SOLUTION BRIEF

The Benefits of Virtual CPE – Business User

A study commissioned by Intel Corporation in collaboration with BT

Executive Summary

Virtual customer premises equipment (vCPE) is an alternative way for Communications Services Providers (CSPs) to deliver functions to their enterprise customers. Most of the functions of the CPE are virtualized, either being moved into the service provider's cloud and located near the service edge, or into a server at the customer's site. In this network architecture, the CPE is a simple layer 2 bridge- forwarding device, and the services run as virtual network functions (VNFs) on common-off-the-shelf (COTS) x86-based platforms.

On behalf of Intel Corporation, PA studied the impact of deploying virtual CPEs to small, medium, and large enterprise sites, where the VNFs are hosted in the network cloud or an on-site CPE server. This was done for four developed markets: Europe, US, Latin America, and Asia Pacific. Although there is a general consensus in the industry that the main driver for vCPE implementation is cost reduction, there is little information on the quantification of the associated costs and benefits. The benefits are likely to include reduced time to roll out new services to customers and easier management of a less varied fleet of installed CPEs.

PA developed a total cost of ownership (TCO) model for business users. This report presents the conclusions of that model. Our findings are based on the results of a five-year TCO that includes both capital expenditure (CapEx) and operating expenses (OpEx), extensive research, and our own industry insight. Our key findings for vCPE business users are summarized below.

The reduction in cost to the CSP of deploying CPE to a large enterprise is between 32% and 39% when they use vCPE in the cloud

The enterprise vCPE solution represents an attractive opportunity for CSPs in all four geographies analyzed. The impact of vCPE implementation in the cloud represents greater savings from end users that are large enterprises than small and medium enterprises (SMEs) and is similar in the four geographies—the cost reduction in the US is 32%, in Europe and Asia Pacific 36%, in Latin America 39%. The calculations in our analysis show potential savings worth USD $259M over a period of five years for CSPs with a 10% market share of large enterprises in the European market.

The CSP's cost savings are on average 17% lower for large enterprises and 71% lower for SMEs if CPE virtualization is in the customer premises rather than in the network cloud. This is mostly due to the increase in software costs and the decrease in hardware savings, as the efficiencies of scale are lost. The efficiencies of scale for a VNF platform include the possibility of sharing that platform with other users, that is, multi-tenancy. Most of the software cost increase is due to on-demand CPE VNF, such as WAN optimization.

Up to a 90% reduction in hardware costs for CSPs serving large enterprises

Traditionally, purchasing and managing hardware on the customers' premises represents around 42% of the total CPE costs in a large enterprise and can be as high as 59% in individual large offices and 62% in SMEs.

So the potential for cost reduction here is driving CSPs to implement vCPE solutions. Our calculations show that moving the equipment and support services to the carrier's network can result in cost savings in SMEs of 29% and in large enterprises 36% of the overall costs.

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Although the network cloud scenario delivers high savings for CSPs from both SMEs and large organizations, the savings are significantly lower for virtualization on customer premises. Our calculations show that in SMEs the hardware cost savings are cancelled out by software cost increases and the overall savings of 9.2% are due to the lower service costs.[1]

The cost savings in this case come from using the same hardware in a wider range of customer types and sizes than at present, thereby making it easier to manage the installed base of CPEs. This conclusion is valid for all the markets analyzed. In the case of Latin America the lower cost of service compared to hardware and software means the overall cost saving is only 2.4%.

Conversely, the cost benefits for small offices in large enterprises with on-premises virtualization are up to 40%. The hardware cost savings considerably outweigh the software costs and the changes in service costs are small. A similar conclusion is reached for medium and large offices in the same enterprise, with savings of 26% to 32%.

Service costs can be reduced by up to 48% when serving SMEs

vCPE is a vehicle for CSPs to reduce service costs by changing complex hardware used for customized services to virtual machines (VMs) on a cloud server. Alternatively, it could be replaced by generic hardware on customer premises running the VMs.

Reducing the hardware on customer premises lowers the likelihood of truck rolls to a site to deploy, upgrade, or swap CPE hardware. The associated service costs related to site visits for maintenance, commissioning of services, and decommissioning are much lower.

The difference in the cost of staff is significant among the analyzed markets. The day rate costs for CSP staff are assumed to vary by up to 6:1 between developed and developing countries. Despite those differences, our calculations showed savings in all of the four markets analyzed. Service cost savings can be as high as 48% when serving SMEs and 37% when serving large enterprises.

vCPE brings increased flexibility and scalability to network functions

Cost savings are the immediate driver for CPE virtualization by replacing expensive proprietary hardware, reducing the effort needed for upgrades and site visits. However, the other major benefit is in the flexibility that it brings, giving both CSPs and users greater power to scale and integrate network functions.

The use of virtualized telco platforms improves network agility, flexibility, and scalability by decoupling network functions from the hardware where they traditionally run, onto high performance standardized servers. This supports the evolution of the CSP's business model based on the provision of new services and capabilities with shorter time-to-market and less tie-in to vendors.

Intel can provide the model to interested parties

The TCO model on which the figures in this white paper are based can be made available by Intel subject to conditions, and with generic cost information only. This will enable interested parties to model the costs of virtualizing the CPE into the cloud or on servers at the customers' premises, compared to those of a conventional implementation. Users can enter their own costs, the number and usage profiles of their customers, and various technical parameters about the hardware and software involved.

1 Introduction and Background

Over the last few years the Communications Service Provider (CSP) community has begun moving towards a virtualized approach for network appliances. This allows CSPs to choose whether network functions are deployed as hardware-based appliances on customer premises or as virtualized software-based versions of their appliances that run on commercial-off-the-shelf (COTS) x86-based hardware platforms. This document contains PA's estimates of the total cost of ownership (TCO) and benefits of virtualizing the customer premises equipment (vCPE).

Just as cloud platforms revolutionized the IT industry, vCPE is revolutionizing the CSP segment by enabling CSPs to move beyond the restrictions of proprietary network appliances to improve service agility and time-to-market. It is no longer an innovative concept, but is widely recognized as the route for the CSPs to follow to build the next generation of lower cost, more adaptable, and more scalable network infrastructure. For enterprise users this will be achieved either by moving most of the CPE functions into the CSP's cloud or to a standard x86 server on the customer's premises.

This document contains PA's views on the TCO and benefits of virtualizing the CPE in emerging network architectures. This assessment was assisted by Intel Corporation, which commissioned the study, and by British Telecom (BT), which provided guidance based on their extensive practical experience[2] of virtualization in a CSP environment.

PA has developed a model of the TCO as seen by the communications service providers. These are shown relative to the costs of deploying conventional CPEs. This paper focuses on the results for business users, both small and medium enterprises (SMEs) and large enterprises (ENTs).

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To carry out this assessment we have:

- **Researched publicly available data** sources that contain information on market data such as Ovum, ETSI, 4G Americas, TM forum, Barracuda, Cisco, and Juniper
- **Interviewed knowledgeable personnel** within PA and CSPs that are familiar with virtual CPE services in the UK and tested assumptions and inputs with them
- **Performed a cost analysis**, CapEx and OpEx, and determined the potential benefits from virtualizing the CPE and architectures in the core network
- **Identified savings** set out as quantified TCO benefits for service providers
- **Identified possible non-TCO benefits**.

2 Cost Benefits of Moving to a vCPE Solution

The modernization in CSPs' networks has been restrained as it needs to accommodate legacy and proprietary network appliances and legacy services. vCPE, however, can provide CSPs with the business and technological capability, and the opportunity to change, giving them the ability to deliver agile and on-demand services in the same way as customer self-provisioning capabilities.

PA's TCO model for a Tier 1 CSP with a 10% share of the European market demonstrates that the vCPE-related costs in SMEs and large ENTs can be reduced by USD $6.3B and USD $2.6B respectively by implementing a virtualized solution in the cloud. Using a cloud-based solution may not always be possible, so the alternative of virtualizing onto a virtual network functions (VNFs) platform located at the customers' premises has also been considered. The cost savings in this case are reduced to USD $2.2B for large ENTs and USD $1.6B for SMEs.

The CPE cost over a five-year period has been modelled in terms of both capital expenditure (CapEx) and operating expenses (OpEx). This has been carried out for both the conventional implementation and vCPE in the customer premises through a COTS server or in the CSP's private cloud. The cost saving for vCPE as a percentage of the conventional network's cost was calculated.

The model was based on a CSP with a business footprint in Europe, US, Asia Pacific, or Latin America. For our example CSP we have taken a 10% market share of subscribers in the chosen region, 33% annual CPE refresh rate, 90% annual customer retention rate, and a TCO period of five years. The SME subscriber is assumed to be a single site; the ENT subscriber is assumed to have multiple offices with a split of 61% small offices, 34% medium offices, and 6% large offices. Other assumptions are given in Appendix A.2.

There are six contributors to the CPE costs considered in our analysis:

- Hardware costs
- Software costs (VNFs)
- Datacenter costs
- Service costs
- Communications links
- Tax

All the costs are specified for each year except Tax, which is assumed constant over time.

PA has analyzed the costs of these on the basis of a conventional approach and a virtualized approach - virtualization in the customer premises and virtualization in the network cloud.

The conventional TCO results over a five-year period are shown in Figure 1. The largest costs for CSPs are hardware costs and communications links. Communications link costs are the annual rental rates for various speeds of a Metro Ethernet connection and for DSL and are assumed to be the same in the conventional and virtualized models. Therefore, the largest savings of the model came from hardware and service costs, which are quite significant for SMEs particularly in developed markets.

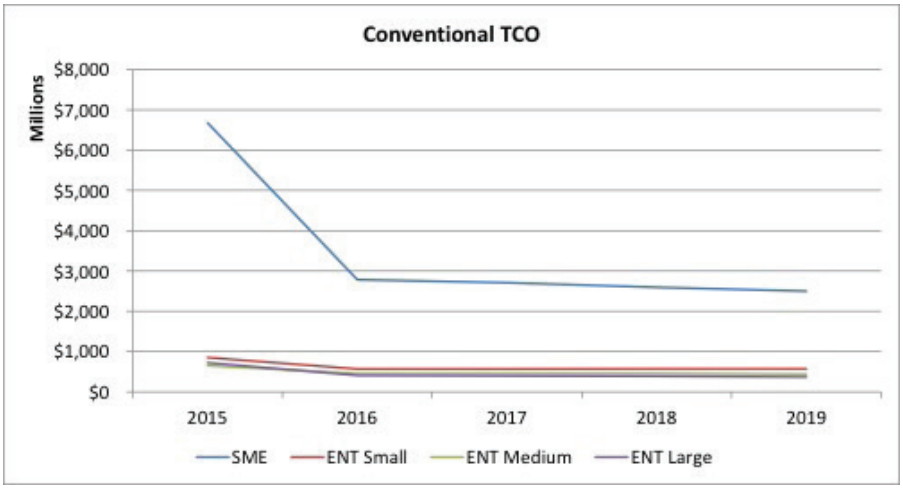


Figure 1. Conventional CPE TCO for Europe.

The reduction in cost to the CSP of deploying CPE to a large enterprise is between 32% and 39% if they use vCPE in the cloud

The results of a business vCPE solution are an attractive opportunity for both CSPs and vendors in the four markets analyzed. CPE virtualization in the network cloud evidenced greater savings than in the customer premises and large entities generally achieve larger savings in comparison with SMEs. Figure 2 shows the impact of CPE virtualization in the cloud for large enterprises in Europe.

An analysis of the costs to the CSP of CPE for large enterprises in Europe shows a five-year TCO of USD $7.3B. Most of these costs are hardware and communications link rental with just 2% being service costs. Of these, we have assumed that the cost of the communications links themselves will be unchanged by virtualization of the hardware functions at the end of the link.

The savings from virtualizing into a cloud service in the network range from 32% to 39% across the four markets analyzed.

By implementing a vCPE solution in the customer premises, the savings range from 27% to 33%. Enterprises choosing this approach to virtualization are likely to be driven by factors such as security and data handling regulations. Consequently, the price charged by the CSP is not the only consideration and it offers a way of realizing savings while still complying with the other requirements.

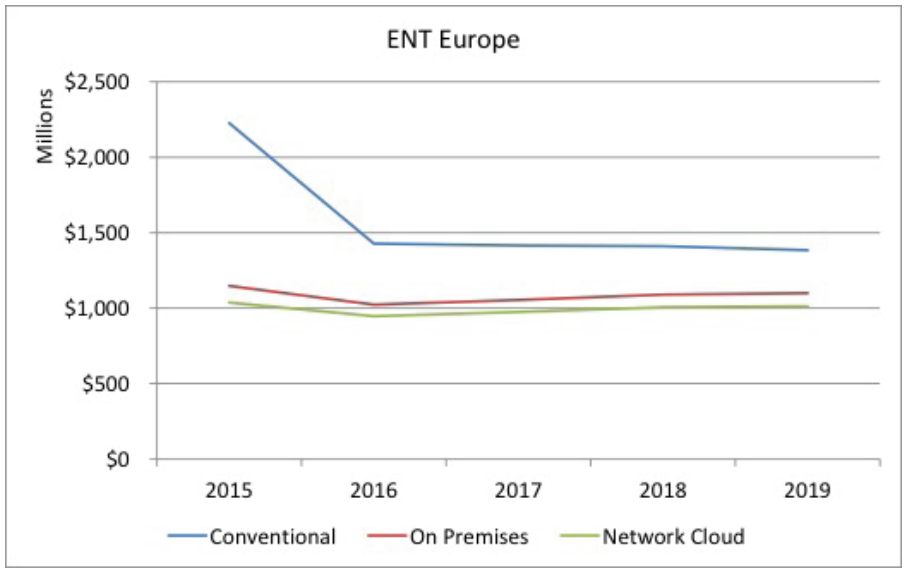


Figure 2. Relative costs of different CPE implementations.

Figure 2 illustrates the different levels of expenditure on conventional implementation and the two forms of virtual implementation.

Why does vCPE reduce costs?

CPE virtualization reduces the hardware capital expenditure by installing minimal equipment at the customer premises. Traditionally, purchasing and managing hardware on premises represent more than 44% of the total CPE costs and can be as high as 55% for large offices. Moving the hardware equipment, services, and human assets associated with the CSP's network can save costs for large enterprises.

Currently, the major items of expenditure in buying and running the CPE on premises are the WAN optimization and the firewall. WAN optimization by itself accounts for almost 80% of the hardware costs of a large enterprise.

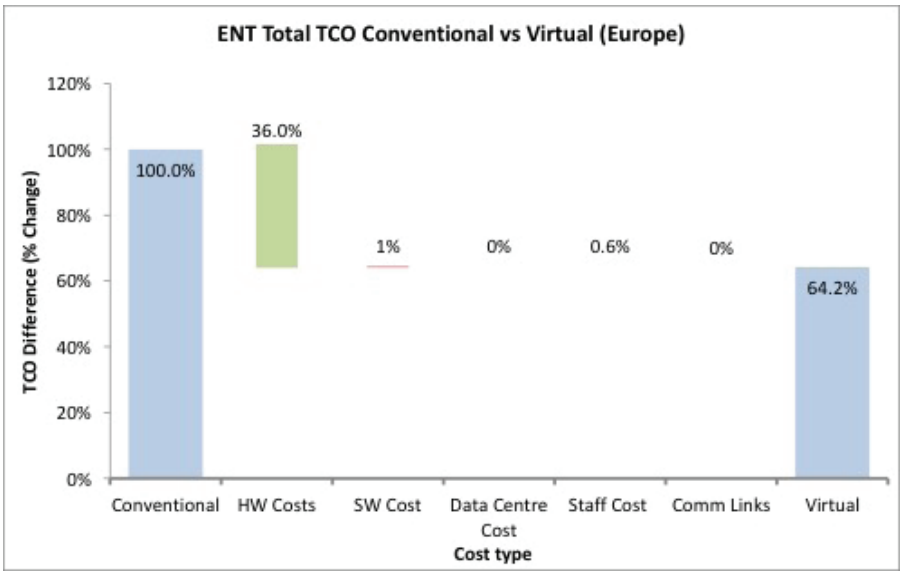
By changing those expensive hardware appliances to virtual appliances in the CSP's cloud, the equipment required is less in quantity and cost in comparison with the conventional scenario.

The savings from virtualizing onto hardware in the customer premises are lower but still positive.

Using a common hardware and low-level software platform across most or all users reduces the effort needed to manage and maintain it.

How much are the savings for a CSP serving a large enterprise?

The cost reduction in a large enterprise from virtualizing CPE in the CSP's cloud is 36% as demonstrated in Figure 3. For a CSP with a 10% market share in Europe, this represents a total savings of USD $259M over a period of five years.



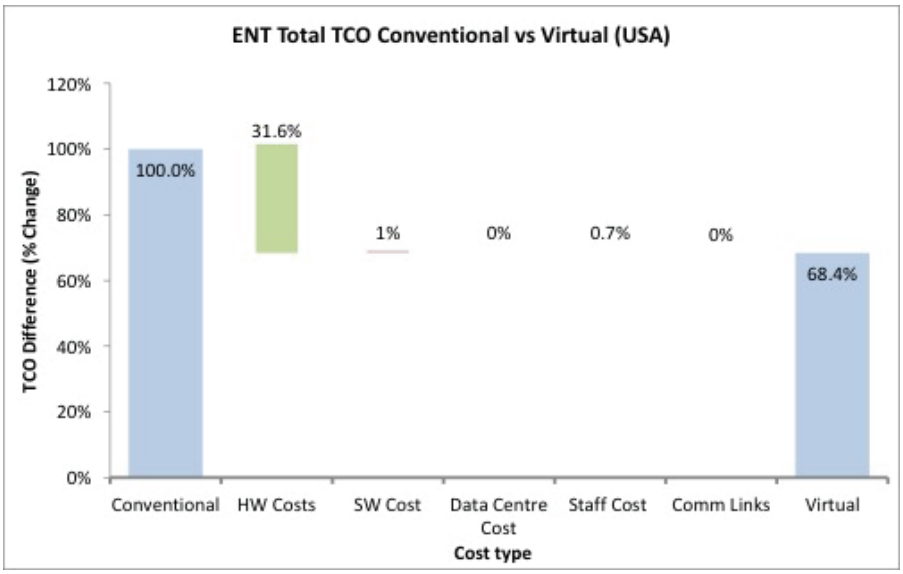


Figure 3. ENT total TCO conventional vs virtual % change in Europe.

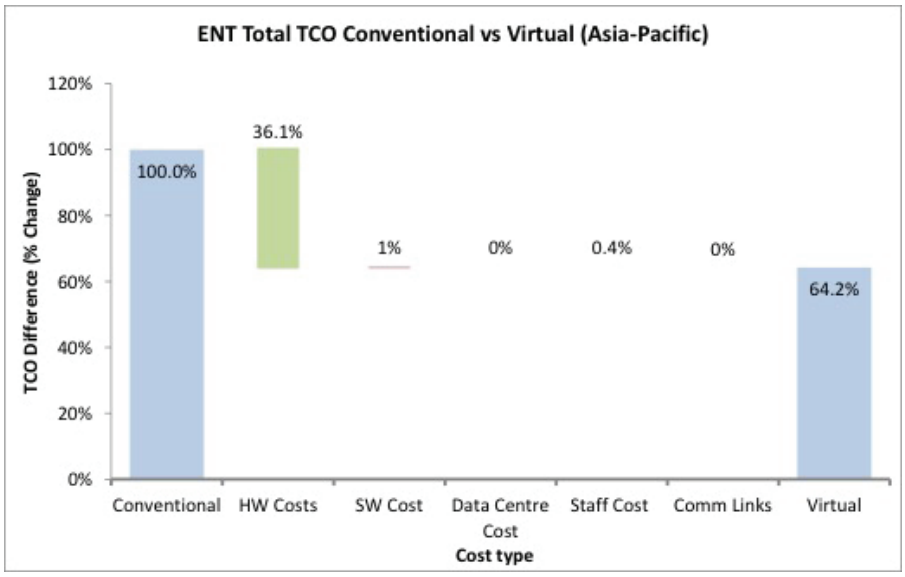
The main saving is achieved by moving from expensive, proprietary hardware to a low-cost, x86-based server. This can reduce CPE hardware costs for large enterprises by 85% or 90% depending on whether CPE virtualization is on the customer premises or in the cloud respectively.

The results for the remaining markets gave the same conclusions with an overall savings of between 32% and 39% as per Figure 4.

The reduction in cost to the CSP of deploying CPE to an SME is up to 33% if they use vCPE in the cloud

A comparison between SMEs and large enterprises shows that implementing a vCPE solution in the CSP's cloud represents greater savings for the CSP in large enterprises than in SMEs. The results of the model demonstrate that implementing a vCPE solution on-premises for SMEs is not particularly attractive. There is an initial savings on hardware costs partially offset by the software costs. However, the ongoing costs are similar or even marginally greater for on-premises virtualization compared to a conventional implementation. Only virtualization into the cloud shows a sustained saving in SMEs. The problem is that with lots of small installations the advantages of scale are lost.

On-premises virtualization may still be attractive for other reasons. For example if the link to the customer's site is low or has variable bandwidth, the service quality may be improved by putting the VNF servers on site. Advantages such as the ease of software management over a hardware implementation would still apply.



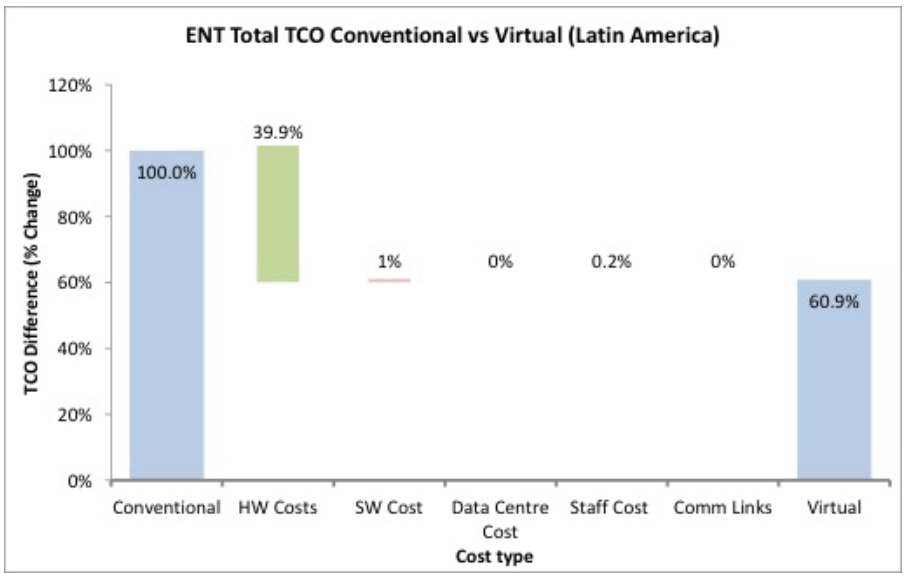


Figure 4. Cost reductions from implementing a cloud-based vCPE solution in different regions.

An analysis of the conventional CPE costs in SMEs shows a five-year total of USD $17.3B. Virtualization at the customer premises reduces this to $15.7bn, and virtualization in the cloud further reduces it to USD $11.3B. The cloud arrangement is cheaper throughout the five years; the on-premises arrangement is cheaper in the first year then similar in cost to the conventional arrangement.

This is illustrated in Figure 5.

Why does vCPE implemented in the cloud reduce costs for a CSP serving SMEs?

CPE virtualization reduces the hardware capital expenditure and service costs by installing minimal equipment at the customer premises and by reducing the amount of support required.

Traditionally, purchasing CPE hardware represents around £7.3B over the five years, as shown in Figure 6. The saving comes from making the firewall into a software appliance.

The main service costs in a traditional model are CPE delivery and installation, and CPE decommissioning. Resolving problems ('trouble tickets') and service commissioning are also significant, as shown in Figure 7. By reducing the CPE hardware on-site, the cost of these activities is lower. CPE virtualization is a driver for CSPs to reduce service costs by moving complex hardware to the network cloud and replacing it with simple hardware on customer premises.

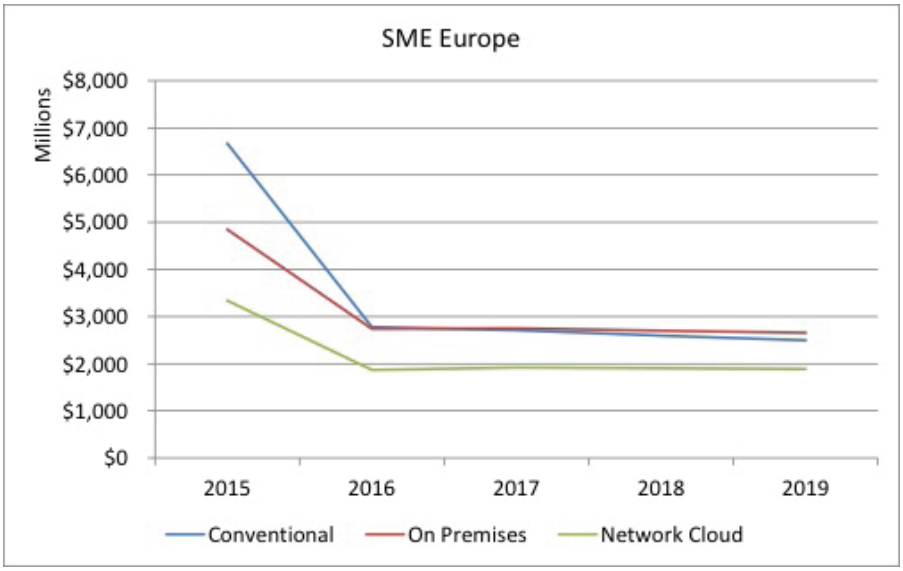


Figure 5. Impact of vCPE for SMEs in Europe.

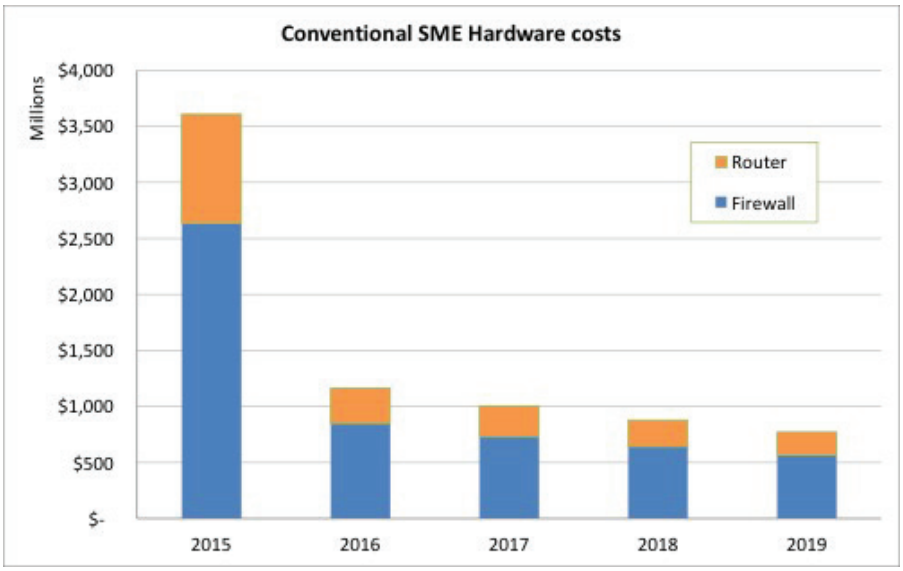


Figure 6. SME hardware costs – conventional model, European market.

How much are the savings relating to SMEs?

The cost reduction for a CSP serving SMEs by virtualizing CPE in the CSP's cloud is 37%, as illustrated in Figure 8. This represents a total savings of USD $6.3B over a period of five years in the European market.

The main savings is achieved by moving expensive CPE hardware to the carriers' network cloud. This can reduce SME CPE hardware related costs by $5.0bn. The results for the remaining markets showed the same conclusions in regards to the hardware savings. As per Figure 8, the reduction in hardware cost by changing from conventional to virtual functions is 29% of the conventional TCO.

In terms of absolute numbers, service costs tend to be higher in small organizations compared to large offices. Figure 9 shows the total service costs in the conventional and virtualized scenarios for SMEs in Europe. The service cost savings for SMEs in Europe can be up to 48% or USD $1.6B over five years. Similar cost savings are applicable for the remaining markets: 48% in the US, 47% in Asia Pacific, and 45% in Latin America.

Why does vCPE implemented on the SME's premises have a smaller effect on the CSP's costs?

Virtualizing the CPE functions onto cloud servers in the network is undesirable in a number of situations. If the link between the customer site and the network is of low or variable bandwidth, a reduction in the quality of service may result. In some jurisdictions and/or types of business there may be data protection requirements that mean the data must remain within the customer's facilities.

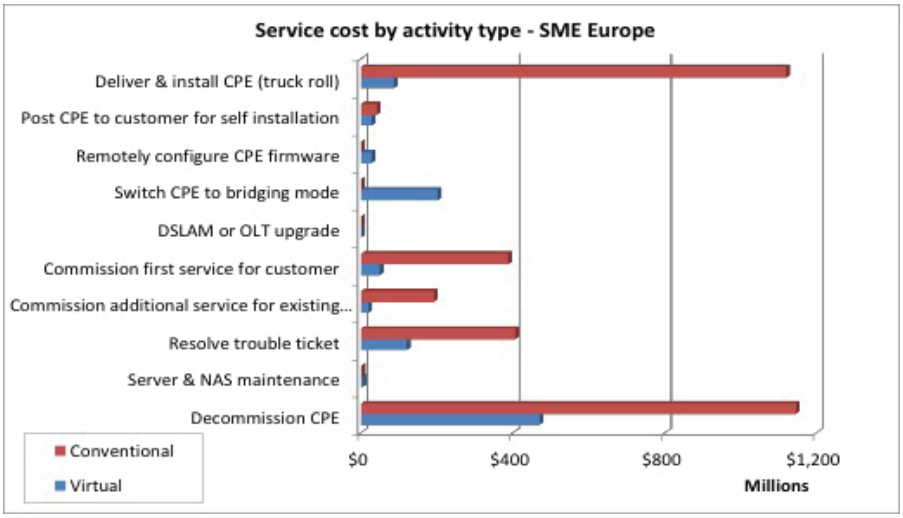


Figure 7. Service costs per function – conventional versus virtual (Europe).

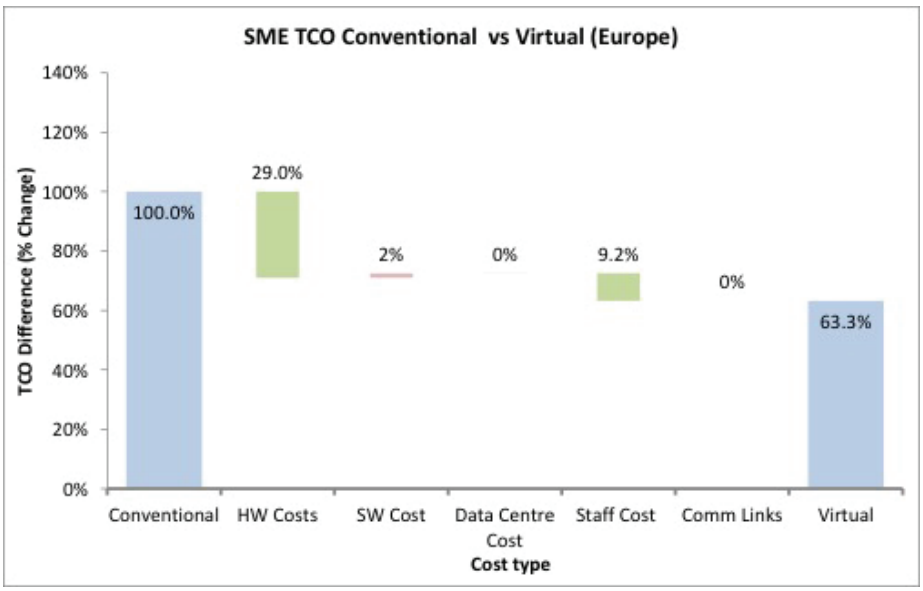


Figure 8. SME total TCO conventional versus virtual % change.

Repeating the above analysis with the CPE functions virtualized onto servers at the customer premises shows that there is still a cost benefit from virtualization, although it is smaller than if network cloud servers are used. This is illustrated in Figure 10.

It can be seen that compared to Figure 8 the savings in hardware costs is lower and the cost of VNF software is much higher, to the point that they largely cancel each other out. The overall savings are due to the reduction in service costs.

The increased hardware costs for on-premises virtualization are because a large number of individual servers are now needed. Although the cost of each is lower than the high-performance servers used in the cloud model, the total hardware cost is still higher. The software cost increase is because the cost per subscriber for the VNF software is lower where there are many users of one high-capacity server compared to many licences for small numbers of users.

As with cloud virtualization, the effect is broadly similar across the different regions. However, as the savings are mainly from the service cost, their variation has a much larger effect on the overall savings. In the case of the region with the lowest staff costs, Latin America, the net savings for virtualizing SMEs is just 2.4%.

The business case for virtualization in this scenario may still be justified when factors other than TCO are considered, as described in the following sections.

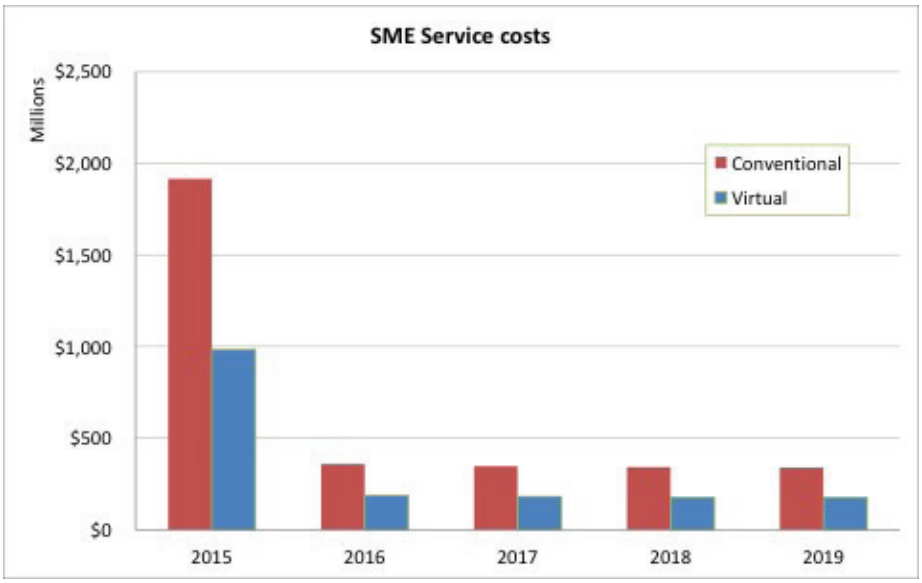


Figure 9. Service costs for SMEs in Europe.

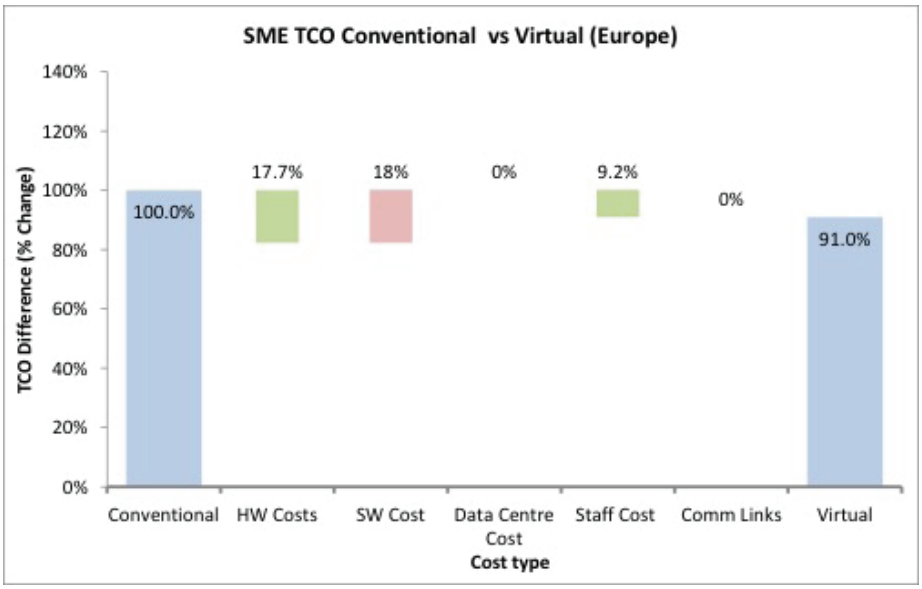


Figure 10. Effect on SME costs from virtualization on-premises.

3 Time to Market

Virtualizing the CPE brings a benefit to CSPs of reducing the time to bring a new service to market. This is not directly a cost benefit but is about creating, or realizing, a market opportunity.

Bringing a new service to market will in many cases involve a new item of CPE hardware, or an upgrade to an existing device. The time taken to develop the new device will involve printed circuit board (PCB) layouts, possibly new chips in some cases, and the build and test of the prototypes. A virtual appliance equivalent will still need specification, design, development, and testing. But it can shorten or skip altogether some stages of a hardware development, such as the time to fabricate and build, and the environmental and electromagnetic compatibility (EMC) tests.

Once the development and testing is complete, the deployment is faster too. There is no manufacturing ramp-up time for VNFs. The distribution is done via near-instant online software distribution rather than shipping hardware, usually in several stages from factory to customer.

Some of the new services may require an upgrade to the server platform. Even in this case, the servers are more likely to be COTS equipment than an equivalent dedicated CPE device This removes the design, development, and testing stages, and reduces the time to obtain the new hardware in volume.

The financial benefit will broadly come from the time savings described above, multiplied by the customers' combined spend on the new service. Both of these factors are highly dependent on the specific service being deployed. For that reason, the financial benefit is not quantified here.

The earlier start to earning revenue brings two advantages: the increase in total revenue from having typically several extra months of service provision and the benefit from interest or discounted cash flow (DCF) factor in getting the revenue with a shorter delay from the time of the up-front cost investment.

4 Other Non-TCO Benefits

Although costs savings are the immediate driver for CPE virtualization by replacing expensive proprietary hardware, reducing the need for upgrade and site visits, its true power is the flexibility that it brings to the network functions, giving both CSPs and users greater power to scale and integrate network functions.

The use of virtualized CSP platforms improves network agility, flexibility, and scalability by decoupling legacy network functions from the hardware where they traditionally run, to the CSP cloud. This supports the evolution of the CSP's business model based on the provision of new services and capabilities with shorter time-to-market and with less tie-in to vendors.

CPE virtualization improves network agility, flexibility, and scalability

Network functions virtualization improves network agility, flexibility, and scalability by shifting IP functions from dedicated hardware platforms such as firewalls, load balancers, application accelerators, routing, and mobile packet gateways to the CSP's own network. CSPs can now instantiate, configure, scale, and manage a variety of network functionalities and features dynamically on any server as VMs. This helps them to operate a flexible and customer-oriented network with services that continuously improve, evolve, and upgrade.

vCPE solutions improve customer experience and customized services

CSPs around the world see the benefits that will accrue from the adoption of virtualization and look at it as adding new growth potential into their business models. They are looking to rapidly introduce new services, to utilize their resources more efficiently, to increase operational savings, and to add the flexibility to address customer needs in a cost-effective way. CPE virtualization helps CSPs to retain current customers by improving their customer experience at lower cost. It is now cost-effective to provide personalized services to current customers in a short period of time. It also opens the door to new clients and new revenue sources; it is now viable to provide customized network services to small virtual network operators and upsell new revenue-generating applications.

vCPE allows the provision of services to new customers more quickly

By virtualizing the CPE, new services and capabilities can be launched instantaneously from the CSP cloud, making it easy to add, remove, or scale services dynamically and with minimal up-front investment in new hardware. Some examples include bringing up new sites, offering customized network capabilities and services for individual subscribers, adding a new firewall or router, or on-boarding a new subscriber. These are now possible in a short period of time and without purchasing or installing any physical appliances. This allows CSPs to profitably operate in a future market that demands services with a much shorter life cycle.

"Try before you buy" is made much easier

As the CPE function is turned from a physical machine into a virtual one, installing and removing it becomes much easier. This enables a CSP to offer a time-limited trial with little cost or risk. This could be of benefit to a customer that is unsure whether to commit to a new service or is unsure what specifications they may need.

CPE virtualization enables vendor-agnostic services

The fast-paced market demands CSPs to be agile and offer new services and capabilities quickly and without locking into proprietary hardware-based features. CPE virtualization allows CSPs to select the best suited and most cost-effective gateways and software functions, regardless of vendor or physical devices, to enhance network flexibility and accelerate the deployment and upgrade of new services and features.

Virtualizing CPE into the cloud brings savings from synergies between different users

Where the vCPE is implemented using a network cloud server, different usage profiles can be combined to make more efficient use of the resources. For example, enterprise users are typically daytime users and residential users are typically evening/night time users. The same resources can be used for both, reducing the overall investment required.

5 The Challenge of Changing to a Virtualized CPE

In considering whether to switch to a virtualized CPE solution, a number of factors need to be considered. The main challenges behind vCPE are the perception that integrating a virtualized solution with other services will be difficult and expensive. Not all vCPE solutions are mature enough, which creates concerns about security and reliability. Transition and transformation is also complex, requires staff training, and may have budget requirements that are perceived as an unknown cost.

CPE virtualization can offer the breakout from the current slow but steady decline in CSPs' profitability. It can do this both by reducing CapEx and OpEx costs and by opening up potential new revenue streams from IP-based managed network services. Having invested in a hardware and low-level software platform to run the VNFs, this could be offered as Platform-as-a-Service or Infrastructure-as-a-Service (PaaS/IaaS) to other application service providers. Business models could include a simple lease agreement or a revenue-share arrangement.

PA analyzed the market opportunity for vCPE and concluded that for a mobile operator with 10% market share in Europe, CPE virtualization in the cloud can deliver a total cost savings of 59% to large enterprises and 32% to SMEs over a five-year period compared to a conventional deployment, as demonstrated in section 2 of this report.

Also, a recent report from Ovum predicted that the market for NFV products at CSPs would reach USD $3.4B by 2020, equalling a "market roughly the same size as the service provider IP core router market."[3]

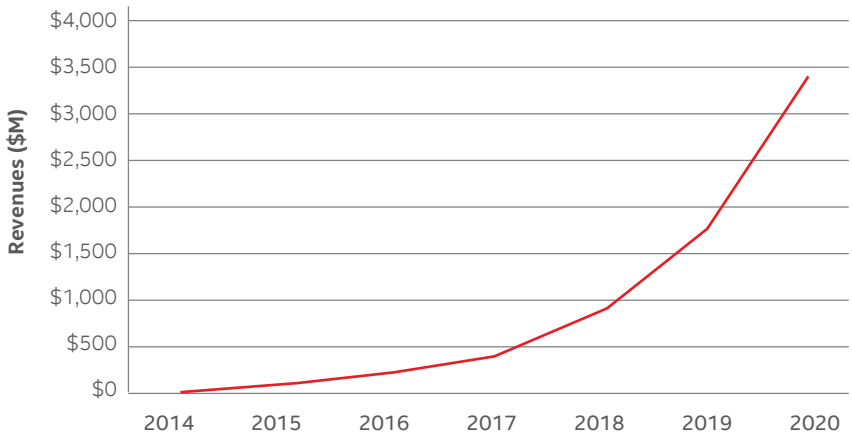


Figure 11. Ovum's forecast for NFV revenues 2014–2020.

Despite this growth, Ovum does not expect the global NFV market to exceed $500m in revenues until 2018, as per Figure 11. Also, a broader NFV implementation is not likely to kick off until 2016.

The European Telecommunication Standards Institute (ETSI) identified nine potential use cases for NFV and estimated the plan and rollout of each of the specific virtualized network functions:

- Security: Firewalls, IDT systems
- Application optimization
- Traffic analysis
- Network functions: AAA, policy control
- Switching: BNG, CGNAT, routers
- Tunnelling gateway elements
- Home routers, set-top boxes
- Mobile network nodes: HLR/HSS, MME, xGSN, RNC
- Signalling: SBCs, IMS

According to ETSI research, the opportunity for CPE virtualization will be sooner rather than later and will be focused on network services' appliances, such as access routers, WAN optimization controllers, firewalls, IDT (intrusion detection systems) and devices for packet inspection. This is illustrated in Figure 12.

What are the perceived challenges and barriers for vCPE implementation?

Transformation and migration: New skillsets for the workforce are essential and staff training is a must as CSPs historically have not had as much as experience with virtualization as the IT industry. Hence this experience needs to be bought in, acquired, or learned and could be a significantly heavy investment. The processes, technology, and people transformation is also perceived as complex, although that will change as virtual networks become more commonplace.

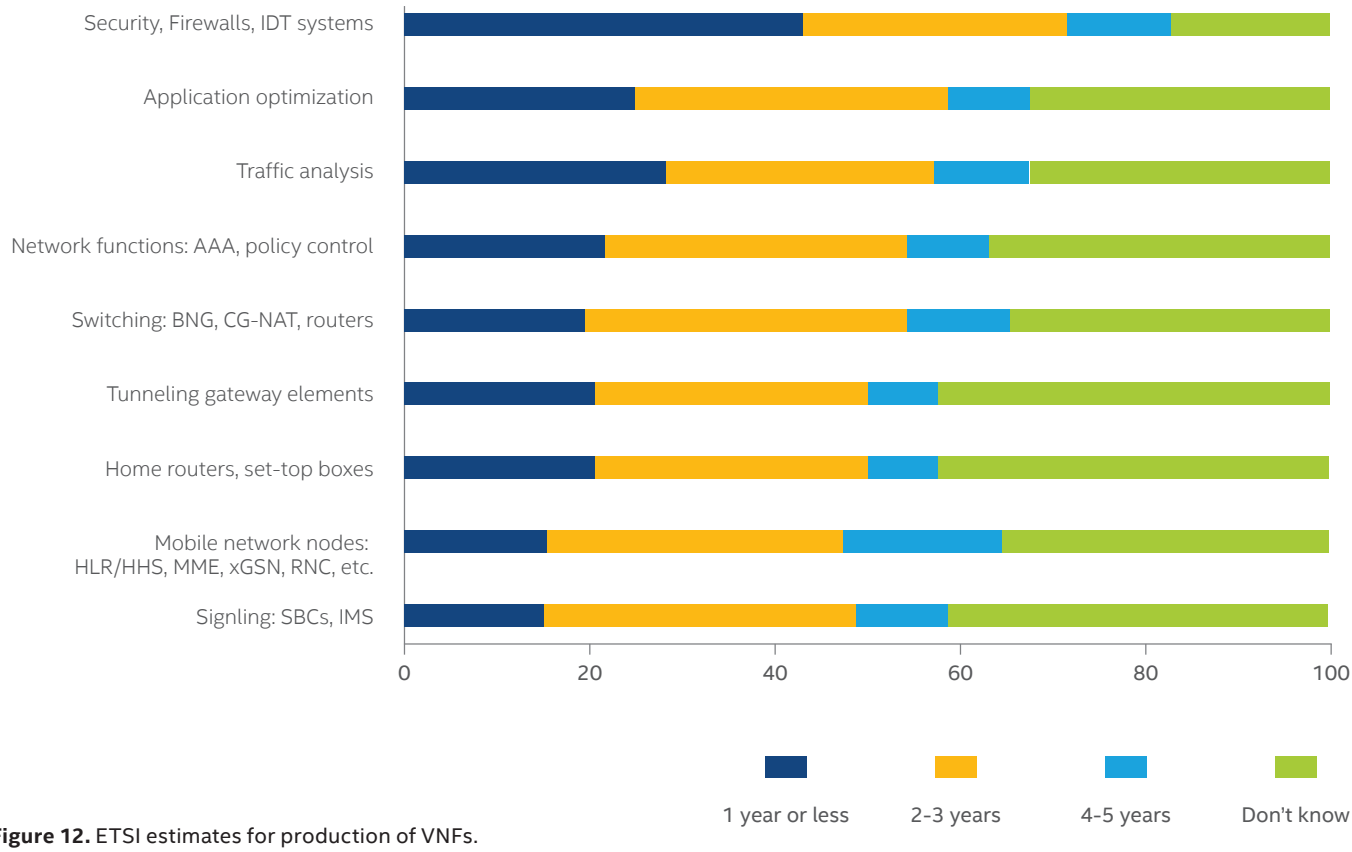


Figure 12. ETSI estimates for production of VNFs.

Maturity and interoperability: Technology is still not mature, which is creating concerns about reliability, security, responsibilities, and availability; for example, commercial availability of vCPE infrastructure to support the high throughput. The integration with legacy systems is also perceived to be difficult, namely, when multi-tenant or supplier solutions are required. This last point is in fact a reason why it makes sense to virtualize the CPE first, since enterprise CPE is usually supplied independently of the network supplier already.

Economies of scale and business issues: It is important to build sufficient scale to realize the benefits and pay back the investments in a reasonable time frame. It is also necessary to address the business-related issues, such as supporting the same level of service-level agreements and ensuring sufficient bandwidth to enable cloud-based services.

Management and operations: CSPs have to ensure network performance and user experience within the new vCPE architecture. Efficiency step changes in how virtualized networks are operated is challenging; for example, considerations for the cloud model (own private, hosted, hybrid) and how to maintain performance levels, how to cater to peak capacity, or how to ensure that service deployment and delivery are fast enough.

Benefits case: The TCO case may be challenged to achieve the targeted benefits through advances in technology and faster rollouts. There are some uncertainties about the size of "hidden cost."

Appendices

A vCPE Business User TCO Details

This section includes a description of the scenarios, principles, and assumptions behind the model, detailed results, and a sensitivity analysis.

A.1 Scenarios

The cost model considered three scenarios for virtualizing the CPE, as described below. PA has developed two TCO models: one for the home user and one for the business user. The models are similar, although the home version is simpler than the business version due to the latter having more permutations of user scenarios. The results of the virtual home scenario are described in a separate paper.

Small and Medium Enterprise (vSME)

The SME is a business on a single site. The connection to the network is unchanged, but upgrades and new services can be deployed without site visits. The CPE functions are virtualized into a cloud server in the network, leaving a simple router or L2 device only at the customer's premises. The client would access the functions through an edge router on the provider's network.

Large Enterprise (vENT)

This is a large enterprise that has multiple locations of different sizes. The user can specify a blend of small, medium, and large offices in terms of a percentage for each. The small offices are similar in characteristic to the vSME office. The large offices are characterized by virtualization of the CPE functions on a standard server at the customer's premises. The CSP has remote access to this server for maintaining and upgrading the software, including deploying new functions.

The vSME and vENT scenarios were modelled in the same file; the user is able to select between them using a drop-down menu.

The model also offers a choice of four geographic regions. These can be programmed with data from whichever regions the user requires. It is intended that the default regions are USA, Europe, Asia-Pacific, and Latin America. Alternatively, a user-defined number of subscribers and growth rate can be selected.

A.2 Principles and assumptions behind the model

A.2.1 Principles of operation

The main principles used in developing the vCPE TCO model are:

This model calculates TCO to the CSP of implementing the CPE in conventional form and in virtualized form.

For the virtual implementation the user can specify the percentage of instances of each function that are virtualized; the rest remain as conventional implementations.

The user specifies general parameters such as the region of operation and the length of the TCO period.

The user defines the customer scenario being modelled:

– The functions provided by the CPE. These are assumed to be the same before and after virtualization in order to give a meaningful comparison.

– Whether the functions can be virtualized and if so whether it is on the customer's premises or into a network cloud server.

– The number of each type of CPE hardware unit and telecom (comms) link.

The user inputs data on various parameters, grouped into three areas:

– Market parameters, specifically the number of subscribers and the adoption rate over time of the CPE functions.

– Costs of hardware, software, comms links, datacenters, and staff.

– Technical parameters such as traffic demand, server capacity, and manpower.

The comparison between conventional and virtual implementations is shown on the Output sheet.

There are two types of subscribers that are referred to throughout the model:

– SME - a small or medium sized business at a single site with up to 25 staff.

– ENT - a large business operating from multiple sites of different sizes. The sites are classified as small, medium, and large.

– A Small site is taken as similar to an SME, a Medium site is from 25 to 500 people, a Large site is over 500 people.

An ENT subscriber could use the cloud service in the operator's network to host the VNFs. All SMEs are assumed to do this.

Alternatively, the ENT subscribers could host the VNFs on servers located at their premises; both options are provided.

A.2.2 Assumptions behind the model

The main assumptions used to develop the vCPE TCO model are shown in the table.

General inputs

Inputs	Value	Rationale
CPE refresh rate	33%	CPE refresh rate is the percentage of CPE hardware units that are replaced each year. This could be for any reason; for example, upgrade, breakage, rationalization.
Customer retention rate	90%	Customer retention rate is the number of subscribers renewing their contract with the network operator for the next year.
Small, medium and large ENT	61% small; 34% medium; 6% large	Small, Medium, and Large ENT are the percentages of small, medium and large offices in a large enterprise. They must add up to 100%.
TCO period	5 years	TCO period is the length of time over which the TCO is calculated. There is a drop-down menu with a choice of 3, 4, or 5 years.
Geography	Europe, US, Asia Pacific, LatAm	Geography is the selection of which region is used for the purposes of selecting subscriber numbers and costs.
Market share	10%	Market share is the proportion of the total subscribers in the selected region that are subscribers to the network being modelled.
Virtualization	On customer premises; network cloud server	Virtualization is a choice of whether, for a large ENT, the virtualized functions would be run on a server at the customer's premises or in a network cloud server.

Sensitivity Analysis

Inputs	Value	Rationale
Hardware and software costs	0% hardware cost 0% software cost	The hardware and software costs can be adjusted by a specified percentage to show its effects on the TCO. Figures >0% give an increase; <0% give a decrease on the figures specified in the cost data sheet

Sensitivity analysis for other parameters is carried out by manually varying the data.

Scenario definition

Functions in CPE and virtualized functions where: N if the function is not present in the CPE; F if the function is present and cannot be virtualized; V if the function is present and can be virtualized; VC if the function is not in the CPE but will be present in the network cloud if virtualization is used. In the virtualized case, it may be that not all subscribers virtualize all functions. A percentage of the subscribers' virtualizing is specified for each function.

Function	SME	ENT Small	ENT Medium	ENT Large	Proportion Being Virtualized
Firewall	V	V	V	V	100%
Router	V	V	V	V	80%
CGNAT	VC	VC	VC	VC	100%
SDN Controller	VC	VC	VC	VC	100%
SBC	N	N	N	V	50%
VPN	N	N	N	V	80%
WAN Optimization A	N	V	V	V	100%
WAN Optimization B	N	V	V	V	80%
WAN Optimization C	N	VC	VC	V	80%

Number of discrete CPE units–hardware. This table specifies the quantity of hardware per subscriber at the customer premises, for the virtual implementation.

Number of Discrete CPE Units - Conventional	SME	ENT Small	ENT Medium	ENT Large
Firewall	1	1	1	2
Router	1	1	2	4
CGNAT	0	0	0	0
SDN Controller	0	0	0	0
SBC	0	0	0	1
VPN	0	0	0	1
WAN Optimization A	0	1	1	2
WAN Optimization B	0	1	1	2
WAN Optimization C	0	0	0	1

Number of Discrete CPE Units - Conventional	SME	ENT Small	ENT Medium	ENT Large
L2 switch	1	1	2	4
Small VNF server	1	1	0	0
Medium VNF server	0	0	1	0
Large VNF server	0	0	0	1

Number of Discrete CPE Units - Conventional	SME	ENT Small	ENT Medium	ENT Large
High-capacity cloud server	0	0	0	0
SDN Control server	0	0	0	0

Network units. This table specifies the additional hardware in the network, for the virtual implementation. It specifies whether or not the hardware is present; it does not specify quantity (that is calculated later in the model). Therefore it is shown as either 1 or 0.

HW Units in Network - Virtual	SME	ENT Small	ENT Medium	ENT Large
L2 switch	0	0	0	0
Small VNF server	0	0	0	0
Medium VNF server	0	0	0	0
Large VNF server	0	0	0	0
High capacity cloud server	1	1	1	1
SDN control server	1	1	1	1

Comms links cost are the various speeds of Metro Ethernet connection and DSL that are used for connecting the subscriber's site to the network. It is assumed that this does not change just because the CPE functions are virtualized.

Communications Links - Conventional	SME	ENT Small	ENT Medium	ENT Large
10M	0	2	0	0
100M	0	0	2	0
1G	0	0	0	2
10G	0	0	0	0
DSL	1	0	0	0

Communications Links - Virtual	SME	ENT Small	ENT Medium	ENT Large
10M	0	2	0	0
100M	0	0	2	0
1G	0	0	0	2
10G	0	0	0	0
DSL	1	0	0	0

Market data

Subscriber numbers. The total number of subscribers in each of four geographic regions over a five-year period. The figures are taken from Ovum's forecasts for DSL and for Metro Ethernet. Because DSL can serve both residential and SME premises, a second table specifies the percentage of DSL subscribers that are SME.

Number of DSL Subscribers	2015	2016	2017	2018	2019
Asia-Pac	328,458,500	350,390,900	367,448,100	380,841,300	391,725,700
Europe	221,309,000	228,473,300	233,322,400	236,697,200	239,144,000
US	102,497,000	104,951,500	107,097,000	109,039,000	110,844,000
LatAm	74,337,600	78,889,300	82,635,900	85,771,800	88,455,200

Proportion of SME Subscribers	2015	2016	2017	2018	2019
Asia-Pac	3%	3%	3%	3%	3%
Europe	15%	15%	15%	15%	15%
US	3%	3%	3%	3%	3%
LatAm	3%	3%	3%	3%	3%

Number of Subscribers ENT	2015	2016	2017	2018	2019
Asia-Pac	726,259	810,675	902,438	1,004,724	1,119,979
Europe	608,937	689,538	781,398	886,189	1,003,868
US	393,762	443,442	504,797	574,643	650,639
LatAam	58,219	71,267	80,407	90,756	102,259

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[1] Service costs in this paper refer to direct and indirect costs of employment, including transport costs where relevant.

[2] http://www.globalservices.bt.com/uk/en/point-of-view/nfv

[3] Ovum, "Market Opportunity Analysis: NFV" 28 Jan 2015

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