When will NFV Cross the Chasm?

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Executive Summary

As explained in the TM Forum e-book *Transforming to a Digital Business*, one of the factors driving telecommunications service providers to implement fundamental change is the impact that over the top (OTT) social messaging applications are having on telecommunications service providers. According to Ovum, OTT social messaging applications currently cost communications service providers over $30 billion annually in lost SMS revenues, which is predicted to reach $54 billion by 2016[1]. Additionally, in 2018, OTT VoIP providers will have cost the global telecoms industry $63 billion in lost revenues[2]. As was also explained in *Transforming to a Digital Business,* implementing NFV is one of the changes that service providers need to make in order to be more competitive against a range of players.

The primary goal of this report is to provide insight into when Network Functions Virtualization (NFV) will *cross the chasm* and become a mainstream architecture. As explained in Section 1, to better understand how service providers are approaching NFV, we conducted a survey of service providers and we also interviewed 25 key players who work for service providers, Standards Developing Organizations (SDOs), vendors and industry communities. These interviews are used throughout the e-book to provide insight into the drivers, enablers and inhibitors to broad NFV adoption. Section 1 identifies the primary characteristics that ETSI associates with NFV and uses survey data to identify the factors that are most influential in driving interest in NFV. It also discusses how various industry players view the relationship between SDN and NFV.

Section 2 builds off the material contained in the TM Forum e-book *NFV: Are you prepared?* and presents survey data that shows that the primary business related impediments to NFV adoption are the need to make significant organizational and cultural changes. This section discusses other business related impediments such as the need to make significant changes to a company's product management processes and to their operating models. As discussed in this section, the primary technology related impediment to NFV adoption is the concern about how to do end-to-end service provisioning that includes physical and virtual resources and which may cross multiple partners' domains. Also included in this section is insight from the interviewees about the role of open source and the need to re-engineer the procurement process.

In section 3 we explore in detail two key changes that telecommunications service providers must make in order to reap the potential benefits of NFV. One of those changes is taking a DevOps-like approach to network operations. The discussion of DevOps builds off the material contained in the TM Forum e-book *NFV: What does it take to be agile?* In this section we include survey data that shows that very few service providers have begun to implement DevOps and even fewer have begun to apply a DevOps-like approach to network operations. To discuss the other required change, implementing a new management model, this section builds off the material contained in the TM Forum e-book *NFV: can it be managed?* Section 3 also discusses the some of the key characteristics of the required management

[1] "Counteracting the Social Messaging Threat," Ovum, July 2012

[2] Ibid.

model including the challenges associated with managing a hybrid environment, the need for a policy based architecture and the requirement for a shared information model.

Section 4 discusses the changing role of industry players including SDOs such as the IETF, industry groups such as the TM Forum and open source communities such as OpenDaylight. We include survey data that shows while service providers see a wide range of benefits being provided by the varying types of industry players, the primary benefit they see is the development of effective end-to-end management models. As explained in this section, part of the role of industry groups such as the TM Forum and ETSI is to create use cases, architectures, information models and POCs. The work of these industry groups is often picked up by open source communities who either develop new, or enhance existing software platforms which are frequently used as the basis for vendor's products. Along the way, standards will likely be developed by traditional SDOs or increasingly defacto standards will be created by the open source communities.

In section 5 we include survey data that demonstrates the great importance of TM Forum sponsored Catalysts relative to service providers identifying the suppliers to whom they will send an RFx. This section also provides detailed insight into when NFV will cross the chasm by discussing some of the NFV-related Catalysts and what is happening and what needs to happen to move these Catalysts into production. Some of the impediments that the interviewees mentioned were the difficulty associated with modifying their OSS/BSSs and the challenges associated with selling the technology within their company and engaging the relevant organizations including the line of business managers as well as their architecture and product development groups.

In section 6 we pull together input from the interviewees on when they think NFV will cross the chasm as well as a summary of the key impediments to that happening. One observation made in this section is that based on the breadth and depth of these impediments, and using the broad ETSI definition of NFV, that NFV will not cross the chasm in multiple geographies in the foreseeable future. Another observation is that NFV solutions that are focused on classes of virtual network functions such a virtualized CPE or virtualized evolved packet core (EPC) and which don't have as much automation or performance as is envisioned by ETSI will cross the chasm within certain micro markets in the next two years. The final observation contained in this section is that few if any telecommunications service providers will make significant revenue from NFV in 2015 or 2016. However, sitting on the sidelines will significantly increase how long it takes for that to happen.

Introduction

> ***We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten[3].***

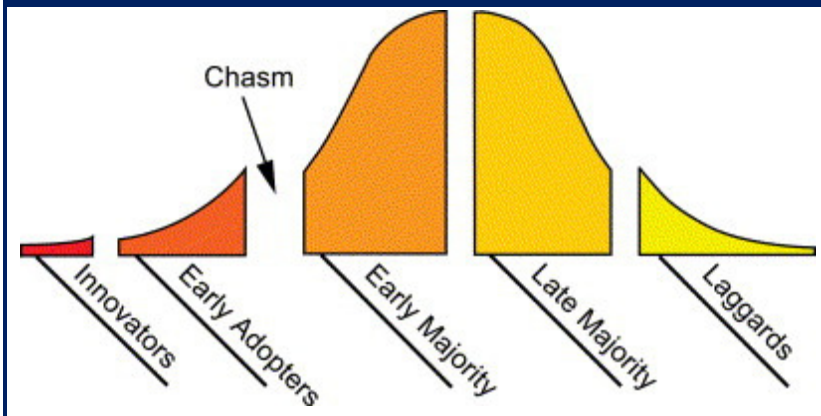
Goals

The primary goal of this report is to provide insight into when Network Functions Virtualization (NFV) will *cross the chasm* and become a mainstream architecture. As part of providing that insight, this report describes some of the enabling functionality that must be in place for that to happen, discusses the relationship between Software Defined Networking (SDN) and NFV and describes how service providers need to re-engineer their approach to end-to-end management and to adopt a DevOps-based approach to NetOps. The report discusses the changing role of SDOs and industry communities that are shaping the development of NFV and describes the role of some of the major players. The report also describes some of the NFV-related Catalysts that the TM Forum has sponsored and outlines what has happened and what needs to happen in order for these Catalysts to move into production.

Crossing the chasm

In 1991 Geoffrey Moore wrote *Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers*. In the book, Moore argues that there is a chasm (Figure 1) between the early adopters of a technology and the early majority or pragmatists and that these two groups approach the adoption of technology very differently. For example, the early adopters of a technology are typically the organizations who identify the primary use cases of a technology and who have both the capability and the orientation to work through the issues that are associated with implementing early stage technologies. In contrast, the early majority typically adopts a technology once the use cases have been identified and validated and once the solutions are stable. In addition to there being a chasm, or discontinuity, between the early adopters and the mainstream adopters, there is typically a continuum of risks and rewards that separates the early majority from the late majority and from the laggards.

Figure 1: Crossing the Chasm



[3] Bill Gates: http://www.brainyquote.com/quotes/quotes/b/billgates404193.html

New technologies and architectural approaches take varying amounts of time and often take different paths to go from where they are only used by innovators and early adopters to where they are used by the early majority of users. Some technologies, such as LAN switching, cross the chasm relatively quickly while others, such as voice over IP (VoIP), take a lot longer. Some technologies, such as ATM in the LAN and SMDS in the WAN, never cross the chasm while others such as ISDN and ATM in the WAN cross the chasm, but are not as successful in the market as was predicted. There are also instances in which a technological approach such as acquiring applications from an Application Service Provider (ASP) fail initially and then get re-incarnated in a somewhat different way several years later and end up crossing the chasm in a somewhat different form; e.g., Software-as-a-Service (SaaS).

Input from the broad IT community

To better understand how service providers are approaching NFV, we interviewed 25 key players who work for service providers, SDOs, vendors and industry consortiums and communities. The interviews covered a broad range of topics including the drivers and inhibitors to NFV adoption, the role of open source, the role that SDOs and other organizations play in the evolution of NFV, the progress that has been made implementing TM Forum sponsored Catalysts and when NFV will cross the chasm and be used by more than just innovators and early adopters.

We also conducted a survey of service providers and had 84 responses to the survey. The survey respondents represent a broad cross section of geographies, with Asia having the most representation. In addition, the companies that the survey respondents work for offer a wide range of services with the most frequent response being that the company offers converged services.

The Emergence of NFV

Virtualization isn't a new topic. Starting in the mid-1990s, IT organizations implemented various forms of network virtualization; i.e., VLANs, VPNs, VRF. In addition, server virtualization has been widely adopted for roughly five years. Over the last couple of years there has been growing interest on the part of service providers in a new form of virtualization: NFV.

The European Telecommunications Standards Institute (ETSI) and the TM Forum are two of the organizations associated with the evolution of NFV. A more complete discussion of the relevant SDOs and other industry communities is contained in a subsequent chapter of this report.

Some of the key characteristics of the ETSI vision for NFV include[4]:

- Achieving high performance virtualized network appliances which are portable between different hardware vendors and across different hypervisors.
- Achieving co-existence with hardware based network platforms.
- Managing and orchestrating many virtual network appliances while ensuring security from attack and misconfiguration.
- Implementing automation to enable the scalability of the solutions.

[4] https://portal.etsi.org/NFV/NFV_White_Paper.pdf

- Ensuring the appropriate level of resilience to hardware and software failures.

As defined by ETSI, NFV is applicable to all data plane packet processing and control plane functions in both fixed and mobile networks. This analysis will focus not just on that broad NFV definition of NFV but also on the classes of virtual network functions (VNFs) that are associated with NFV. A taxonomy of those classes of VNFs is shown in Figure 2.

Network Element	Function
Switching elements	Broadband network gateways, carrier-grade network address translation, routers
Mobile network nodes	Home location register/home subscriber server, gateway, GPRS support node, radio network controller, various node B functions
Customer premises equipment	Home routers, set-top boxes
Tunneling gateway elements	IPSec/SSL virtual private network gateways
Traffic analysis	Deep packet inspection, quality of experience measurement
Assurance	Service assurance, service level agreement monitoring, testing and diagnostics
Signaling	Session border controllers, IP Multimedia Subsystem components
Control plane/access functions	Authentication, authorization and accounting servers, policy control and charging platforms
Application optimization	Content delivery networks, cache servers, load balancers, accelerators
Security	Firewalls, virus scanners, intrusion detection systems, spam protection

Figure 2: Taxonomy of VNFs

Cecilia Corbi, Senior Project Manager, Services and IT Standards, Telecom Italia stated that from a purely technical perspective, some of the functions in Figure 2, such as security, application optimization and the mobile core, could be virtualized relatively easily over the next year or two. She added, however, that there are other issues such as the difficulty of implementation and the challenges of end-to-end management that would impact when these functions could be put into production.

Factors driving interest in NFV

The survey respondents were asked to indicate the two primary factors that are driving their company's interest in NFV. Their responses are shown in Figure 3.

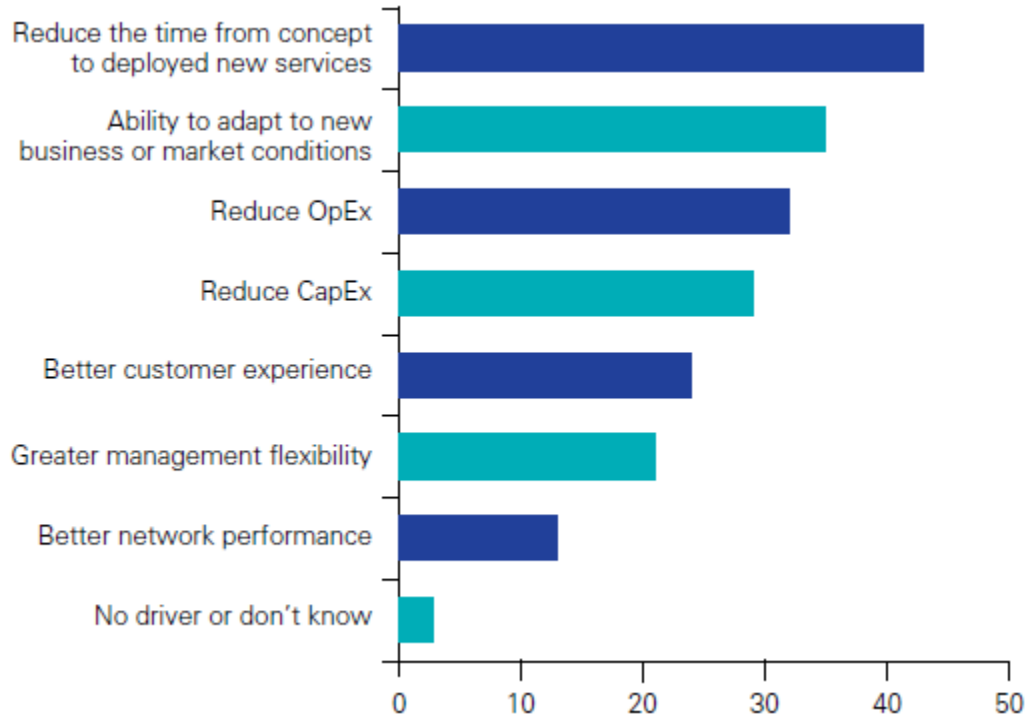


Figure 3: Factors driving interest in NFV

It is clear from Figure 3 that reducing cost, both CAPEX and OPEX, is a major factor driving interest in NFV. However, Steve Vogelsang, VP and Chief Technology Officer, IP Routing and Transport, Alcatel-Lucent said that since most vendors base their products on COTS equipment, he doubted that there would be significant CAPEX savings. It is also clear from Figure 3 that a more significant factor is increasing business agility; e.g., reducing the time it takes to go from concept to deployed new service and enabling the company to adapt to new business or market conditions.

When asked about the factors driving interest in NFV, Carl Piva, VP Strategic Programs, TM Forum said ""We have observed that service providers are aiming for a new set of core capabilities. Those capabilities include the ability to create service mashups on the fly, ubiquitous zero-touch self-service and the ability to easily do catalog driven service chaining with third party service providers and cloud providers. These capabilities will lead to drastically reduced TTM and the possibility of providing complex services at a much lower price point. They also introduce an opportunity to create fundamentally new service concepts - which will likely be the next wave of M2M, IoT and other communication intensive services."

When asked the same question, Mark Bieberich, Senior Director, SDN and NFV Strategy, NetCracker said that "Service providers are still trying to figure out how to differentiate themselves vs. the OTT players, which VNFs make sense for them, and is NFV strictly about driving out cost or is it also an engine for service growth?" He added that ""A lot of service providers have some ideas about what they want to

do, but we are still in the early innings." Vogelsang stated that he thought that few communications service providers would be able to leverage NFV to create "the next cool service". He did think, however, the communications providers could become "fast followers" and so the next time a service such as dropbox begins to become popular, they can quickly add it or similar functionality.

The Relationship between SDN and NFV

SDN is relevant to this discussion of virtualization for two reasons. One reason is that one of the primary use cases for SDN is network virtualization. The second reason is because in some instances SDN is seen as a key enabler of NFV. In March 2014 the Open Networking Foundation (ONF) released a document entitled the *OpenFlow-enabled SDN and NFV Solution Brief* [5]. That document discussed how OpenFlow-enabled SDN can meet the need for automated, open, and programmable network connectivity to support some of the ETSI-defined use cases such as *Network Functions Virtualization Infrastructure as a Service* and *Virtual Network Function Forwarding Graph*".

In a recent white paper[6] ETSI expressed their belief that NFV and SDN are highly complementary efforts. The ETSI view is that both efforts are seeking to leverage virtualization and software-based architectures to make network infrastructures more cost-effective and more agile in their ability to accommodate the dynamic nature of the workflows demanded by applications and end users. While NFV can be implemented using a non-SDN infrastructure, the ETSI vision is that NFV and SDN will increasingly be intertwined into a broad, unified software-based networking paradigm based on the ability to abstract and programmatically control network resources.

According to Dave Hood, Chair, ONF Architecture Project Group, "Networks can be overlaid, with both (all) levels of overlay considered to be SDNs in their own right. This implies that SDN controllers can be recursively stacked, with each controller responsible for whatever real and/or virtual resources are under its scope." He added that "From this background, NFV is an overlay network, whose nodes are VNFs, are provisioned via the SDN controller, and whose forwarding graphs are just examples of ordinary network connectivity."

Stephen Liu, Sr. Dir. of Service Provider Product Marketing, Juniper said the SDN makes NFV much more useful because it makes the network more dynamic. Marc Cohn, Chair, Market Education Committee, ONF believes that it is very difficult to create a dynamic software environment [such as NFV] without the type of dynamic network environment that is enabled by SDN and that "the traditional approach of over-provisioning the network will not work". Because of that belief, Cohn also believes that SDN will have to make significant progress before NFV can cross the chasm.

Antonio Armengol, Head Virtualization Strategy and Technology, Telefonica thinks that SDN is a useful tool for connecting VNFs and he believes that all of the promised benefits of NFV will not be realized without the level of automation that SDN provides. However, Armengol doesn't believe that SDN is necessary in order to Telefonica to get started implementing NFV.

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[5] https://www.opennetworking.org/images/stories/downloads/sdn-resources/solution-briefs/sb-sdn-nvf-solution.pdf
[6] http://portal.etsi.org/NFV/NFV_White_Paper3.pdf

NFV Readiness

The TM Forum authored e-book entitled "NFV: Are you prepared?" answered questions such as:

- How does virtualization impact network operations?
- How does NFV impact the product lifecycle and how must operational procedures evolve?
- Why do procurement and operations have to change?
- What questions should you ask before purchasing NFV functions and services?
- What questions should you ask about deployment and support of NFV functions and services?

This section of this e-book will analyze the primary business and technological inhibitors to broad NFV adoption. It will also discuss some of the key functionality that must be in place in order for NFV to be broadly adopted and how a range of processes must change to enable this key functionality.

A big bang vs. an incremental approach

Dave Duggal, Founder and managing director, Enterprise Web pointed out that communications service providers need to choose between a big bang and a piecemeal approach to NFV and that the choice represents "A tension that has existed in technology forever." To him the decision comes down to choosing between a strategic architectural approach or a tactical approach. Communications service providers, such as AT&T, who choose the big bang approach are looking to deploy a platform that can support whatever they choose to do with NFV. Providers such as BT who choose the piecemeal approach are focusing on responding to well defined opportunities. Duggal went on to say that the big bang approach offered big risk and big reward while the piecemeal approach offered short term rewards and long term risk. To him the best approach is to deploy a platform that is flexible enough to enable both approaches to exist simultaneously.

Antonio Armengol, Head Virtualization Strategy and Technology, Telefonica said that his company is attempting to implement both approaches simultaneously. Towards that end, Telefonica is working to develop a control and services platform for NFV and at the same time planning production trials of virtualized CPE and virtualized EPC functionality. He added that when appropriate "both approaches will be combined."

Business inhibitors to NFV adoption

The survey respondents were asked to indicate the primary business inhibitors to their company broadly adopting NFV sometime in the next two years. Their responses are shown in Figure 4.

Figure 4: Business inhibitors to the adoption of NFV

As shown in Figure 4, one of the primary business inhibitors to the adoption of NFV is the need to make significant cultural changes. Armengol agreed with the survey results and said that overall he sees the three biggest impediments to broad NFV adoption being culture, organizational resistance and the need to change key processes. Mike Stefaniuk, Marketing Manager, Service Development, SaskTel said that he doesn't believe that NFV will cross the chasm until it is lead there by business needs and opportunities. Stefaniuk added that most of the NFV related activities that he is aware of are focused on technology and that he plans to conduct POCs on a few use cases with a focus on new business and operating models for service delivery. He also pointed out that most service providers traditionally "take forever to launch a new service because it has to be perfect day one" and that one measure of the business impact of NFV is whether or not service providers leverage it to be able to take a "launch and learn" approach to offering new services. Stefaniuk also noted that a change in organizational culture is needed to leverage the benefits of NFV, as he believes that most service providers don't have the culture or the operating models in place to enable a launch and learn approach.

The types of cultural changes that service providers need to make are detailed in *Transforming to a Digital Business*. That e-book references Peter Drucker's statement that "Culture eats strategy for breakfast." Applying both Drucker's insight and the concerns about culture reflected in Figure 4 leads to the conclusion that unless effectively addressed, a service provider's culture will not embrace the changes brought on by the adoption of NFV and that will extend the amount of time it will take for NFV to cross the chasm. Duggal summed up the time it will take to modify a company's culture: "Change ain't happening in a day."

As was also shown in Figure 4, two of the leading business related inhibitors to the broad adoption of NFV are the need to reskill the employee base and the need to make organizational changes. AT&T is an

example of a carrier that is attempting to mitigate those inhibitors. In June 2014 AT&T announced[7] an online "nanodegree" program that is designed to develop a new crop of software experts. Shortly after that announcement AT&T also announced a major change in its organizational structure. According to an article in the Wall Street Journal[8], "The reorganization, which also includes the formation of three new business units, is designed to reduce complexity and make it easier for the carrier to offer services to customers as it transforms its hardware-focused network into a software-centric one."

The survey respondents were asked to indicate how extensive an activity they thought it would be to integrate virtualized functions with their current product management processes and their processes for rolling out a new service. Their responses are shown in Figure 5.

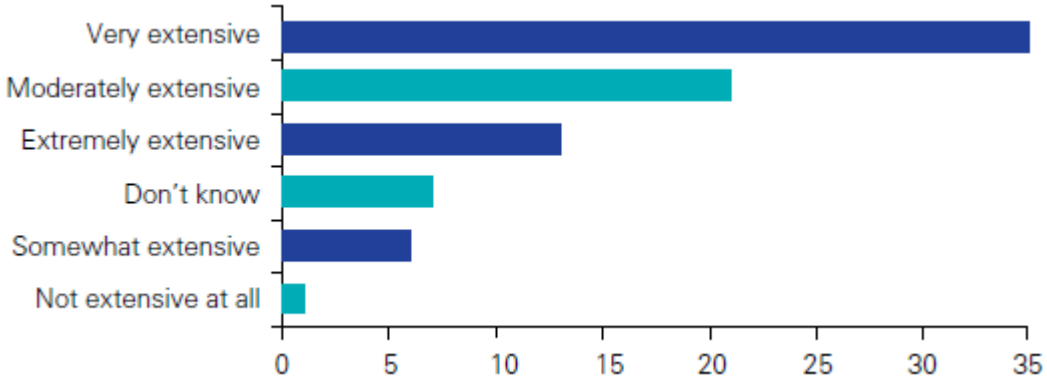

Figure 5: Extent of activity to integrate virtualized functions with current product management processes

As shown in Figure 5, well over half of the survey respondents indicated that it would either be a very or an extremely extensive activity to integrate virtualized functions with their current product management processes and their processes for rolling out a new service. Armengol agreed that integration would be a challenge but stated that "the challenge can be controlled if you do things well."

In order to further explore the organizational impediments associated with the adoption of NFV, the survey respondents were asked to indicate how challenging it would be for their organization to expand both its operating model and its end-to-end service management model to incorporate a combination of virtualized and non-virtualized network functions. Their responses are shown in Figure 6.

[7] http://www.fiercewireless.com/tech/story/atts-nanodegree-gets-workers-ready-sdn-nfv-future/2014-06-18
[8] http://blogs.wsj.com/cio/2014/09/09/att-names-new-cio-amid-it-reorganization/

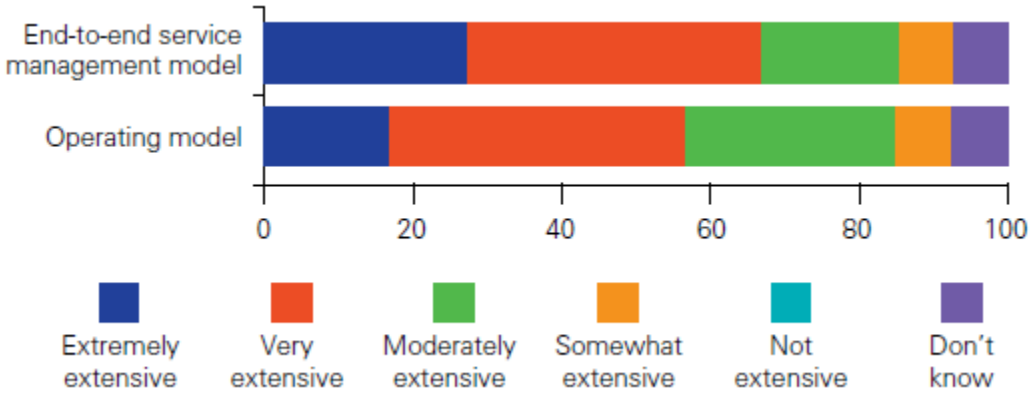

Figure 6: The extent of the challenge to expand operating models and end-to-end management models

As shown in Figure 6, relative to the extent of the challenges associated with the necessary changes to a service provider's operating model, the majority of survey respondents thought that those challenges would either be very or extremely extensive. When asked the same question about their end-to-end service management model, the vast majority of survey respondents thought that those challenges would either be very or extremely extensive.

Armengol said that Telefonica is starting to address the need to change its operating models by working on changing its processes as part of conducting a POC. One change he anticipates is a relaxation on the decades old requirement that the hardware they implement must have the highest possible levels of availability as they expect that NFV will enable them to respond to an outage by spinning up another VNF. Referring to the cultural impact of this change he said "This approach [requiring the highest possible levels of availability] is buried deep in the mind set of carriers."

Technological inhibitors to NFV adoption

The survey also explored some of the technological challenges associated with the adoption of NFV. Towards that end, the survey respondents were asked to indicate the primary technological inhibitors to their company broadly adopting NFV sometime in the next two years. Their responses are shown in Figure 7.

A number of the interviewees agreed with the survey respondents concern over the amount of time it takes for standards to be developed and implemented. Both Duggal and Cecilia Corbi, Senior Project Manager, Services and IT Standards, Telecom Italia stated that in the current environment it isn't acceptable to spend two years developing a standard and then wait two more years for the standard to be implemented. Duggal added that since standards are evolving and will continue to evolve, that communications service providers should implement a NFV architecture that doesn't hard code service to the underlying implementation details. In his model a carrier would describe a new service (i.e., I want a video service with this SLA) and the NFV platform would postpone implementation decisions until run time.

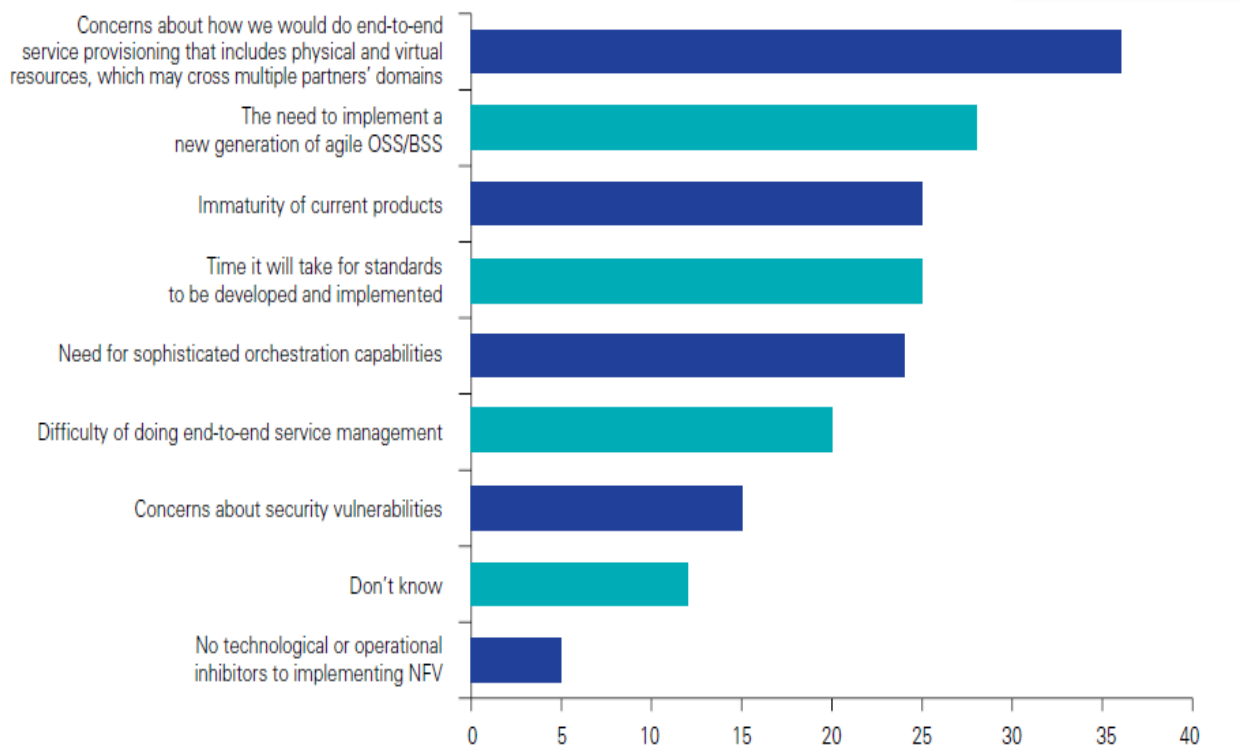

Figure 7: Technological inhibitors to the adoption of NFV

Armengol agreed with the concern that was expressed by the survey respondents over the immaturity of the current products and said that "There are a lot of gaps in the current technology, mainly automation, management and orchestration." He said that another concern he has relative to the technology is that the established vendors have developed VNFs by merely porting code from their existing products. The result of this approach is that these VNFs typically don't perform well and improving their performance requires a major architectural change. In contrast, products from the newer players are typically architected for a virtual environment, but don't have all of the necessary functionality.

Relative to the concerns that the survey respondents had with OSS/BSSs, Mark Bieberich, Senior Director, SDN and NFV Strategy, NetCracker stated that a traditional OSS/BSS doesn't lend itself to the provisioning of virtual resources and that "We need an orchestration platform that is designed to support that." He added that NetCracker is advocating for the unification of service and network orchestration in part to avoid having the "zoo of orchestrators" that was recently referred to[9] by Axel Clauberg, vice president of IP architecture and design at Deutsche Telekom.

Steve Vogelsang, VP and Chief Technology Officer, IP Routing and Transport, Alcatel-Lucent said that one of the biggest technology inhibitors is the pace of technological change. He pointed out that the initial discussion of NFV focused on the use of CloudStack and now OpenStack has replaced CloudStack. Another example he gave was that most of the discussion of NFVs has them running in virtual machines

[9] https://www.sdxcentral.com/articles/news/nfv-network-functions-virtualization-fuel-deutsche-telekom-transformation/2014/06/

(VMs). However, there is beginning to be discussion about VMs being replaced by containers[10] and a growing discussion about an approach based on leveraging a different technology: Kerberos[11].

To further explore the topic of OSS/BSSs, the survey respondents were also asked relative to how their OSS/BSSs will evolve to support a combination of virtualized and non-virtualized network functions and services, how important are open, standards-based APIs for uniform multi-technology, multi-vendor, multi-operator operations? Their responses are shown in Figure 8.

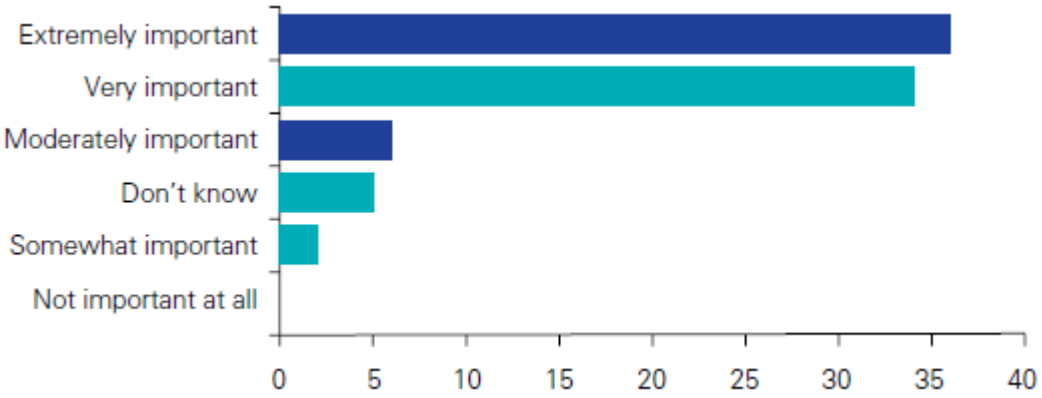

Figure 8: Importance of open, standards-based APIs

The answers to a number of the survey questions were clear cut in terms of showing what is and is not important. However, the answers to the question about the importance of open, standards-based APIs are the clearest cut of any of the survey questions: They are extremely important.

The Role of Open Source

One of the factors that will potentially accelerate the development of NFV is the use of open source. With that in mind, three open source initiatives are described in a subsequent section of this e-book.

Armengol stated that the traditional way of developing standards doesn't lend itself to interoperability and that he believes that if vendors build products based on open source then those parts of the products that are based on open source will interoperate and that the open source code becomes "a working standard."

Neela Jacques, Executive director, OpenDaylight Community stated that based on what people do with the solutions, open source may or may not lead to interoperability. He added that nobody dictates how a company implements an open source solution and he speculated that some companies will implement OpenDaylight solutions in a proprietary way in part because that reduces their time to market.

Marc Cohn, Chair, Market Education Committee, ONF suggested that SDOs such as the ones described later in this e-book can add value by guiding open source development and by adding rigor to that

[10] http://searchsqlserver.techtarget.com/definition/container
[11] http://en.wikipedia.org/wiki/Kerberos_%28protocol%29

development. According to Cohn, guidance would add value because “Open source is the wild west. Anybody can do anything. Gaps are ok. People can put in multiple proposals for the same thing.”

Prodip Sen, Board chair, OPNFV agreed that open source can be like the wild west but said that over the last ten to fifteen years it has been shown that open source projects, most notably Linux, add value. He added that using open source in networking may appear to be novel but that in fact for the last few years a number of vendors have included open source in their products.

The requirement to re-engineer the procurement process

In order for a service provider to be able to readily procure and deploy VNFs from a variety of potential suppliers, a number of procurement and operational practices need to be developed to support the particular needs of VNFs throughout their life cycle. This includes:

- Selection
- Acquisition
- Acceptance testing
- On-boarding
- Deployment

Armengol said that “Telefonica is used to procuring products from large vendors with solid financial muscle. We are now talking about working with new kids on the block – smaller players that come out with new ideas. This will be a challenge for how we procure and are organized.”

Scott Boorman, Enterprise Architect, BT said that one of the biggest impacts that NFV will have on procurement processes is that it will place new importance on making software licensing more flexible and less complex. He said that one option is to move away from paying for software on a per instance basis and to move to a usage sensitive “pay as you go, pay as you grow” model. He added that the adoption of NFV will also put pressure on service providers to examine how they structure their procurement teams and the skills needed by the members of their teams.

DevOps and a new management model

The surveys and the interviews that we conducted as part of creating this e-book clearly indicated that technological issues are only a part of the overall set of barriers that have to be overcome. As will be discussed in this section, in order to successfully implement NFV service providers also need to modify their approach to network operations and to end-to-end management.

The role of DevOps

The TM Forum authored e-book entitled *NFV: What does it take to be agile?* answered questions such as:

- Why is agility imperative for network operators?
- What are the lessons learned from IT operations?
- What does it take to go from concept to operations?
- How can your company adapt DevOps methodology for network operations?
- What is the organizational impact of adopting a DevOps methodology?

That e-book pointed out that DevOps is usually associated with the following characteristics:

- Collaboration;
- Continuous development, integration and delivery;
- Continuous testing and monitoring;
- Automation;
- Automated management interfaces.

The survey respondents were asked to indicate the extent to which their IT organization had already adopted DevOps. The answers are shown in Figure 9.

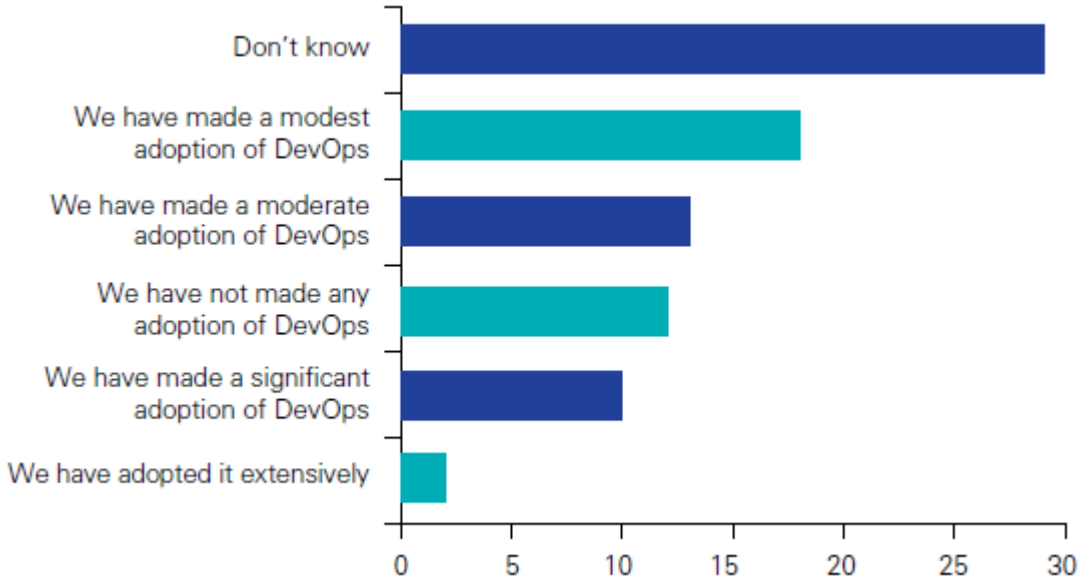

Figure 9: Extent of the current adoption of DevOps

Figure 9 shows that only a minority of service providers have currently made a significant or extensive adoption of DevOps.

Massimo Banzi, Senior Project Manager, Telecom Italia stated that while his company is using agile methodologies to develop new software, they have not implemented a broad approach to DevOps, but that they know they need to. Cecilia Corbi, Senior Project Manager, Services and IT Standards, Telecom Italia added that implementing DevOps inside a large company such as Telecom Italia requires a significant cultural change.

As previously discussed, the two primary factors driving interest in NFV are the goal of reducing the time it takes to go from concept to deployed service and the goal of increasing the ability of the service provider to adapt to new business or market conditions. However, just because the deployment of network functionality is becoming more agile doesn't necessarily mean service providers will be able to achieve those goals as IT organizations also need to make their network operations (NetOps) more agile.

In order to increase the agility of NetOps, carriers must adopt the previously mentioned characteristics of DevOps. However, as was also explained in *NFV: What does it take to be agile?* just applying DevOps principles to NetOps isn't sufficient. As that e-book explains, DevOps is generally applied to discreet services that are frequently delivered over the web on a best effort basis. The network environment is different and those differences create challenges that are not addressed by DevOps. One such challenge is that unlike what happens when delivering an application over the Web, NetOps will need to support dynamic and automated management of service performance and SLAs. As discussed below, this can only be achieved by a policy model that supports end-to-end SLA targets.

The survey respondents were asked to indicate the interest that their organization has in taking the lessons learned from DevOps and applying a similar methodology to NetOps. Their responses are shown in Figure 10.

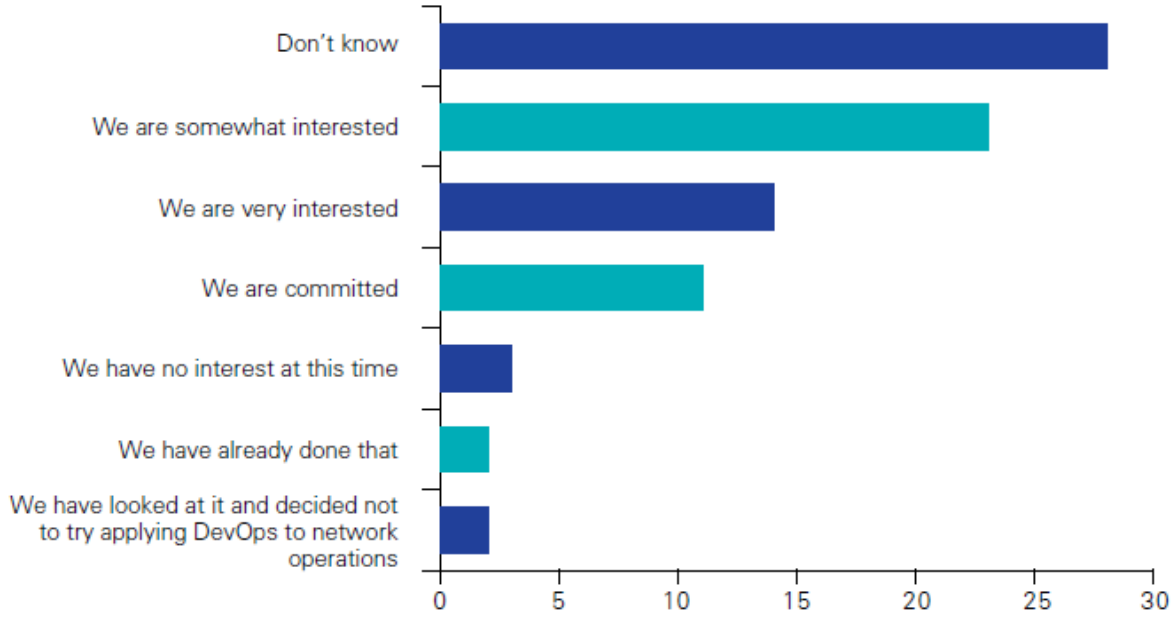

Figure 10: Interest in applying a DevOps methodology to NetOps

Figure 10 shows that while virtually all of the survey respondents' companies have at least some interest in applying a DevOps methodology to NetOps, only a tiny percentage of companies have already started the process. This conclusion taken together with the fact that only a minority of service providers have currently made a significant or extensive adoption of DevOps indicates that service providers are just at the very early stages of making the kind of organizational changes that are necessary to achieve the desired goals of increased agility.

Scott Boorman, Enterprise Architect, BT said that he sees a need to better integrate BT's network and IT operations teams because the current model of siloed organizations leads to finger pointing and confusion which increases the amount of time it takes to find the root cause of a problem. He added that bringing together these two teams will be an "interesting journey" that will take time from a cultural and organizational perspective.

The need for a new management model

The TM Forum e-book entitled *NFV: can it be managed?* analyzed the need for service providers to adopt a new approach to end-to-end management and answered questions such as:

- What's new about virtualization?
- Why does end-to-end management matter?
- How does virtualization affect end-to-end management?
- How can we address the challenges?

This section will identify some of the functionality that is needs to be part of a new approach to end-to-end management.

The requirement for a modified approach to SLAs

In order for NFV to cross the chasm, service providers have to change their approach to SLAs. Traditional SLAs were established as part of contract negotiations. With NFV SLAs are likely to be negotiated dynamically as VNFs are chained together or configurations are modified. In addition, some of the VNFs comprising a virtualized network service may be hosted in multiple collaborating providers' cloud networks. Managing end-to-end service levels and SLA compliance in a multi-provider environment requires an end-to-end management architecture that provides consistent data collection, data definitions and management interfaces across all on-network and off-network resources and technologies.

Boorman said that BT is looking at modeling new services to understand how the underlying systems and architecture can assist them in managing their SLAs. He added that BT is also looking at the structure of their software and services contracts to understand what vendors will sign up for relative to their commitment to collaborate with BT and/or other vendors to get to the root cause of a trouble.

Functionality to manage a hybrid environment

For the foreseeable future, some services will be based on existing physical network functions while others will be based on VNFs and some others will be based on a hybrid environment made up of both. In a hybrid environment both types of function must have management interfaces built on a common

information model (see below) in order to support agile DevOps-style service creation as well as the dynamic management and orchestration that Armengol mentioned was missing from the current generation of products. In a hybrid environment it's crucial that management is policy-based and uses control loops to ensure quality of service. An NFV security fabric is also needed and this requires having security management APIs on every virtual service as well as on the underlying virtualization platform.

The requirement for a shared information model

Where dynamic network service configurations are required, the management interfaces presented by both virtual and physical infrastructure elements need to lend themselves to automated plug and play integration. Information models drive consistency in the design of data payloads in automated interfaces by capturing behavior, defining standard interface communications patterns and specifying information representations; e.g., metrics representation and semantics for reporting SLA and QoS performance.

Boorman said that BT wants to have a single information model to describe how to build a service in part because of their desire to converge service and infrastructure management. He added that figuring out how to best decompose a service across different technology domains is challenging and that he has not seen anything coming out of ETSI on this topic.

The need for a policy based architecture

Taking full advantage of the dynamic mature of virtualization requires an E2E management system that can perform as an autonomic system to support real time operational processes. A policy management architecture is the basis for automated management and orchestration. Policies can be based on hierarchical system of rules designed to deal with the complexities of a hybrid environment, and to manage the relationships among users, services, SLAs, and device level performance metrics. For example, if the CPU utilization of a physical server hosting a VNF becomes excessive, the VNF may be moved to a server with lower utilization.

Boorman said that BT's current architecture does not implement policy based actions very well but that he believes that it is very important to be able to define a set of policies that can be orchestrated as part of service instantiation. When asked about the importance of policy based architecture Bieberich stated that NFV will not cross the chasm until we have closed loop solutions that can take data from monitoring and analytics engines and feed that into a policy engine that can enforce those policies via the orchestration engine. When asked how long it will likely take to get that functionality into production he said that it is "Probably another couple of years away, and longer for those providers who are not currently looking at it."

When asked about the changes he expected to see in their approach to end-to-end management, Antonio Armengol, Head Virtualization Strategy and Technology, Telefonica said that once orchestration is fully developed that it should eliminate the need for a lot of the current provisioning systems. Summarizing his thoughts on the changes that will be required to Telefonica's operating models and end-

to-end management he said “You can imagine a lot about the changes that need to be made, but you won’t know with certainty until you get started.”

SDOs and other SDN and NFV-related communities

Importance of SDOs and Other SDN & NFV Related Communities

The survey respondents were asked to indicate the biggest benefits that their organization gets relative to acquiring and integrating virtualized services from standards bodies, industry consortium and trade associations. Their answers are shown in Figure 11.

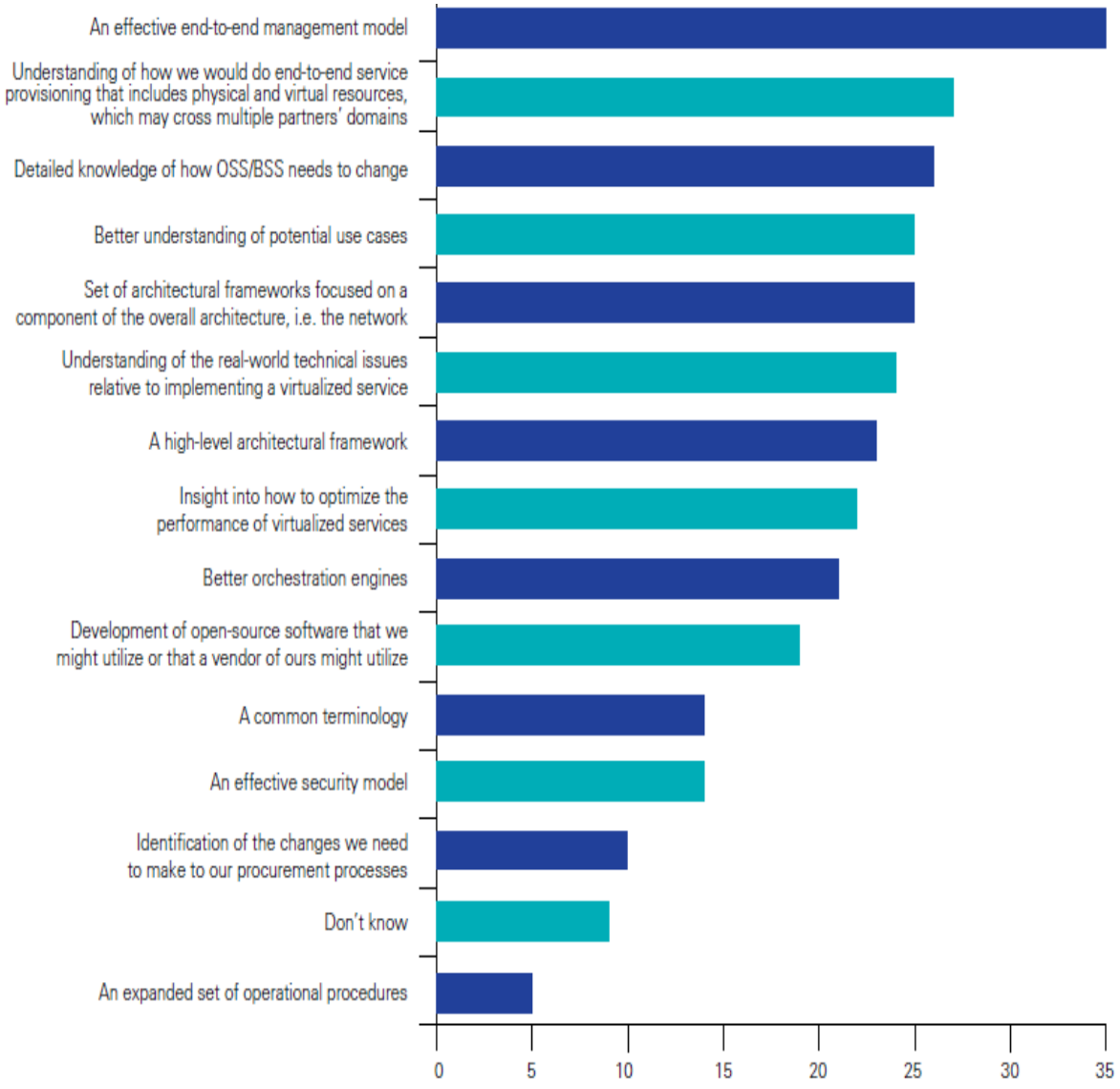

Figure 11: Value provided by industry-wide organizations

Figure 11 demonstrates that carriers receive a wide range of value from standards bodies, industry consortium and trade associations. However, the primary value they receive is an effective end-to-end management model.

The changing role of SDOs and other SDN &NFV Related Communities

There are a number of industry organizations that are shaping the evolution of SDN and NFV. These organizations focus on a range of activities including technology agnostic OSS/Application to Application APIs, best practices, requirements, use cases and the development or enhancement of physical layer technology and protocols. Another set of organizations that are shaping the evolution of SDN and NFV are the open source communities. This class of organization develops open source products often in conjunction with an organization such as the Linux Foundation.

As Marc Cohn, Chair, Market Education Committee, ONF pointed out, a number of factors are changing the way that SDOs and other industry communities operate. One change is that potential users of SDN and NFV are getting heavily involved in those organizations and the potential users are placing more emphasis on the output of those organizations being usable and providing value. Another change is that the focus of those organizations is shifting away from interoperability and vendor interests to use cases and end user requirements.

Cohn suggested that SDOs need to change how they operate. One way he thinks that they need to change is that they need to be more vertically integrated. The example he gave was that SDOs need to be closer to the implementation of whatever standard they develop, possibly by driving conformance testing of those standards. Cohn also pointed out that a traditional SDO is set up to last forever and that SDOs should consider adopting the ETSI model whereby an ISG is project focused and has a life span of two years. He believes this approach places more emphasis on getting something to market than it does on technical elegance.

Key members of the SDN and NFV community

This subsection of the e-book will describe some of the key organizations driving the evolution of SDN and NFV and will provide some insight into the interaction between these organizations.

TM Forum

Early in 2014 the TM Forum announced its Zero-touch Orchestration, Operations and Management (ZOOM) project. According to the Forum[12], the goal of Zoom is to define a vision of the new virtualized operations environment and a management architecture based on the seamless interaction between physical and virtual components that can easily and dynamically assemble personalized services. As of November 2014, the ZOOM team has delivered an assessment of how virtualization impacts SLAs and is currently working on information and policy models, NFV preparedness, and a set of operational support system (OSS) design principles needed for NFV adoption to become widespread.

In addition, the TM Forum has also been active with a wide range of companies to create Catalysts, which are short-term collaborative projects led by members of Forum that address operational and systems challenges. In June 2014 at the TM Forum Live! event in Nice, France there was a demonstration of fifteen Catalyst POCs including five that focused on virtualization. Four additional virtualization centric

[12] http://www.tmforum.org/PressReleases/TMForumBuildsBlueprint/54445/article.html

Catalysts were demonstrated at TM Forum's Digital Disruption conference in San Jose, CA in December 2014.

ETSI

The ETSI NFV ISG has identified nine NFV use cases and is currently driving over 30 POCs. The ETSI NFV ISG was established with a two year life span that expires in January 2015. In late July and early August 2014 the NFV ISG met in Santa Clara, CA. At that meeting the primary objectives of NFV Phase 2 were identified[13]. Whereas ETSI characterizes Phase 1 as being the Requirements Phase, ETSI characterizes Phase 2 as being the Implementation Phase. The objectives of Phase 2 include building on the achievements that were made in the first two years of the ISG and consist of an enhanced focus on interoperability, formal testing, as well as working closer with projects developing open source NFV implementations. In addition, the NFV ISG also released nine draft NFV documents for industry comments[14] and published a publically available document that summarizes the key concepts that are contained in those documents[15].

Internet Engineering Task Force (IETF)

Although their efforts are just getting started, the IETF can be expected to play a significant role in the evolution of standards for SDN and NFV. For example, the IETF Service Function Chaining (SFC) Work Group (WG) currently has over forty active Internet drafts on the topic of delivering traffic along predefined logical paths incorporating a number of service functions. As described in one of those Internet drafts[16], the basic concept of SFC is similar to ETSI NFV ISG's Virtualized Network Function (VNF)-Forwarding Graphs.

The Alliance for Telecommunications Industry Solutions (ATIS)

ATIS is a standards organization that develops technical and operational standards and solutions for the Information and communications technology (ICT) industry. ATIS has launched an NFV Forum to make contributions to NFV and SDN technologies. Phase I of the NFV Forum work program includes virtual network operator capabilities as well as other high priority use cases. The forum will focus on technical requirements, a catalog of needed capabilities, and the service chaining necessary for a third party service provider or enterprise to integrate NFVs into a business application. This process will result in creation of specifications that are complementary with existing industry work with an emphasis on facilitating inter-provider NFV. The forum will also engage relevant open source activities and agile software methodologies for the implementation of these capabilities.

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[13] http://www.etsi.org/blog-subscription-information/entry/repositioning-for-success-at-etsi-nfv-7

[14] http://www.rcrwireless.com/20140806/wireless/etsi-nfv-initiative-gains-new-leadership-set-sights-on-phase-two-tag2

[15] http://portal.etsi.org/NFV/NFV_White_Paper3.pdf

[16] https://datatracker.ietf.org/doc/draft-boucadair-sfc-design-analysis/

The 3rd Generation Partnership Project (3GPP)

3GPP is a collaboration between groups of telecommunications associations. While its initial focus was on 3G as well as the completion of the first LTE and the EPC specifications, 3GPP has evolved to become the focal point for mobile systems beyond 3G. 3GPP standardization encompasses Radio, Core Network, and Service architecture. A number of functions defined in the 3GPP architecture are candidates for implementation as NFVs and have been identified as such in ETSI uses case descriptions. As a result, the 3GPP Telecom Management working group will produce a Study Item on the management of 3GPP NFVs. 3GPP is also considering how the work in the ETSI NFV ISG might impact 3GPP at the architecture and system level.

The Metro Ethernet Forum (MEF)

The MEF is the defining body for the global market for Carrier Ethernet (CE). MEF's flagship work is CE 2.0, including specifications and related certification programs for services, equipment and professionals. MEF has announced a new Third Network vision that delivers Internet-like agility and ubiquity with CE 2.0-like performance and security. The Third Network vision is based upon the concept of Network as a Service (NaaS) incorporating service orchestration functions, APIs, a protocol independent NaaS information model and service definitions.

ONF

The ONF was launched in 2011 by potential users of SDN: Deutsche Telekom, Facebook, Google, Microsoft, Verizon, and Yahoo!. Shortly after being formed, the ONF took over ownership of the OpenFlow protocol from Stanford University. The ONF's primary deliverables to date include revisions to the OpenFlow standard, as well as the OpenFlow configuration and management protocol and an OpenFlow conformance testing program.

A year ago the ONF established the Northbound Interface (NBI) working group with the goal of standardizing SDN's northbound interface. In a recent blog Sarwar Raza, the chairman of the group, stated "Our goal in the next year is to formalize the framework along with the information and data models and then iterate some with code before we even start a standards discussion." The NBI working group intends to work with one or more open source initiatives to develop working code for the NBIs that the group aims to put forward for standardization. In the blog Raza explained that the working group has a good relationship with both the OpenStack and the OpenDaylight initiatives but that none of the open source initiatives are going to agree in advance to produce code for NBIs that are under development.

The OpenStack Foundation

OpenStack is a cloud computing orchestration project offering free open source Orchestrator software released under the terms of the Apache License. The project is managed by the OpenStack Foundation, a non-profit corporate entity established in September 2012 to promote OpenStack software and its community. Apache CloudStack is another open source Apache Licensed orchestration system. Eucalyptus is a third open source orchestrator with tight technical ties to Amazon Web Services (AWS).

Open Platform for NFV (OPNFV)

In September 2014 the Linux Foundation announced the founding of the Open Platform for NFV Project[17]. As part of the announcement the Linus Foundation declared that OPNFV will establish a carrier-grade, integrated, open source reference platform that industry peers will build together to advance the evolution of NFV and ensure consistency, performance and interoperability among multiple open source components. The Foundation also stated that because multiple open source NFV building blocks already exist, OPNFV will work with upstream projects to coordinate continuous integration and testing while filling development gaps.

The OpenDaylight Project

This project was founded in April 2013 and is a collaborative open source project hosted by The Linux Foundation. The goal of the project is to accelerate the adoption of software-defined networking (SDN) and create a solid foundation for Network Functions Virtualization (NFV).

In February 2014 the consortium issued its first software release, called Hydrogen and in September 2014 issued its second software release called Helium. A number of vendors such as Brocade and Extreme Networks have announced their intention to use open source code from the consortium as the basis of their SDN controller.

Jacques described the primary three ways in which the OpenDaylight community is influenced to develop code. In descending order of importance, those ways are:

1. A group such as the ETSI NFV ISG writes a paper and the members of the OpenDaylight community respond to that paper by saying "That's cool. We want to build to this."
2. A member company is involved in another organization such as the ONF or the IETF and agreed to support an initiative sponsored by that organization. Since the member company agreed to support that initiative, they drive it within the OpenDaylight community.
3. A laison between two organizations.

Jacques explained that the liaison model is not as impactful as the other two approaches because in an open source community there isn't currently and never will be a benevolent dictator for life (BDFL)[18]. As such, even if Jacques and Dan Pitt [executive director of the ONF] were to agree on something that the Open Daylight community should develop, Jacques would still have to go and convince the community of that.

[17] http://www.linuxfoundation.org/news-media/announcements/2014/09/telecom-industry-and-vendors-unite-build-common-open-platform

[18] http://en.wikipedia.org/wiki/Benevolent_dictator_for_life

The evolution of NFV-related Catalysts

As mentioned, the TM Forum has sponsored Catalysts on a variety of topics, including NFV at both TM Forum LIVE! in Nice France as well as at Digital Disruption in San Jose, CA. The status of these Catalysts provides key insight into when NFV will cross the chasm.

Multi-Cloud SDN-NFV Service Orchestration

This Catalyst created an integrated architecture to address the major aspects of interconnecting real-world private and public clouds. Bob Combs, senior program manager, Microsoft said that one of the reasons why Microsoft participated in this Catalyst was to demonstrate that the company already uses SDN and NFV functionality in products such as Azure and also to highlight the company's intention to make this functionality part of the new Windows server. One example of this functionality is the requirement to configure, manage and orchestrate virtual functionality.

Brian Promes, senior product marketing manager, SevOne said that one of the reasons why his company was interested in this Catalyst was because it had a focus that spanned multiple public and private clouds and addressed how to best interface with a range of vendors to add value throughout the lifecycle of a service. While this Catalyst focused on Microsoft, Promes said that the opportunity going forward is to address how to gather even more data and make that data available to external orchestration engines. In terms of moving this Catalyst into production Promes said that the biggest roadblocks are not always technology related as "technology can always be tweaked". According to Promes, the biggest roadblocks are how an organization absorbs the new technology and concluded by saying "You don't just pull old stuff out and put this in overnight."

Service bundling in a B2B2X marketplace

This Catalyst showed how a buyer can bundle a collection of services sourced from different suppliers and deliver them seamlessly to a customer in a business-to-business or business-to-business-to-consumer arrangement. One of the companies involved with this Catalyst was BT. According to Derrick Evans, Architect, Infrastructure Integration Platform, BT his company is in the process of implementing the type of functionality demonstrated by this Catalyst. He said the Catalyst is making the process of implementing this type of functionality quicker and that the biggest thing that is currently missing is a standard way of specifying a product. He added that BT working with the TM Forum to determine how to model the data that describes new products and services.

Evans added that one step in the process of getting this functionality into production is to work with their OSS/BSS vendors such as Oracle and Siebel and to encourage them to support the functionality. He also stated his group would work with BT's lines of businesses (LOBs) before they meet with vendors so that those vendors would know that there was business sponsorship for the requested changes. In addition to the LOBs, other groups inside of BT that would need to get involved include their OSS/BSS group, their architecture group and product development.

CloudNFV™: Dynamic, data-driven management and operations Catalyst

This Catalyst focused on solving the problem of how to link orchestration systems in a virtual network with the other business and operational support systems controlling network policy. BT was also involved with this Catalyst and according to Nektarios Georgalas, BT Intel Co-lab director, BT "Orchestration is something we are trying to attack in our lab and participating in this Catalyst was a way of doing that." He added that his lab has been working on pulling together some POCs around policy based mechanisms for cloud based services and that participating in the CloudNFV Catalyst was "a quick win".

Georgalas said "There are tens if not hundreds of different flavors of orchestration engines, each in its own closed little world and they don't integrate with a wider set of management functions." He added that when you talk to a vendor's marketing organization you hear "Oh yes, we can do that. But when you do a POC you realize it is more lip service than real action."

Georgalas added that participating in this Catalyst in Nice "Has given us a way of seeing the future" and that primary value of participating was to get a thorough understanding of the concepts that will drive how they do orchestration in the future. A second version of this Catalyst was demonstrated in San Jose. According to Georgalas, this version of CloudNFV Catalyst brought policy into the heart of orchestration. He added that one of the activities that he would like to see going forward is end-to-end orchestration. In his vision, each domain has their own orchestration engine and there is an orchestration overlay that coordinates over all of the domains. Georgalas acknowledged that this would require the orchestration overlay to state information with the orchestration engine for each of the domains which is a further driver of the need for an effective policy model.

Closing the loop: Data-driven network performance optimization for NFV and SON

This Catalyst was first shown in Nice and it demonstrated how to build a closed loop using key performance indicators to enable network changes, optimization and self-healing using the Forum's Performance Management Interface. Cecilia Corbi, Senior Project Manager, Services and IT Standards, Telecom Italia stated that this Catalyst provided good insight into the kind of performance and quality that service providers can expect and that it also provided insight into what a service provider has to be able to respond to a problem and maintain the SLA they are offering.

The lessons learned in the Catalyst, which was also an ETSI POC, are being incorporated into ZOOM's work on policy management and SLAs and will show up in the next release of Frameworx. The next phase of the project called *Data-driven network performance optimization for NFV and SON,* was demonstrated in San Jose. According to Corbi the San Jose version of this Catalyst demonstrated that it is possible to create a virtual machine in a very dynamic fashion and it also demonstrated performance that was notably better than what was demonstrated in Nice.

NFV Management Ecosystem

This project used open standard APIs to integrate ordering, billing, catalog, inventory and SLA management functions to implement management and operations functions defined by ETSI to deliver real-time, dynamic management of capacity, performance, quality of service and service level agreements, with real-time billing and compensation.

Dave Milham, chief architect, service provider solutions, TM Forum said that "The NFV Management Ecosystem showed that it is possible to rapidly integrate both open source and proprietary management systems using TM Forum Integration Framework APIs to realize an ETSI operations MANO [management and operations] architecture." According to Corbi, part of the value of this Catalyst is that it demonstrated good coordination between the TM Forum and ETSI. She added that part of the value of all Catalysts is that being able to show that the technology works helps them to sell their company on implementing the technology.

Maximizing Profitability with NFV Orchestration

This catalyst project illustrates how to make the orchestration of virtualized network functions driven by business objectives by harnessing the power of analytics and dynamically defined policies. According to Grant Lenahan, Executive Director, Innovation, BUSS Portfolio and Strategy, Ericsson, there is a lot of talk about how to instantiate a VNF, but less discussion about how to do it in the most cost effective way or the way that is most profitable to the service provider. He said that to achieve those goals the service provider needs to be able to perform analytics on a variety of metrics including cost, availability and performance.

In San Jose, the Catalyst didn't have any working software. It focused instead on creating an effective architecture and relevant use cases. Lenahan said that there will be working software in Nice in June 2015 and that they will also be demonstrating additional use cases and that their long term goals is to influence TM Forum's information model and policy schema. He also expressed optimism that in the near term that this Catalyst will be linked with another of the TM Forum's Catalysts that focuses on big data analytics.

Alistair Scott, Office of the CTO, JDSU said that this is an important Catalyst in part because it focuses on an area that is ignored by the existing standards organizations – how to optimally deploy a VNF from a business perspective. According to Scott one possible area of work going forward is to develop a use cases that focuses on moving a VNF to another data center. Another possible area of work is clarifying how real time that architecture needs to be. He concluded the interview by saying that Catalysts are fantastic at bringing together companies to solve problems with a level of cooperation which would not occur without this type of activity.

In terms of this Catalyst crossing the chasm, Lenahan said that "Operators always approach automation with caution." He said that he thinks that service providers will likely deploy VNFs one at a time and back that up with simple fault and performance monitoring. That step will be followed by more sophisticated

auto restoral that will still require some human intervention. He concluded by saying that service providers will “Take this step by step to make sure each step works before they add more automation.”

Pulling it together

Deployment status of VNFs

The interviewees were shown the Taxonomy of VNFs as depicted in Figure 2 and they were asked how long it would be before their company had made at least a modest production deployment of that functionality. Their responses are shown in Figure 12.

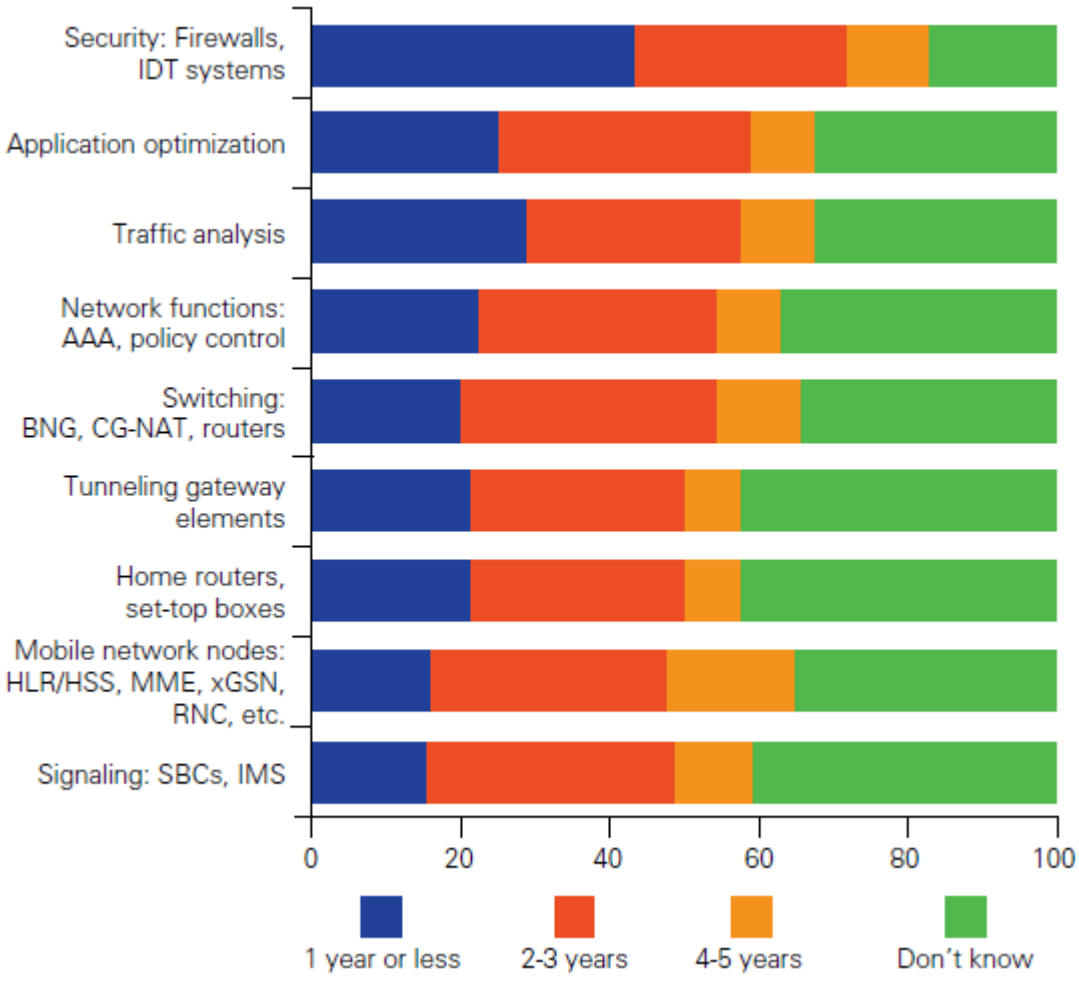

Figure 12: Deployment of VNFs

While the data in Figure 12 shows that there will be a somewhat significant deployment of VNFs in the next few years, there is a very big difference between merely deploying some virtualized functionality and deploying the breadth of data plane packet processing and control plane functions with all of the previously described key characteristics of the ETSI vision of NFV.

Input from the interviewees

As mentioned, the interviewees were asked when they thought that NFV would cross the chasm.

Neela Jacques, Executive director, OpenDaylight Community stated that NFV will not cross the chasm until service providers "start to tackle their OSS/BSS problems", which he speculated would take three years. Jacques added that SDN will not cross the chasm until there is a solution that is supported by a broad ecosystem so that whatever SDN platform is deployed tightly integrates with most, if not all, of the existing infrastructure and management tools. He speculated that it would take three years for SDN to cross the chasm.

Nektarios Georgalas, BT Intel Co-lab director, BT agreed with Jacques that NFV will not cross the chasm until service providers resolve their OSS/BSS problems. He added that while some people are willing to adopt new technologies and new approaches, many others are not. The approach that BT is taking is not a "big bang" approach but rather a piecemeal approach. One area they are interested in is CPE such as firewalls and routers. They have completed a trial in this functionality and now "certain customers are using it". BT is also exploring deploying virtualized functionality such as WAN optimization and leveraging that functionality to build a customized network for customers who want to access a SaaS provider. Stephen Liu, Sr. Dir. of Service Provider Product Marketing, Juniper weighed in on the topic of implementing virtualized CPE and said that "That's the use case that is the most popular right now."

Similar to the interest expressed by Georgalas, Mark Bieberich, Senior Director, SDN and NFV Strategy, NetCracker said that NetCracker is currently conducting POCs with multiple service providers that focus on virtual CPE, most notably to provide security functionality and he added that NetCracker is also conducting a POC with a North American service provider that focuses on the virtual EPC. Steve Vogelsang, VP and Chief Technology Officer, IP Routing and Transport, Alcatel-Lucent agreed and said that Alcatel-Lucent is also seeing great interest and great potential in virtual CPE – both in the home and enterprise markets.

Because of his belief that NFV requires a dynamic network environment, Marc Cohn, Chair, Market Education Committee, ONF believes that SDN will have to make significant progress before NFV can cross the chasm. Cohn also believes that factors such as outdated BSSs will make it hard for NFV to cross the chasm. As Cohn stated "The reality is that we have billing systems and customer management systems that don't acknowledge dynamic systems." He added that one of the huge challenges facing service providers is that they are impacted by a range of factors that don't impact companies that just focus on the data center and he pointed out that relative to crossing the chasm that individual service providers each represents their own micro market segment. Cohn also believes that another factor that will lengthen how long it takes for many service providers' implementation of NFV to cross the chasm is the difficulty of getting their employees to embrace automation, knowing that automation may cost them their jobs. Cohn's sentiments were echoed by Vogelsang who said "If you are automating something, the cultural resistance is one of the biggest challenges."

When asked when he thought NFV would cross the chasm, Swamy Vasudevan, CTO, SDN NFV Cloud, Ericsson, said that based on the service providers he works with, it would probably occur in 2018. He said that Ericsson got involved with NFV trials in 2013 and from what he has seen service providers don't say "I will turn a switch and go to NFV." Instead, they want to see metrics that assuage their concerns about the ease of provisioning and service quality before they implement it. He said that providing

service assurance in a virtualized environment is “pretty tricky due to the layers of complexity that have been added.”

Our best estimate

As described in this e-book there are numerous significant barriers to service providers being able to fully realize the ETSI vision including:

- The dependence of at least some of the potential use cases on SDN and hence the need for SDN to make significant progress;
- A range of business inhibitors, including the need to make organizational changes, reskill the employee base and change the culture of the organization;
- The need to change a number of processes including product management, procurement and end-to-end provisioning;
- A range of technology inhibitors including the immaturity of the current products particularly in regards to automation, management and orchestration;
- The time it takes to develop new standards and the need for a new generation of OSS/BSSs with open, standards-based APIs;
- The need to expand the existing operating models and to significantly change end-to-end management;
- The challenges of performing POCs and then working to get buy-in from the company’s OSS/BSS vendors as well as the company’s line of business managers, architect, product management and service management organizations;
- The need to develop and implement a common information model and a policy based architecture.

Based on the breadth and depth of these impediments, and using the broad ETSI definition of NFV, it is clear that NFV broadly defined won’t cross the chasm in multiple geographies in the foreseeable future. It is, however, highly likely that NFV solutions that are:

- Focused on classes of virtual network functions such virtualized CPE and virtualized EPC;
- Missing at least some of the automation or performance as envisioned by ETSI;
- Being used primarily as a replacement to lower cost and make the provisioning of current services more agile.

will cross the chasm within certain micro markets sometime in the next two years.

However, the use of NFV by carriers to offer new services in a manner similar to the approach used by OTT players will take considerably longer to cross the chasms. The reason being that in that case carriers will face all of the inhibitors listed above and as explained in *Transforming to a Digital Business* will also have to significantly modify their business models and develop a level of customer centricity that is generally lacking.

While it is highly unlikely that service providers will make significant revenue based on NFV services in 2015 or 2016, they cannot afford to sit on the sidelines and do nothing as that will increase how long it takes before they realize the benefits of NFV. Service providers must be active in driving Catalysts and POCs and learning from those experiences. They need to work with the TM Forum and other industry organizations to develop the necessary information models and to define a new model for end-to-end management. They also need to work with open source communities and SDOs to further accelerate the broad adoption of NFV.

About the author: Dr. Jim Metzler

Dr. Metzler has worked in many positions in the networking industry. This includes creating software tools to design customer networks for a major IXC; being an Engineering Manager for high speed data services for a major Telco; being a Product Manager for network hardware; managing networks at two Fortune 500 companies; directing and performing market research at a major industry analyst firm; and running a consulting organization.

Jim's current interests include Application Delivery, Software Defined Networking (SDN) and Network Functions Virtualization (NFV). In July 2014 he published an e-book entitled "The 2014 Guide to Application and Service Delivery" and in January 2015 he finished the serial publication an e-book entitled "The 2014 – 2015 Guide to Software Defined Networking and Network Function Virtualization".

Jim holds a Ph.D. in Numerical Analysis from Boston University. He has been on the faculty of several universities including Bentley University, Northeastern University and Drew University. He has co-authored a book, published in the Prentice Hall series in computer networking and distributed systems, entitled "Layer 3 Switching: A Guide for IT Professionals". He has written for numerous and is a frequent speaker at conferences and at seminars.

Jim can be reached at jim@ashtonmetzler.com