

A large, detailed fist constructed from various electronic components like circuit boards, capacitors, and resistors. The fist is raised from a dark, rectangular tablet. The background consists of bold, diagonal stripes in shades of orange and red, with a sunburst-like pattern radiating from behind the fist.

ORCHESTRATION: GET READY FOR THE PLATFORM REVOLUTION

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ORCHESTRATION: GET READY FOR THE PLATFORM REVOLUTION

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THE BIG PICTURE

Service providers could save, on average, the equivalent of their entire capital budget through orchestration, according to some. This is just from greater operational efficiency, without taking into account the increased agility it could deliver. Yet orchestrating services end to end across virtualized and physical infrastructure, including partners' networks, is proving to be one of the most difficult operational challenges for communications service providers and their suppliers.

Part of the problem is defining what it means. Yes, it's about automation, but automating what and where exactly? How is it implemented? What are the most important steps or architectural features? How should it be accomplished? And perhaps most importantly, where's the business case?

These are the kinds of questions we set out to answer in this, our inaugural *Insights Research* report on the topic. We surveyed more than 50 people at 33 service providers (respondents were fairly evenly split between the network and IT sides of the organizations) to ask them how they define orchestration and why it's important to their businesses.

IT'S ALL ABOUT AGILITY

One thing is clear: The biggest reason service providers are interested in both network virtualization and automation is agility. About 75 percent of all survey respondents ranked the ability to offer service on demand, with updates in real time, and to deliver services to customers more quickly in their top three drivers. By comparison, only about 10 percent put reducing capital expenditure in the top three. For most operators, the end goal is supporting zero-touch customer self-service, and this requires comprehensive end-to-end automation of both operational and lifecycle processes.

THE NO. 1 DRIVER FOR ORCHESTRATION?

6% each ●

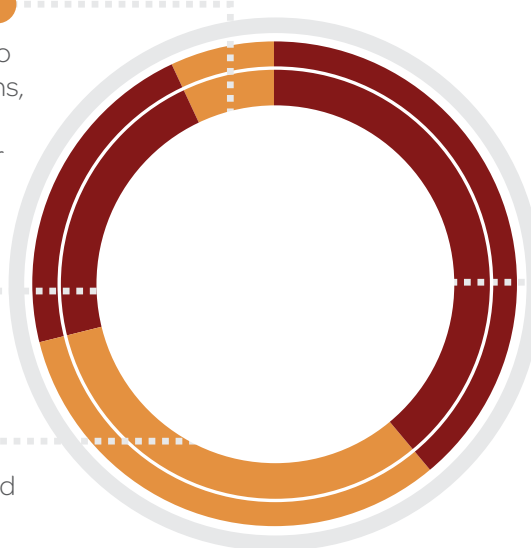
reducing CapEx, ability to adapt to new business or market conditions, and ability to participate in ecosystems of partners to deliver services to end customers

19% ●

reducing OpEx

28% ●

ability to offer services on demand with updates in real time



34% ●

ability to deliver services to customers more quickly

Source: TM Forum, 2016

It's also evident from the survey that service providers include service assurance and other processes beyond provisioning when they talk about orchestration. Several respondents said our definition – which read, “end-to-end management through zero-touch (automated) provisioning across virtualized and physical components” – should have read, “end-to-end **service** management through zero-touch (automated) provisioning, **configuration and assurance.**”



A PLATFORM REVOLUTION?

Our interviews with IT and network executives were particularly illuminating. They see orchestration as a key component in their transformation strategies, which often include plans to turn the network and supporting operations inside out, making them platforms that give customers more control. The idea is for network operators to become platform ‘curators’, connecting digital ecosystems of partners, similar to how Amazon has monetized its infrastructure investment through Amazon Web Services and Amazon Marketplace.

To do this, communications service providers need to become much more software-driven, which is changing their relationship with suppliers. While the service providers interviewed for this report were adamant that they do not intend to become software companies themselves and cut suppliers out of the equation, they acknowledge that the terms and conditions of their relationships with suppliers are changing – fast.

“The immediate answer is not hiring another thousand people and writing everything ourselves,” Verizon’s CIO, Radhika Venkatraman, said during her keynote address at TM Forum Action Week in July. “The timeline and optimizing the timeline become extremely important, so it’s incumbent on both operators and suppliers in this ecosystem to be very mindful of what’s hard to do and what’s not. How can we partner? Do we need to embrace open source a little bit more because there’s a lot of open source code available? I understand everyone has their secret sauce, but maybe we don’t need the secret sauce for everything in the virtualized environment.”

READ THIS REPORT TO UNDERSTAND:



How service providers define orchestration



Where orchestration happens



Why automation is necessary



What the business drivers are



How service providers are implementing orchestration



What the most important architectural considerations or steps are



What the biggest challenges are for deployment



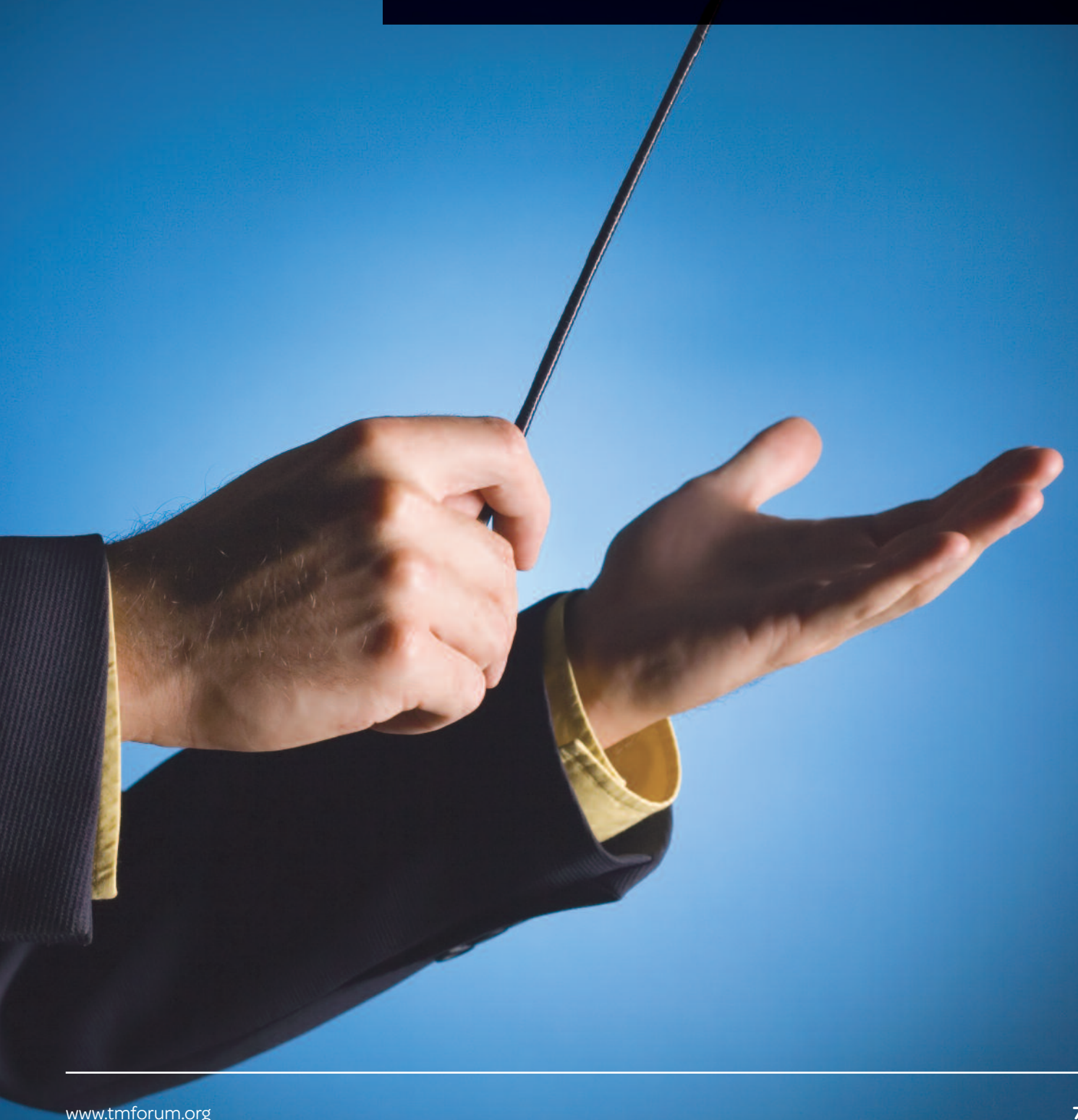
What the role is for open source



How TM Forum’s strategic programs and Catalysts can help

SECTION 1

WHAT IS ORCHESTRATION AND WHY IS IT SO IMPORTANT?





When we launched our survey for this report, we were interested in more than the orchestration and management of network functions virtualization (NFV) – NFV MANO as the European Telecommunications Standards Institute (ETSI) refers to it. We wanted to talk about end-to-end orchestration of services across hybrid networks, made up of physical and virtualized components, in multi-partner networks.

This is an important distinction because the NFV Orchestrator role specified in NFV MANO only focuses on virtual network functions (VNFs) and does not cover network segments that consist of physical network components; yet all service providers acknowledge they will be operating hybrid networks for the foreseeable future. So NFV MANO is too narrow: To manage hybrid networks and enable customers to control their own services (in the future these ‘customers’ could also be represented by autonomic devices in the Internet of Things – IoT), we need end-to-end automation of virtualized and physical functions, which includes operational and business support systems (OSS/BSS).

“If you’re going to do orchestration – and you can see this in both Verizon’s and AT&T’s architecture white papers – you have got to orchestrate top to bottom, end to end, period,” says Tom Nolle, President and Founder, CIMI Corp., an independent consulting company. “Orchestration has to envelop the current OSS, BSS and NMS [network management systems] processes, and also any incremental processes that are put in down at the bottom.”

He adds: “Effectively you have an OSS-driven revolution, where you use operations-level changes to solve the immediate problem and to lay the framework of service automation into which all else fits – and that’s the right way to do it.”

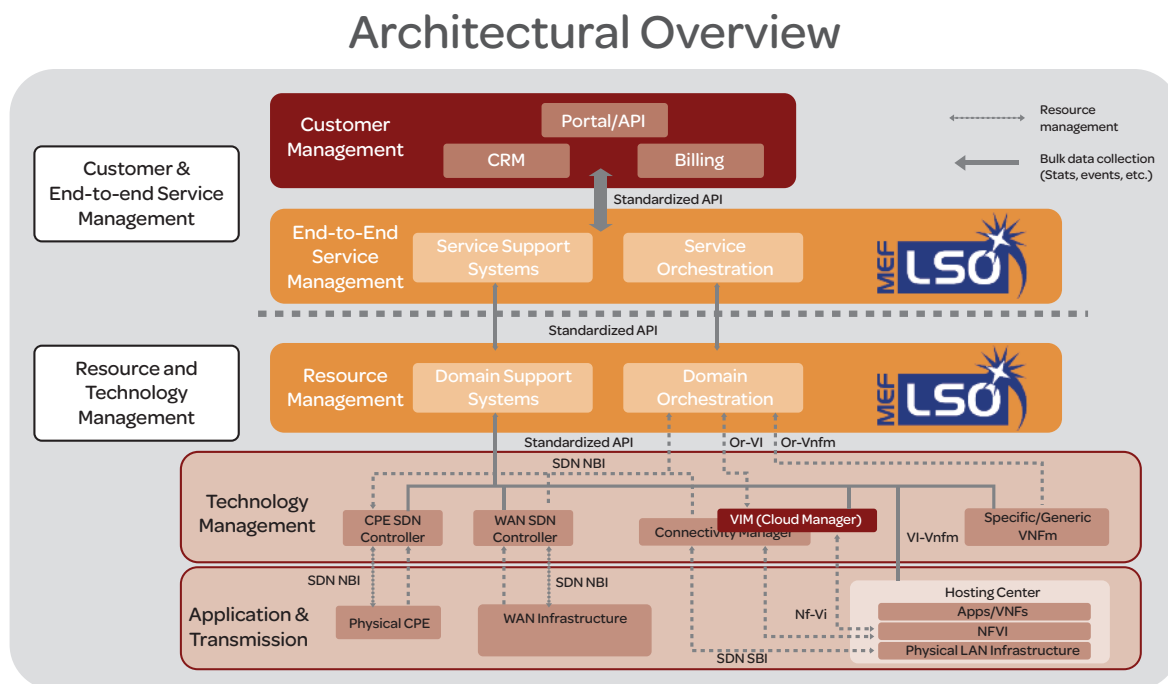
DEFINING ORCHESTRATION

Ron Parker, Chief Architect, Affirmed Networks, a solution provider focusing on vEPC VNFs along with automated configuration management and assurance, echoes Nolle. “In general, the definition of orchestration is too narrow and too specific to VNF lifecycle management,” he says. “Operators have backed away from talking about OSS recently, fearing it sounds ‘retro’, but it is clear we still need a top level layer of intelligence to manage end-to-end services, which is what OSS has traditionally done.”

For the purposes of our survey we defined orchestration as: “end-to-end management through zero-touch (automated) provisioning across virtualized and physical components,” and then we asked people whether they agreed with the definition or, if not, how they would change it.

Many respondents agreed, but several said our definition should have read: “end-to-end **service** management through zero-touch (automated) provisioning, **configuration and assurance**.” While we had, indeed, been thinking about configuration and assurance in addition to provisioning – many of our Catalyst projects have focused on assurance, for example – we clearly didn’t articulate it well enough.

Ultimately orchestration has to happen at multiple levels or layers in a service provider’s network (see Figure 1-1 on page 9.) “Orchestrators are like dark matter,” says Dave Milham, Chief Architect, Service Provider Engagement, TM Forum. “They influence everything and they’re everywhere.”

Figure 1-1: Orchestration happens everywhere

Source: Vodafone's Kevin Brackenpool at MEF London Seminar, May 2016

As is evident in the diagram, orchestration capabilities must communicate with each other and with many other elements, physical and virtual, to deliver service requests initiated by customers through the self-service portal. Generally speaking there are four places in an operator's environment where some kind of orchestration can take place (see below).

4 PLACES WHERE ORCHESTRATION HAPPENS



TECHNOLOGY MANAGEMENT (INCLUDING APPLICATIONS AND TRANSMISSION) – The network infrastructure itself, including physical network functions and virtual network functions, must be configured to deliver a requested service. This includes hardware like radio access nodes, switches and routers, as well as virtual network infrastructure and functions (for example, virtual routers, firewalls, IP Multimedia Subsystem, evolved packet core) and cloud applications.



RESOURCE MANAGEMENT – Both physical and virtual functions are modeled as logical resources, which are stored in product catalogs and can be orchestrated as part of a service chain. This is where the NFV Orchestrator would sit and is where ETSI is focusing its attention.



END-TO-END SERVICE MANAGEMENT – This is essentially the OSS layer, where service planning, provisioning, configuration and assurance happen.



CUSTOMER MANAGEMENT – This is the portal where the customer requests new services or makes changes to existing services.

Source: TM Forum, 2016

“It’s really about abstracting at a high level to simplify and using intent and policy to manage. There are multiple layers of abstraction, and at the highest layer, the customer layer, you’re asking the customer, ‘What’s your intent?’”

Dr. Lester Thomas, Chief Systems Architect,
Vodafone Group

WHY DO WE NEED AUTOMATION?

“What you’re setting out to do is abstract the complexity and drive modularity,” says Dr. Lester Thomas, Chief Systems Architect, Vodafone Group. “If you imagine a future network state where everything is virtualized – all software-defined networks – every customer might have a completely different set of virtualized functions. In a traditional approach you’d never get over that complexity – if something were to break, you’d never be able to fix it.”

What Vodafone and other service providers are proposing is that there will be multiple platforms within the network, each abstracting some of the complexity.

“We are saying to the customer, ‘Here’s a connectivity service you can order that abstracts all the complexity of the network,’” Thomas explains. “For example, OpenFlow abstracts the complexity of an individual router, while things like NETCONF and YANG abstract the variety of SDN controllers you have.”

He adds, “It’s really about abstracting at a high level to simplify and using intent and policy to manage. There are multiple layers of abstraction, and at the highest layer, the customer layer, you’re asking the customer, ‘What’s your intent?’”

We’ll talk more about platforms in Section 2, and we’ll look more closely at intent-based networking in Section 3.

SCALING IOT

Automation is also necessary to scale IoT applications like driverless cars. As Eric Troup, Chief Technical Officer, Worldwide Communications and Media Industries, Microsoft, points out in [this interview](#), the latency requirements for the applications driving 5G are for 2 milliseconds round-trip between a 5G data plane and control plane function hosted in a cloud. That means there is simply no time for any kind of human interaction.

“Everything has to be software-defined,” Troup says. “You can’t be fooling around with provisioning anything manually because the workload is going to move every time the customers move from one geographic location to another, which is what is happening in a mobile environment. Or imagine that someone scores a goal and all the sudden 2 million people join the network and want to stream a live media event. The only way you can react to that is being able to software define everything. Without human intervention has to be the norm.”

Systems must use common information models and application program interfaces for everything from ordering to provisioning, management and billing to be handled in software-defined clouds, which span multiple data centers (possibly in multiple partners’ networks). We’ll discuss this in more detail in the next sections where we look at how service providers are using orchestration.

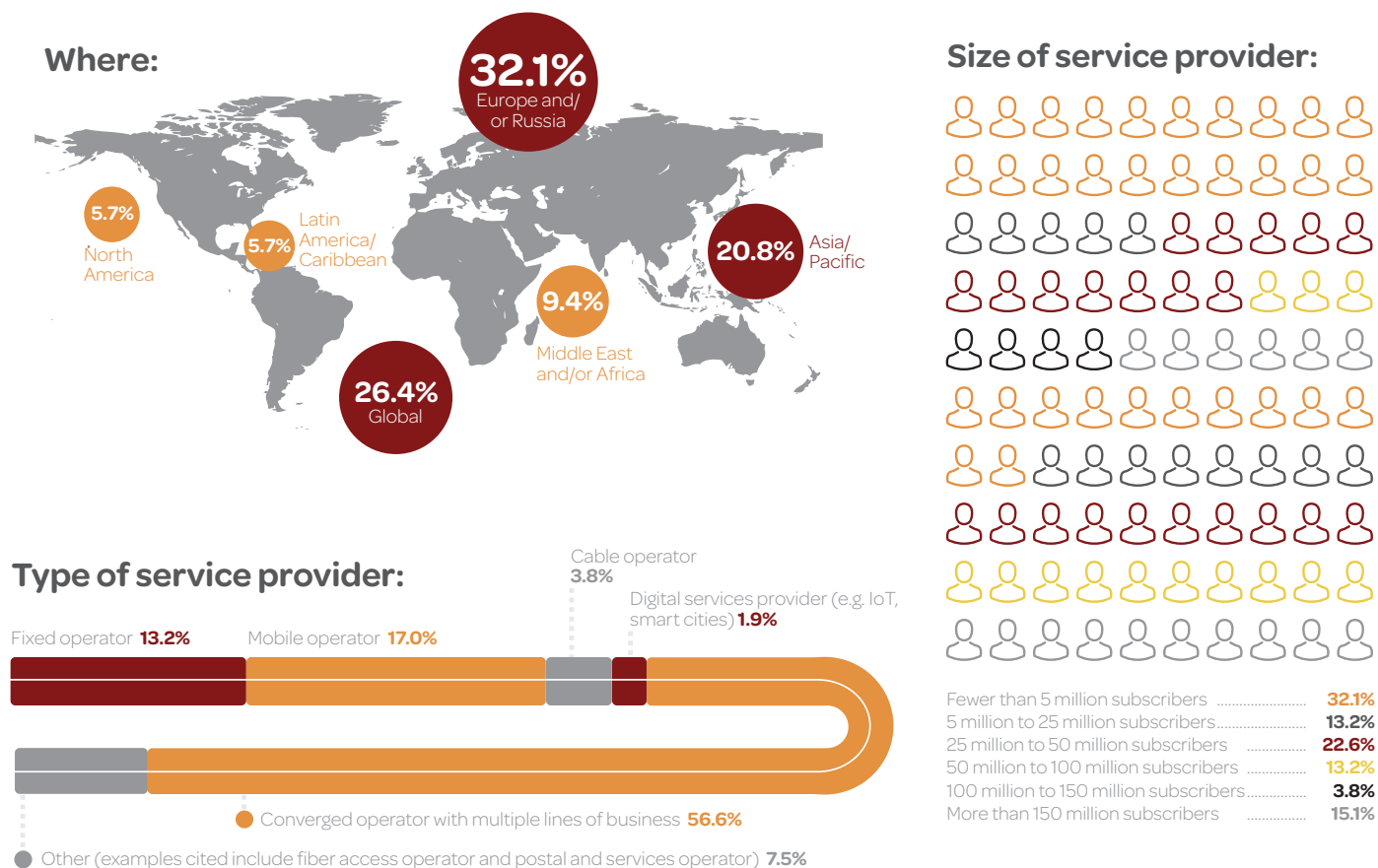


SECTION 2

SERVICE PROVIDERS SPEAK: WHY THEY'RE ADOPTING ORCHESTRATION AND HOW

WHO: 53 SERVICE PROVIDERS

Survey respondents included CIOs and VPs in networking and operations, network and systems architects, IT managers, OSS/BSS directors and software developers from 33 unique companies. In terms of job function, respondents were fairly evenly split between the network and IT sides of the business.

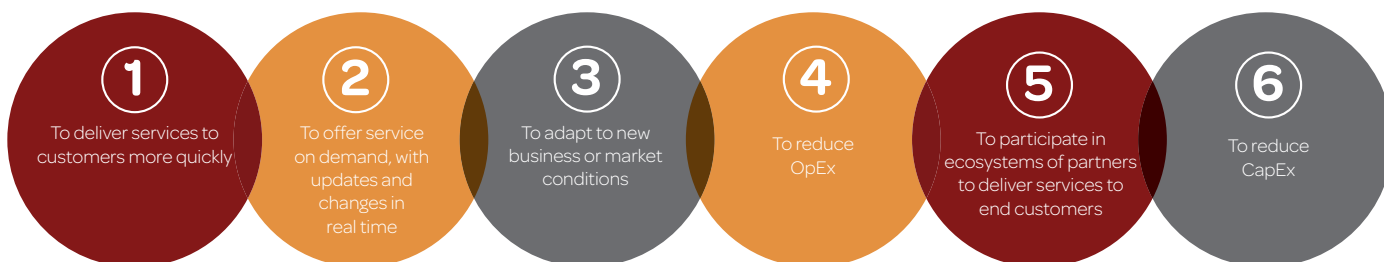


HOW: ONLINE SURVEY, TELEPHONE AND EMAIL INTERVIEWS

The biggest reason service providers are automating their networks through orchestration is to increase agility. A full 75 percent of all survey respondents ranked the ability to deliver services to customers more quickly and being able to offer service on demand with updates in real time in their top three drivers.

The infographic below shows how respondents ranked six drivers overall based on the average ranking of each. Agility is implied in the top three.

RANKING THE TOP BUSINESS DRIVERS FOR ORCHESTRATION

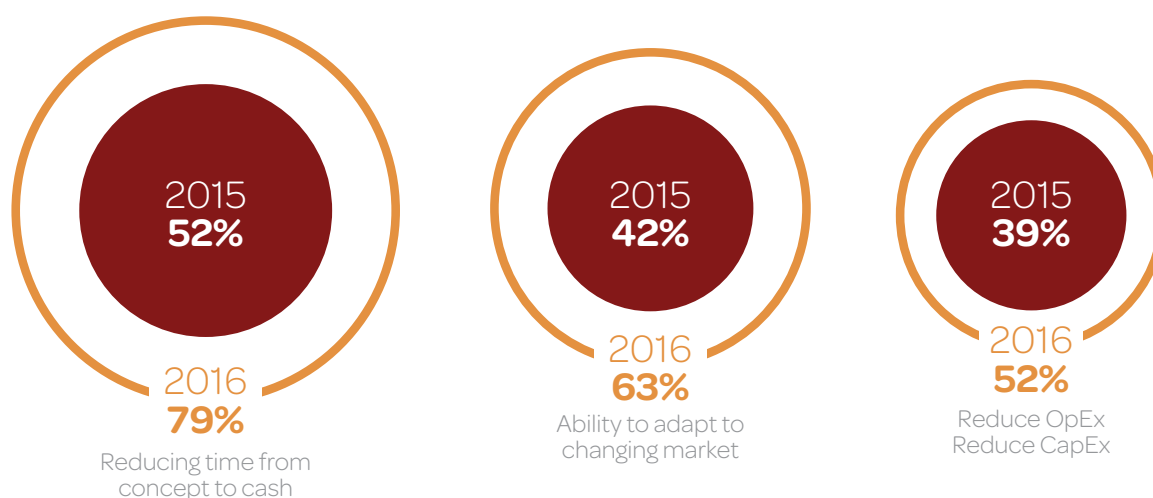


Source: TM Forum, 2016

These results are not surprising. When we surveyed a similar group of executives for our *Insights Research* report *NFV: Bridging the chasm*, which was published in February, nearly 80 percent said reducing the time from conceptualizing a service to billing for it was the primary driver for virtualization (see infographic below). That number represented a healthy increase over our 2015 survey, the results of which were published in our *Insights Research* report *Virtualization: When will NFV cross the chasm*.

"Initially, service providers thought NFV would allow them to immediately reduce costs," says Cyril Doussau, Senior Director, Service Assurance Products and Markets, InfoVista, a service assurance solution provider that participated in a joint MEF-TM Forum orchestration Catalyst (see page 20). "While this is true in the long term, providers are now realizing that today's return on investment for NFV is tightly linked to the launch of innovative and on-demand services."

TOP 3 DRIVERS FOR NETWORK VIRTUALIZATION



Source: TM Forum, 2015 & 2016

REDUCING OPEX

After agility, reducing OpEx is cited as an important driver: Some industry analysts go so far as to suggest that this should be the primary reason for adopting orchestration.

"We're talking about transforming a \$3 trillion industry, which is what telecom network services is worldwide," says Tom Nolle, President and Founder, CIMI Corp., an independent consulting company. "You're not going to do something like that just because someone asserts there's a better way; you're going to have to have an incredibly powerful cost-benefit analysis."

Nolle says some of his own research shows that operators could save an amount equivalent to their entire capital budget in increased operational efficiency through orchestration.

Today for every dollar in operators' revenue, 18 to 22 cents represent their capital budget and 27 cents the operating budget, Nolle says. "There isn't a single operator out there who believes they can achieve even a 25 percent reduction in overall CapEx with a combination of NFV and SDN – zero out of 57 operators surveyed," he says. "But when you ask

them how much, in theory, they could save from the 27 cents on the operations side, the answer is, on average, 20 of the 27 cents. What they're saying is that the operational efficiency achieved through service automation, which is the goal of orchestration, could save on average as much as the whole capital budget."

Caroline Chappell was Principal Analyst, Cloud and NFV, Heavy Reading at the time of the interview for this report, but she is now leading cloud and network virtualization research at Analysys Mason. She contends that operators are still a bit fearful about highlighting OpEx savings, which could be one reason they focus instead on agility.

"Ideally if you could automate all this, you'd get rid of 80 percent of your stuff, but no one is going to say that," she says. "Automation destroys jobs; no one wants to admit that but it does."



For a closer look at how automation is affecting jobs, check out [this article](#) from our recent *Perspectives* publication.

BETTER CUSTOMER EXPERIENCE

We also asked service providers if there were any drivers that are important to them that we failed to include in our survey question. Overwhelmingly the ones who said, 'yes', said we should also have included improving customer experience as an option.

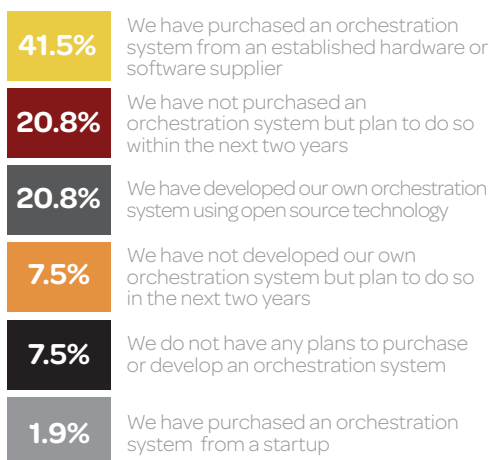
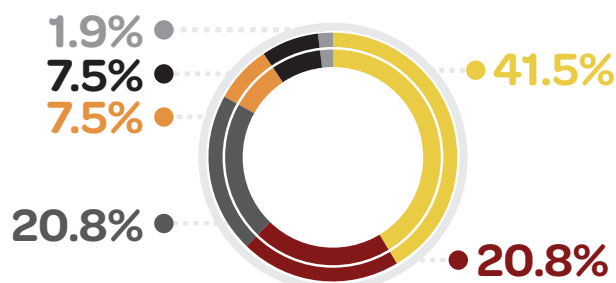
"Delivering better customer experience is the number-one driver," writes the CIO of a network operator in the Asia-Pacific region.

"If you want to develop a real customer-centric business and have better time to market, orchestration is key," writes another respondent from a mobile operator in Latin America.

ROLL YOUR OWN?

Most service providers are already using orchestration systems. Nearly two-thirds of respondents say they have either purchased an orchestration system from a startup or established supplier, or they have developed their own using open-source technology (see infographic below).

HAVE YOU PURCHASED OR DEVELOPED AN ORCHESTRATION SYSTEM?



Source: TM Forum, 2016

Interestingly, close to 30 percent of operators have either built their own orchestration systems using open source technology or plan to do so during the next two years. AT&T and Telefónica have done this and are contributing their work to open source groups. BT also has developed several of its own orchestration systems and is working to consolidate others.

"Orchestration is an integral part of our architecture – it's not something that's decoupled from the architecture and it's not something that's separate from the platforms and capabilities," says George Glass, Chief Architect, BT. "We have a mantra around real-time, self-service, zero-touch, which is how we want to deliver all our products."

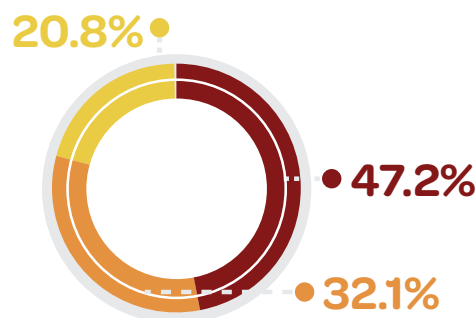
BT developed three of its most important orchestration systems on its own over the past eight to ten years. "We've handcrafted them from scratch partly because we wanted them to be rule- and data-driven, and ten years ago no vendor sold a system that did that," Glass explains.



Check out this [case study](#) about how MyRepublic used the ZOOM guiding principles to build its own orchestration system for an omnichannel order-to-cash process. Today 60 percent of orders are fulfilled without human intervention.

Our survey shows that service providers still don't believe there are enough mature solutions available from suppliers today (see infographic below). Nearly a third of respondents said there are no mature solutions available.

HOW WOULD YOU RATE THE MATURITY OF ORCHESTRATION SYSTEMS AVAILABLE ON THE MARKET TODAY?



Source: TM Forum, 2016

In fairness to suppliers, however, it's only been recently that service providers have been able to articulate what they really need from orchestration systems.

"We're getting real customer requirements now," says Steve Harriman, Senior Vice President, Marketing, Packet Design, an orchestration and service assurance solution provider. "A year ago we were only thinking about what the requirements would be and building to that, but now we are getting customers who know what they need."

He adds: "It's like the cloud was ten years ago – it was this amorphous thing that no one understood. Now even my wife knows what the cloud is and she's a complete technophobe."

MANY ORCHESTRATORS

We also know from our survey that a large majority of service providers are using or plan to use multiple orchestration systems – which we expected because orchestration has to happen at many levels in the service provider's environment. It is interesting to note, however, that more than a third also plan to use a master or 'uber' orchestrator to control other orchestrators.

HOW TO ORCHESTRATE THE SYMPHONY?

77% are using or plan to use multiple orchestrators

37% expect to use an orchestrator of orchestrators

Source: TM Forum, 2016

What we couldn't glean from the survey data is at which layers operators are using these orchestration systems, but our interviews with several Tier 1 operators shed a great deal of light on this.

YOU SAY YOU WANT A REVOLUTION

Companies like BT, Orange and Vodafone see orchestration as a key component of their strategies to become platform providers: Multiple orchestrators in multiple software platforms will communicate with each other and with other network and operational and business support system (OSS/BSS) components to deliver services – through open application program interfaces (APIs).

At TM Forum Action Week in July executives from all three companies participated in a workshop on platforms, during which TM Forum also announced a shift in strategic direction to embrace the platform economy.

The service providers and the Forum are taking their inspiration from work by The Center for Global Enterprise and Geoffrey G. Parker's (with co-authors Marshall W Van Alstyne and Sangeet Paul Choudary) seminal book on the platform economy, Platform Revolution, as well as platform providers like Airbnb, Amazon, Google, Netflix and Uber – companies that have achieved billion-dollar valuations almost overnight simply by linking buyers and sellers. They don't own anything except infrastructure – and sometimes not even that. They build their businesses by curating ecosystems that bring together end customers or users with those offering goods and/or services.

"What the telecom industry envies about the platform providers is the agility they have because they work purely in the software realm. [They] leverage orchestration to more efficiently control applications and the physical network – which for them is data center infrastructure," says Kevin Wade, Senior Director, Product Marketing, Ciena Blue Planet Division. "We want those same capabilities so the orchestration layer needs to be equally capable of orchestrating a service from end to end across the physical and virtual worlds. The service providers want to move to virtualization, but they absolutely don't want to leave behind the physical networks, which are the primary advantage they have over their competitors."

The first step for operators on the platform journey is transforming infrastructure, back-office operations and business processes through NFV, SDN and cloud technologies to become on-demand and efficient. The next step is turning those assets 'inside out' as platforms that can serve partners and customers in a dynamic way and support radically new business models for themselves and third parties.

WATCH EXECUTIVES FROM BT, ORANGE AND VODAFONE DISCUSS THE PLATFORM ECONOMY





VODAFONE OCEAN

Vodafone is undergoing major transformation and adopting the platform approach. The company recently made its NFV and SDN transformation, dubbed Ocean, its top priority, as David Amzallag, Head of SDN and NFV, Vodafone, explains in [this video](#).

The idea is to take a “black box platform” approach, so that what’s inside the platform can be vendor- or operator-specific to allow companies to have their own secret sauce that sets them apart competitively, says Dr. Lester Thomas, Chief Systems Architect, Vodafone Group.

“We’re not setting out to standardize what’s inside the platform, but open application program interfaces will make them interoperable platforms,” he says.

Thomas compares this approach to the way Amazon transformed into one of the biggest platform companies in the world. Back in 2002 Amazon was just an online bookstore, but its CEO Jeff Bezos mandated that all technology teams within the company expose their data to each other and communicate through specified APIs.

“He said, ‘There are no back doors – you have to use these APIs or service interfaces,’” Thomas says. “This wasn’t a really a technology concept; it was more an operating model. And when the APIs were developed, they were designed to be consumable externally, which is how AWS was born.”

It’s also important to note that Amazon is a platform curator at many levels, says Barry Graham, Senior Director, Agile Business & IT, TM Forum. “If I am a bookseller I can register as a seller on Amazon’s marketplace and sell books in direct head-to-head competition with them,” he explains. “They expose the marketplace, where they act as a shopfront like eBay; then they also expose the fulfillment service where I get to use more of their infrastructure; or I can use AWS where I can buy a web platform or compute and storage infrastructure.”

He adds: “Communications service providers are already familiar with this – most are involved in selling services at many levels, from MVNOs [mobile virtual network operators] down to local loop unbundling and dark fiber, and in some cases even cloud infrastructure. It is being able to do all these things in a role of curator that is the real opportunity.”

BT ADOPTS PLATFORMS

Similarly, BT has been working to consolidate operational and business support systems (OSS/BSS) during the past six or seven years, reducing the number from 4,500 down to 1,798 today.

“We started this work to transform ourselves internally, but then a few light bulbs went on and we realized it could be useful to our customers too, who were trying to manage their services through self-service portals,” says George Glass, Chief Architect, BT.

The company decided to partition its IT functionality into a set of cooperating IT platforms with reusable common capabilities (called SDKs, or software-development kits). The transformation includes reusable process blocks, which provide consistent customer experience. Today BT has about 15 platforms in place.



Check out this [case study](#) to learn more about BT's Cloud of Clouds transformation.

MAKING THINGS 'ORCHESTRATABLE'

With a platform approach, it's not really all that important which features an individual orchestration system has or whether it meets particular standards. What's important is that it can communicate with other orchestration systems, virtual and physical network components, and other OSS/BSS via open APIs.

"The standardization that's required is around making things so they can be orchestrated, which largely comes down to publishing what a service does in a catalog and then being able to get the metadata so that you know how to orchestrate it," says Dave Milham, Chief Architect, Service Provider Engagement, TM Forum. "So it's less about the orchestrator and more about the thing that's being orchestrated."

This is a chief finding from several TM Forum Catalyst projects and is also an underlying principle of the work the Zero-touch Orchestration, Operations and Management ([ZOOM](#)) team is doing on IG1139, an information guide about orchestration. We'll talk more about this in the next section.

A DIFFERENT APPROACH

While some European operators are embracing the platform approach wholeheartedly as a kind of business-focused, top-down strategy, their North American counterparts appear to be taking a more tactical, bottom-up approach to their transformations, preferring to solve some of the technology issues surrounding orchestration first.

Both AT&T and Verizon have released technical white papers about their NFV and SDN architectures which include details about how orchestration is being handled (AT&T's white paper is available [here](#) and Verizon's [here](#)), but neither company explicitly offers the platform approach as a business strategy behind the architecture.

"We want to orchestrate our own network functions and services as well as support additional orchestrated enterprise solutions like SD-WAN. Getting this right will open all sorts of different possibilities," says Andrea Caldini, Director of SDN and NFV Operations Transformation at Verizon.

AT&T CONTRIBUTES ECOMP

AT&T recently announced it is contributing to open source its ECOMP (Enhanced Control, Orchestration, Management & Policy) software platform and also named Amdocs as collaborator and industry integrator for ECOMP (we'll discuss this more in Section 4 where we talk about open source and standards).

During a webinar press and analyst briefing in July, Chris Rice, Vice President, Advanced Technologies and Architecture, AT&T Labs, likened ECOMP to the Apple App Store. "Our goal with ECOMP is to facilitate the onboarding, operation and scaling of VNFs [virtual network functions] on our network," he said. "To do that we need this automation layer... I like the Apple App Store idea as an analogy – we own the app store itself, which reduces the friction because there is a standard way to order."

While Rice did not confirm that AT&T is moving toward adopting a platform strategy per se, it's clear that ECOMP can support a curator role, as can Verizon's SDN-NFV architecture.

In the end, operators may take different paths to get there, but they are all headed in the same direction. The days of owning a huge physical network, taking months to develop new services and controlling the relationship with the customer are gone. To remain competitive, they must be able to work with other service providers and partners like insurance companies, healthcare providers and automakers to deliver the services consumers and businesses – who may or may not be the operator's customer – are demanding. This requires zero-touch, end-to-end service orchestration facilitated through open APIs. There is no other scalable way to do it.

"We need to allow consumers to compose and manage their own services," says Laurent Leboucher, Vice President of APIs and Digital Ecosystems, Orange. "We need to divine the new business models and how to match producers and consumers. We need the basic capabilities that will enable this platform ecosystem to provide curation, operation and trading."

SECTION 3

WHAT DO WE NEED FOR ORCHESTRATION?

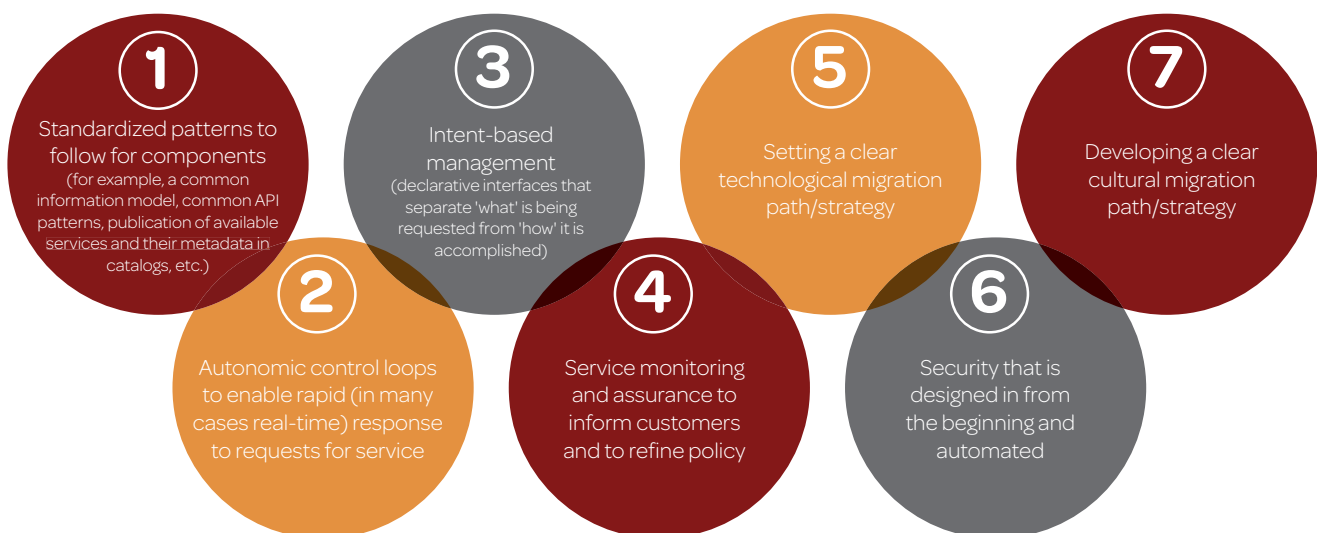


When it comes to end-to-end service orchestration, there are some key steps and architectural requirements service providers must consider. Adopting them will help operators develop a platform approach and move toward the Operations Center of the Future (OpCF).

Using the TM Forum ZOOM team's learnings about the OpCF from workshops and Catalyst projects, we developed a list of seven features or steps important to orchestration and asked respondents to rank them in order of importance. The infographic below shows how respondents ranked the features overall, based on the average ranking of each.

As you can see from what follows in this section, these seven elements overlap a great deal.

WHAT'S MOST IMPORTANT FOR ORCHESTRATION?



Source: TM Forum, 2016



For more about the OpCF, check out our *Extra Insights* publication *Building the Operations Center of the Future* and our *Quick Insights* report *Agile operations: Moving toward the Operations Center of the Future*.

The ZOOM team's learnings about orchestration will be published in an upcoming information guide called *Business Rationale and Technical Overview for Orchestration and Autonomic Control Loops* (IG1139). The document is currently available only to members for their consideration, but once approved will be published on the [TM Forum website](https://www.tmforum.org).

STANDARDIZED PATTERNS

Common information models and APIs are the most important considerations for service providers when it comes to orchestration. Close to 40 percent of respondents ranked it number one, and two-thirds put it in their top three considerations.

STANDARD PATTERNS ARE KEY



66% of respondents ranked common information models and APIs in their top 3 requirements

Source: TM Forum, 2016

As it turns out, end-to-end service orchestration is a lot like playing with Lego blocks and Meccano parts, according to Shahar Steiff, Assistant Vice President, New Technology, PCCW Global: It's easy until you try to combine them.

During his keynote speech at TM Forum Action Week in July, Steiff recounted how as a child he loved playing with Lego building blocks, but sometimes knocked on his neighbor's door: "I would borrow from him to build because I didn't have enough [Lego] resources myself."

SPEAKING DIFFERENT LANGUAGES

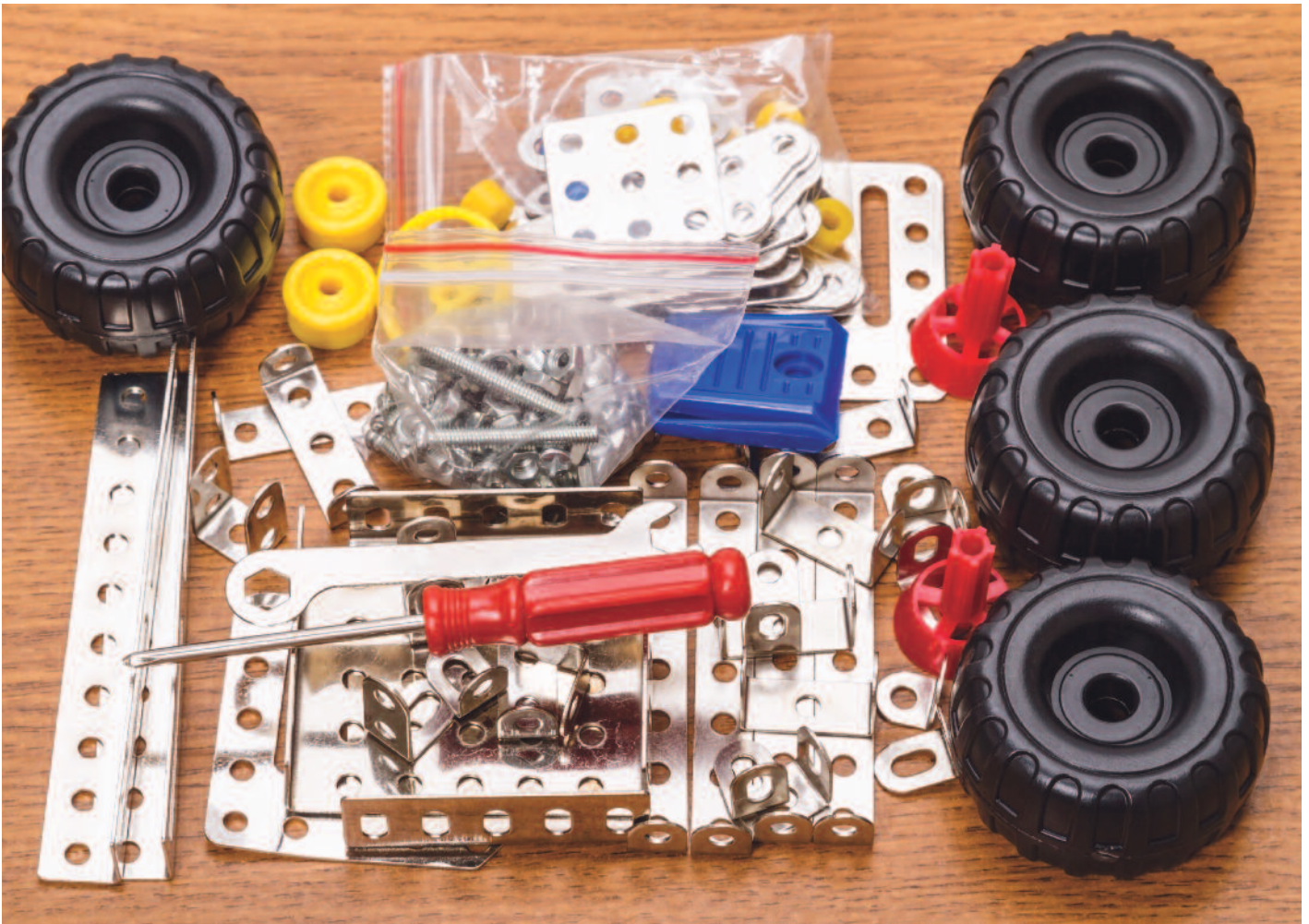
That's what it's like for network operators, too – increasingly they need to partner to deliver the services customers are demanding, but some partners don't speak the same language. "We speak Lego and they speak Meccano, so we have to use barbed wire duct tape and glue to put it together manually," he says.

Steiff, who sits on the board of directors of MEF and serves as co-chair of MEF's Service Operation Committee has been working on the joint MEF and TM Forum Network-as-a-service Catalyst to help develop the common language, definitions, information models and APIs needed to help service providers automatically order, provision, manage and assure virtualized services across partners' boundaries. The idea is to build a network connectivity services layer, delivered across multiple operators through MEF's Lifecycle Service Orchestration (LSO). This combined with TM Forum's platform, B2B2X partnering, ZOOM and Open API initiatives allows operators to provision and manage services end to end.

"Delivering a service today takes one to three months," Steiff says, explaining that that's how long it takes to work out the arrangement between partnering providers. "[During the Catalyst] we were able to deliver the service in fewer than ten minutes." The team would like to get that down to milliseconds in future phases of the Catalyst.



Catalysts are rapid fire proof-of-concept projects connecting service providers, technology suppliers and global enterprises to create innovative solutions to common industry challenges.



A SINGLE BRAIN?

Time to market is faster because there is no physical equipment to install. In addition, the Catalyst team used what Steiff calls a “single brain,” or orchestrator that had full visibility of all partners’ domains.

“This is an assumption that doesn’t really work in reality, but for the purposes of the Catalyst it worked great,” Steiff says. “The service was predefined; we all spoke the same language and used the same service definitions. Everything was fine and dandy, but that’s where it gets ugly in the real world.”

In the real world, a service provider will never have a master service orchestrator that has complete visibility into other providers’ networks and operational and business support systems. Instead, providers will have to agree to use the same information and data models along with APIs so that orchestrators in different domains can communicate. This, combined with intent-based management, is how service providers will automate service provisioning and management end to end. The intent-based management abstracts the complexity of the network at a high level, then uses a customer’s intent and policy to manage it.

“We speak Lego and they speak Meccano, so we have to use barbed wire, duct tape and glue to put it together manually.”

Shahar Steiff, Assistant Vice President, New Technology, PCCW Global

MODELS THAT WORK

It is very unlikely that the industry will coalesce around a single data model; rather service providers and their suppliers likely will adopt a few and then map them to one another.

TM Forum's Information [Framework](#) (SID), part of the [Framework](#) suite of standards-based tools and best practices (see page 37), is a high-level information model that provides standard definitions for all the information that flows between communications service providers and their business partners. It provides a common vocabulary for implementing business processes and reduces complexity in service and system integration, development, and design by providing an off-the-shelf model that can be quickly adopted by all parties.

But the Information Framework doesn't configure devices or systems or automate them. Data models are needed, such as TM Forum's [Open Digital Ecosystem Data Model](#), which renders the Information Framework in JSON; the Internet Engineering Task Force's (IETF's) [YANG](#), which describes

configuration information for network devices and services and is used in conjunction with the IETF's NETCONF protocol; and [TOSCA](#) (Topology and Orchestration Specification for Cloud Applications), an orchestration data modeling language that OASIS is developing.

Abel Tong, Senior Director of Product Marketing, Ciena Blue Planet Division, penned a good [blog](#) explaining YANG and TOSCA: "TOSCA can describe the coordination between diverse resources across a potentially complex application environment," he writes, adding that both models can work well together. For example, YANG can be used to define the interfaces for configuring individual virtual network functions (VNFs), while TOSCA describes the end-to-end service including the creation, configuration and chaining of VNFs.

TM Forum has been working closely with OASIS as part of another Catalyst project called [NFV Ecosystem Enabler: A well-enabled VNF package](#), and one of the next steps for the project is to map the Information Framework and TOSCA (see panel below).

THE MAGIC OF COMBINING VIRTUAL AND AUTOMATED

The [NFV Ecosystem Catalyst](#), championed by AT&T, China Mobile, Orange and Verizon, is a multi-phased project aimed at automating procurement and onboarding of VNFs.

The first phase of the [award-winning Catalyst project](#) described the business and operational aspects of a VNF package to help advance the thinking around transforming traditional procurement processes, which take months, to a new paradigm where procurement and onboarding can be automated. This level of agility and standards are required to develop a component-based architecture and specifications for the Operations Center of the Future ([OpCF](#)). The first phase of the project also developed a clear view of the NFV ecosystem, the roles within it and its lifecycle management.

The next phase, which will be demonstrated at [TM Forum's Innovation InFocus](#) in November, will actually implement a component-based architecture using the Forum's Information Framework and TOSCA. To achieve this, the Catalyst is merging with another multi-phased, award-winning project called [Future State](#), which developed a working model of the OpCF that dynamically connects stakeholders in an end-to-end lifecycle of digital services using open APIs.

"First we need to have industry agreement on non-functional elements that need to be described in a VNF package," says Jenny Huang, Lead of OSS/BSS Standards Strategy Group, AT&T, and Co-leader of the ZOOM project. "The information needs to be delivered as part of the product package to reduce manual hand-off and to increase clear responsibility between the service providers to reach automation and business agility."

The non-functional information includes, for example, metadata about licensing model, maturity model, metrics model and service level agreements (SLAs). The implementation of the OpCF in this Catalyst will then put the metadata into action to automate the procurement and onboarding processes, as well as facilitate the lifecycle management of the components and their composed services in an ecosystem environment.

THE IMPORTANCE OF APIS

Just as common information and data models are required for end-to-end orchestration, so are standard, open APIs. By combining the two and using intent-based management, service providers can solve the dilemma Steiff outlines, where an orchestration system has no visibility into a partner's environment.

Earlier versions of the *Future State Catalyst* referenced in the panel showed how to do this by using dynamic APIs to mediate connections between diverse systems. Dynamic APIs allow the payload to vary depending on the product or service that's being ordered, procured or managed. In the case of the *Catalyst*, the Open Digital API acted as a bridge between an orchestration system and the OSS/BSS, allowing suppliers to invest in a single set of APIs and use them to supply multiple products to many buyers. Conversely buyers could also use a single API investment to integrate with many suppliers, which allows a true marketplace to form.

Dynamic APIs are the wave of the future. "It means I can use an API in one way and someone else can use it a bit differently," says George Glass, Chief Architect, BT. His company championed the dynamic API Catalyst along with AT&T, NTT Communications, Orange and Verizon. "It's a little more difficult for us to manage because how do you test something that's dynamic and changes every time you use it? What are the test cases you run to verify it's working? And how do you certify them?"

Likely what will happen is that dynamic APIs will be certified against the core components and as long as the extensible parts follow the pattern as defined by the API it will be certified, Glass says. Or perhaps if a set of APIs keep being extended in the same way by multiple service providers and supplier, then what's in the extension can be integrated into the core. "We think we've got a way to govern it," he says.

WATCH PARTICIPANTS EXPLAIN THE DYNAMIC APIS CATALYST



API MANDATE

As we noted in Section 2, APIs are key to the success of platforms. They're so important, in fact, nine of the world's largest operators – Axiata, Bharti Airtel, BT, China Mobile, China Unicom, NTT Group, Orange, Telefónica and Vodafone – have officially adopted TM Forum's suite of Open APIs for digital service management.

They have committed to adopt TM Forum Open APIs as a foundational component of their IT architectures, to promote global adoption of the API suite by their partners, and to expect technology vendors and systems integrators to support these APIs in their products and cloud-based services. More service providers are expected to announce their endorsement of them shortly.

Glass has some advice for suppliers looking to do business with BT: "Read the API Manifesto," he says. "We will be publishing those APIs in our RFIs and RFPs. Your job as vendors will be easier if you conform to the APIs."

WHEN PATTERNS AREN'T ENOUGH

It is important to note that not every service use case can be addressed through standardized patterns, which is why it's important for orchestration systems to be data- and rule-driven.

"One of the reasons we implemented our own orchestration components is the data- and rule-driven nature of the orchestrator, which not only allows me to simply bring another element or component in the orchestration environment but also to describe how that component behaves or operates in the context of the other elements I'm orchestrating," Glass says. "Getting standard patterns is fine – it covers 80 percent of your use cases – but the problem is that you end up hard-coding the other 20 percent. If I've got a rule-driven, data-driven orchestrator, that other 20 percent is something I can cope with without having to go back to coding."

This is particularly important at the resource layer, where the level of complexity increases greatly. "The number of moving parts and the different parameters you've got to apply beg for a rule-driven capability that you can then configure with data parameters, and that gives you much, much more flexibility."

CONTROL LOOPS AND ASSURANCE

Close to half of survey respondents ranked autonomic control loops in their top three requirements for orchestration, and 40 percent ranked service assurance high. The two are closely related, and in hindsight perhaps we could have grouped them together in the survey along with policy management.

In networking, closing the loop means collecting and analyzing performance data to figure out how the network can be optimized and then applying policy, usually through orchestration, to make the changes in an automated way. This is crucial for ensuring SLAs, and it's how service providers will be able to achieve zero-touch provisioning and management.

Orchestration got its start in service provisioning as a way of dealing with the numerous proprietary drivers for different hardware suppliers' equipment. It allowed operators to activate services on any vendor's device in a standardized way. But then operators started to realize that in a virtual network, you have to consider assurance too, because configuration changes can affect performance.

"The focus in the industry until now has been on service activation, with only limited efforts to make sure the service actually works from the customer's perspective," says Marcus Friman, Co-founder and Chief Product Officer, Netrounds, a service assurance solution provider. "Moving to automated fulfillment is a huge step, but you also have to know, once the service is delivered, was it delivered right? This is key for the customer."

Indeed, there is ample research showing that customers, particularly consumers, are not willing to put up with poor service – and most won't even bother to complain before they churn (see infographic).

ANALYTICS AND MACHINE LEARNING

Analytics are critical to ensuring quality of service. In order to measure performance, BT is designing its capabilities to have a standard payload that contains information about the transaction ID, the user responsible for it and the function that's being carried out. This gives the company end-to-end traceability across the network and OSS/BSS environment so that they know where a transaction is at any given point in time. The other reason for doing this is because the information can be stored and fed into an analytics environment.

"It gives me very, very rich information around what's going on within my IT estate," Glass says. "We've developed an app in our research department that allows us to visualize the transactions as they flow through our estate. I can see very clearly the happy path through the process and I can also see where things fall out."

BT has been looking at the patterns over a period of time and using the results for service assurance. Today, there is a team of data scientists eyeballing the data to see what's going on, but in the future machine learning will analyze patterns and make changes automatically based on policy in order to ensure and improve service.

Vodafone also has an eye toward machine learning. "Our assumption is humans should not play any role – it's zero-touch," says Dr. Lester Thomas, Chief Systems Architect, Vodafone Group. "Humans should be looking from the side and saying, 'I'm setting the policy, or these algorithms might have some levers they can pull'. Eventually machine learning may become the expert in how to adjust the policy or algorithms we use."

YOU MAY NOT GET A SECOND CHANCE



82% of churn is due to frustration over the service and the service provider's inability to deal with it effectively



On average, one frustrated customer will tell **13 other people** about their bad experience



About 90% of customers will not complain before defecting – they will simply leave

Source: *QoS and QoE Management in UMTS Cellular Systems*

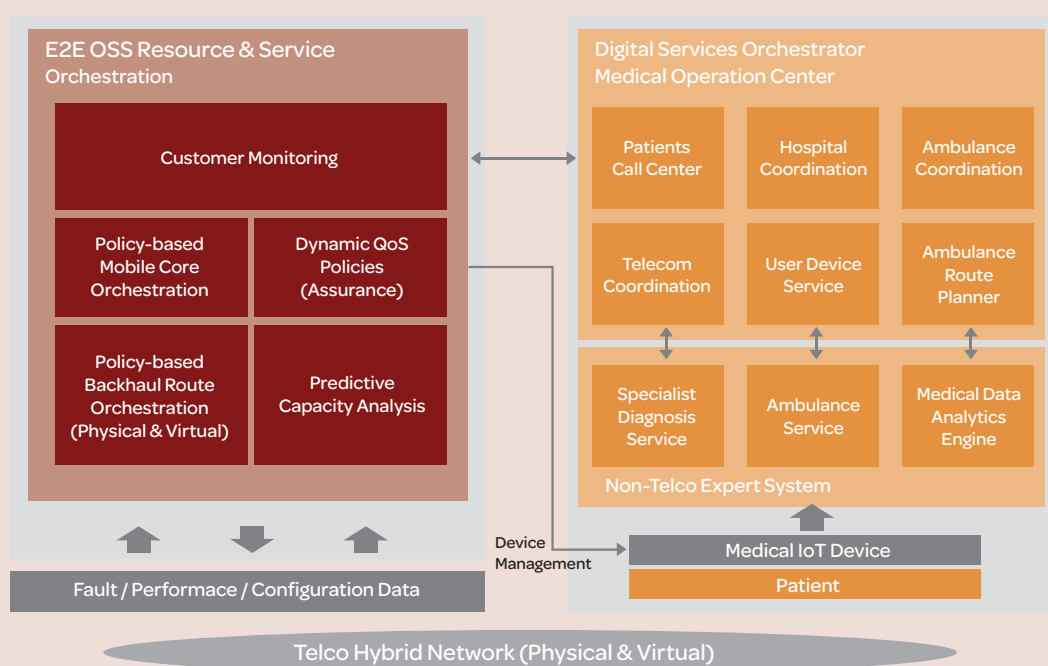
CATALYSTS SHOW HOW TO CLOSE THE LOOP

Several TM Forum Catalysts have addressed closed-loop automation and service assurance. One team has applied what it has learned in multiple projects demonstrating how to build a closed loop using key performance indicators (KPIs) relevant to network performance, customer experience and service quality in order to enable network changes, optimization and self-healing.

In two projects during 2015 the team used data analytics to automatically monitor the network, identify needed changes in capacity, request the changes and then complete them in a hybrid network scenario. At TM Forum Live! 2016 they applied what they learned to digital health services as part of a new Catalyst called *E2E service orchestration for smarter health*. The project, which was championed by Telecom Italia and TeliaSonera, worked on a service to provide end-to-end remote monitoring of patients using varying levels of quality of service (QoS). The team also built a specialized operations center for healthcare services (see Figure 3-1).

Figure 3-1: Orchestrating patient care end to end

Smarter Health Architecture



Source: TM Forum, 2016

"The challenge was to come up with a common information and data model that would allow the operator's digital operations center to 'talk to' the medical operations center," explains Yuval Stein, Associate Vice President of Product Management, TEOCO, and leader of the Catalyst. "Ambulance service is not something OSS is familiar with."

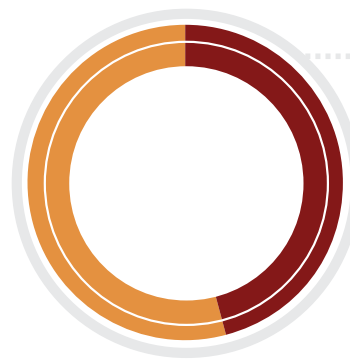
During the demo, bandwidth was increased or decreased based on the patient's need at home and in transit to a hospital. For example, if the patient's condition worsened at home, the policy-based orchestrator could increase bandwidth to ensure that the patient's connection with their physician was not interrupted.

"It took us some time to decompose the digital services and understand the differences between the medical domain and the operator's domain – this was an understanding we didn't start with," Stein says. "As we understood the systems we realized what the needs are for a new data model and new interfaces. We are contributing back to the Forum the need for new APIs. It's really a new area – even the work being done inside the Forum for digital services is more focused on the service itself than on the orchestration between the systems."

INTENT-BASED MANAGEMENT

Close to half of survey respondents put intent-based management in their top three architectural requirements for orchestration. As we noted in Section 1, intent-based networking is the idea of abstracting the complexity of the network at a high level and then using intent and policy to manage it.

The intent is quite simply what the customer wants to do on the network – the service they want to use and the desired end state – which they select through a self-service portal – see panel.



● **46%**

of respondents put intent-based management, or using declarative interfaces that separate 'what' is being requested from 'how' it is accomplished, in their top three requirements for orchestration

Source: TM Forum, 2016

DO DRONES DREAM OF ELECTRIC SHEEP?

At Mobile World Congress in February, Vodafone conducted a proof of concept showing how intent-based, closed-loop management and orchestration can be used to automatically scale and self-heal networks.

During the demonstration, as demand for service grew the orchestrator used analytics and policy to automate all of the necessary configuration changes to meet the demand. Then when demand dropped off again, the orchestrator switched back to the smallest possible configuration.

"This is part of the sharing economy – all our networks need to use shared resources," explains Dr. Lester Thomas, Chief Systems Architect, Vodafone Group. "How do I consume only what I need to but have the ability to elastically scale never running out of capacity?"

The proof of concept also demonstrated a denial of service (DOS) attack where orchestration was used to move traffic to a different network architecture that had a DOS firewall in the loop. "While the attack was going on, we had these extra resources to ensure that customer service was still being delivered – the intent was guaranteed," Thomas says. "But when it was finished it went back to using the minimum amount of resource. So essentially we had a service that was able to defend itself against attack even though most of the time it was using zero resources for that. It just new how to handle it if and when it happened."

ONBOARDING PARTNERS

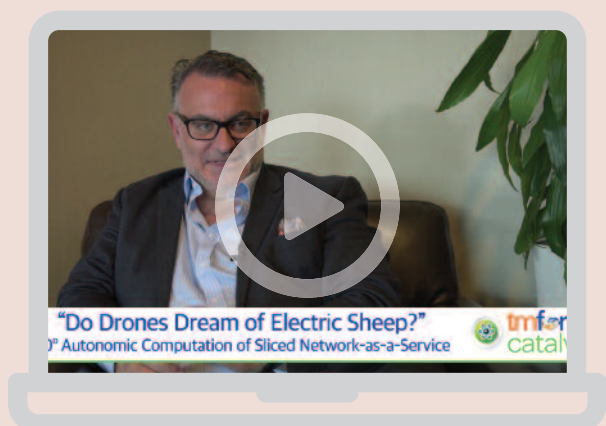
At TM Forum Live! 2016 in May, Vodafone took the proof of concept a step further as part of a Catalyst called *Open cloud ecosystem for SMEs* (small and

medium enterprises). In this case, an API was added to orchestration, allowing partners to onboard their own applications automatically and SME customers to order online through a self-service portal.

"This two-sided business model for the platform, which is our target model, has to have orchestration, and the things it's orchestrating have to be well packaged," Thomas says.

The Catalyst will continue in Dallas under the moniker *Do drones dream of electric sheep?* – a play on the Philip K. Dick sci-fi novel, *Do Androids Dream of Electric Sheep?* This phase of the project will work on a business process portal and 5G slicing for IoT applications, such as using drone services to improve the safety of machines used in agriculture.

WATCH HUAWEI'S DEREK COLLINS EXPLAIN WHAT THIS PHASE OF THE CATALYST HOPES TO DEMONSTRATE.





“The key to making this work is the abstraction itself, the representation of NaaS [network as a service],” writes Tom Nolle in a recent [blog](#). “The abstraction of a connection service has to describe the connection in terms of endpoint behaviors and service-level agreements (SLAs). Think of it as a ‘description’ of the service (the logical topology, which in the case of a vLAN [virtual local network] is a ‘multipoint’ service, and its QoS attributes, for example) and a list of endpoints.”

So basically, an abstraction describes what the service is supposed to do – the end points it needs to connect and what the agreed terms are for QoS. Then using closed control loops, policy and analytics, the orchestration system provisions and manages the required service automatically.

“We are talking about separating the model from implementation,” says Dave Duggal, Founder and Managing Director, EnterpriseWeb, an orchestration solution provider that has been involved in several Catalyst projects including the *Future State* project which has now merged with the NFV Ecosystem Catalyst (see page 22). “That separation of concerns – that decoupling – provides for modularity and flexibility and adaptability. I tell you what I intend to do, but I don’t tell you how to do it. That’s a really powerful concept.”

As part of the ZOOM project, TM Forum members are working in conjunction with other organizations like ETSI, MEF and OASIS on these abstractions and the mechanism for reaching and maintaining the desired end state. The goal is to build a Hybrid Network Management Platform.

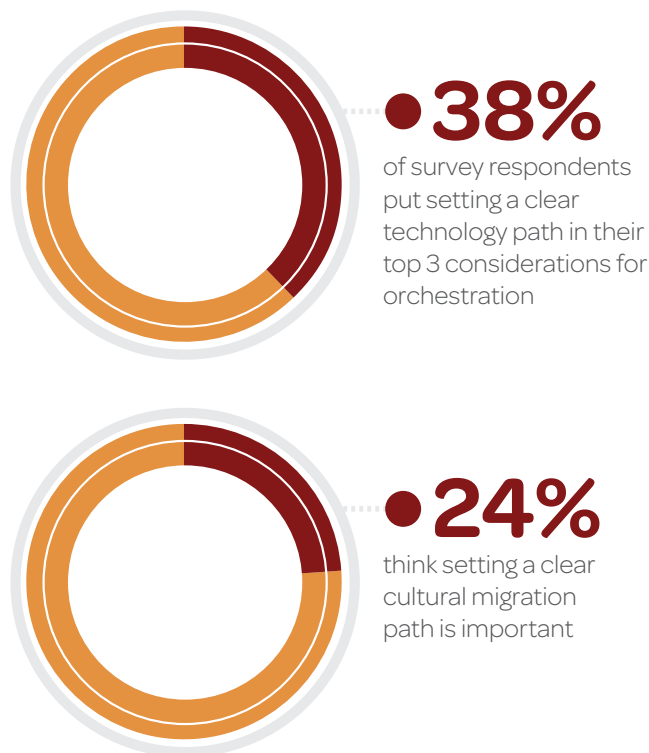
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**Dave Duggal, Founder and Managing Director,
EnterpriseWeb**

PLANNING THE TRANSITION

The success service providers have in adopting end-to-end orchestration and a platform approach will depend greatly on how well they plan the transition. That means setting a clear migration strategy both technologically and culturally.

CHARTING THE MIGRATION PATH



Source: TM Forum, 2016

While service providers seem to understand the importance of setting a clear technological migration path, we find it a bit troubling that cultural migration strategy falls low on the list of priorities. Orchestration may seem like a technology problem to solve, but it won't happen without setting a clear cultural and business strategy. This really comes down to learning to think like a software company.

"We're moving into a software-driven world, and at some point the telcos have got to become very much more software-savvy and be masters of their own destiny," says Caroline Chappell, who at the time she was interviewed was Principal Analyst, Cloud and NFV at Heavy Reading, but is now leading cloud and network virtualization research at Analysys Mason. "They have relied on vendors in the past because the investment costs of building a huge physical appliance were massive, but the economics of software changes everything and part of becoming a software-driven company is to take on more of this themselves."

The service providers we interviewed for this report insisted they do not intend to become software companies and cut out suppliers, but they did note that their relationships with vendors are changing. And they agree they need to become much more software-savvy.

"We need to change the focus to services away from functions," says Andrea Caldini, Director of SDN and NFV Operations Transformation at Verizon. "We have to start thinking like software engineers."

Caldini believes setting a clear cultural migration strategy should be operators' number-one priority. "We have to look at the people and process piece of this," she says. "It's a mindset change."

DEVOPS FOR NETOPS

Indeed, adopting DevOps-like practices for network operations is crucial to the success of end-to-end orchestration and embracing the platform economy, but it isn't easy. It means learning to allow for failure – something that is in complete opposition to the way network operators have done business since their inception.

"The challenge we have is that we have network experts who we absolutely need to keep because they're the ones who really understand how to build these massively scalable networks," says Vodafone's Thomas. "But we have to educate them in how to take a software approach. They're not familiar with these levels of abstraction and the sorts of things you see in the cloud space, where at the infrastructure level I assume everything fails."

Thomas points to Netflix as an example. The Netflix platform assumes nothing of the underlying infrastructure – it does not expect any specific service levels. It just consumes infrastructure as a service from Amazon Web Services. Netflix assumes the IaaS will fail and then manages its own service in such a way that it can cope with failure.

"This is about educating our network engineers, who are used to saying I want five-nines reliability in my network and therefore every component has to be perfect, to assume these things will fail," Thomas says. "Netflix kills its services to test them. That's what we should be doing."

SECURITY CHALLENGES

Security also ranked low among service providers' orchestration priorities – only 26 percent ranked it in their top three requirements. Other surveys we've conducted have showed a mixed response on the issue of security. Respondents ranked it last in questions about important areas for digital operations but positioned it as the top priority for the Operations Center of the Future (OpCF).

Security is a critical issue that should not be an afterthought when it comes to end-to-end orchestration. In the past, most network security has been based on the concept that there is physical control, a firewall located on the customer's premises, for example. This cannot be the case once functions are virtualized.

Virtualized environments provide ample opportunity for security breaches because hypervisors (software, firmware or hardware which create and run virtual machines) create many new attack surfaces. For example, mixing multiple functions on a physical machine can lead to compromise if a physical server is breached. Mixing many applications on a physical server running several virtual machines raises the risk, as does moving apps around from one virtual machine to another.

One of the requirements we've discovered for the OpCF is that security must be designed in upfront, because trying to bolt it on afterwards simply won't work (see infographic). An orchestrator that can call on internal or external security functions and the ability to apply security policies to users or systems accessing NFV components in order to detect configuration-related security vulnerabilities are both required.

Moving toward the Operations Center of the Future

TM Forum's ZOOM project is working to develop the principles and guidelines to help service providers evolve their networks, support systems and business processes to digital Operations Center of the Future (OpCF).

REQUIREMENTS FOR THE OPCF



Open, dynamic APIs exposing standardized network and management functions are required at all layers



Closed loop control and automation is necessary, with orchestration and management being real-time and zero-touch, and requests being executed rapidly without human intervention



Real-time data analytics should be used to ensure and enhance customer experience



Transparent end-to-end management across partners' boundaries is essential



Orchestration can be used to increase profitability



Security must be designed in from the beginning and provided at multiple levels

Source: TM Forum, 2016

A multi-phased Catalyst called *Security Functions in NFV Orchestration* used service providers' real-world experiences to test security in virtualized networks. The team created an environment that emulates an NFV architecture (a virtual evolved packet core) which included an orchestrator that was able to call upon internal or external security functions, such as IP or Domain/URL reputation checking, behavior analysis, file inspection, content filtering, etc.

Using their real-world experience, service providers created subscriber profiles – for example a subscriber that has paid for premium security inspection, an enterprise customer, generic users, and suspicious or unknown users. Based on each profile's requirements, an appropriate level of protection was determined for each subscriber's session. To test the protection, 'fake' malicious traffic flows were created emulating real-world traffic and key performance indicators for speed, risk, latency, false positive rates, etc., were used to measure performance.

A ROLE FOR MACHINE LEARNING

Machine learning as part of the automation process will also play a big role in security. "There are going to be categories of services that require automated orchestration without human intervention to react fast enough for the task at hand," says Wayne Cheung, Director of SDN and NFV Product Marketing, Juniper Networks.

To combat security threats that are constantly evolving, for example, machine learning and orchestration will have to be combined to automate security updates, enforce new rule sets and dynamically adapt to new threats.

END-TO-END SECURITY AND SLAS

While it did not feature an NFV component, a continuing *smart city Catalyst* championed by BT, the City of Milton Keynes and NRECA (National Rural Electric Cooperative Association) has been working on a digital ecosystem platform that demonstrates end-to-end management of security and SLAs, and use of analytics and APIs.

In the first iterations of the Catalyst, BT worked with participants to build a data hub, which serves as an aggregation point for various data feeds from sensors deployed around the city. This data is communicated through gateways to the hub, or platform, where analytics applications then can be used to provide value-added services to ecosystem partners.

At TM Forum Live! 2016, the team added security and SLAs to the data hub to introduce guarantees around the services and data feeds that are traded through the hub and to ensure that the consumers and users of the data can trust that what comes from the sensors is accurate and not tampered with.

"We are trying to tell a story of end-to-end security, ensuring that sensors and gateways are within legitimate relationships – meaning there are no rogue devices pairing up with gateways to send false data through the gateway," says Nektarios Georgalas, BT-Intel Co-lab Director. "We also want to make sure that all the sensors in place are authorized to access the gateways and close the loop with the data hub."

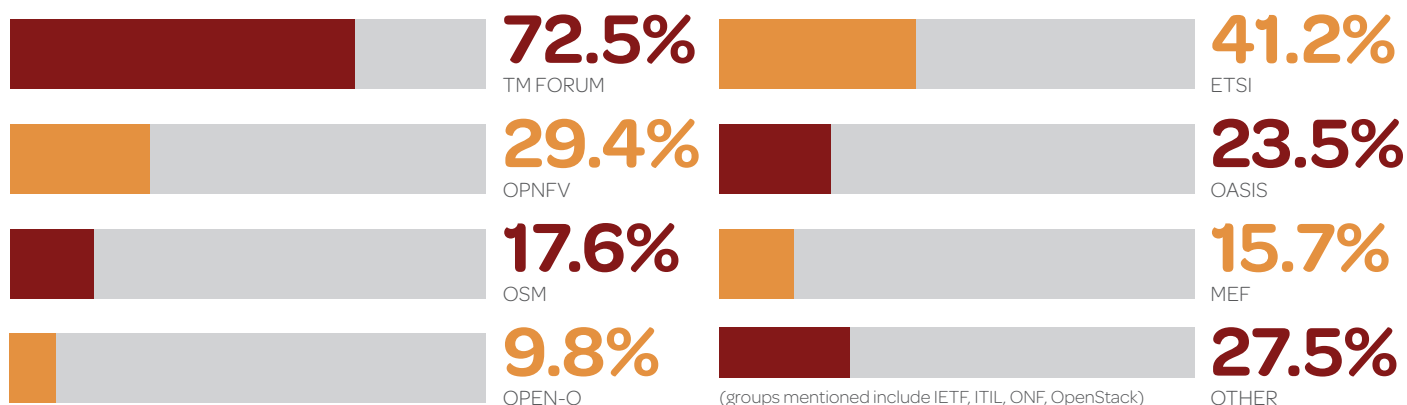
Data transmitted between the sensors and gateways and from gateways to the hub are also encrypted. Security then becomes part of an SLA, which can be used to guarantee quality of service and offer differing levels of service to ecosystem partners.

SECTION 4

WHAT IS THE ROLE FOR STANDARDS AND OPEN SOURCE?

As part of our survey, we asked service providers which standards bodies and open source groups they are relying on for help with orchestration. The results are shown in the infographic below.

WHICH STANDARDS BODIES/OPEN SOURCE GROUPS ARE YOU RELYING ON FOR HELP WITH ORCHESTRATION?



Source: TM Forum, 2016

It's not surprising that a large majority chose TM Forum because most of the survey respondents were, indeed, Forum members. Still, we're encouraged by the percentage who are looking to the work we're doing to help them sort through the end-to-end orchestration challenges.

We're also encouraged by the support for ETSI, MEF and OASIS. As we noted in the previous section, we are working closely with all three to develop the Hybrid Network Management Platform. We are also working with open source groups. Open Platform for NFV (OpNFV), for example, is a participant in the NFV Ecosystem Catalyst (see page 22).

Nearly two-thirds of the service providers we surveyed and interviewed for our Insights Research report *NFV: Bridging the chasm*, said open source is either extremely or very important for NFV and SDN deployment because it represents a way to create a consensus in the software community, especially when strong alignment is needed in a digital ecosystem of partners, and because it can help service providers avoid vendor lock-in.

"You need a way to ensure that everyone understands the requirements in the same way," says Laurent Leboucher, Vice President of APIs and Digital Ecosystems, Orange. "One way to address this complex issue of interoperability at least in some areas is to decide to work together on a common source code, so open source will play a strong role."

THE IMPORTANCE OF BEING OPEN



Source: TM Forum, 2016



THREE CAMPS

The open-source landscape around orchestration has become quite interesting in recent months. Essentially there are three major factions now led by AT&T, China Mobile and Telefónica – AT&T with its recent announcement that it's contributing ECOMP to open source, China Mobile's support for the OPEN-Orchestrator Project (OPEN-O), and Telefónica's contribution of its virtual infrastructure manager and orchestrator to Open Source MANO (OSM), an ETSI-sponsored group.

By contributing ECOMP to open source, AT&T is clearly pushing for its platform to become the de facto industry standard for NFV orchestration, and Chris Rice, Vice President, Advanced Technologies and Architecture, AT&T Labs, said as much during a press briefing announcing Amdocs as collaborator and industry integrator for ECOMP.

"There is probably not room for three or four open source groups in this size industry," he said. "If we can align around one, it's easier to build around one and get the benefits of scale."

AT&T is working with The Linux Foundation to determine exactly what will be contributed as open source code, but generally speaking the company is planning to contribute the core orchestration code from ECOMP, not policy or analytics which it considers proprietary.

By aligning with Amdocs, AT&T could risk alienating the other groups. Open-O, for example, which is led by China Mobile, is closely aligned with Huawei, and OSM integrates open source components from OpenMANO with Canonical's Juju VNF manager and an orchestrator from RIFT.io. However, AT&T has said that the ECOMP code itself is vendor-neutral and the company will consider other integrators besides Amdocs.

FOR THE GREATER GOOD?

The geopolitical issues at work here can't be discounted. China Mobile is not likely to want to adopt AT&T's ECOMP for the same reasons AT&T doesn't really want to join Open-O, points out Caroline Chappell, who is now leading cloud and network virtualization research at Analysys Mason. "That's the challenge with open source groups – they are on surface very altruistic, but there is an undercurrent of politics."

To move the industry forward, there likely will have to be some kind of agreement – not necessarily on a specific approach to orchestration or a specific orchestration system, but agreement on how to federate disparate approaches. Again, this is where common information and data models and APIs play a critical role. Ultimately, all the players need to realize that change will come faster if everyone works together.

"People are best motivated by altruistic means," Chappell says. "We've seen this in wars – if there's a bigger goal, like we've got to develop a technology or we will get blown out of water by our aggressor, it's amazing how quickly it develops. There's not quite that motivation with open source, but it is tapping into the best of humanity."

SECTION 5

MAKE IT HAPPEN: STRATEGIES FOR IMPLEMENTING ORCHESTRATION



Orchestrating services end to end across virtualized and physical infrastructure, which increasingly requires stretching into partners' networks, is, indeed, a huge challenge, but it's not insurmountable. Following are some key takeaways to help service providers adopt orchestration and move toward becoming platform providers.



UNDERSTAND WHAT END-TO-END ORCHESTRATION MEANS

Orchestration is about automation. Many people think about it only in terms of network functions virtualization (NFV) – the NFV Orchestrator role specified in ETSI's NFV MANO typically comes to mind. But NFV MANO alone isn't enough.

To manage hybrid networks and give customers the ability to control their own services (in the future 'customers' may be devices), end-to-end automation of virtualized and physical functions is required. And that means it has to include operational and business support systems (OSS/BSS).



ADOPT A PLATFORM APPROACH

Companies like BT, Orange and Vodafone see orchestration as a key component of their strategies to become platform providers for third parties. Well-known platform providers like Airbnb, Amazon, Google, Netflix and Uber have achieved billion-dollar valuations almost overnight simply by providing an interface between customers and sellers. They don't own anything except infrastructure – and sometimes not even that. They build their businesses by curating ecosystems that link end customers or users with producers of goods and/or services. Network operators need a similar model to offer the network platform as a service.



DETERMINE WHERE ORCHESTRATION HAS TO HAPPEN

The easy answer to this is that orchestration happens everywhere. Orchestration systems must communicate with each other and with many other elements, physical and virtual, to deliver a service request that the customer initiates through the customer portal:

- at the technology layer, which includes physical and virtual functions;
- at the resource layer where functions are modeled as logical resources;
- at the services layer where provisioning, configuration and assurance happen; and
- at the customer layer where customers order services through a self-service portal.



USE COMMON INFORMATION MODELS, OPEN APIS AND INTENT-BASED MANAGEMENT

In the real world, a service provider will never have a master service orchestrator that has complete visibility into other providers' networks and operational and business support systems. Instead, providers will have to agree to use the same information and data models along with APIs so that orchestrators in different domains can communicate. This combined with intent-based management, which abstracts the complexity of the network at a high level and then uses customer intent and policy to manage it, is how service providers will automate service provisioning and management end to end.

As Dave Milham, Chief Architect, Service Provider Engagement, TM Forum so aptly puts it: "The standardization that's required is around making things so they can be orchestrated, which largely comes down to publishing what a service does in a catalog and then being able to get the metadata so that you know how to orchestrate it," says Dave Milham, Chief Architect, Service Provider Engagement, TM Forum. "So it's less about the orchestrator and more about the thing that's being orchestrated."



IMPLEMENT CLOSED CONTROL LOOPS, POLICY AND ANALYTICS

In networking, closing the loop means collecting and analyzing performance data to figure out how the network can be optimized and then applying policy, usually through orchestration, to make the changes in an automated way. This is crucial for ensuring service level agreements and is how service providers will be able to achieve zero-touch provisioning and management.



CHART THE MIGRATION PATHS

The success service providers have in adopting end-to-end orchestration and a platform approach will depend greatly on how well they plan the transition. That means setting a clear migration strategy both technologically and culturally. Orchestration may seem like a technology problem to solve, but it won't happen without setting a clear cultural and business strategy. This really comes down to learning to think like a software company.



DON'T FORGET SECURITY

One of the requirements we've discovered for the Operations Center of the Future is that security must be designed in from the beginning, because trying to bolt it on afterwards doesn't work. To detect security vulnerabilities that are configuration-related means an orchestrator that can call on internal or external security functions, and apply security policies to users or systems accessing NFV components.



WORK TOWARD A COMMON GOAL IN OPEN SOURCE GROUPS

There are now three major factions in the open source community around orchestration: AT&T ECOMP, China Mobile-led Open-O and Telefónica/ETSI-backed OSM. While getting everyone to align around a single approach would certainly make end-to-end orchestration easier, the reality is this may never happen. But it may not be necessary if we can find ways to federate the approaches through collaborative work on common information and data models and APIs.

We need to quickly develop the technology and business models we need to carry us into the world of 5G and the Internet of Everything. This will only be possible if we all work together.

COLLABORATIVE R&D MAKES DIGITAL BUSINESS REAL WITH FRAMEWORX 16

Since February 2016 hundreds of individuals from a diverse range of member companies have worked in TM Forum's unique collaborative environment to deliver new features in [TM Forum Framework™ 16](#). The projects were all within the context of the Forum's strategic programs: **Agile Business & IT, Open Digital and the Internet of Everything, Customer Centricity, and Security & Privacy.**

AGILE BUSINESS & IT

This program, which includes the Zero-touch Orchestration, Operations and Management ([ZOOM](#)) helps enterprises continuously optimize their IT and business operations. Additions include:

- evolving the [Business Process Framework](#) to support DevOps;
- extending the [Information Framework](#) to support the new concepts required for network functions virtualization (NFV) and software-defined networking (SDN);
- working with other standards-development organizations (SDOs) and open-source groups to develop a common network resource model; and
- publication of the first draft of an [end-to-end orchestration architecture](#).

CUSTOMER CENTRICITY

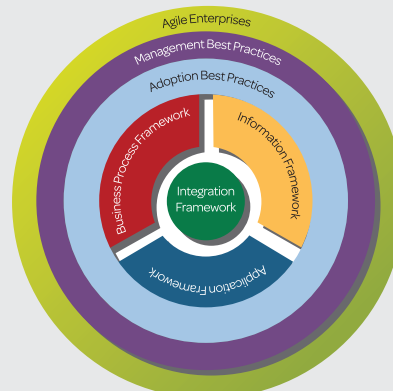
This program focuses on development of the Forum's extensive library of customer experience management (CEM) assets, metrics and best practices for big data analytics. New features include:

- enhancement of the [Omnichannel Guidebook](#) with a fully functional omnichannel architecture;
- 12 new [CEM](#) use cases, which expand the library to 40 business scenarios for service providers to improve customer experience;
- more than 400 new [metrics](#) for managing virtual CPE and networks, SLAs, business process and more; and
- a new [Data Governance best practice](#), along with a roadmap of how to achieve a high level of maturity in this area.

OPEN DIGITAL AND THE INTERNET OF EVERYTHING

The goal of this program is to enable an open digital ecosystem where new services can be delivered quickly, easily and securely using a wide range of business models and partners. New additions include:

- a fascinating new whitepaper called [Navigating the IoE Roadmap of Challenges](#), which catalogs the common challenges encountered across multiple industry sectors, provides insights and options, and maps the



challenges to existing best practices to help translate challenges into actionable steps;

- a new technical report, [Building and Enabling a Digital Payment Ecosystem](#), which helps communications service providers and other stakeholders understand business requirements, challenges and opportunities, and take advantage of existing TM Forum assets; and
- an updated [B2B2X Partnering Step by Step Guide and Business Scenario Template](#)

OPEN APIS

TM Forum offers [18 Open APIs](#) (with more under development) to manage services end to end and throughout their lifecycle in a multi-partner environment. Enhancements include:

- a new [Onboarding API](#), which enables rapid onboarding of partners and helps rapid mash-up of new products;
- a new [Privacy API](#) enables service providers (of any kind) to ensure alignment with new European Union privacy requirements which come into effect next year; and
- [MEF Lifecycle Service Orchestration Reference Architecture](#) mapping to TM Forum APIs, which ensures alignment on the configuration and activation capabilities across different standards organizations and in this instance for ease of management of Ethernet services.

SECURITY & PRIVACY

This program, which underpins all others, aims to bring security and privacy to the forefront of organizational thinking. With the EU Parliament's recent approval of the European General Data Protection Regulation ([GDPR](#)), it is timely that the latest version of the [Privacy Management Technical Report](#) now includes a 'dashboard template' and API that will make compliance easier.

Succeeding in the Market Transition to NFV and SDN with Orchestrated Service Assurance

Many CSPs are productizing or launching commercial-grade network-as-a-service (NaaS) products that include on-demand Ethernet and vCPE. Some examples of commercial deployment of NaaS services are AT&T Network on Demand and Colt DCNet-as-a-service. These solutions provide an array of benefits to the business service customer, including fast service activation, as well as self-service purchase through customers' portals. Best of all, network services can all be virtualized either on the customer premise or in the CSP's point of presence (PoP). This translates to reduced OPEX and CAPEX and an opportunity to further monetize the network with value-added services such as application visibility and control as well as security services.

Although the telecommunication industry's transition to network functions virtualization (NFV) and software defined networking (SDN) is well underway, it will still be at least 4-5 years before mass adoption takes place. CSPs have service-level agreements (SLAs) with their existing business service customers that they need to honor. While these customers are usually happy to adopt enhanced services, they aren't interested in an evolution of their existing network technology that doesn't bring innovative solutions to their problems. Introducing NFV and SDN technology components in one's network can therefore only be done in a risk-controlled manner.

NAAS REQUIRES SERVICE PERFORMANCE ORCHESTRATION

In previous network service evolutions – such as the transition to ATM/FR or IP-VPN – service assurance often came as an afterthought. However, when it comes to network virtualization, service assurance is mandatory at service launch. It holds the keys to automate service activation and fulfillment while meeting customer SLAs. Delaying the adoption of a carrier grade service assurance solution will impact service quality. To illustrate this impact, consider the following:

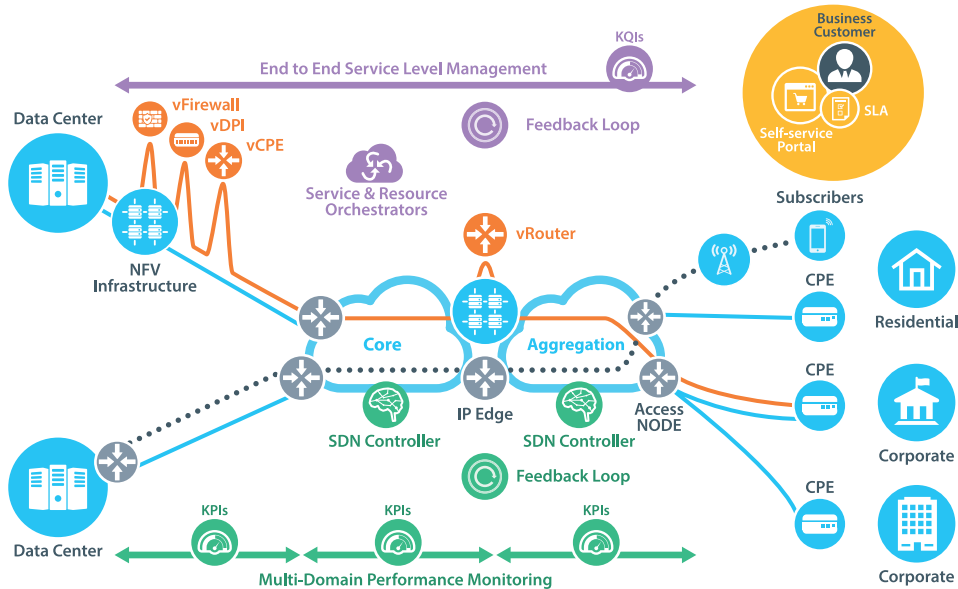
- **How can a CSP offer network connectivity with specific SLAs through their self-service portal without understanding the current end-to-end network performance?** Doing so would be similar to an airline selling tickets online without knowing when flights have sold out.
- **How can an SDN controller automatically reconfigure physical or virtual functions without understanding the impact on a subscriber's QoE or an enterprise customer's SLAs?** This would be like designing a building in a way that cuts costs and completes the project as quickly as possible, but neglecting to consider safety and building codes in the process, arguably the most important aspect to consider.

- **How can a VNF Manager(s) understand if virtual functions from different vendors have reached their limit without a solution that monitors their health and capacity in a vendor-agnostic manner?** This would be like the police trying to enforce highway speed limits using their own sight-based judgement.

Another widespread industry trend driving investment into NFV/SDN technologies is collaboration. CSPs are becoming more collaborative which will lead to wider cooperative competition, or co-opetition. Most Mobile Network Operators (MNOs) understand that their profit margin can be augmented by sharing some connectivity costs with their competition, which drives an increase in backhaul and RAN sharing deals. Business service providers need to connect their customer's employees in various offices, at home or on the go in every region where their customer operates. A U.S.-based business service provider will therefore need to contract last-mile connectivity with French and Chinese CSPs if it wants to establish VPN connectivity between Miami, Bordeaux and Beijing.

All of this drives the need for service APIs and an elastic OSS that can negotiate and fulfill connectivity orders on demand. The MEF address this need within their LSO concept and associated reference architecture.

Service Level Management and Performance Monitoring Role within NFV/SDN Based Networks



ORCHESTRATED SERVICE ASSURANCE BRIDGES THE CURRENT GAPS

As many CSPs have come to realize, service assurance is the missing link to productizing commercial-grade NaaS services that can deliver on their SLAs. They are also realizing that service assurance solves problems brought on by the complex nature of NaaS technologies. When offered as a commercial application visibility product, service assurance can increase the monetization potential of the CSP's business services.

During this disruptive industry transition, service assurance has a greater role to play. Companies that are equipped with a carrier-grade, multi-tenant, elastic and open performance assurance platform will maintain customer satisfaction and ultimately secure their successful transition to NFV-based services, reaping the associated rewards.

Performance management tools designed for the enterprise market lack some basic capabilities due to the unique requirements of CSPs. CSPs demand technology that can scale in real time, which requires partnering with companies that focus on designing and continuously enhancing solutions that mirror their requirements.

The adoption of NFV/SDN will push these requirements even further. Therefore, CSPs should understand the critical success factors when selecting their service assurance solution:

- A solution that can model CSPs' and MNOs' services with end-to-end SLA monitoring and vendor-agnostic performance monitoring capabilities
- A solution that has demonstrated its ability to follow CSPs' and MNOs' growth, and has proven itself in the market, supporting leading Tier 1 providers

- A solution offering RESTful APIs that allow users to exchange information with orchestrators, controllers and other complementary functions such as self-service portals
- A fully-automated solution that operates within a real-time framework driven by self-service portals
- A solution that can easily adapt to new technologies and vendors
- A solution aligned with industry standards such as TM Forum and MEF lifecycle service orchestration (LSO).

Many of these success factors were demonstrated in the recent multi-vendor proof of concept (PoC) with InfoVista Oracle and Juniper as part of a TM Forum Catalyst. The PoC exemplifies how CSPs can achieve NaaS delivery that introduces NFV and SDN components into a network that is fully automated and assured. The result is greater business agility and a simplified end-user experience.

As CSPs and MNOs embark on their NFV/SDN initiatives, service assurance must be part of their strategy. Without it, the benefits of NFV/SDN cannot be realized and any success will be short-lived. Service performance intelligence that dynamically provides an assessment of network performance in real-time and full service-level visibility will ensure CSPs successfully bring these innovative services to life.

For further information, please download our whitepaper from <http://inform.tmforum.org/sponsored-feature/2016/09/assuring-network-service-performance-quality-virtualized-dynamic-networks/>

Orchestrated Assurance

Enhancing customer quality of experience with active end-to-end assurance of the full service lifecycle

Service assurance and quality insights are among the foremost drivers of profitability for service providers. Surveys show that more than 80% of customer churn can be attributed to frustrations with a service and the inability of the service provider to deal with issues quickly and effectively. In addition, 90% of customers will not actually contact their provider to complain before deciding to leave; they will simply cancel their service plan once they have become unsatisfied. This shows that customer quality of experience is highly correlated with a service provider's ability to deliver services right the first time and to troubleshoot problems speedily when they do occur, instead of waiting for customer complaints to assess service quality levels.

Current methods of service assurance leave plenty of room for improvement and most cannot handle the ongoing transformation efforts to next generation network architecture that is software-defined and programmable. Today's service assurance systems are also not well integrated with the fulfillment process of service delivery.

To address the challenges that service providers are facing with service assurance in existing and emerging networks, the concept of Orchestrated Assurance was developed in ETSI NFV PoC #36. The model-driven Orchestrated Assurance methodology is designed to bridge the gap between service fulfillment and assurance, where end-to-end activation tests and monitoring scenarios are defined at the service design stage and automated throughout the full service lifecycle in closed-feedback loops. Orchestrated Assurance is also customer-centric; it allows service providers to assess services the customer is actually using as opposed to collecting passive network device counters for metrics only loosely correlated to real customer experience.

In what follows, the issues with today's service assurance methods will be outlined and how Orchestrated Assurance can address these challenges will be shown.

CHALLENGE #1: INADEQUATE SERVICE ACTIVATION TESTING

Upon ordering a new service, customers expect it to be accessible and working as soon as possible; therefore, service providers must not only speed up service delivery, but also make sure that services will be delivered right the first time. Despite this, many services are delivered without service activation testing today, or they are only tested at a very primitive level. This is because proper activation testing in the past has required expensive field efforts which service

providers are often reluctant to undertake as a strong business case has not been proven due to capital and resourcing requirements. As a result, deliveries frequently fail with costly fieldwork and customer frustrations as consequences.

The solution is to conduct multi-layer, end-to-end service activation testing using active traffic generation that mimics the actions of a real customer. To reliably catch errors, this testing needs to be comprehensive, as opposed to simple manual tests with inadequate coverage. Such thoroughness, in turn, requires the testing to be software-based in order to be economically feasible.

CHALLENGE #2: INFRASTRUCTURE-CENTRIC ASSURANCE

Customers expect their services to work without interruption at all times, requiring service providers to continuously monitor the quality and performance of a customer's specific service. Most service assurance solutions today assess customer experience indirectly by interpreting infrastructure-centric counters or other service-independent data. This commonly results in a poor correlation to actual customer perception of the service.

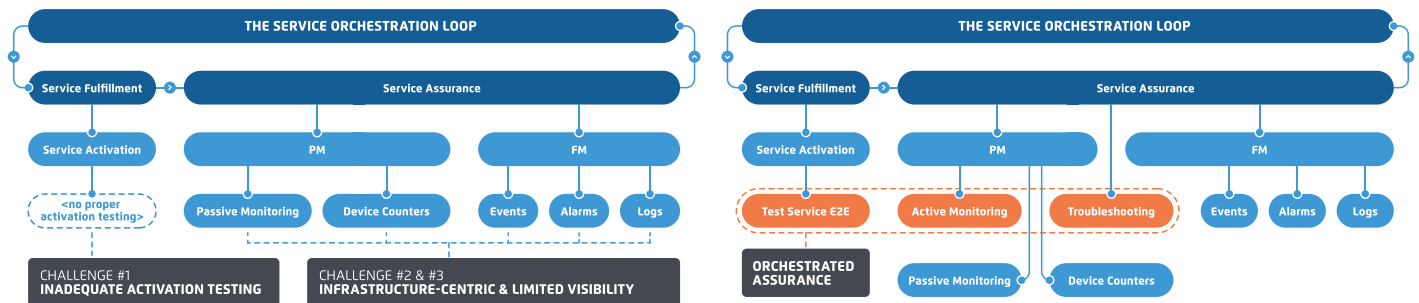
The solution is to actively monitor individual services by sending and receiving real-world traffic, where metrics collected are truly diagnostic of the customer's perceived quality of service. When service levels degrade, alarms are triggered so that support technicians are notified in real time.

CHALLENGE #3: LIMITED VISIBILITY AND LENGTHY RESOLUTION TIMES

When service issues arise, they must be resolved promptly – ideally before the customer notices, but if that cannot be achieved, with minimal performance degradation time. With current service assurance solutions, the insight into an individual customer's service quality and performance is often limited, inhibiting the service provider's ability to troubleshoot issues quickly and effectively, and they cannot do this remotely. As a result, delays in finding and fixing problems are extended, and again, cost-intensive fieldwork is needed.

The solution is to monitor the quality comprehensively enough to detect any performance issues that arise. Such events should then automatically trigger remote troubleshooting which systematically tests the service for malfunctions and notifies support staff about its findings.

Figure 1: Service lifecycle with traditional service assurance and with Orchestrated Assurance



The following improvements are introduced with Orchestrated Assurance:

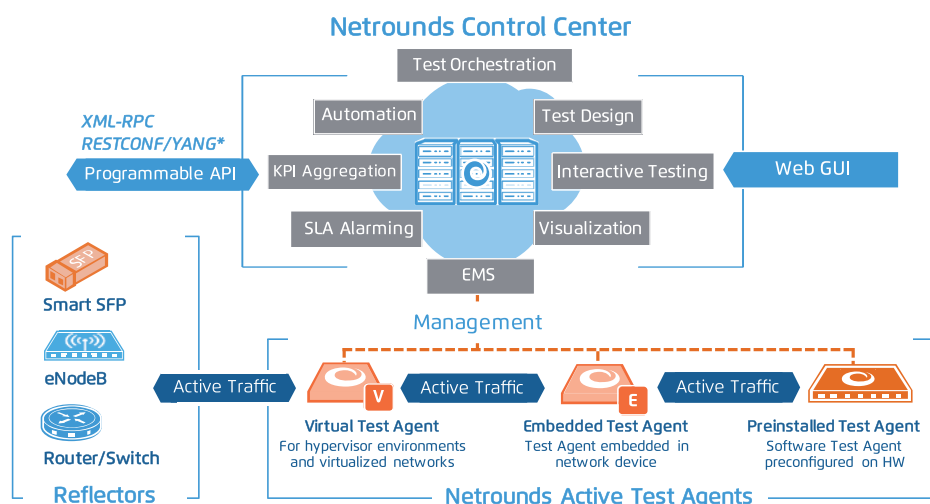
- Service Activation Testing. End-to-end service activation testing using real-world traffic, supplemented by carrier-grade, network-level measurements, ensures the viability of the service from the customer's perspective. This testing may be contrasted with the simple methods often used today, such as ICMP Pings, or no activation testing at all.
- Active Quality Monitoring. Active monitoring of individual services and network circuits, analyzing metrics that are directly related to customer experience rather than data pulled from device counters. Passive monitoring may still be complementary.
- Remote Troubleshooting. Triggered remotely and automatically in order to resolve problems: a vast improvement on manual field testing with an assortment of proprietary, handheld hardware tools.

Netrounds offers a comprehensive Orchestrated Assurance solution for the full service life cycle, spanning activation testing, quality monitoring, and troubleshooting. This active, automated assurance solution helps service providers to improve customer experience with IP-based services such as Internet, TV, voice, and other quality-demanding services. This improves operating margins by automating manual tasks and enabling remote troubleshooting, decreasing capital expenditures for test equipment in the process.

Suitable for physical, hybrid, and virtual networks, the Netrounds solution is software-based and can run on standard x86 servers or on hypervisors in virtualized environments. The core component of Netrounds is a unifying multi-tenant control center that provides a consolidated GUI for operations staff, as well as a complete API for external OSS and NFV orchestrators to remotely control Netrounds' traffic-generating active test agents.

Netrounds' solutions are used by more than 270 network operators, service providers and enterprises worldwide. For further information, please visit www.netrounds.com or contact info@netrounds.com.

Figure 2: Netrounds complete controller-based solution



*Roadmap Q1 2017

The importance of SDN analytics in orchestration

Many service providers are betting on software-defined networking (SDN) technologies to enable them to build agile networks with a higher degree of workflow automation. Automating network provisioning and service activation affords compelling benefits, including the ability to offer more services for greater ROI, reduce time to revenue, and improve operating efficiency.

However, automation alone will not enable service providers to achieve their business goals. SDN presents many management challenges, including loss of visibility into and control of changes taking place in the network as well as the need to capture engineering know-how in SDN applications. The next step in this evolution is to apply SDN architecture, particularly programmability, to the wide area network (WAN) and address the management challenges facing operators.

To create networks that adapt to business needs, service providers need SDN analytics for real-time orchestration and enhanced service visibility across both legacy and SDN network infrastructures. Here's a look at the issues facing service providers, the case for SDN analytics, and some use cases.

SERVICE PROVIDER CHALLENGES

Service provider networks are complex because they often support many types of services ranging from Internet access, streaming video, voice over IP, layer 2 and layer 3 VPNs, mobile backhaul and core transport, and cloud services. Running multiple applications on a converged network is especially difficult given their different performance requirements, growth rates, and fault-tolerance characteristics.

Service providers also face increasing rates of service activation and deactivation requests combined with demands for speedier service provisioning times – from weeks to hours, and even seconds. For instance, many service providers offer customer portals for self-service provisioning.

Optimizing a dynamic multi-services network is much harder and probably not achievable without automation due to each service's specific requirements. For instance, each service requires a traffic matrix and an appropriate optimization algorithm, which must run concurrently with those for all other services.

The problem is that current SDN architectures lack management intelligence. In complex networks – especially multi-service, multi-SDN controller WANs – operators risk controllers making automatic changes that may conflict with the commands of other controllers, degrade application and service performance, and under- or over-utilize links.

In addition, most SDN technologies are being deployed in existing networks. As a result, management and orchestration (MANO) solutions must be aware of both legacy and SDN-enabled infrastructure. Some people assume that the SDN controllers will know everything about the network. In fact, controllers only know about the devices that they own/provision. An SDN controller can simplify and speed provisioning, but the right analytics are needed to make intelligent, automated traffic engineering, service creation and activation, and risk mitigation possible.

Traditional NMS/OSS tools that periodically capture aggregated health metrics are incapable of detecting and analyzing the hundreds or thousands of events that occur in dynamic networks between polling intervals. Deploying probes to monitor constantly shifting virtual devices, network functions, and service traffic is problematic and expensive.

THE NEED FOR SDN ANALYTICS

There are two important functions for SDN analytics. The first is to maintain management visibility into the network even while changes are being made programmatically. SDN analytics provide visibility into the network – the devices and the controllers – by recording real-time routing telemetry from the network's control plane protocols, traffic flow data, and performance metrics. Back-in-time forensics can be very helpful in identifying the root cause of issues.

The second important function of SDN analytics is to provide management intelligence. For viable, programmatic SDN orchestration, the planning know-how of network engineers must be replicated in analytics software. The basis of this is a combination of real-time and historical telemetry, projections, and optimization algorithms.

USE CASES FOR SDN ANALYTICS

Here are a few examples of these analytics in action, showing why they are so critical for service providers investing in SDN.

Rapid service provisioning: This provides critical workflow optimization. One of the major goals of service providers is to bring down service creation and activation time from weeks to minutes. Organizations can achieve this by eliminating manual, time-intensive planning for tasks such as traffic engineering and automatically generating optimized network configuration recommendations.

This requires analytics, such as traffic matrices for different network segments, times and conditions; real-time route modeling to predict the impact of changes; and optimization algorithms, all governed by user-specified policies.

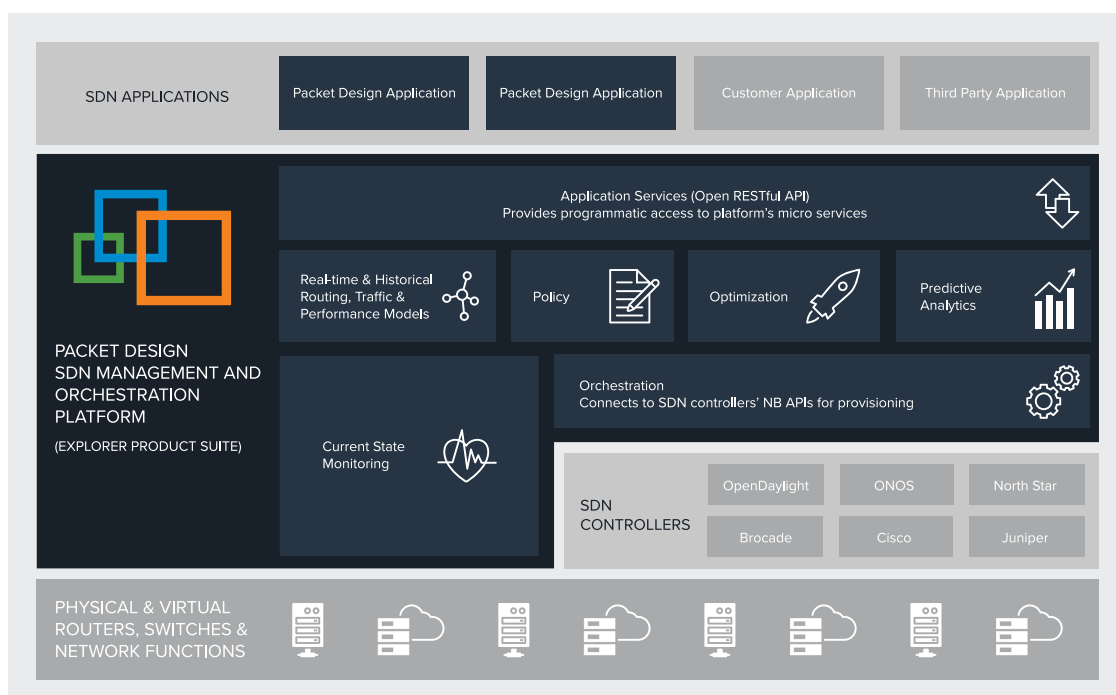
Time of the day service: Service providers deliver multiple services by over-provisioning networks for peak traffic. Alternatively, by using predictive analytics based on historical models, service providers can optimize networks for multiple peaks over a day or week and minimize additional capital expenditures.

Hybrid cloud use cases: Bandwidth on demand and calendaring capabilities are required to efficiently use WAN resources and support new services such as cloud backup and disaster recovery needs. This requires the ability to record and baseline network routing, traffic, and performance data to feed machine-learning algorithms that calculate optimum network configurations.

ENTER THE PACKET DESIGN SDN MANO PLATFORM

Packet Design's Explorer Suite delivers the first independent, vendor-agnostic SDN Management and Orchestration (MANO) platform to address these challenges across both legacy and SDN-enabled infrastructure (see diagram below). By capturing all IGP/BGP routing events, traffic flows, and the performance of key services, the platform maintains real-time and historical models that are used to calculate future states based on various conditions and business policies. Predictive analytics give operators accurate impact assessments of application requests for network resources, and the best way to provision them. If approved, the changes can be automated via an SDN controller with a single mouse-click. Real-time telemetry from the network, not just the controller, provides immediate, closed-loop feedback with no visibility gaps.

The platform's open RESTful API gives customers and third parties programmatic access to the functions needed to enable intelligent provisioning of network services via SDN controllers. Network operators can use the API to populate customer portals with service-specific performance metrics as well as develop their own custom SDN applications. By enabling integration of the platform's micro services with other technologies, including OSS and BSS systems, Packet Design is helping operators create service differentiation and gain first-mover advantage.



Driving service agility with automated multi-layer service orchestration

Communication service providers (CSPs) and enterprises alike have expressed the need to move to a new paradigm of deploying and managing network services. This new paradigm is built with on-demand, rapid delivery models similar to current cloud services; whereby enterprises can order and customize managed network services through self-care portals allowing them to instantly respond to global demands and new market requirements.

The emergence of software defined networking (SDN) and network function virtualization (NFV) has fostered a new standard that spans across network, cloud, and service orchestration. Service orchestration, acting as a cerebrum, orchestrates and integrates legacy operations and billing support systems (OSS/BSS), virtual network functions (VNFs), cloud compute and storage resources, and network hardware infrastructure.

More importantly, orchestration automates the entire service lifecycle and transforms traditional networks into an agile end-to-end programmable platform. The service lifecycle encompasses all of the steps involved in managing and operating network services. Today, many of these steps are complex and manual processes. Automation effectively streamlines each step and reduces service deployment time as well as operating costs. Below, we have highlighted each step anchored within the service lifecycle and their respective drivers and objectives:

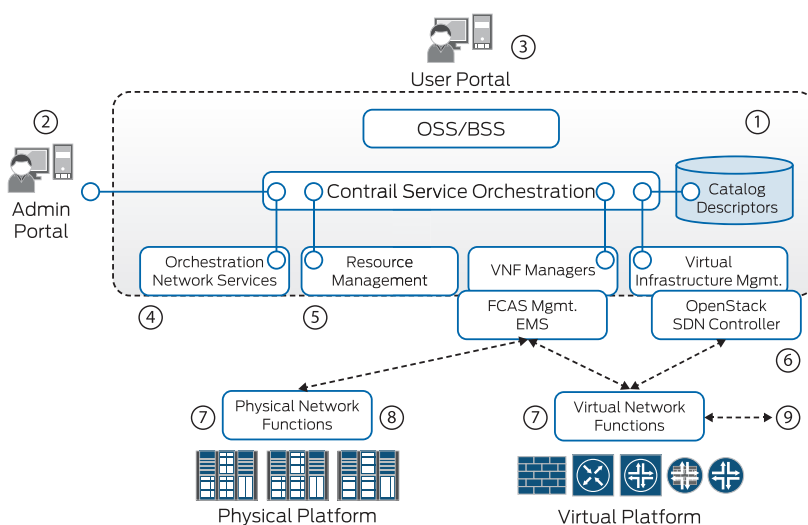
- **Order & Fulfillment:** Enterprises, using a self-care portal, can design service parameters, network architecture and footprints and can automate fulfillment provisions services based on existing service templates and configure the required parameters and resource allocation. Zero-touch provisioning cross-reference distributed on-premise devices with the network to ensure optimal performance.
- **Control:** Enterprises retain substantial visibility into and control over network services, with the flexibility to activate, modify, and remove services. Automation distinguishes the virtual overlay network from the underlying physical network hardware, enabling chaining of VNFs without manual configuration of the underlying network infrastructure. This empowers enterprises with the ability to dynamically scale network services to address revolving business requirements.
- **Security:** Automated security creates policy-driven user profiles where only authenticated profiles are allowed access to the network. From an enterprise standpoint, automated security improves overall business process by providing differentiated and secure network access. From a network operations standpoint, automated security provides encryption and key management, where only authorized users and applications can access network management and control functions. It also supports virtual routing and forwarding (VRFs), enabling multiple secured network paths. Automation proactively uses real-time feeds on emerging threats so that security enforcement points within the network can automatically filter malicious traffic without requiring any human interaction.
- **Policies:** Centralized policy management provides effective configuration, control, and enforcement across network resources. Service objectives and user profiles can be incorporated as part of network policy that dynamically adjusts network bandwidth, routing, and traffic priorities.
- **Assurance:** Network assurance capabilities provide automated error detection and fault reporting. Error information is collected at each network component and aggregated to provide a global view on service level impact. Network administrators can, based on fault reporting, recover or re-route services to minimize network disruptions.
- **Performance:** Service quality across network elements is constantly monitored, analyzed, and benchmarked against specific performance KPIs.
- **Analytics & Reporting:** Analytics capability automatically collects and analyzes information across network domains, assembling real-time reporting of end-to-end services, network components, and both physical and virtual network infrastructures. Analytics ensure that network operations have real-time visibility and access to critical data needed to accelerate capacity planning, traffic prediction, and optimization.

Juniper Networks offers an automated and programmable end-to-end NFV solution—the only one that combines carrier-grade reliability and security bundled with intelligent service orchestration and automation to address every step of the service lifecycle. At the heart of Juniper’s service orchestration is Contrail, a cloud network automation and orchestration platform powered by open technology. Contrail consists of three fundamental components: Contrail Service Orchestration, Contrail Cloud Platform, and Contrail Networking.

Contrail Service Orchestration is a comprehensive management and orchestration platform that simplifies service creation and reduces the network services delivery from months to minutes. With Contrail Service Orchestration, CSPs can orchestrate services across virtual and hybrid as well as centralized and distributed network deployment models. An automated framework intelligently manages service chaining where the path for any packet traffic can be dynamically managed based on policy,

subscriber, or a defined set of service parameters. Contrail Service Orchestration also provides a clean polished user experience. For network administrators, it provides a robust service management and troubleshooting vantage point. And for enterprises, it delivers a personalized self-service portal for self-service activation - a critical component for a managed service platform.

Contrail Service Orchestration fully supports open protocols and seamless API integration. The northbound API towards operations and business support systems (OSS/BSS) is an open and standardized REST and RESTConf API, enabling third-party OSS and BSS vendors to integrate business workflow and management applications. The southbound API supports integration with the VIM layer based on OpenStack, as well as kernel-based virtual machine (KVM) virtualization. Contrail Service Orchestration supports the configuration of virtual and physical functions via VNF and PNF managers with Netconf and RESTconf protocols.



1. Onboard, validate and catalog network services
2. Create, associate, and manage users roles and policies
3. Instantiate network service from user portal
4. Instantiate network service workflows
5. Resource allocation based on policies, performance KPIs, and SLAs
6. Create and update network services configuration, forwarding graphs, inter-VNF instance connectivity
7. Configure virtual and physical network functions
8. Monitor network service resource usage and analyze performance KPIs
9. Scale up and out by allocating additional resources

SERVICE LIFECYCLE MANAGEMENT WITH CONTRAIL SERVICE ORCHESTRATION

Contrail Cloud Platform is an integrated turnkey cloud management platform based on open-source technologies supporting OpenStack, OpenContrail, Ceph, and Puppet. The Contrail Cloud Platform automates the orchestration of compute, storage, and networking resources to create and scale federated clouds and elastic infrastructures with speed and agility.

Contrail Networking is a simple and agile cloud network automation product that leverages SDN to orchestrate the creation of highly scalable virtual networks. Combining a scale-out architecture featuring open interoperability with physical routers and switches, Contrail Networking can elastically scale infrastructures beyond data center or cloud boundaries to facilitate dynamic workload mobility in a hybrid environment. CSPs can use Contrail Networking to accelerate the deployment of innovative new services, while enterprises can use it to increase business agility by enabling the migration of applications and IT resources to more flexible private or hybrid cloud environments.

Additional information on Juniper’s Contrail platform can be found [here](#) or visit www.juniper.net/

Service Orchestration: Building the Next Generation of Service Creation

Mobile Network Operators are struggling to compete with agile web companies. Being able to create, launch, modify and kill services in a matter of days, rather than months or years is crucial to capture consumers' and enterprises' business. Current network architectures simply don't allow fast services provisioning and roll out. An automated service creation environment that can lift legacy networks to the cloud's level of agility and elasticity can be a game changer.

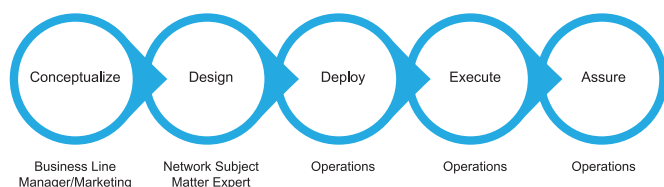
WHAT IS SERVICE ORCHESTRATION?

Service orchestration is the life cycle management of services- conceptualizing new services and delivering them to customers who are interested in purchasing them. It stitches multiple network elements—and even multiple networks—together to create and deliver a service. At the heart of service orchestration is automation. The goal of service orchestration is zero-touch provisioning: everything is automated and propagated throughout the entire network, across both virtual and physical elements (since, for the foreseeable future, operator networks will consist of both).

SERVICE LIFE CYCLE MANAGEMENT

Affirmed Networks empowers operator business unit teams to conceptualize new services and rapidly introduce them to their customer base. These five steps of service life cycle management define how operators can achieve shorter time to revenue, lower risk and higher agility of service creation.

Figure 1: Service Life Cycle Management



Conceptualize – Operator business unit owners and marketing teams can leverage the service agility of an automated service provisioning platform to conceive new services that are targeted to multiple groups of subscribers with specific interests (ex. sports video streaming) or wholesale customers, either MVNO or enterprises as an example. With a lower upfront cost to create these new services (a reduction from millions to thousands of dollars), operators can set break-even targets and make quick decisions about whether to continue or decommission

unprofitable services in an efficient and non-disruptive manner. As these services are conceptualized, they can then be handed off to network subject matter experts (SMEs) to design and deploy.

Design – One of the end goals of service orchestration is to move service design into the hands of network subject matter experts (SMEs), often comprised of network engineers and operations staff, and out of the hands of programmers. This requires an orchestration platform that can effectively bridge the marketing and the operations worlds. To accomplish this, SMEs require the ability to quickly create service templates from Method of Procedures (MOPs) using the orchestration tool (vBuilder), with no programming experience required. These service templates need to support a variety of network element interfaces ie. YANG/NETCONF, REST, SOAP or CLI.

Deploy – Network SMEs can simplify and accelerate service creation by using an abstraction layer to create specific configurations based on best practices that can then be pushed out to all appropriate network elements at once. This can be achieved with a platform that has the ability to record all of the steps in a MOP, including the configuration artifacts, in its native form (CLI, configuration file...) using a native interface (NETCONF, SOAP/XML, SNMP, SSH/CLI, REST, etc.). Each method for each element and vendor could then become a modular ingredient from which the network operator could create a service using a specific template.

Execute – Once recorded, these MoPs would be stateful and could be re-deployed at will from a centralized configuration manager that would translate the template back into specific configuration files pushed individually and in the right sequence to the proper network element (vTransactor). Using an automation platform not only dramatically increases service velocity, but also provides other business advantages: direct OPEX savings by reducing time to deploy, test, edit and launch as much as 90%; reduced risk through the use of a single master configuration for subsequent deployments; and extremely agile re-allocation of resources to meet shifts in demand, turning down of services, etc. with minimal impact to the network.

Figure 2: Affirmed Service Automation Platform (ASAP)

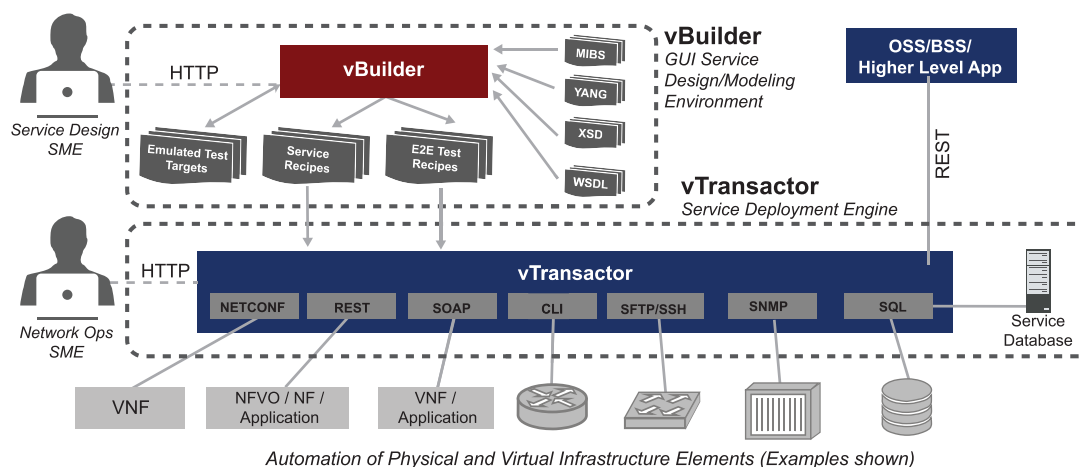










Figure 3: Tier 1 Operator savings from virtualizing EPC and automating onboarding of MVNO customers

EPC and MVNO	Legacy EPC		EPC Virtualized + Automation	
		\$3.1 million		\$0.78 million
		19.5 months		9.75 months
	Add MVNO		Add MVNO with Automation	
		\$48,000		\$1,610
		2 months		2 days

Ultimately, the service would be ready to be promoted and sold to subscribers or available to wholesale customers (ex. MVNOs) to bring to market. As these services prove profitable for the operator, additional services can be rapidly realized and resold at a fraction of cost of older, manual methods.

Assurance – Service orchestration is more than turning up a new service quickly. It's also the ability to re-orchestrate the quality of that service as network traffic changes, in order to maintain service level agreements (SLAs). This requires end-to-end visibility into the network and even into the end user device. This will ensure that the configuration has not drifted and correct it if it has. Additionally, poll status attributes must be gathered and results aggregated, which are compared to key performance indicators to determine status.

CONCLUSION

Operators today should be focused on unifying their service orchestration strategy, identifying short-term revenue opportunities from among their existing services and preparing for 5G and a massive increase in IoT traffic by adopting a virtualized, automated approach to service creation.

Operators can find that solution today with Affirmed Networks. As a leader in network virtualization and service orchestration, Affirmed can help operators accelerate their future and become Disruptors rather than the Disrupted. Affirmed's virtualization and orchestration solutions today are driving the next-generation of services in some of the world's leading networks. From our virtualized Evolved Packet Core (vEPC) solution to the Affirmed Service Automation Platform (ASAP), operators can revolutionize the way they operate and innovate with Affirmed in their network.

For further information, please download our Total Cost of Ownership Report

<http://www.affirmednetworks.com/tco-report/> and The Business Case for Service Automation in Mobile Networks

<http://www.affirmednetworks.com/products-solutions/service-automation-report/>

Our whitepaper can also be found at

<http://inform.tmforum.org/sponsored-feature/2016/09/total-cost-ownership-study-virtualizing-mobile-core/>

Orchestration and the New Digital Service Provider

Today the vast majority of traditional network operators acknowledge that becoming a digital service provider tops the list of strategic priorities. According to Netcracker's recent survey of over 100 customers, more than three-fourths of service providers already have working digital strategies in place.

Leveraging software-defined networking (SDN) and network functions virtualization (NFV) technologies is a fundamental part of service providers' digital strategies. As network operator costs grow, revenues in traditional markets flatline and web-scale competition intensifies, network operators are left with no choice but to decrease their time-to-market and recalibrate their capex and opex. All these aspirations point to the need for agility. Service providers have no choice but to become faster at rolling out change in the form of new business models, products and technologies. They need to become faster at responding to changes in their external environment and better at controlling the cost of change.

In other words, they must become agile, and flexible, more like their web-based competitors. Traditional service providers now have a mode of operation that constrains how fast they can react to change. Forward-looking service providers who are adopting an Agile approach must embrace end-to-end orchestration if they aspire to streamline their operations and provide zero-touch service management to their customers.

Service Orchestration is the key. It allows for the lifecycle management of a service across all hybrid network domains: legacy networks, SDN networks, cloud and NFV environments. Service Orchestration decomposes customer-facing service requests from customer management systems into network service requests that are directed to underlying network orchestration. Meanwhile, requests for physical connectivity, WAN connectivity and XaaS services are sent to legacy OSS, Transport/WAN SDN controller(s) and cloud manager(s). Service Orchestration provides multivendor service-specific configuration of VNFs and PNFs via different industry-adopted protocols, such as NETCONF, SNMP as well as CLI-based and web services. Virtualization demands automation and, in order to achieve that end-to-end orchestration, it is a must-have.

To be truly responsive to change, operators must adopt an approach to virtualization and automation that is founded in Agile culture and practices, supported by Agile methodologies and tools. This approach applies to:

- The design and development phase for networks and customer-facing services.
- The runtime phase, after deployment or fulfillment.

One of the largest impacts of an Agile approach is that operational elements are designed and developed alongside customer-facing services. Agile assumes that service operations will be automated. Creating the automation artifacts (such as scripts, service models, resource descriptors and policies) needed to manage a specific type of customer-facing service takes place in the design and development phase. The artifacts are then ready to be used by management tools that execute them in the runtime, operational phase. Collaboration between development and operations is a hallmark of DevOps, the Agile set of software practices that has been adopted globally by internet players and enterprises, which want to be leaders in their field.

NEC/NETCRACKER'S AVP

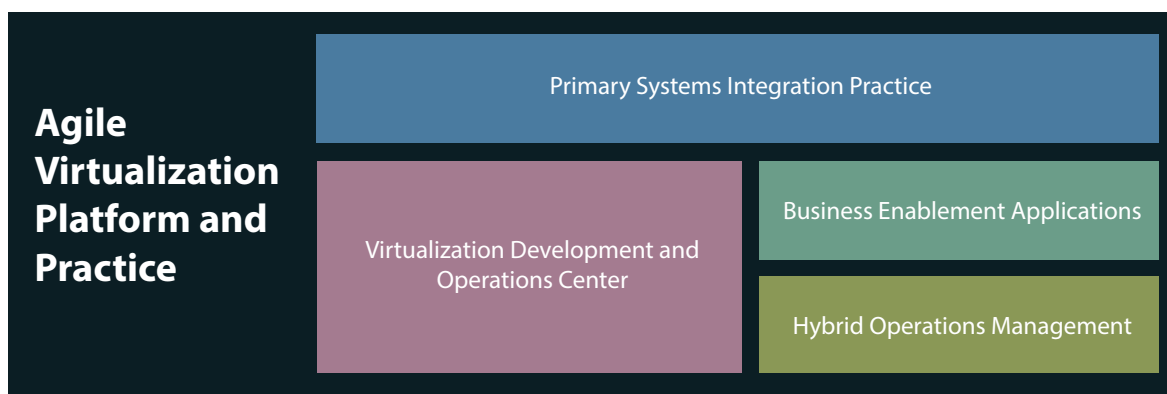
NEC/Netcracker's Agile Virtualization Platform and Practice (AVP) makes it possible for service providers to manage and integrate existing and virtualized network operations. It helps them create Agile development environments to support both IT and network requirements. Here are some of the characteristics enabled by AVP that service providers need to consider when adopting virtualized technologies or undergoing a digital transformation:

- The end-to-end orchestrator is needed to manage and orchestrate VNFs and PNFs. This end-to-end orchestration layer must work closely with a centralized catalog.
- Agile and policy-driven service modeling should be possible in hours or days, not weeks or months. An orchestration solution should have the ability to create new services based on customer needs via an intuitive and flexible service design environment, not a rigid programming process that leaves the customer waiting.
- Service fulfillment and assurance should be policy-enabled and include reusable policy definitions centered around availability, QoS, security, access, etc.
- Integrity between service and device configuration is critical to avoid inconsistency, reduce order fallout and ensure accurate device support.
- Real-time service chaining of virtualized and non-virtualized network functions is a critical component of next-generation service management platforms.

- Automatic discovery and reconciliation is critical for real-time discovery of network topology and correlation of that with customer, services, physical and virtual resources.
- Big data predictive analytics is critical to identify trends, patterns and subscriber behaviors.
- Real-time responsiveness to changing requirements and events, for example, new customer orders and change requests on demand.
- Automation is needed at both the local, domain-specific level and end-to-end across services, network layers, customer and technology domains.
- Support for continuous deployment. Continuous deployment is the runtime counterpart to the agile, continuous integration of new service features and network technologies in the design and development phase. It is a critical enabler of change. The runtime phase needs a methodology and mechanism for absorbing these changes and their accompanying automation artifacts without interrupting existing operations.

Netcracker provides an evolutionary approach to operationalizing SDN/NFV. NEC/Netcracker's AVP simplifies service providers' transition to hybrid networks and, ultimately, their transformation into digital service providers. It comprises four primary components, as shown in the Figure below:

Figure. Agile Virtualization Platform and Practice



- The Virtualization Development and Operations Center (VDOC) is a first-of-its-kind Agile collaboration environment designed to automate end-to-end service lifecycle management. It enables collaboration across departments and with third-party partners, including systems integrators. VDOC simplifies and accelerates service integration, testing and deployment by leveraging an always expanding library of reusable service components.
- Hybrid Operations Management (HOM) is focused on making virtual and traditional networks simultaneously operate at scale a reality. HOM solves the gaps missing in today's solutions for automating hybrid network management, including assurance, continual optimization and security. HOM integrates with VDOC to create a dynamic and continuous feedback loop between product and development environments.
- Business Enablement Applications (BEA) are designed to accelerate the commercialization of new digital services. BEA fills the gaps with existing BSS by providing applications that support on-demand services, cost-effective partner management and the monetization of emerging business models. Delivered through an architecture built on micro services, it enables a plug-n-play approach to expanding existing BSS functionality vs. today's options of carrying out expensive upgrades or full-scale transformations.
- The Primary Systems Integration Practice (PSIP) helps service providers overcome the commercial, operational and organizational challenges preventing them from leveraging virtualization technologies in multivendor, best-of-breed ecosystems. NEC/Netcracker's services cover all stages of virtualization initiatives – from the initial definition of the program and its business case to the full transfer of operations. Leveraging years of experience with Agile deployments and software-driven services, PSIP helps service providers transform their static, proprietary hardware-dependent environments into dynamic, software-driven ecosystems.

This industry is naturally excited by all the talk about next-generation services, but service providers know that their immediate opportunity for innovation revolves around lowering the cost of delivering services today. Next-gen services will come down the road, but right now – this very minute – service providers need faster order-to-cash cycles. With the right orchestration, they can optimize operations and build a foundation on which to deliver and manage revenue-generating services on both traditional and virtualized network infrastructure.

OUR SPONSORS



AFFIRMED NETWORKS

Affirmed Networks is the industry leader in virtualized mobile networks, as its Network Functions Virtualization (NFV) solution has become the standard for the world's top mobile operators.

With more than 20 customers and 40 trials underway with Tier 1 and Tier 2 operators globally, the company's Mobile Content Cloud solution is enabling operators to experience the technical and economic benefits of NFV. The deployment of Affirmed Network's solution in mobile operator networks provides many key benefits over legacy solutions.

First, a virtualized mobile network provides operators with the ability to dynamically adjust capacity on the network to keep pace with traffic growth without the need to continually add additional expensive "boxes". Second, as operators continue to face declining Average Revenue Per User (ARPU), the ease in which a virtualized mobile network allows operators to develop and deliver compelling new applications capable of driving additional revenue streams, is a key reason for operator interest. With Affirmed's software-based solution, operators can now develop and deliver new applications in days and weeks, when similar efforts on legacy solutions typically took as long as a year to complete.

For more information.. <http://www.affirmednetworks.com>



INFOVISTA

InfoVista is the leading provider of cost-effective network performance orchestration solutions for a better connected and collaborative world. Our award-winning solutions empower communications service providers and large enterprises to ensure a high-quality user experience by achieving optimal network performance and guaranteeing business-critical application performance. InfoVista's expertise and innovations provide a new level of actionable network, application and customer intelligence, visibility and control across all services, all technologies, and all domains of both the fixed and mobile networks. Using our solutions, eighty percent of the world's largest service providers and leading global enterprises deliver high-performing and differentiated services, plan and optimize networks to match application and service demands, and streamline network operations while keeping total cost of ownership as low as possible. For more information, please visit www.fovista.com.



JUNIPER

Juniper Networks is in the business of network innovation. From devices to data centers, from consumers to cloud providers, Juniper Networks delivers the software, silicon and systems that transform the experience and economics of networking. The company serves customers and partners worldwide.



NETCRACKER

Netcracker Technology, a wholly owned subsidiary of NEC Corporation, is a forward-looking software company, offering mission-critical solutions to service providers around the globe. Our comprehensive portfolio of software solutions and professional services enables large-scale digital transformations, unlocking the opportunities of the cloud, virtualization and the changing mobile ecosystem. With an unbroken service delivery track record of more than 20 years, our unique combination of technology, people and expertise helps companies transform their networks and enable better experiences for their customers.



NETROUNDS

Netrounds provides programmable, software-based network performance and service assurance solutions that help service providers enhance the end user experience of IP-based services such as Internet, TV, voice, and other quality-demanding business services. Netrounds reduces the need for proprietary hardware instruments, lowering network test and assurance costs while also enabling remote support to rapidly identify the root cause of network issues with minimal onsite visits. Its solutions are used by more than 270 network operators, service providers and enterprises worldwide. Netrounds is headquartered in Luleå, Sweden, with offices in Stockholm, Sweden and Boston, Massachusetts. For further information, visit <http://www.netrounds.com/>.



PACKET DESIGN

Packet Design's network service assurance technology helps leading network operators, enterprises, and government agencies worldwide to deliver critical services across the cloud. The Explorer product suite uniquely combines routing, traffic, and performance analytics for real-time, path-aware operational monitoring, and a network DVR capability for isolating the root cause of transient problems. Interactive modeling helps engineers predict the impact of changes, simulate new workloads for capacity planning, and test failure scenarios to build more resilient networks. With these analytics as a foundation, Packet Design is delivering an SDN management and orchestration platform to enable next generation applications in complex, multi-service networks.

TM FORUM TOOLKIT FOR ORCHESTRATION



AGILE & VIRTUALIZED

OSS/BSS Futures Architecture

This exploratory report provides initial steps toward the required architecture for the Future Mode of Operations, which incorporates virtualization and software-defined networking with current networking architectures.

Transformation of NetOps to DevOps

This report is a guide for communications and digital service providers detailing what DevOps is and how it can apply to network operations.

Business Rationale and Technical Overview for Orchestration and Autonomic Control Loops

This information guide proposes an architecture based on orchestration accomplished through a federation of domains and autonomic control loops.



OPEN & PARTNER EFFECTIVELY

Open APIs

TM Forum offers 18 Open APIs (with more under development) to manage services end to end and throughout their lifecycle in a multi-partner environment.

Digital Services Toolkit

Currently under development, this toolkit will help companies rapidly address business problems using a collection of interlinked assets based on Frameworkx.

Online B2B2X Step-by-Step Partnering Guide

This guide explains the five stages required to build a partner relationship. Each stage provides key concepts, strategy and approach, worksheets, examples and exit criteria to enable streamlined and repeatable implementation.



CUSTOMER CENTRICITY

Customer Experience Management Solution Suite

This set of tools consists of six components: a guidebook, hundreds of metrics, a maturity model, a lifecycle model, more than 40 implementation use cases and an ROI model.

Big Data Analytics Solution Suite

This set of tools includes a big data reference model, a guidebook containing 65 use cases and 1700+ pre-defined metrics.

360 Degree View of a Customer

This guidebook offer a 360-degree view of a customer and explains how to put customers at the center of considerations and actions.

RESEARCH & PUBLICATIONS

Extra Insights

- [Collaborate to innovate: A universal approach to winning in the digital world](#)
- [Building the Operations Center of the Future](#)
- [NFV: What does it take to be agile? Transforming operations for the digital ecosystem](#)
- [NFV: Are you prepared? Operations and procurement readiness](#)
- [NFV: Can it be managed? Blueprint for end-to-end management](#)

Insights Research

- [NFV: Bridging the Chasm](#)
- [Delivering end-to-end services in a hyper-connected world](#)
- [Virtualization: When will NFV cross the chasm?](#)

Quick Insights

- [Digital Transformation: So hard, so necessary – so here's what to do](#)
- [Agile operations: Moving toward the Operations Center of the Future](#)



For more about the Forum's work on end-to-end orchestration, please contact Barry Graham, Senior Director, Agile Business & IT, via bagraham@tmforum.org



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