Nokia mobile transport solutions

Choosing the best mobile transport technologies to support diverse RAN architectures

Application note

Abstract

Mobile transport networks are essential because they provide connectivity to radio access networks (RANs). They cannot be an afterthought. To deliver flawless 5G mobile services, network operators need transport networks that can support massive connectivity, super-high data rates and ultra-low latency. These networks must also have built-in flexibility to address evolving RAN architectures, which can include a mix of distributed, centralized and cloud RAN deployments.

This application note discusses a Nokia solution that enables network operators to use a mix of wired and wireless technologies to efficiently build mobile transport networks that meet the performance demands of 5G across different RAN architectures.

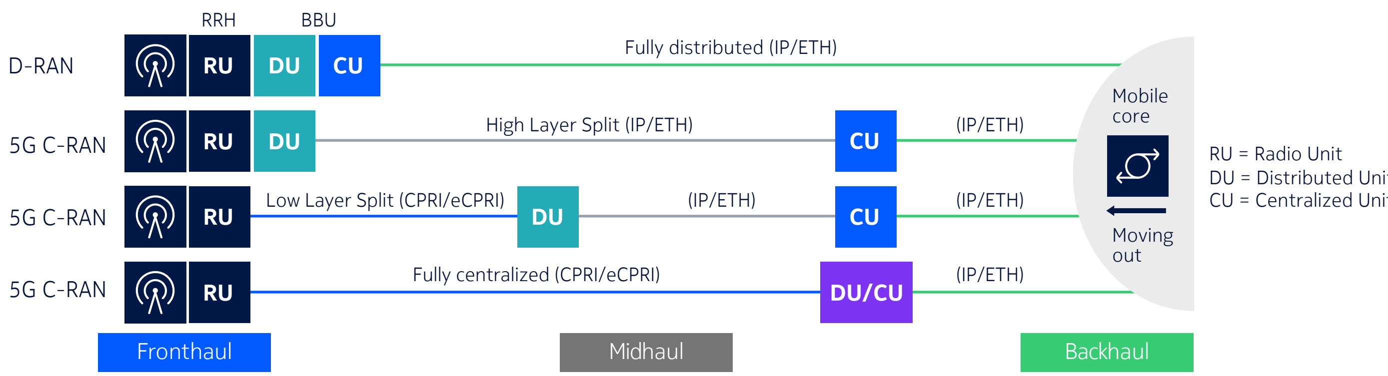
Contents

Radio access network evolution

Wireless networks that predate 5G typically use distributed RAN (D-RAN) architectures. These networks have contained functions in baseband units (BBUs) at the base of radio towers. The BBUs convert the radio frequency (RF) signal into digital data streams for transport on the backhaul to the core network.

With 5G, it is possible to disaggregate the BBU (Figure 1) by breaking off functions beyond the Radio Unit (RU) into Distributed Units (DUs) and Centralized Units (CUs). This disaggregation introduces flexibility by letting network operators decide where to locate these functions and maximize performance. Its aim is to support flexible hardware and software implementations to allow scalable, cost-effective network deployments as part of centralized RAN or cloud RAN (C-RAN) architectures. While not shown in figure 1, the C-RAN architectures can also virtualize the DU and CU functions onto common hardware to better scale the network.

Figure 1. RAN functional splits



For C-RAN architecture deployments, industry consensus has focused on a high-layer and low-layer functional split. These two main split points include:

- Low-latency functional split (Fs-LL): This split is mainly intended to reduce the interface bandwidth compared to Common Public Radio Interface (CPRI). However, the split is within the hybrid automatic repeat request (HARQ) loop. The latency requirements are similar to those of 4G networks (100 µs one way).
- High-latency functional split (Fs-HL): This split is intended to increase latency tolerance and reduce bandwidth for the interface that 3GPP calls F1. The traffic over this link relates to user traffic – and has the same bursty characteristics – so it can be statistically multiplexed. The latency requirements for this functional split are related to end-to-end application latency. For applications that require 10 ms end-to-end latency, a budget of 2–4 ms is allocated to transport. This allows the mobile data center to be positioned up to 400 km away from the RAN edge.

The RAN-Low functions are performed within the DU, while the RAN-High functions are performed in the CU. The CU function is architected so that it can be located on virtual machines on servers within a mobile data center.

Mobile network operator evolution paths to 5G

Mobile operators can choose from several deployment models for their move to 5G:

1. Distributed RAN (D-RAN), where baseband processing is located at the macro site
2. Centralized or cloud RAN (C-RAN), where the higher split functions of the baseband processing is implemented on cloud servers in a data center, and the lower split functions are implemented in a unit at the macro site

3. Virtualized RAN (V-RAN), which is similar to C-RAN except that the RAN functions (DU and CU) are virtualized to run on commercial off-the-shelf (COTS) servers as found in data centers

Of these models, D-RAN is by far the most popular for several reasons, including:

- Self-contained cell sites where baseband and radios are colocated
- Lower transport capacity requirements on backhaul links because RAN processing stays local
- The ability to use any transport technology (e.g., wireless and wireline), which means fiber is not mandatory
- A relaxed latency requirement in backhaul compared to fronthaul, which removes distance limitations regarding where the equipment can be located
- Simpler problem solving because cell site issues are contained with the site (e.g., a baseband issue only impacts the site)
- Reduced site acquisition costs because D-RAN deployments can reuse existing sites that typically house multi-gen RAN equipment

There is also interest in using C-RAN architectures for 5G, particularly in urban or dense suburban areas that have access to fiber. For example, C-RAN could be a good choice for cities where high capacity is needed to serve dense population areas, and where new cell sites must be installed in space-constrained locations. In such cases, C-RAN offers several benefits, including:

- Cell sites having less equipment and reduced space, power and cooling requirements
- Functional splits (Low-PHY) that alleviate transport bandwidth requirements by keeping the real-time Layer 1 radio processing at the cell site
- Simpler radios that perform less processing and reduce cost as a result
- Pooling gains that enable better resource utilization across cell sites
- Better performance of coordinated RAN functions (e.g. CoMP, eICIC, carrier aggregation)
- Simpler operations and maintenance because baseband equipment is housed more centrally in one location

However, using a C-RAN architecture that physically removes the baseband processing from the radios entails having fronthaul links (and potentially midhaul links if the RU and DU functions are performed at different locations). This means that the transport network will need to address more stringent fronthaul requirements, including:

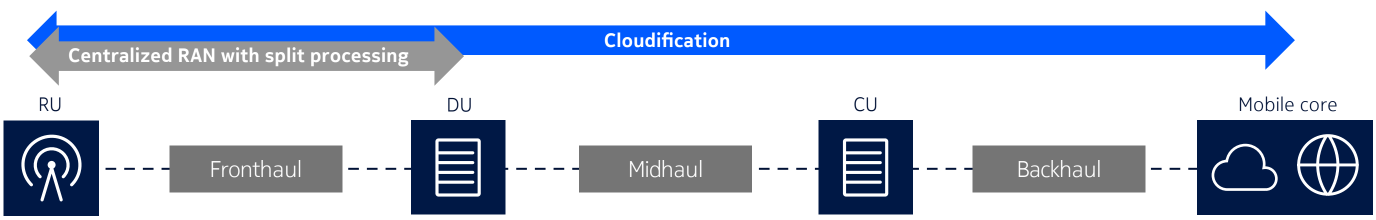
- More stringent synchronization accuracy (e.g., achieving T-BC Class C accuracy, which comes with a maximum time error of 30 ns)
- Higher-capacity links of Nx10/25G on the client and Nx100 links on the line side
- Support for fronthaul protocols (CPRI/eCPRI) either transparently or through conversion to packet
- Deterministic performance to minimize latency of fronthaul flows

As shown in Figure 2, transport requirements will vary in each of the mobile segments (fronthaul, midhaul and backhaul) depending on which architecture(s) a network operator chooses. The fronthaul segment of the network has the most stringent transport requirements. The one-way delay budget between the RU and DU is a mere 100 μs for eCPRI compared to the milliseconds in the midhaul and backhaul segments. This creates the need for deterministic, time-sensitive networking solutions that use capabilities such as fast nodal switching and routing to drive latency out of the network.

Synchronization requirements are also the most stringent in fronthaul, which has relative timing error requirements in the 130 ns range. Since the disaggregated RAN functions must operate as if they were co-located, the transport network must support both relative and absolute timing requirements for all services. To minimize timing error, highly accurate telecom boundary clocks (T-BCs) are needed to recover the correct timing.

The high bandwidth required by each radio creates a clear need for fronthaul systems to support Nx10/25G client links and Nx100 links on the line side. The capacity required in midhaul and backhaul networks is much smaller by comparison, in the range of 10G collectively instead of per radio as in fronthaul.

Figure 2. Transport requirements per mobile segment



Connectivity	Static connectivity	Dynamic connectivity (statistical multiplexing)	Dynamic connectivity (statistical multiplexing)
1-way delay	CPRI: ≤ 75 µs eCPRI: ≤ 100 µs[1]	F1: <3 ms[1]	S1/N3: <5 ms[2]
Synchronization	SyncE, IEEE1588v2, IEEE 802.1CM/CMde, ITU-T G.8273.2 T-BC (Class C – 30 ns), ITU-T G.8275.1 FTS, ITU-T G.8262.1 eEEC, Relative: 130 ns/260 ns Absolute: ±1.5µs	SyncE/IEEE1588v2 ITU-T G.8273.2 T-BC (Class A 100 ns or Class B 70 ns), ITU-T G.8275.1 FTS or ITU-T G.8275.2 PTS (Absolute: ±1.5µs)	SyncE/IEEE1588v2ITU-T G.8273.2 T-BC (Class A 100 ns or Class B 70 ns), ITU-T G.8275.1 FTS or ITU-T G.8275.2 PTS (Absolute: ±1.5µs) (NTP in case of cloud RAN)
Typical interface	N x 10G/25G	10GE/25GE	10-100GE
Node-node connection	Initially point to point, later TSN bridged (~20 km)	Point to multipoint (~100 km)	Point to multipoint (>100 km)

Mobile transport options

Several options are candidates for anyhaul (fronthaul, midhaul and backhaul) transport, including those described in the following sections. Ultimately, network operators will choose a transport option after considering several factors, including fiber availability, radio capacity, type of radio (integrated all-in-one or distributed), type of traffic (e.g., CPRI vs eCPRI), distance between radio and baseband, type and size of enclosure, indoor versus outdoor environment, power availability at site, and embedded base to leverage.

Nokia offers a comprehensive solution that enables network operators to use different transport technologies independently or combine them to address different RAN architectures and operating environments. Table 1 shows the applicability of each of these transport technologies based on its capabilities.

1 Nokia design recommendation. Can be reduced to enable more stricter E2E requirements.

2 Use case dependent

Table 1. Comparison of mobile transport technologies

	Benefits	Challenges	Applicability
Passive WDM	• Increased fiber capacity • No power supply needed • High reliability • Low footprint (compact) • Near-zero latency • Protocol transparent (CPRI/OBSAI/eCPRI/Ethernet) • Transparent synchronization	• Lack of native OAM makes fault isolation difficult • Colored SFPs required in the remote radio head (RRH) or BBU increase the power burden on radio, and some higher-powered transceivers may not be supported by remote radios • Lack of demarcation point • Inventory management to align optical color with RRH-BBU link • Wavelength granularity (less efficient for packet services) • Cost of dedicated back-to-back transponders per wavelength for each CPRI flow	Primarily used for fronthaul at small cell sites that have space or power constraints (sometimes collocated within the radio shroud).
Packet TSN	• Multiservice support (CPRI, RoE, eCPRI, Ethernet) • Supports CPRI via Radio over Ethernet modes, which increases bandwidth efficiency and interworking • Deterministic transport with frame preemption (IEEE 802.1Qbu) • Support of 802.1CM TSN for fronthaul profiles A and B • Best-in-class (Class C and D) nanosecond phase/time synchronization accuracy • Bidirectional optical timing channel (OTC) ports to bypass asymmetric delay variation • Carrier-grade OAM and high resiliency/availability in a compact form factor • Ultra-low-latency TSN switching • Packet aggregation for increased bandwidth efficiency	• Power supply required • Higher cost than passive WDM (more electronics) for smaller cell sites • Higher latency than WDM fronthaul • Optics not suited for far-reaching backhaul applications • Lacks Layer 3 IP service capabilities	Primarily used for packet fronthaul at larger macrocell sites where there is a mix of CPRI and eCPRI radio traffic to be transported and where packet aggregation can be used to increase bandwidth efficiency.
Integrated packet over OTN/WDM	• Highly accurate synchronization (Class C T-BC) • Support for hard and soft traffic isolation • Improves bandwidth efficiency through statistical multiplexing • Bidirectional OTC ports to bypass asymmetric delay variation • Carrier-grade OAM and high resiliency/availability • Ultra-low-latency TSN switching	• OTN framing adds overhead • Not fronthaul optimized • Not all variants are temperature hardened	Primarily used for backhaul at metro aggregation points where they can aggregate the traffic from mobile, business and residential services.

	Benefits	Challenges	Applicability
IP Routing	• Full Layer 2 and 3 services support (mobile, enterprise and residential traffic) • Scalable any-to-any connectivity (better than Layer 2) for backhaul • Highly accurate synchronization (including Class C) enables fronthaul transport • Multi-access • Built-in GNSS receiver and T-GM support • Advanced automated network slicing • High-capacity access and edge aggregation • Full suite of IP routing, load balancing and resiliency features as well as automated performance management tools • Very granular per-service and per-forwarding class policing and queuing features support differentiated quality of service (QoS) • High resiliency through IP/MPLS fast rerouting and segment routing traffic engineered paths	• Lacks inherent support of CPRI/OBSAI protocol (can be mitigated with FHGW or underlay WDM) • More complex than Layer 2 • Synchronization accuracy lower than packet TSN • Higher nodal latency than packet TSN	Primarily used for backhaul to provide cell site access as well as access to other IP/Ethernet business and residential services. IP routing is also used in multi-access aggregation, edge aggregation and core transport.
xPON	• Can leverage existing FTTH resources • Fast rollout where FTTH exists • Flexible traffic shaping and scheduling and enhanced QoS • High resiliency • Accurate synchronization (Class B T-BC for backhaul/midhaul and in future Class C for fronthaul)	• No CPRI/OBSAI support • Bandwidth shared with other FTTH services • Higher latency than passive WDM • Point-to-multipoint architecture	Primarily used where existing FTTx networks (offering voice, data, video services) are present and where the existing fiber investment can be leveraged to quickly and cost-effectively offer backhaul or fronthaul services.
Microwave	• Flexible and fast deployment (including temporary installations) • Cost effective in areas where fiber is not available • Can complement fiber-based technologies	• Bandwidth limited (10G or lower) for niche C-RAN deployments • Distance limited at high data rates of 10G (under 1 km) • Line-of-sight constraint limits site placement • Weather-related impacts	Primarily used for backhaul at cell sites that lack fiber availability, where trenching fiber is cost-prohibitive or where very fast deployments are needed.

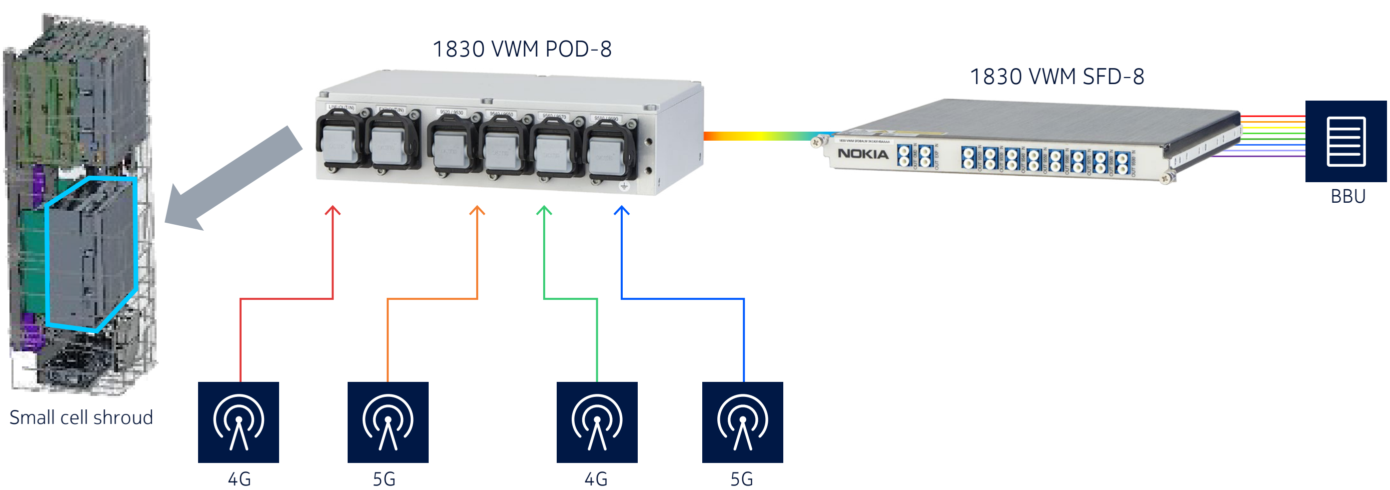
Passive WDM

Fully passive WDM solutions enable highly reliable, cost-effective CPRI/OBSAI/eCPRI transport while meeting the strict latency and jitter requirements of these protocols. These solutions expand fiber capacity, providing multiple channels per fiber. They are also very reliable and power efficient because no power is needed for data transport.

However, passive WDM solutions lack networking flexibility and robust operations, administration and maintenance (OAM) capabilities, which can lead to operational challenges. They also lack the clear network demarcation points required between a mobile network operator (MNO) and the fronthaul transport provider. This limits their applicability in cases where visibility of the transport network is required to coordinate the dependencies across the RAN and transport network.

The Nokia 1830 Versatile WDM Module (VWM) portfolio includes a diverse set of passive WDM solutions for indoor and outdoor applications. Where fiber is readily available, passive WDM is the simplest solution for CPRI/OBSAI fronthaul. Passive WDM requires no power at either end of the fiber link, which enables the MNO to realize significant ongoing operational cost savings for fronthaul deployment. In addition, the Nokia solutions are suited for placement within radio shrouds (as noted in Figure 3) to minimize space needed at cell sites. The 1830 VWM POD-8 uses multi-fiber push-on (MPO) connectors where each provides two fiber pairs that support up to two optical channels per radio. However, passive WDM solutions use wavelength-level grooming, which can lead to suboptimal bandwidth usage if the majority of traffic being transported is packet based (e.g., eCPRI/Ethernet).

Figure 3. Passive WDM fronthaul with Nokia 1830 VWM



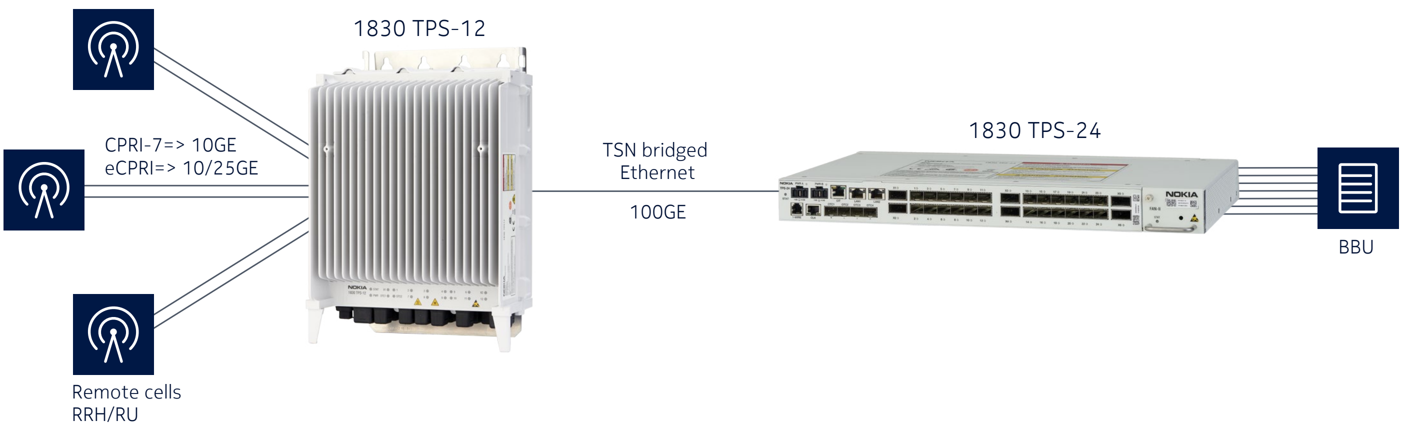
Packet Time-Sensitive Networking (TSN)

Packet TSN fronthaul solutions help reduce the cost and complexity of C-RAN deployments by unifying mobile transport for 4G and 5G networks, and provide powerful Ethernet service OAM capabilities to improve the management of the network. Many 5G networks will coexist with existing 4G networks, and will require a mobile transport solution that addresses multigenerational rates and protocols. With Radio over Ethernet (RoE) encapsulation, a packet TSN fronthaul solution – such as the Nokia 1830 Time-sensitive Packet Switch (TPS) - can transport CPRI streams over Ethernet and combine them with other native Ethernet traffic (e.g., eCPRI or business services) onto a unified time-sensitive network that meets strict fronthaul latency requirements. The mapping of constant bit rate CPRI streams onto Ethernet together with packet-level aggregation onto 100GE uplinks helps improve bandwidth efficiency compared to traditional WDM fronthaul solutions. It also eliminates the need for the costly bookended transponders used in WDM fronthaul solutions.

Using strict traffic prioritization and frame preemption (of non-fronthaul streams) in accordance with profile B of the IEEE Std 802.1CM TSN for fronthaul standard, the 1830 TPS can create deterministic paths through a switched Ethernet network. Such determinism was previously unavailable in packet-switched networks. It is essential for ensuring the reliable delivery of critical traffic with stringent latency demands.

The 1830 TPS also delivers highly precise synchronization distribution to 5G radios over the packet fronthaul (or midhaul) network. It supports SyncE/eSyncE and the Precision Time Protocol (PTP) with Class C and D T-BC performance to meet and exceed the very strict fronthaul requirements for frequency and phase/time synchronization. Because packet TSN systems are designed for fronthaul in terms of the optical pluggables, switching capacity, port density, interface speeds and protocols supported, packet TSN fronthaul solutions are generally not suited to long-distance backhaul applications.

Figure 4. Packet TSN fronthaul with Nokia 1830 TPS



Integrated packet over OTN/WDM

Metro optical networks can be used to support mobile backhaul in addition to collecting traffic (e.g., xPON or enterprise traffic) from other access networks (Figure 5). A packet-optimized metro OTN/WDM solution based on the Nokia 1830 PSS portfolio takes advantage of the fact that most traffic originates and terminates in the metro rings. Many network operators choose to have Layer 2 Ethernet services in this part of their networks. Operators can add Ethernet packet transport and aggregation to the 1830 PSS by using SR-OS based Layer 2 muxponder cards.

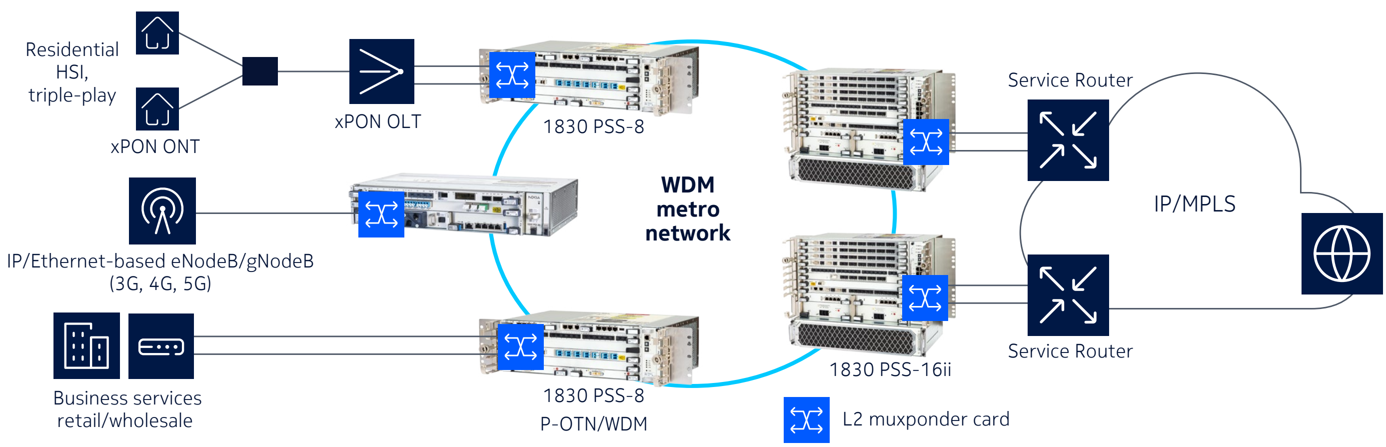
Using integrated packet aggregation and switching over OTN/WDM, the 1830 PSS enables network operators to maximize network utilization through statistical multiplexing of traffic flows. Packet integration also reduces the number of wavelengths and router ports needed, which helps optimize the IP and optical networking equipment and interconnection ports. It strengthens service management and SLA monitoring by providing deterministic carrier-grade and ITU-T-transport grade Ethernet Service OAM and protection in support of mission-critical services. The solution is fully compliant with the MEF 22.3 (Transport services for mobile networks).

The 1830 PSS supports the creation of network slices using both hard and soft traffic isolation. Hard isolation provides independent, circuit-switched connections for the exclusive use of one virtual network. These dedicated resources are implemented using wavelengths within a WDM network and ODUflex partitioning to channelize the streams within OTN containers. This traffic separation is well suited for networks where multiple tenants are served by a wholesaler (because there is no traffic impact across the slices) or where high security from dedicated connections may be required, such as for mission-critical networks or to meet regulatory requirements. Soft isolation is also supported and implemented with Layer 2 VPNs using either Ethernet Provider Bridging or MPLS-TP, which allow statistical multiplexing and better bandwidth efficiency by enabling traffic from two or more virtual networks to share resources.

The 1830 PSS supports accurate frequency, phase and time synchronization distribution. To eliminate delay variations caused by link asymmetry, it provides out-of-band synchronization over a dedicated wavelength using bidirectional transmission. This is called the optical timing channel (OTC). The OTC prevents asymmetry from OTN mapping/demapping and photonic layer protection in ROADMs.

With the 1830 PSS, operators get an end-to-end Carrier Ethernet packet transport solution that allows them to “pay as they grow” by adding wavelengths to boost line-side capacity as needed. The 1830 PSS is also an easy-to-provision solution that lets operators add line interfaces or nodes as needed.

Figure 5. Mobile backhaul with Nokia 1830 PSS



IP routing

IP routers are well proven in IP backhaul deployments worldwide and provide the versatility to connect a broad mix of services by providing Layer 3 any-to-any connectivity. They provide deterministic paths using traffic-engineering based on RSVP-TE or segment routing to meet SLA requirements. Specialized variants also support eCPRI fronthaul applications by providing highly accurate synchronization that meets Class C T-BC performance requirements for noise generation. Several models have Global Navigation Satellite System (GNSS) receivers and provide IEEE 1588v2 (Precision Time Protocol) grandmaster capability to provide cost-effective timing sources at the remote edges of the network.

IP routers are well suited to deployments where IP/Ethernet flows must be transported from radio sites and enterprises. Nokia offers a broad selection of routers designed specifically to address mobile anyhaul applications and all multi-access aggregation requirements in a scalable, flexible and cost-optimized manner.

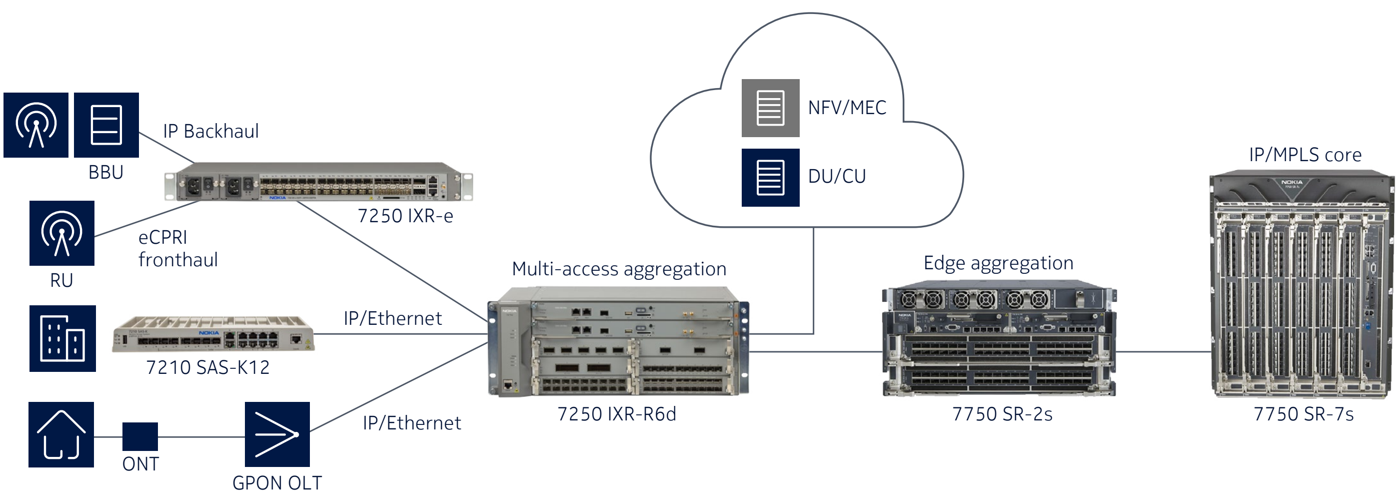
The Nokia IP Anyhaul solution uses Nokia 7250 Interconnect Routers (IXR) for all layers of access and aggregation. These routers enable operators to integrate the transport of backhaul, midhaul and eCPRI fronthaul streams over a low latency packet-optimized time-sensitive network. In cases where CPRI radios are used, the Nokia AirFrame Fronthaul Gateway (FHGW) can be used to convert the CPRI flows to eCPRI for packet transport.

The 7250 IXR routers revolutionize transport economics at cell sites and aggregation hubs by delivering multi-gigabit connectivity, efficient packet aggregation, advanced power management features and insight-driven dynamic interconnectivity using advanced routing protocols. These capabilities greatly simplify sites, speed time to market and enable significant cost reduction. Models are available to provide a cost-effective fit for small to large densities and a variety of architectures, including leaf-spine designs. The 7250 IXR platforms support up to 400GE port speeds.

At the edge and core, Nokia 7750 SR-s routers based on Nokia FP silicon are used when highly scalable, time-sensitive performance and advanced security are required. These routers support up to 800GE port speeds and additional edge routing and specialized services, which enables them to fulfill multiple roles in the network.

Nokia IP routers help to reduce operational costs through fast and efficient automated service delivery and service assurance. They support advanced IP routing protocols such as segment routing and traffic engineering, which provide the foundation for network slicing. In this regard, the routers create slices (virtual connections) on top of a common shared physical infrastructure to serve the specific requirements of each service and improve the overall utilization of the transport network. They implement traffic isolation using Layer 2 Ethernet VPNs (EVPNs) or Layer 3 IP virtual private routed networks (VPRNs) and work with SDN controllers that can compute paths through the network based on specific application requirements.

Figure 6. IP Anyhaul with Nokia 7250 IXR / 7750 SR routers



Passive optical networks (xPON)

Recent advances in PON technology – including multi-gigabit capacity of 25G and beyond, sub-1 ms latency and mission-critical reliability – make fixed broadband networks, which carry both residential and business traffic, well suited to address the challenging network requirements presented by LTE Advanced and 5G. Broadband access optical point-to-multipoint distribution networks (ODNs) allow multiple xPON technologies to coexist. This allows operators to use existing passive fiber ODN resources to reduce cost and add new xPON technologies by simply changing the active endpoint.

Increasing the synergies between fixed and mobile access will allow operators to create responsive transport networks that adapt to the bandwidth and latency needs of different services as they arise and change over time. This includes supporting mobile backhaul as well as latency- and synchronization-sensitive fronthaul connectivity.

Nokia Broadband Anyhaul gives network operators a strategic platform for providing anyhaul transport alongside ultra-broadband services for residential and business customers. With the Nokia fiber access portfolio, operators can cost-effectively introduce more bandwidth and extend beyond backhaul with 5G-ready transport options for eCPRI fronthaul.

The Nokia Lightspan portfolio offers a range of fixed access solutions that support mobile transport, including:

- Optical line terminals (OLTs), which are access nodes that aggregate traffic from thousands of endpoints (e.g., homes, businesses, small cells)
- Optical network terminals (ONTs), which terminate fiber and connect user devices (PCs, TVs, etc), cell routers or cell sites

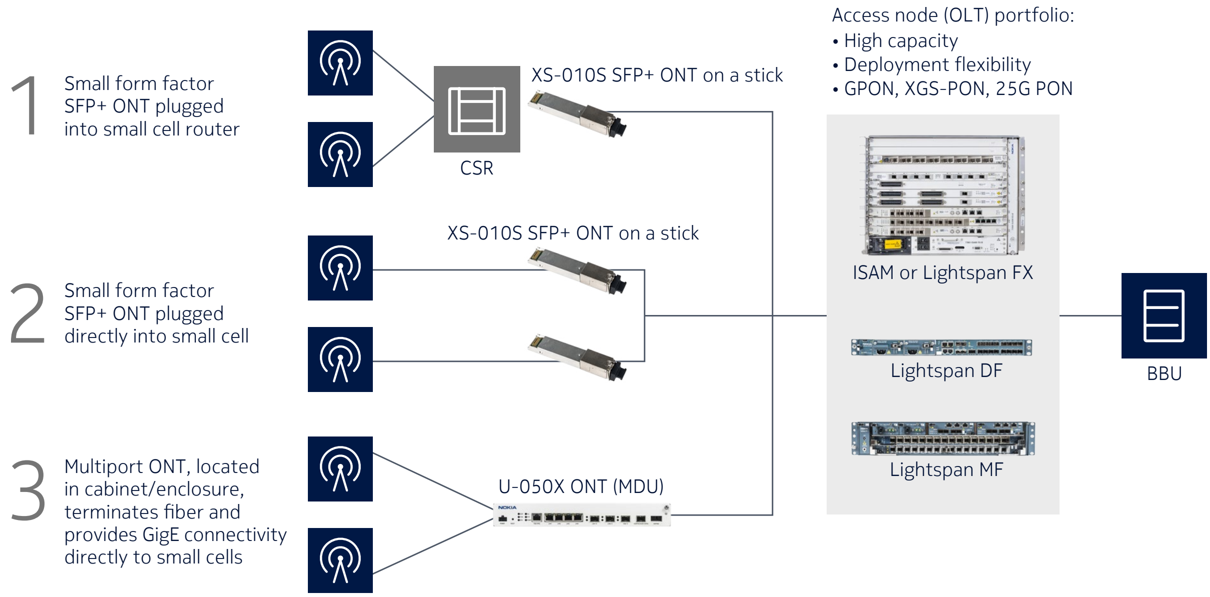
Nokia has OLT access nodes for deployments in a central office, outdoors and in data centers. The variety of access node types ensures that specific deployment needs, including outdoor or indoor and high or low density, are efficiently addressed. Offering higher-speed xPON technologies, traditional fiber-to-the-home deployments are becoming fiber-for-everything deployments where fiber broadband networks provide a single infrastructure for all services. This includes meeting the needs of 5G mobile transport with Nokia Lightspan systems that provide:

- Smooth evolution to massive connectivity with data rates up to 25G, 50G or 100G
- No single point of failure, ensuring the highest availability (six-nines) in the market
- Sub-millisecond latency for 5G transport and a new array of Industry 4.0 applications
- Power efficiency that is 20 percent higher than the industry average to reduce operating cost
- A modular software architecture that supports greater agility
- SDN programmability and open APIs to Nokia or third-party network control functions
- Fast telemetry and a digital mirror in the cloud for enhanced network operations

Nokia provides an extensive portfolio of ONTs that combine low power, high bandwidth and the smallest possible footprint. Size, power and installation flexibility are often significant considerations for mission-critical mobile anyhaul applications. Two typical solutions include:

- The Nokia U-050X ONT (MDU) is a cost-effective solution that can connect up to four cells. It is fully temperature hardened for indoor deployments and durable outdoor installations in a cabinet or other enclosure.
- The Nokia XS-010S SFP+ ONT is small form-factor pluggable that is easy to deploy in almost any environment. This “ONT on a stick” can be plugged directly into a small cell or small cell site router. Support for industrial temperature ranges allows for indoor and outdoor usage. Since the Nokia SFP+ ONT resides in an SFP cage in a host device, it does not require additional power or cabling.

Figure 7. Broadband Anyhaul with the Nokia Lightspan portfolio



Microwave transport

A lack of fiber is a common challenge for rural cell site deployments. It's also a frequent issue in suburban and urban areas, where operators are often forced to place cell sites locations where fiber does not exist. There may also be cases where a Mobile Transport Provider (MTP) such as an Alternative Access Vendor (AAV) has fiber, but the cost to lease an Ethernet backhaul circuit is not cost effective for the network operator.

Operators can address these fiber deployment challenges with microwave backhaul alternatives. With the new 5G functional splits and the move to packet fronthaul, operators can also use microwave transport solutions to provide fronthaul connectivity, especially as network density increases and mmWave radios are used to increase capacity. Microwave transport solutions enable fast deployments because they do not require operators to lay new fiber. They can also complement fiber-based solutions to provide cost-effective access to IP/MPLS aggregation networks.

The Nokia Wavence microwave portfolio provides operators with a comprehensive and flexible transport solution. The portfolio supports backhaul and fronthaul evolutions with multi-gigabit capacities and low-latency transport. It is applicable to all radio configurations and supports full indoor, split mount (indoor/outdoor), standalone and full outdoor configurations with the same hardware and software.

Nokia Wavence is composed of two main building blocks:

- Ultra-Broadband Transceiver (UBT) or Microwave Packet Transport (MPT): These units include a radio and modem. They can work connected to the Wavence Microwave Service Switch or in a standalone mode, and require only a software configuration. MPT–HL and UBT-I are the solutions for long-haul indoor systems.
- Microwave Service Switch (MSS): This indoor unit includes all user interfaces, switching capability, carrier aggregation functionalities and radio protection.

The Nokia Wavence portfolio includes multiple units for different applications. The UBT-mX offers high capacity and uses the E-band with a data rate of 20 Gbps, while the UBT-mU is used in urban applications and offers a rate of 10 Gbps. For long-haul use, the Outdoor Combiner Module (OCM) is used with the UBT-T and can provide a data rate of 5 Gbps.

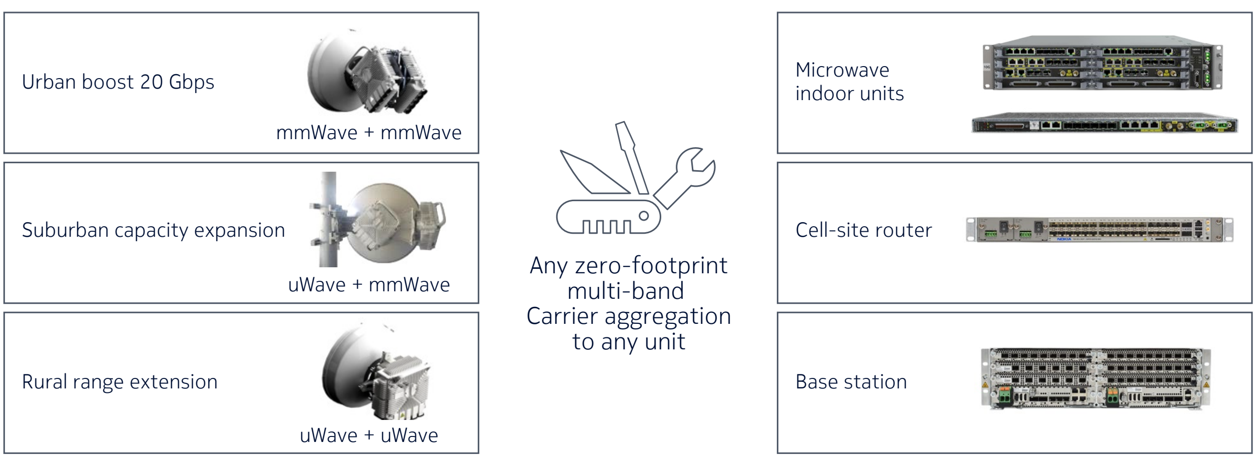
In urban and suburban areas, where both high capacity and high reach are required, the unmatched performance of the UBT-mX (the high-power version of the Wavence UBT-m) in combination with its cross-polarization interference cancelation (XPIC) capability, allows longer links at a data rate of 20 Gbps. If a compact, integrated zero-footprint hub solution is needed, the UBT can be combined with the Networking Interface Module (NIM), which supports 8 ports of 10G aggregation.

The UBT platform can be connected to either a microwave indoor unit with full automation and SDN based Layer 3 VPN, an IP router for full mesh backhaul up to 100Gbps, as a single network element with the microwave outdoor unit or directly to a base station for optimized operations as a site solution.

There are several aggregation units where the microwave radios can connect. These include the NIM, the Nokia AirScale baseband, the microwave service switches, as well as cell site routers such as the 7250 IXR and 7705 SAR.

The Wavence microwave portfolio supports backhaul and fronthaul evolutions with multi-gigabit capacities and low-latency transport. It is suitable for all backhaul and Ethernet fronthaul architectures.

Figure 8. Nokia Wavence provides a toolkit to address varying connectivity requirements



A comprehensive toolkit for mobile transport

Nokia offers a comprehensive and unified solution across different transport technologies to address different RAN architectures and operating environments. The transport technologies can be used independently or combined to deliver a holistic solution that supports:

- **Any access** through wireline and wireless access options with minimal impact on aggregation and edge.
- **Any generation** by enabling support for 5G and beyond while continuing to support previous generations for a smooth evolution.

- **Any topology** by addressing distributed, centralized and cloud RAN architectures with different functional splits.
- **Any place** with indoor and outdoor transport solutions that enable space and power optimization and minimize site acquisition costs.
- **Any service** by enabling multi-service delivery while assuring a consistent subscriber experience.

Figure 9 shows how the Nokia Anyhaul solution applies the various transport technologies to different transport segments.

Figure 9. Nokia E2E Anyhaul solution for 5G

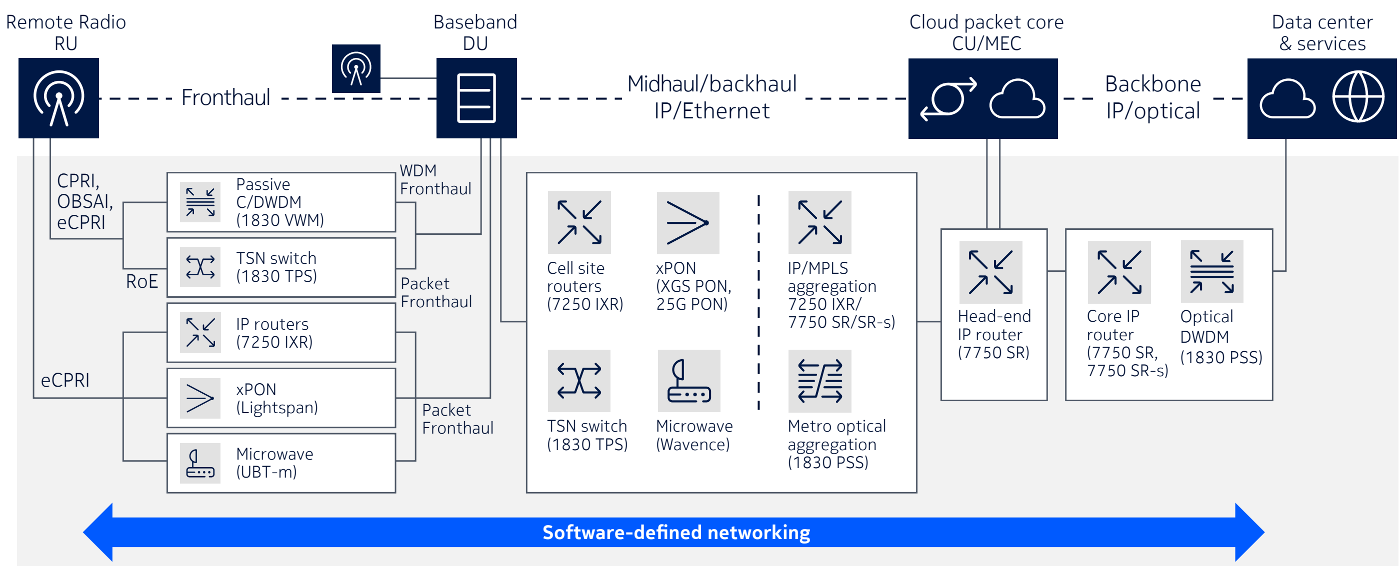


Figure 10 shows the products that make up each of the mobile transport solutions. The diversity of the portfolio ensures that operators can select the “right-sized” products for any given application. Nokia mobile transport systems have been deployed globally and are proven in the largest networks worldwide.

Figure 10. Nokia provides comprehensive mobile transport solutions

Summary

Mobile transport networks must have built-in flexibility to address evolving RAN architectures, which can include a mix of distributed, centralized and cloud-RAN deployments. Nokia addresses this need with a comprehensive mobile transport solution that uses wireline and wireless transport technologies to address the widest possible range of deployment scenarios.

A network operator's choice of transport technology will ultimately depend on different factors that span both technical and business considerations. Up to now, D-RAN architectures have dominated deployments, partly because of their familiarity and less stringent transport requirements. This is likely to continue for 5G-related deployments. Because D-RAN architectures need backhaul connectivity, many operators use IP routers at cell sites to flexibly combine multiple generations of cell site backhaul traffic with other IP/Ethernet business and residential traffic flows.

IP routers also serve multi-access aggregation, edge aggregation and core transport functions. They are complemented by other access technologies, including xPON technologies that leverage the fiber plant of existing FTTx and microwave networks at cell sites that lack fiber availability, where trenching fiber would be too expensive or where very fast deployments are needed.

In 4G C-RAN deployments, where the baseband functionality is completely centralized and requires CPRI connectivity, passive WDM fronthaul has dominated deployments. At sites with power and space constraints, passive WDM systems have been deployed, at times collocated with the radios in a common outdoor housing.

For 5G C-RAN, the introduction of new functional RAN splits and the new Ethernet-based eCPRI protocol have spurred a migration towards packet fronthaul technologies that can take advantage of statistical multiplexing of the packet streams for improved bandwidth efficiency. In cases where a mix of CPRI and eCPRI radio traffic needs to be transported, packet TSN switches can be used to convert the CPRI to packet and aggregate it with eCPRI and other Ethernet flows to increase bandwidth efficiency and minimize the number of links needed. At sites that require only eCPRI fronthaul, specialized variants of IP routers, xPON and microwave systems can be used depending on the transport requirements.

Nokia offers a broad portfolio of transport systems that provide the right tools to address different RAN architectures and diverse operating environments. This flexibility enables cost-efficient solutions in support of all RAN generations, including 5G and beyond.

Learn more

Visit the following web pages to learn more about Nokia mobile transport solutions for 5G:

- Optical Anyhaul
- IP Anyhaul
- Broadband Anyhaul
- Microwave transport

Abbreviations

3GPP	3rd Generation Partner Project
AAV	Alternative Access Vendor
API	application programming interface
BBU	baseband unit
CoMP	coordinated multipoint
COTS	commercial off the shelf
CPRI	Common Public Radio Interface
C-RAN	centralized or cloud RAN
CU	Centralized Unit
D-RAN	distributed RAN
DU	Distributed Unit
eCPRI	enhanced CPRI
eICIC	enhanced Inter-cell Interference Coordination
EVPN	Ethernet VPN
FHGW	Fronthaul Gateway
Fs-HL	high-latency functional split
Fs-LL	low-latency functional split
FTTH	fiber to the home
FTTx	fiber to the x
GNSS	Global Navigation Satellite System
GPON	Gigabit-capable Passive Optical Network
IP	Internet Protocol
IXR	Nokia 7250 Interconnect Routers
MDU	multi-dwelling unit
MEC	multi-access edge computing
MIMO	multiple-input, multiple-output
mmWave	millimeter wave
MNO	mobile network operator
MPLS	Multiprotocol Label Switching
MPO	multi-fiber push on
MPT	Microwave Packet Transport
MSS	Microwave Service Switch
MTP	Mobile Transport Provider

NFV	network function virtualization
NG-PON	Next-Generation Passive Optical Network
NIM	Networking Interface Module
OAM	operations, administration and maintenance
OBSAI	Open Base Station Architecture Initiative
ODN	optical distribution network
OCM	Outdoor Combiner Module
OLT	optical line terminal
ONT	optical network terminal
OTC	optical timing channel
OTN	optical transport network
PON	passive optical network
PSS	Photonic Service Switch
PTP	Precision Time Protocol
QoS	quality of service
RAN	radio access network
RF	radio frequency
ROADM	reconfigurable optical add-drop multiplexer
RoE	Radio over Ethernet
RRH	remote radio head
RSVP-TE	Resource Reservation Protocol – Traffic Engineering
RU	Radio Unit
SDN	software-defined networking
SFP	small form-factor pluggable
SLA	service-level agreement
T-BC	telecom boundary clock
T-GM	telecom grandmaster
TSN	Time-Sensitive Networking
UBT	Ultra-Broadband Transceiver
VPN	virtual private network
VPRN	virtual private routed network
V-RAN	virtualized RAN
VWM	Versatile WDM Module
WDM	wavelength division multiplexing
XPIC	cross-polarization interference cancelation

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.

With truly open architectures that seamlessly integrate into any ecosystem, our high-performance networks create new opportunities for monetization and scale. 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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