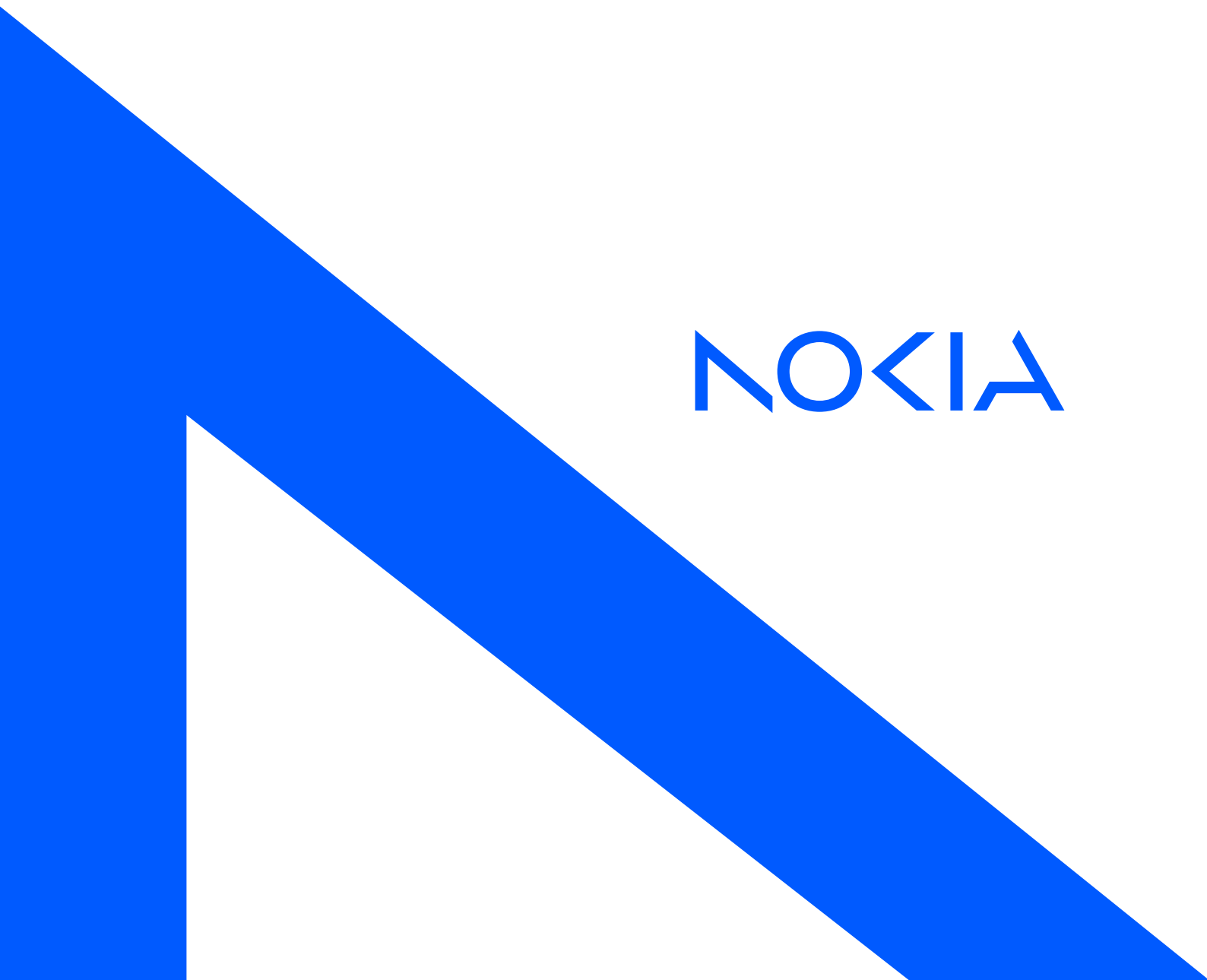
Intelligent Power Manager

Optical Power Management for Submarine Networks

Application note



Abstract

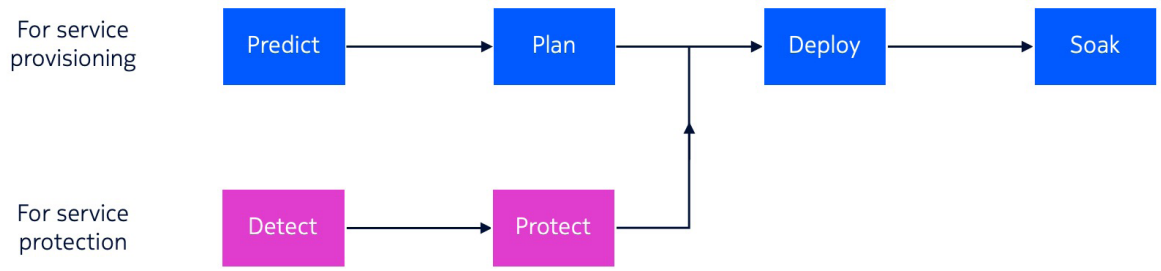
Intelligent Power Manager (IPM) is a suite of applications designed to simplify and automate the day-to-day operations of a submarine network. Given that a submarine fiber pair operator is responsible for deciding the total optical power level for optimum performance and maintaining this total power level regardless of what is happening in both the submarine cable, and potentially an optically expressed terrestrial backhaul, IPM provides the intelligent software support to perform and document these processes. For service provisioning, IPM simplified the workflow to Plan, Predict, Deploy and Soak before service acceptance. In protection scenarios, IPM can automatically Detect and Act to maintain optical power stability in the case of losing transponder portions of the spectrum and then assist in the Redeploy and Soak of these services once repairs are made. And automated documentation support ensures that your operations team is always up to date. All of these functions are available in all submarine cable types and topologies, including integrated terrestrial backhaul and spectrum sharing. IPM is there to make the day-to-day operations of the fiber spectrum as smooth and predictable as possible.

Contents

Introduction

Nokia's Intelligent Power Management (IPM) software suite works hand in hand with transponder and ROADM hardware in the 1830 GX Submarine Line Terminating Equipment (SLTE) solution to enable the simplification and automation of critical operational functions of an open submarine cable network. As shown in Figure 1, this is especially useful in-service provisioning operations where IPM simplifies the process of predicting fiber spectrum performance, spectrum planning, transponder deployment and soak testing. In service protection scenarios IPM works in conjunction with SLTE hardware to detect optical power faults, protect the spectrum using ASE, assisting in the redeployment of spectrum and capacity after a repair, and automating soak testing before services are handed over.

Figure 1. IPM Operational Simplicity for Submarine Networks



Many of the key advantages of IPM are based on the philosophy of bringing together hardware functions and operational processes that were previously discrete elements and manual processes in the subsea industry. These include:

- Reducing the time required to characterize the spectrum of a submarine fiber pair based on ITU-T G.977.1 recommendations and automating this process to save operator time and eliminate the possibility of human errors.
- Simplifying performance optimization through the integration of spectrum equalization and channel power optimization pre-emphasis with options for flat, SNRASE-Equalized or PFIB.
- Simplifying capacity optimization through baud rate selection and the optimization of transmission parameters (i.e., optimum Forward Error Correction, and chromatic dispersion and nonlinear compensation) for the Nokia ICE6 and ICE7 transponders.
- Simplifying operational awareness by offering a whole spectrum view for both performance and capacity optimization and stitching this view into an integrated map of the fiber spectrum.
- Automating the power balancing function as service wavelengths are added by working with the Nokia 1830 GX SLTE optical loading hardware.
- Providing integrated soak testing for new services wavelengths using Bit Error Rate Testing (BERT) and Generalized Signal to Noise Ratio (GSNR) without the need for external equipment.
- Supporting automatic spectrum protection in fault conditions by replacing lost service wavelength optical power with amplified spontaneous emission (ASE). Recovery from failure conditions is then performed under manual control.

- Providing automatic documentation of the entire process as a baseline and in an editable format for ongoing spectrum maintenance.
- Supporting all of these capabilities for optional user configurations, such as branched cable topologies, spectrum sharing, and the integration with terrestrial backhaul networks.

The need for Open Submarine Cable characterization

For over ten years the direction of the submarine wet plant sector has been to deliver an open cable architecture – one in which the wet plant is treated as an analog optical pathway with specific performance characteristics for both the optical fiber and the repeater chain. A given fiber pair on a cable is designed and verified before customer acceptance by the wet plant provider, and its performance is represented by the GSNR values across the range of wavelengths supported in this cable. Note that GSNR is the result of several years of industry collaboration and development, coordinated and documented by the Open Cable Working Group within the Suboptic Foundation.

It is important that the fiber pair operator is able to independently validate GSNR values on the cable during cable acceptance, and to update these values as the cable ages. Nokia IPM enables this characterization and validation using Nokia ICE6 and ICE7 transponders to scan across the spectrum and produce a GSNR report. Given that this process can be time consuming and would usually require expensive external equipment, the ability to integrate this function into the SLTE and to automate it within IPM is extremely valuable.

The need for optical power management in provisioning and protection

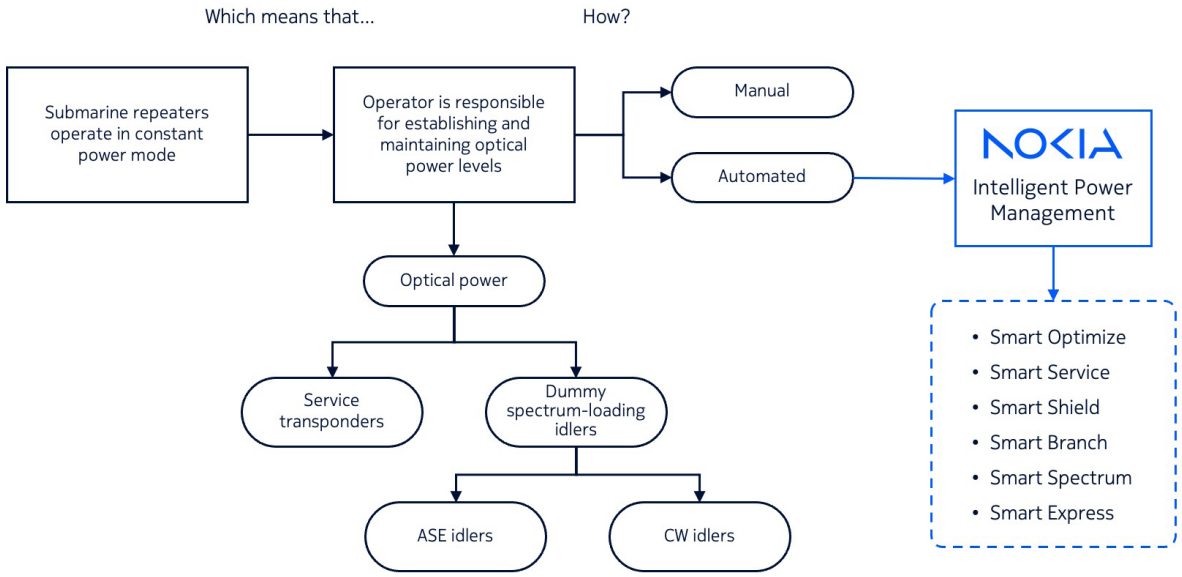
Long-distance submarine cables make use of in-line optical repeaters spaced between 60 to 90 km apart, depending on the cable design. Subsea optical repeaters leverage Erbium-doped fiber amplifiers (EDFAs) which operate in constant power mode, in contrast to terrestrial optical amplifiers which normally implement automated power control protocols to achieve constant gain per channel. This has significant consequences for submarine network operations, which have historically involved high levels of operator expertise and consumed significant amounts of time.

During the provisioning of new wavelengths, IPM Smart Service assists the operator in balancing the optical power by reducing ASE spectrum while new transponder spectrum is added. Automated soak testing is then available before these new wavelengths are handed over for service. Similarly, when a planned removal of transponders is performed, ASE spectrum replaces the transponder spectrum.

In the event of the unexpected loss of transponders, perhaps due to a break in an optically expressed terrestrial route, the Nokia SLTE terminal detects a power loss and triggers IPM Smart Shield to automatically replace the lost spectrum with ASE.

The philosophy behind Nokia IPM is to bring together hardware features for optical power generation and waveband management in the SLTE with a suite of software applications that reduce the operator workload, speed up and automate repetitive processes, support new service types such as automated protection and spectrum sharing, and support automated documentation and updates of the system configuration.

Figure 2: The need for optical power management



Without this type of software support, operators of submarine cables would be responsible for manually establishing, maintaining and documenting the optimum total optical power that is transmitted into the fiber. On a “cold fiber” with no service traffic, the process begins with baseline optical load being generated using idler channels – sources of dummy optical power.

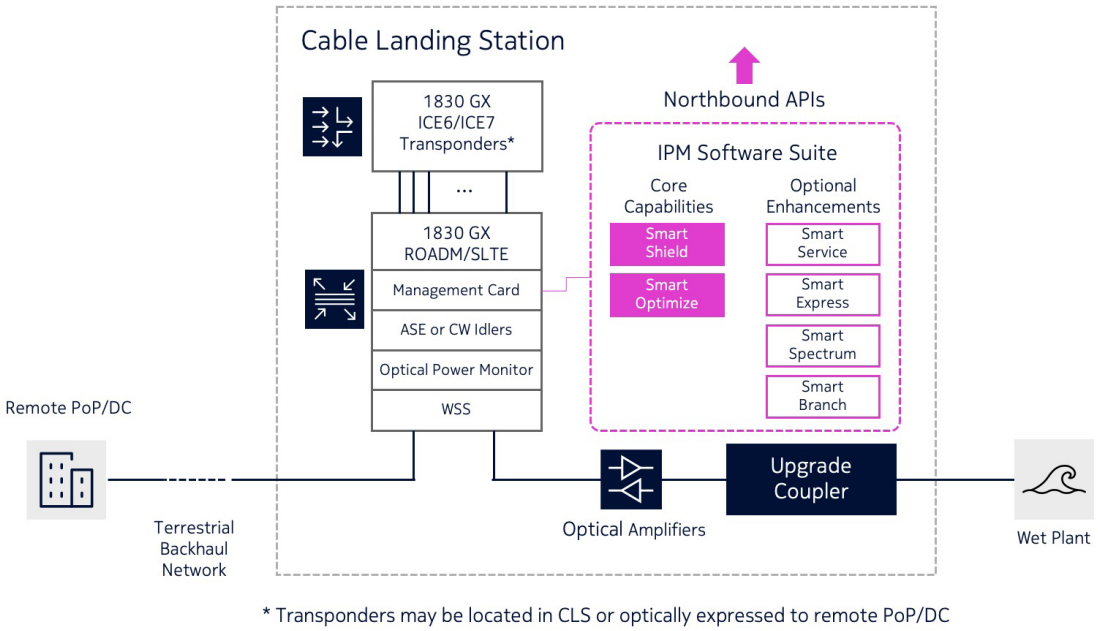
These idlers are usually based on a modified EDFA that generates ASE noise across a wide spectrum, or Continuous Wave Idlers (CW Idlers), which are basically coherent laser transmitters with very narrow spectrum and provide a more precise optical power control for dummy channels. ASE is used for bulk optical power generation on all types of cables, and the width and shape of the noise can be controlled using line system elements such as a flex grid ROADM. CW Idlers are typically required for use on older fiber cables which implement dispersion compensation with alternating positive and negative fiber dispersion slopes.

As service transponders are added, reconfigured or removed from the fiber spectrum, constant power operation of the amplifiers is maintained across the total of ASE power and transponders by adjusting loading optical power levels of ASE and/or CW Idlers.

In the past this process of optical power optimization was done manually, and it could be both time-intensive and stressful for the operator to achieve and maintain successfully. This can be especially evident during outages in a terrestrial section that is part of the subsea optical spectrum, where a manual approach can lead to extended service outages.

Nokia Intelligent Power Manager

Figure 3: Summary of Nokia Intelligent Power Manager



Nokia's Intelligent Power Manager (IPM) suite of software is designed to simplify the process of spectrum characterization and establishing and maintaining optimum optical power levels in a submarine cable, including branched cables, sections of optically expressed terrestrial backhaul networks and spectrum sharing. Figure 3 shows how IPM is implemented as an integrated hardware/software architecture.

The IPM software elements work directly with elements of the SLTE such as optical power hardware (ASE and CW idlers), ROADM power control and spectrum policing, and transponder configurations. These capabilities are further enhanced with guided automation of key operational processes as well as automated documentation.

The IPM Software Suite in Detail

In use IPM is designed to simplify and automate the workflow for all aspects of configuration and day-to-day operations of submarine cable systems.

Smart Optimize

The process begins with fiber spectrum characterization and is based on recommendations in ITU-T G.977.1. The monitoring, viewing and analysis of the spectrum is critical in optimizing the subsea fiber pair capacity and determining the cause of failures. Manually scanning the spectrum and configuring optimum modes in transponders is a time-consuming process that is prone to errors, and must be

carefully documented and updated. Smart Optimize dramatically simplifies this process by combining a spectrum view with the ability to scan and measure optical performance for both full spectrum analysis and verification of performance as new wavelengths are added in the future.

Sections of the spectrum can be analyzed and stitched together to create a complete deployment template, including both automated coarse preemphasis and manually optimized fine preemphasis. These features are designed to be compatible with Suboptic Working Group recommendations for open cable systems, including Flat TX launch, Flat Rx OSNR and PFIB preemphasis strategies. Once preemphasis is complete, Smart Optimize establishes a baseline that is stored automatically and can be used for future performance comparisons. This is extremely useful after cable repairs, or for historical cable performance comparison.

Documentation of the spectrum and transponder configurations is automatically created and updated when changes are made. This is true for all aspects of IPM, and it is vital in saving time and operator effort, as well as minimizing the risk of manual errors.

Smart Shield

Smart Shield is the software function that coordinates the optical power from ASE, CW idlers and service transponders. It works directly with the line system ROADM card at the cable landing site and calculates the optical power within a spectrum passband and determines if these are outside of agreed power ranges. Smart Shield allows automatic insertion of ASE in the event of the loss of transponder optical power, while recovery from ASE back to transponders following a repair is performed by IPM under manual control. Protection thresholds and timers are fully customizable.

Smart Service

Smart Service is an automated deployment tool that is an optional feature within IPM for operators who wish to perform their own provisioning procedures. It includes a complete workflow for service provisioning, including options for automated deployment, optimization and testing.

Automation for initial deployments can be further automated, based on Nokia's Submarine Network Automation features set

Smart Branch

Smart Branch is an optional IPM features that extends support for Smart Optimize and Smart Shield to branched submarine cable systems. One useful feature is the ability to stich sections of spectrum from the different branches together within an intuitive GUI. In contrast a manual approach would add significant time to configure and maintain different sections of the spectrum from different branches. Both fixed filter and ROADM configurations are supported.

Smart Express

Optical express is a network architecture in which the end-to-end optical path of a subsea wavelength transits through a ROADM at the CLS without regeneration and is extended optically over a terrestrial backhaul link onwards to its end-point at a Point of Presence or Data Center. The implications can be significant from a service protection point of view, since an outage in a terrestrial link could remove a significant amount of optical power from the submarine cable instantly. Smart Express is an optional IPM feature that can be used to implement enhanced protection capabilities in conjunction with Smart Shield. Smart Express also exposes the terrestrial link to Smart Optimize so that it can be included in spectrum planning.

Smart Spectrum

Spectrum sharing on submarine cables is an important service offering that bridges the gap between managed digital services and whole fiber IRUs. But optical power management in a spectrum sharing environment is especially important, firstly to always maintain operational stability and secondly to protect spectrum used by one tenant against mistakes made by another tenant. Smart Spectrum is a complete solution to spectrum management, operating in concert with ASE idlers and the capabilities of Nokia line system WSS elements to ensure that both goals are achieved.

The above software modules fall into core capabilities and optional enhancements available from IPM, where:

- Core Capabilities: Smart Shield and Smart Optimize are regarded as core capabilities – required in all scenarios.
- Optional Enhancements: Smart Service, Smart Express, Smart Branch and Smart Spectrum are optional capabilities in specific cable scenarios.

Summary

IPM addresses the challenge of simplifying all aspects of submarine fiber pair optical power management operations. For provisioning IPM simplified the workflow to Plan, Predict, Deploy and Soak before service acceptance. In protection scenarios IPM can automatically Detect and Act to maintain optical power stability in the case of losing transponder portions of the spectrum and then assist in the Redeploy and Soak of these services once repairs are made. And automated documentation support ensures that your operations team are always up to date.

IPM supports all submarine cable topologies, such as linear links, branched links, and links that include terrestrial backhaul in the optical pathway. Moreover, IPM supports these functions for full spectrum and shared spectrum service scenarios.

Nokia OYJ
Karakaari 7
02610 Espoo
Finland
Tel. +358 (0) 10 44 88 000

Document code: (December) CID215244