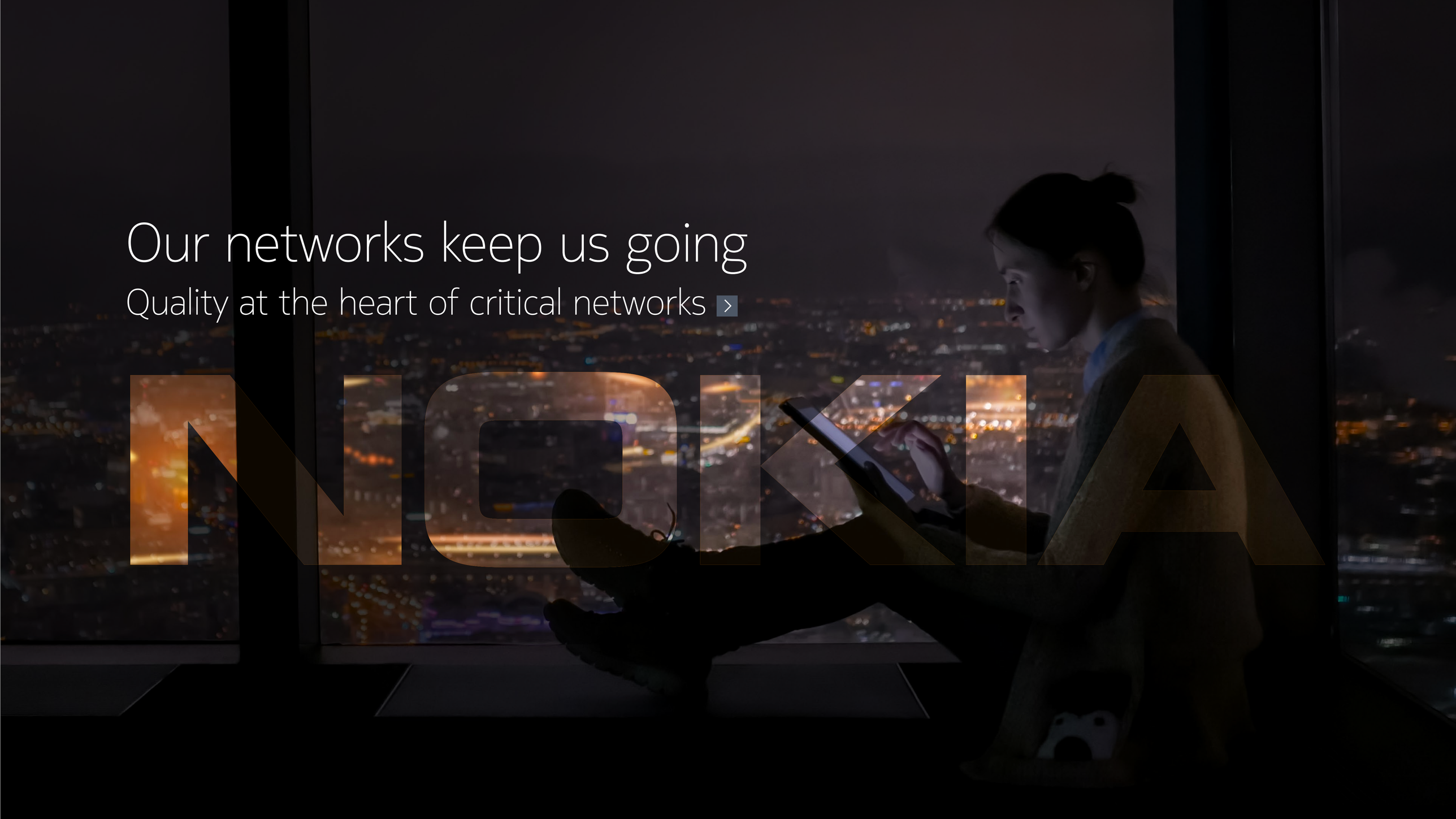

Our networks keep us going
Quality at the heart of critical networks ›
NOKIA

Networks are on the frontline

The relentless pursuit of growth and productivity is ubiquitous across industries. The expansion of the Internet, clouds, and fixed, mobile and wireless technology innovations is transformative. Their virtuous cycle creates new service opportunities for the organizations who build and operate networks:

Communications Service Providers (CSPs) delivering extraordinary 5G and fixed broadband services at massive scale to consumers and enterprise; cloud service providers rewiring the economics of IT and the applications used for work and play; and a multitude of verticals whose modernization projects are the very definition of Industry 4.0.

The demands of these services on networks has never been greater nor more different. Yet the underlying IP and optical systems at the heart of modern infrastructure are expected to perform and work non-stop; there is no rest, no time off for good behavior. In the digital world everything must work all the time because lives and livelihoods are on the line.

IP and optical networks are the connectivity fabric that powers services, ensuring what is wanted gets to who wants it in a blink of the eye. Across town, around the globe and all at points in between, they give tailored connectivity to and among an evolving collection of endpoints.

Building and operating modern networking infrastructure is complicated and essential to keeping society running. The people who do so are modern-day heroes, and yet their efforts are largely hidden from view. We should know: at Nokia, we are building and modernizing their network foundations for 5G, cloud transformation, and Industry 4.0.

IP and optical networks must interconnect a growing number of evolving endpoints:

- Broadband fixed access networks, gateways, and clouds
- Mobile radio access networks, core, and clouds
- Enterprise offices, branches, data centers, and private/public clouds
- Industrial network operations centers (NOCs) and field equipment (meters, grids, rolling stock, autonomous haulage systems, etc.)
- Central clouds, edge clouds, and distributed points of delivery (PoDs)/caches
- Internet peering and wholesale exchanges
- Internal network functions and IT systems

This is – and remains – our sole focus. We are proud to be the most trusted systems partner to the world's most critical networks.

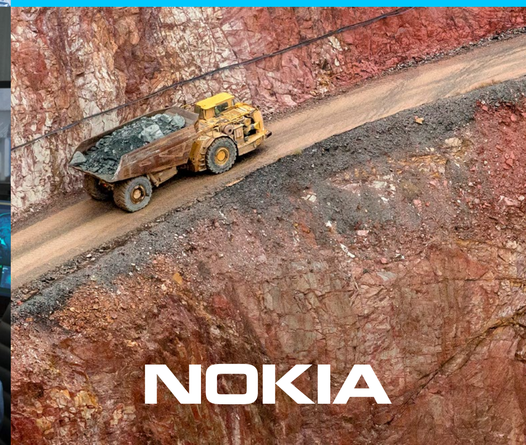






For networks, there is no rest, no time off for good behavior.





Rewiring the demands on critical networks

Networks that interconnect "things" must adapt to how those "things" evolve. Growth in the use of residential broadband, 5G mobile, clouds, and industrial digitalization is placing a greater burden on networks than they've ever had to manage before. Instead of struggling under the load, networks must be built to accommodate this new normal.

Residential broadband:

The COVID-19 pandemic is making visible the vital importance of networks generally and residential broadband Internet service in particular. With 'shelter-in-place' and 'work-from-home' mandates instituted throughout the world, traffic originating from fixed networks grew 45 to 50 percent, a full year's worth in just a couple of weeks.

The results of Nokia's analysis of several networks during the first week of country-wide lockdowns are unprecedented. Families are keeping in touch and consuming more high-definition video streaming. There is also a huge increase in upstream traffic due to the phenomenal growth of videoconferencing and collaboration tools, which require lower latency and higher bandwidth to the cloud. A similar increase is happening in Microsoft Office suite upstream traffic as almost everyone that can work from home is doing so.

The 'busy hour' for CSPs occurs Sunday evening as families enjoy streaming ultra-high-definition video into their homes. 90 percent of streaming video consumption is sourced by content delivery networks (CDNs), particularly from local caches. Unfortunately, the increased demand for video streaming has exceeded cache capacities, driving extra traffic across the IP and Optical network to distant peering points. Furthermore, all traffic between broadband access networks and CDNs transits a broadband network gateway (BNG) for authentication, authorization and accounting, etc. Our analysis indicates the data plane capacities on some BNGs are hitting their limits.



Rewiring the demands on critical networks

Daytime traffic is increasing as people work from home, attend online schooling, participate in exercise classes and generally keep in touch. The volume of daytime traffic is less than the Sunday night busy hour and explains why networks keep going. Much of this traffic, however, is bi-directional (unlike uni-directional video streaming) and upstream traffic has increased 30 percent. In addition, video conferencing is latency sensitive and poor service quality is highly visible to consumers.

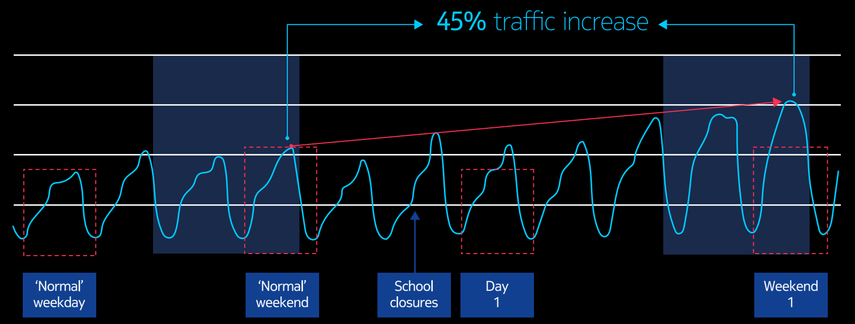
Notwithstanding the immediate and unprecedented impact of COVID-19, traffic and application trends for broadband services have become more unpredictable. It is common for traffic surges to occur anytime from a multitude of sources. Examples include updates to popular online games (Fortnite, Call of Duty), special events and episodes (the Spanish crime drama 'La Casa De Papel' – the Money Heist), software updates (Windows, IOS, Android), and the continuous workflow optimization by webscale companies as they redirect massive 'elephant' flows among peering points.

"In the past few weeks, we've received a huge surge of customers calling to improve their connectivity. Families who cannot leave their homes need digital connectivity. Family members and students moving back home to support their parents need to be connected. People want more connections: one in 10 of our EE customers are asking for second lines. Demand for mobile broadband and tablets has gone up, as customers ask for better connectivity to support home schooling. And some of our PAYG customers are asking us to move their old-style phones to smartphones for the first time. The reason? WhatsApp works only on smartphones – and that's just one important way people are staying connected with their families."

Marc Allera,
Consumer CEO, British Telecom

Find out more >

Lockdown measures had a significant impact on network traffic





Rewiring the demands on critical networks

5G innovations:

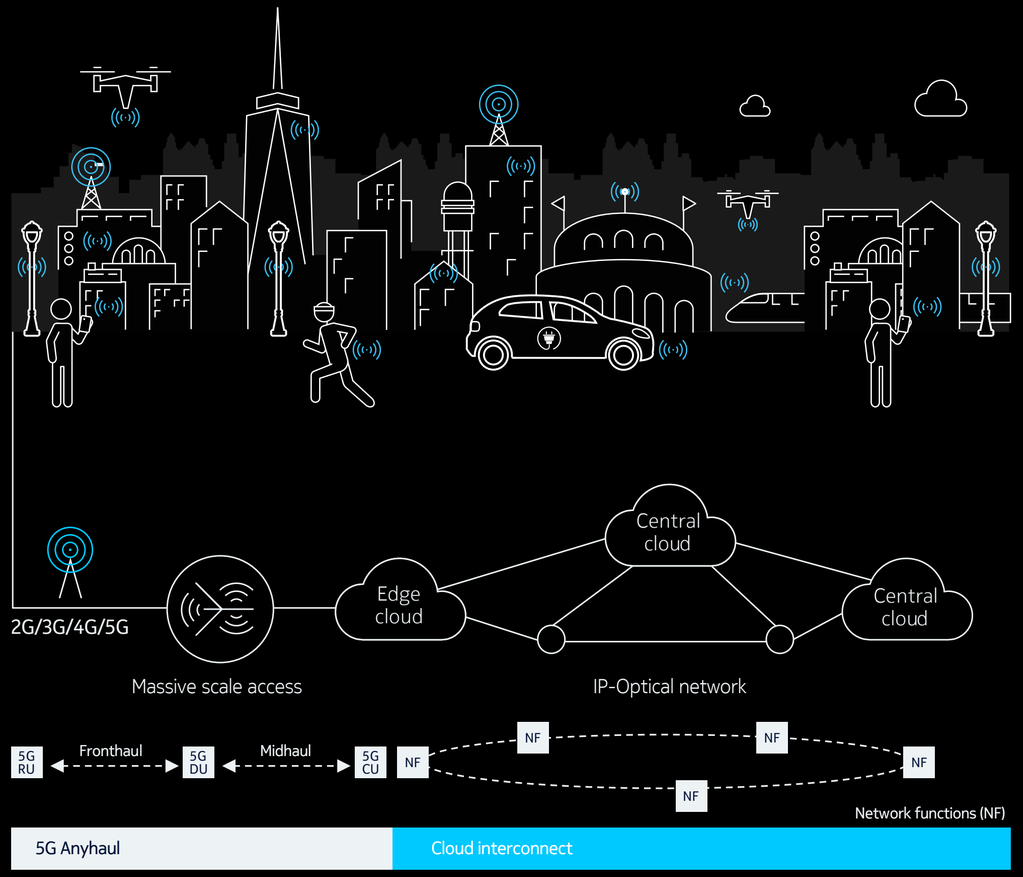
A decade of 5G innovations will bring an expanded portfolio of mobile and wireless services to market. 5G brings broadband performance to mobile devices, for example, and opens up new opportunities for industrial wireless applications and the Internet of Things (IoT). To deliver them with agility and flexibility, radio access network (RAN) and mobile core technologies are migrating to cloud architectures and adopting virtualized, end-to-end 'network slices' to partition resources as needed. The roadmaps for new 5G capabilities are deep and will be rolled out over many years. Suffice it to say, the impacts on IP and optical networks are significant.

5G RANs will generate 10 times more traffic than 3G/4G combined. The new radios will be deployed in new sites as well as existing ones to increase densification. New RAN architectures introduce deployment options that require fronthaul, midhaul and backhaul connectivity to the mobile core.

Fronthaul is a particular challenge for mmWave radios. They require massive capacity, ultra-low latency, and precise timing and synchronization.

Mobile packet cores have been migrating to 'cloud native' architectures for several years under LTE and in preparation for 5G. Instead of a single entity, cloud-based packet cores are a multitude of disaggregated network functions which can, and will be, distributed among edge and central clouds to provision the 5G service and its 'network slice' in the most optimal way. This means the network must interconnect more endpoints among multiple clouds with strict service level agreements (SLAs). Automation is essential to scale and provision network services with the same agility and flexibility as the cloud-based mobile endpoints they interconnect.

5G RANs will generate 10 times more traffic than 3G/4G combined



Rewiring the demands on critical networks

Cloud:

The story of computing architecture evolution and the transformation of enterprise IT from data centers to private clouds is well documented. Indeed, the same can be said of the dominant webscale players whose cloud-based applications and content for consumers have been prevalent for only a short decade and yet underpin our daily lives and lifestyles. The confluence of cloud computing, the global Internet and ubiquitous broadband may well be considered the 8th Wonder of the World.

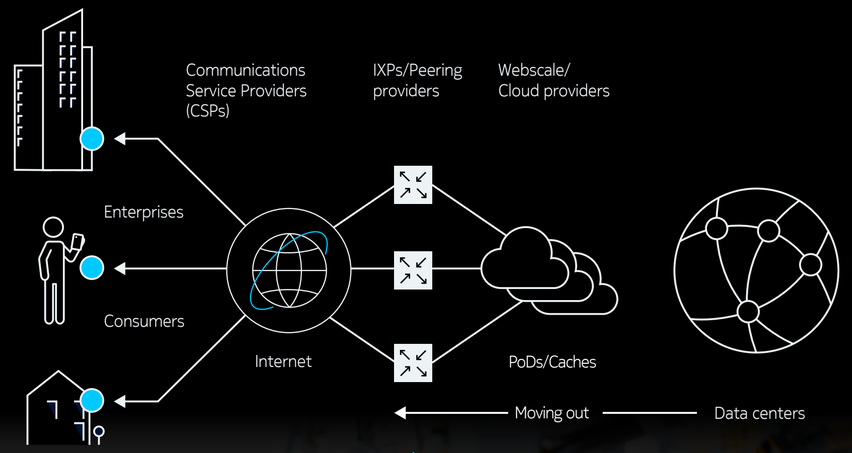
And there is so much more to come!

Enterprise IT migration to public clouds and the adoption of software as a service (SaaS) models are growing rapidly. Compared with residential CDNs, however, they have a long way to go in terms of market penetration and network deployments. But they will catch up quickly: witness the rapid adoption of SaaS applications Microsoft Office suite and Zoom during the pandemic.

The battle for public cloud market share is relentless as participants strive to deliver the utmost quality of experience to enterprise. Public clouds are moving deeper into networks and closer to enterprise locations and employees, much as CDNs have for high-quality video streaming. For example, AWS Outposts and Azure Edge Zones are designed for deployment on the customer premises. And as Clouds move out, so too does the network to interconnect branch offices, data centers and peering points.

Public clouds – so easy to use and consume – are appealing: they provide instant gratification better than private clouds in many cases. They enable IT workloads to become virtualized and containerized and now include telecom applications as well. The dynamism of cloud applications that spin up, spin out and spin down demands the network services that interconnect them be as agile and as easy to use and consume.

Evolving structure of the Internet





Rewiring the demands on critical networks

Industrial digitalization:

We are at the beginning of a new industrial revolution. This "Automation of Everything" era will be brought about by digital interfaces, data analysis and control of the physical world through networks. It promises to unlock trillions of dollars of economic value in the next decade by driving massive improvements in productivity for physical, asset-intensive industries that will enhance the quality of life in safer, healthier and more sustainable communities.

Physical industries have machinery, tools and systems that must be monitored, controlled and optimized. The key to creating efficiencies is by controlling these physical assets using digital technologies.

This is the promise of combining advances in information technology (IT) and operations technology (OT) to enable industries to drive closed-loop automation in their physical environments. It allows companies to leverage a wealth of state information to sense, analyze, optimize and control their complex systems. In doing so, they will ensure that they are making the most efficient use of their assets and resources, minimizing the occurrence and impact of failures, and maximizing their productivity.

The opportunities to energize traditional industries are countless and within reach. Digital transformation will connect everything, locate compute power where needed and apply insights and operational execution with precision. They will leverage IoT, edge computing, deep analytics based on artificial intelligence/machine learning (AI/ML), augmented reality (AR), robotics, remote control and digital twinning technologies. Each of these innovations places new demands on the networking infrastructure. In many cases, this extends far beyond what has traditionally been acceptable for even the largest enterprise networks. In other cases, it greatly expands the capabilities required of today's mission-critical network infrastructures.

In addition, as smart devices and systems proliferate and business applications evolve, networks will require dramatically more bandwidth to deliver richer information about the state of systems and the operating environment. Further, as business-critical applications extend to industrial automation and real-time asset coordination, they will demand latency that is orders of magnitude lower than required for today's simpler applications. High-availability networks and services with strict SLA enforcement are table stakes and will become vastly more challenging – yet no less essential - as legacy TDM networks are refreshed, network perimeters expand and the natural environment becomes no less hostile.



Core values at the heart of critical networks

Our customers believe networks are a critical asset. We agree: quality networks are a core building block of our society. At their heart is the IP and optical network through which consumer, business, and industrial traffic is routed and transported. The increasingly unpredictable demands placed upon the network directly fuels the essential and complex task of designing a network architecture built to perform, protect and last.

IP and optical networks are a system comprised of automated components that interwork to deliver end-to-end functions and capabilities. Components are distributed end-to-end over wide areas and optimized according to their role and location in the network architecture. Furthermore, networking systems distribute and/or layer tasks 'up and down' between IP and optical domains to achieve architectural effectiveness and resource efficiencies.

This end-to-end and up-and-down systems view is what drives network planning and design. The build ultimately operates as single system. And while no two networks are the same, there are common attributes to guide design and investment choices.

End-to-End: IP and optical networks have many functions

- Core, longhaul and subsea backbone networks
- Internet peering, cloud and wholesale provider interconnect
- Data center switching, gateways and interconnects
- Packet network services gateways at the network edge (BNG, CPC, MSE, etc.)
- Metro, regional, field and mobile backhaul aggregation networks

Up-and-Down: IP and optical networks have layers and may include:

- IP routing and forwarding
- Ethernet/MPLS packet switching
- Optical Transport Networking
- Wave Division Multiplexing



Core values at the heart of critical networks

When society and industries depend on networks to keep the world going, designing an IP and optical network should focus on three things:

Scalable and assured network performance engineers can count on

- Assuring performance at scale means networks can be engineered according to strict rules and policies that will stand up in all service combinations and usage circumstances.
- Use of historical traffic analysis and network engineering helps forecast future demands, but it is impossible to predict all possible user/client scenarios and over-subscription models driving traffic over your packet-based network. Detailed analysis of components generally, and the silicon in particular, is essential to designing a network that can manage traffic bursts and extreme variability at high-scale and efficient, high-utilization rates.
- Edge service gateways, core and peering routers, and optical longhaul and subsea components are the most critical for managing traffic. These nodes have the most impact on a network's ability to mitigate variability and ensure the consistent, predictable delivery of multiple services with strict SLA enforcement, for multiple scaling dimensions and over long distances.

Robust and secure network infrastructure your operations can trust

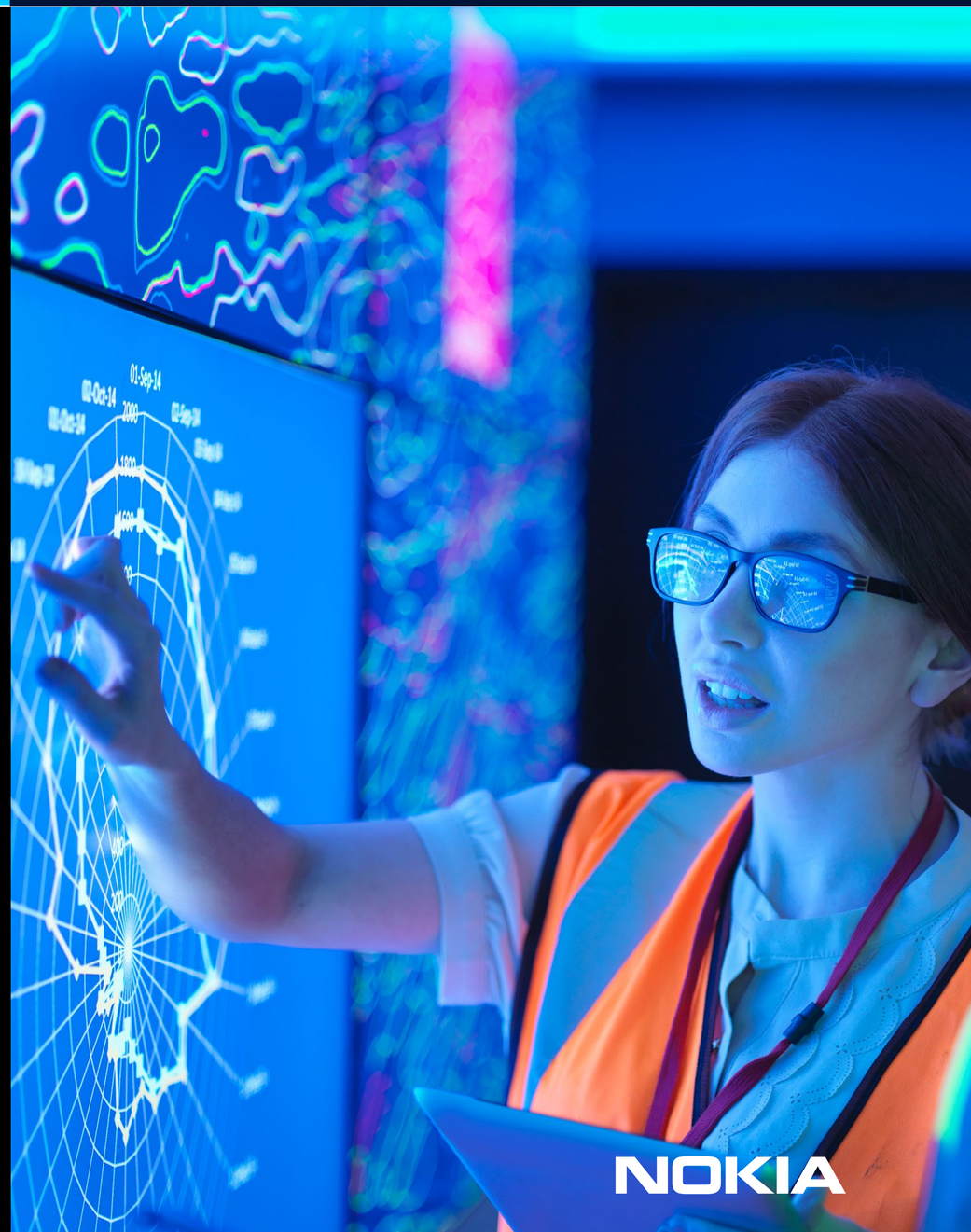
- As network capacities scale and perimeters expand, so too increases the day-to-day challenge of operating high-availability networks. More network means a larger attack surface, more optical fiber in the ground and all the other issues that come with controlling networking assets distributed over wide areas and in hostile environments.
- Adversity is bound to happen, so networks must be designed to protect themselves. Knowing you can trust your network to maintain its high availability is essential.
- Designing robust and secure networks involves a multitude of architectural decisions.
  - End-to-end policies, automation and analytics to eliminate configuration errors while also scaling the provisioning, assurance and optimization of network services.
  - The software underpinning the stability of networks must be rock solid and frequently updated to respond to security threats and provide new functionality.
  - Redundancy and protection mechanisms to provide resiliency and restoration between IP and optical layers and between centralized software defined networking (SDN) controllers and the networking nodes they control.
- High availability is a hallmark of critical networks. By reducing the scope of networking issues that cause disruptions, you ensure service delivery KPIs are met even during adversity.



Core values at the heart of critical networks

Efficient and programmable network architecture your business can build on, again and again

- An efficient and programmable network means investing in a solution that will last and allow countless software updates. By reconfiguring your existing network anytime, your business can experiment, enter and grow into attractive new segments, offer new services and support new requirements as they arise.
- Neil Bohr could have been summarizing a vision for network evolution, not atomic physics, when he said: "It's difficult to make predictions, especially about the future". Network architects are being asked to define a network that addresses immediate needs efficiently while supporting unknown needs effectively and without a forklift upgrade for a decade or more. The service demands on critical networks; an open ecosystem for innovation; and the economics that govern investment, TCO and lifecycle all point to a need for flexible, software-driven network architectures.
- Programmable hardware and silicon enable network efficiency, longevity, and the precise performance needed at each point. By evaluating the requirements of networking equipment based on their location and role in the architecture, a clear picture will emerge to govern technology choices. For example, edge, core, peering and longhaul applications experience the most duress and demand the most dexterity. Aggregation and metro applications demand the most efficient grooming and fanout across shorter distances. Choosing the appropriate components for each provides structure where needed and efficiency where cost is the primary driver.
- New technology will become available and added, especially during an extended life. New generations of silicon and hardware must work with previous generational pairs to eliminate premature forklift upgrades and the stranding of assets before their time. Software analysis is similar in determining how many software streams are required, their hardware dependencies and hence lifecycle, and the breadth of features and functions required end-to-end to facilitate uniform operations.
- The right architecture gives your business a competitive edge to grow over an extended life, embrace new opportunities as they emerge, and realize the lowest TCO.



Our customers' networks keep the world going

Nokia's singular focus has always been delivering quality solutions and expertise to solve the world's most critical networking challenges. Decades of focus brings insight and the technology depth our customers value including CSPs, verticals, enterprise and webscale companies. We are proud to be their trusted systems partner.

At Nokia, our expertise and technologies are building the world's most critical networks. Public and private networks alike require quality solutions that perform, protect, and last. Here are a few of the ways we are helping our customers solve tough networking challenges.

Uncompromising attitude

While other vendors downplay the role of hardware, we develop our IP and optical hardware with an uncompromising attitude.

Our IP portfolio has products based on our own silicon as well as products based on merchant silicon and cloud environments. For the most challenging applications our IP routers use our fourth-generation router silicon, the FP4. These network processors allow us to build routers that guarantee **deterministic performance** for any service combination and do so even during non-steady-state events such as oversubscription and microbursts.

FP4 silicon performance is at the heart of these networks:

- BT's nationwide IP core network operating at more than 17 Tb/s
- DE-CIX's Apollon platform, the world's largest and most advanced peering network
- Hundreds of high performance, multi-terabit networking projects throughout the world including Proximus, LG U+, and Telefonica.

Where networking applications and locations are driven by cost-effectiveness, our customers deploy specialized fit-for-purpose routers based on merchant silicon. Where highly flexible IP gateways are required for rapid service innovation and accelerate time to market, our customers can deploy virtual, cloud-native or physical network function instances.

- T-Mobile USA uses a combination of custom and merchant silicon to deliver a high-performance, robust and cost-effective IP network for 5G
- Vodafone Idea use a cloud-native packet core to deliver more than 1 Tb/s mobile services in India



Our customers' networks keep the world going

For the most demanding metro, longhaul, subsea and data center interconnect applications our OTN components use our Photonic Service Engine PSE-3 and our 5th generation PSE-V to deliver capacity-reach combinations approaching the Shannon Limit. Furthermore, our open line systems were the first to support C and L bands and **double the capacity** of fiber.

We are the #1 vendor in Japan for nationwide optical networks:

- Rakuten Mobile's backbone network is optimized for maximum capacity and lowest cost per bit using the Photonic Service Engine 3 (PSE-3) super coherent chipset and C+L Ultra-Wideband wavelength routing

We build two variants of the PSE: our latest super-coherent **PSE-Vs provides the highest performance while the compact PSE-Vc provides the lowest-power applications**. Combined with our acquisition of Elenion enables a new **portfolio of vertically integrated optical transceiver modules** that will further optimize and refine the price/performance spectrum across an expanding range of networking applications.

Our IP and optical silicon is highly programmable and has demonstrated longevity and functionality upgrades beyond what merchant silicon allows. We have **never stranded a platform**.



Our customers' networks keep the world going

Rock-solid methodology

Software and automation bring networks to life; they operationalize the features and functions needed to solve current and future demands. Our software is rock-solid, as it must be, since the slightest instability can have massive consequences.

We are the **only vendor with a single software – SROS – for our entire IP portfolio**. It affords a unified and consistent operational model across all IP networking applications and network hardware. Its stability is proven in 1 million routers deployed in critical networks worldwide.

The growth and expansion of networks introduce significant security risks that must be addressed end-to-end. We provide an innovative and award-winning in-line solution to filter and mitigate volumetric DDoS threats and attacks at terabit line-rate, at up to 85 percent less cost than traditional solutions. Using Deepfield real-time analytics to monitor, recognize and stop DDoS attacks, networks are protected against attacks inbound (from the internet) and outbound (from hijacked or malicious devices within your network).

Our optical software is equally secure and robust. A Japanese customer's nation-wide DWDM network survived the devastating Typhoon Hagibis with no optical service interruptions even after a double failure consisting of two consecutive fiber cuts. The automatic network recovery function of our system, relying on L0 GMPLS and CDC-F, **maintained critical communications during rescue and recovery efforts**.

Network automation is a key strategic initiative to improved operational accuracy, accelerated time to market, and reduced OPEX. Our comprehensive SDN technologies provide overlay and underlay solutions for end-to-end network service automation for public and private clouds and as the **open automation platform in multivendor environments**.

- In Korea's LG U+'s 5G network, our Network Services Platform (NSP) provides SDN automation of the IP transport network comprised of Nokia and 3rd party routers
- Collaboration between Microsoft and Nokia enabled BT to be the first global CSP to offer its enterprise customers a managed service that integrates Microsoft Azure cloud and our Nuage SD-WAN solutions

Industrial networks benefit hugely from our technology's proven operational stability in the world's largest public networks:

- The Irish Aviation Authority's high-availability solution for air traffic control
- Healthcare provider UPMC's robust, trauma-grade solution

Along with railways, energy, mining and other verticals, we have delivered private networks to support digital transformation for more than 10 years including the modernization of existing infrastructure and the expansion of connected devices with private wireless technologies.



Our customers' networks keep the world going

Systems-driven innovation

Historically IP routing and optical transport were deployed and operated by CSPs as separate domains, which has some benefits, but also makes it difficult to coordinate and automate cross-domain service provisioning and assurance processes, and duplicates functions and costs. We believe that **SDN-based automation solutions have matured to the point where appropriate IP/optical integration is achievable in multi-vendor environments**. Our SDN solutions are pre-integrated by design to enable robust IP and Optical networks out of the box. They provide operational benefits faster and with less effort than competitors' discrete solutions.

- SDN Communications use the Network Services Platform (NSP) to provide dynamic control and management of services throughout their IP and optical networks. The solution helps drive efficient operations and enhanced service quality, using multi-layer coordination to quickly respond to fast-changing customer demands like the eventual rollout of 5G services.

For Industry 4.0 our end-to-end systems expertise created an 'Industrial IoT' device for private wireless applications. An IP router with a cellular uplink, it extends IP/MPLS services deep into distributed field operations with connectivity to remote equipment.



Quality at the heart of networks

Our singular ambition is to be the world's most trusted systems partner for the world's most critical networks. It drives our intent, defines the problems we choose to solve, and describes the uncompromising attitude and perseverance of our engineers who develop and deliver projects.

Our networks keep us going.

Built by Nokia.
Made amazing by you.

Find out more >



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About Nokia
Nokia is a global leader in the technologies that connect people and things. Powered by the innovation of Nokia Bell Labs and Nokia Technologies, the company is at the forefront of creating and licensing the technologies that are increasingly at the heart of our connected lives.

With state-of-the-art software, hardware and services for any type of network, Nokia is uniquely positioned to help communication service providers, governments, and large enterprises deliver on the promise of 5G, the Cloud and the Internet of Things. **http://nokia.com**

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