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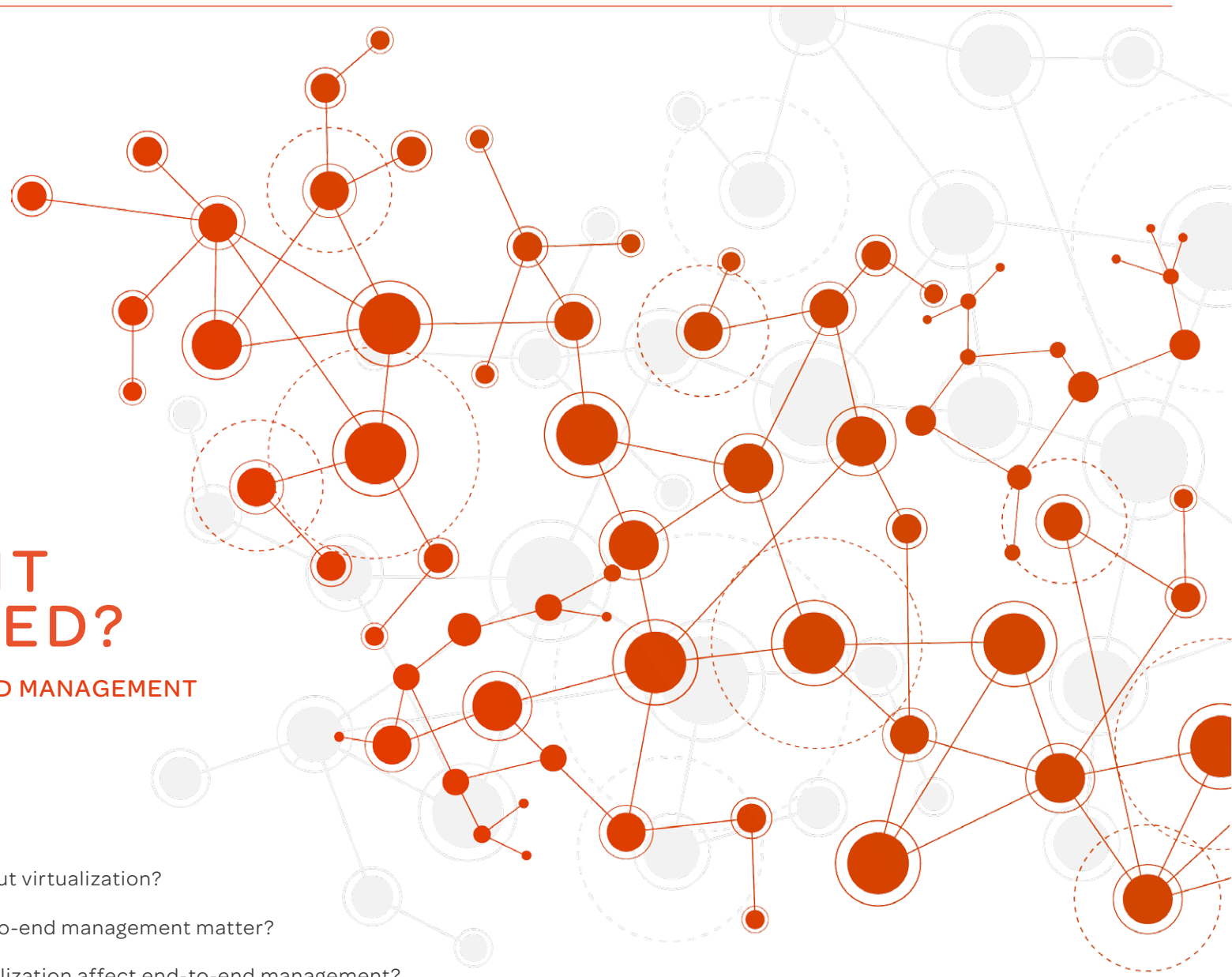
EXTRA INSIGHTS

NFV: CAN IT BE MANAGED?

BLUEPRINT FOR END-TO-END MANAGEMENT



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BLUEPRINT FOR END-TO-END MANAGEMENT

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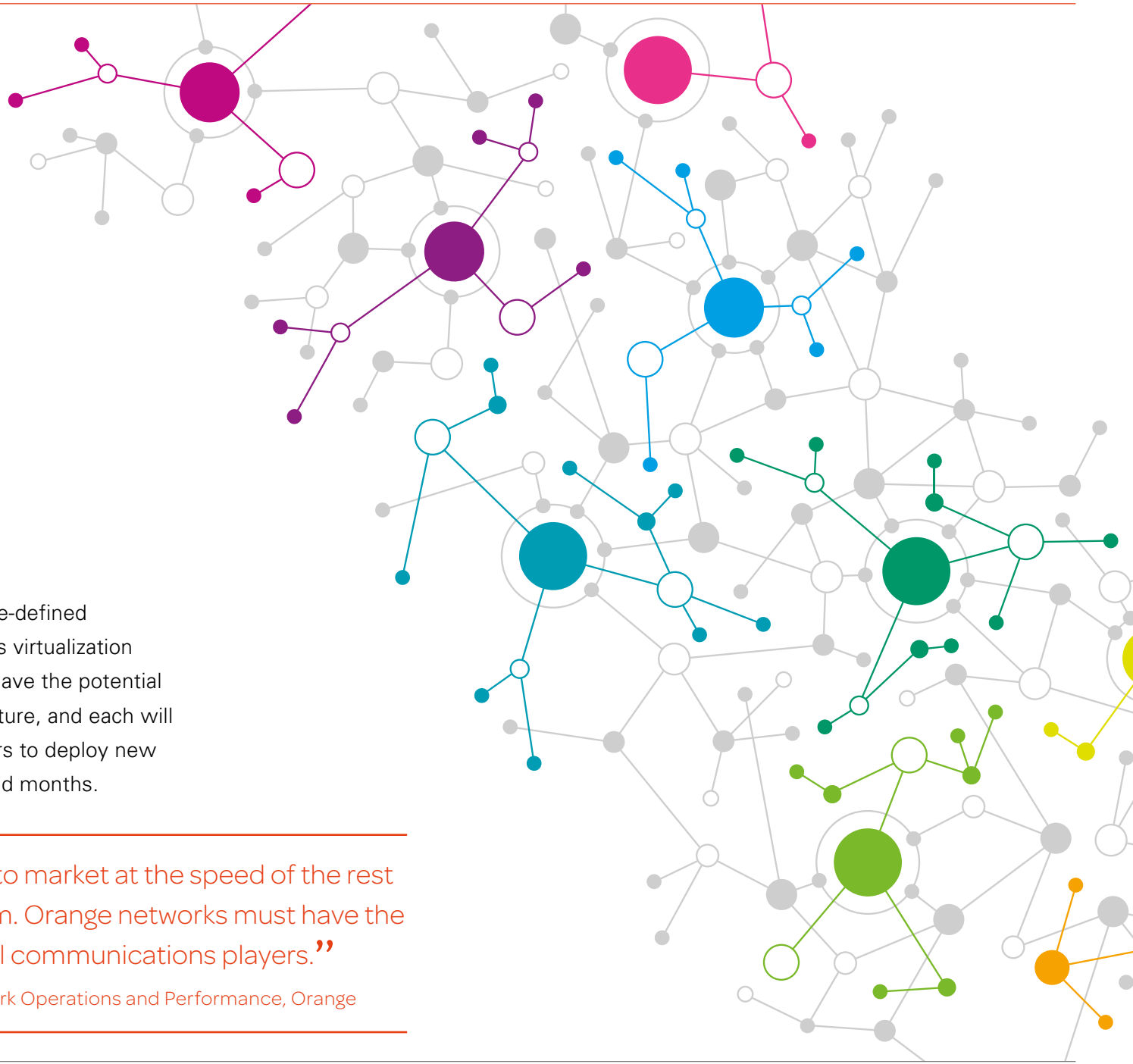


Introduction

It's not hard to understand why software-defined networking (SDN) and network functions virtualization (NFV) receive so much attention. They have the potential to lower capital and operational expenditure, and each will enable communications service providers to deploy new services in minutes instead of weeks and months.

> "Service providers need to get to market at the speed of the rest of the digital business ecosystem. Orange networks must have the same flexibility as those of digital communications players."
>
> Roberto Kung, Senior Vice President Network Operations and Performance, Orange

But virtualization technology isn't an easy cure-all. Implementing it is turning out to be quite complicated and will take many years, because it requires fundamental changes in the way networks are designed, configured and operated. This publication, the second in a series of *Extra Insights*, is designed to help executives like you understand the significant challenges associated with managing virtual networks and hybrid networks made up of virtualized and physical components. The information in this publication is drawn from the extensive work that TM Forum's Zero-touch Orchestration, Operations and Management team is doing on information, data and policy models for end-to-end management.

If you're like most executives within service provider organizations, you're excited about the promise of NFV, but you're also wondering about the management challenges virtualization brings, and what you'll get for an investment in new end-to-end management tools and new operational models. In this primer we highlight the challenges and offer some of the early lessons learned as part of several Catalyst proof-of-concept projects focused on how to implement virtualization technology.

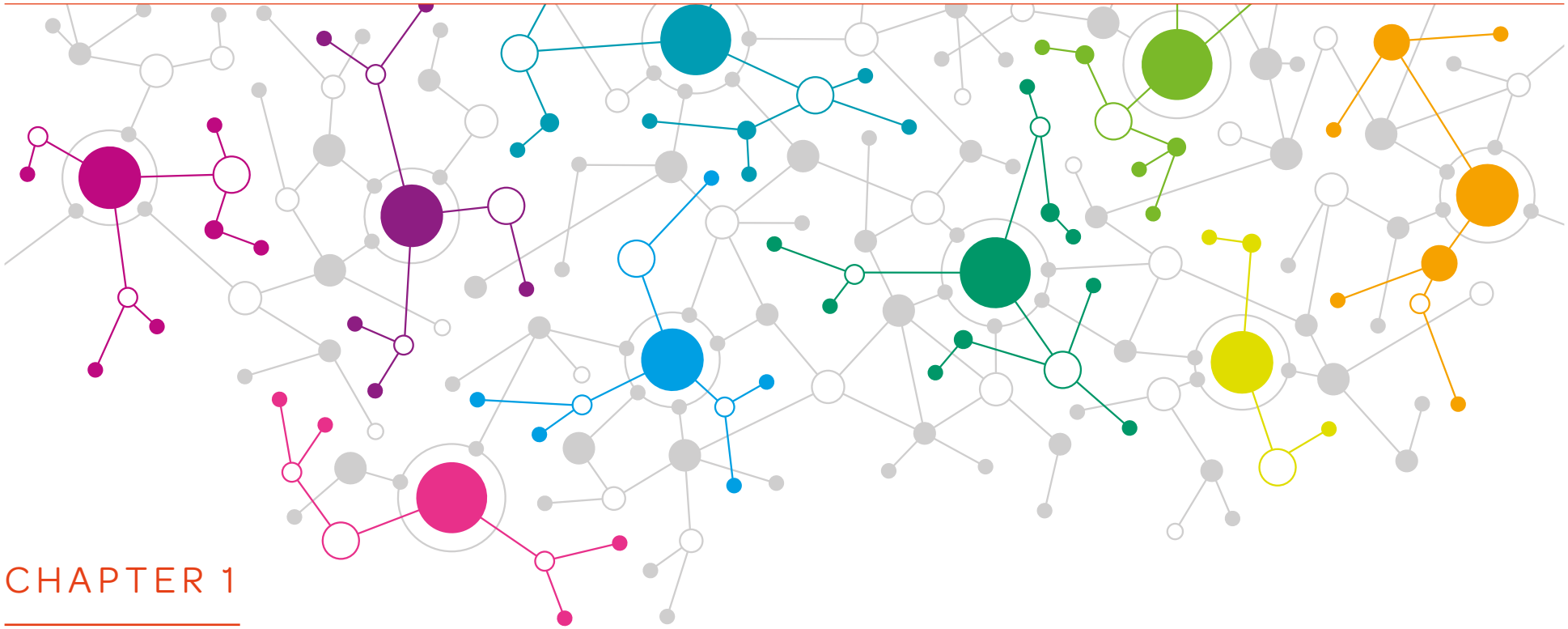
We'll answer questions such as:

1. What's new about virtualization?
2. Why does end-to-end management matter?
3. How does virtualization affect end-to-end management?
4. How can we address the challenges?
5. What should you do next?

To put this publication into context, let's consider an important NFV 'user story':

As an operations executive responsible for planning and operating the end-to-end management of services, I need *to understand how to manage services end-to-end across multiple providers on a combination of physical and virtualized infrastructures that utilize multiple vendors.*

To do this I need to *extend my current end-to-end management architecture. I need an information model to manage and correlate diverse and disparate data from managed systems.*



CHAPTER 1

What's new about virtualization?

Communications service providers have been implementing virtualization techniques for decades – for example, virtual local area networks. Today virtualization refers to the ability to simulate what has traditionally been a dedicated hardware platform, such as a server, storage device or network appliance, in software that runs on commercial off-the-shelf hardware platforms. Unlike traditional forms of virtualization, these network functions can be created on the fly, configured, moved to a different hardware platform and decommissioned. It's the dynamic nature of creating and moving software-based functionality that gives rise to the cost savings and agility associated with SDN and NFV.

End-to-end management refers to the ability of the network management system or operational support system (OSS) to maintain visibility and control of all the infrastructure and application components involved in delivering a service to an end customer and maintaining a high level of quality for that service.

TM Forum's ZOOM program is advancing a large body of work underpinning four key themes for virtualization, which include: moving away from the traditional service provider operations model to a more agile DevOps model; focusing on end-to-end virtual network and operations management; working on NFV readiness support for procurement and operations; and clarifying how open source technology can be used. Much of the team's work is delivered as part of the Frameworx suite of tools and best practices.

The team has delivered an assessment of how virtualization impacts service level agreements (see pages 9-10) and is currently working on information, data and policy models (see page 18); NFV preparedness; Catalyst projects solving real-world implementation issues (see page 17); an end-to-end security fabric for NFV; and a set of business and operational support system (BSS/OSS) design principles needed for NFV adoption to become widespread. The team calls this work 'OSS Futures', and it draws heavily on existing TM Forum assets, including the Digital Service Reference Architecture, the Software-enabled Services Management Solution and the B2B2X Partnering Accelerator. For more information, please contact Dave Milham via dmilham@tmforum.org or Ken Dilbeck, via kdilbeck@tmforum.org.

> "Since there is no one service provider who is operating exactly the same as another, nor a single set of standards, the ZOOM project has been focusing on identifying and developing architecture design patterns and data-driven interfaces. In other words, we are trying to define the rules and specifications on how to produce Lego™ blocks, so that when they are joined up, they are interoperable and form a consistent end-to-end view. This will allow service providers and suppliers to assemble their own solutions and to anticipate the future."
>
> Jenny Huang, ZOOM project co-chair and Lead of OSS/BSS Standards Strategy Group, AT&T

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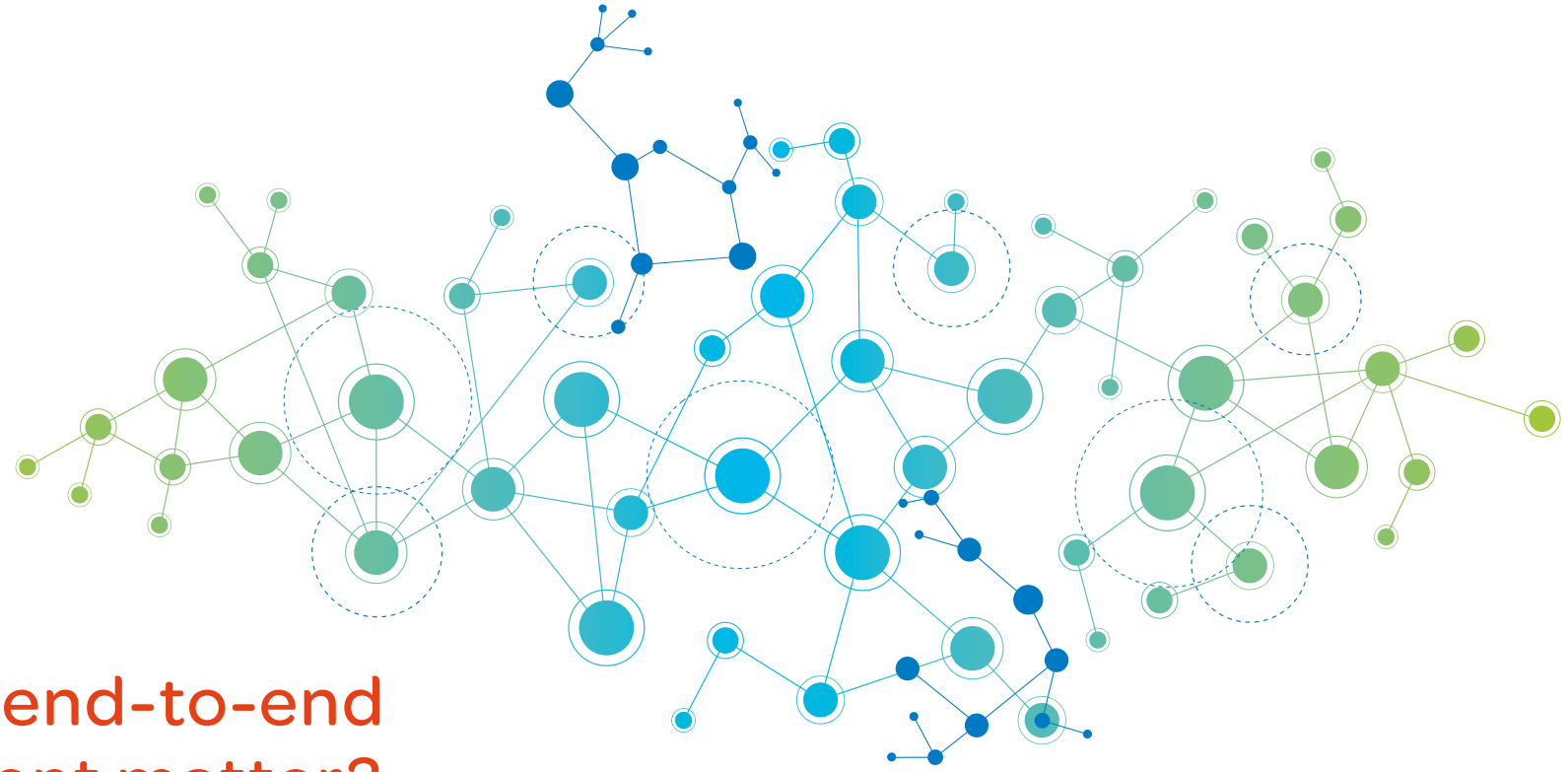
You can download more detailed information about ZOOM's work on NFV readiness; information, data and policy models; SLA management; security; and future BSS/OSS design principles from our ZOOM website.



CHAPTER 2

Why does end-to-end management matter?

End-to-end management of network infrastructure is based in part on the ability to discover a complete network topology and update it as changes are made. In a traditional hardware-centric environment, topology changes occur infrequently, but in a virtualized environment they will be frequent. Service providers need tools that enable them to dynamically discover, procure, allocate and reconfigure the resources.

End-to-end management capability has traditionally made it possible for operations groups to perform basic tasks such as root-cause analysis and impact analysis when faults occur. In a virtualized environment, operators will focus on monitoring end-to-end network and application performance, and service restoration, and they will need the ability to dynamically add resources when performance degrades.

Even in a traditional environment, end-to-end management has been a challenge for operators, because of the need to span multiple technology domains. In a virtualized environment, the challenge is magnified,

because in addition to spanning multiple technology domains, end-to-end management must also cover both virtualized and physical infrastructure, and it must reach across partners' networks to cover the entire value fabric.

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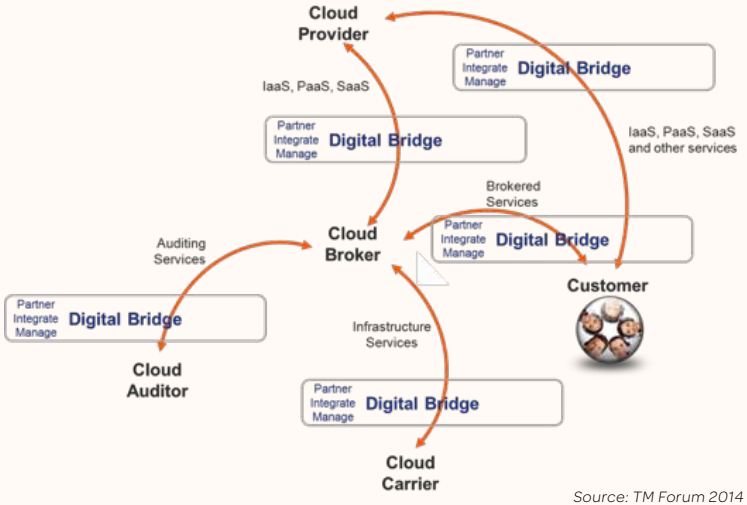
WHAT IS A VALUE FABRIC?

A value fabric is a mesh of interwoven, cooperating organizations and individuals. Value chains tend to be sequential with well-defined roles for each party in the chain. Value fabrics, on the other hand, are not sequential and often involve multiple collaborating parties who play a variety of roles.

Some parties engaged in a value fabric deliver value in the form of goods or services directly to their customers and assure that customers' expectations continue to be met, while others deliver and assure value indirectly. Customers also play an important role in the digital ecosystem represented by the fabric. Below is an example of a cloud value fabric.

The key to making the most of the value fabric is that all parties are able to collaborate effectively in delivering goods and services to customers. The TM Forum approach is based on operationally deployed solutions as described in the Online Partnering Guide. The end result is a kind of 'digital bridge' between parties based on reusable concepts and components. Building this



Source: TM Forum 2014

bridge using TM Forum's Frameworx suite of standards-based tools and best practices provides common language, business processes, information, key performance indicators and APIs for successful digital partnerships.

For more information about the value fabric, check out John Reilly's blogs on *Inform* or see his book *Frameworx: Mastering the Digital World*. You may also contact John directly via **jreilly@tmforum.org**.

Evolving SLAs

Recently the focus of service level management has shifted to the quality of end users' experiences as they access a network service or application. Providing SLAs that are meaningful to the customer is a key way for a service provider to differentiate itself. Therefore, capturing end-user performance data throughout the entire value fabric will become an increasingly important component of end-to-end management. End-to-end service management will also have to adapt to composite services that are partially hosted in the cloud networks of multiple service providers.

The Forum's work on SLAs takes this into account. For example, a technical report called *Enabling end-to-end cloud SLA management: A collaboration of standards bodies* provides "a set of common approaches for two parties to determine their cloud service level agreements, define what to measure, the threshold and indicators as well as some architecture design principles for the service providers to 'connect the dots' so that end-to-end cloud SLA management can be achieved with process automation and architecture flexibility to support different business scenarios and customer needs."

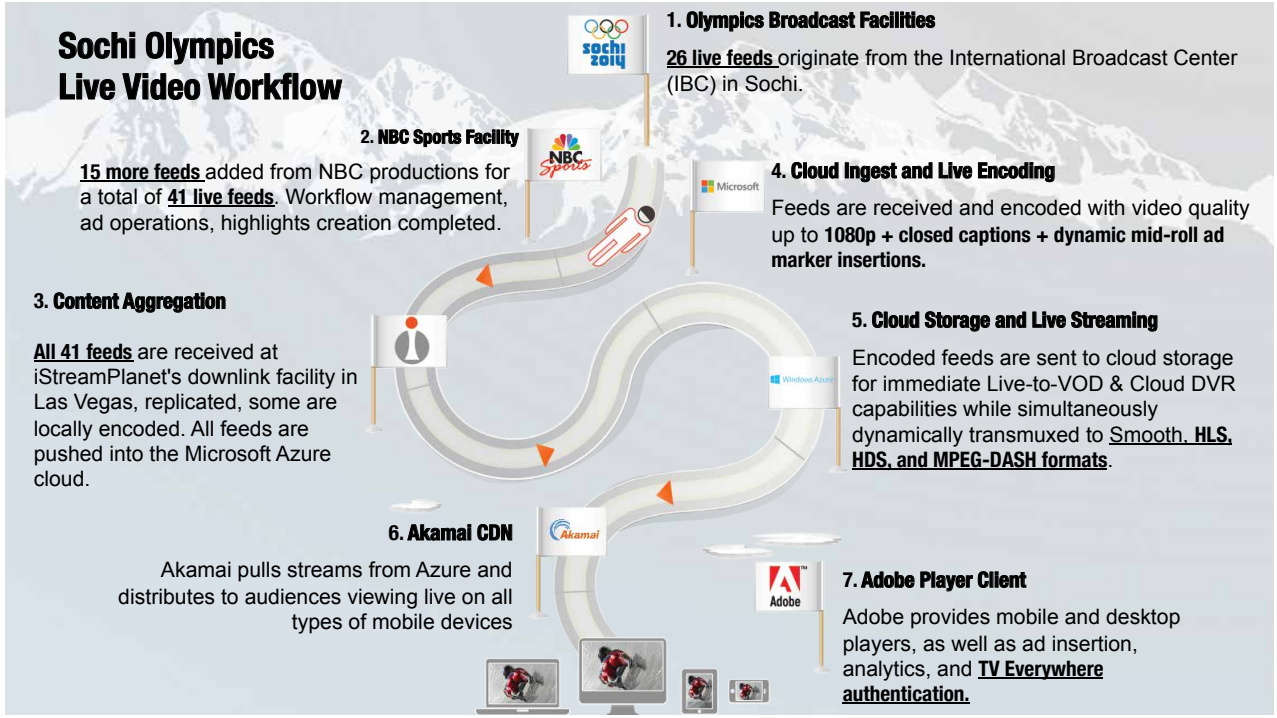
ZOOM is taking this work even further by focusing on the enhancements needed to support template-based SLA contracts, added service-level specifications, a new metrics model, dynamic SLA management infrastructure, closed-loop control and policy-based management. For a more detailed look at the SLA changes required, see ZOOM's *virtualization impact on SLA management*.

> "Providing SLAs that are meaningful to the customer is a key way for a service provider to differentiate itself."

Catalyst for change

A TM Forum Catalyst project that will be demonstrated at Digital Disruption this month is looking at how to orchestrate services and ensure SLAs in a multi-cloud environment. Microsoft and AT&T are championing the project called *Lifecycle management for multi-cloud networks*, which is based on the work of a previous Catalyst demonstrated in Nice. Using Microsoft's experience managing video streaming for the 2014 Olympic Winter Games in Sochi, Russia, the Catalyst will demonstrate seamless management for services relying on virtualized resources in a public cloud.

Below is a look at how Microsoft managed its value fabric of partners to deliver Olympic coverage. For more about Microsoft's Sochi experience, check out this case study on *Inform*.



> "The challenge is how to manage quality of service across networks when there's more than one network controller involved – what's the higher level control plane that controls what's going on in multiple clouds? That's a limitation today. We're exploring how to do it so that we have end-to-end quality of service and how to automate it."
>
> Eric Troup, Chief Technical Officer, Worldwide Communications and Media Industries, Microsoft

CHAPTER 3

How does virtualization affect end-to-end management?

Virtualization poses a number of significant challenges for service providers as they try to manage services end to end, particularly when they may not control every portion of the network and when services may be delivered using a combination of virtualized and current infrastructure. This chapter outlines many of the challenges service providers and their suppliers are facing.

"The challenges related to the introduction of NFV in a hybrid environment can be classified in three categories: infrastructural, operational and organizational."

Marc Flauw, Chief Technologist, HP

Dynamic relationships between software and hardware

In traditional networks, application and network function software generally run on dedicated hardware that is statically provisioned using largely manual processes. With virtualization, software running on virtual machines (VMs) can be readily moved among physical servers or replicated to run on newly created VMs in order to dynamically maintain availability, expand or shrink capacity, or balance the load across physical resources. Many of these infrastructure changes can be automated and activated programmatically to conform to specified policies. In this environment, network topology changes can be made in a matter of seconds or minutes.

Configuration changes on the fly

To accommodate the dynamic nature of virtualized networks, end-to-end management systems must be able to adjust the configuration of devices to react to changing conditions in the network. For example, consider the traffic of an important application flow that is designated as 'medium' priority. If the network becomes congested, it may be necessary to designate the traffic as 'high priority' in order to continue to meet an established SLA.

In the example of Microsoft delivering content during the Sochi Olympics (see page 10), the company used virtualized compute nodes in the Azure cloud to facilitate live transcoding in parallel across multiple nodes. If one virtual machine went down, then the content was automatically distributed to a new one. As the load peaked, the whole environment had to be able to expand and contract automatically.

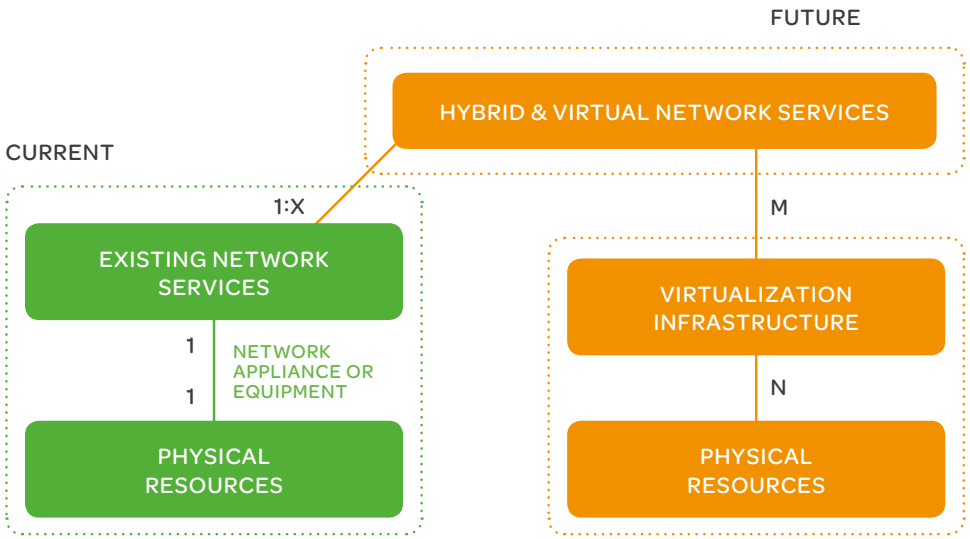
This is fairly easy to orchestrate inside one data center where there is tight control, but not when multiple clouds are involved. Microsoft had to do a lot of upfront planning to overcome the limitations, but what the company really needs are industry standard interfaces and APIs so that the necessary expanding and contracting of the network happens automatically.

Many-to-many relationships

In a typical traditional network infrastructure there is a one-to-one relationship between a network service and a set of dedicated physical resources. In a virtualized infrastructure a network service can be supported by more than one virtual network function (VNF), which may be running on one or several VMs.

A single VNF may also support more than one network service. In addition, the group of VNFs supporting a single network service could be running on multiple physical servers. As a result, end-to-end management systems need to support a three-tiered network model based on many-to-many relationships among network services, virtualization infrastructure and physical infrastructure, as shown on the right side of the image here.

IMPACT OF VIRTUALIZATION



Source: TM Forum 2014

"In a virtualized infrastructure a network service can be supported by more than one virtual network function."

Hybrid physical and virtual infrastructure

As service providers gradually adopt virtualization, they will need to implement end-to-end management of a combination of current and virtualized infrastructure. Therefore, end-to-end management systems developed for the virtual infrastructure must be backward compatible.

Collaboration among partners

Some of the VNFs comprising a virtualized network service may be hosted in multiple collaborating providers' cloud networks. As we have noted, one major challenge in a multi-cloud environment is managing end-to-end service levels and SLA compliance. Since visibility into portions of the end-to-end path that are external to a service provider will always be limited, some form of aggregated external SLA data will have to be developed and imported from partner providers and the Internet. This requires a flexible and extensible end-to-end management architecture that provides consistent data collection, data definitions and management interfaces across all on-network and off-network resources and technologies. Multi-cloud environments also require new approaches in managing end-to-end security.

Deciding what comprises a VNF

In order for a service provider to be able to mix and match VNFs from a variety of network equipment suppliers, it will necessary for the industry to establish standard definitions for the functionality of VNFs, the hypervisors that are supported, and the management interfaces and data models that they present to end-to-end management systems. For their part, end-to-end management systems must support these standards as they evolve.

> "Today, it is unclear to operators what exactly a VNF package contains, how it will be managed and what the granularity of that 'thing' is. It is important that we have a clear view on how this package will be delivered to the service provider and what level of testing the vendors should be responsible for versus the service providers."
>
> Jenny Huang, ZOOM project co-chair and Lead of OSS/BSS Standards Strategy Group, AT&T

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For more information about end-to-end security, check out *ZOOM's NFV security fabric overview*.

IT and network operations must collaborate

In the past, IT and network operations teams have operated in silos. This must change: The two groups have to cooperate effectively to establish new operational processes that meet the demands of end-to-end management of hybrid infrastructures. This requires an effective DevOps organizational model for the development of network services based on NFV, which we cover in the third primer in this series, *NFV: What does it take to be agile?*

One of the challenges will be sharing responsibility for the various tasks involved in rolling out a new service. A key aspect of this cooperation will involve selection and management of component VNFs, as well as testing and deploying the end-to-end management capability for network services.

BSS/OSS must also change

In the European Telecommunications Standards Institute's (ETSI's) initial NFV work, a decision was made to assume that existing legacy business and operational support systems (BSS/OSS) would not change and that NFV would be supported by adding new networking and BSS/OSS functions. However, research by the ZOOM team has shown that the ultimate impact of NFV on BSS/OSS will be significant and that it will require transformation not only of service providers' operational practices, but also of existing BSS/OSS.

The ultimate goals of NFV are to roll out services faster while reducing operating costs. As it turns out, current OSS and BSS solutions are a significant barrier to achieving overall service agility, unless they, too, are re-engineered.

To help service providers and suppliers transform BSS/OSS, the ZOOM team is revamping the proven and deployed practices in the Forum's Frameworx suite of standards-based tools and best practices, in particular the Information Framework (SID). The evolution builds on the existing information model and minimizes the impact of, and unnecessary disruptions in, the modeling of services, while at the same time introducing the necessary concepts to account for the added virtualization layer and the non-functional characteristics and new capabilities it enables.

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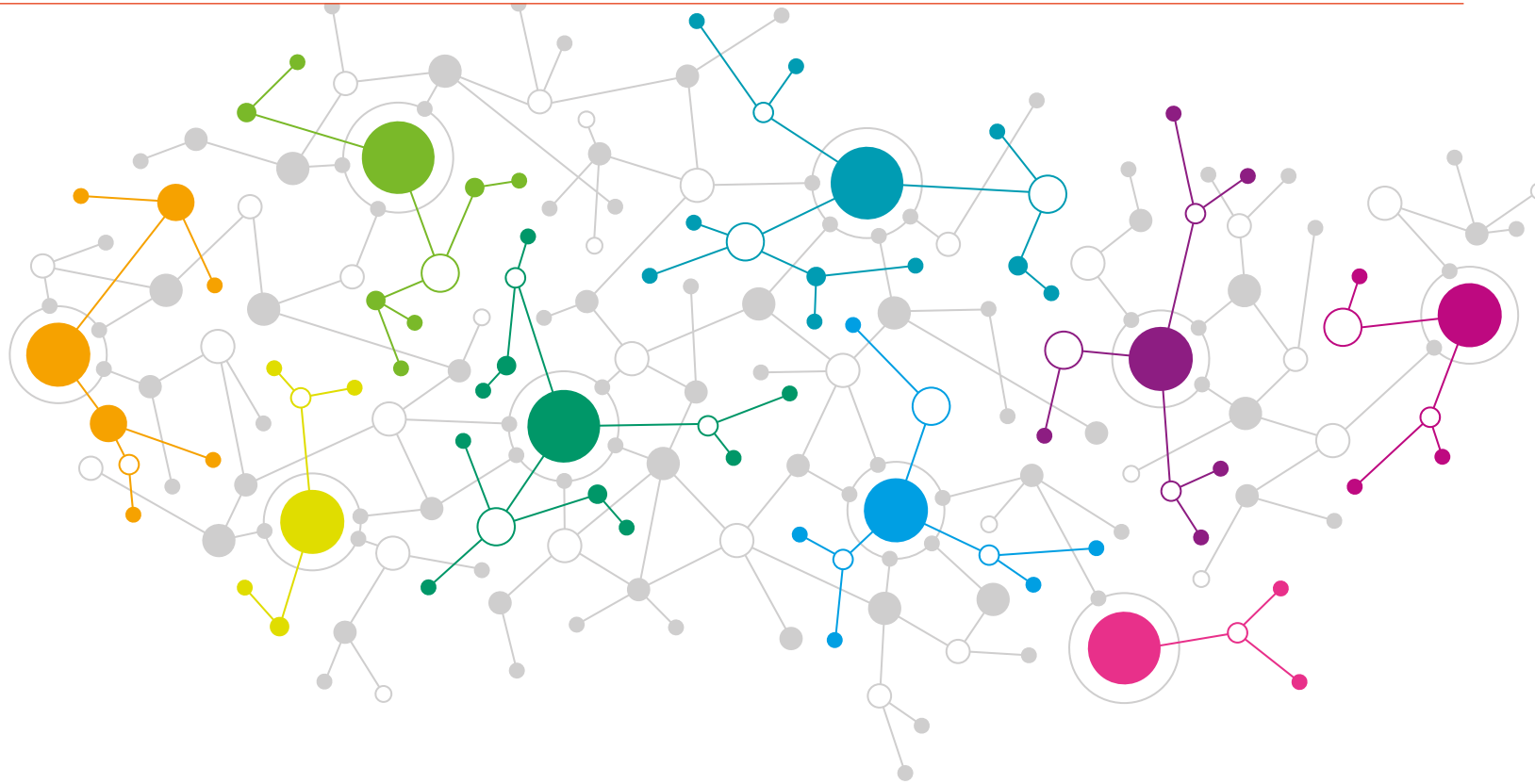
We'll talk a bit more about information and data models in the next chapter, but for a detailed explanation of the changes needed in OSS/BSS design and implementation, see ZOOM's *OSS/BSS futures overview*. You can also find an summary of the changes needed to the Information Framework in ZOOM's *Why information models are needed for agile operations*.



CHAPTER 4

How can we address the challenges?

The true vision of NFV will not be realized until an initial set of standards and best practices are established by ETSI in collaboration with other standards-defining organizations and open source groups, including TM Forum. This chapter focuses on the changes service providers and suppliers will have to make to take full advantage of network virtualization and some of the progress that's been made so far.

As we have explained in the preceding chapters, the introduction of a virtualization layer helps network operators provision and modify services dynamically, but it requires real-time, policy-driven management. Where dynamic network service configurations are required, the management interfaces presented by both virtual and physical infrastructure elements must support automated plug-and-play integration. This will be especially challenging for services that span hybrid virtual and physical networks or are delivered across partners' networks.

The hybrid challenge

In a hybrid network there will be a contention for resources, so it's crucial to manage them in a way that's policy-based and uses control loops in order to ensure quality of service. In networking, 'closing the loop' means collecting and analyzing data to figure out how the network can be optimized and then implementing those changes. In virtualized networks, this has to be automated, and several TM Forum NFV Catalysts have been exploring ways to accomplish this.

At TM Forum Live! 2014 in Nice in June, participants in a project called *Closing the loop: Data-driven network performance optimization for NFV and SON (self-organizing networks)*, demonstrated how to build a closed loop using key performance indicators (for example, network performance, customer experience and service quality data) to enable network changes, optimization and self-healing using the Forum's Performance Management Interface. Configuration and performance data was collected in a mobile network and then analyzed to understand where problems existed or where there was potential for improvement.

The lessons learned in the Catalyst, which was also an ETSI NFV Proof of Concept (POC), are being incorporated into ZOOM's work on policy management and SLAs and will show up in the next release of Frameworx. The next phase of the project, called *Data-driven network performance optimization for NFV and SON*, will be demonstrated at Digital Disruption and will look at service fulfillment in addition to service assurance.

CloudNFV™: Dynamic, data-driven management and operations , another TM Forum Live! Catalyst and ETSI POC, delivered a metamodel for event-driven management and operations, and included a live demonstration of a dynamic implementation of a network service as a VNF deployed via OpenStack cloud orchestration and optimized to maintain quality of service. A key result of the project was contribution to the TM Forum Information Framework on metamodel extensions to support dynamically defined management APIs. This Catalyst is also continuing at Digital Disruption with a new name, *Preparing NFV for prime time*,

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TM Forum Catalysts are short-term, collaborative projects led by our members that create solutions for addressing today's most pressing operational and systems challenges.

Enhancements in the next iteration of the Catalyst include integration with TM Forum's Integration Framework to leverage existing investments and expertise; user interfaces to provide role-based views; and policy-based management for security, optimization, compliance and governance.

New information and data models

Automated management interfaces need high levels of consistency so that composition of services can be managed by simple configuration rather than ad hoc code-driven integration. Meeting these challenges will require end-to-end management systems, VNFs and physical infrastructure to adopt new information models and derived data models.

In this context, an *information model* is a way of describing a wide range of network entities, such as network functions (for example, firewall or routing functions), customers and product information. This description includes the characteristics and properties of each of the entities and their relationships with others. A *data model* is a specific representation of an information model. Information models drive interface consistency by capturing behavior, defining standard communications patterns and specifying how information is represented, for example how metrics are represented for reporting service-level and quality-of-service performance.

TM Forum's Information Framework is an example of a core common information model, and the *Service bundling in a B2B2X marketplace* Catalyst project was based on this model. The project showed how a buyer can bundle a collection of services sourced from different suppliers and deliver them seamlessly to a customer in a business-to-business or business-to-business-to-consumer arrangement.

Using shared product definitions, the Catalyst combined a cloud service, a software-defined network and a firewall mocked up by Cisco Systems with fiber access service provided by NBN Co of Australia. A catalog management system provided by DGIT dynamically configured these three components into a managed bundled service with catalog-defined, dynamically rendered management APIs. A key result of the Catalyst was formal contribution of a metamodel extension similar to the CloudNFV™ Catalyst and a set of guidelines and examples.

New SLA requirements

In the case of the B2B2X Catalyst demonstration, traditional SLAs were negotiated and included in business agreements for network services. In the world of virtualized network services, SLAs are likely to be negotiated dynamically as VNFs are chained together or configurations are modified. This new, dynamic model will require that SLAs be generated by a set of flexible policies that can take into account the end-to-end characteristics of the service chain path, including the available SLA metrics, SLA enforcement capabilities, and the overall ability to measure service quality and guarantee SLAs.
As we discussed in Chapter 2, the Microsoft-led Catalyst is working to address some of the issues related to service level management (see page 10).

Another Catalyst and ETSI POC called *NFV Management Ecosystem*, which was demonstrated in Nice in June, showed the value of an ecosystem of applications in the context of NFV management and operation. The demonstration used open standard APIs to integrate ordering, billing, catalog, inventory and SLA management functions with ETSI NFV Management and Orchestration (MANO) functions.

In addition, this implementation demonstrated real-time, dynamic management of capacity, performance, quality of service and SLAs, with real-time billing and compensation. This was achieved through the use of open standard APIs to integrate applications using a combination of synchronous and asynchronous operations. The NFV Management Ecosystem showed that it is possible to rapidly integrate both open source and proprietary management systems using TM Forum Integration Framework APIs to realize an ETSI operations MANO architecture.

An additional Catalyst to be demonstrated at Digital Disruption, called *Maximizing profitability of NFV orchestration*, will consider how service providers can harness the power of analytics and dynamically defined policies to minimize costs and maximize profitability through NFV orchestration. The project envisions an environment in which service providers can continually optimize their infrastructure against a range of objectives, such as cost, performance, SLA performance or other specific business goals.

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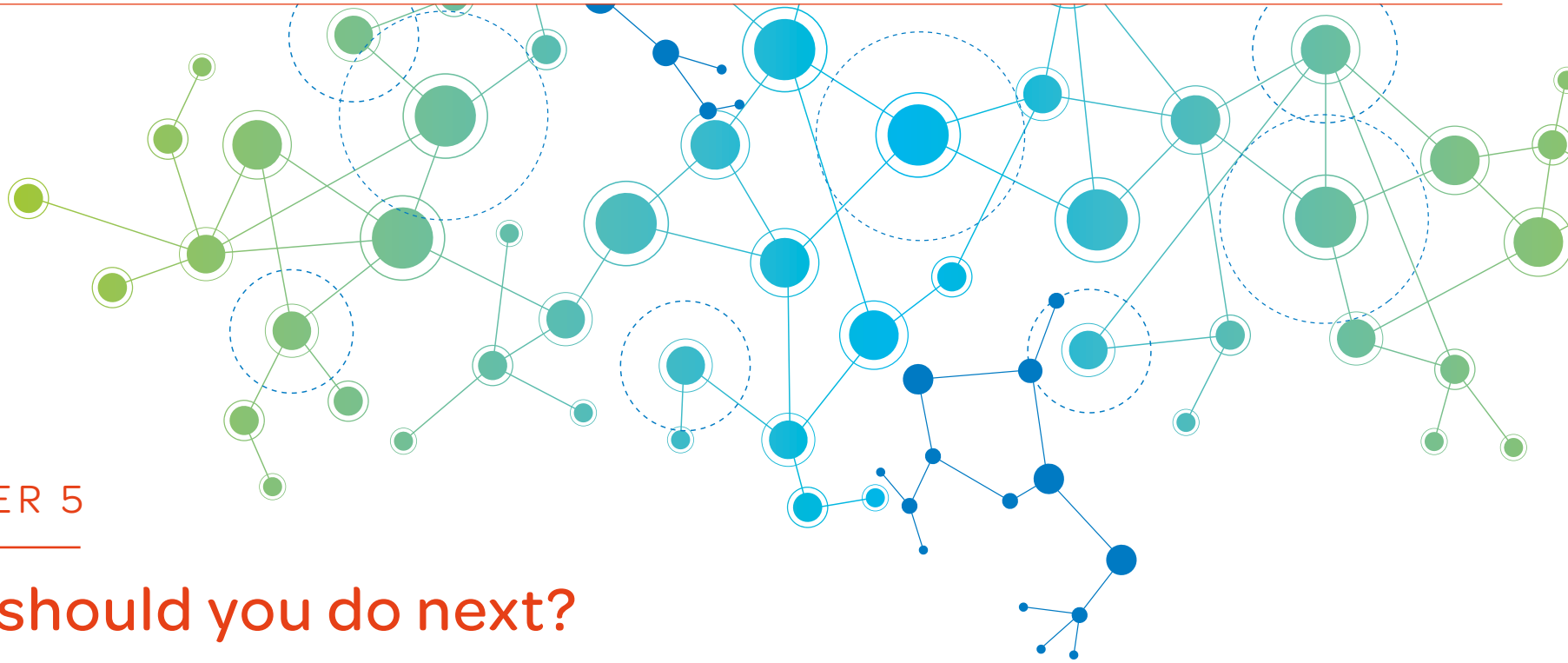
For a more detailed look at TM Forum's NFV Catalyst projects, check out this article on *Inform*.



CHAPTER 5

What should you do next?

Hopefully this primer has helped you understand the end-to-end management challenges associated with virtualization. The benefits of virtualization are compelling: lower costs and increased agility, including the ability to implement new services in days rather than weeks or months. Unfortunately, the impact of virtualization on end-to-end management, and hence on customer satisfaction, is dramatic and potentially quite challenging.

A lot of work has already gone into revamping end-to-end management and much more remains to be done. However, it will be worth the effort, because it will help you reduce costs and serve your customers better and more quickly, with the kinds of services they are demanding.

The next steps to take include learning more and getting involved. To learn more about NFV readiness and the move toward DevOps for networking, check out the first and third primers in this series. You can find them here. You can also find more detailed information about end-to-end management and ZOOM here.

Finally, get involved! Don't be content to wait for virtualization technology to mature; instead join the ZOOM team and make your voice heard as we set the course for the future of networking by developing the tools and best practices required to make network virtualization a success.

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