FIELD TRIAL OF OPTICAL MAINTENANCE OF PONs USING A TUNABLE OTDR

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Abstract: Optical maintenance of PONs by a tunable OTDR is demonstrated by the reference reflector method and the wavelength routing method. Branched individual path can be analyzed by the measurement at the central office as active fiber monitoring. The prospective of the practical use has been offered by the field trial on ATM-PON.

Introduction

PONs (Passive Optical Networks) are cost effective architecture for the local loop, and the access network FSAN FTTx systems are based on this PONs /1/. But the optical maintenance is a very important issue in the case that the splitter is located in the field outside the CO (Central Office), several approaches have been proposed and tried /2/. We took note of the wavelength tuning technologies related to the today's D-WDM (Dense-Wavelength Division Multiplex) and demonstrated the practical and cost-effective method using tunable OTDR (Optical Time Domain Reflectometer).

Experimental setup

The experimental setup is designed for ATM-PON of 1 fiber WDM, the transmission signal wavelength of which is 1.55μm for the downstream and 1.31μm for the upstream and the maximum branch number is 8 as the standard of the practical application. Although consensus to use the 1600-1650nm region for the optical maintenance is growing /2/, we chose 8 wavelengths (λ1-λ8) in the 1586-1610nm region spacing of 400GHz (≈3.4nm) and used L-EDFA (L-band Erbium Doped Fiber Amplifier) for the tunable OTDR. A commercial OTDR is modified to become a tunable OTDR as Fig. 1. AO switches make optical pulses synchronized to the LD emission timing signal of the OTDR, and the optical tunable filter cuts the ASE (Amplified Spontaneous Emission) of L-EDFA. The peak power at the output port is +26dBm.

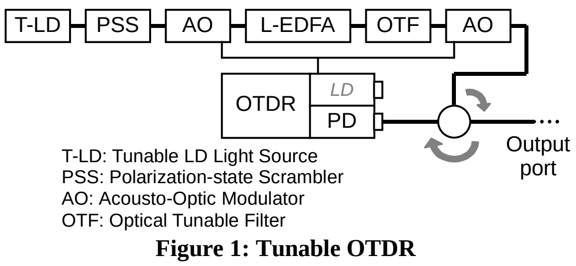

Figure 1: Tunable OTDR

The linewidth of the tunable LD is only 500MHz (≈4.3pm) and the high coherency of such a light generates the fluctuation noise on the OTDR trace. To reduce this noise the tunable LD sweeps the wavelength in the range of 1.5nm during the averaging time of the OTDR. For practical application we can use FBG-ECL (Fiber Bragg Grating - External Cavity Laser). A widely wavelength tunable FBG-ECL employing a fiber transfer type optical switch /3/ is able to tune the linewidth and its coherency for the tunable OTDR.

The system configuration of the field trail is shown in Fig. 2. The optical cables are of Osaka Media Port Corporation and laid in Osaka City. The 1x8 splitter is set in the closure hung on the aerial cable. The SWPFs (Short Wavelength Pass Filters) are installed on this side of the OLT (Optical Line Terminal) and ONUs (Optical Network Units) to stop the maintenance wavelength. This SWPF is a dielectric multilayered interference filter. It passes both wavelengths of 1.31μm and 1.55μm and cuts above 1.584μm. The SWPF of this side of the OLT is assembled as the WDM module for the access of the tunable OTDR. By use of these SWPFs any alarm was not given by the OLT or the ONUs during the OTDR measurement at the wavelength of 1586-1610nm, and active fiber monitoring is successful.

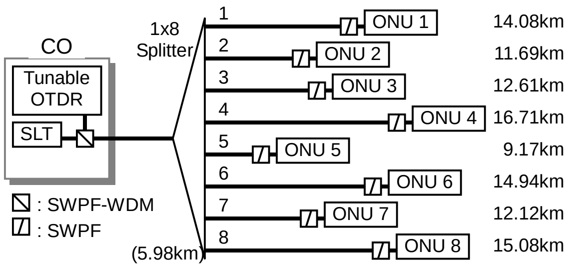

Figure 2: The System Configuration of the Field Trial

Reference reflector method

The selective reflectors of FBG tuned on λ1-λ8 (one wavelength for each branch) are implemented on this side of the SWPF at the far end of each branch as shown in Fig.3. The tunable OTDR is set at the assigned wavelength and the presence of the reflection by this reference reflector in the OTDR trace points out the integrity of the path.

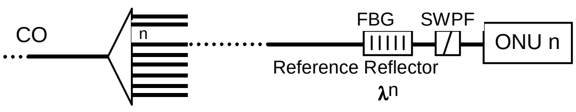

Figure 3: Termination of Reference Reflector Method

Fig. 4a is the trace at the wavelength of 1613nm (not assigned to any branch) and Fig.4b is that of λ2. The

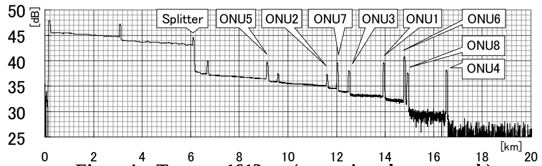

Figure4a: Trace at 1613nm (not assigned to any path)

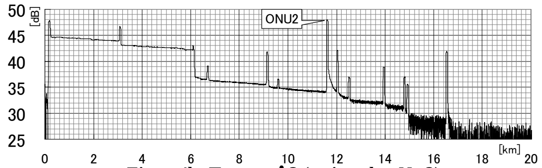

Figure4b: Trace at λ2 (assigned to No.2)

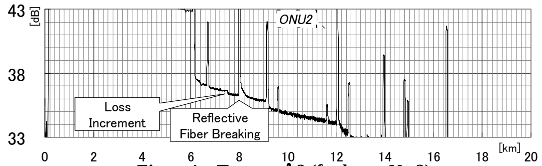

Figure4c: Trace at λ2 (faults on No.2)

reflection at 11.6km is higher than that of Fig.4a. Since this method can detect the far end of each branch by selecting the wavelength there is no need to provide a distance trimming of each branch /4/.

Fig.4c is the trace of λ2 in the case that the loss increment of 3dB at 7.5km and the reflective fiber breaking at 8.0km occur on branch No.2. The disappearance of the high reflection at 11.6km indicates that the light cannot reach by the far end of branch No.2. The attenuation at 7.5km and the reflection at 8.0km, which newly appear point out that something unusual happen at these location, but we can not identify which of branch these events occur on.

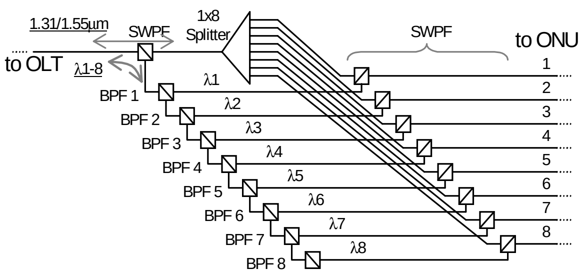

Figure 5: Wavelength Router and Splitter

Wavelength routing method

To detect a slight fault such as loss increment of less than 1dB, the wavelength routing method is effective. AWG (Arrayed Waveguide Grating) is often used as the router and the way to compensate the optical characteristic change caused by the temperature variation is proposed in /5/ and /6/. To realize the outdoor use of the router with the splitter and moreover to simplify the system configuration, we use BPFs (Band Pass Filters) of λ1-λ8 and SWPF using dielectric multilayered interference filter and set beside the splitter as shown in Fig.5. The temperature shift of the spectral characteristic of these filters is less than 3pm/°C and the OTDR traces were almost independent of the temperature in the field trial. In addition, since the maintenance signal light does not run through the splitter, the OTDR measurement is independent of the coupling loss of the splitter at the maintenance wavelength.

Setting this router with the 1x8 splitter in the closure, the individual trace of each branch can be obtained by the tunable OTDR measurement at the wavelength assigned to each branch as shown in Fig.6a-h. (These graphs show only the branched path.) Fig.6i is the trace of λ2 in the case that the same events as Fig.4c occur on branch No.2. By this method it can be point out that these events occur on branch No.2. In addition, compared with Fig.4c, the attenuation level at 7.5km can be obtained directly by the OTDR trace. This method is available as the preventive maintenance for the path that requires high reliability.

Conclusion

We carried out the field trial of the optical maintenance of ATM-PONs using a tunable OTDR, demonstrated the effectiveness of both the reference reflector method and the wavelength routing method. We confirmed that the both methods are ready in practical use. Since the former does not need to add any additional function on the splitter, it can be applied to the existing PONs easily. The latter meets the maintenance required higher reliability.

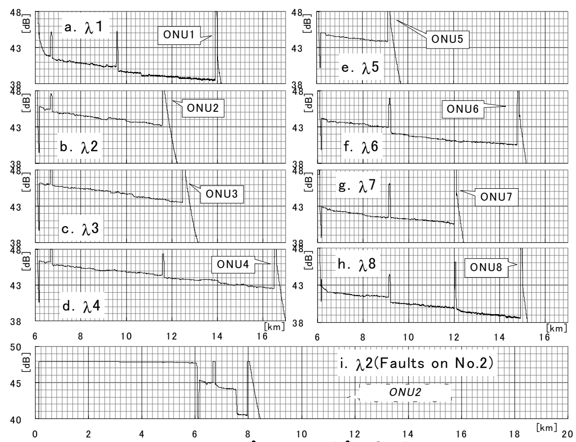

Figure 6: Trace at λ1 -8, and λ2(faults on No.2)

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