2024

THE
QUILT CIRCLE

Advanced Regional Networks in Support of Research and Education

A Letter From the President

It is with great pleasure that I welcome you to the latest edition of our annual Quilt Circle magazine, spotlighting the remarkable endeavors of regional research and education networks across our nation. As President of this esteemed community, I am honored to present to you a compilation of stories that exemplify the dedication, innovation, and collaborative spirit that define our non-profit research and education networks.

In this year's edition, you will find a diverse array of topics that highlight the transformative impact of our collective efforts. From pioneering broadband initiatives in rural communities to advancing quantum networking technologies, each article showcases the invaluable contributions of our members to the national and global research and education landscape.

As you navigate through the pages of this magazine, you will encounter inspiring tales of progress and discovery. Learn how Quilt members are championing broadband access in their states, empowering rural communities with connectivity and opportunity. Explore how OSHEAN's Wi-Fi project is enhancing quality of life in Rhode Island, underscoring the profound societal benefits of robust networking infrastructure.

Delve into the frontiers of scientific inquiry with stories like LONI's exploration of one of the brightest stars in the sky, or OneNet's dissemination of groundbreaking discoveries from Oklahoma to the world. Witness the democratization of science through initiatives like the Education DMZ in Arizona and the Regional Science DMZ in Pennsylvania, ensuring that all institutions have access to the tools and resources they need to thrive. Explore the innovation of our members on the frontiers of spectrum and artificial intelligence.

Beyond technological advancements, this magazine also celebrates the human aspect of our work. Discover how our community is elevating women in IT networking, reinforcing cybersecurity measures in libraries, and fostering science collaborations that transcend geographical boundaries.

As we reflect on the past year, marked by both challenges and triumphs, it is evident that our physical IT networks and our human networks are stronger than ever. We are united in our collective non-profit missions to advancing the frontiers of knowledge and empowering future generations.

I extend my heartfelt gratitude to all our members, partners, and stakeholders for their unwavering support and dedication to our Quilt community. It is through our collective efforts that we continue to shape the future of research and education networking, paving the way for a brighter tomorrow.

Thank you for joining us on this journey of exploration and discovery. May the stories within these pages inspire you, as we continue to chart new horizons and push the boundaries of possibility.

Warm regards,

Jen Leasure

Jen Leasure
President and CEO
The Quilt

THE QUILT

The Quilt Members and Board of Directors

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HERO PROJECT
HIGH-SPEED ECONOMIES FOR RURAL OPPORTUNITY
MCNC · NTIA

In June 2023, MCNC successfully secured funding to expand its flagship broadband network once again throughout North Carolina. MCNC received $11.2 million from the U.S. Department of Commerce's National Telecommunications and Information Administration (NTIA) for the High-speed Economies for Rural Opportunity, or HERO Project, which will directly support improvements to broadband access and affordability in central and southeastern North Carolina. MCNC was the only REN in the country to receive direct funding through the federal *Internet for All* initiative.

MCNC's network currently sits at 4,536 miles serving all 100 counties in North Carolina. The HERO Project will increase the network by another 209 miles, filling in some areas that unfortunately remained unserved after the massive Broadband Technology Opportunities Program (BTOP) build was completed in 2012-13.

The HERO Project will extend MCNC's network via two strategic routes. Those routes include Albemarle to Winston-Salem (74 miles) in central North Carolina, and between Sanford via Fayetteville to Jacksonville (135 miles) in southeastern North Carolina. The 11 total counties to benefit from this project currently have more than 16,000 unserved and 12,000 underserved housing units, including many substantially unserved local communities. In total, the HERO Project is projected to positively impact more than 350,000 housing units and 696 community anchor institutions, bringing new opportunities to these economically challenged areas.

"The pandemic exposed a very serious problem for many rural communities in North Carolina, but we didn't have the proper resources to address it at the time," said MCNC President and CEO Tracy Doaks. "Now we have a once-in-a-generation opportunity to do something good and something right for these communities."

MCNC has been recognized as a White House Champion of Change and has been a celebrated steward of funding over the years, including the successful completion of the $144 million Golden LEAF Rural Broadband Initiative through BTOP, which expanded broadband infrastructure by more than 2,600 miles across the state. The Golden LEAF Foundation once again is supporting MCNC's efforts and awarded $1,382,782.18 to be used as matching funds towards the southeastern North Carolina portion of the HERO Project. MCNC also provided a 41 percent matching investment of $7,773,435, making the total project just over $20 million.

Investing in broadband infrastructure is an investment in the future. MCNC has a vision of digital equity, and the HERO Project is part of a long-term endeavor to unlock the full potential of everyone in North Carolina.

Construction for the HERO Project is expected to begin by summer with completion planned for June 2025.

MCNC - 20 YEARS OF EXPANSION

Expansion

- 2003 NCREN
- 2011-2013 BTOP
- 2016-2017 Hamlet to Greensboro
- 2018-2019 RTP Expansion Project
- 2019-2020 Sanford to Farmville
- 2020-2021 Western Expansion Project
- 2022-2024 Winston-Salem to Dobson
- 2023-2025 Projected HERO Project

0 20 40   80   120   160
Miles

MCNC®

As of 8/24/2023
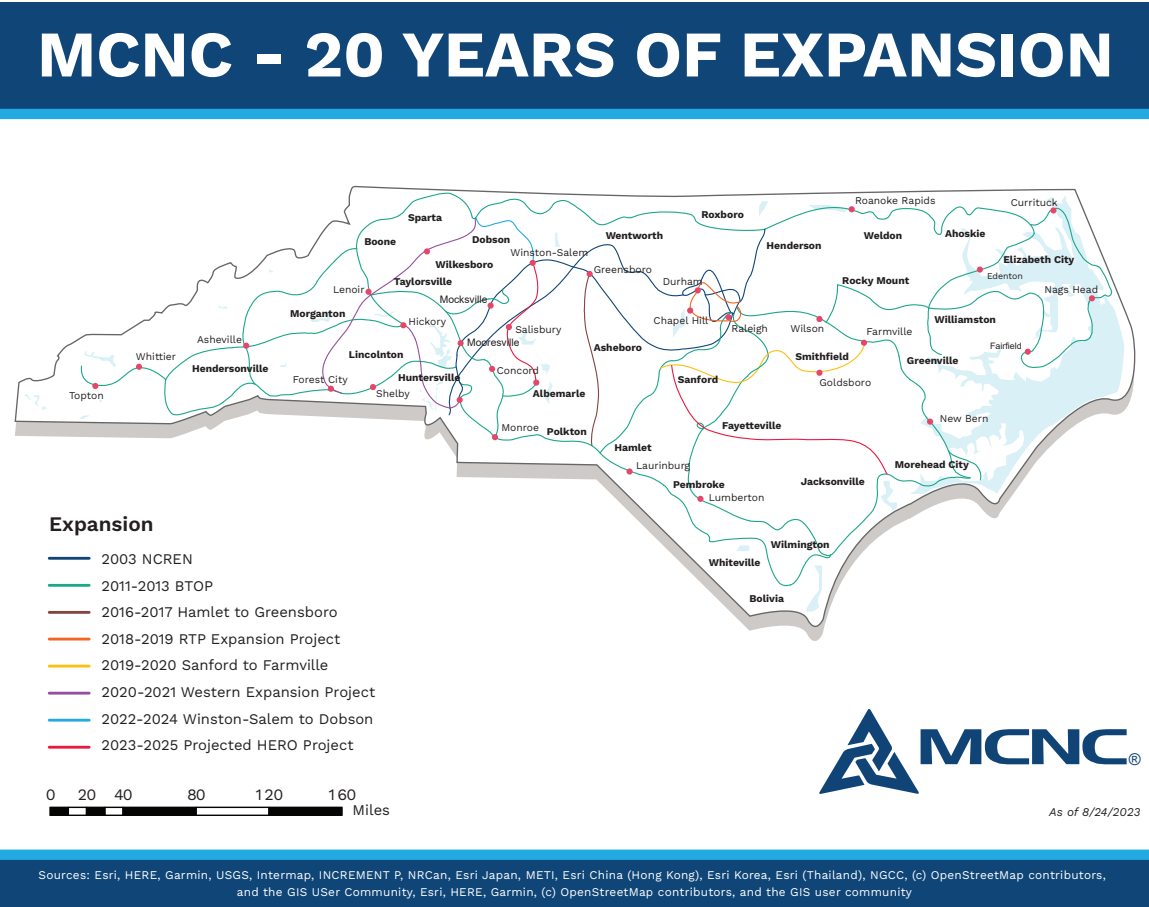
MCNC is a non-profit, client-focused technology organization. Founded in 1980, MCNC owns and operates NCREN, one of America's longest-running regional research and education networks. With more than 40 years of innovation, MCNC continues to provide high-performance services for education, research, libraries, health care, public safety, and other community anchor institutions throughout North Carolina. Visit **www.mcnc.org**

OSHEAN's Wi-Fi project improves quality of life in one Rhode Island community

During the COVID-19 pandemic, the Housing Authority of Newport (HAN) in Rhode Island, like many communities, faced a critical challenge – ensuring affordable and reliable internet access for its residents. This need was particularly acute among the elderly and low-income families, who found themselves increasingly reliant on digital connectivity for essential activities.

HAN Executive Director Rhonda Mitchell emphasized the profound impact of digital exclusion on low-income families, noting its adverse effects on educational achievement, job opportunities and health outcomes. With HAN serving more than 2,000 residents, many of whom have an annual household income of about $18,000, the digital divide was a glaring issue. Responding to this pressing need, Tommy Sheehan, a resident and member of the HAN Board of Commissioners, had a proactive approach to work with OSHEAN.

OSHEAN CEO Dave Marble and Vice President of Business Development Mark Montalto collaborated with HAN to design a community Wi-Fi network suitable for the senior housing complexes Donovan Manor and Chapel Terrace. Though technically feasible, the project's financial requirements were significant. An incumbent commercial provider's annual quote of $300,000 was far beyond the authority's budget. To address this, Mitchell and Sheehan reached out to Daniela Fairchild, then the director of Operations and Special Projects at Rhode Island Commerce Corporation, who played a key role in connecting HAN with OSHEAN.

The journey to secure funding required resilience and determination. Sheehan's brother Dennis, a retired finance professor, became instrumental in this endeavor. His expertise in grant writing helped secure more than $1 million in broadband equity funds through Community Development Block

The Housing Authority of Newport's Donovan Manor

Grant (CDBG) programs. Despite the lengthy process, this funding was transformative, enabling the construction and maintenance of the network for five years, and ensuring that HAN would ultimately own the network infrastructure.

The initiative has had a tangible impact on the community. Since 2022, nearly 100 residents at Donovan Manor have enjoyed free, high-speed and reliable internet, markedly enhancing their quality of life and access to services. Encouraged by this success, the project expanded to Park Holm, benefitting nearly 200 additional families. Mitchell recently shared that HAN is receiving another $300,000, which will allow them to serve most of remaining properties, providing free high-speed, reliable internet for almost 500 families.

HAN's community Wi-Fi project is a potential blueprint for tackling the challenges of the Broadband Equity, Access, and Deployment (BEAD) program's vision of Internet for All. OSHEAN, inspired by the project's success, plans to replicate this model across other municipal housing authorities. The collective optimism and determination of all stakeholders underscore the transformative impact that equitable internet access can have on communities.

With the knowledge and experience gained from this project, OSHEAN is ready to face the challenges ahead and extend the benefits of digital inclusion to more communities throughout Rhode Island.

ICN teleports to the future with quantum networking

It's an exciting time to be in Illinois if you're a quantum information scientist.

Illinois has received more than $280 million as part of the National Quantum Initiative, a congressional act calling for a coordinated federal program to accelerate quantum research and development for the economic and national security of the United States. Four of the 10 national centers for quantum research are located in Illinois, and Gov. J.B. Pritzker has followed up with an additional $200 million to fund quantum research at the University of Chicago and the University of Illinois Urbana-Champaign.

The Illinois Century Network (ICN) is supporting quantum research by providing 12 strands of high-quality fiber between these two universities, allowing for testing and research in quantum networking.

A quantum network enables secure transmission of data by using the unique properties of particles of light called photons. One unique property is that of entanglement, where two photons can be associated with each other such that a measurement of one affects the outcome of a measurement of the other (irrespective of the distance between the two as long as the state of entanglement

An Entangled Photon Source

is maintained). If two photons are entangled, and one is sent to another location (such as a fiber-optic strand) after an initialization and measurement process on the two photons, information transfer can occur between the photons; such that information at the source photon is "magically" seen at the destination photon without having the information transferred in the traditional sense via ones and zeros. Among quantum researchers this transfer of information is known as quantum teleportation.

To initially distribute the entangled photons, the fiber has to be clean, meaning low signal loss, to ensure the state of entanglement is maintained for as great a distance as possible. When entanglement breaks, there is no information transfer. Even with clean fiber, there is still a limit to the distance where entanglement is maintained. To address this limitation, ICN and quantum researchers are collaborating with Kankakee Community College, located midway between Champaign and Chicago, to house quantum "swapping" technology. With this quantum lab now in Kankakee, researchers can explore and test

novel methods for maintaining entanglement across large distances.

Kankakee Community College will become a regional hub and also offer courses in quantum information science, where students can participate in the lab and get to "touch" the equipment.

"Kankakee Community College is extremely excited to participate in this endeavor," said Michael S. OConnor, senior director of Information Technology Services at Kankakee. "The quantum network will provide a myriad of opportunities for the college and for the surrounding community. We realize we're at the forefront of something big, something that will be as game changing as the Internet itself."

It's an incredible motivator for ICN staff to be involved with the pioneers of quantum information science, and being able to fine tune the ICN Network to support quantum communication opens up a whole new world – a world that ICN staff had a hand in creating with an exciting future ahead.

NYSERNet's Rapid Analysis process streamlines innovation, implementation

Innovation requires great ideas. But, without efficient implementation, those ideas might be left sitting on the shelf. When Jeanne Casares became NYSERNet's president and CEO in 2022, the organization started looking at innovation and efficiency processes, including a formal way to speed up ideas that might benefit staff or members. One of the results was Rapid Analysis, a process aimed at fostering a workplace culture of innovation and responsiveness that ensures that promising opportunities are swiftly assessed and, if found feasible, quickly brought to fruition.

"NYSERNet has always been open to new ideas, but, in the past, the process was often ad-hoc, leading to duplicated efforts or tasks being completed incrementally. This slowed things down or meant that some great ideas never left the ground," said Casares. "Today, Rapid Analysis has enabled us to prioritize projects and address needs promptly as well as encourage staff to bring ideas forward and know that they don't have to tackle them alone."

Rapid Analysis was piloted in 2022 and rolled out in 2023. NYSERNet developed gating criteria – at least one of which must be met for a project to be considered – alignment with mission and strategy; requests from staff, membership or board members; an idea that improves operational effectiveness, efficiency and enhances business continuity; or is compliance related.

If the criteria are met, the idea moves to Phase I, where the "owner" presents details at a staff meeting, including intended solutions or opportunities, why existing methods are insufficient, alignment with business objectives and strategies, and implications and risks. Questions are answered, and staff provides feedback, followed by a timely decision about moving to Phase II. Phase II assigns a team to return with details of what is needed for successful implementation, including staff and resource

allocation, timeline, budget, outline features, pros and cons, a competitive analysis, stakeholder feedback, and preliminary contract observations. Again, a quick decision is made on implementation of proof of concept, a need for refinement or, in some cases, a denial.

One example of using Rapid Analysis was a request from ADVA (now known as Adtran), a European telecommunications vendor, for a field trial of its 800 Gbps optical responder using NYSERNet's statewide optical network – the first deployment of this technology on an actual network. The request was put through Rapid Analysis, where it was determined that it would take approximately 10 hours of staff time and two

employees to implement, and the trial itself would take 16-24 hours with minimal cost or risk. The team also determined this would promote NYSERNet as a leader in the optical networking space and improve its partnership with ADVA. Using Rapid Analysis, the request resulted in a successful field trial within five weeks.

"Rapid Analysis has created a clear path in determining what best meets the needs of staff, membership and partners, while furthering our mission and strategies," says Akshata Mahale, NYSERNet project manager, who led the implementation of the new process. "It continues to allow NYSERNet to put great ideas into action quickly."

Sun Corridor Network looks to democratize science nationwide with their Education DMZ in Arizona

Sun Corridor Network (SCN) in Arizona is developing an innovative approach to cyberinfrastructure and IT targeted at making science universally available – in other words, the democratization of science. This concept called an Education DMZ has the potential to provide improved access to data, applications, instruments and collaboration for the education community. It is initially being applied at testbeds in Arizona while SCN collaborates with The Quilt and other RENs across the country to scale the concept.

How does it work?

The Education DMZ concept builds on Science DMZs, which are designed to provide high-throughput, low-latency network paths for very large science data sets, usually across university research centers and national labs. Education DMZs operate in a similar fashion, but instead of focusing on high-performance data flows, they are tailored to address challenges faced by science at community college and high school levels. Improved science delivery is based on providing a stable, persistent and highly-usable platform that will make access to science easy and consistent. SCN will be working with universities, community colleges, and high schools to develop standards and a reference architecture for science delivery and collaboration.

Finding success working with RENs

Sun Corridor Network is currently working with NevadaNet and other members of The Quilt to define and develop the Education DMZ concept. "As a member of a national community of research and education organizations striving to increase access to science for underrepresented communities, The Quilt believes that the Education DMZ will be an important stepping stone to bridge this gap," said Jen Leasure, president and CEO of The Quilt. "An Education DMZ creates a platform for other K-20 environments to reduce the burden on educators to educate the scientists and researchers of tomorrow."

Scotty Strachan's research engineering group at NevadaNet has been developing a "Research & Teaching" DMZ since 2018. In 2023, three University of Nevada Reno computer science faculty members, one high school teacher, and a community college faculty member were able to teach five courses with more than 300 students that included cutting-edge methods and materials too large to use on a campus enterprise network.

Applying Education DMZ to precision agriculture

SCN recently received a National Science Foundation (NSF) grant to expand wired and wireless networks and Internet of Things (IoT) systems to Yuma precision agriculture research farms. The plan is to apply the Education DMZ concept to this project supporting research in precision agriculture in Yuma, with participation from Arizona State University, Northern Arizona University, and University of Arizona at the university level, Arizona Western College at the community college level, and Yuma School District at the high school level.

Elevating Women in IT Networking: Indiana University assumes leadership of WINS program

The Women in IT Networking at SC (WINS) program, dedicated to bridging the gender gap in information technology, is now under the leadership of Indiana University (IU). Under IU's leadership, WINS will continue the strong partnership with American Indian Higher Education Consortium (AIHEC), the Energy Sciences Network (ESnet), and the University Corporation for Atmospheric Research (UCAR).

This transition, effective Nov. 20, 2023, aims to maintain and expand the program's success in promoting diversity in the fields of network engineering and high-performance computing. Brenna Meade, senior network architect at International Networks at IU, is now the WINS program director.

Dave Jent, IU associate vice president for networks, has long been a champion of WINS, both financially and philosophically. "WINS embodies IU's commitment to a more inclusive IT community," he said. "Together, we champion diversity and unity, forging a brighter future for network engineering and high-performance computing."

Meade herself is a proud alumna of the WINS program. "WINS changed my career and my life dramatically," she said. "I'm honored to help other women experience the same career-altering opportunities that I did through WINS. I'm excited to bring more women into the field of networking."

WINS began in 2015 with the first cohort of WINS awardees participating in SC15 SCinet. It was a joint effort between ESnet, the Keystone Initiative for Network Based Education and Research (KINBER), the UCAR and SCinet. Its success led to a three-year grant from the National Science Foundation, with UCAR's Marla Meehl and Wendy Huntoon, now with the American Indian Higher Education Consortium, serving as original principal investigators.

"Leading the WINS program was a privilege, and I'm excited to witness its continued success under Indiana University's stewardship," said Meehl. "This transition is a testament to the program's enduring impact in promoting gender diversity in IT."

Each year, WINS sponsors up to 70 early- to mid-career women from the U.S. research and education IT community for "hands-on" experience with SCinet, one of the fastest and most advanced computer networks in the world. When WINS started, fewer than 14 percent of SCinet volunteers were women. Now, that number has tripled, with several alumni moving on to SCinet management roles.

In the past three years, WINS has focused on not only increasing the number of women, but also reaching out to underserved and underrepresented minorities and Minority Serving Institutions to broaden representation, and again, significant results have been achieved.

As shown in the figure below, The Quilt and other RENs nationwide have been instrumental in providing direct and indirect support of WINS including applicants. RENs provide essential dissemination of the WINS application process, encouraging applicants from both their own and member organizations. In addition, The Quilt and RENs have provided direct support for WINS awardees to participate in the MOR Leadership program and at regional and Quilt conferences.

Legend		
Color	Year	Number of People
	2015	18
	2016	28
	2017	33
	2018	33
	2019	28
	2020	9
	2021	19
	2022	20
	2023	19
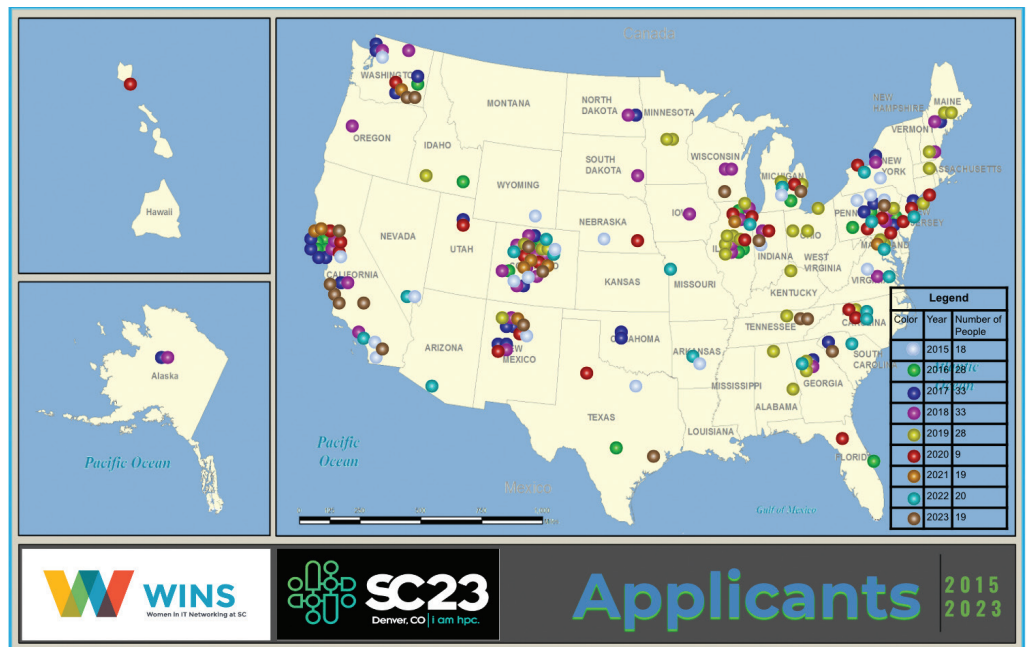
The Women in IT Networking at SC (WINS) program was developed in 2015 as a means for addressing the prevalent gender gap that exists in Information Technology particularly in the fields of network engineering and high-performance computing. What is SC? - SC is an annual conference co-sponsored by the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE) Computer Society. The conference focuses on the science and application of HPC and communication technologies. Since 1988, volunteers funded from academic, government and corporate organizations in the HPC industry have worked together to produce the SC Conference series. Visit **women-in-networking.net/**

MOREnet's cybersecurity partnership reinforces Missouri's libraries

Thanks to state funding managed through the Missouri State Library, nearly 100 public libraries in the state are now benefiting from enhanced network and security solutions to improve bandwidth management and cybersecurity protections.

Existing Partnership Expands

The Missouri State Library has a long history of partnering with MOREnet for network and technical services for its public libraries. MOREnet takes a thorough approach to network management and cybersecurity threat mitigation through a collaboration with Fortinet.

Revolutionizing MOREnet Member Libraries

Located in rural Missouri, the Texas County Library is one example of a community anchor institution plagued by slow connectivity and minimal malware protection. Users were able to access unsafe and copyrighted content across their four branches, which triggered DMCA notices to the library system. After a full network assessment, MOREnet engineers configured and installed the new access points, switches and firewalls along with MOREnet and Fortinet solution management for five years.

"Over the years, things were just cobbled together," explained Janet Fraley, library board member. "We are so thankful for the network assessment and installation. Being so rural we could not find someone to install our products; we didn't even know who to ask," said Fraley.

Texas County Library patrons are now able to access the internet easily and safely, and the four-branch system has had no complaints from patrons who log on through a secure sign-in system. Library Director Louise Beasley appreciates that she can easily access network user statistics and monitor what is happening now at each of the different branch connections. Even more so, Beasley appreciates the support from MOREnet, stating that "…they are just right there with us."

Network Quality and Control

Salem Public Library is another example that had an ineffective firewall and local area network. The library staff did not understand how the library network was designed, and it took multiple trips from MOREnet experts to inspect and resolve the issues. "The tremendous thing that this state funding did for Salem was give us control of the internet," shared Kate McBride, the library director. "Because of MOREnet, we know more now and feel more in control."

Streamlining Vast Rural Networks

In areas of rural Missouri, there are very few technological consultants available to help libraries build safe and effective networks. Frequently, it has been up to the library director or volunteer staff to manage and secure Internet infrastructure. Another common challenge for rural library systems is having multiple library branch locations spread across a large geographical area. Ozark Regional Library has four branches spanning two counties. John Jones, head of technical services for the system, drove more than an hour between branches when issues arose. "It's so helpful to have the singular platform. Now, I can log into any of the routers remotely." Reynolds County Library Director Megan Bishop shared similar struggles with distance. "We are an 86-mile round trip drive between branches," noted Bishop. "This technology has made my job easier now that I am able to access and share the information from one location."

Ongoing Commitment and Support

MOREnet supports Missouri libraries with Fortinet's all-inclusive solution, empowering libraries with local control while providing support and guidance along the way. Kate McBride from Salem Public Library once again shared that she found the entire process empowering, adding that "our staff understands more about our technology than we did before because MOREnet took the time to explain what was needed, why we needed it, and where it was going."

The Missouri Research and Education Network (MOREnet) is both a data network as well as a human network. It provides internet connectivity, access to Internet2, technical services, resources and support, as well as technical training to Missouri's public sector entities, including K-12 schools, colleges and universities, public libraries, health care, government and other affiliated organizations. Visit **www.more.net**

LONI helps scientists explain mystery about one of the brightest stars in the sky

In the last decade, it has become clear that stars are far from living in isolation.

Astronomers have discovered that most massive stars (stars that weigh 8 times or more than our sun) exist within binary systems, and that a significant portion of these systems undergo binary interactions at some point during their life. These binary interactions can substantially alter the evolution of each star in the system and, in extreme cases, can result in the complete merging of the two stars – a "merger" phenomenon from which a new star with peculiar properties forms and cannot be explained by "traditional" single stellar evolution theories.

Recent observations have revealed that Betelgeuse, the second-brightest star in the constellation Orion, possesses several such unexplained properties. This giant star spins much faster and has many more heavy elements mixed within it than typical giant stars should. However, modeling the exact evolution of such a merger is challenging. Complex flow patterns, which can be sub and supersonic at different regions, are expected in these cases. In addition, due to the asymmetrical nature of the merging process, a computer program that solves the hydrodynamic equations in three dimensions needs to be invoked. Furthermore, massive stars that quickly burn the hydrogen in their core form a condensed core of helium surrounded by an extended, more diluted envelope of hydrogen. Simulating such a star with a compact core involves very fine resolution in both length and time, which causes the number of calculations to increase exponentially, requiring computing power far beyond what a personal computer or even a powerful workstation can provide.

A team led by Dr. Manos Chatzopoulos, an associate professor in the Department of Physics and Astronomy at Louisiana State University, used Octo-Tiger, an adaptive mesh refinement hydrodynamic code based on a computational framework called High Performance ParallelX (HPX), to simulate the merger. Thanks to the unique features of the code that allows it to run efficiently on thousands of cores on LONI (Louisiana Optical Network Infrastructure) supercomputers, they were able to greatly reduce the computation time and simulations that could take a prohibitively long time to complete. After burning through almost 10 million CPU-core-hours in a year, they were able to confirm that, under certain conditions, a merger can indeed produce red giants with properties like those observed in Betelgeuse.
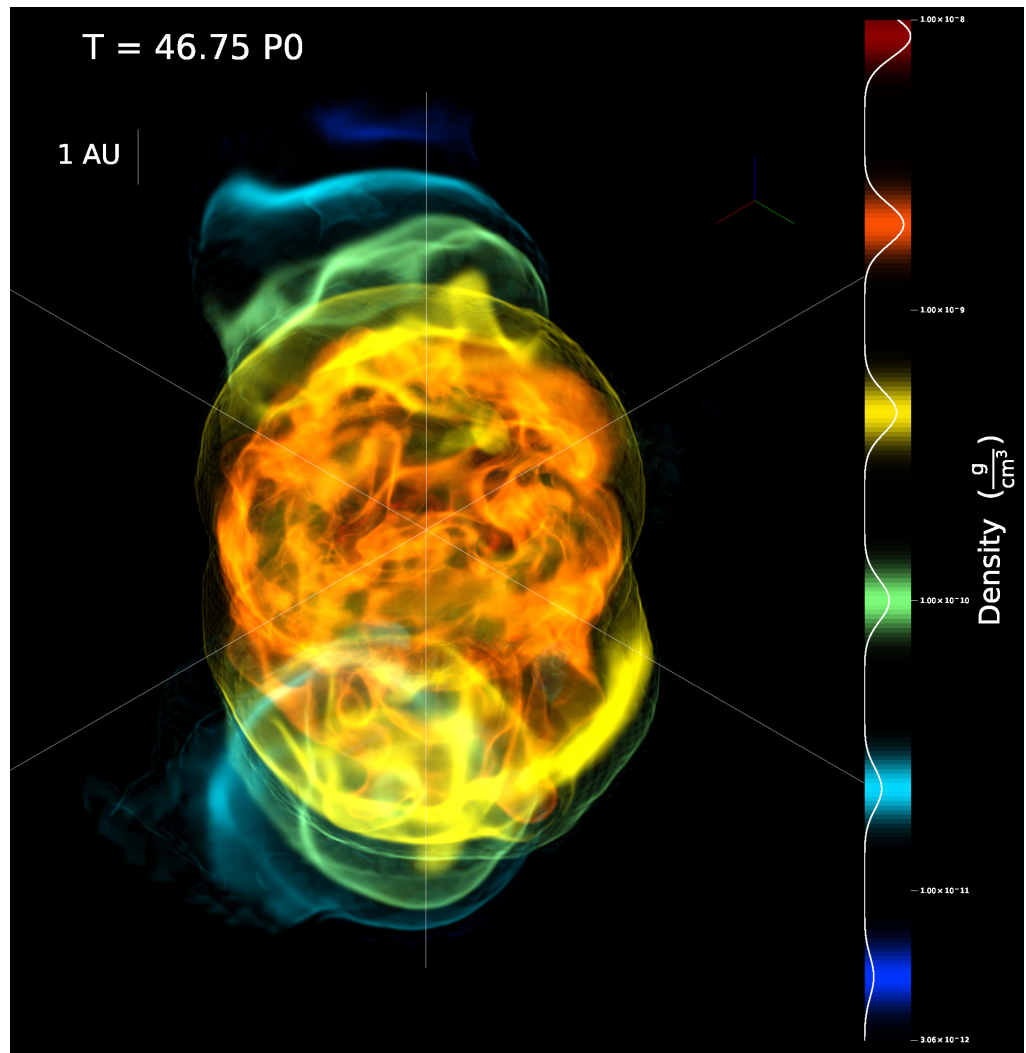
Dr. Chatzopoulos' team is among many in Louisiana whose research is enabled by cyberinfrastructure provided by LONI. Last year, LONI Queen Bee 2 and 3 supercomputers supported 244 research projects, which consumed more than 78 million CPU-core-hours. With the addition of the Queen Bee 4 that will be available to users in 2024, LONI will significantly boost its HPC offerings in terms of CPU (3X), GPU (10X) and storage (5X), and take the overall cyberinfrastructure of the state to a whole new level.

OneNet shares scientific discoveries in Oklahoma with the world

OneNet serves as Oklahoma's leading research and education network, helping to advance innovation and scientific discovery in global research initiatives such as high-energy physics to bioscience to climate modeling. These important initiatives and more require high-capacity bandwidth to support big data movement in real-time across the country and around the globe.

OneNet is strategically positioned within higher education to support research computing and networking, including the following projects:

ATLAS Project

The Oklahoma Center for High Energy Physics (OCHEP) is a collaboration of researchers at the University of Oklahoma (OU), Oklahoma State University (OSU) and Langston University. OCHEP scientists are conducting research for the ATLAS Project, a high-energy physics experiment at the Large Hadron Collider at the European Organization for Nuclear Research (CERN). ATLAS explores the fundamental nature of matter and the basic forces that shape our universe by examining head-on collisions of protons of enormously high energy. These particle physics experiments have large data transfer requirements supported by OneNet.

"Particle physics experiments have large networking needs, since data must be transferred among scientists," said OU Research Scientist Horst Severini. "OneNet has been invaluable in making these fast and important data transfers possible to all our collaborating ATLAS institutions, both in the U.S. and all across the globe."

Genomics and Real-Life Research

Researchers at OSU are utilizing high-performance supercomputers and OneNet's network to evaluate the use of fungi in biofuels, study pathogens that damage poultry populations, analyze the human genome for diseases, and numerous other experiments that have real-life implications. OSU's participation in this research is making genome mapping to scan for genetic risks like cancer a routine health assessment for everyone. OSU collaborates with researchers across the country to advance these research initiatives and requires big data movement among research partners.

NOAA Forecasting Testbeds

The Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma periodically runs ensembles of high-resolution weather prediction forecasts covering the continental United States. These forecasts are produced on National Science Foundation high-performance computing resources in collaboration with the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Testbeds, which test new forecast products in a quasi-operational setting. CAPS utilizes OneNet's network to exchange forecasts across the country during each of these experiments.

Equipping Students

Oral Roberts University (ORU) leverages OneNet's network for a variety of scientific research, including molecular modeling, subatomic physics modeling, computational fluid dynamics, seismic imaging, bioinformatics and molecular spectroscopy. Low-latency, high-bandwidth data motion capabilities enable researchers to participate in large-scale collaborations, moving large datasets across the state and around the world. ORU undergraduate students are gaining substantial experience that greatly enhances their skill sets and scientific understanding, making them competitive for the next step beyond graduation.

"OneNet spends the time to understand the challenges, how they are changing and proactively participates in pursuit of the solutions," said Stephen Wheat, professor of computer science and director of the ORU Research Computing and Analytics Facility. "Any institution with network connectivity challenges to the outside world would find OneNet capable of addressing their challenges."

Link Oregon rolls out new strategies to advance middle-mile broadband

Advancing middle-mile broadband connectivity for a future-ready Oregon

In sync with the nationwide momentum by states to prepare for historic levels of broadband funding facilitated by the NTIA BEAD Program, the Oregon Broadband Office (OBO) made solid progress last year in laying the foundation to receive its share of funding to expand internet access for all Oregonians. As a non-profit, middle-mile broadband provider to Oregon's public and non-profit sectors, Link Oregon also rolled out a strategic plan outlining an approach to advance broadband across the state to better support greater inclusion, resilience and economic sustainability.

Highlights of this plan include:

Legislative Advocacy. Link Oregon actively participated in the consultative and legislative advocacy processes for two bills in the Oregon Legislature. HB 3201, the statewide broadband bill, is a revised statute to ensure Oregon is prepared to receive all federal funding available and distribute it efficiently and equitably to all Oregon communities. HB 2049 established the Oregon Cybersecurity Center of Excellence (OCCoE) at three of Link Oregon's founding member universities to focus on cybersecurity threat mitigation. Both bills have been signed into law by Oregon Gov. Tina Kotek.

BEAD Participation. Link Oregon submitted detailed comments to the OBO on Oregon's Initial Proposal Volumes I and II, Digital Equity Plan, and the proposed handbook for the Broadband Deployment Program.

Middle-Mile Advancements. Link Oregon offered support for Zayo's proposal for the NTIA Middle-Mile Grant Program and looks forward on the progress on their $92 million award to build critical middle-mile connections in south-central Oregon. "We need a strategic approach to middle-mile investments, including this interstate award, so that the influx of federal investment doesn't result in last-mile islands," said Steve Corbató, executive director at Link Oregon.

Momentum for eduroam. As the designated eduroam support organization for Oregon's K-12 schools, libraries and museums, Link Oregon – in partnership with Internet2 – is working to roll out eduroam connectivity across the state, currently conducting a comprehensive pilot program for 16 school districts within the Lane Education Service District (ESD) and plans to expand to additional ESDs in 2024.

Broadband Ecosystem Collaboration and Advocacy. Link Oregon hosted its fourth Oregon Tribal Broadband Summit in 2023 with leaders from federally-recognized Tribes to focus on broadband planning, infrastructure and emerging funding opportunities in the state. This work alongside the Western States Broadband Alliance and the National Digital Inclusion Alliance continues to advance the sharing of best practices, insights and middle-mile collaborations between the other states including California, Colorado, Idaho, Nevada, Oregon, Utah, and Washington.

Service Delivery Excellence. Link Oregon drove optimizations across their statewide middle-mile network for improved resiliency, greater automation, a rich set of direct connections to major cloud providers as well as support for private cloud networks, and rigorous cybersecurity protocols. Link Oregon has activated more than 80 new or upgraded services since the migration to the new network.

Link Oregon is ready to help write the next chapter of Oregon's broadband future in 2024.

Edge understands the value & promise of the AI university

Edge understands that in the future the artificial intelligence (AI) university concept holds immense promise and potential as technological advancements continue to reshape the landscape of higher education, health care and government. As AI becomes increasingly integrated into various aspects of society, Edge understands its influence on academia is set to be transformative. The university of the future will not merely be a traditional institution enhanced by technological tools; it will be a dynamic ecosystem that leverages AI to revolutionize the way knowledge is acquired, disseminated and applied.

In this envisioned future, AI will seamlessly integrate into every facet of the learning experience. Intelligent algorithms will personalize curricula, adapting content to individual learning styles and paces, ensuring every student receives a tailored education journey. Learning materials, assessments and feedback will be dynamically adjusted based on each student's strengths, weaknesses and progress, fostering a more engaged and effective learning process.

AI-powered virtual assistants will serve as tireless companions for students and faculty alike. These assistants will provide real-time support, answer queries, offer insights, and even facilitate peer collaboration. Faculty members will find their roles evolving, transitioning from traditional lecturers to mentors who guide students through advanced concepts, ethical considerations, and critical thinking exercises pertaining to AI technologies.

As AI university advances it will also redefine the boundaries of research and innovation.

The AI university's impact will extend beyond campus borders, connecting with industries and communities worldwide. Lifelong learning will be seamlessly facilitated through AI-powered platforms, enabling professionals to upskill and adapt to rapidly evolving job markets. Moreover, the AI university will be a catalyst for inclusive education, breaking down barriers of access and enabling learners from diverse backgrounds to partake in quality education.

As we embark on this transformative journey, ethical considerations and responsible deployment will be paramount. Safeguarding data privacy, mitigating bias, and fostering transparency will be integral to shaping an AI university that truly empowers and enriches the lives of all learners. The future of the AI university beckons as an exciting era that combines the power of technology with the essence of human potential, propelling education into new frontiers of knowledge, innovation and societal impact.

Edge is a non-profit research and education network and technical partner to educational institutions, hospital networks, government entities, and other nonprofit organizations. Their mission is to empower members' digital transformation by providing affordable, reliable, and thought-leading technology, connectivity, and services. Visit **www.njedge.net**

CENIC is doing more with less: balancing network energy budgets through Spectrum Services

From 2010 to Today:
More Bandwidth with Less Equipment

400 Gbps

10 Gbps

2010   2023

BANDWIDTH

A **SINGLE** Rack Space

EQUIPMENT
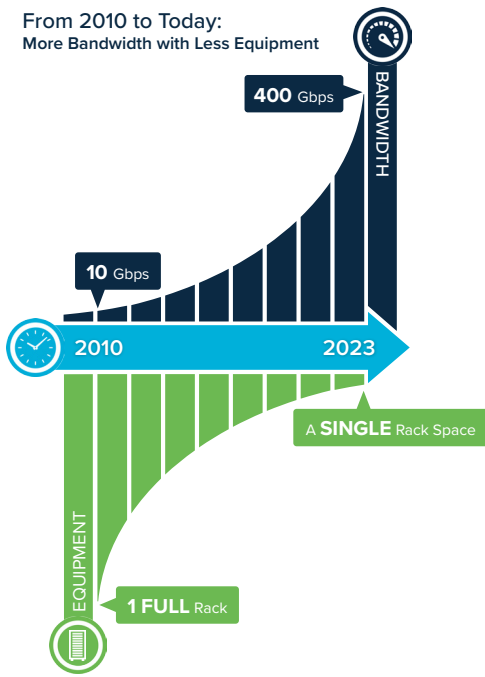
1 **FULL** Rack

CENIC has implemented many innovations to improve the energy efficiency of the California Research and Education Network (CalREN) while delivering ever greater capacity.

In 2010, CENIC used one full rack of equipment for 10 Gbps of data traffic (as shown in the diagram). Today, CENIC has achieved 400 Gbps or more with only 1/24th as much equipment, a major savings of space and power when one-third of network-related power consumption is related to equipment and data transmission.

Doing more with less: Spectrum Services

The more data you can move with less equipment and power, the better. CENIC's Spectrum Services is an example of an innovation in optical services that will help exceed these already impressive achievements in network energy efficiency, both for CalREN and the communities CENIC serves.

Spectrum Services are a special power – and equipment-thrifty subset of what are called

Optical Services, which uses one or more "slices" of the total spectrum of light carried by a fiber pair. The capacities a carrier or last-mile provider can obtain through such services typically run into the hundreds of gigabits per second, making Optical Services equivalent to a dedicated high-performance fiber path. The different types of Optical Services are defined by the way the total spectrum of light is divided. In the Wave Services Model, also known as fixed-grid, the full 4800 GHz spectrum that a typical pair of fiber-optic strands can carry is evenly divided into a fixed grid of uniform 50 GHz-wide slices, and services are provisioned by the slice. Depending on the transponder used to turn data signals into light pulses, each 50 GHz slice can carry up to 200 Gbps of data traffic. To do this, each slice requires a transponder on each end of the fiber pair.

CalREN features the ability to provide a customer's desired capacity on a pair of fiber strands with Spectrum Services – combining multiple smaller slices (currently 6.25 or 12.5 GHz wide) – into one composite slice of flexible size. This composite slice is treated as a single signal by one pair of Next-Generation Internet (NGI) transponders, enabling considerably higher data throughputs. Additionally, customers can reach near-Terabit data rates depending on the size of the purchased slice of spectrum and which NGI transponder is used.

Pushing limits even further: Terabit Capacity and Beyond

Using only Spectrum Services, a single optical fiber can already carry a total of 25.6 Terabits per second. However, the coherent pluggable optics already validated by CENIC (both with and without integrated amplifiers) can fit 400 Gbps into a slice only 65 GHz wide, boosting that number to nearly 30 Tbps. Also, transponders and pluggable optics are improving in throughput, and more and more of them are fitting into a given unit of rack space.

Yet another area of coming innovation is the expansion of the spectrum of light used to carry data over an optical fiber. Light rays come in a wide range of wavelengths and frequencies, and fiber technology most often uses the subset of this range with the best performance and lowest loss, called the "C-band." Once a fiber's C-band is carrying its full capacity, these other subsets of the total light spectrum can be used to carry even more data, now and in the future.

Energy Efficiency: More than just Spectrum Services

By implementing other process-related efficiencies, CENIC was able to reduce its power by over two-thirds.
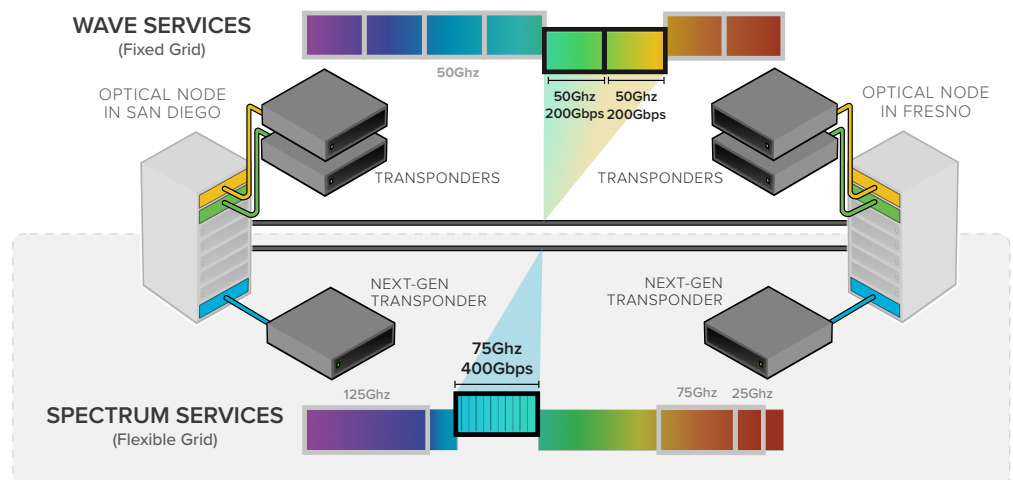
WAVE SERVICES
(Fixed Grid)

50Ghz

50Ghz   50Ghz
200Gbps 200Gbps

OPTICAL NODE
IN SAN DIEGO

OPTICAL NODE
IN FRESNO

TRANSPONDERS   TRANSPONDERS

NEXT-GEN
TRANSPONDER

NEXT-GEN
TRANSPONDER

75Ghz
400Gbps

125Ghz   75Ghz   25Ghz

SPECTRUM SERVICES
(Flexible Grid)

EPOC accelerates science collaborations for The Quilt

Collaborative science demands that data is seamlessly accessible to all partners regardless of geography. In practice, data sharing is built on top of a complex system of hardware, software, networks, and policies that must perform as a smooth, uniform and continuous whole to meet the demands of researchers. When components of this pipeline fail or is unable to scale to meet needs of its users, data transfer speeds can be significantly reduced and impact research productivity.

The Engagement and Performance Operations Center (EPOC) is a coordinated center of expertise and resources to improve end-to-end network performance and is led by staff at the Energy Sciences Network (ESnet) and Texas Advanced Computing Center (TACC) at the University of Texas at Austin. EPOC partners with members of The Quilt community, including FRGP, GPN, iLight, KINBER, LEARN, NOAA N-Wave, NJEdge, NYSERNet, OARnet, PIREN, PNWGP, SoX, SCN and TACC, and offers services to anyone sharing data for education or research.

EPOC supports five main activities:

1. **Roadside Assistance and Consultation.** This enables researchers and network engineers to reactively resolve network performance problems with end-to-end data transfers. EPOC has worked with over 350 cases as part of this effort, and addressed questions that range from re-architecting a campus network to understanding point-to-point, time-constrained transfers.

2. **Application Deep Dives.** EPOC staff uses this to bring together compass and regional engineers and related application communities to understand full workflows for diverse research teams in order to evaluate bottlenecks and potential capacity issues. EPOC has published 19 reports to date.

3. **NetSage.** EPOC supports the NetSage Monitoring Suite to proactively discover and resolve network performance issues. NetSage can be deployed by a regional network or campus HPC center to understand data movement and patterns as well as provide valuable information about where performance may need attention. EPOC is currently supporting deployments for six regional networks and several HPC centers.

4. **Fasterdata DTN Framework.** EPOC contributes to Fasterdata Data Transfer Node (DTN) Framework (formerly the Data Mobility Exhibition) as a way to encourage baseline performance testing between sites. EPOC supports this effort in part to encourage educational institutions to be able to transfer a Terabyte of data in an hour.

5. **Training.** EPOC also devotes staff time to Coordinated Training to ensure effective use of network tools with members of the University of South Carolina team (NSF #1829698). EPOC uses a virtual laboratory environment for easy set-up, scaling, and quick creation of custom training scenarios using open-source tools for instruction on DMZs, TCP, BGP, perfSONAR, and Zeek.

EPOC has the potential to be transformational to science and education by providing not only a depth of understanding to achieve better data transfers, but also the human expertise needed to make the most of research collaborations.

I-Light network refresh benefits from member volunteer engagement

Marianne Chitwood, Executive Director of I-Light and Indiana Gigapop networks, speaking at the annual member's meeting

Member engagement is the secret ingredient in I-Light's ability to serve education and research institutions in Indiana. Sure, the I-Light Network is driven by power, fiber, cutting-edge routers, switches and optical hardware, but the powerhouse that goes unnoticed is the involvement of the institutions that connect to the network.

Member volunteer engagement got a kick start in 2023 during a February town hall meeting where I-Light CTO Tom Johnson asked members if they would be willing to volunteer their time to participate on the I-Light Refresh Committee. Many stepped forward from several institutions, giving them a voice in how the network is designed and ensuring the network continues to serve the education and research community.

"Being part of the I-Light refresh team has been a wonderful opportunity to contribute to the future enhancement of an already great educational network," said Casey Carlson, network architect at Purdue University.

"Member volunteer engagement is appreciated by I-Light staff," added Ryan Taylor, senior network engineer at I-Light. "As an engineer I appreciate having members of the network involved in the hardware refresh project because each member brings a fresh perspective, extensive networking experience, and first-hand knowledge of the connectivity needs of a college or university in Indiana," said Taylor. "Their participation will certainly focus our efforts and help improve the overall outcome."

In addition to the I-Light Refresh Committee, I-Light member engagement opportunities are available at monthly town halls and at quarterly Network Advisory Council meetings.

I-Light looks forward to the network refresh with anticipation and pride, due to the volunteer involvement from the institutions that make up I-Light membership.

I-Light is Indiana's high-speed, fiber-optic research and education network, enabling high-quality lives through high-quality connections. Connecting every public university and private college in the state, we're lighting up Indiana's higher education community. Visit **www.ilight.net**

ESnet's Confab23 highlights future of integrated science and networking

The Energy Sciences Network (ESnet) serves as the "data circulatory system" for scientific researchers funded through the U.S. Department of Energy (DOE) and is an innovative creator of high-speed networking products and services offering widespread potential benefits. Confab23, ESnet's second annual user gathering held last October in Maryland, drew a diverse group of more than 150 domain and computer scientists, network engineers, program managers, user facility staff, and Research and Education (R&E) leaders.

The Confab23 theme was *Co-Designing the Future of National-Scale Integrated Science and Networking*, which was inspired by the DOE's Integrated Research Infrastructure (IRI) program. Researchers routinely collaborate across multiple facilities, utilizing instruments, high performance computing, artificial intelligence and other tools, while sharing massive, complex datasets. IRI focuses on seamlessly integrating facilities, data and computing to power scientific discovery – and ESnet is a key part of that integration as are members of The Quilt and other R&E networking organizations.

The first day of the packed program began with a DOE programmatic macro view of IRI, followed by an introduction to the proposed IRI testbed by Arjun Shankar, interim division director for the National Center for Computational Sciences at Oak Ridge National Laboratory. There was also an overview of IRI workflow patterns across DOE Office of Science programs by Eli Dart, a network engineer in ESnet's Science Engagement group. Several additional scientists then provided in-depth looks at how their work has benefited from IRI-like

Left to right: ESnet Chief Technology Officer Chin Guok moderated an IRI testbed discussion with Damian Hazen from ESnet, Amber Boehnlein from Jefferson Lab, Eric Lançon from Brookhaven National Laboratory, Debbie Bard from NERSC, Kjiersten Fagnan from the Joint Genome Institute, Thomas Uram from the Argonne Leadership Computing Facility, and Arjun Shankar from Oak Ridge National Laboratory.

collaborations, including Nicholas Schwarz, scientific software and data management lead at the Advanced Photon Source at Argonne National Laboratory, and Frank Würerthwein, director of the San Diego Supercomputer Center. Fourteen other scientific researchers also delivered rapid-fire summaries of their work during a lightning talk that embodied the kind of big-data, multi-facility collaborations that IRI is intended to streamline and accelerate. Rachana Ananthakrishnan, executive director of the University of Chicago's Globus Project, closed out the day.

The second half of Confab23 focused more on existing tools or ones being developed that will facilitate IRI, such as ways that different laboratories and facilities might use the proposed IRI testbed or the creation of a "data butler" in the cloud by the Vera Rubin Observatory. Confab23 closed with presentations by ESnet staff on IRI-related

applied research with discussion focused on the ESnet testbed, the ESnet SmartNIC (and its successful iteration, the EJ-FAT load balancer), network orchestration and automation, and measurement and analysis tools.

"Confab23 really demonstrated the power of this interconnected vision of an integrated research infrastructure and the ways in which the research communities are embracing it – and who better to do that than ESnet, which is already working with so many attendees on early IRI prototype projects, to facilitate the conversation," commented Amber Boehnlein, chief information officer of the Thomas Jefferson National Accelerator Facility (Jefferson Lab).

ESnet is in the process of setting a date for the next Confab. If you would like to be notified when the next event is announced, please email **engage@es.net**.

The Energy Sciences Network (ESnet) is a high-performance, unclassified network built to support scientific research. Funded by the U.S. Department of Energy's Office of Science and managed by Lawrence Berkeley National Laboratory, ESnet provides services to more than 50 DOE research sites, including the entire National Laboratory system, its supercomputing facilities, and its major scientific instruments. ESnet also connects to more than 140 research and commercial networks, enabling DOE-funded scientists to productively collaborate with partners around the world. Visit **www.es.net**

KINBER and KeystoneREN receive $1.1 million NSF grant to transform higher education in Pennsylvania

The National Science Foundation (NSF) has awarded KINBER and KeystoneREN, in partnership with Penn State University and other Pennsylvania universities, a $1.1 million grant. The grant will support a collaborative effort to provide essential cyberinfrastructure resources to under-resourced higher education institutions throughout Pennsylvania.

KINBER and KeystoneREN will be collaborating with several universities including Penn State, Swarthmore College and Indiana University to develop cyberinfrastructure solutions that will support the needs of each institution. The grant also will provide students and researchers at these universities with adequate advancements in their digital landscapes, allowing exploration of new opportunities and innovations.

"We are proud to play a pivotal role in this important initiative," said Grant Dull, executive director of KeystoneREN. "By utilizing our expertise and resources to manage the infrastructure, we aim to create a transformative impact on higher education institutions that may face barriers to accessing advanced cyberinfrastructure." The project and collaboration are a continuation of an NSF-planning grant KINBER received and completed in 2023. This grant allows KINBER, KeystoneREN and their partners to establish a statewide science DMZ to continue progressing toward improving advanced cyberinfrastructure to under-resourced institutions.

"Penn State's Institute of Computational and Data Sciences (ICDS) is ready and excited to work with researchers across Pennsylvania and beyond to leverage the grant's new cyberinfrastructure resources," said Wayne Figurelle, co-PI and assistant director of ICDS. "We are eager to see the impact on data-intensive science research programs and applications."

The Keystone Initiative for Network Based Education and Research (KINBER) is Pennsylvania's statewide research, education, and community network. The non-profit organization is a trusted technology partner that provides a strategic and competitive advantage to 100+ Pennsylvania-based organizations through high-speed broadband connectivity, collaboration, and innovative use of digital technologies. KINBER is committed to delivering equitable, reliable, and affordable digital infrastructure and tools to inspire tomorrow's scientific discoveries, enable the exchange of ideas and culture among diverse populations, educate the next generation of citizens, and revitalize Pennsylvania's economy. Visit **www.kinber.org**

OARnet shows advancements in Ohio technology on national stage

OARnet hosted its 2023 Fall Member Meeting in conjunction with national meetings of The Quilt, the National Science Foundation's Campus Cyberinfrastructure (CC*) Program Workshop and the KNIT 7 FABRIC Community Workshop, all held in Columbus, Ohio, in September.

These meetings provided an opportunity for OARnet to celebrate its 35th anniversary with members as well as state and national stakeholders. OARnet also shared plans and outcomes of major initiatives underway and spotlighted advancements being made in broadband technologies, cybersecurity, digital equity and quantum networks for the State of Ohio.

"By selecting Ohio as the location for their meetings, The Quilt, the NSF and FABRIC gave OARnet's members a unique opportunity to meet and learn from our national partners," said Pankaj Shah, executive director of OARnet. "Here in Ohio, we're making great strides in technology innovation and adoption, and we're enthusiastic about sharing more about our collaborations and successes with our peers across the United States."

Ohio technology thought-leaders who spoke at the national meetings included:

Dr. Anish Arora of Ohio State University made a presentation about Artificial Intelligence in Networking and 5G/Broadband, the NSF-funded AI-EDGE Institute, and a new broadband workforce internship program in partnership with OARnet.

Holly Drake, chief information security officer for the State of Ohio, participated in a panel discussion about cybersecurity. Dr. Ronald M. Reano made a presentation about the Ohio State's Center for Quantum Information Science and Engineering (CQISE), educational initiatives such as QuSTEAM, and research initiatives such as the intercity Ohio regional quantum network and long-distance quantum network security project with OARnet.

Angela Siefer, executive director of the National Digital Inclusion Alliance, made a presentation about digital equity focused on local and state digital inclusion ecosystems.

Peter Voderberg, chief of BroadbandOhio, led a panel with state broadband leaders from Kentucky and Louisiana about strategic planning and the Broadband Equity, Access and Deployment (BEAD) program.

Spencer Wood, advisor to the Cybersecurity and Infrastructure Security Agency (CISA), participated in a panel discussion about cybersecurity.

OARnet also highlighted the progress it has made on several initiatives:

Completion of significant connectivity upgrades for all higher education members as well as several large urban K-12 districts and the Information Technology Centers (ITCs) that serve hundreds of school districts in Ohio, spanning all 88 counties.

Development of aggregate purchasing of cybersecurity services to meet customer needs.

In partnership with Ohio State's 5G and Broadband Connectivity Center, creation of a new internship program designed to help train more college students in the skills needed to join the fast-growing broadband networking and wireless technology field.

Development of a new fiber connection to the Springfield-Beckley Municipal Airport, which is the site of the new National Advanced Air Mobility Center of Excellence (NAAMCE) that will support research in aircraft innovation.

"We would not have the kind of state we have without OARnet's abilities," said Ohio Department of Higher Education Chancellor Randy Gardner during his introductory remarks at the OARnet meeting.

From left to right: Nicholas Goldsmith (Assistant Program Director, National Science Foundation), Pankaj Shah (Executive Director, OARnet), Jen Leasure (President, The Quilt)

From left to right: Meghan Sandfoss (Executive Director, Team Kentucky Office of Broadband Development); Peter Voderbeg (Chief, Broadband Ohio); Jen Leasure (President, The Quilt); David Lehman (Program Manager, Connect Louisiana); Pankaj Shah (Executive Director, OARnet)

The Ohio Academic Resources Network (OARnet), a division of the Ohio Department of Higher Education's Ohio Technology Consortium (OH-TECH), serves the state's government, education, healthcare and public broadcasting communities. Through innovative public-private partnerships and a state-of-the-art fiber optic network, OARnet expands access to affordable broadband and delivers critical networking and technology services for academic and commercial R&D. Visit **www.oar.net**

Florida LambdaRail deploys FLRnet4, nation's first 400 Gbps backbone

Florida LambdaRail

The emergence of 400G networking is a pivotal advancement as it delivers the necessary bandwidth and performance to keep in front of the ever-increasing demands of research professionals. With this level of networking, researchers can seamlessly exchange data, collaborate across geographic boundaries, and leverage cutting-edge technologies like AI and machine learning. As research becomes increasingly data-driven, 400G networking facilitates breakthroughs and innovation across diverse fields, ultimately paving the way for a brighter and more connected future.

FLRnet4 embodies not only a major infrastructure upgrade but is more efficient in nearly every regard, including an observed 80 percent reduction in power consumption and nearly 85 percent reduction in space needed for core routers. As data centers become more crowded and power costs rise, space and power concerns are always present. The efficiencies gained in rolling out FLRnet4 are of great benefit to FLR's members in the form of enhanced performance at a reduced expense.

"2023 was a year of landmark achievements in our network's evolution," said Jon Ellis, CEO of Florida LambdaRail. "The expansion to 400G reaffirms our commitment to our members as they push the boundaries of knowledge and expand economic opportunity in their communities. The exceptional technology supported by this network enables new possibilities for scientific collaboration, educational excellence, and helps ensure a smarter, more prosperous future for us all."

Florida LambdaRail (FLR) had an eventful 2023. September saw Florida A&M University, one of the nation's pre-eminent HBCUs, come aboard as the network's 13th equity partner and board member. Accompanying the move was an announcement that FAMU would become the first HBCU in the nation to deploy 100 Gbps campus networking. Then, in November, FLR announced completion of FLRnet4, and with it, became the first R&E network in the nation to implement full 400 Gbps across its entire backbone network. The self-funded move represented a groundbreaking milestone in FLR's mission to provide the highest quality, ultra-high-speed connectivity to academic and research institutions.

Immediately following FLR's move to 400G networking, the University of Florida took immediate advantage by increasing their campus connection to a full 400G. Other FLR university members are universally adopting 100G campus networking platforms and improving their campus research environments by deploying campus science DMZs and connecting them to FLR's Regional Science DMZ.

FLRnet4 FAST FACTS

1,540 miles of dark fiber

28 optical sites

Total of 8 FLRnet4 POPs

7 POPs have redundant core routers (large POP)
- 8th POP uses neighboring POP for redundancy (small POP)

Each large POP has:
- 64x400G ports (can be reconfigured up to 256x100G ports)
- 64 1-25G ports

Each small POP has:
- 32x400G ports (can be reconfigured up to 128x100G ports)
- 32 1-25G ports

400G Backbone between all POP locations.
- The Backbone may be upgraded with the usage of additional 400G ports and optics.

Support member connections from 1G to 400G

Dedicated Performance monitoring and packet analysis hardware at each POP

Large route scale (6M+ routes)

Small power scale (77% reduction in power usage for core routers)

Small footprint (8x smaller footprint for core routers)

Enhanced peering (upgraded peering connections to 10x capacity vs. FLRnet3)

Florida LambdaRail (FLR) is Florida's independent statewide research and education fiber optic network. FLR is owned and operated on behalf of its partner institutions and affiliates and is dedicated to producing knowledge and prosperity within the state of Florida through education and research activities that drive our members' 21st century economy initiatives. Visit **www.flrnet.org**

Great Plain Network's GP-ENGINE Project expanding supercomputing across Midwest

In a significant stride towards advancing high-performance computing accessibility, the University of Arkansas Medical System (UAMS) in Little Rock has become the site for the final node installation in the National Science Foundation's (NSF) GP-ENGINE Project. The initiative is jointly sponsored by the NSF, the University of Missouri, and the Great Plains Network (GPN).

GP-ENGINE, short for Great Plains Extended Network of GPUs for Interactive Experimenters, is a collaborative effort aimed at enhancing research capabilities and accelerating scientific discoveries through state-of-the-art computing resources. By strategically situating nodes throughout the Midwest, the project aims to democratize access to high-performance computing (HPC) resources that enable AI and machine learning workloads, particularly in underserved areas.

According to Lawrence Tarbox, UAMS Director of High-Performance Computing, the decision to house the final node at UAMS signifies a pivotal moment for both the institution and the broader research community in Arkansas. "With this installation," explained Tarbox, "UAMS will further enhance its role as a hub for cutting-edge computational research, facilitating interdisciplinary collaboration and innovation across various fields."

Elon Turner, executive director of the Arkansas Research and Education Optical Network (ARE-ON), was enthusiastic about the state's pivotal role in the project. "We are honored to be selected as host sites for these research and education-enabling resources in the GP-ENGINE Project, directly available to those connected to the ARE-ON network."

The installation of the final node at UAMS holds immense promise for central Arkansas, as it will significantly enhance the region's research capabilities and technological infrastructure. In addition to UAMS, a node also was placed at the main University of Arkansas campus in northwest Arkansas. Researchers, scientists and educators across disciplines now will gain access to unparalleled computational power, enabling them to tackle complex challenges and push the boundaries of knowledge. Moreover, the expansion of the NSF-sponsored supercomputing grid into central Arkansas underscores the critical role of HPC in driving economic growth and innovation. By providing researchers with the tools and resources needed to conduct

Bobby Clark, Network Engineer for ARE-ON, completes the testing of the GP-ENGINE node

cutting-edge research, the GP-ENGINE project fosters a conducive environment for scientific breakthroughs and technological advancements.

GP-ENGINE Director Grant Scott said the impact of this project advances the adoption of advanced computing and data resources in the GPN region. The nodes housed at UAMS and eight other sites in six states hold the promise of accelerating research efforts aimed at addressing pressing scientific issues and improving quality of life.

The completion of the GP-ENGINE node deployments marks a significant milestone in the quest to democratize access to HPC resources and foster a culture of innovation across the Midwest. With UAMS and ARE-ON at the forefront of this endeavor, both Arkansas and GPN are poised to emerge as a dynamic hub for research, discovery and technological innovation in the years to come.

From left to right: GPN Executive Director, Mickey Slimp; Bobby Clark, Network Engineer for ARE-ON; and Grant Scott, GP-ENGINE Primary Investigator and Associate Professor at the University of Missouri

The Great Plains Network (GPN) is a non-profit consortium aggregating networks through GigaPoP connections while advocating research on behalf of universities and community innovators across the Midwest and Great Plains who seek collaboration, cyberinfrastructure and support for big data and big ideas, at the speed of the modern Internet. GPN was founded by researchers and for researchers to advance regional capabilities with respect to advanced networking and access to national cyberinfrastructure. Visit **www.greatplains.net**

Merit is democratizing access to broadband in Michigan

THE MICHIGAN **MOONSHOT** | PROJECT **MOON** - Light

MICHIGAN'S DIGITAL AUTOBAHN

LEARN MORE AT MERIT.EDU

merit

Last year, Merit Network, in collaboration with Michigan State University, began the rollout of Project MOON-Light (Michigan Open Optical Network – Leveraging Innovation to Get High-Speed Technology), upgrading Merit's 4,000-mile network to a new era in fiber-optic telecommunications.

This project is supported by a $10.5 million federal Broadband Infrastructure Program grant through the National Telecommunications and Information Administration (NTIA). Coined the Digital Autobahn, it will be one of the first next-gen infrastructure projects of its kind in the country once completed in 2024.

MOON-Light is an equipment-only upgrade and does not involve the buildout of any additional fiber but will impact Merit's entire statewide footprint. Project MOON-Light will increase Merit's capacity, enabling the network to meet future needs across Michigan. Starting this spring, its coherent channels will be able to support up to 200G at deployment and up to 800G in the future. This will future-proof Merit's middle-mile infrastructure, ensuring upgrades prove worth the investment deep into the 21st century.

MOON-Light to Dark Wave

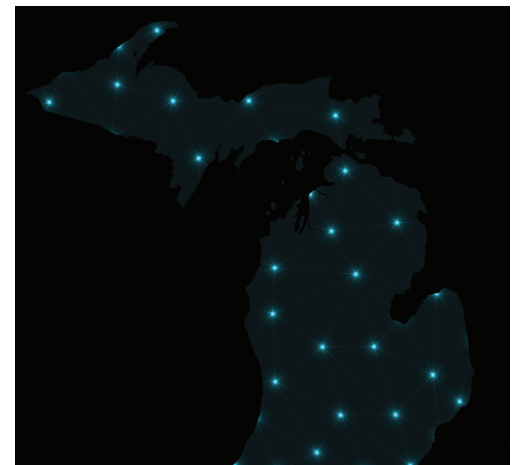The next steps for MOON-Light reflect a heightened emphasis on the open network and deployment needs of Merit's existing members and rural broadband collaborators, including last-mile providers and the launch of Merit Dark Wave Services. The new capabilities will enable Merit to optimize deployments of existing and future high-speed coherent optical interfaces in a multi-vendor, multi-service environment at carrier-neutral interconnection facilities. Direct interconnect facilities that will facilitate the provision of broadband service to anchor institutions are located within 1,000 feet of the middle-mile infrastructure at speeds of at least 1 Gbps symmetrical service.

Collaborations with commercial and community last-mile operators will be key. The optical upgrade will create excess network capacity to serve local private ISPs, cooperatives and community networks that operate last-mile facilities. Operators stand to benefit from improved speeds, reduced expenses, and accelerated timelines for their last-mile deployments to unserved and underserved communities. This democratization of network interconnections brings the same connections available in Ann Arbor as it would in Escanaba, bringing a first-class internet experience all across the state. Merit refers to this as "democratization of access," enabling robust connectivity for both economic prosperity and social vitality for all Michiganders. ISP and tribal partners also have drafted letters of intent to utilize Dark Wave Services that will result in over 17,000 homes in Michigan gaining access to broadband services.

Challenge Accepted

Incoming BEAD funds will be imperative in supporting further investments in broadband infrastructure. Unlocking those funds is literally a challenge. Merit is serving as the third-party aggregator for the State of Michigan BEAD Mapping Challenge. By activating anchor institutions to encourage citizen participation and providing access to an automated speed test challenge, Merit is helping to open more funding opportunities in the state and encourage greater investment for those in need.

SAINTCON grows from UEN's leadership in ed tech, cybersecurity

SAINTCON is an annual cybersecurity conference presented by the Utah Security Advisory and Incident Network Team (UtahSAINT). The Utah Education Network (UEN) initiated the conference in 2001 with a convening of about 25 ed tech professionals. Now the conference brings together hundreds of experts and participants from across the country to collaboratively address the dynamic needs of network management.

Last October more than 1,700 technology professionals from across the nation gathered in Provo to explore solutions to the growing challenge of providing network security through SAINTCON 2023. This year's event featured a track focused on education developed by UEN and its education partners. Many of the education track's sessions were standing room only. Through more than 30 breakouts, participants explored a wide range of topics, from securing online learning platforms to the intricacies of data protection in schools.

"This new track was an instant hit as it appealed to education and business leaders by providing a unique lens into trending technologies," said Troy Lunt of the Iron County School District, whose team presented. "Dozens of current leaders and technology experts shared solutions and experiences that have had the greatest impact on their organizations."

Enthusiasm for the education sessions underscored the importance of statewide collaboration and resource-sharing in promoting safer, more robust online environments for learners.

"After SAINTCON, (our) tech crew left feeling excited and connected. We had wonderful presenters that opened our eyes to areas of improvement," said Miguel Echeverria of Sevier School District. Overall, we now have better tools to help our students and create a safer environment."

Leading on development of the education strand is one example of how UEN is uniquely positioned to coordinate and amplify efforts to strengthen cybersecurity for Utah school districts and higher education institutions. UEN also supports education networking through software licensing and management, 24x7 monitoring of the wide area network, and other services.

"SAINTCON is an integral part of the San Juan School District's planning, detecting and responding to security threats," added Aaron Brewer of San Juan School District. "The students, staff, parents and guardians in our district are safer and more secure because of the support we get from SAINTCON and UEN."

The Utah Education Network (UEN) connects people and technologies that improve education in Utah. As one of the nation's premier education networks, UEN provides internet access to Utah schools, higher education, libraries and community partners throughout Utah, connecting institutions to a robust network and quality educational resources. We also operate the independent public television station UEN-TV (KUEN), which broadcasts 24x7 content for Utah learners and educators. Visit **www.uen.org**
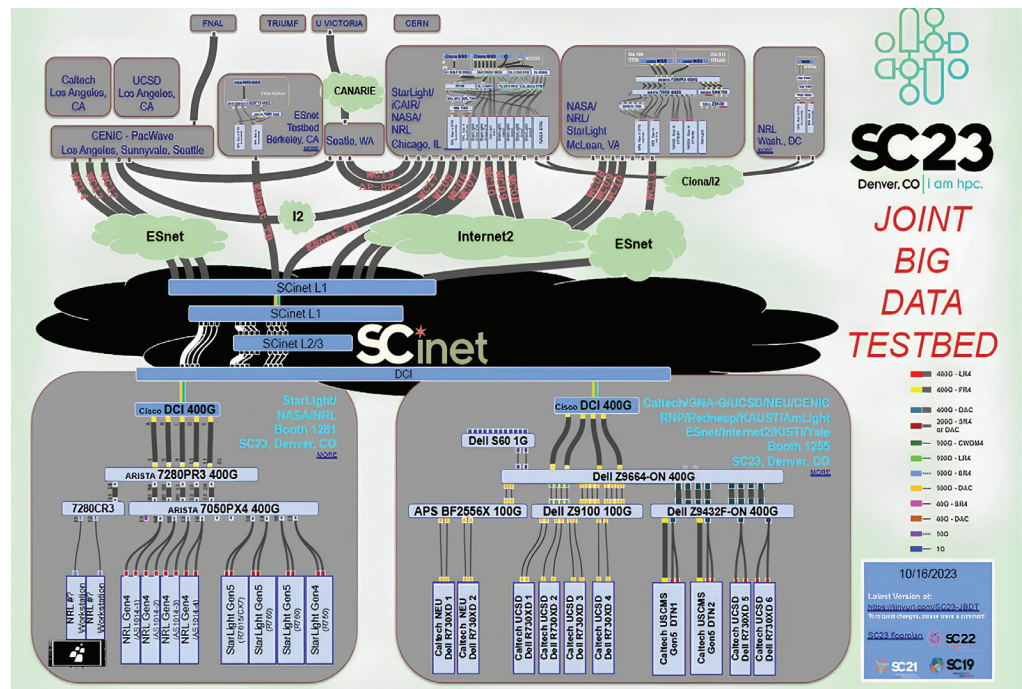
MREN creating next-gen networks for data intensive science

With its international, national and regional partners, the Metropolitan Research and Education Network (MREN) annually collaborates with SCinet to create a national testbed with international extensions to support experiments and demonstrations for the ACM/IEEE International Supercomputing Conference for High-Performing Computing, Networking, Storage, and Analysis (SC23).

For SC23, held in Denver, Colorado, SCinet, MREN, the StarLight International/National Communications Exchange Facility, and its research partners designed, implemented and operated a national testbed with international extensions to showcase demonstrations and experiments related to data intensive science research applications, including high energy physics, bioinformatics, synchrotron experiments, High-Performing Computing (HPC) research, radio astronomy, astrophysics, atmospheric science, oceanography, and large-scale modeling and simulation including using AI/ML/DP models.

Global science research requires gathering, analyzing and transporting large volumes of data that includes use of high-capacity, end-to-end multi-100 Gbps data flows among sensor sites, instruments, analytic sites, HPC centers, and data repositories. For SC23, a key theme was investigating and demonstrating WAN services over thousands of miles of 400 Gbps, 800 Gbps and Tbps paths.

The SCinet WAN testbed included a 1.2 Tbps path between the Joint Big Data Testbed Facility (JBDT) in McLean, Va., and the StarLight International/National Communications Exchange in Chicago; a 1.2 Tbps path between the StarLight Facility and the StarLight booth on the SC23 show floor in Denver; a 400 Gbps path between the JBDT and the StarLight booth on the show floor; a 400G path between the StarLight Facility and Pacific Wave in Seattle on NA REX; a 400 Gbps path between the StarLight Facility and Pacific Wave in Los Angeles; a 400G extension of the national ESnet 400 Gbps testbed to the StarLight booth; and a 400G ESnet testbed link to the StarLight Facility. Each site had multiple international network connections.

With its research partners, MREN used this testbed to successfully stage 26 large-scale demos, including a SCinet "Data Tsunami" generating over 6 Tbps. Techniques demonstrated included innovative multi-100G path services based on Software Defined Networking (SDN), Software Defined Exchanges (SDXs), Data Transfer Nodes (DTNs), Network Services Interface (NSI), transport protocols, measurements, P4 data plane programming, and dynamic L2 provisioning based on AI/ML/DP models. Additional demonstrations included: advanced services for Global Petascale science; dynamic provisioning with the NSF StarLight International SDX; programmable dynamic WANs; Global Research Platform; advanced services based on AI/ML/DL for High Energy Physics (Large Hadron Collider Open Network Environment); DTN-as-a-Service; 400G WAN Disk-to-Disk transfers; dynamic systems provisioning among open exchange points across WANs; Named Data Networking (NDN) for data intensive science; and high-fidelity visibility for science data flows with packet marking, analytics and automated responses.

Last year MREN also participated in the design and implementation of a 100G international testbed for the Data Mover Challenge hosted by the Supercomputing Asia Conference and supported a multi-organizational competitive submission. In addition, MREN also supported 400G WAN service and quantum networking demonstrations at the OFC conference in San Diego. Finally, with Argonne National Laboratory, Fermi National Acceleratory Laboratory and Northwestern University, MREN continues to support a quantum networking testbed located in Chicago.

The Metropolitan Research and Education Network (MREN) is an advanced, high-performance, regional network supporting organizations in seven states in the upper Midwest. MREN's primary focus is on providing advanced digital communications for leading-edge research and educational applications, primarily communication services for data intensive science. MREN is a founding member of the NSF-supported Pacific Research Platform initiative (PRP), developing a regional Science DMZ that extends from the west coast to the StarLight facility. MREN also is creating a regional MREN Research Platform (MRP) and participating in developing a National Research Platform (NRP). Visit www.mren.org

KANREN makes upgrade for future deployments

The Kansas Research and Education Network (KANREN) is a national leader in public service connectivity – a member-based consortium providing internet, professional services and network technologies to research, education and public service institutions in Kansas.

KANREN recently updated DWDM equipment and moved to Ciena 6500 RLS line systems and Ciena WaveServer 5 transponders. This upgrade moved KANREN from 2.4 Tbps to an astounding 8 Tbps of aggregate lit capacity. The new Ciena equipment facilitates a forthcoming core route/switch platform upgrade to 400 Gbps as well as upgraded datacenter interconnect services for KANREN's university community – all with a dramatically reduced physical footprint and attractive "scale out" design.

The line system features integrated ROADM with Line Amplifier (RLA) cards per fiber degree, which allows services to be quickly provisioned between fiber paths without external fiber patching at mid-span locations. KANREN also elected to utilize RAMAN amplifiers to skip ILA sites; reducing equipment cost and points of failure. The RLS platform allows for Colorless, Directionless, Contentionless (CDC) ROADM deployments; however, the design was kept simple with a more standard, legacy-fixed filter ROADM solution. Ciena's WaveServer 5 platform enables flexible optical channels between OTU4 (100 Gbps) and OTUC8 (800 Gbps) with 50 Gbps incremental steps based on fiber line conditions. The increased capacity provides parallel service drop ports for their existing 100 Gbps core network and an upcoming 400 Gbps upgrade to IP/MPLS nodes, making the upgrade process dramatically simpler and less impacting to user services. The WaveServer capacity also provides upgraded datacenter interconnects for KANREN's member universities who share floor space. Many of these links were upgraded during this process from Nx10 Gbps to Nx100 Gbps.

KANREN is in the process of upgrading all low-speed customer premises equipment (CPE) to Ciena 3924. The upgraded equipment provides dual power supplies, multiple 10 Gbps ports, on-prem IPv4/IPv6/MPLS routing, and full hQoS features. The new equipment provides a pathway to tail circuit handoffs beyond 1Gbps at a reasonable expense. KANREN members can easily now move from 2 Gbps to 10 Gbps without needing to upgrade CPE.

As part of the DWDM and CPE upgrades and vendor alignment, KANREN deployed Ciena's MCP management platform. The system has already proven valuable when troubleshooting issues and deploying services. KANREN staff look forward to making use of the system for future deployments.
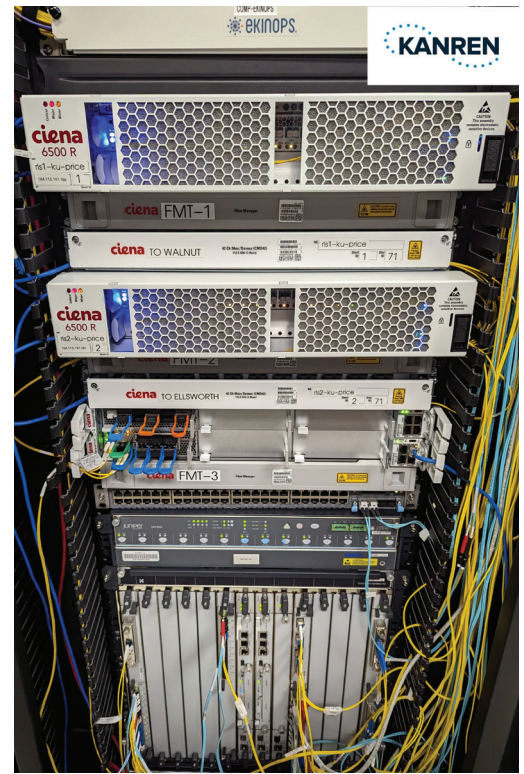
Research and Education Networks (RENs)

What are they? What do they do? Who do they serve? Below we provide you with some fast facts about these special organizations to better understand their public-missions and value.

Things you should know about Research and Education Networks...

RENs are different than Internet Service Providers (ISPs) who connect homes and neighborhoods.

The purpose of RENs and ISPs are very different. RENs are not-for-profit specialized networks that cater specifically to the needs of researchers, educators, and other community anchor institutions. RENs focus on dedicated, high-capacity, secure and resilient network connectivity, data sharing, optimized cloud access, and other specialized IT services for these target communities. Whereas, residential ISPs provide mass-market internet services to individual consumers and households. RENs have a successful track record of forging mutually beneficial public-private partnerships with ISPs, and a variety of other telecommunications partners, for common broadband infrastructure goals.

RENs across the U.S. are unique and united in a common mission.

There are over 40 RENs that provide advanced high-capacity, resilient, and secure networking services throughout the country. While united in a common mission, each of these networking organizations are unique in geographic scope, organizational structure, and service offerings reflecting the often-unique state and regional landscapes for community anchor institutions. RENs interconnect with each other and the national research and education network, Internet2, to facilitate specialized collaborations among researchers and educators spanning the country and globe. Through The Quilt, these organizations strengthen alliances with their fellow RENs resulting in greater regional and national opportunities.

REN services benefit a wide range of community anchor institutions.

RENs play a crucial role in supporting academic and research institutions. Yet, their impact extends beyond these sectors to other community anchor institutions. RENs provide broadband connectivity, foster innovation and collaboration, drive technology development, promote community engagement, and contribute to economic development. RENs are valuable assets to a diverse set of organizations including state and local government.

RENs operate on a cooperation model to make services affordable for both large and small organizations.

As not-for-profits, RENs secure cost savings for our constituents providing resilient and cost-effective services. We achieve these savings through strong fiscal stewardship, expert vendor negotiations, and resource aggregation for greater economic efficiencies. These savings, combined with other collaborative benefits, extend to organizations of varying sizes and financial capacities. RENs aim to make their services accessible and affordable in order to promote inclusivity and drive innovation across the national community anchor institution landscape.

Find a REN in your state or region and learn more about The Quilt on our website.
THEQUILT.NET

THE QUILT

About Us

The Quilt is a national coalition of non-profit U.S. regional research and education networks representing 43 networks across the country. Participants in The Quilt provide advanced network services and applications to over 900 universities and thousands of other educational and community anchor institutions. Our goal is to promote consistent, reliable, inter-operable and efficient advanced networking services that extend to the broadest possible community and to represent common interests in the development and delivery of advanced cyberinfrastructure that enables innovation through our education and research mission.

Our Mission

The Quilt: A collaboration of U.S. research and education networks committed to innovation and advancement of these purpose-built networks that empower our public service missions.

Our Name

Just like the various fabric patches of a quilt highlight different colors, patterns and textures, each regional network reflects the diversity and the unique qualities found in different parts of the country and the different institutions that particular network serves. Yet all regional patches must be stitched together seamlessly, coherently and interoperably to serve a larger purpose and community.

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Acknowledgements

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