Achieving efficient IP-optical network automation

Cross-domain coordination with the Nokia NSP

Application note

Abstract

As networks transform to cloud-based architectures, the services being offered are becoming more dynamic; they must be rapidly instantiated, assured, maintained and re-engineered to efficiently accommodate shifting traffic patterns in short time frames. Efficient IP-optical operational coordination is becoming key in the global management and engineering of dynamic and high-bandwidth IP and optical transport network resources.

The advent of broad-scope carrier software-defined networking (SDN) architectures brings many opportunities in automating, optimizing and securing the operation of IP-optical networks. SDN brings efficient solutions to multilayer, cross-domain, coordination issues through a combination of open, programmable and standardized interfaces, data abstraction, as well as open-source, web-scale system integration techniques.

This application note explains how the Nokia Network Services Platform (NSP) embodies these capabilities and brings a holistic approach to multilayer automation and optimization—so you can deliver, assure and maintain network services quickly, securely and cost effectively.

Contents

Introduction

Traffic growth continues unabated and operators are challenged to meet aggressive targets of operational excellence and financial performance. Engineering and business agility are needed to allow network operators to prosper as new service opportunities appear.

These opportunities are emerging in the context of distributed cloud architectures, data center interconnect and 5G networking. All of these will be underpinned by IP-optical transport and networking infrastructure services, which require massive scale, solid reliability and the ability to be securely delivered, assured, maintained and reconfigured at speed.

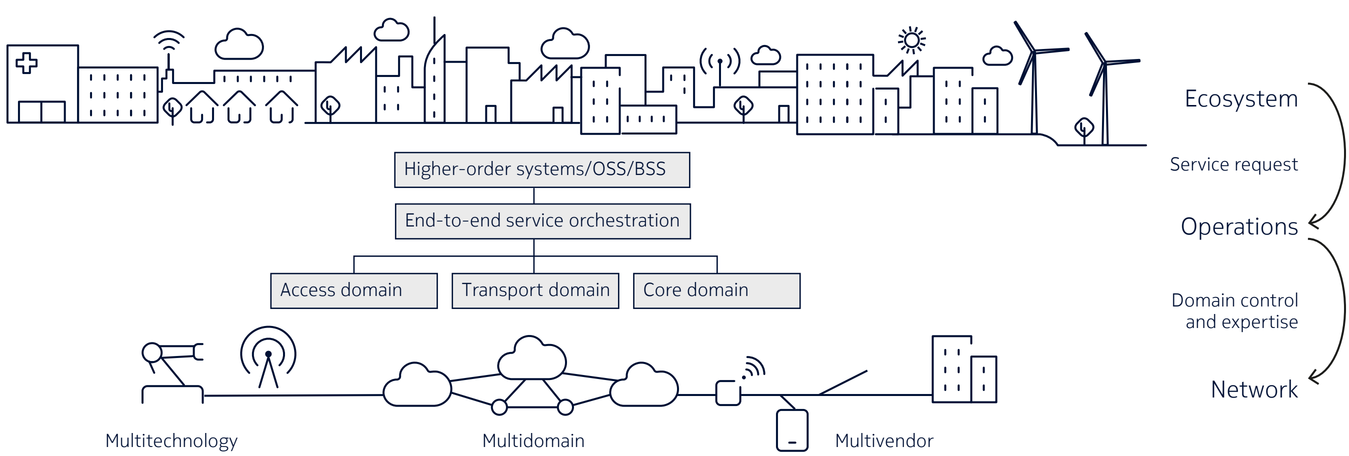
The advent of broad-scope carrier software-defined networking (SDN) architectures brings many opportunities in automating, optimizing and securing the operation of IP-optical networks. SDN brings solutions to multilayer, cross-domain, coordination issues through a combination of open, programmable and standardized interfaces, data abstraction, as well as open-source, web-scale system integration techniques.

The Nokia Network Services Platform (NSP) embodies these capabilities and brings a holistic approach to multilayer operational automation and optimization for many of the world's largest and most crucial networks.

Multilayer management of network services

An end-to-end service often passes through several network layers and domains. Hierarchical domain controllers can be orchestrated to automatically support life cycle operations such as creation, assurance, updating and deletion (see Figure 1).

Figure 1. Automation hierarchy of an end-to-end network service



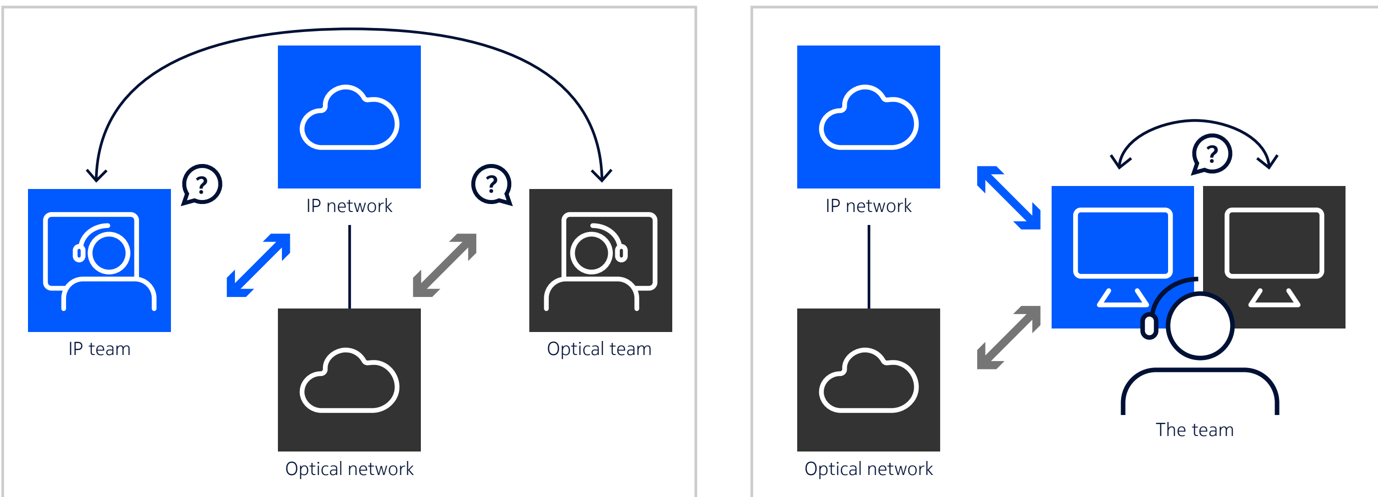
This open, hierarchical, automation and control framework is reflected in the work of a number of standards bodies, including the 3GPP, IETF and ONF.

In the transport domain, operators often rely on multiple teams and experts assigned to specialized operational functions within a layer. For example, particularly in large, well-staffed network operations groups, the person who starts investigating IP failures in a multilayer problem analysis often is not the one who performs trouble shooting in the optical domain (where the originating causal failure may lie), as shown on the left side of Figure 2.

In smaller installations a single person may attempt to troubleshoot the entire issue across all network layers involved by navigating between independent, specialized tools, as shown on the right side of Figure 2.

In either case, better tools for multilayer navigation and coordination of operations can improve operational efficiency and network availability.

Figure 2. Operational coordination issues in multilayer networks



These challenges are influenced by a simultaneous trend in the network elements comprising the multilayer architecture. While, traditionally, the demarcation point between the IP and optical layers has been a gray, back-to-back optical connection, this is beginning to change.

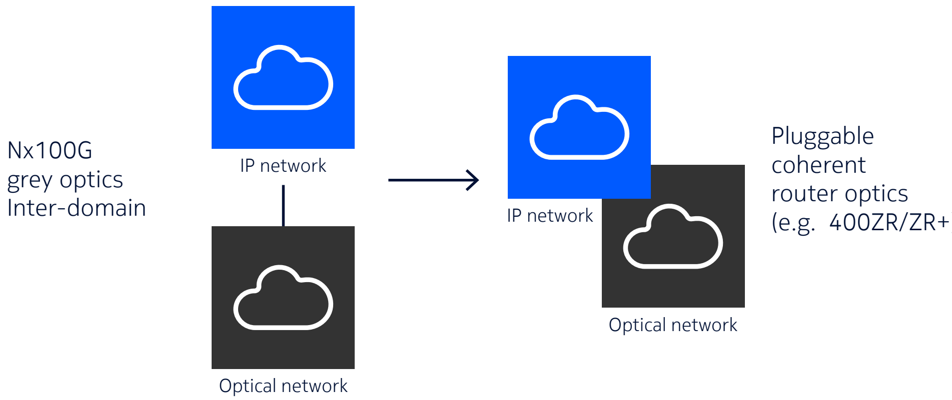
As shown in Figure 3, coherent, pluggable optical modules are becoming available for routers, enabling physical IP-optical integration. This transition will transform the relationship between IP routing and optical transport and simultaneously restructure some operational responsibilities and practices.

Dense wave division multiplexing (DWDM) transport systems will remain critical for the optimal usage of available frequency spectrum and fiber plant. However, IP routers will eventually become less reliant on these systems for simple point-to-point link topologies, shorter distances and packet-centric data transport.

As IP routers cross over into the domain of coherent optical transport, they are exposed to new port and link management practices that were traditionally in the jurisdiction of the optical transport network. Operational tasks such as optical channel provisioning, connectivity discovery, maintenance and troubleshooting of optical connectivity will be incorporated into the scope of overall router management.

This shift will accelerate and intensify the need for flexible and powerful tools to operate efficiently across layers, navigating and coordinating operational activities between the IP and optical worlds. The operational requirements and use cases for managing coherent routing applications are explored in the application note, "IP-optical coordination and automation for 400GE and beyond: Managing coherent routing applications with the Nokia Network Services Platform".

Figure 3. The transition to 400G and beyond



The following sections explain some of the principal challenges of IP-optical coordination.

Discovering and visualizing topologies and risk exposure

Network topology discovery and planning

In IP-optical networks, capturing and accurately visualizing the combined topology and interconnection points between the network layers from Layer 0 to Layer 3 has been a significant challenge for operators.

In large carrier networks, organic growth over time is often driven by disparate, siloed departments; this can lead to inaccurately inventoried network architectures. Inconsistencies can exist between operators' inventory data and the equipment and facilities deployed in the actual network. These inconsistencies heighten the potential for severe operational issues, such as unpredictable failure impacts on crucial network traffic and sub-optimal latency control.

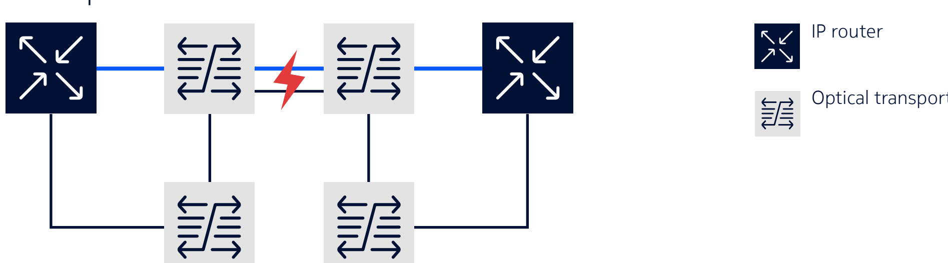
To establish a baseline for future evolution and to support ongoing planning, operators need reliable tools to capture and visualize multilayer topologies. This will enable them to more effectively leverage their true network assets by providing an accurate picture of the deployed resources.

Coordinated risk mitigation through path diversity

To make network planning simpler, and the network more reliable, requires a full understanding of risk scenarios in the optical transport layer and their potential impact on IP traffic paths. Correlating these multilayer views allows operators to understand and mitigate the scope of exposure to infrastructure risks but requires accurate tools to examine the real-world physical infrastructure in the separate layers.

Path diversity may be apparent at the IP routing layer, but deeper insights into the actual optical transport infrastructure can reveal shared risks. For example, this can happen where two apparently disjoint paths, in fact, traverse a common fiber, duct or optical layer forwarding (see Figure 4).

Figure 4. A shared risk path



The ability to assess the exposure of network services to accidental or malicious damage or outages of shared infrastructure components such as fiber ducts or amplifiers is critical for network reliability.

Correlation across layers for operational efficiency

Optical service provisioning

There is often a need to provision an optical service as a part of complete transport connection capability. It should be possible to carry out comprehensive optical management from a single platform , with the IP and optical layers being provisioned almost simultaneously, without the need to involve a complex operational support system (OSS). This results in simplified operations and faster time to turn up a complete transport service.

Cross-domain connection management

There is a need to avoid cumbersome cross-domain connection management via manual, error-prone processes and/or expensive OSS systems development with long integration intervals. The requirement is to support automated connection management based on standard protocols interworking with multi-vendor domain controllers . This will bring faster time to market and faster service delivery with cost savings via simplified, error reduced operations.

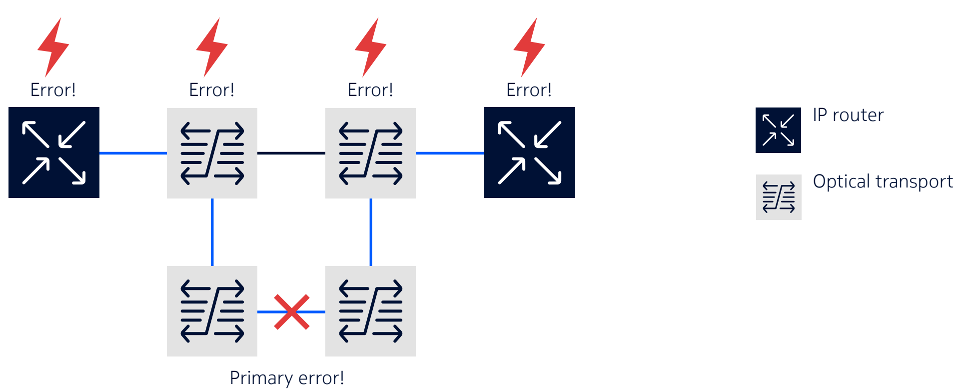
Optical aware IP routing

Optical aware IP routing is useful for transport connectivity that needs to adhere to a service level agreement (SLA) , such as latency optimization or path diversity in the optical domain. For example, while an IP-only view may show apparently diverse paths, visibility into the optical domain shows otherwise. The need is to use shared risk information to compute optimal paths, with diversity, through the infrastructure, reducing the risk of outages and enabling compliance to route diversity SLAs.

Coordinated troubleshooting

Problem symptoms can mask root causes, and root cause faults can trigger floods of related secondary alarms (see Figure 5).

Figure 5. Symptomatic alarms masking a root cause



Navigating between the IP and optical domains can be problematic due to the siloed nature of the teams in many companies and the lack of integrated operations tools that cross layer boundaries. This can hinder inter-team communications.

Tools are needed to allow rapid identification of root causes, especially when a causal error occurs in a different, lower-order support layer than the layers affected by it. Cross-layer navigation will allow faults and performance issues to be rapidly identified and resolved.

Coordinated operations

As the foundation of the network, optical fiber plant equipment requires ongoing monitoring and maintenance. Automation of multilayer maintenance procedures will minimize negative impacts to user traffic. Proactive rerouting of IP services prior to and during optical maintenance events will limit the impact on IP traffic when infrastructure components are taken out of service for maintenance activities.

Hitless optical reversion is also needed to minimize impacts to end-user services. Before restoring an optical failure (i.e., switching back to the primary path after repairs), IP traffic should be moved off the link that will be affected.

Optimization to maximize effective use of resources

Resource efficiency

Greater and more dynamic control of their network assets enables operators to run their networks more efficiently and lets services make the best use of available bandwidth.

Bridging the gap between service provisioning and network engineering allows operations to satisfy dynamic service requests while making optimal use of available IP-optical assets. It should be possible to dynamically adjust link bandwidth to accommodate traffic fluctuations. A coordinated, multilayer protection strategy protects traffic at the most cost-effective layer without, for example, the need for costly 1:1 redundancy.

The failure of optical transport components can negatively impact, and possibly disable, multiple IP services. Operations staff need a “what-if” analysis capability to simulate failure modes, for example: a fiber cut or the loss of an optical device . The resulting impacts on IP services can be assessed and plans put in place to mitigate them.

Service velocity and assurance

The pervasive, instantaneous access characteristics of cloud-based services and applications have set an expectation of rapid, simple service delivery and consumption. From consumers of point services to enterprise architects building virtual infrastructures, the goal is to accelerate and simplify the definition, provisioning and reconfiguring of network services.

To accelerate service delivery requires significant automation in provisioning all network layers. In addition to establishing paths across multiple layers, paths must also be stitched together laterally across multiple (possibly multivendor) domains.

Furthermore, the service life cycle must be completed by an automated assurance process so that operators can dynamically and proactively ensure ongoing network and service health.

Nokia NSP for resource control and coordination

Nokia addresses these multilayer management requirements and enables carrier SDN transformation with the Network Services Platform (NSP).

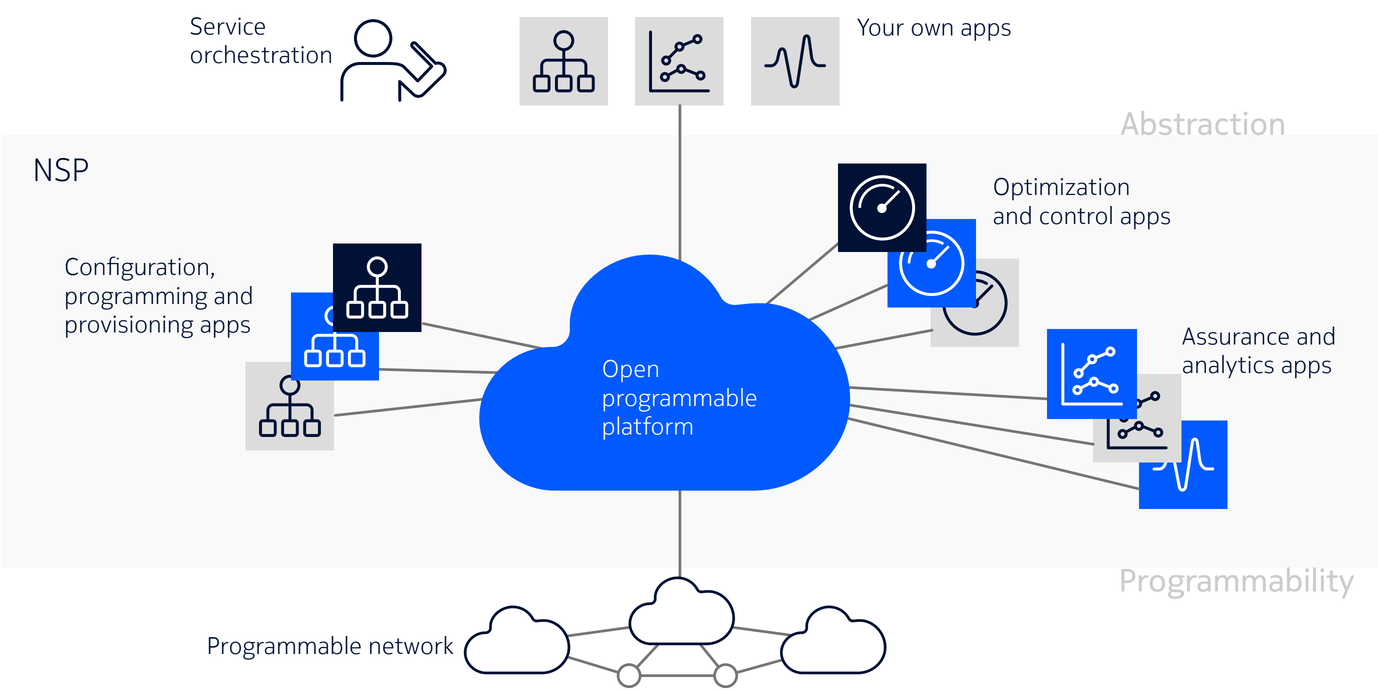
As shown in Figure 6, the NSP unifies service automation, network optimization and assurance in a single integrated software platform so that network operators can deliver on-demand network services quickly, securely, cost effectively and at great scale.

The NSP helps you automate your IP and optical networks to simplify your operations, respond quickly to fast-changing demand, get the most from your resources and ensure maximum service performance and reliability.

The NSP answers your need for more responsive, efficient and reliable IP networks with:

- A complete suite of ready-to-use applications that help your network operations teams address all NSP use cases for network management, orchestration and control
- An SDN resource controller that lets your network engineering teams control the network and optimize traffic in real time
- An open, programmable platform that enables your engineers and developers to automate network operations and ease integration with orchestrators and operations support systems (OSS)

Figure 6. The Nokia NSP



Nokia NSP capabilities to address challenges

The Nokia NSP provides a set of capabilities designed, as holistic use cases, to mitigate the challenges outlined earlier in this document.

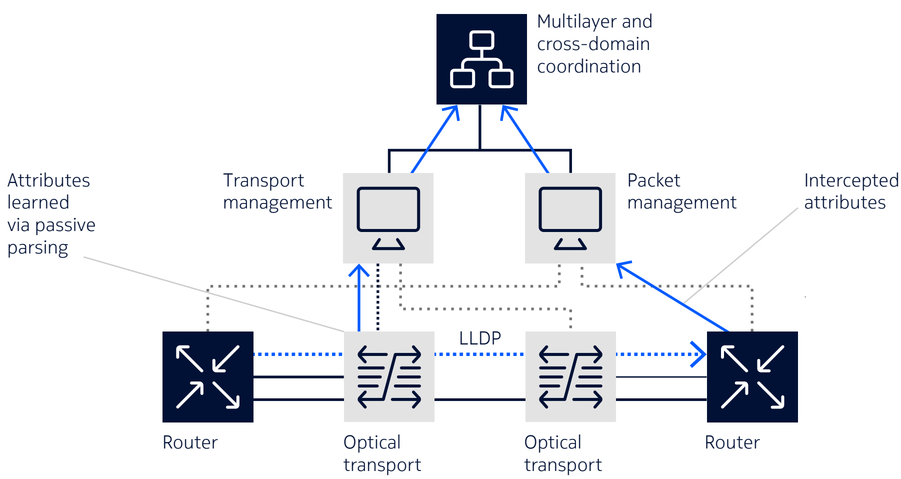
Discovery use cases

Network topology discovery and planning

Traditionally, operators have had to manually enter the details of topology and particularly the connection points between the IP and optical network layers into spreadsheets or similar information repositories. The main disadvantages of this approach are that it is inherently time consuming and error prone. A better, fully automatic and deterministic approach uses embedded operations, administration and maintenance (OAM) protocols to reliably detect and communicate topological and connectivity details to the Nokia NSP.

The Link Layer Discovery Protocol (LLDP) is a link-layer protocol in the IP suite that is used by network devices to advertise their identity, capabilities and neighbors. LLDP snooping leverages LLDP (see Figure 7),
which is also used for discovering links to optical transponders. LLDP snooping has many benefits, including the avoidance of cumbersome manual processes and configuration verification. It can also detect misconfigurations.

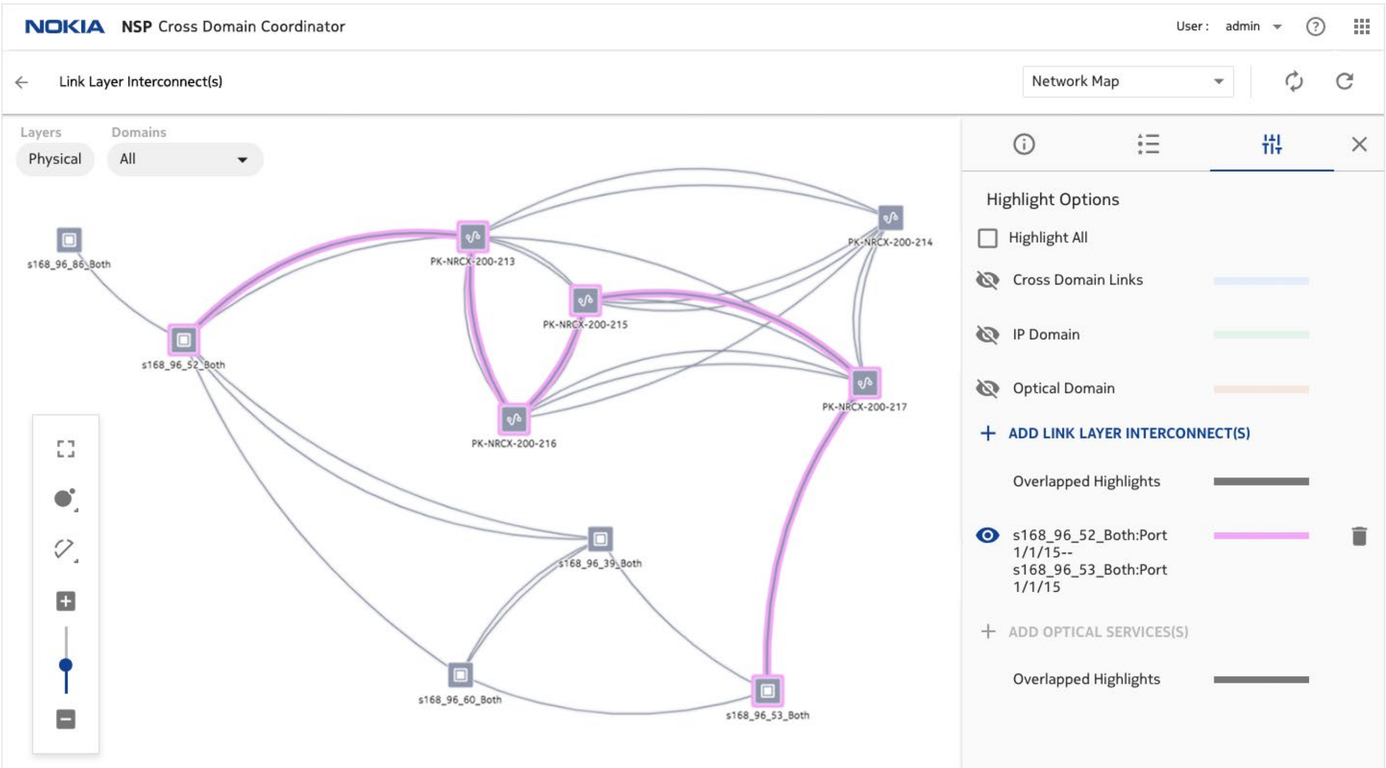
Figure 7. Topology discovery



As not all optical networking devices support LLDP, the NSP offers a solution based on traffic count comparisons. This approach allows the identification of cross-layer links by counting transmitted and received packets on ports of routers and on optical layer devices. By comparing those traffic counts, the controller is able to deterministically identify connected ports between layers.

The results of the cross-layer topology determination are graphically rendered by the Cross Domain Coordinator app (see Figure 8).

Figure 8. A discovered multilayer topology in the Cross Domain Coordinator app



The discovered connections are also listed in the cross-domain links list. The operator can validate the links in the cross-domain links list and commit to the database. The Cross-Domain Coordinator can also determine if there any misconfigured links in the system. Once committed by the operator, these links are shown as solid lines on the physical topology map.

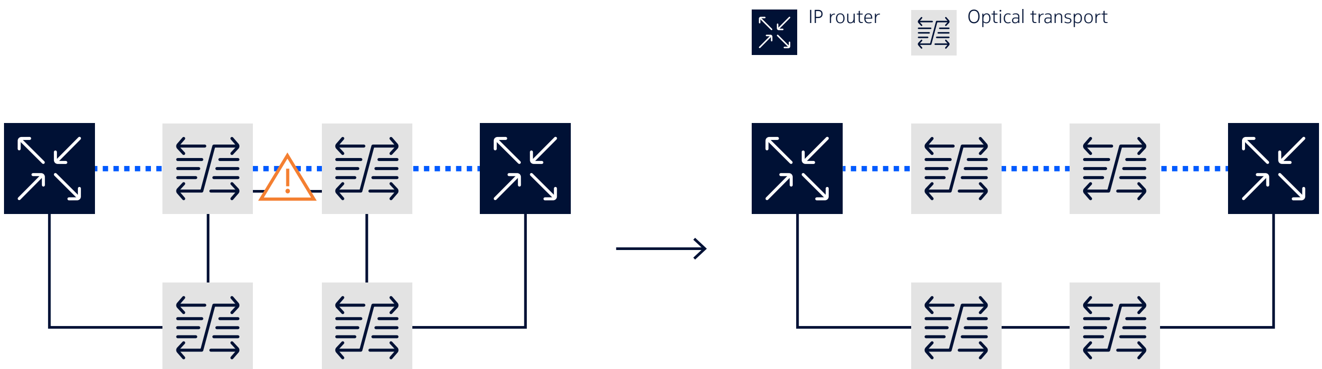
Diversity analysis for coordinated reliability and risk mitigation

Path diversity may be apparent at the IP layer, but deeper insights into the actual optical infrastructure can reveal shared risks.

SDN resource controllers at the IP and optical domains share information about optical topology. The IP layer typically needs to know only an abstraction of the optical topology details. However, knowing the shared risks that are evident from a detailed examination of the optical layer is highly advantageous. This information exchange is enabled by the Nokia NSP, which provides a coordinating and information sharing function between the IP and the optical layers.

Figure 4 showed a situation where a pair of disjoint label switched paths (LSPs) have been requested by the IP layer but traverse a shared-risk component in the optical infrastructure. Figure 9 shows the capability of the NSP to identify this shared risk as well as the affected Shared Risk Link Groups (SRLGs). This allows LSPs that are truly SRLG-disjoint to be established.

Figure 9. Shared risk detected and SRLG-disjoint path routing established



Correlation use cases

Optical service provisioning

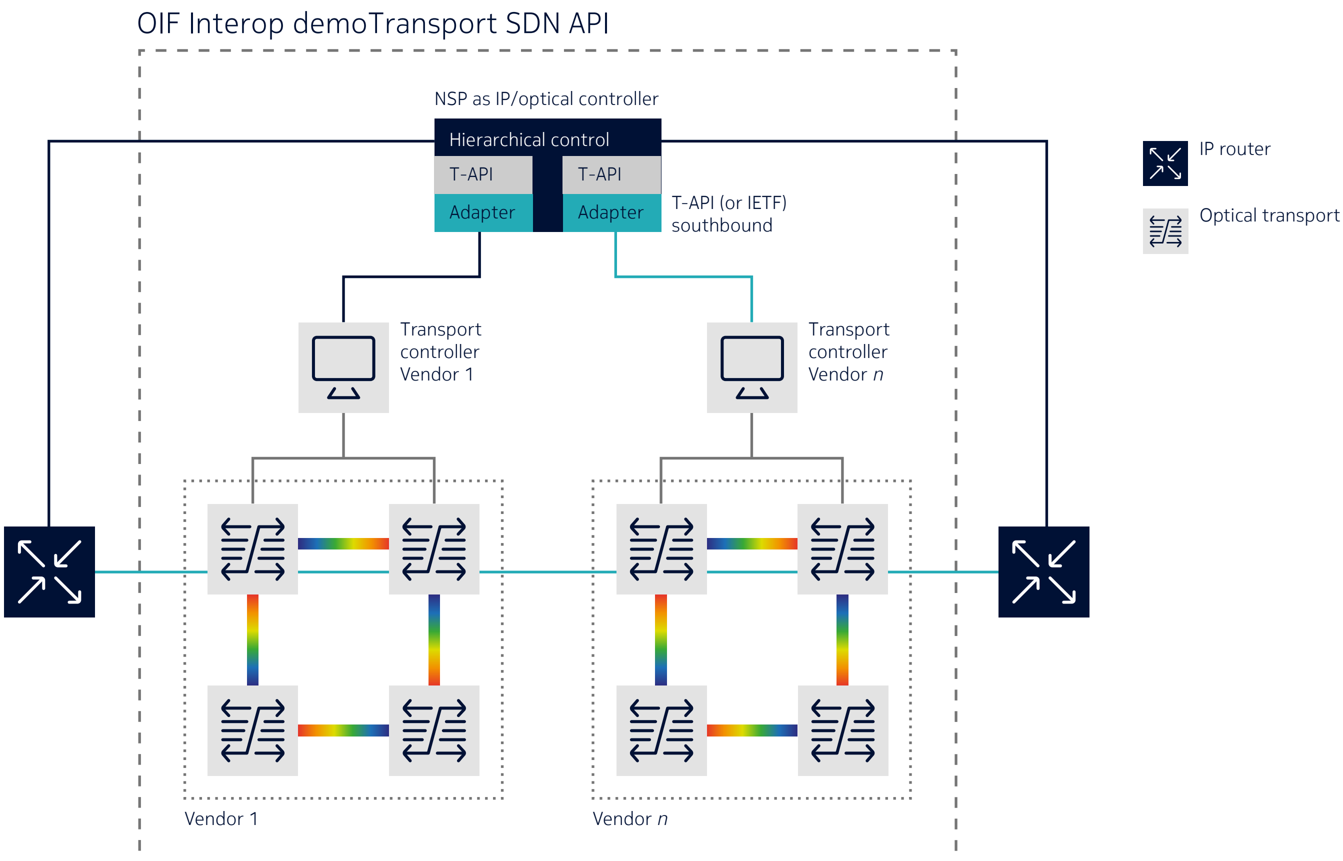
The NSP supports the provisioning of an optical service as a part of constructing a complete transport connection. Optical connectivity provisioning commands can be passed from the NSP through to the optical management platform using the industry standard Transport API (T-API) interface, including the Wavesuite Network Operations Center (formerly the Network Functions Manager – Transport (NFM-T). This permits comprehensive optical management, with the IP and optical layers being provisioned from a single platform. Optical layer attributes such as interface type, resiliency and diversity can be provisioned. This simplifies the operational task flow and accelerates the time to establish a complete transport service, reducing the time to revenue for improved business performance.

Cross-domain connection management

Nokia has been active in supporting the work of the Optical Internetworking Forum (OIF) in Transport SDN Application Programming Interface (T-API) development and interoperability testing. Several Nokia products and solutions, including the NSP, have been engaged in this work to simplify and automate cross-domain service connection life cycle management in multivendor networks. (For more information about these activities, read "Accelerating SDN-enabled automation with road-tested APIs.")

The intent is to avoid cumbersome cross-domain connection management via manual, error-prone processes and/or expensive OSS systems development with long integration intervals. The goal is to support automated connection management based on standard protocols with domain controllers (see Figure 10).

Figure 10. Multivendor, multidomain connectivity service support



Multivendor, multidomain connectivity service support with the NSP brings faster service delivery, faster time to revenue and overall cost savings in management systems integration.

Optical aware IP routing

The NSP uses shared risk information to compute optimal paths through the infrastructure, allowing true path diversity to be achieved and avoiding exposure to risks such as a fiber or a conduit cut. This infrastructure diversity reduces the risk of outages and helps to support compliance to route diversity SLAs.

The NSP can also import latency values from the optical domain, resulting in more accurate QoS results when paths are placed according to latency.

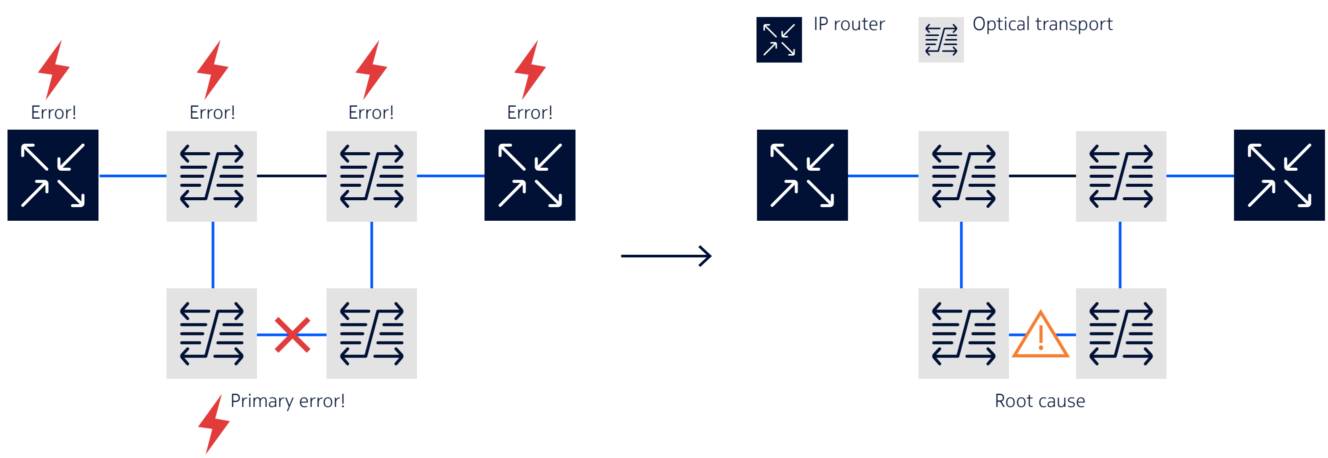
Coordinated operations

The cross-layer, cross-domain capabilities of the Nokia NSP are ideally suited to ensure little or no impact to IP services during planned maintenance activities. The NSP coordinates and orchestrates activities at the IP and optical layers, which is particularly relevant for unprotected optical services. IP/MPLS LSPs are proactively rerouted to keep IP traffic away from affected optical links during maintenance activities. The Path Computation Element (PCE) capabilities of the NSP ensure that performance targets are still met.

Coordinated troubleshooting

Nokia NSP smart alarm correlation allows operators to see past problem symptoms and rapidly identify the true root cause or causes, as shown in Figure 10. Cross-domain navigation allows the fault location to be rapidly identified and the issue resolved through efficient troubleshooting operations and rapid resolution of service-affecting issues.

Figure 11. From floods of errors to root cause identified



Optimization use cases

Resource efficiency

The centralized, global role of the Nokia NSP enables clear insight into the way in which traffic is engineered onto network paths. This permits comprehensive computation to take place with the goal of best utilizing network resources for maximum efficiency.

The NSP uses real-time network KPIs to drive the network optimization process. The data triggers operator-defined policies that can adapt the network to optimize services in real time by rerouting existing paths or by adding more service bandwidth to paths that reach a specified utilization threshold. 3D visualization of the network paths/tunnels is provided across all layers.

By reducing complexity, enabling more efficient use of network assets, and lowering overall congestion, operators can lower overall CAPEX and OPEX and increase revenue from existing assets.

Cost-effective multi-layer protection

Another benefit of intelligent service and network provisioning in a multilayer IP/optical network is being able to better leverage the complementary strengths of the two layers to support resiliency of connectivity services.

The IP/MPLS routing layer is very capable in routing and grooming granular IP service flows and protecting these end to end. However, reliance on only MPLS layer protection can be very costly. This is because protection relies on intermediate router hops making local detours, and underlying transport network failures can result in major control plane activity to recover potentially thousands of LSPs.

Modern optical transport networks can dynamically route and recover aggregate traffic flows with execution times ranging from hundreds of milliseconds to a few seconds. As transport networks evolve from traditional ring to mesh topologies, network protection strategies can evolve from costly 1+1 redundancy to highly efficient 1:N redundancy strategies based on dynamic optical restoration using flexible optical port assignment.

Elastic IP/optical bandwidth

Bandwidth between layers can be dynamically and elastically adjusted using the Link Aggregation Group (LAG) expansion capability of the NSP. The Cross Domain Coordinator app can add (or reduce) capacity between the IP and optical layers. This allows bandwidth resources to be appropriately aligned to offered and anticipated traffic needs.

“What-if” analysis

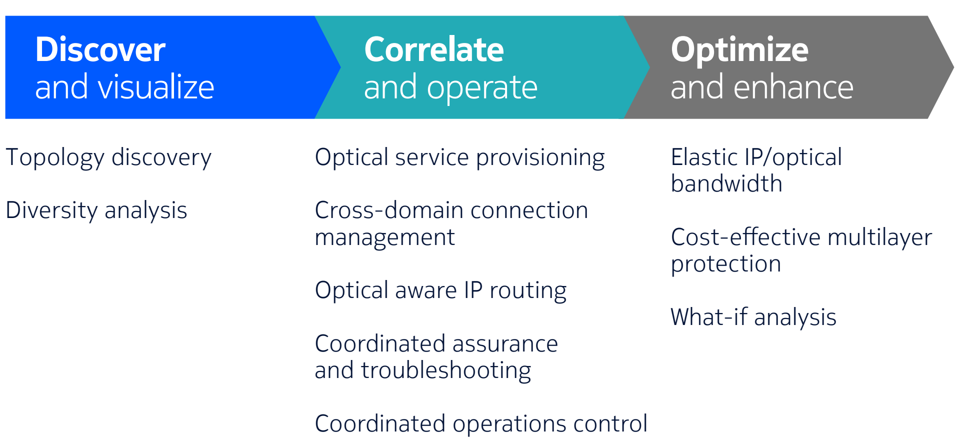
The NSP provides operations staff with the ability to simulate failure modes such as fiber or conduit cuts or the loss of optical network components. The resulting impacts on IP services can be assessed. Failure reports are generated from a “what-if” exercise showing the result of a simulation, as well as a network view which highlights the effects of the failure on the LSP paths. The predicted effects on traffic routes and on LSP paths are presented for review and possible action in terms of network engineering, of capacity and backup resources, to mitigate against such an event happening in the future. This active contingency planning boosts network and service resiliency leading to increased customer satisfaction.

Summary

Centralized, combined management and control of the IP and optical layers in a broad-scope SDN platform architecture delivers solutions to many networking challenges. The Nokia NSP enables a significant transition in the service-assured, efficient operation of multilayer, multidomain and multivendor network architectures.

As shown in Figure 12, a range of high-value use cases are addressable, as in the areas of discovery, correlation and optimization across network layers, enabling operators to keep both service quality and network efficiency high.

Figure 12. NSP multilayer coordination use case summary



Operators can realize significant improvements in operational efficiency whether across teams dedicated to the separate layers or by personnel with a wider mandate in operating the total transport infrastructure. The white paper "Multilayer and multidomain management using the Nokia NSP" emphasizes the real-world benefits that are achievable using IP-optical multilayer resource control and coordination with the Nokia Network Services Platform.

For more information

For more information about the Nokia NSP, visit the NSP web page.

For more information about IP-optical coordination visit the IP-Optical Coordination web page

Abbreviations

3GPP	3rd Generation Partnership Project
BSS	business support system(s)
CAPEX	capital expenditures
IETF	Internet Engineering Task Force
IP	Internet Protocol
KPI	key performance indicator
LLDP	Link Layer Discovery Protocol
LSP	label switched path
MPLS	Multiprotocol Label Switching
NSP	Nokia Network Services Platform
OAM	operations, administration and maintenance
ONF	Open Networking Foundation
OPEX	operating expenditures
OSS	operations support system(s)
OTN	Optical Transport Network
SDN	software-defined networking
SRLG	Shared Risk Link Group

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Document code: (June) CID201789