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Central office transformation to converged edge cloud nodes from legacy CO sites

White paper

"With networks and services undergoing transformation, what should we do with the central offices (CO)?" This is the $270 billion question on the minds of top communications service provider (CSP) executives.

In this paper, one in a series of white papers on CO evolution, we focus on the fundamental business questions about the future roles of central offices in the cloud-centric environment. In an earlier white paper, we concentrated on the optimization and operating expense (OPEX) savings aspects of the CO operations and infrastructure, including CO consolidation and exit initiatives. Here, we discuss the advances in technology and network architectures and the CSP options for COs — exit, optimize or repurpose the CO into converged edge cloud nodes. The edge cloud model helps the best CSP over the top (OTT) players have a tighter control of the virtualized functions and data centers, stay relevant in the cloud value chain, monetize the CO real estate, deliver significant synergies with ultra-broadband fixed network deployment initiatives and 5G projects, as well as prepare the CSP infrastructure for new latency sensitive services in the future.

We will explain how new cloud networking requirements of highly reliable performance and security or short latency would drive the need for the cloud services in the edge and what it means from the CO perspective. We will touch on architectural aspects of the next-generation central office (NGCO) and offer a framework that Nokia is using to actively help CSPs decide on the optimal method for selecting their COs for exit, optimization or transformation to NGCO. We will also briefly touch on the nature of the CO transformation business case. Some of the topics addressed here will be discussed in greater detail in the upcoming white papers in this series.

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Introduction

What is a CO?

A central office (CO) is the communications service provider (CSP) gateway to its customers and is primarily used to house public switched telephone network (PSTN) switches for voice switching, data termination equipment for internet access, and in some instances, video caching for broadcast video and other distribution equipment.

The world's first commercial telephone exchange (precursor to the current CO) opened in Friedrichsberg, Germany, a city near Berlin, in 1877. Today, an average Tier 1 CSP may have over 10K central offices with each serving over 10K+ residential/mobile and 1K+ enterprise customers. While there are no reliable numbers, it is estimated that worldwide there are over 250K COs or remotes with ~32K in the U.S., Canada and Japan alone, per Nokia's assessment.

With these estimates, it is natural to ask questions such as "What should a CSP do with the CO?" and "How can a CSP unleash the full potential of the CO assets?"

In this series of white papers, we will explore the rationale and opportunities necessitating change in the traditional CO architecture. We will briefly consider the new application demands and Bell Labs' Future X network architecture and analyze its impact on the CO. Then we will explore the strategic options and the business case of CO transformation. Finally, we will provide a simple high-level framework on how to migrate to the new CO model.

Strategic opportunity in central offices

Why transform the CO? What are the problems with the current CO model? What are the new opportunities driving CO transformation?

Our discussion about the role of COs in the cloud era starts from the analysis of the network and service environment driving the need for CO transformation.

Over the past 40 years, the CSPs have steadily rolled out COs closer to the population and gradually added new equipment that delivers voice, data and video services over fixed or wireless connectivity. Consequently, the COs became a significant sink of capital expenditures (CAPEX) and OPEX. With a central office housing an average of more than 300 in proprietary equipment, the CO is complex and a significant contributor to energy costs. By its nature, CO infrastructure lacks programmability that inhibits innovation. Moreover, the legacy staff managing the COs are nearing retirement which makes the management of the COs more expensive with time (see Figure 1). Per A. T. Kearney, the book value of the top 30 CSP fixed assets is more than $2.4 trillion, of which nearly $270 billion is locked away in real estate.[1] This gives CSPs a significant financial incentive to transform the legacy COs.

1 A.T. Kearney, 2014, "Telecom Assets: Unlocking the Trillion-Dollar Treasure Chest."

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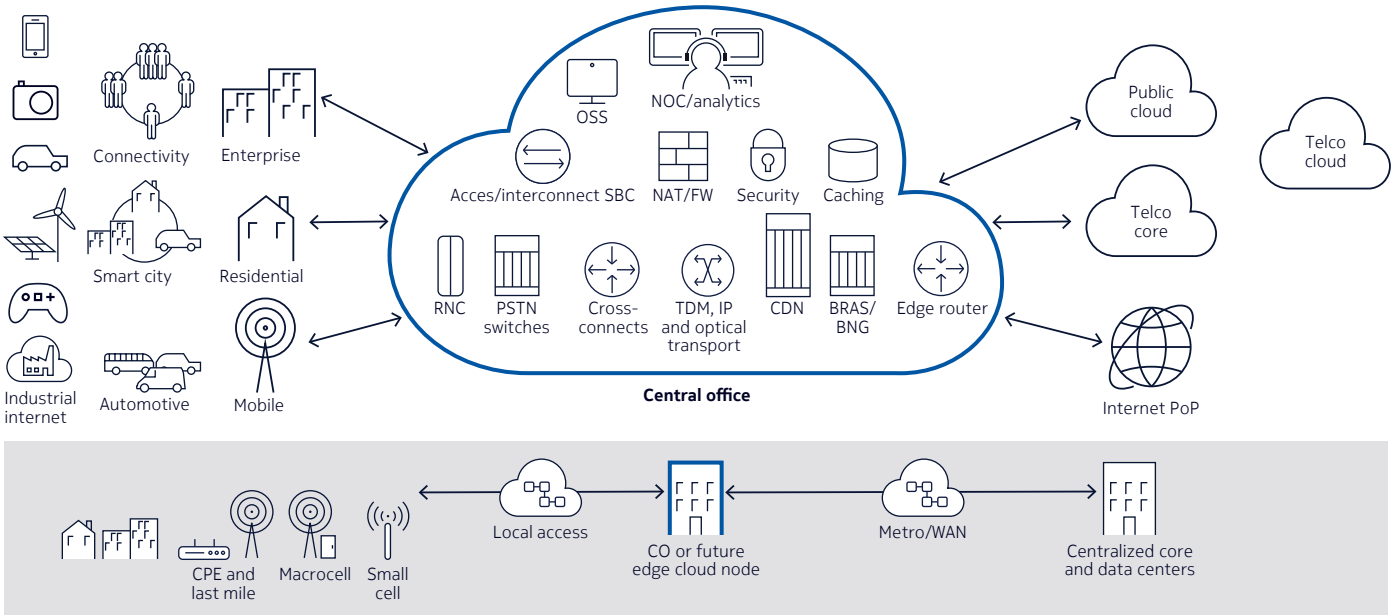
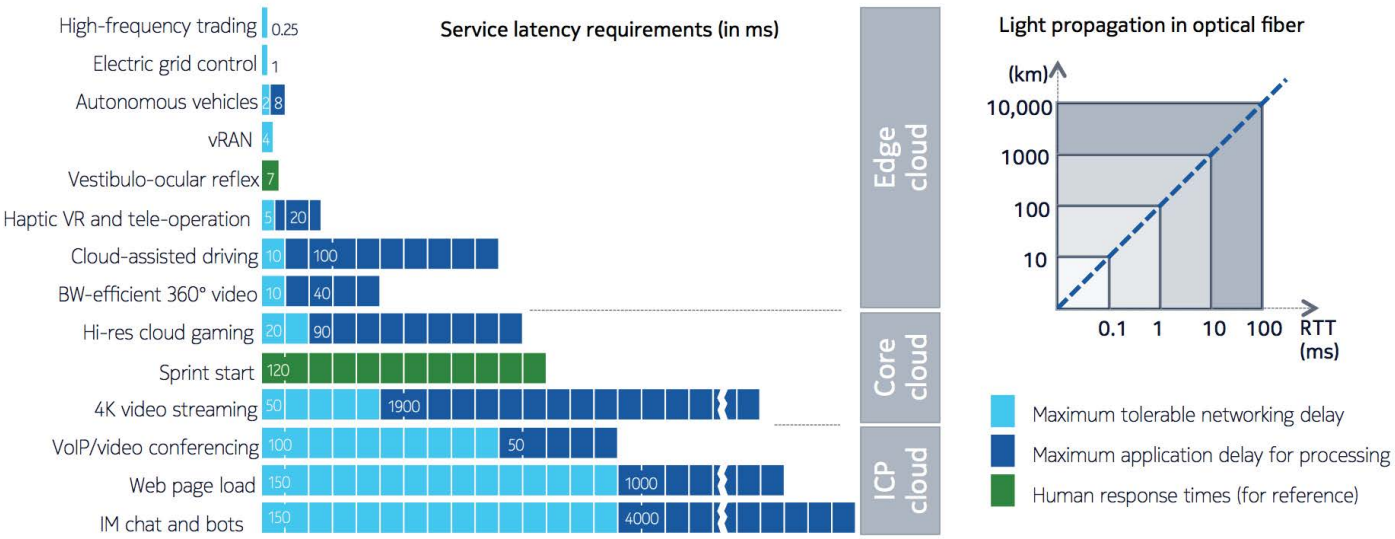
Figure 1. Typical central office landscape



On the technology front, Bell Labs researchers articulated in their groundbreaking book, "The Future X Network," that the Future X network in 2020 would have to deal with a global traffic increase of 2.6 to 4.3 zettabytes per year, driven by emerging new services (see Figure 2). New applications like augmented reality (AR), virtual reality (VR), gaming, autonomous vehicles, remote tele-surgery, and next-generation electric grids demand a network with sub-10 millisecond round-trip latency. However, the propagation speed of light in fiber (~300,000 km/s in the typical fiber cable) dictates that to achieve this round-trip service latency the data centers providing the service must be located within 40 km to 50 km from the end device (factoring computation time). Therefore, CSPs will require highly distributed, edge data center infrastructure where existing CO locations could play an important role in providing these capabilities.

Figure 2. Why latency matters?



Source: Bell Labs Consulting "The Future of the Cloud"

Table 1, as developed from Nokia's extensive experience in network transformation, identifies some additional reasons for CO re-architecture. Combined with a cloud operations model of decoupling of the network hardware infrastructure from software, these will significantly transform the traffic pattern and new revenue potential at CSPs.

Table 1. Central office challenges and opportunities

Threats to current CO-based service delivery	Opportunities to re-architect the COs
Changing subscriber traffic patterns to OTT services (e.g., video); cloud and Internet of Things (IoT) changes traffic and backhaul demands in a CO.	Virtualization and SDN enable service distribution and convergence of fixed and mobile operations into an IT service delivery model.
Need for faster service innovation demands a CO infrastructure that supports DevOps and Agile IT approaches.	Faster and longer fiber reach access solutions that enable CO consolidation.
To compete with OTT operators, CSPs need CO economics that mirror the OTT centralized cloud efficiency.	Emerging 5G, IoT and vehicle to vehicle (V2V) traffic need more access nodes and data processing units closer to the end user.

Next Generation Central Office (NGCO) architecture

If and when transformed, what would a NGCO look like?

Today, most IT-based cloud deployments are centralized in core data centers. Their networks are agnostic of the application-specific needs and are built and optimized primarily for processing power (performance) and total cost of ownership (TCO). However, future applications such as V2V traffic, AR, VR, and IoT require not only a high-powered cloud computing resource, but also networks that can efficiently connect these resources to the end users and automated applications with the low latency, high bandwidth, high security and the right economics. It is the reason that IT cloud and telco networks must come together. IP-fication and cloud-fication present a significant opportunity for CSPs to dynamically and tightly integrate the cloud computing and access networks infrastructure together and uniquely position CSPs in the driving seat of cloud revolution.

Network transformation

To achieve optimal performance, latency and economics, the Future X architecture recommends a hybrid or distributed network with a centralized core and edge cloud service delivery. This hybrid model is a shift from a dedicated hardware infrastructure to a software platform model that leverages the most convenient allocation of network functions and user services and paves the way for Agile service creation, together with access as a service (AaaS) and software as a service (SaaS) delivery models. The resulting edge data center function supports both connectivity as well as virtualization services and stores data to provide computing services closer to the users to reduce service delivery delays, increase service quality, scalability and network resiliency. The transport infrastructure between the core and the edge cloud must guarantee flexibility, reconfiguration, adaptability and automated resources provisioning.

Figure 3 on the following page provides one such proposal for a generic CO edge architecture that employs dedicated hardware for interfacing with several access networks, and a general purpose computing hardware for computing and storage hardware for the user plane, control plane and application functions.

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Figure 3. Detailed NGCO architecture

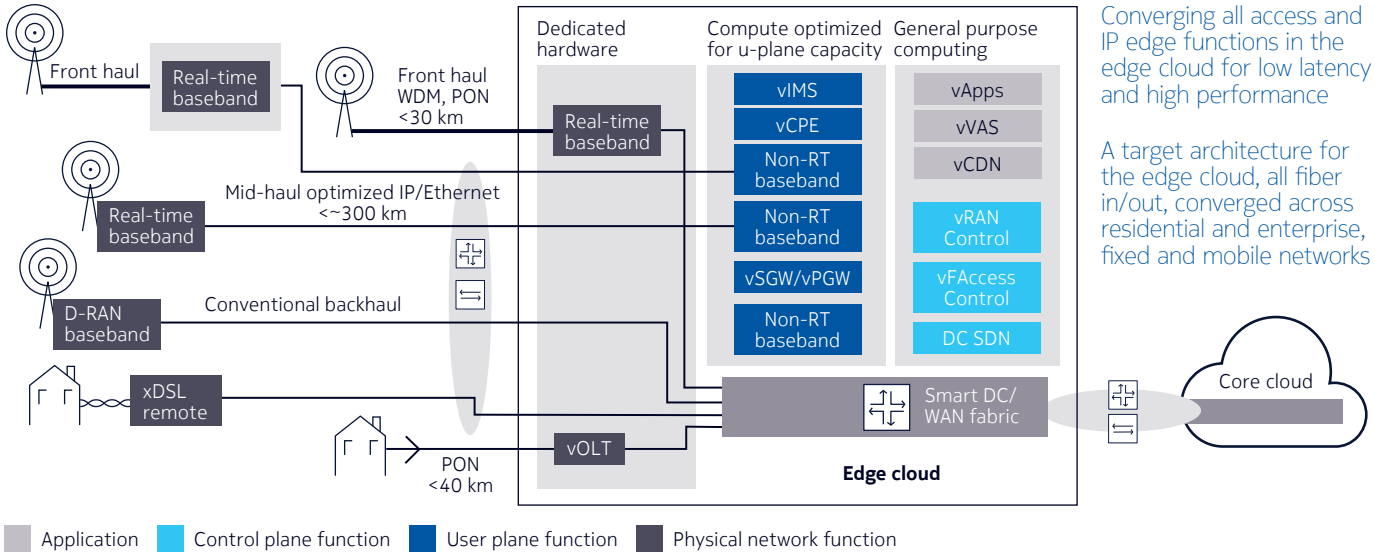
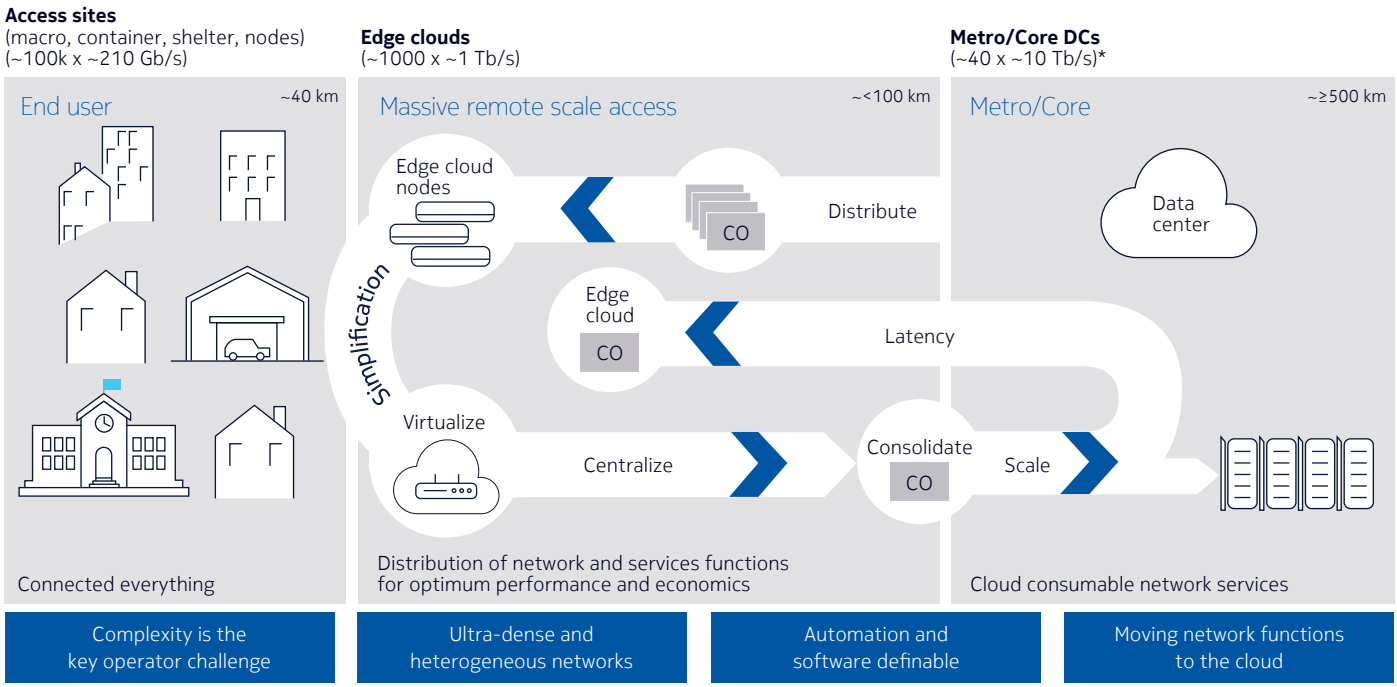


Figure 4 steps it up a level and provides an overview of the fixed network evolution. It highlights the different CO repositioning options, with respect to the dynamic distribution of virtualized functions — their centralization or de-centralization, depending on processing and latency requirements, as well as overall performance and economics. The general rule for design is to "centralize all functions in the core network for scale and efficiency except those that demand unique application or performance characteristics which can only be achieved from the edge cloud."

Figure 4. Fixed network evolution regarding central offices



*Order 1000 Tb/s busy-hour traffic for ~40 million households including enterprise by 2020

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Operational transformation

From an operational perspective, the NGCO replaces legacy infrastructure with IT grade hardware. NGCO also automates many networking and maintenance operations, leaving many locations unattended, with mostly centralized CO and cloud management and maintenance functions. It is typically built with a high level of business continuity and security, including none to low risk from natural disasters. The power usage effectiveness (PUE[2]) should be 1.10 to 1.20, versus a PUE of 1.70 or 2 for traditional CO sites. These NGCOs also use a modular configuration in technical spaces, a mix of indoor and outdoor containers, and on the ground or underground options to accommodate diverse placement, security requirements and changing traffic loads.

CSP strategic options

What should a CSP do? What are the strategic options that a CSP has? What are the key decision criteria?

Having a cursory understanding of the NGCO architecture, the next logical question to ask is, "How should a CSP decide the fate of a CO?" The strategic objective of a CSP is to find the right balance between saving costs from the CO assets in a short to medium timeframe (or even monetizing some of the most expensive CO real estate) and enable new revenue generation in the long term by adapting the network to the future architectures and service needs. Thus, a CSP has three options:

1. Strategically **exit** certain COs and generate cashflow from the real estate assets.
2. **Optimize** certain COs to generate savings in OPEX, or potentially phase out the CO and eventually repurpose it in the future.
3. **Transform** the COs into a NGCO to build competitive advantage in the new 5G and cloud era of disruptive services and deliver new innovative services.

CSPs around the world are actively pursuing different strategies with respect to their COs, but they have concluded that doing nothing is not an option. The advent of IP connectivity and cloud-based service delivery has enabled OTT players to start using up operator core services, including messaging, video and voice services, data center services and host-added value services. With the risk of OTT competition and the growing sense of urgency to lower OPEX and at the same time develop the infrastructure that supports emerging applications, CSPs are beginning to act now.

Many CSPs have decided to:

- Exit: Some CSPs (for example, Proximus in Belgium) have decided to phase out the COs and monetize the buildings.
- Optimize: Many CSPs (for example, DTAG in Germany, Telefónica, Proximus, NTT, CenturyLink and TIM) are actively engaged with Nokia in legacy consolidations and migrations, predominantly to save on real estate and energy costs.
- Transform: Many others (for example, AT&T, Verizon, Telefónica, China Unicom, NTT and SK Telecom) are engaged in a strategic transformation discussion on the future role of their COs.

2 Power usage effectiveness (PUE) is a measure of how efficiently a CO site or DC site uses energy; specifically, how much energy is used by the telco or computing equipment in contrast to cooling or other overhead. PUE is the ratio of total amount of energy used by a telco and IT active equipment to the energy delivered to this equipment.

The decision to exit, optimize or transform is CSP specific. It depends on many factors including CO utilization rate, CO distribution within a territory, the metro backhaul and transport infrastructure, complexity of legacy gears in the CO, costs incurred in running a CO (for example, the cost of supporting the legacy gears or owning or leasing the building as well as its utility costs), value of the building in the commercial market, demands for emerging applications, and capital available for transformation. In fact, several Bell Labs studies confirm that up to 50 percent or more of CO locations could be optimized or exited. However, as explained in sections above, cloud networking at the edge requires highly distributed data center architectures with many edge cloud centers located in proximity to the end users.

To facilitate these discussions and turn them into pragmatic actions, leading CSPs along with telco and IT vendors have joined forces to create an open framework for a NGCO under the central office re-architected as data center (CORD) standardization umbrella. The primary aim of CORD is to combine network functions virtualization (NFV), software-defined networking (SDN), and the elasticity of commodity clouds to bring data center economics and cloud agility to the telco central office.

Solving the CO transformation paradox

If a CSP has decided to migrate, how do they migrate to a new CO? Where do they begin?

Universally, CSPs have an urgent need to lower their OPEX and improve their assets. Optimizing and exiting a CO generates quick cashflow. Yet, as one CSP discovered after exiting, they lacked the infrastructure to deliver optimal cloud services from the edge. This is clearly a paradoxical situation —exiting and monetizing COs is reasonable and desirable from the OPEX savings perspective, but at the same time the CO locations are required to provide edge cloud services.

Fortunately, the CO paradox can be solved. Nokia has developed a proven methodology to consolidate or exit many of the existing CO buildings, while providing highly distributed network architecture, services point of presence and flexible access to the cloud applications. However, it is of utmost importance to understand which assets can be released without risking the business and services provided — now and in the future. This action requires a thoughtful analytical process of assets classification and selection, including the following points.

1. Strategic classification of CO sites

As the long-term view may impact short-term decisions on the CO functions and localization, CO sites require proper assessment and identification of both current and future needs. Classification of CO sites needs to be dynamic and future network architectures that will be considered should be different from the ones we know today.

2. Middle level designs

While strategic assessment and classification of sites is a challenge on its own, problems multiply when we take a deeper analysis. Every CO is unique in its arrangement and equipment set. Many CSPs find it very complex and time consuming to prepare a CO transformation project for execution. Questions range from “Which sites to select?”, “What is the execution sequence?”, “Where to start?”, “How to progress?” to “Where to end?”. Additional considerations are “Should we start the transformation with big and complex locations or from small and relatively easy ones?” and “How large should the sample of sites be for the initial analysis?”.

Nokia understands that design time and cost is limited and some compromises are necessary. Therefore, we introduced a concept of middle level design (MLD) that provides a reasonable, field-proven balance of design detail, effort and design accuracy. This concept also brings business decisions to a higher level and generates a detailed business case before accepting sites for transformation execution.

3. Detailed designs and CO transformation execution

Detailed design prepares a specific CO site for execution. Nokia leverages a proven concept of the "capability design" and tools to help service providers optimize the design procedures, enhance execution agility and automate the execution process with the optimized balance of quality, speed and volume.

Nokia can assist the CSP to find the best path to implement these processes. Service industrialization, with its three core principles of methodical design, repetitive execution, and precise operational management and control, supported by 13+ years of field experience, automation and tools is the differentiating factor, especially for large and complex projects. Arguably, every CO transformation project belongs to these categories. More details on the CO site selection and categorization process will be delivered in one of the upcoming white papers in the series.

Business case for transforming to NGCO

What is the business case and return on investment (ROI) of CO transformation?

In a previous section, we learned that CSPs have three options on the future of the CO. Nokia is actively engaged in this activity with many Tier I CSPs. A complete understanding of the CO transformation business case, its parameters, sensitivity factors and overall value generation is very important for the decision-making process, project definition and execution. It is the focus of one of the upcoming white papers in this series.

A decision on the future of the CO is strategic and is typically done at the C-levels of the CSP. The right answer to the question, "Should we exit, optimize or transform a CO?" is all of the above. A typical CO has over 300 proprietary legacy equipment types (telco and IT) and is therefore expensive to operate and maintain. This equipment translates often into thousands of racks and chassis spread across different floors of a building and only partly utilized. While regular operation improvement initiatives may include gradual consolidation of equipment/racks or technical spaces, only complete phase out of the last services and subscribers will lead to true facility savings (see Figure 5). Moreover, rapid attrition of an older workforce may additionally motivate some CSPs to accelerate the phase out of their CO infrastructure. While the transformation of the CO is inevitable, its migration is expensive and can take years,[3] is intrinsically risky, and depends not only on the CO design but also on the planned future service offerings and the access and metro transport infrastructure.

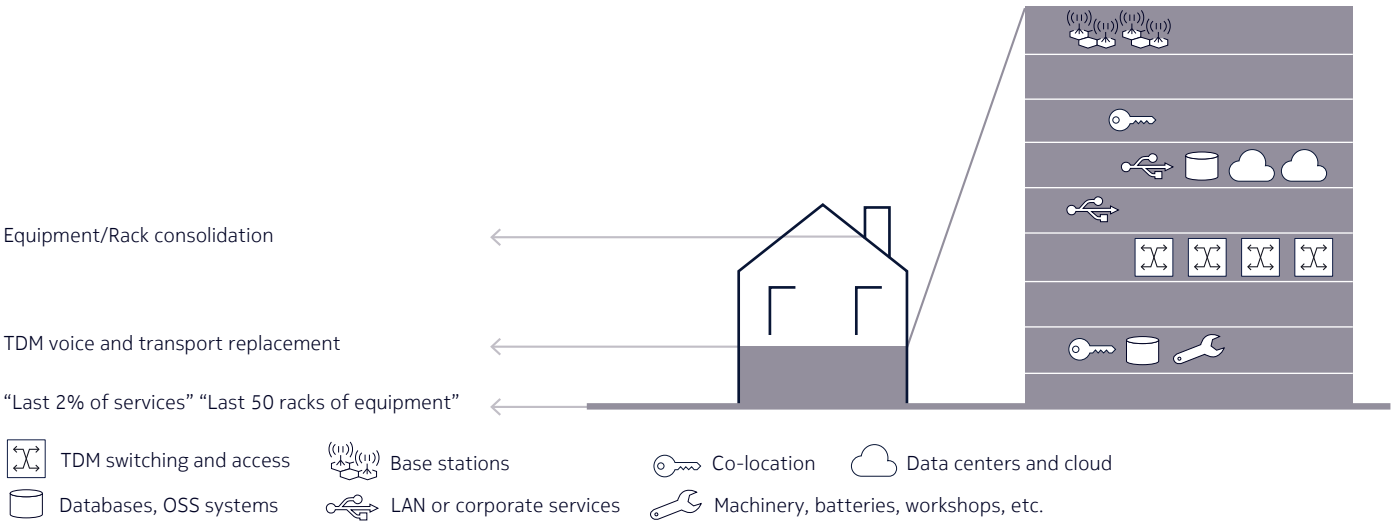
However, CSPs are in a unique competitive position due to their extensive metro/access networks and CO footprint. Per Tom Nolle,[4] "Nearly all profitable Internet traffic transits less than 40 miles," and this enables CSPs to reposition many of the existing COs as a converged edge cloud node. Upgrading existing CO to NGCO saves significantly on the cost, complexity and effort of building new greenfield edge cloud nodes because the CSP can leverage existing infrastructure, including network (fiber, ducts) and different real estate assets — something that most other OTT and cloud service providers cannot emulate.

3 For example, as Nokia experience shows, the complete CO shutdown can take anywhere from 3 to even 5 or more years per site.

4 Tom Nolle, President of CIMI Corporation, a strategic consulting firm specializing in telecommunications and data communications.

Nokia experiences reveal that combining the OPEX savings with optimization of some COs and transformation of others has shown to significantly improve the business case of CO to NGCO. Moreover, as the transformation process is likely to be gradual, the cash outflow can be synchronized with additional cash income from new services. Additionally, the target architecture with NGCOs would result in fewer main central offices, increased access and service coverage, reduced space needs and heating, ventilation and air-conditioning (HVAC) costs due to new high-density equipment. Not only does this transition reduce CAPEX and OPEX, it also helps to drive innovation and drastically cut time to market for new services from months to days.

Figure 5. Complexity of CO infrastructure



CSPs pursue the optimal path for CO transformation and address the business case from different perspectives. For example, a leading Tier 1 CSP in the Asia-Pacific (APAC) region looks for monetization of its most attractive CO locations and then wants to leverage real estate income to fund legacy phase out programs and edge cloud NGCOs builds. A Tier 1 CSP in Europe decides to consolidate technical space in most of their existing CO locations, but maintains most of the buildings for future use — any decisions to fully exit them will depend on the future service needs, legacy phase out progress, real estate values and other conditions that will be evaluated in the future. Another Tier 1 CSP in the Middle East tries to combine ongoing programs of core data center build, legacy phase out and fiber-based ultra-broadband deployment, with 5G ready cloud radio access network (RAN) and NGCO initiatives to find the right balance of investment and benefits. No doubt, there are plenty of options to approach CO transformation and both business case planners and strategic designers will be very busy in the coming months to deliver the best business and technical solutions. Nokia can offer support in this process, combining its global experience and lessons learned with business and technical modeling experience and tools.

Summary

CSPs have nearly $270 billion invested in CO real estate. With the advances in technology and network architectures, they have the option to exit, optimize or repurpose the COs. While Nokia is engaged in many CO optimization engagements, a significant number of CSPs are looking at the hyper-networked architecture of the Future X network that requires transformation of a CO into an edge cloud node. With IT and telco worlds converging, CSPs will need to have a tighter control of the virtualized functions and data centers, both in the core as well as at the edge of the network.

Nokia considers this process as a great opportunity for CSPs not only to remain relevant in the value chain of "cloud-fication," but also to optimize the usage and monetize many of its real estate and other passive assets. Robust strategy, together with appropriate selection and planning of the CO transformation, will help CSPs not only monetize a large part of their CO infrastructure and deliver OPEX savings, but will prepare their passive infrastructure for the disruptive, latency sensitive services of the future. CO transformation, if properly planned and executed, will also deliver significant synergies with ultra-broadband fixed network deployment initiatives or data front-haul and 5G projects.

Central office transformation professional services from Nokia will allow CSPs to capitalize on these opportunities while reducing the risks and mitigating challenges.

Acronyms

5G	fifth-generation mobile network
AaaS	access as a service
APAC	Asia-Pacific
AR	augmented reality
BNG	broadband network gateway
BRAS	broadband remote access server
BW	bandwidth
CALA	Caribbean and Latin America
CAPEX	capital expenditure
CDN	content delivery network
cloud-fication	evolving a CO to become a converged edge cloud
CO	central office
CORD	central office re-architected as a data center
CPE	customer premises equipment
CSP	communications service provider
DC SDN	data center software-defined networking
D-RAN	distributed RAN
DSL	digital subscriber line
EMEA	Europe, Middle East and Africa
EPC	evolved packet core
FMC	fixed mobile convergence
GW	gateway
HVAC	heating, ventilation and air-conditioning
ICP	integrated communications provider

IM	instant messaging
IoT	Internet of Things
IP	Internet Protocol
IP-fication	evolving to all-IP networks
IT	information technology
LAN	local area network
MLD	middle level design
NAT/FW	network address translation/firewall
NFV	network functions virtualization
NGCO	next-generation central office
OLT	optical line terminal
OPEX	operating expense
OSS	operations support system
OTT	over the top
PON	passive optical network
PSTN	public switched telephone network
PUE	power usage effectiveness
RAN	radio access network
RNC	radio network controller
ROI	return on investment
RTT	round trip time
SaaS	software as a service
SBC	session border controller
SDN	software-defined networking
TCO	total cost of ownership
TDM	time division multiplexing
TTM	time to market
V2V	vehicle to vehicle
vBNG	virtual broadband network gateway
vF Access	virtual function
vIMS	virtual IP multimedia subsystem
VNF	virtual network function

VoIP	voice over IP
vPE	virtual provider edge
vPGW	virtual packet gateway
VR	virtual reality
vSGW	virtual signaling gateway
vVAS	virtual value-added service
WAN	wide area network
WDM	wavelength division multiplexing

Further reading

1. "Central Office Transformation – How to make money from Telco Real Estate"
2. Bell Labs, "Future- X Networks – By Marcus K. Weldon & team"

About the authors

Darek Bakula, darek.bakula@nokia.com, is a Portfolio Line Manager and Senior Consultant for Migration and Consolidation professional services in the Nokia Fixed Networks division. With 25 years in the industry, Darek managed technical and consulting teams at AT&T, Alcatel-Lucent and Nokia. His leadership is supported by the hands-on consulting and execution experience in technology, networks consolidation and migration and complex process management, including delivery of multimillion dollar complex transformation projects in EMEA and the Americas. For example, he contributed as the networks stream leader for the large business, network and operations transformation of multiple, merging multi-domain companies in CALA, providing over $400M operations savings over 4 years.

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José holds a Master of Radiocommunications Engineering degree, a Master of Telecoms Laws degree, and an Executive MBA degree. His area of expertise includes network economics and business cases, market opportunity vision and transformation, complex programs and change management. He works with clients to define strategy and execution plans for the transformation of their networks, operations and business ecosystem. He is always pursuing best practices, cutting edge solutions and processes in organizational development to fit client and business needs.

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He is the author of nine worldwide patents, a dozen papers and has participated in multiple speaking engagements. Shri is based in Dallas, Texas, and holds a Master of Telecommunications degree and an MBA from the University of Texas at Dallas.

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