DSP and APD-Enabled Feedforward Monitoring for Optical Distribution Network in High-Speed PONs

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Abstract: We present a DSP- and APD-based feedforward monitoring method for high-speed PONs, enabling real-time ODN monitoring, loss/reflection discrimination, segment-level fault localization, and efficient fiber management via simplified drop fiber identification.

1. Introduction

Next-generation services such as physical AI systems, XR, and autonomous driving are rapidly expanding, resulting in a substantial increase in network traffic. Meanwhile, TDM-PON data rates are evolving from 50G toward 100G and 200G. The notion of "No fiber, No AI" highlights the fundamental role of optical networks in supporting these services. Therefore, reliable and real-time monitoring of the optical distribution network (ODN) in TDM-PON systems is essential for stable operation, as also reflected in ITU-T VHSP standardization [1].

Traditional ODN monitoring relies on OTDR or received power measurements; however, these approaches either require additional hardware or are ineffective in detecting reflection-induced degradation. Recently, digital signal processing (DSP)-based monitoring approaches have attracted considerable attention [2–4].

Incorporating DSP into the ONU receiver is a feedforward monitoring approach that enables per-link monitoring of optical connections between the OLT and ONU. It is particularly effective for identifying faults in distributed fibers beyond the optical splitter at the remote node (RN). In our previous work, DSP-based electronic dispersion compensation (EDC) was used to extract signal quality metrics, such as eye height and SNR, from the electrical equalizer [3]. These metrics are combined with the APD monitoring current to assess ODN conditions. Experimental results show that optical loss reduces both eye height and APD current, whereas reflection primarily degrades eye height with negligible variation in APD current. These distinct responses enable clear discrimination between loss and reflection. Furthermore, by comparing measurements across multiple ONUs, fault locations can be identified in feeder, distribution, and drop fiber segments without additional hardware [4]. In addition, to identify deployed but unused drop fibers or those incorrectly connected to ONUs of other operators, a drop fiber identifier with simplified OLT MAC functionality was evaluated, as illustrated in Fig. 1. This approach supports ODN monitoring by enabling detection of drop fiber connectivity and improving fiber management efficiency.

In summary, DSP-enabled EDC combined with APD monitoring current provides an effective feedforward approach for real-time ODN monitoring and fault localization, while a simplified drop fiber identifier further enhances monitoring by detecting unused or misconnected fibers and improving management efficiency.

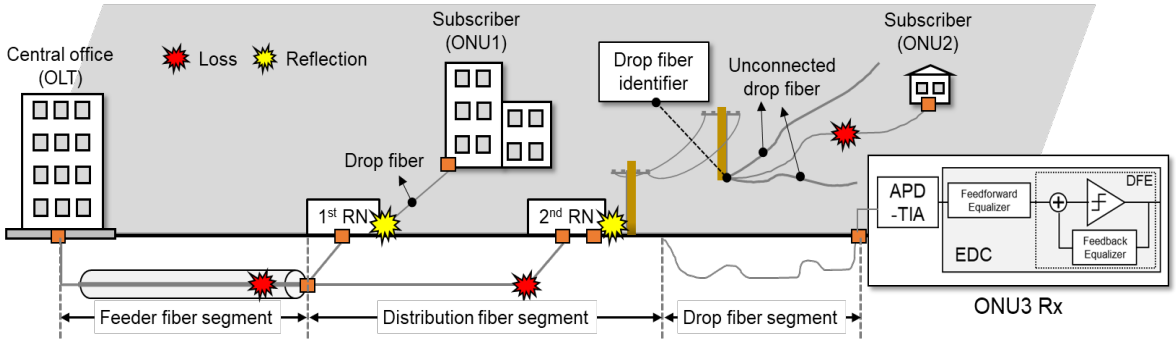

Fig. 1 Feedforward monitoring for ODN consisting of feeder, distribution, and drop fiber segments.

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2. References

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