information Network (PREGINET): -** Chevalier and Addleman met with Banyani Benjamin R. Lara at APAN 48 and discussed a possible OIN-like workshop focused around both Science DMZ and perfSONAR. In addition, Chevalier was introduced to the new perfSONAR administrator. Lara also noted that the PREGINET 10Gbps link to Los Angeles, CA was still in the process of legal contracts, but they expected that the circuit would be live at the end of the calendar year.
- **Research and Education Advanced Network New Zealand (REANNZ)**: We met with Douglas Harre, Community Engagement Officer, to discuss how the NSF was moving traffic from the US Antarctic Program's ground station in Christ Church back to the US and to explore whether it would be possible to move this traffic from commercial networks onto REANNZ's network. We shared our contacts at the Office of Polar Programs, and REANNZ is planning to follow-up.
- **TEIN*CC:** 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 first workshop took place in Laos during Year 5 Quarter 2. The second workshop happened July 8-10 at the IU Gateway Office in New Delhi, 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. TransPAC provides 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 3, we completed the turn up of 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 finished setting up new peerings with ESnet in Los Angeles (via Guam) and with TEIN in Hong Kong.

Moynihan attended the LHCONE meeting in June in Umea, Sweden, and presented on the new LHCONE VRF and peerings. He also presented a talk focused on NetSage and led a discussion on how the LHCONE community could leverage NetSage to better

understand and visualize LHCONE usage. We also continue to track the networking needs of the Belle-II experiment in Japan. Moynihan participated in a discussion in Umea on current Belle-II networking usage and on the future potential needs of the project.

The LHCONE VLAN between NICT and ESnet has the path from NICT Hong Kong, to NICT Japan, then across the TransPAC-Pacific Wave 100G circuit and on to ESnet in Seattle. This VLAN bypasses the TransPAC Seattle Router so we do not have flow data for this traffic. We do see the traffic volume as part of the SNMP data that is aggregated and NICT also provides us a graph showing the SNMP use by the individual VLAN's each quarter, as shown in Figures 1 and 2. Figure 1 shows that the Hong Kong - Tokyo 100G portion of the VLAN was down at the start of this quarter, so traffic was temporarily rerouted (as shown in Figure 2) until the full path was fully restored on June 18th.

In Hong Kong, the TransPAC router does capture flow data and aggregate SNMP interface statistics for LHCONE traffic, however, the Arista router is not capable of per VLAN SNMP statistics so we don't have SNMP data for the specific LHCONE VLANs.

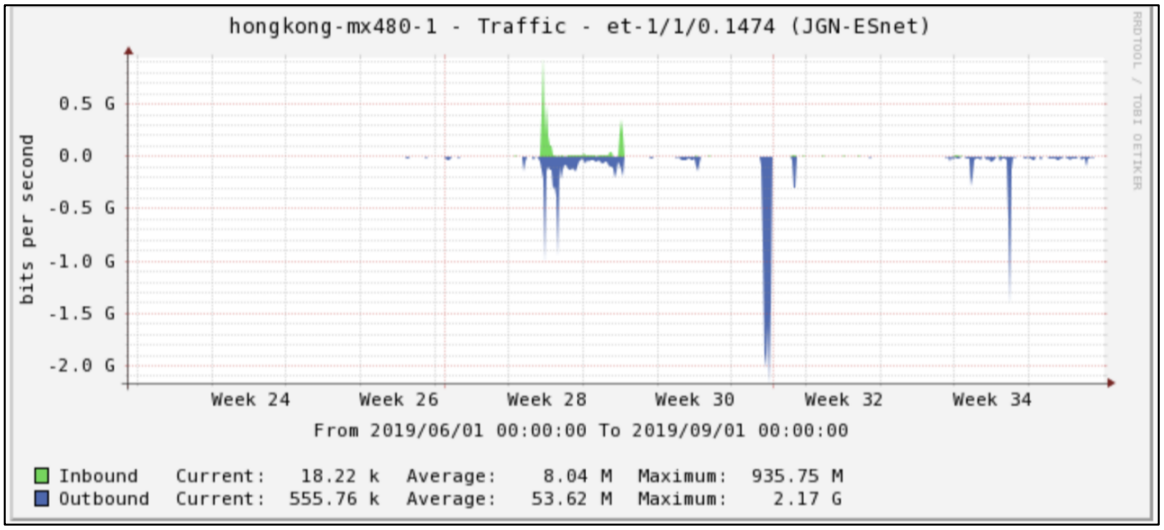

Figure 1: Use of the LHCONE VLAN that includes the TransPAC-PacWave 100G circuit. There was an outage on the Hong Kong-Tokyo 100G link that is part of this VLAN, so the VLAN was remapped until that link became operational again on June 18th.

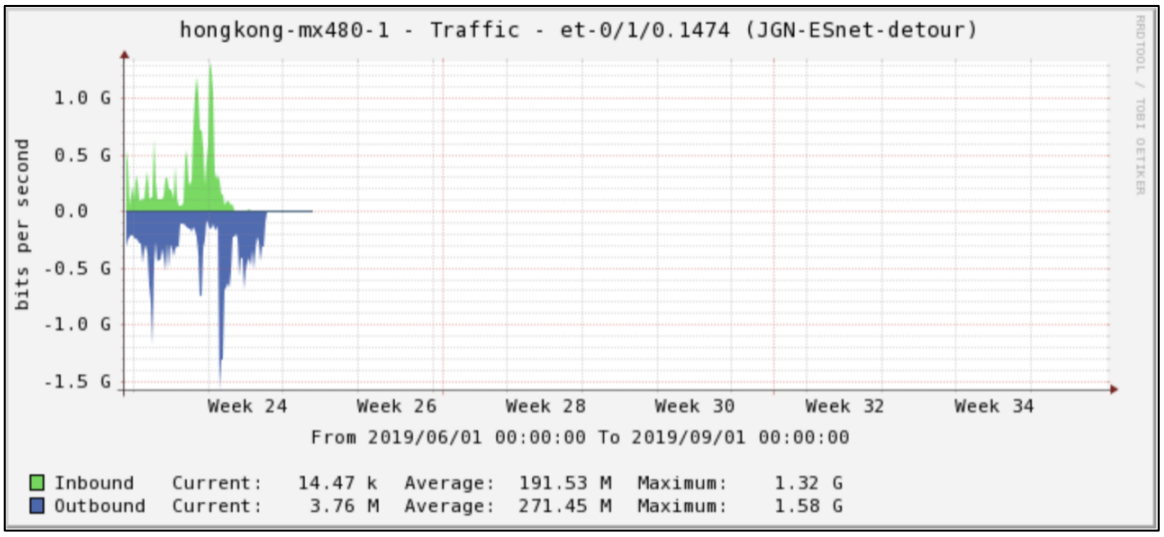

Figure 2: Use of the LHCONE VLAN that includes the TransPAC-PacWave 100G circuit during the outage of the standard mapping of the VLAN (shown in Figure 1).

4.C.2 Geoscience/Climate

We continued our efforts in Quarter 3 to target the US geoscience community. Moynihan attended the Earth Science Information Partners (ESIP) summer meeting in Tacoma, WA, and presented a poster on our current science engagement efforts. The poster presentation led to discussions with scientists from NASA, NOAA, USGS, and other institutions about network performance enhancement and data transfer needs. We are working with the Engagement and Performance Operations Center (EPOC) on a follow-up session submission and potential deep-dive workshop at next summer's ESIP meeting. We also continue to discuss collaboration opportunities with Dr. Tho Nguyen from the University of Virginia (UVA) 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 3, we worked with partners to accelerate our science engagement efforts. These included:

- **Academica Sinica (ASGC):** As a follow-up to our MoU signing last quarter, we reached out to Eric Lu from ASGC to help identify potential engagement targets. We shared information from NetSage on TransPAC usage and ASGC is working to help us identify US researchers with collaborators in Taiwan.
- **Korea Institute of Science and Technology Information (KISTI):** We spoke with Buseung Cho about a genomics collaboration he is involved with that includes McGill University, Johns Hopkins University, and the University of Seoul. We are working to determine exactly who from the US is involved and whether the collaboration is using TransPAC resources.
- **The Chinese University of Hong Kong (CUHK):** At APAN, our partners in Hong Kong expressed an interest in peering with our new LHCONE VRF. We are looking at whether this is possible, and if so we will begin setting this up in Quarter 4.

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 3 we continued our efforts to look more closely at astronomy traffic on the TransPAC circuits. Using NetSage tools, we compiled a list of top talkers sending Astronomy data across our circuits and are now looking at network usage and performance for these collaborations and facilities. With this information, we are planning to contact specific researchers and facilities to learn even more about how they are using our resources and to determine if there is anything we can do to help further support their science.

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.

National Institute of Information and Communications Technology (NICT) asked for help with IPv4 address space for a virtual point-to-point (P2P) link between the JGN network in Japan and The City University of New York. This P2P link will support a research project in the Japan-US Network Opportunity 2 (JUNO2) program funded by the NSF and NICT. The NSF award number is 1818884 and more information can be found online at: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1818884

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

During this quarter, we finished our engagement with CERNET (China) to help Chinese and Asian routes stay in Asia and not transit to America. BGP (Border Gateway Protocol) AS path padding configurations were changed by CERNET. Engineers at University of Hawaii and Guam added BGP communities to allow peers to better control routing policy. We also finished the set up of a VRF for LHCONE in Hong Kong. Details can be found in section 4.C.1.

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 3. The large spikes at the beginning of June 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. A demonstration of MMCFTP during TNC19 can be seen in Figure 4

around June 16th. This experiment used a number of circuits around the world to achieve a 400Gb/s data transfer.

Figures 5 and 6 show the SNMP data for the traffic on the two Guam-Hong Kong 10G circuits. A spike in traffic around June 22 shows ~31TB high energy physics transfer from the Computer Network Information Center in China and the Joint Institute for Nuclear Research in Russia.

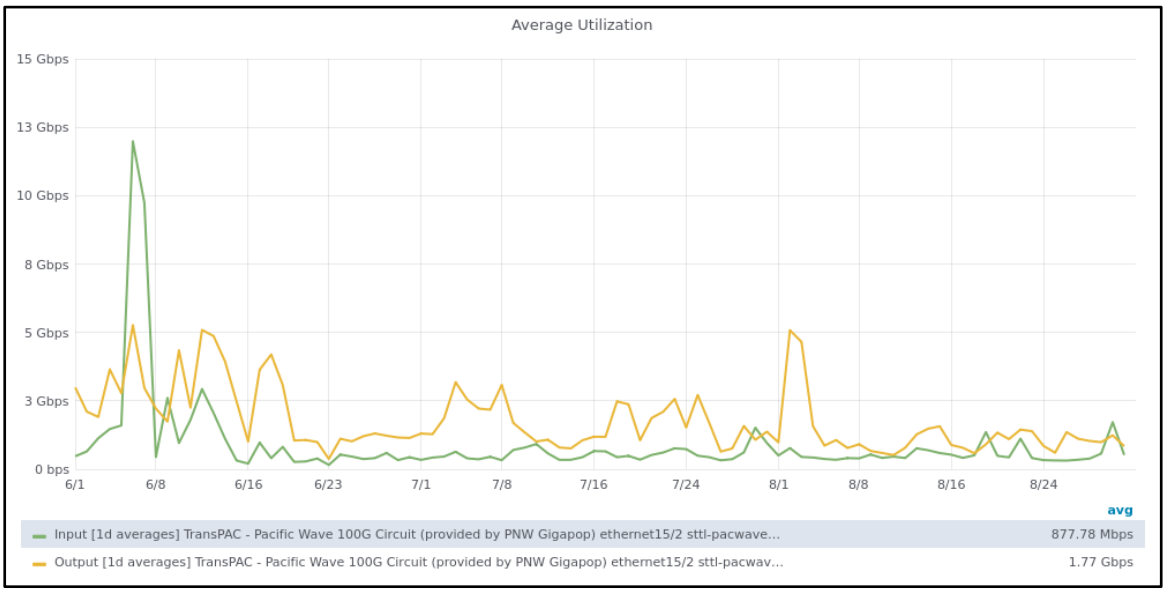

Figure 3: TransPAC-PacWave 100G circuit traffic using smoothed daily averages.

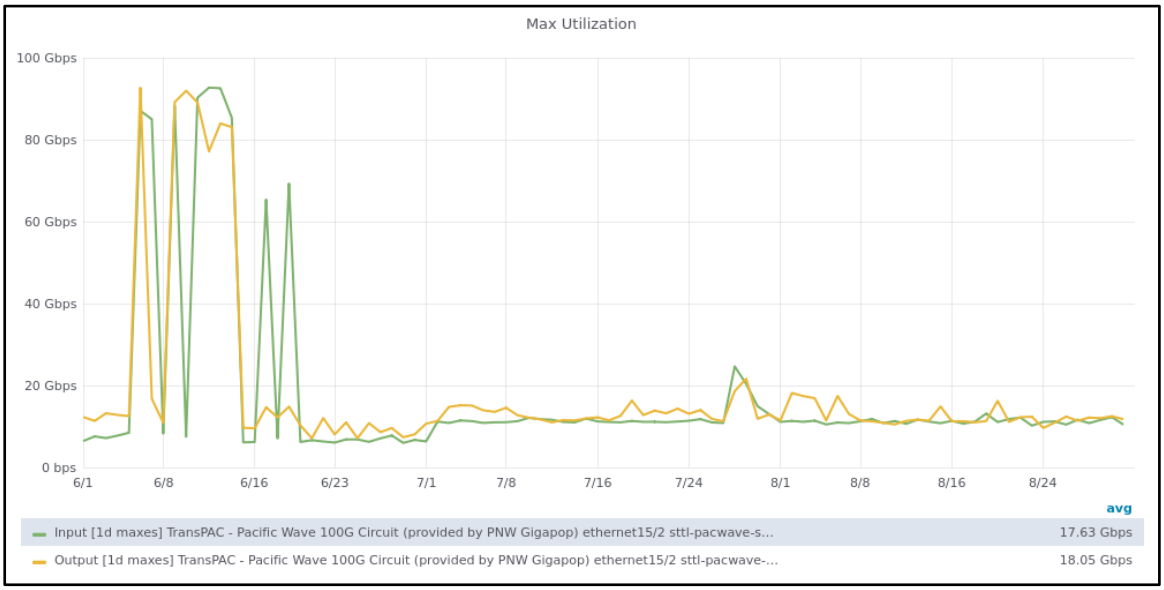

Figure 4: TransPAC-PacWave 100G circuit traffic using maximum daily averages.

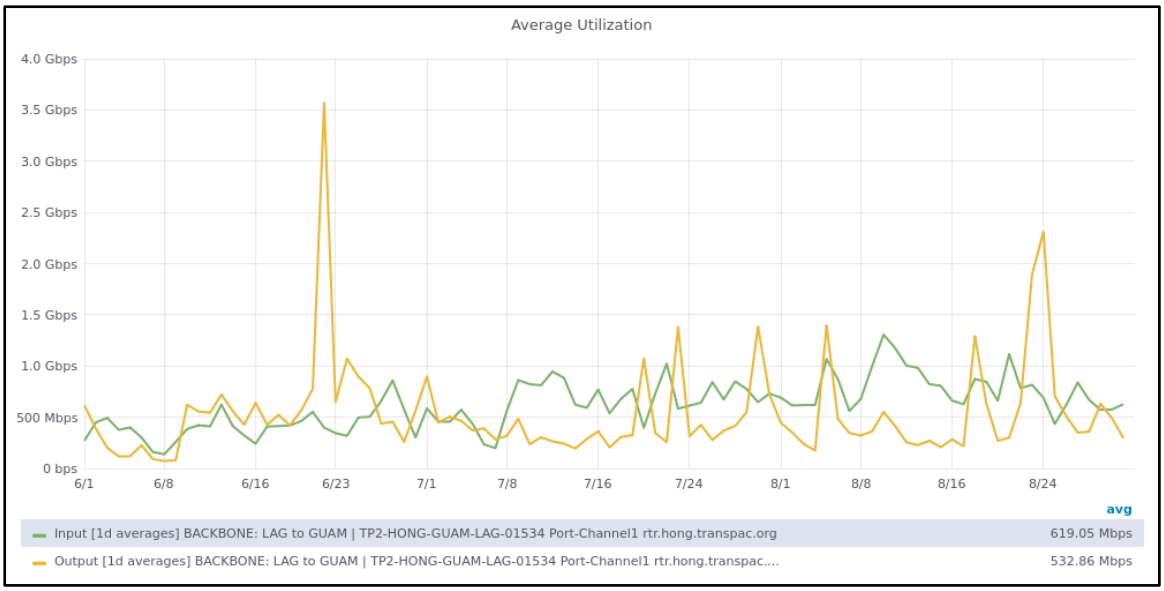

Figure 5: Traffic using smoothed daily averages for the two TransPAC Guam-Hong Kong 10G circuits.

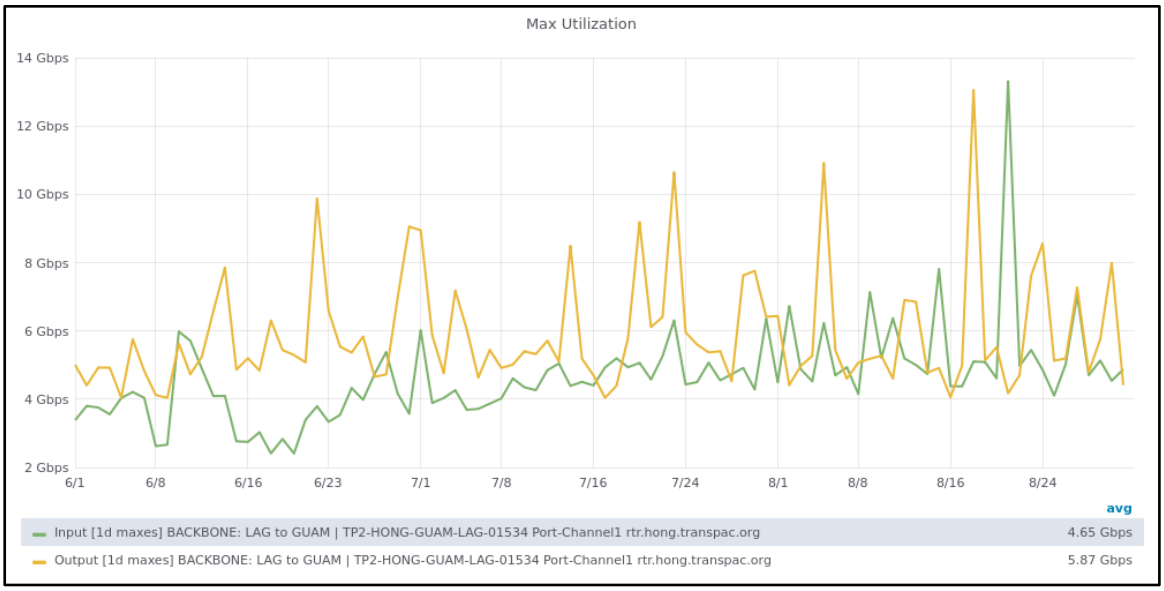

Figure 6: Traffic using maximum daily averages for the two TransPAC Guam-Hong Kong 10G circuits.

Table 1: Traffic in terabytes transferred over TransPAC links, June 1, 2019 - August 31, 2019.

Source-Destination	June	July	August	Total
Tokyo-Seattle	187.17	188.86	496.13	**872.16**
Seattle-Tokyo	424.19	557.24	779.80	**1,761.23**
Guam-Hong Kong	261.8	219.47	133.82	**615.09**
Hong Kong-Guam	186.07	155.66	187.72	**529.45**
Total	**1,059.23**	**1,121.23**	**1,597.47**	**3,777.93**

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 transfers between Italy and Japan continue to dominate the Top Talkers list. Transfers from ALMA in Chile to the National Astronomical Observatory of Japan (NAOJ) via WIDE also continue to be a significant source of traffic. Given the long-term nature of these projects and the size of datasets involved in modern astronomy, we expect these trends to continue indefinitely. Medical science was also well represented in Quarter 3, with over 164TB of data transferred from the National Library of Medicine and almost 100TB transferred to the City University of Hong Kong alone. While there were many large transfers from American institutions to partners in Asia, the large amount of traffic from JISC (EU) to Academica Sinica Network (TW), along with the previously mentioned VLBI transfers, show that transiting US links remains an important path for collaborative science data between these two regions.

Inbound to the US this quarter, the Japanese National Institute of Informatics continued its trend of large data transfers to NASA. While Quarter 2 saw an increase in the amount of traffic to the Microsoft Azure cloud platform from a set of universities in Indonesia, no such traffic made the top talkers list in Quarter 3. Chevalier reached out via email to a contact at Indonesia Research and Education Network (IDREN) to describe what we were seeing and ensure that they were aware of the traffic, understood what they could do to educate users on selecting the proper region, and/or confirm that this was traffic specific to the clouds in the US. The IDREN representative understood the traffic and acknowledged that not all users may be aware of selecting for region others were choosing the US region specifically. As cloud resources aren't tied to a specific geographic region, it's not uncommon to see shifting traffic patterns in that space.

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. Mirroring the large volume of data seen on the 100G TransPAC link from JISC to several locations in Hong Kong, we see a significant volume of traffic to both the Hong Kong University of Science and Technology and the University of Hong Kong. NASA was pushed off of the top talkers list for Quarter 3, with the Computer Network Information Center showing large transfers during this period, along with the University of Pennsylvania and the National Library of Medicine.

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 IU 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 600TB 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. Taken as a whole, these circuits were utilized more in Quarter 3 than Quarter 2, and TransPAC staff will continue to monitor the flow trends in this region with the goal of assisting our partners with their increasing need for reliable, high speed data transfers.

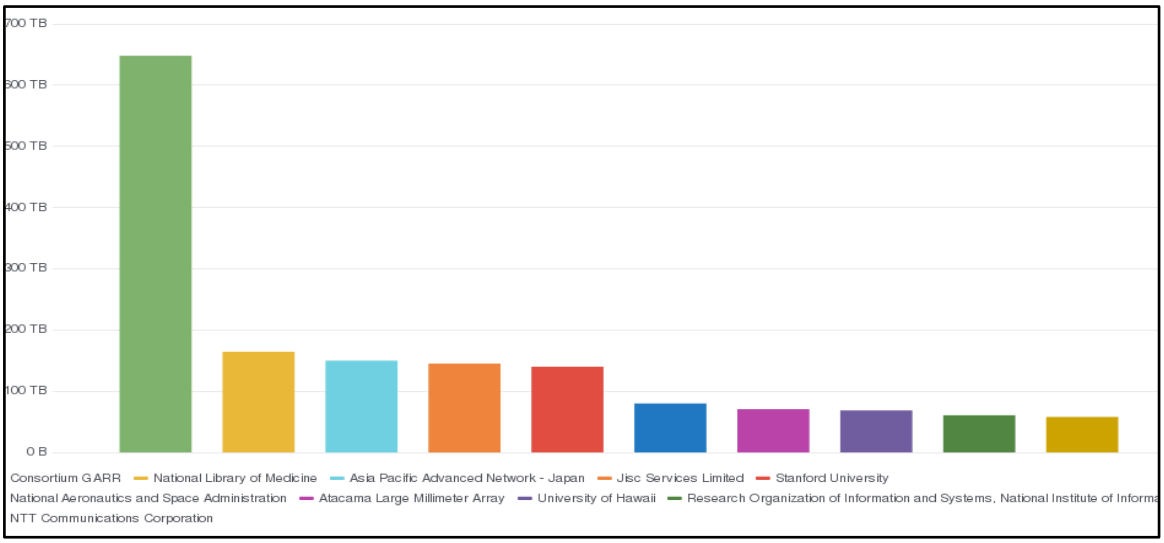

Figure 7: Top Ten Sources on TransPAC-PacWave 100G circuits, June 1, 2019 through August 31, 2019.

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

Source	Total Vol.	Largest Flow	# Flows
Consortium GARR (IT)	648.0 TB	193.7 GB	80.9 K
National Library of Medicine	164.5 TB	84.1 GB	463.0 K
Asia Pacific Advanced Network (JP)	149.9 TB	105.4 GB	164.7 K
JISC (UK)	145.1 TB	9.3 GB	2.3 Mil
Stanford University	140.0 TB	17.2 GB	1.0 Mil
National Aeronautics and Space Administration	80.0 TB	6.9 GB	434.4 K
Atacama Large Millimeter Array (CL)	70.7 TB	34.8 GB	896.4 K
University of Hawaii	68.6 TB	37.3 GB	27.6 K
National Institute of Informatics (JP)	60.7 TB	19.3 GB	667.4 K
NTT Communications Corporation (JP)	57.9 TB	16.7 GB	350.4 K

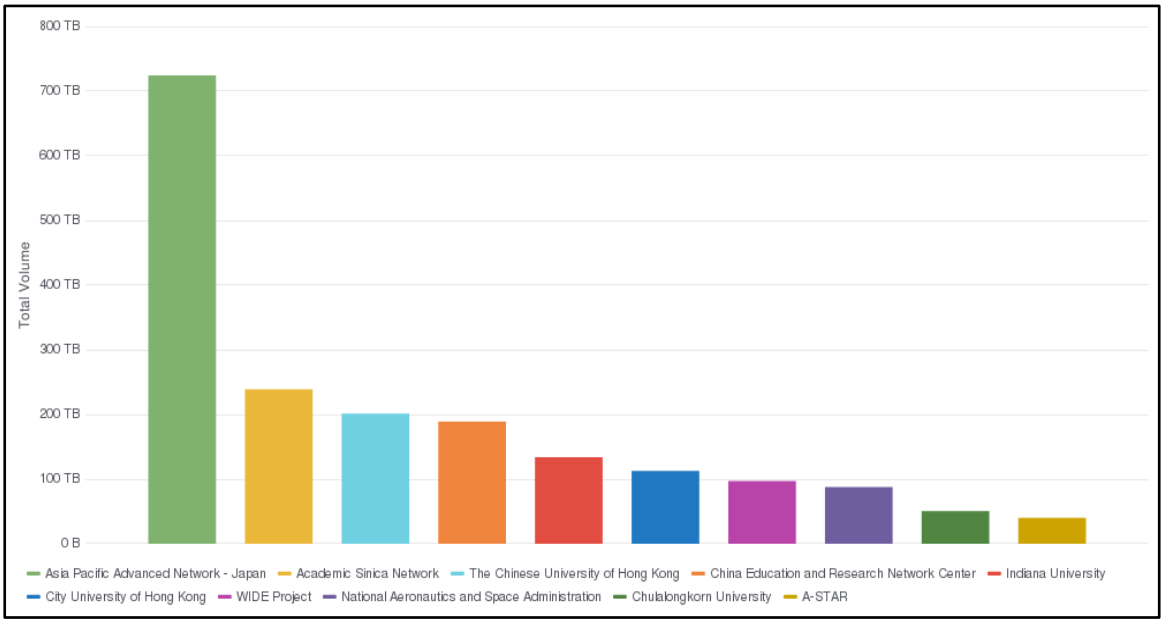

Figure 8: Top 10 Destinations on TransPAC-PacWave 100G circuits, June 1, 2019 through August 31, 2019.

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

Destination	Total Volume	Largest Flow	# Flows
Asia Pacific Advanced Network (JP)	724.4 TB	193.7 GB	221.4 K
Academica Sinica Network (TW)	238.9 TB	17.1 GB	3.7 Mil
Chinese University of Hong Kong (HK)	201.4 TB	38.2 GB	782.8 K
China Education and Research Network Center (CN)	189.0 TB	20.8 GB	2.2 Mil
Indiana University	134.0 TB	38.9 GB	23.6 K
City University of Hong Kong (HK)	112.7 TB	84.1 GB	99.8 K
WIDE Project (JP)	97.1 TB	34.8 GB	1.1 Mil
National Aeronautics and Space Administration	87.8 TB	19.3 GB	740.9 K
Chulalongkorn University (TH)	50.5 TB	15.6 GB	228.4 K
A-STAR (SG)	40.2 TB	15.5 GB	75.1 K

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

Source	Destination	Total Volume	Largest Flow	# Flows
Consortium GARR (IT)	Asia Pacific Advanced Network (JP)	641.4 TB	193.7 GB	25.1 K
National Library of Medicine	City University of Hong Kong (HK)	95.8 TB	84.1 GB	24.8K
Stanford University	China Education and Research Network Center (CN)	73.5 TB	17.2 GB	72 K
Atacama Large Millimeter Array (CL)	WIDE Project (JP)	72.1 TB	34.8 GB	915.2K
JISC (UK)	Academic Sinica Network (TW)	70.9 TB	2.6 GB	2.0Mil
National Institute of Informatics (JP)	National Aeronautics and Space Administration	61.7 TB	19.3 GB	665.1K
University of Hawaii	Indiana University	61.4 TB	37.3 GB	8.4K
JISC (UK)	Chinese University of Hong Kong (HK)	56.4 TB	8.4 GB	190.0K
National Aeronautics and Space Administration	Asia Pacific Advanced Network (JP)	48.1 TB	5.3 GB	146.9K
University of California, Santa Cruz	A-STAR (SG)	34.6 TB	14.6 GB	40.5K

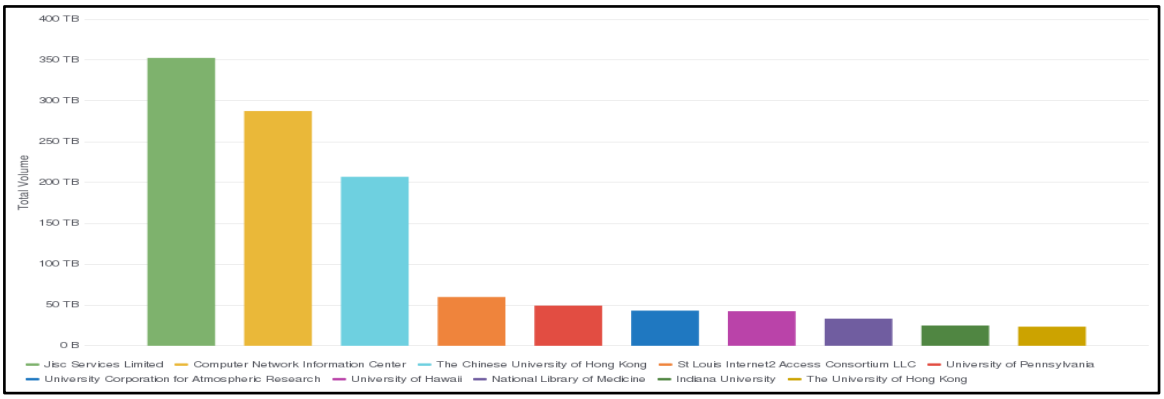

Figure 9: Top 10 Sources on TransPAC Guam-Hong Kong 10G circuits, June 1, 2019 through August 31, 2019.

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

Source	Total Volume	Largest Flow	# Flows
JISC (UK)	352.7 TB	22.6 GB	1.5 Mil
Computer Network Information Center (CN)	287.6 TB	16.2 GB	1.3 Mil
Chinese University of Hong Kong (HK)	207.1 TB	17.4 GB	1.3 Mil
St Louis Internet2 Access Consortium	59.8 TB	44.5 GB	14.8 K
University of Pennsylvania	49.2 TB	13.8 GB	88.7 K
University Corporation for Atmospheric Research	43.1 TB	4.3 GB	240.2 K
University of Hawaii	42.4 TB	13.3 GB	278.9 K
National Library of Medicine	33.3 TB	47.7 GB	148.7 K
Indiana University	24.9 TB	21.3 GB	10.0 K
University of Hong Kong (HK)	23.5 TB	14.2 GB	115.3 K

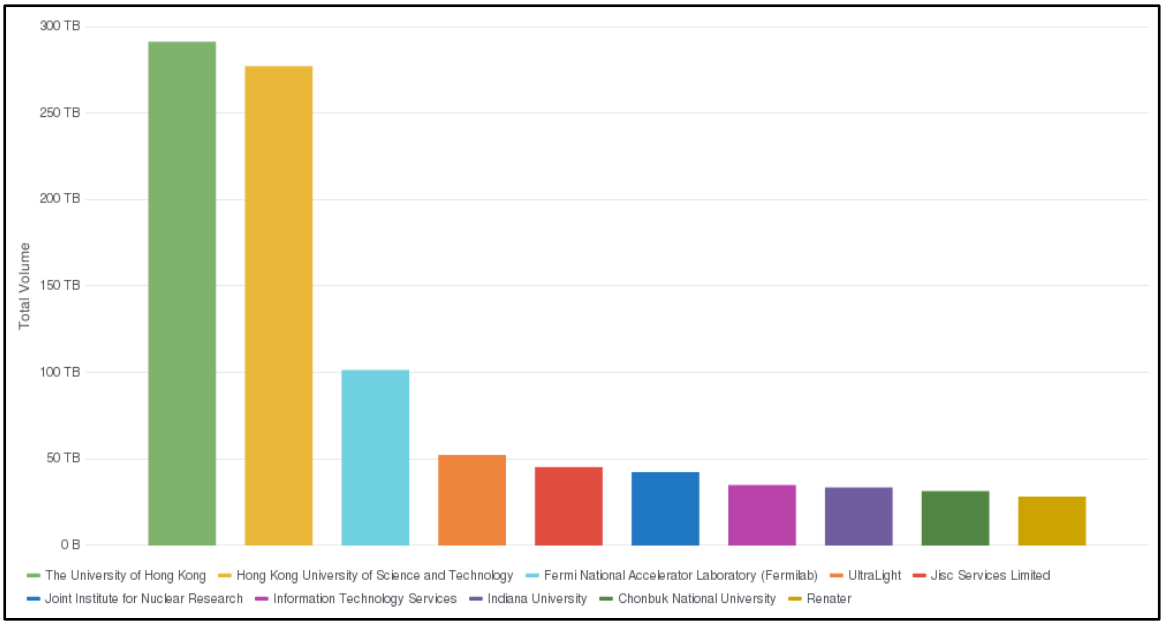

Figure 10: Top 10 Destinations on TransPAC Guam-Hong Kong 10G circuits, June 1, 2019 through August 31, 2019.

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

Destination	Total Volume	Largest Flow	# Flows
University of Hong Kong (HK)	291.2 TB	47.7 GB	882.9 K
Hong Kong University of Science and Technology (HK)	277.1 TB	22.6 GB	1.8 Mil
Fermi National Accelerator Laboratory	101.5 TB	12.0 GB	466.5 K
UltraLight	52.4 TB	16.2 GB	74.4 K
JISC (UK)	45.4 TB	23.4 GB	221.4 K
Joint Institute for Nuclear Research (RU)	42.5 TB	4.8 GB	54.8 K
Information Technology Services (HK)	35.0 TB	17.9 GB	229.1 K
Indiana University	33.6 TB	21.3 GB	7.6 K
Chonbuk National University (KR)	31.5 TB	9.3 GB	143.8 K
RENATER (FR)	28.3 TB	5.4 GB	126.7 K

Table 7: Top 10 flow pairs on TransPAC Guam-Hong Kong 10G circuits, June 1, 2019 through August 31, 2019.

Source	Destination	Total Volume	Largest Flow	# Flows
JISC (UK)	Hong Kong University of Science and Technology (HK)	186.7 TB	22.6 GB	834.4K
JISC (UK)	University of Hong Kong (HK)	158.4 TB	8.7 GB	609.9K
Computer Network Information Center (CN)	Fermi National Accelerator Laboratory	90.0 TB	9.7 GB	427.0K
St Louis Internet2 Access Consortium	University of Hong Kong (HK)	59.8 TB	44.5 GB	14.8K
Computer Network Information Center (CN)	UltraLight	54.3 TB	16.2 GB	105.2K
Computer Network Information Center (CN)	Joint Institute for Nuclear Research (RU)	43.6 TB	4.9 GB	62.1K
Chinese University of Hong Kong (HK)	JISC (UK)	35.0 TB	15.1 GB	168.4K
National Library of Medicine	University of Hong Kong (HK)	28.4 TB	47.7 GB	108.6K
University Corporation for Atmospheric Research	Hong Kong University of Science and Technology (HK)	25.7 TB	4.3 GB	143.6K
University of Pennsylvania	University of Hong Kong (HK)	22.4 TB	13.3 GB	21.7K

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 and Delvaux led a 3-day perfSONAR workshop at the IU Gateway Office in New Delhi, India, 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 twenty-two participants representing NRENs, government organizations, and universities from India, Afghanistan, Bangladesh, Bhutan, Nepal, and Sri Lanka. Invitations were also extended for participants in Pakistan, but they were unable to attend due to visa issues. 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.

Eighteen participants completed the post-workshop survey. Of those responding, seven attendees identified as Engineers, seven identified as Managers and the remaining respondents identified as Directors, IT security, or Network Architects. Seventeen of eighteen respondents said they were "Very Satisfied" with the workshop (with the last responding "Somewhat Satisfied"). 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 India 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

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 a recurring problem within the mesh community: the node in Bangladesh was intermittently inaccessible due to the permissions of a firewall being set incorrectly and blocking test access on the Bangladesh end.

Chevalier and Addleman hosted a perfSONAR Troubleshooting Workshop at APAN 48 in July to address additional problems with the APAN MaDDash. This full-day workshop included a session to introduce perfSONAR and then three open sessions to work through issues on the MaDDash with attending perfSONAR administrators. During these sessions we used example problems from the current APAN MaDDash to work through corrections that could be made and to identify next steps for more complicated issues or when the contact point for the node wasn't present. Chevalier and the APAN MaDDash Administrator also decided that it would be valuable to refactor the entire structure of current testing and to push for all sites to upgrade to the most current version of perfSONAR. This work should occur within Quarter 4.

6.D Trouble Tickets

During Year 5 Quarter 3, there were five unscheduled outages and one scheduled maintenance, as shown in Tables 9 and 10.

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

Incident Number	Cust Impact	Ntwk Impact	Title	Outage Type	Source Impact	Current State	Start Time (UTC)	End Time (UTC)	Duration
INC0033973	2 - High	2 - High	Outage Resolved - TransPAC Backbone 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
INC0037509	4 - Low	2 - High	Brief Outage - TransPAC Backbone HONG-GUAM	Unannounced Maintenance	Vendor	Closed	2019-07-03 10:15:51	2019-07-03 10:20:31	0 days 0 hr 4 min
INC0038584	4 - Low	2 - High	Brief Outage Resolved - TransPAC Backbone HONG-GUAM	Unannounced Maintenance	Vendor	Closed	2019-07-24 01:04:51	2019-07-24 01:10:08	0 days 0 hr 5 min

INC0039055	2 - High	2 - High	Outage Resolved - TransPAC Backbone HONG-GUAM	Undetermined	Vendor	Closed	2019-08-01 02:13:26	2019-08-01 02:49:40	0 days 0 hr 36 min
INC0041020	4 - Low	2 - High	Brief Outage Resolved - TransPAC Backbone HONG-GUAM	Undetermined	Vendor	Closed	2019-08-31 09:35:58 2019-08-31 10:27:02	2019-08-31 09:36:58 2019-08-31 10:27:03	0 days 0 hr 1 min 0 days 0 hr 0 min

Table 10: Scheduled Maintenance for TransPAC equipment and circuits, June 1, 2019 - August 31, 2019.

Incident Number	Cust Impact	Ntwk Impact	Title	Maint Type	Source Impact	Current State	Start Time (UTC)	End Time (UTC)	Duration
CHG0038414			Maintenance Completed - TransPAC Backbone HONG-GUAM	Circuit	Vendor	Closed	2019-08-23 03:01:17	2019-08-23 03:06:43	0 days 0 hr 5 min

6.E Downtime and Availability

The core nodes for the project did not experience any down time during Quarter 3. Table 11 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 11: 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)	00 hr 00 min	100%	99.98%
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)	15 dy 02 hr 54 min	83.56%	88.31%
TP2-HONG-GUAM-10GE-01528 (AT&T Hong Kong-Guam 10G)	00 dy 00 hr 10 min	99.99%	98.73%
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 using Nozzle and Faucet that, if successful, would allow TransPAC to track DDOS traffic on its international links. It was determined this quarter that the Nozzle project is now an internal-only project, and the date of an external release was not currently known and unlikely to be soon due to lack of funding.

Because of this (second choice) software also becoming unavailable, like SciPass before it, Addleman and Southworth are now exploring the possibility to adapt current NetSage dashboard for use in DDoS detection. We are focusing on DNS amplification attacks, and exploring how these might be shown in NetSage dashboards.

8. Security Events and Activities

Basic security measures were maintained throughout Quarter 3 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. TransPAC is negotiating with the GlobalNOC to take over management and patching of our few perfSONAR testing hosts. This will mitigate risk of missing a critical patch while our small team is traveling and allow the GlobalNOC's security hardening policies to be fully enforced.

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.

- ONGOING - Looking at third possible approach in this space - NetSage related tools.

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.

- ONGOING - Looking at third possible approach in this space - NetSage related tools.

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.