The Economic Benefits of Horizontal Telco Cloud Networks with Orchestration and Automation

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EXECUTIVE SUMMARY

ACG Research has estimated that communication service providers (CSPs) can achieve a 40% total cost of ownership (TCO) savings moving from a vertical silo architecture to a VMware horizontal architecture with Telco Cloud Automation, which is due to server resource optimization and labor savings.

Many legacy packet core systems are based on vertical vendor silo architectures where the packet core vendor delivers all components of the stack:

- Packet core software
- Cloud infrastructure (Kubernetes and/or VIM)
- Physical layer (compute, networking, and storage)

The packet core vendor takes responsibility for operations and all KPIs associated with the vertical stack, which reduces the CSPs' responsibilities. As CSPs seek to deploy new virtual and/or containerized network functions (CNFs) in distributed locations they are faced with a vertical vendor stack roadblock. CSPs want to increase revenue with new 5G services, which will require a horizontal telco cloud network where CNFs, VNFs or other applications can be deployed and managed across a common cloud platform without constraints. At the same time, CSPs need to reduce network TCO to maintain or increase service profitability. A key success factor in delivering a telco cloud network is providing a robust and comprehensive automation and orchestration platform across all parts of the network to allow the network and services to scale and to increase resiliency and reliability.

The ACG TCO analysis compares three scenarios:

1. Vertical Vendor Silo Architecture
2. VMware Horizontal Architecture *without* orchestration and automation (showing the benefits of a horizontal architecture over a vertical architecture)

3. VMware Horizontal Architecture *with* orchestration and automation (showing the additional benefits of orchestration and automation in a horizontal deployment)

Scenario 1 assumes the vendor silo contains some level of orchestration, but it is limited to the vertical silo. Scenario 2 assumes traditional network automation using scripts written and maintained by engineers, and Scenario 3 assumes full VMware Telco Cloud Automation across the horizontal network.

Our results show a net **6% TCO savings** when deploying a horizontal architecture instead of a single vendor silo architecture and a **40% TCO savings** moving from a single vendor silo architecture to a horizontal architecture with orchestration and automation.

Moving to a horizontal architecture optimizes server utilization. This results is a 36% reduction of servers, which in turn results in substantial CapEx savings, approximately 23%, and similar savings in OpEx environmental expenses (e.g., server power consumption). Operating a horizontal cloud architecture without automation, however, is not economically attractive, and results in significant additional network integration and management expenses. The compelling TCO benefits of 40% savings are achieved when full orchestration and automation is added to complement the horizontal telco cloud.

The return on investment (ROI) on VMware Telco Cloud Automation over five years is 373%. We also project a 5% revenue improvement within the five-year analysis due to increased service agility as a result of VMware Telco Cloud Automation.

In the TCO analysis, there are three key areas of savings:

1. Reduction of servers due to better server utilization in horizontal architecture,[1] which reduces both CapEx and server-related OpEx.
2. VMware Telco Cloud Automation reduces costs of FTE labor expenses due to automation and orchestration.
3. VMware Telco Cloud Automation packs servers more efficiently with CNF/VNFs, which leads to further reductions in servers.

[1] Note that silos do not allow sharing of servers between silos, which leads to lower server utilization and therefore more servers are required in silo architectures.

Journey to Cloud Native Networks

Horizontal architectures enable cost savings and are also the key to 5G revenue growth. The future success of CSPs rests on the rapid introduction of new services targeted at business, residential, and wholesale markets. Examples of new revenue-generating services are:

- Massive IoT
- Telehealth
- Fixed wireless (business & consumer)
- Connected vehicles
- Video surveillance
- Video game streaming
- AR/VR
- Metaverse
- Others

To rapidly introduce new services, CSPs must improve service agility. Cloud-native networks offer the promise of scalability, flexibility, and service agility; in short, they bring the benefits realized in cloud data centers to large-scale telco networks. In order to effectively manage multivendors' CNFs, Kubernetes, and software upgrades, a robust horizontal automation platform is needed.

True service agility demands a multivendor architecture. Multiple vendors will be required because we expect new services to be varied and deployed in different locations and across multi-cloud architectures. Some solutions might be deployed, for example, in public cloud data centers while other solutions might be deployed at the service provider edge data centers. It is important that CSPs can choose best-of-breed solutions to solve specific problems and create new market opportunities. This is only possible if networks support multi-vendor, multi-cloud architectures.

Cloud-native telco cloud networks provide a horizontal, multi-cloud network architecture that allows multiple network functions, applications, and vendors to run on a common cloud platform that shares common cloud software and compute, network, and storage hardware. The horizontal telco cloud architecture allows CSPs to deploy multiple network functions and applications on a common cloud infrastructure: packet core, vRAN CU/DU, edge computing CNFs, analytics, and many other CNFs and VNFs, ultimately bolstering the CSPs' ability to innovate through best-of-breed network service creation.

Current Industry Problem: Vertical Silo Architectures

Many virtual packet core deployments today use vertical silo architectures. In a silo architecture, a vendor provides all components of the stack:

- Packet core software
- Cloud software (Kubernetes and/or VIM)
- Bare metal layer (compute, networking, and storage)

In the early days of virtual packet core deployments, vendors needed to control all the components of the stack to ensure that the system met performance specifications and KPIs and, as such, vertical silo deployments made sense. Vendors essentially replaced integrated custom hardware platforms with integrated NFV platforms. From the CSPs' point of view, however, there was no difference because both the custom hardware and NFV systems were black boxes. Also, CSPs would typically give complete markets to specific vendors. In modern networks with distributed UPFs, edge computing, and Open RAN deployments, this approach is less practical. This approach instead slows CSP deployment of multivendors' networks and imposes significant cost burdens on CSPs trying to deploy multivendors' cloud-native network functions. As deployments move to edge data centers and cell sites, multivendors' systems will become more common, and these issues will become even more significant.

In silo architectures the vendor is responsible for integration, testing, and life-cycle operation of the entire stack. This simplifies the job of the CSP and reduces deployment risks. The fundamental problem with a vertical stack, however, is that no other vendors' CNFs, VNFs, applications or services can be deployed on a vertical stack; therefore, separate vertical stacks or silos must be deployed for each different service and different vendors' applications. While this is manageable for older centralized packet core deployments, this approach deteriorates as CSPs move to edge deployments, multiple vendors' applications, and seek to offer a wide range of network services.

Examples of the challenges of network deployments are presented in Table 1. Edge functions and applications from multiple vendors need to run in hundreds or thousands of locations, constituting a management nightmare without a common cloud platform with integrated orchestration and automation.

Network Functions & Applications	Deployment Location	Number of Locations
Packet core control plane (SMF, PCF, AMF, NRF)	Central data centers	Tens
Packet core user plane (UPF)	Central & edge data centers	Hundreds
RAN DU	Edge and cell site data centers	Tens of thousands
RAN CU	Central, edge, and cell site data centers	Tens of thousands
MEC edge applications and services	Edge and cell site data centers	Tens of thousands
Management, analytics, and other applications	Central & edge data centers	Hundreds

Table 1. Network Function and Application Deployments in Modern Networks

Another important problem is that silos do not allow sharing of servers and other resources, which leads to poor utilization of servers, directly resulting in increased CapEx and OpEx. Efficient sharing of servers across all network functions and services not only reduces the number of servers required in the network, but also allows for better resiliency and elastic capacity as pools of servers can be used for backup and capacity bursts. This also offers significant environmental and energy savings. In a silo architecture, the CSP is required to configure separate pools of servers in each silo for resiliency and capacity bursting.

An example of the vertical silo architecture is depicted in Figure 1. In this example, each vendor provides a complete stack consisting of orchestration, network functions, Kubernetes, VIM, and HW. Generally, the stacks are incompatible with each other and do not support any additional network functions or applications.

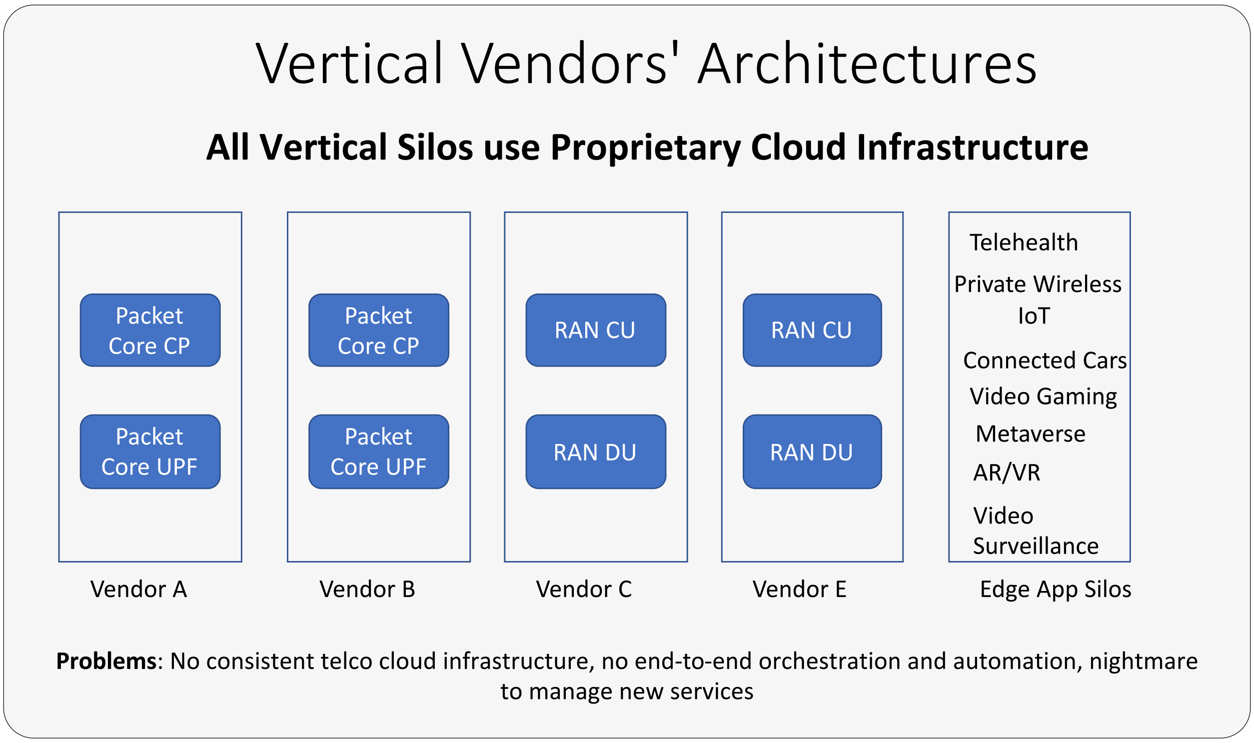

Figure 1. Example of Vertical Vendor Architecture

Some of the key problems with the vertical vendor architecture are:

- CSPs do not invest in interoperability, resulting in sets of closed systems.
- Multiple vertical vendor stacks create significant challenges to implementing end-to-end automation and orchestration.
- Each stack has separate infrastructure (including data analysis tools, network automation tool chains, and network management systems), making integration of open systems complicated.
- Vertical stacks do not allow sharing of compute, storage, and networking resources, which lowers utilization and increases CapEx and OpEx.

Telco Cloud Architecture

Flexibility and service agility are necessary to future growth and profitability. An end-to-end telco cloud architecture is required to achieve this goal. The key characteristics of this architecture are:

- Consistent end-to-end cloud service layer across the entire network.
- Support for multivendor, multifunction deployments.

- Support for multi-cloud, which includes private clouds, public clouds, and edge clouds.
- End-to-end orchestration and automation, utilizing a virtualized management platform, across all data centers, which can include national data centers, regional data centers, edge data centers, and cell sites.

The bottom line is CSPs need to be able to deploy best-of-breed products and technologies from multiple vendors across all parts of the network. This requires a common cloud infrastructure to simplify system integration, testing, and life-cycle management. Consider, for instance, the RAN Intelligent Controller (RIC) in an Open RAN deployment. The RIC consists of a collection of xApps and rApps carrying out multiple functions, including power management, traffic steering, radio optimization, location services, and many other services. The RIC is designed to allow plug-and-play between multiple vendors in a similar way the iPhone and the Apple App Store allow users to download a variety of apps with different functions and features. Without multivendors' support, the RIC and its associated xApps and rApps would be useless. As CSPs deploy new edge services, we expect the number of vendors and functions in the network to increase.

While a multivendor's telco cloud network is required, it is also necessary to implement end-to-end orchestration and automation of the network. The complexity of a highly distributed, multivendor's telco cloud means that automation is a must. One approach to automation is to use an army of engineers to create and maintain scripts for configuration management. The problem with this approach is that different engineers have different preferences for scripting languages and various approaches to scripting. Experience has shown that this has the potential to create a brittle architecture that is easily broken, causing significant impact to platform reliability and an increase in OpEx. A better approach is an end-to-end carrier-class orchestration and automation system designed to manage large, complex networks.

VMware Horizontal Telco Cloud Solution

The solution to solving the problems created by vertical vendor architecture is a common cloud horizontal architecture with integrated automation and orchestration. VMware’s Telco Cloud Platform provides a scalable and reliable horizontal solution as depicted in Figure 2. VMware Telco

Cloud Platform is a horizontal telco cloud architecture suited to multifunction, multivendors' implementations and multicloud deployments. It is a distributed architecture allowing for cloud deployments across national, regional, aggregation, edge, and cell-site data centers with a common cloud platform and management system. It provides fully automated service, network function, and Kubernetes orchestration and automation with VMware Telco Cloud Automation. VMware supports modern and legacy network functions using a cloud-native architecture supporting containers and hypervisors supporting virtual machines and legacy VNFs. It also provides virtual networking, storage, management, and orchestration.

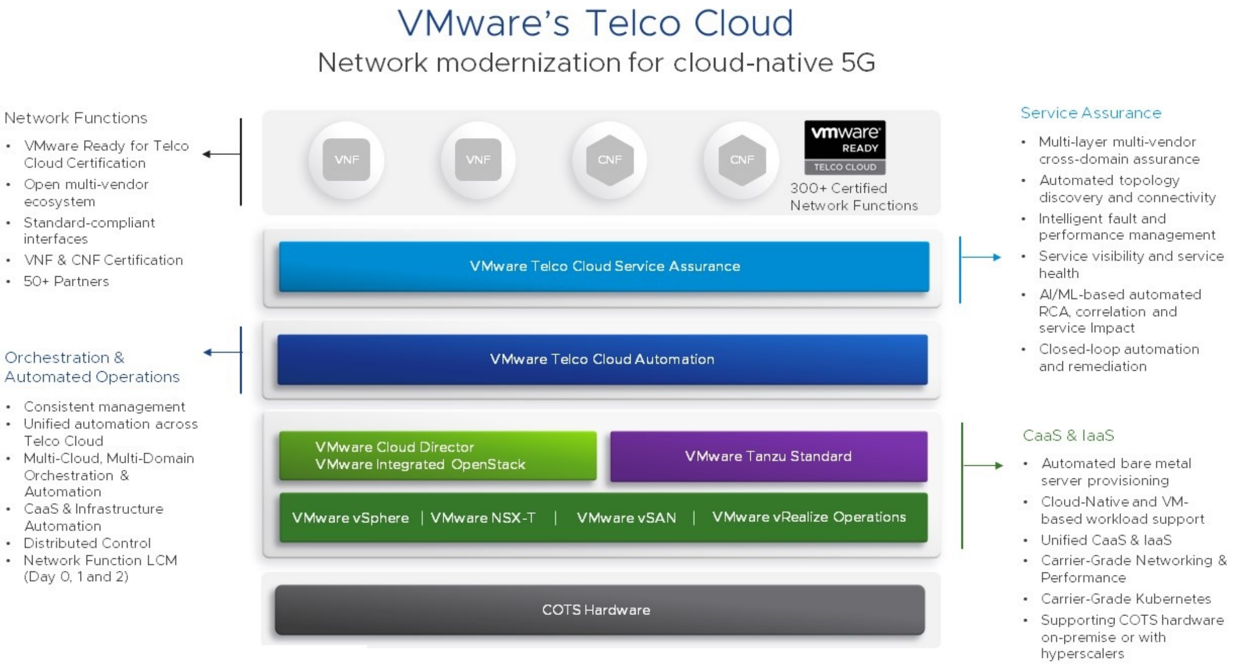

Figure 2. VMware Horizontal Telco Cloud Solution

Some of the key features and benefits of VMware Telco Cloud Platform are:

- VNFs, CNFs, containers, and VMs can run at high performance in a single environment
- Multivendors' HW and SW support
- Consistent architecture and software across regional data centers, edge data centers, and far edge data centers
- Supports applications in private clouds and public clouds
- Fully automated with VMware Telco Cloud Automation
- Reliable and high performance
- Large number of engineers and technical support worldwide are trained with VMware

VMware Telco Cloud Automation

A horizontal telco cloud architecture consists of multiple network functions, multiple vendors, and a complex distributed architecture. The number of network elements and complexity of the architecture drive the need for automation and orchestration.

VMware has recognized the challenge of telco cloud operations and developed a comprehensive, end-to-end, network and service automation and orchestration system. The key features and functions of VMware Telco Cloud Automation are depicted in Figure 3.

VMware Telco Cloud Automation is a comprehensive automation system that works across different layers of the network and across different domains. Examples of network domains are:

- RAN
- Cell Sites
- Provider Edge
- Core
- Public Cloud

Network domains consist of centralized and distributed data centers. VMware Telco Cloud Automation extends all the way to cell sites, which number in tens of thousands.

As Figure 3 illustrates, VMware Telco Cloud Automation provides automation and orchestration for network slicing, network services, network functions, multicloud CaaS and Kubernetes, and infrastructure. VMware Telco Cloud Automation improves efficiency across the network and reduces OpEx for Day 0, Day 1, and Day 2.

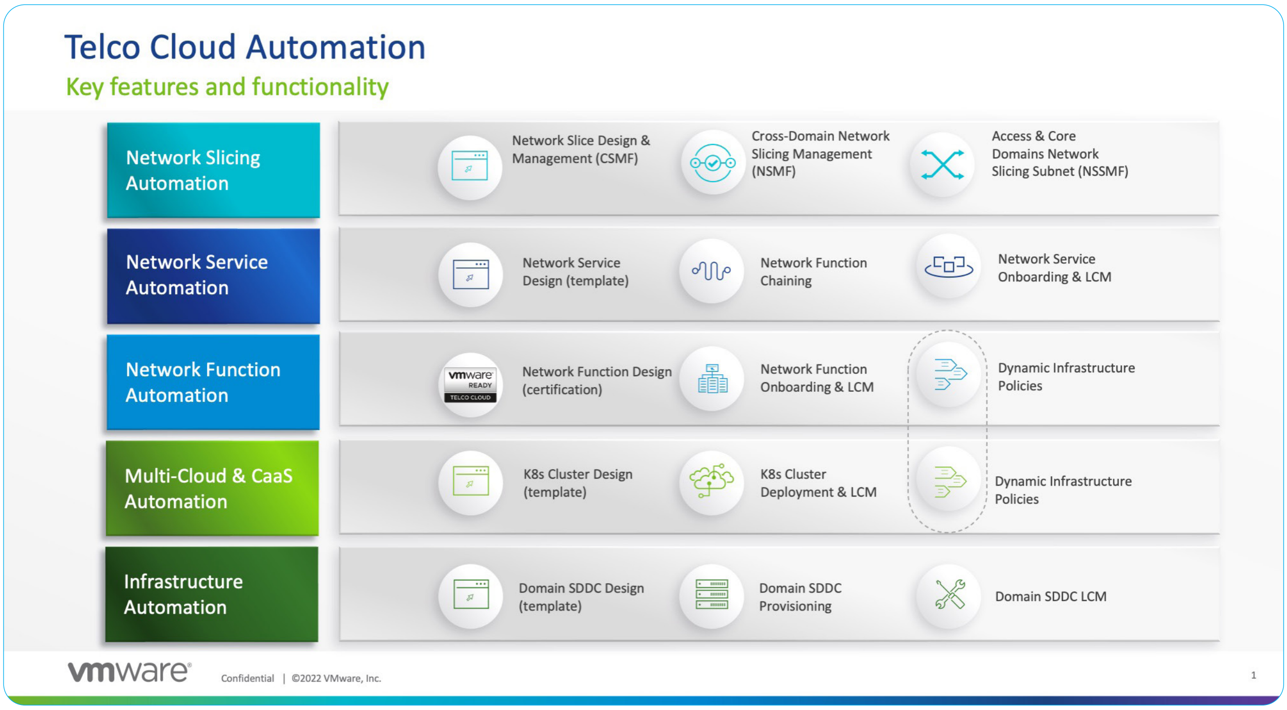

Figure 3. Telco Cloud Automation Features and Functions

Telco Cloud Business Modeling Objectives

The first modeling objective is to compare the Total Cost of Ownership (TCO) of three scenarios:

1. Vertical Silo Architecture.
2. VMware Horizontal Architecture without automation and orchestration software in VMware Telco Cloud Automation (these are the benefits of a horizontal architecture over a vertical architecture). This scenario can also be described as VMware Telco Cloud Platform without VMware Telco Cloud Automation.
3. VMware Horizontal Architecture with automation and orchestration software in VMware Telco Cloud Automation (these are the incremental benefits of VMware Telco Cloud Automation). This scenario can also be described as VMware Telco Cloud Platform with VMware Telco Cloud Automation.

The second objective of the business model is to show the benefits of service agility and accelerated time to revenue.

Network Architecture Assumptions

We have modeled a Tier 1 network in a Western European country or a region in North America. The dimensions of the network are:

- 15 million active subscribers
- 6 regional data centers
- 1000 edge data centers

We are modeling a 5G network with the following components:

- 5G core control plane, regional data centers
- 5G core user plane, regional & edge data centers
- RAN, CU, edge data centers
- RAN, DU, edge data centers
- MEC, edge services, edge data centers

In the first scenario we assume that a vertical silo architecture is used for:

- Packet core
- RAN
- MEC

Additionally, we assume two vendors (A and B) are used for packet core, RAN, and MEC. This leads to eight vertical silos:

- Two silos at the regional data centers
    - Packet core CP A & B
- Six silos at the edge data centers
    - UPF, RAN, & MEC (A&B)

Compute resources cannot be shared between silos. The ACG Business Analytics Engine (BAE) platform uses a visual approach to modeling. The model designer view of the silo architecture is presented in Figure 4. This is a TCO model of the 5G network where servers cannot be shared across the vertical vendor silos.

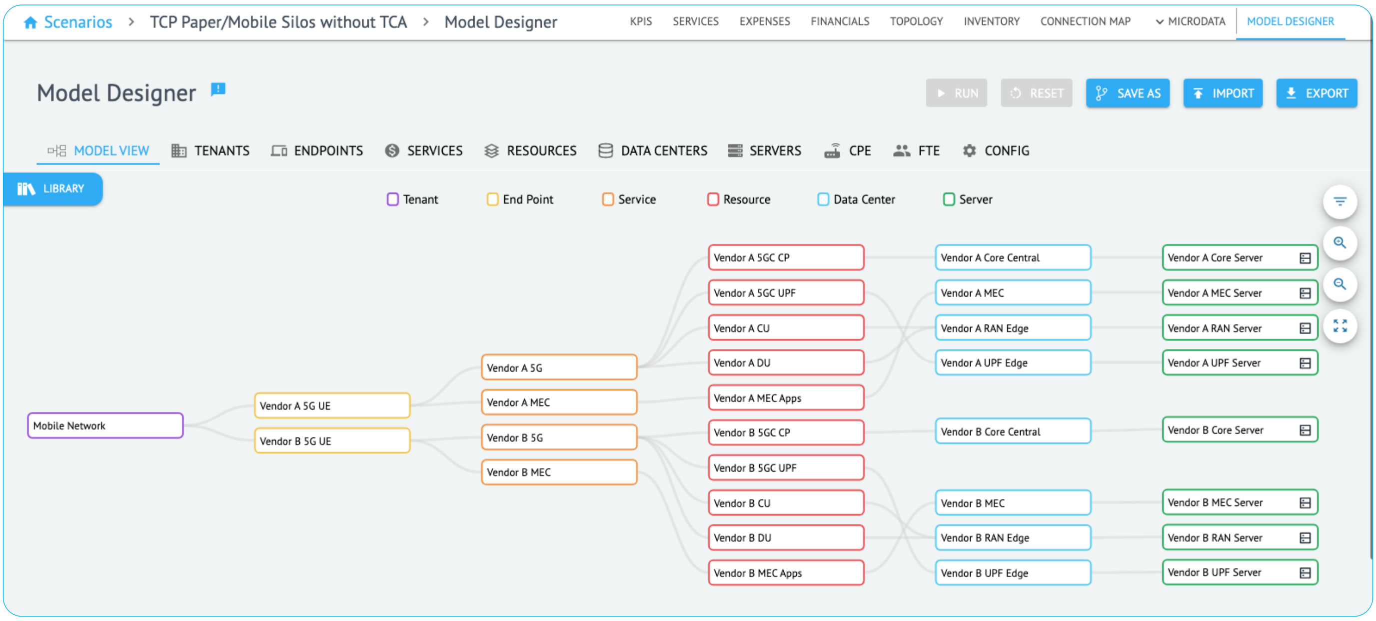

Figure 4. BAE Model Designer View of Vertical Silo TCO Model

The second scenario is the horizontal architecture without Telco Cloud Automation orchestration and automation. The key characteristics of this scenario are:

- The VMware Telco Cloud Platform without Telco Cloud Automation is used to create a telco cloud across the 5G network.
- In both regional and edge data centers all compute resources are shared, and as a result there is better utilization of compute resources.

The third scenario is the horizontal architecture with Telco Cloud Automation orchestration and automation. This is like Scenario 2 but with the additional operational and financial benefits of Telco Cloud Automation.

The BAE Model Designer view of the horizontal architecture is depicted in Figure 5. The visual view of the model shows how servers are shared across services and network functions using a telco cloud.

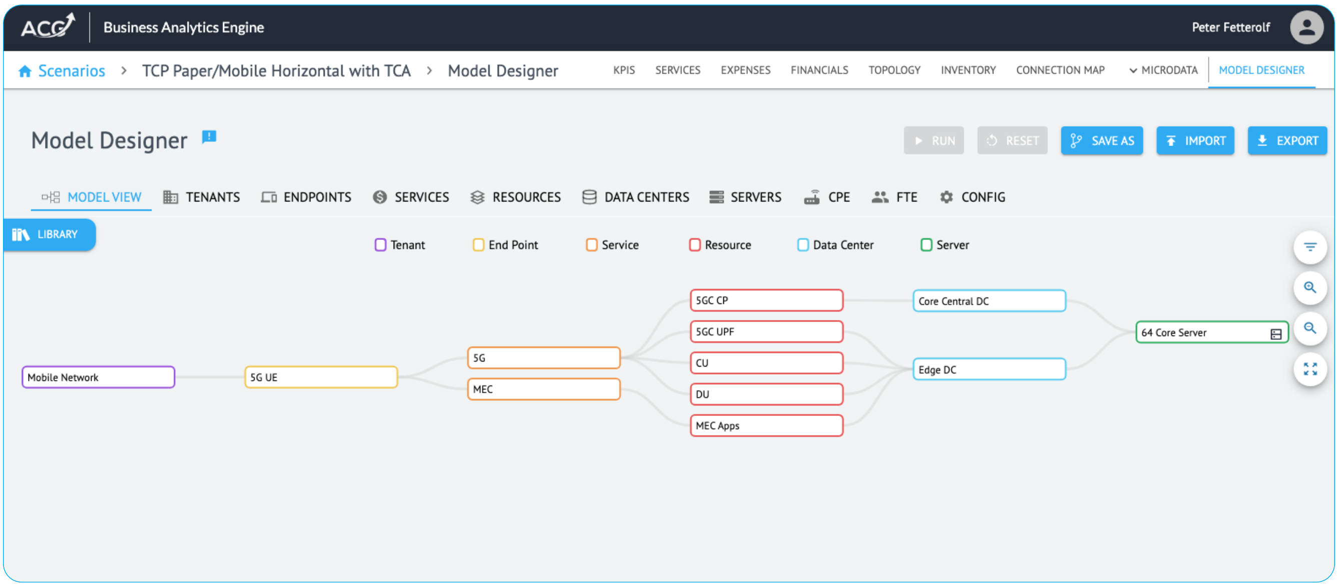

Figure 5. BAE Model Designer View of Horizontal Telco Cloud TCO Model

TCO Model Expense Considerations

The TCO model includes network CapEx and OpEx. The CapEx includes:

- Server costs
- Server installation expense
- Switches, racks, & cabling

OpEx includes:

- Power & cooling
- Facilities expenses
- FTE labor expenses
- Annual software licenses

For network OpEx, we model labor expenses to provision and operate infrastructure and network functions and services.

TCO Results

In the TCO analysis we consider:

- CapEx and OpEx savings
- Revenue acceleration
- Savings in power consumption and reduction in CO_2 emissions

Our results show a net **6% TCO savings** when deploying a horizontal architecture instead of a single vendor silo architecture and a **40% TCO savings** moving from a single vendor silo architecture to a horizontal architecture with orchestration and automation.

Moving to a horizontal architecture optimizes server utilization, which results in substantial CapEx savings, approximately 23%, and similar savings in OpEx environmental expenses (e.g., server power consumption). The significant TCO benefits of 40% savings are achieved when full orchestration and automation is added to complement the horizontal telco cloud.

The ROI of VMware Telco Cloud Automation over five years is **373%.** We also project a 5% revenue improvement within the five-year analysis due to increased service agility from VMware Telco Cloud Automation.

There are three key areas of savings:

1. Reduction of servers due to better server utilization in horizontal architecture,[2] which reduces both CapEx and server-related OpEx, (i.e., power).
2. Telco Cloud Automation reduces costs of FTE labor expenses due to automation and orchestration.
3. Telco Cloud Automation packs servers more efficiently with CNF/VNFs, which leads to further reductions in servers.

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[2] Note that silos do not allow sharing of servers between silos, which leads to lower server utilization and therefore more servers are required in silo architectures.

A TCO comparison of the three scenarios is presented in Table 2 and Figure 6. This TCO is calculated for the end-to-end network that consists of the 5G core, RAN, and MEC edge computing services.

Complete Network	Five-Year Cumulative TCO	Savings over Silos
Horizontal with Telco Cloud Automation	$548 Million	40%
Horizontal without Telco Cloud Automation	$861 Million	6%
Silos without Telco Cloud Automation	$912 Million	N/A

Table 2. Five-Year Results of TCO Comparisons

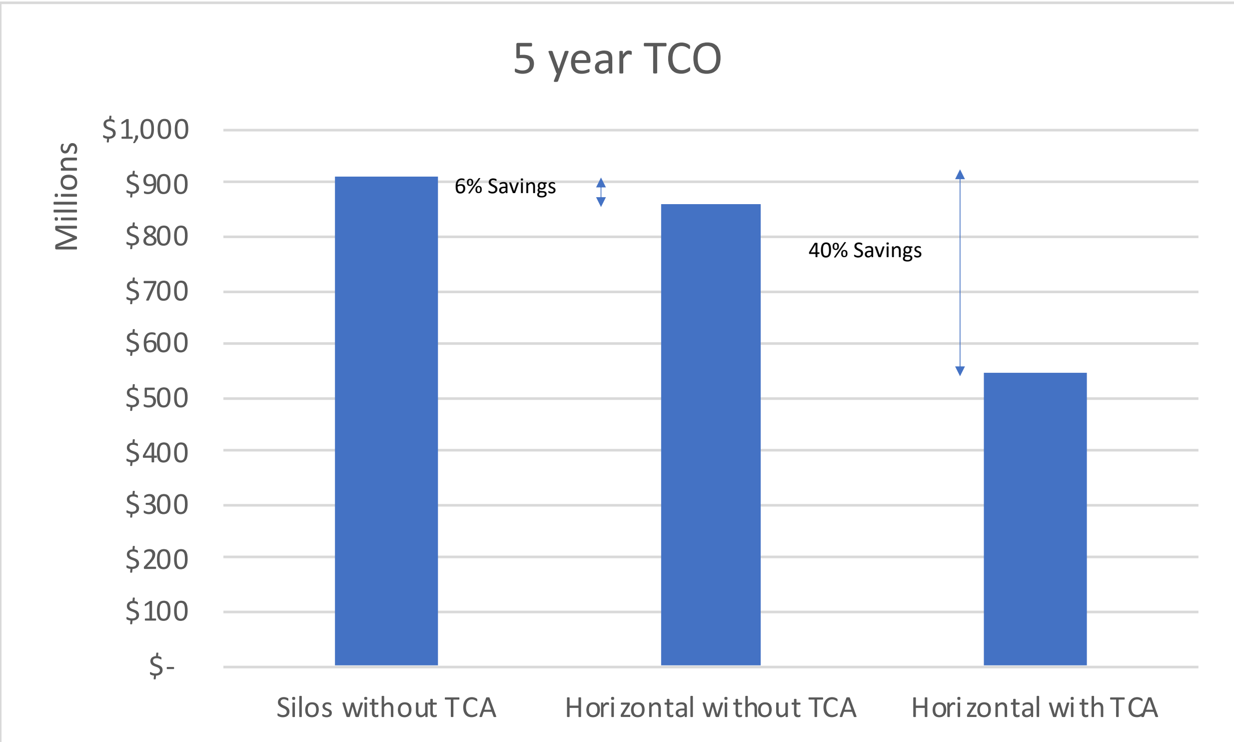

Figure 6. TCO Comparison of Three Scenarios

Telco Cloud Automation significantly reduces network TCO resulting in an ROI on the Telco Cloud Automation investment of 373% over five years.

A key area of savings moving from vertical silos to a horizontal telco cloud is reducing the number of servers, which is due to sharing servers between different vendors and xNFs. The number of servers for each of the eight vertical silos is presented in Table 3. The number of servers in the horizontal telco cloud is presented in Table 4, and a comparison of the number of servers is presented in Figure 7. The reason that fewer servers are required in the horizontal architecture is that these servers support different workloads with various operating system requirements and therefore server utilization is more efficient.

Server Name	2023	2024	2025	2026	2027
Vendor B MEC Server	124	840	1998	2760	4000
Vendor A RAN Server	124	840	1998	3680	4000
Vendor B Core Server	19	84	200	276	300
Vendor A MEC Server	124	840	1998	2760	4000
Vendor B UPF Server	62	560	1332	1840	3000
Vendor A UPF Server	62	560	1332	1840	3000
Vendor A Core Server	19	84	200	276	300
Vendor B RAN Server	124	840	1998	3680	4000
Total Required Servers	**658**	**4648**	**11056**	**17112**	**22600**

Table 3. Number of Servers for Each Vertical Silo

Server Name	2023	2024	2025	2026	2027
5G Core Server	33	136	324	462	486
Edge Server	372	2240	5994	11040	14000
Total Required Servers	**405**	**2376**	**6318**	**11502**	**14486**

Table 4. Number of Servers in Horizontal Architecture

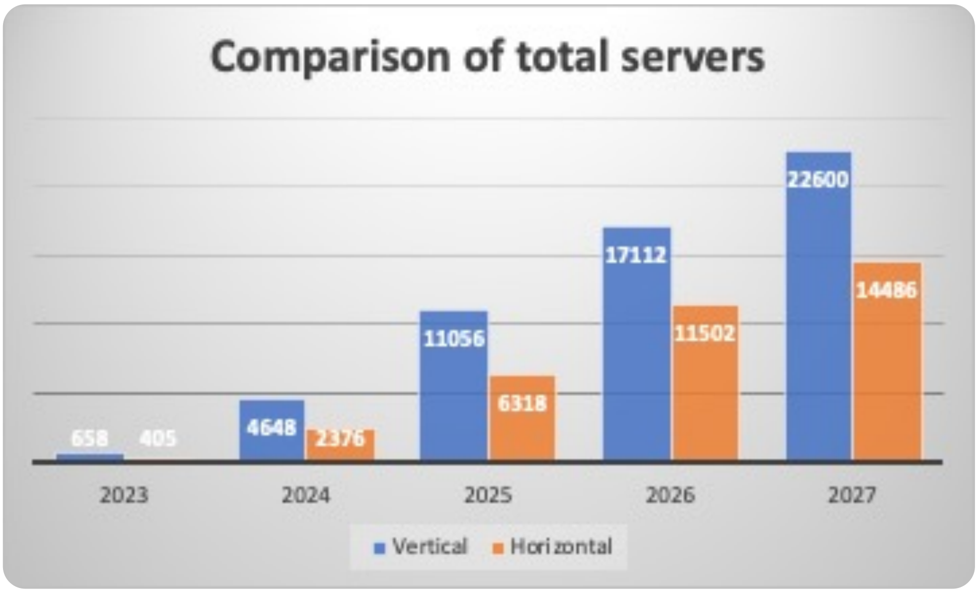

Figure 7. Comparison of Servers between Vertical Silos and Horizontal Telco Cloud

The model projects 22,600 servers are needed for the vertical silo solution while only 14,486 servers are needed for the horizontal solution, representing a **substantial 36% reduction** in required servers.

In our models, we consider application layer FTEs (focusing on services and xNFs) and infrastructure FTEs (focusing on hardware and cloud infrastructure). There are multiple types of FTEs in each category, and we consider Telco Cloud Automation savings in labor as compared to manual automation using scripting languages (i.e., Ansible). Scripts need to be maintained, and they sometimes contain errors and, as such, are labor intensive. Telco Cloud Automation is a comprehensive end-to-end network automation and orchestration platform that reduces manual processes and eliminates the need for cumbersome scripts.

The horizontal VMware Telco Cloud Platform with Telco Cloud Automation also results in significant power savings and carbon reductions. Over five years the savings related to power are:

- US$9.67 million savings
- 69,048,510 reductions in Kilowatt hours
- 29,870 CO_2 metric tons reduced

The savings in CO_2 is equivalent to eliminating 6,436 cars for one year or eliminating heating and cooling 5,812 homes for one year[3]. This is because data center power consumption for both powering systems and cooling is extremely high and the horizontal telco cloud with Telco Cloud Automation results in a 36% savings in power.

Detailed comparisons of vertical vendor silos and the telco cloud horizontal architecture with Telco Cloud Automation scenarios are presented in Figure 8 and Figure 9. In these figures, the charts on the left present the silo scenario and the charts on the right present the horizontal with Telco Cloud Automation scenario. The bar charts in the middle represent the differences between the silo and horizontal with Telco Cloud Automation scenario. Only the top 10 expense categories are presented in these charts.

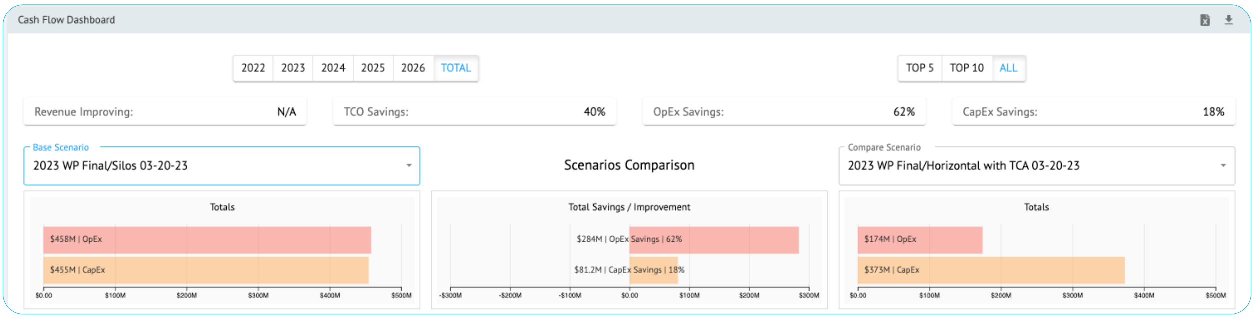

Figure 8. TCO Comparison of Silos with Telco Cloud Horizontal with Telco Cloud Automation

The key results are: OpEx savings: 62%, CapEx Savings: 18%, Total Savings: 40%

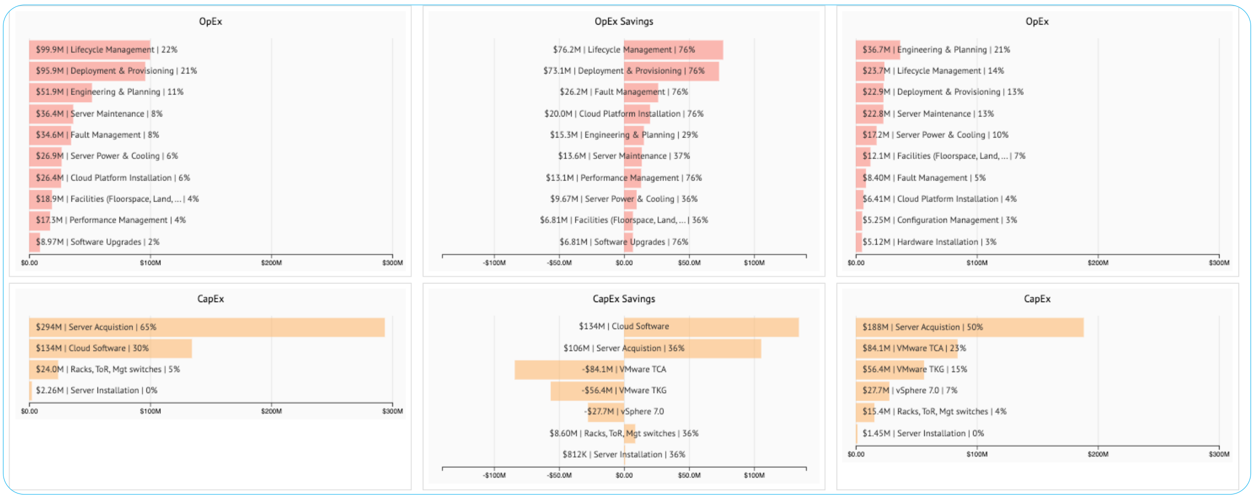

Figure 9. CapEx and OpEx Breakdown of Comparison of Silos with Telco Cloud Horizontal with Telco Cloud Automation

[3] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Within the OpEx savings of 62%, the three top areas of savings are achieved through life-cycle management, deployment and provisioning, and fault management.

We also highlight the 5G core and the RAN domains in separate TCO models. Note that the MEC functions are not included in either of these models. The results for the 5G core are presented in Table 5 and the results for the RAN are presented in Table 6. It should also be noted that as more functions are added to the horizontal architecture the TCO and operational benefits continue to increase, as the value of automation proves very important to manage the greater number of functions.

5G Core	Five-Year Cumulative TCO	Savings over Silos
Horizontal with Telco Cloud Automation	$169 Million	40%
Silos without Telco Cloud Automation	$281 Million	N/A

Table 5. Five-Year Cumulative TCO Comparison for the 5G Core

RAN	Five-Year Cumulative TCO	Savings over Silos
Horizontal with Telco Cloud Automation	$236 Million	35%
Silos without Telco Cloud Automation	$362 Million	N/A

Table 6. Five-Year Cumulative TCO Comparison for the RAN

Revenue Acceleration

In addition to TCO savings, Telco Cloud Automation provides a flexible architecture and increases service agility. This means that new services can be rolled out quickly. For the revenue model we make the following assumptions:

- Telco Cloud Automation allows operations to turn up services three months faster than networks without Telco Cloud Automation.
- Exactly the same revenues over time but with a three-month delay for networks without Telco Cloud Automation.
- $50 per month per subscriber.

Many CSPs take 6–12 months to rollout new services. Since Telco Cloud Automation automates service deployment we assume that service deployment can be reduced by three months, which is a conservative assumption. The results of this analysis are presented in Figure 10. Accelerating revenue by three months over a five years leads to a cumulative five-year revenue improvement of 5%. Since revenue is much larger than expenses this amounts to $1.12B in revenue improvement for the network under consideration. Revenue improvement in absolute dollars is higher than the TCO savings, constituting an example of the power of service agility and revenue acceleration. We have not considered revenue from new 5G services, which could further improve both revenue and profitability.

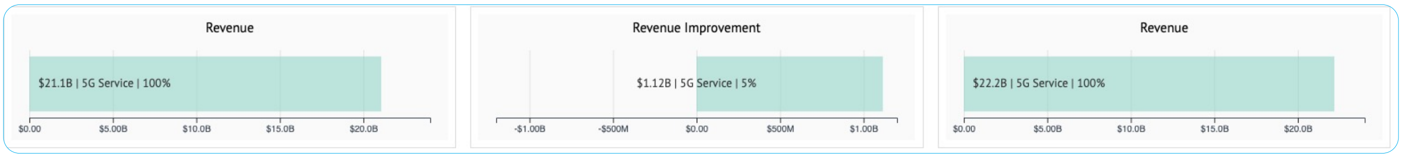

Figure 10. Five-Year Cumulative Revenue Improvement due to Increased Service Agility

Conclusion

Vertical vendor architectures have been attractive to CSPs because the packet core vendors have taken on all responsibilities for network software and hardware integration. While this was beneficial in the early days of virtual packet core deployments, it is now a hindrance to successful deployments of telco cloud and new 5G services. As CSPs implement distributed packet core user planes, deploy vRAN architectures, and deploy edge services and applications, the cost of operating and managing a network based on vertical vendor architectures grows significantly. In our TCO model, we have demonstrated that a horizontal telco cloud network with Telco Cloud Automation orchestration and automation has 40% TCO savings and an 373% ROI over a similar network using a vertical vendor stack.

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Peter Fetterolf, Ph. D. is an expert in network technology, architecture and economic analysis. He is responsible for financial modeling and whitepapers as well as software development of the ACG Research Business Analytics Engine. Dr. Fetterolf has a multidisciplinary background in the networking industry with over thirty years of experience as a management consultant, entrepreneur, executive manager, and academic. He is experienced in economic modeling, business case analysis, engineering management, product definition, market validation, network design, and enterprise, and service provider network strategy.