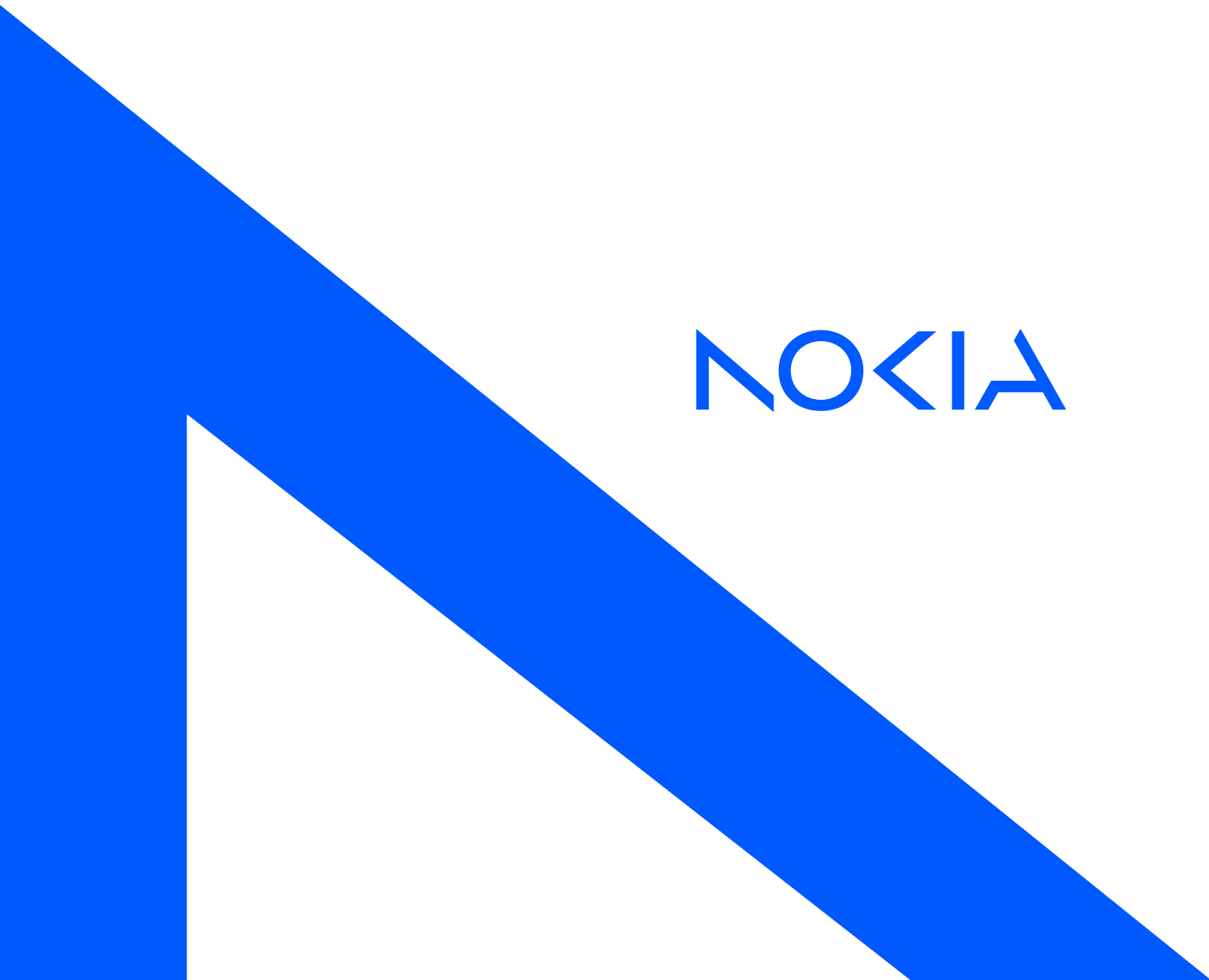
Software-defined access networks

Application note



Contents

Complexity, the key challenge for CSPs

Through years of rapid growth – in subscribers, in services, in traffic, and in demand for bandwidth – fixed access networks have become vastly more complex environments: multi-technology and multi-vendor, with growing numbers of small, remote and widely distributed access nodes. This complexity is also reflected in the way access networks are monitored, planned, upgraded and maintained.

In the not too distant past, it was simple; there was just one communication network: the plain, old telephony system and it came with an element management system (EMS) from the supplier to run the network and its services. Since then, the tool kit for communications service providers (CSPs) has diversified spectacularly with different broadband technologies to connect customers in the fastest or most economical way. New service development and change cycles require significant time and expertise, and operators face a long wait time before starting new OSS projects.

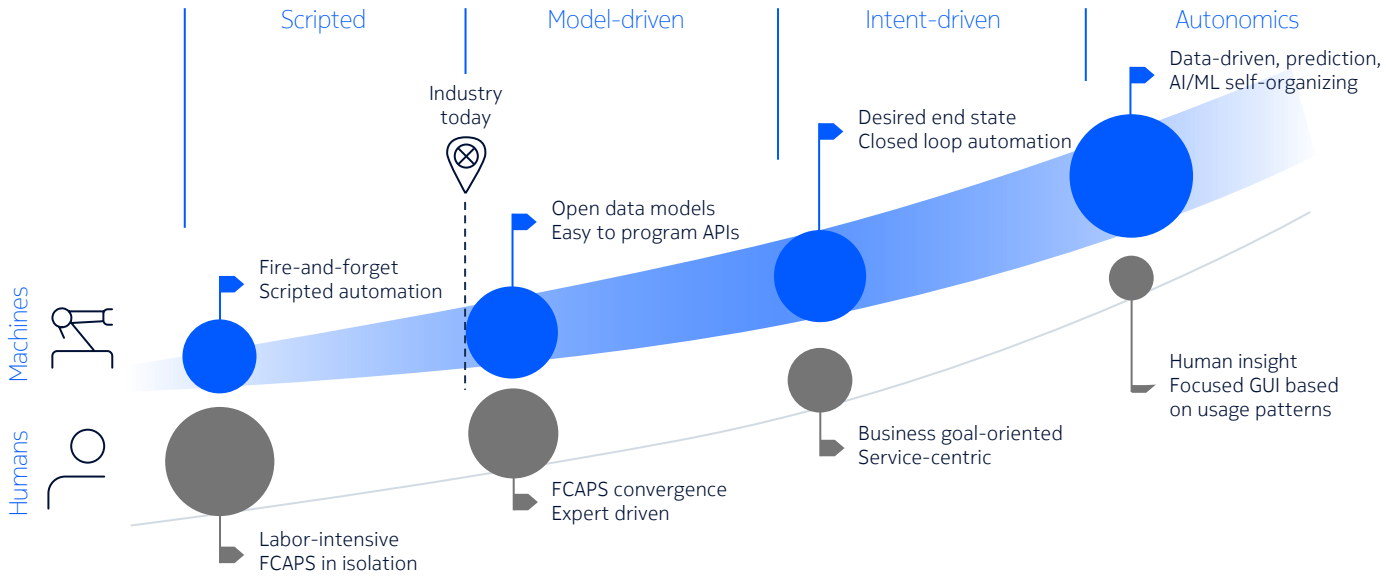
CSPs need to find ways to simplify their networks, operations support system and processes, so that they can gain operational efficiency, improve agility and keep costs in check. Nokia's answer to this challenge is the software-defined access network (SDAN), which enables operators to use the principles of software-defined networking (SDN) and network function virtualization (NFV) to eliminate the operational barriers between IT and access.

Taking incremental steps in automation

Automation is key to deal with network complexity. In the telecom industry, automation and process improvements started already early when automated telephone exchanges came into existence and a telephone operator no longer had to manually connect calls with cord pairs on switchboards. Since then, automation has never ceased. While the industry has become more effective than ever, the knowledge and skills of human experts in the exploitation of networks has never gone away. Humans take care of an overwhelming number of tasks to deliver the best possible broadband experience. The operational landscape is complex, laborious and demands fast reactions to keep everything running smoothly. As shown in Figure 1, we see the modern broadband industry as being less than halfway in a four-phase journey of applying more automated and intelligent control over networks, where transparency and openness becomes indispensable to realize successful network autonomics.

- The **first phase** is characterized by scripted, proprietary, network-centric systems with point-and-click management systems, which are extremely inflexible and where every action needs endless human intervention for each technology and vendor stack. New features or services do not reach CSPs fast enough.
- To advance to the **second phase**, the industry has coalesced around the adoption of open APIs. Nokia contributes widely to open initiatives and standardization bodies to create common data models for the industry to work with. Open APIs make networks easily extensible with different technologies and vendors. Standardization and interoperability are fundamental to save resources for both operators and vendors, as they are freed from endless integration and testing cycles and can focus instead on innovation and customer value.

Figure 1. Taking the next steps on the journey towards autonomic networks



- At the model-driven stage, the programming is still imperative (if x, do y) and network centric. Now, the industry is heading into the **third phase**, where networks are operated in a more intuitive way. This will see us applying intent-based automation where the CSP defines service-centric policies and the network will be able to self-adjust, automatically find misconfigurations, and fix them via audit facilities and coordinated control loops. This allows the automation of repetitive and dynamic processes that are a drain on CSP's resources.
- The **fourth phase** is a more self-aware, self-governing, data-driven network that applies artificial intelligence (AI) and machine learning (ML) to automate operations, predict and prevent issues, and provide detailed analysis for anomaly detection, action recommendation and capacity planning. CSPs get better insight into the customer experience, while the need for detailed inspection by human experts is reduced. Nokia sees AI/ML as an incremental evolution of network automation capabilities.

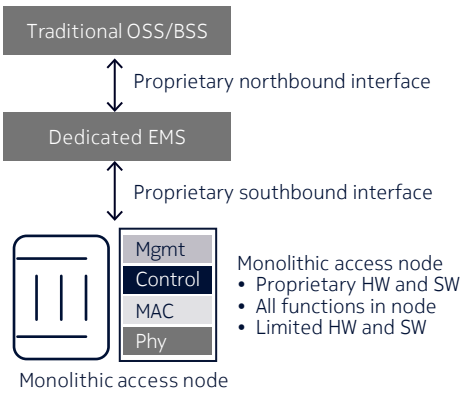
Constraints of traditional networks

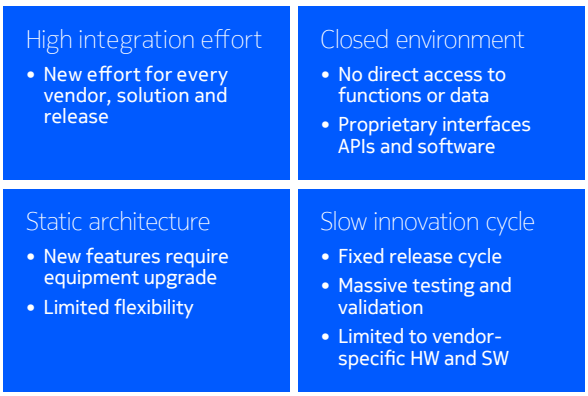
Today's networks are typically made up of monolithic, hardware-centric systems with proprietary interfaces that are exposed to operations and business support systems through vendor-specific EMS. Limited functionality gets exposed via proprietary interfaces (= black box). The tight coupling of hardware and software within network elements creates many challenges for network operations and network automation. Every new service, network enhancement and upgrade a CSP wishes to deploy must be extensively tested across different platforms creating a vast number of permutations in the OSS, leading to long and costly development cycles.

This static and closed design makes it difficult and expensive to expand fixed access infrastructure, integrate support systems, and create new services. It forces CSPs to develop services for each vendor or wholesale solution and spend time integrating each interface within the OSS. If CSPs want to evolve a network solution, they need to give specific attention to different boxes from different vendors for moves, changes, deployments, and upgrades. These extra steps slow the pace of innovation.

A more advanced level of automation is needed to help simplify operations, reduce human error and boost productivity. Automation assists with the increased amount of options, technologies, parameters and dimensions to optimize.

Figure 2. Today's closed proprietary networks are difficult to evolve



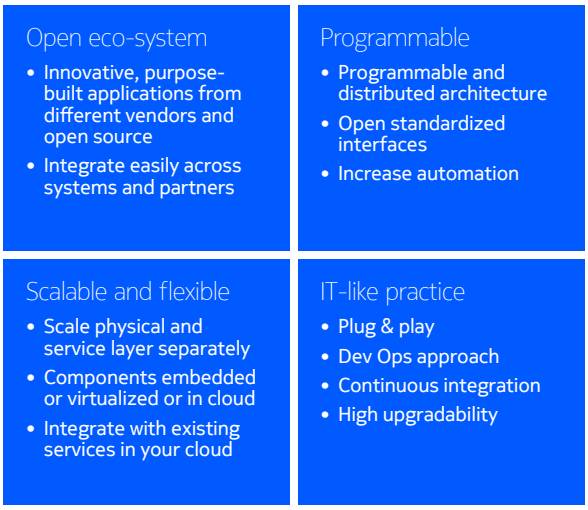


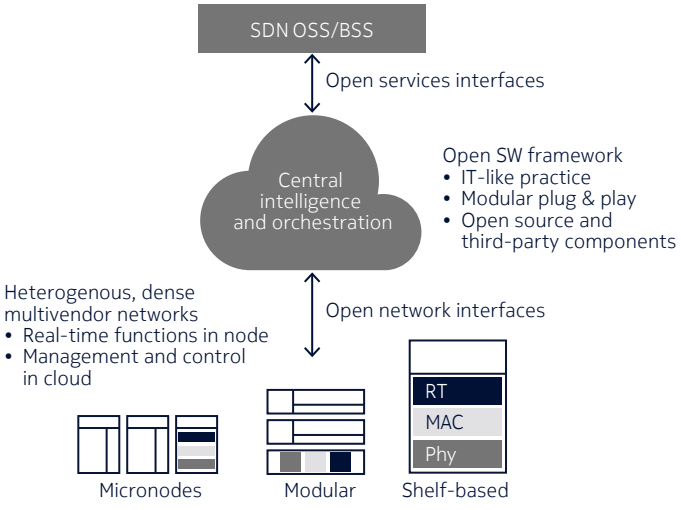
Key principles of SDAN

SDAN enables CSPs to support the changing demands of businesses by mixing traditional connectivity and cloud-based services. From the software, all the way down to the hardware, SDAN decomposes applications to bring forward open, disaggregated data-centric architectures. SDAN enables:

- **Programmability**. Networks are controlled by software functionality, allowing network operations to be automated and adapted in a flexible way.
- **User plane separation**. Separation of the management plane from the forwarding plane allows new services and behaviours to be introduced across underlying hardware.
- **Abstraction**. Operations are abstracted from implementation logic, simplifying provisioning and troubleshooting processes, and maximizing portability in the face of future network evolutions.
- **Central control**. Centralized network intelligence allows decisions to be made based on a global view of the network, facilitating rapid network changes and rollout of network services.
- **Open standards**. Open standards and open APIs for programming the network enable innovation and differentiation by CSPs.

Figure 3. SDAN enables CSPs to build open, programmable, and highly flexible networks





Virtualized network functions

SDAN realizes the evolution of hardware-based networks to software-defined platforms with much of the functionality virtualized. SDAN separates the control and management plane from the forwarding plane: this makes the access network open and programmable and disaggregates the hardware and the software development cycles.

By adopting data center principles, CSPs can rethink central office design and create new engineering options, where part of the network functions can run in the cloud, and scale elastically in response to demand. It allows to react to changing demands or usage trends, increase network performance, and minimize service impact during software upgrades or equipment replacements.

Open and programmable

SDAN introduces open and programmable APIs to create well-defined modular components. CSPs can benefit from programmable solutions, which are easier to customize for their existing IT operations and cloud infrastructure. This programmability creates a foundation for a high degree of automation, high upgradability, and service creation in true DevOps style. The use of open APIs and standardized protocols eliminates the challenge of integrating multiple proprietary interfaces with the OSS/BSS.

The role of NETCONF/YANG

The industry-wide adoption and standardization of NETCONF/YANG is vital for automating the network. It provides several benefits which cannot be natively delivered in traditional SNMP networks:

- **NETCONF/YANG is cloud-friendly**. Devices connect to their manager with call home and strong security models for authentication, integrity, and confidentiality are supported by design.
- **NETCONF/YANG is easy to program and automate**. ACID (Atomicity-Consistency-Isolation-Durability) properties for the transactions are guaranteed, so no micro operations nor manual rollbacks are needed. The full transparency allows easy integration with other components.
- **NETCONF/YANG fits the IT environment**. A rich ecosystem of IT tools becomes accessible for interacting with the network. The network is no longer the exclusive realm of experts.

Data-centric cloud architecture

SDAN is about more than supporting a new protocol like NETCONF. SDAN uses a data-centric cloud architecture that enables an always-on network. The authoritative source of data is in the cloud and not in the individual network elements. All configuration, performance and diagnostic data – including logs and alarms – is centralized in a common data lake.

Configuration updates can be made to network elements at any time, even when devices are off-line or not installed. When the device comes into service it is synchronized with the latest configuration changes. With continuous versioning of the database in the cloud, daily backups of network elements are unnecessary. The network can be instantly restored to any point in time without executing complex backup retrieval and restore procedures.

Similarly, troubleshooting information can be accessed in the cloud at any time, regardless of the operational state of the network elements. Instant access to all data at any time means much more complex and powerful analysis and diagnoses can be performed. In addition, in the event of a service outage, diagnostic data is usually lost in a traditional network, sometimes making it impossible to determine root cause. In SDAN, the data remains available for analysis after a network reset.

The access to big volumes of centralized data is vital for analytics: common data lakes avoid the fragmented and incomplete view over inherently distributed data and uses non-proprietary data sets (config, logs, alarms, counters, time series) to enable direct comparison for AI/ML algorithms. This new paradigm enables incremental steps in automation: event management workflows, closed-loop automation, anomaly detection, automated incident resolution, noise reduction, prediction, correlation and self-organizing dynamic networks all become possible.

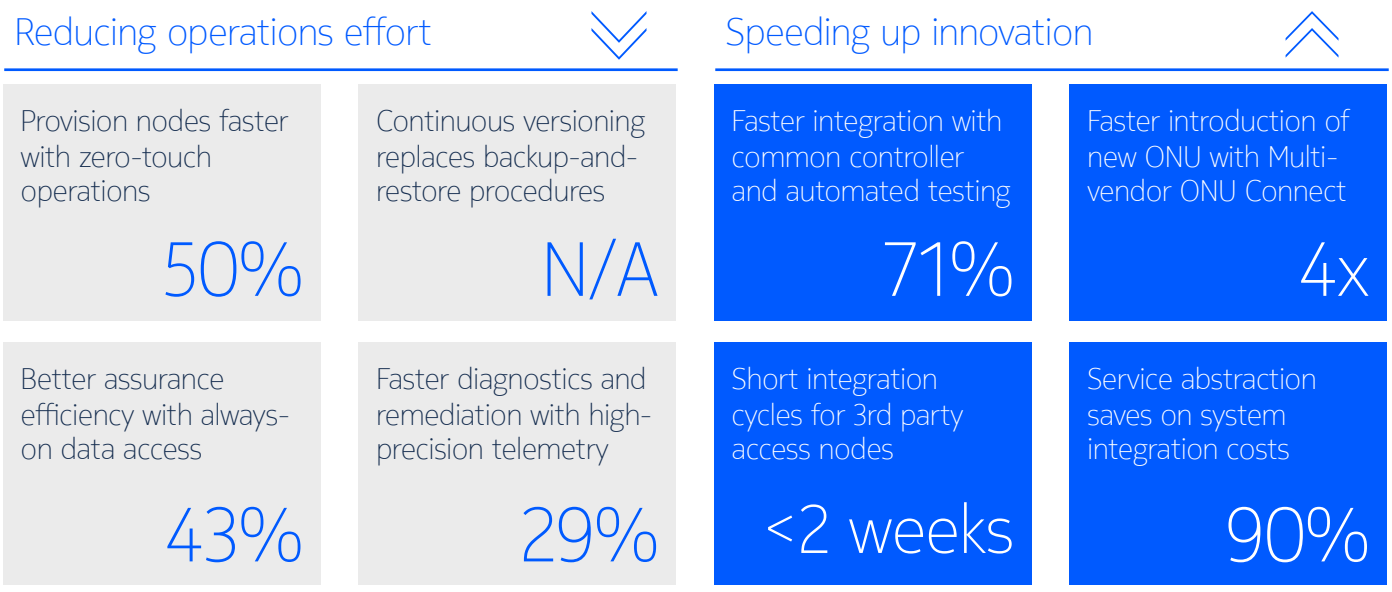
Quantify the operational savings

Overall, key SDAN benefits are related to automating repetitive and manual complex tasks while improving execution quality. The promise of simplified network operations translates into OPEX savings in FCAPS (Fault, Configuration, Administration, Performance and Security) routine tasks. While CSPs have a sense of where the value could come from, quantifying it is complex. Nokia can help CSPs with a thorough economic analysis to identify and quantify SDAN benefits. Based on analysis performed jointly with CSPs, typical FCAPS savings for CPSs are between 25% and 40%.

The modelling shows that OPEX is reduced significantly by using open device models and building automated test suites. Traditional EMS systems were designed for human operators running networks that required little reconfiguration. While some workflows can be automated in legacy systems with the help of scripting and robotic process automation, there are clear limitations since neither data collection nor configuration changes of a traditional EMS can support real-time automation. One of the underlying reasons is that network data is processed multiple times across different applications before any relevant insights can be derived. As discussed, these issues are resolved through having a common data lake, accessible for analysis and automation processes at all times.

The open programmable interfaces and modular architecture allow faster introduction of new capabilities, new services, new technologies, new releases and new applications. SDAN makes changes, upgrades and device replacements much easier, and reduces operational expenditure for the overall solution. It enables better insights for pro-active operations, faster diagnostics and remediation with high-precision telemetry and predictive care.

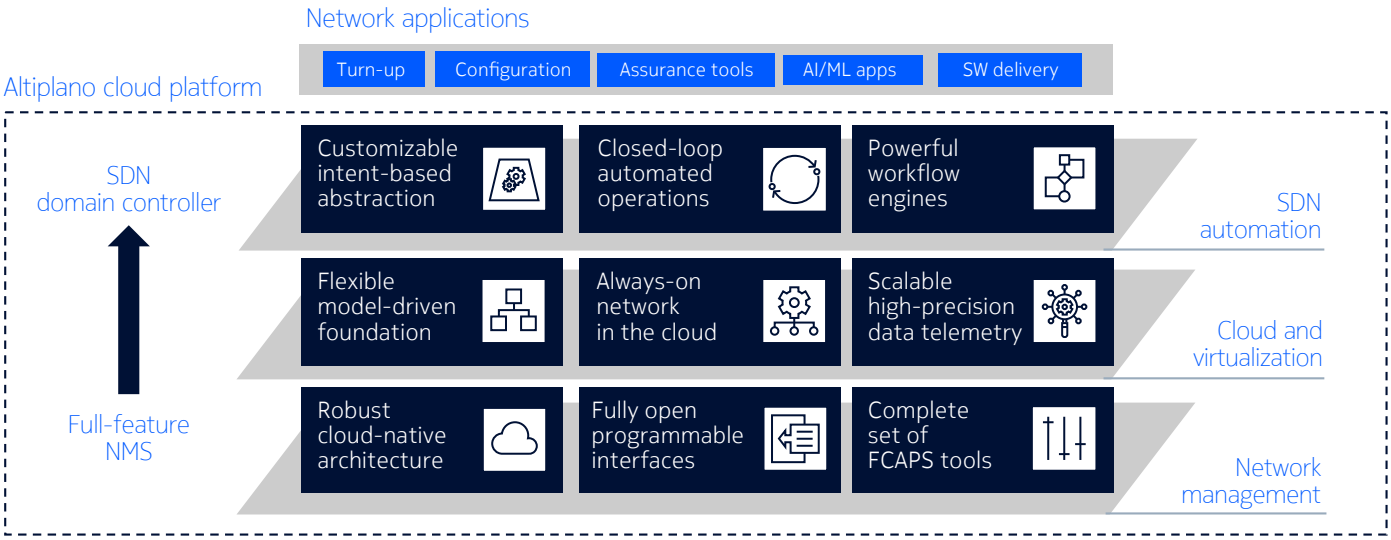
Figure 4. SDAN benefits in facts and figures



Flexible deployment options

The heart of Nokia's SDAN solution is the Nokia Altiplano Access Controller, which moves the center of gravity for application and service deployment for the fixed network into the cloud. Altiplano is a genuine clean-sheet transformational step that replaces traditional practices with a lean, lower-cost design for fast feature delivery.

Figure 5. Nokia Altiplano, a complete suite of management and SDN control functions



Deploy the management and SDN control functions you need and have a path to grow the platform as new requirements arise.

Altiplano Access Controller

The Altiplano platform offers a complete suite of network management functions as well as SDN control that operators need to run a broadband network. It provides CSPs with a single view to manage fixed services, leveraging policy-driven zero-touch operations, powerful intent life-cycle management and real-time automation through open APIs across a multi-vendor, multi-technology environment.

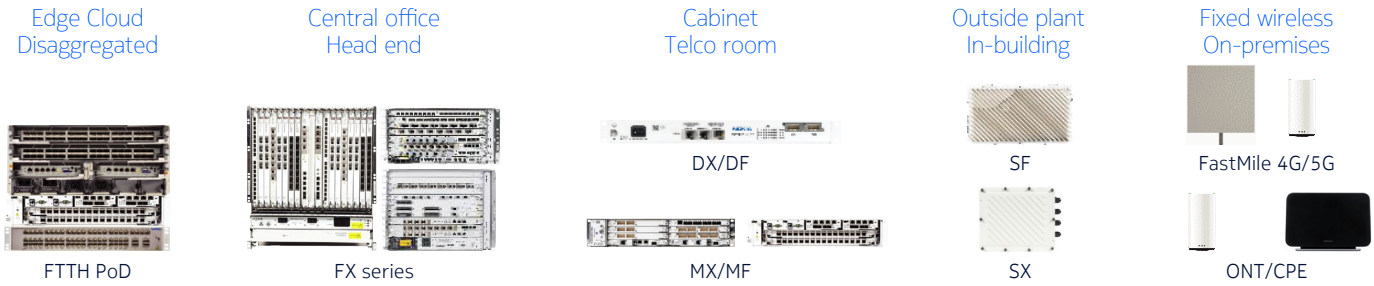
The Altiplano platform caters for various OSS environments with a rich set of protocols and integrates easily with common IT tools and open-source best-practices. The open software framework is designed to be extended and customized, and targets both human operators and M2M automation. It enables CSPs to build a zero-touch network that is truly always-on, with full-time availability for all functions and services that the network needs to provide.

The highly modular software decouples applications from their configuration and operational data, and offers a versatile set of discrete microservices for network management tasks: intent-based automation, network provisioning, service fulfilment, service assurance, software upgrades, high-precision telemetry, system integration and network planning, among others. The platform provides the logic and primitives to efficiently program and monitor hundreds of thousands of nodes. Altiplano also comes with a software development kit (SDK) which allows operators to onboard their own network applications, build extensions and engineer a custom management and control solution. This can include both open-source and proprietary components and can be a mix of Nokia-provided and operator-owned microservices.

SDN programmable access nodes

Nokia supports every fixed access technology, allowing the CSP to use whichever technology makes most sense in any given deployment. The SDN-programmable access nodes include copper, fiber and fixed-wireless access technologies.

Figure 6. Nokia SDN-programmable access nodes



Different form factors can satisfy different use cases; from outdoor sealed nodes and cabinet deployments, to smaller stackable nodes, data center-inspired PoD designs and large chassis-based access nodes. Through considered rearchitecting of industry standard designs, software and hardware of the traditional node architecture are disaggregated. This enables independent development/ validation cycles of the solution components, and delivers more flexible pay-as-you-grow deployment models. The transparent APIs, the modular node software, the decoupling of ONU management and the flexible YANG-based device modeling transform the access network into a programmable infrastructure. Because access node functions are more flexible than those in traditional network elements, it is easier to change and customize functionality to match the CSP's desired operations model. This allows fast feature delivery and easy integration with less functional limitations, customization bottlenecks or change cycles requiring recompiling of monolithic node software.

Many technology options exist but it is important to simplify and converge the deployment and operational models and enable a unified broadband strategy over wireline and wireless networks.

Unified management

A binary switch from a traditional to a full cloud environment is an impossibility. In order to protect investment in the installed base and its existing services, CSPs must be able to roll out software-defined functionality in phases and ensure a smooth transition. Understanding that a hybrid physical/ virtual network will be a mid- to long-term requirement, a key consideration is the ability to have a single management system for both environments. Otherwise the CSP's life in the cloud becomes more rather than less complex.

Nokia Altiplano provides such unified management. It offers options to gradually introduce new deployment models reusing existing management interfaces. It lowers the integration costs by serving as the single management interface for the OSS/BSS. The SDN controller abstracts the service implementation logic across different operational models, vendor device implementations and hybrid SDN networks, decoupling the OSS from the broadband technology complexity. The software can manage different protocol implementations (NETCONF or SNMP). It provides SDN control for SDN native nodes, but also for traditional equipment and third-party element management systems, which lack the APIs

for automation and have only limited monitoring and customization options. The controller is able to accommodate all this, pulling together various data sources and management systems from different suppliers. This orchestration is needed to federate provisioning and monitoring across large, hybrid traditional-SDN networks.

With Altiplano, powerful intent-based automation helps CSPs to define the outcome they want to achieve in terms of a service definition or SLA, and the network will automatically configure to support it across any technology environment. Intent-based networking decouples what is needed (the intent) from how to achieve it. Without the need for the OSS to micro-manage everything, the network can be more intuitive about resolving requests, translating a service requirement into an implementation.

Intent is effectively a new abstraction layer within the network management hierarchy. An intent represents a business goal such as provisioning network infrastructure or setting up the IPTV service for a specific customer. The network will self-monitor and auto-adjust when it finds itself in a sub-optimal state compared to the intent. This makes intent-based networking ideal for automating repetitive and dynamic processes that are a drain on operators' resources. Intent-based networking helps apply consistent operations and create a more adaptive network. With it, CSPs can:

- **Increase business agility**. Easy introduction of new services and apply changes rapidly and consistently.
- **Optimize OPEX**. Automate network operations and reduce time-consuming manual interventions.
- **Improve service assurance**. Help human operators to view, analyze and manage service availability.
- **Increase programmability**. Break down complex configurations with a customizable approach.

Use cases

Zero-touch operations

SDAN can be used to automate the provisioning and management of access nodes. CSPs can configure nodes from a central location and all at once, even if the nodes are offline. The zero-touch reduces the time and expertise required of field staff by supporting automated turn-up, provisioning, upgrades and effortless device replacement. This increases flexibility for deployment: it allows installers to pick equipment and avoid local provisioning. The automated verification and comprehensive consistency checks reduces errors and detect mismatches between Planning & Inventory and physical equipment.

Automated subscriber activation

SDAN reduces activation costs, accelerates time to market, and improves quality of service by automating the activation of optical network terminals (ONTs). With SDAN, CSPs can automate the subscriber activation, adds, move or changes. Configurations can be applied automatically when the device is powered on. The customers and field technicians can activate ONTs with virtually no errors by following a simple process on a smartphone or PC.

Network slicing

Network slicing allows CSPs to partition the physical network into multiple virtual networks, or "slices." Each slice can be independently controlled to address the needs of a specific CSP or application. Slicing is achieved through network abstractions presented as an SDN-programmable infrastructure. SDAN allows CSPs to manage virtual devices as easily as physical devices in a centralized and secure manner. It allows CSPs to share the network with Virtual Network Operators (infrastructure SDN for wholesale) or offer a unique transport SLAs per tenant, per service or per service class (service SDN for 5G slicing).

Fixed wireless access

Another application is the design, installation and operations of fixed wireless access (FWA) solutions. Operators need to manage, provision and monitor the service health and perform device management to ensure minimum guaranteed wireless throughputs. Altiplano allows to manage the coverage of the cell sites, determine the best position of the wireless gateways & optimize the radio planning. The controller also uses real-time cell info, which means that it can do service optimization using intent-based networking. During operations it helps to auto-pair with the best serving cell, re-assign the connection in case of cell site outages or steer traffic to less loaded cells when congestion occurs.

Multi-vendor networks

Altiplano can easily manage 3rd party equipment in a multivendor set-up. Altiplano supports a vendor agnostic device management for any type of equipment, whether it's legacy or SDN. This is all thanks to the flexible device modeling and powerful software plugins that allow to easily extend the platform capabilities. Altiplano can also support virtual OMCI that decouples ONU management software from the OLT. Rather than having one OMCI continuously modified to manage all OMCI permutations, CSPs can choose any ONU from any vendor and add its unique OMCI code into the cloud. This flexibility reduces costs and lets CSPs deploy new services and innovations much more quickly.

Nokia commitment to open and standard

Nokia strongly commits to collaborating with open industry initiatives and standard bodies to increase solution interoperability. Openness at all layers of the network speeds up the pace of innovation and avoids lengthy integration cycles.

Openness also decreases vendor lock-in as CSPs can mix and match the best components. Open solutions are also more transparent and offer high levels of security and quality compared to closed proprietary solutions. In the shift from a proprietary management model to an open management model, open source plays an important role in creating open and interoperable fixed access networks. Open source code is excellent for accelerating proof-of-concepts and validating use cases. The iterative approach of open software architectures helps to renew the focus on implementation rather than exclusively on specification development.

That said, standardization remains extremely important for ensuring compatibility between different implementations. That is why Nokia champions standardization efforts in the BBF and ETSI NFV while simultaneously engaging in initiatives such as Open Broadband-Broadband Access Abstraction (OB-BAA), the Open Network Automation Platform (ONAP), and the Open Networking Foundation (ONF).

Open source has become an integral part of Nokia's R&D process. Best-in-class open software practices and IT tools were heavily used in building our Altiplano framework. The modularity lets CSPs mix and customize Nokia micro-services, 3rd party products and open source solutions, and allows easy integration with existing cloud services to maximize synergies.

Nokia also run an OSS Connected Partner Program to support the specific management and control needs of operators in a highly dynamic OSS landscape. Under the program, best in class independent software vendors (ISVs) work closely with Nokia to proactively integrate their OSS applications with Nokia Fixed Networks solutions and share expertise on how to maintain interoperability.

Nokia is committed to taking an open path and is also a leader in bringing these concepts to standardization and open community-driven ecosystems. It's increasingly evident that open software architectures will renew the focus on true product differentiation and stimulate collaborative development between telecom vendors and service providers.

Conclusion

Any CSP embarking on a modernization program or upgrade should consider what SDN and NFV in broadband access can bring to the table. By adopting software-defined principles, CSPs can bring more automation to their operations, make smarter decisions, and innovate faster.

It allows fixed network operators to take full control of their network assets: wireless and wired access, cloud resources and network services. With more than 250 cloud-ready customer deployments, Nokia has the ambition to be a leader in cloud-based access, systems integration and advanced automation. We are uniquely positioned to pursue this goal, leveraging unique Nokia portfolio in cloud, SDN/NFV & networks, and many years of broadband transformation expertise.

Our approach to software-defined access networks helps CSPs to support the changing demands of their businesses – and win new business for themselves. We are collaborating with CSPs to address real-life use cases and help them transition at a pace which makes sense to them. It is really about how a CSP goes about creating value with cloud technologies while breaking down networking silos and dated operational practices along the way.

Abbreviations

BSS	Business support system
CSP	Communications service provider
EMS	Element management system
NFV	Network functions virtualization
ONU	Optical network unit
OPEX	Operational expenditure
OSS	Operations support system
SDAN	Software-defined access network
SDN	Software-defined networking
SNMP	Simple Network Management Protocol

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

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