

## Chapter 8.2

# Broadband Optical Access using Centralized Carrier Distribution

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### ABSTRACT

*Passive optical network (PON) is considered as an attractive fiber-to-the-home (FTTH) technology. Wavelength division multiplexed (WDM) PON improves the utilization of fiber bandwidth through the use of wavelength domain. A cost-effective solution in WDM PON would use the same components in each optical networking unit (ONU), which should thus be independent of the wavelength assigned by the network. Optical carriers are distributed from the head-end office to different ONUs to produce the upstream signals. Various solutions of colorless ONUs will be discussed. Although the carrier distributed WDM PONs have many attractive features, a key issue that needs to be addressed is how best to control the impairments that arise from optical beat noise induced by Rayleigh backscattering (RB). Different RB components will be analyzed and RB mitigation schemes will be presented. Finally, some novel PONs including signal remodulation PONs, long reach PONs and wireless/wired PONs will be highlighted.*

### INTRODUCTION

It is now well known that there are various technologies for broadband access providing high-speed Internet access and triple-play services including data, voice, and video. Most well-established broadband access platforms now

are digital subscriber line (DSL)-based and the Cable Modem-based. It is generally agreed that fiber-to-the-home (FTTH) provides the bandwidth and flexibility in upgrades when considering high-speed broadband access, especially with data rate of 1 Gbit/s or above. Passive optical network (PON) is considered as an attractive FTTH technology since it is highly cost-effective. A PON is a point-to-multipoint network architecture in

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which passive optical power splitters are used to enable a single optical fiber to serve multiple users. A PON consists of a service provider's central office or head-end office and a number of optical networking units (ONUs) near end users. A PON is cost-effective since generally, there is no active component between the head-end office and the ONUs. Its configuration also reduces the amount of fiber and head-end office equipment required compared with point-to-point architectures. In conventional PON, downstream signals are broadcast to each ONU sharing a fiber. Upstream signals are combined using a multiple access protocol, invariably time division multiple access (TDMA). The optical line terminal (OLT) in the head-end office will "range" the ONUs in order to provide time slot assignments for upstream communication.

The first generation of Gigabit PONs (GPONs) has been standardized. They typically offer 1.244 to 2.488 Gbit/s, shared among 32 customers via passive optical splitters using a TDMA protocol. Whilst these PONs offer significant bandwidth increases compared to the copper-based approaches, they may not provide the best ultimate solution for network operators seeking to significantly reduce the cost of delivering future broadband services in order to sustain profit margins (Payne, D. B., & Davey, R. P., 2002). Hence research attention has recently turned to wavelength division multiplexed (WDM) PONs, or hybrid WDM-TDM PONs. (Talli, G., & Townsend, P. D., 2006)

WDM PON is a type of PON that uses multiple optical wavelengths to increase the bandwidth available to end users and to improve the utilization fiber bandwidth. WDM PON is capable to provide more bandwidth over longer distances by increasing the link loss budget of each wavelength, making it less sensitive to the optical losses incurred at each optical splitter when compared with conventional TDM-based PON. There is no standard for WDM PON now. By some definitions WDM PON uses a dedicated wavelength for each ONU. This means WDM PON can enable a

number of ONUs located at customer premises, each working at different wavelengths, to share the same optical amplifiers and backhaul fiber in the network. However, one great challenge in this WDM PON is the transmitter (Tx) at the ONU, located at the customer premise, which must have a wavelength that is precisely aligned with a specifically allocated WDM grid wavelength. A cost-effective solution would employ the same components in each ONU, which should thus be independent of the wavelength (colorless) assigned by the network. Optical carriers are distributed from the head-end office to different ONUs to produce the upstream signals. The advantages of this scheme are that the cost of wavelength referencing and control is shared among many users rather than being borne by individual users and no multi-wavelength source inventory is required for the end users. Besides, only a single optical laser source is necessary for all the ONUs in a TDM PON if hybrid WDM-TDM PON architecture is used (Talli, G., et al., 2002).

The organization of the chapter is as follows: in section II, various colorless ONUs for the WDM PON will be discussed. In section III, the Rayleigh backscattering (RB) components generated in the carrier distributed PON will be analyzed. Then, in section IV, several RB mitigation schemes will be presented. Some novel PON architectures will be highlighted in section V. Finally, a conclusion will be presented in section VI.

## **COLORLESS ONUS**

Various colorless ONUs have been proposed for the WDM PON. The simplest scheme is to use tunable laser at the Tx. The wavelength is tuned at the installation or for a reconfiguration. The wavelength tuning speed is not critical. However, tunable lasers are too expensive up to now for ONU, since its cost is not shared. A cost-effective tunable ONU based on "set-and-forget" architecture is currently under development within

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