Agile data center fabrics

Where power utility OT meets cloud

NOKIA

Contents

Utilities need high adaptability for energy transition

Utilities are facing accelerating change in their business landscape. In the midst of this energy transition, they have to adapt to changing operating environments, and become more flexible and agile.

Due to a combination of the forces of decarbonization, decentralization and disruption, utilities are today facing monumental challenges at an unprecedented scale.

Answering the call of decarbonization, more utility- and community-scale renewables are being interconnected to the grid as energy resources. Behind-the-meter rooftop solar and storage are turning consumers into prosumers (producers-cum-consumers) and active participants in the energy ecosystem. In addition, from heating to transportation, a growing array of functions in our daily lives are being powered by electricity to achieve net zero emission goals. The way we consume energy is undergoing a rapid shift from relying on fossil fuels to utilizing clean electricity.

With decentralization of energy generation, utilities are extending grid intelligence and automation capabilities to the distribution edge for tasks such as voltage impact mitigation, reverse current flow management and smart inverter control. These are essential for faster, sharper grid control to ensure a stable, efficient grid.

Furthermore, with more frequent, severe weather events and industrial incidents, disruptions are more rampant causing more prolonged power outages. As a multiplier to this disruption, geopolitical developments at times result in energy scarcity, further complicating resource planning.

The changing utility landscape

Decarbonization

Decentralization

Disruptions
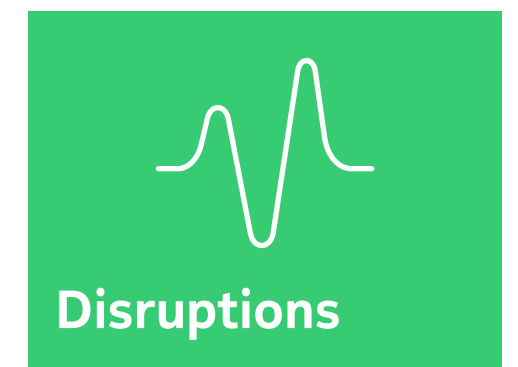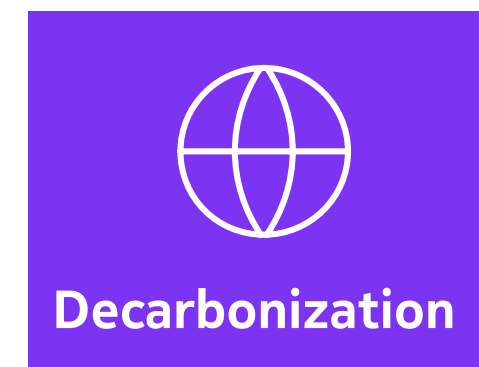
OT cloud powers the energy transition journey

Utilities are not new to change and challenge. They are very adept in the use of digital 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 microprocessor-based relay for expanded capabilities around the same time. They were also early to deploy land mobile radio system for reliable crew communications.
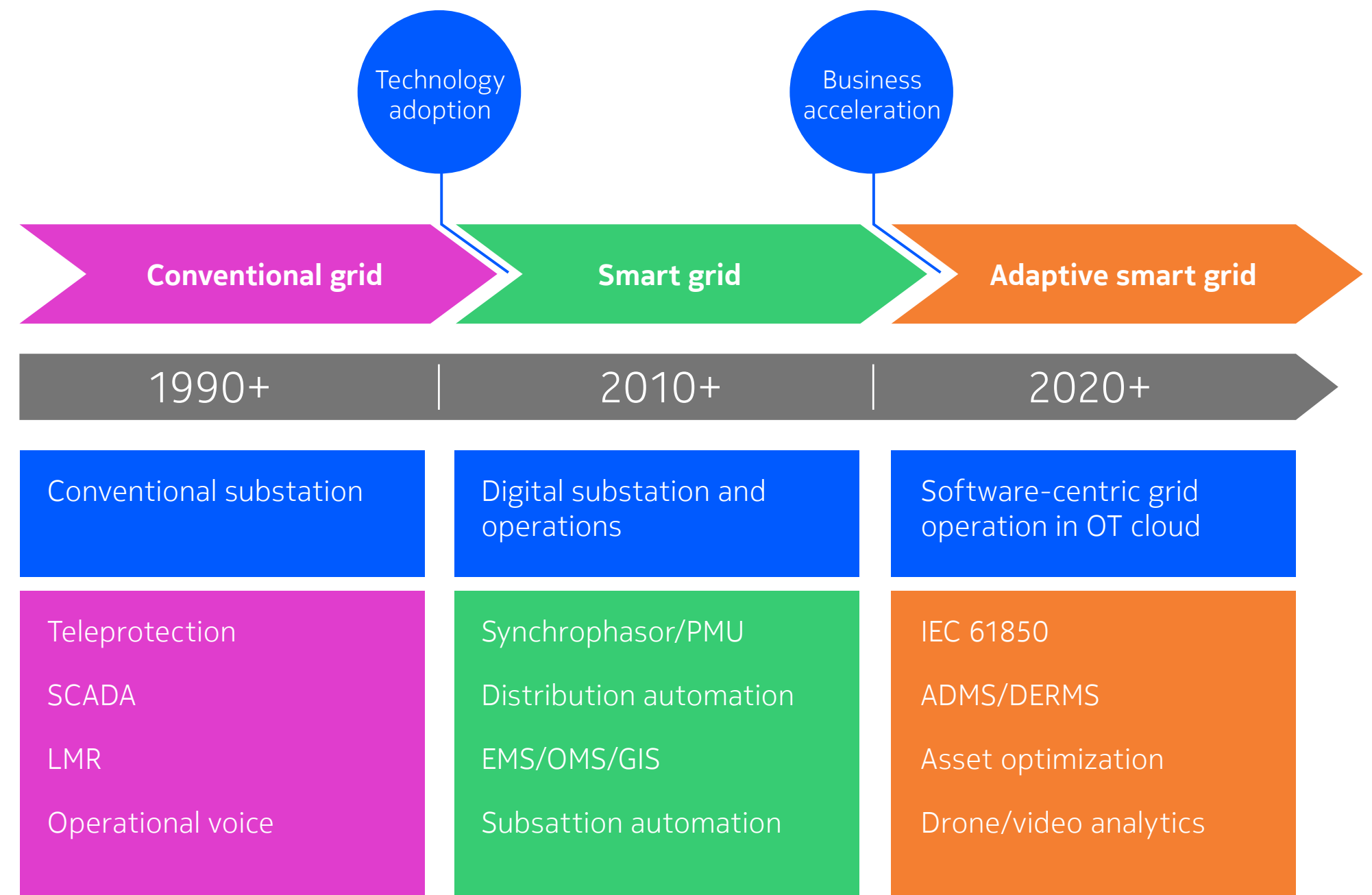
More than a decade ago, utilities embarked on their digitalization journey to a smart grid that is built to last. They focussed on technology adoption for digital substations and operations to deliver greater automation and higher efficiencies, safety and availability.

The energy transition requires exponential change. To thrive in the evolving business and operating environments, utilities are now accelerating their pace and scope of digitalization to create an adaptive smart grid. Driven by business imperatives such as decarbonization and energy equity, utilities are transforming with grids that are built to adapt and to accelerate their business.

In the meantime, the digital technology transforming for grid operation applications enables them to benefit from a cloud1 environment, and ushers in the concept of OT (operational technology) cloud[2].

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 utility private OT cloud

Technology adoption		Business acceleration	
Conventional grid		**Smart grid**	**Adaptive smart grid**
1990+		2010+	2020+
Conventional substation		Digital substation and operations	Software-centric grid operation in OT cloud
Teleprotection		Synchrophasor/PMU	IEC 61850
SCADA		Distribution automation	ADMS/DERMS
LMR		EMS/OMS/GIS	Asset optimization
Operational voice		Subsattion automation	Drone/video analytics

OT cloud as a key part of the adaptive grid infrastructure

The emergence of the concept of OT cloud has transformed the data center into the hub for grid operations, the 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, distribution automation, ADMS and synchrophasor are also increasingly based on cloud technologies.

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

IEC 61850 zone
- IED
- VPAC
- Edge computer/AI

Legacy OT zone
- E&M voice
- Relay
- SCADA

IT zone
- Wi-Fi AP
- Sensors

Distribution feeders
- Sensors
- Micro-synchrophasor
- Line switch

Access networks
- Station/process bus
- TDM gateway
- IT LAN
- Fan

Mission-critical segment routing/ MPLS and optical WAN transmission network
- Quantum safe
- Substation router

ADMS: advanced distribution management system
EMS: energy management system
EPC: evolved packet core
PDC: phase fdata concentrator
OMS: outage management system
GIS: geographical information system
VPAC: virtyualized protection and control

Data center

Data center network
- DC gateway
- Spine switch
- Leaf switch

Utility private cloud

SCADA	PDC
EMS	Wireless EPC
ADMS	MC Group Comm
GIS	AI predictive maintenance
OMS	Video analytics

- Data center
- Public cloud
- Internet

A resilient, agile fabric for OT Cloud

On the one hand, with grid 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 as IP/MPLS mission-critical networks for 24 x 7 grid operation continuity.

OT-class resiliency

- >5-nines availability
- Common proven OS foundation with IP/MPLS routers
- Seamless internetworking with IP/MPLS
- E2E redundancy protection
- High performance energy efficient HW
- Zero-trust network security

Cutting edge IT agility

- Built on Kubernetes
- Event-based automation
- Seamless integration with CMS and other IT ecosystems
- Linux/container-based NOS
- State-of-the-art NDK
- Digital sandbox

The Nokia Data Center Fabric solution

Digital Sandbox

The digital sandbox is a capability within Event-Driven Automation (EDA) 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

Event-Driven Automation (EDA) is a data center fabric management and automation platform that provides built-in and easy to use next-generation data center NetOps fabric automation capabilities.
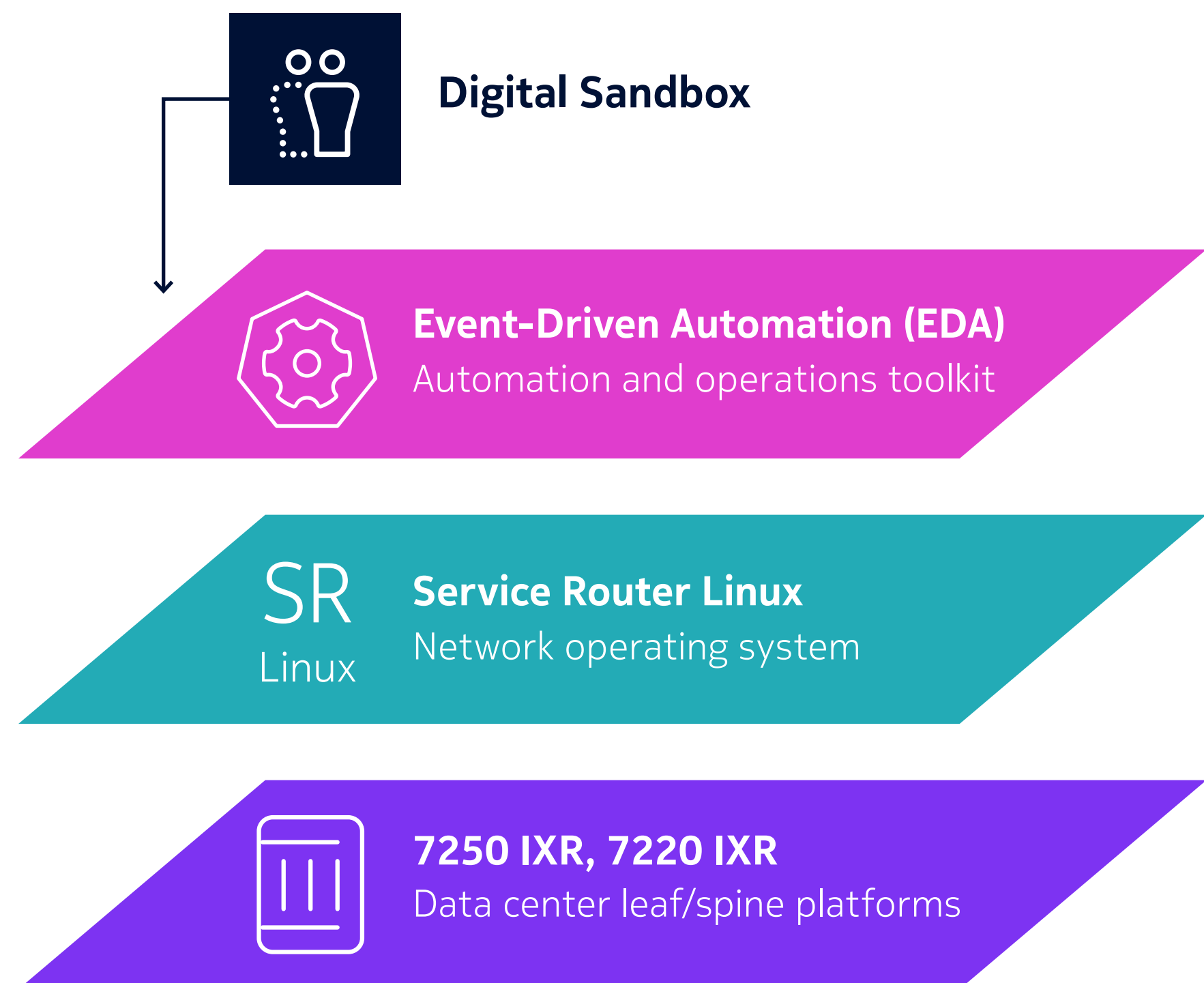
SR Linux

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.

These switches run the SR Linux NOS.

Digital Sandbox

Event-Driven Automation (EDA)
Automation and operations toolkit

SR
Linux
Service Router Linux
Network operating system

7250 IXR, 7220 IXR
Data center leaf/spine platforms

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 400GE/800GE 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 Fabric Services System**.

EDA

Backbone

Data center fabric 1

Data center fabric - N

Pod N

Future mode of operation (FMO)

Pod 1

SR Linux

Next generation NOS
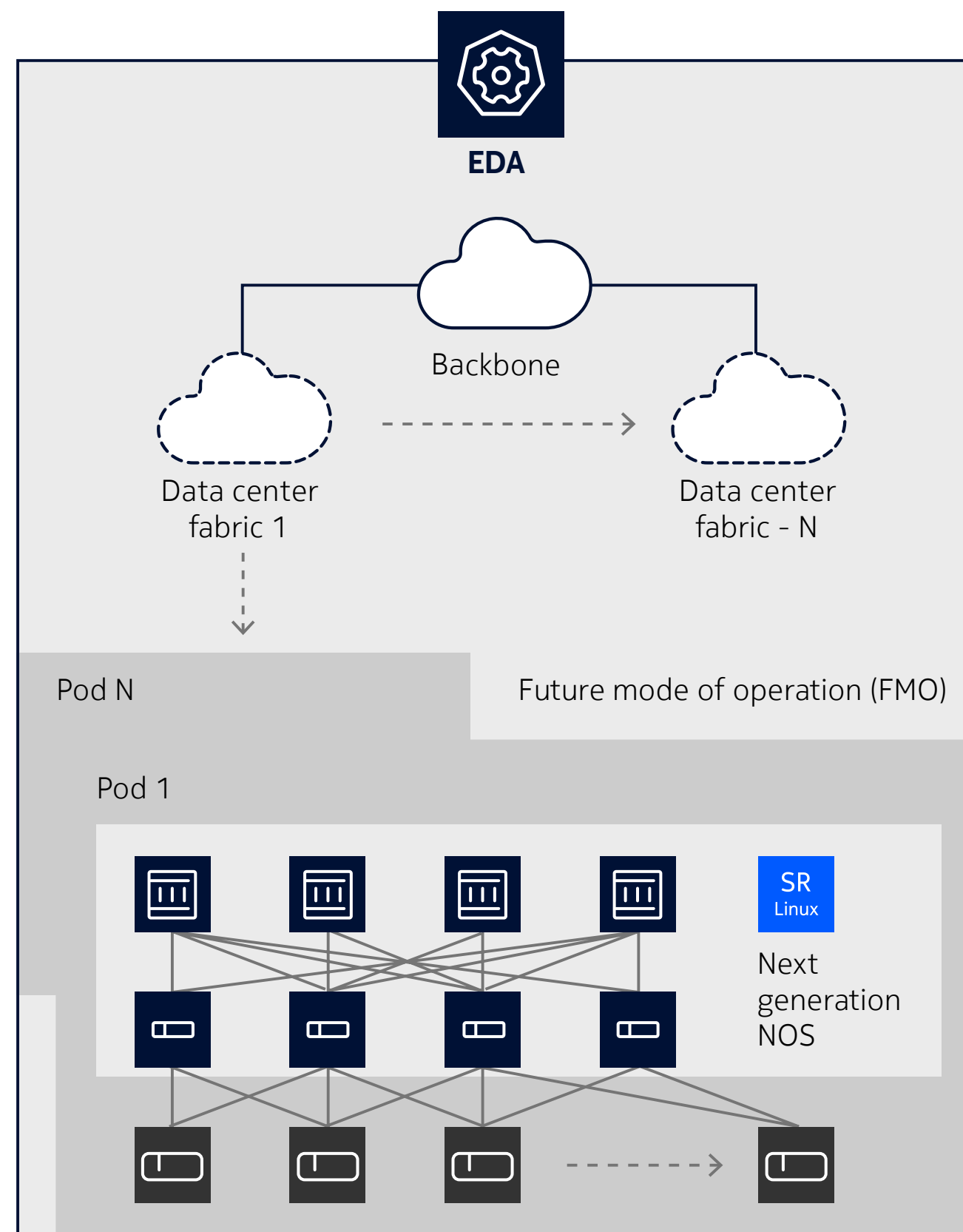
Up to **40%** cumulative effort savings

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

Agile data center fabrics

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. The EDA was built on top of Kubernetes according to cloud-native microservices design with many opensource projects built within its system architecture.

1. Open and extensible
Full interoperability with mission-critical networks to connect workloads with machines and crews
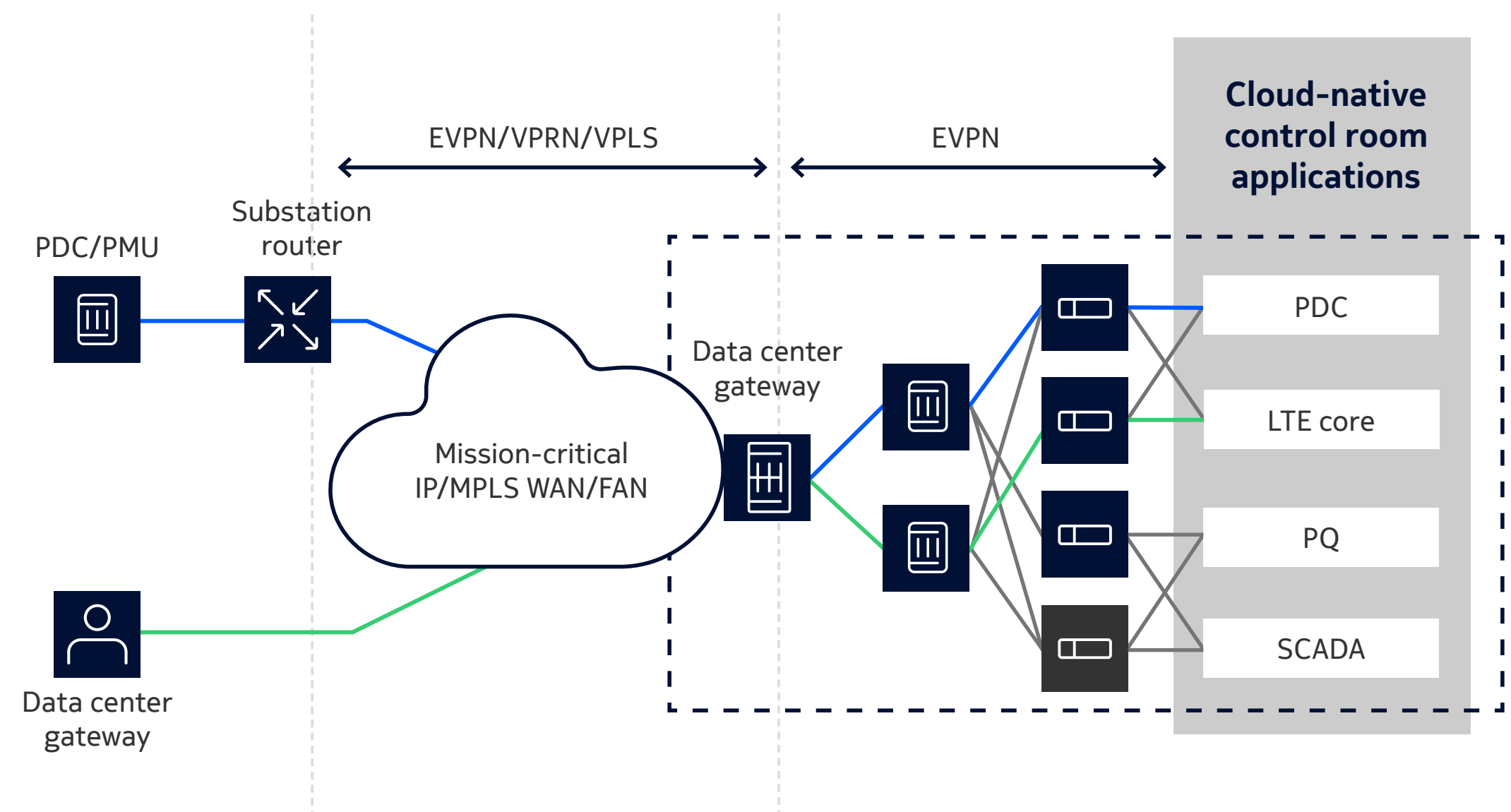
Challenge

How to provide seamless connections between grid assets in substations and in distribution systems with cloud-native applications?

Solution

- Nokia's Data Center Fabric solution is designed to be part of the communication path between the grid assets in the grid and applications hosted in data center

- Data center gateway seamlessly joins the two network domains.

Why Nokia?

- Nokia has deep experience in helping utilities 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.

EVPN/VPRN/VPLS

EVPN

Cloud-native control room applications

PDC/PMU

Substation router

Data center gateway

Mission-critical IP/MPLS WAN/FAN

Data center gateway

PDC

LTE core

PQ

SCADA

1. Open and extensible
Integrate seamlessly into any IT ecosystems
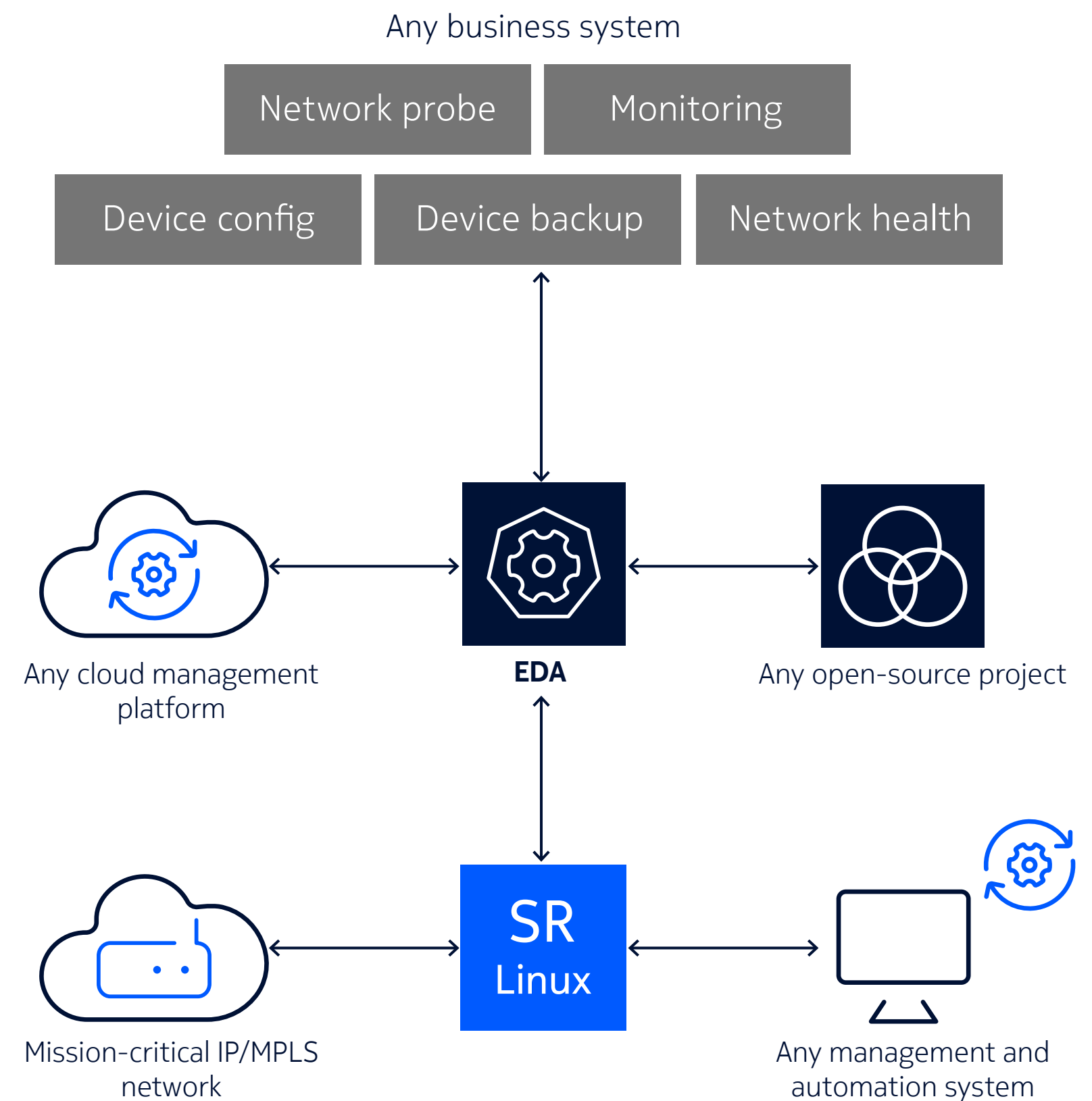
Challenge

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

- Event-Driven Automation is built with a REST API that assures 100% access to all features and capabilities of system

- Event-Driven Automation is integrated with the major cloud management platforms making it compatible with any cloud environment.

Any business system

Network probe	Monitoring

Device config	Device backup	Network health

Any cloud management platform

EDA

Any open-source project

Mission-critical IP/MPLS network

SR Linux

Any management and automation system

1. Open and extensible
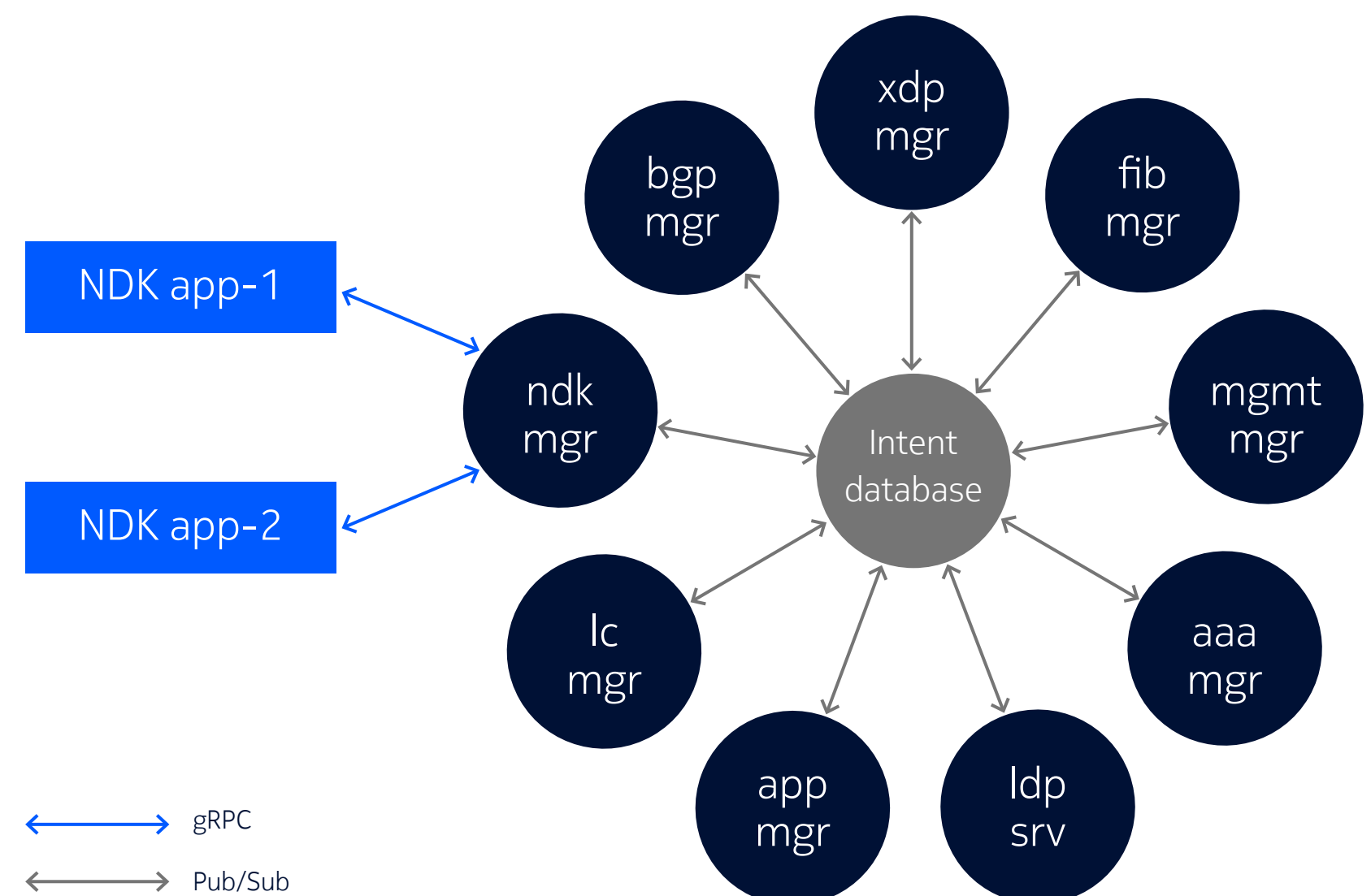## Solve unique operational issues with a flexible development kit

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 utilities customers 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.

NDK app-1

NDK app-2

gRPC

Pub/Sub

xdp mgr

bgp mgr

fib mgr

ndk mgr

Intent database

mgmt mgr

lc mgr

aaa mgr

app mgr

ldp srv

2. Reliability
Multiple layers of redundancy to deliver five 9s availability
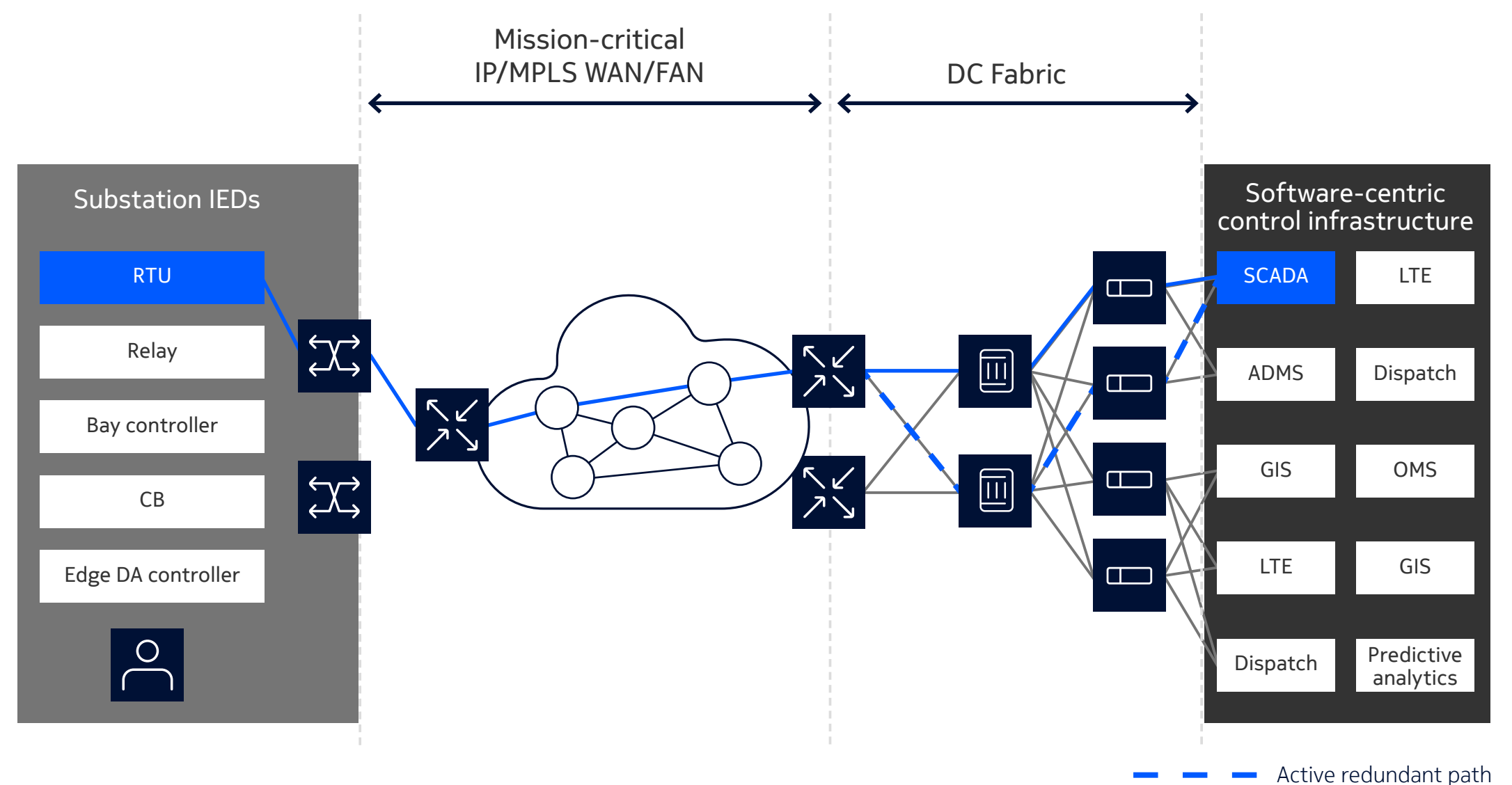
Challenge

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

Solution

Leverage multilayer redundancy protection to achieve 5 9s 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.

Mission-critical
IP/MPLS WAN/FAN

DC Fabric

Substation IEDs

RTU

Relay

Bay controller

CB

Edge DA controller

Software-centric
control infrastructure

SCADA | LTE
ADMS | Dispatch
GIS | OMS
LTE | GIS
Dispatch | Predictive analytics

— — — Active redundant path

2. Reliability
A multilayer and zero trust data center fabric security solution
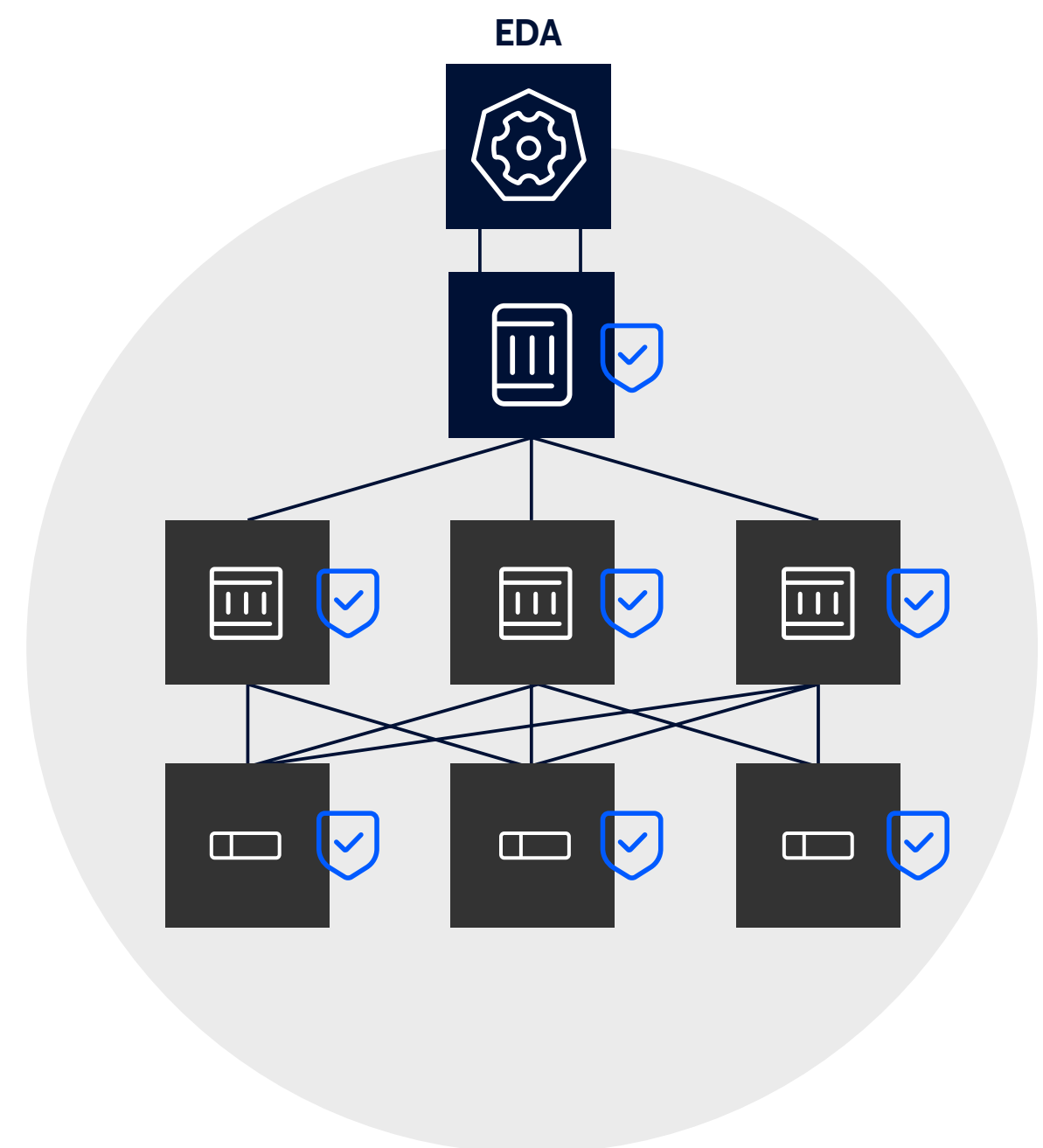
Challenge

As utilities 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 security 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

EDA

3. Digital Sandbox

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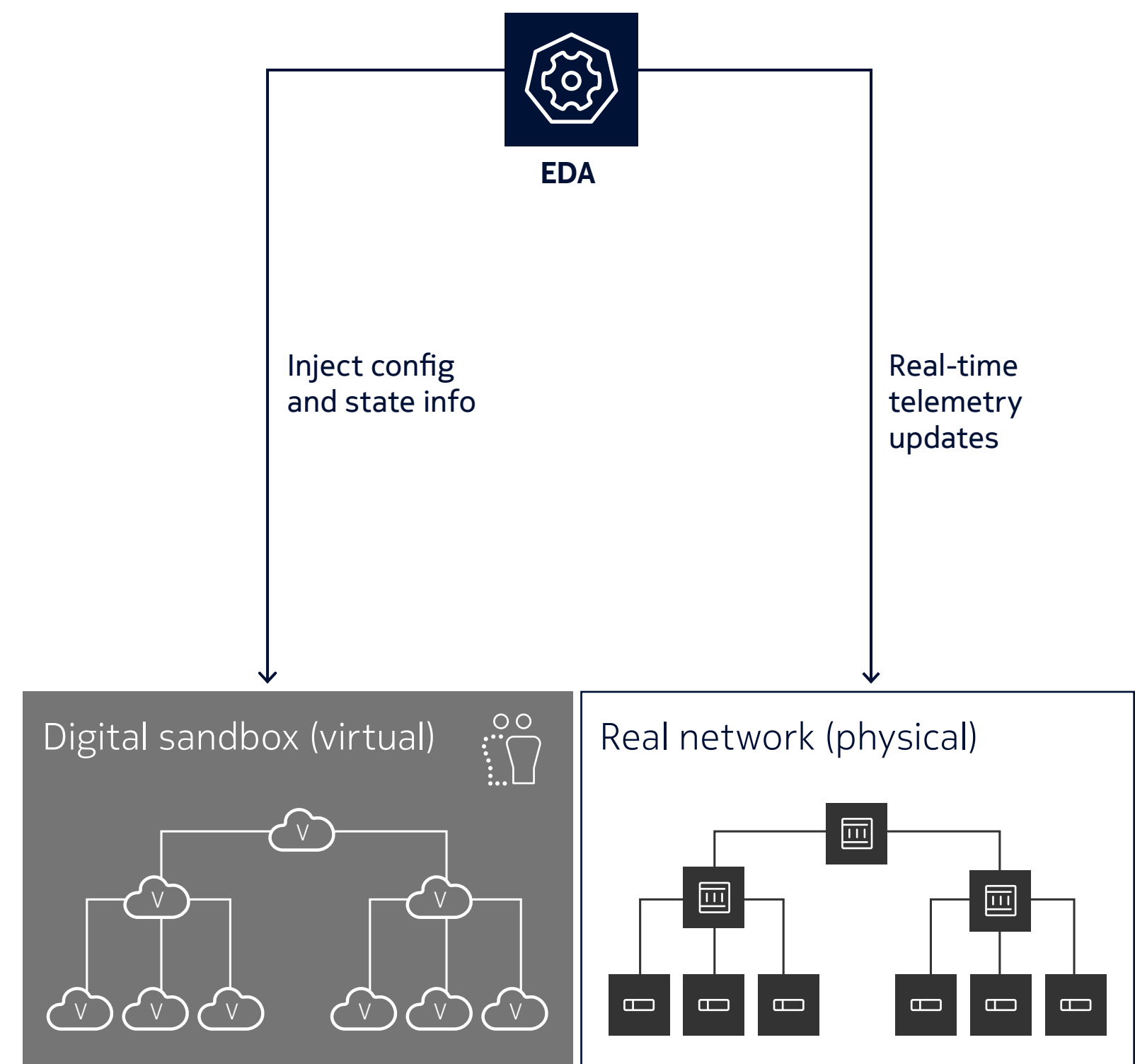
Challenge

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 utilities 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.

EDA

Inject config and state info

Real-time telemetry updates

Digital sandbox (virtual)

Real network (physical)

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 utilities, 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

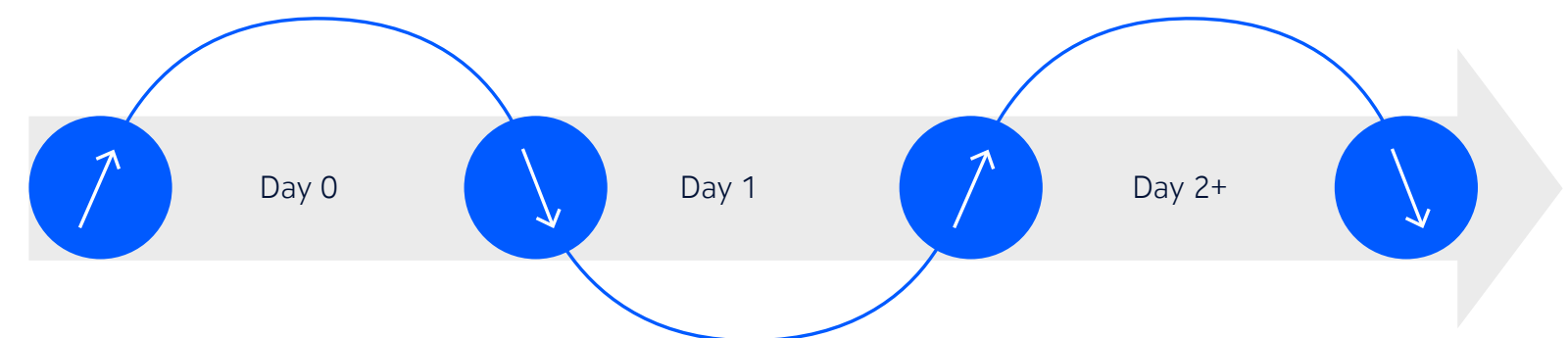- Digital Sandbox reduces risk and saves effort across entire lifecycle.

Intent-driven design and operations	Digital Sandbox for true network emulation	Cloud-native integration model

Cloud-native, Kubernetes-based extensible foundation

Automate operations

EDA

Day 0	Day 1	Day 2+

Covering all stages of the operational lifecycle

4. Easy-to-use automation

Accelerate application deployment to meet changing operational and business needs
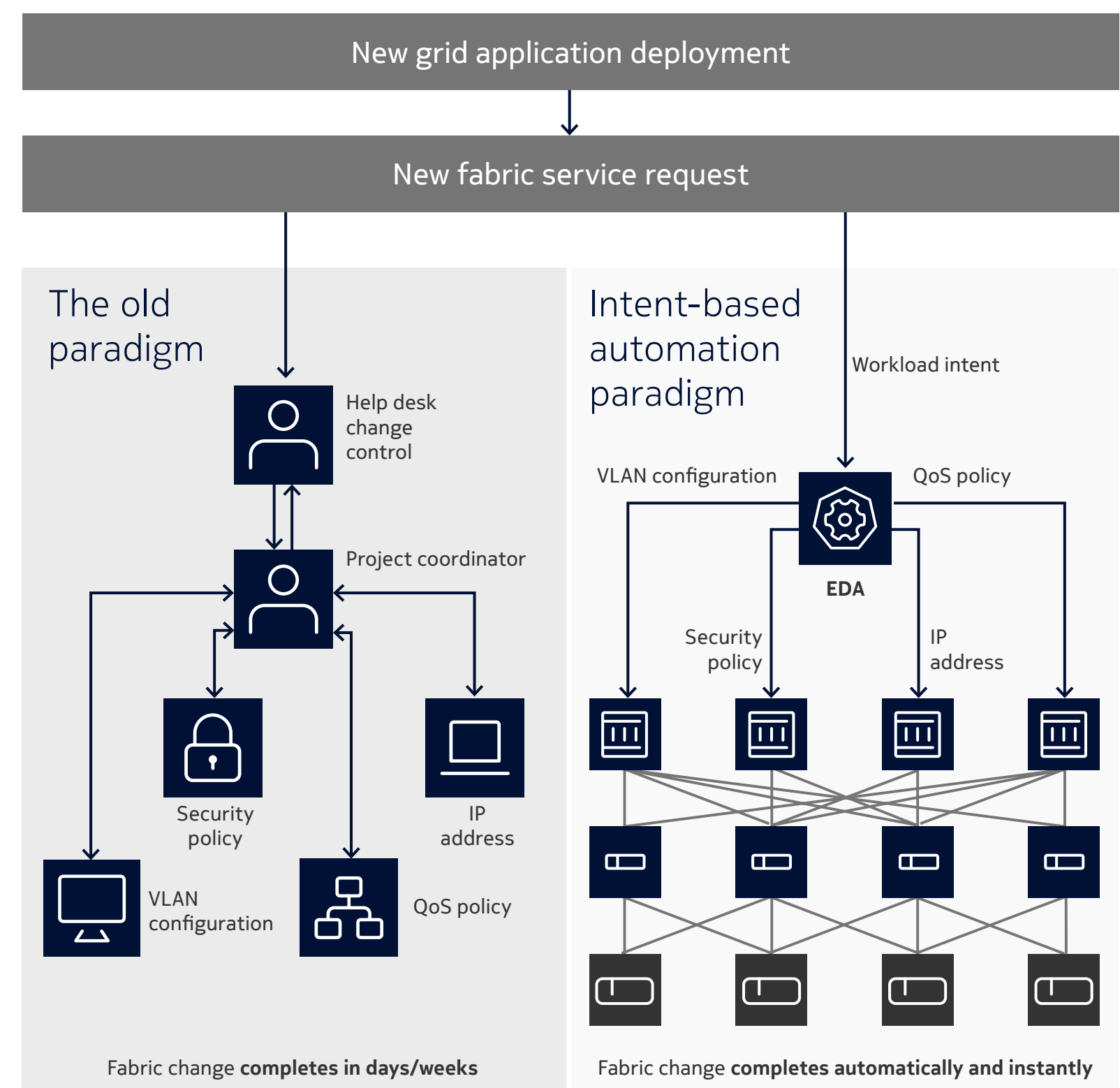
Challenge

Utilities are resorting to grid 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 reduce human error
- Automation ensures service design and configuration consistency for all applications
- Digital Sandbox reduces network risk of adding new services.

New grid application deployment

New fabric service request

The old paradigm

Help desk change control

Project coordinator

Security policy

IP address

VLAN configuration

QoS policy

Fabric change **completes in days/weeks**

Intent-based automation paradigm

Workload intent

VLAN configuration

QoS policy

EDA

Security policy

IP address

Fabric change **completes automatically and instantly**

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 Sandbox 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.
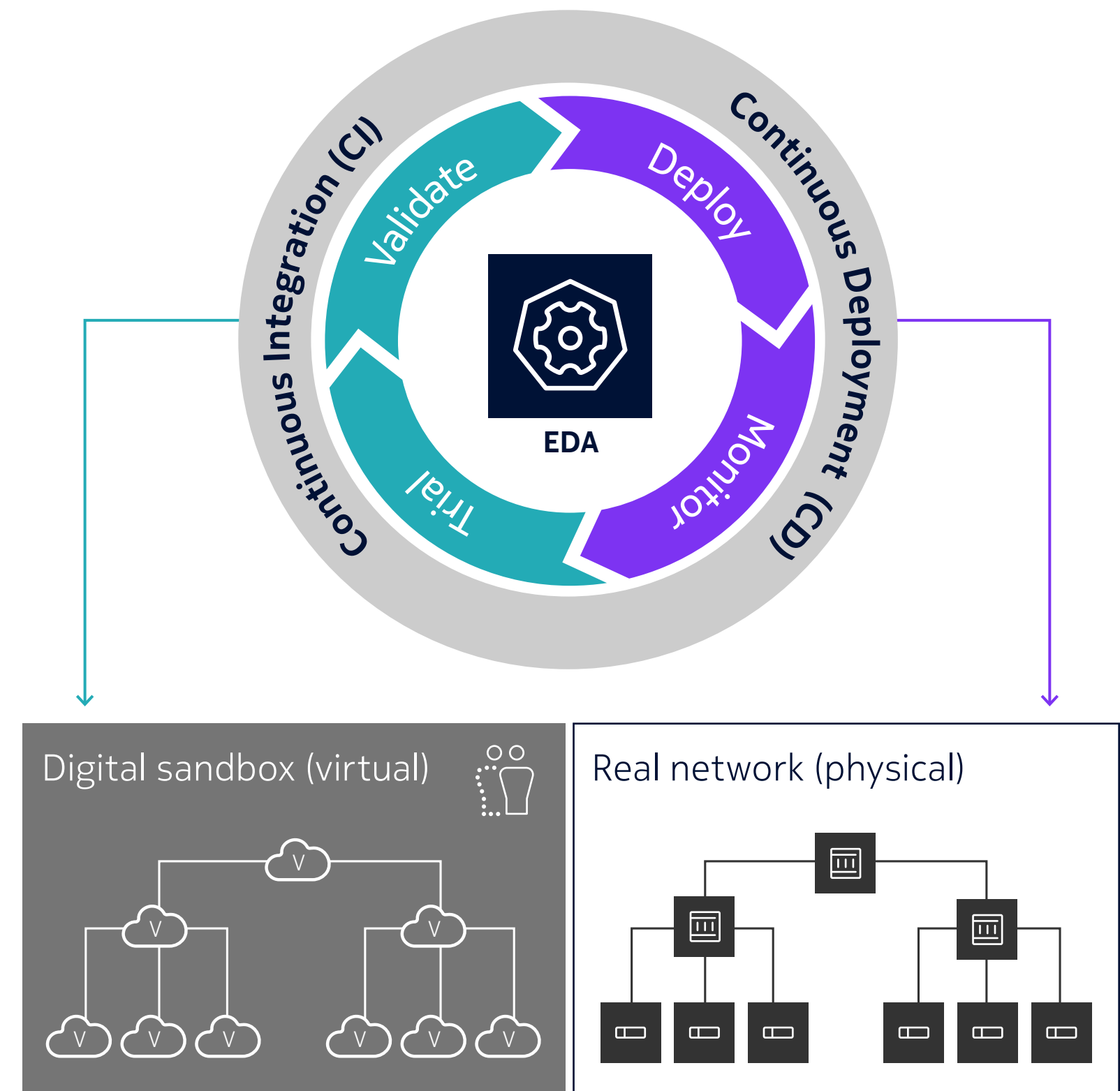
5. Fabric agility
## Keep pace with application change by using an automated agile fabric

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.

Cloud management platforms

EDA

Event updates

Data Center fabric updates

Application updates on compute
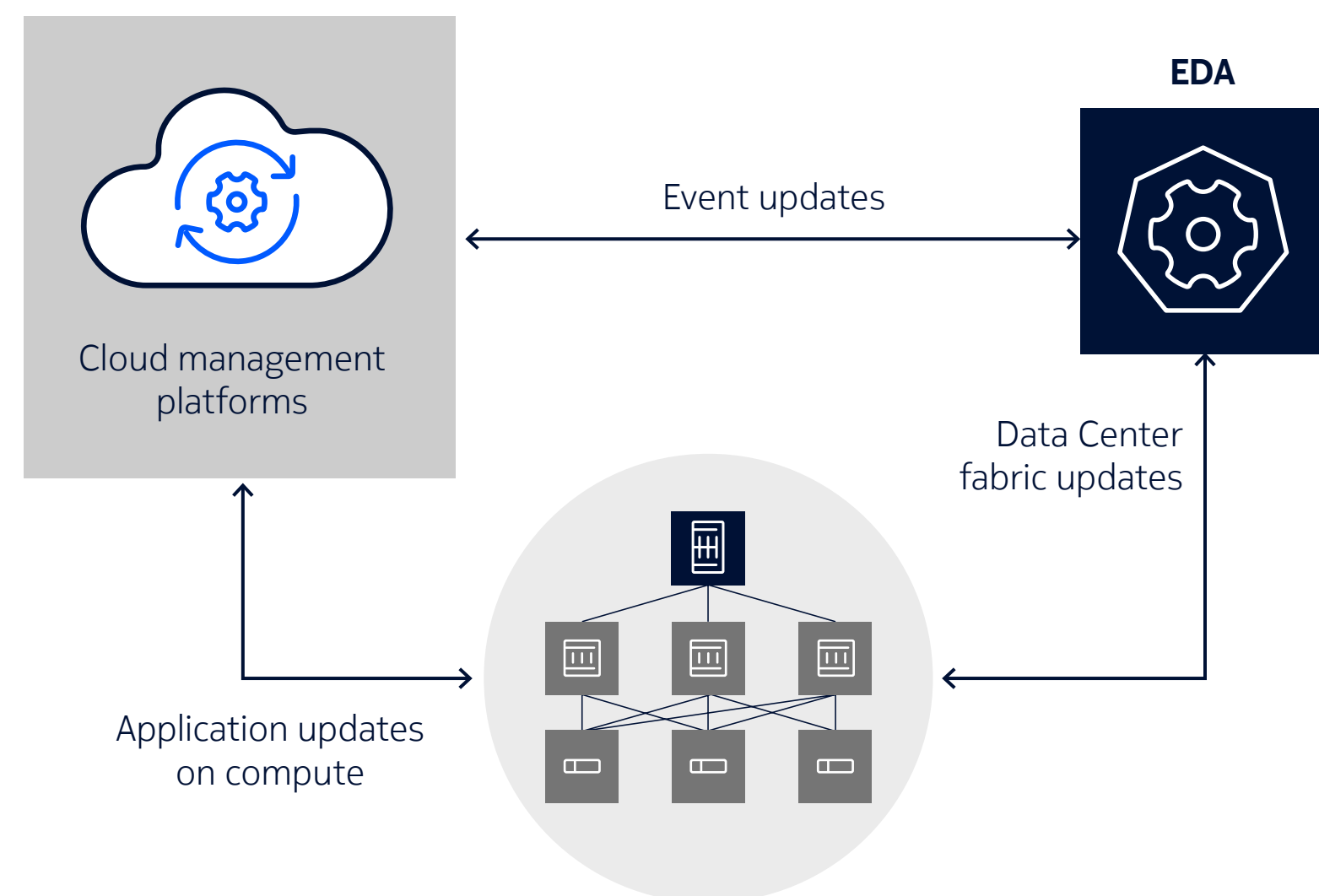
6. Intelligent insights

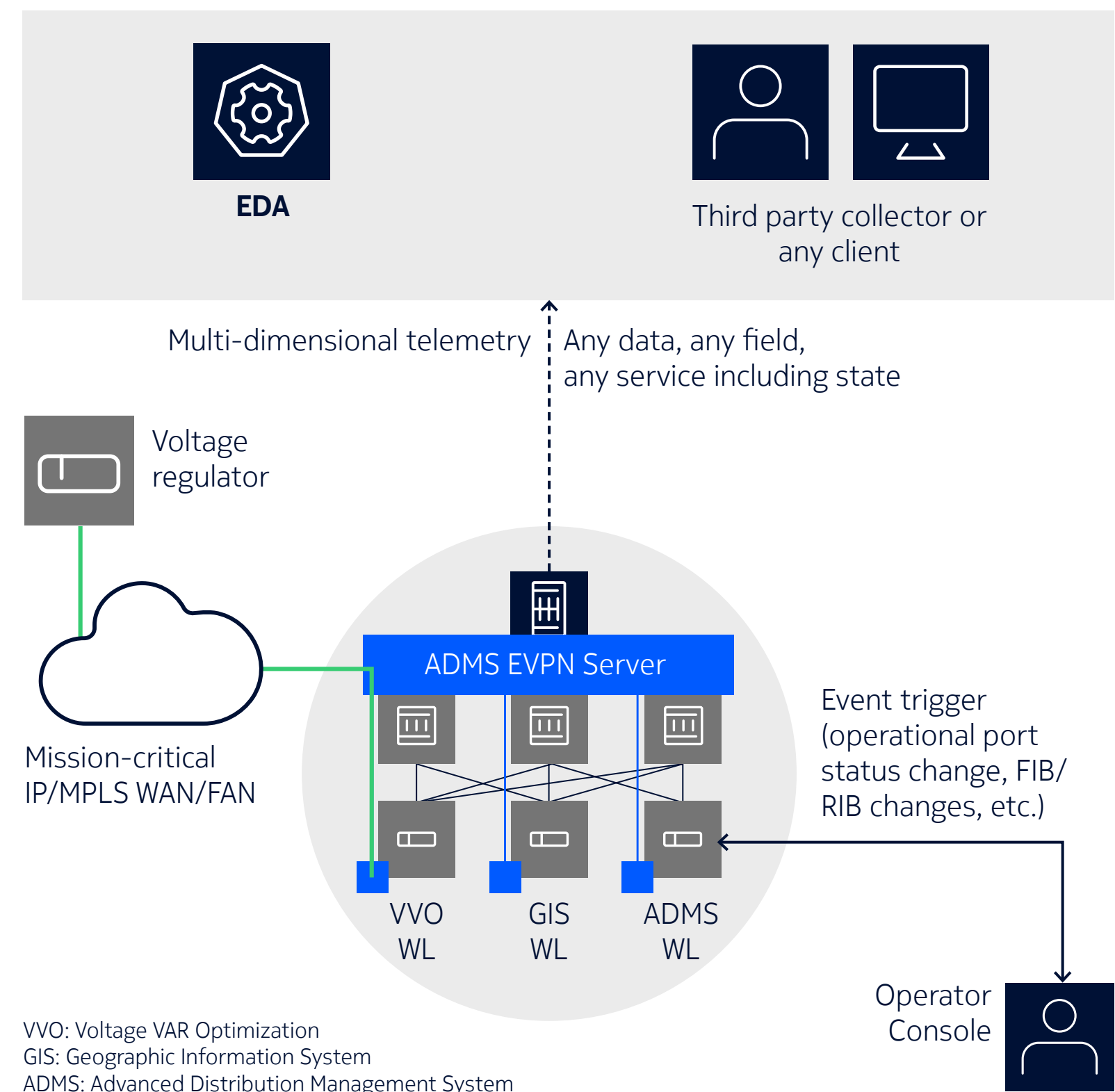Empower operations with broad and granular network insights
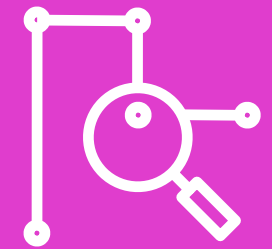
Challenge

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 Promethesus

EDA

Third party collector or any client

Multi-dimensional telemetry | Any data, any field, any service including state

Voltage regulator

ADMS EVPN Server

Mission-critical IP/MPLS WAN/FAN

Event trigger (operational port status change, FIB/RIB changes, etc.)

VVO WL   GIS WL   ADMS WL

Operator Console

VVO: Voltage VAR Optimization
GIS: Geographic Information System
ADMS: Advanced Distribution Management System

Innovative design foundation
Future proof the network and keep up with the pace of change
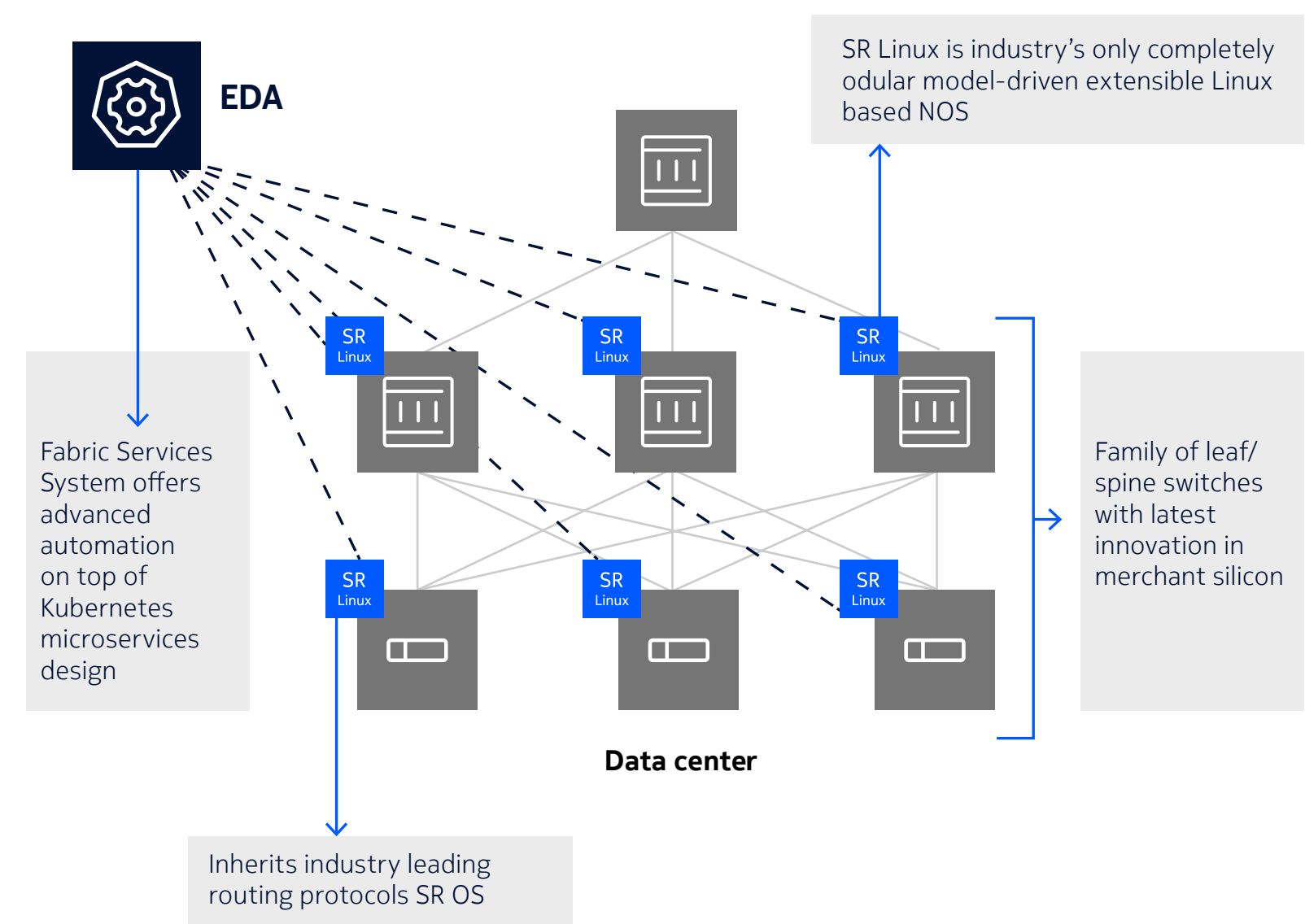
Challenge

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.

EDA

SR Linux is industry's only completely odular model-driven extensible Linux based NOS

Fabric Services System offers advanced automation on top of Kubernetes microservices design

Family of leaf/ spine switches with latest innovation in merchant silicon

SR Linux

SR Linux

SR Linux

SR Linux

SR Linux

SR Linux

Data center

Inherits industry leading routing protocols SR OS

About Nokia

At Nokia, we create technology that helps the world act together.

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.