New techniques to boost the Internet's capacities

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16 July 1999

The rapidly increasing demands being placed on international communications networks are fueling some remarkable technical developments in the field of fibre optics.

The main impetus has been the tremendous expansion in the use of the Internet—both in the number of users and in its extension to areas such as graphics, sound, video and potentially other areas of communications such as voice and video conferencing.

The growth in the number of people on line is staggering. In June 1997 it was estimated that 82 million people were using the Internet, with forecasts that by 2002 up to 329 million people would be going on line each day. Up to 16.6 million people across Europe use the Internet. In Britain it was estimated that 25 percent of the population would be on-line by the middle of 1999. In Australia up to 30 percent of households are already online. In countries like India and Indonesia, Internet usage is low per head of population but still numbers in the millions, especially among younger, educated layers.

The establishment of the World Wide Web in 1993 made possible the extensive use of graphics, sound and video and has led to more and more complex designs for web pages and sites. Each of these new applications has led to greater demand for carrying capacity, technically known as bandwidth, to ensure ease and speed of access to Internet sites.

Over the past 20 years, the use of fibre optic cables by major communications companies has allowed them to stay ahead of demand and substantially improve telecommunications internationally. But the rapidity of the growth of the Internet and telecommunication usage has created pressures on existing fibre optic systems. They are in danger of becoming overloaded and unable to cope with demand.

To lay more cable using the same technology is a very expensive exercise. The other option is to develop new technologies that will enhance the capacities of existing cables. It is the latter to which most attention has been given. Major firms have spent millions to develop the technology needed to expand bandwidth, and there have been some remarkable results.

Information is carried along a fibre optic cable by a laser beam of light at a certain frequency (or colour). In the past, a single fibre optic thread has had the capacity to transmit a single frequency. Now, however, scientists have developed the technical means to enable a number of frequencies to pass along a single fibre.

Two technical breakthroughs were necessary. Firstly, tiny optical filters, called in-fibre Bragg gratings, were developed that create light of a number of slightly different, but distinct frequencies. Bragg gratings are manufactured by irradiating the fibre core with UV light, a process that permanently changes the glass's refractive properties, according to a definite pattern. Secondly, a means of amplifying the signal was developing by “doping” or adding minute quantities of rare-earth ions to the core of the optical fibre.

These components are very effective and also inexpensive to produce, and have rapidly replaced the outdated and cumbersome optical devices that were used previously. The outcome has been a system known as Dense Wavelength Division Multiplexing (DWDM) that has dramatically increased bandwidth.

In the past when one frequency was able to pass through an optic cable, the fibre's capacity was around 2.5 gigabits per second (Gbps). In 1996, Bell Laboratories developed a multiplexer able to pass eight frequencies along an optic cable, boosting the bandwidth to 20 Gbps. Present DWDM technology allows as many as 400 frequencies to be transmitted simultaneously or about 1,000 Gbps—roughly equivalent to the transfer of the information contained in 20,000 novels each second.

So quickly is this technology developing that by the end of the year scientists are preparing to pass up to 1,000 frequencies along an optic fibre, which has the thickness of a human hair. Experiments are now being prepared to test the possibility of transmitting at a trillion bits (terabit) of information per second—more than was being passed through the entire Internet a year ago.

DWDM will reduce costs significantly. In an ordinary fibre optic cable, the signal requires boosting after 40 kilometres, but with the DWDM system the signal only needs to be boosted after 100 kilometres. DWDM also uses fewer components and is more reliable, which means a saving in installation and maintenance costs. It has being calculated that as DWDM technology is introduced more widely its costs will drop by a further 30 percent each year. It can also be used in inter-office and metropolitan networks and by smaller operators such as universities that require large data handling.

Despite these astonishing developments there are still drawbacks to be overcome. The main problem is now not the bandwidth of the optic fibre but rather the processing of the huge amount of data at either end. Information travels at the speed of light along the optic fibre, but at either end the complex switching processes use much slower electronic technology.

To overcome these deficiencies, researchers and scientists are turning to the field of photonics. Just as electronics involves the manipulation of signals imprinted on streams of electrons, so photonics aims to directly manipulate the information in the laser beams in optical fibres. Corporations are now seizing upon what appeared to be a somewhat abstruse area of research in the 1970s and 1980s.

Large amounts of money are being poured into photonic research because huge profits appear likely. The growth in demand for photonic devices including DWDM systems has expanded in the US from almost zero in 1994 to $1.5 billion in 1997, and is expected to grow to $4 billion by 2001.

The present drive is to develop a photonic switching device that can redirect the enormous amount of information without having to carry out the slow and time-consuming process of changing from optical signals to electronic signals and back again. The next generation of DWDM technology will seek to incorporate optical cross-connectors able to switch individual frequencies of light between fibres.

Astarte Fibre Networks already supplies optical cross-connect switches, which use a piezoelectric material to switch light from 72 incoming fibres to another set of outgoing fibres. The device could be used to restore services instantaneously if a fibre is cut. At present, however, their use remains limited and they are not suitable for long distance operations.

The race is also on to develop the optical equivalent of a router—a device which reads the incoming stream of information and switches individual "packets" in the appropriate direction. A European consortium, ACTS, has demonstrated a rudimentary optical device which performs this function, but prospects for an optical router still remain rather distant.

These latest developments provide a glimpse of the enormous potential for further leaps forward in telecommunications and the expansion of the Internet to include facilities such as video-on-line and video conferencing that are beyond the capabilities of the present technology.