# REAL-TIME WET PLANT HEALTH MONITORING AND AUTOMATION

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**Abstract:** Coherent technology, powered by advanced Digital Signal Processing (DSP) provides access to a rich set of detailed information about not only the performance of optical channels, but other key parameters that can provide indication of the state of the infrastructure over which the channels operate. Active supervisory systems and C-OTDR based passive monitoring systems also provide varying levels of information about the operating state of the wet plant. These datasets, when regularly collected and analyzed, particularly in an automated, software controllable fashion, can provide cable owners with performance insights into their assets that were previously not accessible on a large scale.
In this paper, we discuss how network operations can be simplified via automating the collection and analysis of the datasets via interfaces such as REST based APIs and how using SDN functionally can provide real-time insight into the health of a submarine wet plant through long term collection of such information to analyze performance trends and potentially enabling the forecast of future maintenance requirements.
It can also assist in estimating the remaining system life and the technical viability of a system beyond its design life, by analyzing the datasets in order to determine the submersible plant reliability to date and its ageing trend.

## 1. INTRODUCTION

Traditional 10G submarine installations provided data for the end user from the transponders (Q, SONET/SDN PMs), Power Feed Equipment (PFE) (voltage and current), LME (Coherent Optical Time-Domain Reflectometer (COTDR)scan) and, if available, repeater supervisory (input power, output power, pump current). Providing an automated method to monitor and react to changes in systems has been investigated for turnkey applications where all equipment is supplied by one vendor [1].
The latest generation of Submarine Line Terminal Equipment (SLTE) includes measurement points not previously available to monitor the performance of the cable system. With the introduction of coherent technology additional parameters, such as polarization mode dispersion (PMD), polarization dependant loss (PDL), chromatic dispersion (CD) and polarization state, are available from the transponders. Reconfigurable Optical Add Drop Multiplexer (ROADM) based SLTEs have added integrated Optical Spectrum Analyser (OSA) functionality. Passive line monitoring solutions such as COTDR functionality within the SLTE is able to monitor the health of the fiber itself. The additional parameters provide information about the state of the line system through normal operations that previously required specialized test equipment to measure.
The emergence of third party network upgrade suppliers has resulted in this rich

dataset available for a particular line system being reported in an increasing number of disparate monitoring systems. This in turn increases the complexity of providing a method to use the collected data to automate the monitoring and react to changes in the system.

A scalable 'open' (vendor agnostic) platform is required to handle demands for the processing and storing of these expanding data sets. This platform should allow the cable owner to have secured, tiered access to a consolidated global view of this increasingly complex data set. Once the data set is available as a global view it becomes possible to utilize algorithms to process the data for a real time assessment of operational state, historical correlations to current state and predictions on future performance of the network.

## 2. DATA INTEGRATION

To be able to perform real time analysis timely access to the sources of data must be available to a single processing interface. When this data comes from multiple monitoring systems from different equipment vendors a method of collecting and integrating the data becomes necessary. Network operators have had to become system integrators to be able to add these additional systems with diverse data exchange formats to the control and operations process of the Network Operations Centre (NOC). This can result in substantial effort in integrating new vendors into the NOC management tools.

The use of Representational State Transfer Application Programing Interfaces (REST APIs) has allowed for the simplification of the data exchange. Devices that implement RESTful interfaces allow the integration of new devices to be simplified. Combining the concept of RESTful APIs with Software Defined Network (SDN) configurations allows for easier integration of new vendors into the NOC management tools for use in the network. The use of RESTful interfaces provide the ability for the equipment vendors or cable system operators to create and deploy system specific applications ('apps') that provide benefits to the cable system operators in terms of operational efficiency via a single management system for all equipment within their network.

## 3. DATA USE

The use of an SDN infrastructure in submarine networks provides the platform to develop apps that perform analytics analysis on the data sources available from the REST interfaces.

For example we will begin by considering a simple case where the SDN platform is used by the cable owner to monitor bit error performance, reported in terms of Q, for a number of transponders (regardless of vendor) deployed on the same fiber pair of a submarine cable. In our example a fault occurs that results in all transponders on the link reporting degraded performance (i.e. lower Q). The SDN platform provides the infrastructure for an app to be developed and deployed that can be used by the NOC personnel to contextualize the data reported by the transponders. The app interface would provide a method for the NOC personnel to understand easily the faults being reported in our example are common to all transponders on the link. With that data the NOC personnel could begin to localize the fault and investigate possible causes.

Providing multiple data sources to the SDN infrastructure and enabling algorithmic analysis creates a more powerful solution. Using the same example of a fiber pair with all transponders reporting a degradation in Q more efficiencies can be experienced with the NOC operations when the SDN platform has access to additional data beyond the transponder Q. In our example the SDN controller can access, via the REST APIs, the fault information for all equipment that is part of this link (e.g. SLTE, PFE, COTDR). An app running in the SDN environment would have the ability to correlate the performance degradations and can make the decision, based on analysis algorithms, that the fault may be related to a common element. The SDN controller can then trigger the collection of supervisory data and compare to a previous baseline to find a common fault that would impact all technologies on the system. In our example we will assume the supervisory comes back reporting a decrease in input power to a repeater. The SDN platform can now provide the NOC personnel, in real-time, not only with the data that the performance degradation is common to all transponders, but an indication that it is related to a change in the status of the wet plant. With this knowledge the NOC can move directly to developing a plan to mitigate the impact of the fault instead of having to manually perform the collection and correlation of the data to identify the cause and location.

## 4. PERFORMANCE PREDICTION

In addition to correlation of active changes in the reported data an app running in a SDN environment can provide the ability to predict future system impacts. The advent of web scale technologies and the increasing number for devices connected to the internet, known as the Internet of Things (IoT) has led to advances in the way large sets of data (‘Big Data’ [2]) are analyzed to uncover correlations and trends in the data collected by the wide variety of sensors available in the devices that make up the IoT. The use of Big Data analytic techniques combined with the ever expanding data set provided by coherent modems in next generation SLTEs can lead to emergence of correlations that to this point have not been identified due to the lack of measurements. The resulting data can also assist in predicting future performance trends or be used to anticipate any premature wear-out failure mechanism [3].

If we once again look at our example failure scenario, if the Q data of all transponders on a system is correlated with changes in repeater input power reported by the supervisory system the resulting data can provide insights into the impacts of system repair and aging on channel performance.

These results of the performance trend predictions can then be compared against the Power Budget Table (PBT) prepared for the line system to validate the expected system performance and determine if the Q versus OSNR performance impact used by modem vendors to derive aging penalties is accurate.

Further analysis of the system performance trends over the life of the cable can then be performed to predict the rate of faults and the impacts of those faults in terms of PBT margin. As the cable ages the rate of performance margin degradation is expected to increase as components begin to age or fail at an increased rate and the number of cable faults and repairs approaches the number assumed during the creation of the PBT. The correlation and analysis of this data by the SDN controller allows the predicted rate to be compared easily with the measured rate to provide a prediction of system lifetime. This predication data can be used to provide guidance on operational and maintenance decisions, such as determining a cut-off date for cable operation or if the addition of repair repeaters can extend the cable life.

## 5. OPERATIONAL BENEFITS

The use of an SDN infrastructure in cable networks with a growing number of vendors provides the cable owner the ability to manage the resources without spending time and effort becoming a network integrator.
The ability of the SDN platform to support apps which monitor and review the data from the disparate monitoring systems within the network allows the NOC to more efficiently manage the network via a better correlation of data which removes the burden of manually organizing and comparing the data. This further enhances the NOC operations by allowing them to focus efforts directly on recovery activities in the case of faults instead of identifying the list of systems affected and determining how they may be correlated.

## 6. CONCLUSION

The use of an SDN environment provides the ability to perform advanced analysis of network performance using a variety of data input sources. To ease the introduction to SDN functionality the data sources needs to be available to the SDN controller. The concept of an 'open' submarine cable does not only apply to the ability to connect new terminal vendors to the cable but also the ability to extract data from the management systems used on the cable via open interfaces such as REST APIs to ease the integration process of cable owners and extract the most useful data from all the equipment on the cable.
The availability of the 'open' data empowers the owner of the cable to understand how the cable asset is performing and begin to make predictions and judgements on the effective lifetime remaining in the asset that will drive future decisions on investment.

## 7. REFERENCES

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