

### 33.12 Higher-Speed Access And Switching

At the edge of the Internet, access technologies, such as DSL and cable modems, have become standard. When the technologies first appeared, data rates of 2 to 6 Mbps — two orders of magnitude faster than a dialup telephone connection — seemed astounding. However, early DSL and cable modems are now being replaced by other technologies. Cellular providers are starting to offer technologies that can deliver up to 50 Mbps to mobile devices. In some parts of the US, ISPs offer optical connections to residential customers that operate at gigabit speed, three orders of magnitude beyond DSL and cable modems.

The Ethernet switches used in enterprise data centers are also becoming faster. Gigabit Ethernet, once used as a campus backbone technology, is now considered the standard desktop connection speed. Backbone networks use 10 Gbps, and it seems likely that speeds will increase to 40 Gbps or beyond. Higher data rates are sufficient to support high-definition video streaming and other new applications.

### 33.13 Cloud Computing

Large companies rely on computer networks for all aspects of business. However, the availability of reliable, high-speed Internet access is making it possible for companies to change their business model in a significant way: instead of hiring a large in-house staff to maintain hardware and software systems, companies are out-sourcing their IT operations to *cloud providers*, such as Amazon. The cloud provider maintains a set of data centers that include computational and storage services, including software upgrade (e.g., ensuring that updates have been installed on all computers) and backup (guaranteeing that copies of data files will be archived safely).

In terms of reducing cost, a chief advantage of a cloud service arises from its flexibility. If a company maintains its own IT facility, the facility must have capacity sufficient for peak needs. Unfortunately, use varies over time. For example, an accounting firm may need significant resources at the end of the tax year when tax returns are processed and filed, but fewer resources at other times. With a cloud service, a customer only pays for computing and storage resources when they are needed. Instead of complex computers, employees only need basic devices (e.g., tablets) to access cloud services.

### 33.14 Overlay Networks

A general technology that is known as *overlay networking* has emerged that can be used to provide restricted access, improved security, and nonstandard communication. The idea is straightforward: attach a set of computers to the Internet, but instead of conventional IP forwarding, define a set of *tunnels* among the computers. Restrict all packet forwarding to the tunnels. The idea is similar to MPLS except that MPLS re-