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QUANTIFYING THE BENEFITS OF OPTICAL NETWORK AUTOMATION

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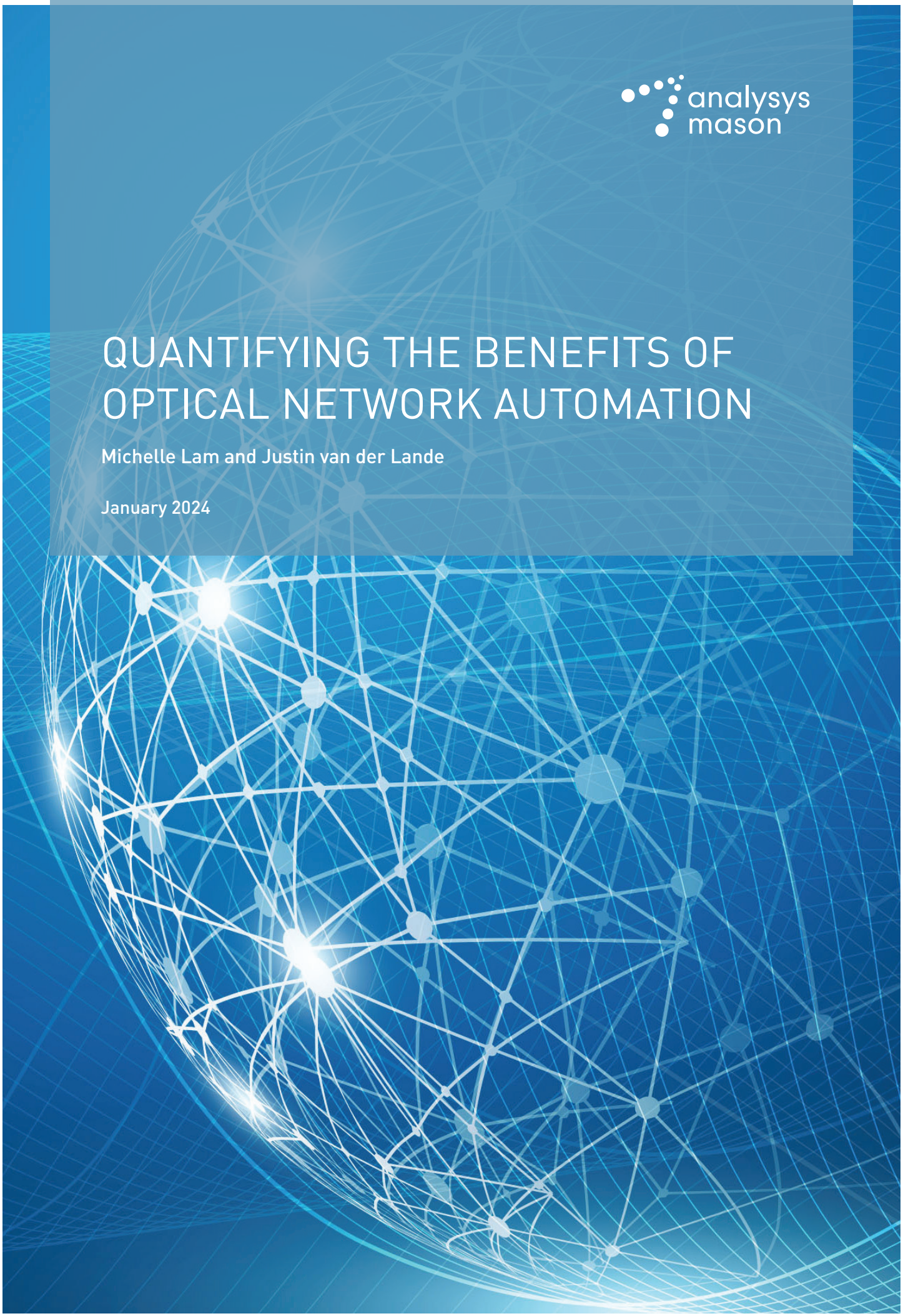

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1. Executive summary

The surge in data traffic over recent years, accelerated by ever-increasing bandwidth requirements, growing data center interconnection traffic and new emerging technologies (such as augmented reality (AR)/virtual reality (VR), internet of things (IoT) and artificial intelligence/machine learning (AI/ML), is driving the need for greater scale in optical networks. Optical networks today provide ubiquitous connectivity for practically all network traffic, across access/edge to metro, long-haul and subsea links.

Managing this growth in optical network capacity requires a new approach to the management and control of optical networks to meet the demand for high-bandwidth services. Optimizing the capacity, reliability and security of optical networks has become a key priority for operators to guarantee enhanced network performance, minimize operational costs, monetize new services and support new business models.

Operators are seeking automation solutions to minimize the total cost of ownership of optical networks and to maximize the efficiency, scalability and profitability of their optical network deployments. Simplifying the management and control of next-generation optical networks by automating manually intensive and repetitive tasks (such as provisioning, configuration and troubleshooting) will help reduce operational expenditure, because skilled technicians are needed to carry out this process to avoid costly errors, and to support new revenue growth.

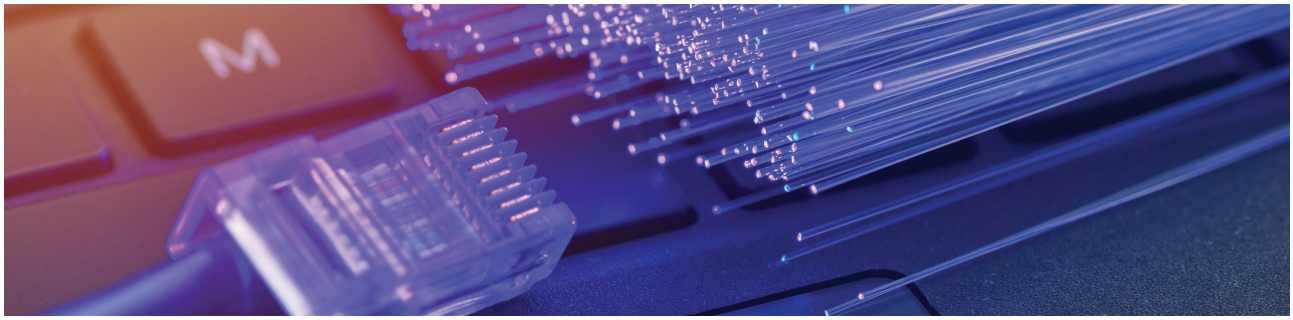
This study aims to demonstrate the benefits of automation for network lifecycle management and service lifecycle management using the Nokia WaveSuite optical network automation platform, which is based on actual Nokia customer deployments. The in-depth analysis in this study is informed by a series of questionnaire responses, operator interviews and Analysys Mason's existing network automation research. We evaluate many use cases for network and service automation. We quantify the benefits of automations in terms of OPEX savings, CAPEX savings, time savings and the ability to generate new revenue.

The key results of the study are summarized below.

- The automation of network lifecycle management processes has led to an overall savings of up to 56% in operational costs: by simplifying complex network operations tasks means that operators can shorten the time to provision, configure, deploy and manage optical networks.
- For network operators offering service virtualization and slicing, automation has resulted in operational cost savings of up to 81%[1], as a result of a reduction in the time that it takes to complete service order orchestration (90%), service fulfilment (83%) and service assurance (54%) processes.
- Automating network planning for both the planned and deployed network optimizes network resources and enables legacy network equipment to be retired, which contributes to CAPEX avoidance of 30%.
- Operators expect to benefit from a 10% uplift in revenue from faster service turn up, combined with an accelerated time-to-market for services that led to higher win rates and the ability to offer differentiated services made possible by optical network slicing and network-as-a-service business models.

[1] The overall operational cost savings for offering service virtualization slicing is the weighted average of the three service automation processes: (0.5 × 90% + 0.3 × 83% + 0.2 × 54%) = 81%

2. Market drivers for optical network automation



The need for higher-capacity optical networks is essential to support low-latency applications.

Optical networks serve as the backbone for high-speed fixed and mobile broadband connections for enterprise, cloud and data center applications. Optical networks also support low-latency data transmission and reliability for emerging technologies and applications. Fiberoptic networks handle large data volumes at high speeds, which serves an important role in multiple applications and services including backhaul networking between the core network and the access network across long distances, linking to data centers for cloud services and storage, connecting distributed locations and resources for enterprise, and high-definition broadcasting and content distribution.

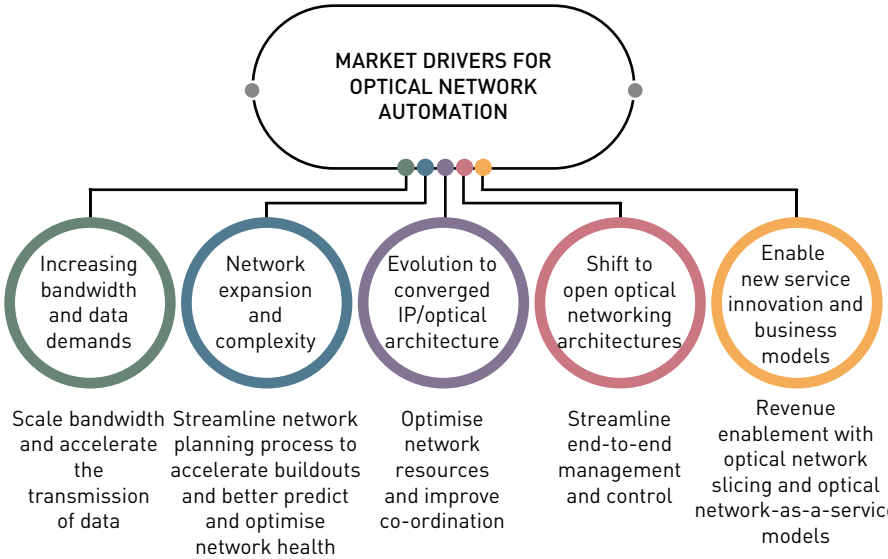


Figure 2.1: Market drivers for optical network automation

(Source: Analysys Mason 2024)

2.1 Growing demand for high-bandwidth applications

Consumer demand and enterprise requirements for low-latency applications in the 5G era are both significant drivers for the need for more-efficient and reliable optical networks. The proliferation of real-time applications (such as online gaming, HD video streaming and conferencing and AR/VR) has heightened consumer demand for low-latency connectivity to enable seamless and immersive experiences, reduce delays and ensure responsiveness.

In addition, enterprise digital transformation is leading to a growing reliance on data-driven processes to support emerging technology applications such as AI/ML, big data and analytics, telemedicine, remote working and blockchain, which require extensive computing and data transfer capabilities. This has resulted in enterprises shifting their IT infrastructure and services to cloud platforms and data centers to handle the massive volumes of data that is generated and transmitted. This increase in data center workloads requires robust and high-capacity networks that can support high-speed data transmission across both data center interconnect and cloud on-ramp (private, direct connection to a cloud service provider) to data center connections to efficiently manage data traffic and maintain the performance standards of distributed services.

These use cases are driving the need to deploy efficient and reliable optical networks with high levels of programmability and automation to support the data-intensive requirements and connectivity requirements of ≥10Gbit/s and <100ms latency.

2.2 Optical network expansion and modernization

Improving network programmability is key to enabling seamless optical network automation.

Increased bandwidth and lower latency demands, combined with operators' desires to expand their addressable markets, mean that optical networks need more capacity, speed and flexibility. These needs are being met with increasingly programmable and agile optical networking technologies. Coherent optical engines now support highly programmable bit rate and baud rate tuning, and thus require a greater degree of automation to enable greater network efficiency and adaptability that these features enable. Wavelength switching and ROADM solutions now support a wide range of degrees, contentionless, directionless and colorless switching, and optical layer restoration capabilities, creating the need for automation tools to simplify the processes for network turn-up, reconfiguration and restorations. In addition, areas of the network that are either obsolete or require modernization need to be identified and addressed. Operators need better visibility of their deployed network resources and performance, as well as a planning process that can consider all these factors to better optimize the network, ensure service resiliency and health is sustained to meet the end subscriber SLAs, accelerate time-to-market and grow revenue.

Optical network automation will allow operators to offer greater service differentiation with new business models.

2.3 Evolution to converged IP/optical architecture

New innovations in the IP routing and optical technologies are presenting operators with another opportunity to make converged IP and optical networks a reality. For example, pluggable digital coherent optic (DCO) modules have reduced in size and in power consumption, which allows transport optics to be equipped directly into routers. In addition, innovations in routing technology (such as segment routing, path computation and the disaggregated control plane) introduce network programmability for dynamic traffic management. However, the integration of pluggable optics brings new operational challenges, especially when coordinating network lifecycle management tasks between the IP and optical domains. This necessitates higher levels of programmability and control to enable unified network management, visualization, correlation and optimization across multi-layer, multi-domain network environments.

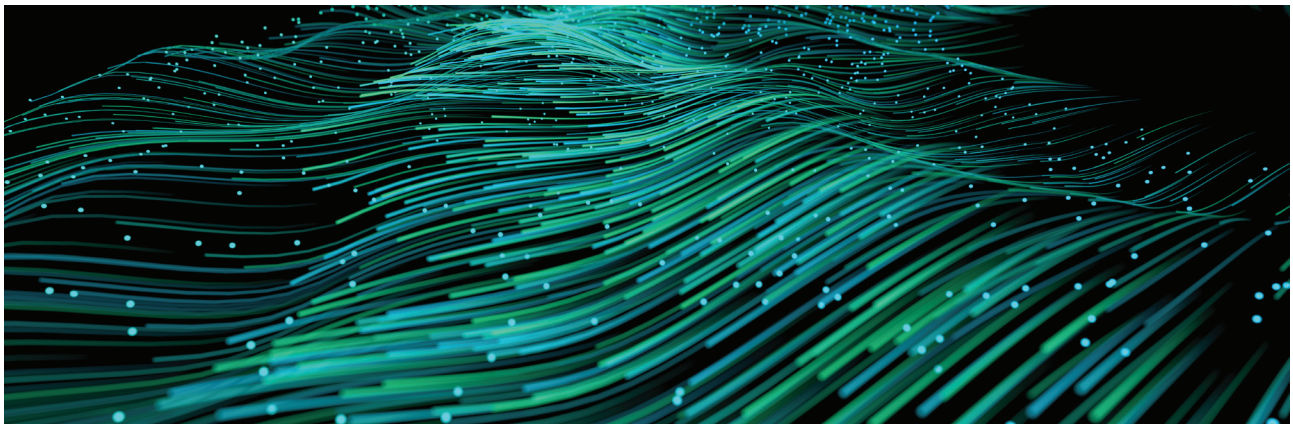
2.4 Shift to open optical networking architectures

The optical networking landscape is evolving towards open architectures as operators break away from vendor lock-in and deploy best-of-breed solutions. Consequently, operators are integrating third-party DWDM transponders into their existing open-line systems. A software-defined networking (SDN) controller can be used to automate and streamline the end-to-end management, multi-domain co-ordination and control partially disaggregated optical line systems. The SDN controller is used alongside an open programmable platform with Open Networking Foundation (ONF) and Transport API (TAPI) interfaces that link external optical domain controllers or external cross-domain controllers (as is typically established for IP/Optical use cases).

2.5 Innovate and monetize new services

Consumer expectations are constantly evolving alongside new technological innovations, which requires operators to respond rapidly to changing demands in real time and to deliver new service instances more quickly. There are also enterprise expectations set by hyperscalers to offer new business models, such as using network-as-a-service (NaaS) to support the creation of new services in minutes. Automation facilitates agility in optical service delivery and allows operators to offer better service differentiation, enabling them to grow their revenue streams and capitalize on emerging trends and opportunities.

3. Methodology



The objective of this study was to develop a model to quantify the benefits of optical transport network automation. This model is based on the inputs from questionnaire responses and interviews with multiple network operators from across the globe, all of which are Nokia WaveSuite customers. The objective of this study is to quantify the achieved or expected benefits in network automation and service automation, in terms of OPEX savings, CAPEX savings, time savings or the ability to generate new revenue.

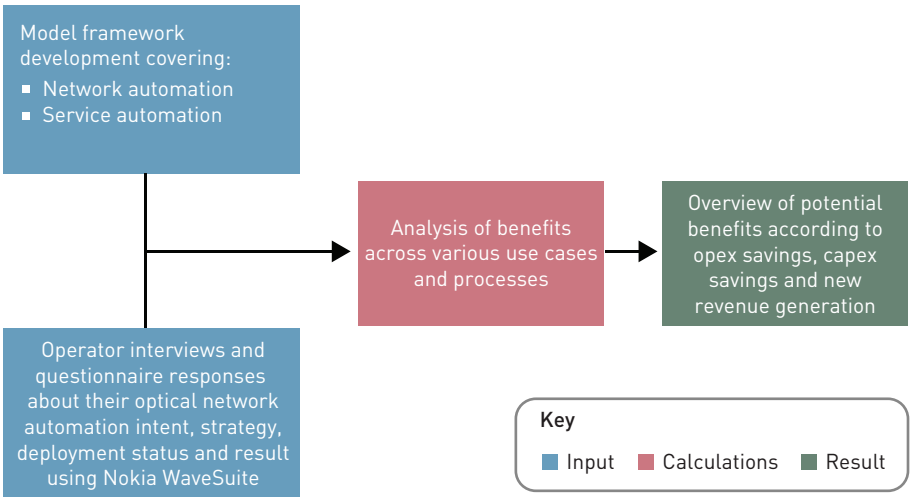


Figure 3.1: Overview of project methodology (Source: Analysys Mason 2024)

4. Quantifiable benefits of automation using Nokia WaveSuite

Operators are using Wavesuite to automate both the network and service lifecycle processes.

WaveSuite optical network applications can be broken down into two areas: **network automation** and **service automation**. Network automation focuses on maximizing operational efficiency and scaling with ease. Service automation focuses on creating more-consumable network services and growing revenue with new business models. Each area is focused on different operational processes and helping to reduce operational costs, ensure efficient use of capital, improve customer experience and increase revenue streams with new service types and business models (see Figure 4.1 below).

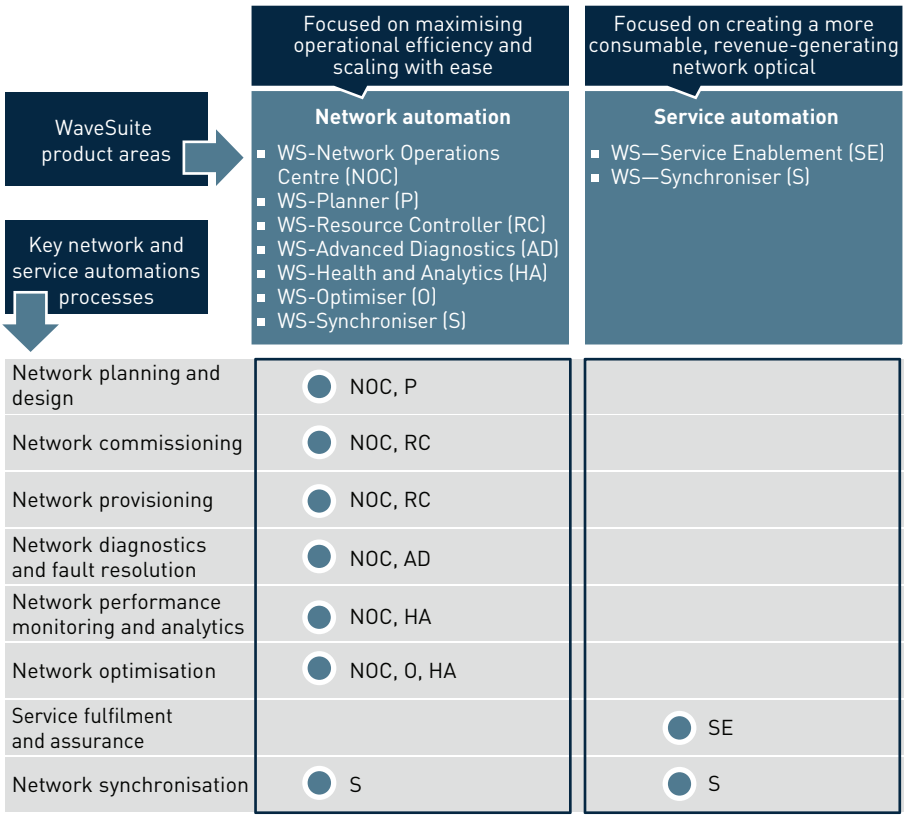


Figure 4.1: The operational areas on which WaveSuite focuses

(Source: Analysys Mason 2024)

4.1 Network automation

WaveSuite Network Operations Centre (WS-NOC) automates network and service lifecycle management processes. These include provisioning, configuration, authentication, node data retrieval, fault alarm display and maintenance routines. WS-NOC reduces the need for manual intervention, allowing operators to accelerate the activation and delivery of new services, which helps to reduce overall operational costs.

Key WS-NOC findings

Zero-touch provisioning has brought the greatest savings in operational expenditure.

- All interviewed network operators had installed WS-NOC. They reported that without its capabilities, they would have been required to make additional operational efforts and manual interventions, which would result in higher operational costs.
- Automation templates in WS-NOC simplify and streamline network lifecycle management processes. This allows operators to maintaining current staff levels and stabilize costs while expanding the number of services and network nodes. **The near zero-touch provisioning capabilities of WS-NOC have also enabled operators to reduce the operational costs of optical network provisioning by up to 81%**.
- **Network operators using WS-NOC have reported that they were able to increase their network capacity by 50% without additional engineering staff**.
- Consolidation of IP and optical teams' software and processes into a single integrated system helped to reduce the costs associated with manual processing between different systems, as well as software development costs and integration costs between different systems. Note, in these instances, WaveSuite is part of a Nokia automation solution in conjunction with the Nokia Network Service Platform.

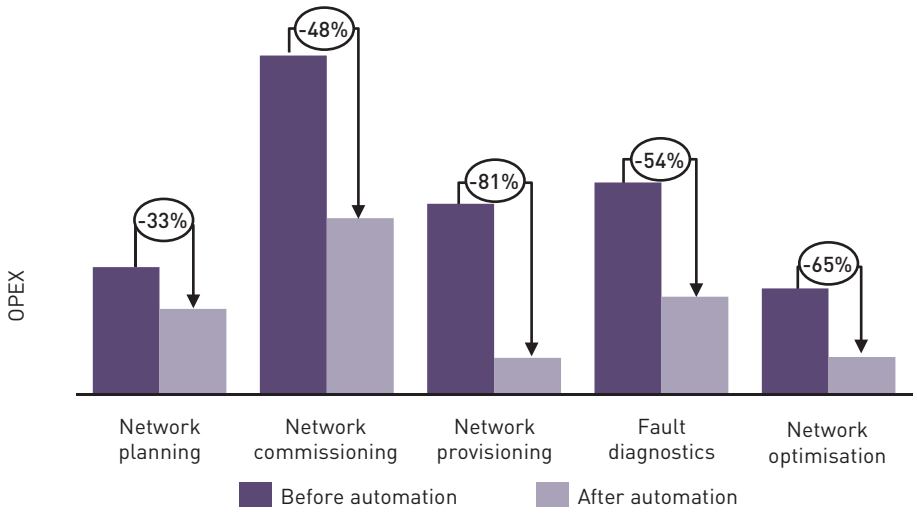


Figure 4.2: OPEX savings expected from network automation, by process

(Source: Analysys Mason 2024)

Wavesuite has helped operators accelerate the network plan-to-build stage of fibre roll-out.

Network planning and design

The WaveSuite Planner (WS-P) has helped network operators to both accelerate the design of the physical network and support accurate network build. Furthermore, WS-P provided data for other WS applications via an API interface, enabling other operational processes to utilize that data. A significant number of fiber network roll-outs are already underway, and WS-P tools provide additional levels of planning that have enabled network operators to offer new capabilities for service protection and restoration using generalized multi-protocol label switching (GMPLS).

Key WS-P findings

- WS-P has helped operators to reduce network evolution planning by making use of capabilities such as automatic uploads and visualization of the deployed network, as well as the automatic generation of bills of materials and provisioning files that help reduce the time needed for network production and implementation processes. **Operators reported up to 33% savings in operational cost savings during the network design and planning stages**.
- Operators claimed that multiple divergent routes in the network have resulted in unnecessary network links and thus a surplus in CAPEX. **WS-P has enabled operators to reduce hardware costs through efficient designs for redundancy and through diverse routing, reducing network capital expenditure on some services by up to 30%**.

CAPEX avoidance in the initial network equipment installation, commissioning and provisioning stages due to more-efficient network design and planning

Network provisioning and commissioning

WaveSuite Resource Controller (WS-RC) supports customer path connection requests in multi-vendor optical networks, as well as multi-domain controller functions, providing a simplified layer with which OSS systems can integrate. It also facilitates the integration of third-party devices and associated systems into single-vendor network planning and optimization systems using standardized interfaces.

Key WS-RC findings

- The ability to more easily integrate coherent, pluggable optics in routers and other multi-vendor systems using a SDN controller brought benefits to network operators in terms of cost reduction and operational simplicity.

Operators were able to save on capex costs through more efficient use of resources.

Operators were able to reduce the costs of the labor associated with the network commissioning process by 48% through automatic configuration and verification of physical connectivity between devices and optical line systems.

- Integrating new third-party equipment and associated systems into a single, vendor-integrated network planning and optimization system meant that some legacy network management systems (NMS) and element management systems (EMS) could be retired. WS-RC allowed the customer to retire their middleware software layer, which had been used to integrate other OSS systems. **This led to 30% savings in CAPEX**.

> We are especially interested in deploying the resource controller because of its API integration capabilities. We intend to leverage those capabilities and make it part of our process itself right from order-to-build process, execute it in automatic fashion and only intervene manually where absolutely required, or if there is a build outward. Based on our evaluation, the programmability aspect of the API layer that WaveSuite can expose about how the network is performing, how it can be managed and how it can be configured, that's a very important capability that is driving us towards adopting WaveSuite.
>
> - Vice President of Transmission Planning, Tier-1 network operator in India

CAPEX savings from the retirement of legacy hardware and under-utilized systems, as well as the integration of new coherent technology

Network diagnostics and fault resolution

WaveSuite Advanced Diagnostics (WS-AD) can be integrated into WS-NOC to enhance fault and performance detection and resolution though the analysis of network data and proactive verification checking.

Key WS-AD findings

- Customers stated that most of their network issues relate to fiber cuts; there are between 300 and 2000 cuts each year. Time and money can be saved by locating and repairing the fiber cuts more efficiently because this type of work represent a significant operational cost (although the time taken to resolve network issues depends on the fiber vendor).
- Overall, operators have found that WS-AD enabled them to quickly identify when and where cuts have occurred. **These efficiencies helped them to improve the meantime-to-repair by up to 54%**.

Improved network visibility allowed operators to guarantee SLAs.

Network performance monitoring and analytics

WaveSuite Heath and Analytics (WS-HA) supports automation and utilizes algorithms to maximize the performance of fiberoptic links and wavelengths. It also provides predictive capabilities in order to potentially pre-empt service issues, and helps network operators ensure that service level agreements (SLAs) are met through the monitoring of KPIs on network management dashboards. WS-HA consolidates real-time data from the network and baselines KPIs into real-time reports, consequently removing the bottleneck of delayed report creation and changes compared to using generic data pipeline systems such as Kafka, which require access to deeper IT knowledge.

Key WS-HA findings

- Customers stated that SLA monitoring was not always in place, or it was only available by customizing their current assurance software. Customers that used WS-HA were able to offer (and monitor) more-stringent network SLAs. This resulted in fewer SLA violations, which led to fewer service delays outages and, ultimately an overall reduction in operational costs.
- Several operators are in the process of establishing a baseline for power consumption and the quality of optical signals (Q-factors) to see if they degrade over time. By using Nokia pre-formed reports, operators were able to reduce the operational time required to create KPI reports.

> “We currently have good visibility of the network but we need to get smarter. We want to be able to predict and analyze the behavior of the network over time, such as fibre span degradation, power consumption and Q-factors, but we do not want to do it ourselves so that is our main driver for H&A adoption. This also helps us with software maintenance – when you develop a product you have to maintain it, so if Nokia has this system, we will leverage that instead of developing it ourselves. This will allow us to free up a lot of man hours and power so that we can focus on other areas.
>
> - Senior Manager of Software Engineering, Tier-1 operator in North America

Network optimizations

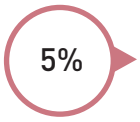
WaveSuite Optimizer (WS-O) extracts real-time data from the network. This means that operators can continually monitor network performance to ensure that the planned design has been delivered. WS-O performs optimization based on links, channels, spectrum and wavelengths in the network.

Key WS-O findings

- Network performance optimizations using new adaptive data and baud rate adjustments available in the latest generations of coherent optical

technologies, combined with automation tools that enable their control, allows network operators to select from a wider range of line rate profiles and channel spacing to achieve higher spectral efficiency and greater **operational cost savings of up to 65%**.

- Nokia customers stated that they performed optimization only during deployments, and not continuously. **This led to a more-efficient use of hardware resources, which means that operators can delay purchasing new hardware and, as a result, save up to 5% of capital costs**.



Additional CAPEX savings from performing network optimisation to enable more-efficient use of network resources

Network synchronization

WaveSuite Synchronizer (WS-S) helps operators to easily manage frequency and phase/time synchronization requirements in their transport networks by providing a network-wide view of the synchronization layer, network elements, KPIs and synchronization inaccuracies. This allows operators to proactively identify faults in the network that are to the result of synchronization errors and to take corrective measures to resolve network issues.

4.2 Service automation

Service orchestration, fulfilment and assurance

Service automation has led to faster quote-to-order and time-to-revenue of new services.

Optical network automation offers several advantages for service fulfilment, including simplifying network operations using service provisioning and wavelength optical route selection. These tasks have traditionally required complex manual configurations, extensive testing and provisioning procedures that often spanned across multiple systems. WaveSuite Service Enablement (WS-SE) enables service providers to abstract service definitions, service definitions, service virtualization and automate network connectivity fulfilment, which results shorter deployment timelines for new services and a faster time to market.

Key WS-SE findings

- Automation has enabled operators to improve the time taken in service order orchestration by accelerating the quote-to-order process from days to hours. **This translates to an average of 90% savings in operational costs**.
- **Operators also reported operational savings in labor costs associated with service provisioning of up to 83%, supporting increased sales with shorter delivery times**. This has led to a faster time-to-market, which has helped the operator to bring the time-to-revenue forward by a week.

- Although operators did not specifically charge for differentiated services (for example, based on latency, protection or diversity), their enablement was critical in securing business with larger, more-demanding and important customers.

> “The process of designing and deploying a new service and integrating it to different CRM systems, billing systems and management systems was taking us about 2 years. Customers with urgent capacity requirements that need to be fulfilled are the ones that took longer because proper analysis has to be done and to see what resources are currently there, what can be used, what impact that will have on other requirements as well. Nokia WaveSuite has the ability to identify common points: it will warn you automatically if you do provision services that will result in commonality.
>
> - Senior Specialist of Core Transmission, Tier-1 operator in Africa

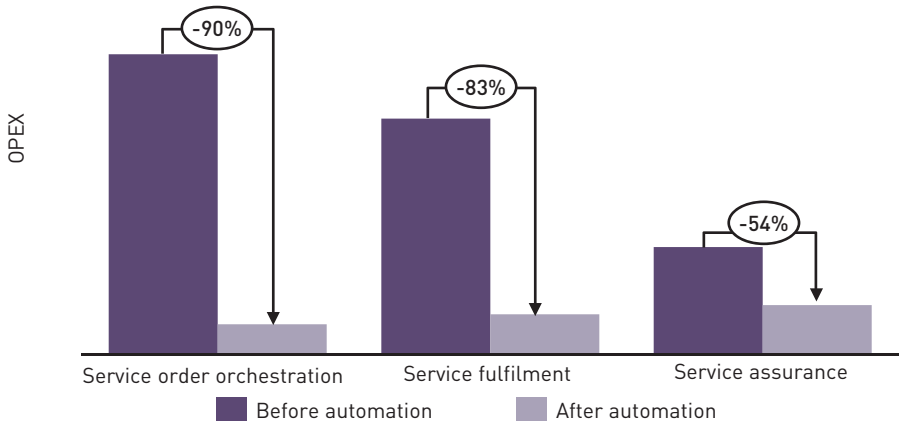


Figure 4.3: OPEX savings expected from service automation, by process
(Source: Analysys Mason 2024)

Opportunities for new revenue generation

Network-as-a-service models provide new opportunities to monetise differentiated services.

WS-SE allows operators to virtualize the network. It also enables operators to work with new business partners using on a NaaS model, as well as support more-complex services such as optical network slicing. The optical network slicing capabilities of WS-SE can be used to provide a copious amount of bandwidth to Layer 1 optical transport network services (OTN), adhering to SLAs, thus enabling operators to offer differentiated services that can be tailored to unique performance requirements.

WS-SE increases revenue potential by using the hierarchical value chain model to virtualize the network and by supporting new services and business partnerships. For example, a physical network operator could sell a virtual slice of its network to a partner. When the partner sells services to its customers, the physical network operator receives revenue without needing to be involved in the partner’s business transactions. WS-SE and associated hierarchical, tenant-based web portals or northbound interface APIs

connecting to OSS/BSS platform applications help streamline the sale of optical services by supporting all aspects of the optical service lifecycle throughout the business hierarchy.

WS-S also provides network operators with the ability to package these capabilities into new "synchronization as a service" (Sync-aaS) wholesale service offerings to mobile network operators, utility/energy grid operators and other end users that require highly accurate synchronization to multiple end-points in their network.

> "Service automation has allowed us to reduce the response times for a new quote from 10 days to 24 hours, contributing to a 5-times increase in win-to-lose ratio. We have been able to reduce the service provisioning time to minutes using WaveSuite.
>
> - Senior Manager of Software Engineering, Tier-1 operator in North America

> "The launch of WaveSuite has allowed us to offer real-time visibility to wholesale clients as a differentiating element of the service.
>
> - Senior Manager of Wholesale and Carrier Business, Tier-1 operator in Africa

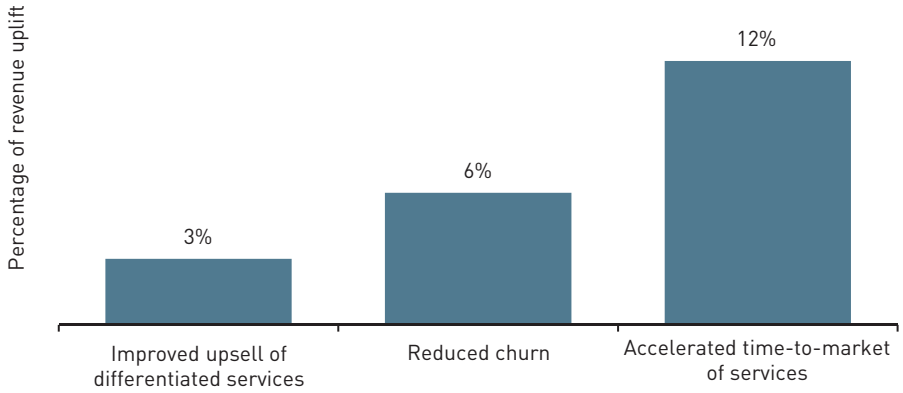


Figure 4.4: Total revenue uplift from network and service automation

(Source: Analysys Mason 2024)

Key WS-SE findings

- WS-SE offers automation-driven optical network slicing, enabling operators to offer a timely deployment of sliced-based services. It also reduces errors and achieves a faster time to market. Although most operators have not yet reached a point where they can automate optical network slicing functionality (because this is not yet one of their key priorities), they see its potential.
- Nokia WaveSuite customers have not yet deployed WS-S alongside WS-SE, but they expect new revenue gains by offering differentiated services via SyncaaS.

5. Summary of total cost savings

Network and service automation enabled operators to shorten the time to provision, configure, deploy and manage optical networks.

The benefits of automation for optical network operations varied significantly among operators because they are at different stages of automation. However, operators reported measurable OPEX savings from using each of the WaveSuite applications.

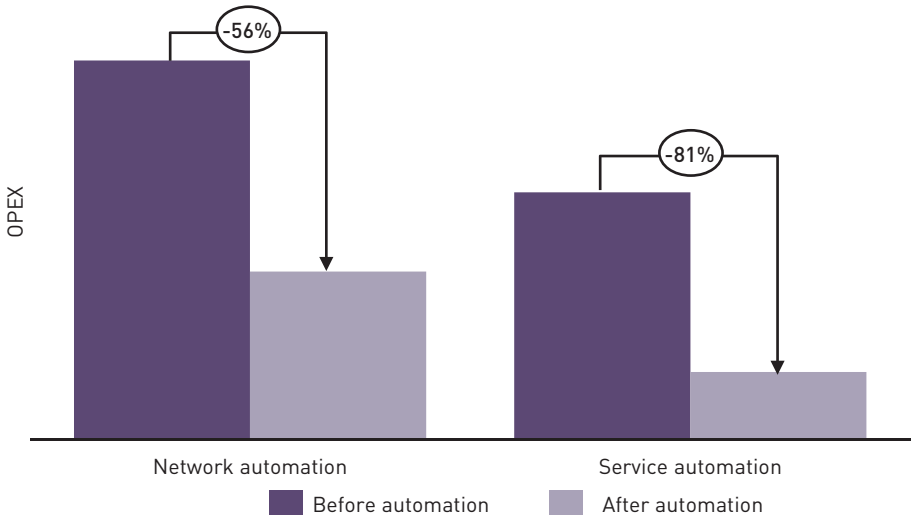


Figure 5.1: Total OPEX savings from network and service automation
(Source: Analysys Mason 2024)

The automation of network lifecycle management processes has led to overall savings in operational costs of up to 56% by simplifying complex network operations tasks, which enabled a shorter time to provision, configure, deploy and manage optical networks.

The automation of service virtualization and slicing has resulted in operational cost savings of up to 81%, due to a reduction in the labor time taken to complete service order orchestration, service fulfilment and service assurance processes.

Many of the operators that we have interviewed are looking to optical network slicing to deliver highly differentiated services such as bandwidth on-demand for enterprises. The ability to provision optical network slices using WaveSuite will enable enterprises to control and manage their own network services in accordance with requirements for latency, QoS and SLAs.

6. Overview of Nokia WaveSuite solutions

WaveSuite is a complete platform for automating optical transport, from access to core and long-haul networks.

WaveSuite is a complete platform for automating optical transport, from access to core and long-haul networks. WaveSuite applications support a wide range of deployment scenarios, including wireless access, public and private cloud connectivity, time-division multiplexing (TDM) transformation and data center interconnect. WaveSuite applications can be deployed individually or in combination with each other to plan, commission, provision, analyze and optimize optical networks. Using these applications will help operators to lower costs, increase the reliability of their networks, help them to go to market with new services more quickly, and finally, to grow revenue.

WaveSuite consists of the following applications.

WaveSuite Network Operations Center enhances the Nokia optical network management software with more openness and functionality. It delivers optical network services faster, ensures service protection and restoration, visualizes networks more clearly and helps to rapidly integrate equipment.

WaveSuite Resource Controller performs SDN controller functions across multiple domains and vendors in the optical network. It optimizes network asset utilization, supports open network initiatives and seamlessly operates multi-vendor network environments.

WaveSuite Health and Analytics provides real-time network intelligence to make more-informed decisions. Developed in partnership with Nokia Bell Labs, it combines expertise in optical networks and data science, including AI and machine learning (ML) algorithms. It can be used to maximize fiberoptic link performance, predict network issues and reduce network disruptions.

WaveSuite Advanced Diagnostics enhances the diagnostic capabilities of WaveSuite Network Operations Center with a troubleshooting automation engine. It rapidly identifies and resolves issues before they impact SLAs, and precisely locates and isolates fiber impairments.

WaveSuite Synchronizer provides control for the entire network synchronization infrastructure. It simplifies the distribution of precise frequency, phase and time synchronization information, and enables operators to monetize network synchronization capabilities.

WaveSuite Optimizer maximizes network performance and enables proactive planning through multi-layer scenario analysis for when unexpected events occur. It efficiently manages the optical network and improves spectrum utilization to deliver maximum capacity and value.

WaveSuite Planner facilitates efficient optical network design, planning, layout and analysis. It simplifies the design process between multiple teams, ensures synchronization between network designs and the physical network, and accommodates optical termination points such as card-based interfaces, coherent pluggable optics such as 400ZR/ZR+ and beyond, alien wavelengths and multi-vendor open photonic networks.

WaveSuite Service Enablement helps to increase revenue without increasing CAPEX. It unlocks revenue potential through patented B2B2X software models, enables network virtualization and facilitates new services and business partnerships based on the optical NaaS business model.

Nokia offers optical professional services to complement its products, which support unique customization requirements with both system integration and digital transformation services, including business process-driven workflows, network test automation, northbound integration, and multi-vendor integration. It also offers digital twinning as-a-service. Nokia also offers a developer portal to help network operators efficiently program and automate their networks, quickly develop connected applications and easily integrate with OSSs, including API reference documentation, Swagger tools and code snippets.

7. About the authors

Justin van der Lande (Research Director).

Justin leads the Applications practice. He specializes in business intelligence and analytics tools, which are used in all telecoms business processes and systems. In addition, Justin provides technical expertise for Analysys Mason in consultancy and bespoke large-scale custom research projects. He has more than 20 years' experience in the communications industry in software development, marketing and research. He has held senior positions at NCR/AT&T, Micromuse (IBM), Granite Systems (Telcordia) and at the TM Forum. Justin holds a BSc in Management Science and Computer Studies from the University of Wales.

Michelle Lam (Analyst).

Michelle is a member of the Analysys Mason's Applications research team in London. She leads the Network Automation and Orchestration programme. Her research focuses on competitive and strategic challenges in the evolution to next-generation networks that are highly autonomous and orchestrated by software-defined networking and network virtualization principles. In addition, her research provides critical insights into the prospects for established and emerging network management, automation and orchestration products and related professional services. She holds a BSc in Physics and an MSc in Quantum Technologies from University College London.

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