Internet 2

By DC Palter and Hank Nussbacher

In what now may seem an entirely different era, the Internet was born on October 1969 and immediately began facilitating communications between the researchers building the network, scattered across various universities, research institutions and government agencies.

The invention of TCP/IP applications including email, ftp and telnet, allowed the Internet to quickly become the artery for communications by the entire research and academic community. Usage at universities began to explode and it wasn't long before commercial networks also started to flourish. With the later development of the World Wide Web and its user-friendly interface, the Internet fundamentally changed the world.

However, this boon to the general public also had its downside. The universities that built the networks were now forced to share it with business and home users who swamped the available bandwidth. As the network became mission-critical for business, researchers could no longer test new technologies, which might impact the performance of the network. Nor would it ever be possible again to make enhancements which were not backwards compatible with the existing infrastructure.

With the commercial Internet no longer suited to the needs of the academic community, a consortia of 34 universities banded together in October 1996 to launch the Internet2 as a separate network dedicated to the needs of research and education.

The Internet2 (http://www.internet2.edu) is a new, high-speed, quality of service (QoS) enabled network being built by a consortia of universities to serve specific needs of research and education. Within Israel, the Internet2 network (http://www.internet-2.org.il) is now being tied to the U.S. Internet backbone over a high-speed satellite link, which provides a unique test bed to validate the ability of satellites to support high-speed Internet access.

According to Greg Wood, Internet2 director of communications, "The project now has 160 member universities, working in cooperation with 55 companies, several dozen affiliate members and more than 10 international partners." Member universities fund the $70 million per year cost of infrastructure improvements on their campuses, and corporate partners are contributing more than $30 million.

In essence, the Internet2 acts as a parallel, dedicated, QoS-enabled, high-speed network for specialized applications of relevance to the scientific and educational communities. At the same time, the Internet2 functions as a large-scale testbed for new networking technologies needed to support these applications. Once the usefulness and stability of these new technologies and applications are verified through use on the Internet2, they can be transitioned to the standard Internet.

As Wood explains, "More than the network itself, the Internet2 is really about developing new applications required for research and education. The development of the network comes out of a realization that the fundamental technology underlying today's Internet could not support these applications."

Internet2 application development is focusing on five broad areas: digital libraries, real-time video, distributed computing, virtual laboratories and tele-immersion. Fundamental to supporting these applications are new networking technologies including QoS, IPv6 and native multicasting – technologies that will see their first large scale testing in a production environment on the Internet2.

For example, one of the most critical technologies for enabling a new generation of applications is QoS, which introduces the concept of prioritizing data traffic. QoS ensures that time-sensitive voice or video packets don't get held up behind emails or Web downloads. QoS also makes it possible to reserve bandwidth, allowing a remote medical specialist to assist in a medical operation over the Internet without having to contend with degradation in the quality of the connection as home users check sports scores.

As an analogy, today's Internet can be compared to a socialist environment. Every user receives an equal share of the available bandwidth. If 100 people are using the network, each will receive one hundredth of the available bandwidth. In contrast, the Internet2 is capitalist in nature. Users willing to pay more are able to receive a better service, similar to first class, business class and economy class on an airplane. This fundamental change allows economics to ensure that bandwidth resources are used more efficiently, and the QoS technology developed and tested on the Internet2 will affect how the Internet operates over the coming decade.

Internet2 in Israel

In Israel, the Internet2 network is being developed by the Israeli Inter University Computation Center (IUCC). The IUCC was established in 1988 as a consortia of Israel's eight public universities, tasked with coordinating and enhancing the country's university network. The IUCC initiated Israel's first Internet link to the United States, and for a number of years, functioned as the sole Internet provider in the country, servicing the academic community as well as corporations and Internet service providers (ISPs). Today, the IUCC's network provides access for approximately 100,000 students and 20,000 faculty members.

Within the country, the Israeli Internet2 network consists of a dual ATM-based OC-3 (155 megabits per second [Mbps]) network between the eight universities: Tel Aviv University, Bar-Ilan University, Weizmann Institute of Science, Technion, Haifa University, Open University, Hebrew University and Ben-Gurion (See

takes to the AIR

Figure 1). For the connection from Israel to the U.S. backbone, the IUCC initially considered a terrestrial T3 (45 Mbps) line before realizing that a satellite link, if it could be made capable of supporting high-speed applications, would be more economical than terrestrial options.

Protocol gateways and satellite latency

One of the primary arguments against using a satellite link was the inability of the Internet protocols to support high-speed connections over large latency satellite links (For further details, see RFC 2488 published by the IETF). The default settings for most computers limit the throughput of a single TCP connection to 100 kilobits per second (kbps) or less over a geostationary (GEO) satellite link and a round-trip delay of 550 milliseconds. This, of course, defeats the purpose of a network designed for virtual reality, telemedicine and other high-bandwidth applications. To determine if these limitations could be overcome, the IUCC examined protocol gateways, which promised a solution to the problem of running TCP/IP over the high delay satellite connection.

As explained by Dr. Tokuo Oishi, supervisor of the Intelsat Technical Laboratories, "TCP/IP is the foundation of the Internet, since the majority of applications use the TCP protocol. It is well known that a TCP/IP connection works well over a satellite link if the connection speed is less than 128 kbps. For a higher connection rate, enhanced TCP/IP may be required. Recently, protocol conversion methods to enhance TCP/IP performance over satellite have become available."

The protocol gateway intercepts the TCP traffic destined for the satellite and uses a specialized protocol to transfer the data over the satellite. A protocol gateway

Figure 1. Israeli Internet2 network includes a 45 Mbps satellite link to the U.S. backbone.

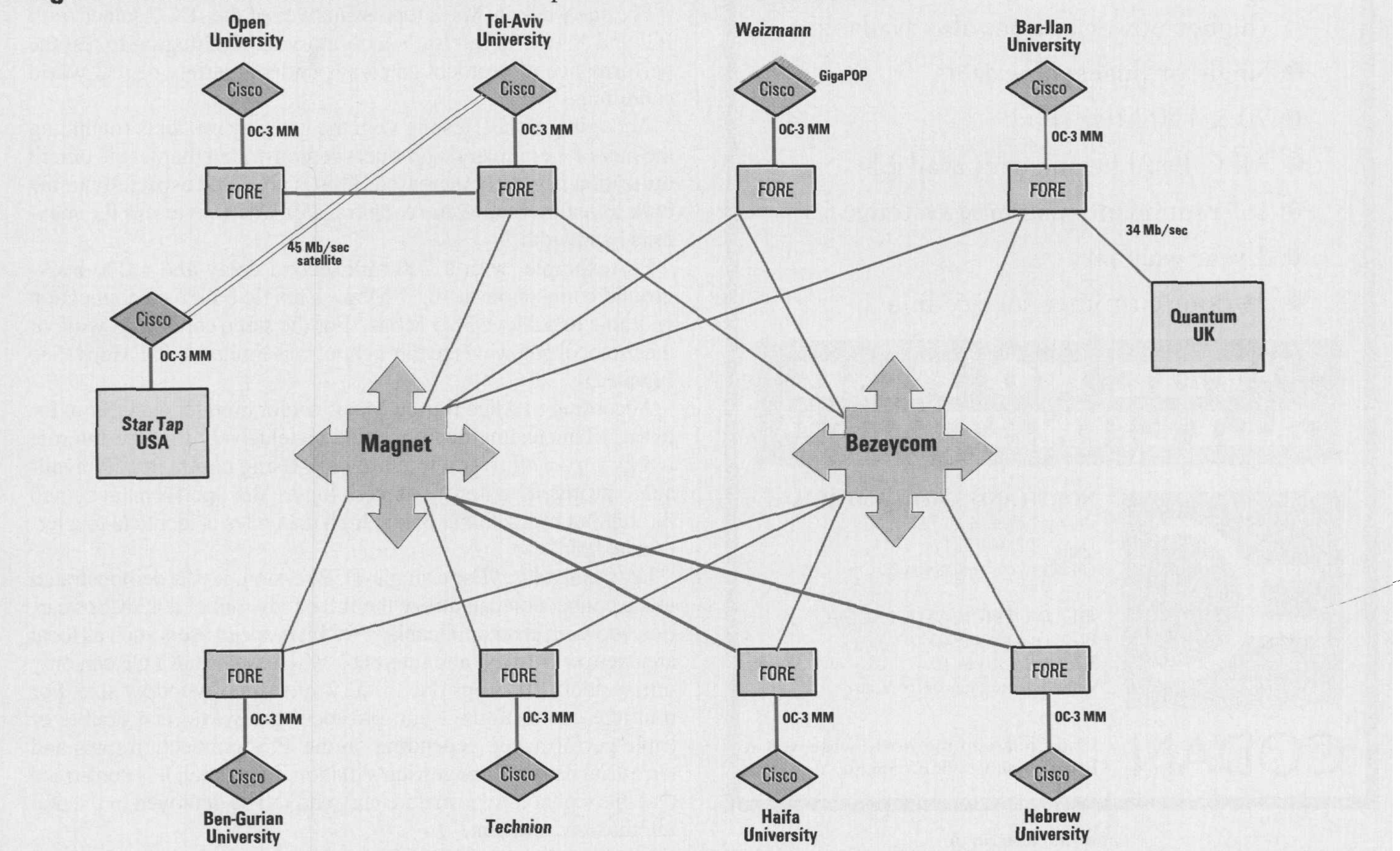
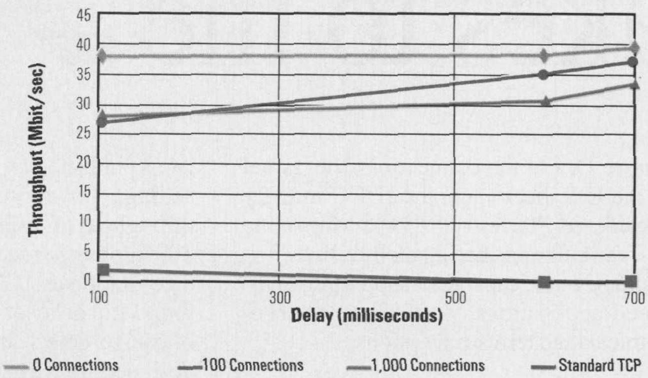


Figure 2. Throughput for a single connection using a protocol gateway with 0, 100 and 1,000 background connections.



on the opposite side of the satellite link then translates the data back to TCP, thereby overcoming the limitations of TCP/IP while remaining transparent to the clients and servers.

The IUCC examined a number of products and hired Infinite Global Infrastructures (IGI - http://www.igillc.com) to assist in testing two of the products. As Arun Welch of IGI explains, "The primary focus was to see if the gateways could mitigate the effects of the bandwidth-delay problem for traffic of the type likely to be found on the IUCC's transatlantic circuit."

For one week in April, representatives of the IUCC joined with IGI and NASA at Intelsat's laboratory in Washington to test the performance of protocol gateways under a variety of real world conditions.

According to IGI, testing with the gateway products (including the author's company's product) demonstrated that "...the circuit utilization is greatly increased. This is observed especially in the bulk transfer case, where each transfer was able to use the maximal bandwidth."

For example, with a 700-millisecond delay and 1,000 background connections using 7 Mbps, a single bulk data connection was able to achieve 33.5 Mbps. For the same conditions without the protocol gateway, the throughput was limited to 0.4 Mbps (See Figure 2).

According to Alice Barrett Mack, senior product manager at Intelsat, "This testing demonstrated conclusively that the Internet works very well over a satellite link. Using commercially available protocol gateway technology, the performance and throughput of a satellite link at high data rates is identical to a terrestrial link."

Dr. Oishi adds, "For a single TCP session, it was demonstrated that a connection can utilize the full bandwidth of a 45 Mbps carrier, showing clear applicability for high-speed users such as local area network (LAN) and Internet2, whereas normal TCP can only utilize about 100 kbps due to the limitation of window size. For multiple connections, again [protocol gateways] can double or triple performance depending on the TCP connection rates and terrestrial network congestion situation. In general, it is confirmed that this technology is mature and ready to be deployed in the real satellite environment."

The IUCC connects

With the completion of testing which demonstrated that satellites could support the needs of the Internet2 network, the IUCC was ready to connect. Through Israsat, an Israeli subsidiary of Gilat Communications (http://www.gilat.net), the IUCC purchased a T3 45 Mbps satellite link on Intelsat 801. The link connects between the Israel Giga-Pop at Tel Aviv University and StarTap (http://www.startap.net), the international connection point for the Internet2 located in Chicago.

To complete the connection to the United States, Israsat needed an Earth station near StarTap in the Chicago area. "We could not find even one Earth station in the area for Intelsat Atlantic Ocean Region satellites," said Rami Orpaz, vice president of marketing and sales at Israsat. "In order to eliminate the local loop that currently exists between the New York Earth station and Chicago, Israsat has decided to build and operate a Standard A 16-meter Earth station in Chicago."

Using EFData's SDM-9000 modems, the satellite link has been tested up to 44 Mbps and is now being used to move both Internet2 and standard Internet traffic between Israel and the United States.

A glimpse of the future?

While the IUCC is currently the only satellite-based connection to the Internet2, the link is attracting the attention of the entire Internet2 community, especially from other high-speed network initiatives outside of the United States. According to Intelsat's Mack, "There is serious interest in at least one more Internet2 link over satellite."

While the link is currently running at 45 Mbps, this bandwidth may increase greatly in the near future. Since the IUCC purchased an entire 72-megahertz (MHz) transponder, future testing at the IUCC will focus on expanding the data rate of this link to 155 Mbps.

Professor Danny Dolev, chairman of the IUCC, states, "The goal of the Israeli Internet2 network is to maximize Israel's research and development (R&D) potential of this emerging technology. Israel anticipates that this R&D will result in remarkable spin-offs to the country and especially to the economic sector of the country."

One of the primary goals of the Internet2 initiative is to test and demonstrate networking technologies that can be transitioned to the commercial Internet. The IUCC link to the Internet2 backbone over satellite is a highly visible testbed demonstrating and validating the use of satellites and protocol gateways for high-speed Internet access and hopefully provides a glimpse into the future of networking.

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