
Microwave transport in the era of 5G
The high-performance vehicle for racing ahead
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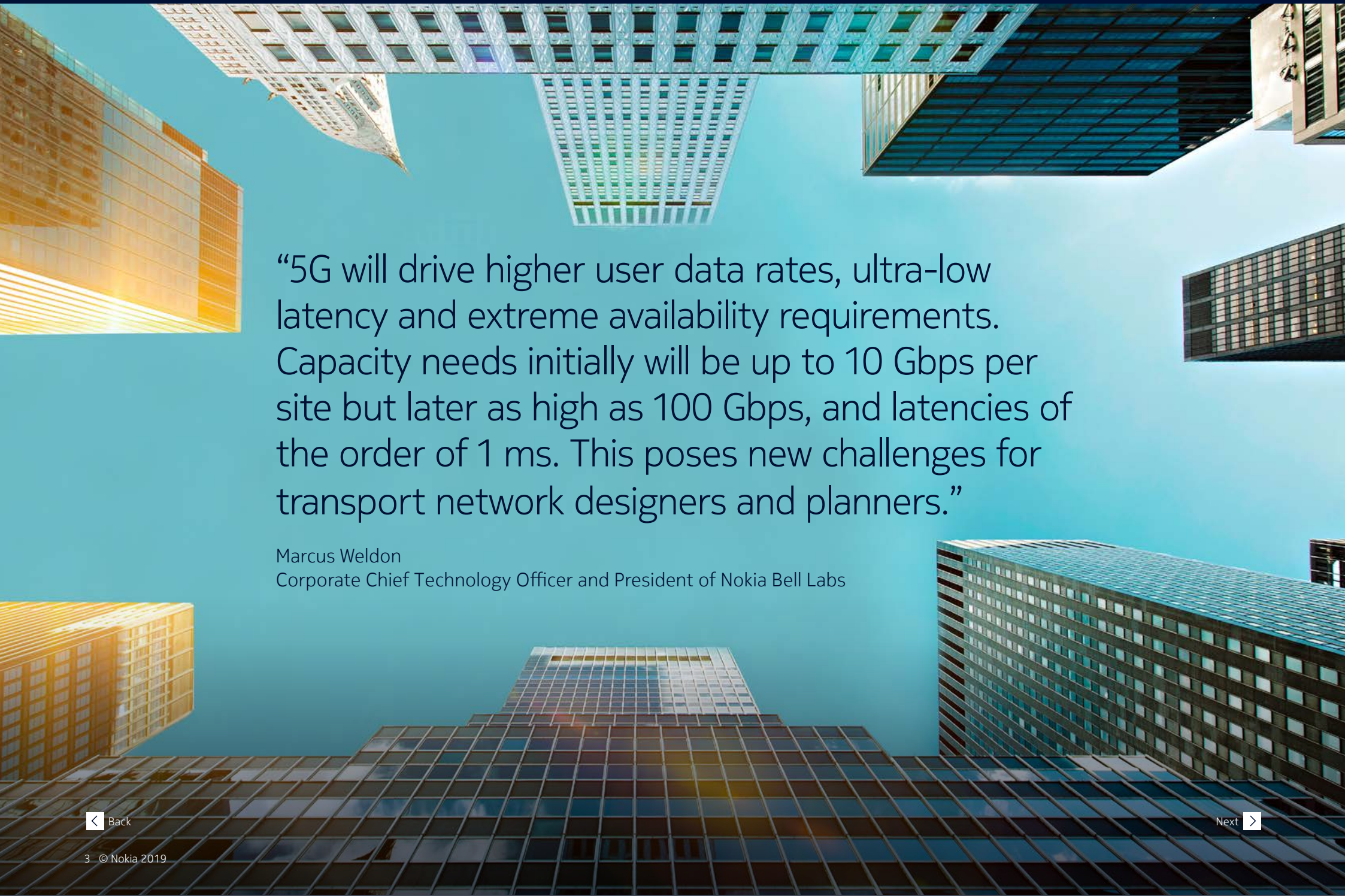

“5G will drive higher user data rates, ultra-low latency and extreme availability requirements. Capacity needs initially will be up to 10 Gbps per site but later as high as 100 Gbps, and latencies of the order of 1 ms. This poses new challenges for transport network designers and planners.”

Marcus Weldon
Corporate Chief Technology Officer and President of Nokia Bell Labs

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5G transport demands fresh thinking

As 5G is deployed, the mobile network transport layer must evolve to meet multiple new demands ranging from network densification and network slicing to RAN decomposition and network function virtualization. The transport network will be based on a mix of technologies, including IP and fiber, and new microwave capabilities will offer compelling and cost competitive solutions to continue to play a vital role in mobile transport networks.

In the next few years, communications service providers (CSPs) will run backhaul transformation projects to meet the needs of 5G Radio Access Network (RAN) service provisioning. With mobile data traffic growing rapidly (40-fold between 2014 and 2020) and the connection of 50 billion Internet of Things (IoT) devices by 2025, many CSPs are rethinking their existing transport network architecture.

Fiber optic presence in transport networks is increasing as CSPs exploit the technology's advantages. Yet fiber is not always available and may be too expensive. When a fiber Point of Presence (PoP) is a few hundred meters away from the radio access point, total cost of ownership (TCO) favors microwave connectivity. What's more, microwave is already used in more than 50 percent of current cell sites.

For all these reasons, microwave transport is a key enabler for 5G and will play an important role.

Meeting 5G challenges

Microwave technology can address 5G's challenging capacity and latency requirements. To meet the increasing 5G capacity requirement, new solutions to optimize the use of spectrum and dramatically increase capacity are now available.

Propagation-medium induced latency depends on the density of the medium, so the latency of a wireless connection is fundamentally lower than that of a fiber cable of the same length. Equipment-induced latencies must also be considered.

Mission-critical applications require high resiliency network performance. Wireless connectivity is generally more reliable than fiber during major events such as earthquakes, fire, or simple road maintenance. Moreover, in these cases, the recovery time is much faster with a microwave connection.

Focus on TCO

The coming 5G network transformation will affect microwave solutions already deployed for 3G and the early stages of 4G probably more than any other transport technology. The substantial installed base of microwave will inevitably be replaced over time in favor of new microwave solutions designed for 5G or, in some instances, fiber. The goal for CSPs will be to optimize budgets during backhaul network upgrades to minimize the TCO of their evolving assets.

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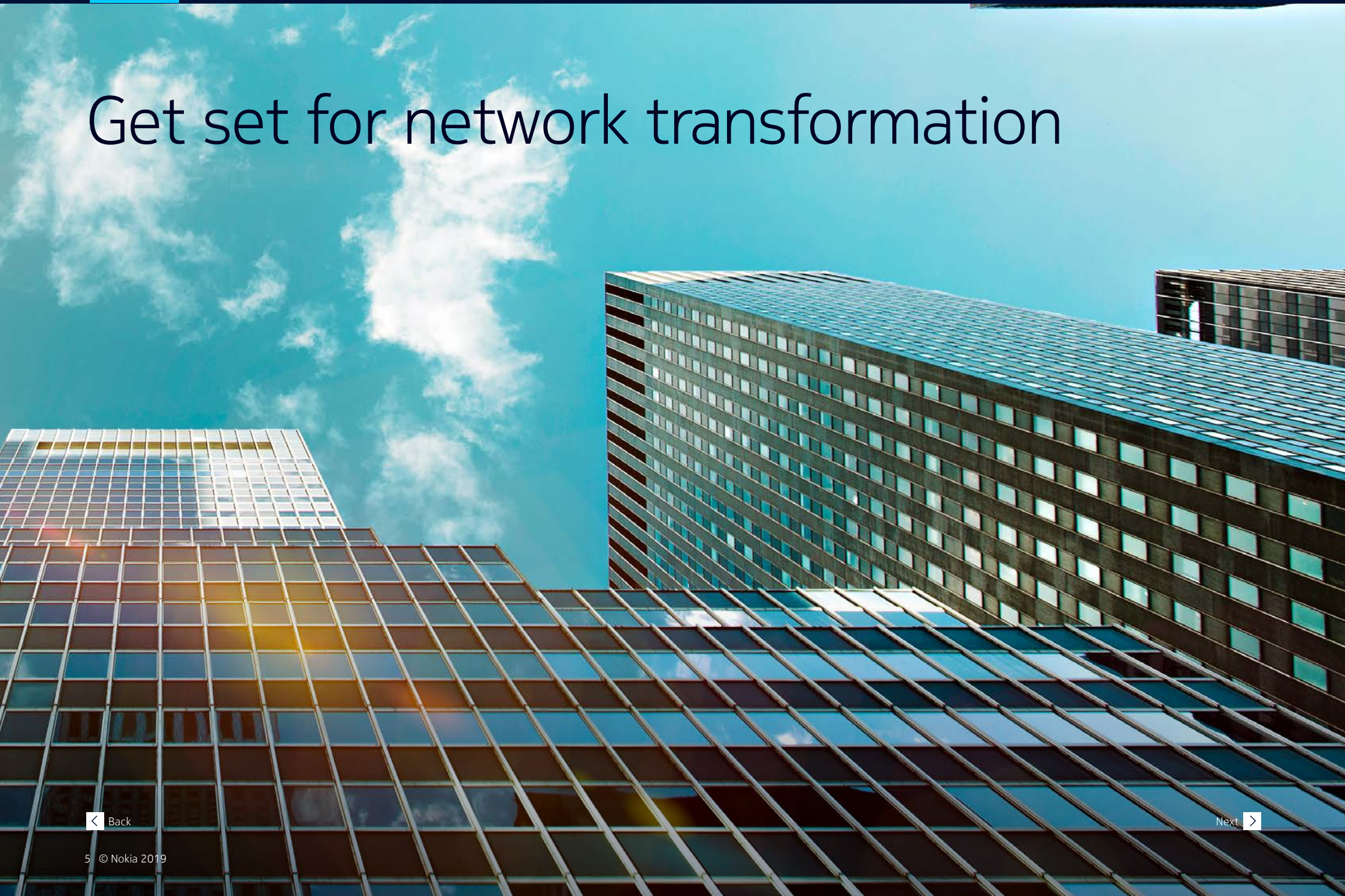
Get set for network transformation



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5G signals big changes

5G is more than just an innovative radio technology using new spectrum.
It introduces a new approach to network architecture that enables new business models.

While previous generational shifts in mobile technology have focused on the radio network, 5G is different.

It introduces a new approach to network architecture that builds on new concepts such as densification, decomposition of network functions (e.g. the separation of user and control planes), programmable transport, end-to-end automation and orchestration, plus network slicing to enable new service business models. A complex interworking of different network domains, technologies, components and services will be needed.

Efficient evolution to 5G will exploit existing 4G/LTE networks. However, 5G brings deep transformation affecting multiple dimensions by providing a common core for several radio technologies (cellular, Wi-Fi, fixed), multiple services and CSPs' networks.

5G will enable many new services, including enhanced mobile broadband, augmented reality, and mission-critical communications, creating an unprecedented traffic mix that will require dramatically improved performance. For example, throughput will need to rise ten-fold (10/25 Gbps for F1 and backhaul interfaces) and latency will need to come down to 1 ms end-to-end.

Break with tradition

CSPs traditionally treat the core, transport and radio access networks independently and tend to integrate the different infrastructure parts only after deployment. However, in new 5G scenarios, post-deployment integration costs, time-to-market and the risks of degraded service quality would increase dramatically using this approach.

Without cross-domain design and pre-deployment integration, CSPs risk missing new business opportunities created by 5G. Business-critical applications depending on ultra-reliable low latency communication and extreme network reliability can only be delivered with the seamless, error-free interaction of radio, transport, core, data centers and management systems.

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Overcoming challenges

Newly converged networks will have to make the transition to IP to support network slicing. Network slicing means that network resources, both Virtual Network Functions (VNFs) and the transport network, can be shared by different services. The network is virtually sliced in several, independent logical resources that can simultaneously accommodate multiple application fulfilment requests.

This demands an end-to-end approach to service fulfilment. The transport network (microwave or fiber) must adapt in step with the distributed IP core and radio access network functions provided by the base stations in order to meet the service levels required for each slice.

Meanwhile, densification will mean more sites to be connected, with heavy implications for transport. For instance, in a typical deployment, a macro cell could act as a pooling site for small cells in its coverage area. High user density (> 150,000 subs/km^2) implies increased connectivity between base station sites with different connectivity technologies. Densification needs a shift in topology toward a meshed or partially meshed structure.

On top of this, complex traffic engineering and the flexibility to deliver shorter service activation cycles (from days or hours to minutes) will combine to make a step change in the level of network automation the only sensible option.

Play to existing strengths

CSPs can optimize the TCO of their 5G networks by exploiting existing assets where possible, at least during the initial transition to 5G. Since microwave already accounts for 50 percent of current cell sites, it will also be an important part of the mix.

Microwave technology has the undisputed lead in mobile backhaul transport today. Based on several industry reports and predictions, microwave will also play an important role in the future.

CSPs with a technology partner that offers a comprehensive mobile transport portfolio (fiber, copper, microwave) will benefit from more effective and easier integration and fast deployment to accelerate their migration to cloud and 5G. The ideal portfolio also needs to provide extreme flexibility and ease of integration through an open, programmable network architecture with service assurance. Any solution must offer CSPs the agility and flexibility to respond to changing market demands and conditions.

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Future X promotes end-to-end network integration

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Welcome to 5G Future X and Anyhaul

The Nokia Future X solution provides CSPs with the opportunity to take advantage of the promise of 5G by overcoming the challenges. 5G will place high demands on the transport layer, including very low latency, high reliability, increased efficiency, extreme bandwidth and many devices.

5G Future X combines an end-to-end portfolio covering massive scale access, converged edge cloud, cloud-native core, programmable and scalable “Anyhaul” transport and process automation.

It uses cross-domain, cloud-native functions to enable rapid deployment of virtualized functions across a distributed cloud infrastructure to simplify service scaling, shorten time to market and deliver cost efficiencies across radio, core and transport networks.

The optimal transport solution will vary from CSP to CSP. It must integrate the radio access and packet core functions to support the breadth of 5G requirements while optimizing the re-use of existing networks. To address these requirements, CSPs need an approach that considers all their needs as well as their accessibility to all types of transport technologies.

Within Future X, the Nokia Anyhaul concept answers the challenges of 5G transport by converging fronthaul, midhaul and backhaul to serve a variety of use cases within the same network. This transport network evolution and the demanding 5G targets will dramatically increase capacity, connectivity and agility requirements.

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Aim for multi-service excellence

To support a wide range of 5G applications and use cases, transport must be a multi-service capable, highly flexible fabric to address greater coverage, connectivity and availability, along with dramatic capacity and latency improvement, and all of this must be cost effective.

End-to-end transport
Any transport solution must offer CSPs the flexibility to respond to changing market demands and conditions. CSPs can also control the costs of transitioning to 5G by reusing existing assets (fiber, copper, microwave) in combination with new investments. An effective technology partner will therefore offer a comprehensive mobile transport portfolio, combined with an open, programmable network architecture to deliver extreme flexibility and service assurance.

Get set for added complexity
High reliability densification (>99.999 percent) will mean more sites to be connected, with heavy implications for transport. Furthermore, connectivity will continue to evolve, requiring cell sites' transport connectivity to be more flexible and dynamic.

RAN decomposition is a further consideration. Virtual RAN functions will be distributed over multiple platforms and new interconnectivity ("X-Haul") interfaces are created. Cloud shift and centralization of some functions is TCO driven when there is the possibility to optimize the network; other functions are moved closer to the end user to better comply with stringent low-latency requirements.

Accelerate through automation
Such flexible and complex networks will require automation to allow granular end-to-end traffic engineering and to satisfy different Service Level Agreements (SLAs) through automated and programmable transport pipes in the shape of network transport slices that dynamically adapt to changing needs.

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Tailored solutions promise optimized transport

Solutions for all scenarios

Wireless microwave transport solutions can accommodate different characteristics and requirements to suit possible 5G scenarios in different geographical areas.

Ultra-urban
In ultra-dense urban areas or hot-spots, such as crowded squares, airports and stadia, 5G networks will be deployed with the radio access millimeter wave layer (26/28/39 GHz). Very high capacity backhaul is needed (10 Gbps and above) and the transport link lengths are always less than 1 km.

Suburban
In the urban/suburban scenario (up to 7-10 km link distance) the access layer will be based mainly on sub-6 GHz frequencies with connectivity requirements that are still quite demanding in terms of capacity (5-10 Gbps).

Rural
In rural settings, where the geographical area coverage is larger, the access network will be based on frequencies below 1 GHz. The transport network will need to backhaul up to 2 Gbps and link lengths commonly exceed 7-10 km.

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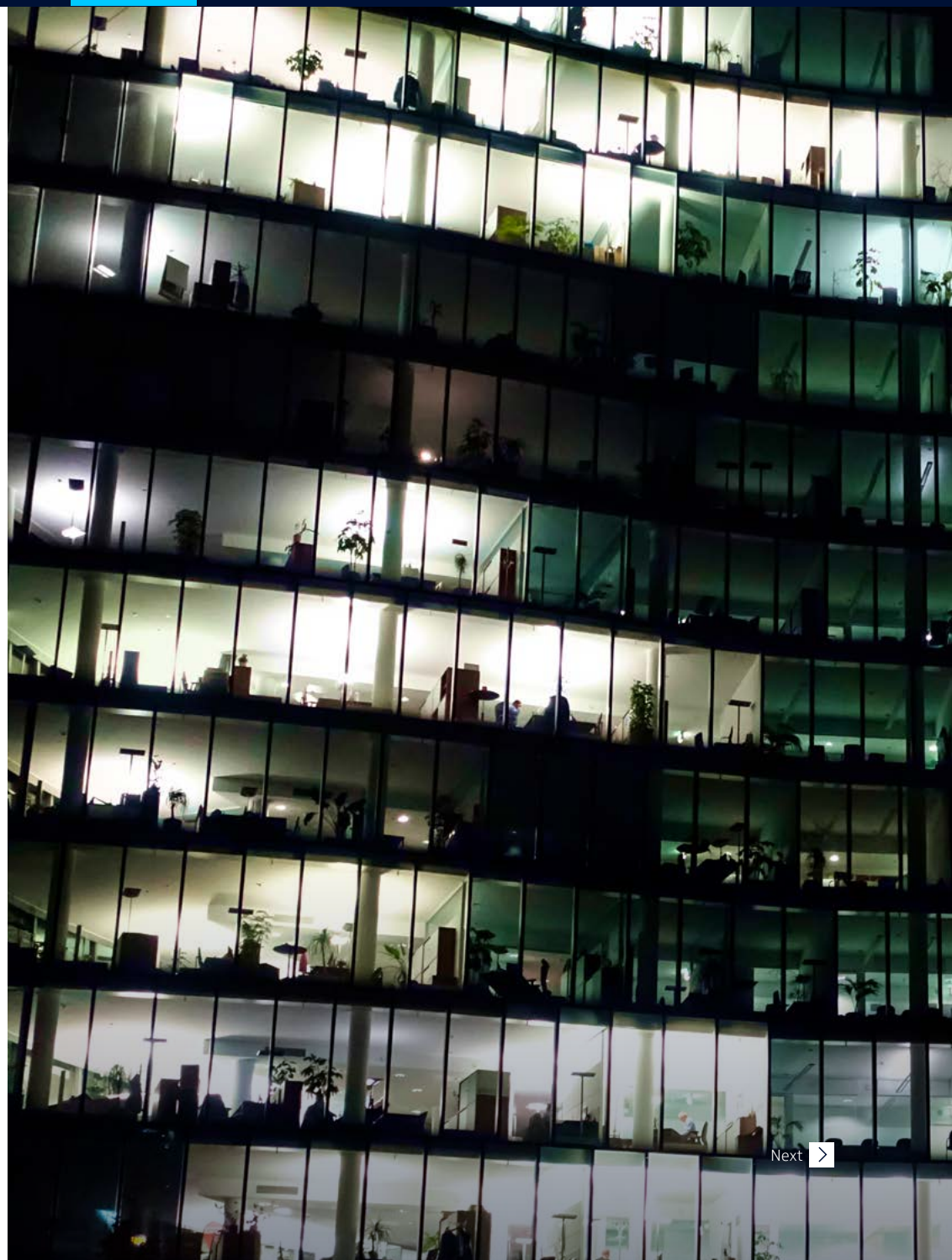
How do CSPs feel about microwave?

Many vendors and CSPs are convinced that microwave has much more to offer in 5G than with 4G. Recent discussions with a major North American CSP revealed to Nokia the importance of microwave solutions for existing and future mobile networks.

DENSIFICATION: "... a subset of our wireless network is fed by microwave supporting macro-sites; more and more we are trying to fiberize them. These sites then become access, then distribution points and we can then expand further into the respective area."

MICROWAVE ADVANTAGE VS. FIBER: "...if we can start generating revenue earlier by using microwave, this also helps the business case and is hence where microwave can be a strong solution. There are also risks of losing that customer if we can't deliver their network."

MICROWAVE AS ENABLER OF 5G: "5G is coming ... with densification, customers may be closer to the base station; we may have to use microwave; we kind of have a vision of fiber everywhere, but we're not seeing it yet developing as we'd hoped, so having microwave in the toolbox will be important."



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Everyone wants a slice

Network slicing requires substantial service automation and optimization capabilities. Such a dynamic environment cannot be managed by humans due to network complexity and the required life-cycle speed of each service. However, a successful implementation will yield benefits all round.

By carefully and dynamically tuning network resource utilization according to real-time needs, a software-defined network (SDN) can also optimize the power consumption and significantly reduce TCO. Automation brings other cost optimizations including advanced troubleshooting functions to reduce maintenance windows; smart analytics to identify critical situations and bottlenecks; and automated network release roll-out to reduce the software deployment life-cycle.

SDN delivers flexibility

SDN is an evolution of existing technologies, where applications are added based on the CSP's needs.

5G network evolution introduces new capabilities but also brings extra complexity, which makes network automation a priority. If managed in traditional ways, new complex networks would become expensive and error-prone operationally, increasing the time needed to respond to new network demands. CSPs would be forced to use valuable human resources in repetitive and sometimes impossible tasks, due to the large amount of information to be correlated to reach the right decisions.

Automation delivers manageability

Automation and abstraction capabilities in the transport network are essential for dealing with dynamic service deployments, more challenging service requirements and limited network resources. CSPs will only need to define the mandatory end-to-end service requirements, leaving the SDN controller to evaluate the best way to instantiate the services. Moreover, new sites can be seamlessly added to an existing network and immediately deliver the required services.

Monitoring and optimization takes place in real time.

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Resource allocation in network slicing

Network slicing is a key benefit of 5G, sharing network resources between different services. The network is virtually sliced in several, independent logical resources that can simultaneously accommodate multiple application fulfilment requests.

This differs from the conventional set-up, in which a host provides hardware and software resources to one or more guests. Instead, an SDN-capable microwave network makes its resources available through a virtualized Anyhaul transport service, with the SDN controller acting as a hypervisor to allocate the resources.

For example, ultra-low latency applications could be served by a network slice allocating the service to the E-Band channel in carrier aggregation. Other services not requiring low latency will be allocated by the SDN controller to the load balancing algorithm to efficiently exploit the carrier aggregation bandwidth.

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Microwave solutions meet the challenge

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Current and future microwave solutions for 5G

Suppliers need to be able to provide end-to-end capabilities to fulfil access, transport and management demands. A microwave portfolio needs also to be fully integrated into an end-to-end vision and provide the best fit for all scenarios. Future microwave solutions with very small form factors will be even more integrated with RAN equipment.

To meet the 5G requirement for more capacity, new microwave solutions for optimizing the use of spectrum are now available. Carrier aggregation (using multiple bands on the same link), more powerful and efficient power amplifiers that enable the use of wider channels and the availability of millimeter-wave spectrum provide key functions for future network solutions.

For example, in today's frequency bands used for RAN backhaul (6-42 GHz), several vendors can provide transceivers capable of 2.5 Gbps in a single box (thanks to 4096 QAM modulation schemes in 2 x 112 MHz frequency channels).

Beyond this, current E-Band (80 GHz) based solutions stand ready to satisfy the initial wave of 5G introductions that require up to 10 Gbps transport capacity and 20 microsecond latency in urban environments. By combining E-Band with a traditional microwave frequency band (6-42 GHz), it is possible to achieve longer distances and preserve the usual high availability for the most valuable traffic. Combined with 100 percent efficient carrier aggregation it is possible to achieve between 10 and 20 Gbps bidirectional capacity.

Integration for urban environments

Low visual impact is a key factor to facilitate deployment in dense urban environments. Nokia, for example, has integrated the antenna with the radio unit, achieving a very small form factor.

The telco industry has already started to consider the possible use of frequency bands above 100 GHz for the transport segment of future 5G network and beyond.

Recent activities indicate the highest interest in D-Band (130-174.8 GHz) and W-Band (92-114.25 GHz). While W-Band is viewed today as a likely extension of E-Band because of the similar propagation behavior, the peculiarities of D-band enable innovative approaches in equipment design.

Moreover, the very small form factor will aid the integration of the radio and the antenna (which will be just a few centimeters square) and between transport and access products, enabling new network topologies such as point-to-multipoint and mesh connectivity in conjunction with beam-steering.

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Why Nokia?

Nokia can help CSPs reach 5G faster using microwave within an end-to-end network.

Network transformation will have a major impact on microwave transport solutions deployed for 3G and the early stages of 4G. The substantial installed base of microwave will eventually be replaced by new microwave solutions designed for 5G or fiber and CSPs will look to minimize the cost and disruption associated with this transformation.

Nokia has developed appropriate solutions and tools to help optimize budgets during backhaul network upgrades. Both CAPEX and OPEX are considered because, while a program of network ‘renovation’ is costly over many years, CSPs will need to manage their investment within the constraints of their normal annual budget. A common goal is to provide innovative and technologically advanced solutions within a constrained TCO to match budgets.

Nokia’s portfolio also spans the full spectrum of transport media, offering CSPs maximum flexibility when choosing the best way forward for their transformation.

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5G solutions for today and tomorrow

5G is hurtling towards us and CSPs must act fast or risk losing out on the huge opportunities that the transformed telco environment will offer. Microwave technology has proved itself in 4G/LTE transport networks and will continue to play a vital role going forward.

Every CSP will follow a unique path to 5G, but each one will need to tackle the evolving transport network. Right now, the transport layer needs to handle many technologies, both legacy and evolving, and will soon need to flex to meet new, more extreme demands.

CSPs therefore need to adopt an end-to-end approach to transport, and microwave technology will play a vital role as a key enabler of the new, Anyhaul, approach. It will help CSPs leverage existing investments while continuing to build the new capabilities that 5G needs.

Nokia's 5G Anyhaul offers solutions for now and for then, helping to secure a competitive advantage today and to drive growth over the coming decade.

For further insights into microwave transport please see our white paper:
The evolution of microwave transport - enabling 5G and beyond

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