Chapter 3
Enabling Techniques for Broadband Access Networks

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Abstract A number of techniques are introduced which enable to deliver broadband services to residential users. The ultimate capacity is provided by optical fiber all the way to the user, thanks to the fiber’s huge bandwidth and very low losses. Also in combination with other media (twisted copper pair cable, coaxial cable, or radio link) fiber can considerably improve the capacity of the access network. Fiber access network topologies are discussed, including their economic aspects. For shared fiber topologies, a number of multiple access techniques are introduced, deploying time slot multiplexing, frequency multiplexing, code multiplexing, wavelength multiplexing, and combinations thereof. Wireless delivery of broadband services to mobile users is efficiently enabled by radio-over-fiber techniques, which consolidate the radio signal processing functions at a central site. Next to delivery by optical beams through fibers, broadband services may also be delivered by optical beams through free space, for short and clear line-of-sight links.

3.1 Introduction

Access networks need to provide ever more bandwidth in order to keep up with the rising demands from residential users. The spectrum of services has broadened significantly in the past years and will expand further in the foreseeable future. Users are requesting that services are personalized, well fit to their preferences. They want video services of high-definition quality and want these on demand at any time. They like to participate in multi-party multi-media real-time games. They want to not only receive huge amounts of information, but also transmit these themselves. In the spirit of “everybody can become a service provider”, they want to upload large amounts of video information and alike. They need ways for fast file transfer,

thus demanding from the access network high capacity in not only the downstream direction, but also upstream.

### 3.2 Fiber in the Access Network

Much effort is made to squeeze the ultimate capacity out of the legacy access networks based on copper. Advanced DSL techniques are deployed in the twisted-pair telephony network and cable modem techniques in the coaxial cable CATV network. However, these copper-based networks are reaching their limits now, and inevitably optical fiber with its inherent huge bandwidth and low losses has to come in. The higher capacities on the copper-based networks are achieved at the expense of a shorter reach, and thus fiber is making its way toward the user’s home [1]. Fiber is replacing copper cables in the feeder lines, handing over to the copper lines in cabinets put at the street curb site. These so-called fiber-to-the-curb (FTTC) solutions are illustrated in Fig. 3.1. In the (near) future, fiber will run all the way to the user’s home, providing the ultimate capacity in the so-called fiber-to-the-home (FTTH) topologies.

#### 3.2.1 Fiber-DSL

In offering data rates up to 6 Mbit/s, asymmetric digital subscriber line (ADSL) modems may still enable twisted copper pair line lengths up to a few kilometers, which typically is sufficient to bridge the installed lines from the local exchange to