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OPEN NETWORKING SURVEY REPORT

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“WITH COLLABORATION ACROSS THE TELECOM ECOSYSTEM, REAL PROGRESS IS BEING MADE, WITH THE FOUNDATION FOR EVEN GREATER ACHIEVEMENTS BEING BUILT EVERY DAY. WE ARE DELIGHTED TO SHARE THIS STORY OF CHANGE, GROWTH AND OPPORTUNITY AND LOOK FORWARD TO CONTINUING THE DISCUSSION.”

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CSPs are increasingly virtualizing and cloudifying their networks and automating their operations, and open networking solutions play a key role in those transformations. This global study of CSPs provides insights into numerous dimensions of open networking, including performance, automation, cloud-native principles, big data and analytics, MANO and SDN.

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Some CSPs worried early on that open networking wouldn't provide the performance they were accustomed to. Many have since deployed open networking solutions themselves and discovered they had nothing to fear.

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Introduction

Light Reading/Heavy Reading and Linux Foundation Networking are very excited to present the results of a study we executed in collaboration with our sponsors.

We joined forces to deliver a multi-faceted look at the open networking technologies and solutions that will help telecom and cloud service providers transform their networks to achieve greater agility and flexibility.

The survey covered the hottest open networking topics in the industry: open networking performance, automation, cloud-native architectures, big data and analytics, software-defined networking (SDN) and management and orchestration (MANO).

Heavy Reading worked closely with the project's sponsors to develop a survey to glean insightful, intelligent and meaningful information. In late August 2018, email invitations were sent to contacts in the Light Reading database. After culling disqualified and incomplete entries, we tallied 150 valid responses from nearly 100 different

communications service providers (CSPs) worldwide.

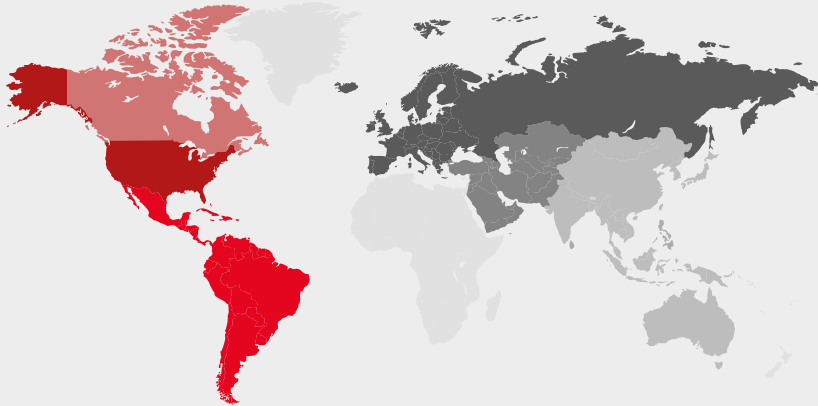
The largest group of respondents, 48%, work for converged CSPs – those with both fixed and mobile networks. Mobile CSPs made up a quarter of the sample, while wireline and cable/satellite operators made up 22%. The remainder of the sample came from other CSPs like wholesalers and submarine cable operators.

A little more than half of respondents, 57%, came from North America. Relatively equal portions came from Europe and Asia/Pacific – 17% for the former, and 14% for the latter. Respondents from Central/South America comprised 8% of the sample, and those from Middle East/Africa represented 4%.

Respondents worked at companies large and small. Just over a third, 36%, came

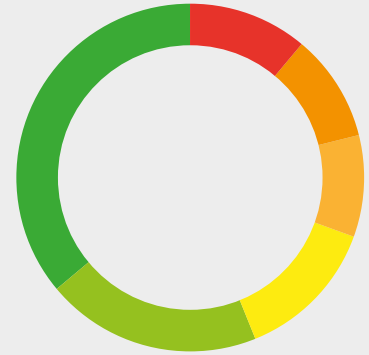
Profile of Survey Respondents

Where is your company located?



U.S.	49.3%
Canada	7.3%
Central / South America (including Mexico & the Caribbean).....	8.0%
Europe.....	17.3%
Middle East/Africa.....	4.0%
Asia/Pacific (including Australia).....	14.0%

What is your company's annual revenue?



● Less than \$50 million	11.3%
● \$50 million to \$200 million.....	10.0%
● \$200 million to \$500 million.....	9.3%
● \$500 million to \$1 billion.....	13.3%
● \$1 billion to \$5 billion.....	20.0%
● More than \$5 billion	36.0%

from the largest CSPs – those with more than \$5 billion in annual revenue. Another 20% came from companies with more than \$1 billion in revenue. Nearly that same amount, 21%, came from smaller companies with less than \$200 million in revenue and 23% were mid-sized, with revenues of \$200 million to \$1 billion.

Primarily, survey respondents worked in technical roles. Nearly a quarter came from engineering, and almost as many, 20%, came from network design and planning. 19% worked in network operations and 11% came from R&D. Some did come from more business-oriented roles: 6% worked in product management and 5% in sales and marketing. 11% worked in corporate management, which could be on the technical or business side of the house. The remainder came from a mix of functions, including architect and procurement.

The picture painted by the survey results is largely positive, with CSPs showing an unexpected level of sophistication around new technologies and approaches. A good number have already made great strides in evolving their technologies and processes by adopting open networking solutions in numerous domains, and actively automating processes across their operations. Despite legitimate concerns about integrating new technology and changing mindsets, many CSPs are boldly seizing the opportunity to transform every aspect of their business through virtualization, automation, big data analytics, cloud-native principles, MANO and SDN. With collaboration across the telecom ecosystem, real progress is being made, with the foundation for even greater achievements being built every day. We are delighted to share this story of change, growth and opportunity and look forward to continuing the discussion. ■

“THE PICTURE PAINTED BY THE SURVEY RESULTS IS LARGELY POSITIVE, WITH CSPS SHOWING AN UNEXPECTED LEVEL OF SOPHISTICATION AROUND NEW TECHNOLOGIES AND APPROACHES.”



OPEN NETWORKING PERFORMANCE

Concerns about performance emerged early in the move toward virtualization. Moving from purpose-built boxes to standard servers made some doubt that applications would perform as well with the new approach. Numerous acceleration techniques – both hardware- and software-based – are now available to help assuage those concerns. Today, those concerns have been somewhat minimized, although there remains some question as to where in the network CSPs will be comfortable deploying disaggregated open networking solutions. This section of the report discusses CSPs' perception of performance in the context of open networking, deployment plans, awareness of acceleration techniques and lingering concerns.

KEY TAKEAWAYS:



73% of CSPs say they are “extremely” or “mostly” confident that open networking solutions can achieve the same level of performance as traditional networking solutions.



59% of CSPs are currently using open networking solutions to achieve high performance, and 84% of those that are not, plan to do so within the next three years. CSPs will deploy open networking solutions to varying degrees in every domain.



Technology immaturity is CSPs' biggest concern regarding deploying open networking solutions to improve network performance, with 46% of respondents indicating as such. The next closest concern, at 23%, was performance itself.



Three-quarters of CSP respondents say that cost savings are the expected outcome of deploying open networking solutions. Just under half, 48%, say that they would consider open networking if it is at least price-competitive with traditional networking solutions.

Performance Is Less of a Worry for CSPs

Open networking is attractive to CSPs for the same reasons it is attractive to the hyperscalers who have widely deployed it in their data centers – agility, flexibility and programmability lead the list. However, CSPs who have been accustomed to purpose-built appliances and network elements initially suspected that running network functions on standard server platforms might not give them the performance they require.

Our survey shows that performance concerns have largely subsided since the early days of virtualization. 16% of CSPs say they are “extremely confident” that open networking solutions can achieve the same levels of performance as traditional networking solutions, and 57% say they are “mostly confident.” Another quarter say they are “somewhat confident.” Only 2% say they have no confidence that these solutions will provide the requisite performance.

Perhaps this finding is informed by the fact that more than half of CSPs, 59%, currently use open networking solutions to achieve high performance. 51% of these respondents are using open source solutions in both their production and internal networks; nearly a third, 31%, are using them only for internal networks carrying IT workloads. It seems reasonable to expect that many of these CSPs will, in time, start to use open networking solutions to carry customer traffic as well, as they build confidence in their capabilities. The remaining 18% of CSPs are using open networking solutions in production networks carrying customer traffic.

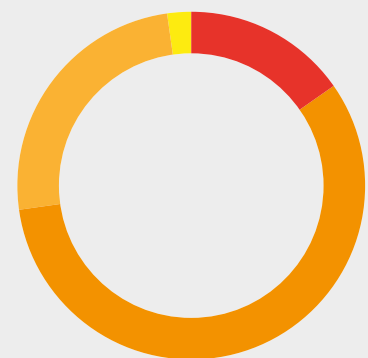
Encouragingly, of the 41% of CSPs not currently using open networking solutions, 29% say they are “very likely” to do so within the next three years, and 55% say they are “somewhat likely” to do so. It

is unclear whether their reluctance is due to not having a pressing business need to adopt open networking, or because they have concerns about the technology.

If it is the latter, they would not be alone. Our survey shows that the most significant concern across those currently using and those not using open networking solutions is the maturity of the technology itself, with 46% of respondents indicating this. It obviously hasn’t kept CSPs from deploying the technology, and presumably with more users, the pace of innovation will accelerate and others will gain confidence from the positive experience of early adopters. 23% of respondents said that performance was the biggest concern, showing that while improved, the perception that open networking isn’t always suitable remains. Total cost of ownership (TCO) was a distant third, with 13% of respondents citing it. As will be seen in other results, CSPs expect open networking solutions to provide a cost benefit, so TCO rightly rates as a relatively low concern. Support for open networking solutions was cited by only 11% of CSPs, which suggests that the possibility of using new suppliers isn’t an issue. Interestingly, only 4% cited contributor immaturity as a concern, reflecting confidence in the capabilities of those driving the open networking ecosystem.

In addition to the attributes noted above, CSPs expect to achieve numerous outcomes by deploying open networking solutions. The most commonly cited benefit is cost savings, chosen by 75% of respondents. The cost savings from open networking come both from lower capex by using high-volume servers, as well as from reduced opex from automation. >

How confident are you that open networking solutions can achieve the same level of performance as traditional networking solutions?



Extremely confident.....	15.5%
Mostly confident.....	57.4%
Somewhat confident.....	25.0%
Not confident at all.....	2.0%

Does your company currently use open networking solutions to achieve high performance?



The next most commonly cited benefit, at 69%, was “freedom from vendor lock-in,” which is usually code for “more pricing power” for the CSP. 58% of respondents cited “quicker innovation” as an outcome of deploying open networking solutions, which becomes possible when they are no longer beholden to a single vendor’s development cycle.

Given the concerns noted above, it was somewhat surprising to see that CSPs are largely planning to deploy these solutions across the different network domains. 58% said they expect to deploy open networking solutions in the access layer, 53% in the edge layer, 46% on the customer premises and 43% in the aggregation and core layer. Each of these domains has different performance, availability and scale requirements. Open networking solutions are deemed suitable for all, which is encouraging.

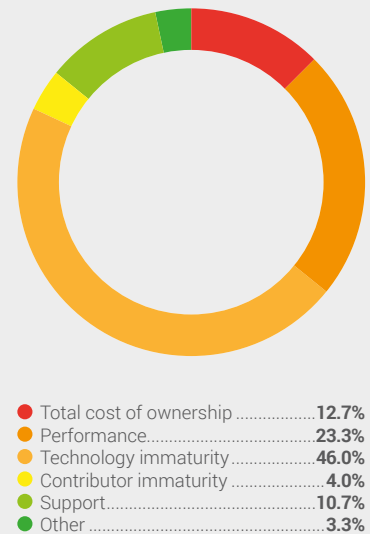
Looking at use cases, though, reveals more variability. Respondents were asked to rate the importance of

performance for five use cases. The only two that saw more than 50% say performance is critical were firewall, at 63%, and routing, at 53%. Intrusion detection came in just under, at 47%. Load balancing had 28% and traffic inspection only 20%. It should be noted that for all use cases, performance was said to be at least marginally important at least 99% of the time.

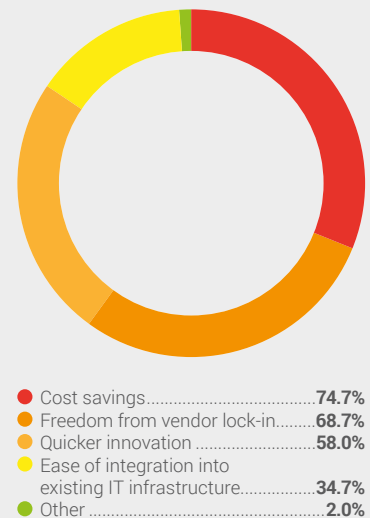
Multiple technologies and techniques are available to help improve the performance of open networking solutions. The survey showed that most remain under the radar of most CSPs, which is not terribly surprising given that these sorts of technology decisions are typically made by the solution providers. The only technology that more than half of respondents were familiar with was containers, with 56%. 40% were familiar with YANG data modeling. Around a third were familiar with Data Plane Development Kit (DPDK), Free Range Routing (FRR), RESTCONF, SmartNICs and Vector Packet Processing (VPP). Only 21% were familiar with PCI Passthrough/SR-IOV.

Nearly half of respondents indicated that their company would consider an open networking solution “if it is at least price-competitive to purchase and operate because of the freedom and flexibility that open source solutions provide” – a somewhat surprising finding, given that cost savings were the most important outcome. Accordingly, the next highest rating, 29%, was for companies that “would only consider open networking if it is significantly less expensive to purchase (capex) and operate (opex).” Less than 10% indicated that they would only consider open networking if it was cheaper in terms of capex or opex, or that they didn’t have “any cost expectations regarding open networking.” ■

What is your company's biggest concern regarding deploying open networking solutions to improve network performance?



Which of the following outcomes does your company expect to achieve by deploying open networking solutions? (choose all that apply)





Opening the Way to High Performance

The standing joke with software development has been "Good, cheap, fast – pick any two." That has certainly been the case with carrier-class, high-performance networking. No more. Open networking technology is changing the game. Telecom and cloud service providers can have all three – while at the same time transforming their networks to achieve greater agility and flexibility.

As an example, who would have thought it possible to see a 100 Gbit/s software router running on commercial-off-the-shelf (COTS) hardware just a few years ago? And why does it matter? Service providers are under constant pressure to provide greater bandwidth at lower latency under increasingly demanding traffic conditions – especially owing to modern application design and encrypted transport.

But are service providers ready to exploit the power of open networking for the most demanding consumer and business subscriber applications? How aware are they of the latest packet processing advancements? Do they believe it is commercially viable? Are we ready for a wholesale shift from proprietary to open-source infrastructure? If not, what's holding us back?

These questions were designed to provide insight. Here is what we learned.

Service providers are highly confident that open source networking solutions can deliver on high performance. Performance

and acceleration gains are needed at every layer of service provider architecture – from the customer premises to the network core. In fact, most are already using open networking technologies to address high-performance networking requirements – for production and internal networking needs.

But there remains work to be done. The biggest impediment to faster adoption of open networking solutions is not performance, but rather technology immaturity. And that could be rooted in a lack of use-case familiarity, confidence in testing and verification, or the fact that many high-performance open networking projects are still relatively new.

Nonetheless, the appeal of high-performance, open-source networking solutions vs. closed-source, vendor proprietary alternatives is irresistible. Respondents point directly to cost savings, freedom from vendor lock-in, faster innovation, and ease of integration into existing IT infrastructure as the driving forces for adoption. And this is true across networking (routing, load balancing, traffic inspection) and security (firewall, IDS/IPS, traffic inspection) functions.

It is also clear that familiarity with core building blocks for a pervasive open networking infrastructure is not high across the board. While technologies related to containerization are recognized by more than 50% of the respondents, data plane and orchestration terms (e.g., VPP, FRR, DPDK, RESTCONF and SmartNICs) are significantly less well-known.

Perhaps the most interesting finding of all is that while cost savings is usually the obvious pull for open-source adoption, that isn't necessarily the case with high-performance networking and acceleration. Almost half of the respondents said they would consider high-performance open networking if it is at least price-competitive with mainstream proprietary alternatives – given the freedom and flexibility it affords.

These are exciting times for open networking initiatives across the board for service provider adoption. As technology awareness and maturity continue to make headway, service providers are positioned to enjoy "good, cheap, and fast."

"SERVICE PROVIDERS ARE HIGHLY CONFIDENT THAT OPEN SOURCE NETWORKING SOLUTIONS CAN DELIVER ON HIGH PERFORMANCE."



AUTOMATION

Automating operations is critical to CSPs' goal of improving efficiency and lowering opex. Disaggregated open networking solutions more easily integrate with automation tools such as Ansible, and are therefore an important element in CSP transformation. Methodologies like DevOps, where the same team is responsible for the development and ongoing support for applications, and Continuous Integration/Continuous Development (CI/CD) will also play a role, as technology alone will not be sufficient if the processes around them don't change as well. While virtualizing network functions is a critical first step in CSP transformation, the true benefit will come when their lifecycle is automated. Containers and PaaS platforms loom on the horizon as additional tools to further CSPs' automation goals.

KEY TAKEAWAYS:



88% of CSPs are engaging with or evaluating some aspect of DevOps, and 77% believe it is "essential" or "important" to the long-term success of service delivery at their company.



The most commonly cited benefits of adopting DevOps are "faster application and service deployment" and "lower cost of operations." The two biggest barriers are "risk of service disruption" and "internal culture."



47% of CSPs have adopted Infrastructure-as-Code (IaC) for at least some projects, but 18% have no plans to adopt IaC at all. 32% have automated configuration management, and 31% are considering it. 38% have adopted CI/CD, while 14% have no plans to do so. 42% have adopted Kubernetes/OpenShift to some degree, while 24% have no plans to do so.



More than three-quarters of CSPs, 78%, agree to some extent that "automating operations using open source tools and validating them for interoperability with open source APIs and control planes is strategic and helps us control our own destiny."

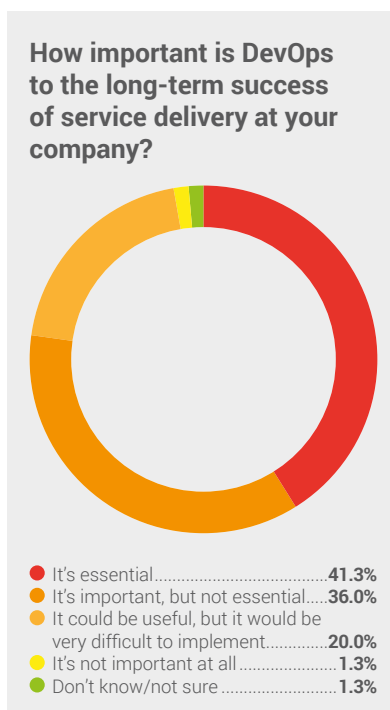
Somewhere on the Horizon

CSPs on their transformation journeys point to automation as their ultimate destination. They know that to fully benefit from their cloud infrastructure and improve their operational efficiency – or even stand a chance of managing their 5G/IoT infrastructure – they must automate. Knowing this, though, doesn't always translate to doing. The survey showed that while most CSPs are aware and understand the benefits of automation technologies, fewer have actually taken the plunge and deployed them.

When asked about their company's current level of engagement with DevOps, a plurality, 31%, said they are "working on automating our testing/development environment." The next-largest segment, 22%, said they are "evaluating various DevOps tool chains and methodologies, but are unsure when and how to roll out." However, combining the two options that capture active engagement with DevOps shows that a fair percentage, 36%, are either pushing "multiple small changes to production every day using automated tools and validation" (19%) or "building CI/CD pipelines internally to continuously integrate and build code from multiple sources" (17%). 11% haven't started adopting DevOps, and only 1% say they have no plans to adopt DevOps at all.

Even with that mixed implementation status, the vast majority of respondents recognize the importance of DevOps. 41% say DevOps is "essential" to the long-term success of service delivery at their company, and 36% say "it's important, but not essential." Another 20% say "it could be useful, but it would be very difficult to implement," while only 1% say "it's not important at all."

Respondents were asked what the top two expected benefits/outcomes of adopting DevOps are. The leading choice was "faster



application and service deployment," followed by "lower cost of operations." CSPs clearly understand what DevOps methodologies are designed to accomplish. The third-ranked outcome was "respond to changing conditions more quickly," which contributes to lowering opex. "Improve customer experience" ranked a distant

fourth, while "attract the best talent" and "improve control over development" barely registered – suggesting that CSPs' are thinking about the near-term impact rather than long-term.

Not surprisingly, respondents said the biggest barrier to adopting DevOps at their company is "risk of service disruption." "Internal culture" came in only a couple points lower. The changes DevOps entails are wide-reaching, including changing mindsets, so CSPs are right to highlight this potential challenge. Somewhat surprisingly, though, "lack of understanding of DevOps processes" came in third – surprising in that DevOps is a relatively new practice, especially within telecom. The next barrier, "transforming the skills/talents of the teams" is another side of that coin. CSPs weren't too concerned about inertia or the time it might take to implement DevOps.

Moving to Infrastructure as Code (IaC) reveals even less adoption than DevOps. 20% of respondents say they "have adopted IaC for some projects and it is going well," and another 22% say they "are having challenges expanding to other parts of our business." A small segment of early adopters reports they have deployed "IaC across the organization." >

What are the top two expected benefits/outcomes of adopting DevOps?

Faster application and service deployment	Lower cost of operations	Respond to changing conditions more quickly	Improve customer experience	Attract the best talent	Improve control over development
SCORE: 149	SCORE: 120	SCORE: 94	SCORE: 53	SCORE: 15	SCORE: 14

What are the two biggest barriers to adopting DevOps at your company?

Risk of service disruption	Internal culture	Lack of understanding of DevOps processes	Transforming the skills / talents of teams	Inertia	Time to implement
SCORE: 104	SCORE: 102	SCORE: 85	SCORE: 78	SCORE: 37	SCORE: 36

More common, though, are the 35% who say they are considering IaC. Unlike with DevOps, fully 18% say they have no plans to adopt IaC.

CSPs are somewhat farther along with automating network management. 9% automate “network elements across the organization,” and 53% have adopted automation for some projects. 31% say they are considering adopting network automation, and only 6% say they have no plans to adopt it.

Adoption of CI/CD comes in a little behind DevOps, but ahead of IaC and automated network management. 11% of respondents say they have already adopted CI/CD (and IaC) for infrastructure software and virtualized network functions (VNFs.) Just more than a quarter, 27%, have adopted CI/CD for application workloads, and another 25% are considering it for those workloads. 23% are considering CI/CD for infrastructure services, network functions and application workloads, while 14% have no plans to adopt CI/CD.

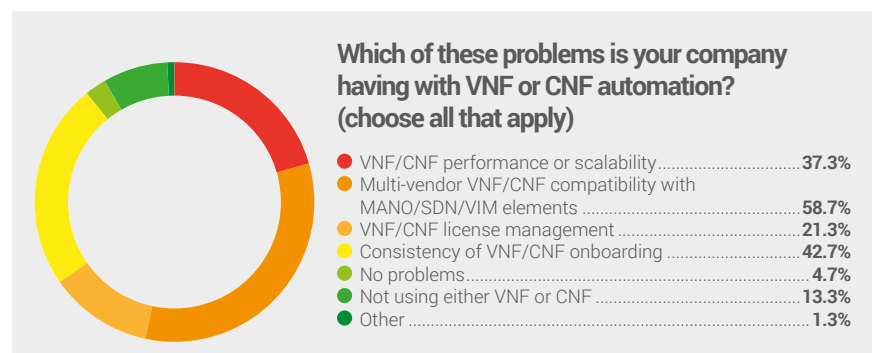
Given that it is still very early days for containers – and few network functions have been containerized – it’s no surprise

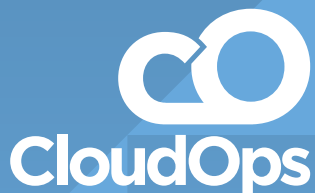
that adoption of Kubernetes/OpenShift is low. Only 5% of CSPs are running IT and network function workloads in production, while 24% are running only IT workloads there. A plurality, 34%, are considering it, and 24% have no plans to do so. 13% have adopted it in development and test environments and plan to use in production.

CSPs want to automate the deployment and management of VNFs and containerized network functions (CNFs), but face a number of problems doing so – many of which have to do with the functions and infrastructure elements rather than the automation tools themselves. 59% of respondents cited

“multi-vendor VNF/CNF compatibility with MANO/SDN/VIM elements,” and 43% cited “consistency of VNF/CNF onboarding.” VNF/CNF performance and license management were also noted. Happily, 5% reported no problems with automating VNFs/CNFs.

To get a feel for how important open source is for automation, CSPs were asked their level of agreement with this statement: “Automating operations using open source tools and validating them for interoperability with open source APIs and control planes is strategic and helps us control our own destiny.” Most agreed, with 28% agreeing strongly and 50% agreeing somewhat. 19% were neutral, and only 3% disagreed. ■





Tackling Operational Challenges With DevOps & Automation

Although not new in concept, DevOps is becoming a popular topic today, as a key means of scaling capacity and creating agility in the new era of virtualization and cloud services delivery. With 77% of respondents seeing DevOps as either essential (41%) or important (36%) to the long-term success of service delivery at their company, it is unsurprising to see the focus of CSPs shift from whether to adopt this approach to the more operational elements of how and when to best roll it out.

The automation of processes is critical to operational excellence. To achieve this, operations need to become something developers solve in code, instead of an afterthought to be figured out by a team of sysadmins. DevOps team practices, wherein operational success is owned jointly by application developers and platform operators, have become the new standard. As this Heavy Reading survey highlights, automation will be the key to accelerating application and cloud service delivery, lowering opex and ultimately helping end users to achieve their compliance and performance objectives.

Beyond the hype, it's clear that end users are still in the early stages of figuring out how to operationalize and support Kubernetes in production. This survey indicates that nearly 50% of end users are either considering adopting Kubernetes/OpenShift or have already begun proofs of concept and are planning to use it in

production. The exponential growth of Kubernetes has placed a strain on the technical skills available and needed to support not only the initial deployment, but the ability to use, automate and operate the platform over time. To help meet these needs, the Cloud Native Computing Foundation has launched the Kubernetes Training Program (KTP) to provide training for organizations. As one of 12 KTP partners in the world and a member of Linux Foundation Networking, CloudOps works with the international community to realize and promote the value of Kubernetes for automated delivery of applications and network services.

Furthermore, the vast majority of end users (78.5% of survey respondents) agree with the importance and strategic value in avoiding vendor lock-in and owning their destiny through the adoption of open source tools, APIs and software. When working well, open source communities help improve transparency and scale, allowing participants to derive amazing value while owning their destiny. For example, Bell Canada has made significant investments in containerizing the Open Network Automation Platform (ONAP) by co-developing the operations manager with the goal of improving efficiency and reducing the size and complexity when deploying the core components of ONAP.

CloudOps' investments in OpenStack, CloudStack, Terraform, Docker, Kubernetes, OpenShift, Ansible and a variety of other open source communities

have been key to building value for our customers, and we plan on continuing to build upon this reputation as a leader in delivering solutions that leverage open source where appropriate.

"THE AUTOMATION OF PROCESSES IS CRITICAL TO OPERATIONAL EXCELLENCE. TO ACHIEVE THIS, OPERATIONS NEED TO BECOME SOMETHING DEVELOPERS SOLVE IN CODE, INSTEAD OF AN AFTERTHOUGHT TO BE FIGURED OUT BY A TEAM OF SYSADMINS."



BIG DATA AND ANALYTICS

CSPs are awash in data. Their consumer and enterprise customers generate thousands of terabytes of data every day, a flood that is only going to increase with the digitalization of the global economy. CSPs know they are sitting on a treasure trove, with so many networks and systems generating data 24/7, but struggle to make sense of it all. Big data and analytics systems offer the promise of turning data into information that can help CSPs make better business decisions. Artificial intelligence (AI) will likely drive the most powerful innovation in this domain, as humans cannot possibly process data at the scale and pace needed to maximize its value.

KEY TAKEAWAYS:



By an enormous margin, the two most important drivers for big data initiatives at CSPs are **revenue maximization and improving customer experience and loyalty**. CSPs are most likely to deploy big data on-premises.



Over the next 2 years, 60% of CSPs plan to use big data and analytics for proactive customer care, 46% for predictive network and service assurance and network/resource optimization and 45% for customer profitability analysis and forecasting and capacity planning.



74% of CSPs use network and applications data as a source of data, 52% use OSS systems, and 45% use BSS systems. Most often the data is near-real time, but could be as old as a month.



The most important criteria in selecting a big data and analytics platform are scalability, price and performance, but for AI/ML solutions, they are scalability, reliability and security. CSPs say network optimization and customer experience management are the most important domains to apply AI/ML.

The Search for Those Golden Nuggets

CSPs have long been the owners of customer usage and network traffic data. What's changed recently is the sheer volume of it. High-speed networks have unleashed a tsunami of data that CSPs know they should mine for nuggets of gold. They recognize that this data holds the key to improving network performance and higher customer satisfaction. The challenge is how to harness it in a way that is consumable and actionable – in real time, ideally.

"IT IS NO SURPRISE THAT THE MOST COMMONLY CITED AREA TO DEPLOY BIG DATA AND ANALYTICS SOLUTIONS OVER THE NEXT 2 YEARS IS PROACTIVE CUSTOMER CARE."

CSPs indicated in our survey that revenue maximization and improving customer experience and loyalty are, by a wide margin, the two biggest drivers for big data initiatives at their companies – with scores of 115 and 113, respectively. Ensuring the latter will go a long way to achieving the former. The next closest driver, "growth driver/new business opportunities," scored 76. There's a similar gap to the fourth biggest driver, "improve planning and strategizing," which scored 50. As with the first two drivers, improving planning and strategizing should uncover new business opportunities. Capex, opex and churn reduction were the remaining drivers, with scores of 42, 31 and 14, respectively. It should be noted that churn reduction should be a byproduct of improved customer experience and loyalty.

Given the drivers above, it is no surprise that the most commonly cited area to deploy big data and analytics

solutions over the next 2 years is proactive customer care, with 60% of respondents selecting it. CSPs clearly believe that getting to a customer before he or she experiences an issue is the best way to improve customer satisfaction and presumably reduce churn. The next most commonly cited areas (tied for second place at 46%) are "predictive network and service assurance" and "network/resources optimization." Both of these will help CSPs achieve their goal of improving the customer experience. Tied for fourth, at 45%, are "customer profitability analysis" and "forecast and capacity planning." The former result is interesting, as it is not directly tied to improving the customer's satisfaction, but rather the CSPs' shareholders.

With a weighted score of 220, on-premises was by a huge margin the most commonly cited location for CSPs to deploy big data and analytics platforms. >

What are the two biggest drivers for big data initiatives in your company?

Revenue maximization	Improve customer experience and loyalty	Growth driver/new business opportunities	Improve planning & strategizing	Capex reduction	Opex reduction	Churn reduction
SCORE: 115	SCORE: 113	SCORE: 76	SCORE: 50	SCORE: 42	SCORE: 31	SCORE: 14

In which of the following areas does your company plan to use big data and analytics over the next two years? (choose all that apply)

Proactive customer care **60.4%**



Improve revenue assurance & minimize fraud in real time **41.6%**



Dynamic profiling and enhanced customer segmentation **42.3%**



Customer profitability analysis **45.0%**



Location-based services & personalized advertising **31.5%**



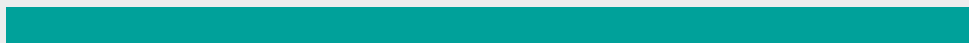
Churn prediction & social network analytics **37.6%**



Network dynamic congestion control **34.9%**



Predictive network and service assurance **45.6%**



Network/Resources optimization **45.6%**



Marketing **33.6%**



Forecasting & capacity planning **45.0%**



"THE AGE OF DATA USED BY BIG DATA AND ANALYTICS SYSTEMS CAN RANGE FROM REAL-TIME TO MONTHS OLD. **SOME DATA IS MORE VALUABLE IN REAL TIME, BUT TRENDS ARE BEST DETERMINED BY COMPARING DATA OVER TIME.**"

This shouldn't come as a surprise, given that most of the sources of data reside on-premises. The next most cited areas, the edge and private cloud, scored only 165 – which was still a decent amount ahead of the fourth-most common area – “SaaS-based system either in public or private cloud,” which had a score of 120. Hybrid cloud came in just behind, at 118. Public cloud came in last, at only 71. Taken together, these results suggest that CSPs will deploy big data and analytics systems in a similar manner as their traditional OSS and BSS.

The least surprising result in this section is that 74% of CSPs use network and application data as a source for their

big data initiatives. As the owners of the network, CSPs can glean insights that others in the value chain cannot. Their traditional OSS and BSS systems are the next most commonly cited sources, with 52% and 45% respectively. While virtualization is an inexorable trend, the physical network and the systems managing them will remain an important part of CSPs' operations for the foreseeable future – and indeed is where the valuable network and application data is stored. Less commonly used are data mediation platforms, with 39%, and less still is DPI (which comes as a bit of a surprise). Social networks, the most recent addition, are used as a data source by only 28% of CSPs.

The age of data used by big data and analytics systems can range from real-time to months old. Some data is more valuable in real time, but trends are best determined by comparing data over time, so accordingly, CSPs use data of all ages – and in almost equal measure. The highest percentage for any age of data was 49% for near-real time (a few minutes' lag). Day-old and month-old data were next, each with 45%, followed by week-old data at 44%. Hour-old data came in at 38%, while real-time was last at 33%. As will be seen later in this section, real-time data capture is not a huge priority for CSPs at the moment. >

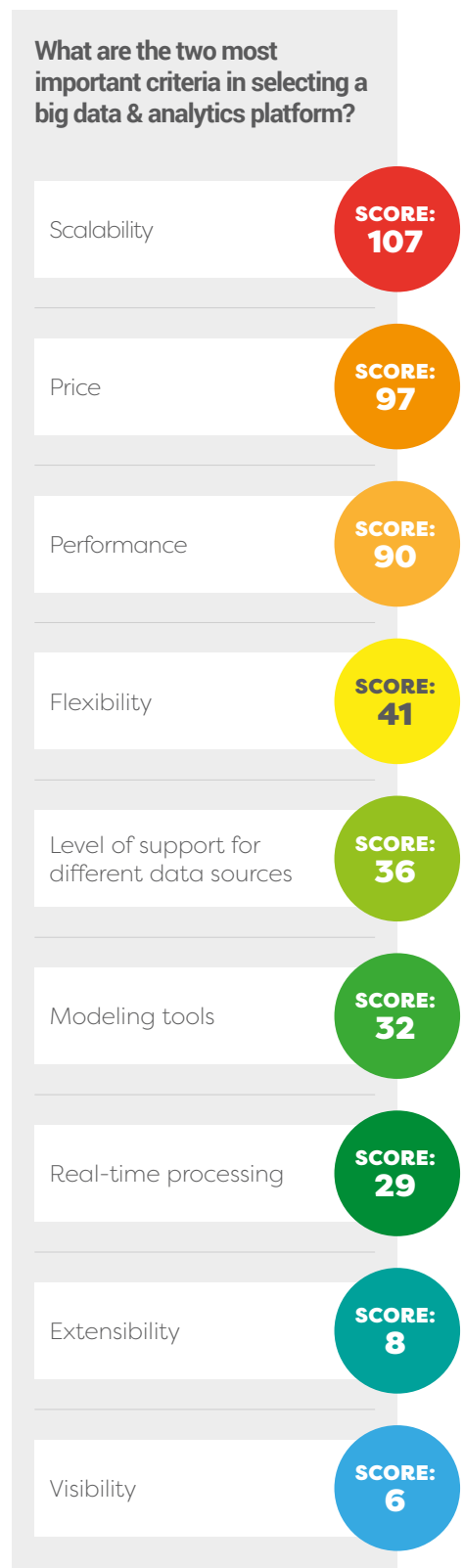
REFLECTING THE IMPORTANCE GIVEN TO PERFORMANCE WHEN EVALUATING BIG DATA PLATFORMS, THIS WAS THE HIGHEST RATED FACTOR WHEN EVALUATING SUPPLIERS, WITH 84% SAYING IT IS CRITICAL OR VERY IMPORTANT."

CSPs were asked what the two most important criteria are when selecting a big data and analytics platform, and the results are unusually stark. Scalability, with a score of 107, price, with a score of 97, and performance, with a score of 90, are clearly the most important criteria. The next highest score was for flexibility, which only rated 41. As mentioned above, CSPs expect the enormous amounts of data they are dealing with to only increase over time, making it paramount that their big data platforms scale accordingly – but also at a price that CSPs can handle. Scoring 36 was “level of support for different data sources,” which seems fitting, given that CSPs are currently only using a handful of data sources. Real-time processing scored only 29, perhaps an acknowledgement that CSPs have a limited ability to react to real-time events – a situation AI and machine learning (ML) may help to address.

In terms of AI and ML, CSPs see them as important for multiple domains, with all five domains in the survey being considered at least somewhat important for more than 90% of respondents. The domain receiving the highest number of votes for “very important” was network optimization. This seems fitting, given the millions of data points that could be considered at any given point in time, and could have the most significant impact on network quality and customer experience. In fact, 60% of CSPs also said “customer experience management” was a very important domain for AI/ML. This, however, refers to the myriad factors (including, but not exclusively, network quality) that impact a customer’s perceived experience. Both of these results are consistent with the finding that improving customer experience and loyalty is a big driver for big data. Network configuration, assurance and planning are other domains in which AI and ML will play important roles.

CSPs also indicated their top three criteria for open source versions of AI/ML solutions. As with big data and analytics platforms, scalability was the number one criteria – this time with a score of 166. (It should be noted that the list of criteria offered was not the same for AI/ML as for big data/analytics.) Reliability was next, at 144, which may reflect the important role that AI/ML systems will have in processing real-time data. Next were security and flexibility, with scores of 108 and 101, respectively. Security always rates highly for any system in a telecom environment, while the need for flexibility captures the potential for more variable data sources to be leveraged in the future. The next two attributes, integration costs and multi-vendor API, with scores of 85 and 81, are in the mid-point of responses, and reflect the fact that CSPs will rarely be deploying these systems in a greenfield environment.

CSPs were also asked to rate the factors they use when evaluating suppliers of big data and analytics solutions. Reflecting the importance given to performance when evaluating big data platforms, this was the highest rated factor when evaluating suppliers, with 84% saying it is critical or very important. Another platform attribute, “availability of data sources” was next, with 82% saying this is critical or very important – somewhat surprising, given that the level of support for different data sources rated only in the middle of criteria when asked about the platform. The next most common factors were more specific to the suppliers. Their integration and customization of use cases capabilities were third and fifth, with pricing coming in between them. These are all consistent with the attributes considered important for the platform. ■





ERICSSON

The advent of 5G, over-the-top (OTT) players, open source and network transformation that has already started will bring new innovations, disruptive business models and new use cases for all industries. Automation, leveraging policy and AI/ML, is critical to introduce and manage new services, resources and complex networks. As networks expand, automation will help to deliver services faster, continuously optimize networks, run efficient networks at scale and thus increase profitability. Virtualization, SDN, orchestration, adaptive policy and AI/ML will play a vital role in achieving the desired automation. AI/ML-influenced policy decisions, along with orchestration across modern and legacy networks, is needed to deliver end-to-end automation.

As our recent survey shows, operational efficiency improvement will continue to be an important driver for AI/ML-driven big data analytics and closed-loop automation for hybrid (virtual + physical) networks. However, revenue maximization and improving customer experience will also drive big data analytics initiatives and investments in the next two years.

As both modern and legacy networks will coexist for the foreseeable future, it is vital that data is collected and correlated across the existing and modern networks. Existing networks can be physical network function (PNF), probes, NMS, EMS, OSS and BSS systems. Modern networks can be virtual network function (VNF), cloud-native function (CNF), microservices, SDN and serverless. Various types of data from different sources at different velocities

will be collected. Our survey clearly shows that data from probes (physical and virtual), data mediation platforms and OSS systems are being increasingly analyzed to proactively find and fix service degradation issues before customers perceive an impact. Such data is also used for enhancing network capacity planning and optimization. In addition, data from DPI and BSS systems is used to enhance customer segmentation and customer value analysis. Also, as part of automation, AI/ML along with policy will be used in the areas of network configuration, planning, optimization and assurance.

Our survey also indicates that much of the data used in analytics today is slow data – near-real time/daily/weekly/monthly. However, as networks move to 5G, edge cloud becomes more important, as many services will require low latency and high bandwidth. Consequently, data will be collected and analyzed at the edge of the network, as well as at centralized big data platforms. Real-time data and the use of AI/ML will be critical for effective service assurance, network planning and optimization of hybrid network.

With data privacy concerns at the forefront, along with strong data regulations such as GDPR, our survey shows that many service providers prefer on-premises or private cloud deployments, with public cloud least preferable. As edge cloud is gaining increasing attention, service providers indicate that some part of the big data systems will be at the edge. Many service providers seem interested in exploring the SaaS model as well. Price-

performance ratio, scalability and ease of integration with third parties are the top three criteria for evaluating analytics vendors. Service providers are increasingly looking for open-source solutions for their cost-effectiveness and availability of a vibrant ecosystem. Scalability, reliability and security are the top three criteria for selecting open-source solutions.

Our survey indicates that the biggest drivers for big data initiatives are revenue maximization, customer experience/loyalty and new business opportunities. Ericsson believes that by automating the networks with AI/ML-influenced policy decisions, operators can achieve significant gains in investment and increase revenues by delivering services faster and introducing new services to the market.

"AS BOTH MODERN AND LEGACY NETWORKS WILL COEXIST FOR THE FORESEEABLE FUTURE, IT IS VITAL THAT DATA IS COLLECTED AND CORRELATED ACROSS THE EXISTING AND MODERN NETWORKS."



CLOUD-NATIVE

“Cloud-native” is a term that encompasses a range of ideas. It incorporates a mindset of extreme automation, DevOps and CI/CD processes, and stateless applications built using microservices. The hyperscalers are the most notable practitioners, but increasingly, CSPs are looking at becoming more cloud-native as part of their transformation journey. Virtualization, the first step on the path to cloud-native, certainly offers some benefits, but it’s the operational efficiencies gained with a fully automated, cloudified infrastructure that CSPs ultimately hope to achieve. The business models around network functions and the open networking solutions that compose part of the infrastructure they run on will also change, since they will be delivered as software rather than bundled with hardware. CSPs can deploy their own clouds or leverage a public one. Either way, going cloud-native will be a major undertaking requiring changes for everyone in the value-chain – but to the benefit of all.



KEY TAKEAWAYS:



34% of CSPs believe the biggest benefit of cloud-native architectures is more hardware abstraction and potentially eliminating proprietary VNF managers. Just under a third say the biggest benefit is because it shortens time to develop and deploy new applications.



50% of CSPs say they will use both public and private clouds to support cloud-native VNFs. Just over a third say they will only use a private cloud, and only 5% say they will use only a public cloud. A third plan to use Kubernetes to manage containerized network functions (CNFs), but 40% say they aren’t sure if they will or not.



CSPs expect to license VNFs/CNFs using a variety of models, with most, 68%, saying that the need to attribute investment/budgets as capex instead of opex is the biggest barrier to using subscription pricing models.



Complexity is the biggest potential barrier to managing and orchestrating VNFs, with upgrades in virtualized environments rating as an important factor. Auto-healing and microservices architectures are viewed as critical attributes for cloud-native VNFs.



Cloud and the Art of Abstraction

Cloud-native describes most of what CSPs and their suppliers want to achieve with their technology, processes and architectures. Containers, Kubernetes, DevOps and CI/CD, stateless, microservices-based applications – all are part of a cloud-native approach that, when fully implemented with automation tools, can provide a flexible, scalable and highly efficient operational environment.

What's not to love? Well, the fact that everything changes, including how products are sold, consumed and managed, makes going cloud-native more than a notion. Getting from where they are to where they want to be means a heavy lift for CSPs and the rest of the open networking ecosystem.

34% of CSPs indicated that the biggest benefit of cloud-native architectures is that containers and container orchestration provide more hardware abstraction, and have the promise to eliminate proprietary VNF managers. CSPs are loath to recreate the vendor lock-in of the physical world in the virtual one. Around a third of CSPs said that shortening the time to develop and deploy new applications is the biggest benefit. The broader concept of "hyperscale" received the third-most votes for biggest benefit, cited by 14% of respondents. 13% selected "highest application and geo-resiliency," which is, in a way, a function of being "hyperscale." Recognizing the flexibility and consistency cloud-native architectures can provide, 10% said "can be deployed anywhere" was the biggest benefit.

Half of CSPs surveyed said they intend to support cloud-native VNFs on both public and private clouds. Different workloads have different needs, so leveraging a diversity of clouds seems a reasonable approach. Just over a third said they would use only their own private cloud, while only 5% said they would use only a public cloud. Some prefer to maintain control over everything, while

others don't want the hassle of managing more than the applications themselves. 11% of CSPs said they weren't sure which cloud(s) they would use.

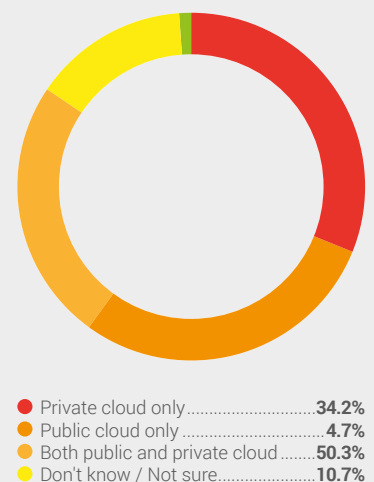
A plurality of CSPs, 45%, said they expect their network function vendors to bring in both the VNFs/CNFs and platform-as-a-service (PaaS) components. This would give them the most flexibility in terms of which cloud to run the functions on. 21% indicated they plan to build the PaaS on top of existing NFV infrastructure (NFV-I) and expect vendors to bring only the network functions. 10% said they will adopt a PaaS offering such as OpenShift rather than build their own from scratch. Reflecting the newness of this cloud-native approach, 25% of CSPs said they haven't decided on their plans for NFV-I and PaaS.

CSPs indicated their concern around a number of aspects to achieving high availability of NFV-I. The most significant challenge is that "stateful applications require more planning and operational complexity for redundancy and geo-redundancy," cited as a "major challenge" by 32% of respondents and garnering the highest weighted score. The next most significant challenge is "recreate PNF availability architecture of N+1, or at best N+M)," cited by 29% of respondents as a "major challenge." The other option in the survey, "affinity to hardware like same server, CPU pinning, etc.," was less of a perceived challenge, but still rated as a "moderate challenge" by 56% of respondents.

On a similar note, CSPs were asked about

the importance of different factors for achieving faster upgrades in virtualized environments. "No easy roll-back upon failures" was cited by 38% of respondents as a critical factor, just ahead of "full software upgrades required for small incremental patch releases," which was cited by 36% of CSPs as being critical. The next highest rated factor was "required planning and cooperation of multiple departments," cited by 34% of CSPs as being critical. Notably the first two factors are in the domain of the VNF and NFV-I suppliers – which re-emphasizes the earlier points that going cloud-native will take work from everyone in the ecosystem, not just the CSPs. >

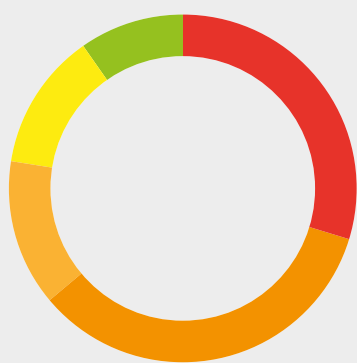
On which cloud type will your company support cloud-native VNFs?



Despite all of the current hype around Kubernetes, only a third of CSPs said they plan to use Kubernetes to orchestrate their CNFs. 12% said they plan to use a different container orchestrator, and 14% merely said they wouldn't use Kubernetes. A full 40% said they weren't sure if they would use it, which again reflects the relative newness of containers in the telecom environment.

Cloud-native virtualized functions have numerous attributes that CSPs value. Auto-healing was cited by 36% of CSPs as being of critical importance, and received the second-highest weighted score. "Microservices architecture delivered in containers" was deemed critical by 33% of CSPs, and had the highest weighted score. These first two relate to the VNFs themselves, while the next two relate to CSPs' own operations. "Incorporate testing as part of delivery" and "Use of continuous delivery (DevOps principles) for rapid deployment of new code" were cited as

What is the most significant benefit of cloud-native architectures?



- Shortens time to develop and deploy new applications**29.9%**
- Containers and container orchestration provide more hardware abstraction and have the promise to eliminate proprietary VNF managers.....**34.0%**
- Hyperscale.....**13.6%**
- Highest application and geo-resiliency**12.9%**
- Can be deployed anywhere**9.5%**

Please rate the importance of the following attributes of cloud-native virtualized functions.

Microservice architecture delivered in containers

● Critical **32.9%** ● Important **52.4%** ● Marginal **11.9%** ● Not Important **2.8%**

Kubernetes orchestration

● Critical **21.8%** ● Important **46.5%** ● Marginal **26.1%** ● Not Important **5.6%**

Stateless microservices

● Critical **19.3%** ● Important **49.0%** ● Marginal **26.9%** ● Not Important **4.8%**

Rely on service discovery mechanisms for intra-VNF communications

● Critical **16.0%** ● Important **65.3%** ● Marginal **17.4%** ● Not Important **1.4%**

Software in each container must be able to self-initialize

● Critical **25.2%** ● Important **51.7%** ● Marginal **21.0%** ● Not Important **2.1%**

Configuration database is separated and shared across all nodes

● Critical **20.8%** ● Important **58.3%** ● Marginal **20.8%** ● Not Important **0.0%**

Auto-healing

● Critical **35.7%** ● Important **44.1%** ● Marginal **18.9%** ● Not Important **1.4%**

Use of continuous delivery (DevOps principles) for rapid deployment of new code

● Critical **22.1%** ● Important **58.6%** ● Marginal **17.2%** ● Not Important **2.1%**

Incorporate testing as part of delivery

● Critical **26.4%** ● Important **50.0%** ● Marginal **21.5%** ● Not Important **2.1%**

critical by 26% and 22% CSPs respectively, and tied for the third-highest weighted score.

Keeping on the theme of CSPs' operation, CSPs were asked to rate how big a problem various attributes are to the management and orchestration of VNFs. By a wide margin, complexity is seen as the biggest barrier, cited by 51% of respondents as a "big" problem, and generated the highest weighted score. The "need to integrate proprietary VNF managers" was cited by 33% of respondents as a "big" problem and had the second-highest weighted score. 56% said "the need for correlated monitoring of NFV-I and VNFs for closed-loop orchestration" was a "moderate" problem. 61% said the "amount of planning required for VM sizing, VM placement and anti-affinity" was a "moderate" problem.

An area that doesn't get as much press, but is just as important as the technology, is the manner in which CSPs will purchase VNFs/CNFs. A plurality, 38%, expect that they will use both perpetual and subscription licenses. 8% think they will only use perpetual licenses, while 16% think they will use only subscription licenses. 9% think they will use "right to use with limited terms (1-3 years)." More than 20% said they expect to use all of these models, while 6% say they won't use any of them. Just over two-thirds of respondents said that the need to attribute investments/budgets to capex instead of opex would be a barrier to using subscription pricing models. 28% believe there are no barriers to them, while 20% said that network function vendors aren't offering subscription pricing. ■



Telco Journey to Cloud-Native: We Want What They've Got

There's little argument that the ultimate architecture for telecom operators to deliver virtual network functions (VNFs) will be the cloud. But the road to Valhalla is littered with monolithic software, manual processes and purpose-built hardware.

The cloud titans have shown the way, with containerized, open source software stacks that are dynamically orchestrated using automation that allows them to run their vast, white box-based, disaggregated hardware estates with a fraction of the staff the telecom operators use. There's nothing that precludes telecom operators from doing the same.

The mobile operators led the initial wave of virtualization, and with 5G they have shown all indicators that they want to take the next step to the cloud. In order to meet the network demands of 5G, operators need a web-scale infrastructure and dynamically reconfigurable software services similar to what the Amazons and Googles have today to deliver a wide variety of cloud services.

As this Heavy Reading survey highlights, more than 84% said their companies are moving toward a cloud-based approach for VNFs, with 50.3% citing hybrid cloud as their preferred choice, while private cloud is the second most picked option at 34.2%.

There is a greater need for faster, shorter application development and deployment

cycles to gain a greater competitive edge against OTT providers, with more than 64% citing the most important benefits of cloud-native architecture as hardware abstraction achieved through container and container orchestration and reduced time to deploying new applications.

There are two aspects to the cloud-native journey – one is making the network function cloud-native, and the second is to make the underlying cloud richer. Operators have also realized that just VM as a service is not sufficient, and there is a need for a common PaaS layer that provides container as a service, service mesh, logging, monitoring, database as a service that can be leveraged by the cloud-native network functions and thereby increasing the commonality and reducing operational overhead. 44% of the respondents said they would prefer NFV vendors that provided VNF/CNF and PaaS combos, while 25% remain undecided and 21% plan to build PaaS on top of the existing NFVI and expect NFV vendors to provide only the VNFs/CNFs.

Just putting a VNF in a container does not make it cloud-native. Respondents of the survey clearly identified that cloud-native network functions' characteristics are different. 65.3% considered reliability on service discovery mechanisms for intra-VNF communications as the most important attribute for cloud-native functions, followed by both the need for DevOps principles for rapid code deployment, and separation and sharing of configuration database across all nodes at 58%, indicating that the need

for a hyper-scalable, agile and flexible network is more pronounced than before, and can be achieved by moving microservices into Docker containers that can be centrally orchestrated through an open source tool such as Kubernetes.

"THE MOBILE OPERATORS LED THE INITIAL WAVE OF VIRTUALIZATION, AND WITH 5G THEY HAVE SHOWN ALL INDICATORS THAT THEY WANT TO TAKE THE NEXT STEP TO THE CLOUD."



MANO

Management and orchestration (MANO) encompasses the systems responsible for managing virtualized/containerized network functions (VNFs/CNFs), the infrastructure supporting them and the service created out of them. It represents a new approach to management in the same way that open networking represents a new approach to infrastructure – and the two are often deployed as part of the same transformation effort. MANO solutions will need to support multi-vendor environments, and a wide variety of workloads, potentially including IT and public cloud workloads. MANO will also play a crucial role in automating operations, with the open source project Open Networking Automation Platform (ONAP) achieving traction among some of the world's largest CSPs. Artificial intelligence (AI) is poised to make MANO solutions even more impactful in CSPs' operations.

KEY TAKEAWAYS:

-  **CSPs have not coalesced around a single approach to orchestrating different types of workloads.** Almost a third, 32% say they will use separate orchestrators, and nearly as many, 31%, say they haven't decided yet. Only 20% say they will use a single orchestration tool for all workloads.
-  **When asked about MANO pain points broadly, CSPs ranked multi-domain orchestration first** and VNF onboarding a distant second. When asked about VNF lifecycle management specifically, they only rated it the fourth-biggest concern, after scaling up/down, troubleshooting and fulfillment.
-  **CSPs say the most critical functions needed to achieve fully autonomous networks are** service orchestration, big data/analytics and AI – and that self-healing, network configuration and traffic management would benefit most from AI.
-  **The top two use cases driving new MANO deployments are** complex, chained virtualized network services such as SD-WAN and vCPE, and simpler services such as firewall and load balancing. **A plurality of CSPs, 40%, say they are testing an orchestrator for service chaining.**

A Tougher Nut to Crack

CSPs have had a few years to dig into NFV, and are now really digging into the operational issues – in which MANO plays the critical role. While issues around managing the lifecycle of VNFs/CNFs remain, CSPs tended to express more concern around the orchestration part of the puzzle.

Given that this is how they make their money – by creating (and delivering) services – this is to be expected. CSPs have highly complex environments that can include multiple domains and locations, from which they need to deliver highly complex services. Disaggregated open networking solutions add to the management changes MANO systems need to address. CSPs' MANO systems need to make the complex simple, and AI should be able to help.

One of the initial value propositions around NFV was that CSPs could have a single network to support internal IT, VNFs and enterprise cloud workloads. The pendulum has swung back and forth between separate and common infrastructure since. This latest survey shows that more CSPs plan to have a separate orchestrator for each type of workload (32%) than plan to use a common one (20%). Splitting the difference, 17% say they will use one tool for internal IT, and a separate one for VNFs and enterprise cloud workloads. Surprisingly, at this stage of the market's evolution, 31% say they haven't decided on their approach yet.

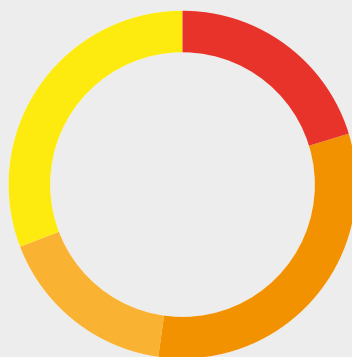
When asked about their biggest pain points regarding MANO, survey respondents ranked multi-domain orchestration highest, with a score of 111 (which represents a weighted score of all responses). The next closest, VNF onboarding had a score of only 75. Reflecting the fact that most CSPs are dealing with brownfield and not greenfield deployments, "integration with BSS and

existing OSS systems" came in third, with a score of 57. Right behind, with a score of 52, was service assurance. Interestingly, "confusion about different approaches to orchestration," rated only a 39 – right around the middle of the pack. The remaining items were operational (e.g., inventory and subscriber management) and weren't seen as particularly painful.

Digging deeper into VNF lifecycle management reveals that onboarding is

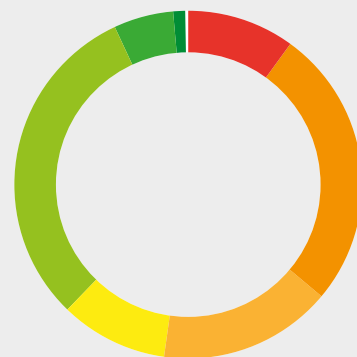
hardly the biggest concern. Rather, 26% cited that scaling up/down is the biggest concern, followed closely by troubleshooting at 24%. 22% of respondents said fulfillment was the biggest concern, edging out onboarding, cited by 21%. Updating VNF was cited by only 7%. The fact that so many of these aspects were cited in relatively equal amounts suggests that all of them are important – which seems appropriate, given that VNF management is at the core of service delivery and CSPs' operational processes. >

How does your company plan to orchestrate its internal IT, VNF, and enterprise cloud workloads?



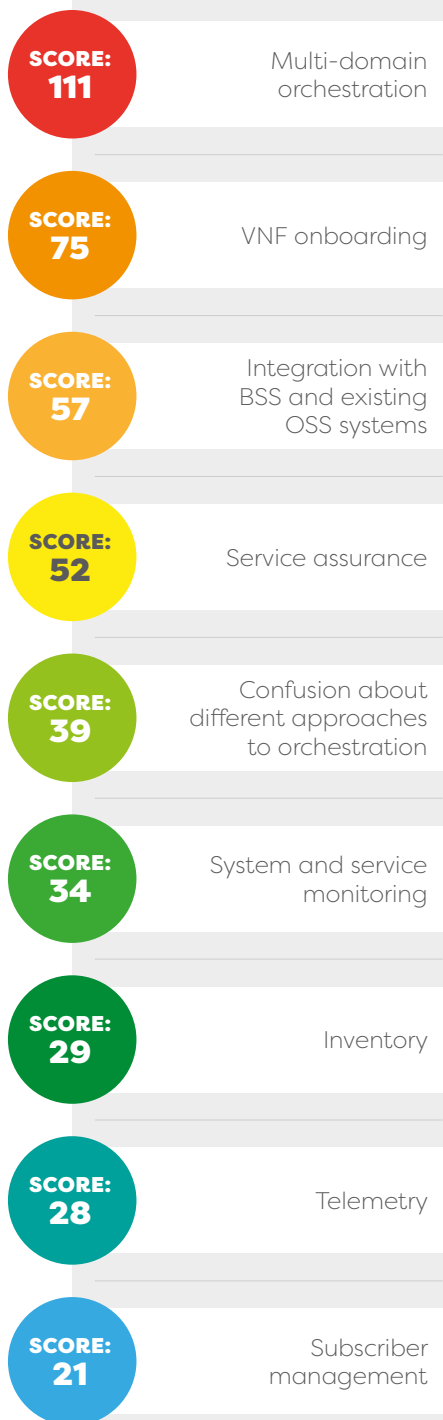
- We will use a single common orchestration tool for all types of workloads **20.4%**
- We will use separate orchestration tools for each type of workload..... **32.0%**
- We will use one orchestration tool for internal IT workloads, and a separate one for VNFs and enterprise cloud workloads..... **17.0%**
- We haven't decided on this yet..... **30.6%**

Which of the following is most critical for achieving fully autonomous network operations?



- Telemetry, probe and monitoring tools **10.1%**
- Big data/Analytics..... **26.2%**
- Artificial intelligence..... **16.1%**
- Machine learning..... **10.1%**
- Service orchestration **30.9%**
- Service design and policy editor **5.4%**
- Other **1.3%**

What are your company's two biggest pain points regarding MANO?



While NFV has been around for more than five years, only recently have many of these operational issues come to the fore, as CSPs move from trials to production.

As mentioned elsewhere in this report, many CSPs see fully autonomous operations as the end point of their transformations. When asked what the most critical function for achieving that was, a plurality, 31%, said service orchestration, further demonstrating the importance to CSPs' businesses. 26% of respondents said that big data/analytics was most critical. Please refer to the Big Data/Analytics section of this report for further detail. AI came in third, with 16% of responses. In a separate question, CSPs indicated that self-healing and closed-loop operation would benefit most from AI, with traffic management and network configuration tied for second.

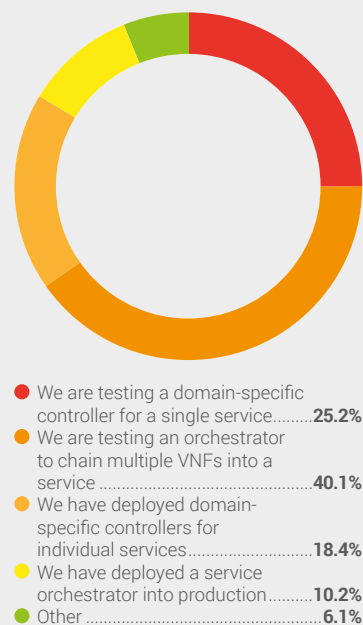
The need for new MANO solutions is being driven by service creation. The use case with the highest score in the survey, 141, was "complex, chained, virtualized network services," with "simple, virtualized network services" next with 111. Full network virtualization transformation came in a distant third, at only 80, with 5G mobile core just behind at 78. This finding re-emphasizes how CSPs are focused on generating revenue with their transformed networks and operations.

Yet another indication of the importance of services is that the most common current use of MANO is to test chaining multiple VNFs into a service, cited by 40% of respondents. 25% said that their company is testing a domain-specific controller for a single service, while 18% have already deployed them. Only 10% say they have deployed a service orchestrator into production. It should be noted that "domain-specific controller" generally refers to SDN controllers. The industry is still figuring out the best way to architect the management of

different domains, with some preferring a hierarchical approach, and other advocating for a flatter architecture.

ONAP and Open Source MANO (OSM) are both open source projects with the goal of creating a multi-vendor MANO stack. ONAP addresses more than just MANO, but the two projects are often considered as peers. In the survey, around a quarter of CSPs, 24%, said they expect the two projects to ultimately merge, while 18% said they will each continue on as separate projects. 16% said ONAP will become the standard and OSM will go away, and 5% said the opposite. 7% said that both projects will go away. Notably, 31% said they don't know or are not sure. CSPs said that their interest in deploying ONAP could come from sandbox/test-bed environment, training, a trial version of software, and professional services support in nearly equal measure. ■

Which of the following best matches your company's current use of MANO?





When it comes to managing and orchestrating the network to meet the needs of the digital world, it's evident that no single approach fits all. There are many different flavors of orchestration and approaches to implementation, as is clear from the results of this survey. However, Amdocs strongly believes that there is a common requirement for a service-driven layer that glues network capabilities to business imperatives to achieve agile service delivery and enhanced customer experience.

Amdocs' experience in the industry indicates that there are three main approaches to network management and orchestration:

- **Domain-specific orchestration** for use cases like vCPE and SD-WAN, involving multiple, multi-vendor VNFs with integration to BSS/OSS and the network, as seen for example in the enterprise SD-WAN deployment at Comcast.
- **End-to-end orchestration** that addresses the challenge of multiple network domains and brings together NFV and SDN. This is the long-term vision for NFV deployment, as seen for example at AT&T and Bell Canada.
- **Intent-driven networking** relies on an abstraction layer that exposes network capabilities for IT to consume as a service. Rather than trying to integrate the network and IT functions, this approach maintains clear boundaries and provides a bridge between the two – IT creates an order of intent that the network delivers.

The network is transforming to cost-effectively fulfill exponentially increasing customer expectations for data speed, latency, security, reliability and time to activate new services. Only virtualized networks with end-to-end, dynamic and adaptive orchestration capabilities and strong automation across both fulfillment and assurance can deliver such promises.

Results from this report highlight the challenges of VNF onboarding and the need for fast, low-cost service chaining and innovation to address the complexities of building new services in a hybrid environment. In our experience, automation cuts the time to onboard VNFs and design, test and launch complex multi-vendor NFV-based services from the typical nine months or more, down to eight weeks or less.

Open source also plays a significant role in network modernization, reducing "cost per bit" and moving the industry away from vendor lock-in. Open source initiatives like ONAP and OSM open the network to a larger ecosystem of NFV/VNF providers, encouraging innovation and reducing prices. For open source solutions to succeed, they rely on the power of a vibrant, active community of contributors. Amdocs believes that there is a need for standardization and interoperability. By joining forces, OSM and ONAP increase the likelihood of success, and Amdocs is therefore taking a leading role in both initiatives.

For service providers looking for a sandbox to test and validate new virtual services,

Amdocs offers a cloud-based, hosted development environment – Amdocs ONAP Discovery Kit. This enables service providers to fast-track PoCs and slash innovation time, and offers a perfect first step toward network virtualization, open source and the service-driven network.

For more information, visit www.amdocs.com.

"RESULTS FROM THIS REPORT HIGHLIGHT THE CHALLENGES OF VNF ONBOARDING AND THE NEED FOR FAST, LOW-COST SERVICE CHAINING AND INNOVATION TO ADDRESS THE COMPLEXITIES OF BUILDING NEW SERVICES IN A HYBRID ENVIRONMENT."



SDN

Software-defined networking (SDN) represents a paradigm shift in how networks are built and operated. Separating the control plane from the data plane paves the way to automation, simplifying service creation and delivery for CSPs. The ability to use Linux-based tools would enable them to use a single management and automation system across the compute, network and storage domains. SDN is not a requirement for NFV, but it is often planned in conjunction with NFV transformation. CSPs also see SDN as playing a key role in extending their data center networks in the wide area network (WAN) and support services like SD-WAN. The networking supplier market is being disrupted by new entrants, and new products from traditional vendors, offering disaggregated open solutions to help CSPs lower both their capex and opex.

KEY TAKEAWAYS:



39% of CSPs report that they have already deployed SDN, and 20% are currently trialing SDN. 44% say that SDN is critical to their NFV data center evolution and will implement SDN and NFV simultaneously. 63% of CSPs said the highest-priority use case for SDN deployment over the next three years is SD-WAN.



Network automation is, by a wide margin, the biggest benefit CSPs hope to achieve with SDN, with a score of 171. The next biggest benefit, faster service delivery, had a score of 106. CSPs' biggest concern about SDN deployment is a lack of skills to integrate SDN and NFV services, which scored 122. The next biggest concern, interoperability, scored 93.



55% of CSPs say their biggest motivation for automating SDN deployment is to increase efficiency and/or consistency when deploying new network devices. The next biggest motivator, with 18% of CSPs selecting it, was compliance.



CSPs are pretty equally divided on their company's strategy for SDN management: 33% say they will use the SDN vendor-provided tool, 32% say they will use OpenStack as the Virtualized Infrastructure Manager (VIM) and 30% say they will use a third-party NFVO.

SD-WAN Takes Center Stage

Networking has always been a complex science, be it in the data center or the WAN. As CSPs virtualize and cloudify their infrastructure, the networking domain is transforming as well.

SDN is now well established in the data center, with the hyperscalers demonstrating to the rest of the world how much more efficient networking can be. Programmability for better control, and automation for faster operations are both achievable with SDN, and CSPs increasingly see it as an important component of their NFV-led transformations.

39% of CSPs in the survey indicated that their company was already deploying SDN. This is slightly behind the pace for NFV according to recent Heavy Reading research, but encouraging nonetheless. Another 20% are trialing it, and 13% are in the proof-of-concept (PoC) stage. Nearly

a quarter, 24% are in the early stages of learning about SDN, and only 5% say they are not thinking about SDN at all.

44% of CSPs say that SDN is “critical to your NFV data center evolution and we will implement SDN and NFV simultaneously.” Not all CSPs agree, however. A third say that “SDN is secondary to our NFV data center evolution and we will implement SDN after NFV,” and 5% say that “SDN is not required for NFV and we will implement NFV without it.” A small group of CSPs, 18%, say that “SDN is a greater priority for our data center than NFV at the moment and we will implement SDN before NFV.” Most, if not all, of the large CSP early adopters of NFV speak about how important SDN is for achieving their NFV goals, so over time the rest of the market may come around to the plurality’s point of view.

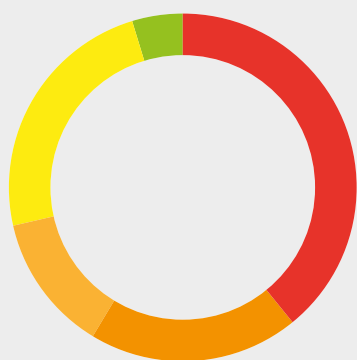
The SDN deployment use case cited as a high priority over the next three years by the highest portion of CSPs, at 63%, was SD-WAN. SD-WAN allows for more cost-efficient access to data center resources by remote and branch offices – essentially extending the data center network across the WAN. OpenStack networking was nearly as high a priority, with 45% saying it is a high priority, and 47% saying it is a medium priority. Related to this, perhaps capturing it in a different way, was “software control of data center connectivity,” which 88% of CSPs said was either a high or medium priority. Bandwidth-on-demand services were cited as a high priority for

43% of CSPs, and 42% cited “portal-based control of enterprise services, apps and connectivity” – the latter of which often includes bandwidth-on-demand services. Interestingly, hardware disaggregation/white box was the least-cited use case, with only 32% saying it is a high priority. Presumably this is because white boxes are the mechanism for delivering the other use cases, so CSPs may not prioritize deploying them outside of those circumstances.

CSPs were asked what the top two benefits their company expects to realize with SDN are. Network automation received the highest score, 171. CSPs clearly recognize the important role SDN can and should play in their overall automation strategy. Faster service delivery was the second-highest scoring benefit, at 106. This can be seen as a function of the first, as automation will allow CSPs to deliver services more quickly. Network programmability, which was the key value proposition of SDN from the outset, came in third, with a score of 91. Better traffic management and improved security and telemetry rated much lower than the other benefits.

CSPs were also asked to identify the two biggest concerns their company has about SDN deployment. The highest-scoring item was “lack of skills to integrate SDN and NFV services,” at 122. As discussed elsewhere in this section, CSPs often consider SDN and NFV together as part of their transformation effort. >

What is the status of SDN deployment at your company?



● Already deploying.....	39.2%
● In trials.....	19.6%
● PoC stage.....	12.8%
● Early stages of learning (pre-PoC).....	23.7%
● Not thinking about SDN.....	4.7%

Interoperability rated 93, which, like many other data points in this survey, reflects the fact that most CSPs are dealing with brownfield environments. The third-highest rated concern, complexity, rated a score of 63. Given that SDN requires such a fundamental change in approach, it is somewhat surprising this rated in the middle of the pack. Security and Cost/ROI rated just behind complexity, with scores of 56. Technology immaturity rated only 38 – a considerably lower level of concern than was seen for open networking itself. Dynamic upgrades rated the lowest, at 21.

CSPs were almost evenly split on the question of how to manage their SDN. 33% said they will use the SDN vendor-provided tool, 32% said they will use OpenStack as a VIM, and 30% said they will use a third-party NFV Orchestrator (NFVO). Only 5% indicated they didn't know or hadn't decided. Having such an even distribution of results is fairly common in the early days of a technology's adoption. As more users gain experience, the market will see which approach or approaches drive the best outcomes.

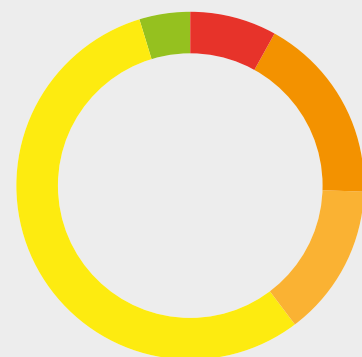
CSPs are also considering using automation to manage the deployment of SDN itself. 55% of respondents indicated that their biggest motivation for doing so is to increase the efficiency and/or consistency when deploying network devices. Indeed, this was one of the first use cases to get traction when SDN was first introduced. 18% said that compliance was the biggest motivator, which can be seen as an outcome from the consistency referenced in the previous motivation. 14% said that control is the biggest motivator, while 5% said increased efficiency when verifying the configuration of network devices – which again, is related to the consistency angle. Only 8% of respondents said they don't plan to automate their SDN deployment.

In addition to SDN controllers, CSPs also leverage automation tools to manage their networks. According to the survey, the most commonly used one is Ansible, with half of CSP respondents indicating their company currently uses it. The next two most commonly used tools are Chef and Puppet, with 30% and 29%, respectively. Saltstack came in fourth, with 23%. 19% of respondents indicated they were using tools from their network equipment suppliers, an internally developed tool, didn't know what their company used, or hadn't decided on an automation tool yet.

As described elsewhere in this report, CSPs are generally comfortable with open source solutions. 32% indicated that it was "very important" that the SDN products their company uses are open source. More than half, 54%, said it was "moderately important." Only 10% – perhaps a bit higher than would have been expected – said it's not important at all. 5% of respondents said that all they need are open APIs. What CSPs really want is easy integration and flexibility, and open APIs are one way to achieve that.

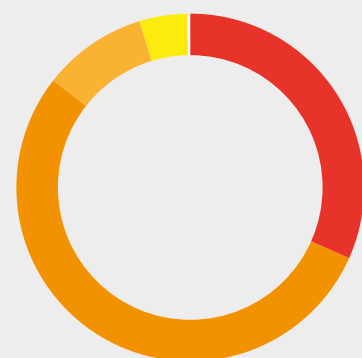
Because open networking is such a departure from traditional networking architectures, new companies have joined the vendor landscape. The incumbents, too, offer open networking solutions, and indeed, may well maintain their leading positions. When asked which vendors their company would consider for an SDN controller, 85% of CSP respondents picked Cisco and 53% picked Juniper. These have long been the leading suppliers of data center and WAN networking for CSPs. Nokia/Nuage and VMware tied for third place, with 45% share – an interesting result, given that one has a heritage in network equipment and the other in enterprise software. Another traditional network equipment provider, Ericsson, came in fourth at 41%. Red Hat and Huawei came in next with 34% and 30%, before a large drop-off for the remaining suppliers. ■

Which of the following best matches your company's current use of MANO?



● We don't plan to automate SDN deployment.....	8.1%
● Compliance.....	17.6%
● Control.....	14.2%
● Increased efficiency and/or consistency when deploying network devices.....	55.4%
● Increased efficiency when verifying the configuration of network devices.....	4.7%

How important is it that the SDN products your company uses are open source?



● Very important.....	31.8%
● Moderately important.....	54.1%
● Not important at all.....	9.5%
● All we need are open APIs.....	4.7%



NFV and SDN continue to be strong drivers of telecommunications service provider network transformation and modernization projects. While the deployment of NFV and SDN are not necessarily in lockstep, they are definitely closely related and often deployed together. The majority of service providers are working to deploy NFV and/or SDN in some capacity, showing that service providers are making good progress toward their stated network modernization and transformation goals. These efforts are also extending outward from the data center to the edge as expected. Service providers are looking for open source NFV and SDN solutions to be the cornerstone for service delivery to residential, enterprise and mobile subscribers.

Another important trend in the industry is the fact that the automation of network provisioning and automation and scale go hand in hand. It is clear that automation has gained popularity among service providers that are using these tools to maintain deployment consistency and compliance with organizational and regulatory requirements. Automation also allows service providers to increase the efficiency of their SDN and NFV deployment projects by automating tasks that are repetitive or require a degree of consistency across devices in the network. They are also using automation to handle onerous tasks such as router configuration and access control list audits. This helps to reduce the time consumed by those tasks, thereby

increasing productivity by liberating resources for use in more relevant activities.

The adoption of open source software and the ability to tap into a more rapid rate of innovation also continue to be of paramount importance in the telecom industry. A majority of SDN controller vendors are basing their product offering on open source technologies, and more specifically, the OpenDaylight Project. Because of this, great progress has been made to accommodate the industry's requirements, and we are now seeing the benefits of open source in production environments.

It is important to note that not all service providers view open source in the same way; some have forked the community code in an effort to control their own destiny, and have incurred significant technical debt while doing so. The cost and risk of maintaining and self-supporting a distribution is high.

Because open source community code is provided "as is," and is not subject to any support or service-level agreements, it is critical for service providers to work with a vendor/partner that understands open source and has worked with open source projects. This will ultimately afford service providers the freedom to focus on their core business, thereby minimizing operational risks and maintenance and maximizing the opportunity to create new revenue streams. Such a partner can leverage a developer community that is far larger and more effective than

any single organization can achieve alone. Partners and ecosystems can act as advocates for service providers by working closely with them to get new code accepted upstream and ultimately integrated into fully supported, production-ready downstream products.

Overall, respondents to this survey have indicated overwhelmingly that they are either beginning or very much underway with NFV/SDN deployments, and it should be expected that this will only increase as SDN software improves. It is likely that NFV and SDN will reach a lockstep state where one will be deployed with the other, due to the necessity of preparing for 5G and other edge-related service delivery projects. Look to major SDN vendors to continue their NFV integration efforts as well as explore new avenues for SDN deployment from the core to the edge.

Your future is open:

Open platforms.

Open collaboration.

Open innovation.

"IT IS IMPORTANT TO NOTE THAT NOT ALL SERVICE PROVIDERS VIEW OPEN SOURCE IN THE SAME WAY."



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