The Science, Technology and Research Transit Access Point (STAR TAP)[1]

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What is STAR TAP?

In February, 1995, the G7 nations-the United States of America, Canada, France, Germany, Italy, Japan, and the United Kingdom-as part of the Global Information Infrastructure (GII) initiative, commissioned the Global Interoperability of Broadband Networking (GIBN) project, designed to encourage the establishment of international links among existing high speed networks of the G7 and other industrialized countries. These networks were to serve as test beds for a wide variety of applications, thus providing an opportunity to experiment on interconnectivity and interoperability and to promote the rapid establishment of standards. [6] GIBN enjoyed limited successes in that Canada and Europe were able to support several useful demonstrations of advanced applications over trans-Atlantic capacity donated by the international carrier, Teleglobe, and four point-to-point ATM links were established between selected universities in Japan and the USA under the sponsorship of the Japanese Ministry of Posts and Telecommunications. But, Neither the USA nor Japan could connect with either Canada or Europe, and vice versa. The approach that several of us suggested was to bring all the advanced networks to a single point so that they could all "talk" to each other. Well, it never really happened under GIBN, because the national carriers never warmed up to the idea. But, the National Science Foundation (NSF) pursued the idea of establishing a single point to facilitate the long-term interconnection and interoperability of advanced international networking, and thus the Science, Technology and Research Transit Access Point (STAR TAP) was born in 1997 [15]. Canada's Network for the Advancement of Research, Industry and Education (CANARIE) was the first non-USA partner to connect its advanced network (CA*Net II) to the NSF-sponsored Very High-Performance Backbone Network Service (vBNS) at the STAR TAP. Singapore's Next Generation Advanced Research and Education Network (SINGAREN) was next. It was followed by the TransPAC consortium (Australia, Korea, Japan and a secondary Singapore connection), Taiwan's Tanet2, and then the Netherlands' SURFnet, France's Renater 2, Israel's Internet-2, the new Nordic backbone, NORDUnet2, and CERN (which comprise the Euro-Link Consortium) and MIRnet (Russia). In addition, all of the USA's Next Generation Internet networks: NSF's vBNS, NASA'S NREN and NISN, Defense's DREN and Energy's ESnet as well as Abilene, the new network initiative of the University Corporation for Advanced Internet Development (UCAID) are connected at STAR TAP. The global perspective of STAR TAP is shown in Figure 1, and the logical connectivity of the international and domestic networks can be seen in Figure 2.

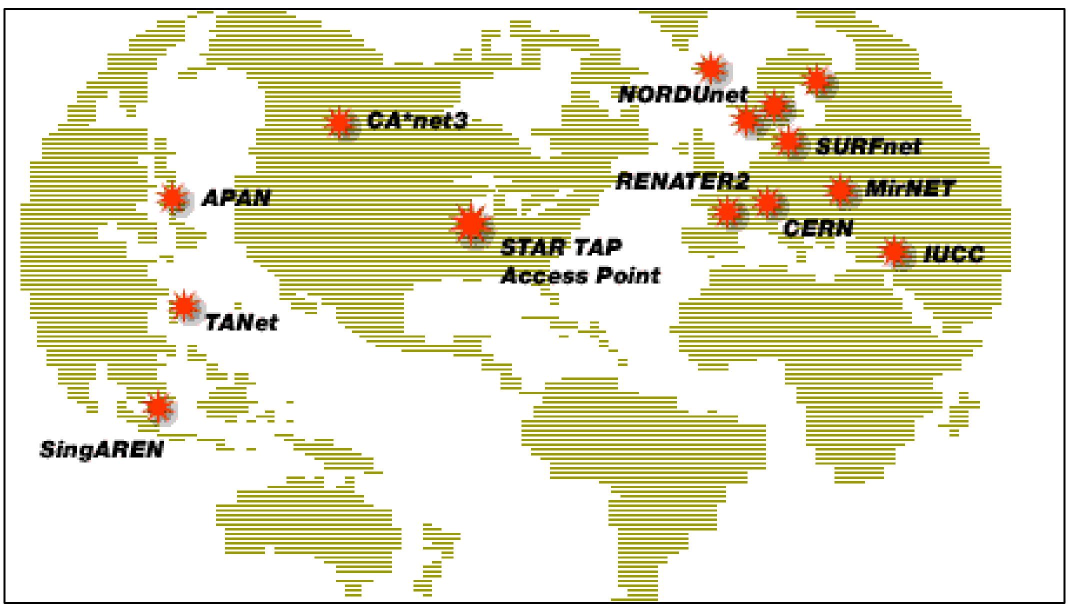


Figure 1: STAR TAP International Networks

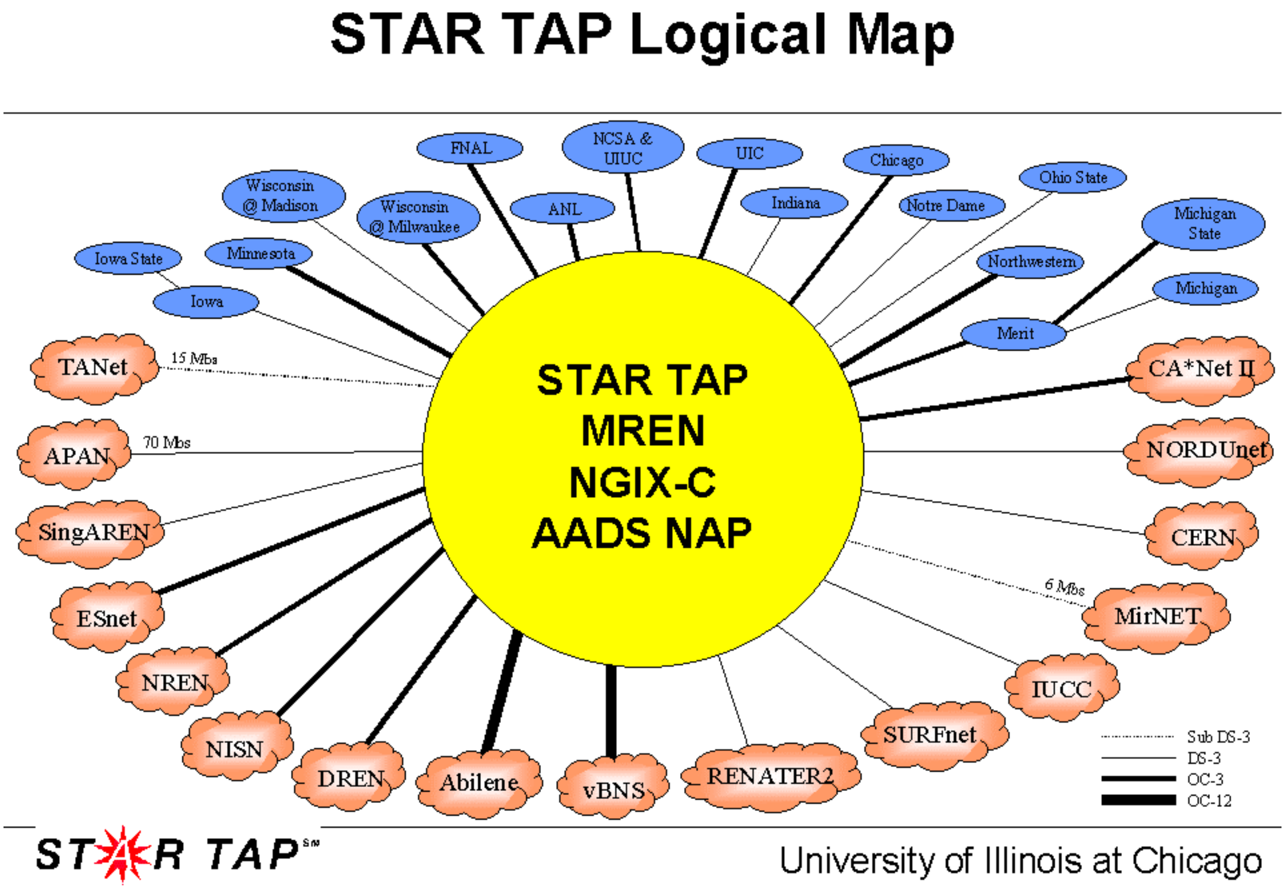


Figure 2: STAR TAP Logical Map

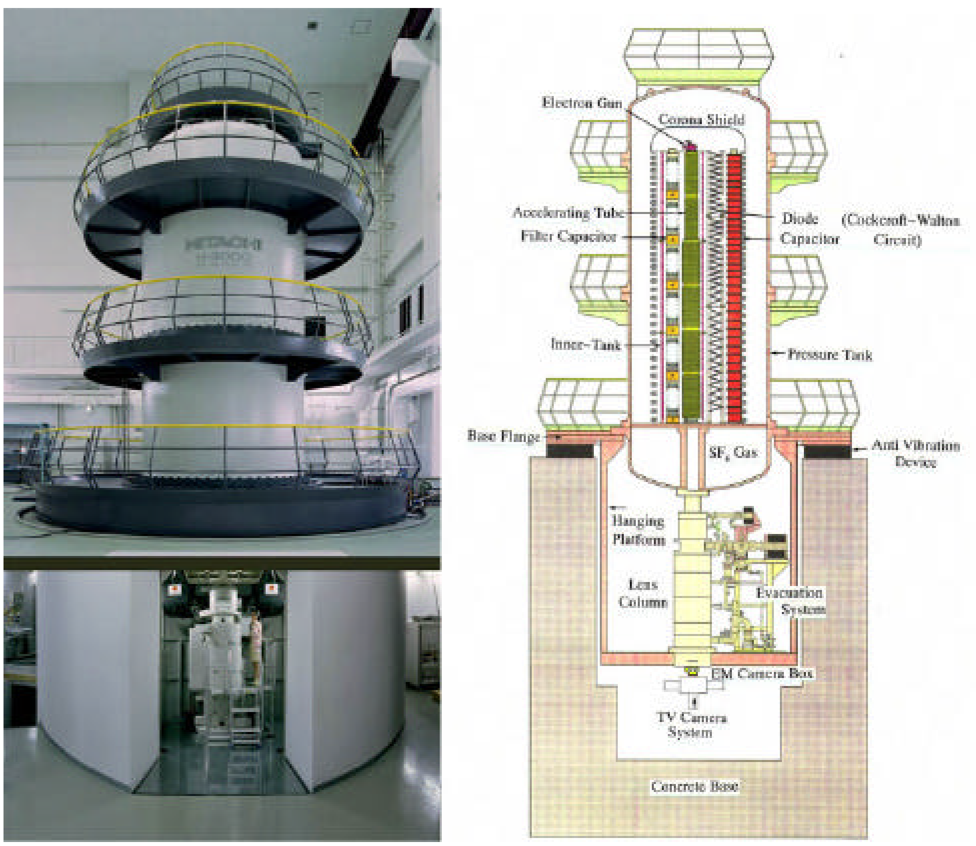
What is all this talk about “Advanced” and “Next Generation” and “xyznet-2”

Yes, it is very confusing, all these terms. So, here’s a quick explanation: the Internet gets congested, and even ordinary activities like downloading files don’t seem to work well—there’s bumper-to-bumper traffic on the “Information Super Highway.” But, there are important collaboration activities that could take place over the Internet, if only there were a way to reserve tens of millions of bits/sec. (Mbps) of capacity resources and to provide other service parameters (like consistently short transit times for information packets). Some examples include modeling climate change with an ocean simulation running on one powerful computer and an atmospheric simulation running on another, and the two interacting over the network; “mining” very large data sets to discover new trends (market research, epidemiology); remote participation in experiments on unique research equipment like electron microscopes or high-energy particle accelerators; medical imaging; tele-immersion; collaboratories; distributed genome sequencing, etc. These are examples of “advanced” applications. And, the networks that support them have to be “high-performance,” and not of the current generation Internet, but “Next Generation” or “Internet x”, where x=2 denotes second generation, etc. (Canada is already implementing CA*net 3, based on sending Internet Protocol datagrams directly over individual wavelengths from among many available wavelengths of laser-generated light on glass fibers, and they are doing this without using intervening SONET/SDH or ATM network elements to carry them. In France, the advanced network Renater 2 has been launched. Renater/Renater 2, of course, connects to STAR TAP and can talk with (the technical term is “peer with”) all the other networks that also connect to STAR TAP. (N.B., these last three hyper-linked web pages are all in French; no need for Francophones to shy away from the Internet anymore!)

Why support of advanced applications is important

It helps to see an example of a so-called advanced application. In mid-1999, researchers at the National Center for Microscopy and Imaging Research in San Diego, California, USA, were able to use remotely the world's most powerful transmission electron microscope that was located at the Research Center for Ultra-High Voltage Electron Microscopy in Osaka, Japan. The high penetrating power of the Osaka Ultra High Voltage Electron Microscope (UHVEM, Figure 3) makes it possible to study 3-dimensional structures that could not be seen in thinner samples. The UHVEM is an example of a unique research instrument that can be shared by means of high-performance networks.

In fact, the collaboration we describe here was made possible by the connection of Japan's advanced Inter-Ministry Research Information Network, IMnet, to the vBNS by means of the 70 Mbps TransPAC link between Tokyo and the STAR TAP. The application used a digital video (DV) stream of about 35 Mbps as well as Java applets (control programs transferred from the server to run on the client computer). The major link from Japan to the United States was provided by TransPAC, an NSF and Japanese Science and Technology Agency (STA) project led by Indiana University and Asia-Pacific Advanced Networks (APAN). TransPAC connects APAN to the vBNS through the STAR TAP. Needless to say, this did not work perfectly the first few times that it was tried. It took the combined efforts of specialists in the microscopy centers in San Diego and Osaka as well as vBNS, STAR TAP and TransPAC network specialists to adjust parameters all along the path until success was achieved.[2]



http://em1.uhvem.osaka-u.ac.jp/official/features.html

Figure 3. The 3 million volt electron microscope at Osaka University. Photo © 1999, Osaka University; used by permission.

[2] To learn more, see "Web-based Telemicroscopy" http://www-ncmir.ucsd.edu/CMDA/jsb99.html and
"Seeing Submicron Structures from 10,000 Kilometers: Trans-Pacific Microscopy Enabled by International Advanced Networks" http://www.npaci.edu/online/v3.10/telemicroscopy.html

Figure 4. NCMIR Director Mark Ellisman at the "knob box" in the remote control pavilion at UC San Diego, operating the Osaka microscope. Photo ©1999 Osaka University, used by permission.

Figure 5. A stereo pair taken through the Osaka UHVEM camera: the white object making its way from the center to the left hand edge of the picture is a blood capillary in the 4.5 micrometer thick sample. The dark tree-like object is the Purkinje cell; the branches are called dendrites. Photo © 1999, Osaka University; used by permission. <- Le Recherche needs to get permission

To sample other advanced collaborations, the reader is invited to look at APPLICATIONS on the STAR TAP Web site.

OK, so what's so special about STAR TAP?

There are many Internet eXchanges (*IXs) around the world. So what is so special about STAR TAP? Well, for sure, it is located at an existing commercial *IX, the "Chicago NAP" operated by Ameritech Advanced Data Systems. The Chicago NAP is an ATM switching center that extends over two buildings in downtown Chicago, Illinois in the central part of the USA. Many commercial Internet Service Providers (ISPs) exchange traffic with each other at the Chicago NAP. Ameritech's record in keeping the switch operational without failure and without congestion has been superb. We know of no outages since we implemented STAR TAP there in 1997. Because the Chicago NAP employs an ATM switching "fabric," it is possible to make a separate virtual connection (Permanent Virtual Circuit) between each network that connects there and all other networks that connect there (for N connecting networks, that means N(N-1)/2 individual PVC's!). The result is that networks can choose to exchange traffic directly with each other through the switch without having to use common pathways other networks—in short, other networks' traffic will not congest the exchange medium and burden your own traffic. But, for international matters, there is an even greater benefit: **national networks' choices to peer with each other are strictly bilateral decisions, free from policy constraints that could otherwise be imposed by the hosting organization**. That means, for example, that if France's Renater 2 chooses to exchange traffic directly with Taiwan's TAnet 2, neither NSF, nor Ameritech, nor anybody else other than France and Taiwan is involved in that decision or in deciding just what kinds of traffic France and Taiwan will exchange. We purposely implemented the STAR TAP that way. Every network that connects can connect with every other network, but whether or not they connect directly with each other is a bilateral decision.

Advanced STAR TAP services

STAR TAP provides, or is host to, several advanced networking services. Brief descriptions follow.

IPv4 routing. As time passed, and the number of connecting networks grew beyond the first few, administrators of some STAR TAP networks realized that being able to exchange traffic with all the other connected networks meant making separate agreements with each of the others. For some, this was a burdensome proposition. At a meeting of the STAR TAP Advisory Committee (to which all connecting networks belong), we were asked to provide a router through which all the networks could exchange traffic with each other (by default) as an alternative to direct ATM connections through the PVCs. So, recently, we implemented the router service. If a great deal of traffic passes through the router, performance will suffer. So, networks that exchange traffic with each other at high data rates are still encouraged to do so with direct PCV connections that are automatically set up by Ameritech. But, connections to networks with which traffic exchanges are more casual can be obtained through the common router. Internet Protocol version 4 (IPv4), the current version, is used for the exchanges of traffic. With reference to Figure 6, this takes place in the Cisco 7505 Router).

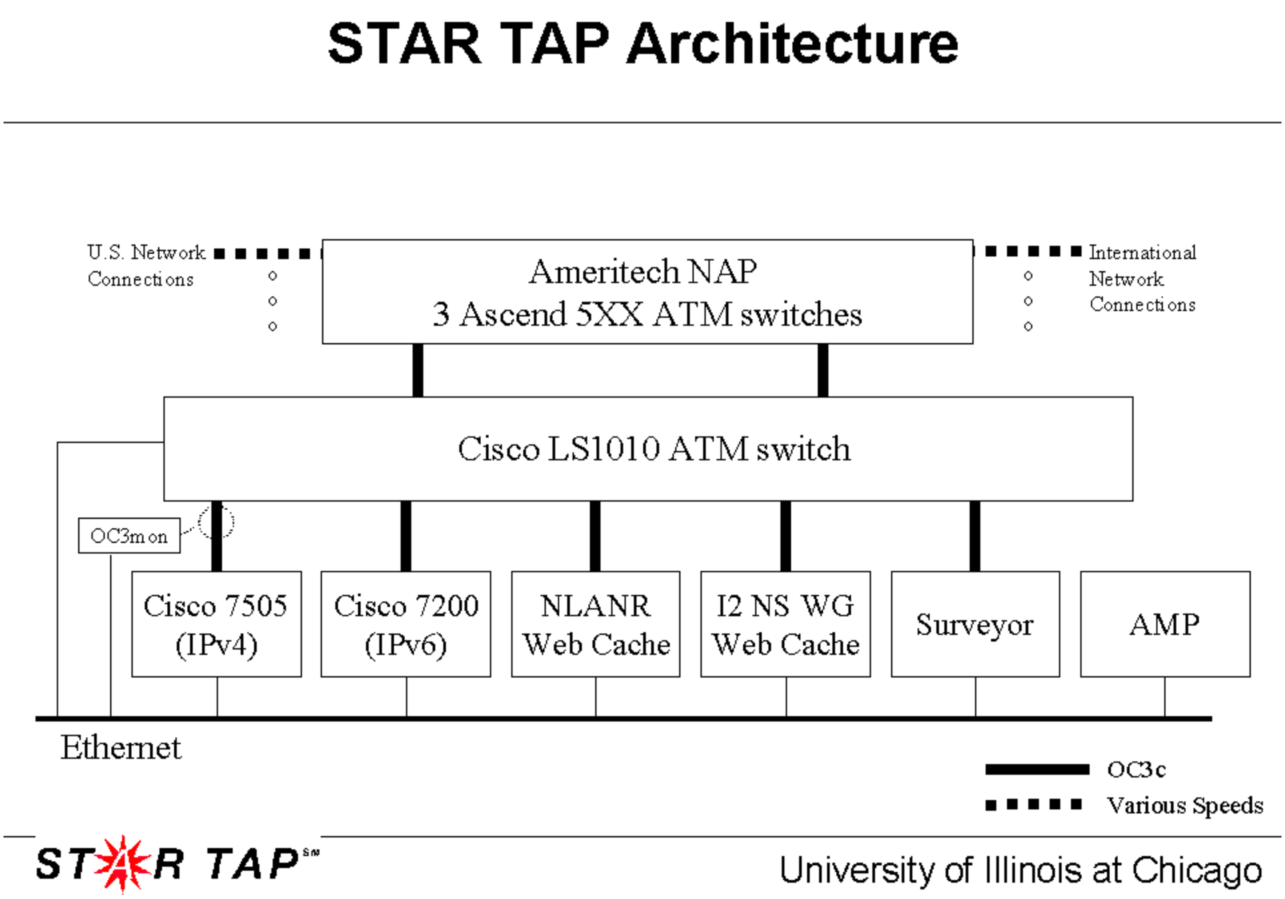


Figure 6. STAR TAP Architecture

IPv6 routing.

A new version of the Internet Protocol is under development. It is IP version 6 (IPv6). IPv6 holds several promises for transcending limitations inherent in IPv4, the primary one being an address space too small for the burgeoning Internet. The U.S. Department of Energy's ESnet and Canada's CANARIE have jointly implemented the 6TAP as a persistent global peering point for the growing number of operational networks that employ IPv6. ESnet and CANARIE have co-located the 6TAP with the STAR TAP to take advantage of the confluence of international advanced networks, some of which have carved out a portion of their bandwidth for dedicated IPv6 development. The 6TAP router is shown in Figure 6 as the Cisco 7200.

DiffServ/Qbone.

QBone is an international Internet2 initiative to build a testbed for new IP quality of service (QoS) technologies. QoS offers a promise of providing the special services that advanced applications will need in all but the least congested and "cleanest" networks. The QBone testbed will initially implement the differentiated services (DiffServ) approach to QoS that is now taking shape within the DiffServ Working Group of the Internet Engineering Task Force (IETF). The differentiated services approach to providing quality of service in networks employs a small, well-defined set of building blocks from which a variety of services may be built. Many of the international STAR TAP partners participate in QBone activities. The Cisco 7505 IPv4 router is used for the DiffServ activities.

Information Caching.

Web caching of information can decrease the load on network links by temporarily saving copies of popular information objects (files, web pages, etc.) at sites closer to the users than the originating site. Both the IRCache group of the NSF-sponsored National Laboratory for Applied Network Research (NLANR) and Internet2 Network Storage Working Group have deployed web caches at the STAR TAP. They are shown as the NLANR Web Cache and the I2 NS WG Web Cache, respectively, in Figure 6.

Measurement Devices: OC3mon, Surveyor.

It would be nearly impossible to understand what is taking place on any network without being able to measure key operating parameters like flow, packet loss, delay, and so forth. As with web caching, both NLANR and I2 have a measurement presence at STAR TAP. The NLANR Measurement and Analysis Team maintains both an OC3mon and an Active Measurement Program (AMP) monitor, and the Internet2 Measurement Working Group maintains a Surveyor monitor at STAR TAP. All three monitors are shown in Figure 6.

So, in a nutshell…

STAR TAP has become the global crossroads for advanced networks and networking test beds. The project is nearing the end of its third year of operation, and NSF has renewed the project for another three years. This demonstrates the persistence that has made STAR TAP a credible and dependable catalyst in global high-performance application and networking development. STAR TAP has achieved a critical mass of connected networks and networking specialists, both on staff and affiliated. These resources and STAR TAP's value-added services continue to attract the contributions of many members of the networking community. To our colleagues in France, we express our delight in the opportunity to support collaborations with researchers served by Renater2, and we look forward to learning new things together.