White Paper

SD-WAN: A Modern Hybrid-WAN to Enable Digital Transformation for Businesses

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April 2018

IDC OPINION

IDC sees strong growth opportunity among UAE enterprises for services related to software-defined WAN (SD-WAN). The growth of SD-WAN is attributed to the increasing popularity of modern telecommunications networks and datacenter infrastructure concepts such as software-defined networks (SDN) and network function virtualization (NFV). These technology concepts have enabled SD-WAN to provide enhanced capabilities such as agility, scalability, cost competitiveness, and reliability, as well as faster installation and provisioning times, over legacy WAN solutions. Key points for enterprise and IT decision makers considering moving from legacy WAN to SD-WAN include:

- Evaluate SD-WAN in the broader cloud migration and digital transformation (DX) journey of the enterprise.
- Align SD-WAN plans with enterprise IT and business strategies to support existing and future business applications, reduce costs, and increase efficiency and business agility.
- Evaluate potential SD-WAN service providers based on their competencies and level of support in providing end-to-end solutions to fulfill immediate and future business requirements.
- Consider a deployment model that reduces overall total cost of ownership (TCO) for the enterprise without compromising quality of service (QoS) or service-level agreements (SLA).
- Consider transitioning to managed SD-WAN services and avoiding the risk of managing complex technology and network roadmaps while future-proofing the network and application environment.

METHODOLOGY

This IDC White Paper on SD-WAN enterprise opportunities in the UAE market is based on our in-depth knowledge of local, regional, and global enterprise markets. It is built upon our ongoing research in the areas of SDN, NFV, and SD-WAN technologies, as developed by IDC's worldwide analysts.

IN THIS WHITE PAPER

This IDC White Paper highlights the growing importance of SDN and NFV technologies for enterprises and their digital transformation journeys. It also discusses the relevance of the technologies for enterprises in the UAE, examines key features and benefits, and presents a future outlook for the enterprise market. This White Paper also covers various implementation models for SD-WAN, and the role played by telecom operators in meeting enterprises' long-term network rollout objectives. It also highlights the possible challenges that enterprises may encounter during implementation of SD-WAN technology and provides guidance on best practices for overcoming those challenges.

April 2018, IDC #CEMA43697618

SITUATION OVERVIEW

The Age of Digital Transformation

Enterprises are embracing digital technologies (such as cloud, mobility, big data/analytics, and social media) to increase their competitive edge by fundamentally changing the way they conduct business. Incorporating these digital technologies into the fabric of enterprise processes to drive new revenue streams and improve efficiencies represents the core of what has become known as digital transformation. IDC defines digital transformation as a continuous process by which enterprises adapt to or drive disruptive changes across their internal operations and external ecosystems of customers and markets.

DX is a journey that is continuously evolving based on internal and external business imperatives, such as changes in consumer demand and the need to improve the customer experience, ongoing regulatory changes and compliance issues, and the need to compete effectively in increasingly disruptive digital markets. Whether a business is using technology to better engage with its customers and suppliers, utilizing new business models to keep pace with the explosive rate of change, or simply creating new strategies that rely on technology to accomplish day-to-day tasks, it has already taken its first steps towards DX. IDC believes the single most important competency required to thrive in this new digital economy is the ability to rapidly respond to and even predict changing conditions within the ecosystem in which the organization does business. And while forewarnings of change are nothing new in an industry that is driven by innovation, the current rate of change in the ICT market is truly unprecedented.

In the UAE, many enterprises in both the private and public sectors are embracing DX technologies to transform their businesses and enhance their ability to effectively respond to rapid changes in their environments. According to IDC's 2018 CIO Summit Survey, approximately 46% of UAE organizations are either already engaged in digital transformation or in the process of planning and evaluating their transformation strategies.

The Role of Networks in Digital Transformation

DX entails shifting an ever-increasing proportion of business online and requires flexible and agile network infrastructures that can dynamically adapt to meet changing business needs. Cloud and associated technologies (i.e., innovation accelerators) represent both a foundation for — and a key enabler of — DX. The growing adoption of cloud technologies has already impacted datacenter networking, giving rise to SDN and other architectural innovations such as NFV, designed to bring greater agility to LAN. As WANs are increasingly critical and fundamental in the realization of cloud strategies for enterprises, attention is now turning to how WAN must adapt to accommodate the more dynamic business requirements of the cloud era.

The traditional WAN came of age in the client/server era, when applications resided exclusively behind the legacy router in enterprise datacenters. As such, WANs were not architected to facilitate digital transformation. Instead, legacy WANs were designed and constructed to support branch-to-datacenter and branch-to-branch traffic, not to support increasingly critical branch-to-cloud, data, video, and voice traffic. Furthermore, the traditional WAN is poorly suited to the security requirements associated with distributed and cloud-based applications. An additional complication is that legacy WANs are complex and difficult to deploy, configure, manage, and troubleshoot.

The digital transformation of enterprise processes, products, and go-to-market strategies needs to evolve hand in hand with WANs. Network connectivity underpins every aspect of ICT transformation, which accordingly increases the demands on the network. Hybrid network architectures, cloud connectivity, and network virtualization have become key building blocks for delivering the improvements in flexibility, manageability, scalability, availability, QoS, SLAs, and TCO that enterprises will require from their modern WAN. Therefore, careful consideration should be given to

implementing a SD-WAN architecture that provides the same degree of benefits for WANs that SDN brought to datacenters (virtualization, agility, flexibility, scalability, etc.).

WAN transformation involves adoption of SD-WAN solutions and technologies. However, as an architectural approach to addressing the shortcomings of the legacy enterprise WAN, SD-WAN is a relatively recent phenomenon. Dynamic networking made possible by SDN technology enables a more robust and scalable architecture to support new demands imposed on enterprise networks. As such, SD-WAN has emerged as the ideal solution for enterprises that are dependent on the cloud and workforces requiring reliable access to the network and applications anytime, anywhere.

SD-WAN — An Enabler of Hybrid WAN for DX

A hybrid WAN includes at least two WAN connections from each branch office leveraging two or more different access technologies (such as MPLS, broadband Internet, or 4G/5G). SD-WAN is a new type of hybrid WAN that is flexible and resilient, utilizing an intelligent centralized, cloud-managed, and policy-enabled network to dynamically set up and manage all WAN connections for enterprise communications. These communication services may include VPNs, managed Internet access, VoIP, bandwidth performance management, and network-based firewalls. SD-WAN leverages hybrid WANs via a centralized, application-based policy controller that provides analytics for application and network visibility, a software overlay that abstracts underlying networks, and an optional forwarder (routing capability) among other features that together allow intelligent path selection and controls across hybrid WAN links, based on policies defined in the controller.

Although SD-WAN is a new approach with numerous capabilities and benefits, it is not expected to immediately leverage broadband services over existing access technologies (such as MPLS and Ethernet), but will rather enable their coexistence in a hybrid model in order to leverage the benefits that each access technology can provide.

Although SDN has separately enabled the evolution of both NFV and SD-WAN, many features of both NFV and SD-WAN can be integrated into an end-to-end solution. SDN is an architectural approach to networking that separates the data control and application planes. This separation enables the intelligence of a network device to be split from the packet-forwarding engine and controlled centrally while data transport is distributed. In addition, SDN allows applications to interface with the network based on software for improved control, automation, and orchestration of network behavior. Similarly, SD-WAN provides a software abstraction layer to create a network overlay and decouples network software services from underlying hardware WAN circuits. SD-WAN adopts a similar approach to NFV's feature of virtualizing network node functions into "building blocks" for creating communication services and removing the need for dedicated standalone network elements at enterprise edge networks. Having pursued network virtualization in the datacenter and across the WAN to the edge of the branch, enterprises will look to extend automation and virtualization throughout the branch and remote sites, deploying platforms and technologies that allow for automated provisioning and remote management of WANs, firewalls, and a range of other network and security services. SDN and NFV have become key building blocks for delivering the flexibility, manageability, scalability, and cost effectiveness that enterprises will also demand from their modern WAN (SD-WAN).

SD-WAN Defining Principles

SD-WAN solutions are built using the following principles:

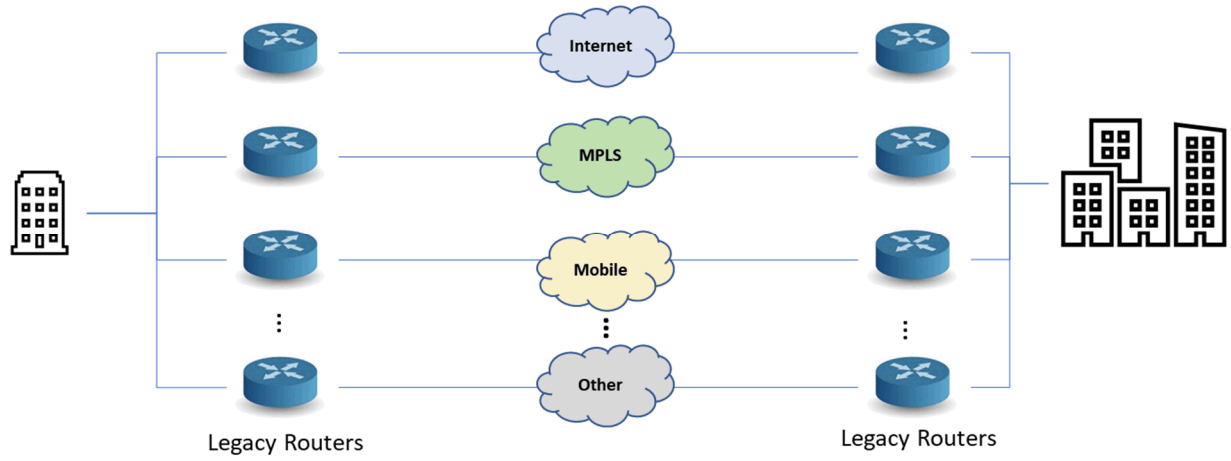
- **Centralized application-based and policy-based WAN infrastructure control:** Taking one of the basic principles of SDN and applying it to the WAN infrastructure, SD-WAN introduces controller software that acts as a unified intelligent network control plane treating the WAN as a unified fabric to define traffic classes, security parameters, and QoS characteristics.
- **Physical link abstraction and use of diverse physical WAN links:** Policy-based traffic steering controlled by the centralized control function may use diverse connectivity services, such as MPLS, Ethernet, commercial broadband, or mobile (wireless) broadband, and tunnel traffic

through one or multiple types of links based on varying requirements such as cost, bandwidth latency, and reliability.

- **CPE transformation:** Although traditional router CPEs can support and will be used in hybrid SD-WAN solutions, they are not required. Some proposed SD-WAN solutions do not feature routers at all, but instead rely on much cheaper forwarder devices, known as virtual CPEs, that primarily monitor WAN link performance and forward individual data flows through links considered most appropriate for a given flow's QoS requirements. The QoS requirements and policies are implemented from the centralized control plane. Virtual CPE provides an advanced level of provisioning that can dramatically improve available cost and consumption models by adopting an open ecosystem approach and avoiding vendor lock-in.
- **Application and network analytics:** These allow the SD-WAN to react to changing network topology, link load, and circuit performance in real time by providing web-based dashboards to view application behavior. In line with increasing automation in SDN architectures, the implementation of analytics insights in WAN operations can be performed automatically or with limited intervention from network management staff.

FIGURE 1

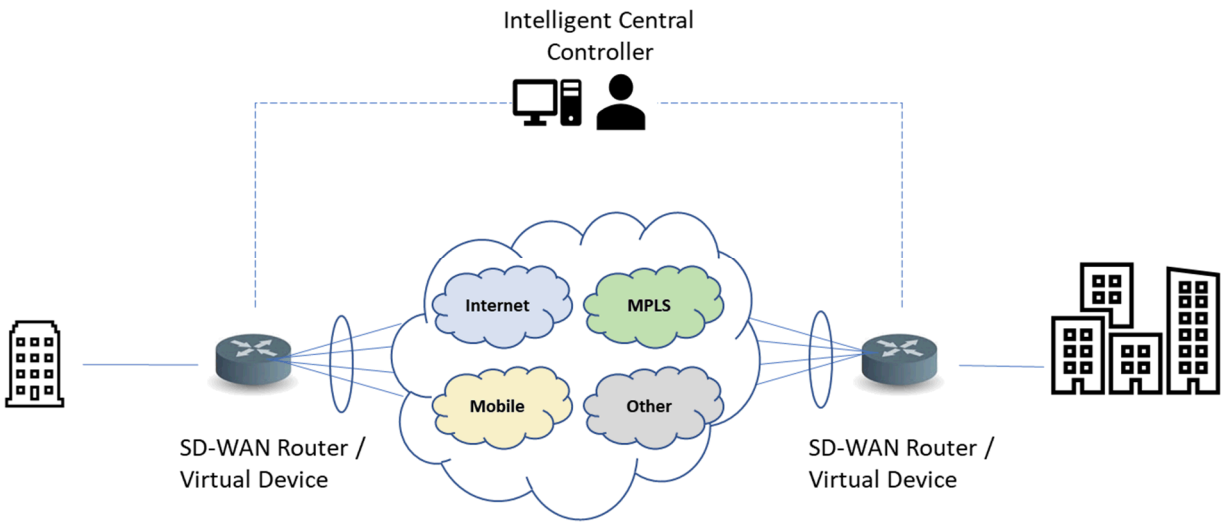
Legacy WAN Connectivity



Source: IDC, 2018

FIGURE 2

SD-WAN Connectivity



Source: IDC, 2018

SD-WAN Deployment Models

There are four main types of SD-WAN deployments:

- **Mixed WAN infrastructure-based solutions:** These solutions enable policy-based traffic forwarding and may include centralized control using SD-WAN existing legacy router installed bases. Although it may be initially considered by organizations, the downside of this deployment model is its limited flexibility, as it does not provide full SD-WAN for the organization, and the cost of self-managing the mixed environments is high.
- **Pure-play SD-WAN:** This type of solution relies on deploying the centralized controller and analytics software in conjunction with CPE transformation, which may include CPE virtualized functions in edge routers completely replacing in-house legacy CPEs. The approach lends itself more to large enterprises with internal networking resources that can afford the higher CAPEX to acquire the technology and are able to address the management complexities themselves. It is less attractive for companies seeking gradual transition to SD-WAN and that are more averse to vendor lock-in and high CAPEX. This solution also offers limited control of the WAN provider.
- **Self-deployed SD-WAN:** This is a solution whereby controller and analytics functionality are provided through a SaaS model. The CPE plant usually consists of cloud-managed zero-touch provisioning forwarders or virtual appliances. Although this approach provides an on-demand pay-per-use model (OPEX) and quick deployment times, it too allows limited control over the internetwork of the WAN provider, thus limiting the QoS. This may prove problematic in markets that require strict oversight of data residency and compliance, in addition to higher maintenance costs and limited or no SLAs.
- **Managed-service SD-WAN:** This entails enterprises subscribing to SD-WAN offerings from service providers (SPs) as a fully managed solution. The main advantage of this model is the ability to leverage the SP's strong position in the existing WAN internetwork ecosystem for QoS assurance and SLAs. Additionally, the SPs are capable of alleviating concerns over data residency and compliance due to their ability to deploy SD-WAN solutions locally. Managed service models also help enterprises to transition to OPEX models, thus reducing TCO and avoiding the need to manage complex technology roadmaps, while providing flexibility in future-proofing network and application environments.

As with SDN, SD-WAN provides the opportunity for the network to transform from a perceived "cost center" to a valuable business enabler and possible market differentiator. Nevertheless, before enterprises jump on the SD-WAN bandwagon, they will need to consider the following:

- How is the organization's application profile changing, and what are the implications for the WAN?
- What are the organization's strategic IT priorities, and how does SD-WAN fit into them?
- At what stage of the DX journey is the enterprise, and is the enterprise WAN ready to support the transformation?
- What is the organization's exposure to cloud-based applications today and in the future? How will the WAN have to change to accommodate the shift?
- If the organization is a hybrid enterprise, has it adopted a hybrid WAN to accommodate its needs and to serve as a precursor to SD-WAN?
- Does the organization's IT team have a thorough understanding of what features and functionality are most important for the enterprise in an SD-WAN solution?
- What would be the deployment strategy for the SD-WAN solution? Onsite as a technology solution from a vendor, as a cloud-based service from a SaaS vendor, or as a service (obtained from a service provider)?

To effectively address these considerations, enterprises are advised to adopt a consultative approach with their SP, which should have proven experience in dealing with their specific requirements. In addition, SPs are perceived to have better insight into evolving technologies, thereby allowing them to offer educated advice to customers on investment outcomes.

New Business Models and New Possibilities

While a business case can be made for SD-WAN at a single site, it is especially relevant to verticals and organizations that have branches or remote locations seeking to provide cost-effective, cloud-enabled networking. Here are examples of benefits and use cases of SD-WAN for six vertical markets:

- **Retail:** Providing in-store WiFi for customers is a common requirement, as is strong security for credit card operations. Retail organizations run on thin margins and can reduce OPEX and CAPEX by leveraging SD-WAN functionalities to run on the fastest Internet connections available in order to process payment transactions as swiftly as possible.
- **Banking and financial services:** Banks and financial services organizations rely on reliable, secure communications with central datacenters to serve customers via local branches. SD-WAN can deliver hybrid WAN — typically, a mixture of MPLS and Internet — with improved security, reliability, availability, and performance.
- **Manufacturing:** Industrial organizations control IT operations through distributed plant networks connected to centralized datacenters. An SD-WAN deployment can segment networks to isolate specific product lines, divisions, or contractors; connect devices on the plant floor; and support a range of wireless WAN links such as 4G LTE in remote areas.
- **Education:** SD-WAN can help deliver a better learning experience for students at schools, colleges, and universities with lower-cost, higher-throughput, and improved availability. An SD-WAN can also securely segment student, teacher, administrative, and guest traffic, thereby protecting privacy. Aggregating links and automatically managing QoS and bandwidth can ensure live streaming of audio and video for classes reliably and cost effectively.
- **Hospitality:** SD-WAN can provide multiple broadband connections simultaneously to improve internet performance and availability for guests, thus boosting customer satisfaction and brand loyalty. It can also be used to optimize high bandwidth data support for such services as video conferencing and collaboration applications by allocating capacity on demand for events, seminars, exhibitions, and conferences.

- **Technology:** Higher bandwidth at lower cost and multiple bonded links can provide improved real-time collaboration, remote access, and accelerated database backup, thus boosting employee satisfaction and productivity on a consumption-based model.

Other enterprise use cases for SD-WAN include:

- Supporting video streaming and collaboration applications and interfaces with new managed unified communication and collaboration (UC&C) services.
- Providing dynamically segmented networks, such as WiFi and VLAN.
- Faster deployment and optimization of WAN bandwidth with automated self-provisioning, providing network programmability and customization.
- Maximizing value from server virtualization.
- Elastic web scaling for cloud service providers by supporting multitenant network environments managed from a centralized controller, enabling deployment of common network resources for individual customers with dynamic rapid scaling provided automatically (no need for manual intervention).
- Providing new virtual datacenter security services.
- Providing enterprise IT with real-time visibility to application dependencies and traffic congestion as well as network analytics (for diagnosing problems before they result in costly outages and for automatic dynamic load balancing and traffic shaping).
- Supporting the Internet of Things (IoT) and other digital services with the aim of integrating these services into the SD-WAN architecture to make setting up and managing IoT networks easier and more cost effective.

FUTURE OUTLOOK

Market Opportunity

The combination of SDN (which allows the dynamic programming of networks) and NFV (which brings about network function decomposition and programmatic orchestration) in conjunction with SD-WAN services disrupts the legacy architecture and management of enterprise networks by offering greater agility, security, availability, and scalability.

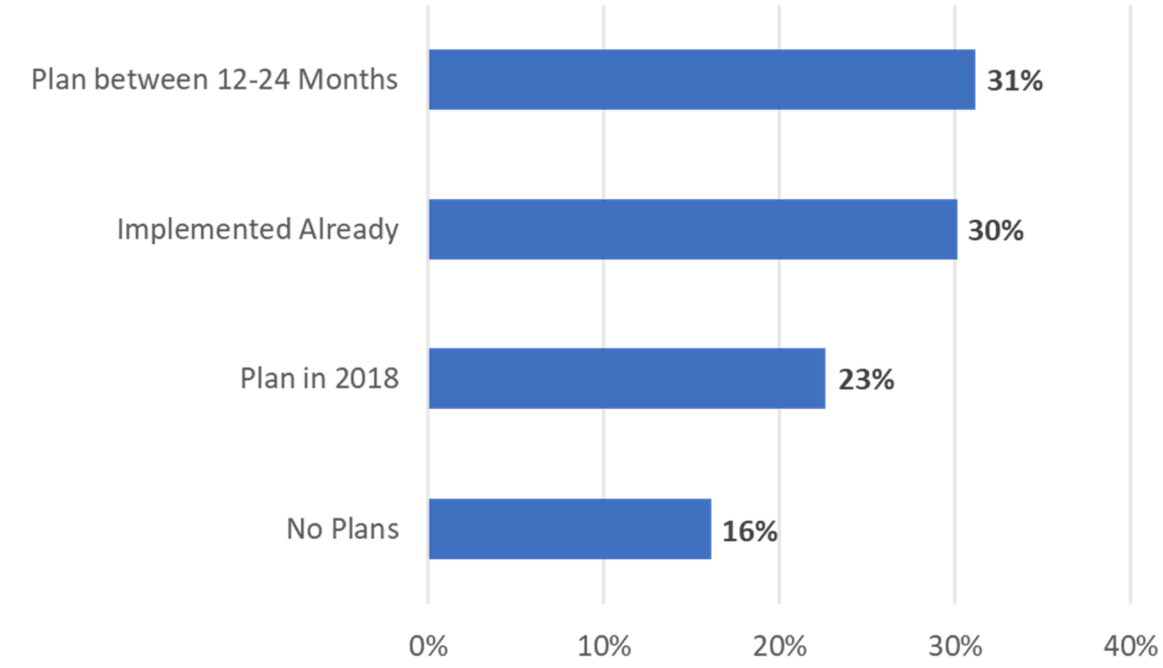
Enterprises across the Middle East and Africa (MEA) are increasingly transforming their businesses to achieve lower TCO with greater operational efficiency and flexibility. A key part of the region-wide transformation trend is the gradual adoption of SDN and NFV technologies, which helps to underpin organizations' critical DX goals. NFV is expected to become a mainstream architecture for service providers' infrastructure in the near future. As more is demanded of existing legacy networks, NFV functionality will be increasingly applied to existing hardware to manage the surge in workloads.

Organizations are becoming more aware of the value propositions entailed by adopting SDN technology, such as achieving their business objectives more quickly, with improved TCO and/or ROI, management, and security. A recent IDC survey among CIOs in MEA revealed that a little over 30% have already implemented some form of SDN solution, while approximately 23% expect to implement SDN in 2018. A little over 31% cited plans to implement in the next one to two years.

FIGURE 3

SDN Implementation Plans of MEA Organizations

Q. Has your organization already implemented SDN? If not, are there plans in place to implement it in the future?

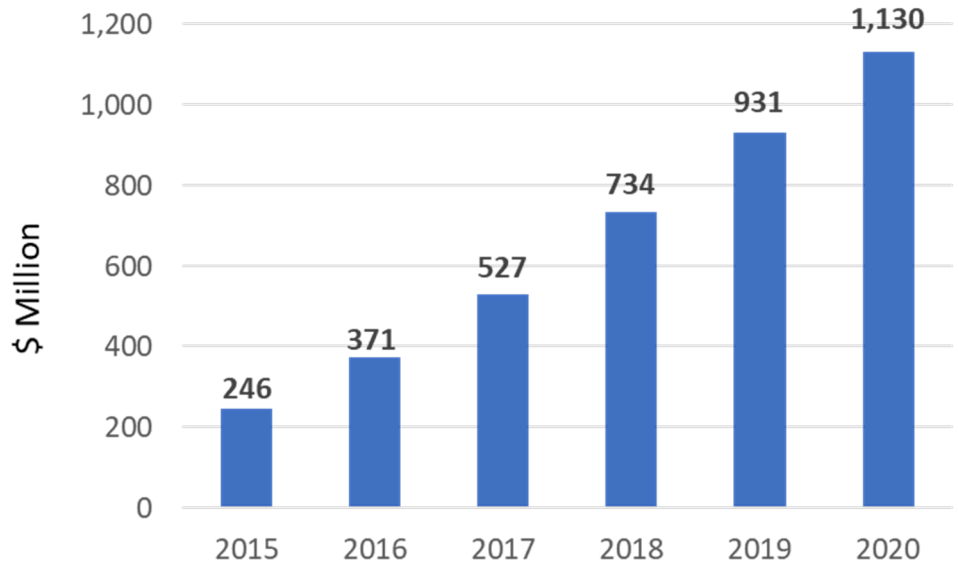


Source: IDC MEA CIO Summit Survey, 2018

NFV serves as a standard approach for optimizing network capacity in the enterprise by implementing software-defined infrastructures that use general IT hardware in communications SP domains. NFV spending in the MEA region is expected to grow from $527.10 million in 2017 to $733.80 million in 2018, representing year-on-year growth of 39.2%. This is no surprise, as an increasing number of SPs race to virtualize and adopt software-based networking architectures to accelerate their digital transformation journey, in addition to staying competitive in an environment increasingly dominated by web and cloud services. Figure 4 below depicts the expected NFV market opportunity for MEA over the coming years.

FIGURE 4

MEA NFV Revenue ($M), 2015—2020



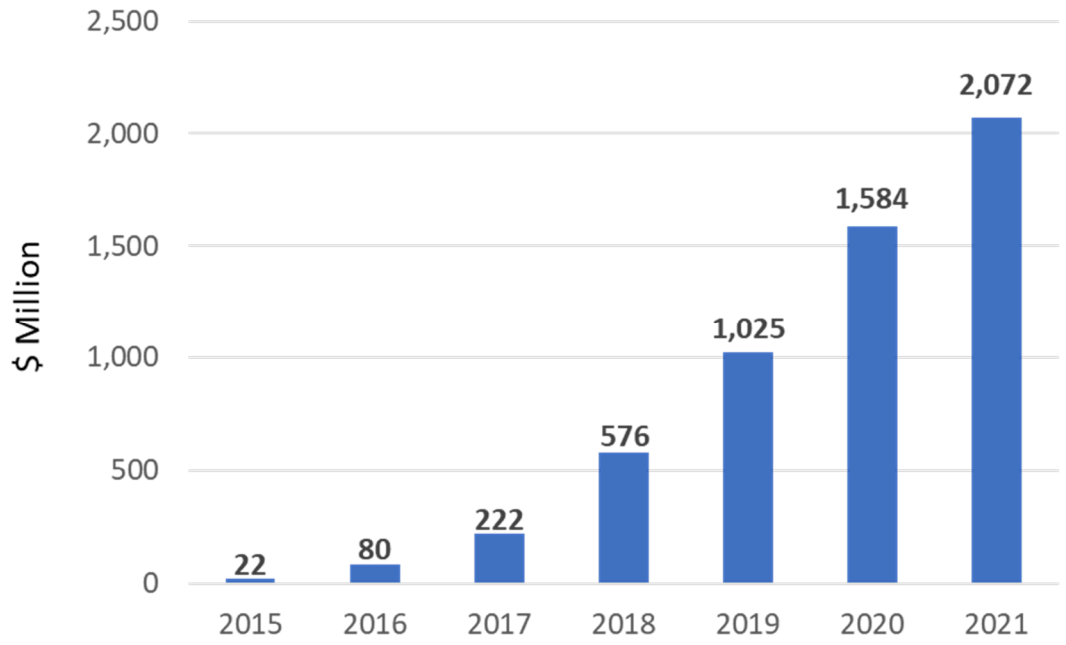
Source: IDC, 2018

Enterprises aiming to increase their competitive advantage through digitalizing their operations, processes, and go-to-market strategies will need to be supported by the evolution of WANs. As a result, organizations are increasingly demanding cost-effective WAN solutions that can help them effectively meet rapidly growing network requirements.

The emerging SD-WAN market in Europe, the Middle East, and Africa (EMEA) was valued at about $222 million in 2017. The market is poised to grow 159.5% year on year in 2018 to reach $576 million. The SD-WAN market in EMEA is expected to post a compound annual growth rate (CAGR) of 91.7% between 2016 and 2021 to reach a total of $2.1 billion, as shown in Figure 5 below.

FIGURE 5

EMEA SD-WAN Revenue ($M), 2015—2021



Source: IDC, 2018

There is increasing support for SD-WAN implementations, with many start-ups, established vendors, and service providers jumping on the bandwagon. For organizations, the rationale for adoption is compelling, and the range of benefits will only continue to grow as the solution matures.

Essential Benefits to Businesses

SDN and NFV offer significant economies of scale. Most of the issues faced by enterprises with over-subscribed ports, under-subscribed ports, or too few ports are eliminated when software functionality is introduced to replace physical, single-function network devices. In a software-driven infrastructure, updates, upgrades, and changes are all faster and much easier. The following are immediate benefits that enterprises stand to gain from deploying SDN- and NFV-based solutions:

Real-time bandwidth scalability: In an SDN/NFV network architecture, the underlying network is automated to enable enterprise users to scale their network bandwidth in real time as often as needed, much like that of virtual machine provisioning. For example, if an enterprise needs to increase bandwidth on its network when connecting its on-premise datacenter to a hosted cloud datacenter for bi-weekly backups, it could configure bandwidth on demand for the required duration. This functionality does not just reduce network costs, but also offers network procurement flexibility.

Network resilience: The ability to offer enhanced SLAs by aggregating links and types of links (e.g., Internet and 4G/5G) provides enterprises with improved availability and mitigates unplanned and often costly network outage.

Network optimization: The ability to introduce acceleration and compression features to enable applications to respond better and optimize the throughput, as well as enabling QoS policies to segment traffic based on type and priority, depending on the connections available.

Reduced installation times: As with traditional network architectures, installation and delivery time can be lengthy, due to a number of factors that may include: evaluating the site for readiness; ensuring all

the required network elements are in place; logistics regarding hardware to be installed at the customer site; and actual network configuration. That said, NFV and SDN can reduce the amount of time needed to automate network processes. The combination of SDN and NFV functionalities can accelerate the provisioning of virtual CPE and network resources in near real time, as opposed to several months in the case of traditional network architectures. Nevertheless, software-based network solutions give enterprises the ability to deploy network resources faster based on ever-growing business demand. Telcos can offer software-defined wide area networking (SD-WAN) through a self-service portal that can then automatically be activated across mixed networks and across virtual or physical components.

Built-in security: In a software-based network architecture, SDN controllers provide the capability to apply uniform security policies across services, and to effectively deploy additional security measures, in real-time, given it is in the virtual machines. Key security aspects of SDN and NFV-based network solutions include:

- Automated security patching, which involves giving network administrators the ability to efficiently set up policies for security patches to happen at scheduled times depending on business peak periods.
- Traditional security measures practiced by network administrators are still prone to growing sophisticated security threats. Given the capabilities offered by SDN controllers, network administrators can effectively introduce security at virtual machine level to ensure the necessary level of security on critical enterprise applications.
- In the case of a DDoS attack on a virtual machine (such as a router or a firewall) with Virtual Network Function (VNF) or an SDN controller, the affected virtual machine can be quickly detected, isolated, shut down, quarantined, and replaced by dynamically initiating another virtual machine on the network in real time and with almost no downtime. With such capability, resiliency and reliability of infrastructure can be quickly restored by enterprise IT teams in different locations by initiating identical virtual machines.
- SD-WAN includes built-in encryption capabilities that would otherwise be provided by multiple appliances and at additional costs.

Reduced TCO and operational complexity: SDN/NFV implementation eliminates the need for proprietary hardware, which is usually expensive and time consuming to procure, and facilitates the ability for routers, switches, firewalls, load balancers, content delivery systems, end-user devices, and almost any other network function to run as software on virtual machines. The ability to run these network functions on commodity servers can result in high cost savings, and enhance the service provider's ability to quickly deploy services to enterprises in a limited amount of time. Currently, managed CPE services that are offered with IP-VPNs, Ethernet, and managed security services account for a significant share of enterprise investment in network services. However, SDN/NFV-based services facilitate the move from dedicated hardware to virtual CPEs, which can be deployed in minutes at lower cost than physical hardware and help simplify network management activities for IT teams.

Guidance for Businesses

Other than evaluating the capabilities of SDN/NFV/SD-WAN, enterprise IT teams should consider a number of essential factors to enable them to attain the full benefits of deploying these technologies. It is important to accurately determine branch site virtualization needs and the requirements of applications intended to be used on the SD-WAN to foster implementation of sufficient virtualization capacity while avoiding wasteful over-provisioning of virtual machines. With a growing number of dynamic application requirements in the age of digital transformation, it is increasingly important to deploy virtualized network infrastructure with elastic provisioning capability. To eliminate uncertainty in the network over which corporate data is transferred, enterprises must look to deploy SD-WAN solutions with robust analytics capabilities that provide data on critical metrics (such as application

performance, path status, latency, and packet loss, among others) and to allow enterprise IT teams to detect anomalies and act in real time.

Furthermore, aside from a technology standpoint, it is extremely important to understand that telcos stand in a unique position as a key driving force for SD-WAN adoption given that they already have existing infrastructures and skillsets to provide end-to-end solutions to mitigate enterprises' OPEX and CAPEX costs, including the ability to fulfil comprehensive SLAs. In addition, telcos are well positioned to provide a gradual migration plan from currently installed traditional WAN solutions, as many organizations in the UAE might favor a gradual adoption of SD-WAN over a sudden big-bang approach.

Telcos are also better placed to provide SD-WAN as a managed service owing to their experience in providing managed connectivity solutions, and they are well versed with QoS and SLA requirements for connectivity solutions. For enterprises, managed SD-WAN services will allow them to transition to OPEX models and avoid the risk of managing complex technology and network roadmaps. Enterprises should reach out to their service providers to better understand their offerings, specific features, and tool sets, as well as their level of support services in providing end-to-end solutions to fulfill their SD-WAN business needs.

CHALLENGES

While SD-WAN has many benefits, enterprise adoption of the service has been slow and cautious. Operating a hybrid network that consists of both physical and virtualized technologies is sufficiently complex to serve as one of the key hindrances to the adoption of SDN/NFV technologies.

Although software-defined technologies are known to significantly reduce operational costs due to automation, a growing challenge facing organizations is the need to effectively implement complete operational transformation across lines of business (LoB) and the IT department. The following are key inhibitors to enterprise adoption of software-centric network solutions:

- **Technical skills:** In the past, enterprise IT teams were trained to correspond with technology silos such as network infrastructures, storage, servers, and virtualization. Currently, such specialization is insufficient, as a growing number of technologies converge on a single appliance combining SDN/NFV capabilities. Therefore, IT professionals must have skills that span multiple technical domains, as well as experience in software management, troubleshooting, and developing applications that take full advantage of network programmability. It is challenging enough to train someone to address all these requirements, let alone finding a single professional who already possesses the requisite skills set.
- **Organizational structure:** With networking and datacenter technologies converging into single appliances that are embedded with virtualized solutions, it is necessary for isolated technology silos to be eliminated over time. For example, organizations operating in silos could run into outage problems if there is no unified team in place to manage stacks of controllers hosted in a telecom SP's cloud or public cloud environment.
- **Cultural shift:** The increasing change in network infrastructure from traditional hardware boxes to software-based, programmable, automated, and converged architectures makes SDN/NFV/SD-WAN disruptive in nature. To gain a competitive advantage and continue delivering superior customer experience while going through the transformation process, a different mindset is necessary. It is important to acknowledge that enterprise IT teams will require a significant amount of training and hands-on experience before they can comfortably and competently manage hybrid and converged solutions.
- **Unclear ROI:** Another key challenge for enterprises aiming to adopt SDN/NFV/SD-WAN technology is uncertainty regarding the quantifiable value of the implementation. The promise of increased agility and reduced CAPEX/OPEX can seem vague when the solution is not tied to a specific use case and no clear ROI has been established. One way to mitigate this

inhibitor is to carefully study SDN/NFV/SD-WAN solutions before investing and select the one (or more) that can demonstrably satisfy critical business requirements. The total cost of ownership will vary from use case to use case, depending on such factors as deployment model, WAN costs, resourcing costs, and business needs.

CONCLUSION

NFV and SDN will continue to play a pivotal role in providing new business models, thereby creating new opportunities for both existing and new providers. That said, usage-based charging models and deeper insight into security, privacy, and location can also be gradually introduced. Given the implementation flexibility offered by SDN/NFV/SD-WAN, service catalogs and marketplaces could be created alongside roles for users (such as service brokers). Government regulations may also evolve to ensure transparent network operation.

For enterprises considering implementation of SDN/NFV/SD-WAN solutions, it is important to understand that it is a journey, an ongoing process rather than a one-time initiative. As such, it should not be abandoned if ROI is not realized as quickly as it may have been with previous IT implementations. Beyond the freedom from vendor lock-in, other benefits (such as ROI) are likely to be evident only in the longer term. Different solutions will be offered by various vendors and service providers each providing different feature sets, SLAs, and support contracts, and understanding the underlying details will therefore be necessary to maximize value and reduce risks. It is recommended that enterprises work closely with service providers that already have proven capabilities in managed services, as well as experience in providing extensive end-to-end connectivity solutions. They should also be well-versed in QoS and comprehensive SLAs to support critical business requirements.

Furthermore, SDN, NFV, and SD-WAN are positively disrupting the traditional vendor business model, moving it from a siloed proprietary vendor stack (primarily CAPEX, licensed-based, and AMC models) to a hybrid, multi-vendor model based upon OPEX and more extensive SLAs. This will facilitate a much lower barrier to entry for adoption, as providers will be able to offer services based entirely on software coupled with open-source capabilities.

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