Future X Network cost economics

A network operator's TCO journey through virtualization, automation and network slicing

White paper

This paper examines typical network cost behavior, as a physical, static and monolithic network evolves to one that is virtual, dynamic and optimally sliced. While this transformation eventually results in a more efficient network with significantly lower TCO, Bell Labs Consulting analysis found that the intermediate evolution stages will experience cost increases that result from transformation expenses, suboptimal manual slicing and operational inefficiencies. The key to achieving TCO reduction is through end-to-end automation that enables efficient network and service slicing and helps realize the full cost-saving potential of network virtualization.

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1 Introduction

Virtualization and programmability of network resources have emerged as key prerequisites for telecom operators to efficiently deliver digital services at web scale. Driven by the high-bandwidth and low-latency needs of a wide variety of applications, these services require a highly distributed network capable of flexibly supporting real-time customization of network elements. Creation of service slices, enabled by closed-loop, end-to-end automation, is a key requirement.

Evaluating the economics of digitized network resources operating in steady state is clearly important for determining a network's long-term viability. However, operators need to understand the behavior of network costs and the impact of automation during the transformation phase, as a traditional, physical and static network evolves into a virtualized, programmable and dynamic one. This information is critical for evaluating and optimizing the return on digitization investment.

In this paper, we identify two intermediate stages between the evolution's two end states and quantify network cost behavior for a typical transformation along this path. Our analysis shows that the intermediate stages incur higher costs — resulting in a "hump" in the cost curve — due to lack of automation and ongoing virtualization. Without full automation, creating slices further exacerbates network cost performance, resulting in a cost penalty of up to 30% during transformation, relative to the initial physical network. However, with full automation, the digitized end state can lead to a 32% cost reduction. We conclude that complete automation is critical for enabling the significant network cost savings made possible through digitization.

2 Stages of network evolution

To capture the impact of evolution from a physical network with largely manual network operations to a fully-automated, sliced, virtual network, we first characterize the end points.

2.1 Physical CSP network

A physical CSP network (PCN) is a traditional network comprising physical network elements and platforms that are dedicated to specific applications and services. As these special-purpose appliances are dimensioned for peak application loads, and there is no resource sharing, network assets are significantly underutilized, which results in high CapEx. Resource overprovisioning to buffer against demand variations during the long cycle times required for capacity addition tends to reduce resource utilization even further.

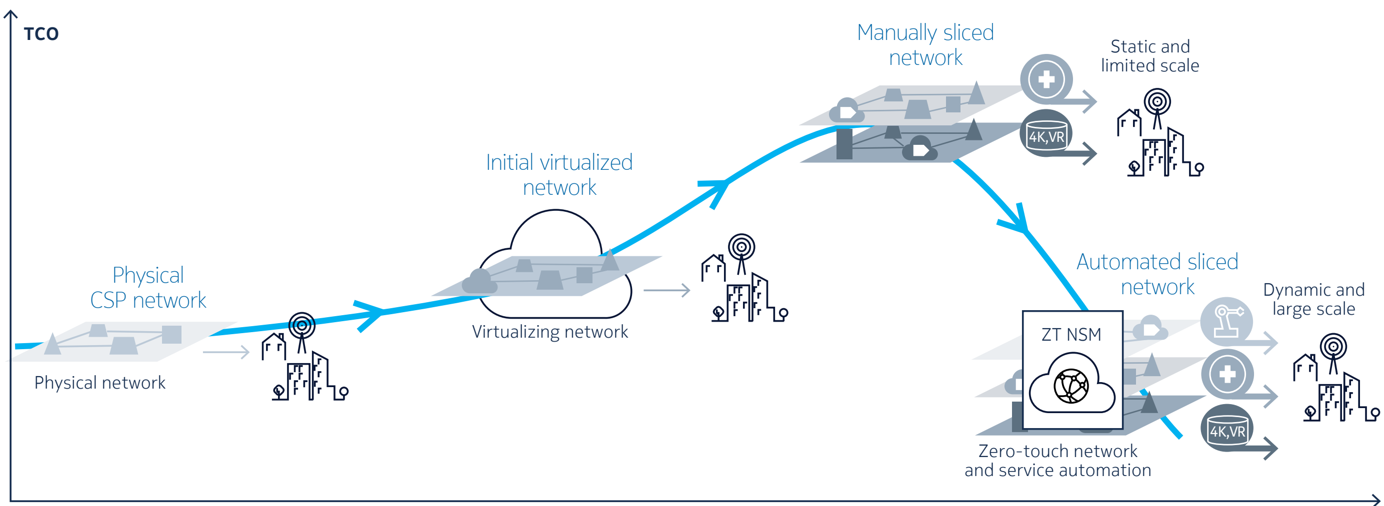
Service offerings are homogenous across customers with minimal slicing, resulting in monolithic network resources that are not optimized for individual services. Processes are largely manual with automation limited to a few life cycle management (LCM) operations. OSS/BSS systems are complex, and they require interacting with a multitude of individual vendor-specific element management systems (EMSs), leading to high build-time integration costs and run-time operating expenses. PCNs represent most operator networks today and clearly stand to benefit significantly from real-time automation.

2.2 Automated sliced network

An automated sliced network (ASN) is an optimally virtualized and optimally sliced network, comprising a blend of virtual machines, containers and bare metal servers based on a cloud native architecture. Service and network control make extensive use of open APIs, while Dev-for-Ops principles drive network function LCM operations — and enable continuous integration and delivery (CI/CD) of network software. The network deploys an edge cloud architecture with widely distributed network functions targeted at meeting service performance and cost-minimization objectives.

An ASN creates service slices to meet new demands through decomposition and re-composition of granular service elements, it also builds network instances and sub-instances with the performance guarantees required to support these service slices. Such network constructs are composed of network functions executed through microservices supported by a shared data layer. Life cycle management of service operations and network function processes is fully automated through the zero-touch NSM capabilities shown in Figure 1.

Figure 1. Operator evolution



2.3 Intermediate stages

An operator network's transformation from PCN to ASN can span multiple years, depending upon factors such as the pace of network virtualization (through SDN and NFV implementation) and the remaining life span of current physical assets. Therefore, we identify two intermediate stages between the end points. These four stages of the transformation journey, shown in Figure 1, are characterized by the degree of network virtualization achieved and the implementation of network slicing.

An initial virtualized network (IVN) is the first stage of network evolution involving the virtualization of a limited number of network functions, typically ones with strong economic justification or those reaching end of life or capacity exhaust. Even these functions are not cloud optimized, and automation is minimal. Most OSS/BSS processes continue to be manual with little orchestration between physical and virtual resources. Service slicing is absent and network functions continue to be monolithic and are supported by dedicated servers.

A manually sliced network (MSN) is the next stage that represents an operator's initial attempts at creating service and network slices. At this stage, however, only a limited number of slices is created through manual processes to meet the targeted needs of specific customer segments, such as low-cost slices for IoT applications or ultra-reliable low-latency slices for collaborative robot applications. These slices are not optimized for reducing network cost. SDN- and NFV-based network transformation has advanced further but is not yet complete. There is a minimal level of automation. Only a few activities, such as slice instantiation, are automated while critical life cycle management tasks, such as performance management, fault management and resource optimization, are driven by largely manual processes.

3 Behavior of network cost

Figure 1 charts the typical behavior of a network's total cost of ownership (TCO) as an operator goes through the transformation process. Starting from the initial PCN stage, the network TCO is likely to increase continuously through the intermediate stages, before the benefits of full automation are realized at the ASN stage, leading to significant TCO reduction. TCO percentages shown in Figure 1 for individual stages are relative to the TCO of a PCN. They illustrate the typical values experienced by an operator, and actual values can vary depending upon the case in point.

3.1 Evolution to initial virtualized network

The progression of network cost from PCN to IVN is driven primarily by virtualization-enabled TCO savings, as well as the expenses incurred for setting up SDN/NFV-based transformation. During this evolution, automation has minimal impact, and slicing is absent. Our analysis assumes that 40% of network functions are virtualized at this stage, and this generates a TCO reduction that is 20% of the total savings realized with maximum virtualization. TCO savings reflect CapEx and OpEx gains from migrating network functions to general-purpose servers, coupled with higher asset utilization achieved with pooled resources and greater multi-tenancy through shared platforms. Transformation costs primarily comprise expenses incurred for operating parallel processes and platforms that simultaneously manage physical and virtual network segments to ensure minimal disruption to ongoing operations.

Figure 2 illustrates the impact of these drivers for an example network transformation that is evenly spaced over five to six years. We assumed that the time required for operating the parallel platforms and processes — including their installation, integration, validation and testing — is 12 months before they are cut over to production.

Figure 2. Drivers of IVN TCO increase

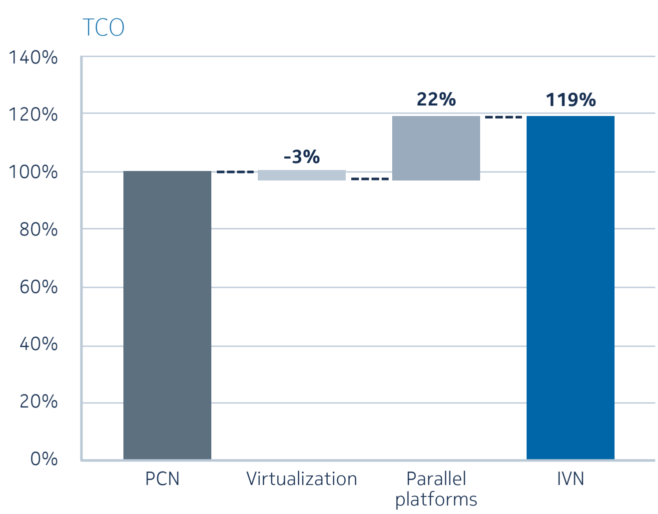
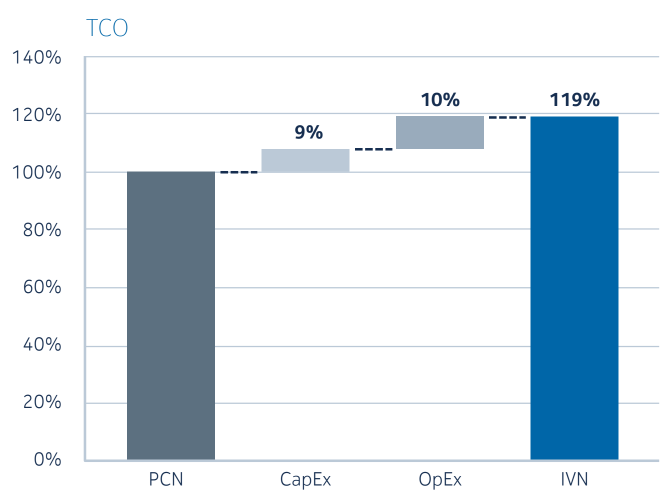


Figure 3. Breakdown of IVN TCO increase



As shown in Figure 2, virtualization-based TCO saving at this stage is merely 3%, which is outweighed by the 22% increase in transformation costs. The result is a net TCO increase of 19% for IVN over PCN. Virtualization saving is marginal for two reasons. First, it reflects TCO gains for only an initial subset of network functions. Second, it does not capture the benefits of cross-domain orchestration. In the absence of proper automation, the virtualized network functions merely mimic the siloed nature of their physical predecessors. As shown in Figure 3, CapEx and OpEx contribute evenly to this increase.

3.2 Evolution to manually sliced network

As the operator evolves into an MSN, virtualization-based saving and network transformation costs continue to drive network TCO behavior. However, it is also impacted by the creation of manually controlled service and network slices. At this stage, we assume that 75% of the total planned virtualization is realized, leading to a TCO reduction that is 50% of the savings that can be achieved with maximum virtualization.

As shown in Figure 4, virtualization-based savings increase to 9% as advancing SDN and NFV migration leads to more functions being virtualized, which then adds synergistic benefits from greater resource sharing. While there is increased automation at this stage, the physical and virtual network resources continue to be siloed. Transformation expenses for adopting SDN and NFV continue to be incurred at about the same rate because of the even-paced migration strategy, adding 21% to the TCO increase. Manual slicing creates coarse, suboptimal network slices that result in lower asset utilization. In addition, they require more dedicated staff to manage services — toward customer care, service fulfillment and assurance — as well as to manage network instances required for supporting the service slices. As shown in Figure 5, these factors collectively increase network TCO by 30%. CapEx and OpEx, respectively, contribute 14% and 16% toward this increase.

Figure 4. Drivers of MSN TCO increase

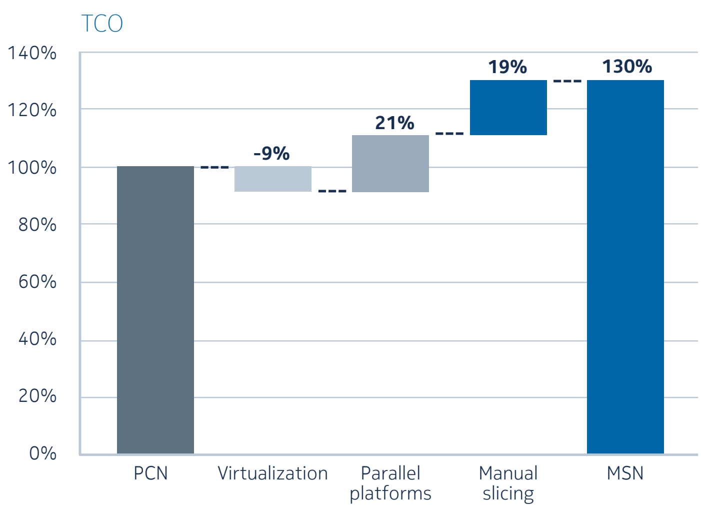
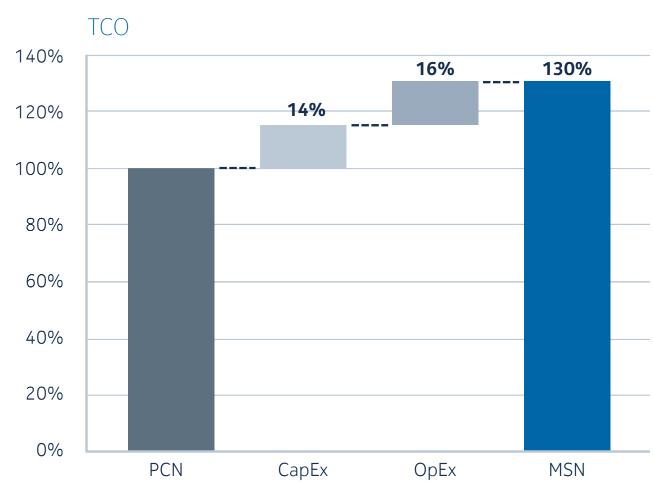


Figure 5. Breakdown of MSN TCO increase



3.3 Evolution to automated sliced network

Evolving into an ASN completes the network transformation process for the operator. This stage eliminates the parallel processes and platforms, and more importantly, with full automation, an ASN enjoys the synergistic benefits of network virtualization and network slicing.

Figure 6 shows that these benefits lead to 33% lower network TCO, relative to a PCN. Automated virtualization accounts for 22% TCO reduction through the following CapEx and OpEx factors.

15% reduction in CapEx, driven by factors such as:

- Optimized mix of virtual and physical infrastructure
- Stateless virtual resources
- Greater resource sharing with lower overprovisioning

- Separation of user and control plane processing
- Extensive API use and dynamic adaptation of VNFs and the cloud platform.

27% lower OpEx through:

- Lower labor costs due to the automation of DevOps-driven network function LCM operations
- Lower power and real estate costs
- Lower outsourcing costs.

Automated slicing results in 10% TCO reduction, based on 8% CapEx and 12% OpEx reduction. CapEx reductions arise from higher network resource utilization through efficient generation of network instances and sub-instances incorporating optimal functional disaggregation and microservices. OpEx savings are generated by reductions in labor costs that result from complete automation of all life cycle processes pertaining to service slices and supporting network instances. These processes include necessary service and resource orchestration, catalog-driven provisioning and service assurance.

Figure 7 shows that, while ASN results in a 9% lower CapEx relative to PCN, the major contribution to TCO reductions comes from a 23% decrease in OpEx.

Figure 6. Drivers of ASN TCO decrease

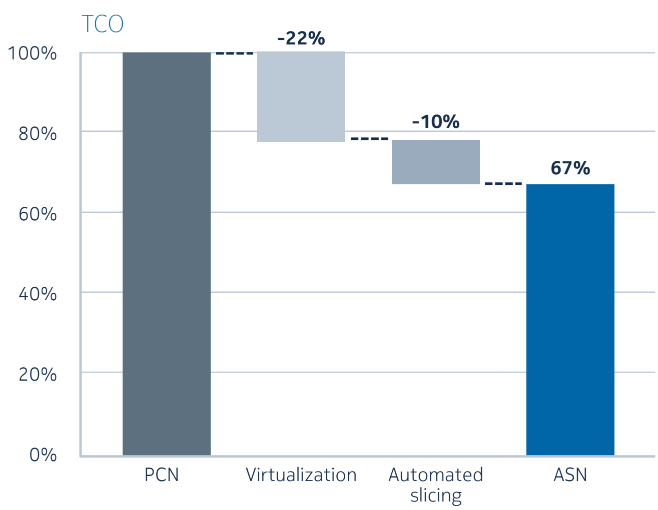
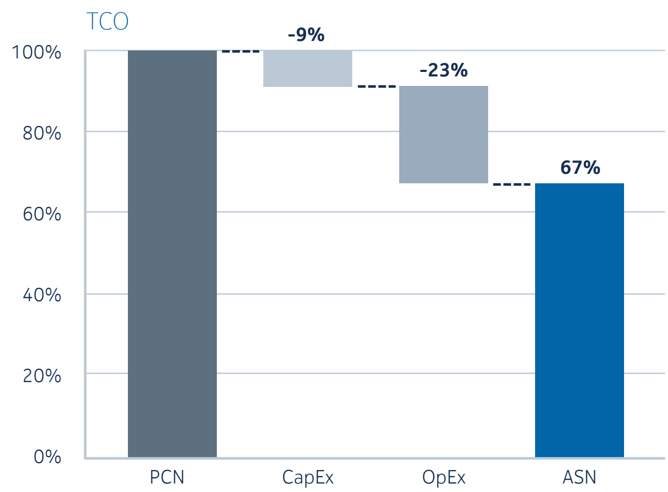


Figure 7. Breakdown of ASN TCO decrease



4 Conclusion

In this paper, we examined typical network cost behavior, as a physical, static and monolithic network evolves to one that is virtual, dynamic and optimally sliced. While this transformation eventually results in a more efficient network with significantly lower TCO, we found that the intermediate evolution stages will experience TCO increases resulting from transformation costs and manual processes. Automation is key to achieving cost reduction through virtualization as well as network and service slicing. Increasing the level of automation will lead to greater TCO savings through the automated sliced network.

While network TCO behavior typically follows this pattern, the actual costs are closely aligned with the virtualization and slicing strategies adopted by the operator. An aggressive SDN and NFV migration plan, for example, will increase the amplitude of the cost curve by increasing the cost penalties incurred at the intermediate stages. However, it will also lead to faster realization of ASN and its associated TCO benefits.

Transformation costs, as well as the recurring CapEx and OpEx required to support ongoing operations, can be particularly high for field-integrated solutions involving products from multiple suppliers. The increased complexity of multi-vendor solutions not only leads to greater integration effort and higher TCO during the intermediate stages, it also results in a longer time required to realize the efficiencies of an ASN network and diminishes its gains.

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Abbreviations

ASN	automated sliced network
BSS	business support systems
CapEx	capital expenses
CD	continuous delivery
CI	continuous improvement
CSP	communication service provider
EMS	element management systems
LCM	life cycle management
IVN	initial virtualization network
MSN	manually sliced network
NFV	network function virtualization

NSM	network and service management
OpEx	operating expenses
OSS	operations support systems
PCN	physical CSP network
SDN	software-defined networking
TCO	total cost of ownership
ZT	zero-touch

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