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OPTICAL TIME-DOMAIN REFLECTOMETER SCHEDULING IN OPTICS

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ABSTRACT
With increase in usage of optical fiber for digital data communication which is replacing copper cables. Optical fiber cuts or bends identification with emerging technology is also important, as we cannot dig and check by binary search to check where actual fiber cut has happened. Optical time domain reflectometer(OTDR) is one among this technology to check fiber cuts which uses scattered light to check cuts or bends. This paper explains how OTDR checks fiber cuts and how OTDR scans can be scheduled along with proposed architecture.

KEYWORD: Optical time-domain Reflectometer, Scheduling, Architecture.

INTRODUCTION
An optical time-domain reflectometer (OTDR) is an optoelectronic instrument used to characterize an optical fiber. An OTDR is the optical equivalent of an electronic time domain reflectometer. It injects a series of optical pulses into the fiber under test and extracts, from the same end of the fiber, light that is scattered (Rayleigh backscatter) or reflected back from points along the fiber. The scattered or reflected light that is gathered back is used to characterize the optical fiber. This is equivalent to the way that an electronic time-domain reflectometer measures reflections caused by changes in the impedance of the cable under test. The strength of the return pulses is measured and integrated as a function of time, and plotted as a function of fiber length.

Figure 1: OTDR

WORKING
Unlike sources and power meters which measure the loss of the fiber optic cable plant directly, the OTDR works indirectly. The source and meter duplicate the transmitter and receiver of the fiber optic transmission link, so the measurement correlates well with actual system loss. The OTDR, however, uses backscattered light of the fiber to imply loss. The OTDR works like RADAR, sending a high power laser light pulse down the fiber and looking for return signals from backscattered light in the fiber itself or reflected light from connector or splice interfaces. At any point in time, the light the OTDR sees is the light scattered from the pulse passing through a region of the fiber. Only a small amount of light is scattered back toward the OTDR, but with sensitive receivers and signal averaging, it is possible to make measurements over relatively long distances. Since it is possible to calibrate the speed of the pulse as it passes down the fiber, the OTDR can measure time, calculate the pulse position in the fiber and correlate

what it sees in backscattered light with an actual location in the fiber. Thus it can create a display of the amount of backscattered light at any point in the fiber.

Since the pulse is attenuated in the fiber as it passes along the fiber and suffers loss in connectors and splices, the amount of power in the test pulse decreases as it passes along the fiber in the cable plant under test. Thus the portion of the light being backscattered will be reduced accordingly, producing a picture of the actual loss occurring in the fiber. Some calculations are necessary to convert this information into a display, since the process occurs twice, once going out from the OTDR and once on the return path from the scattering at the test pulse.

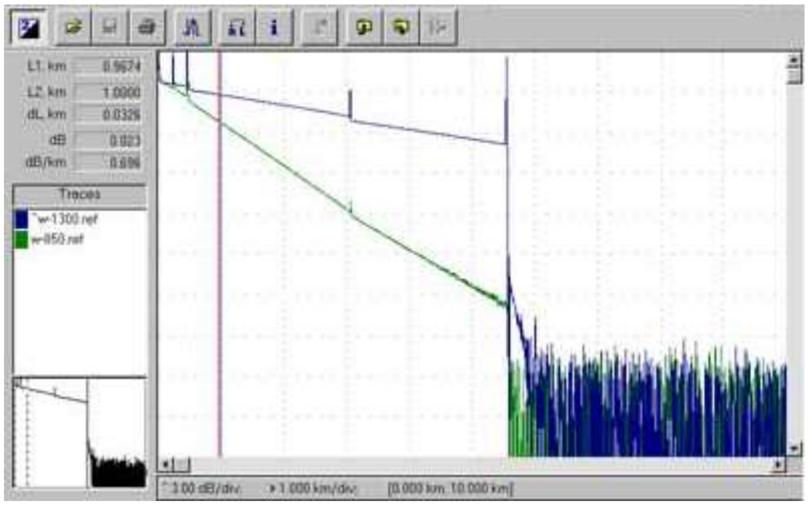

Figure 2: OTDR Graph

There is a lot of information in an OTDR display. The slope of the fiber trace shows the attenuation coefficient of the fiber and is calibrated in dB/km by the OTDR. In order to measure fiber attenuation, you need a fairly long length of fiber with no distortions on either end from the OTDR resolution or overloading due to large reflections. If the fiber looks nonlinear at either end, especially near a reflective event like a connector, avoid that section when measuring loss.

Connectors and splices are called "events" in OTDR jargon. Both should show a loss, but connectors and mechanical splices will also show a reflective peak so you can distinguish them from fusion splices. Also, the height of that peak will indicate the amount of reflection at the event, unless it is so large that it saturates the OTDR receiver. Then peak will have a flat top and tail on the far end, indicating the receiver was overloaded. The width of the peak shows the distance resolution of the OTDR, or how close it can detect events.

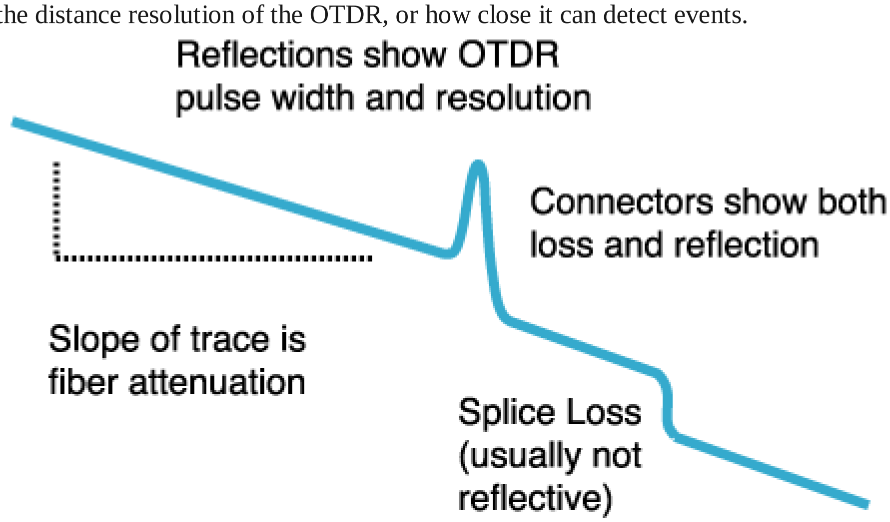

Figure 3: OTDR Graph Explanation

OTDRs can also detect problems in the cable caused during installation. If a fiber is broken, it will show up as the end of the fiber much shorter than the cable or a high loss splice at the wrong place. If excessive stress is placed on the cable due to kinking or too tight a bend radius, it will look like a splice at the wrong location.

PROPOSED ARCHITECTURE

OTDR card have 8 ports (P1 to P8) which will be mapped to amplifier of physical connections (OPS/OTS) consisting of LINEIN, OTDRRX, OTDRTX, LINEOUT, OSCSFP & OSC. Each connection will mapped to OTDRRX & OTDRTX, where OTDRTX will transmit test pulses into the optical fiber while OTDRRX will receive test pulses from other end.

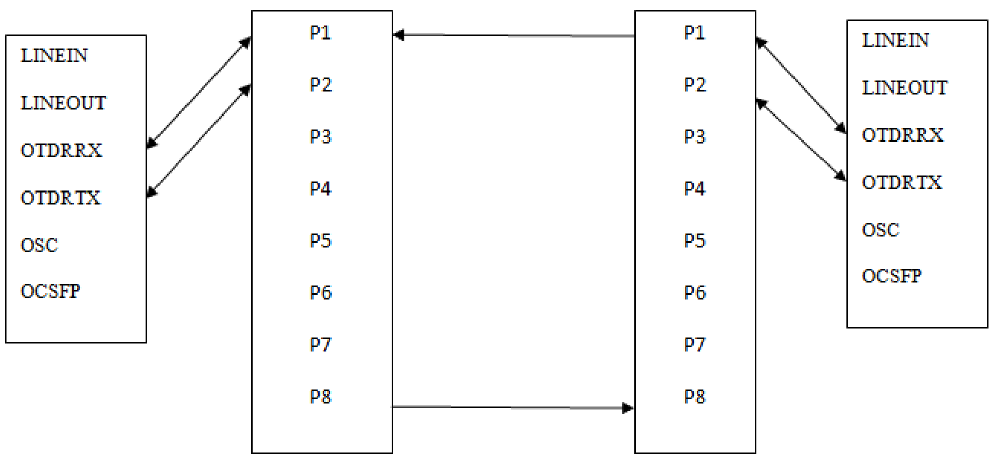

Figure 4: OTDR Pack Block Diagram

With OTDR pack having 8 ports, OTDR scan can be scheduled for four physical connections. OTDR scanning can be done for one connection at a time. So by using eight ports four connections can be scheduled for OTDR scan but scan can be done for one connection at one time. To avoid this conflict we need to write algorithm to alert scheduler that scheduling conflicts are found. Some of conflicts resolving algorithms are Min-Conflicts Algorithm and Genetic Algorithm. I used genetic algorithm to resolve scheduling conflicts.

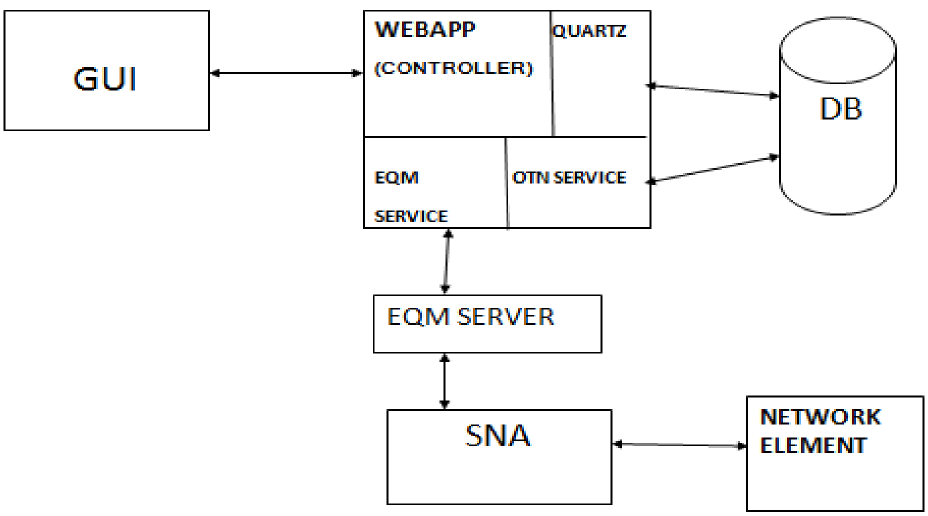

Figure 5: Architecture of Proposed OTDR scheduling

Figure 5 shows proposed architecture of OTDR scheduling. For GUI design I used javascript, webapp controller uses Spring Framework, Quartz used to trigger OTDR scan for scheduled time. Controller also has conflicts resolving algorithms. EQM service and sever will provide details about physical connections for which scheduling is done. Smart Network Adaptor (SNA) uses TL1 and SNMP protocol to update Network Element about scan scheduling.

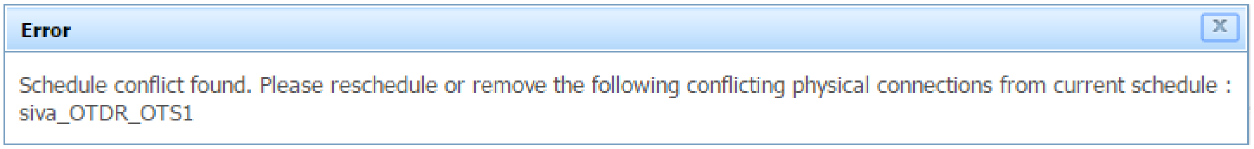

Figure 6: Error Message showing Conflict Message

Figure 6 shows conflict found message for OTDR scan for "siva_OTDR_OTS1" physical connection to which OTDR scan is already exist at same time for some other connection. Fig shows GUI of OTDR scan where scan can scheduled Once, Hourly, Daily, Weekly and Quarterly based on user interest. Start time has 10 minutes gap has for it needs minimum ten minutes to complete one scan, so that it cannot overlap with other scans.

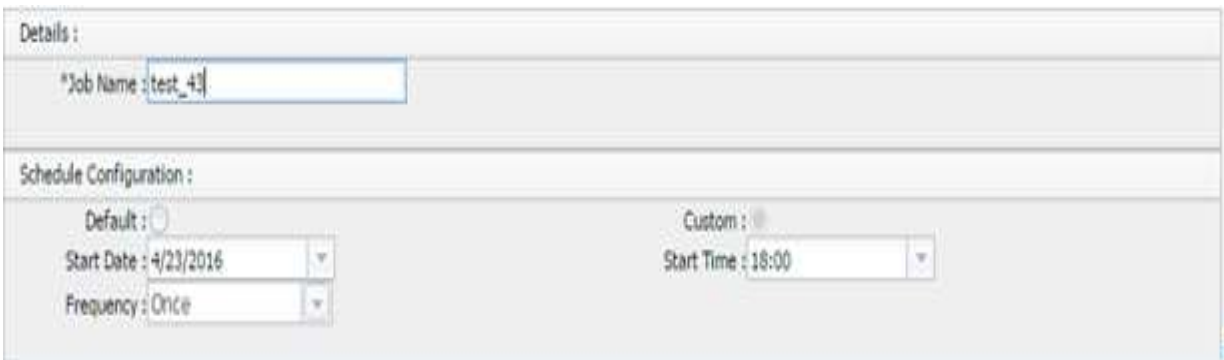

Figure 7.1: GUI to schedule OTDR scan

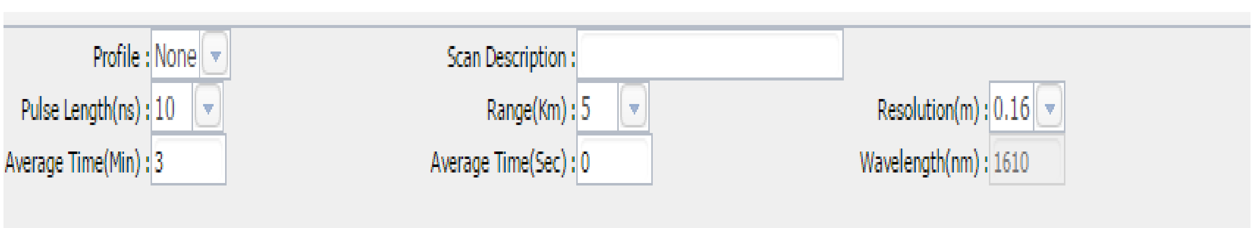

Figure 7.2: GUI to schedule OTDR scan

Figure 7.1 & 7.2 shows front end of OTDR scan, where user asked to provide data required for OTDR scan. Data required are

- Frequency which can be Once, Daily, Weekly, Monthly and Quarterly.
- Start Time, Start Date and End Date.
- Range (in Km) will provide user to check in which region actual cuts or bench which causing loss of data. Example: In 100Km fiber communication, if data is not reaching destination. Then operator will start OTDR scan with 5Km Range and increasing by 5Km to check where exactly fiber cuts or damage happened.

APPLICATION OF WORK

Present telecom market supporting up to 400GbE data over optical fiber for communication of data. Telecom operators need to check cuts and bends in fiber with latest technology without digging to check at every Km. This OTDR scheduling allows telecom operators to check cuts and bends in optical fiber hourly or daily or weekly or monthly based on the requirement, this scheduling can be done using this. Telecom Operators whoever switched from copper cables to optical fibers can use this for Optical Loss detection.

RESULTS

Figure 8 shows three types of jobs based on scheduled status are Scheduled, Failure and Success. After OTDR scan scheduled without conflicts, Job will be listed in Job List with job name, scheduled time, end time and its status. If scheduled job is success, then job flow will be shown on double click on job. If scheduled job is Failure, then job flow showing where it's failing and reason will be shown on double click on job.

Name	Job Type	User Name	Latest Run Status	Creation Time (UTC+5:30)	Last Updated Time (UTC+	Schedule (UTC+5:30)	Next Run (UTC+5:30)	Job State
test_93	OTDR Scan - Schedule	otdr	Scheduled	2016-04-22 16:59:06	2016-04-22 16:59:06	2016-04-23 06:00:00	--	Scheduled
test_32	OTDR Scan - Schedule	otdr	Scheduled	2016-04-22 16:58:29	2016-04-22 16:58:29	2016-04-22 18:00:00	--	Scheduled
ForSwagger	OTDR Scan - Schedule	otdr	Complete - Failure	2016-04-15 12:45:38	2016-04-21 20:10:01	2016-04-22 20:10:00	--	Scheduled

Figure 8: GUI showing Job list of OTDR scan

CONCLUSION

In this Paper I explained what OTDR is about and architecture for OTDR scheduling. Why scheduling is needed, how this help telecom operators which are switching from copper cables to optical cables without digging to check where optical fiber cuts or damage happened. Testing fiber optic cable plants are easy if you have the right instruments and follow industry testing standards. When diagnosing problems, you must be creative to develop techniques that help reveal problems that show up on standard tests. It is most important to know your tools operation and limitations, and how to work around them. Get to know the applications support staff at your instrument vendor so you can call with questions. Finally, it is most helpful to have good cable plant documentation, since knowing what you are looking at will make it much easier to find problems.

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