WHAT IS BACKBONE?

describing optic-fiber connectivity

In describing optic-fiber connectivity, you will often hear us refer to the telecommunication backbone as an example. For those of you that have not been following the telecommunication industry, let me explain.

The backbone refers to the principal data routes between large, strategically interconnected networks and core routers. These data routes are hosted by commercial, government, academic and other high-capacity network centers, the Internet exchange points and network access points, that interchange Internet traffic between the countries, continents and across the oceans of the world. Internet Service Providers (often Tier 1 networks) participate in Internet backbone exchange traffic by privately negotiated interconnection agreements, primarily governed by the principle of settlement-free peering.

The Internet backbone is a conglomeration of multiple, redundant networks owned by numerous companies. It is typically a fiber optic trunk line. The trunk line consists of many fiber optic cables bundled together to increase the capacity. The backbone is able to reroute traffic in case of a failure. The data speeds of backbone lines have changed with the times. Fiber-optic cables are the medium of choice for Internet backbone providers for many reasons. Fiber-optics allow for fast data speeds and large bandwidth; they suffer relatively little attenuation, allowing them to cover long distances with few repeaters; they are also immune to crosstalk and other forms of EM interference which plague electrical transmission.

Because of the enormous overlap between long-distance telephone networks and backbone networks, the largest long-distance voice carriers such as AT&T Inc., Verizon, Sprint, and CenturyLink also own some of the largest Internet backbone networks. These backbone providers sell their services to Internet Service Providers (ISP’s). Each ISP has its own contingency network and is equipped with an outsourced backup. These networks are intertwined and crisscrossed to create a redundant network. Many companies operate their own backbones that are all interconnected at various Internet exchange points (IXP’s) around the world. In order for data to navigate this web, it is necessary to have backbone routers, which are routers powerful enough to handle information on the Internet backbone and are capable of directing data to other routers in order to send it to its final destination. Without them, information would be lost because data does not know how to locate its end destination

The largest providers, known as Tier 1 providers, have such comprehensive networks that they never need to purchase transit agreements from other providers. As of 2013 there are only five Tier 1 providers in the telecommunications industry. Current Tier 1 carriers include; Level 3 Communications, CenturyLink, Cable & Wireless Worldwide (Vodafone), UUNet (Verizon), Sprint and AT&T Corporation.

At the beginning Fiber-Optic Backbone networks had utilized the slowest data rate of 45 Mbps. However the changing technologies allowed for 41 percent of backbones to have data rates of 2,488 Mbps or faster by the year 2000. Today the typical data rate is between 40 Gbps and 100 Gbps with companies starting to deploy 400 Gbps data rates and that’s in hopes of keeping up with our growing need for speed!

Future News:

As rapidly increasing demand for bandwidth strains the Internet's capacity, a team of engineers has devised a new fiber optic technology that promises to increase bandwidth dramatically. The new technology could enable Internet providers to offer much greater connectivity from decreased network congestion to on-demand video streaming.

Described in the June 28 issue of the journal Science, the technology centers on donut-shaped laser light beams called optical vortices, in which the light twists like a tornado as it moves along the beam path, rather than in a straight line.

Widely studied in molecular biology, atomic physics and quantum optics, optical vortices (also known as orbital angular momentum, or OAM, beams) were thought to be unstable in fiber, until BU Engineering Professor Siddharth Ramachandran recently designed an optical fiber that can propagate them. In the paper, he and Alan Willner of USC demonstrate not only the stability of the beams in optical fiber but also their potential to boost Internet bandwidth.

"For several decades since optical fibers were deployed, the conventional assumption has been that OAM-carrying beams are inherently unstable in fibers," said Ramachandran. "Our discovery, of design classes in which they are stable, has profound implications for a variety of scientific and technological fields that have exploited the unique properties of OAM-carrying light, including the use of such beams for enhancing data capacity in fibers."

The reported research represents a close collaboration between optical fiber experts at BU and optical communication systems experts at USC. "Siddharth's fiber represents a very unique and valuable innovation. It was great to work together to demonstrate a terabit-per-second capacity transmission link," said Willner, electrical engineering professor at the USC Viterbi School of Engineering.

Ramachandran and Willner collaborated with OFS-Fitel, a fiber optics company in Denmark, and Tel Aviv University.

Funded by the Defense Advanced Research Projects Agency, the technology could not come at a better time, as one of the main strategies to boost Internet bandwidth is running into roadblocks just as mobile devices fuel rapidly growing demands on the Internet. Traditionally, bandwidth has been enhanced by increasing the number of colors, or wavelengths of data-carrying laser signals -- essentially streams of 1s and 0s -- sent down an optical fiber, where the signals are processed according to color. Increasing the number of colors has worked well since the 1990s when the method was introduced, but now that number is reaching physical limits.

An emerging strategy to boost bandwidth is to send the light through a fiber along distinctive paths, or modes, each carrying a cache of data from one end of the fiber to the other. Unlike the colors, however, data streams of 1s and 0s from different modes mix together; determining which data stream came from which source requires computationally intensive and energy-hungry digital signal processing algorithms.

Ramachandran's and Willner's approach combines both strategies, packing several colors into each mode, and using multiple modes. Unlike in conventional fibers, OAM modes in these specially designed fibers can carry data streams across an optical fiber while remaining separate at the receiving end. In experiments appearing in the Science paper, Ramachandran created an OAM fiber with four modes (an optical fiber typically has two), and he and Willner showed that for each OAM mode, they could send data through a one-kilometer fiber in 10 different colors, resulting in a transmission capacity of 1.6 terabits per second, the equivalent of transmitting eight Blu-RayTM DVDs every second.

Has your head exploded yet?

DOUG SCHWARTZ   Western US Client Relations Executive