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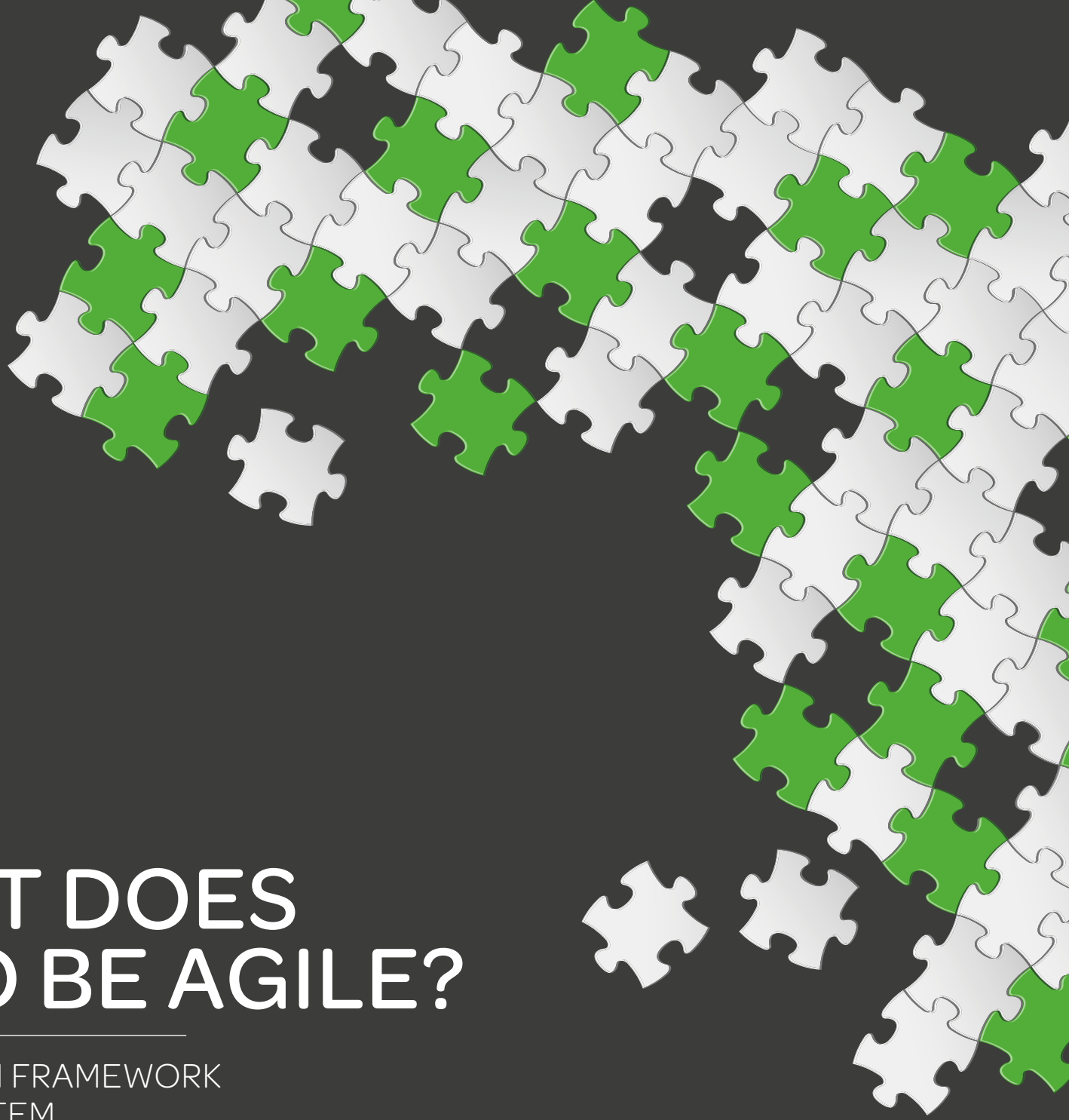

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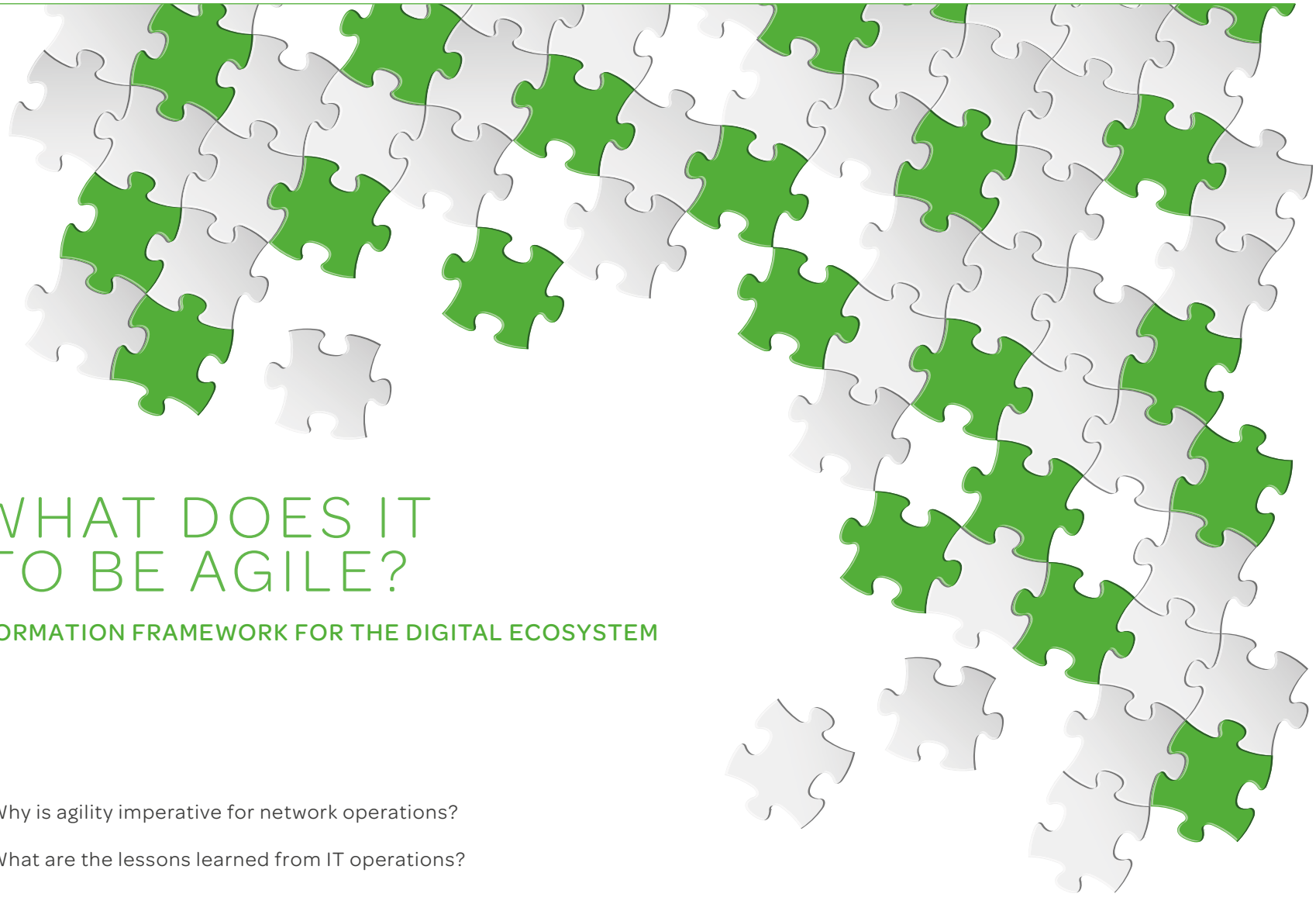
EXTRA INSIGHTS

NFV: WHAT DOES IT TAKE TO BE AGILE?

DevOps TRANSFORMATION FRAMEWORK FOR THE DIGITAL ECOSYSTEM



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DEVOPS TRANSFORMATION FRAMEWORK FOR THE DIGITAL ECOSYSTEM

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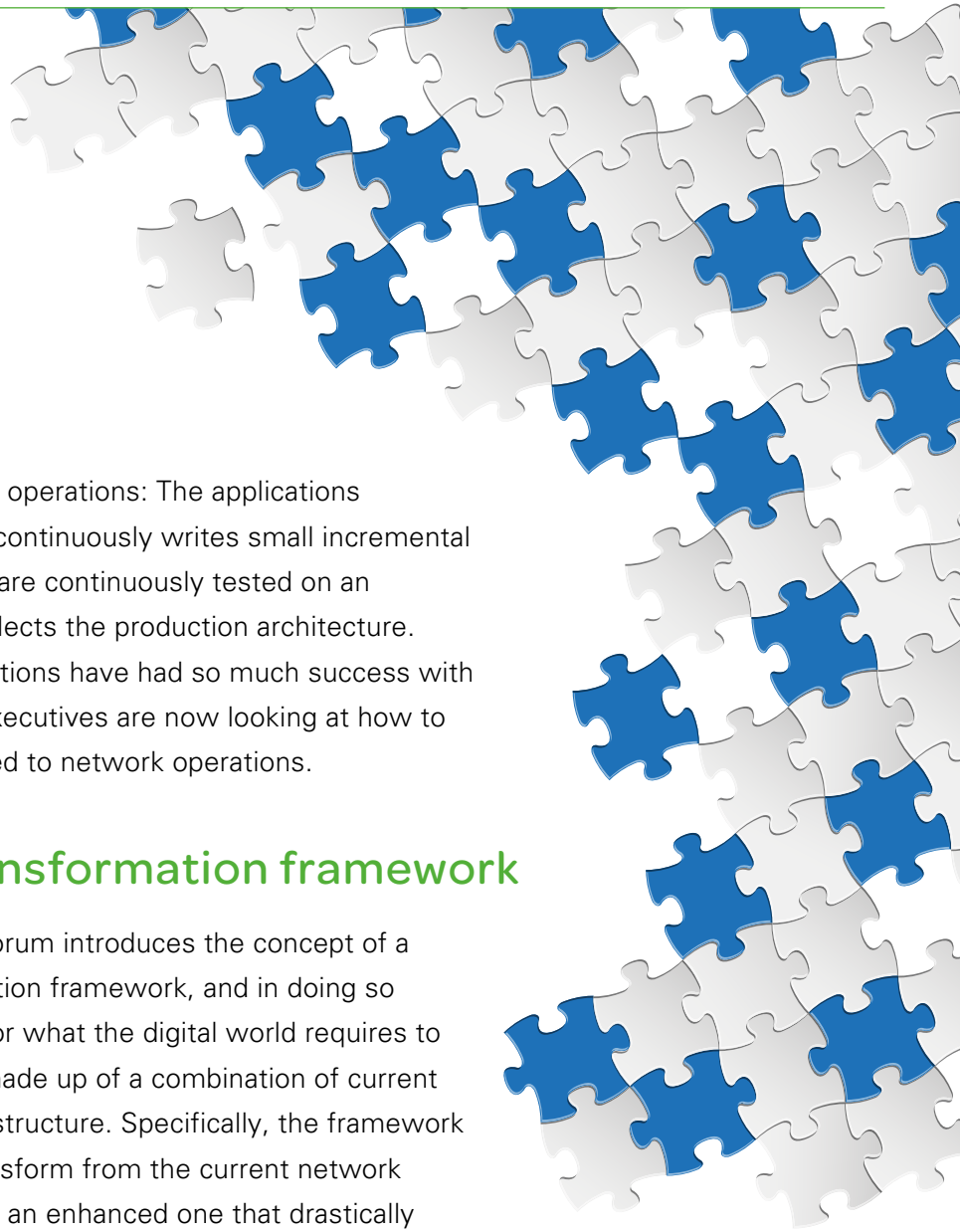

Introduction

In a traditional IT environment, applications development teams go through a lengthy process of gathering requirements followed by coding and testing before an app can go into production. Not only is this process time-consuming, it often takes place with little if any consideration of the operating environment in which the application will run. The introduction of DevOps makes this process more agile and less time-consuming.

Wikipedia defines DevOps as "a concept dealing with, among other things: software development, operations, and services. It emphasizes communication, collaboration, and integration between software developers and information technology (IT) operations personnel. DevOps is a response to the interdependence of software development and IT operations. It aims to help an organization rapidly produce software products and services." Since the term can be interpreted in many ways, to avoid confusion this *Extra Insights* publication accepts this definition.

As the name implies, DevOps is a combination of development and operations: The applications development team continuously writes small incremental pieces of code that are continuously tested on an architecture that reflects the production architecture. Because IT organizations have had so much success with this model, many executives are now looking at how to apply lessons learned to network operations.

DevOps transformation framework

In this primer TM Forum introduces the concept of a DevOps transformation framework, and in doing so sets a clear vision for what the digital world requires to operate networks made up of a combination of current and virtualized infrastructure. Specifically, the framework outlines how to transform from the current network operations model to an enhanced one that drastically reduces the time and resources it takes to introduce new services and improves a service provider's ability to compete in the digital world.

We will answer the following questions about moving toward a DevOps model for network operations:

1. Why is agility an imperative for network operations?
2. What are the lessons learned from IT operations?
3. What does it take to go from concept to operations?
4. How can your company adapt DevOps methodology for network operations?
5. What is the organizational impact of adopting a DevOps approach?
6. What should you do next?

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

As a leader in the CTO/CIO organization accountable for transforming my company so that it can take advantage of virtualization, I need to *move to an operations approach that supports a dramatically more agile service lifecycle, one that lowers capital and operating expenses and supports continuous service innovation and delivery.*

To do this, I need to *understand how operations must change so that I can manage hybrid environments.*

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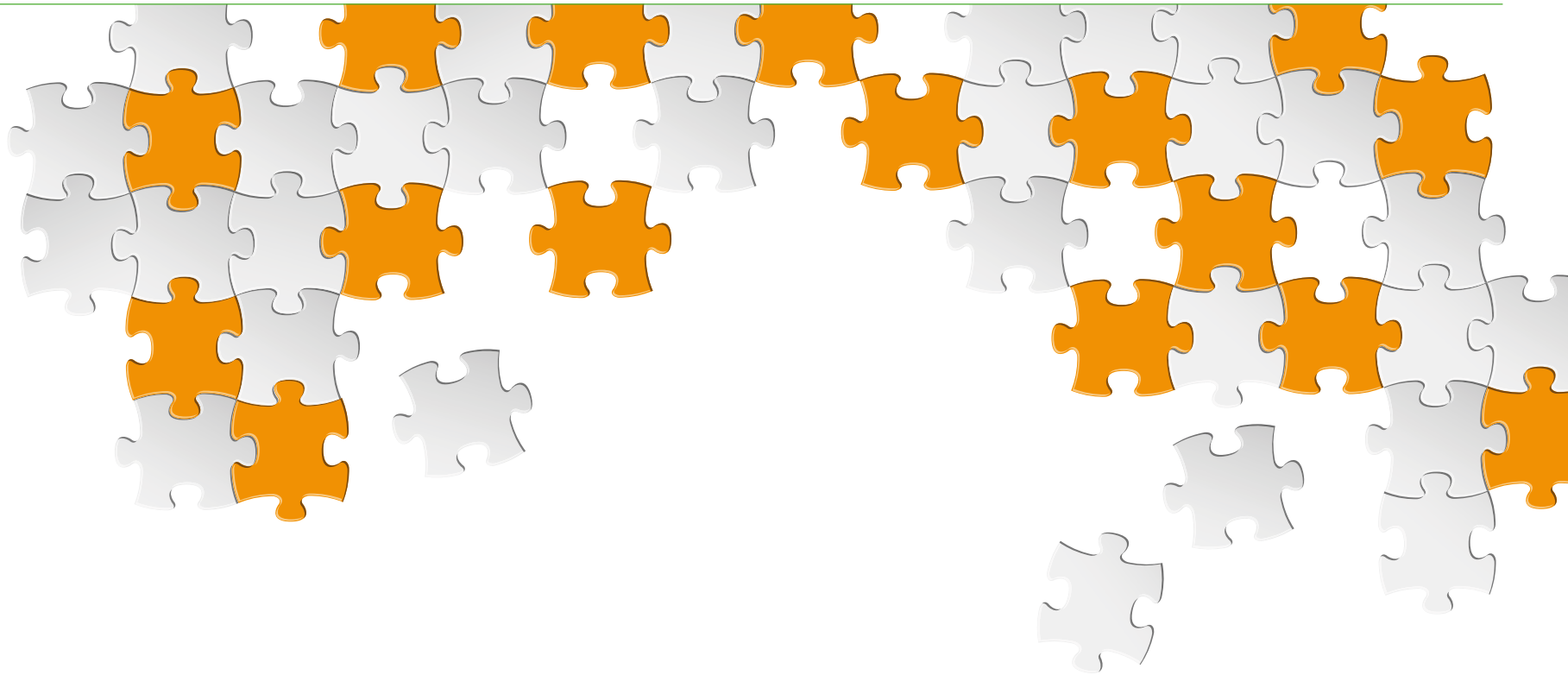
TM Forum's ZOOM program is advancing a large body of work underpinning four key themes for virtualization, which include: moving away from the traditional service provider operations model to a more agile DevOps model; focusing on end-to-end virtual network and operations management; working on NFV readiness 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 and is currently working on information, data and policy models; NFV preparedness; Catalyst projects solving real-world implementation issues; an end-to-end security fabric for NFV; and a set of operational support system (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**.



CHAPTER 1

Why is agility imperative for network operations?

Virtualization of compute, storage and network resources has many significant benefits for communications service providers: It lowers capital and operating costs and helps them develop new services more quickly; provides just-in-time capacity to meet dynamic changes in user demand for services; and delivers a higher-quality experience for the end customer.

As service providers begin to transform their networks to embrace virtualization in the form of software-defined networking (SDN) and network functions virtualization (NFV), their network operations teams need to adopt IT's DevOps practices to maximize the potential benefits of the evolving software-defined infrastructure. This includes adopting new tools that enhance agility, implementation of agile operational and organizational models and procedures, and in some cases adopting a new culture.

"DevOps has always been about culture, not just about tools and processes. We found that the cultural practices and norms that characterize high-trust organizations – good information flow, cross-functional collaboration, shared responsibilities, learning from failures and encouragement of new ideas – are the same as those at the heart of DevOps."

Puppet Labs' 2014 State of DevOps Report

In a traditional environment, implementing services such as network optimization or security is cumbersome because it requires acquiring network appliances and cabling them together in the correct order. Since each appliance has its own unique interface, configuration is a time-consuming, error-prone task.

As we explain in the second primer in this series, *NFV: Can it be managed? The blueprint for end-to-end management*, the deployment of virtualized network functions (VNFs) improves this process significantly. For example, it is now possible to dynamically create optimization or security as a virtual function that can be moved around from server to server and rapidly decommissioned when it's no longer needed.

"Network operations teams need to adopt IT's DevOps practices to maximize the potential benefits of the evolving software-defined infrastructure."

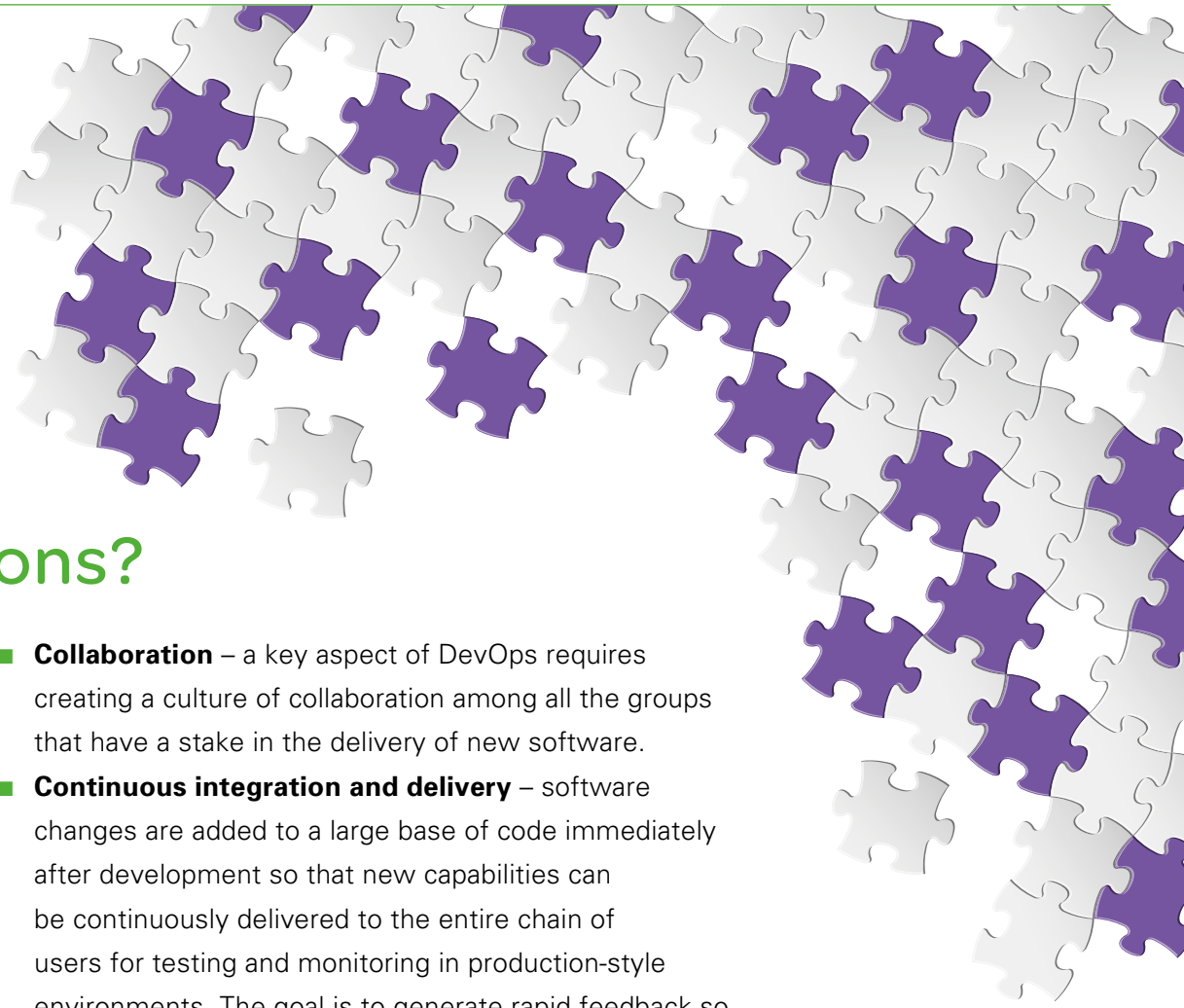
Time for change

The adoption of VNFs has a dramatic impact on end-to-end management (again, see *NFV: Can it be managed?*) and requires many changes. The new tools, models, procedures and culture adopted by the network operations team must be able to respond to them. For example:

- End-to-end management systems must be re-architected to support dynamic creation and decommissioning of network functions in accordance with a set of highly granular policies designed to ensure quality of experience for the end customer.
- The fact that VNFs can be dynamically created and moved makes it difficult to identify where a VNF is running.
- In contrast to being negotiated and included in business agreements for network services, service level agreements (SLAs) are likely to be negotiated on the fly as VNFs are chained together or as configurations are modified.
- Topology changes, which occur infrequently in a traditional environment, occur frequently in a virtualized environment.
- Setting quality of service goes from being a laborious, one-time manual process to a dynamic process that is repeated as needed.
- The focus on fault management is replaced by a focus on network and application performance.
- In a traditional environment, end-to-end management has to be performed across technology domains. In the emerging environment, end-to-end management happens across technology domains that span both current and virtualized infrastructures and in some instances multiple service providers' domains.

In the next chapters, we'll provide guidance on how DevOps processes can help service providers address many of these necessary changes.

"Adoption of virtual network functions has a dramatic impact on end-to-end management and requires many changes."



CHAPTER 2

What are the lessons learned from IT operations?

One of the problems in traditional software development is how to address the conflicting goals of rapidly deploying new capabilities versus maintaining a highly stable, error-free environment. IT operations teams that have successfully adopted DevOps methodology have managed to overcome this obstacle. When asked in a *2014 InformationWeek survey* to indicate the level of improvement in application development speed that they had either already gained or expected to gain as a result of adopting DevOps, 41 percent of respondents indicated 'significant improvement' and 42 percent noted 'some improvement'.

To apply DevOps to network operations, it's important to understand the principles used in a successful DevOps software development environment:

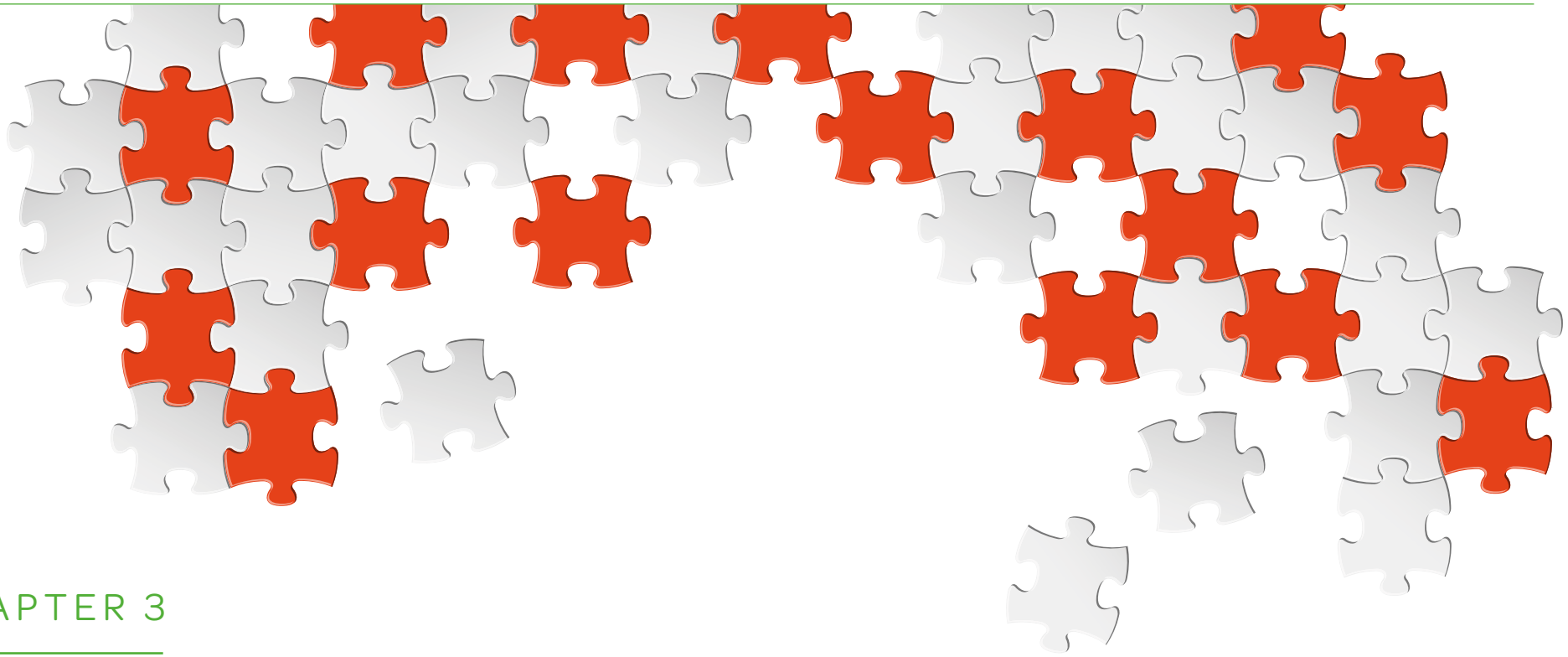
- **Collaboration** – a key aspect of DevOps requires creating a culture of collaboration among all the groups that have a stake in the delivery of new software.
- **Continuous integration and delivery** – software changes are added to a large base of code immediately after development so that new capabilities can be continuously delivered to the entire chain of users for testing and monitoring in production-style environments. The goal is to generate rapid feedback so that defects can be identified and corrected as soon as possible.
- **Continuous testing and monitoring** – testing is performed continuously at all stages of the release process, and not just by the quality assurance team. Developers perform testing and provide test data and procedures that can be used by all collaborating groups.

The operations group is also typically involved in testing and monitoring. This team can add value by specifying load patterns to make test environments more realistic, and they can monitor continuously to identify service issues and resolve them in near real time. Note that the same set of tools that monitor the production environment can also be used in development to identify potential performance issues.

- **Automation** – all stages of software delivery are highly dependent on automated tools. Automation is essential because it enhances agility and provides the productivity required to support the continuous nature of integration, delivery, testing and monitoring of many small incremental changes to the code base.
- **Automated management interfaces** – software-defined environments (SDEs) are an emerging core capability of DevOps that allow organizations to manage the scale and speed with which environments need to be provisioned and configured to enable continuous delivery. SDEs use technologies such as automated management interfaces in the form of application program interfaces (APIs) that define entire systems made up of multiple components. These interfaces are based on information models that define the characteristics, behaviors, configurations, roles, relationships, workloads and workload policies for all the entities that comprise the system.

In the IT world, applying DevOps principles has delivered significant benefits. It provides enhanced customer experience for service differentiation, which is maximized by incorporating customer feedback as an important aspect of the DevOps continuous monitoring function. Organizations also enjoy increased capacity for innovation because they can leverage emerging technologies, such as cloud computing, mobile applications, big data and social media. Finally, they realize faster time to value because they have adopted the methodology, tools and culture required to minimize the time between conception and delivery.

TM Forum does a significant amount of work around APIs. For more information check out the API Zone. We'll discuss information models more in the next chapter, but you can find additional information in the second primer in this series, *NFV: Can it be managed?* and in ZOOM's *Why information models are needed for agile operations*.



CHAPTER 3

What does it take to go from concept to operations?

In order for service providers to realize the value of virtual and hybrid networks, operations staff must develop additional skill sets and adopt more agile operational and organizational models. Managing virtual network functions running on virtual machines requires skills and processes similar to IT's best practices for data center operations – for example, automatically spinning up a VM when utilization crosses a pre-set threshold.

To maximize the benefits of policy-driven automation in network operations, service providers must be able to dramatically reduce the amount of time it takes to develop and introduce new network services supported by a range of VNFs from a variety of suppliers. As the adoption of virtualization progresses, end-to-end management systems and other OSS/BSS capabilities will have to evolve rapidly to keep up.

> "Our experience on this journey to date has been that the small, self-directed teams required in a DevOps world require an amalgamation of skills spanning everything from IT security to database design and application architecture, plus everything in between. While each individual on the team has a particular strength (say, application design and coding), each one also needs to have working knowledge in other areas (maybe UX or network design)."
>
> Eric Reed, CTO, GE Capital as quoted in *InformationWeek*

Continuous integration and testing

The use of DevOps in IT operations has taught us that continuous integration and testing is required and that these processes must be automated. To achieve automation, an information model is required to develop the necessary management interfaces.

An information model is a way of describing a wide range of entities, such as network functions (for example, firewall or routing functions), customers and product information. The 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. For example, a data model may describe the exact schema used to represent customer information in a database or to exchange customer information across an interface between two or more OSSs.

When models are implemented correctly, it's possible to precisely combine information from multiple suppliers and multiple technologies to automate service operations and create consistent end-to-end views. Very often this doesn't happen, however, which leads to the need for labor-intensive OSS integration. This is a major reason why existing OSS/BSS solutions are inflexible and expensive.

How to ensure interoperability?

In order to implement a DevOps-like continuous development model, service providers must determine how they will ensure interoperability. Standards traditionally have been defined by creating a detailed set of requirements and a single, specific implementation with supporting test tools. This assumes that all the requirements are known at the outset, which is rarely the case.

Using core common information models that incorporate best practices is a more flexible way of ensuring interoperability. TM Forum's Information Framework, which is part of the Frameworx suite of standards-based tools and best practices, is an example. The ZOOM team is working to enhance this model for virtualized and hybrid networks by incorporating lessons learned from several Catalyst proof-of-concept projects.

The *Service bundling in a B2B2X marketplace* Catalyst, which was demonstrated at TM Forum Live! in June, 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.

A second *TM Forum Live! Catalyst called CloudNFV™: Dynamic, data-driven management and operations*, 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. That Catalyst is continuing at Digital Disruption under a new name, *Preparing NFV for prime time*.

A key result of the CloudNFV™ project was a contribution to the Information Framework on metamodel extensions to support dynamically defined management APIs, while the B2B2X project contributed a similar metamodel extension along with a set of guidelines and examples.

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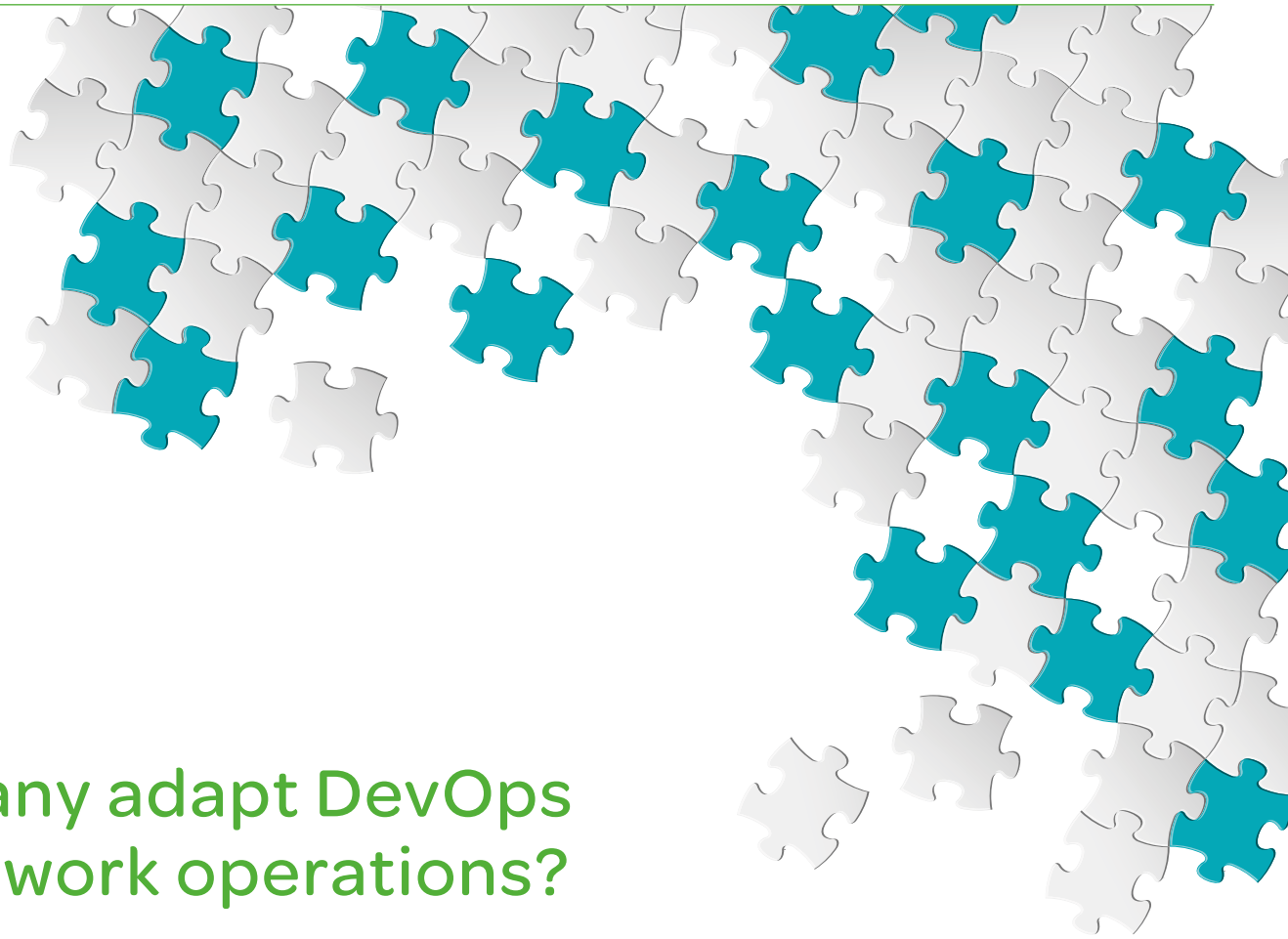
TM Forum Catalysts are short-term, collaborative projects led by our members that create solutions for addressing today's most pressing operational and systems challenges. For more about the Catalysts mentioned here, see the second primer in this series *NFV: Can it be managed?* or check out this article on *Inform*.



CHAPTER 4

How can your company adapt DevOps methodology for network operations?

Current network service development and operations are based largely on manual and/or static techniques, such as those required to configure quality of service parameters on switches and routers. However, the transition to virtualized network infrastructure and network services based on VNFs creates a more flexible environment similar to DevOps-based IT operations.

In a virtualized environment, network services are created by linking together, or chaining, VNFs that may have been sourced from a variety of suppliers. One of the primary goals of NFV is to streamline the integration of these VNFs. For example, a service provider may purchase network optimization functionality from one supplier and security from another.

It is important to minimize or eliminate the need for manual intervention of any sort when incorporating VNFs. The *Service bundling in a B2B2X marketplace* highlighted in Chapter 3 (see page 12) demonstrated how to bundle a

collection of services from different suppliers. In this case shared product definitions were used to combine a cloud service, a software-defined network and 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.

Ensuring quality end to end

All of the basic DevOps principles discussed in Chapter 2 are applicable in a NetOps setting. However, DevOps is generally applied to discrete services that are frequently delivered over the Internet on a best-effort basis. Communications service providers, on the other hand, need to be able to ensure quality of service and guarantee service level agreements (SLAs) end to end – often across multiple partners' networks.

Another Catalyst demonstrated at TM Forum Live! in June called *Orchestrating SDN and NFV while enforcing an SLA over a WAN* highlighted some of the limitations of applying DevOps to network operations. The Catalyst used a DevOps 'service mesh' and use cases provided by the Open Data Center Alliance to demonstrate SLA management in a cloud environment.

The Catalyst highlighted the difficulty of ensuring compatibility between VNFs. When VNFs are chained together for an end-to-end service, strong interdependencies between them are created. For example, if a service provider updates an optimization VNF, it needs to ensure that it is fully compatible with other VNFs, such as those used for security. As a result, much stronger version control and compatibility testing is needed than would be typical in an enterprise application.

The Catalyst is continuing at Digital Disruption with Microsoft and AT&T championing it in the hopes that they can learn how to eliminate the necessary upfront planning now required to ensure SLAs in a multi-cloud environment. For more about the Catalyst, see the second primer in this series *NFV: Can it be managed?* and this article on *Inform*.

It's not going to be easy

Other challenges in the NetOps world that need to be addressed by a new hybrid DevOps model include:

- Since the vast majority of environments will be hardware- and software-based for the foreseeable future, NetOps methodology must accommodate services that depend on network functions running on dedicated hardware platforms as well as VNFs.
- Virtualized services will often be created by integrating services from multiple suppliers. This will require NetOps and DevOps methodologies and best practices to support concurrent, synchronized development and integration across the domains of multiple partners using dynamic APIs.
- In contrast to the Internet's best-effort service delivery, NetOps will need to support dynamic and automated management of service performance and SLAs. This can only be achieved by a policy model that supports end-to-end SLA targets.
- Again, in contrast to what happens when delivering an application over the Internet, NFV services are often mission critical. This creates a need for high levels of resilience and rapid fallback capabilities to restore services.
- Virtualized services will cover a wide range of network functions and technologies. As a result, consistent frameworks and interfaces are needed across suppliers' solutions to minimize or eliminate the need for manual intervention of any sort when incorporating VNFs into a network service.
- Because of the large number of network functions and technologies, creating NetOps test environments that accurately simulate production environments is much more difficult to do than in a DevOps environment.

"NetOps will need to support dynamic and automated management of service performance and SLAs."

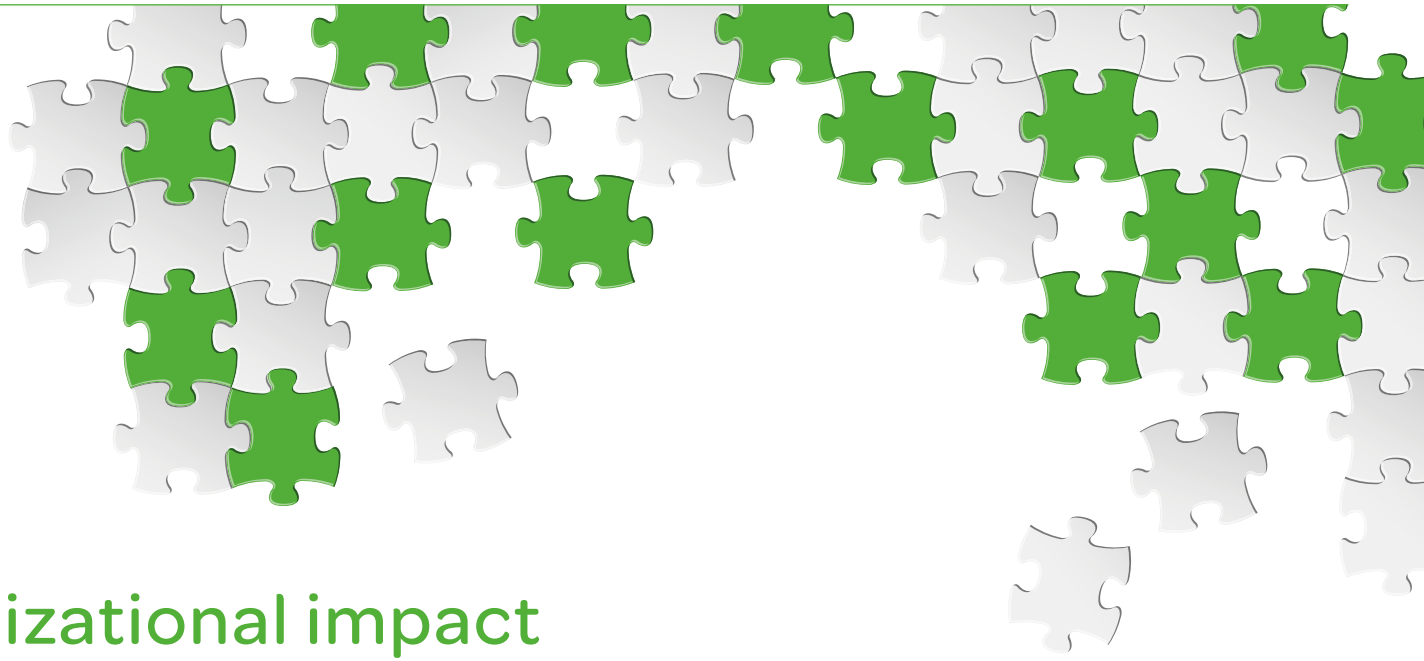
ZOOM can help

ZOOM's vision for NFV is based on the ability to flexibly integrate a wide variety of suppliers' solutions covering multiple technologies. Several other standards-defining organizations (SDOs), collaboration groups and open source groups are tackling the challenges as well, but inevitably the work is diverging, which means that multi-technology integration is becoming more complicated. It is clear that some umbrella organization needs to drive the multi-technology, converged management agenda.

TM Forum is well positioned to help in this effort. The Forum's OSS/BSS futures framework leverages best practices and experience from many Catalyst demonstrations featuring collaboration between the Forum and groups such as the 3rd Generation Partnership Project, the Alliance for Telecommunications Industry Solutions, the European Telecommunications Standards Institute, the Internet Engineering Task Force, the Next Generation Mobile Network Alliance and the Open Networking Foundation.

In addition, the Forum's Digital Services Reference Architecture (DSRA) proposes a simple set of modeling principles and API patterns, which if widely adopted would alleviate the current integration challenge and lay the foundation for automated APIs that can be integrated by configuration rather than coding to support DevOps for network operations. Such a capability is an essential pre-requisite for achieving automated development and integration, and without widespread adoption of these principles, solutions will be unable to support the necessary levels of automation to deliver on the promise of NFV.

"It is clear that some umbrella organization needs to drive the multi-technology, converged management agenda."



CHAPTER 5

What is the organizational impact of adopting DevOps methodology?

The greatest organizational challenge in applying DevOps methodology lies in fostering effective collaboration across all the groups involved in bringing network services to market, including standards-defining organizations.

There are a number of possible approaches to creating a culture of closer collaboration. One that has been used successfully within IT DevOps is merging some or all of the application developers with some or all of the operations organization to create a single, multi-functional team with a set of performance incentives and metrics that align closely with the overall business objectives of the organization – for example, reduced time to deployment for new applications.

An alternative approach is to leave the basic organizational structure in place and focus on replacing conflicting objectives and incentives with a common set of metrics, such as for measuring the quality of applications.

In either case, collaboration is greatly enhanced by a common set of automated tools that span organizational and/or technological boundaries. With both types of organizational structure, new processes must be developed to support the DevOps practices of continuous integration, delivery, testing, monitoring and feedback. Where these new practices are based on well-defined and automated processes, business objectives for agile development of innovative, high-quality services can be met more efficiently.

"In the forward-looking CTO group where we're looking at technology down the road, we can't make decisions or requirements in a vacuum – we have to be able to have everybody's review of it. We need to eliminate silos between organizations. We have included the IT group in our proof of concepts and in writing framework documents for deployment, and we also have the network team involved in helping review test plans. We're getting input from everyone on RFIs, and we're learning how to work together across the borders."

C-level Executive, Tier 1 Service Provider

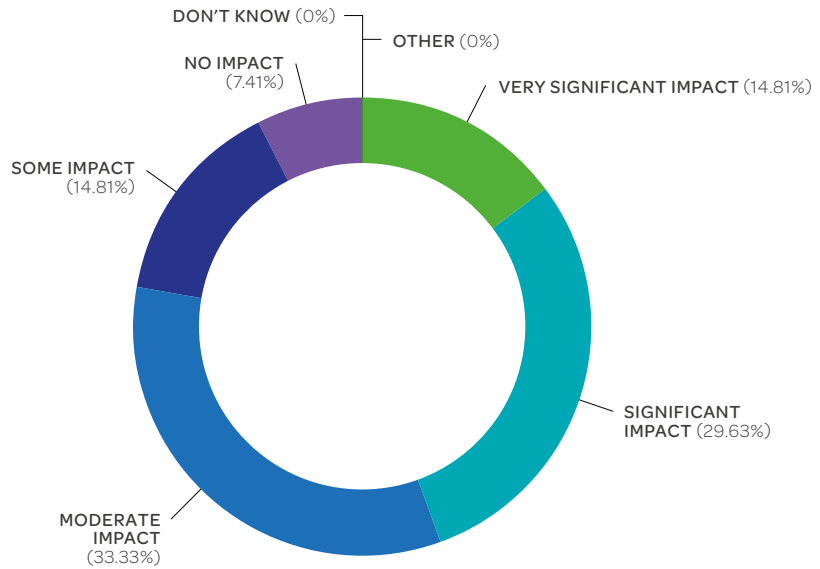
Change is underway

In a recent survey, 33 communications service provider executives were asked about the impact NFV will have on the organization of their companies over the next two years. More than 44 percent indicated it would have either a 'significant' or 'very significant' impact.

Some of the answers from service provider respondents when asked to indicate the type of organizational changes that have already occurred or that they expect to occur include:

- The operations group is likely to be restructured;
- The company's technical experts have been consolidated into a single group;
- The company has set up a subsidiary and is in the process of moving IT employees to that subsidiary; and
- The organization's OSS/BSSs need to be revamped.

HOW WILL NFV IMPACT ORGANIZATIONS OVERALL?



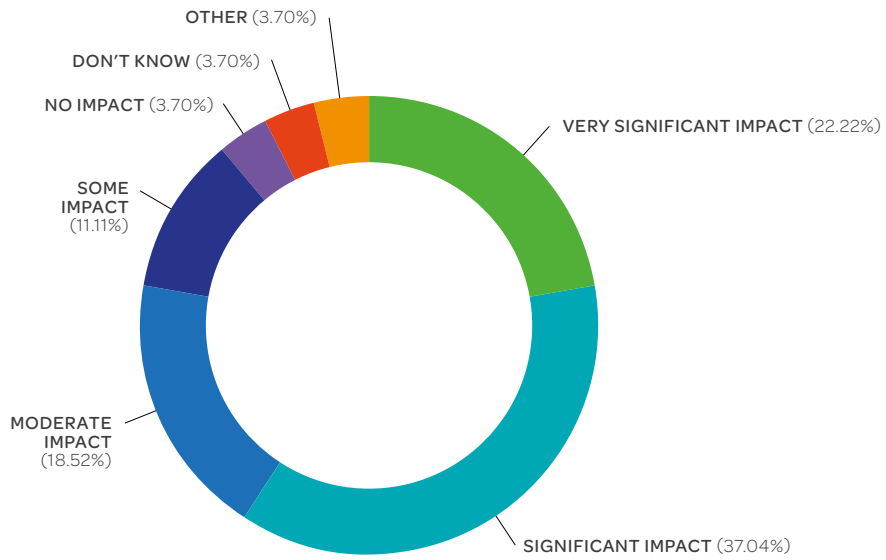
Source: Ashton, Metzler & Associates

Survey respondents were also asked how much of an impact they think NFV will have on the nature of their jobs over the next two years. Nearly 60 percent said it would have either a 'significant' or 'very significant' impact.

Some of the answers from service provider respondents when asked to indicate the type of changes that have already occurred or that they expect to occur to their jobs include:

- The product development lifecycle will change;
- The job will require new skills in general and more knowledge of software in particular;
- There will likely be a new, unknown set of customer demands;
- Product development needs to be able to provide tools to manage and monitor the environment; and
- There will be new business models and new product offerings that must be supported.

HOW WILL NFV IMPACT JOBS?



Source: Ashton, Metzler & Associates

"Jobs will require new skills and more knowledge of software, and there will be a new, unknown set of customer demands."

Addressing the challenges

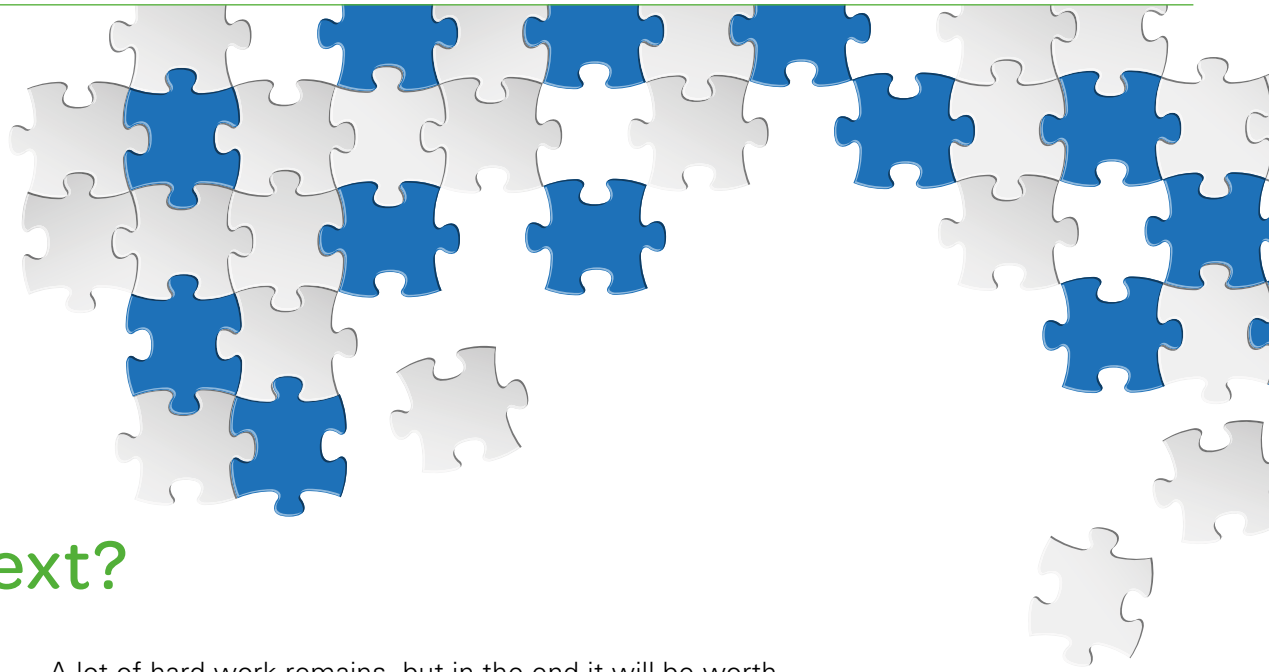
The network operations team's use and enhancement of DevOps practices and automated processes will impact the activities and organizational structure of the entire service-delivery chain. For example, changing the focus of service-development activities from code generation to VNF chaining via configuration will require significant structural changes for existing development groups. In addition, many network organizations are adopting the DevOps practice of removing middle line managers in favor of setting up self-organizing teams with end-to-end responsibility for a specific feature.

Another significant organizational challenge is the need to support the rollout of network services that partially depend on VNFs hosted by partners. This requires organizations to be able to integrate and synchronize NetOps processes across the boundaries between administrative domains. For this to be feasible, new standards and best practices will be needed to share responsibilities and exchange data between the automated systems of multiple partners.

Since current DevOps practices do not address enterprise development synchronization, there clearly is a need for best practices and standards for the exchange of product and service definitions, lifecycle state and other development and operations metadata. The Forum's work on the Digital Services Reference Architecture, the Software-enabled Services Management Solution and the B2B2X Partnering Accelerator provide a starting point for addressing these challenges, and potential solutions using these best practices have been demonstrated in the Catalysts discussed in Chapter 3 (see page 12).

The ZOOM team is incorporating the lessons learned from the Catalysts in the next iterations of Frameworx, which will help service providers make a successful transition to DevOps-based network operations.

> "Best practices will be needed to share responsibilities between automated systems of multiple partners."



CHAPTER 6

What should you do next?

Hopefully this primer has helped you understand the opportunities and challenges associated with adopting a modified DevOps approach to network operations. The benefits of adopting such an approach are compelling: lower costs and increased agility, including the ability to implement new services in days rather than weeks or months. Unfortunately, the challenges are significant and include extending existing information models, adopting new tools, implementing new operational and organizational models, and in some instances, changing a company's culture.

TM Forum's ZOOM team has done a significant amount of work already, creating best practices and experiences, crafting blueprints for operational models, extending the information model, modifying the DSRA and demonstrating practical solutions through the Catalyst program.

A lot of hard work remains, but in the end 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 necessary changes to end-to-end management, check out the first and second eBooks in this series. You can find them here. You can also find more detailed information about DevOps and more information about ZOOM here.

Finally, get involved! Don't be content to wait for virtualization technology to mature – 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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