Optical Technology Uses Electronics and Photonics for Higher Data Rates

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The rapid development of broadband services and delivery technologies has been a response to business and consumer desires for faster and easier access to information and communications. Optical transmission is one of the enabling technologies for broadband, providing the backbone of the Internet, network infrastructure for wireless telecommunications and high-capacity networks for government and business. This short report notes some of the recent developments in optical technology, while the article that follows on page 30 describes developing optical transmission techniques in greater detail.

Early optical fiber communication systems anticipated the need for higher capacity. Companies that invested in fiber transmission were sufficiently far-sighted to either run extra fibers or construct their systems using conduit through which additional fibers could be pulled for future expansion. The story of a temporary excess fiber capacity and its effect on the market is well-known—but is rapidly receding into the past.

The electronic circuitry of optical transmission—solid state lasers, laser drivers, photodetectors, transimpedance amplifiers, modulators and signal processing—continue on a path of steady development. These supporting components and circuits must keep pace with developments in the understanding of the physics of optical fiber and manufacturing methods that enhance the performance of the optical transmission medium.

Photonic Signal Processing

Until now, most switching, multiplexing and modulation tasks have been handled electronically. This requires detection, signal processing and re-modulation of the lightwave signals. Photonic processing that handles the signals while they remain light waves is on the verge of mass production, particularly in switching, where micro electromechanical system (MEMS) technology is being used to operate tiny mirrors that can direct light beams between input and output ports.

True quantum processing of light waves is still in the laboratory, but holds promise for additional signal processing functions that are now being performed on the baseband electronic signal instead of the light beams. This type of technology is expected to enable Terabit/s data rates, a significant step beyond the 10 to 20 Gigabit/s rates now in development.

The switching technology that is poised for production will enable new means of optical transmission. In the following article by Lopes, Abdalla and Soares, the authors note how pulses or commutation can be used to achieve optical CDMA transmission in a manner that cannot be easily achieved by electronic signal processing and modulation.

Free-Space Lightwave Communications

Laser-based communications saw a brief surge in popularity several years ago, as a secure, high-capacity alternative to conventional microwave links. Well-known problems with weather and pollution (dust, smoke and smog) were accepted limitations for the range and performance of such systems. These early systems never developed into a significant market as alternative transmission methods proved to be more satisfactory.

Recent work in signal processing, tunable lasers, and understanding of lightwave propagation in difficult media has resulted in a small, but significant resurgence of interest in free-space lightwave transmission. Although the marketplace is still considered to be niche-oriented, there are a number of specific situations where direct laser communications is the most effective solution to a communications problem. Most often, these situations represent a unique combination of geography, data rate requirements and security needs. Many of the current projects involve military communications.

Future Developments

It does not require any special insight to see that demand will keep growing for near-instant communications and access to vast amounts of information and entertainment. As the radio spectrum becomes more crowded with wireless communications users, lightwave communications will continue to have an essential role in the transport of information.

Like many types of infrastructure, it is not highly visible to the average consumer, but many analysts believe that the capacity of the optical fiber infrastructure is the single most important factor for meeting future telecommunications objectives.