TECHVIEW: INTERNET

The Internet of Tomorrow

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The Internet is a creation that changes fast. It was designed to connect computers, and computers keep evolving, as does the industry that surrounds them. So the Internet has to change just to keep up with the computers it serves. The most obvious change is that everything seems to be getting faster. According to Moore's law, computers can increase in speed by a factor of 10 every 5 years, given suitable research and development. This increase in capability also translates into lower cost for constant performance, which lies behind the dropping cost of PCs, and the embedded processors that are showing up everywhere: in cars, appliances, hand-held gadgets, and toys. Chip producers make faster processors and bigger memories, disk producers make disks with more capacity, and software vendors make bigger applications to take advantage of that power. The Internet must also get faster or become irrelevant to the faster computers of tomorrow. Is it going to be up to the task?

The answer to this question depends to a large extent on the information transfer technology that underlies the Internet. The long-distance physical communication paths from which the Internet is built are mostly made of optical fibers, strands of glass down which light is sent. By modulating information onto this light, data is transferred between the attached computers. Today's fibers are capable of carrying billions of bits of information per second, and the fiber optics technology is advancing so fast that the fibers of tomorrow will carry trillions of bits of information per second. The trick is to transmit multiple colors of light (or wavelengths) at the same time down the same optical fiber, each carrying a separate stream of information. This concept, called Wavelength Division Multiplexing, or WDM, has allowed the capacity of a single fiber to increase at a rate substantially faster than that predicted for the silicon industry by Moore's law. New cross-country (and cross-ocean) fibers are continually being installed, such that the total data transmission capacity across the United States may be doubling more than twice a year.

Of course, fiber optics are not the only component from which the Internet is built. Devices called routers are used to switch the information being transferred from one link to the next. These devices are themselves getting faster. And local area networks like Ethernet, which started at 10 Mbps (bits per second), then jumped to 100 Mbps, then 1 Gbps, will be able to handle 10 Gbps in the near future. This represents an increase in speed by a factor of 1000 since the inception of Ethernet no more than 25 years ago.

But not just the speed of the Internet is changing. A range of issues from more reliable and secure operation to more complex billing must be resolved. A particularly important advance goes by the name of "quality of service," and refers to the emerging ability of the Internet to carry different types of traffic requiring different sorts of handling at the same time. The original transmission service provided by the Internet was called "best effort" service, in which the Internet tried its best to deliver all the data it was given as fast as possible, but made no explicit commitment concerning the actual speed at which any transfer would take place. If more users were sending data at a particular moment, each transfer slowed down a little. This type of service is appropriate for e-mail and the World Wide Web, which are not really affected if a Web transfer takes a few seconds longer. But the Internet is now starting to carry other sorts of traffic, like telephone calls, real-time high-fidelity music, and (coming sooner than you might think) television. The quality of these services suffers greatly when transfer is delayed due to heavy traffic. In fact, as anyone who has made Internet-based telephone calls or listened to music on the Internet can attest, these applications simply do not work if there is not enough capacity to carry the data at the required rate. The Internet therefore has to evolve to support other sorts of transmission services, in addition to the "best effort" service. A service giving controlled delay and reserved capacity will support the real-time applications discussed above. Other transmission services will support users who need to move very large amounts of bulk data, such as medical images, or need to make very quick transfers such as financial transactions.

These changes require constant investment in research and development. Some funding comes from inside the industry. The U.S. government has also been a major supporter in Internet research and development, which is one of the reasons why the United States is currently the dominant producer of Internet technology. One particular program of the U.S. government is of key importance for the future of the Internet. The goal of the so-called Next Generation Internet, or NGI, is to encourage the deployment of an advanced version of the Internet—faster, certainly, but also with new features such as multiple transmission services.

Another, important goal of NGI is to inspire the creation of new applications of the Internet. An Internet without applications is of no more use than a computer with only an operating system. Today, the World Wide Web and e-mail are the most widespread and popular applications, but there are many others, ranging from telephone over the Internet, to multiplayer games, and military command and control and many more that have not even been envisioned yet. To facilitate the conception and realization of new innovative uses of the Internet, the NGI program has proposed to make the NGI available to U.S. universities. There are two goals: first, to make sure that universities continue to have a first-class, cost-effective research infrastructure, and second, to stimulate creative students to invent applications that will sweep the Internet, as the World Wide Web did in the last decade. Past experience suggests that this sort of investment in unplanned creativity will pay off. For example, federally funded workers at the University of Illinois developed the prototype of the first commercially successful Web browser, an effort that led to the founding of Netscape. Other countries, inspired by the payoff from the U.S. investments in the Internet, have started their own programs aimed at improving their own information infrastructure.

Of course, the world of the ever-faster and powerful Internet is not without problems. One major barrier to progress is not going away very fast—the ability to connect to homes and small businesses at high speed and low cost. Most who use the Internet from home are still stuck behind a dial-up modem, which more or less tops out at speeds of 56 kbps. Slightly less than 1% of U.S. homes today have broadband connections to the Internet, mostly using cable television modems and to a lesser extent using a new technology based on telephone wires, called Digital Subscriber Loop or DSL. The cost of rewiring all the homes in the United States for a new broadband connection has been estimated to be as much as $100 billion. That is a lot of money, either for private sector investment or federal subsidy. So for most of us at home, we have to wait a lot longer than we might want for all this speed to make it to our houses.

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