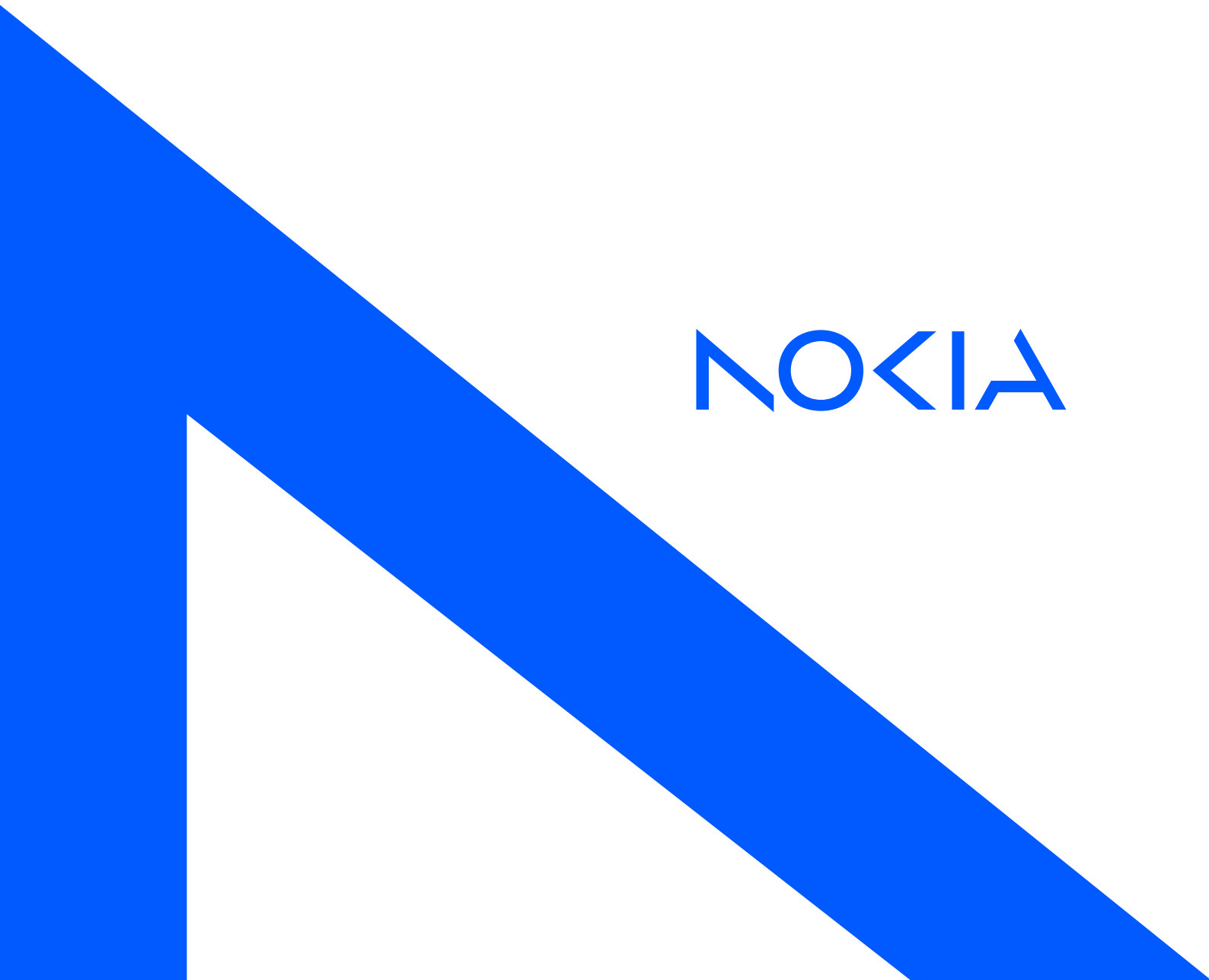
Innovations for environmentally sustainable IP networks

Application note



Abstract

Digital communication networks provide tremendous benefits by connecting people and things across cities, communities, businesses and supply chains, and have become a critical lifeline for society. At the same time, they contribute to greenhouse gas emissions and impose an environmental footprint. Network operators need to continually strive to minimize any potential negative impacts these networks have on the planet.

Nokia is a global leader in environmental sustainability. We are committed to reducing the greenhouse gas emissions and environmental impact of our products in our customers' networks. This application note discusses design innovations built into the Nokia IP networks portfolio to minimize energy consumption, ensure performance certainty, deliver deployment longevity and support circular operations for highly sustainable IP wide area and data center networks.

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Introduction

Our approach to combatting climate change has been to put sustainability at the very heart of our purpose. At Nokia, we create technology that helps the world act together. We believe we have a unique opportunity to address some of the world's biggest challenges through connectivity and digitalization. We aim to maximize our positive impact—our handprint—while we work to minimize any negative impact—our footprint.

Through technology leadership, we enable critical IP digital communication networks to help address global issues such as climate change. Our enhanced connectivity solutions help the world decarbonize and dematerialize, reduce waste, limit the use of natural resources and increase the reuse of materials. Our solutions also help restore failing productivity and bring more inclusive access to digitally delivered services to ensure no one is left behind. These benefits represent the handprint of digitalization and connectivity.

At the same time, we continually strive to minimize any potential negative impacts of IP networking technology. To reduce our environmental impact, we set ambitious environmental sustainability goals and use the design advances of our IP routers to help our customers reduce energy consumption and minimize the environmental footprint from their IP wide area and data center networks.

IP network imperatives

Digital communication networks have become essential for society at large. IP wide area and data center networks are crucial because they provide the connectivity fabric for transporting broadband, mobile, cloud and mission-critical industrial traffic. Performance, quality and reliability expectations have never been higher. As a trusted partner to operators of critical IP wide area and data center networks worldwide, we are committed to using innovation and technology leadership to help communications service providers (CSPs), webscale companies and enterprises solve the world's most difficult networking challenges.

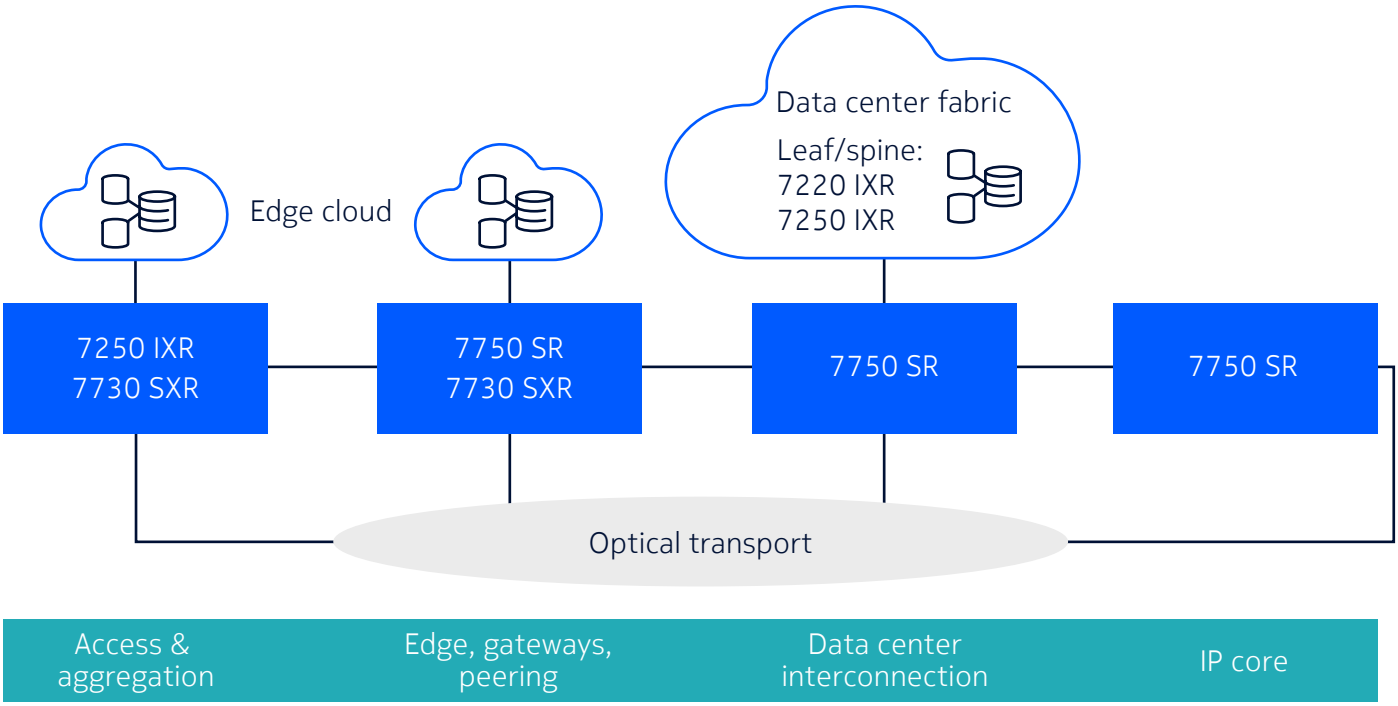
Highly sustainable IP networking imperatives require that routers maximize energy efficiency, performance certainty, deployment longevity and product circularity. With continued year on year traffic growth, unpredictable traffic conditions, stringent service level agreement (SLA) requirements and service guarantees for diverse traffic types, the IP network is under continual pressure to perform. Predictable and consistent performance is table stakes, even in the harshest conditions. IP networks must meet strict performance requirements and maximize energy efficiency to minimize their energy use and their carbon footprint. Our IP networking portfolio is designed to address these realities.

A comprehensive portfolio

Routing silicon sits at the heart of every router. Silicon drives platform capability and, ultimately, network capability. Our IP networks portfolio offers silicon diversity, which allows our customers to choose the platform that delivers the right capability for the right networking role. It provides router options using a "fit for purpose" approach to address IP networking imperatives for wide area and data center applications.

For high-performance routing applications, our in-house custom FP5 and FPcx silicon delivers industry-leading capabilities in our 7750 Service Router (SR) and 7730 Service Interconnect Router (SXR) platforms. For highly scalable interconnectivity applications, merchant silicon, with reduced capabilities compared to Nokia FP silicon, is used in our 7250 Interconnect Router (IXR), 7250 IXR for data center fabrics and 7220 IXR platforms. Figure 1 shows how the platforms in our IP networks portfolio address different wide area and data center network applications.

Figure 1: IP networks portfolio for wide area and data center applications



Our IP networks portfolio delivers a wide range of energy-saving mechanisms and advanced network capabilities to ensure that our customers have performance certainty and deployment longevity in their technology and design choices.

Energy efficiency

Energy-efficient routing silicon and system design innovations help reduce IP network energy consumption and emissions. When combined with 800GE routing, advanced network designs and automation capabilities, IP energy use is reduced to an even greater degree.

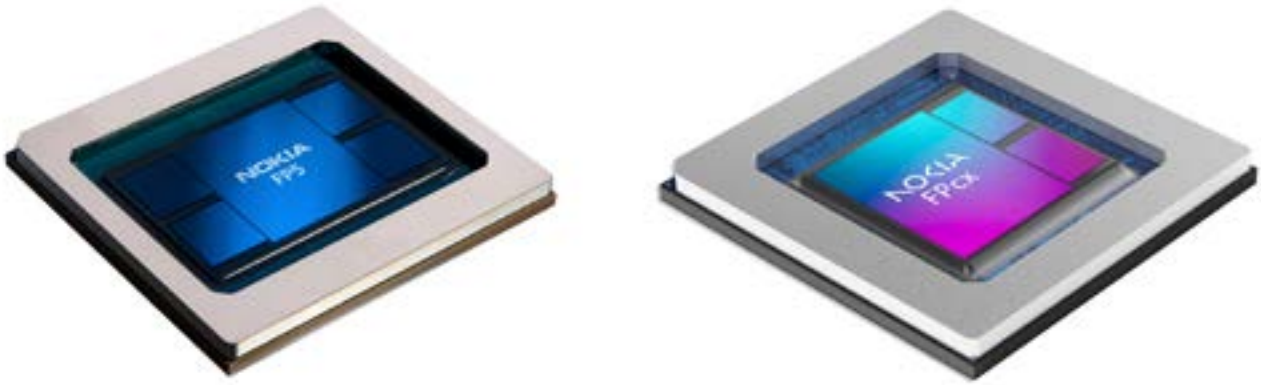
Silicon design

Silicon is the largest driver of platform energy consumption. Nokia FP silicon demonstrates how silicon innovation deliver energy savings without compromising router performance, scale, services or features.

Nokia FP5 silicon

Each generation of FP technology significantly improves on energy efficiency. In 7750 SR systems, FP5 silicon delivers three times more capacity while driving down energy consumption by 75 percent compared to FP4-based systems.

Figure 2: Silicon innovation with Nokia FP5 and FPcx



Silicon innovation is the largest driver of this energy savings. Key contributing innovations include on-package network processing unit (NPU) consolidation, smaller geometry and integrated memory, along with power density optimization, a design attribute that tunes silicon performance to deliver the lowest energy consumption in the smallest package. FP5 is also the first silicon to support 800G interfaces with next-generation optics. We first began shipping 800G ports in volume in 2021.

Nokia FPcx silicon

The Nokia FPcx is our newest silicon family. It brings the value of FP silicon to a broader range of routing applications. Delivering energy-efficient mechanisms similar to those of FP5, FPcx features a fully integrated chip with on-chip integrated memory, compact geometry and power density optimization.

FPcx also enables new energy-saving network architectures. The FPcx-enabled Nokia 7730 SXR is the first simplex routing platform to provide upgradability without a service impact. As a result, control plane upgrades can be performed on a non-redundant router and data plane upgrades can be achieved without dual homing to two routers. This reduces the number of network elements that need to be energized and lowers overall total cost of ownership (TCO).

System design

Each of the leading platforms in our IP networks portfolio features energy-saving system design innovations.

Nokia 7750 SR

Powered by Nokia FP5 silicon, the 7750 SR delivers typical energy efficiency in the order of 0.1 watts per gigabit (W/Gig) in systems. With FP5 silicon, the 7750 SR achieves this level of energy efficiency without compromising router performance or minimizing features. The 0.1 W/Gig measurement is realized with all features enabled, full buffering on ingress and egress, and line rate memory on buffers and tables.

With the architecture of the 7750 SR, energy consumption scales with capacity. With a choice of ten fixed and chassis-based 7750 SR variants using FP5 silicon, six line card options and multiple capacity and port scaling licenses on each, operators can design any network location to meet energy use, performance, scale and footprint requirements. The mechanical cooling and line card designs incorporate belly-to-belly cages, dual-sided printed circuit boards (PCBs), honeycomb mesh air intakes, intelligent fan control and air flow that minimizes turns, all of which combine to lower fan speeds and reduce overall system energy consumption.

800GE routing

800GE routing support on the 7750 SR enables a 2X–8X link capacity increase over 400GE/100GE networks. This reduces the number of interfaces, line cards and routers in the network that need to be energized. Despite a significant thermal profile, the 7750 SR has a proven design to support 800G optics in full density with significant cooling margin to spare. This allows operators to maximize density requirements on fewer systems, which also minimizes the number of network elements that need to be energized and lowers TCO.

Next-generation 800G optics provide a 20–40 percent energy savings compared to 400G and 100G optics. As the 800G density of each system goes up, the energy consumption associated with optics alone becomes a significantly larger portion of total system energy consumption. The 7750 SR supports 2 x 400G and 8 x 100G optical breakouts to provide energy savings for 100GE and 400GE networks.

Nokia Bell Labs has conducted a detailed comparison of the scaling properties of 400GE and 800GE. Refer to "The business case for 800GE routing in the age of sustainability" for a summary of the study, which quantifies the substantial energy savings and operational benefits of upgrading IP networks with Nokia 800GE routing technology.

Nokia 7730 SXR

Powered by Nokia FPcx silicon, the 7730 SXR delivers typical energy efficiency in the order of 0.1 W/Gig in systems with full features enabled. With FPcx silicon, there is no compromising of router performance to achieve this level of energy efficiency.

Available in six fixed and chassis-based systems, the 7730 SXR provides "right-sized" capacity options to efficiently meet performance objectives and ensure the right density with the right energy use for each network location. The 7730 SXR supports next-generation low-energy SFP-DD and coherent optics. Its cooling design incorporates intelligent fan control and honeycomb mesh air intakes in fixed systems for better cooling and lower energy consumption.

Nokia 7250 IXR

The 7250 IXR uses merchant silicon and is ideal for large-volume, cost-sensitive access and aggregation applications where the routers are mostly moving bits. It offers fixed and modular system configurations to help operators optimize cost and performance and ensure the right density with the right energy consumption. It also leverages hexagonal mesh air intakes and intelligent fan control technology to improve cooling and lower energy consumption.

Nokia innovation leads the industry with superior silicon integration and differentiated system designs. Our component-minimizing design use of increases reliability and reduces energy consumption. It shines in platforms such as the 7250 IXR-e, which consumes up to 50 percent less energy than comparable products using the exact same merchant routing silicon. This tight system integration extends across the 7250 IXR family. The chassis-based 7250 IXR-R delivers the lowest energy consumption per port in its class with an overarching design that provides the highest port density in its class.

Nokia 7250 IXR and 7220 IXR for data centers

The merchant silicon-based 7250 IXR and 7220 IXR for data center fabrics provide modular, high-capacity platforms that allow deployment of open leaf–spine architectures using modern data center switches. Offering fixed and modular system options, these platforms are designed to minimize energy consumption while delivering massive scale, flexibility and density.

The modular 7250 IXR platforms support 800G interfaces, bringing the energy efficiencies of 800GE routing into the data center. The 7250 IXR-6e/10e platforms have the highest 100GE density in the industry, driving down W/Gig. The 100GE-optimized fabric configuration on the IXR-10e reduces fabric power consumption by 50 percent. Inherited from the market-leading 7750 SR platform, the honeycomb mesh air intakes and exhausts minimize energy usage for cooling. Nokia supports the tallest line card pitch in its class for the 7250 IXR-6e/10e/18e. These platforms have more air intake by design and deliver best-in-class energy consumption.

The 7220 IXR-D and 7220 IXR-H platforms provide optimal energy consumption per application, offering fixed variants to meet the needs of compact deployments with reduced buffering and latency. The 7720 IXR-H delivers the highest 100GE density in the industry, driving down W/Gig.

Network design

Our routers provide advanced network design capabilities that help operators take energy consumption even lower.

IP-optical network evolution

The advent of coherent router optics presents an opportunity for operators to optimize IP–optical network designs. The 7750 SR, 7730 SXR and 7250 IXR platforms support coherent optics, which eliminates the transponder layer and allows routers to extend their optical reach without sacrificing port density. Our coherent routing solution helps operators use less energy and space and reduce their footprint by directly interfacing the IP and optical layers using pluggable, profile-optimized DCOs. Removing transponders and collapsing the data center interconnect (DCI) layer into the routing domain frees up valuable CAPEX and allows for operational tuning of human resources to focus on the needs driving next-generation networks.

The key to getting the most from coherent router optics is to use them in systems designed for longevity in the WAN. For example, maximizing high-density 400G today and being able to maximize 800G optics in the same generation of FP5-based 7750 SR systems drives network efficiencies by collapsing network layers and allows for the greatest possible reductions in energy consumption and TCO based on IP–optical evolution solutions available today.

IP network consolidation

The high-performance 7750 SR enables separate networks to be consolidated into a single backhaul and core network. This requires highly capable silicon with sophisticated quality of service (QoS), operations, administration and maintenance (OAM), synchronization and intelligent aggregation capabilities.

The flexible gateway and OAM functions of the 7750 SR platform make it easy to collapse layers and deliver operational efficiency. A single 7750 SR router addresses the full spectrum of routing needs to satisfy multiple, demanding network roles, including IP gateways, provider edge virtual private networks, DCI, internet, peering and core. This significantly reduces the number of network elements, which provides significant energy savings and reduces overall TCO.

The intelligent aggregation capabilities of the 7750 SR platform eliminates pre-aggregation, allowing multiple aggregation layers to be collapsed into a single network layer. This significantly reduces the number of network elements, providing significant energy savings. It can also deliver savings in the order of one-third the cost of a traditional leaf–spine topology, resulting in significantly lower TCO.

Automation and management

The Network Services Platform (NSP) enables operators to automate and manage multilayer transport networks across the IP and optical domains. It provides scalable network path control and optimization using closed-loop automation based on network utilization, latency, availability and packet loss.

Acting as a centralized Path Computation Element (PCE), the NSP can route traffic along the lowest-energy path identified by the operator. It enables operators to utilize their network capacity more efficiently and postpone the introduction of new routers and links, thereby reducing energy costs. Using the Nokia Bell Labs self-tuned adaptive routing (STAR) algorithm, the NSP has been able to increase network utilization from 40–60 percent, which ultimately leads to energy savings of 20–30 percent year over year. For more information on the Nokia Bell Labs study, ask your Nokia representative for the "Manage sustainable IP networks" paper.

The NSP enables programmable network operations with a workflow-based approach to automating repetitive and error-prone manual tasks. It provides a set of automation frameworks and tools that network engineers and developers can use to build and adapt their own automation use cases. For example, the NSP fully automates the commissioning of a new Nokia IP router with a use case that leverages the zero-touch provisioning feature of the Service Router portfolio. This leads to faster operations at lower cost and eliminates the emissions from a truck roll.

The NSP also offers powerful analytics capabilities that incorporate machine learning (ML) algorithms to provide deep, real-time insights into the network, such as the status of the hardware resources and the power usage by different entities. These telemetry counters can be used for reporting, planning, predicting and troubleshooting. They also make it possible to program and trigger automatic corrective actions, which can enable operators to optimize network power consumption.

Network capability

Our FP5 and FPcx-based routers include performance certainty and deployment longevity capabilities that help operators meet diverse performance requirements for critical IP networks and minimize their impact on the environment.

Performance certainty

Performance certainty is essential for critical IP networks because expectations have never been higher. Nokia FP5 and FPcx silicon technology is at the heart of our high-performance 7750 SR and 7730 SXR platforms. These platforms are deterministic and enable performance certainty under real-world network conditions.

Being deterministic means providing predictable, consistent performance where performance never degrades under all operating conditions, without exception. Performance certainty is delivered irrespective of the number of access control lists (ACLs), the mix of IPv4 and IPv6, MPLS loading, or the combination of packets that may hit the router at any given time.

Our platforms ensure that routing performance will not degrade over time, and that the same performance will be delivered whether it's day one or year ten. This predictability ensures that network bandwidth need not be the solution to every networking problem. As a result, FP5- and FPcx-based routers can do much more in a smaller footprint, which reduces energy consumption and overall TCO.

Deployment longevity

Our programmable FP silicon, backwards compatibility, upgradable router designs and future-ready interfaces maximize network lifespan to minimize the impact on the environment, ensure investment protection and significantly reduce overall TCO.

Fully programmable silicon

Our FP5 and FPcx silicon technology offers a 100 percent programmable pipeline. This programmability can mitigate unknown future networking requirements and ensure that hardware can adapt to new standards with a simple software update. For operators, this means no hardware swap outs, which ensures that FP-powered systems can provide years of service and drive the lowest TCO compared to any other silicon architecture in the industry.

Seamless backwards compatibility

FP silicon has been proven across five generations of technology. Each new generation supports seamless backwards compatibility that extends the product life of deployed systems, services and line cards—to more than ten years in many cases. For example, deployed FP4-based technology interworks at full line rate with FP5-based technology in the same chassis with no performance or feature penalty and no power or fan upgrades. Operators can use FP5 technology as needed and get best-in-class investment protection.

Upgradability to new product family

Nokia system design innovation enables the first system upgrade between product families. This extends the lifespan of deployed Nokia 7250 IXR systems by providing an evolutionary path to highly capable FPcx-based 7730 SXR. The upgraded system can reuse all 7250 IXR parts, which preserves the life of existing hardware. It also offers an option to support new line cards with significantly enhanced scale and capabilities in the same system. (Note: This is planned future functionality. Contact your Nokia representative for details.)

Customers with a merchant silicon-based 7250 IXR-R6d/dl system can upgrade it to an FPcx-based 7730 SXR-R6d/dl system with only a Control Processor Input-Output Module (CPIOM) change. The upgraded capabilities include:

- Programmable silicon
- Deterministic performance
- Double the scale
- A density increase of 20–56 percent
- Deep buffering with double the buffers and table memory
- Advanced QoS
- Distributed denial of service (DDoS) mitigation
- MACsec and ANYsec line rate encryption.

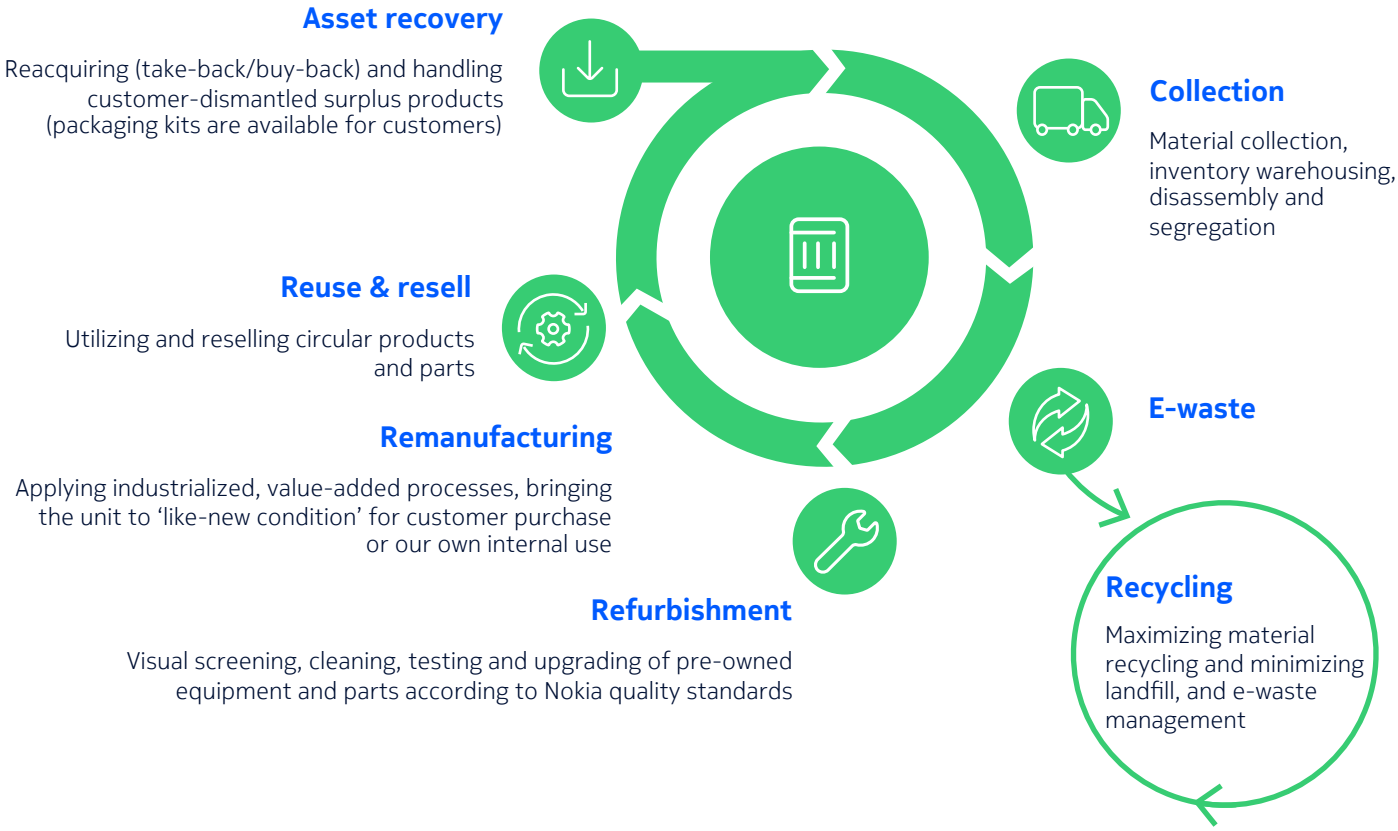
Future-ready interfaces

With the future in mind, the FP5-based 7750 SR and 7250 IXR support 800G interfaces today. With the flexible licensing for FP5, operators have the option to deploy line cards and systems with 400G interfaces now and use a software upgrade to enable 800G interfaces in the future. By supporting 400G and 800G optical interfaces today, FP5-enabled platforms extend the life of the hardware and minimize the impact on the environment.

Product circularity

Nokia is committed to ensuring sustainable network evolution. We continuously look for ways to enhance the circular practices we have established over the past 30 years and enable our customers to shift more quickly into the circular economy.

Figure 3. Leading the way with well-established circular practices



Remanufacturing

Nokia is a member of the Remanufacturing Industries Council (RIC) and uses ANSI-approved standards to remanufacture to a "like-new condition." We work proactively to increase product take-back/buy-back from our customers and to ensure the quality of our remanufactured products. In 2023, we saw a 31 percent increase in customers for our circular products and a 17 percent increase in the number of remanufactured products.

Compared to manufacturing products from new raw materials, up to 95 percent of greenhouse gas emissions are avoided with the direct reuse of products. Up to 80 percent of greenhouse gas emissions are avoided when greater than 5 percent of components are replaced. These figures are based on our lifecycle-assessment approximation calculations in line with accepted greenhouse gas protocol methods for the ICT sector.

Circular operations

We continue to increase the use of recycled materials in our new products. Modular components and products that cannot be reused or repurposed at end-of-life are sent to recycling vendors to generate reclaimed material for another application or industry.

Our design approach helps ensure that we create technologies according to environmentally sustainable principles. We apply holistic product lifecycle thinking to minimize environmental impacts and ensure compliance with regulatory policies and our own policies as early as possible in the product and packaging design and development process.

Our design practices help us maximize the success of our take-back/buy-back program through designing for modularity, repairability, remanufacturing and ease of deconstruction for material recycling. Our take-back/buy-back program also helps us minimize the volume and negative environmental impact of the materials we use.

Product packaging

Our highly circular product packaging designs maximize product protection throughout its logistical flow while minimizing the impact on the environment. We have reduced and eliminated plastics, using cardboard cushions instead for shock absorption. We have also eliminated non-recyclable materials such as polyurethane foam and have increased the use of recycled content in our packaging to limit resource depletion. Finally, our space-saving designs reduce the quantity of materials used per package and decrease associated transportation emissions.

Summary

Nokia is committed to developing products that consume less energy and have a smaller environmental impact. Through technology leadership and innovation, we deliver highly sustainable and highly performant IP wide area and data center networks. Through energy-efficient product innovations, network capabilities that provide performance certainty and deployment longevity, and product circularity practices that ensure a sustainable network evolution, the Nokia IP networks portfolio is helping network operators minimize their greenhouse gas emissions and environmental footprint.

Our high-performance 7750 SR and 7730 SXR platforms use our FP5 and FPcx silicon, platform breadth and mechanical cooling innovations to drive energy savings. We achieve our industry-leading 0.1 W/Gig energy efficiency without compromising performance, scale, services or features. 800GE routing along with advanced network design and automation capabilities provide network operators with even greater energy savings.

With fully programmable FP5 and FPcx silicon, backwards compatibility, system upgradability, future-ready interfaces, Nokia design innovation maximizes the network lifespan of our 7750 SR and 7730 SXR platforms and minimizes our impact on the environment. Superior merchant silicon integration, breadth of variants system designs that maximize interface density ensure leading energy savings from our 7250 IXR and 7220 IXR platforms.

For more information:

Product page: 7220 IXR

Product page: 7250 IXR

Product page: 7250 IXR for data center fabrics

Product page: 7730 SXR

Product page: 7750 SR

Product page: Network Services Platform

Solution page: 800GE Routing

Solution page: Coherent Routing

Video: The business case for 800GE routing in the age of sustainability

White paper: The business case for 800GE routing in the age of sustainability

Web page: Sustainability at Nokia

Abbreviations

ACL	access control list
ANSI	American National Standards Institute
CAPEX	capital expenditure
CPIOM	Control Processor Input/Output Module
CSP	communications service provider
DCI	data center interconnect
DDoS	distributed denial of service
GE	Gigabit Ethernet
ICT	information and communications technology
IP	Internet Protocol
IXR	Interconnect Router
MPLS	Multiprotocol Label Switching
NPU	network processing unit
NSP	Network Services Platform
OAM	operations, administration and maintenance
OPEX	operating expenses
PCB	printed circuit board
PCE	Path Computation Element
RIC	Remanufacturing Industries Council

SFP-DD	Small Form-factor Pluggable Double Density
SR	Service Router
STAR	self-tuned adaptive routing
SXR	Service Interconnect Router
TCO	total cost of ownership
W/Gig	watts per gigabit

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.

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