INDIANA UNIVERSITY
BICENTENNIAL

BLAZING TRAILS, ADVANCING CONNECTIVITY

COMPREHENSIVE NETWORKS FOR RESEARCH AND EDUCATION

NETWORKS AT
INDIANA UNIVERSITY
2019 ANNUAL REPORT

Mosaic active learning classrooms, supported by IU Campus Networks, facilitate active and collaborative learning with cutting-edge technologies.

WHAT'S **INSIDE**

A LONG HISTORY OF NETWORKING ACROSS INDIANA AND AROUND THE WORLD

Just over 20 years ago, and at the dawn of the commercial Internet, the IU networks team launched a strategic plan to join the burgeoning movement to build a research and education networking community that would protect and support research and discovery. Today, IU Networks remains at the forefront of networking operations and initiatives, propelling research and fostering collaboration for scientists and scholars around the globe.

As Indiana University celebrates the 200th anniversary of its founding, IU Networks is proud of its contributions toward making IU a world-class institution of education and research that continues to grow and innovate in IU's third century.

LEADERSHIP

Each division of IU Networks has a distinct focus and function, but they all share the same goal: to provide the highest quality of service to institutions, agencies, and consortia in the research and education fields by transmitting and securing critical data across Indiana and around the world using the most advanced, effective technology available.

JENNIFER **SCHOPF, Ph.D.**

Director
International Networks, EPOC

Schopf and her International Networks staff lead projects that connect U.S. scientists with peers in Africa, Asia, and Europe. At EPOC, in partnership with ESnet, Schopf's team provides outreach and support for collaborative science throughout the U.S.

DAVE **JENT**

Associate Vice President
Networks at IU

Jent has 30 years of experience and expertise in network design, installation, project management, and strategy at IU. Today, Jent leads senior technical staff, manages complex network engineering issues, and maintains critical relationships with the national research and education network community.

JON-PAUL **HERRON**

Executive Director
Internet2 NOC

Herron oversees GlobalNOC network engineers and GlobalNOC's overall efforts in support of Internet2, enabling large-scale research and scientific collaboration among higher education institutions across the U.S.

LUKE **FOWLER**

Director, Software and Systems
GlobalNOC

Fowler leads a group working on developing new technologies that make networks faster, more reliable, and easier to manage for the GlobalNOC partner networks.

KIRT **GUINN**

Director, Telecommunications Infrastructure,
Enterprise Infrastructure

With his team of network engineers, Guinn supports more than 114,000 users, and maintains hundreds of networked buildings and 10,000 wireless access points across IU.

MARIANNE **CHITWOOD**

Director, I-Light

Chitwood and her staff ensure member institutions can conduct high-profile research collaborations through powerful connections across the state and the world.

IU Networks has many partnerships to support research and education

- Advanced North Atlantic Network (ANA)
- AmLight Express
- AMPATH
- Arkansas Research and Education Optical Network (ARE-ON)
- Asia Pacific Advanced Network (APAN)
- Big Ten Academic Alliance (BTAA OmniPop NOC)
- Campus Research Computing Consortium (CaRCC)
- Capital Area Advanced Research and Education Network (CAAREN)
- CENIC
- Connecticut Education Network (CEN)
- Earth Science Information Partners (ESIP)
- ESnet
- Extreme Science and Engineering Discovery Environment (XSEDE)
- Front Range GigaPop (FRGP)
- GlobalNOC
- GOREX Guam Open Exchange
- Great Plains Network (GPN)
- I-Light
- International Networks at Indiana University
- Indiana GigaPOP
- Campus Networks of Indiana University
- International Research Network Connections (IRNC)
- Internet2
- The IU Grand Challenge Precision Health Initiative
- LBNL
- Keystone Initiative for Network-Based Education and Research (KINBER)
- Manhattan Landing Exchange Point (ManLan)
- MCNC (North Carolina)
- Midwest Big Data Hub (MBDH)
- North East Research and Education Network (NEREN)
- National Institute of Allergy and Infectious Diseases
- National Science Foundation Cybersecurity Center of Excellence (CCOE)
- NCAR
- NetSage
- Networks for European, American & African Research (NEAAR)
- N-Wave NOAA Enterprise Network
- Ocean State Higher Education Economic Development and Administrative Network (OSHEAN)
- Ohio Academic Resources Network (OARnet)
- Oklahoma Telecommunications Network (OneNet)
- Open Storage Network (OSN)
- Pacific Islands Research and Education Network (PIREN)
- Pacific Northwest GigaPop
- Pacific Wave
- The Quilt
- Science Gateway Community Institute (SGCI)
- Southern Crossroads (SoX)
- Starlight
- Texas R&E Network (LEARN)
- TransPAC
- The University of Hawai'i System Astronomy Community
- The World Climate Research Programme's International Climate Network Working Group (ICNWG)
- Washington International Exchange (WIX)

▲ *Space observatories on top of Haleakalā Crater on Maui, Hawai'i are supported by some of IU Networks' collaborations.*

CAMPUS NETWORKS

Blazing trails and advancing connectivity across IU campuses

Campus Networks empowers the learning and business of Indiana University. The team installs and maintains network connectivity for all of Indiana University's faculty, staff, and students. The network oversees more than 200,000 outlets and 10,000 wireless access points in hundreds of buildings on the Bloomington and Indianapolis campuses.

Campus Networks also manages a core routing environment that continues to grow by more than 30 percent in bandwidth each year. By guarding the network with dependable firewalls and secure wireless, the team ensures easy access and exceptional reliability.

IU Campus Networks aids the optimization of teaching and learning with state-of-the-art classroom and student technologies. Credit: Liz Kaye

ACCOMPLISHMENTS

UPGRADES UNDER WAY FOR WIRED AND WIRELESS NETWORKS AT IU BLOOMINGTON AND IUPUI

Since late 2018, the Campus Networks team has been working on improvements to the wired, switched, and wireless components and the controller environment of its edge network. In 2019, the team installed more than 5,000 access points and 300 switches in Bloomington alone. Anticipated completion for the upgrades is spring 2021 for IU Bloomington and summer 2021 for IUPUI.

UPGRADED SYSTEM INFRASTRUCTURE TO STRENGTHEN AND PROTECT THE IU NETWORK

Working with a single vendor, Campus Networks upgraded the switch and wireless environment and the management infrastructure. In addition to increased optimization of IU's network capacity and assessment of traffic usage and bottlenecks, the improved system better secures the IU network from outside attacks and protects it from viruses and malware inside the network.

CONTINUED REPLACEMENT OF OUTDATED WIRING

For nearly a decade, the Campus Networks team has been implementing wiring upgrades at the IU Bloomington and IUPUI campuses. Through this process, old and outdated wiring is replaced with upgraded technology that is able to support modern high-speed bandwidth requirements. In 2019, the team completed work in several residence halls and classroom buildings at IU Bloomington, as well as student service and medical facilities at IUPUI.

▲ LAUNCHED EDUROAM FOR EASIER INTERNET ACCESSIBILITY

Campus Networks began the move from IU Secure to eduroam, a worldwide Wi-Fi system that provides Internet access for faculty, staff, and students from participating institutions. By using the same infrastructure as IU Secure, IU wireless users experienced a seamless transition to eduroam, and gained the ability to safely and securely connect to hundreds of institutions and territories worldwide.

I-LIGHT AND INDIANA GIGAPOP

Blazing trails and advancing connectivity across Indiana

Since 2001, the I-Light network has provided reliable, high-speed network connectivity to nearly every college and university in the state of Indiana. With operations managed at IU, I-Light provides member institutions with high-quality video connections, access to supercomputers and scientific data storage, along with responsive expert support.

From Indiana's smallest colleges to its largest research universities, the I-Light network connects members seamlessly to each other, as well as to the Indiana GigaPOP, which gives them access to national and international R&E networks and enables collaborative research with partners across the country and around the world.

A unique collaboration of higher education, government, and private sector broadband providers, I-Light serves as the state's high-speed fiber optic network for R&E.

ACCOMPLISHMENTS

CREATED A NEW NETWORK NODE AT IU BLOOMINGTON

In 2019, the I-Light team at IU added a new network node on the campus of IU Bloomington. This additional capacity increased network resiliency between Bloomington and Indianapolis, and in turn benefits I-Light members throughout the southern half of the state.

REROUTED FIBER SEGMENT IN CONJUNCTION WITH I-69 CONSTRUCTION

I-Light engineers worked with the Indiana Department of Transportation to create an alternate path for I-Light fiber running between Martinsville and Indianapolis. Rerouting the fiber ensured that it would not be cut or damaged during the I-69 interstate construction. As part of the interstate project, a new broadband corridor will be constructed to house the fiber in its original path.

AUGMENTED LIFELINE DATA CENTERS

I-Light engineers performed an augmentation of the co-location space at Lifeline Data Centers to make room for additional co-location needs of its members. This work ensures I-Light members have adequate space for their existing needs in addition to future growth opportunities. Ivy Tech was the first I-Light member to take advantage of the additional capacity at Lifeline.

INCREASED MEMBER INSTITUTIONS' CONNECTIONS TO 100G

Purdue University and the University of Notre Dame increased their Indiana GigaPOP connections to 100G. As a result of the added connectivity, scientists and researchers on these campuses will have the ability to share information faster and more efficiently, and will have better access to the Monon400 network, the fastest network ever built for the R&E community.

▲ HELD I-LIGHT/INDIANA GIGAPOP MEMBERS MEETING

I-Light/Indiana GigaPOP held its 13th Annual Members Meeting in May 2019. Once again, this event provided a forum for members to exchange ideas, engage with the larger community, and help shape the future of I-Light/Indiana GigaPOP.

DEPLOYED NETSAGE TOOL FOR RESEARCH INSIGHT

Working in conjunction with IU's EPOC team, I-Light engineers installed the network analysis tool NetSage in 2019. NetSage's development was funded by National Science Foundation (NSF). By using NetSage to identify who is using member sites for research, I-Light will be able to identify new opportunities for NSF grant proposal submissions.

COLLABORATED WITH GLOBALNOC'S GRP-INITIATED NETWORK AUTOMATION TEAM

I-Light was among the first GlobalNOC networks to implement anti-spoofing and AS-Path filtering solely using the new automation environment developed with IU's GlobalNOC. The automation tool allowed network engineers with the aid of systems engineers to define a template that queried information from the GlobalNOC Database and updated router configurations. Previously I-Light engineers had been auditing and updating internal and member IP addresses for synchronizing data to RADb for IRR updates. Having two distinct uses for the same data set illuminates the benefits of automating tasks with a high level of precision and accuracy. Additional efforts continue, creating templates for all sections of router configurations with further integration and yielding service provisioning from a common data set.

PARTNER PROFILE

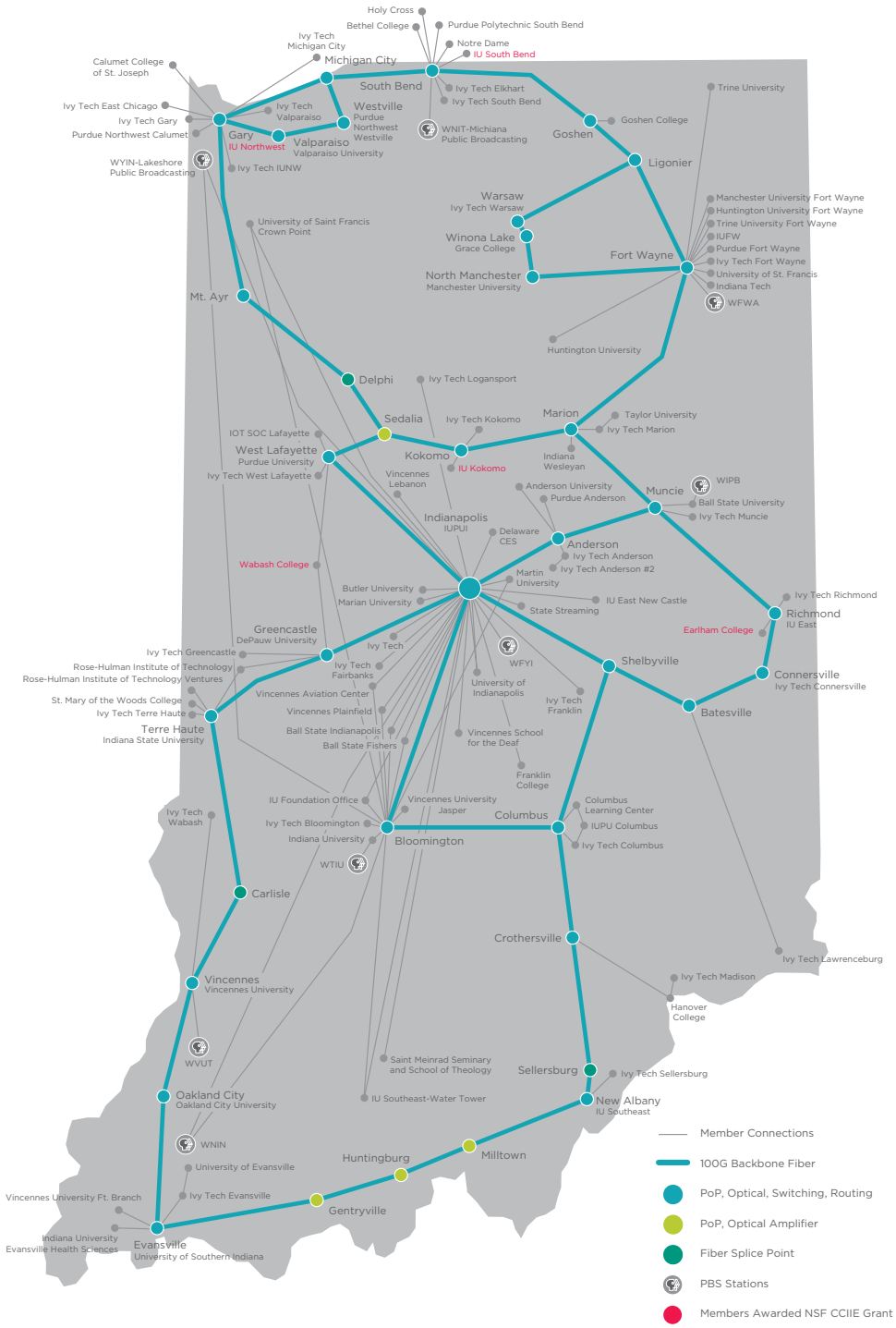
BUTLER UNIVERSITY

One of over 40 I-Light higher education members, Butler University was named among *U.S. News & World Report's* list of top schools in the country for enriched undergraduate offerings that yield student success. The report concluded that Butler is providing all undergrads with the "best possible educational experience."

In 2019, Butler University announced plans for an innovative addition to its student experience: the Esports and Gaming Lounge. Located in the school's Atherton Union, the space will be open to the campus community and will include stations for competitive organized video gaming. The Esports and Gaming Lounge will ultimately be part of a larger 7,500-square-foot multi-use space slated to open in fall 2020. Beyond allowing the Butler esports team that competes in the Big East to practice in the new space, gaming and technologies are being incorporated into the wider Butler curriculum, as the new spaces will enable the campus to serve as a sports hub for the greater Indianapolis community. These new spaces will foster student access, community partnerships, and innovations in teaching and learning—all key aspects of Butler's new strategic direction.

I-Light will provide network access to the Butler Esports and Gaming Lounge. I-Light is also working with Butler to enhance the resiliency of its connectivity to I-Light, which will enable the campus overall to benefit from increased capacity on the network.

I-LIGHT CONNECTIONS



GlobalNOC

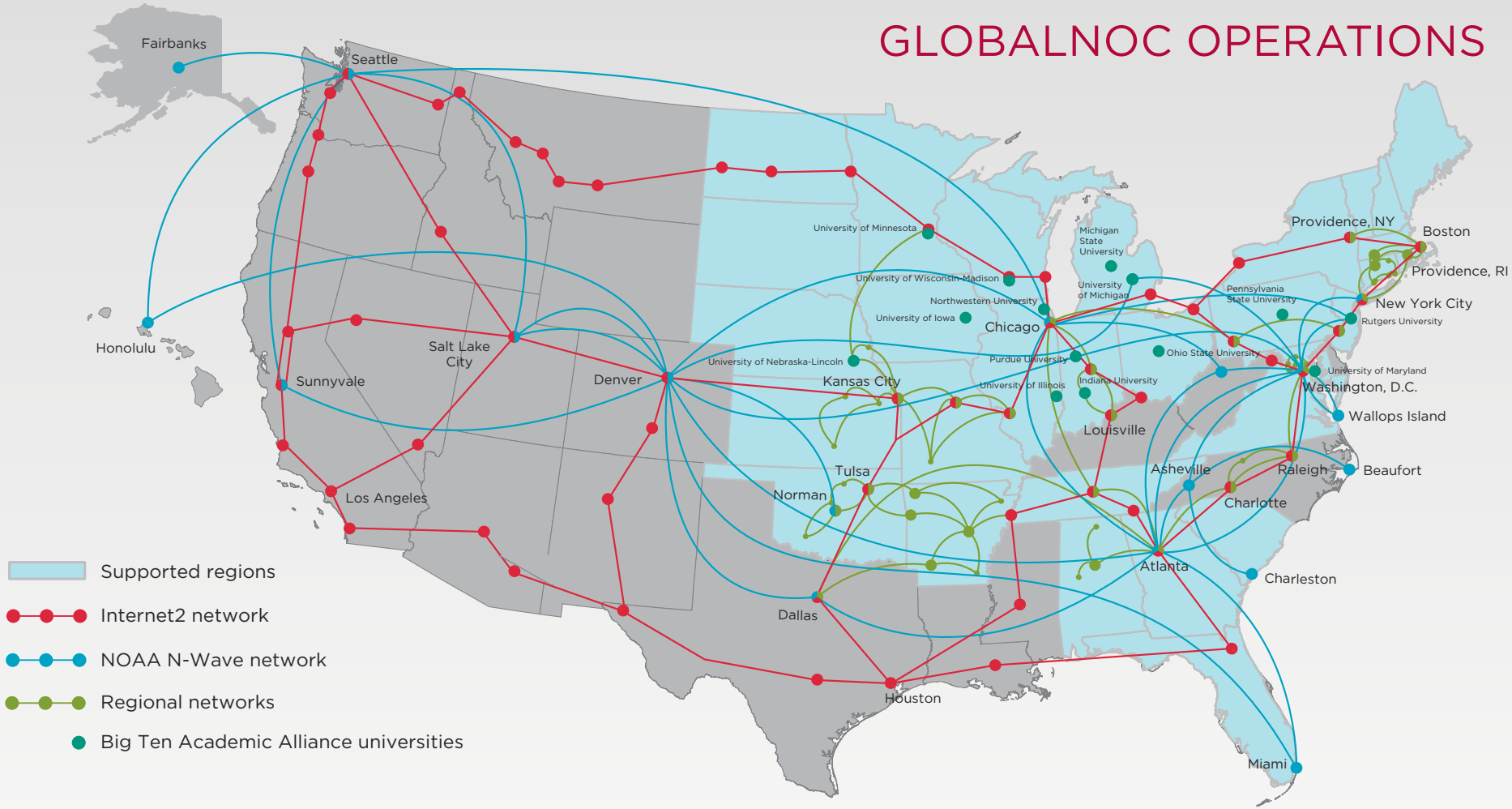
Blazing trails and advancing connectivity across the United States—and beyond

The Global Research Network Operations Center (GlobalNOC) at Indiana University collaborates with some of the nation's most important R&E network partners to engineer, operate, and monitor powerful high-speed networks that link thousands of researchers and educators across the United States and around the globe to advance learning and discovery.

IU's GlobalNOC launched in 1998 in response to a competitive solicitation process put forth by Internet2 seeking operations support for its R&E-dedicated Abilene network. Since then, GlobalNOC has grown from a handful of people focused on engineering and deployment for Internet2 to over 120 world-class service desk technicians, engineers, and developers and almost two dozen network partners in research, education, public service, and municipal operations.

Data from NOAA's GOES-16 and GOES-17 weather satellites are transported via N-Wave with support from GlobalNOC.

GLOBALNOC OPERATIONS



From its dual sites in Bloomington and Indianapolis, GlobalNOC remains engaged in its commitment to ongoing enhancement of its operations, which offer:

- fully redundant service desk locations;
- 24×7×365 monitoring and problem resolution;
- strategic network engineering for Tier 1, 2, and 3 networks of any type or scope;
- deployment, architecture, and consulting for improved service planning; and
- software and systems development that includes continuous status updating as well as management and measurement tools.

GLOBALNOC IN 2019

- 1,565,471 total edits of open tickets
- 334,322 emails processed (sent and received)
- 15,852 inbound phone calls

SUPPORTED ELEMENTS

- 4,000 locations (525 Internet2)
- 9,200 devices (1,400 Internet2)
- 390,000 interfaces (25,000 Internet2)
- 22,000 circuits (7,200 Internet2)
- 4,100 BGP sessions (1,750 Internet2)

ACCOMPLISHMENTS

GLOBALNOC RENEWAL PROGRAM YEAR 1

The GlobalNOC Renewal Program, a two-year plan to build on the first 20 years of growth and evolution, is forging a new generation of GlobalNOC. Through a comprehensive, ground-up assessment and organizational overhaul, the program is modernizing and preparing for the future.

In its first year, the program focused on building the GlobalNOC OS, the foundation of the organization's mission, strategy, and culture. It also sought to fulfill its stated goals: become indispensable to client partners; boost engagement and better leverage staff talents; and move the R&E community toward a more automated networking future.

Highlights of the GlobalNOC Renewal Program's first year:

- Relaunched the GlobalNOC User Group to foster community among supported networks and focus GlobalNOC efforts
- Launched the GlobalNOC network automation initiative and the network automation technical program manager role to oversee these efforts
- Developed the GlobalNOC OS to define the mission, vision, strategy, and culture for a next-generation GlobalNOC
- Gathered input from staff about workplace changes to reduce time waste and distractions, resulting in multiple proposals
- Launched organizational experiments to improve speed and support, including a dedicated client manager, software integrator, and developer, as well as a GlobalNOC service desk position for completing simple requests
- Completed an initiative to foster a culture of feedback and continuous improvement, to improve usefulness and quality, including effective feedback training, peer feedback, and a new performance review system

The Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory detector site in Livingston, LA. LIGO uses Internet2's Grouper enterprise access management system. Credit: Caltech/MIT/LIGO Lab

PARTNER PROFILE

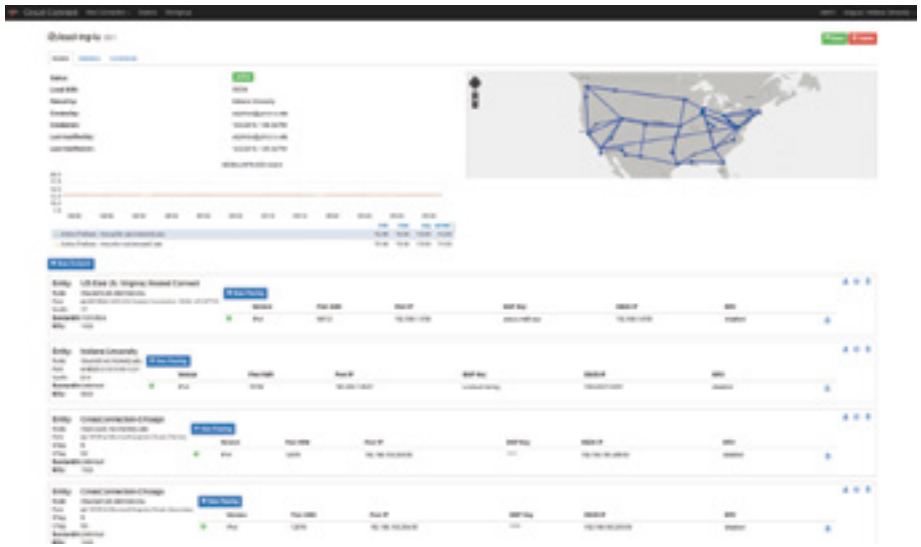
INTERNET2

Internet2 is a non-profit, advanced technology consortium founded by the nation's leading higher education institutions in 1996. It provides national, globally interwoven technology infrastructure and collaboration capabilities for the nation's researchers, scholars, and learners.

Internet2 exists to facilitate critical technology in support of educational, research, and community service missions, enabling the power of collaborative scale to make possible vitally important capabilities that no single institution could produce on its own and no other source will provide.

Internet2 interconnects U.S. universities, government agencies, industry partners, and regional and state education networks. Internet2 supports not only the work of these groups but more than 100,000 community anchor institutions such as K-12 schools, community and vocational colleges, public libraries, health care facilities, museums, and other cultural and historic organizations.

Internet2 also collaborates with more than 70 national research and education network partners in more than 100 countries. These partnerships help ensure global interoperability in the next generation of networking technologies, mobile connectivity, security and privacy considerations, identity and access management, and cloud services tailored to the needs of research and education.



▲ ADDED CLOUD-CONNECT FUNCTIONALITY TO OESS

In collaboration with Internet2, GlobalNOC developed an updated version of the Open Exchange Software Suite (OESS 2.0) for use across the Internet2 network. OESS allows Internet2 users to create their own virtual network across Internet2 on demand. The updated version adds a focus on capabilities to support Internet2's Cloud Connect Services and supports the creation of Layer 3 VPNs throughout the Internet2 system.

RELEASED NEW VERSION OF PERFORMANCE TESTING TOOL

The perfSONAR consortium, made up of Indiana University, Internet2, University of Michigan, ESnet, and GEANT, introduced version 4.2 of the perfSONAR network measurement suite. Developed to simplify performance testing inside and across networks, the tool's newest capabilities include testing disk-to-disk data transfer performance and additional test prioritization functionality.

OMNISOC

GLOBALNOC PARTNERS WITH OMNISOC FOR FRONT-LINE SECURITY COVERAGE

The GlobalNOC Service Desk partnered with OmniSOC—a shared cybersecurity operations center for higher education—to provide 24×7×365 coverage, ensuring round-the-clock vigilance for OmniSOC member institutions. GlobalNOC's state-of-the-art security analytics platform powers OmniSOC's event detection and analysis, alerting OmniSOC staff to security issues and using data to give a full picture of the severity of the incident.

Founded by Northwestern University, Purdue University, Rutgers University, the University of Nebraska-Lincoln, and Indiana University, this pioneering initiative strives to help higher education institutions reduce the time from first awareness of a cybersecurity threat anywhere to mitigation everywhere for members.

OMNISOC LAUNCHES CYBERSECURITY INTERNSHIP PROGRAM

In the summer of 2019, OmniSOC began its inaugural eight-week cybersecurity summer internship program, hosting 10 students from IU, Rutgers University, and University of Nebraska—Lincoln. OmniSOC partnered with GlobalNOC for program content and logistics. The internship program started on the Bloomington campus, where students spent four weeks becoming acquainted with operations at all levels. They finished out the experience at their home institutions, working with their local IT security professionals for the remaining four weeks.

OMNISOC SUPPORTS RESEARCHSOC

OmniSOC services are a key component of the ResearchSOC, the first NSF-funded collaborative security response center that addresses the unique cybersecurity concerns of the research community. ResearchSOC helps make scientific computing resilient to cyberattacks and capable of supporting trustworthy, productive research by providing the operational cybersecurity services, training, and information sharing necessary to a community as unique and variable as research and education.

▲ HOSTED FIRST-EVER GLOBALNOC DAYS

In 2019, members of the GlobalNOC community gathered for the first-ever GlobalNOC Days meeting in Indianapolis. Throughout the event, attendees discussed priorities and shared concerns relating to the creation of network operational portals and the reinvention of operational notification methods.

WITH INTERNET2, LAUNCHED NEXT GENERATION COMMUNITY INFRASTRUCTURE

A joint team of Internet2 and GlobalNOC began the first phase of installing Internet2's Next Generation network, a more reliable, flexible, and cost-effective system for sending and storing data across the nation. When completed, the new network will provide support for cloud and virtual network services, and quadruple the base speed for Internet2 connectors to 400G. Significant reductions in space and power requirements make the Next Generation network more cost-effective, with a smaller carbon footprint.

GLOBALNOC CLIENT PORTAL

The GlobalNOC Users Group created standard and customized portals to provide individual views into the status and usage of network services for their clients. By aggregating data, the portal system creates a concise view of the client's connectivity that results in a simple, unique report for each of their customers.

Ali Bayless, NOAA/NMFS/PIFSC

PARTNER PROFILE

NOAA'S N-WAVE

From reliable weather forecasts to severe storm prediction models that save lives, the National Oceanic and Atmospheric Administration's N-Wave network securely and efficiently transports the data needed to make sense of the changing environment. N-Wave enables NOAA's mission of science, service, and stewardship through highly available, secure, high-speed network transport and services.

N-Wave transports a myriad of data including climate and ocean data—up to 25 petabytes per month—from the depths of the ocean floor to satellites in space. In doing so, N-Wave connects thousands of scientists and engineers to the information and resources needed to advance environmental science in a variety of fields such as oceanography, chemistry, biology, and meteorology.

Since 2010, N-Wave has operated a national network backbone that has been the foundation for continuous growth and new services to meet the needs of NOAA's critical operations and science. The N-Wave network is built in partnership with the national science, research, and education network community.

NEW 10-YEAR NOAA CONTRACT

In May 2019, GlobalNOC renewed and expanded its partnership with the National Oceanic and Atmospheric Administration (NOAA) with a new 10-year agreement for services for the rapidly growing nationwide N-Wave network. This cements the deep and critical partnership between GlobalNOC and NOAA, dating back to 2010, when N-Wave first began, and will support a period of immense expansion for the network as it grows to accommodate more NOAA researchers and divisions.

The effort not only supported the world's climate researchers, it also generated an economic boon to the state of Indiana that included hiring 17 highly skilled staff members.

"NOAA's mission depends on the advanced, high-speed, high-availability, and secure networking capabilities of N-Wave. Our partners in the science, research, and education networking community—including GlobalNOC—play an essential role in delivering the innovative underpinnings of the N-Wave network."

—Rob Sears, Director of N-Wave, May 2019

IU proudly supports NOAA's large-scale efforts to understand and predict changes in climate, weather, oceans, and coasts; to share that knowledge and information with others; and to conserve and manage coastal and marine ecosystems and resources.

Over the past year, GlobalNOC accomplished the following with NOAA:

- Upgraded the N-Wave backbone to 100G, improving network speed by 10×
- Expanded its role with NOAA by supporting its new managed LAN and wireless services
- Expanded N-Wave into Alaska with new Utqiaġvik site
- Supported NOAA demand for new cloud services with connectivity to major cloud providers

▲ NOAA VISITS IU GLOBALNOC

In December 2019, a delegation from the United States Department of Commerce (DOC) and its National Oceanic and Atmospheric Administration (NOAA) bureau visited Bloomington and Indianapolis to learn more about NOAA's partnership with IU Networks in service of the agency's N-Wave enterprise network.

Led by DOC's Chief Information Officer (Acting) André V. Mendes and NOAA's Chief Information Officer and Director of High Performance Computing and Communications Zachary G. Goldstein, the delegation met with IU Network leadership and heard about the GlobalNOC's service desk operations, emergency response, engineering solutions, and cybersecurity for N-Wave as well as customized tools and software for monitoring and diagnostics geared to specific network needs.

The group also toured the Bloomington and Indianapolis facilities to see the GlobalNOC in action as well as the IUB Data Center, which protects the university's critical computing and networking equipment. The Data Center houses Big Red 200, a Cray Shasta supercomputer entering production service in January 2020. Equipped with NVIDIA V100 GPUs and second-generation AMD EPYC processors, Big Red 200 is capable of achieving 5.9 petaFLOPS, making it about six times faster than its predecessor Big Red II and one of the most powerful systems owned and operated solely for the benefit of a single university.

INTERNATIONAL NETWORKS

Blazing trails and advancing connectivity around the globe

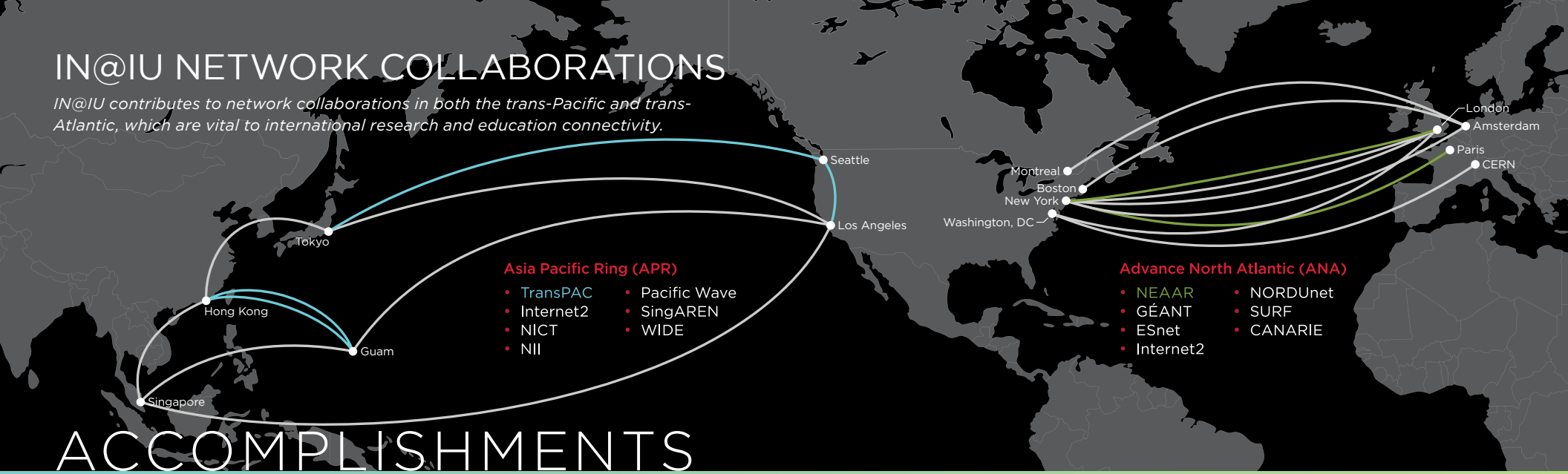
As part of the global R&E community, International Networks at IU (IN@IU) knows that international collaboration is the lifeblood of scientific research and discovery. IN@IU supports network connections and services that enable cooperation and advances in research and science to flourish across oceans and between continents.

From its Midwestern location, IN@IU uses high-performance networking to support scientific diplomacy for projects large and small, across the globe. As home to the Networks for European, American, and African Research (NEAAR) and TransPAC, IN@IU provides an "on-ramp" for the world's R&E communities, connecting U.S. scientists with their counterparts in Africa, Asia, and Europe. The third core project for IN@IU is the IRNC NetSage project, funded by NSF to understand the behavior of all of NSF's international networking investments.

In collaboration with the University of Guam, IN@IU recently put in place two 10 gigabyte circuits connecting Guam to research and education networks in Hong Kong, increasing bandwidth, resiliency, and redundancy across the Pacific Ocean to support global scientific research.

IN@IU NETWORK COLLABORATIONS

IN@IU contributes to network collaborations in both the trans-Pacific and trans-Atlantic, which are vital to international research and education connectivity.



ACCOMPLISHMENTS

SUPPORTED DATA TRANSFER FOR THE LARGE HADRON COLLIDER THROUGH VIRTUAL ROUTING AND FORWARDING INSTANCE

TransPAC began participation in a virtual routing and forwarding (VRF) instance to help support scientific work done at the Large Hadron Collider (LHC). In addition to being the world's largest and most powerful particle accelerator, the LHC moves the most data of any international R&E consortium in the world currently.

The VRF is a worldwide overlay network that sits on top of R&E networks, providing greater speed, control, and redundancy when transferring large amounts of data. TransPAC's support of the VRF allows for faster and more reliable data transfer between international sites, enabling important research that could change the way we look at the universe.

CONTINUED SUCCESSFUL ROUTE ANALYSES SERVICES

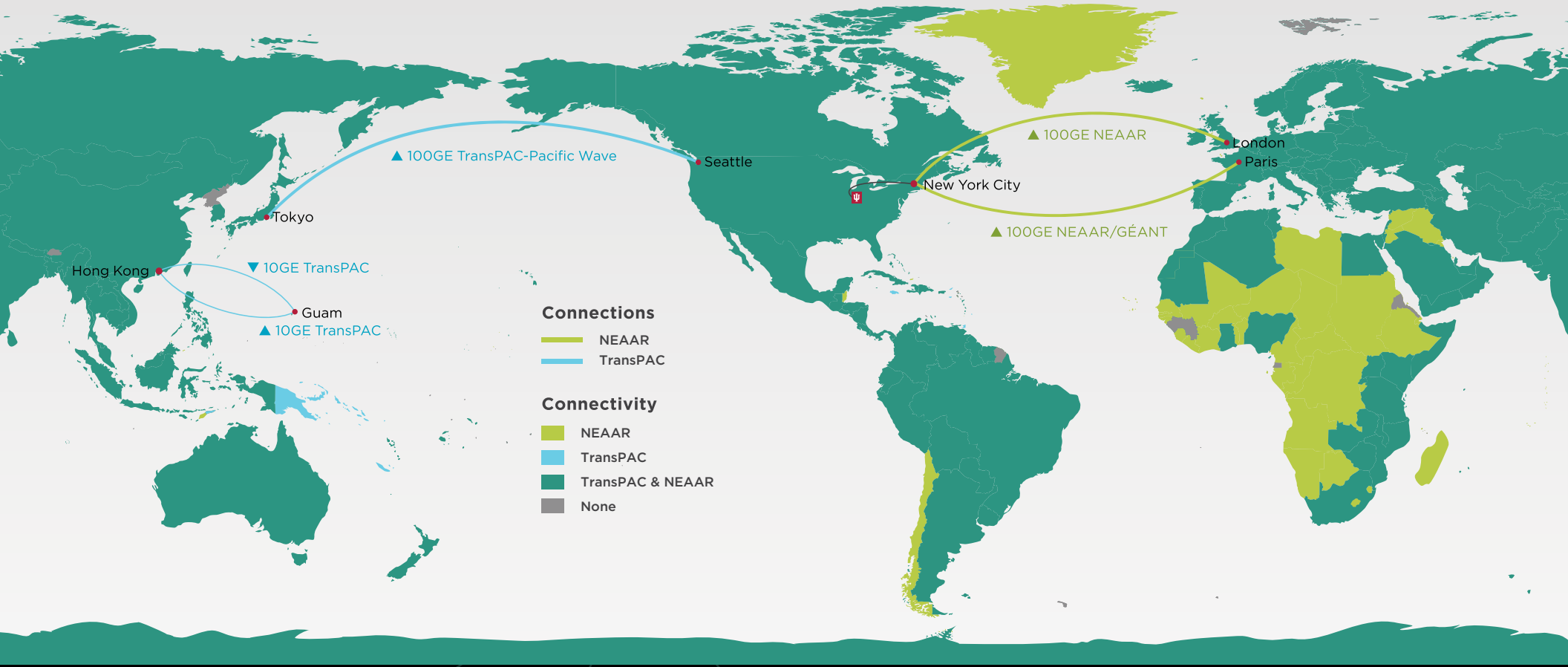
In collaboration with international partners, IN@IU helped resolve asymmetric or inefficient routing issues that could create adverse effects on flow transfer speeds. IN@IU's route analysis service identifies the best traffic paths for overall network performance across the globe. Through these partnerships, IN@IU is able to monitor and modify when international data traffic issues affect U.S. networks—resolving these issues leads to more symmetric routing, increased throughput, and ultimately, better, faster science.

PROVIDED TRAINING FOR NETWORK ENGINEERS AROUND THE WORLD

Participants from underserved regions around the world took part in training sessions focusing on the perfSONAR monitoring and measurement tool. Attendees learned how to use and deploy the tool locally, giving them the ability to watch their own networks' behavior and support researchers sharing data. In 2019, IN@IU's workshops trained engineers in more than 20 countries, ensuring improved data transmission infrastructure and better collaboration and knowledge sharing.

The IU India Gateway office in New Delhi hosted IN@IU's perfSONAR training workshops, focusing on participants from TEIN-defined lower middle income countries with no previous access to the subject. This workshop, and another in Laos, were partially funded by Asi@Connect. Such workshops generate useful information about the state of the regional networks, and give insight about troubleshooting and transfers for U.S. researchers working in these regions.

IN@IU CONNECTIVITY AROUND THE WORLD



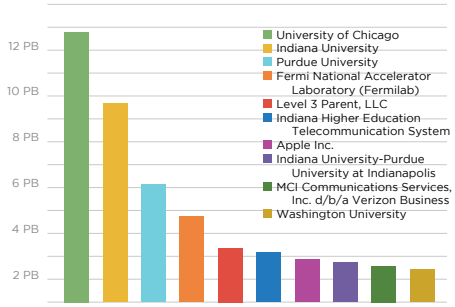
"We are thankful for Indiana University's collaboration on the GOREX project. The new circuit from Hong Kong to Guam has created a second crucial link for increasing Pacific R&E networking diversity in the Southwestern Pacific, through GOREX. We say *Si Yu'os Ma'ase* (thank you) and congratulations to Dr. Schopf and the International Networks team for this successful implementation."

—Rommel Hidalgo, Chief Information Officer, University of Guam
February 2019

ACCOMPLISHMENTS

RELEASED NEW NETSAGE DASHBOARDS FOR BETTER INSIGHT INTO RESOURCE UTILIZATION

The IU-led NetSage project released additional dashboards that provide NSF-funded international networks better insight into the use of their resources. The dashboards give organizations the ability to see the amount of data being delivered through their international links, or to analyze patterns of behavior and overall performance.



IMPROVED INTERNATIONAL DATA TRANSFER RATES

Working with the National Center for Physics (NCP) at the Quaid-i-Azam University Campus in Islamabad, Pakistan, IN@IU diagnosed and improved data transfer performance for data sets related to the Large Hadron Collider (LHC). After identifying issues with the NCP's connection to their national R&E network, Pakistan Education and Research Network (PERN), IN@IU was able to increase data transfer performance speed to more than 10 times its previous rate.

PARTNER PROFILE

UBUNTUNET ALLIANCE

The UbuntuNet Alliance is the regional research and education backbone network with points of presence across eastern and southern Africa and in Europe, delivering affordable and dedicated internet connectivity to its members.

The UbuntuNet Alliance is a non-profit regional association of National Research and Education Networks (NRENs) in Africa. It was formed in 2005 by five established and emerging NRENs in eastern and southern Africa—MAREN (Malawi), MoRENet (Mozambique), KENET (Kenya), RwEdNet (Rwanda), and TENET (South Africa)—with a driving vision of securing high speed and affordable Internet connectivity for the African research and education community in Gb/s rather than Kb/s.

Today, the UbuntuNet Alliance's footprint stretches across the largest land mass of eastern and southern Africa and includes NRENs in 16 countries. In addition to improving interconnectivity for the R&E community, the UbuntuNet Alliance seeks to develop the knowledge and skills of ICT practitioners at member institutions and provide related auxiliary services to Research and Education Networking (REN) participants.

EPOC

Engagement and Performance Operations Center

Blazing trails and advancing connectivity across the full data transfer pipeline

Over the last decade, the scientific community has experienced an unprecedented shift in the way research is performed and how discoveries are made. Highly sophisticated experimental instruments are creating massive datasets for diverse scientific communities and hold the potential for new insights that will have long-lasting impacts on society. However, scientists cannot make effective use of this data if they are unable to move, store, and analyze it.

Established in 2018 and jointly led by IU and the Energy Sciences Network (ESnet), the Engagement and Performance Operations Center (EPOC) is a production platform for operations, applied training, monitoring, and R&E support as well as a collaborative focal point for operational expertise and analysis. EPOC provides researchers with a holistic set of tools and services needed to debug performance issues and enable reliable and robust data transfers. By considering the full end-to-end data movement pipeline, EPOC is uniquely able to support cooperative science, allowing researchers to make the most effective use of shared data, computing, and storage resources to accelerate the discovery process.

Indiana University graduate student Di Wu works with a test subject in Swain Hall. Photo: James Brosher

▲ HOW EPOC SERVES AND SUPPORTS RESEARCH

EPOC works with regional network partners to develop and provide materials to small or medium-sized institutions that may lack the financial and human resource capacity for advanced services. Doing so allows EPOC to not only increase these teams' abilities, but also to provide a broad set of materials to the general public.

EPOC's initial regional network partners include the Indiana higher-education network (I-Light), Ohio Academic Resources Network (OARnet), Keystone Initiative for Network-Based Education and Research (KINBER), the Great Plains Network (GPN), the Texas R&E Network (LEARN), and Front Range GigaPOP (FRGP).

As the platform grows, EPOC's goals include offering expansion of the following services to assist scientists and researchers:

- Providing immediate help, or Roadside Assistance, via a coordinated operations center to reactively resolve network performance problems with end-to-end data transfers
- Working proactively with science communities to create better data transfer behaviors, enabling faster data sharing and collaboration through Application Deep Dives
- Using the NetSage monitoring suite for discovery and resolution of network performance issues
- Provisioning managed data services with support from the IU GlobalNOC and EPOC's regional network partners
- Continuing training programs pioneered by IU and ESnet to ensure effective use of scientific tools and science support

ACCOMPLISHMENTS

COLLABORATED TO SOLVE A HIGHER-EDUCATION NETWORK PERFORMANCE PROBLEM

Working with engineers at Iowa State University (ISU), the Great Plains Network, and additional upstream providers, EPOC tackled an ISU researcher's issue with increasingly poor performance while transferring data files. EPOC's Roadside Assistance program helped diagnose the issue, and through the coordinated effort was able to increase network performance by nearly 200 percent.

FACILITATED APPLICATION DEEP DIVES WITH NETWORK PARTNERS

In 2019, higher-ed institutions and R&E networks from across the country took part in EPOC's Application Deep Dives. Through these engagements, engineers gained skills for identifying storage needs, marking network connection adaptations, and explaining collaborative science workflows, all of which enable them to better support their institutions' research.

EXPANDED TRAINING REACH THROUGH PARTNERSHIP AND COLLABORATION

To ensure effective use of scientific tools and ongoing science support, EPOC continued its work with its regional networking partners. In addition to attending each partner's regional conference, members of the EPOC team visited 22 states in 2019, giving talks, speaking on panels, and leading training sessions. And an EPOC training session at Navajo Technical University, led in collaboration with Front Range GigaPop, educated participants from a group of tribal colleges about advanced CI technologies to help support their schools' data transfers.

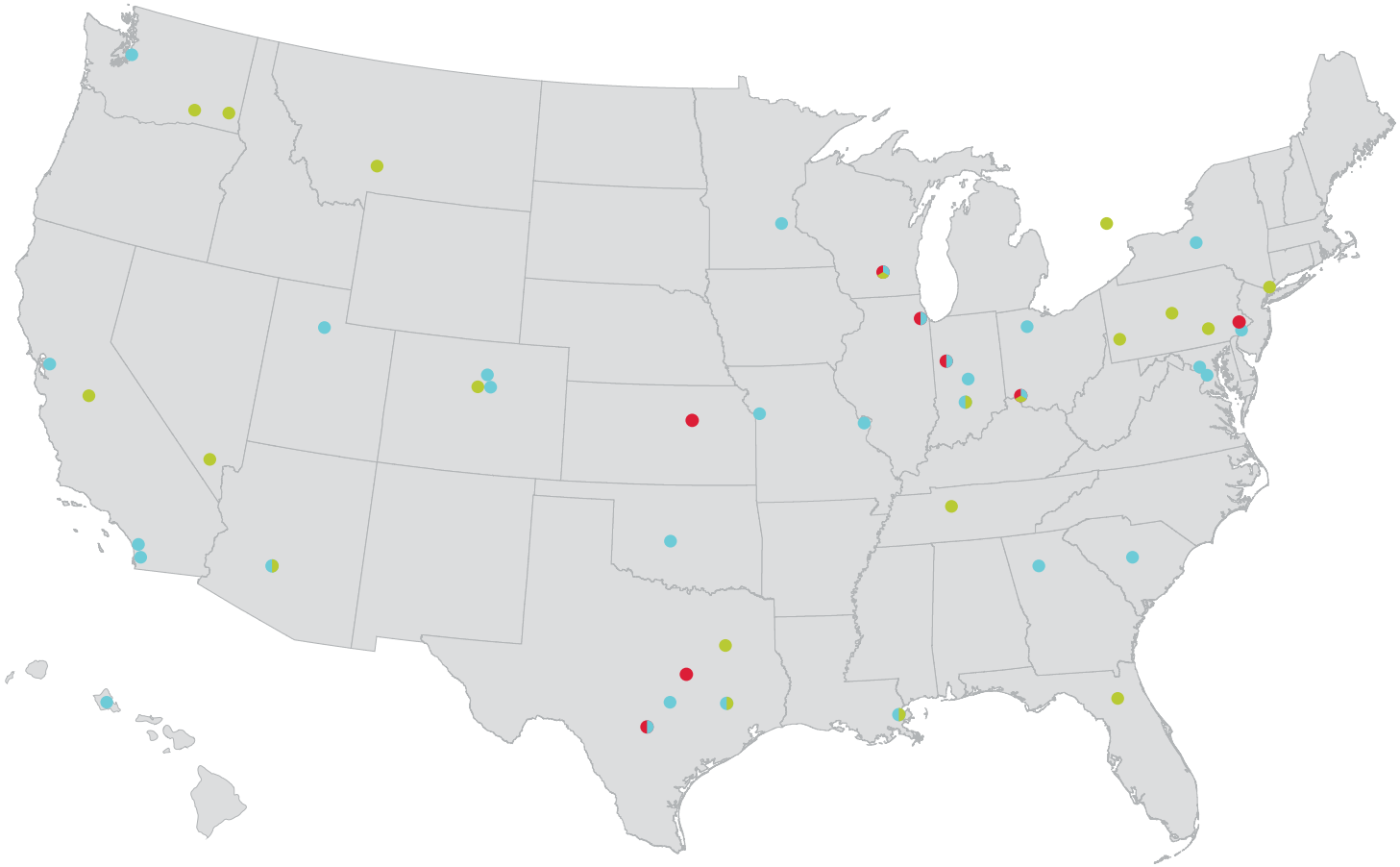
RESOLVED NETWORK PERFORMANCE ISSUES TO IMPROVE DATA TRANSFERS

EPOC's Roadside Assistance program provides on-demand help for network performance problems via a coordinated operations center. In 2019, EPOC helped institutions from colleges to museums resolve network issues, resulting in redesigned networks, data transfer node deployment, and real-time data movement.

EPOC'S APPLICATION DEEP DIVES IN ACTION

In 2019, EPOC ran eight Deep Dives with KINBER and Arcadia University, OARnet and University of Cincinnati, the Great Plains Network and Kansas State University, LEARN and Trinity University, Purdue University, University of Wisconsin, at PEARC 2019, and LEARN and Baylor University.

Each engagement helped CI engineers better understand how to support their researchers, from identifying needs for storage and local compute to showing where network connections needed to be adapted, to explaining collaborative science workflows for future plans.



Deep Dive locations

- Chicago, IL
- West Lafayette, IN
- Manhattan, KS
- Cincinnati, OH
- Glenside, PA
- San Antonio, TX
- Waco, TX
- Madison, WI

Travel for meetings

- Tempe, AZ
- Berkeley, CA
- La Jolla, CA
- San Diego, CA
- Boulder, CO
- Denver, CO
- Washington, D.C.
- Atlanta, GA
- Honolulu, HI
- Chicago, IL
- Bloomington, IN
- Indianapolis, IN
- Lafayette, IN
- New Orleans, LA
- Bethesda, MD
- Minneapolis, MN
- St. Louis, MO
- Kansas City, MO
- Syracuse, NY
- Bowling Green, OH
- Cincinnati, OH
- Norman, OK
- Philadelphia, PA
- Columbia, SC
- Austin, TX
- Prairie View TX
- San Antonio, TX
- Salt Lake City, UT
- Tacoma, WA
- Madison, WI

Roadside Assistance and consultations

- Arizona State University, Tempe, AZ
- University of California Merced, Merced, CA
- Colorado School of Mines, Golden, CO
- University of Florida, Gainesville, FL
- Indiana University, Bloomington, IN
- Louisiana State University Health Science Center, New Orleans, LA
- Montana State University, Bozeman, MT
- WestNet, Las Vegas, NV
- American Museum of Natural History, NY, NY
- NYU School of Medicine, NY, NY
- University of Cincinnati, Cincinnati, OH
- Compute Canada, Toronto, ON
- Franklin & Marshall College, Lancaster, PA
- Duquesne University, Pittsburgh, PA
- Pennsylvania State University, State College, PA
- Vanderbilt University, Nashville, TN
- Texas A&M University, College Station, TX
- Prairie View A&M, Prairie View, TX
- Pacific Northwest National Laboratory, Richland, WA
- Washington State University, Pullman, WA
- University of Wisconsin Madison, Madison, WI

LOOKING FORWARD
TO 2020 AND BEYOND

CAMPUS NETWORKS

- Completing network hardware upgrades, including switches and wireless access points, at IUPUI by summer 2020 and IU Bloomington by spring 2021
- Retiring IU Secure and moving to eduroam, a wireless "service set identifier" (SSID), that will simplify access for IU wireless users at many universities in the U.S. and around the world

I-LIGHT/ INDIANA GIGAPOP

- Securing a redundant path into Chicago
- Building a metro fiber ring in Ft. Wayne to provide greater resiliency for I-Light members in the Ft. Wayne area
- Developing improved dashboards

EPOC

- Working with additional community partners with a focus on application groups
- Developing a managed service for perfSONAR measurement software, enabling regional partners to better support their small and medium-sized members
- Expanding Application Deep Dives to work beyond a single campus and benefit an entire region

GLOBALNOC

- Deploying and turning up the first new elements of the Internet2 Next Generation infrastructure
- Building a new generation of NOAA's Trusted Internet Connection architecture, allowing for significant improvements in speed and readiness for the latest security requirements, and continuing to support the push toward greater use of cloud resources

GLOBALNOC RENEWAL PROGRAM

- Rethinking the structure of the GlobalNOC and working to take the lessons from our experiments
- Investigating new and expanded GlobalNOC service offerings
- Using network automation knowledge to assist the community in their training transitions
- Developing staff expertise and engagement with career advancement plans and knowledge-sharing initiatives

INTERNATIONAL NETWORKS

- Continuing to work with MOU partners to engage science and improve data transfer behaviors
- Providing support for 500G international data transfer experiments
- Using analysis work and NetSage displays to help understand performance anomalies

Networks
at Indiana University

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Indianapolis, IN 46202

2715 E. Tenth Street
Bloomington, IN 47408

globalnoc.iu.edu

200 YEARS