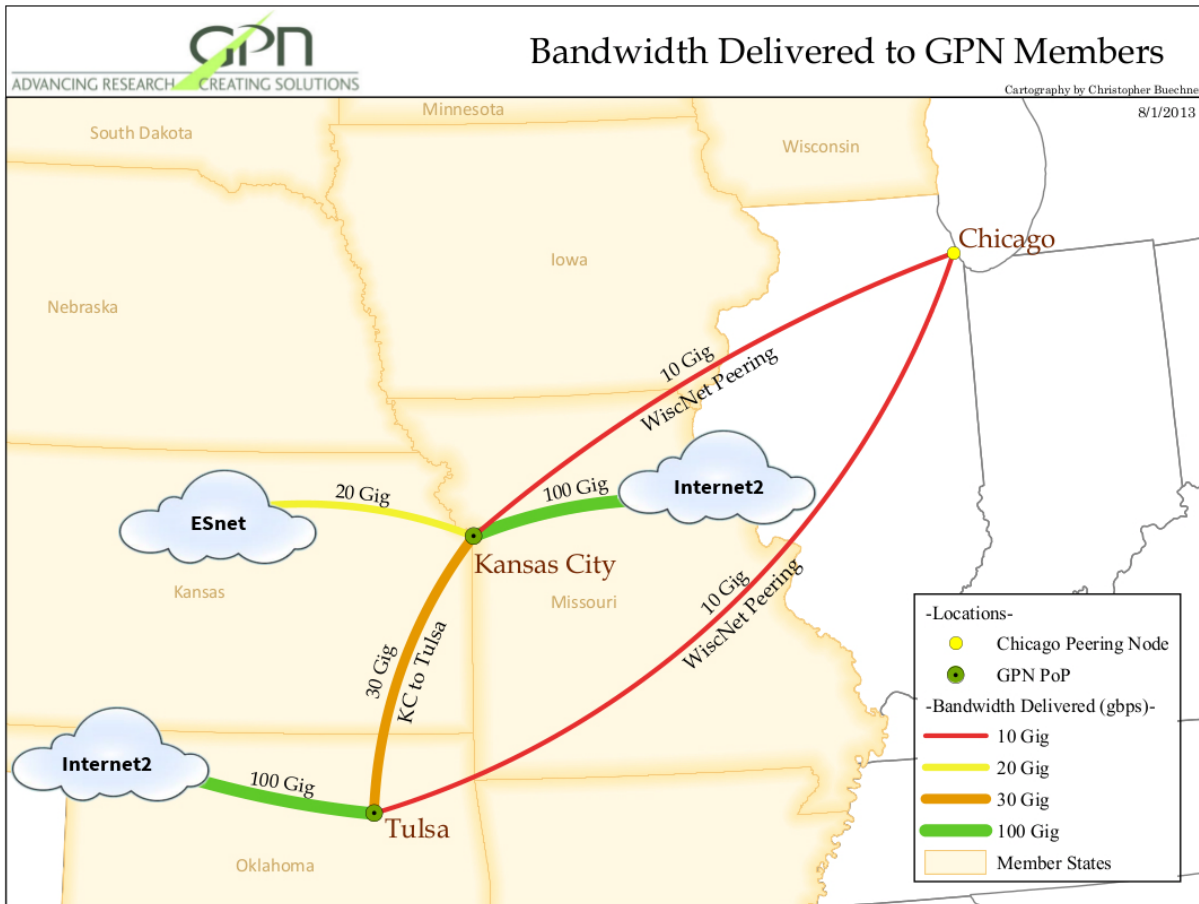


Cyberinfrastructure Plan

GPN

GPN connects research and education networks in 6 states to the Internet2 backbone and to ESnet. GPN provides redundant connectivity for several other affiliated campuses and networks outside the GPN region. GPN operates a 100G network point of presence in Kansas City and a second 100G PoP in Tulsa. The PoPs are interconnected at 30G with plans to upgrade to 100G. GPN peers with other state and regional networks for commodity Internet traffic.



GPN core equipment was refreshed in 2013. The new equipment has multiple 100G ports. GPN is ready to connect member institutions to the national infrastructure at 100G.

The network has robust monitoring and reporting via contract with GRNOC and 24x7 support via MOREnet. GPN has perfSONAR deployed and a MaDDash dashboard for monitoring and debugging.

Network performance is monitored by the GPN Network Technical Advisory Committee (GPN-NTAC), comprised of representatives from each member state network. The GPN-NTAC makes recommendations to the GPN Network Program Committee (GPN-NPC). The GPN-NPC also receives recommendations from member institutions as well as from the GPN Cyberinfrastructure Program Committee. Final recommendations for network and CI expansion are approved by the GPN Executive Council, the GPN governing body. In

addition to upgrading connectivity between the PoPs to 100Gbps, GPN is pursuing additional collocation space in Kansas City and is in the pilot stage of facilitating shared rack space among member institutions.

With respect to IPv6, GPN is fully IPv6 capable and advertises IPv6 routes. GPN is a Research & Education member of the InCommon Federation and operates both Identity Management and service providers. GPN offers a federation among members and has supports members in their efforts to become part a regional and national federated identity framework.

KanREN

The current KanREN ring backbone was implemented in the summer of 2007, with a major refresh and upgrade in 2011 (Funded by NSF EPSCoR PrairieLight Project). Design goals established the following requirements for the network:

- Redundant multi-ring architecture providing diverse connections to each backbone node
- Backbone nodes located at each state university, including, University of Kansas Medical Center, University of Kansas, Kansas State University, Fort Hays State University, Wichita State University, Emporia State University, Pittsburg State University, Washburn University
- Colocation of a backbone node in a carrier-neutral facility in downtown Kansas City
- Aggregation points for other members at geographically diverse backbone locations
- Multiple connections to the commodity Internet at geographically diverse locations
- Equal access and services availability to all state universities
- Ability to provision both ISO layer 2 and layer 3 services at each backbone node
- Presence in the Internet2 colocation suite in Kansas City
- Connections and layer 3 services into the Kan-ed network

KanREN is fully IPv6 capable and has perfSONAR boxes deployed across the network.

MOREnet

MOREnet established the first fiber-optic backbone in 2008. MOREnet is in the final stage of extending that backbone into the southeast region of the state. MOREnet has peered with Google Fiber and maintains a connection to the GPN peer point in Kansas City. MOREnet carries a 100 Gb Internet2 segment from St Louis (from Chicago) to the Columbia AL2S node and on to the AL2S node in Kansas City. MOREnet has fully implemented IPv6 in the core and offers IPv6 to the edge. As mentioned above, MOREnet has built and implemented a number of network tools for MOREnet staff and MOREnet members to diagnose, monitor and manage appropriate network elements.

MOREnet operates the GPN infrastructure as well as the Inter-Campus Network (ICN) which connects all four campuses of the University of Missouri. PerfSONAR nodes are implemented in the MOREnet core network and on the ICN.

As a part of the University of Missouri System, MOREnet has been a part of the InCommon Federated Identity infrastructure. MOREnet is one of a handful of R&E networks working with InCommon to establish technical and business model to support and pilot a statewide identity infrastructure for higher education and community college institutions and K-12.

OneNet

OneNet, a division of the Oklahoma State Regents for Higher Education, has operated since 1996 as the research and education network for all of Oklahoma's public higher

education institutions, and also serves nearly every private higher education institution as well as both public and private K-12 schools, libraries, museums and government (state, local, federal, tribal). Over many years of operation, OneNet has continually refined its infrastructure to meet the ever-growing requirements of research institutions. Via public and private partnerships, optical fiber has either been built or acquired to span the distances between OU's campuses in Oklahoma City and Norman and OSU's campuses in Stillwater and Tulsa, at ever increasing bandwidths, by deploying both evolutionary and revolutionary technology.

OneNet's strong focus on Oklahoma's CI needs began with the creation of the first Internet2 Network in 1998. By utilizing partnerships and experience with fiber construction, Oklahoma's universities were among the first to connect to the new national network, and have since been provided very high levels of bandwidth to both regional and national research backbones. In recent years, the NSF EPSCoR RII C2 grant funded upgrades of OneNet's Dense Wave Division Multiplexing (DWDM) network, leading to improvements in the ability to provide additional research bandwidth more cost effectively.

Simultaneous to the C2 project, Oklahoma was also awarded an NTIA BTOP CCI grant, providing nearly \$74M to build fiber to facilitate middle-mile initiatives through areas of the state underserved by broadband providers. The project, the Oklahoma Community Anchor Network (OCAN), directly serves 33 community anchors at the outset but is positioned to serve Oklahomans through over half the state's counties. OneNet is responsible for the ongoing operations and maintenance of this new network and is establishing new partnerships with telecommunications providers to meet the needs of OneNet's constituents in other areas of the state not directly served by the BTOP grant.

In the fall of 2012, OneNet recognized an opportunity with Internet2's newly unveiled Innovation Platform, rapidly taking steps to garner the support of research institutions and to coordinate appropriate hardware and fiber, to become the first official member connection to Internet2's new nationwide Software Defined Network (SDN). The new 100G connection is already being leveraged for research activity as well as the diverse needs of community anchors throughout Oklahoma.

With OCAN complete, OneNet is already proceeding through the next phases of upgrades in Oklahoma's CI. Recently, 100GE service was extended from Tulsa to Stillwater and 100GE service from Tulsa to Norman is nearly complete. This expansion of 100GE paths will continue over the next year. Beyond the traditional research ring, OneNet anticipates that the 10- to 100-fold increases in bandwidth being experienced by over a dozen higher education institutions directly served by OCAN in rural areas of Oklahoma will lead to new collaborations and opportunities for partnership.

In addition to the investments in bandwidth, OneNet remains focused on extending other CI technologies with robust monitoring and measurement tools providing transparency on all aspects of traffic through the state. OneNet is leading an effort to deploy and centrally manage perfSONAR devices across the state and bridging SDN infrastructures with production networks.

OneNet has fully supported IPv6 across state infrastructure for several years, and participates in World IPv6 Day. With a direct allotment (2610:1D8::/32) from ARIN, OneNet can serve all constituents and maintains IPv6 peering relationships with nearly all external network transit providers and peers.

Network Nebraska

Network Nebraska (NN) was initially formed as a partnership between the State of Nebraska and the University of Nebraska. Although the initial planning started in the late 1990s, the name “Network Nebraska” was not created until 2001. The name was later introduced to the Nebraska legislation in 2006 as the official network transport for K-12 distance education. In 2004, the University of Nebraska applied for Internet 2 SEGP membership on behalf of Network Nebraska.

NN has three distinct and segregated networks which includes 1) The Nebraska State Agency network, 2) the Nebraska Statewide Telehealth Network and 3) Network Nebraska – Education. When the term “Network Nebraska” is used, it is generally referring to the education network environment.

Network Nebraska does not receive any direct State funding and is completely funded by the members of the network. The backbone consists of multiple 2-5G network segments between the 4 major network hub sites (Omaha, Lincoln, Grand Island and Scottsbluff).

In addition to the core network infrastructure of the backbone, the main service area is the provision of Internet services. The current aggregation of commodity Internet is approximately 13G of bandwidth provided across three carriers. In addition, we also acquire 3G of Internet Commercial Peering Service, 1G of Wiscnet, and of course SEGP access to Internet 2 services. The cost of internet services has dropped from approximately \$320 per meg in 2003 to under \$1.50 per meg effective July 1, 2014 with the expected total purchase close to 20G.

In addition to the backbone segments mentioned, the University has also acquired (leased) a dark fiber ring between Lincoln and Omaha. We have installed DWDM equipment and there are approximately sixteen 10G waves in operation between the Lincoln and Omaha sites (University of Nebraska Omaha, University of Nebraska Medical Center and University of Nebraska Central Administration, which is also fiber connected to the University of Nebraska Lincoln).

In 2009, with the assistance of an NSF/EPSCOR grant, the Nebraska University Regional Optical Network (NEURON) initiative was kicked off. The primary objective was to improve network connectivity for research in Nebraska. The project has multiple phases with the first phase including the acquisition of fiber between the University System and Creighton University in Omaha, provision of multiple (4) 10G fiber waves between super computers in Lincoln and Omaha, increased connectivity to the three tribal college campuses, plus additional bandwidth to higher education institutions in Northeast Nebraska. The grant was also used to fund a portion of the University fiber installed between Lincoln, Grand Island and on to the University of Nebraska Kearney, providing multiple 10G waves between Kearney and Lincoln.

As additional funding comes available, additional phases of NEURON will continue building two 10G rings connecting all of the higher education institutions in the state. A portion of the 10G ring will be used as a research DMZ. The eastern ring will include the fiber and network infrastructure in place now as well as a 10G network segment to Wayne State College, Northeast Community College and back down to Grand Island and Central Community College. The western ring will include connectivity to Chadron State College, Western Nebraska Community College, Mid-Plains Community College, and the University of Nebraska Kearney. The two rings will meet in both Grand Island and Kearney.

The University of Nebraska Lincoln is continuing to work on improving the network connectivity between Nebraska and the regional networks including the Great Plains Network and Internet 2. UNL will be migrating from multiple 10G waves to 100G waves in 2014 for the connection between Lincoln and Kansas City.

SDBOR Reed Network

The Research Education and Economic Development (REED) network was installed in 3rd quarter of 2008. The backbone has dual 10Gbps waves in use today with the ability to expand to 5-10Gb waves. The operation of the transport equipment and fiber maintenance is contracted through SDN Communications (SDN). Existing backbone equipment will be 6 years old in September of this year.

REED is in the process of budgeting for our network refresh scheduled to occur over the next 2 years. The extent of the network refresh depends on appropriations from the state, funds available in current and next year's budget along with grant proposals to funding agencies.

The 3 major objectives for this refresh are:

- Provide a competitive research infrastructure by implementing 100G capable equipment provisioning 100G ports as funds become available. The major components to be refreshed are the transport equipment at SDN, aggregation routers and campus routers.
- Improve redundancy throughout the REED network by providing alternate paths at each connecting institution. Currently, there is one fiber path to each location. A design is in place to provide an alternate fiber path to each.
- Improve performance monitoring network analysis

Implementation:

- The schedule for 100G capable equipment in the backbone is scheduled for completion by the end of the FY2016 budget;
- The Infinera equipment used in the backbone is upgradable to 100G waves. Budgetary quotes have been request for upgrades to the Infinera equipment maintained by SDN for upgrades to include 1- 100G wave in the backbone;
- A review of the MX480 and MX960 has been conducted and it's been determined that the equipment can be upgraded to be 100G capable. Budgetary quotes have been requested from Juniper;
- An alternate fiber path to each campus has been designed in conjunction with SDN. Budgetary costs have been gotten and funds allocated. 3 of the 10 connections to REED have been completed. The remaining campuses are scheduled to be completed by July 2015.
- Network monitoring and analysis has been divided into phases. The current phase is scheduled to be completed by July 1, 2014. The plan is to implement perfSONAR sensors at each location in the REED network. Four of the 10 locations have been completed.