Network Management in Optical Communication

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Abstract
The objective of this research is to study the application of wireless systems in distributed real-time monitoring for fibre fault identification in optical communication networks. In this paper, focus on the realization of the real embedded system on the internet, which stand to benefit most from the use of web services technology. In the online mode, this web page service monitoring can be used to support optimum network operation and engineering under dynamically changing traffic and physical network condition. Topics covered by the project and briefly related here include network architecture, design, and applications issues.

Keywords: management, optical fibre, wireless, fibre fault, real time monitoring, remote control, web page

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INTRODUCTION
The rapid growth of data traffic, primarily internet traffic, in the past several years is driving the demand for high-speed communication network. Optical network based on passive optical network (PON) have been established as the most promising solution for satisfying the ever increasing capacity requirement in telecommunication network [1].

The reliability of such network is critical for failure can cause tremendous data loss. Optical performance monitoring is much more difficult since it must be performed in the optical domain [2]. Online monitoring is one crucial function and prerequisite for protection and restoration schemes. All-optical components are not by design abilities to comprehend signal modulation and coding; therefore, intermediate switching nodes are unable regenerating data for all channels, making segment-by-segment testing of communication links more challenging. As a direct consequence, failure detection and localization using the existing integrity test method are made difficult. Online monitoring mechanisms are highly dependent on alarm signal received from optical monitoring equipment. Optical monitoring devices that are currently available include optical power meters, optical spectrum analyzers, optical time domain reflectometer (OTDR), and others [3,4,5].

Due to the high cost of such equipment, it is not realistic to assume all nodes are equipped with full monitoring capabilities. Thus, obtaining monitoring information from nodes with high monitoring capabilities efficiently is critical for successful failure management. In this study, an optical switch can be used to monitoring [6], optical switch is an important component in any optical communication system. These systems use switches to establish communication channels among two or more of their interfaces. Fibre optic switches have been developed for selectively switching optical signals from one fibre to another fibre. An optical switch is capable of optically connecting, or aligning, any one of a first group of optical fibres with any one of a second group of optical fibres, or vice versa, enabling an optical signal to propagate through the optical interface junction from one fibre to the other. Switching for these fibres has previously been achieved with optoelectronic devices. Optical fibres are coupled with circuitry that permits the switching to be done electrically, and then the electrical signals are converted back to optical signals for further transmission. Optical switching technology's main advantage is to route optical data signals
without conversion to electrical signals, resulting in the independence of data rate and data protocol. In general, a pure optical switch routes beams of light with encoded data from one or more input optical fibres to a choice of two or more output optical fibres [7,8, 9].

To remote monitor and control any optical switch, we are using a microcontroller. Among all the PIC microcontroller families, especially the PIC18F46J50 MCU of devices feature rapidly prototype low-power wireless applications. It was MiWi stack support, making wireless communication possible. By adding wireless connectivity to an embedded system, microcontrollers can distribute data over a network and can be controlled remotely [10], which is one of the important factors in such a system was chosen due to its variety of hardware modules needed for online monitoring technology.

**EXPERIMENTAL SETUP**

In this paper, a network management in optical communication based on monitoring service via a website a proposed and demonstrated. Generally, it is integrated in a single system, which also includes optical switch, optical splitter, OTDR, and personal computer (PC). Monitoring service controls the status of any optical switch device connected to it and transmits its status to the microcontroller. It’s then arranges the information in the form of a packet and transmits it over the wireless system, the optical communication system such as fibre to the home (FTTH) is collaterally together with the wireless network as illustrated in Figure 1. The FTTH-PON used fibre to carry the information signal, meanwhile the wireless system to carry control signal. The wireless used as the access control network to activate the installed devices/elements in the network system. Besides, if the optical network is going down, the wireless system will be used for high priority signal communications.

To locate a failure without affecting the transmission services to other customers, it is essential to use a wavelength different from the triple-play services operating wavelengths (optical signals; 1310 nm, 1490 nm, and 1550 nm) for failure detection. Monitoring service integrated wireless system is using the 1625 nm testing signal for failure detection control and in-service troubleshooting. The triple-play signals are multiplexed with 1625 nm testing signal from OTDR. The OTDR is installed in the OLT and will be connected to a PC to display the troubleshooting result. The principal limitation to live fibre monitoring at 1625 nm, will come from the spontaneous Raman scattering noise that reaches the OTDR port. In case of bidirectional transmission, OTDR power and transmission power levels may require adjustments so that effect remains negligible. Tapping 3% of the downstream and upstream signal by using coupler can recognize the status of feeder section and drop section. If the breakdown occurs in feeder section, the monitoring service will send a signal to activate the dedicated protection scheme. But if the breakdown is then detected in drop section, the monitoring service will recognize the related access line the 3% tapped signal that is connected to every access line. The activation signal is then sent to active the dedicated protection scheme. But if the fault is still not restored, the shared protection scheme will be activated. The monitoring signal section is responsible for sensing fault and its location, whereas the generation of activation signal is sent from the activation section in monitoring service [11].

When four kinds of signals are distributed, the testing signal will be split up by the wavelength selective coupler (WSC) which is installed before the optical splitter. The WSC coupler only allow the testing signal at 1625 nm to enter into the taper circuit and reject all unwanted signals (1310 nm, 1490 nm, and 1550 nm) that contaminate the OTDR measurement. The downstream signal will go through the WSC coupler which in turn connected to splitter before it reaches the ONU. The distance between the OLT and ONUs is about 20 km. On the other hand, the 1625 nm testing signal which is de-multiplexed by WSC coupler will be split up again in power ratio 99:1 by using directional coupler (DC) to activate the monitoring service. The 99% 1625 nm signal will then be configured by using optical splitter which each output is connected to single line of ONU. The operational of optical switch is controlled by monitoring service system that is activated by 1% of 1625 nm signal [12].

In order to enable wavelength splitting (de-multiplexing) and combining (multiplexing) in the taper circuit, WSC coupler is designed for the optical signals having different light
wavelengths can be separated or combined to transmit in single optical fibre as shown in Figure 2 [12]. The WSC coupler is designed on silica substrate with compliance of FTTH-PON wavelengths. The designed WSC coupler is used as a router for specific wavelength in order to detect any optical line failure in FTTH-PON application. The triple-play signals enter the waveguide in port 1 and OTDR testing signal (1625 nm) enters the waveguide at port 3. The 1625 nm testing signal generated by the OTDR will be used to scan the status of FTTH-PON. All the wavelengths must flow out through port 2. In reverse mode, the device is applicable to split the 1625 nm testing signal from triple-play signals [13].

**Fig. 1:** Proposed Architecture for Failure Management

**Fig. 2.** Structure of the WSC

RESULT AND DISCUSSION

The online monitoring in optical communication deals with the countermeasures taken to compensate for vulnerabilities in the network and failures that can occur. Failures can be due to component faults and deliberate attacks on the proper functioning of the network. The countermeasures taken by failure management to ensure secure network operation include prevention, detection, and reaction mechanisms. Prevention schemes can be realized through hardware (e.g., strengthening and/or alarming the fibre), transmission schemes (e.g., coding schemes), or network architecture. Detection mechanisms are responsible for identifying and diagnosing failures, locating the source, and generating the appropriate alarms or notification
messages to ensure successful reaction. Various alarms generated by monitoring equipment, changes in performance trends, and customer call-ins all help to detect failures.

In an optical communication network, the impact of failures also propagates through the network and therefore cannot be easily localized and isolated. The huge amount of information transported in optical networks makes rapid fault localization and isolation a crucial requirement for providing guaranteed QoS and bounded unavailability times. The placement of monitoring equipment to reduce the number of redundant alarms and lower the CAPEX, and the design of fast localization algorithms are among challenges of fault localization in optical communication networks.

In Figure 3, web page monitoring service used to centralize control and monitoring system that enhances the network service providers with a means of viewing traffic flow and detecting any breakdown. Online monitoring is done via simple webpage interface. The standard HTML code is used to populate the majority of the web page text and graphics. The functionalities of web page, which can help network services providers and field engineers in the optical communication network to perform the following activities:

- Monitors and remote control the network performance.
- Detects degradations before a fibre fault occurs for preventive maintenance.
- Detects any fibre fault that occurs in the network system and troubleshoots it for post-fault maintenance.
- Provides the network service providers with a control function to intercom all subscribers with CO.

![Web Page Monitoring Service](image)

Fig. 3: Web-page monitoring service

After that, the measurement results for each line are saved in the OTDR and then transferred into PC. Later completing the transferring process, all the results are being recorded in database and then loaded into the developed program for further analysis. Web service monitoring is potentially to improve the survivability and increase the monitoring capabilities in FTTH-PON as well as overcoming the upwardly or downwardly monitoring issues with conventional fibre fault localization technique by using OTDR. Overall, it can reduce the time needed to restore the fibre fault to maintain and operate the FTTH more efficiently.

Monitoring service is focusing on providing survivability through event identification against losses and failures. It is involving the fibre fault detection, notification, verification, and restoration functions. Under working condition, it allows the network services providers to determine the path used by the services through the network, whereas under non-working conditions, it allows the fields engineers to identify the faulty fibre and failure location without making a site visit. The system enables the network service providers and field engineers to
analyze the optical fibre line’s status, display the line’s detail, track the optical signal level, and losses as well as monitor the network performance. In combination of the distinctive features, failure management provides a convenient way to solve the particular upwardly or downwardly measuring issues with OTDR and produce capability of fibre fault localization in an optical access network.

Figure 4 shows the ability of service provider to specify a faulty fibre and failure location among a number of optical fibre lines in an optical access network by measuring the optical signal level and losses. Every eight network testing results will be displayed in Line’s Status window for centralized monitoring, where the distance (km) represented on the x-axis and optical signal level (dB) represented on the y-axis. A failure message “Line x FAILURE at z km from CO!” will be displayed to inform the field engineers if monitoring service detect any fibre fault in the network system. To obtain further details on the performance of specific line in the network, every measurement results obtained from the network testing are analyzed in the Line’s Detail window. It is able to identify and present the parameters of each optical fibre line such as the line’s status, magnitude of decreasing at each point, failure location and other details as shown in the OTDR’s screen. In Figure 4, an example of failure line in the Line’s Detail window. The line 8 is failure at 15.1918 km when the fibre is unplugged at distance 15 km to represent the break point in a testing line. It represented the break point occurs at that distance in optical access network system in a real condition. The line 8 is failure at 30.4601 km when the fibre is unplugged at distance 30 km.

CONCLUSION
Monitoring service could significantly speed up monitoring information exchange and potentially improve reliability. As a result of the increasing complexity of optical communication networks and the tremendous amount of information they carry, efficient failure management is crucial. While online monitoring offers many advantages, it also imposes various maintenance cost in optical network. Self-protection concepts could possibly be applied to develop a highly scalable and robust failure management scheme. In this article we propose using these models to develop a more efficient fibre fault identification to deal with failure management in optical communication networks.

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