Introduction to Nokia NI solutions for Enterprise market

November 2024

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Delivering networks that sense, think and act across our best-of-breed portfolio

Network Infrastructure

- IP networks
- Fixed networks
- Optical networks
- Submarine networks

€8.0bn
net sales 2023

Mobile Networks

- Radio access networks
- Microwave radio links
- Related network management software and services

€9.8bn
net sales 2023

Cloud & Network Services

- Core networks
- Business applications
- Private wireless and edge
- Managed services

€3.2bn
net sales 2023

Nokia Technologies

- Patent licensing
- Technology licensing
- Brand licensing

€1.1bn
net sales 2023

Nokia Bell Labs

- Core research
- Solutions research
- Consulting

~€150bn invested in R&D since 2000

10 Nobel Prizes for ground-breaking inventions

Network infrastructure

Our portfolio

IP networks

IP networks & services for residential, mobile, enterprise and cloud interconnect applications

Optical networks

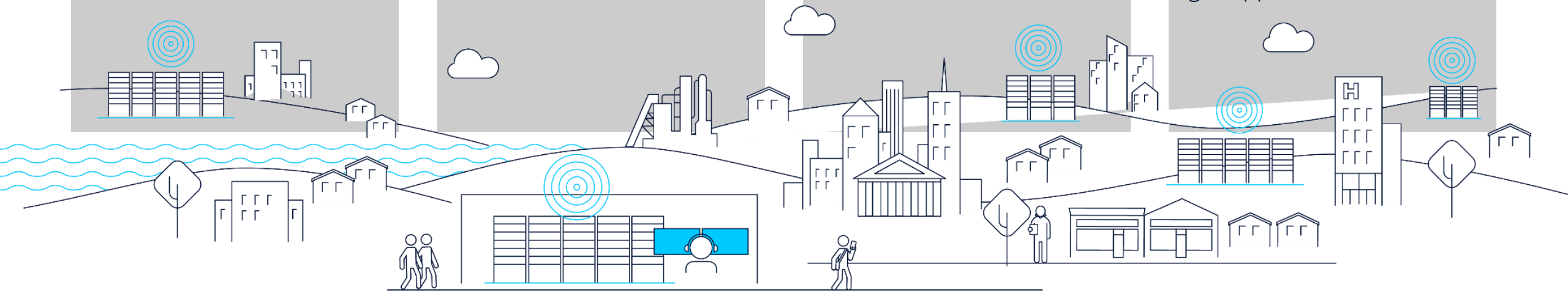
Optical transport networks for metro-access, regional, longhaul and ultra longhaul applications

Fixed networks

Fixed network services and solutions spanning copper, fiber and 5G fixed wireless applications

Submarine networks

Turnkey global undersea transmission systems for CSPs, webscale, and oil & gas applications



Nokia, the European network technology provider

...with a global footprint

HQ

Nokia headquartered in Finland, listed in Helsinki Stock Exchange

R&D

R&D Centers in Germany, Italy, Belgium, France, Finland, UK, ...

Factories

Optical factory in Italy, Mobile in Finland

Field

2,000 NI experts on the ground, serving Europe

Focus on industry, enterprise and public customers with digital transformation ambitions

- Power Utility
- Utility Broadband
- Natural Resources

- Mainline Railway
- Metro Railway
- Air Navigation
- Airport
- Highway

- Defense
- Public Safety
- Connected Territories
- Research & Education

- Neutral Host
- Digital Equity

Enterprise IT of

- Finance & Banking
- Real Estate
- ...

Nokia positions on the market

Proven industry leadership – 2024 update

NI Net Sales (2023)

EUR 8.0 billion

Includes

IP Networks net sales of **EUR 2.6bn,**
Optical Networks net sales of **EUR 1.9bn**,
Fixed Networks net sales of **EUR 2.4bn** and
Submarine Networks net sales of **EUR 1.1bn.**

- ✓ IP edge router – EMEA[1]
- ✓ XGS-PON OLT/ONT[1]
- ✓ In ON for Europe, India, RoAPAC[2]
- ✓ Market leader in submarine networks[4]

#1

- ✓ IP total router CALA[1]
- ✓ IP edge router North America, CALA, Global[3]
- ✓ ON Global excl. China[2]
- ✓ in fiber (OLT)
- ✓ ONT w/o China

#2

1.8M IP Routers shipped

>541K 100G-equivalent coherent ports shipped (lifetime count)

>0,5bn+ DSL, VDSL, Vectoring, XGS lines & GPON ports shipped to date

CSP, cloud provider, digital industries & government customers

4400+

- ✓ Own Tech and Silicon
- ✓ Complete Network Infrastructure's end-to-end portfolio
- ✓ Global Presence

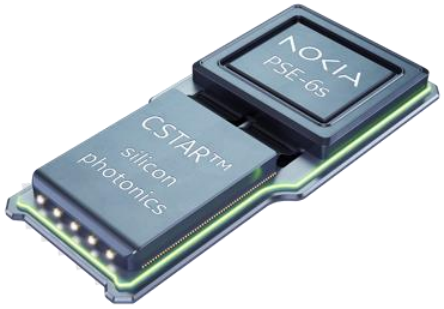
1- Dell'Oro 3Q23
2 – Analyst consensus, 12-month rolling market share
3 - Using 4-quarter average
4 - Based on orders on three-year rolling basis

Strategic silicon investments…

…complete Network Infrastructure's end-to-end portfolio

Quillion
access processing

- 50% reduction in power consumption vs. previous generations;
- Lightspan MF-14: the world's most advanced fiber broadband platform.



PSE-6s
coherent optics

- Opportunity to leap-frog competition;
- 60% less network power consumption per bit.

FP5 IP
packet processing

- 50+ FP5 contracts;
- 75% reduction in power consumption vs. previous generations;
- Additional 25-43% power savings with 800G optics vs 400G.

NI e2e Services Portfolio – across the network lifecycle

Program Management and Governance

1 Audit & Plan

- Network Readiness Evaluation
- Network Review/Audit
- Broadband Access Modelling

2 Design & Build

- Deployment
- System Integration
- Automated Home Connect & Activation
- ONT Easy Start
- Network Build Control Management

3 Optimize & Transform

- Planning & Optimization
- Broadband Migration
- Legacy Transformation
- Network Software Upgrade

4 Maintain

- Technical Support
- Return for Repair /Replace
- Advanced Replacement
- Refurbishment
- Predictive Care
- Resident Engineer

**%	>95%	20-30%	1.5x	3x	30-50%	99%	1.5x
Risk reduction	Planning accuracy	Roll-out cost reduction	Higher roll-out capacity	Less roll-out failures	Cost reduction	First-time accuracy	Faster network upgrade

Our portfolio

Fixed networks

Technologies

- Passive Optical Network (PON), incl. GPON, XGS, 25G, ...
- Wi-Fi
- Fixed wireless access (FWA)

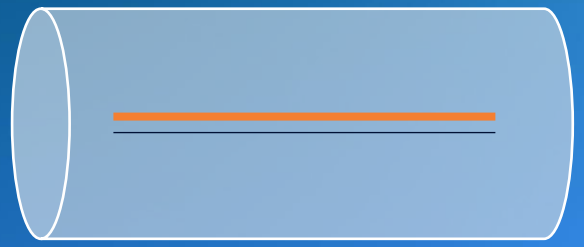
Portfolio elements

- Optical line terminals (OLT)
- Optical network terminals (ONT)
- Network management
- Wi-Fi beacons
- FWA gateways & receivers

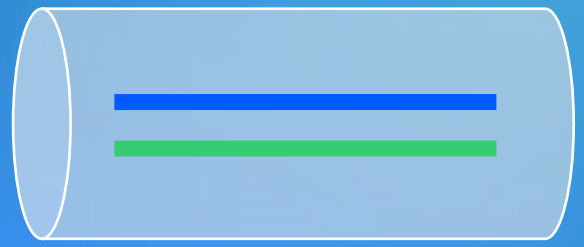
Benefits

Future-proof performance

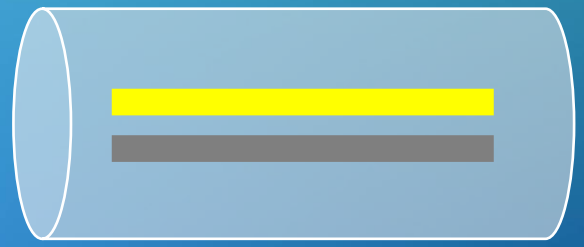
GPON
- 2.5Gbps downstream
- 1.2Gbps upstream



XGS-PON
- 10Gbps downstream
- 10Gbps upstream



25 GPON
- 25Gbps downstream
- 10 or 25Gbps upstream



Be ready for the future

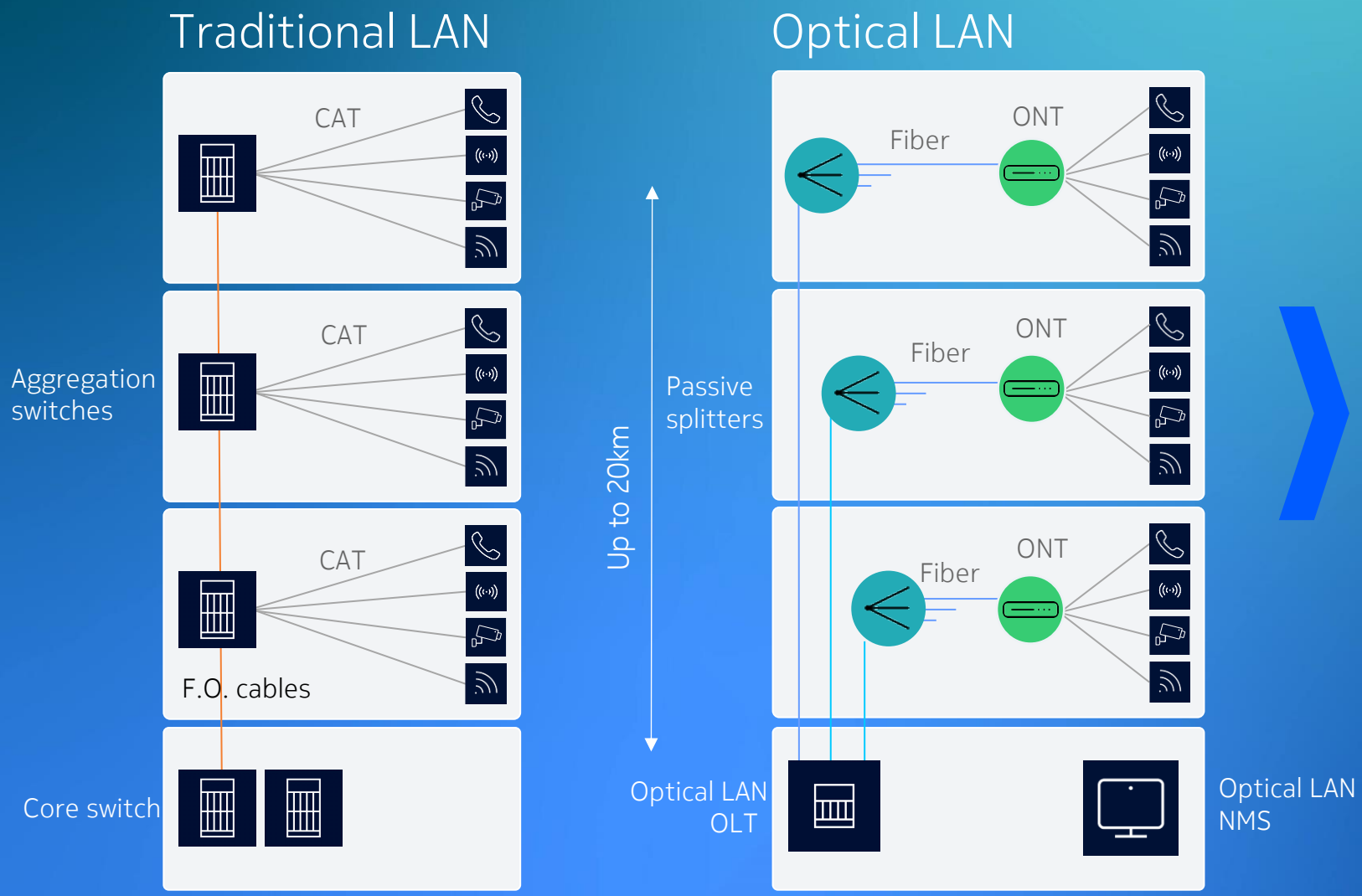
- Boost bandwidth & performance
- Choice of split ratio and splitter stages
- Increase number of users

On existing infrastructure

- Same fiber, splitter & OLT
- Can be deployed on top of GPON
- Full-service separation on same network

What is Optical LAN?

A smarter way to structure the network

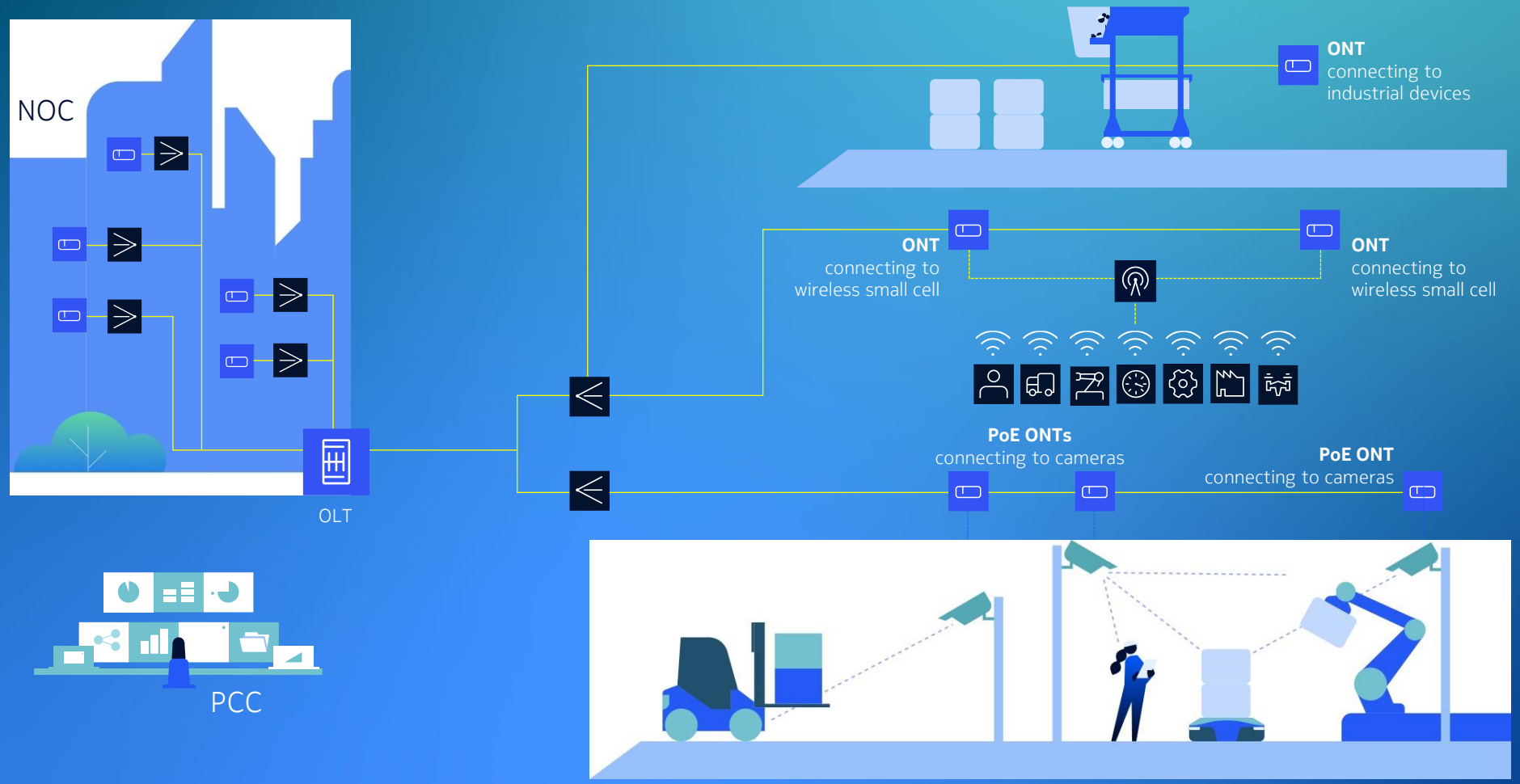


- Less equipment , less cables
- Less floor space
- Less power consumption
- Easier maintenance
- Cost-efficient upgrades
- Carrier grade reliability
- Military grade security

Nokia Optical LAN: Sales Playbook

Benefits

In-building and campus multi-service connectivity



Nokia Optical LAN
ONT Portfolio

GPON

SFP ONT

G-010S-Q

Data ONT

G-010G-T
G-010G-R
U-050X-A

Data & Voice ONT

G-120G-E
G-240G-E

Wifi 5 ONT

G-2425G-A
G-0425G-B
G-240W-L

Wifi 6 ONT

G-2426G-A(2+2 11ax)

GPON PoE

G-040P-Q

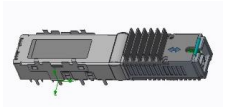
U-490XP-P

New 1Q24

G-040P-R inwall ONT

XGSPON

SFP ONT



XS-010S-Q

Data ONT

XS-010X-Q

Data & Voice ONT

XS-250X-A
XS-230X-A

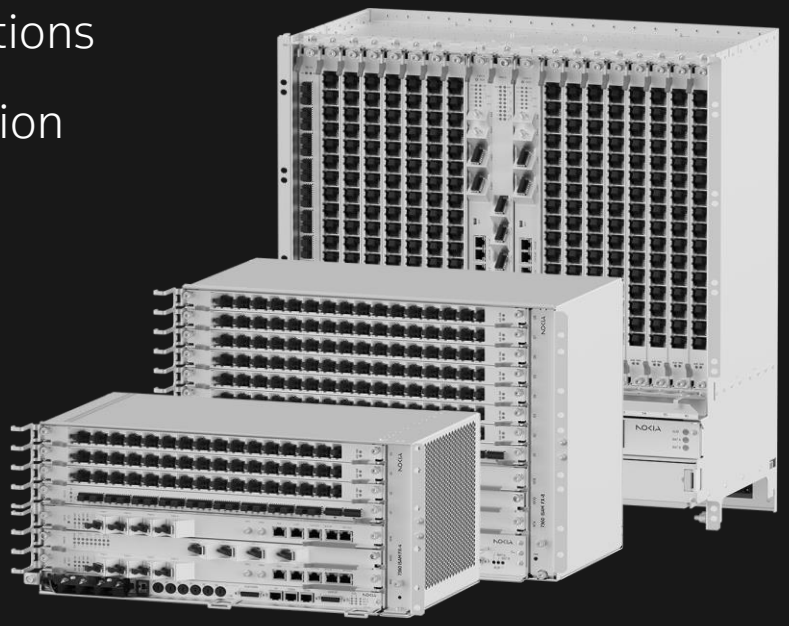
Wifi 6 ONT

XS-2426G-A(2+2 11ax)

Market leading solutions leveraging experience from >1000 networks

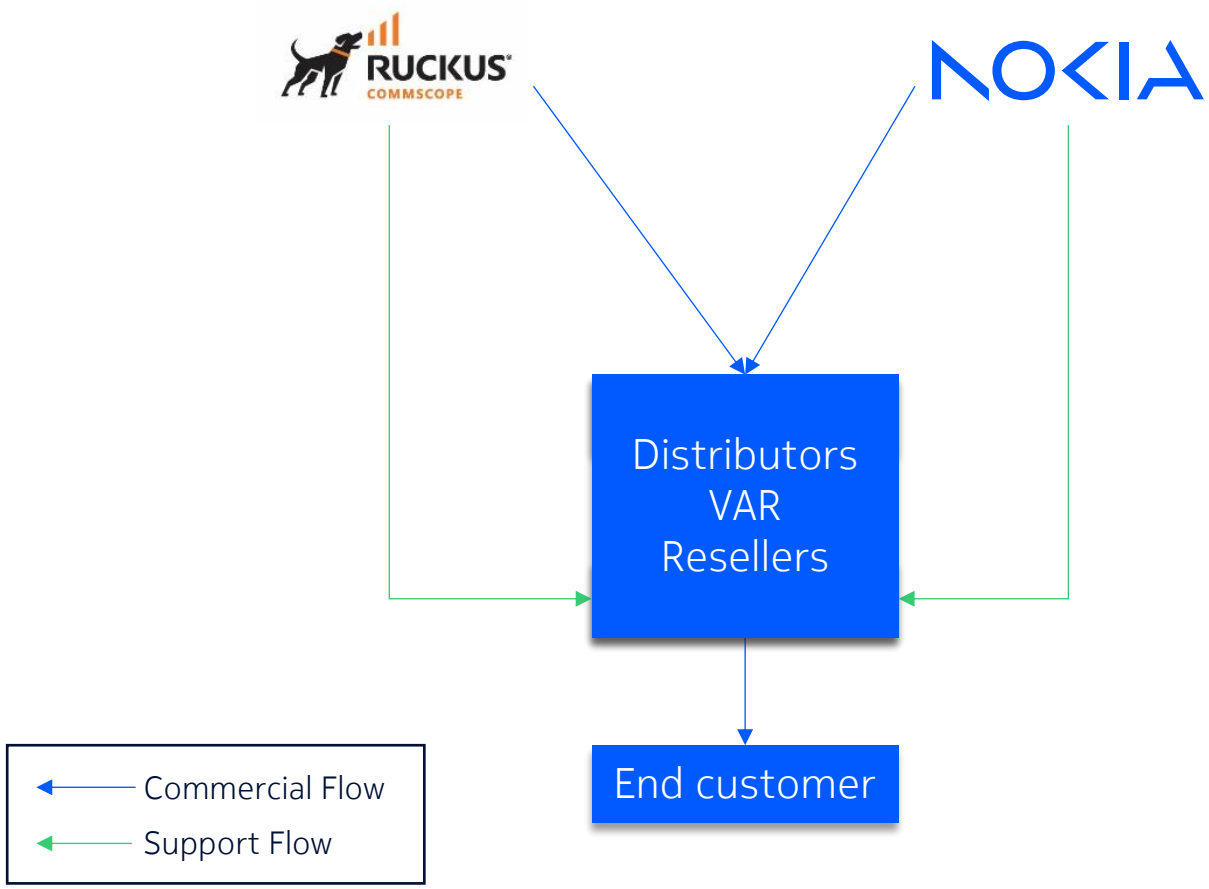
Industry leading enterprise Wi-Fi

- Less integration effort
- Streamlined operations
- Lower power consumption
- Lower TCO
- Wi-Fi 7 + 10G fiber
- Joint go-to-market



#1 next gen fiber broadband solution

Go to market principles



Partnership based on co-selling.
Partners order separately to Ruckus and Nokia

Indirect/Sell-through only.

Common Partner preferred (to avoid end-customers dual route)

Preferred/Common distributor list available

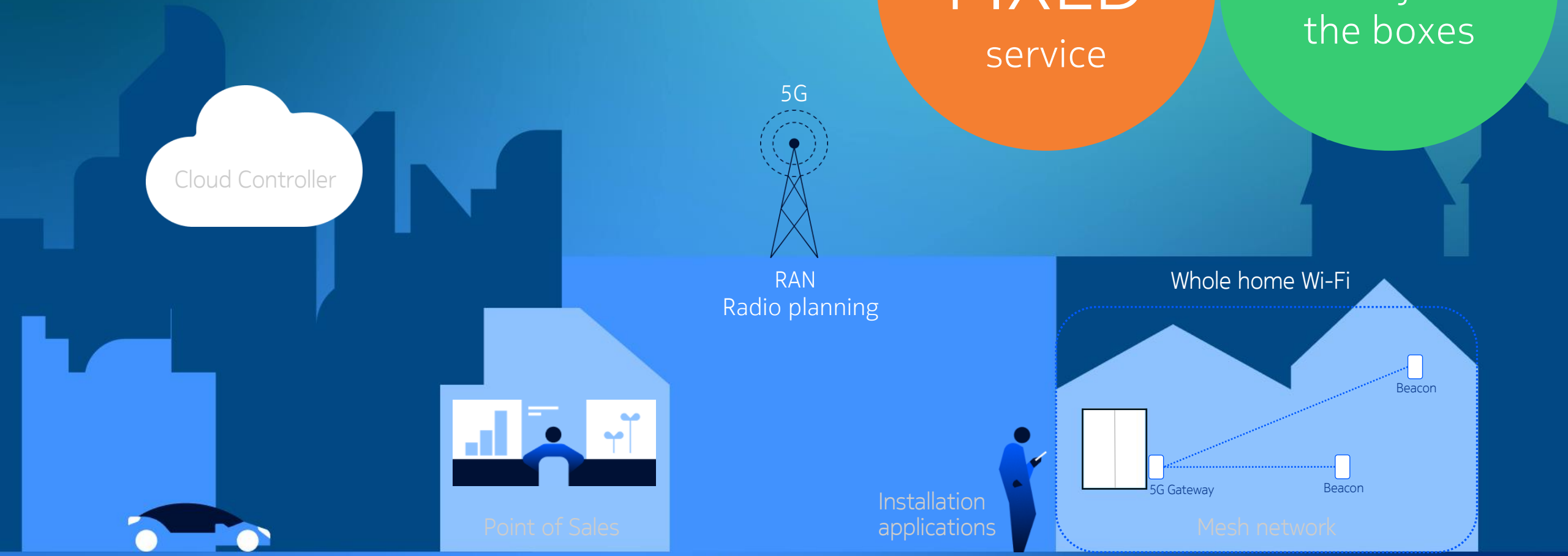
Regional link-up for Service Provider as a partner / Service Provider sell-through engagements (see contacts)

Common VAR list under finalization

The keys to successful FWA

FWA is a **FIXED** service

FWA is more than just the boxes



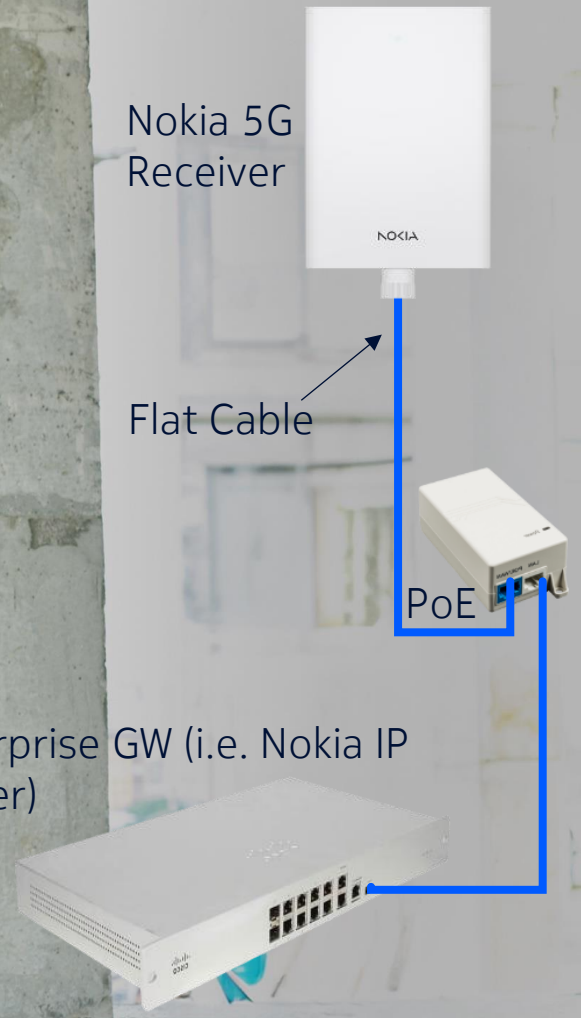
Enterprise marketplace

4G/5G Receiver for enterprise broadband LAN&WAN

Agile solution,
instant connectivity

Typical use cases:

- Branch connectivity
- Construction sites
- Pop up/temporary stores
- Substations
- Metering Stations
- SOHO/SME primary/backup link (depending on SLA)



Our portfolio

Optical networks

Technologies

- Wavelength Division Multiplexing (WDM)
- Optical Transport Network (OTN) & Packet-OTN
- Encryption, incl. Quantum Safe Network (QSN)
- Ethernet
- Synchronization

Portfolio elements

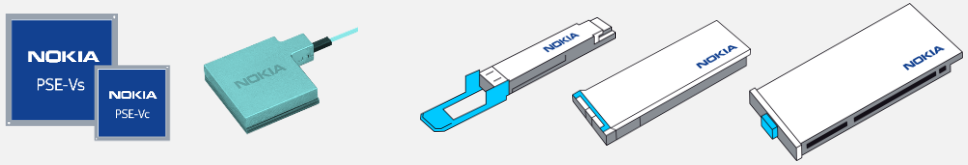
- Optical platforms
- Encryption & security
- Network management

Nokia Optical Networks – scaling from edge to core

Network automation

- Open and Transformative Software
- Connected NaaS Partner Ecosystem
- Value-added Professional Services

Photonic Service Engine (PSE)



Vertically integrated coherent opto-electronics and pluggable DCOs

1830 ONE
Edge P-OTN and ROADM family

WaveLite
Multi-service CPE and WDM transport family

1830 PSD
10G CPE

1830 VWM
Access WDM family

1830 PSI-M

Compact modular
Disaggregated transponder/SLTE

1830 PSI-L/CL

Open optical
Disaggregated line systems

1830 PSS

Optical transport
Transponders packet transport and ROADMs

1830 PSS-x

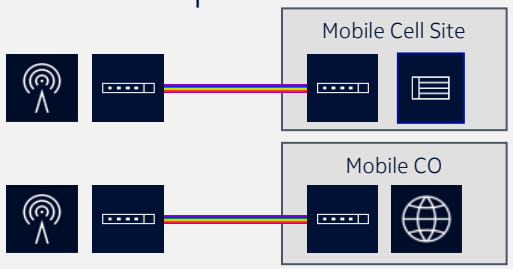
P-OTN switching
ODUk switching with Integrated WDM

Access / Edge | Metro / Regional | Core / Backbone

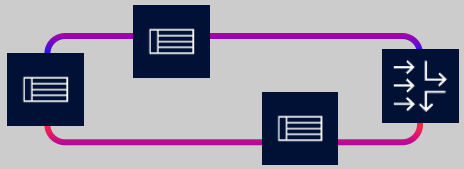
Scalable optical networking solutions

Transport, ROADM and P-OTN solutions optimized for access to core

Mobile transport



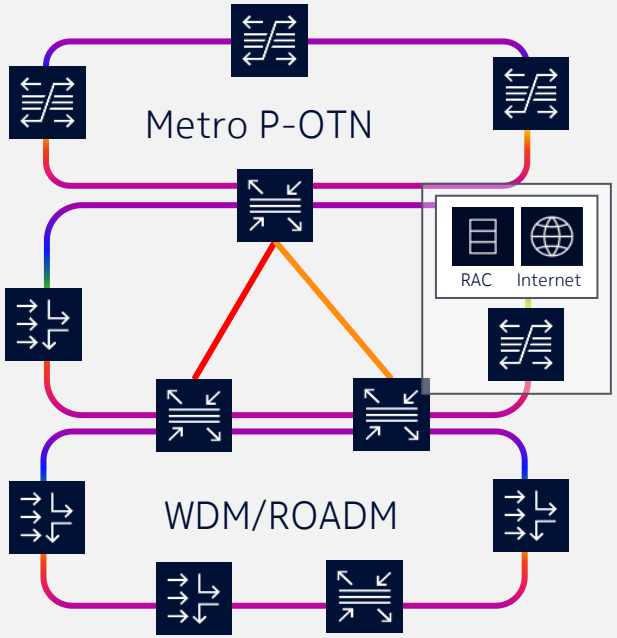
Access and aggregation



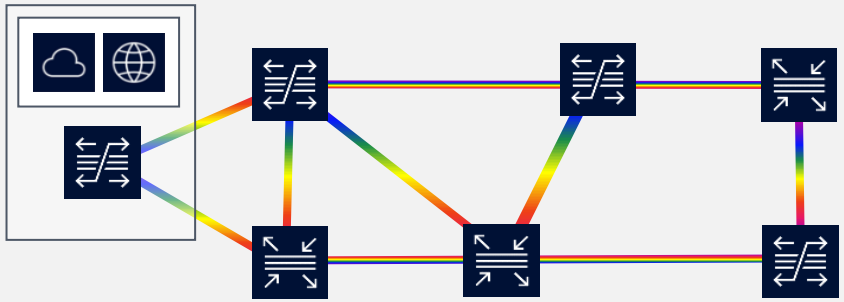
Business services and CPE

Private networks

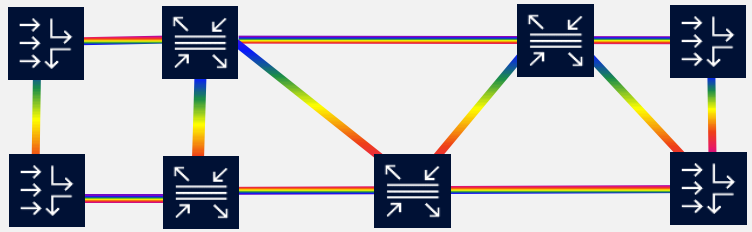
Metro-regional core



Long-haul / ULH core



Core P-OTN wholesale



WDM/ROADM backbone

Metro – regional/LH Data Center Interconnect (DCI)

Subsea/SLTE

NOKIA

Nokia Optical Networks

Recent world speed records

#1 in technology leadership

- 301 Tbps over 50km!
- 800 Gbps on a single optical wavelength at a distance of 7865 km!
- 41 Tbps over 291 km via a C-band unrepeated transmission system!

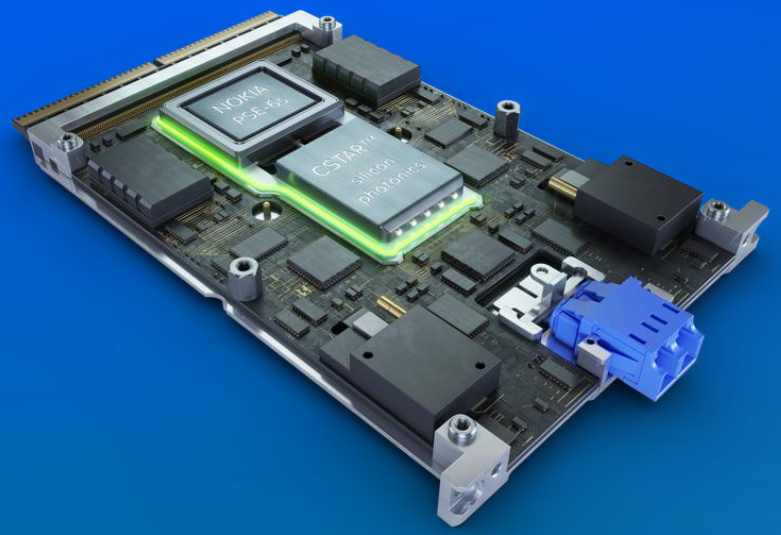
more details are here https://lnkd.in/d5j7yZnC

and here https://nokia.ly/3vRorIK

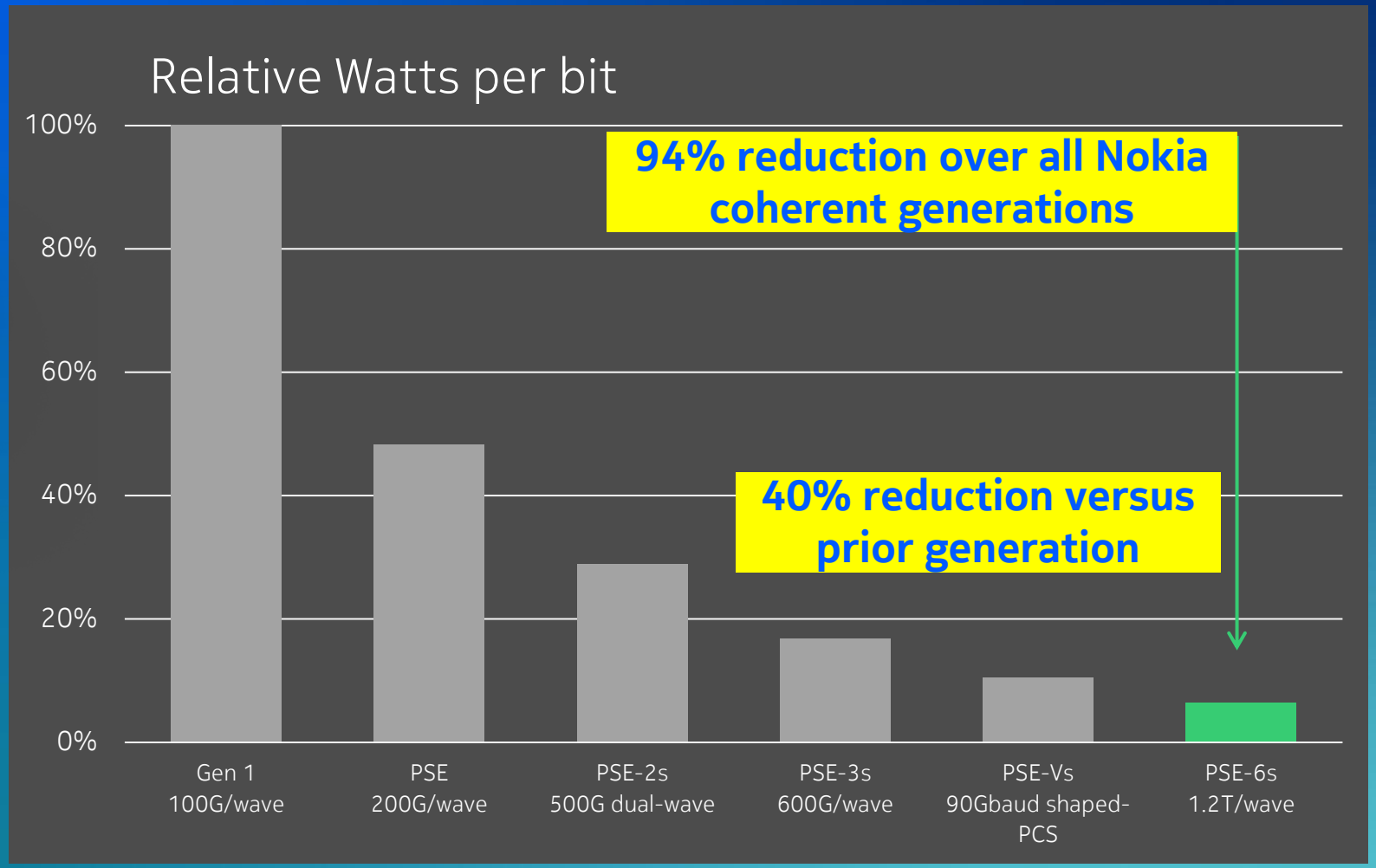
PSE-6s: Nokia leading 5nm DSP race

40% Power Saving versus previous generation

ESG TARGETS

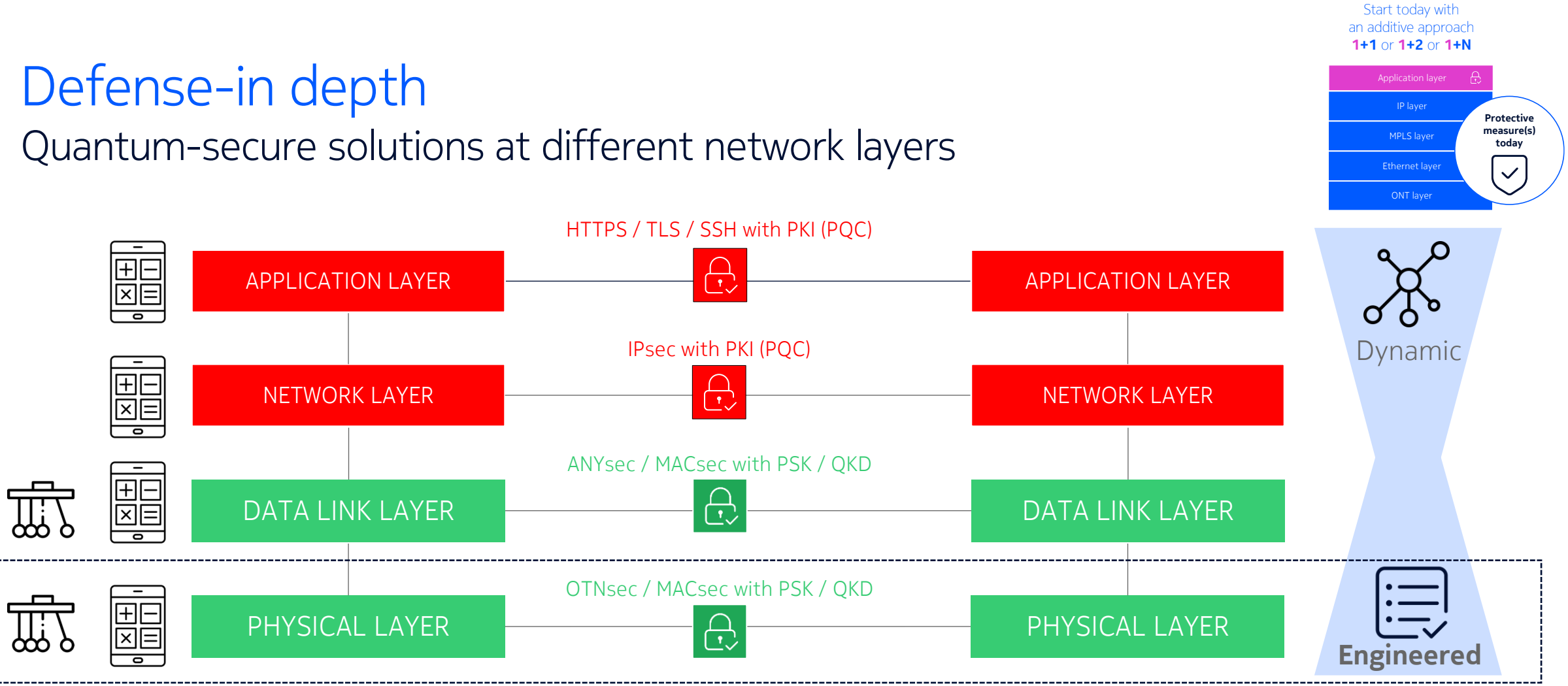


Only 5nm DSP being massively deployed



Defense-in depth

Quantum-secure solutions at different network layers



- The physical layer is more exposed to physical attacks (intrusion, tapping, jamming, service interruption)
- Optical networks transport engineered connectivity provisioned for a long period and carrying sensitive data with a long life cycle

What Makes a Network Solution Quantum Safe

Physics based Key generation, symmetric encryption and key distribution

INCREASING SECURITY THREATS

KEYS

- **Key quality** with **true random numbers** based on unpredictable physical processes
- **Key strengths** using **256 bits** to comply with the Grover's algorithm
- **Key distribution** using **symmetric pre-shared keys** fully separated from the encrypted data plane, evolvable to QKD / PQC
- **Key rotation** to minimize the amount of data available for decryption and avoiding that a compromised key is used to decrypt previously stored data

LOCKS

Data In-flight protection

Symmetric AES-256 Encryption

Nokia Quantum-Safe Networks

3 steps to protect your network against quantum threats **today**

INCREASING SECURITY THREATS

1. Generate keys a quantum computer cannot decipher

- Current math-based keys are no match for a quantum computer
- Bell Labs uses physics-based entropy to generate 256-bit keys

2. Distribute keys symmetrically to end-points

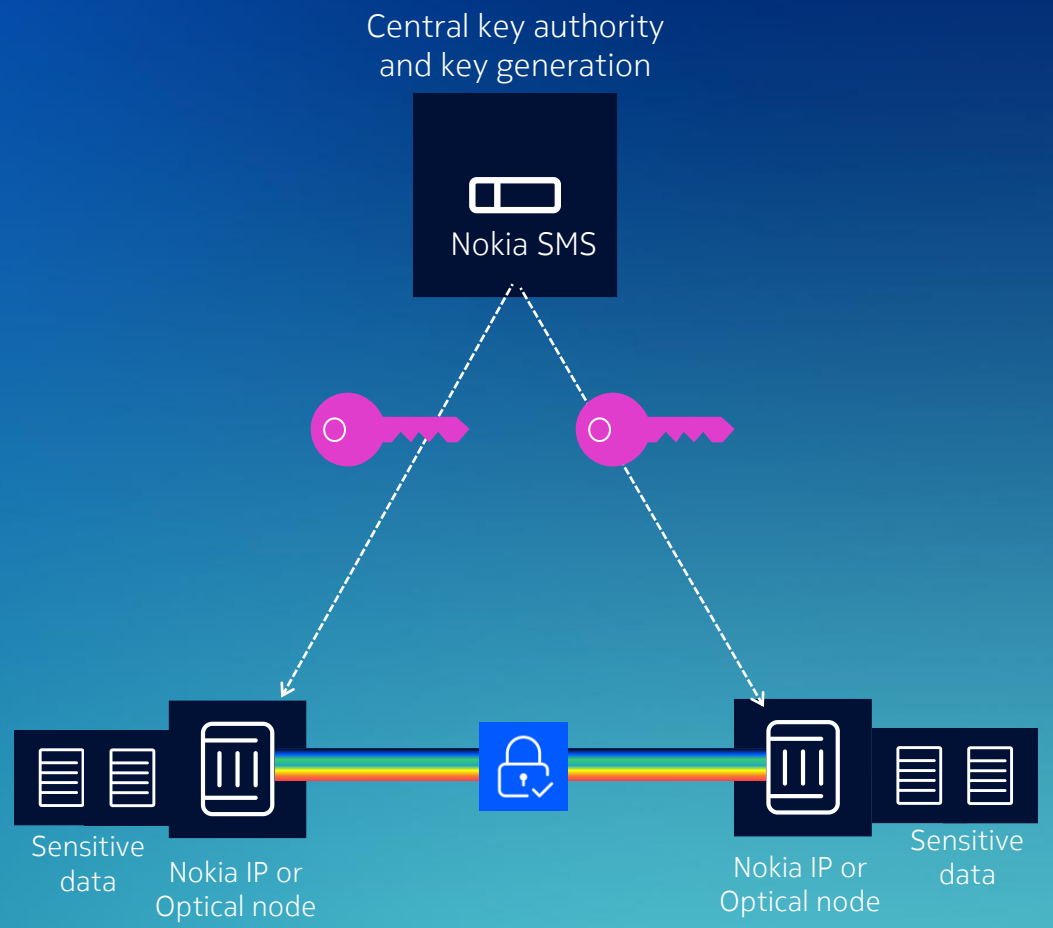
- Asymmetrical key distribution (PKC: Public Key Cryptography) is vulnerable
- Nokia SMS can distribute and rotate keys symmetrically (PSK: Pre-Shared Keys)

3. Encrypt data at line rate with minimal latency impact

- Nokia PSE optical networks and FP5/FPcx IP networks deliver unique multi-layered protection

While ensuring compatibility with future technologies

- Nokia solution easily evolves to QKD (Quantum Key Distribution) and other emerging blueprints, as they become available



Adaptable and evolving QSN

Blueprints for engineered connections

Quantum-Safe key (QSK)

Backup Quantum-Safe key (BQSK)

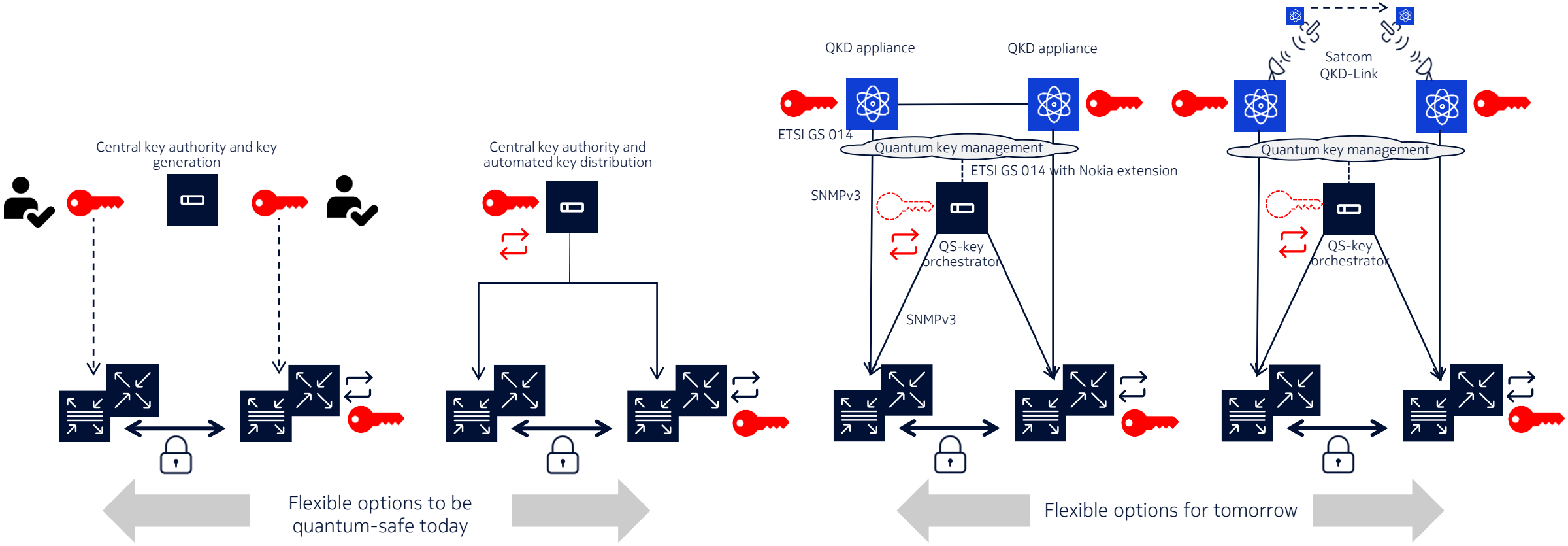
Key rotation

MACsec/ANYsec SAK rotation

Pre-Shared Keys with Manual distribution

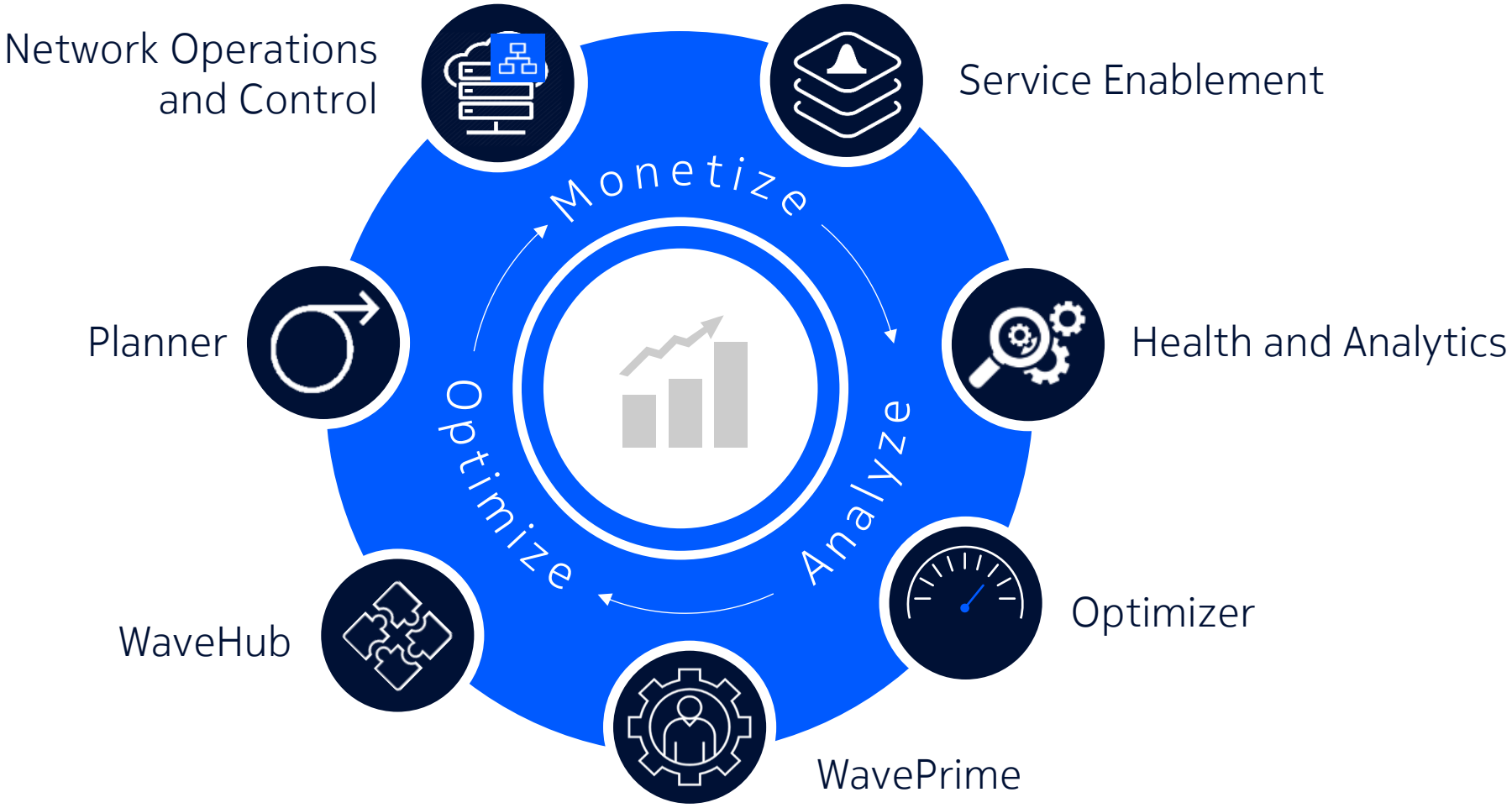
Pre-Shared Keys with Automated symmetric distribution

Pre-Shared Keys with Quantum physics **hybrid** QKD distribution



Scale made simple – efficiently scale the network

Comprehensive WaveSuite solutions for network automation



What AI means for Optical Networks

Predictive analytics and AI intelligence

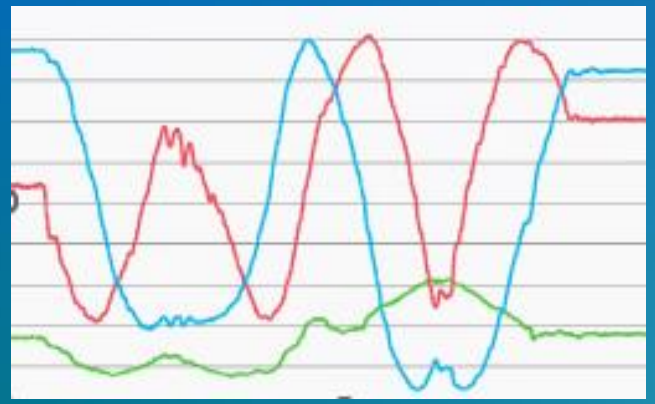
AI DRIVING GROWTH

Network Health Prediction
to better diagnose network degradations

Capacity Forecasting
for time-to-market improvement or premium connectivity upselling

Fiber Sensing
for predictive risk awareness and events detection

Event Detection



Operational Simplification
through contextual language & interfaces

AI Wavesuite Taara

Customer Focus

Wavesuite Taara Experimental version available end of 2024

AI DRIVING GROWTH

Executives

Have there been any outages in the last 24 hours?

What are the challenges in growing the network in the next quarter?

- Efficiency improvement
- Information in fingertips
- Faster Decision making
- Effective forecasting

NOC Operators

What action I need to take to fix this alarm in the network?

Why is my service showing such low uptime?

- Efficiency in day-to-day operations
- Reduce mean time to repair

Enterprises

Is my aerial fiber being impacted by heavy winds?

Are there any civil works happening in the vicinity of my fiber plant?

- More efficient use of optical infrastructure
- New advanced services
- Savings in ad-hoc equipment

Our portfolio

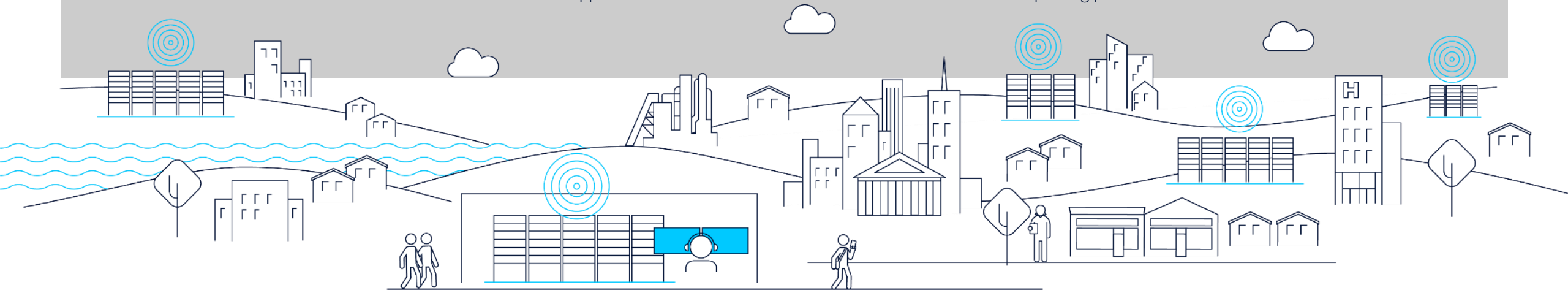
IP networks

Technologies

- IP/MPLS
- Segment Routing
- Ethernet
- Ethernet VPN (EVPN)
- Encryption, incl. Quantum Safe Network (QSN)
- DDoS attacks protection
- Synchronization
- TDM and industrial client interfaces support

Portfolio elements

- Core, aggregation & edge routers
- Access routers & switches (including industrial)
- Cellular access routers
- Data center switches
- Broadband network gateways (BNG)
- Security gateways
- Network management, orchestration & automation
- DDoS internet peering protection



IP routing portfolio

7750 Service Router (SR)

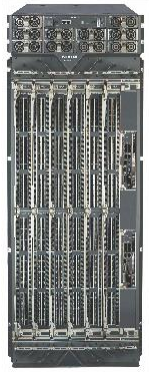

7750 SR-1s


7750 SR-1se


7750 SR-2s


7750 SR-2se


7750 SR-7s


7750 SR-14s


7750 SR-1


7750 SR-1x-48D
7750 SR-1-48D
7750 SR-1-24D


7750 SR-1x-92S
7750 SR-1-92S
7750 SR-1-46S


7750 SR-7,
7450 ESS-7


7750 SR-12,
7450 ESS-12


7750 SR-12e

7705 Service Aggregation Router (SAR)


7705 SAR-Wx
(2 variants)


7705 SAR-Hm
7705 SAR-Hmc


7705 SAR-Hc


7705 SAR-X
7705 SAR-Ax


7705 SAR-8


7705 SAR-18

7730 Service Interconnect Router (SXR)


7730 SXR-1x-44S


7730 SXR-1-32D


7730 SXR-1d-32D


7730 SXR-1d-60S


7730 SXR-R6d


7730 SXR-R6dl

7250 Interconnect Router (IXR)

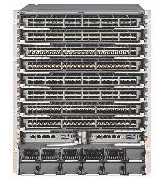

7250 IXR-e series


7250 IXR-R4
7250 IXR-R6


7250 IXR-R6d
7250 IXR-R6dl


7250 IXR-X series
7250 IXR-s


7250 IXR-6


7250 IXR-10

7210 Service Access System (SAS)


7210 SAS-K30 ETR
7210 SAS-K12 (ETR option)
7210 SAS-K5 (ETR option)


7210 SAS-Dxp-16p 7210 SAS-Dxp-24p
(DIN rail and ETR)


7210 SAS-Dxp
(ETR option)


7210 SAS-Sx and SAS-S 1/10GE
7210 SAS-Sx 10/100GE


7210 SAS-Mxp
(ETR option)


7210 SAS-R6

Portfolio Building Blocks


FP5 routing silicon


FPcx routing silicon

Service Router Operating System

Service Router Linux Operating System

Virtualized Service Router


Network Services Platform (NSP)


Deepfield Network Analytics and DDoS Security

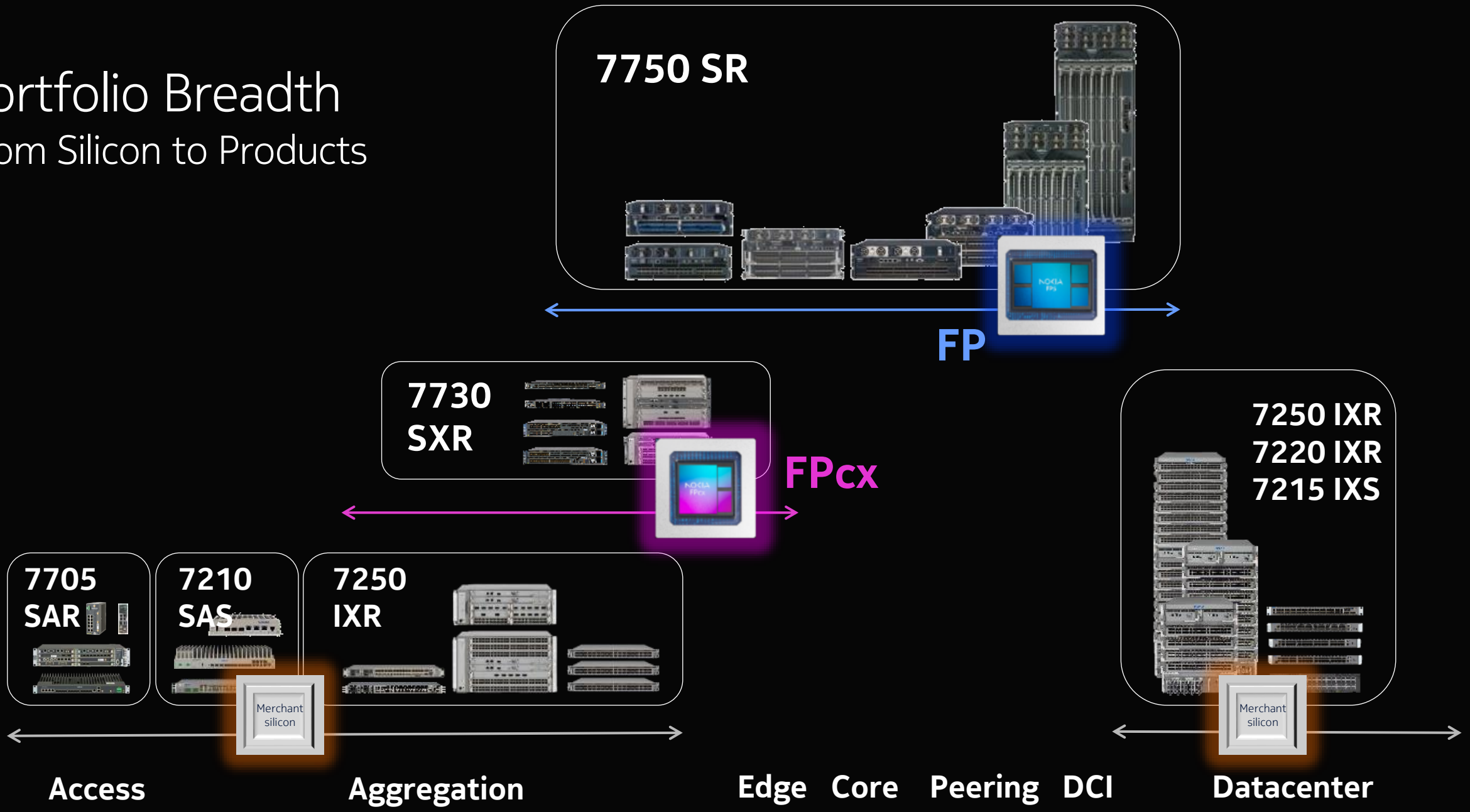
Nokia IP Routing Product Portfolio

Event Driven Automation (EDA) Network Services Platform (NSP) Deepfield

Network Operating Systems (SR OS, SR Linux)

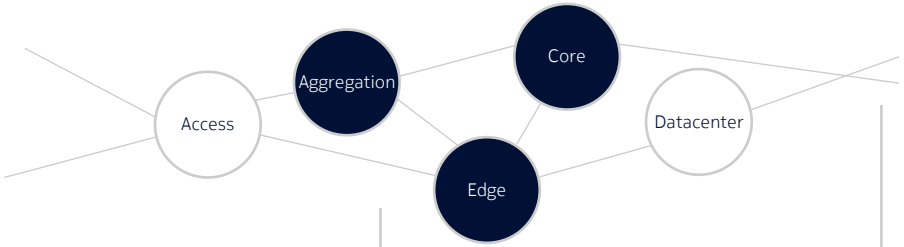
Portfolio Breadth

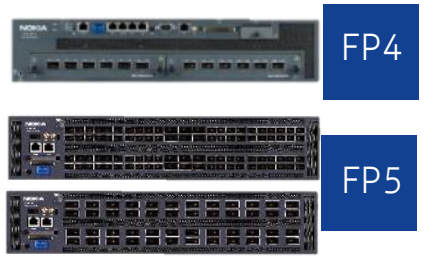
From Silicon to Products



7750 SR

Master the unexpected



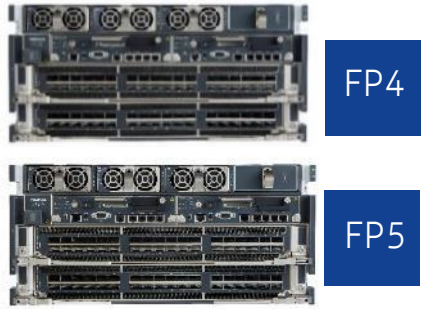


7750 SR-1/1x
Modular or Fixed
Integrated GNSS (1x)

1.5T - 6.0T FD
Up to 19.2T IA

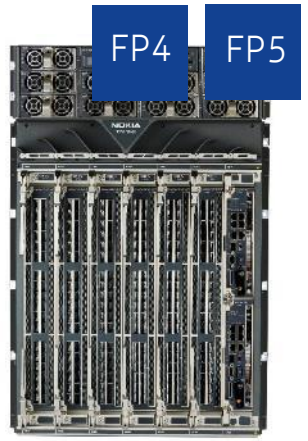
7750 SR-1s/1se
High-Capacity Edge
Modular or Fixed
Integrated GNSS (1se)

2.4 - 19.2T FD



7750 SR-2s/2se
Control/Fabric Redundant
2-slots
Integrated GNSS (2se)

9.6T / 36T FD
24T / 38.4T IA



7750 SR-7s
Control/Fabric
Redundant
6-slots

108T FD
115.2T IA

7750 SR-14s
Control/Fabric
Redundant
12-slots

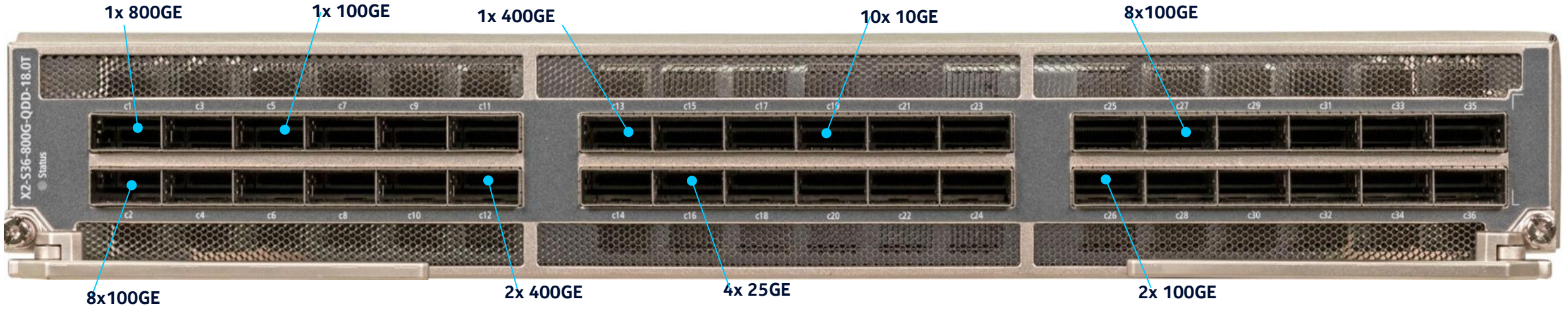
216T FD
230.4T IA

800G today, best-in-class optics cooling, 0.1W/gig

FP: NPU, deterministic, feature-rich with quality day-1, secure

36port 800G QSFP-DD XMA2

Performance for demanding roles



License upgradable

1. 14.4T, 36p 400G QSFP-DD
2. 18.0T, 36p 800G QSFP-DD to 19.2T iA

3x capacity & 3x buffer increase FP4 to FP5

800G now

Universal ports

Belly-to-Belly cage design

Honeycomb mesh air intakes

33W+ cooling per port with margin

Nokia 7250 IXR

7250 IXR-ec

7250 IXR-e small

7250 IXR-e big

7250 IXR-e
Compact
ETR with GNSS
64G, 120G or
300G FD +
conformal coat

7250 IXR-e2c NEW

7250 IXR-e2 NEW

7250 IXR-e2
Compact
ETR with GNSS
100G FD or
800G FD

7250 IXR-R4

7250 IXR-R6

7250 IXR-R
Control Redundant
ETR & GNSS (R6)
160G FD/slot
300G or 800G FD

7250 IXR-R6d

7250 IXR-R6dl

7250 IXR-Rd
Control Redundant
ETR & GNSS
300/500G FD/slot
2.4T FD

7250 IXR-s

7250 IXR-s
Fixed form factor
800G FD

7250 IXR-X3b NEW

7250 IXR-X1b NEW

7250 IXR-X3

7250 IXR-X1

7250 IXR-Xs

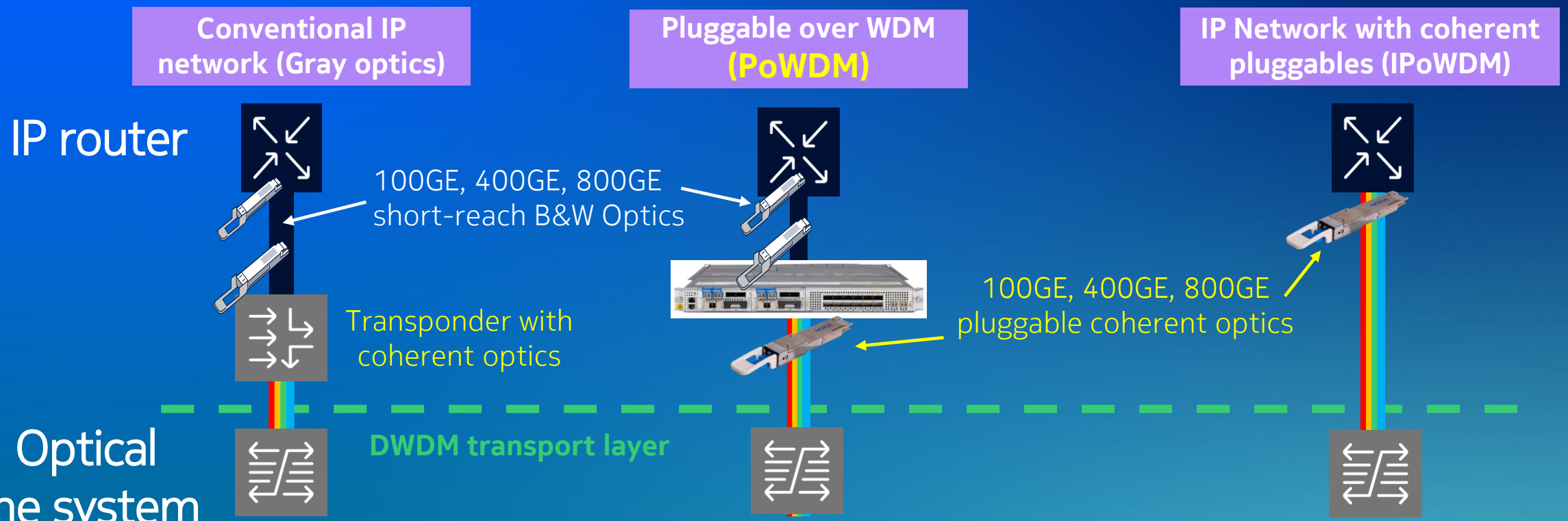
7250 IXR-X
Fixed form factor
4.8T to 14.4T FD

Scalable, common design approach

300mm ETSI compliant

Nokia Options for IP and Optical Networking

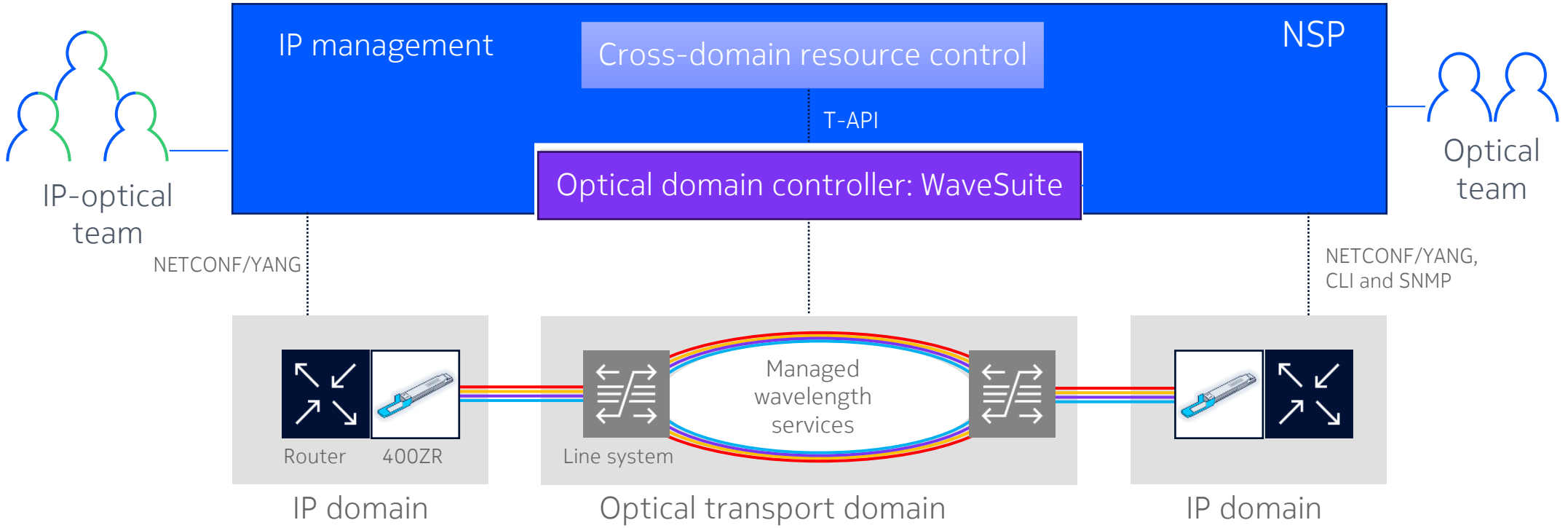
DISSAGREGATION



PoWDM is about using compact & cost effective coherent modules in optical transport platforms to address suitable applications and enrich Nokia ON toolbox so we deliver the most optimal solution for every network
PoWDM further complements our Coherent Routing story offering more flexibility to our customers

Coordinated operations across and between network domains

Managing Coherent Routing applications with the NSP



The IP domain controller uses model-driven mediation to manage routers from Nokia and third-party vendors

The cross-domain resource controller uses the Transport API to interface with optical domain controllers from Nokia or third-party vendors

800G Coherent Routing

7750 SR-1se

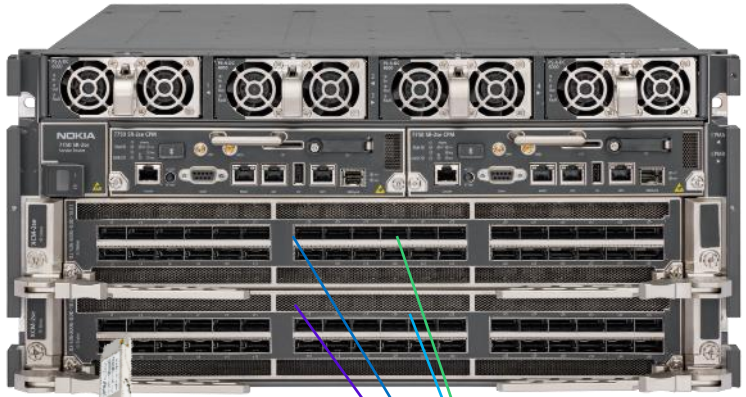
1x QSFP112-DD 800G ZR
2x QSFP-DD 400G ZR
1x QSFP28 100G ZR

QSFP-LS

1,700 Gb/s

120 km

7750 SR-2se



QSFP-LS

1x QSFP112-DD 800G ZR
2x QSFP-DD 400G ZR
1x QSFP28 100G ZR

Need for an enhanced version of MACsec

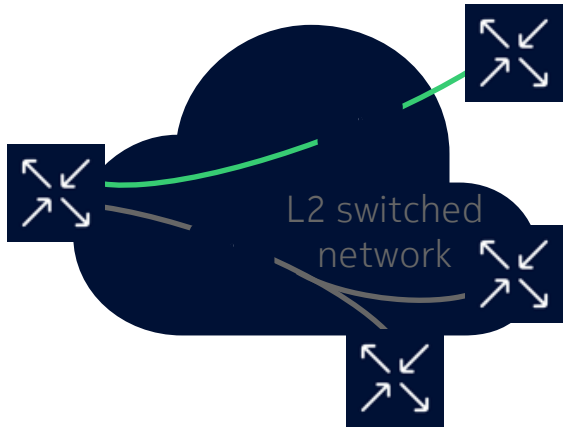
Post Quantum Safe

MACsec

- Low latency, line rate encryption via IEEE802.1AE
- L2 encryption

Shortcomings

- Hop-by-hop MPLS/IP encryption/decryption
- For MPLS/IP encryption every router must be MACsec capable
- For end-to-end MPLS/IP encryption packet must be decrypted on ingress of the router and after routing decision encrypted on egress



ANYsec support in SR OS

Dynamic signaling of datapath encryption keys

- MKA over UPD/IP to negotiate datapath encryption keys
- Interworking with MACsec

Multi-slice encryption

Encryption group per

- Flexible algorithm
- IGP instances
- Group of LSPs with in a single plane

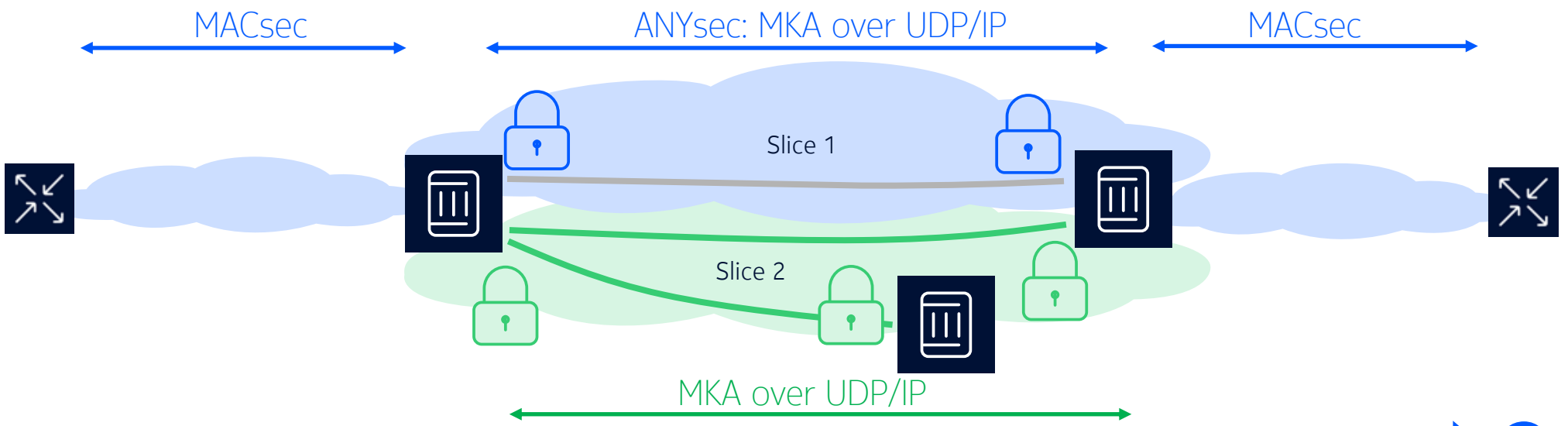
SR tunnel encryption

End-to-end SR tunnel encryption

- SR-ISIS
- SR-OSPF
- SR-OSPF3

Encryption group (EG)

- Single Pre-Shared Key (PSK) for a group of SR tunnels
- Ease of PSK management and rollover



Nokia hardware supporting ANYsec

FP5

ANYsec is implemented in the E5 chip

E5

FPcx

Interworking with the E5 chip

Some platforms are provided with this functionality

- Fixed platform: SXR-1-32D
- Modular platform: SXR-R6d/R6dl (selected MDA's)

FP4

Interworking with the E5 chip

A number of E5 based MDAs are planned for IOM-s, IOM5-e, SR-1s and SR-1

Ensuring quality

What makes SR OS quality so different

SR OS

Software 100% developed in house for total control

A uniquely balanced team for quality

500+ development engineers

500+ test engineers

Permanent quality testing

350 000+ test cases

3+ years test hours run in **2** weeks

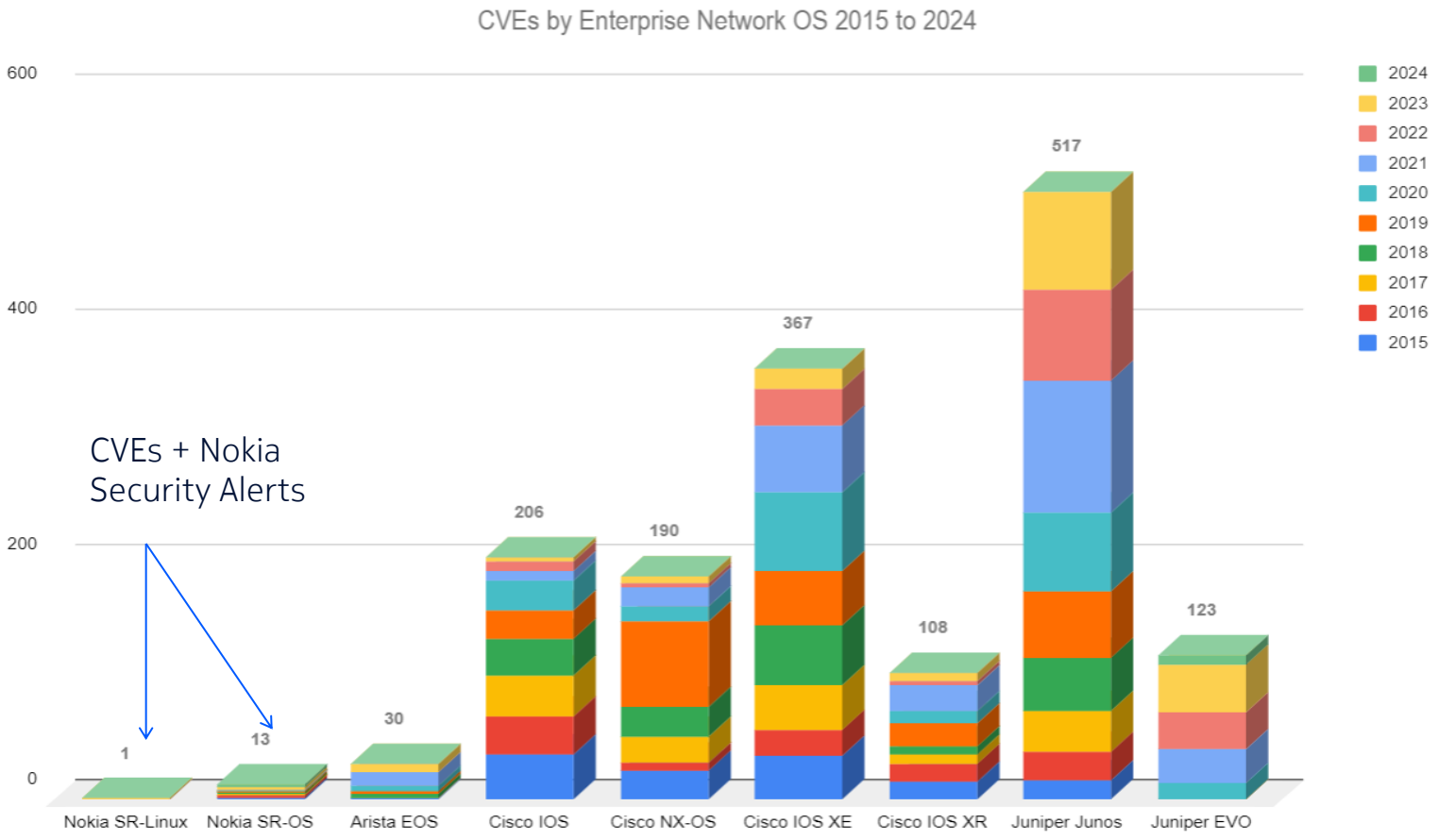
Demonstrated quality

No major network outages requiring emergency patches in **>15** years

Proven predictability with no major release date missed by more than 2 days in 20+ years…

Quality gives you peace of mind

Nokia's ingrained culture of quality



Nokia security alerts timely communication on known issues to minimize disruptions

Nokia's commitment to ultra-reliable software gives you peace of mind, so you can focus on innovation and growth

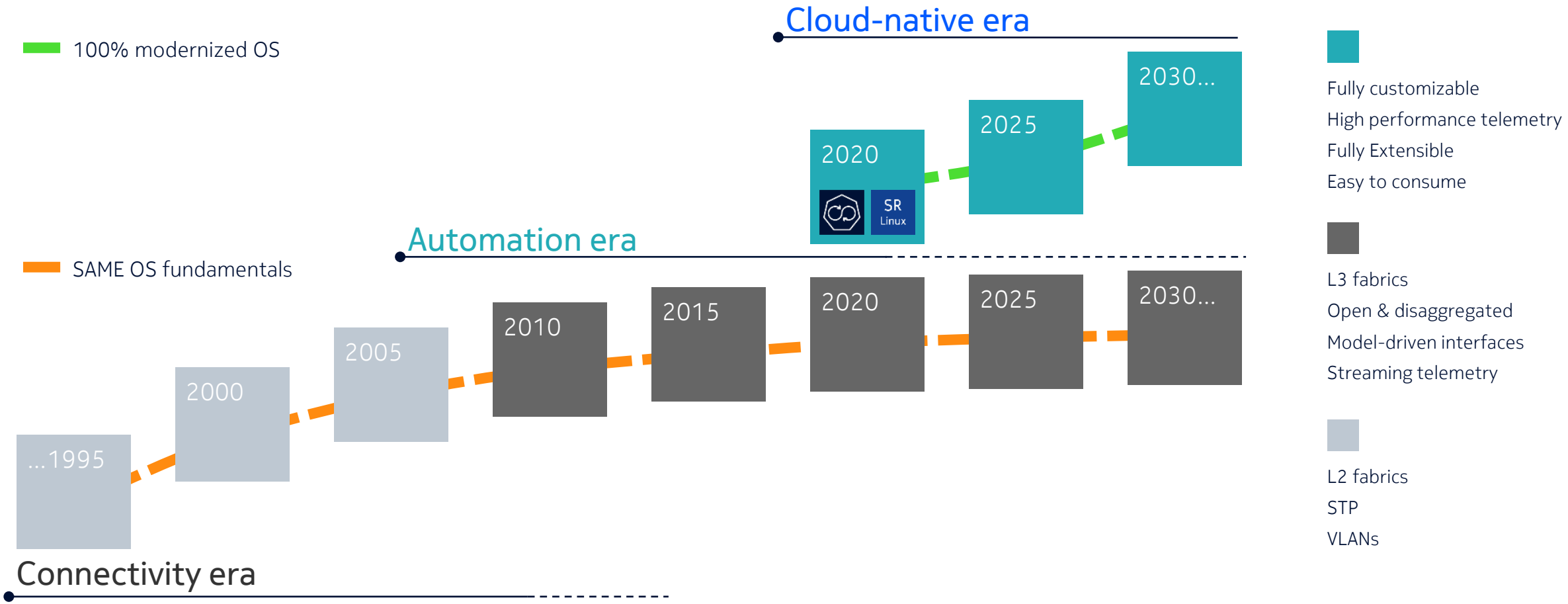
This graph excludes vulnerabilities found in open-source and third-party software

Nokia CVEs & PSIRT extract as of 3/5/2024

Data Center Fabric (DCF)

Evolution of Data Center Switching

Delivering enhanced NetOps for the cloud native era



Nokia data center fabric solution

Key building blocks

Silicon

- FP — Nokia FP
- J — Jericho
- TD — Trident
- TH — Tomahawk
- M — Marvell

Event-Driven Automation (EDA)

Fabric intent, observability, operations, and integrations

Network emulation and modeling

Open OS

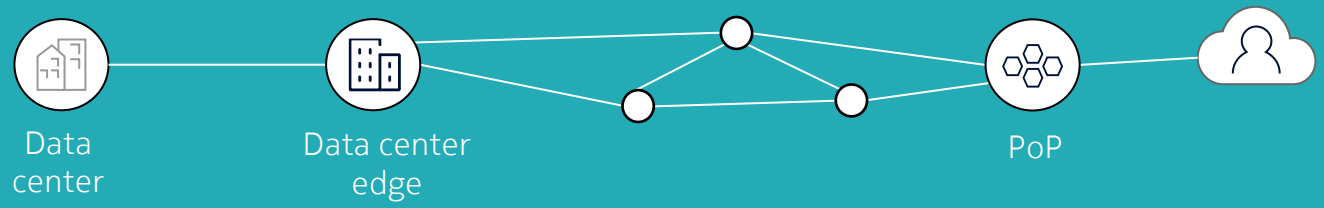
SR Linux

SR Linux (SRL)
Purpose built, scalable, model driven architecture

Hardware platforms

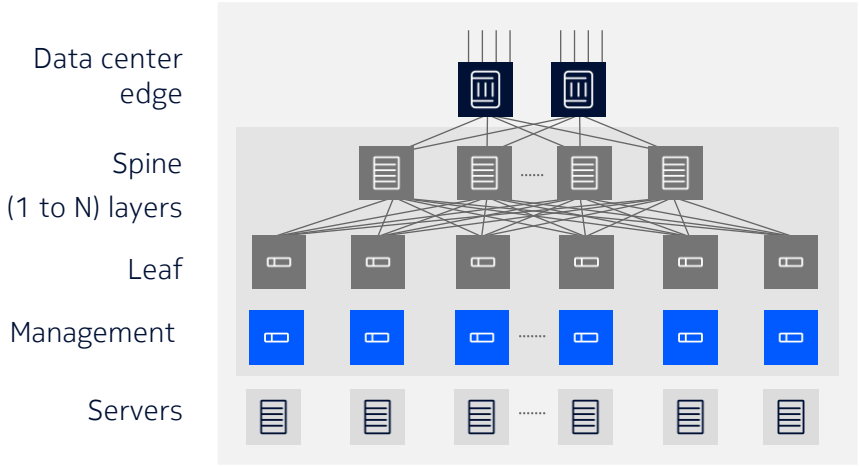
IXR

7250, 7220 and 7215
Chassis and fixed platforms



Data Center Fabrics

SR Linux



Nokia 7750 SR

Nokia 7250 IXR-6e/10e

Nokia 7250 IXR-6e/10e

Nokia 7220 IXR D5/H2/H3/H4

Nokia 7220 IXR D1/D2L/D3L/D4/D5

Nokia 7220 IXR-D1

Nokia 7215 IXS-A1

Management ToR

7215 IXS-A1

7220 IXR-D1

- 88G (FD)
- 48x GE
- 4x 10GE

Leaf

7220 IXR-D2L

- 2T (FD)
- 48x 25GE
- 8x 100GE
- 2x 10GE

Leaf/Fixed spine

7220-IXR-D3L

- 3.2T (HD)
- 32x 100GE
- 2x 10GE

Leaf/Fixed spine

7220 IXR-D4, D5

- 6T (FD)
- 28x 100GE + 8x400GE (D4)
- 12.8T (FD)
- 32x 400GE (D5)
- 2x10GE

Fixed spine

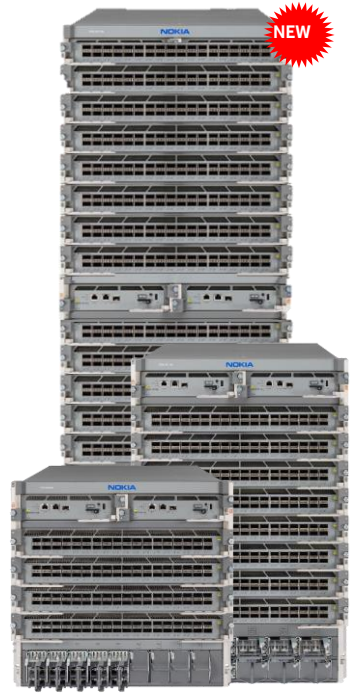
7220 IXR-H2, H3, H4

- 12.8 T (FD)
- 128x 100GE (H2)
- 32x 400GE (H3, H4-32D)
- 25.6T (FD)
- 64x 400GE (H4)

Fixed spine

7250 IXR-X1b, X3b

- 7.8 T (FD)
- 24x 100GE + 12x400GE (X1b)
- 14.4T (FD)
- 36x 400GE (X3b)



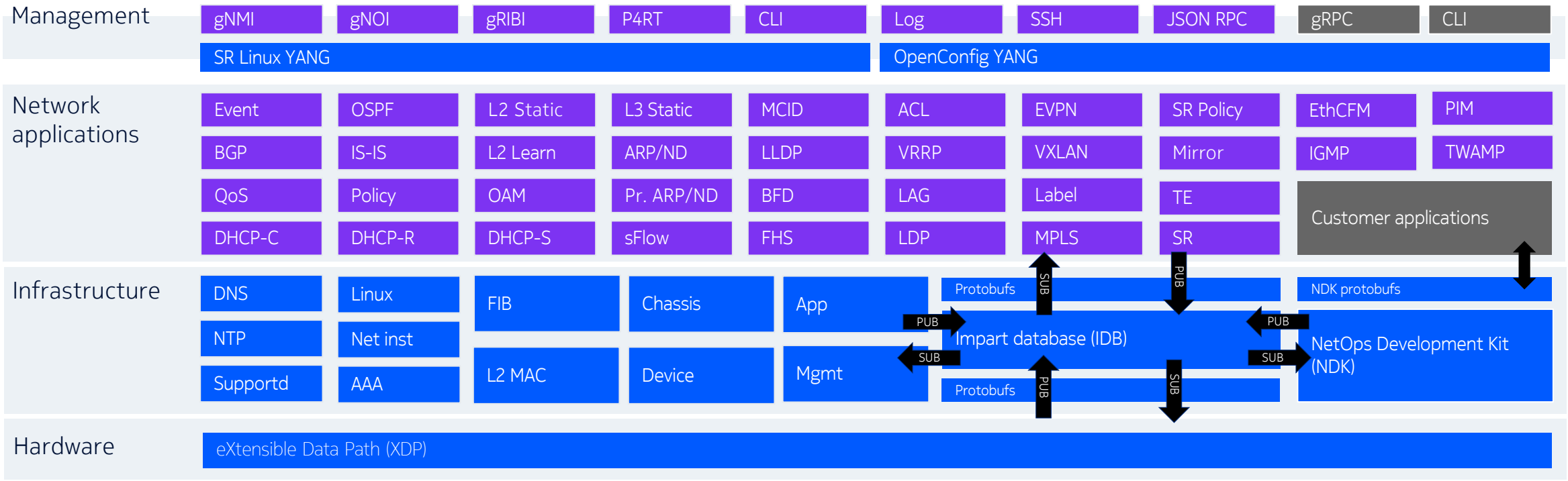
Super spine/DCI

7250 IXR-6e/10e/18e

- 115.2T/230.4T/460.8T (FD)
- Cntrl/Fab Red
- 36 x 400 IMM
- 60 x 100 IMM
- 36 x 800 IMM

SR Linux - Architecture

Modularity, extensibility, reliability



A pedigree apart

20+ years of field hardening in Nokia's protocol stack and network services

Million+ routers deployed in 1300+ IP networks

Rich protocols feature set – BGP, OSPF, IS-IS, LDP, SR-MPLS, EVPN, BFD, ...

Model Driven Management

Enabling flexible, uniform programmability with ground up built-in streaming telemetry

Per-application management stack with auto telemetry

OpenConfig and native models available

Open Infrastructure

Native, gRPC/proto extensions via the NetOps Development Kit

Open source Python CLI with extensibility via plugins

Pluggable telemetry-based event management via uPython

SR Linux

Example of “AI Assistant” app for your IP router

SR Linux

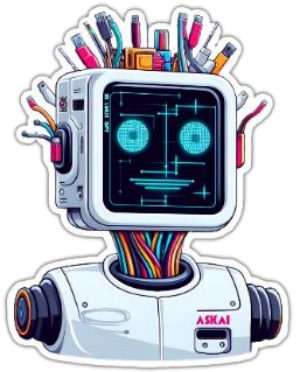
Develop and test an SR Linux NDK Application

https://network.developer.nokia.com
GitHub: Let’s build from here · GitHub
https://learn.srlinux.dev/

CONTAINERlab

Easily and simply deploy lab environment

https://containerlab.dev/



Chat with the newly installed AI assistant

https://youtu.be/zxwdecY12-E?si=jiYkSD3yYndcDJpt

NOKIA

Validation from customers and industry analysts

Microsoft

"Nokia brings density, performance and flexibility to Microsoft's data center networks and cloud environments and is partnering with Microsoft to deliver chassis switches running the open-source networking operating system SONiC."

David Maltz, Technical Fellow and Corporate Vice President, **Microsoft Azure Networking**

Apple

"We regularly upgrade our data center equipment with technology to increase efficiency and reduce energy consumption. Using Nokia's new system will enable better networking and routing capabilities in our Viborg, Denmark facility"

Adam Bechtel, Vice President and Networking Lead, **Apple**

OpenColo

"Nokia and its SR Linux was an easy choice. We wanted a solution that was extensible, open, supported telemetry and gNMI, and was provided by a company that transforms networking both on the hardware and software side"

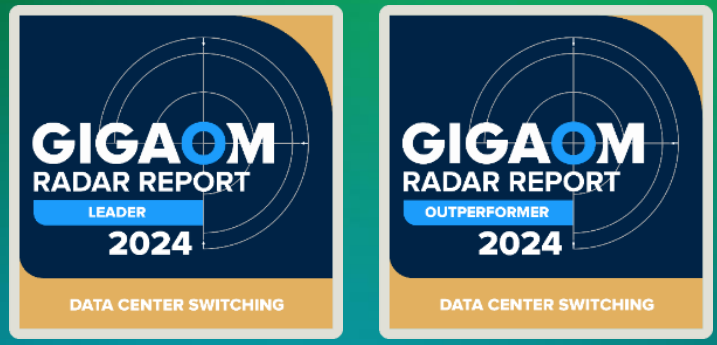
Scott Brookshire, CTO of Energy Group Networks, parent company of **OpenColo**

Stealth COMMUNICATIONS · NAVER Cloud · DCspine · linx · Public Transport Authority

LASERLIGHT · everyWAN · eurofiber · atnorth · SHINSEGAE

Nokia ranked as "Leader" and "Outperformer" for three straight years

Report weighs vendor's execution, roadmap and ability to innovate

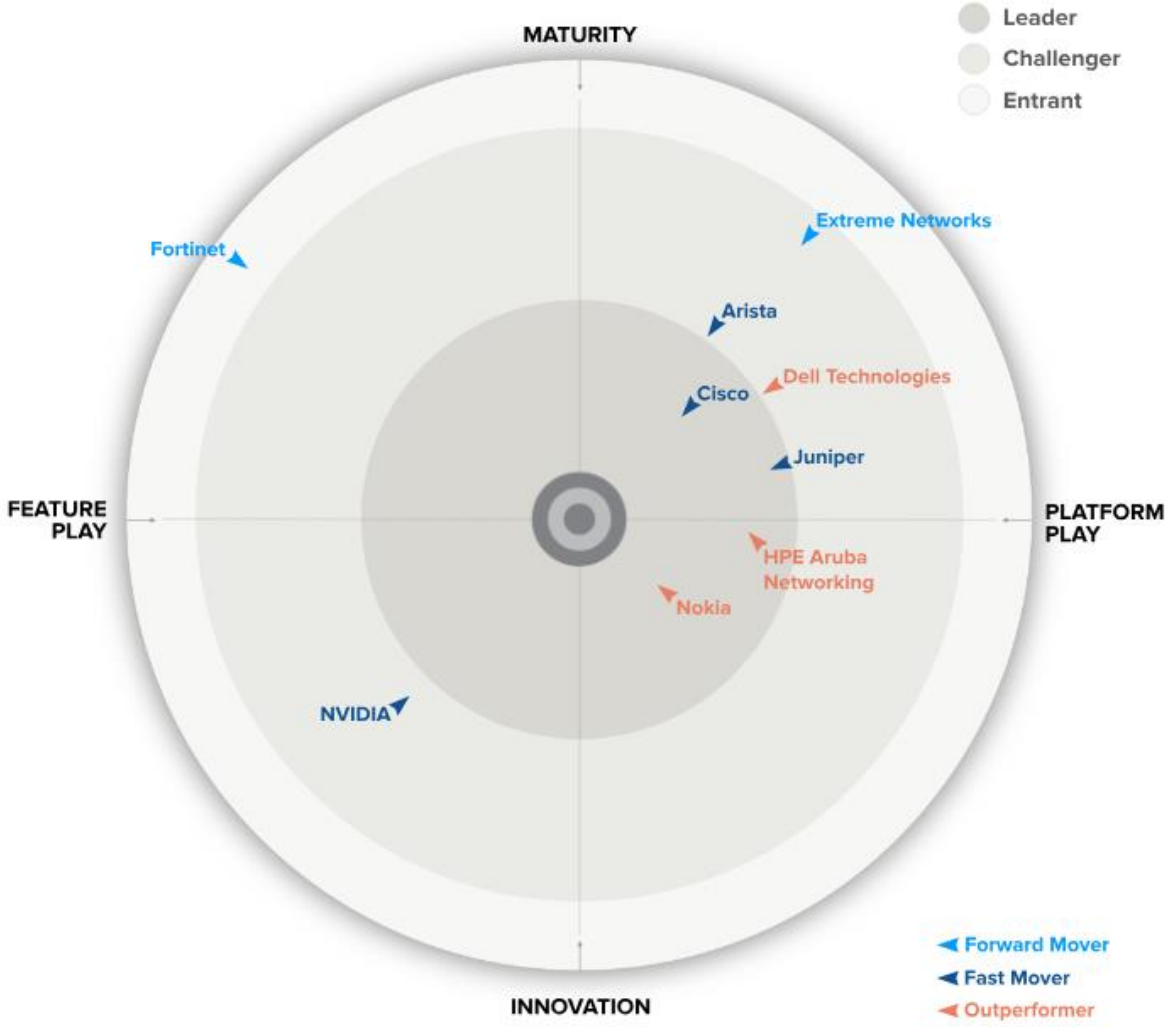


- Cutting-edge innovation, enabling DC automation
- Capabilities, including SR Linux, built from scratch using modern architecture

READ THE REPORT

GigaOm radar for “Data Center Switching”

Nokia recognized for innovation and differentiation



MATURITY: Emphasis on stability and continuity; may be slower to innovate

INNOVATION: Flexible and responsive to market; may invite disruption

FEATURE PLAY: Offers specific functionality and use case support; may lack broad capability

PLATFORM PLAY: Offers broad functionality and use case support; may heighten complexity.

Radar Chart Overview:

Nokia is an Outperformer positioned in the Innovation/Platform Play quadrant because its data center switching solution is newer on the market and many of its capabilities, including the SR Linux operating system, have been built from scratch using a modern architecture.

READ THE REPORT

Nokia Data Center Solution – POD view

DC and WAN Management

Event-Driven Automation EDA

Encryption
1830 SMS delivers key management for encryption inside and between DC's
Optical (L1), Ethernet (L2) and IP (L3) encryption.

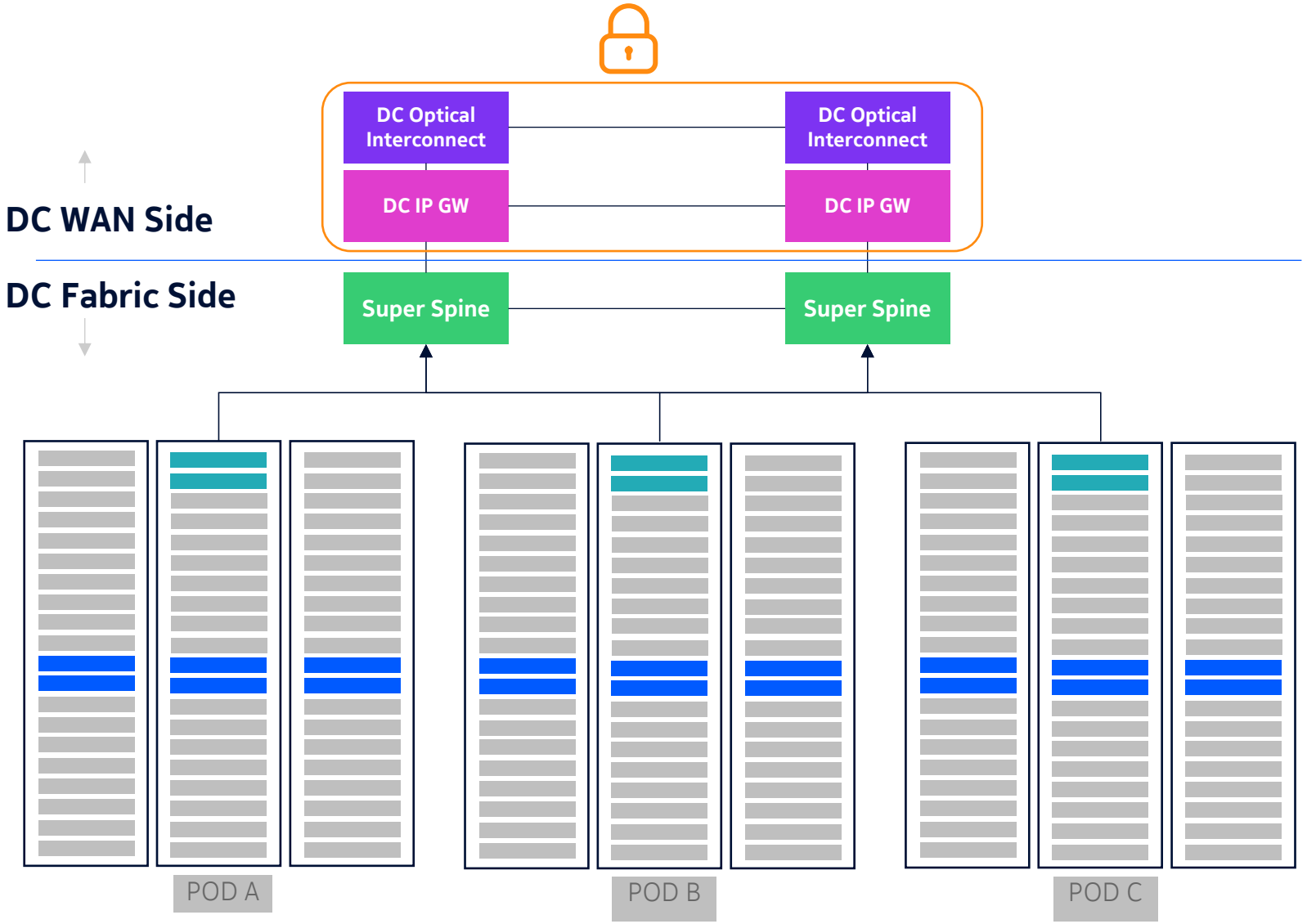
Data Centre Gateway Interconnect
DC to DC connectivity at the optical layer.
1830 PSI or 1830 PSS family

Data Centre Gateway
Aggregates spine switch or super spine switch (if present) traffic .
Provides internet connectivity or DC to DC connectivity across a WAN.
7750 SR family running traditional SROS.

Super Spine : Optional for large DC
Can act as the DC gateway but mostly will act as an aggregator collecting Spine switch traffic for forwarding between PODS or to other DC/Internet via the DC Gateway Router.
7250 IXR. SR Linux

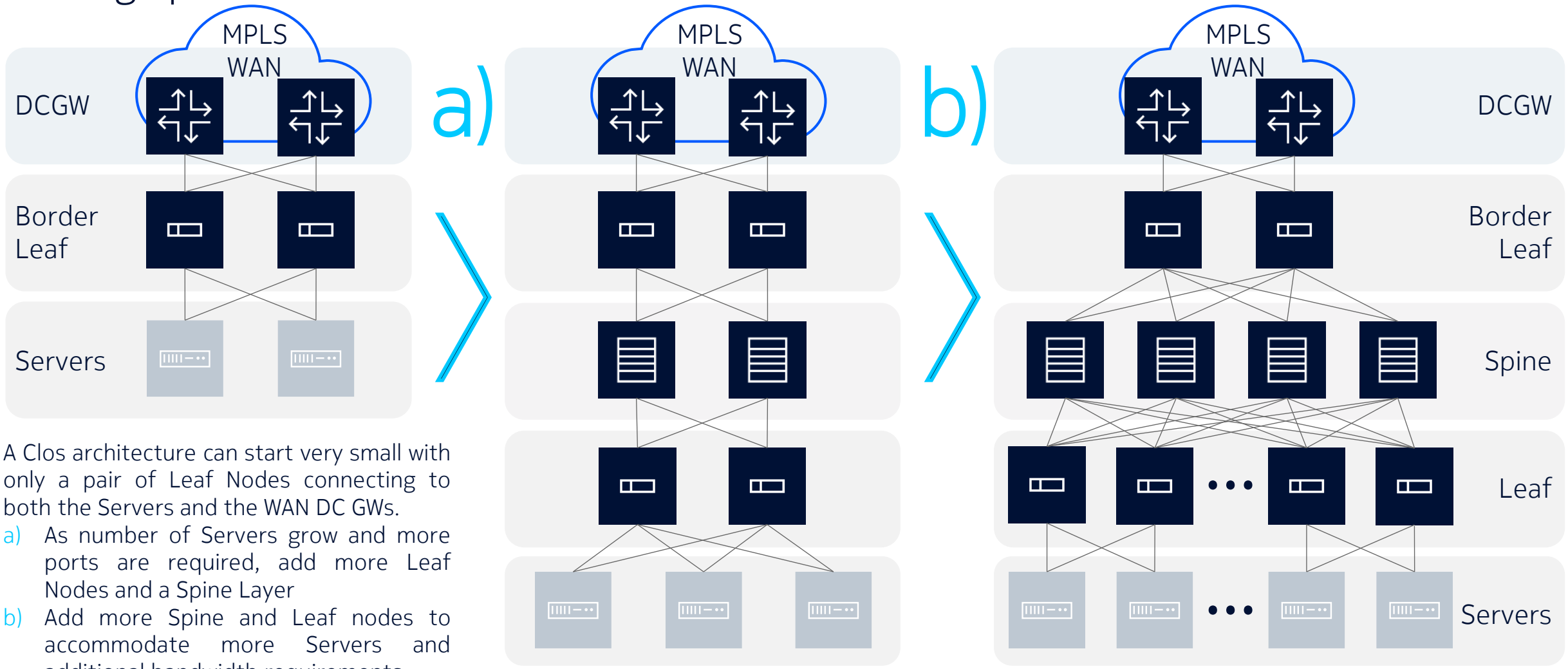
Spine Switches
Aggregates leaf switch traffic in the rack, connects to adjacent racks in the POD and connects to the super spine or DC gateway router.
7220 IXR-H series. SR Linux

Leaf Switches
Aggregate traffic from the servers in the rack.
Forwards traffic to the spine switches.
7220 IXR-D series. SR Linux



Clos Architecture Scale

Scaling up DC Clos Networks



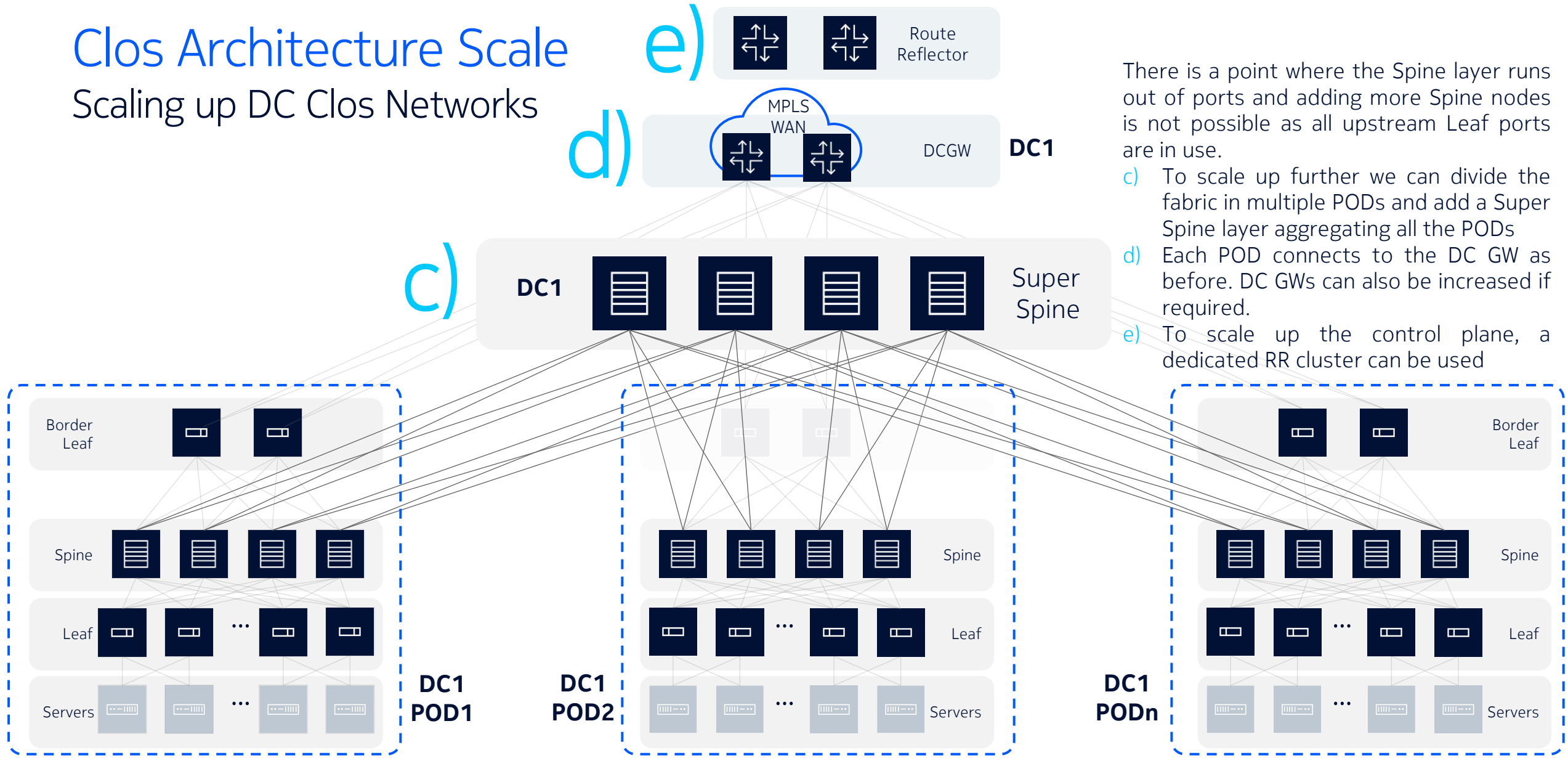
A Clos architecture can start very small with only a pair of Leaf Nodes connecting to both the Servers and the WAN DC GWs.

a) As number of Servers grow and more ports are required, add more Leaf Nodes and a Spine Layer

b) Add more Spine and Leaf nodes to accommodate more Servers and additional bandwidth requirements

Clos Architecture Scale

Scaling up DC Clos Networks



There is a point where the Spine layer runs out of ports and adding more Spine nodes is not possible as all upstream Leaf ports are in use.

c) To scale up further we can divide the fabric in multiple PODs and add a Super Spine layer aggregating all the PODs

d) Each POD connects to the DC GW as before. DC GWs can also be increased if required.

e) To scale up the control plane, a dedicated RR cluster can be used

POD = Performance-Optimized Datacenter
Group of resources closely networked together

EDA's functional blocks

Intent-based automation platform with enhanced DevOps and fine-grained observability

Deliver reliable operations

Intent-based approaches

- Declarative intent-based automation
- Closed-loop automation (auto-remediation)
- Digital twin

DevOps approaches

- CI/CD
- IaC
- Version control
- Rollbacks

Simplify lifecycle management

Ease of operations/ usability

- Single dashboard for all operations
- Drag and drop UI Builder
- GenAI Assistant

Multi-dimensional observability

- Streaming telemetry
- Fine-grained visibility
- Proactive notifications

Adapts to your environment

Seamless integrations

- ITSM/workflow/ trouble ticketing systems
- Event notification systems
- Cloud management platforms
- Kubernetes toolchain

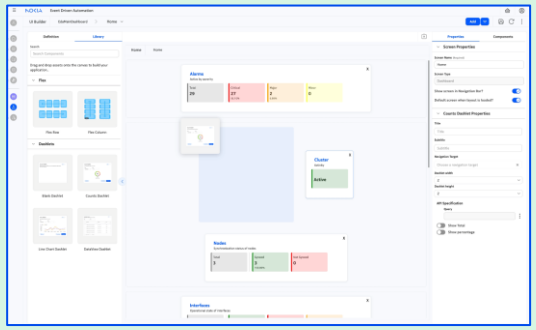
Multi-X

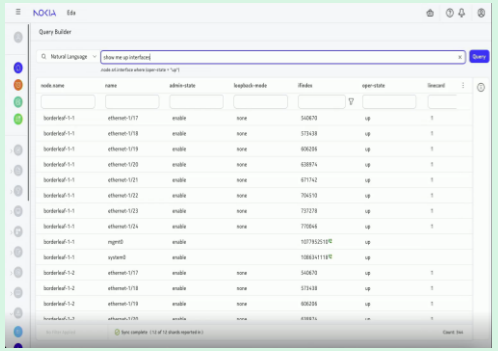
- Multi-domain
- Multi-vendor
- Extending the workloads to multi-cloud

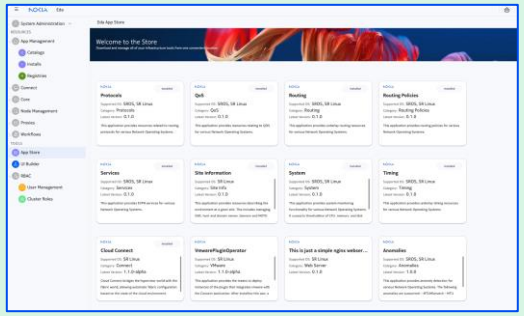
Built on technological foundations of Kubernetes-native orchestrator, microservices-based architecture and modern tooling such as gRPC, gNMI and gNMIc

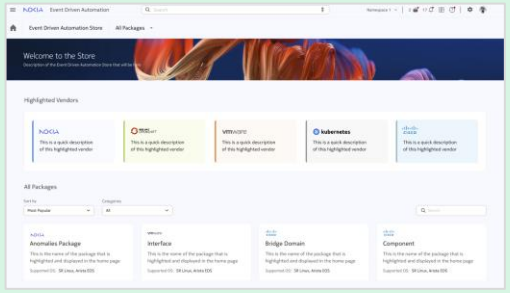
Network operations evolution

Event-Driven Automation (EDA)









Watch the EDA demo here (youtube.com)

Automation toolkit

YANG

SR Linux

Grafana

gNMIc

CONTAINERlab

python

Prometheus

ANSIBLE

GitLab

Grafana loki

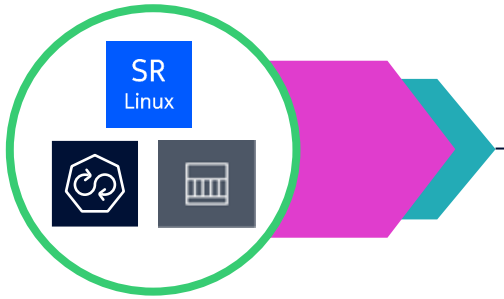
netbox

OPENCONFIG

NDK

Key differentiators to select the Nokia DC Fabric solution

7 reasons to pick Nokia DC Fabric solution



- Scalable and AI-ready architecture
- Intent-based management
- Sandbox enables a change management and CI/CD based operations, reduces risk
- Software quality – proven R&D processes and routing stacks with standards-based EVPN protocols
- Native Yang-based model-driven management/telemetry NetOps-friendly
- Open, customizable CLI and NDK, avoiding lock-in
- DCF Interconnect: Quantum-safe encryption, best-in-class Optics solution, embedded line-rate DDoS protection

Essentially it comes down to **operational efficiency** and a most **future safe** architecture

Learn more about our “Data Center Fabric solution”

Analyst reports

- GigaOm Data Center Switching radar

Application notes

- The NetOps era is here

Blogs

- SR Linux and ChatGPT combine for network AIOps
- Take charge of your data center switching infrastructure
- Powering the new NetOps era with Containerlab

Business Case Analysis (BCA)

- BCA Executive overview
- BCA web page

Byline articles

- Gestalt IT-Implementing NetDevOps in Datacenter Fabric Operations with Nokia
- SDxCentral-Nokia wants to conquer the data center market-Can GenAI help

Data sheets

- 7220 IXR-D for Data Center Fabrics
- 7220-iXR-H for Data Center Fabrics
- 7250 IXR for Data Center Fabrics
- SR Linux
- Fabric Services System

Podcasts

- Nokia's ChatGPT App lets engineers query the network
- Configure devices, stream telemetry with Nokia's free open-source gNMIc
- Event-Driven Automation With Nokia’s SR Linux Event Handler Framework

Press Releases

- Microsoft ; Tier 1 webscaler
- atNorth ; DCspine ; Eurofiber ; every WAN ; LINX Nairobi ; NAVER cloud ; OpenColo ; Stealth Communication
- Laser Light , Public Transport Authority ; Shinsegae I&C

Product Descriptions

- Service Router Linux (SR Linux)
- Event-Driven Automation (EDA)

Product deep dive

- **NFD33:** Nokia presents at Networking Field Day 29 (all presentation videos)

NFD33: Post event coverage from attending delegates

- Jordan Villarreal – Video - … the best thing to happen in labbing in a loooong time with the folks @Nokia
- Tim Bertino-Linkedin post- Lab as Code with Nokia and Containerlab
- Nokia presents at Networking Field Day 29 (all presentation videos)

Segment specific content

- CSP Telco clouds
- Webscale

Technology

- Videos-TechTalks in 10: All videos ; EVPN for DC's ; EVPN multi-homing ; EVPN Route Types

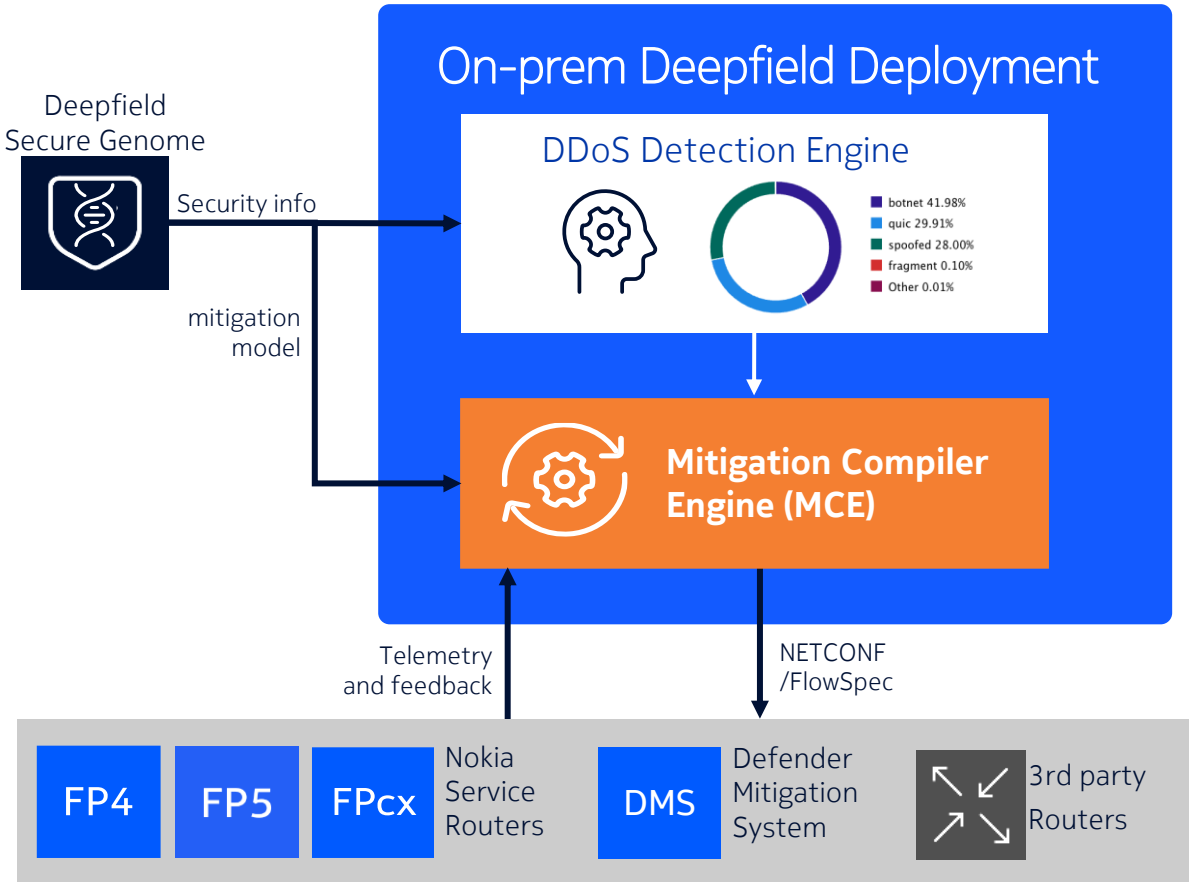
Web sites

- Data Center Fabric solution
- SR Linux
- Fabric Services System
- 7220 IXR for DC fabrics
- 7250 IXR for DC fabrics

Network Analytics and Security

Defender mitigates attacks using the most efficient strategy

For the observed attack and the deployed hardware



Mitigation Compiler Engine

The **intelligence** to build in real-time the AI optimized mitigation strategy

- Using Deepfield Secure Genome ML models trained on real-world attack samples
- Compiles surgical filters and countermeasures for deployed hardware
- Effective against all known DDoS and emerging vectors

" It's not just an anti-DDoS product, it's a DDoS protection 'services' "

Tristan Suerink - IT Architect at NIKHEF/NL Anti –DDoS coalition)

Deepfield Secure Genome

AI powered "DDoS threat map" of the Internet

Internet-wide security context

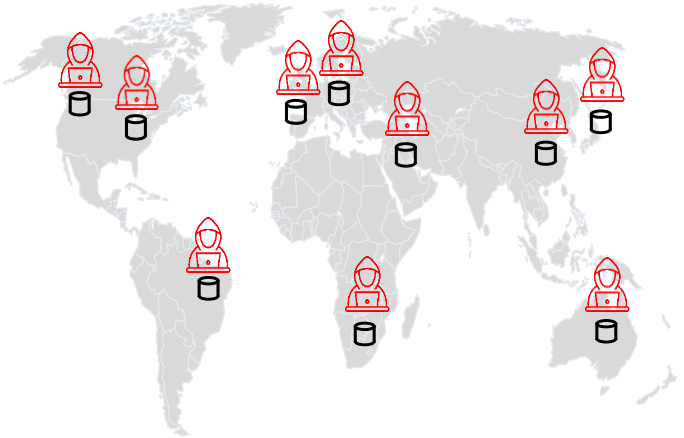
- Over 5 billion IPv4+IPv6 addresses scanned and categorized
- DDoS samples – from GDTA customers and honeypots
- Open and commercial data feeds

Up-to-date visibility into:

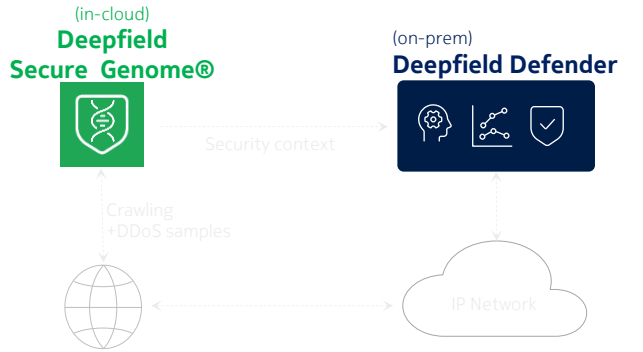
- DDoS vectors and details
- Botnets and residential proxies
- Known/open reflectors
- Booter & spoofed fingerprints
- IoT device details
- Device software versions and CVEs

Supervised learning + model training for Defender

- DDoS Detection Engine
- DDoS Mitigation Compiler Engine

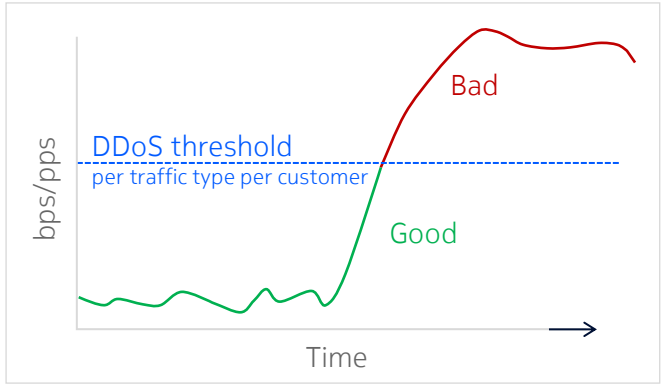


Knowing the Bad actors



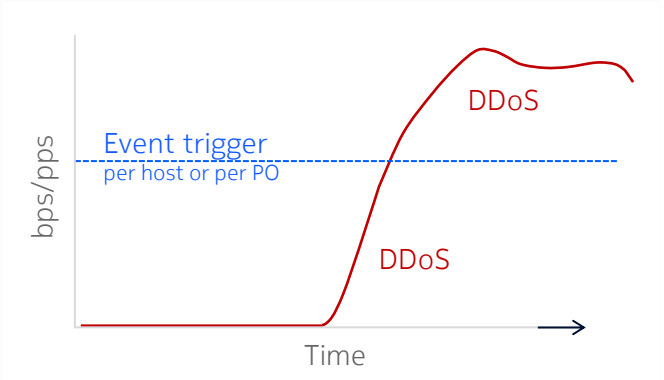
Defender detection versus legacy detection

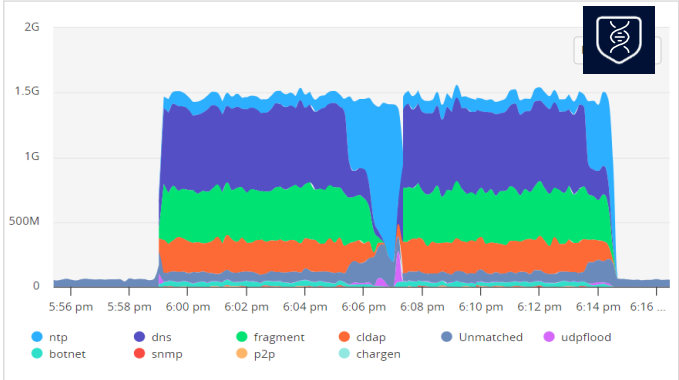
Legacy detection



Misuse Type	Trigger Rate	High Severity Rate
chargen Amplification (bps)	250 Mbps	500 Mbps
chargen Amplification (pps)	25 Kpps	50 Kpps
CLDAP Amplification (bps)	250 Mbps	500 Mbps
CLDAP Amplification (pps)	25 Kpps	50 Kpps
DNS	10 Kpps	30 Kpps
DNS Amplification (bps)	250 Mbps	500 Mbps
DNS Amplification (pps)	25 Kpps	50 Kpps
ICMP	5 Kpps	10 Kpps
IP Fragment	25 Kpps	50 Kpps
IP Private	5 Kpps	10 Kpps
IPv4 Protocol 0	5 Kpps	10 Kpps
L2TP (bps)	25 Mbps	50 Mbps
L2TP (pps)	25 Kpps	50 Kpps
mDNS (bps)	25 Mbps	50 Mbps
mDNS (pps)	25 Kpps	50 Kpps
memcached Amplification (bps)	250 Mbps	500 Mbps
memcached Amplification (pps)	25 Kpps	50 Kpps
MS SQL RS Amplification (bps)	250 Mbps	500 Mbps
MS SQL RS Amplification (pps)	25 Kpps	50 Kpps
NetBIOS (bps)	250 Mbps	500 Mbps
NetBIOS (pps)	25 Kpps	50 Kpps
NTP Amplification (bps)	250 Mbps	500 Mbps
NTP Amplification (pps)	25 Kpps	50 Kpps
RIPv1 (bps)	25 Mbps	50 Mbps
RIPv1 (pps)	25 Kpps	50 Kpps
rpcbind (bps)	25 Mbps	50 Mbps
rpcbind (pps)	25 Kpps	50 Kpps
SNMP Amplification (bps)	25 Mbps	50 Mbps
SNMP Amplification (pps)	25 Kpps	50 Kpps
SSDP Amplification (bps)	250 Mbps	500 Mbps
SSDP Amplification (pps)	25 Kpps	50 Kpps
TCP null	1.5 Kpps	20 Kpps
TCP RST	1.5 Kpps	20 Kpps
TCP SYN	1.5 Kpps	20 Kpps
TCP SYN/ACK Amplification (bps)	125 Mbps	150 Mbps
TCP SYN/ACK Amplification (pps)	125 Kpps	150 Kpps
UDP	30 Kpps	400 Kpps

Defender detection





Legacy DDoS detection

- Traffic is good until it crosses some configured threshold, then it's bad
- **Imprecise** because you need to guess what is an acceptable threshold value for each traffic type
- **High operational effort:** requires tuning of thresholds per traffic-type, per customer.
- **High false positives** risk: flash crowd events, sudden changes in traffic patterns, etc
- **High false-negative** rate – especially with botnet /Proxy DDoS which looks like legitimate traffic

Defender DDoS detection

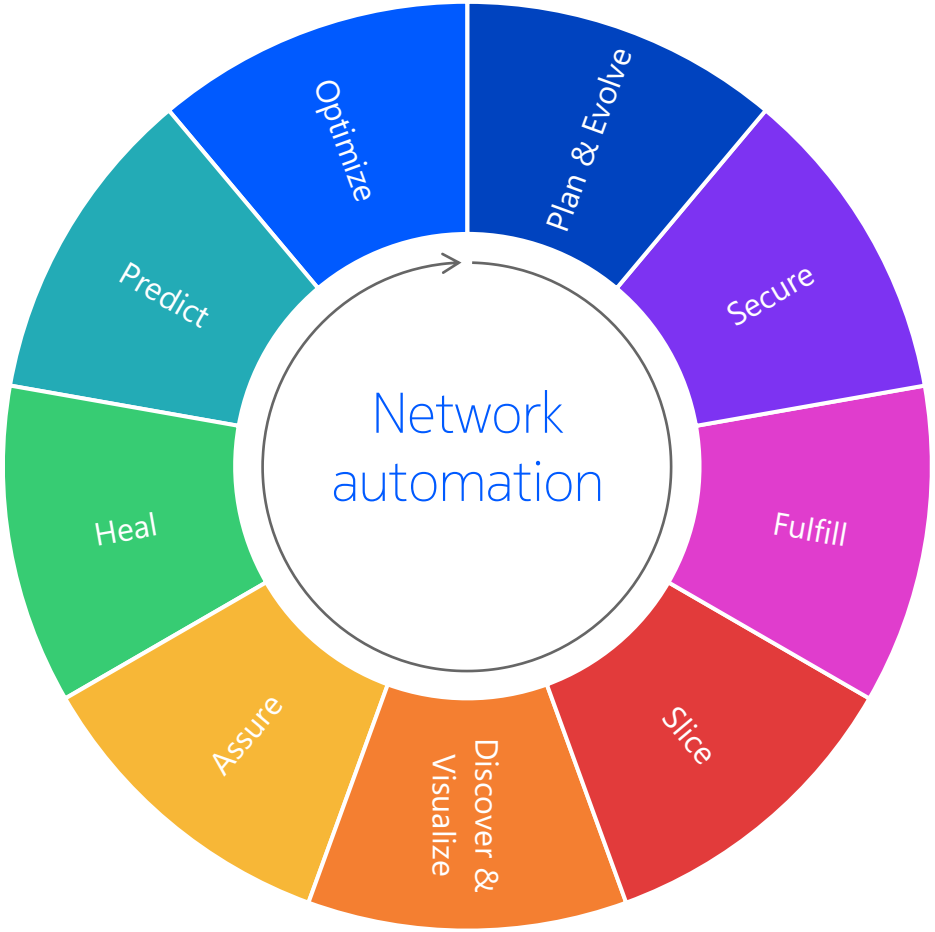
- AI-powered classification of every flow as "ddos" or legitimate applications
- **Much more accurate** – context based detection for all types of DDoS including carpet-bomb – eliminating false positives and false negatives
- **Minimal operational effort** – works out-of-the-box for all customers – without need for configuring and tuning detection threshold
- Detection rules **automatically updated** through Secure Genome - to include latest attack vectors

Automation

Network automation use cases

Network monetization and automated operations for the network lifecycle

- Use cases to deliver outcomes across the entire network lifecycle
- Enabled by programming NSP to speed up automation
- Applicable to Nokia and multi-vendor networks, single and cross-domain



Use cases for network monetization and automated operations

Discover and visualize

- Physical topology discovery
- Brownfield service discovery
- IGP topology discovery
- Brownfield config. discovery
- IP/MPLS (LSP path) topology discovery and visualization
- Telemetry enablement
- Prepackaged reports
- Custom reports
- IP-optical topology discovery

Slice

- Transport slice enablement
- Transport slice monitoring

Fulfill

- E-Line
- C-Line
- E-LAN / EVPN
- L3 VPN
- Internet enhanced services
- Composite services
- Bandwidth on demand
- NE provisioning - Day 0 (ZTP enabled Nodes)
- pLTE provisioning - Day 0
- NE provisioning - Day 1
- NE provisioning - Day 2
- 400ZR point-to-point
- ZR+ managed alien with ROADM
- Enterprise bundle

Plan and evolve

- Mass scale NE upgrade
- Mass scale NE backup
- Service migration - port | Lag | card
- Service migration - tunnels
- Closed-loop automation / capacity growth
- Coordinated maintenance

Optimize

- Elastic IP/optical bandwidth
- LSP path placement
- LSP enhancement path control
- Optical aware IP routing enablement

Assure

- Fault and network assurance
- Service assurance
- Network perf. monitoring

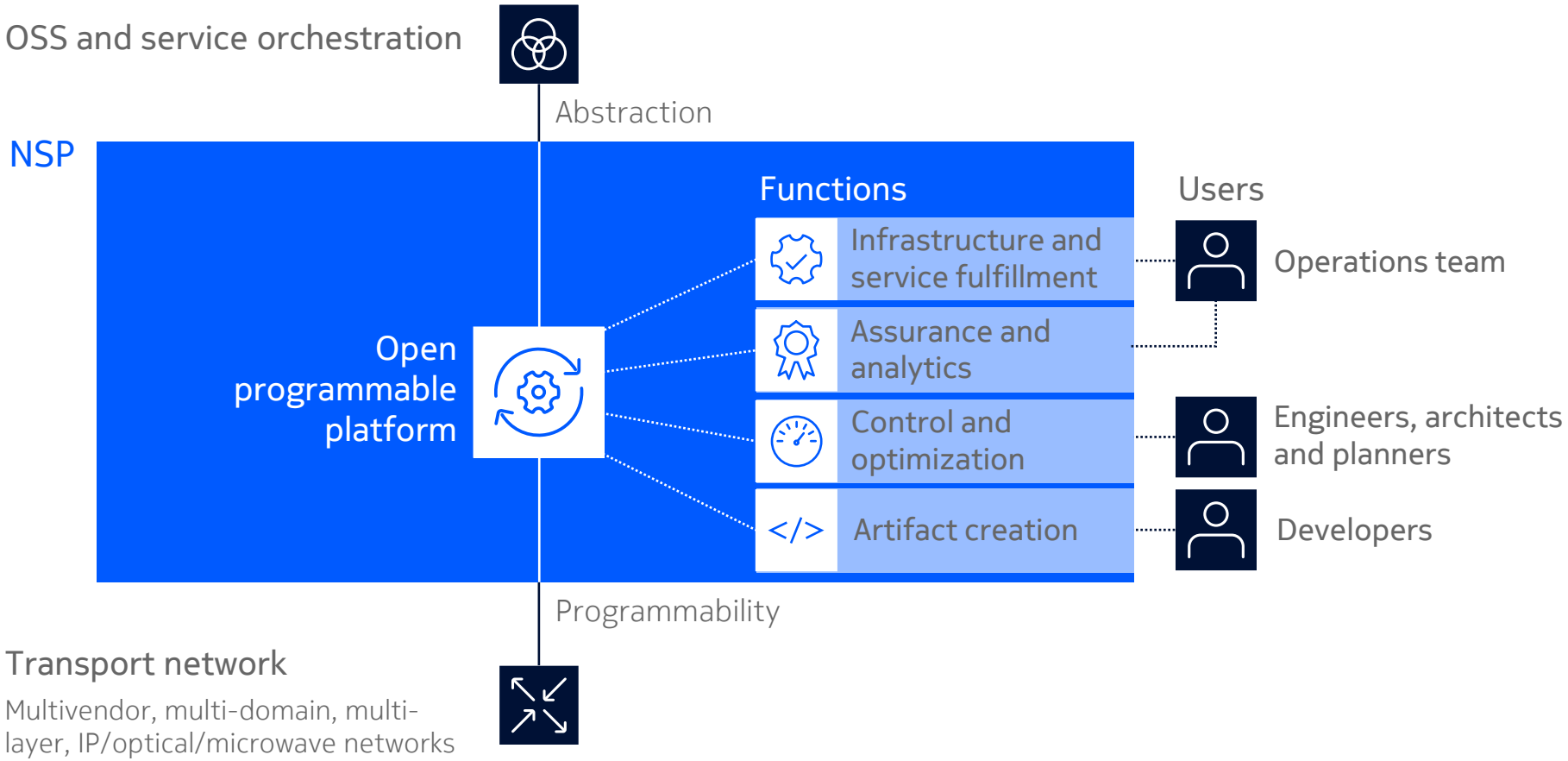
Heal

- IP-optical diversity analysis
- 1:N floating port restoration
- Wavence interference detection

Predict

- Custom alarm correlation
- LSP network simulation
- What-if analysis

An open, programmable platform to automate, manage and control multivendor IP/optical networks



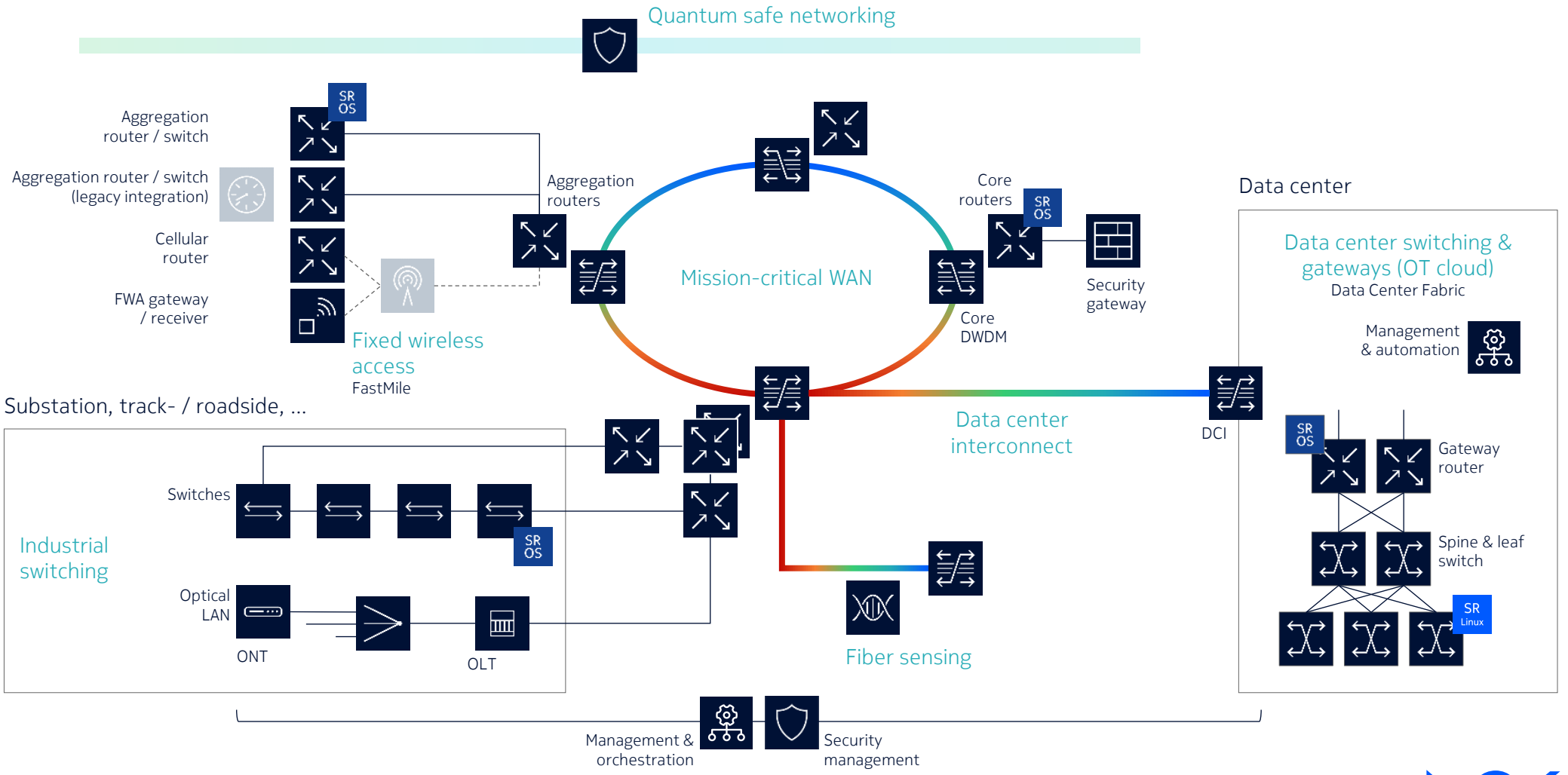
Examples of the high-level network architectures for various segments

We address critical networking needs via three distinct solution domains with each a stack of customer solutions

	OT	Telco	IT
			Volume & program business
	Value & project business		
Solution domain	Mission-critical networking Dedicated network infrastructure optimized to support a specific operational purpose with connectivity among required systems, machines and staff Primary business depends on network	Commercial networking Shared network infrastructure that one organization builds to sell connectivity services to other enterprises and / or residential users Primary business is network monetization	Enterprise networking Common network infrastructure that organizations use to provide connectivity among their own users, devices and applications for general needs Primary business is supported by network
Customer solutions	• Mission-critical WAN • Data center switching & gateways (OT cloud) • Data center interconnect • Industrial switching • Quantum safe networking • Fixed wireless access • Fiber sensing	• Fiber access • Multi-service WAN • Data center switching & gateways • Data center interconnect • Broadband network gateway • Fixed wireless access • Residential Wi-Fi • DDoS protection	• LAN • Enterprise WAN • Data center switching & gateways • Data center interconnect • Quantum safe networking • Fixed wireless access

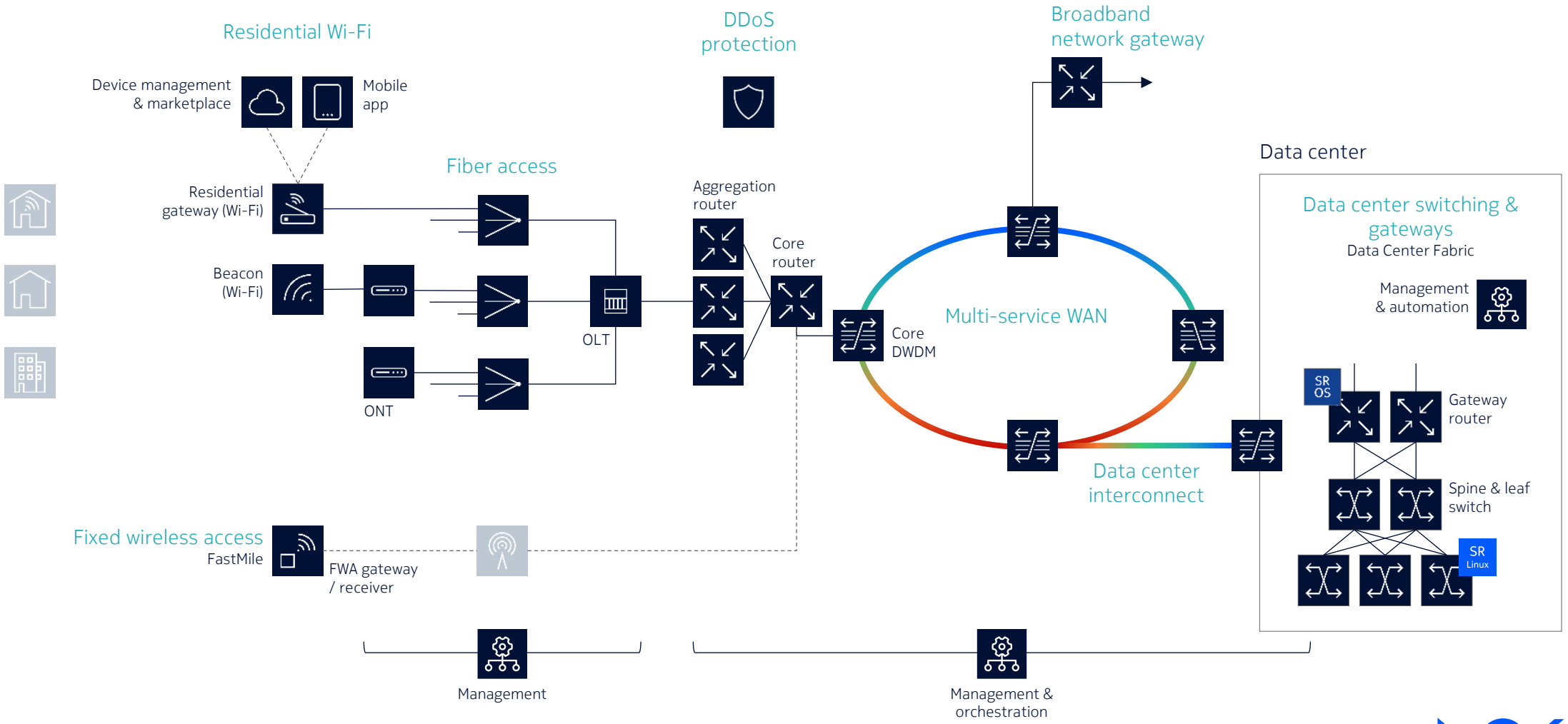
Our solution domain ‘mission-critical networking’ (OT)

Infographic



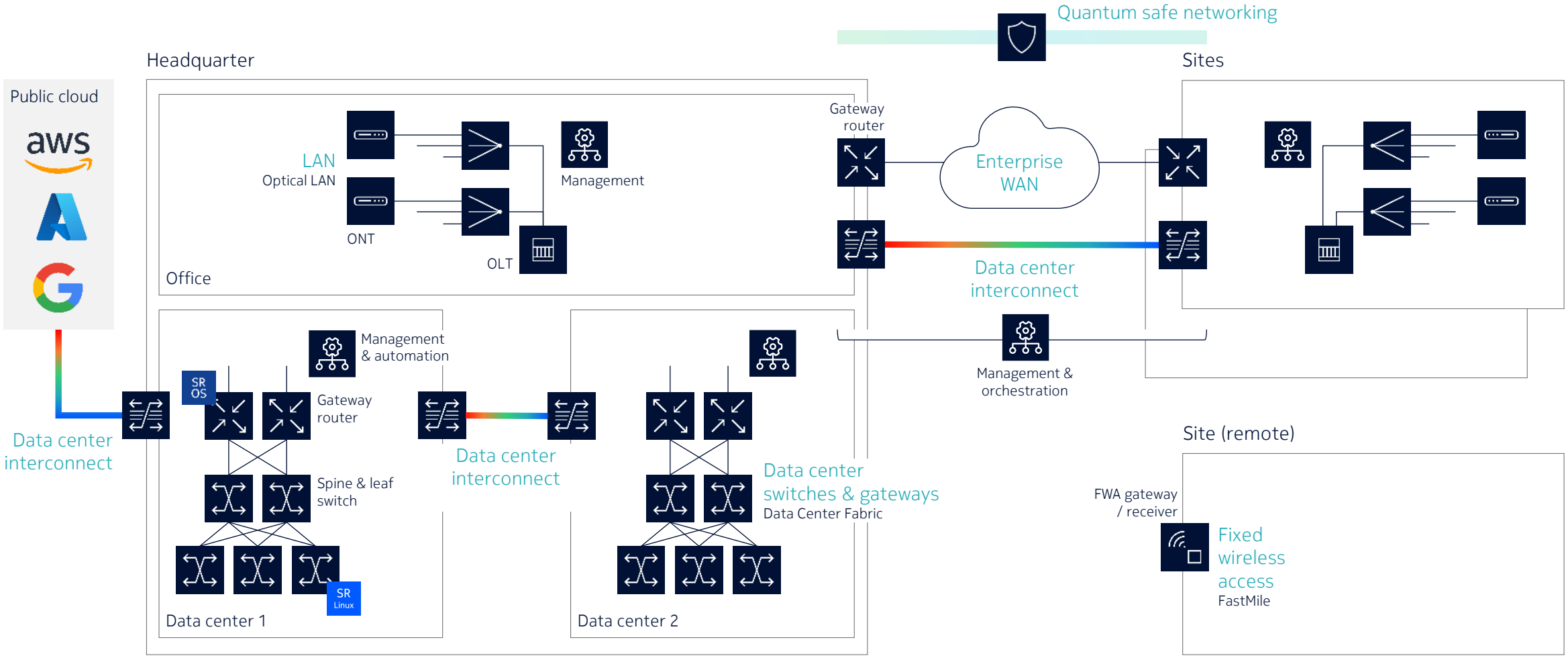
Our solution domain ‘broadband networking’ (Telco)

Infographic



Our solution domain ‘enterprise networking’ (IT)

Infographic

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