Chapter 2
Optical Access Comes of Age in a Packet-Delivery World

William Yue
Fujitsu Network Communications Inc., USA

Brian Hunck
Fujitsu Network Communications Inc., USA

ABSTRACT
The access network is the last loop, or last mile, in the provider network between the central office (CO) or point of presence (PoP) and the customer premises. Competitive pressure to provide high-bandwidth services (such as video) to consumers, and Ethernet transport to enterprises, is forcing service providers to rebuild their access networks. More optical fibers are being added in the last mile to meet these new bandwidth demands since legacy access networks have not been sufficient to support bandwidth-intensive applications. This chapter reviews the multiple definitions of “optical access” and the migration from direct copper loops to a variety of optical architectures, including Synchronous Optical Networking (SONET), Synchronous Digital Hierarchy (SDH), Fiber to the x (FTTx), Ethernet and wavelength delivery. Key business drivers such as carrier competition, bandwidth needs, and the reliability and service level agreement issues of optical technology are covered. The chapter concludes by considering the near future of optical access product trends and key optical deployment options in applications such as cellular backhaul. The data presented in this chapter is mainly based on our recent deployment experience in the North American optical access market segment.

INTRODUCTION
Optical access is the use of optical fiber to span the “local loop,” or “last mile” of network transmission between a central office or point of presence and the customer premises. The idea of using optical fiber to connect last-mile equipment to the customer edge has been pursued for decades, but critical economic factors have only recently aligned to facilitate large-scale deployment.

Bandwidth demand is driven by new consumer and business applications such as High-Definition TV (HDTV), Web advertising, e-commerce, tele-medicine, high-quality videoconferencing and
interactive gaming. This demand creates new revenue opportunities for service providers, who are seeking ways to compensate for the steadily eroding revenue stream from traditional voice applications.

The traditional copper-based access network has gone through a number of technology upgrades in recent decades. Advances were made to drive capacity per loop from a single voice channel up to a full Digital Signal 1 (DS1), also known as T-carrier (T1), of 28 channels (ANSI, 1991). Copper span distances also have consistently been improved via repeated T1 and various High bit-rate Digital Subscriber Line (HDSLx) technologies. Finally, the embedded copper plant has been stretched to provide significant data services by the use of a family of Asymmetric Digital Subscriber Line (ADSL) and Very High Bit-rate DSL (VDSL) solutions. These advancements have extended the useful life of the copper-based access network, but they are not able to scale to the much greater bandwidth levels now being targeted for new data services (Yue & Mocerino, 2007, p.1).

Optical access technologies have also been undergoing generational improvements in the last ten years, as technology has migrated from equipment platforms, which were deployed previ-ously in the core network. Optical access products have become more affordable, more feature-rich, and more broadly available from a wide range of vendors. Advancements in the manufacturing of fiber optic cable have also seen steady progress, which has led to higher quality and lower prices. This has virtually eliminated any price premium when a service provider considers copper or fiber installation in new access construction. Today fiber deployment is the strategic choice when service providers choose to invest in new infrastructure for both residential and business access.

The optical access network has finally delivered on the promise of becoming an effective and economical choice for network operators who are driving innovative new services to the customer edge. Figure 1 shows the multiservice offering delivered via the broadband access network.

**BACKGROUND**

In the last decade, unprecedented levels of Internet usage and the need for new broadband applications have created exploding demand for emerging digital video and high-speed data services. In the U.S., the Federal Communications Commission