

Research Wave Program

RAC Recommendation

I. Background

The Internet2 Research Wave program will make available four channels to the research community out of the 88-channel optical system on every segment of the Internet2 backbone lit by Internet2.

The purpose of the "Research Wave Program" is to stimulate innovative transformative research uses of the network by providing dedicated access to Internet2's services at a reduced cost for a specific time period. By allowing researchers to experiment, on a short-term basis, the program is expected to stimulate new ideas and innovative approaches that can then grow into funded projects and collaborations. The Research Wave Program will allow researchers to experiment with and test different types of infrastructure and services, providing concrete information on what services will fit best with their specific applications. Network research projects will be able to test their protocols and algorithms on experimental test beds prior to being deployed on permanent network infrastructures. Discipline scientists will have the ability to request infrastructure for specific, fixed time projects and grant proposals, as well as for demonstrations at conferences and workshops. In limited cases, the resources can be used to support existing persistent meritorious research projects that are exploring at the frontiers of their fields.

Research Wave Program participants will be required to cover a pro-rated share of Internet2's capital costs associated the resources requested, as well to provide the necessary equipment to terminate each wave.

A description of the program components, the process for requesting waves, and relationship to other Internet2 services and programs is provided below.

II. Program Components

Figure 1 illustrates the Internet2 Backbone topology. The fundamental components of the backbone include a nationwide pair of dark fiber that is lighted using Internet2 provided optical networking equipment located at each of the optical nodes along the network footprint. Four (4) channels out of the 88-channel optical system on every segment of the Internet2 backbone will be available to the research community. The research wave program will make point-to point Ethernet waves or dark channels available on a segment-by-segment basis along the entire backbone footprint. Using the current technology, each Ethernet wave can operate at up to 100 Gbps and, in order to accommodate more research projects, it can be subdivided into up to ten waves each operating at 10 Gbps.

A. Point-to-Point Backbone Ethernet Waves

Point-to-point Ethernet waves, in increments of 10, 40 or 100 GE, are available between any two optical nodes (a segment) on the Internet2 backbone. Internet2 assumes the responsibility for the ongoing operations and maintenance of the underlying optical infrastructure, as well as the equipment to light the waves. Because these waves are considered production waves on the Internet2 backbone, they will have the same uptime expectations as the rest of the Internet2 backbone. Two types of Point-to-Point Ethernet Waves will be available to the research community: no-capital waves and capital-only backbone waves. Both are described in more detail below.

1. No-Capital Backbone Research Wave

One 10 GE wave per segment along the entire Internet2 backbone will be available for up to one year for qualified research projects. No-Capital Waves are not renewable, with the expectation that they will be returned to Internet2 at the project's approved endpoint or transitioned into a Capital-Only or production wave.

2. Capital-Only Backbone Research Waves

Researchers can request 10, 40, or 100 GE waves between any two optical nodes on the Internet2 backbone. Internet2 will provide the equipment (transponders) to light the appropriate bandwidth wave on the segment or segments with the research project paying any applicable capital costs as described below. Internet2 will assume all associated recurring operating and maintenance costs. The exact capital costs are dependent on the number of backbone segments, the bandwidth per segment, and the performance period requested by the project. Rough pricing, on a per-segment per-year basis, for 10, 40, and 100 GE waves is given below:

10 GE	\$10,000
40 GE	\$41,000
100 GE	\$119,000

For both no-capital and capital-only backbone research waves, the research project will be required to cover any additional out of pocket expenses incurred as part of the project, including but not limited to:

- Cross connect fees
- Incremental colocation space and power
- Incremental installation costs
- Regional infrastructure
- Local infrastructure
- End host or terminating equipment

Internet2's Research Support Group will work with prospective projects to identify associated costs.

B. Channels

For researchers who wish to deploy their own equipment and waves, an optical channel is available between any two optical nodes on the Internet2 backbone. Unlike the Ethernet waves, the researcher is responsible in this case for providing the equipment to light either native (Ciena) waves or alien (non-Ciena) waves. In both cases, the researcher will be required to collaborate with Internet2, ensuring that the deployed equipment meets the production standards for the Internet2 backbone.

The researcher should be prepared to acquire colocation space for their placement of their equipment. There are no standards for the lighting of alien waves across multi-vendor platforms and the ability to support alien waves by the campuses RONS and Internet2 in the end-to-end path for the project may be limited by the capabilities of the various products deployed. The researcher should work closely with their campus and regional provider to understand the capabilities of the equipment along the path prior to requesting access to Internet2 channels.

The underlying optical channel is a component of Internet2's production network infrastructure and will be supported as such. However, Internet2 is not responsible for supporting the researcher-provided equipment. Prior to deploying the equipment, a support plan will be worked out between Internet2 and the researcher outlining the responsibilities for operation, maintenance, diagnostics, and support of the researcher-provided equipment.

Internet2 will provide, at no cost, the ongoing maintenance and support for the underlying optical channel, but not for the researcher-provided equipment. Depending on the equipment deployed, the researcher may have to cover any out of pocket expenses associated with deploying the equipment. In addition, the researcher may incur additional out-of-pocket expenses including but not limited to:

- Installation costs
- Cross-connect fees
- Incremental colocation space and power
- Regional infrastructure
- Local Infrastructure
- End host or terminating equipment

Internet2's Research Support Group will work with prospective projects to identify costs associated with the project.

III. Colocation Space and Power

It is assumed that most projects will cover any colocation, space, and power costs associated incurred by the project. However, on a very selective basis, meritorious research projects can request and then receive colocation space and power as part of their project. Internet2 has over fifty points-of-presence (PoPs) on its optical footprint. Since the PoPs vary in the availability of space and power available and do not have unlimited resources, projects will be evaluated based on their suitability for a specific PoP.

IV. Relationship to Other Internet2 Services

Internet2 provides a wide range of network infrastructure and services and researchers may request access to these services as part of their research projects.

- Regular 10G, 40G, or 100G waves between any two points on the network, which can be used indefinitely
- Help procuring waves to an Internet2 PoP from elsewhere
- Internet2's ION or OS3E service to provide a Layer2 path on our network, possibly as an on-ramp to installed equipment or a research wave
- Access to Internet2's NDDI infrastructure which provides OpenFlow capable switching at Internet2 nodes
- IP access to any collocated equipment
- Measurements taken regularly on the IP network as part of the Internet2 Observatory
 - o Utilization, latency, results of 1G and 10G throughput tests, IGP and BGP messages, router configurations
 - o Packet flow data
- Access to the Internet2 "router proxy," which provides on-demand queries of Internet2 equipment in PoPs
- Trouble ticket data
- Requests for additional measurements for their project, possibly for inclusion in the set long term regular measurements

V. Process for Requesting Resources

The researcher will be required to submit a proposal to Internet2 detailing the research project and the specific resource(s) requested from Internet2. Requests will be submitted via rs@internet2.edu using a form that will include information regarding: the PI(s), participating institution(s), proposed project, a one-page proposal abstract delineating the plan for deploying these resources within the project, a list of requested resources, a list of project-provided resources, timeline and milestones, budget requirements and justification, and letters of support representing the regional and campus networks included in the end-to-end path of the project. Researchers will need

to confirm their agreement with use conditions, including making the data inaccessible to individuals beyond the approved project, and employing the data only for the approved project. Projects that will use colocation equipment will need to answer additional questions, due to space limitations. Although proposals will be accepted on a rolling basis in order to accommodate researchers with deadlines on short notice, researchers will need to allow up to 3 weeks for formal review/approval.

The review process will involve a review panel involving members of Internet2’s Research Advisory Council, and representatives from Internet2’s Office of the Chief Technology Officer and Network Services. Each researcher will be required to submit a brief quarterly report on the ongoing status and findings of their research, and will be required to list their use of the Research Wave service in any publications. Following completion of their use period, researchers will be required to submit a final annual report. Once the initial research period is over, the researcher may submit another proposal for continued use.

Review criteria will include the project’s scientific merit and likely impact (in terms of numbers of participating collaborators and disciplines, the project’s likelihood of completing wave use within the approved project period, and the impact and value to the community). Technical review of the proposal will include evaluation of the risk to the Internet2 backbone along with the adequacy of colocation space and power. In addition, projects proposing footprint-wide usage (as opposed to those only requesting segment access) will require additional documentation.

Figure 1: Internet2 Optical Backbone Topology

