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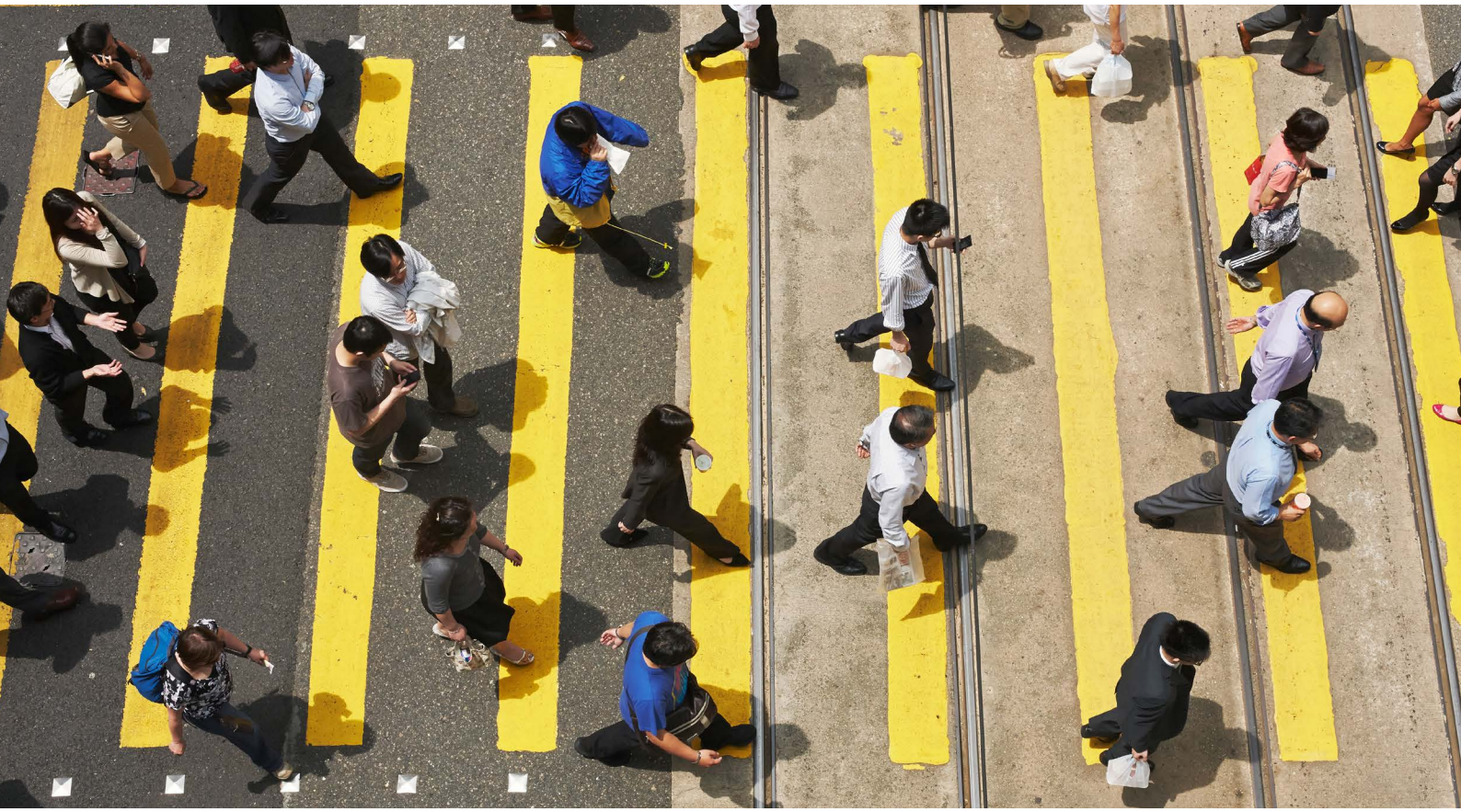

Professional services for mobile backhaul

How to efficiently solve the mobile backhaul challenges brought by new mobile network architectures, services, and business opportunities

Application note

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Contents

The mobile radio access network (RAN) is evolving rapidly, driven by the need to improve capacity and coverage, as well as support new services and applications while keeping capital and operating expenses under control. Generational improvements to the radio network from 3G to 4G and the intermediate steps towards 5G have brought enhancements to the radio domain and efficiencies to the architecture. However, innovations such as the increasing density brought by small cells and distributed RAN architectures, plus the advent of mobile edge computing, are placing specific requirements and challenges on both the backhaul and fronthaul network.

Nokia's professional services experts for mobile backhaul (and fronthaul) can help operators address these challenges. Our experts offer a development strategy and design approach focused on minimizing costs and maximizing profitability. Professional services experts can assist with all lifecycle aspects, including overall planning, technical design and topology choices, investment planning, security analysis, integration, training, and overseeing the deployment and successful operation of backhaul networks.

This paper illustrates how Nokia's professional services experts for mobile backhaul use industry-proven methodologies, as well as Bell Labs innovations and toolsets to prepare mobile network operators (MNOs) to meet the backhaul challenge.

Mobile backhaul challenges

MNOs need to efficiently backhaul traffic to the core network, minimizing costs as much as possible, in addition to achieving backhaul scale, quality of service (QoS) and simplified operations. The attributes of small cells — short radius (typically within 25 to 100 meters), diversity of cell site locations (street furniture, inside buildings, outside buildings), and density (5, 10 or even more times dense than macro layer) — introduce new constraints on RAN and mobile backhaul planning. The backhauling of small cells also requires an understanding of the coverage and capacity objectives for various generations of cellular and Wi-Fi® networks. Distributed cloud or centralized RAN (CRAN) architectures drive the need for more efficient fronthaul transport that can co-exist with, and complement the backhaul. Emerging Internet of Things (IoT) traffic will require particular emphasis on security and granular QoS planning.

Mobile backhaul and fronthaul have therefore become of strategic importance to the success of mobile network deployment. In order to achieve an economically sustainable and secure solution, the final RAN and backhaul design will necessitate a trade-off between the backhaul constraints and effective cell site planning. In particular, the viability of the small-cell backhaul business case requires a careful technical design and a thorough financial analysis of the total cost of ownership (TCO) to help guide the MNO toward the optimal evolution path.

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Diversity of backhaul media and technologies

Many technologies and media can be used as an infrastructure to support the backhaul of both macro and small cell traffic, including microwave technologies, fiber, Wi-Fi and broadband technologies, such as bonded xDSL. Given the diversity of backhaul options, one of the fundamental challenges, therefore, is to find a consistent approach to deployment and ongoing operations and management.

The key is to find the right technology mix that addresses the following requirements:

- **Cost control** – Small cells offer a good economical solution for growing RAN capacity compared with the use of macro cells only. To control TCO, the cost of backhauling small cells also needs to be cost effective from both a capital and operational expenses viewpoint.
- **Optimization for urban/dense urban deployment** – To improve street-level coverage and capacity, small cells are being deployed on lampposts and utility poles. These new locations place new requirements on backhaul solutions. Operators can choose between Line-of-Sight (LOS), Near Line of Sight (nLoS) or Non Line of Sight (NLOS) microwave installations. In urban streets, it can be a challenge to establish LOS to backhaul hub locations, making traditional point-to-point wireless backhaul ineffective.
- **High-capacity small cell site connectivity** – Driven by increasing demand for mobile data and higher air interface efficiency, backhaul requirements for small cells are expected to be on the increase in the next three years.
- **Interference management**– The proximity of cell sites creates possible interference issues for the microwave/wireless backhaul systems. These interference issues are relatively new for backhaul systems and need to be carefully managed.
- **QoS preservation** – The optimal architecture is a trade-off between the financial and technical constraints expressed above. However, it cannot be at the expense of the QoS, which needs to be preserved, especially if small cells are used to provide coverage or offer seamless mobile service mobility with macro cells. To validate the architecture, an end-to-end QoS analysis is mandatory.

Deliver the most cost-effective solution with design and optimization services

Nokia's Professional Services for Mobile Backhaul help operators design, optimize, and transform their backhaul (and fronthaul) network to be ready for the latest advances in RAN architecture. The design process includes the following steps:

- Optimizing the architecture's TCO, based on industry-proven methodologies and tool sets

- Devising the best technology — or technology mix — to enhance performance, making use of advanced technologies for combating interference and difficult propagation conditions
- Analyzing each deployment to ensure QoS is optimized
- Establish simplified, consistent operational management practices.

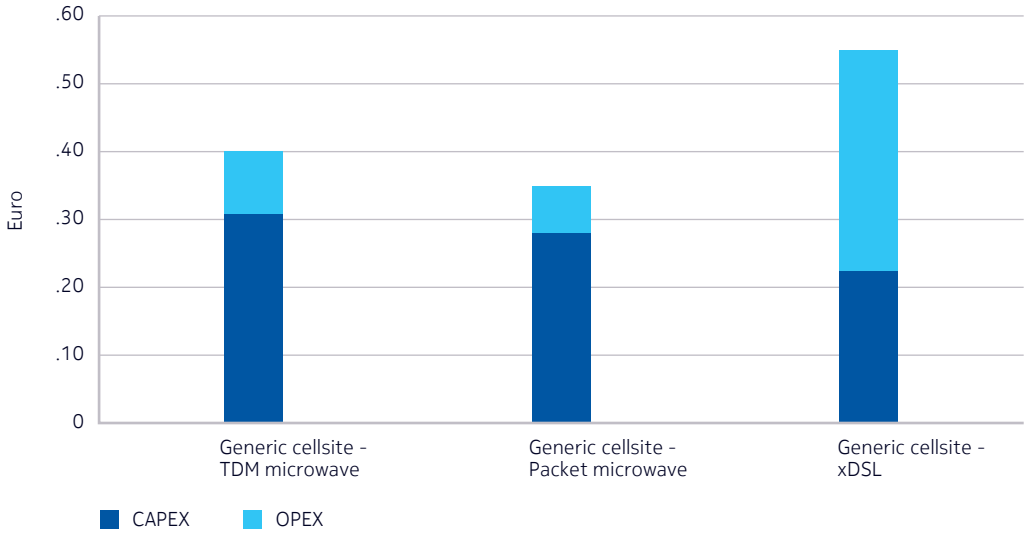
Optimizing TCO with expert analysis

Backhaul is the largest OPEX challenge for both macro and small cell deployments. That is why the TCO analysis is a critical step. The chosen mobile backhaul architecture is often a compromise between technological and financial constraints. For example, reusing copper infrastructure may be an inexpensive solution in the short term, but will necessitate a complete and costly renovation at some point in time. Conversely, the deployment of fiber is a heavy initial investment, but will continue to serve the network well into the future. The latency and throughput requirements of CRAN architectures may mandate the use of fiber and drive the associated fronthaul design.

Financial and technical analyses are always an essential element in backhaul planning, but the need is even greater with small cells. Flexibility in placement of small cells introduces connectivity challenges in backhaul planning. These include constraints on bandwidth and distance impact optimization. The need for connection capacity to address future demand compels analysis. To address this challenge, Nokia's CAPEX and OPEX modeling tool builds the business case and guides the operator through the decision process.

As shown in Figure 1, the CAPEX and OPEX analysis and comparison of various technologies is an important step in the design process. Figure 1 provides an example comparison of the TCO breakdown and evolution over time for options, including packet microwave and xDSL.

Figure 1. Comparing TCO over time for several backhaul options



Achieving the best mobile backhaul network design for small cells

Nokia's design and optimization experts rely on a comprehensive and efficient toolset to devise the best technology mix for small cell backhaul networks. Members of the professional services for mobile backhaul team perform enhanced performance analysis, including an assessment of how the operator can best avoid interference between small cells.

Built on Bell Labs algorithms and Professional Services' innovation expertise, Nokia's design tools compare different topologies and scenarios so advisors can determine the best technology choices and approach for supporting small cells. Design modeling extends to mobile fronthaul working with Common Public Radio Interface (CPRI) carried on newer fiber types. The detailed topology analysis is automated for networks of any size and all mobile backhaul technology options. The RAN is modeled in the design tool and small cells added to that model for analysis. Embedded algorithms simulate the traffic growth and its impact on the backhaul network, yielding the most effective plan to support the growth of small cells.

Use Case: Nokia's toolset is used in optical fronthaul deployment. Traffic flow for CPRI links is modeled to determine optimal design. The configuration hub and spoke locations are installed and integrated. TCO reduction is leveraged with fronthaul OPEX savings.

Figure 2 depicts a traffic forecast simulation generated by Nokia's backhauling design tools. The color indicates the congestion status for each link from green (no congestion) to red (congestion).

Figure 2. Simulating the growth of mobile traffic to be backhauled

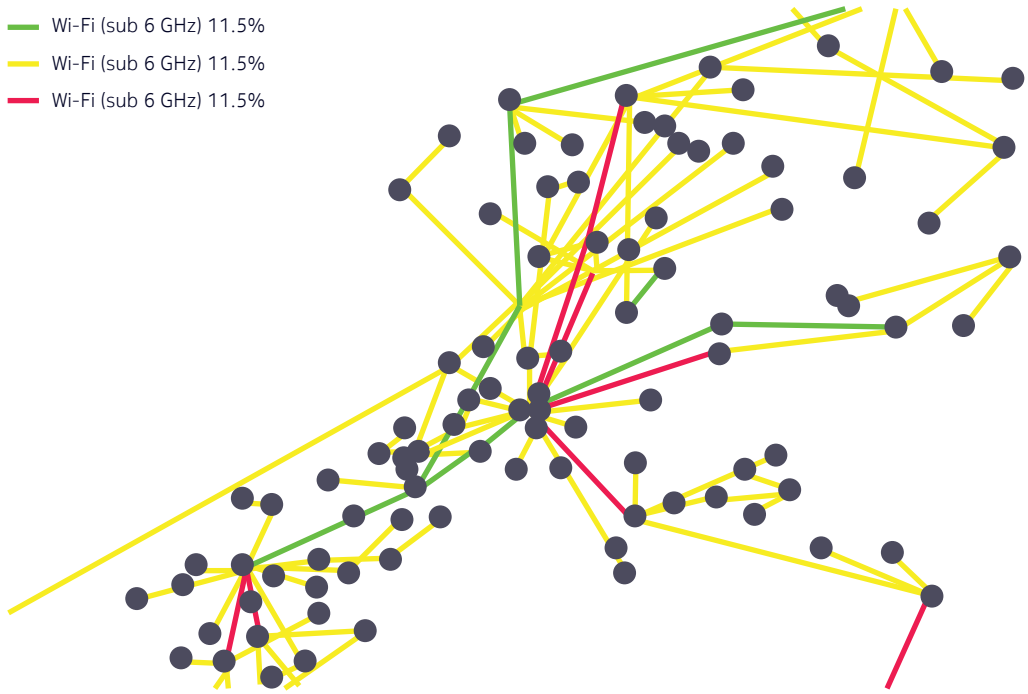


Figure 3 illustrates how Nokia's backhauling design tools can be used to perform a first LOS validation without a site visit. By providing a fast and efficient scenario comparison, the tools enable Professional Services experts to investigate many different options leading to an optimal design (see Figure 4).

Figure 3. Line-of-sight illustration shown by Nokia's backhaul design tools

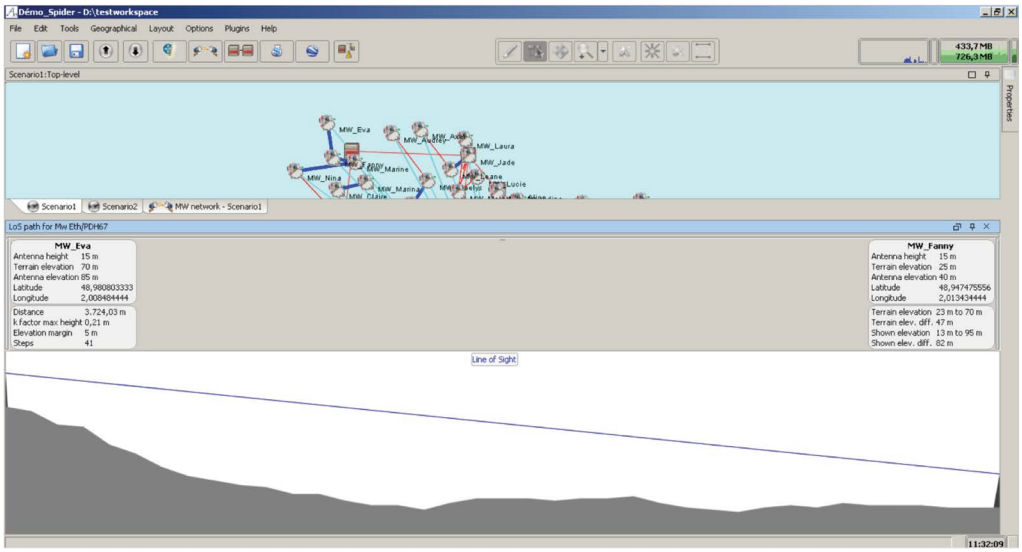
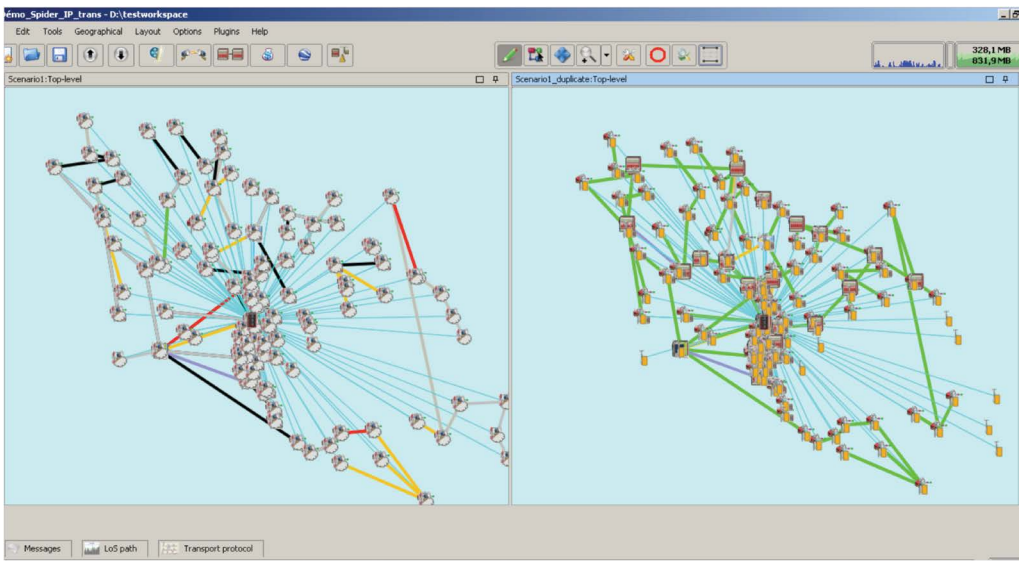


Figure 4. Before and after reconfiguration of the network shown with Nokia's backhaul design tools

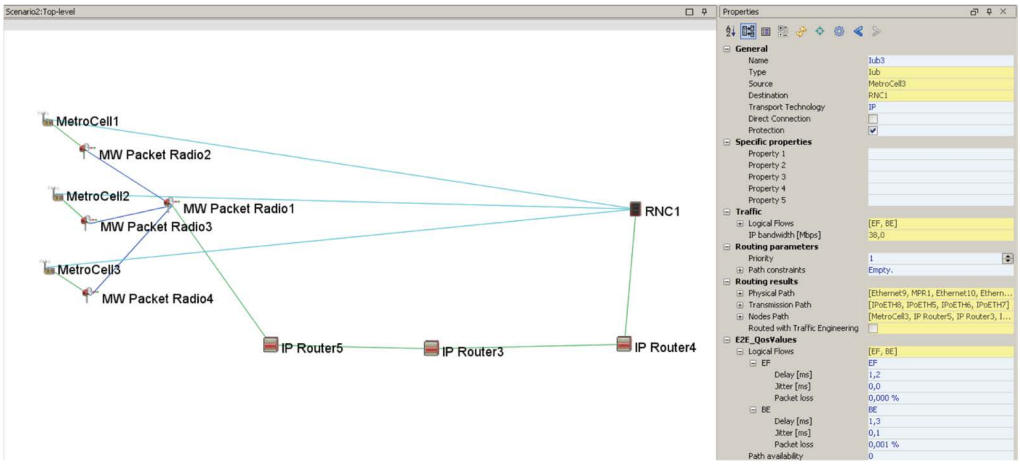


Quality of service analysis for each deployment

A QoS analysis is necessary to validate the network design. Using Nokia's industry-proven analytical models, Professional Services experts perform a comprehensive analysis of the end-to-end backhaul performance. This includes performance on all links and a mix of traffic profiles, allowing advisors to model the network and QoS behavior. Detailed reporting on key metrics includes average packet delay, jitter, and packet loss statistics across the network. To assure optimum network availability, weak links are identified by testing path availability for different scenarios.

Figure 5 illustrates the QoS and availability analysis results for a 3G small cell network. Analysis for subsequent generations of the radio network in various architectural configurations is also supported.

Figure 5. End-to-end QoS and availability analysis



Conclusion

The right mobile backhaul strategy and design is essential to minimize costs, as well as achieve reliability, scale, QoS, and operational efficiency. This is particularly true in emerging transport architectures such as those supporting the backhaul and fronthaul of small cell and CRAN system generated traffic. Nokia's Professional Services for Mobile Backhaul can assist MNOs to make the best choices, both in terms of technology and topology. Working closely with the operator, professional services experts can help operators design and deliver an optimized small cell network.

Nokia's field-tested methodologies help speed time to market and simplify the transformation of the mobile backhaul (and fronthaul) network, identifying the best technology mix to address short and mid-term requirements. Professional services address all planning aspects, including the market study, traffic assessment and forecast, design and optimization. Expert analysis includes a customized multi-year business case and projected return on investment, showing how a CAPEX investment can bring significant OPEX saving over a multi-year period.

With a global reach and expertise in more than 150 mobile backhaul transformations, combined with industry-leading innovations, tools and methodologies, Nokia's professional services for mobile backhaul can help mobile network operators build transport networks to support their business goals, now and into the future.

Acronyms

CRAN	Centralized, or Cloud, RAN
LOS	line of sight
LTE	long term evolution
MMW	millimeter microwave
MNO	mobile network operator
nLOS	near line of sight
NLOS	non line of sight
OFDM	Orthogonal Frequency Division Multiplexing
QoS	quality of service
RAN	radio access network
TCO	total cost of ownership

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