Accelerate the digital rail transition journey with agile data center fabrics

Where railway OT meets cloud

NOKIA

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Railways need high adaptability to navigate the challenging landscape

As the railway industry faces rapid changes, adaptability becomes paramount. Rail operators are in a state of transition—evolving infrastructure operations towards a software-based and data-driven paradigms. They're not only digitalizing physical trackside assets, rolling stocks and stations but also revamping their digital infrastructure using cutting-edge cloud technology for a higher degree of automation and to embrace emerging technologies including artificial intelligence (AI). The goal? Greater flexibility, responsiveness, sustainability, and agility for future growth.

Due to a combination of growing demand for sustainable inter-city travel and freight transportation and the need to provide enhanced passenger-centric mobility service while ensuring a higher level of safety and security, the rail infrastructure is under momentous strain today.

Capacity and sustainability constraints

Passengers and freight shippers alike are demanding efficient and sustainable transportation options. They want to reach their destinations faster and on-time with reduced emissions. To resolve this challenge, rail operators need the agility to schedule more trains running at higher speed with increased energy efficiency without jeopardizing traffic safety as demands rise and ebb. To do that they need to enlist the power of automatic train operation.

Resilience, reliability and responsiveness

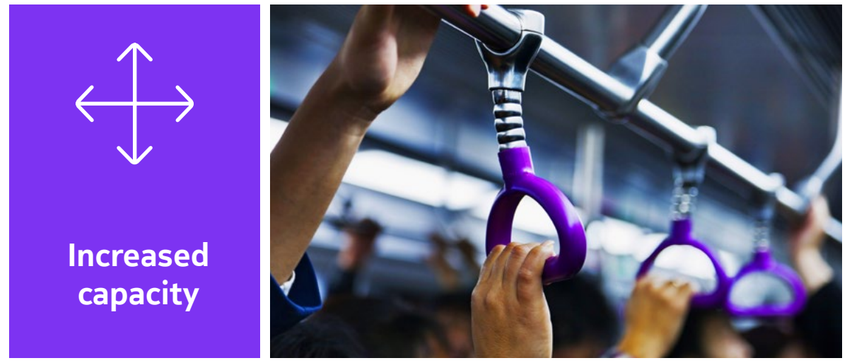
With more frequent and severe weather events, as well as industrial incidents, disruptions to mobility services are rampant. Unpredicted rail system failures also cause service outages and cancellation. Rail operators need deeper insights into the track conditions, weather information, and real time intelligence to respond effectively to inclement changes in operating conditions. Predictive maintenance and intelligent traffic management systems play a crucial role in ensuring resilience, reliability and responsiveness.

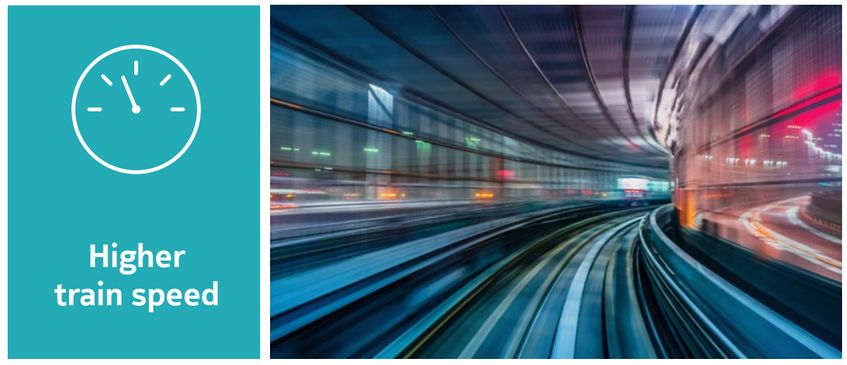
Customer-centric service

With heightened customer expectations driving rail operators to prioritize passenger-centric services for seamless journey experience, rail services must cater to passenger needs. A customer-centric approach not only enhances satisfaction but fosters greater loyalty.

In this dynamic railway landscape, rail operators must be agile, resilient and forward-thinking. The journey ahead demands an adaptable, digital rail system.

The changing railway landscape





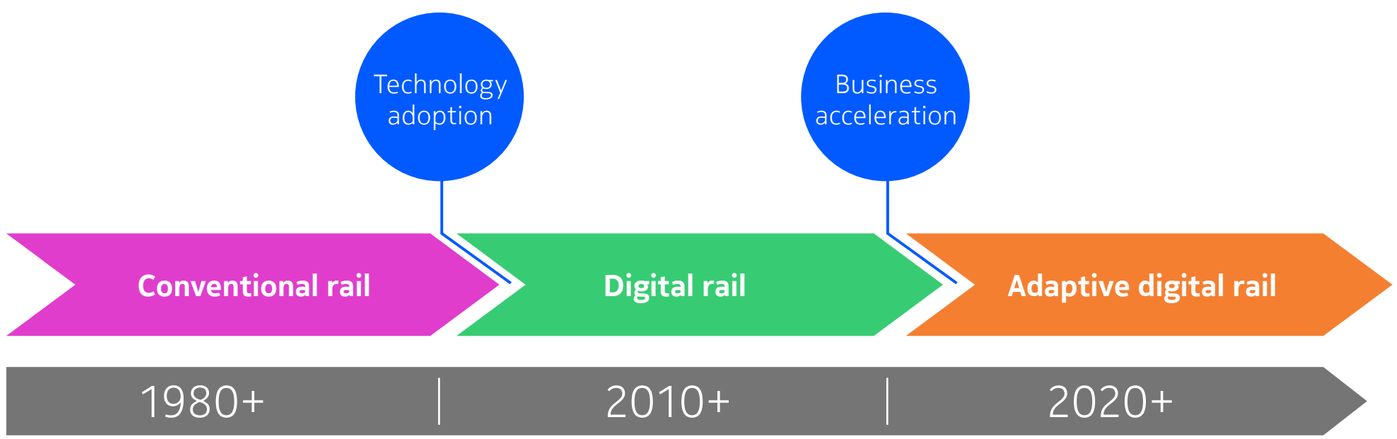
OT cloud powers the rail transition journey

Railways are not new to change and challenge. They are very adept in the use of technology to tackle them. They were among the first adopters of SCADA, which can be considered as the grandfather of IoT, back in the 1980's. They were quick to adopt processor-based interlocking for enhanced operational flexibilities and better integration with railway control and signaling systems around the same time. They were also early to deploy analog land mobile radio system for reliable crew communications.

More than a decade ago, railways embarked on their digitalization journey to a digital rail that is built to last. They focussed on technology adoption for digital rails and operations to deliver higher efficiencies, safety and availability.

However, the current transition requires exponential change. To thrive in the evolving business and operating environments, rail operators are now accelerating their pace and scope of digitalization to create an adaptive digital rail. Driven by business imperatives, safety concerns and the ambitious goal of net-zero, rail operators are transforming the rail systems that are built to adapt and to accelerate their business.

In the meantime, the digital technology transforming for rail operation applications enables them to benefit from a cloud[1] environment, and ushers in the concept of OT (operational technology) cloud[2].



Traditional rail	Digital rail	Adaptive digital rail
Analog LMR	**GSM-R/TETRA/PTC ETCS level 2**	**FRMCS/LTE/MOX**
Conventional signaling	Digital signaling	ETCS level 2 -> 3
SS-based IXL	Computer-based IXL	Centralized IXL/RBC
SCADA	Telemetry (IoT/CCTV)	AI-powered predictive maintenance
Dispatch		IP SCADA

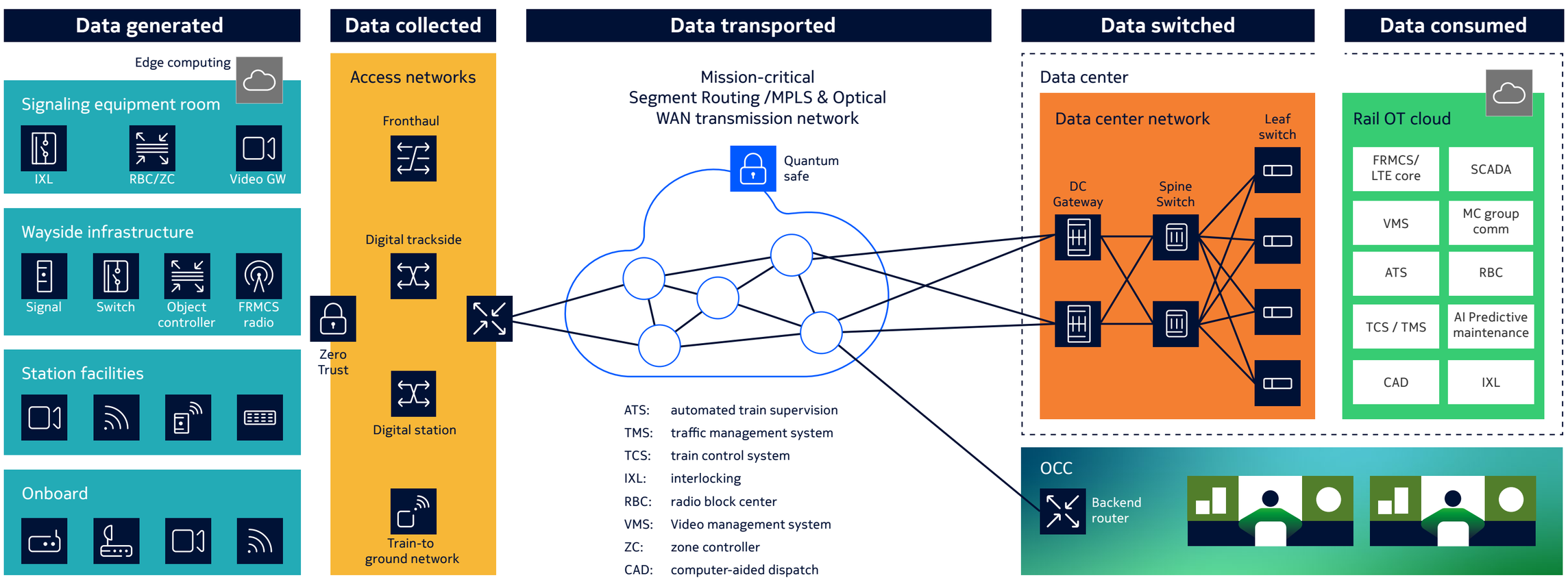
1 Cloud is not about the location of the compute pool. Rather, it is about the consumption and operating models of the pool whose location can be in private data center, public and colo facilities.

2 Download paper Harness the power of a rail private OT cloud

OT cloud as a key part of the adaptive rail infrastructure

OT cloud plays a pivotal role in enabling rail operators to harness the power of automation and data, enhance decision-making and response to situations. With OT cloud becoming a pivotal part of rail infrastructure, the data center becomes the hub for rail operations. Rail operators need to rethink its interconnection to mission critical networks. The first wave of applications in the OT cloud are critical applications including LTE and 5G cores, and group communications supporting push-to-talk, push-to-video and dispatch. Now OT applications including SCADA, RBC, IXL, TMS and ATS are also increasingly based on cloud technologies. OT cloud will also host emerging predictive AI applications such as predictive maintenance.

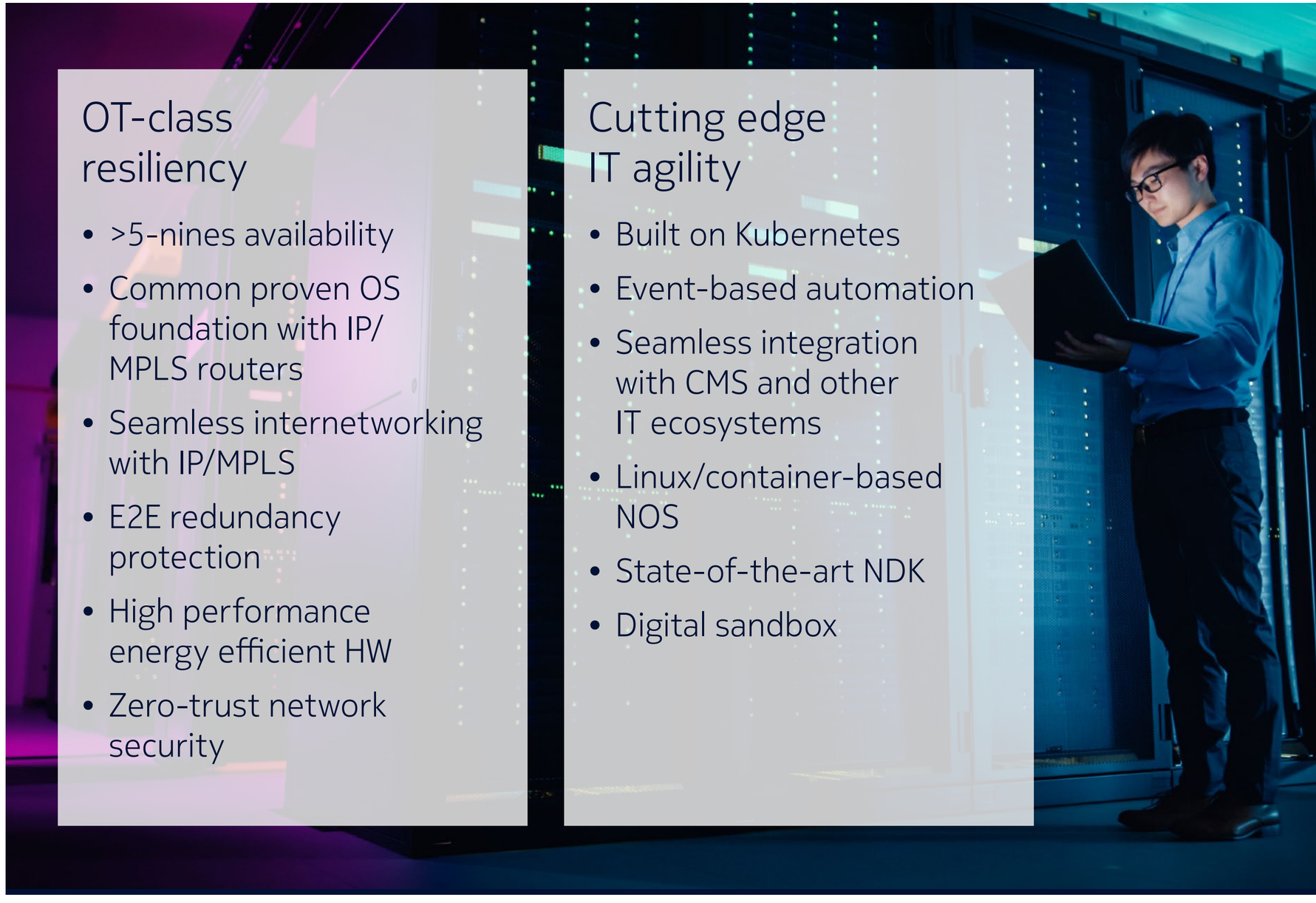
Consequently, the data center network, or simply the fabric in IT speak, is a pivotal part of end-to-end mission-critical communications connecting devices in the field and staff in the data center. Hence the fabric would need to seamlessly internetwork with the mission-critical WAN with the same level of resiliency. Additionally, the fabric also needs to be agile to adapt to changes and disruptions for business continuity.



A resilient, agile fabric for OT Cloud

On the one hand, with rail applications increasingly based on cloud technologies and to be ready for IT/OT convergence across the whole organization, the fabric needs cutting edge IT automation capabilities to move fast when required.

On the other hand, as part of the mission-critical communications infrastructure, it requires the same level of IP/MPLS mission-critical networks for 24 x 7 operation continuity.



The Nokia Data Center Fabric solution

Digital Sandbox

The digital sandbox is a capability within Fabric Services System and represents a digital twin of the data center fabric, which it emulates with absolute parity. It is built in to all work flows of Fabric Services System enabling operators to provide programmable testing and validation of network changes before deployment.

Event-Driven Automation (EDA)

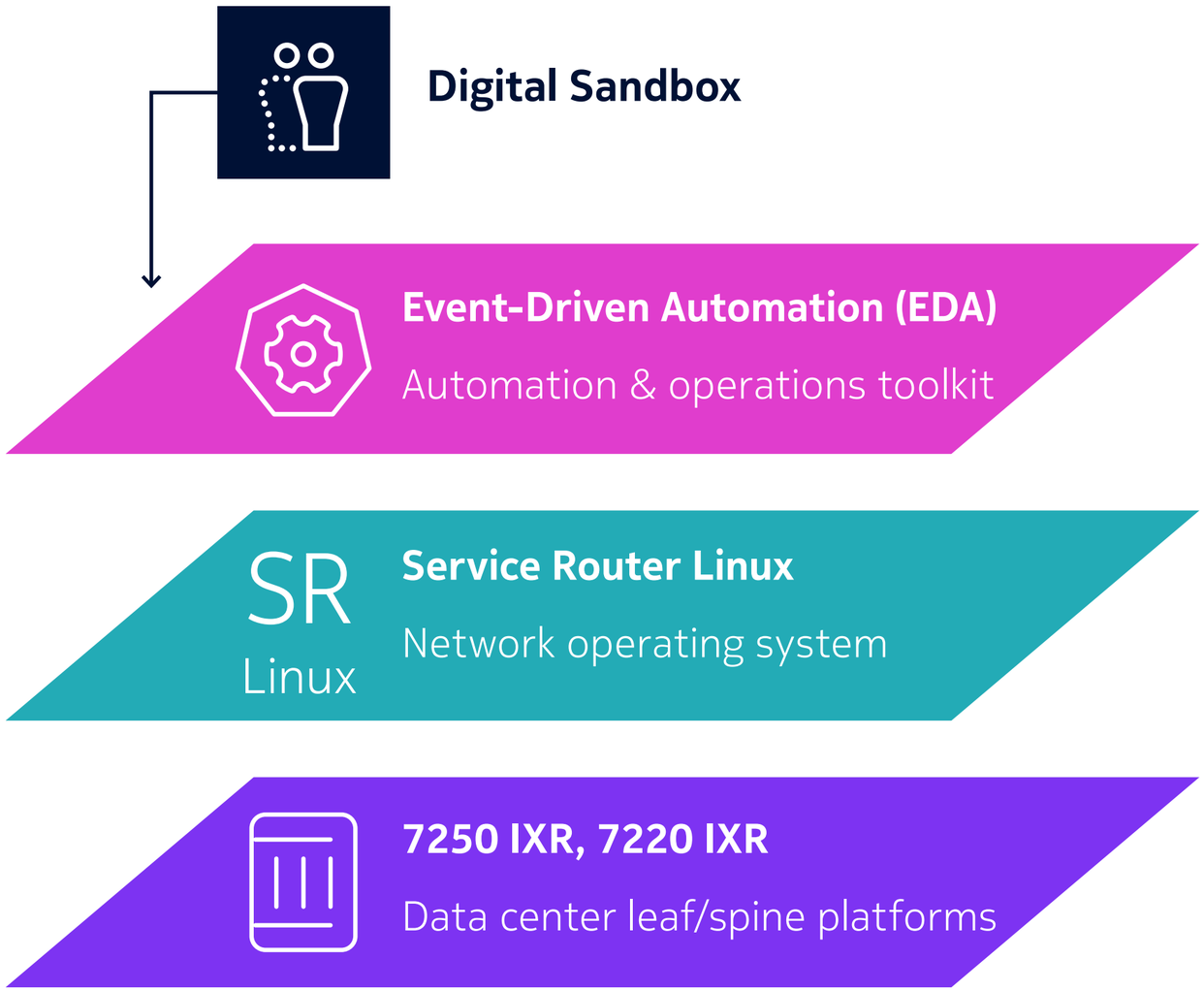
Nokia Event-Driven Automation (EDA) is a modern data center infrastructure automation platform that combines speed with reliability and simplicity. It makes data center network automation more trustable and easier to use, from small edge clouds to the largest AI fabrics.

SR Linux

Nokia SR Linux NOS was built from the ground up to provide an open, extensible model-driven architecture providing uncompromised visibility with a rich and broad telemetry implementation.

7250 IXR, 7220 IXR for data center fabrics

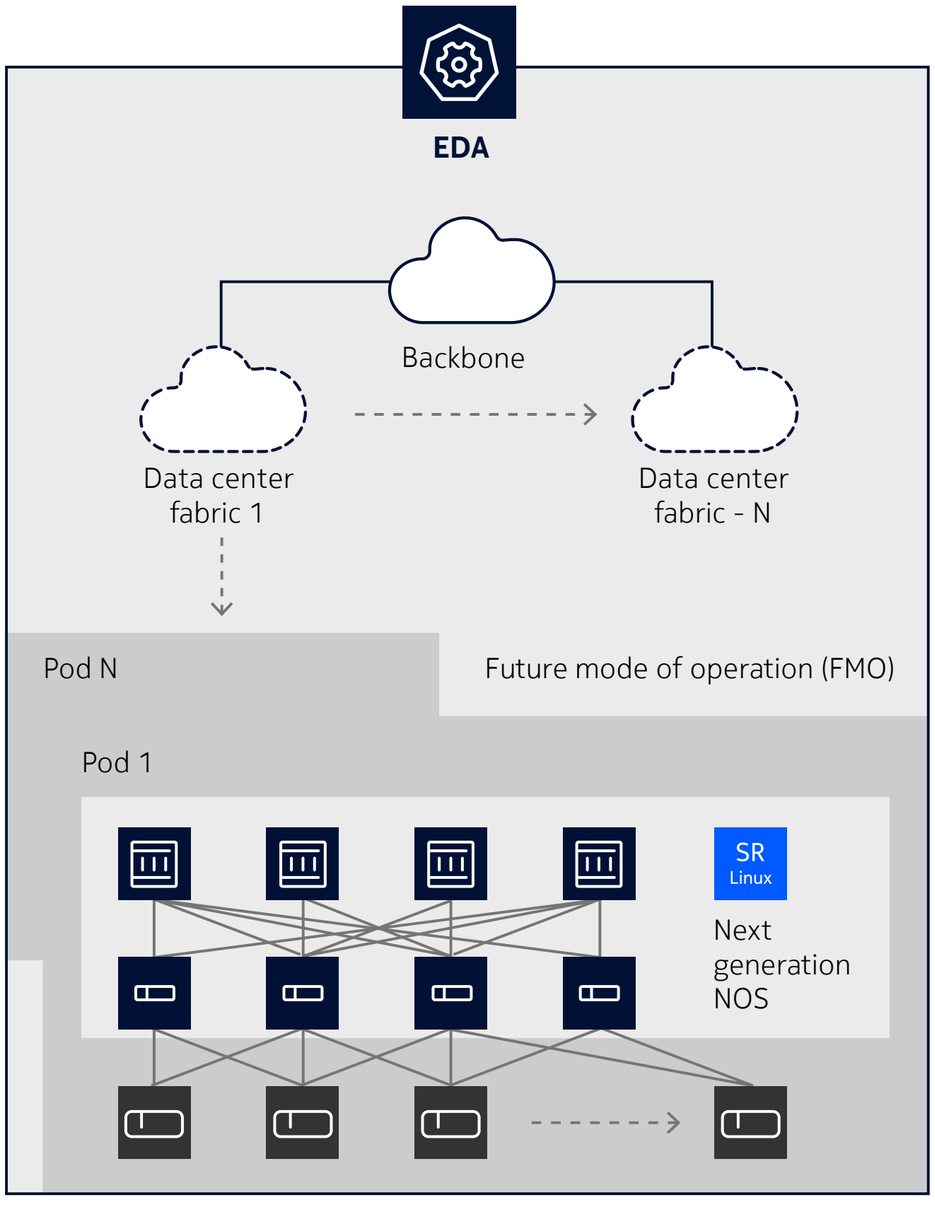
Nokia 7250 IXR and **7220 IXR** represent a range of 100 GE/400 GE optimized fixed configuration and modular data center leaf/spine platforms supporting very high performance, scale and power efficiency.



Significant reduction in effort as found by Bell Labs business case analysis (BCA)

The BCA models a migration scenario from a present mode of operation (PMO) to a future mode of operation (FMO). The PMO is a data center fabric based on a 10GE/40GE or 25GE/100GE leaf-spine architecture.

The FMO is a higher scale and capacity data center fabric based on a 10GE/25GE/100GE, 100GE/400GE or 100GE/400GE leaf-spine architecture. The FMO is powered by the **Nokia SR Linux NOS** running on Nokia's high performance data center platforms (**7220 IXR** / **7250 IXR**). Data center fabric management, operations and automation in the FMO is provided by the **Nokia EDA**.



Up to **40%** cumulative effort savings

Over four years for all data center operations phases and associated tasks

Up to **43%** effort savings

With Nokia SR Linux for specific operations tasks

Up to **60%** effort savings

With Nokia SR Linux + Fabric Services System for specific operations tasks

Differentiated use cases

1. Open and extensible

2. Reliability

3. Digital sandbox

4. Easy-to-use automation

5. Fabric agility

6. Intelligent insights

The Nokia Data Center Fabric solution

Accelerate next generation innovation

1 Open and extensible

Seamless interconnection with IEDs and integration with IT ecosystems.

2 Reliability

Built from the ground up to be resilient, secure, scalable and sustainable OT cloud networking that operations can rely on during the unexpected.

3 Digital Sandbox

The industry's only "built-in" network digital twin for testing network change before implementation; key to recapture peace of mind.

4 Easy-to-use automation

A complete set of built-in UI-driven NetOps automation tools to drive productivity.

5 Fabric agility

Adaptive to application changes in real time with cloud platform integration.

6 Intelligent insights

The most broad and deep access to network telemetry for enhanced fabric insights and comprehensive view of the state of fabric.

Innovative design foundation

Nokia Data Center Fabric solution was built from the ground up with the latest in technology innovation. SR Linux was built with an open, extensible and modular model-driven architecture making it much more efficient, scalable and futureproof. Integrated with AI capabilities, EDA is built on Kubernetes according to cloud-native microservices design while taps into its vast open-source ecosystem. This reduces risks and lower barriers to entry for users.

1. Open and extensible

Full interoperability with mission-critical networks to connect workloads with machines and crews

Challenge

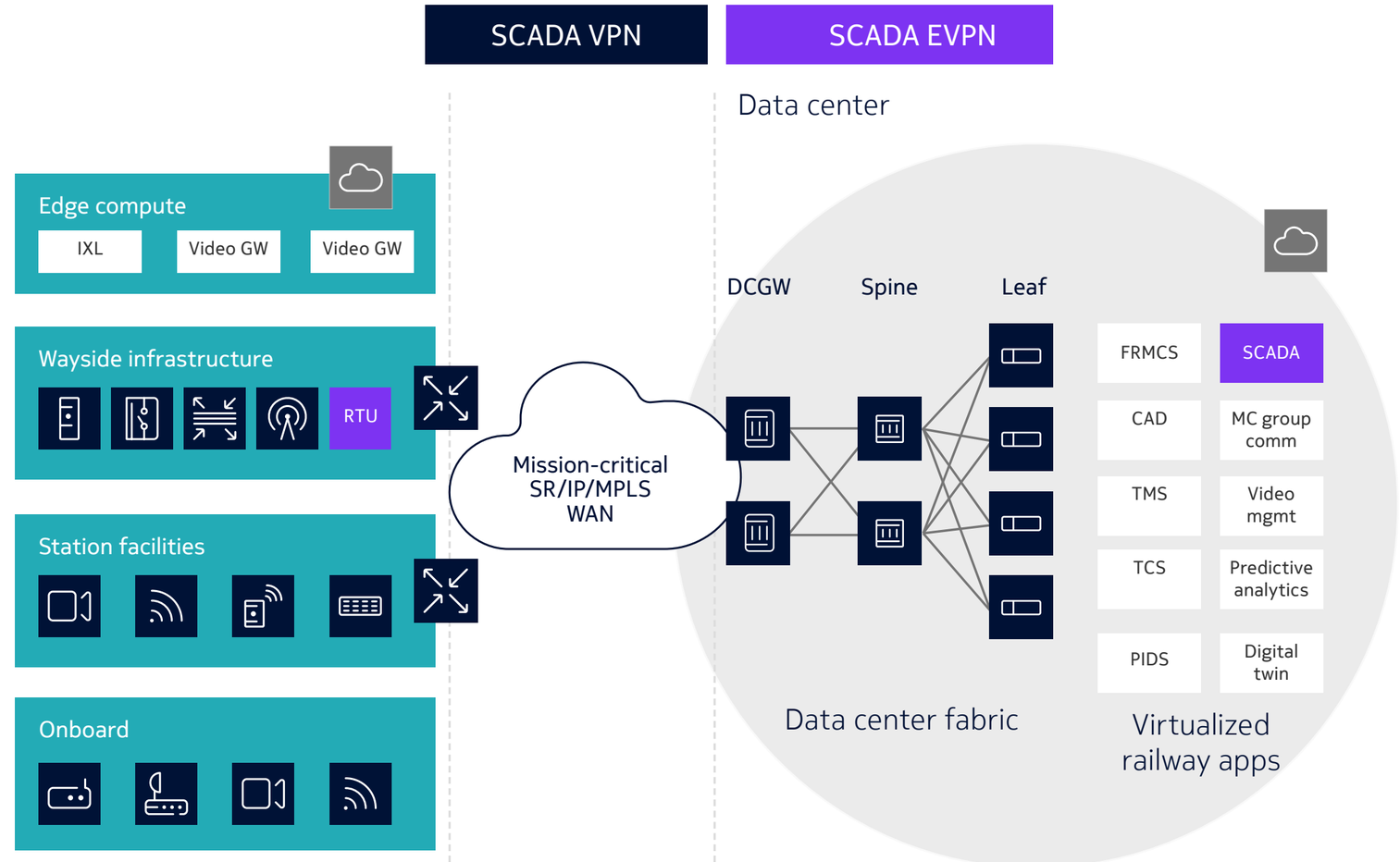
How to provide seamless connections between rail assets in the field with cloud-native applications?

Solution

- Nokia's Data Center Fabric solution is designed to be part of the communication path between rail assets in the field and applications hosted in data center
- Data center gateway seamlessly joins the two network domains.

Why Nokia?

- Nokia has deep experience in helping railways design and deploy mission-critical network infrastructure
- Nokia uniquely offers a common network operating system (NOS) foundation for WAN, data center gateway and fabric platforms
- Nokia has the most hardened and robust IP routing implementation in the industry.



1. Open and extensible

Integrate seamlessly into any IT ecosystems

Challenge

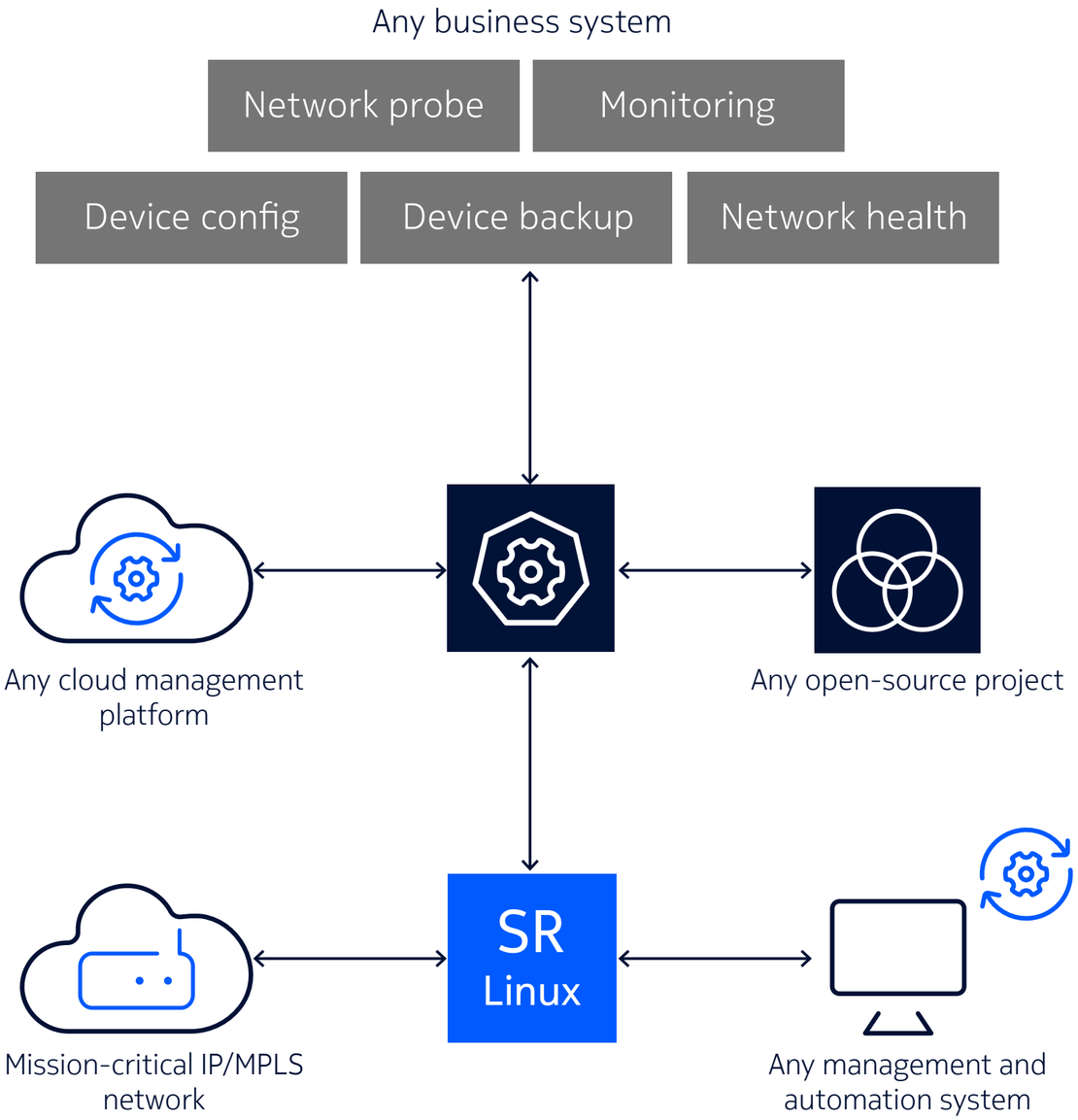
Technology and operations teams lack the ability to rapidly and easily integrate their IT infrastructure. How can they seamlessly integrate a data center fabric solution into this ecosystem?

Solution

Nokia's Data Center Fabric solution is designed with the latest interfaces and protocols allowing it to seamlessly integrate into any business ecosystem with performance and scale.

Why Nokia?

- SR Linux is designed to be consumable by any authorized client and is equipped with advanced interfaces like gNMI
- Fabric Services System is built with a REST API that assures 100% access to all features and capabilities of system
- Fabric Services System is integrated with the major cloud management platforms making it compatible with any cloud environment.



1. Open and extensible

Solve unique operational issues with a flexible development kit

Challenge

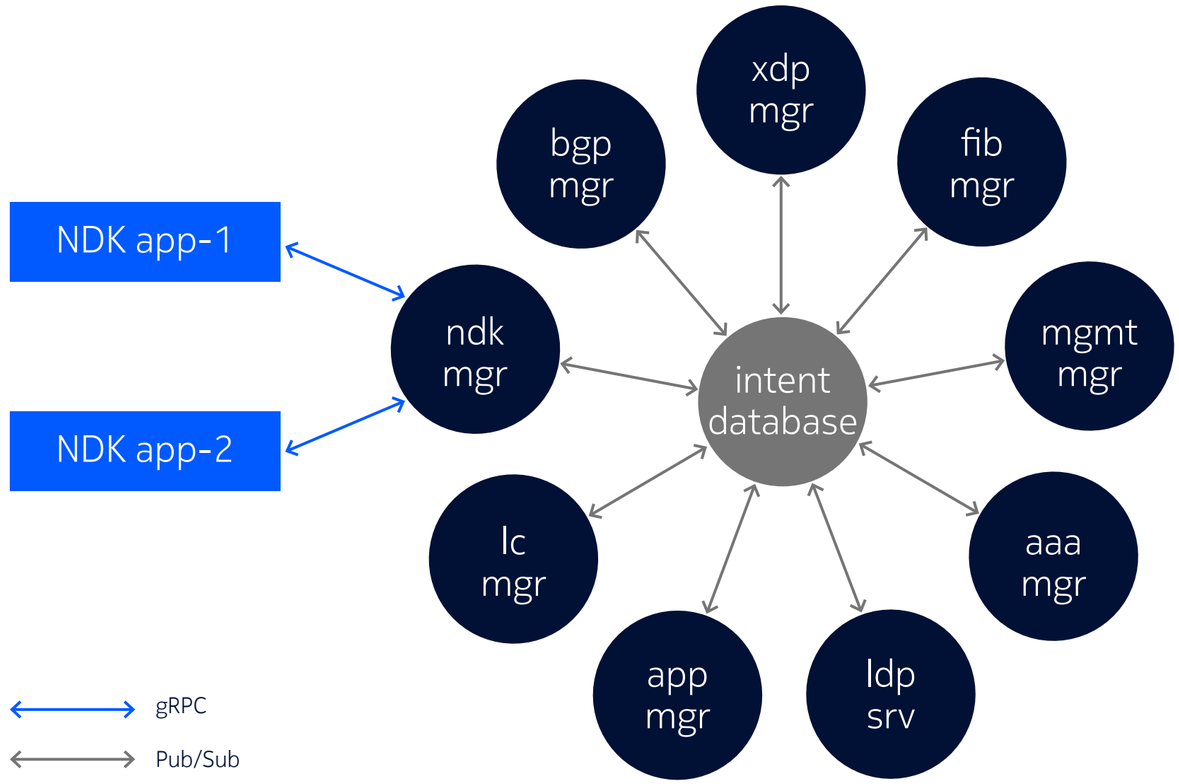
Data center NetOps teams need control and the ability to create custom operational tools quickly and easily, allowing them to solve specific issues unique to their network deployment.

Solution

SR Linux's NetOps Development Kit (NDK) allow railway operators to develop custom operational tools (a.k.a. agents) that deeply integrate with other native SR Linux applications.

Why Nokia?

- Simplified approach with single interface and API to all external systems like monitoring
- A resultant tool is treated natively in SR Linux inheriting the benefit of model-driven architecture, making network data easy to access and scalable
- Reduces integration complexity and simplifies operations post-deployment.



2. Reliability

Multiple layers of redundancy to deliver five 9s availability

Challenge

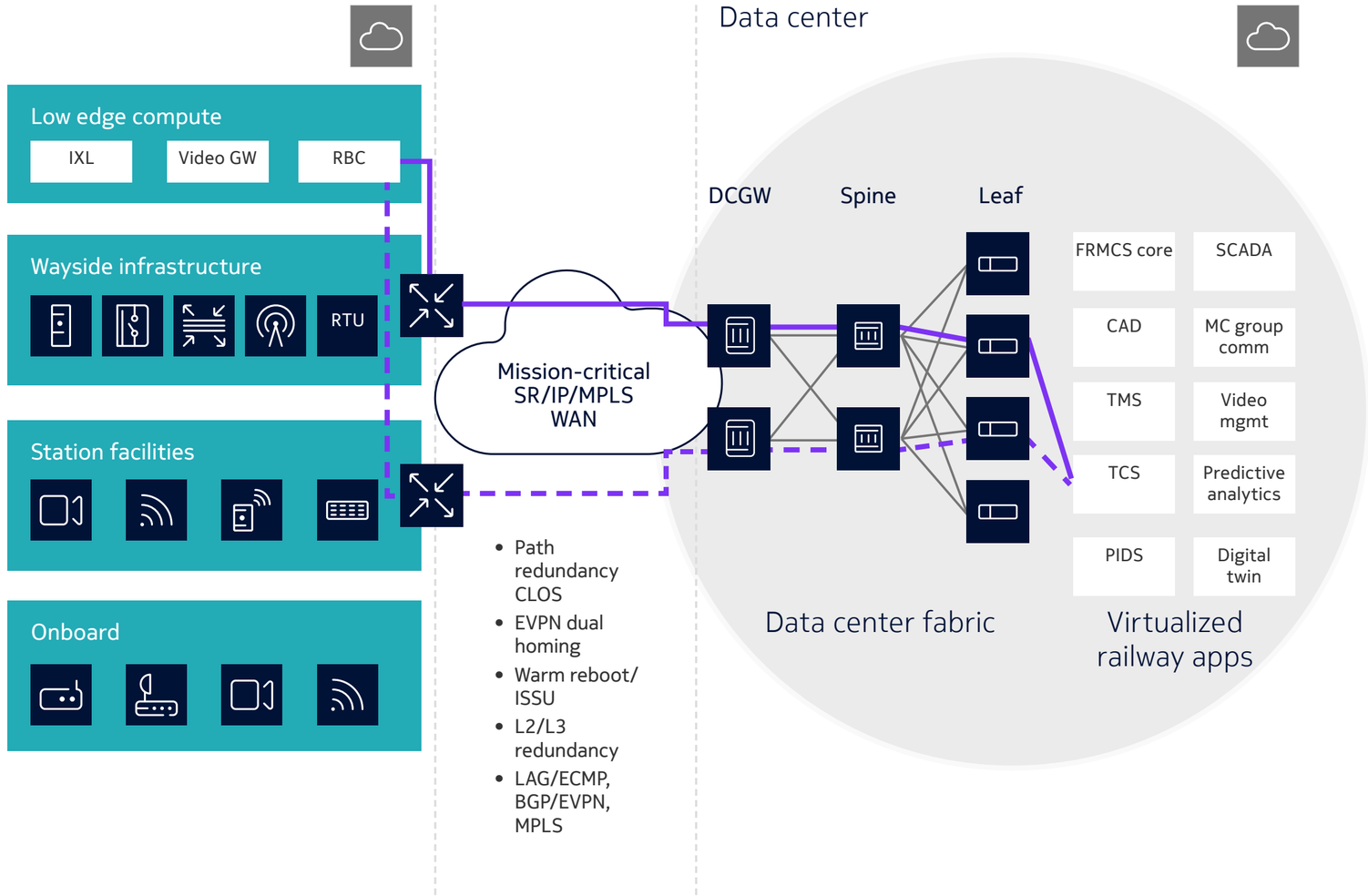
Many mission critical applications require availability performance previously not thought possible within data center fabrics.

Solution

Leverage multilayer redundancy protection to achieve 5-nines availability.

Why Nokia?

- Warm application restart
- Full path redundancy in CLOS architectures
- Leverage LAG/ECMP, BGP/EVPN and multi-homing for fabric redundancy
- Leverage node redundancy (Fabric/Fan/Power/IMM on 7250 IXR)
- Full IP/MPLS redundancy protection.



2. Reliability

A multilayer and zero trust data center fabric security solution

Challenge

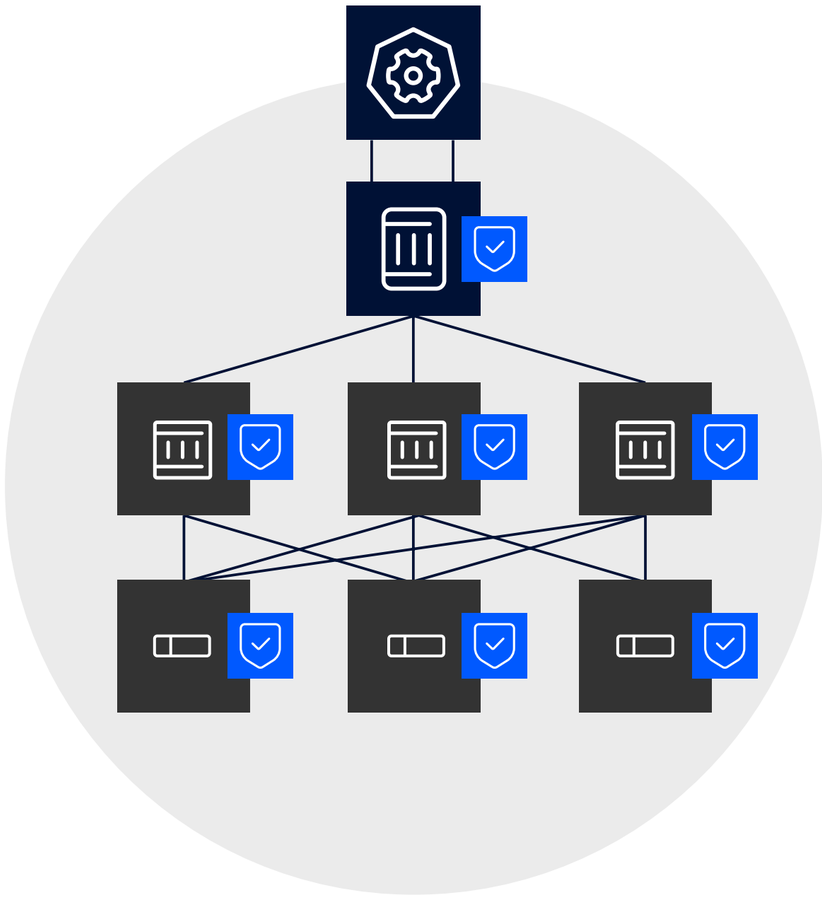
As railway operators embrace more and more applications, they need to protect the expanding attack surface of their infrastructure in general and data center in particular.

Solution

- A multilayer and zero trust data center network solution which includes platform and network level security features
- Fabric automation ensures consistent security policies for new application deployment and workload migration

Why Nokia?

- Consistent security posture integrity with EDA
- Control/management/data plane security with access control lists (ACLs)
- Confidentiality, integrity and authenticity protection with MACsec encryption
- User security with Role-based Access Control (RBAC)
- Data plane monitoring with fine grained AC
- Platform security with a physically attached Trusted Platform Module (TPM)
- SR Linux process security with containerized processes and contained fare share of system resources.



3. Digital Sandbox

Emulate and validate network changes with confidence before deployment for peace of mind

Challenge

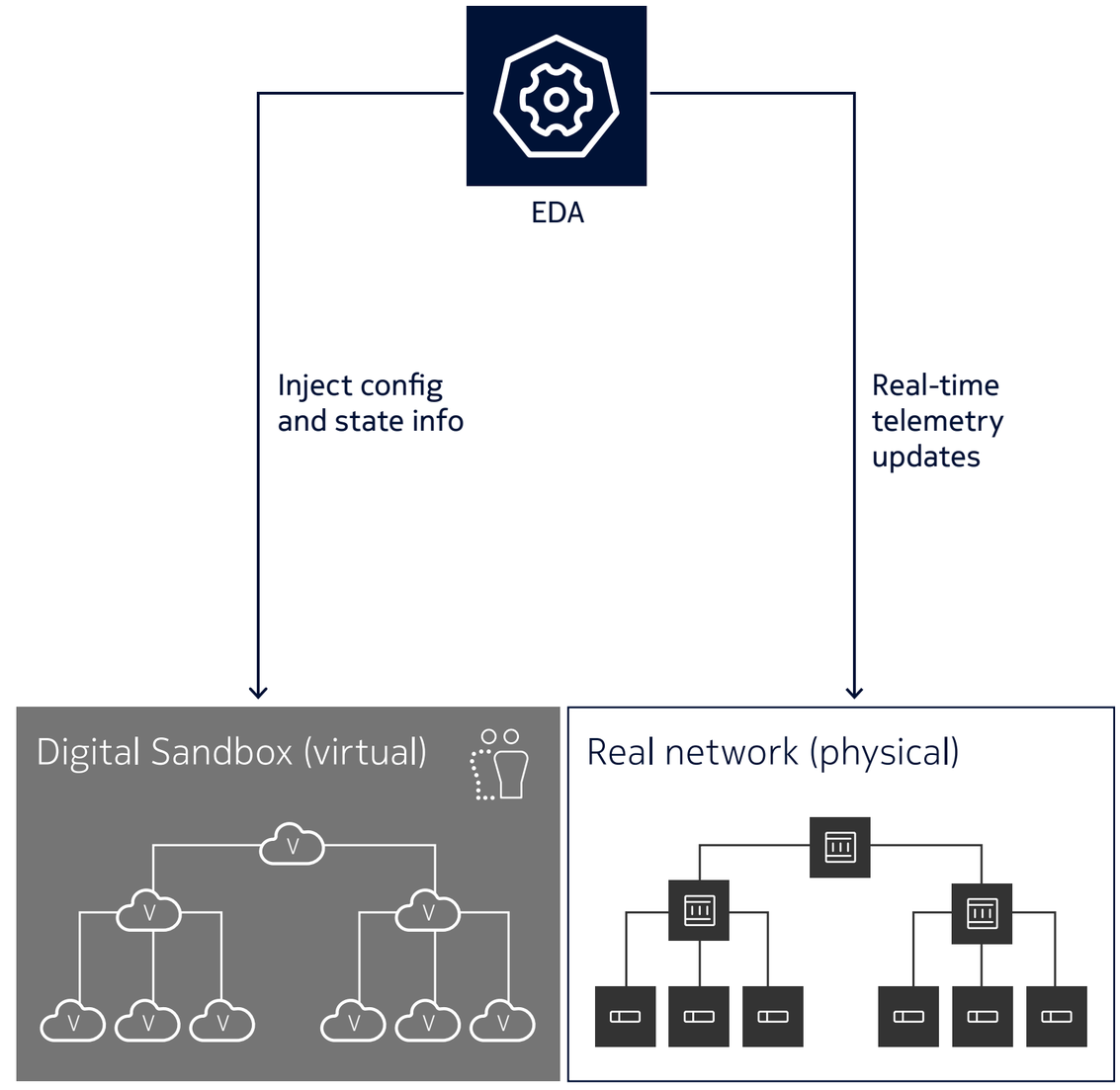
From NOS upgrade to network expansion to configuration optimization, implementing network changes always carries risk. Operations want to de-risk network changes, but lack the capability to automate the testing and validation of the changes at speed before deployment.

Solution

EDA Digital Sandbox allows rail operators to move fast with confidence. It adopts a digital twinning approach emulating the fabric with absolute parity. Planned changes can be fully tested as if in the production environment.

Why Nokia?

- Network digital twin emulates a live data center fabric with absolute parity greatly reducing implementation risk
- Perform what-if scenario network planning and analysis
- Test network changes without a physical lab reducing cost, power, and setup time
- The only solution in the market with complete integration of digital twin making it easy to use.



4. Easy-to-use automation

Simplify and reduce efforts across the entire lifecycle of operations

Challenge

As OT applications based on cloud technologies become central to railway operators, data center network operations want to accelerate and scale fabric operations while empowering their staff with easy-to-use automation tools for all phases of network operations.

Solution

- Advanced built-in automation across the entire lifecycle of operations (i.e., Day 0 design, Day 1 deployment, Day 2+ operations)
- Capabilities are programmable through UI-driven workflows that simplify automation operations for staff.

Why Nokia?

- Dramatically reduce operational effort and reduce human error across all phases of the data center fabric lifecycle
- The industry's most complete built-in automation tools
- Easy-to-use UI-driven approach that empowers staff
- Digital Sandbox reduces risk and saves effort across entire lifecycle.

Intent-driven design and operations

Digital Sandbox for true network emulation

Cloud-native integration model

Cloud-native, Kubernetes-based extensible foundation

Automate operations

Covering all stages of the operational lifecycle

4. Easy-to-use automation

Accelerate application deployment to meet changing operational and business needs

Challenge

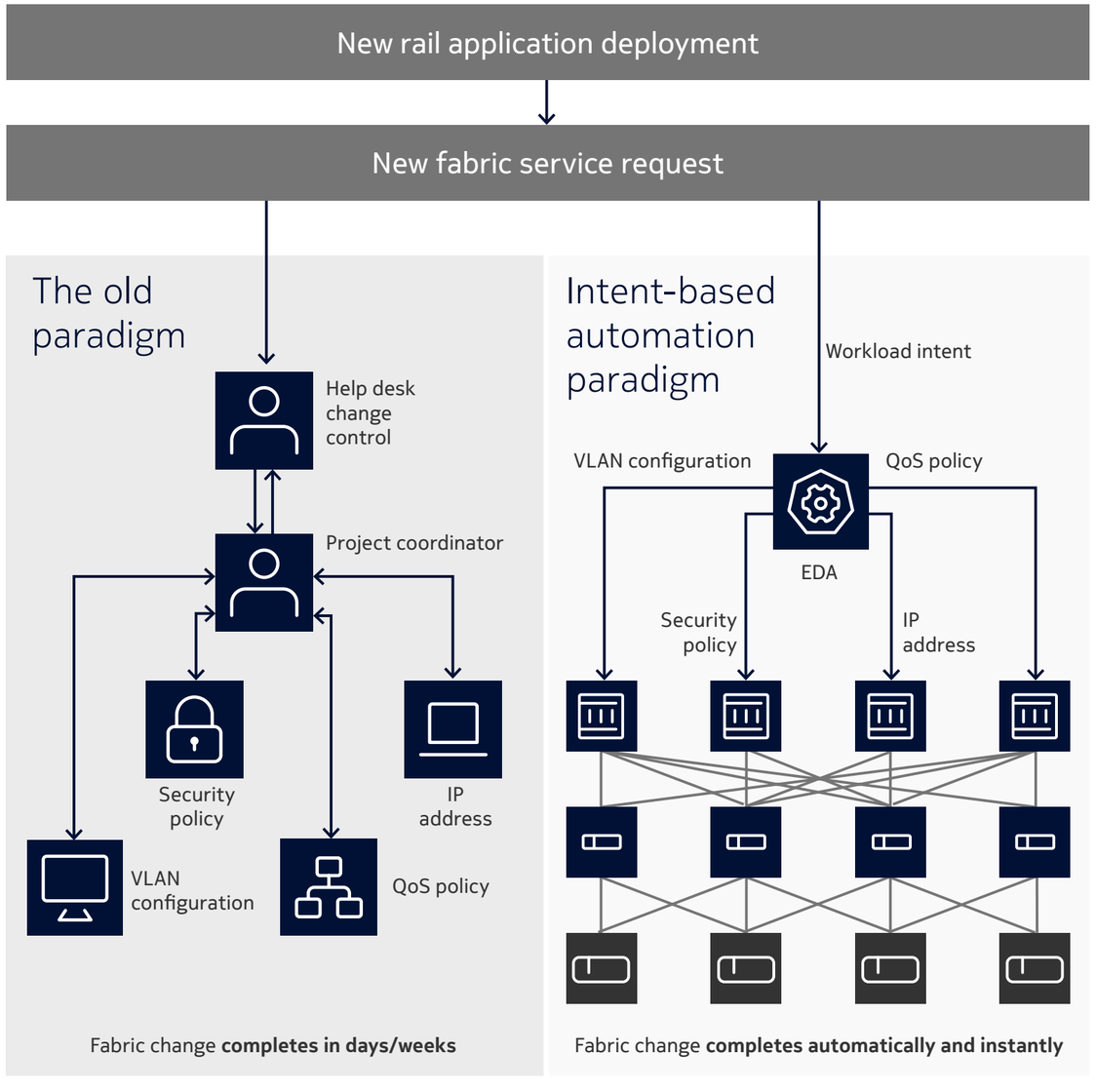
Railway operators are resorting to automation for faster response and high operation efficiency. To satisfy the quickened pace of applications deployment, data center fabric operations want to accelerate the speed of provisioning fabric services to connect workloads faster. Today's approach typically requires extensive co-ordination with different network teams, impeding project progress.

Solution

- Workload-intent based automation

Why Nokia?

- Automation dramatically reduces coordination efforts and human error
- Automation ensures service design and configuration consistency for all applications
- Digital Sandbox reduces network risk of adding new services.



4. Easy-to-use automation

Constantly ensure that the data center fabric operates at desired state

Challenge

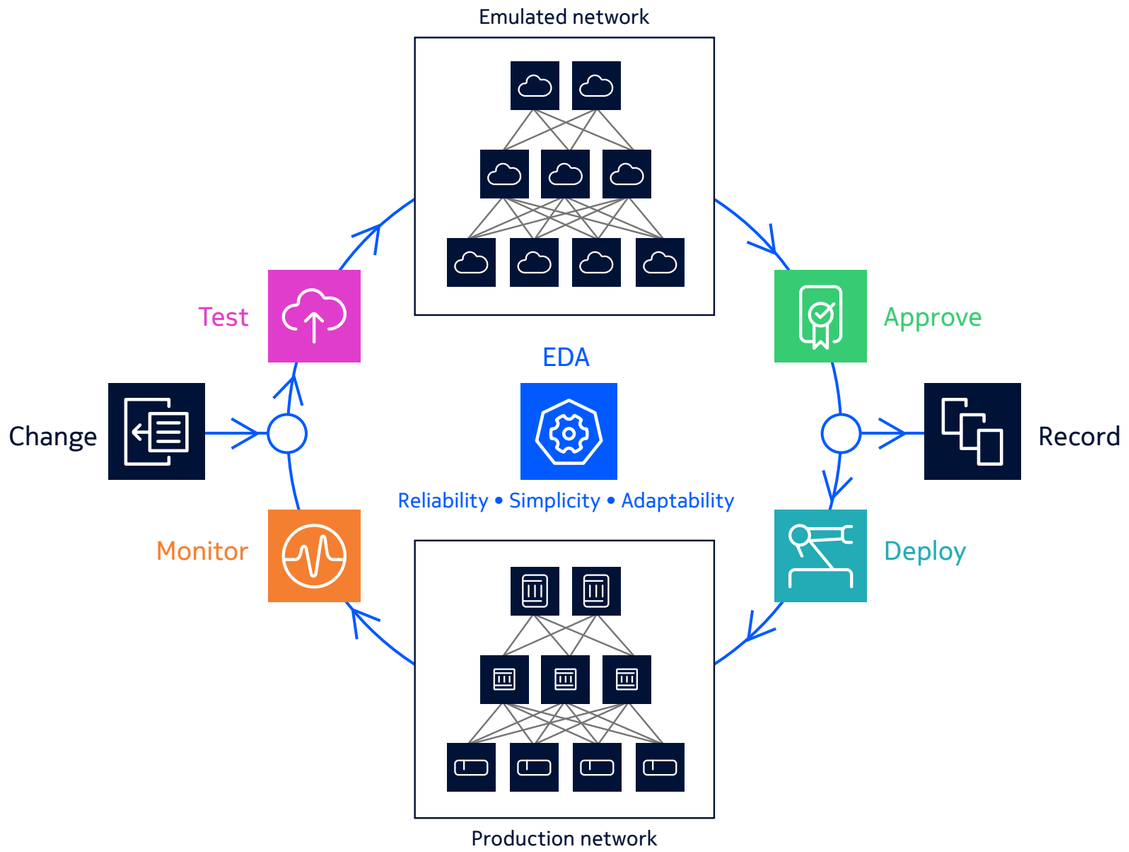
Operations teams want to greatly reduce work effort while ensuring that the network maintains the desired state and operates at peak performance.

Solution

- Programmable built-in closed loop automation (Continuous Integration (CI) / Continuous Deployment (CD) leveraging:
- Digital Sandbox for automated testing and validation during the CI phase
- Programmable simplified UI-driven deployment options
- Advanced telemetry for monitoring.

Why Nokia?

- Reduce network risk with industry's only built-in digital twin for CI
- Empower automation accuracy with industry's richest and most complete data center fabric telemetry information
- Constantly monitor the network and compare to the intent ("single source of truth") to ensure that the desired state is being achieved.



5. Fabric agility

Keep pace with application change by using an automated agile fabric

Challenge

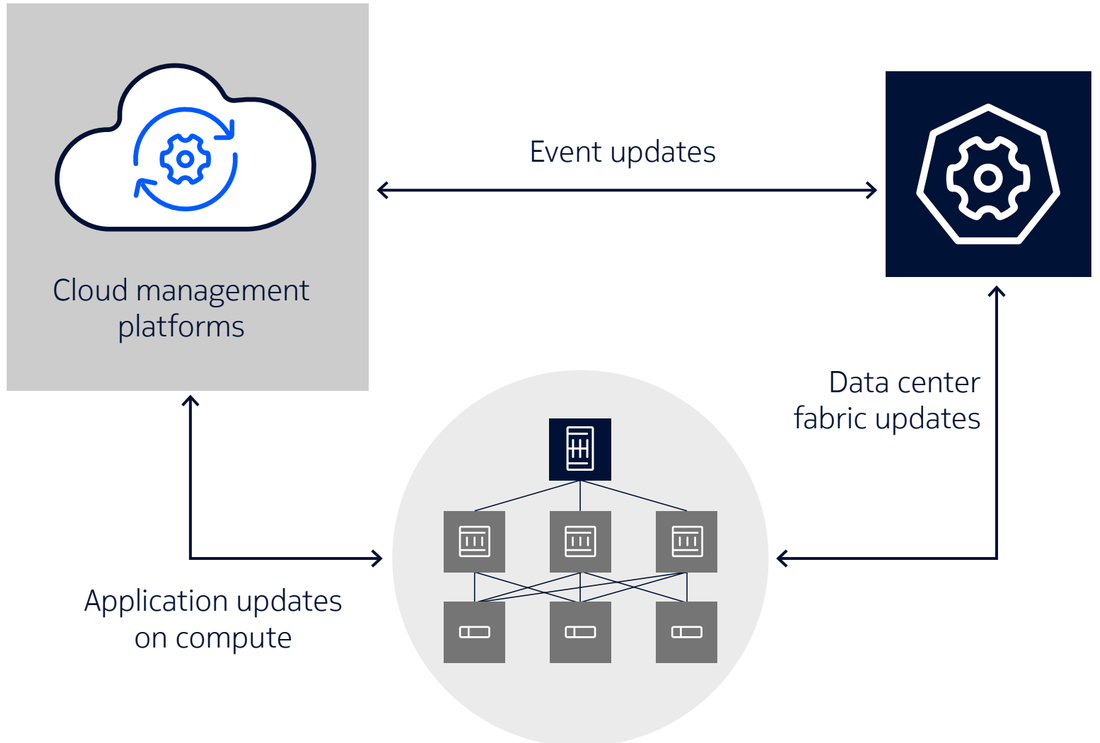
Operational teams lack the ability to dynamically react to application changes such as scaling and workload migration, which are happening with much more frequency in today's data center fabrics.

Solution

- Integration with major cloud platforms provides real-time insight into application's networking requirements
- Real-time intent-based instantiation of network updates to support new application requirements.

Why Nokia?

- Industry's most complete integration with major cloud management platforms including OpenStack, OpenShift, VMWare vSphere, Kubernetes, etc.
- Provides real-time understanding of each application's network requirements
- Dynamic instantiation of network updates to support network needs of applications.



6. Intelligent insights

Empower operations with broad and granular network insights

Challenge

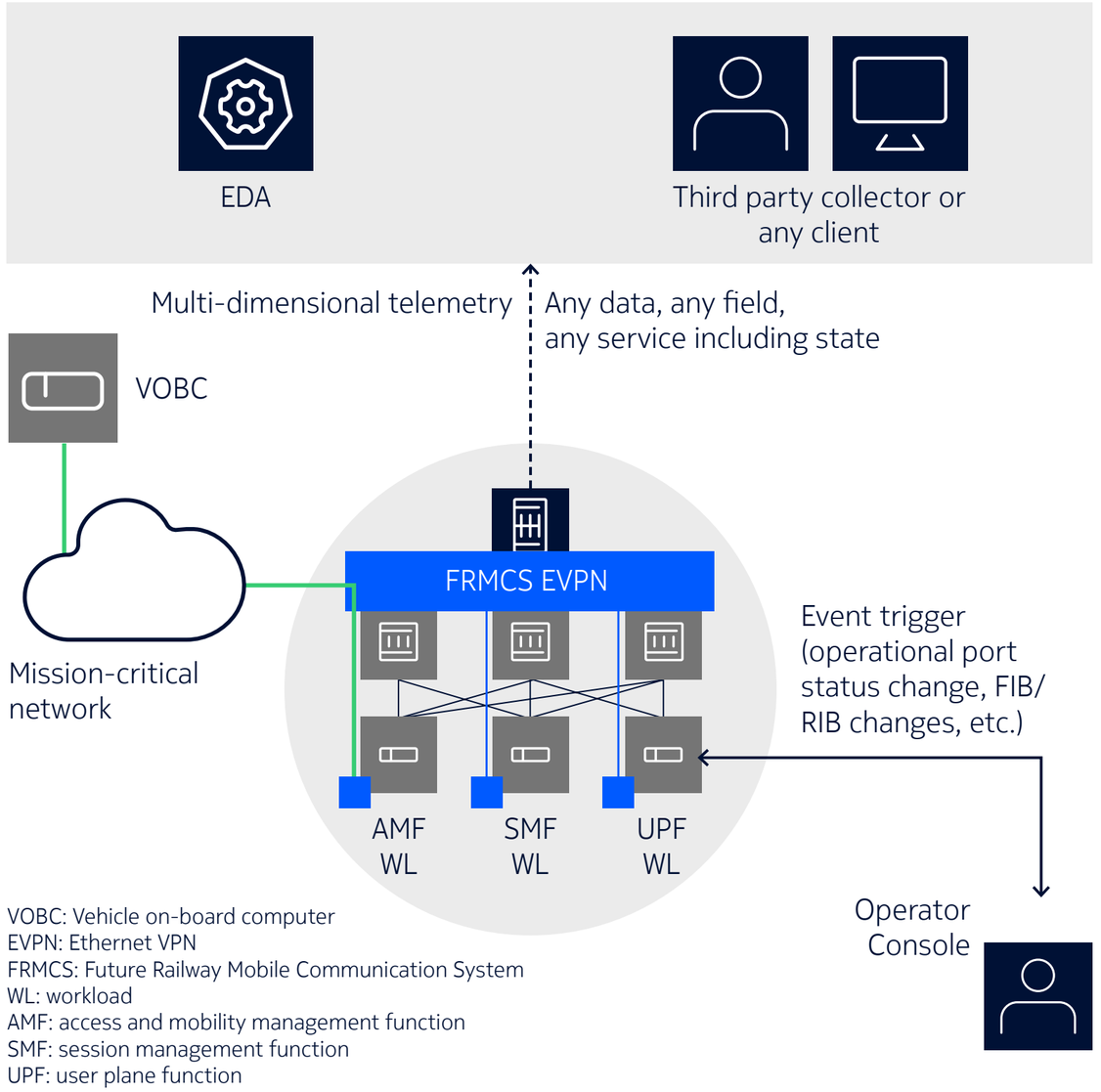
Operational teams lack the visibility and rapid access to network data needed to monitor OT application data traffic and to empower their operational processes. They rely on manual approaches and poll-based data gathering, which is slow and inefficient.

Solution

- Ubiquitous and real-time visibility into the fabric to optimize automation and other systems with enriched and consistent network insights
- Leverage model-based architecture from SR Linux to access granular and broad-based network data through “on change” telemetry.

Why Nokia?

- Only data center fabric vendor to offer modular model-driven architecture for simple and quick access to any data across all system services in fabric switches
- Dramatically reduce processing burden to stream massive data demands
- Fabric Services System contains a highly scalable gNMI collector service to ingest streaming telemetry offered by SR Linux
- This data can be used by other third-party northbound IT systems for automation and other tasks
- Integration with IT automation system including Prometheus



VOBC: Vehicle on-board computer
EVPN: Ethernet VPN
FRMCS: Future Railway Mobile Communication System
WL: workload
AMF: access and mobility management function
SMF: session management function
UPF: user plane function

Innovative design foundation

Future proof the network and keep up with the pace of change

Challenge

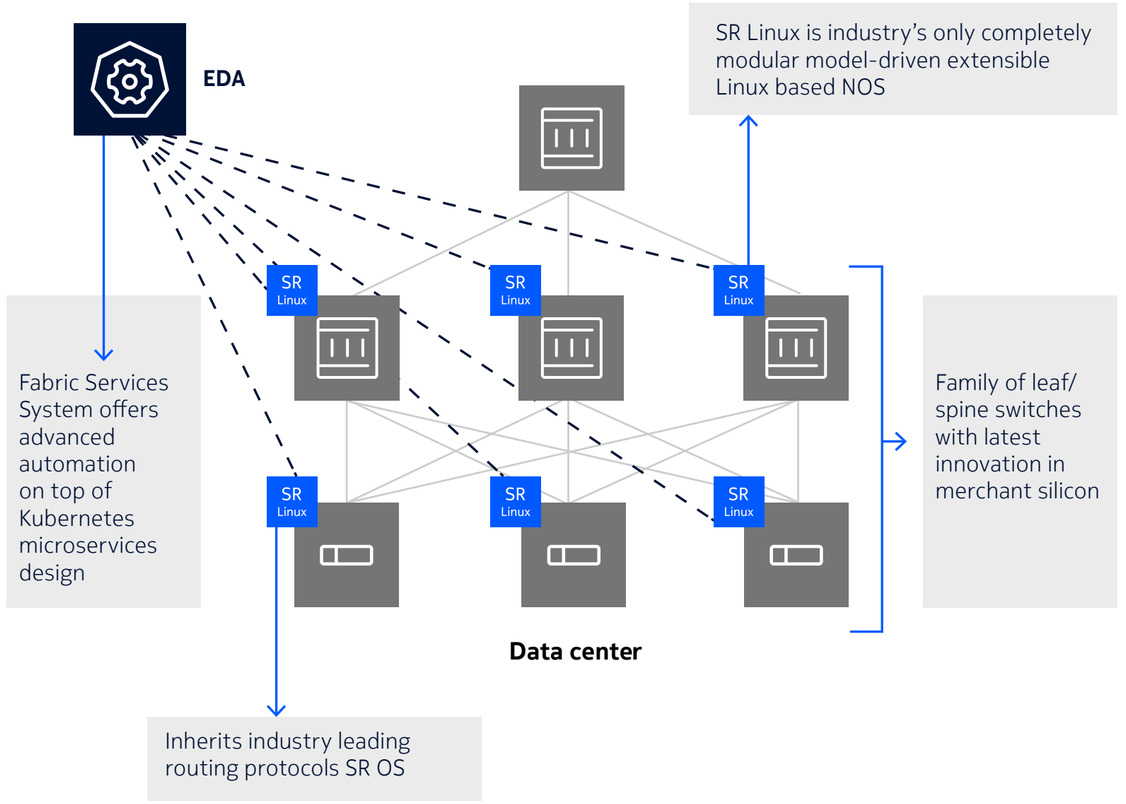
Data center infrastructure and operations teams need to keep up with the rapid pace of innovation now and in the future. Applications and the data center fabrics they run on have to adopt the latest in technological innovation to alleviate these concerns.

Solution

Nokia's Data Center Fabric solution is designed from the ground up to adopt the most innovative, open and extensible technology allowing it to easily evolve.

Why Nokia?

- Built with modern interfaces and APIs like gNMI and REST API
- A complete range of fixed and modular high-performance 400GE-optimized hardware platforms, innovatively designed for data center leaf/spine deployments
- The industry's only ground-up modular, model-driven NOS (SR Linux) offering a range of benefits including marketing leading extensibility, granularity and scalability
- Inherits the most scalable and robust routing stacks from SR OS
- The Fabric Services System leverages Kubernetes, microservices foundation with built-in open-source projects.



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As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.