

Internet2 Network

Network Characteristics

Internet2 has entered into a partnership with Level 3 Communications, a leading national telecommunications carrier, to provide the U.S. research and education community with a dynamic, innovative and cost-effective hybrid optical and packet network. An extension of the Internet2 cutting-edge tradition, the new network is designed to provide next-generation production services as well as a platform for the development of new networking ideas and techniques.

Internet2 is committed to ensuring community involvement in the development, implementation, and operations of the new network.

The new Internet2 Network will be deployed nationally over 13,000 miles of dedicated fiber, providing complete control of the optical layer and highly granular lightpath services that can be provisioned dynamically.

technical superiority

It will provide short-term and long-term waves, as well as on-demand or advanced reservation "lightpath" scheduling. The IP network, corresponding to the current Abilene footprint, will be built on the optical network.

Basic connectivity package for direct connectors is expected to include two 10 Gbps waves, one for IP and one for point-to-point optical services.

Optical (layer 1) network characteristics:

- Initial deployment – 10 x 10 Gbps wavelengths along network footprint
- Future Capacity – potential migration to 40 Gbps and 100 Gbps wavelength capabilities
- Wavelength Scalability – unlimited availability of additional wavelengths, through additional fiber pairs
- Reliability – carrier-class standard assurances for wavelengths
- Flexibility – support for sub-wavelength (e.g., 1 GigE) dynamic provisioning across every wave on the network backbone.
- Community control – provisioning and switching of wavelengths and subchannels

community control

The Level 3 carrier agreement will **provide the community with unprecedented control over the networking infrastructure**, without taking on the risks of equipment sparing and obsolescence as well as the burden of substantial operational responsibilities. Level 3 will be responsible for meeting a Service Level Agreement (SLA).

seamless deployment

Internet2 engineering support will include:

- Control Plane aspects of dynamic provisioning
- Application and Advanced Services Support
- Engineering, Monitoring and Management

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Network Architecture

The architecture of the new Internet2 Network consists of: the national footprint; the connection to the regional optical networks (RONs) and the equipment and interfaces to support those connections; and the ability to support services to the research and education community, including campus researchers and community wide participants.

innovation

The hierarchy of the architecture is similar to previous networks: backbone to regional to campus. However, the network itself is completely different. It is no longer an IP network like those found in the commercial sectors of the Internet. Rather, it is a hybrid network that supports layer 1 dynamic and static services along with innovative new techniques at layer 3.

Its most important feature is the ability to experiment with new protocols and ideas for the research and education community. In defining the architecture, several crucial design goals were considered, including but were not limited to:

community advantages

- **Serve all Internet2 members** – campuses, affiliates, sponsored participants, SEGPs, and corporate participants – and enhance the ability to serve a wider community. All current RONs are to be supported.
- **A hybrid network capable of point-to-point services together with an IP network.**
- **Every connector (RON) attaches to a backbone ring at a metro location not requiring extensive backhaul.**
- **The community retains complete control of the layer 1 optical system, including the provisioning and switching of wavelengths and sub channels.**
- **The community does not have to concentrate on reliability and sparing. The carrier is responsible for an SLA.** The carrier provides the operational support, allowing the community to focus on networking. Control of the system is left to the community, allowing the development of new and dynamic services.
- **The system is capable of supporting network research in a wide variety of ways,** including the ability to set up networks at will for research communities.

The system is provisioned on fiber that is used by the community and maintained by the carrier. There is significant financial advantage to the community, if the community provides the fiber under an IRU with the carrier.

flexibility

That the system lies on dedicated fiber has substantial advantages. Dedicated wave equipment currently used by Level 3 will provide the waves for the system. That wave system is provided by Infinera, which supports advanced technologies with substantial add/drop capabilities and significant advantages in provisioning and redundancy. Provisioning a static wave is accomplished by simply installing the endpoint interfaces. This is far different from most current optical systems where many interfaces must be installed along the entire path.

Moreover, since the system is completely dedicated to Internet2, it is possible to leap beyond the carrier's standard offerings to utilize the advanced technology provided by Infinera.

grooming

The system will also incorporate a grooming capability – the ability to provide sub channels through waves using either an Ethernet or advanced SONET infrastructure.

The ability to provide point-to-point services down to the campuses through the RONs will be provided by an advanced grooming device that has yet to be determined. The goal is to provide lightpath capabilities provisioned within seconds that last for durations of at least hours.

The topology consists of optical nodes connected by waves maintained by Level 3 that connect to RONs and other participants. The carrier footprint primarily determines the topology of the network, but the use of the Infinera gear allows for great variability in drop/add locations.

The new Internet2 Network design encourages aggregation at the RON layer in the hierarchy.

The new IP network, corresponding to the current Abilene backbone, is built on top of the optical network. The IP backbone is provisioned across the waves in the system, and each RON connects to the IP network through the optical system.

reliability

Since the carrier provides an SLA for the waves on the system, the IP network will have carrier-quality provisioning, which is expected to be minimally three 9's (99.9%) uptime, but is likely to be closer to five 9's (99.999%).

There are substantial redundancy options. The Infinera platform can provide control plane redundancy for IP connectors, and SONET restoration is also a possibility. These options will be determined by consulting the community as a whole.

The IP network will initially use Internet2's existing Juniper routers, which remain state of the art and are capable of migrating to 40 Gbps services.

The architecture provides the capability of providing a variety of circuit (or lightpath) services on the new Internet2 Network, but the agreement provides additional wave provisioning capabilities on the entirety of the carrier's footprint. Services provisioned on the new network:

- Short Term and Long Term dynamically provisioned circuits
- Long term static, full wave services
- "Off net" services provided by the carrier through "WaveCo," provisioning circuits – optical carrier and digital signal – for regional networks and other Internet2 participants needing to extend connectivity anywhere the Level 3 optical network reaches. The "off-net" service will be provided at cost-effective, aggregated rates.

services

Engineering support for the new network will be drawn from members of the community and the Internet2 staff. Building on our experience in designing, developing, and maintaining Abilene, HOPI and NLR, Internet2 expects operational support to fall into three broad categories: control plane activities and dynamic provision of basic services; application and advanced services support in hybrid networks; and engineering, monitoring and management.

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Value-Added Capabilities

In addition to the advanced network circuit-based services, the new Internet2 Network will embrace a number of other services that are intended to add value to the connectors.

- Higher Networking Speeds:** The Infinera platform that the new network will use has several forward looking advantages including the ability to support new and higher networking speeds. A platform that scales to 40Gbps per interface and potentially higher is anticipated, representing a four-fold increase to the current interface speed.
- Connection to the Commercial Internet:** In order to assist Internet2 members financially and to reduce management complexity and overhead, the new network will offer connectivity to the commercial Internet that may utilize the same connections used by the members to connect to the new Internet2 Network. Due to the capacity and nature of the network, it will be possible to offer research traffic an unimpeded facility and allow for commercial traffic to flow over the same infrastructure.
- Dedicated Wavelengths:** In addition to waves across the Internet2 Network footprint, WaveCo will work with Internet2's carrier-partner, Level 3 Communications, to provision circuits – optical carrier and digital signal – for regional networks and other Internet2 participants needing to cost-effectively extend their connectivity anywhere on the Level 3 optical network. Through Internet2's agreement with the carrier, the "off-net" service will have the advantage of aggregated rates. This is especially cost-efficient for regional networks that wish to extend their reach for only a few connectors with varying demands for circuit capacity or duration. Providing dedicated optical waves, as well as fiber (FiberCo), will support community control of fundamental networking infrastructure, and will enable a wide variety of bandwidth-intensive applications under development at campuses and research labs today.
- Access to Dark Fiber:** Internet2, through the establishment of FiberCo, has placed over 13,000 miles of dark fiber in the hands of the U.S. research and education community and helped facilitate the placement of another 10,000 miles. Through the agreement with Level 3, dark fiber, collocation, and remote hands services will continue to be offered to the community at competitive rates.
- Professional Services:** FiberCo is making available a suite of professional services that range from consulting on fiber availability and acquisition, to outsourced network operation center (NOC) services, equipment procurement, testing and deployment, and asset tracking. The effort to provide these supporting services is undertaken to strengthen and facilitate the success of the RONS operating across the United States.
- Voice over IP (VoIP):** This technology has the ability to dramatically reduce operational expenses related to telephone service and can add a significant number of features that are not possible, or very difficult and expensive to implement, under the current telephony model. By leveraging the strengths of the Level 3 carrier partnership, Internet2 will be able to offer VoIP transit services at the highest level of reliability.
- Disaster Recovery:** Vulnerability to and devastation from natural and man-made disasters reveal the need for geographically distributed facilities that can provide the restoration and resumption of critical services. The new Internet2 Network, with its multiple high-speed links and presence in distributed carrier collocation facilities, will provide easy access to geographically diverse sites that can be utilized for disaster recovery.

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Carrier Class Reliability

Addressing the research and education community's relatively small size with its need for the latest cutting-edge technologies, the Level 3 partnership with the new Internet2 Network assures reliability and expanded breadth of services on a national scale, at incremental costs to achieve long-term affordability.

responsible

The Level 3 carrier agreement will provide the community unprecedented control over the networking infrastructure, without taking on the risks of equipment sparing and obsolescence as well as the burden of substantial operational responsibilities. Since the carrier provides an SLA for the waves on the system, the IP network will have carrier-quality provisioning, which is expected to be minimally three 9's (99.9%) uptime, but likely to be closer to five 9's (99.999%).

Because Level 3 already has the organizational and procedural structure in place to ensure network reliability, it has no difficulty in offering production-level support (service level agreements) on its layer 1 wavelength services as part of this partnership. These wavelength services will reach beyond the new network backbone to everywhere the carrier and its business relationships deliver networking services.

accessible

Additionally, Internet2 has guaranteed access to strategic assets such as long-haul and metropolitan fiber for years to come, ensuring continued industry engagement with the community.

Internet2 decided to form this relationship with a carrier, and not a particular vendor technology, to sustain a neutral relationship with its technology partners and to provide the community the flexibility to deploy best-of-breed equipment over the life of the network partnership.

advanced

Level 3 was chosen partly due to its decision to deploy Infinera's next-generation Digital Transport Node optronics. The low cost and fully flexible add/drop capabilities of Infinera's photonic integrated chip technology align perfectly with the service objectives for the new Internet2 Network.

An aggressive roadmap, which includes 40 Gbps and 100 Gbps as well as GMPLS optical user-to-network interface (UNI) development, ensures this network's usefulness well into the foreseeable future. Level 3 and Internet2 will therefore not be facing difficult end-of-life equipment.

versatile

Internet2's new network creates an asset that serves the needs of the entire research and education community – from the regional optical networks to K-12 students. This new infrastructure will provide both experimental and production services within the same architecture through the most cost-effective means possible. Researchers will be able to perform experiments across their own on-demand wavelengths while universities will be able to obtain low cost commodity IP through their Internet connection.

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Community Control

The Level 3 carrier agreement with Internet2 assures the community unprecedented control over the networking infrastructure, without taking on the risks of equipment sparing and obsolescence as well as the burden of substantial operational responsibilities.

focus

Community control of the new Internet2 Network – provisioning, measurement, and research support at layer 1 – is not dependent on ownership of the infrastructure. Continuing a successful model in advanced network reliability, the Internet2 – Level 3 partnership allows the community to focus its resources on research and education applications, innovation and partnerships.

flexibility

The new Internet2 Network will allow the community the ability to provision and switch wavelengths at will, while technology upgrades can be performed when the community requires them.

The partnership with Level 3 allows the community to have direct access to the entire system for management and research purposes, while also allowing for the development and deployment of new dynamic services.

access

The resources afforded by FiberCo and WaveCo allow regional networks and other Internet2 participants to control strategic assets of their advanced networking. FiberCo enables cost-effective purchase of dedicated dark fiber on a nationwide scale. Through WaveCo, regional networks and other participants can provision circuits – optical carrier and digital signal – at aggregated rates to extend their connectivity anywhere on the Level 3 optical network.

Under considerably relaxed use constraints in the carrier agreement, Internet2 members may use this infrastructure to carry essentially all traffic generated by the community and its broad set of affiliates and, thus, help establish a firm, long-term network neutrality position for the research and education community.

The basic structure and ideas have been developed for the new Internet2 Network, but there is substantial engagement needed from the community to complete the design.