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SD-WAN — Playing the Orchestration Game

RESEARCH BRIEF

Table of Contents

SD-WAN Services for Communication Service Providers (CSPs) . . . 1

SD-WAN — First and Second Waves . . . 1

Key drivers for the second wave of SD-WAN . . . 1

Second wave SD-WAN requirements . . . 2

Role of Orchestration in SD-WAN . . . 3

Why orchestration is critical for SD-WAN . . . 3

Key Learnings and Considerations for SD-WAN and Beyond . . . 4

Establishing an intermediary layer — the master orchestrator . . . 4

Putting in place hierarchical orchestration and intent-based frameworks . . . 4

Ensuring fast onboarding of VNFs . . . 5

Supporting virtualization and multicloud . . . 5

Utilizing telemetry and driving closed-loop assurance . . . 5

Cross-domain and 5G — network slicing and beyond . . . 6

SD-WAN: What's Around the Corner . . . 6

Model unification and standardization . . . 6

Open standards and open-source software in orchestration . . . 6

Automation and programmable networks . . . 7

Artificial intelligence (AI) and machine learning (ML) in closed-loop assurance . . . 7

Conclusion . . . 7

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SD-WAN — Playing the Orchestration Game

Software-defined wide area networks (SD-WAN) has undoubtedly captured the attention of enterprises worldwide. Promising a significant upgrade to traditional enterprise WANs, SD-WAN brings improved bandwidth without significant cost increases, superior reliability compared to typical broadband internet, easier and faster deployment, better security, and greater visibility. With the majority of post-deployment surveys trending positive in terms of customer satisfaction, SD-WAN uptake will continue in the next few years. If there was ever a magic IT pill in recent years, SD-WAN would be the number one candidate to fill that role.

Most of the industry to date has been focused on rapid SD-WAN deployment, SD-WAN feature sets, and occasionally the relationship between SD-WAN platforms and the underlying connections. In this AvidThink research brief, we'll take a look at the evolution of SD-WAN deployments and highlight the increasingly important role that orchestration will play as SD-WAN rollouts grow in sophistication.

SD-WAN Services for Communication Service Providers (CSPs)

Given the renewed interest in WAN services from enterprises, CSPs around the world are scrambling to find a way to tap into this trend. Many early deployments by enterprises were a do-it-yourself (DIY) model, often with the assistance of SD-WAN vendors. As the SD-WAN market progressed, the need for assistance in deploying, operating, and managing these solutions offered an opportunity for CSPs to participate. Initially, for last-mile carrier incumbents, it was a defensive move against MPLS revenue erosion. However, enterprise early-adopters, many of whom jumped into SD-WAN in the hope of reducing MPLS spend, have discovered that, in reality, that spend hasn't always been reduced. Instead, for the same level of spend or a little more, businesses receive much higher bandwidth, improved reliability, better security, and increased functionality. Now, most network operators look to SD-WAN as a growth opportunity for revenue enhancement and increased enterprise penetration.

SD-WAN — First and Second Waves

AvidThink has seen SD-WAN deployments at CSPs come in two major waves. In the first generation of SD-WAN deployments — driven by time-to-market — CSPs picked one of the leading vendors and partnered with them in customer rollouts. The goal was to quickly capture the interest and dollars of enterprises looking to upgrade their WANs. First wave deployments were mostly single vendor platforms deployed as single-tenant solutions, either managed by the service provider or co-managed with the enterprise. As the sophistication of CSPs' SD-WAN offerings grew, they embarked on a quest to create a platform supporting multiple SD-WAN vendors.

Many CSPs who saw success with initial SD-WAN offerings realized that **to maximize their leverage in the longer term**, they needed to partner with more than one vendor.

Key drivers for the second wave of SD-WAN

Many CSPs who saw success with initial SD-WAN offerings realized that to maximize their leverage in the longer term, they needed to partner with more than one vendor, and so embarked on a second wave of SD-WAN deployments.

The multivendor nature of the second wave of SD-WAN is driven by the following factors:

- **Increased choice:** There is a desire to provide enterprise customers with multiple SD-WAN options, since customers might have unique needs better addressed by different vendors. Further, CSPs view SD-WAN as a platform on which other value-added services can be offered, e.g., managed security, and may want to include other virtual network

functions (VNFs) as part of their deployment.

- **Enterprise preferred vendor:** Some enterprises have an IT mandate to purchase from a certain vendor or prefer one vendor over another. Even if they choose to purchase a fully managed SD-WAN service from the CSP, enterprises might strongly favor a specific vendor.
- **Lock-in mitigation:** By building a platform that can accommodate multiple SD-WAN vendors, the CSPs have a more diverse portfolio to select from when engaging enterprise customers, reducing the leverage that a single SD-WAN vendor has. However, it has to be said that it's not trivial to swap one SD-WAN vendor for another: UIs and APIs are unique, operating models will differ, and even network, policy, and object models can be quite diverse. In any case, even though there is expense in switching, building the right multivendor foundation can reduce switching costs down the road.

Second Wave SD-WAN Requirements

Based on lessons learned from the first wave of deployments, the second generation of SD-WAN architectures look more like generalized network function virtualization (NFV) platforms than a collection of multiple SD-WAN vendor offerings. CSPs have also gone from seeing SD-WAN as a simple enterprise edge router upgrade, to part of their longer-term edge-platform strategy. This edge-platform strategy usually involves platform disaggregation, which almost always means a multiplayer ecosystem.

As part of the ongoing second wave of SD-WAN deployments, AvidThink believes the following are essential requirements for the CSP architectural foundations on which SD-WAN will be hosted:

- **Support for a disaggregated platform:** Many of the Tier 1s and a few of the innovative mid-tier CSPs are driving a Universal Customer Premises Equipment or uCPE-based approach for their SD-WAN deployments. The deployment stack for this looks more like a standard NFV stack, with an NFV infrastructure-layer (NFVI) that encompasses the uCPE hardware and uCPE operating system, and a virtualized infrastructure management (VIM) layer with support for managing a hypervisor that hosts VNFs as virtual machines (VMs). Further, as we extend deployments into public clouds, support for deploying parts of the overall stack into cloud platforms cloud become a necessity.

This edge-platform strategy usually involves platform disaggregation, which **almost always means a multiplayer ecosystem.**

- **Multi SD-WAN vendor support:** As described earlier, CSPs are looking to offer customers their choice of SD-WAN solutions. Many Tier 1 CSPs today offer at least two major SD-WAN vendor options. And these Tier 1s are often open to managing other SD-WAN vendor solutions for key enterprise accounts, who may have chosen a different vendor. As a result, whatever infrastructure the CSP builds needs to be able to support multiple SD-WAN vendors.
- **Multi VNF support (beyond SD-WAN):** CSPs are looking to offer more than just SD-WAN solutions. SD-WAN is now viewed as the perfect entry to an enterprise account, and as a potential platform play on which CSPs can add other value-add services like routing, WAN optimization, unified communications, branch management, and enterprise security. These services are usually available as VNFs hosted on a branch CPE platform. Therefore, the CSP infrastructure needs to extend beyond handling SD-WAN to provide a viable hosting vehicle for these value-add services VNFs as well.
- **Flexibility to support fully managed, co-managed and self-managed options:** Enterprises today vary in terms of their sophistication and desire to manage their infrastructure. As enterprises scale and mature, their needs may change. As a result, the new wave of SD-WAN deployments needs to provide flexibility on the manageability spectrum, from self-managed to fully managed. A good part of that will be provided by the SD-WAN product itself, but

the CSP infrastructure will need to provide additional options for management support. For example, many CSPs have self-service portals, which will need appropriate underlying APIs. Some examples of API options include underlay provisioning, underlay service-level agreement (SLA) upgrades and downgrades, and bandwidth calendaring.

- **Cross-domain capabilities:** Many CSPs have multiple last-mile assets that are wireline and wireless. As SD-WAN services are provisioned, the underlying platform needs to support concurrent provisioning of the underlay assets as well. The ability to leverage wireline and wireless as part of SD-WAN service provisioning provides potentially faster turnup for customers and increased reliability over the last mile through multiple links. Other elements that need to be coordinated could include integration of SD-WAN with existing private VPNs or express lanes to private or public cloud data centers. Only through cross-domain support can the orchestrator facilitate capabilities like end-to-end service quality.

As such, no matter how CSPs try to slice their SD-WAN rollout architectures, **orchestration is a critical success factor.**

To successfully build out the second wave of SD-WAN solutions, CSPs will need to invest in an appropriate foundation that meets the above requirements. Even if CSPs decide to run multiple parallel SD-WAN offerings without using a shared underlying infrastructure, they will still have to manage across multiple different SD-WAN. Dealing with the SD-WAN management, gateway, and configuration servers in either multi-tenant or multiple single-tenant deployments will prove challenging without a way to orchestrate across them. As such, no matter how CSPs try to slice their SD-WAN rollout architectures, orchestration is a critical success factor.

Role of Orchestration in SD-WAN

Orchestration had been somewhat overlooked in the early rush of SD-WAN deployments. However, in conversations with Tier 1and Tier 2 CSPs, AvidThink is seeing a clear recognition of its importance. To address the requirements in the next-generation of SD-WAN deployments, there will be a need for a cross-vendor, cross-domain orchestration solution. In many ways, this orchestration solution will manifest many capabilities as described in the NFV-Orchestrator (NFV-O) role of the ETSI NFV framework. In many cases, VNFs such as SD-WAN will ship with their own VNFMs; however, there might be other situations where a generic VNFM (G-VNFM) can play a role in managing different VNFs from multiple vendors.

Why orchestration is critical for SD-WAN

Let's examine each of the key requirements we laid out earlier and discuss the value that orchestration brings to each of those attributes:

- **Platform disaggregation:** In a deployment with disaggregated components, we need to coordinate and orchestrate between each of those elements, from the NFVI, to the VIM, to the VNFs that run on top of those. The NFV-O, and potentiallythe G-VNFM, are critical elements for operating the NFV framework and orchestration is paramount in a disaggregated architecture. The orchestration system should also adapt to running parts of the overall stack on public clouds.
- **Multi SD-WAN vendor support:** Unless the CSP is partnering with a pure over-the-top (OTT) SD-WAN provider who both operates and manages their own OTT infrastructure, headend SD-WAN elements

Even if the CSP isn't running SD-WAN on a disaggregated NFV platform, **they will still need an orchestration system** to manage across the multiple SD-WAN offerings.

will exist on the CSP's infrastructure, and multiple VNFs will live on uCPEs. There are components that need to be managed and orchestrated as part of the CSP's operations. Only the orchestration system can understand which SD-WAN system needs to be appropriately provisioned for which customer. As we discussed earlier, even if the CSP isn't running SD-WAN on a disaggregated NFV platform, they will still need an orchestration system to manage across the multiple SD-WAN offerings.

- **Multi VNF support (beyond SD-WAN):** To effectively offer multiple VNF support, there needs to be an orchestration system that can manage the provisioning, placement and chaining of multiple VNFs from multiple VNF vendors, mixing and matching them with SD-WAN VNFs.
- **Cross-domain capabilities:** The key to rolling out SD-WAN across existing wireline assets, extending into 4G LTE and eventually into 5G, is a cross-domain orchestration system that can coordinate provisioning and configuration tasks across different domain management systems. Further, when we include provisioning and configuration into public cloud, then there's no doubt that a comprehensive SD-WAN solution involves cross-domain integration into systems that might even be outside CSP ownership. Essentially, to ensure end-to-end quality-of-service as part of any enterprise SD-WAN deployments, the orchestrator needs to span all relevant domains that impact the underlay.
- **Flexibility to support fully managed, co-managed and self-managed options:** Each vendor's SD-WAN system will support a range of management options. However, some end-user visible management options deal with items outside the SD-WAN's control, and will have cross-domain impact — e.g., setting up things like bandwidth upgrades or bandwidth calendaring, or turning on quality of service (QoS) in the underlay. In this situation, the orchestration system needs to step in and extend the spectrum of end-user management options beyond what a single SD-WAN solution might provide.

Key Learnings and Considerations for SD-WAN and Beyond

Now that we have established the importance of orchestration in SD-WAN, we'll discuss some key thoughts and learnings from our research with leading vendors and CSPs who have already developed and established SD-WAN orchestration frameworks. Some of these rollouts are quite sophisticated with multi-vendor, multi-domain support, and offer management options that range from co-managed to fully managed.

Establishing an intermediary layer — the master orchestrator

Successful CSPs recognized the need to introduce an additional layer of orchestration and management over and above what, ostensibly, is the SD-WAN EMS layer. This master orchestration layer is what integrates with the OSS layers above and multiple vendors and domains below. Without this intermediary layer, it would be much harder to swap between SD-WAN vendors or introduce new VNFs into the service. And it would not be possible to orchestrate across, say, a physical link and the SD-WAN service to coordinate link turnup with the SD-WAN overlay bringup while ensuring end-to-end QoS.

Without this intermediary layer, it would be much harder to swap between SD-WAN vendors or introduce new VNFs into the service.

In real-world deployments, this master orchestration layer integrates with the management and control systems (effectively, the EMS) of each VNF, including SD-WANs. It is this system that can handle bundled services consisting of an SD-WAN solution along with one or more other VNFs — such as security and SBCs — through service chaining. Since most SD-WAN and VNFs today have slightly different models and APIs, the master orchestrator needs to reflect a flexible architecture that supports loose coupling to tie all the disparate pieces together.

Putting in place hierarchical orchestration and intent-based frameworks

As described, the master orchestrator insulates the OSS and customer portal layer from the nitty-gritty of the different underlying systems. Key to success in this layer is to ensure a model-based approach that appropriately captures the underlying services in a vendor-agnostic manner while having rich enough northbound constructs to address configuration and control needs. This hierarchical orchestration framework should interface with the SD-WAN controller and management system and let it perform the tasks it is best at. This approach allows the system to scale better and, by maintaining the right level of abstraction, fosters innovation within each domain without burdening each layer with unnecessary details.

As intent-based frameworks gain maturity, the orchestration layer is the ideal interface to translate that into instructions to the underlying systems.

Finally, as the intent-based frameworks gain maturity and enterprises come to understand how best to represent and codify intent, the orchestration layer is the ideal interface to translate that intent into provisioning, configuration, and management instructions to the underlying systems. Whatever orchestration system is developed or installed needs to have a robust framework and roadmap to support intent-based management as the paradigm matures.

Ensuring fast onboarding of VNFs

CSPs who've tried this master orchestrator model have highlighted the need to rapidly onboard VNFs. Certainly, if all that's at stake is a few SD-WAN services, then perhaps these services could be pre-validated and hand adapted. However, to meet diverse enterprise customer needs, CSPs need the capability to rapidly add other VNF services, like firewalls, or WAN optimizers, or more sophisticated routers from third parties. Ensuring that the VNFs can be onboarded by the orchestrator and accompanying generic VNFM quickly will be critical to the success of the overall offering.

Supporting virtualization and multicloud

In most enterprise deployments today, workloads are virtualized and might live in an enterprise private cloud, or a virtual private cloud in a public cloud infrastructure. The orchestration system needs to adapt and potentially integrate with provisioning and monitoring APIs of cloud platforms on-premises or in the cloud. The cloud platform could be an enterprise private cloud, a telco cloud, or a public-cloud platform-as-a-service (PaaS) or infrastructure-as-a-service (IaaS) from Amazon Web Services, Microsoft Azure, or Google.

To facilitate expansion of SD-WAN's reach, service providers need to ensure that the orchestration foundation they lay today can accommodate integration with multicloud workloads as well. Most leading SD-WAN solutions already have the ability to connect into multiple clouds, and so the orchestrator needs to dynamically coordinate with those capabilities while initiating cloud provisioning or configuration prior to turning on SD-WAN in those locations.

Service providers need to ensure that the orchestration foundation they lay today can **accommodate integration with multicloud workloads** as well.

Further, to take full advantage of virtualization, the master orchestrator should provide the capability to appropriately backup and restore settings and state, as well as provide snapshotting support. This allows an entire system to be saved from an instantiation as necessary, increasing the robustness and agility of the SD-WAN service.

Utilizing telemetry and driving closed-loop assurance

Beyond the ability to reach across multiple domains and services, to ensure success in ongoing SD-WAN and other services, CSPs need to build a closed-loop assurance model that leverages automation. The assurance system needs to provide end-to-end monitoring of the SD-WAN service and any relevant service chains in the overall service chain topology. To do so requires the ability to feed key telemetry information into an assurance component to understand how to map the incoming information to key performance indicators (KPI) to determine if the service is performing to specifications. After determining root cause, the assurance component can then utilize the orchestration layer to perform remediation. More intelligent orchestration systems will have the ability to perform multi-step remediation across several services and many domains of control.

> Intelligent orchestration systems will have the ability to perform **multi-step remediation across several services** and many domains of control.

Importantly, the master orchestrator needs to take maintenance windows into account and not attempt to mitigate shutdowns during maintenance windows or cause unnecessary alarms.

Cross-domain and 5G — network slicing and beyond

We've already discussed the importance of supporting multiple domains within the master orchestrator. As CSPs with mobile capabilities extend into 5G, what ostensibly is just LTE backup links within SD-WAN deployments could turn into primary high bandwidth links with 5G. Further, SD-WAN overlay technology is likely to extend to edge deployments as 5G brings about IoT services on the carrier network. Some industry proponents believe that SD-WAN will essentially become the end-to-end network fabric that connects edge devices to each other and to applications and data in private or public clouds. As part of these rollouts, CSPs will likely implement network slicing in their 5G networks to provide some semblance of isolation, as well as unique QoS and SLAs on a per slice basis.

In such rollouts, the master orchestrator coordinates the SD-WAN fabric from the enterprise edge all the way to the carrier edge, including outreach into the public clouds. With the right orchestration in place, the CSP will be able to achieve the promise of a true end-to-end fabric that supports the necessary QoS for different applications and meet the SLAs promised to enterprise customers.

SD-WAN: What's Around the Corner

Having established the key role that orchestration plays in SD-WAN deployments today, we'll take a quick look at what's coming down the pike and how it will impact the orchestrator.

Model unification and standardization

Today, SD-WANs from different vendors have differences in their object models and APIs for integration. To enable much tighter integration and offer higher-level SLAs and stricter QoS, as well as offer remediation and improved automation, the models across these vendors will need to be normalized and unified. Support for configuration frameworks like OpenConfig[1] may eventually come to pass, and we remain hopeful that efforts by organizations such as the MEF will succeed in unifying the northbound APIs and models for SD-WAN deployment.

> With the right orchestration in place, the CSP will be able to **achieve the promise of a true end-to-end fabric.**

[1] http://www.openconfig.net/

Open standards and open-source software in orchestration

Speaking of standards and open-source organizations like the MEF, there are also ongoing related projects and standards-creation by other organizations, such as Linux Foundation, ETSI, ONUG, and TMForum. Key orchestration projects in these areas include Open Network Automation Platform (ONAP)[2] from the Linux Foundation and Open Source Management and Orchestration (OSM)[3] from ETSI. In particular, ONAP has been identified as capable of playing the role of master orchestrator. It has significant support from both CSPs as well as major network solution vendors, such as Amdocs, Ciena, Ericsson, Huawei, Nokia, and ZTE.

Automation and programmable networks

In parallel with the progress in open standards and open-source software, we are also seeing the continuation of API-development within network devices and a drive towards automation and programmable network. The concept of NetDevOps, that mirror the DevOps of the server and application programming world, will continue to advance, and the orchestration platform will evolve to be a key element of any network programmability initiative. Any type of continuous integration/continuous deployment (CI/CD) model will almost certainly interact with the orchestration system.

As technologies like AI/ML are brought into the ecosystem, the orchestrator will migrate towards an intelligent self-healing solution.

Artificial intelligence (AI) and machine learning (ML) in closed-loop assurance

In time, as technologies like AI/ML are brought into the ecosystem, the orchestrator will migrate towards an intelligent self-healing solution that ensures a seamless customer experience tolerant of hardware faults or VNF failures. With AI/ML, and from observing historical and ongoing telemetry data, the orchestrator in conjunction with the assurance component can figure out appropriate workload placement to optimize the system or even provide predictive analytics that warn of impending faults or capacity issues, proactively provisioning or reconfiguring the system to ensure no downtime.

Conclusion

As SD-WAN deployments evolve at CSPs worldwide, the role of orchestration will grow to be increasingly important. To support the multivendor, multidomain reality today, and to lay a foundation that can support a rich set of service around SD-WAN, any significant deployment of SD-WAN will need to be accompanied by an overarching orchestration system. This system must be sufficiently sophisticated and dynamic to handle the challenges of integrating with SD-WAN and wireline and mobile services, including upcoming 5G, edge, and IoT deployments. While establishing such a foundation will not be easy, CSPs should seek orchestration partners that can help them build out the right framework. The benefits that will accrue downstream from taking the right architectural steps will be significant, as CSPs come to reap the financial benefits that stem from being more agile, flexible, and scalable.

While establishing such a foundation will not be easy, **CSPs should seek orchestration partners that can help them build out the right framework.**

[3] https://osm.etsi.org/
[2] https://www.onap.org

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