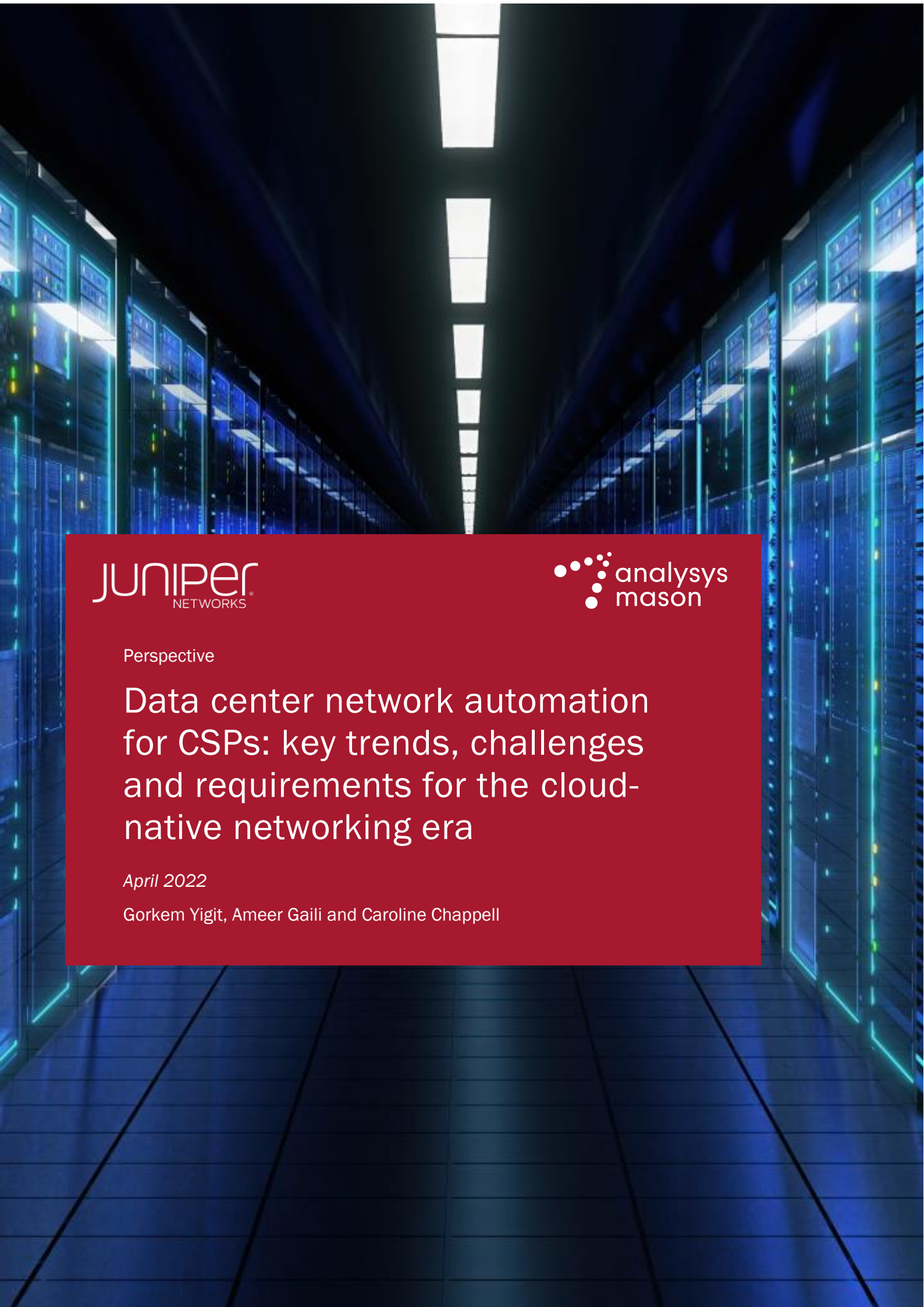

Perspective

Data center network automation for CSPs: key trends, challenges and requirements for the cloud-native networking era

April 2022

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1. Executive summary

Data center (DC) automation is becoming a strategic imperative for all communications service providers (CSPs). This requirement is being driven by the increasing roll-out of both 5G and edge networks, as well as the accelerating shift towards cloud-native 5G network functions and edge applications that will be running across many centralized and distributed data centers. A key objective of this network transformation is to deliver new and more-advanced consumer and industry vertical services, which require an underlying data center network infrastructure and operations that are highly automated, reliable and scalable.

Analysys Mason conducted a survey with 30 Tier-1 CSPs worldwide in 4Q 2021 and carried out in-depth interviews with 5 additional CSPs in 1Q 2022 to understand the current state of data center network automation and to assist with future roadmaps. We examined the key drivers and trends for CSPs' data center strategies, focusing on areas including CSPs' approaches to data center network automation, the main challenges and barriers to network automation, target use cases and the tools that CSPs are using to automate their data center networks. This perspective presents the key findings of this research, which are summarised below.

- **5G, enterprise and edge service opportunities are the main drivers of CSPs' data center strategy, but investment priorities vary significantly by region.** CSPs' data center strategies are shaped around three main areas: new opportunities in the enterprise managed services and connectivity market; network cloudification for 5G; and deployment of new edge computing locations to support both 5G and enterprise and consumer edge services. Most CSPs in North America and Western Europe are reducing and consolidating the number of their traditional data centers as they increasingly move IT workloads to public clouds and SaaS and partner with colocation providers for their data center needs. However, in Asia–Pacific CSPs are investing in new on-premises data center sites and capacity to support their 5G and enterprise service strategies. Some large CSPs in this region are also competing in the data center infrastructure services market and expanding their data center presence across many geographies.

- **Most CSP data centers are not ready for the automation, programmability and agility requirements of 5G, edge and new enterprise service opportunities.** Our research indicates that there is a disconnect in CSPs' thinking between their digital transformation and future service ambitions and the actual focus and investments in data center network automation that is needed to support these goals. CSPs have so far made very limited progress in automating their data center network operations and do not show strong ambitions or urgency to address this area in the near term, which poses a significant risk to their 5G, enterprise and edge service aspirations. In particular, CSPs are struggling to automate their fundamental Day 2+[1] processes such as capacity management, monitoring and assurance, and service provisioning and change. This will cause major obstacles for CSPs when they are expected to meet key service metrics such as time to market, on-demand provisioning and service-level agreements (SLAs), especially for the more-advanced services that they are preparing to launch once their 5G networks and edge data centers are in place.

- **The operational complexity of fragmented data center network technologies and operations is the top barrier to automation.** Serving a wide range of network services and use cases (IT, telco cloud and enterprise) that use a diverse set of vendor- and/or domain-specific siloes makes it difficult for CSPs to

[1] Day 0 automation refers to the design of the data center. Day 1 automation refers to simplifying configuration, testing and verification and deployment with zero-touch provisioning. Day 2+ automation refers to transforming operations in the data center. This includes streamlining network changes, resolving network outages and more.

rationalize and automate their data center networks. CSPs often have to use multiple management and automation software solutions provided to them by a range of hardware and IT vendors, as well as scripting tools (for example, Ansible and Python) and in-house grown solutions. These disparate systems result in high operational complexity, which is the main challenge CSPs associate with their data center network automation technologies. This is especially the case for CSPs that mainly rely on single-vendor automation solutions, which focus only on the operations of their own network elements and/or domains.

- **CSPs are struggling to justify the opex-based business case for automation investments despite the high costs attached to manual operations and in-house development.** Most Day 0, 1, 2+ processes in CSP data centers are highly manual which leads to large operational headcounts and slow, costly and error-prone operations. In addition, we found that in-house automation tooling is prevalent among CSPs, and most CSPs face cost and scalability challenges with their custom DIY automation tools. Yet, many CSPs are finding it difficult to build a strong business case to sign off on new data center automation investments. This is largely because on-premises operations and in-house development costs are actually 'hidden' within the multiple lines of businesses and the shared, entangled engineering, operations and development responsibilities of the data center staff. Most CSPs do not have a clear-cut, granular view of the existing costs and as such they cannot carry out an accurate evaluation of the costs and benefits of new automation solutions and efforts against the status quo.

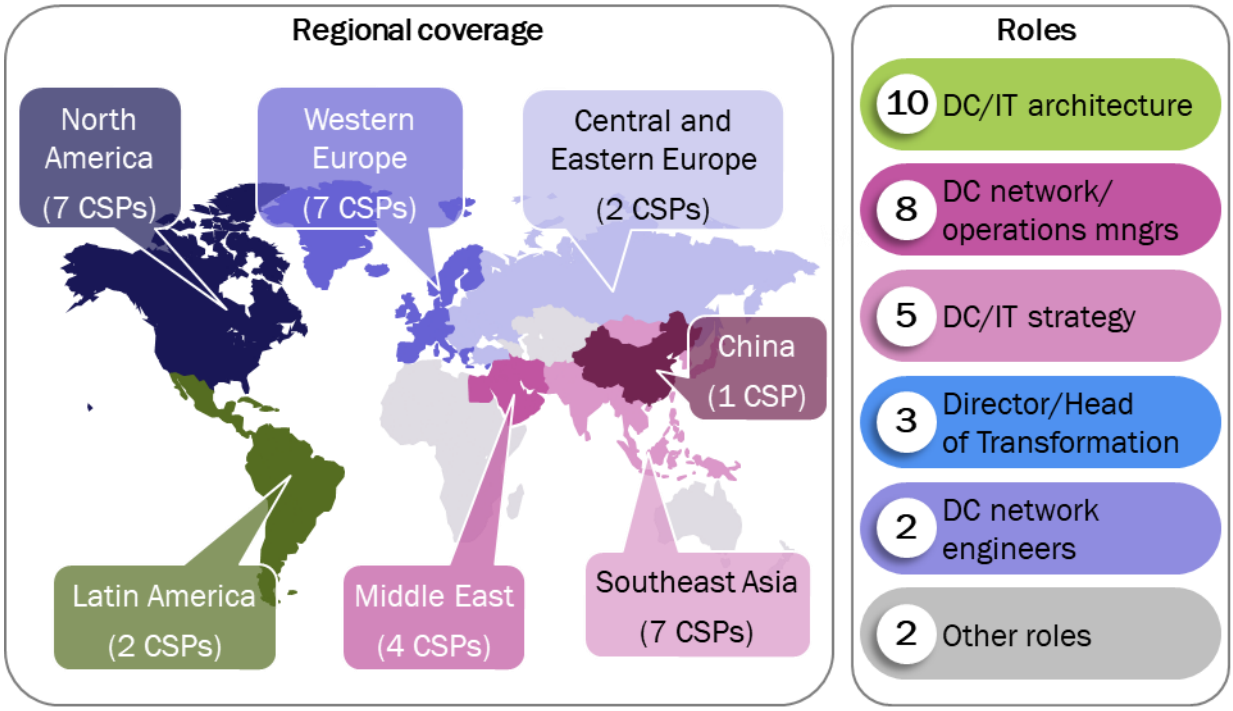
- **The existing organizational structure of CSP data centers, as well as a lack of an automation-driven mindset, means that the progress of data center network automation is inhibited.** Our research shows that the CTO is often the main budget holder, not the CIO. CTOs typically have much greater focus on mobile and fixed networks than on data centers, which may be a factor behind the low priority given to data center automation. In addition, we found that CSPs have an entirely different mindset toward data center networking and automation compared to enterprises and hyperscalers. CSPs are more accustomed to allocating more people as ''human glue' or carrying out expensive custom integrations or implementing ad-hoc tools to solve their operational challenges rather than having an automation-first mindset. In addition, data center staff are highly protective of their jobs and resist automation initiatives for fear of losing jobs to automation. These findings indicate that the tendency to rely on manual processes and in-house tools development is fostered by the CSPs' organizational setup and culture and such issues may be flying under the radar of CTOs.

2. Key drivers and trends influencing CSP data center strategies

Data centers are an integral part of every CSPs' digital and network transformation journey. The new cloud-based 5G and edge networks and advanced enterprise vertical services will be deployed at scale across many data centers, spanning from large, centralized data centers to highly distributed, smaller edge nodes. Data center infrastructure will need to meet the demands of the application placement, on-demand consumption and programmable connectivity of these new networks and services. All this will require highly automated and agile data center networking fabric and operational capabilities, without which CSPs will not be able to deliver a quality customer experience, and even more fundamentally in a cloud-native world, a scalable and reliable network experience.

Analysys Mason conducted a survey with 30 Tier-1 CSPs worldwide[2] (see Figure 2.1) and carried out in-depth interviews with five additional CSPs to understand CSPs' strategies, progress and challenges with regard to data centers and specifically to data center network automation in the context of digital and network transformation. The respondents[3] represented a balanced mix of senior executives that are responsible for data center strategy and transformation, and technical staff such as network architects, engineers and operations managers. This provides a holistic view of the state of CSPs' data center network automation today and their future roadmaps.

Figure 2.1: Number of surveyed CSPs, by region and by role in organisation, 4Q 2021–1Q 2022



Source: Analysys Mason

2.1 5G, enterprise and edge service opportunities are the main drivers of CSPs' data center strategy

Our survey reveals that there are three main drivers of CSPs' data center strategies and investment focus. CSPs are evolving their data center strategies to support:

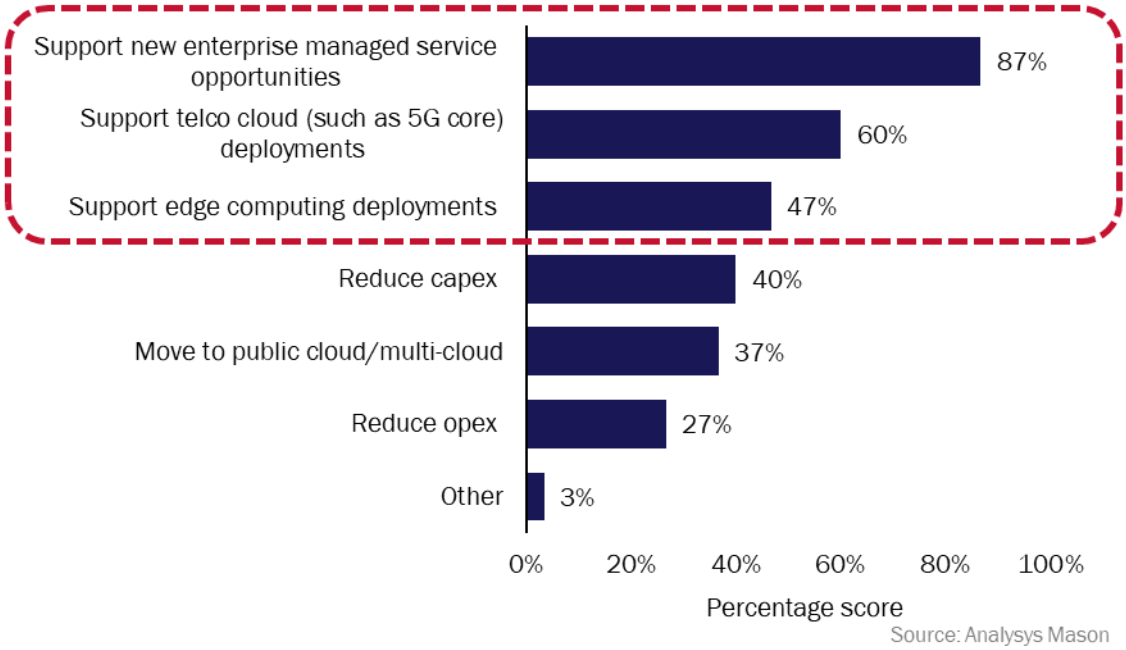
- new opportunities in the enterprise ICT managed services and connectivity market
- network cloudification as part of their 5G roll-outs
- deployment of new edge computing locations (see Figure 2.2).

Operators were surveyed in the following geographies: Central and Eastern Europe (2), China (1), Latin America (2), Middle East (4), North America (7), Southeast Asia (7) and Western Europe (7).

[3] See the annex of this perspective for detailed respondent demographics.

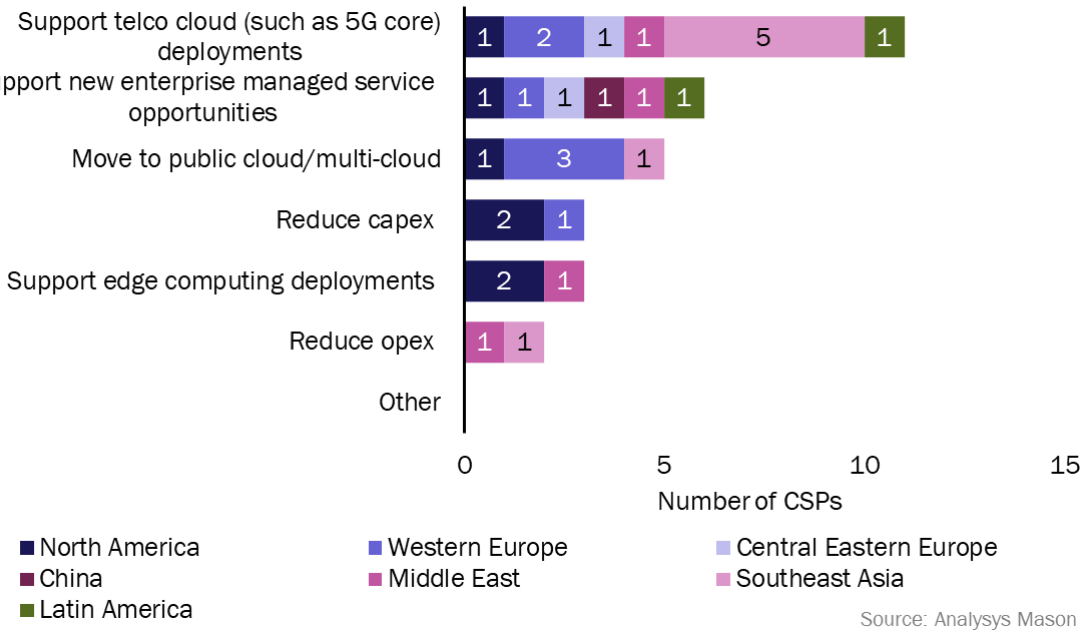
These new technologies and advanced services are interrelated and complementary to each other and require CSPs to invest in state-of-the art, operationally efficient and programmable data centers in order for them to be successful.

Figure 2.2: Top three main drivers of CSP data center strategies, surveyed regions, 4Q 2021



When it comes to the top priority for investing in data centers, most CSPs rank 5G telco cloud deployments as the most-important driver (see Figure 2.2 above). CSPs are increasingly building their 5G networks using cloud-native, disaggregated IT-based software and hardware components. They are beginning their cloud-native transformation with their mobile core networks (5G standalone (SA), evolved packet core (EPC) and IP multimedia subsystems (IMS)) running on centralized data centers. They are gradually expanding into the metro and RAN, where vDU, vCU and distributed core vUPF functions will be deployed in network edge data centers. This finding suggests that CSPs acknowledge the need to modernize and automate their data centers to successfully manage this infrastructure transformation.

Figure 2.3: Main drivers of CSP data center strategies, by region, 4Q 2021

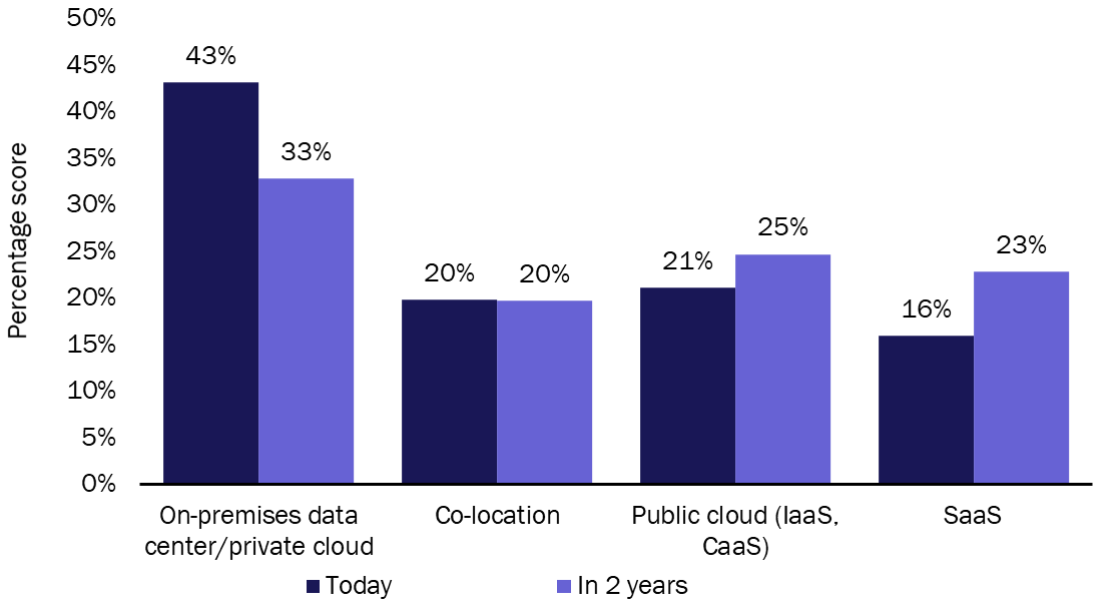


Source: Analysys Mason

2.2 The focus of CSPs' traditional data center investment varies significantly by region and is based on the availability and take-up of public cloud and SaaS

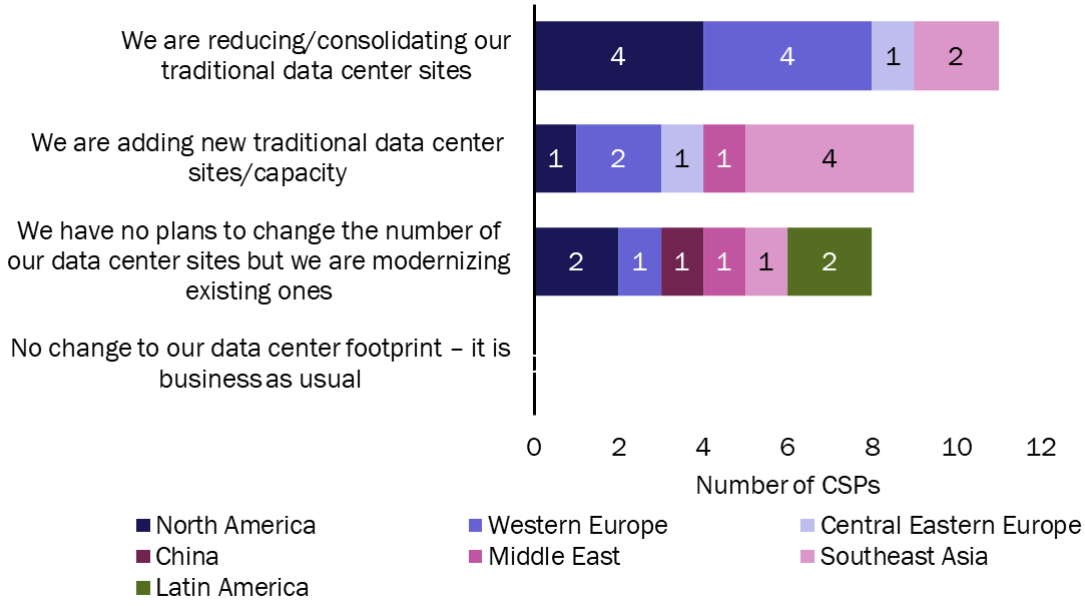
One of the clearest regional variances shown in Figure 2.3 is that the data center agenda of most CSPs in Asia–Pacific is driven by telco cloud, while the main drivers for CSPs from other regions are more evenly spread out. The momentum for deployments of 5G SA core and vRAN/Open RAN in China, Japan and India is strong, which underlines our finding. While CSPs in North America (NA) and Western Europe (WE) are also assertively implementing cloud-based 5G network functions, their main focus on data center investments differs from that of their peers in Asia–Pacific. Figure 2.3 shows that the adoption of public cloud and multi-cloud, capex reduction and (to a lesser extent) edge computing are the top priorities for some CSPs in NA and WE. These drivers are closely connected because many CSPs in these regions are gradually shifting their IT workloads to public clouds and SaaS (see Figure 2.4 below), increasingly using multiple cloud providers at the same time, and reducing the number and size of their on-premises data centers (see also Figure 2.5).

Figure 2.4: The proportion of IT workloads CSPs run on various environments today and in 2 years from survey period, surveyed regions, 4Q 2021



Source: Analysys Mason

Figure 2.5: CSPs' traditional data center footprint plans, by region, 4Q 2021



Source: Analysys Mason

Many CSPs in North America (such as AT&T, Bell Canada, Verizon, T-Mobile) and in Western Europe (BT, DT, Telecom Italia, Telefónica and Vodafone) have divested a large portion of their data center assets over the last decade and they have partnered with carrier-neutral co-location providers such as Cyrus One, Digital Realty, Equinix and others for their data center needs. The number of partnerships between these CSPs and public cloud providers such as AWS, Google Cloud and Microsoft Azure have grown significantly over the past couple of years, most often for multiple aspects of CSPs' IT transformations and, more recently, to support the joint launch of public edge computing services to enterprises. However, our interviews with CSPs have revealed that

the majority regard their remaining data centers as strategic assets and see the ongoing consolidation and rationalization as an opportunity to transform and modernize them.

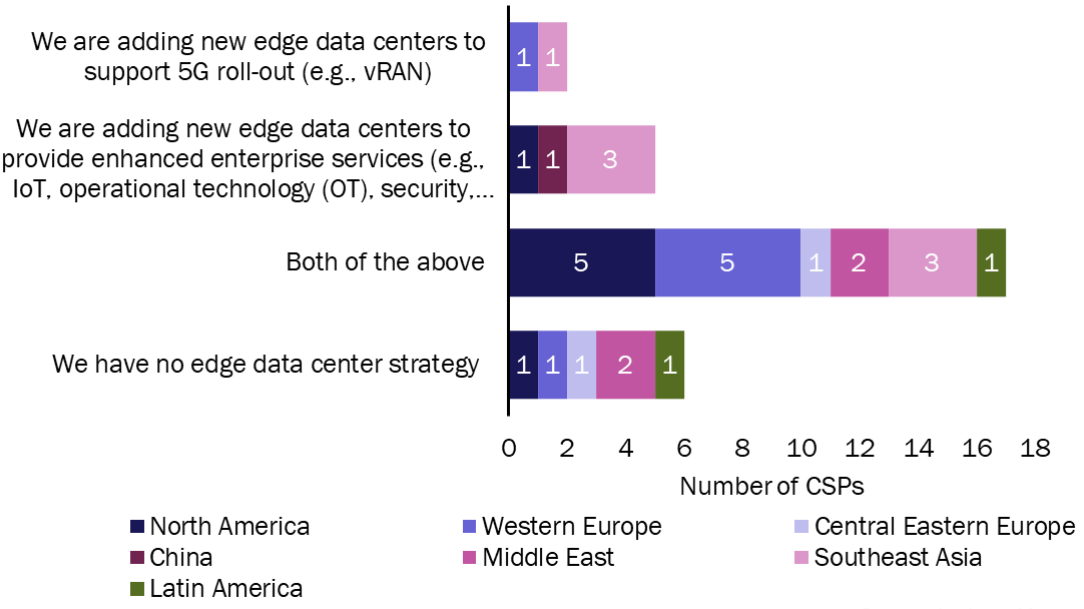
CSPs in APAC have very different data center footprint strategies to those of CSPs in NA and WE, mainly because of a lack of this region's strong historical presence of public cloud providers, high IP transit costs and data localization laws. Many CSPs in APAC are making large investments in growing the number and size of their data centers for their IT and network needs, and some large CSPs such as China Telecom, KDDI and NTT are competing in the data center infrastructure market on a global scale, expanding their data center presence worldwide. Public cloud and SaaS adoption by enterprises and CSPs is also growing in the APAC region. However, public cloud providers are now rapidly expanding their presence and service offerings in new Asian countries, and in some cases, taking advantage of CSPs' strong positions in local enterprise markets to introduce joint offers in partnership with CSPs.

Overall, CSPs' on-premises data centers and private clouds will remain important for supporting their digital transformation and new service ambitions. However, CSPs will need to operate increasingly hybrid infrastructures where IT, network and enterprise applications will be deployed across multiple different data centers and cloud environments.

2.3 CSPs have ambitious plans to roll-out new edge data centers to support new 5G networks and edge computing applications

In contrast to the regional variances in CSPs' strategies for traditional data centers shown in Figure 2.5, our survey shows that many CSPs across all regions are investing in new distributed data centers at the edge (see Figure 2.6). Most CSPs are simultaneously focusing on both enterprise edge clouds to provide new IoT, operational technology (OT), security and enhanced collaboration services and network edge clouds to host 5G functions such as vRAN and Open RAN. However, our research and interviews also indicate that in most CSP organizations, network edge and enterprise edge strategies are executed separately by different business units. Enterprise edge clouds, which are often based on public cloud providers' cloud stacks, are being deployed in regional and metro data centers to serve the immediate needs of enterprises that want to process certain types of data locally for security and regulatory compliance reasons. Network edge clouds, on the other hand, are mainly located in cell sites or near-cell sites to cater to the needs of real-time processing requirements of cloud-based RAN functions. Some advanced CSPs are joining up or planning to join up these different edge strategies and deployments to deliver new enterprise use cases that require near-real-time response and processing in the RAN.

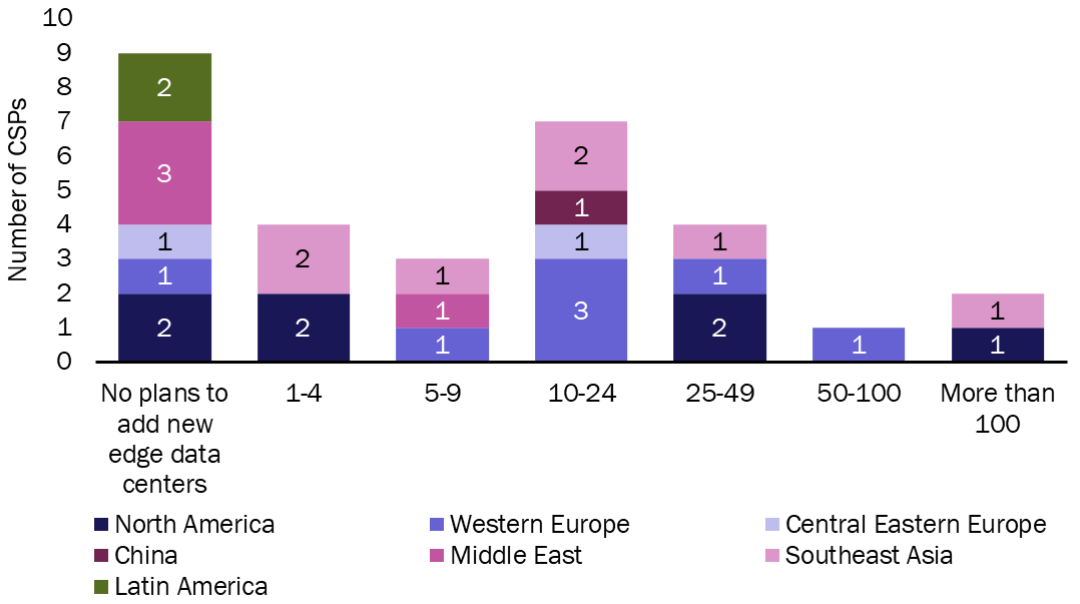
Figure 2.6: Motivations for CSP edge data center investments, by region, 4Q 2021



Source: Analysys Mason

Figure 2.7 (below) shows the number of new edge data centers that CSPs are planning to add by 2023. Most CSPs with an edge strategy are expecting to have between 10 to 24 edge data center locations and several CSPs from NA, WE and APAC have more-aggressive edge roll-out plans with more than 50 or 100 edge locations in the near term. However, based on our general edge computing research, we expect that edge footprints will likely be much bigger in the long term because enterprises will increasingly require a more-distributed, edge-native compute fabric that is available at every conceivable location, leading to potentially hundreds or thousands of edge nodes in a country or region. This will also require a transformation of CSP legacy metro networks to accommodate these trends. Furthermore, this means that the sheer number and scale of centralised and distributed edge data centers will make data center automation and programmability capabilities critical for CSPs that are trying to manage this infrastructure to meet the needs of the different industry vertical use cases.

Figure 2.7: The number of CSP edge data center deployments expected by 2023, by region,4Q 2021



Source: Analysys Mason

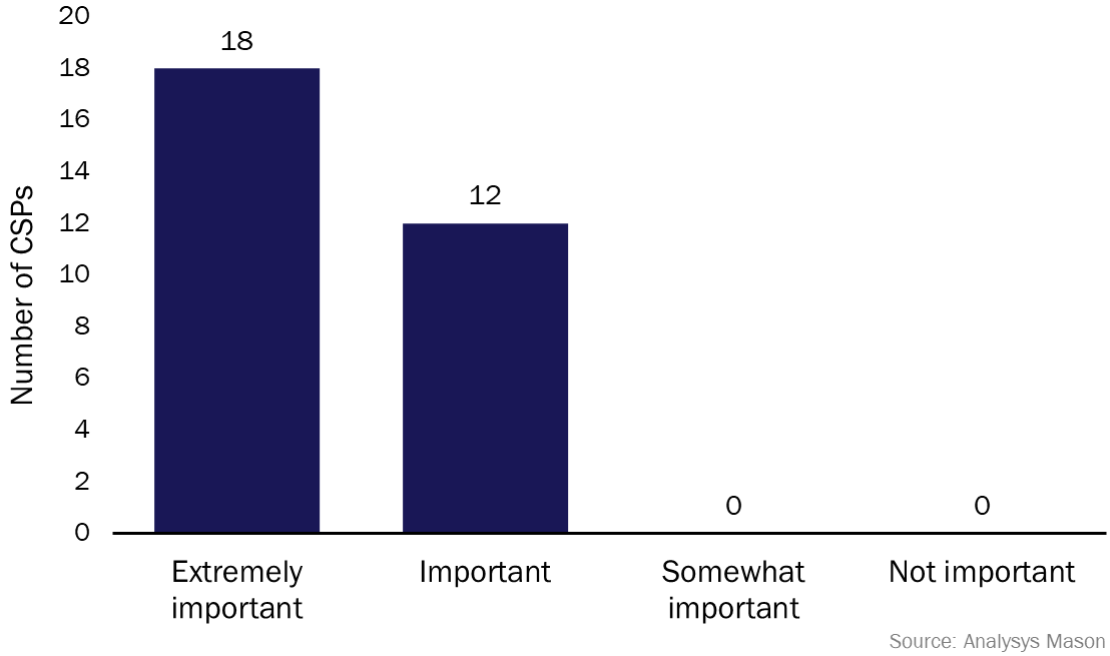
3. The state of CSP data center network automation

3.1 CSPs are aware of the strategic importance of data center network automation but their slow progress and lack of urgency put their 5G and edge ambitions at risk

With the introduction of 5G, network-as-a-service (NaaS) and edge computing services, as well as the accelerated shift of network functions to cloud-native software running in the data center, automation of the data center operations lifecycle is becoming a strategic imperative for CSPs. Data center networks, which consist of underlay switching/routing fabric and an overlay virtualized network such as BGP EVPN, will be at the core of these services and need to keep up with the pace of automation and agility of compute and storage resources enabled by virtualization, containerization and the Kubernetes ecosystem. CSPs need software-defined, highly automated data center network operations (Day 0, 1, 2+) from core networks to edge to reduce manual NetOps processes and errors and to meet the level of service speed, uptime and security required by new cloud-native 5G networks and enterprise services.

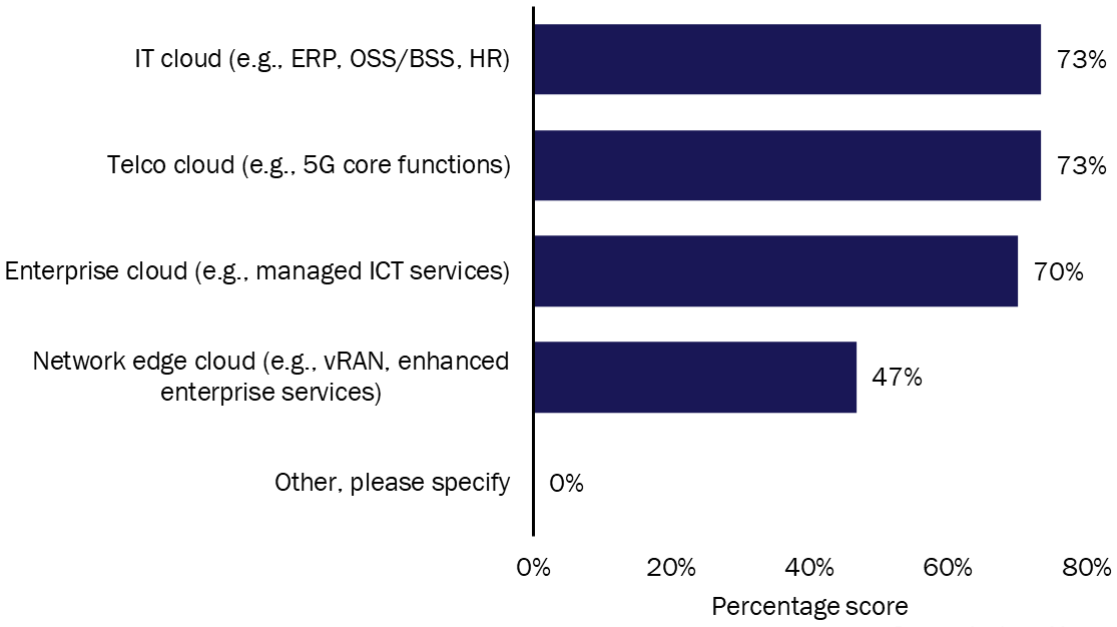
Our survey results show that CSPs acknowledge the importance of data center network automation for their overall business and operational objectives (see Figure 3.1 below). They also have a multi-faceted approach to data center network automation, focusing almost equally on all key domains and use cases including IT cloud, telco cloud and enterprise managed services at the same time (see Figure 3.2 below). CSPs generally seem to place less emphasis on the network edge cloud domain for these automation activities today, possibly due to the nascent stage of the vRAN/Open RAN technology. Overall, these results show that CSPs understand that the data center is key to unlocking opportunities from all these use cases and that the infrastructure that underpins them will be common.

Figure 3.1: Importance of data center network automation to CSPs, surveyed regions, 4Q 2021



Source: Analysys Mason

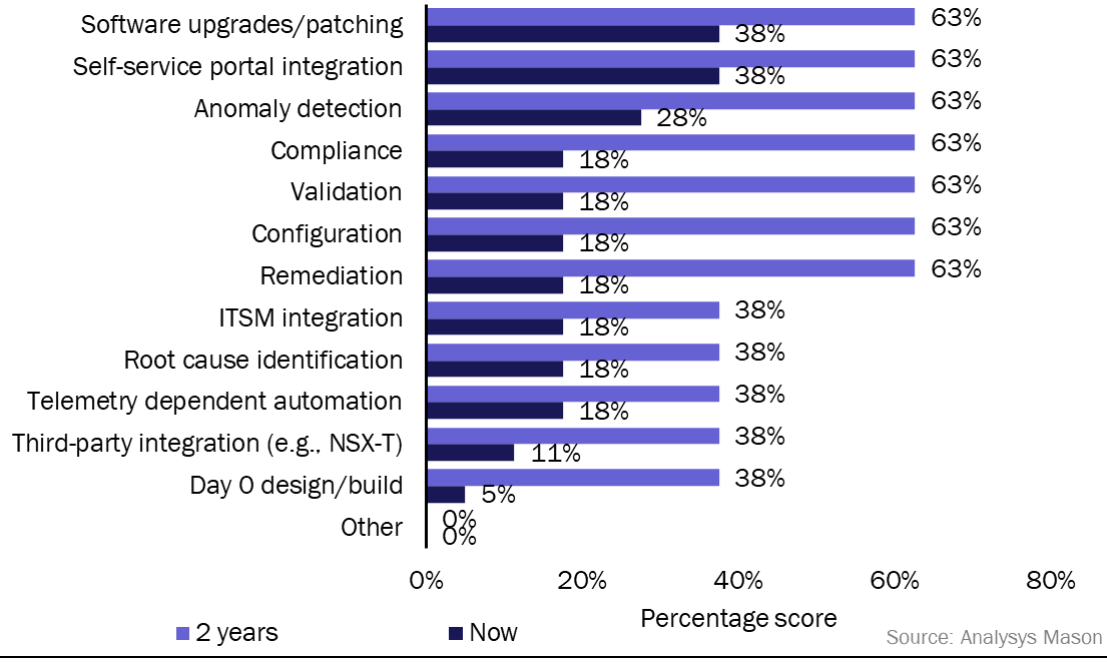
Figure 3.2: The main focus areas for CSP data center network automation efforts, surveyed regions, 4Q 2021



Source: Analysys Mason

The findings illustrated in Figure 3.1 and Figure 3.2 above are consistent with CSPs' strategic objectives discussed in the previous section. However, CSPs have made little progress in automating their data center network operations so far despite its importance, as shown in Figure 3.3 below.

Figure 3.3: The level of automation across CSPs' data center network operational processes, today and by 2023, surveyed regions, 4Q 2021



Source: Analysys Mason

"90% of our data center network operations are manual and there is not a strong push internally to change this quickly because we are not operating like a hyperscaler." -

- **Director IT/Network Strategy, Tier-1 CSP in Western Europe**

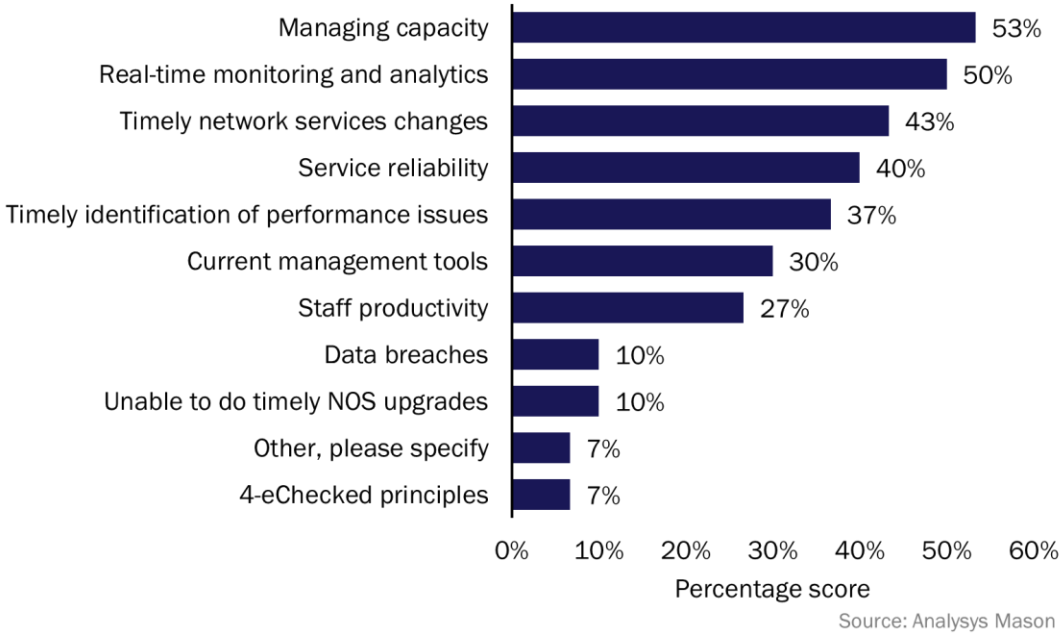
We asked CSPs worldwide to rate their current level of automation for each of these operational areas in percentage ranges (that is, less than 10%, 10–25%, 25–50%, 50–75% and 75+%). Figure 3.3 above shows the median points of aggregated inputs which we used to assess the overall level (for example, 38% means that most of the CSPs automated that particular area between the range of 25 to 50%; 18% means it is in the range of 10 to 25%).

CSPs have made some strides in automating relatively straightforward functions such as self-service portal integration and software upgrades/patching. However, many key operational processes such as configuration, root-cause identification and change validation remain highly manual. CSPs do not demonstrate strong ambition and urgency to ramp up the level of data center automation in the near-term either. We asked CSPs about their expectations for automation in 2 years' time, which is a long time for cloud and data center technologies that are likely to evolve and change rapidly in that period. CSPs expect to introduce automation to just above half of their operational processes within this timeframe, while their expectations for other key areas such as root-cause identification and telemetry are still low. These results suggest a major gap between CSPs and hyperscalers, large-scale enterprises and alternative NaaS competitors in terms of their current data center automation abilities and future plans.

Figure 3.4 below highlights the main areas in which CSPs face the most challenges in their Day 2+ data center network operations. Many CSPs are struggling to automate fundamental Day 2 processes such as capacity management, monitoring and assurance, and service provisioning and change. This will pose major obstacles for

CSPs when they are expected to meet key service metrics (such as time to market, on-demand provisioning and SLAs including mean time to repair (MTTR) and uptime) for the more-advanced services that they are preparing to launch once their 5G networks and edge DCs are in place. In our in-depth interviews with Tier-1 CSPs, most highlighted monitoring and troubleshooting as their main pain points for Day 2 operations. In particular, they highlighted the lack of service intelligence and visibility across multi-vendor network elements due to the underlying fragmentation of vendor-proprietary DC automation tools and data models.

Figure 3.4: CSPs' main Day 2+ operational challenges, surveyed regions, 4Q 2021



"Manual monitoring and troubleshooting processes are very slow and not effective and will affect our reputation. This is why we have to automate, with special focus on Day-2 operation, and it is the core of our day-to-day activities."

- Director, Managed Network Solutions, Tier-1 CSP in North America

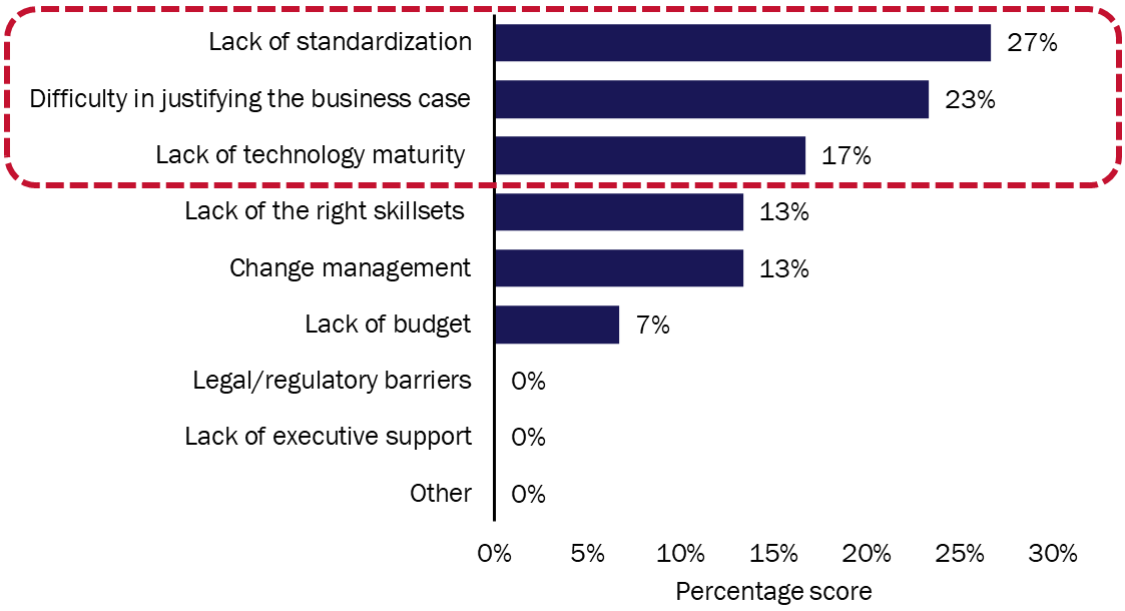
3.2 The lack of technology standardization and the difficulty of justifying an opex-based business case are the main barriers to data center network automation

According to our survey, CSPs are facing two major barriers that are hindering their data center network automation investments and progress (see Figure 3.5 below).

- A lack of technology standardization and fragmentation in data centers.
- Difficulty in justifying opex-driven business cases for automation.

In addition, our interviews surfaced another barrier that is related to data center ownership structure and the organizational mindset. We discuss all three barriers in this section.

Figure 3.5: Top three barriers to CSP data center network automation, surveyed regions, 4Q 2021



Source: Analysys Mason

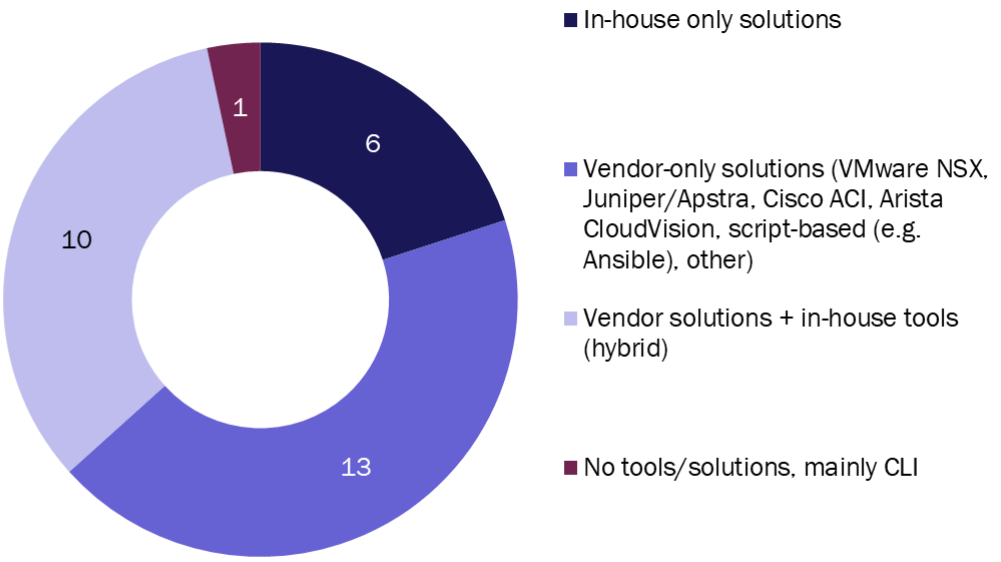
3.3 The operational complexity of fragmented underlay and overlay networks is a major barrier to automation

In our interviews, CSPs pointed out that their data center networking environments are highly fragmented and complex to operate and automate. This is because their data center networks consist of the following.

- several vendor-specific hardware and management software silos. In addition to the heterogeneity of the traditional IT switches and tools procured from different vendors (including Arista, Cisco and Juniper), network function providers for telco cloud (such as Ericsson, Huawei and Nokia) also bring their own and/or partner networking hardware and software components to CSP data centers, which further increases the technology and operational fragmentation
- Multiple overlay network approaches (a mix of different EVPN VXLAN architectures and proprietary SDN control mechanisms) that are used for different services and use cases
- Enterprise-managed service customer environments, each of which requires a different mix of network vendor solutions.

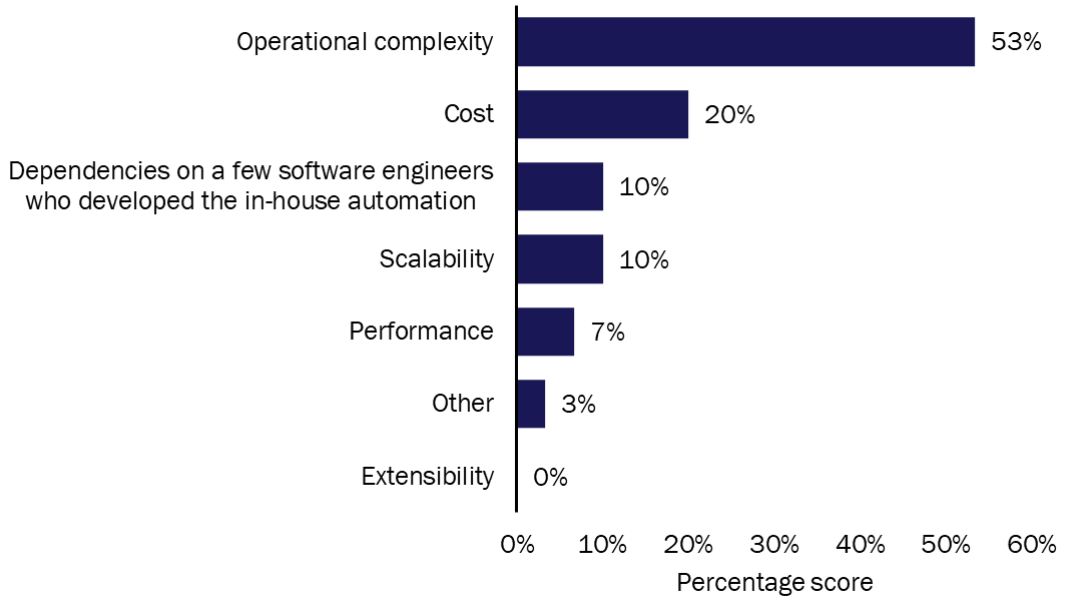
It is challenging for CSPs to rationalize and automate their data center networks because they need to serve a wide range of services and use cases (IT, telco cloud and enterprise) that are underpinned by a diverse set of underlay siloes and overlay networks. CSPs often have to use multiple management and automation software solutions (see Figure 3.6 below) that are provided by a range of hardware and IT vendors as well as scripting tools (for example, Ansible) and in-house grown solutions. These disparate systems result in high operational complexity, which is the main challenge that CSPs associate with their data center network automation technologies (see Figure 3.7 below). This is especially the case for CSPs that mainly rely on single-vendor automation solutions, which focus only on the operations of that vendor's network elements and/or domains.

Figure 3.6: Tools and solutions that all 30 surveyed CSPs are using to automate their data center networks, surveyed regions, 4Q 2021



Source: Analysys Mason

Figure 3.7: Top challenges that CSPs are facing with their existing network automation technology, surveyed regions, 4Q 2021



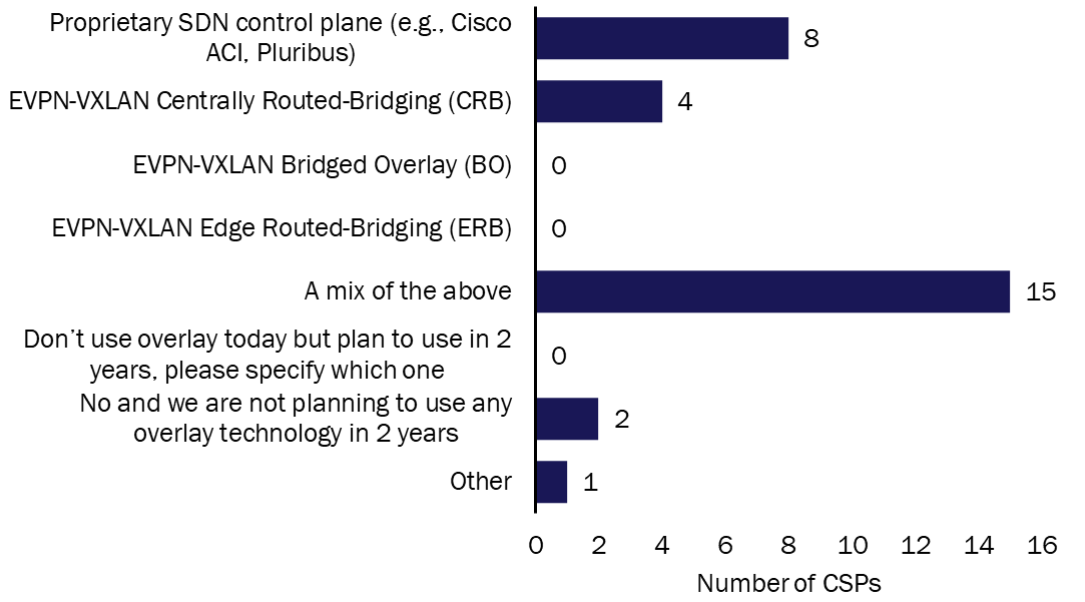
Source: Analysys Mason

"Two years ago, we decided to stop working on data center network automation and SDN because it was bringing in a lot of complexity and risk to our existing environment."

- Director IT/Network Strategy, Tier-1 CSP in EMEA

Most CSPs benefit from overlay network technologies to create logical abstraction layers over underlay networks for managing layer 2 and 3 services inside and between their data centers (see Figure 3.8 below). However, our survey also highlighted that the majority of the CSPs have complex overlay architectures that consist of multiple approaches. Almost every participant CSP uses a different combination of EVPN VXLAN, which are open, IETF-standard architectures (edge-routed bridging (ERB), centrally routed bridging (CRB), bridged overlay (BO)) and proprietary SDN control plane mechanisms. This is largely the result of the ongoing evolution of data center workloads and use cases, which spurred different network and traffic flow designs over time. Most CSPs use CRB and ERB together because CRB was the common approach when data centers had mainly north–south traffic in the past. However, as CSPs move to virtualization/containerization and more-distributed applications that push networking to the edge, ERB is becoming more-suitable for these high east–west traffic flow environments. Some CSPs have also adopted SDN solutions that provide vendor-proprietary control plane technologies as an alternative to the open, industry-standard EVPN VXLAN. Managing these multiple overlay architectures without automation (especially over highly fragmented underlay networks) is slow, time-consuming and poses significant risks to network and application availability and uptime due to potential human errors in configuration and management.

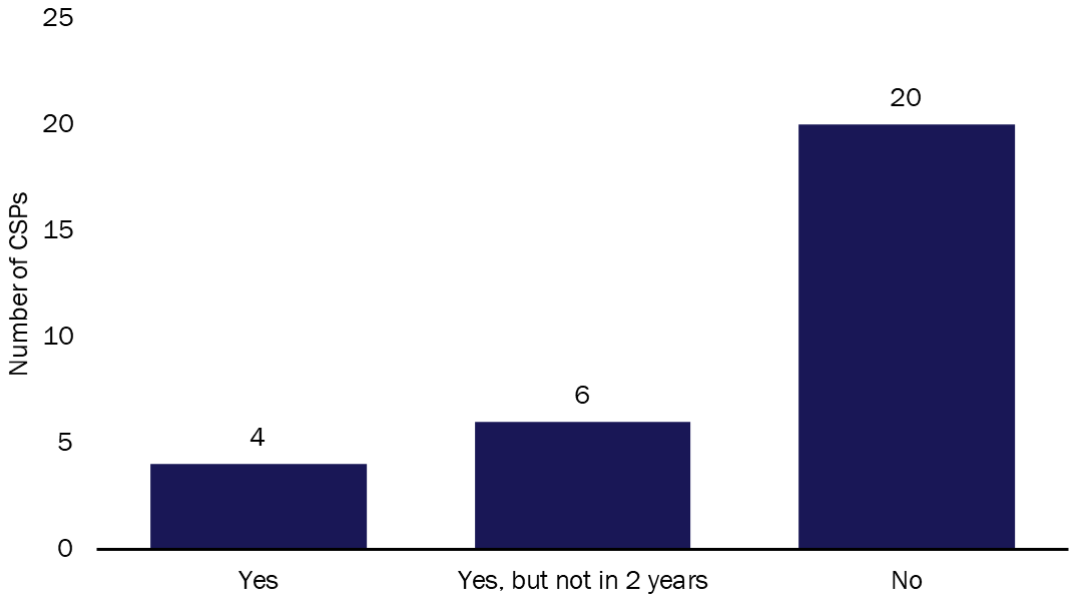
Figure 3.8: Data center overlay architectures used by CSPs today, surveyed regions, 4Q 2021



Source: Analysys Mason

Figure 3.9 below shows that only a third of CSPs worldwide are planning to tackle their overlay network complexity, and a small subset of them will do so within the next 2 years. The most-common drivers for this activity are the need to streamline and converge these architectures to increase the level of automation and cost efficiencies; prevent and manage issues caused by the architectural complexity and facilitate data center network migrations and transformations.

Figure 3.9: CSP plans to migrate to a different overlay architecture over the next 2 years, surveyed regions, 4Q 2021



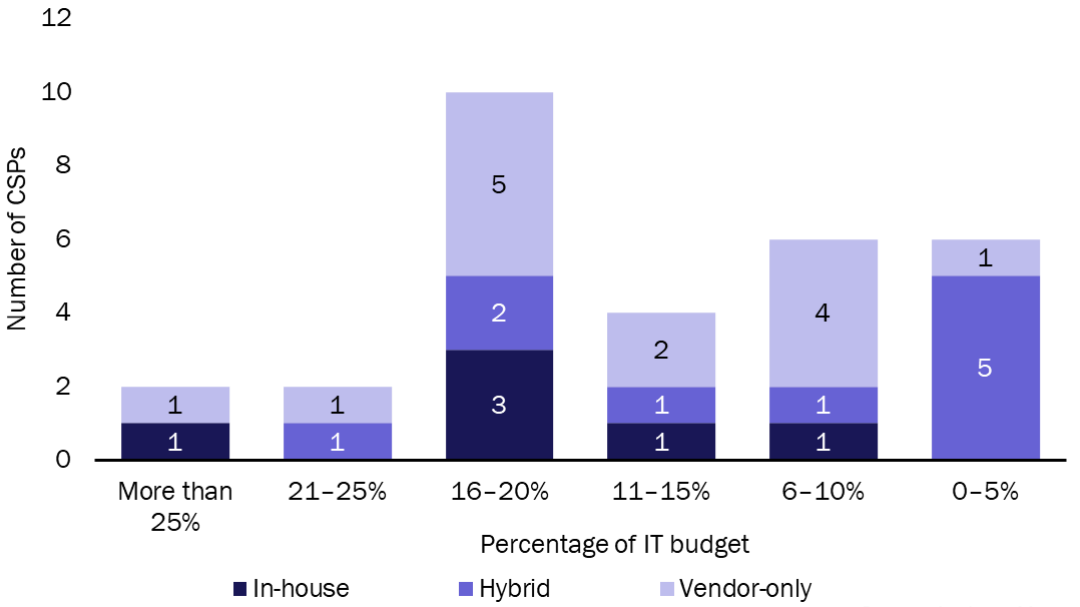
Source: Analysys Mason

3.4 The hidden costs of on-premises data center operations and the prevalence of in-house development present a major challenge for building a strong automation business case

The second biggest barrier to data center network automation for CSPs is the difficulty in justifying the business case for automation investments, as previously shown in Figure 3.5. As discussed in section 2.1, CSPs heavily rely on manual Day 0, 1, 2+ processes, which leads to large operational headcounts and slow, costly operations. In addition, Figure 3.6 illustrates that a large number of CSPs develop their own in-house network automation tools and use them solely or in conjunction with vendor solutions. In-house created automation requires developers and network engineers/operations to spend large amounts of time and effort building, testing and integrating custom DIY automation tools. The maintenance and continuous development and improvement of such tools can become expensive over their lifecycle.

Our survey shows that the CSPs with large numbers of in-house, DIY automation tools have, on average, higher cost bases than their peers that rely mainly on vendor automation solutions (see Figure 3.10 below).

Figure 3.10: The portion of IT budget that CSPs dedicate to data center network automation software on an annual basis, surveyed regions, 4Q 2021



Source: Analysys Mason

CSPs have a high level of awareness of the costs attached to manual operations and home-grown tools, yet many of them are struggling to develop a strong business case to sign off new DC automation investments. This is largely because on-premises operations and in-house development costs are actually 'hidden'. CSP data centers serve multiple lines of business, and costs are shared across different teams/units within them. Data center staff also straddle multiple engineering, operations and development responsibilities at the same time. All these factors make it difficult to have a clear-cut, granular view of the existing costs and as such, CSPs cannot carry out a n accurate evaluation of the costs and benefits of new automation solutions and efforts against the status quo.

Beyond cost savings, there are other key drivers of the business case for data center automation, such as increased service innovation and operational reliability. From Analysys Mason's general research on cloud and automation, we observe that service providers (advanced CSPs, enterprises and hyperscalers) with relatively high levels of automation are achieving the following benefits.

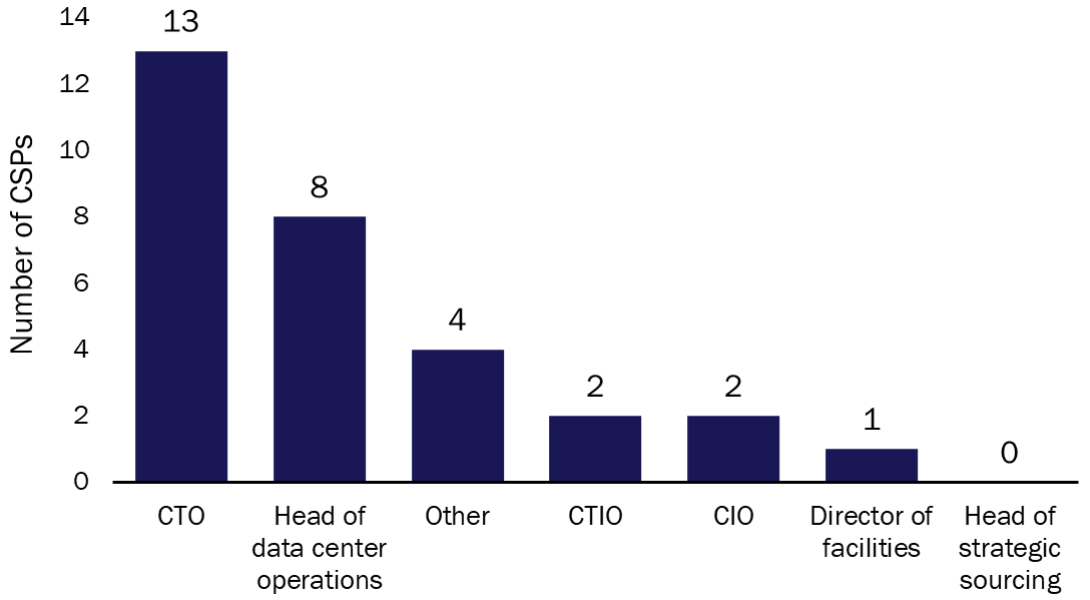
- By freeing up the skilled network engineers and operations personnel from most of the day-to-day toil with automation, CSPs can redeploy them to more-strategic and value-added activities that are directly aligned to their business goals.
- CSPs can minimize human-error (for example, misconfigurations) and reduce its associated operational risks such as performance degradations and outages.
- The velocity in deployment and scaling up of new networks and services is increased.

Overall, CSPs need to undertake a detailed examination of their data center processes and in-house development activities to reveal their hidden costs and operational challenges. These should be benchmarked against the data center best practices from hyperscalers and advanced enterprises, which will form the basis of a more-holistic business case that also considers a complete set of tangible business benefits of data center automation.

3.5 Organizational structure and mindset are often key barriers to data center automation

Our research reveals that CSPs also face other barriers to automation that stem from their organizational structure and ownership of data centers. We found that the CTO is often the main budget holder, not the CIO. This is not the situation in many enterprises and cloud hyperscalers. In some CSPs, DC responsibility is delegated to the heads of data center operations (see Figure 3.11 below). CTOs typically have much greater focus on mobile and fixed networks than on data centers. The fact that CTOs do not give strong backing to lower-level budget holders for DC automation investments may be a key factor behind the low priority given to data center automation.

Figure 3.11: Main buying center/budget holder for data center network automation, surveyed regions, 4Q 2021



Source: Analysys Mason

"Our organizational setup is a 'mess': data center responsibilities are shared between different units/teams and are frequently reassigned depending on the management mood that particular year."

- Senior IT architect, Tier-1 CSP in developed Asia–Pacific

In our interviews, one CSP said that the complex and continuously changing ownership structure of its data centers is inhibiting its automation efforts. Another interviewee mentioned that despite having the budget to implement automation tools, there is no group dedicated to getting this done, and the current staff are too busy with their daily firefighting routines. We also found that staff are highly protective of their jobs and resist automation initiatives for fear of losing jobs to automation. These findings indicate that the tendency to rely on manual processes and development of in-house tools is fostered by the CSPs' organizational setup and culture, and such issues may be flying under the radar of CTOs.

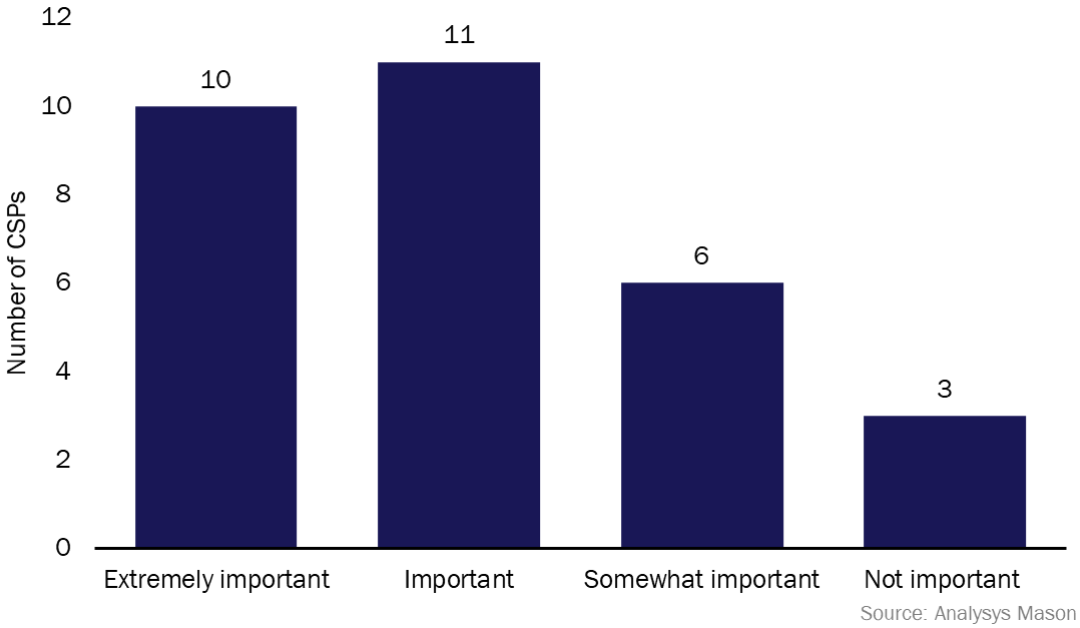
4. Solutions for accelerating CSP data center network automation progress

The findings from our survey and in-depth interviews demonstrate that most CSP data centers are not ready for the automation, programmability and agility needs of 5G, edge and multi-cloud infrastructure and more-advanced enterprise service opportunities. The new application-driven, cloud-native-based networking era will require CSPs to have a unified control plane across multiple clouds, data centers and WAN that allows CloudOps and DevOps to connect applications in an on-demand manner and provision compute, storage, network infrastructure as code from their continuous integration/continuous deployment (CI/CD) pipelines. CSPs put substantial emphasis on WAN automation, but they generally seem to overlook their data center networks. This overall lack of concern and the high level of technology fragmentation and operational silos in CSP data centers (as discussed in section 3.2) will be a major barrier to achieving these goals.

4.1 CSPs should build a horizontal automation layer across all data center networks, underpinned by a vendor-agnostic, intent-based automation platform

As the focus for enterprise networking evolves from site-to-site connectivity to app-to-app connectivity, the way that data center networks are designed and operated will need to change from a traditional, vendor-driven bottoms-up approach to a top-down paradigm. This means that CSPs should start from business intent and applications requirements first and the design and choice of lower-level hardware and software components should be driven by these requirements, not the other way around as is the case today. A key step towards making this paradigm shift will be the creation of a horizontal, end-to-end automation layer that collapses vendor-specific silos with multi-vendor management and automation capabilities. Figure 4.1 below shows that CSPs acknowledge the strong need for such a multi-vendor solution for their data center networks.

Figure 4.1: Surveyed CSPs' ranking of the importance of a multi-vendor solution for data center network management and automation, surveyed regions, 4Q 2021



Source: Analysys Mason

Every CSP has a different starting point for their automation journey, and building this horizontal, multi-vendor automation layer will not be an easy task, especially over siloed and complex brownfield networks. However, having a truly multi-vendor data center network automation platform will be essential for all CSPs that wish to tackle operational complexity and fragmentation within the data center. Figure 4.2 below outlines the key features and capabilities that CSPs should look for in such a platform.

Figure 4.2: Key features and capabilities of a multi-vendor data center network automation platform

Key features and capabilities	Description
Reference designs that map business intent to infrastructure	Vendor-agnostic, industry best practices-based reference designs that enable the abstraction of the low-level technology silos and provide automation templates and blueprints for the complete operations lifecycle. These reference designs should span both leaf and spine and Clos networks as well as the small number of switches and racks at the edge sites to provide common and consistent automation practices across all CSP data infrastructure.
Strong overlay and multi-vendor underlay automation capabilities	Support for a wide range of multi-vendor network devices (Arista, Cisco, Dell, Juniper and others) as well as different EVPN VXLAN architectures to future-proof networks and minimize the need for expensive and disruptive rip-and-replace activities.
Reliable and repeatable automation	CSPs need a single source of truth and deep visibility of the entire network state to have the confidence to zero-touch, close-loop automate their Day 0, 1, 2+ operations and expand and scale these networks in a reliable and repeatable manner. This also requires real-time telemetry and analytics-based mechanisms to continuously track changes and ensure that business intent and outcomes are met.
Maintainability	Strong out-of-the box capabilities that do not require CSPs to dedicate large amounts of resources and time to build automation. They should also reduce reliance on the few network engineers that carry the undocumented critical knowledge (design, configuration, settings) in their minds.

Source: Analysys Mason, 2022

4.2 CSPs need strong C-level leadership and a holistic business case to overcome organisational barriers to automation

Our research highlights an evident disconnect in CSPs' thinking between their digital transformation and future service ambitions and the actual focus and investments in data center network automation required to support these goals. This needs to be addressed by C-level executives urgently as CSPs get ready to launch their 5G, edge and NaaS services. CTOs in particular should step up their efforts to prioritise and accelerate data center automation initiatives and think about restructuring the responsibility for data center operations so that they are equal to network operations and have as much visibility. A long-term transformation and automation plan and vision that is inclusive of all lines of business (LoBs) will be a critical part of this effort.

A key roadblock to overcome in this process is the justification of new automation investments. CSPs need to develop a holistic business case that is driven by the strategic objectives defined in their long-term plan. The

first step for this should be the detailed mapping of their data center network-related processes across operations, engineering and development to uncover hidden costs. CSPs should also consider working with external partners/vendors to develop a framework to identify the realistic benefits and costs of automation based on market evidence and experience, which can help to strengthen the business case.

5. Conclusions and recommendations

Our survey and interviews show that CSPs urgently need to increase their focus and investments in data center automation, given their forthcoming dependence on data center networks to support demanding cloud-native and edge workloads and advanced, multi-cloud connectivity services. We provide the following recommendations to CSPs that want to accelerate their data center automation progress.

- CSPs should establish priorities and timings for the parts of their data center networks and processes that need to be automated. This determination should be based on clear business strategies and goals. Automation of data center networks represents a significant transformation journey, which involves a series of migration and modernization activities. As such, CSPs should start this journey as soon as possible rather than waiting for end-of-life replacement/technology refresh cycles.

- As a key step to tackling technology fragmentation and complexity, CSPs should consider investing in a horizontal, multi-vendor abstraction and automation platform that will break down existing vendor and operational silos with an intent-driven, automation-first approach to Day 0, 1, 2+ data center operations.

- Going forward, CSPs should consider introducing new policies and mechanisms to prevent a vendor-dependent, fragmented bottoms-up approach to data center designs. For example, CSPs should institute a board that evaluates whether to introduce a new underlay/overlay technology (for example, brought in by a network function or cloud stack vendor) and insist that any new vendor must conform to the data center automation plan and regime already in place.

- CSPs should choose suitable technology partners to help with their automation journey. CSPs should look for external partners that have extensive automation experience with other CSPs and hyperscalers and provide automation solutions and professional services capabilities to help ease the transformation/migration projects with lower costs, disruption and risk.

- CSPs should devise a plan for staff reorganization and process engineering early on. Automation will lead to a change in existing operational processes and job responsibilities. Having a clear roadmap for how staff will be re-skilled to support the automation and/or redeployed to more-valuable activities can help to overcome the organizational resistance/fear of automation and strengthen the business case.

6. About the authors

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