The 2017
Guide to WAN Architecture & Design

Part 1: State of the WAN

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Executive Summary

The wide area network (WAN) is a critically important topic for number of reasons. Those reasons include:

- The latency, jitter and packet loss that is associated with the WAN often cause the performance of applications to degrade;
- The WAN can be a major source of security vulnerabilities;
- Unlike most of the components of IT, the price/performance of WAN services doesn't obey Moore's Law;
- The outage of a WAN link often causes one or more sites to be offline;
- The lead time to either install a new WAN link or to increase the capacity of an existing WAN link can be quite lengthy.

A discussion of wide area networking is extremely timely for two reasons. One reason is that for the first time in well over a decade the wired WAN is the focus of considerable innovation which is leading to the deployment of a wide range of new WAN-related products and services. The second reason is that on a going forward basis, the WAN needs to support a new set of requirements such as providing connectivity to a growing number of mobile workers and public cloud providers as well as to the Internet of Things (IoT).

The primary goals of the 2017 Guide to WAN Architecture and Design (The Guide) are to make enterprise network organizations aware of the emerging alternatives to the traditional approaches to WAN architecture, management and security and to help them understand the key differences in those alternatives.

The Guide will be published both in its entirety and in a serial fashion. This document, Part 1, is the first of the serial publications and it will focus on providing insight into the current state of the WAN. This document contains the results of a survey that was distributed in May of 2016. Throughout The Guide the network professionals who completed the survey will be referred to as The Survey Respondents.

The remaining sections of The Guide will be:

- Part 2

  This section will contain the description of a hypothetical company called NeedsToChange. Each sponsor can embellish the description of NeedsToChange to bring out any reasonable characteristics of the overall WAN environment. This section also contains how each of the sponsors suggests that NeedsToChange should evolve its WAN.

- Part 3

  This section will have two primary sub-sections. One sub-section will summarize the key WAN architecture, management and security considerations that were brought out in Part 2. The second sub-section will be a detailed call to action.

- Complete copy

  The final publication will consist of an executive summary and Parts 1 – 3 as described above.

The role of the WAN and of a WAN Architecture

The primary objective of a WAN is to enable business operations in a frictionless, cost-effective manner. This includes supporting the existing business models as well as changes to those models, such as those brought about by the transformation to become a digital business. To accomplish that objective, the WAN must support the existing applications as well as new applications and the adoption of new application architectures, such as those based on cloud native applications.

Applications make varying demands on a WAN based on the application's:

- Location: On premise, cloud based or a combination
- Business criticality;
- Sensitivity to transmission impairments;
- Security risk;
- Time criticality;
- Compliance requirements;
- Bandwidth requirements;
- Type of user: fixed or mobile or a combination.

The role of a WAN architecture is to enable an organization to deploy a WAN that can adapt quickly to changing business and technical requirements and to respond appropriately to application demands. In order to be effective, a WAN architecture must:

- Ensure acceptable levels of application performance and availability;
- Provide monitoring and management functionality that enables the organization to plan for the deployment of new functionality and to perform rapid root cause analysis and remediation;
- Provide appropriate security;
- Be cost effective.

WAN Evolution

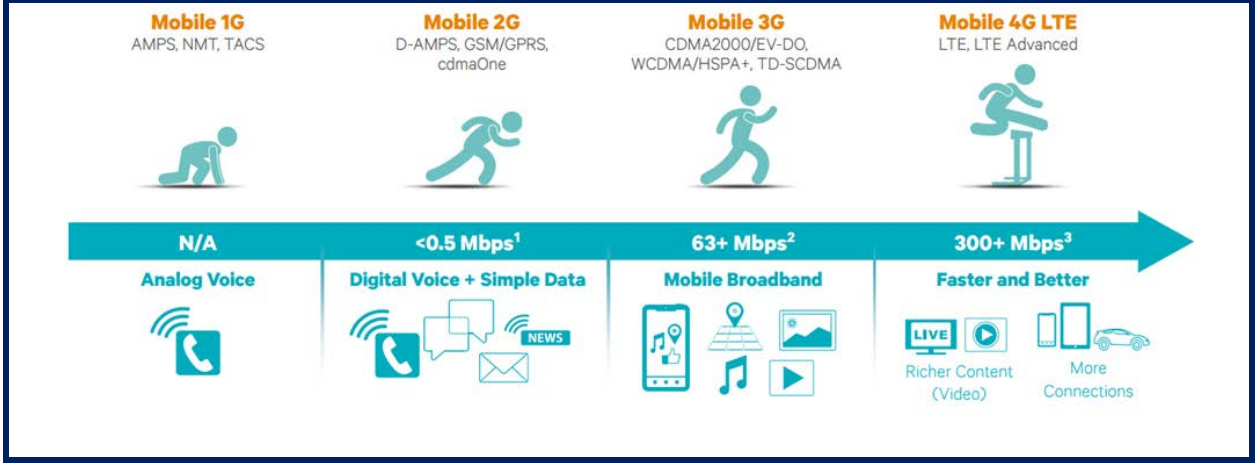
The modern WAN got its start in 1969 with the deployment of the ARPANET which was the precursor to today's Internet. The technology used to build the Internet began to be commercialized in the early 1970s with the development of X.25 based packet switched networks. The Internet itself got commercialized in the 1990s with the advent of the World Wide Web.

In addition to the continued evolution of the Internet, the twenty-year period that began around 1984 saw the deployment of the following four distinct generations of wired WAN technologies and services:

- Mid to late-1980s: Integrated TDM-based WANs;
- Early 1990s: Frame Relay;
- Mid to late 1990s: ATM (Asynchronous Transfer Mode);
- Early 2000s: MPLS.

The early to mid-1980s also saw the beginning of the deployment of four generations of cellular services. **Figure 1** depicts the evolution of cellular services from the 1G services of the 1980s to the current generation of 4G LTE services. The next generation of cellular services, denoted 5G, should be in production in the 2018 to 2020 timeframe.

Figure 1: Evolution of Cellular Services



WAN services that were based on Ethernet technology, such as Carrier Ethernet, began to be deployed in the early 2000s primarily to support high speed connectivity in a metropolitan area. These services are also used in some instances for high speed Internet access and to interconnect data centers.

Why is this important?	Unlike virtually every other components of IT, there have been very few if any advances in wired WAN technologies and services for over a decade. Because the types of challenges that the WAN must respond to have evolved significantly during that time frame, there is a pent up demand for new WAN solutions.

WAN Use Cases

The vast majority of WAN use cases can be put into three broad categories:

- Connecting a distributed set of people and devices to centralized resources;
- Connecting multiple data centers;
- Providing peer-to-peer connectivity.

Connecting a distributed set of people and devices to centralized resources

Over the last twelve to eighteen months the vast majority of what has been written about the WAN has focused on providing connectivity between the users in a branch office and the resources they need to access, whether those resources are in a corporate data center or at a public cloud provider's facility. Some of the challenges of this use case are to minimize cost and to provide secure Internet access.

There are, however, other important use cases in this category. That includes supporting:

- Home users;
- Mobile employees;
- The IoT.

The challenges that are associated with the three use cases listed above are somewhat different than the challenges that are associated with providing branch office connectivity. This follows in part because in each of the use cases listed above it is more difficult, if not impossible, to implement distributed functionality to improve performance, management or security. In addition, similar to supporting mobile workers, in many instances supporting the IoT requires the use of cellular services which have notably different characteristics than do wireline WAN services.

Connecting multiple data centers

In the not too distant past, the primary use cases in this category were disaster recovery and business continuity. While those are still important use cases, another important use case, supporting the movement of workloads between data centers, has recently emerged.

This category of WAN use cases has a number of key characteristics that differ from the preceding category including the requirement for significantly more throughput and in many cases, for higher availability. This category of WAN use cases also introduces protocols that are not found in other categories and this category is often associated with WAN services, such as Carrier Ethernet, which have little relevance to the other categories.

Providing peer-to-peer connectivity

In contrast to the other categories of WAN uses cases, in a peer-to-peer WAN, tasks are partitioned between peers. Peers typically make a portion of their resources, such as processing power, disk storage or network bandwidth, directly available to other network participants, without the need for central coordination.

One key use case of a peer-to-peer WAN, file sharing, is often associated with illegal activities. However, there are legitimate instances of this use case such as Lion Share which enables

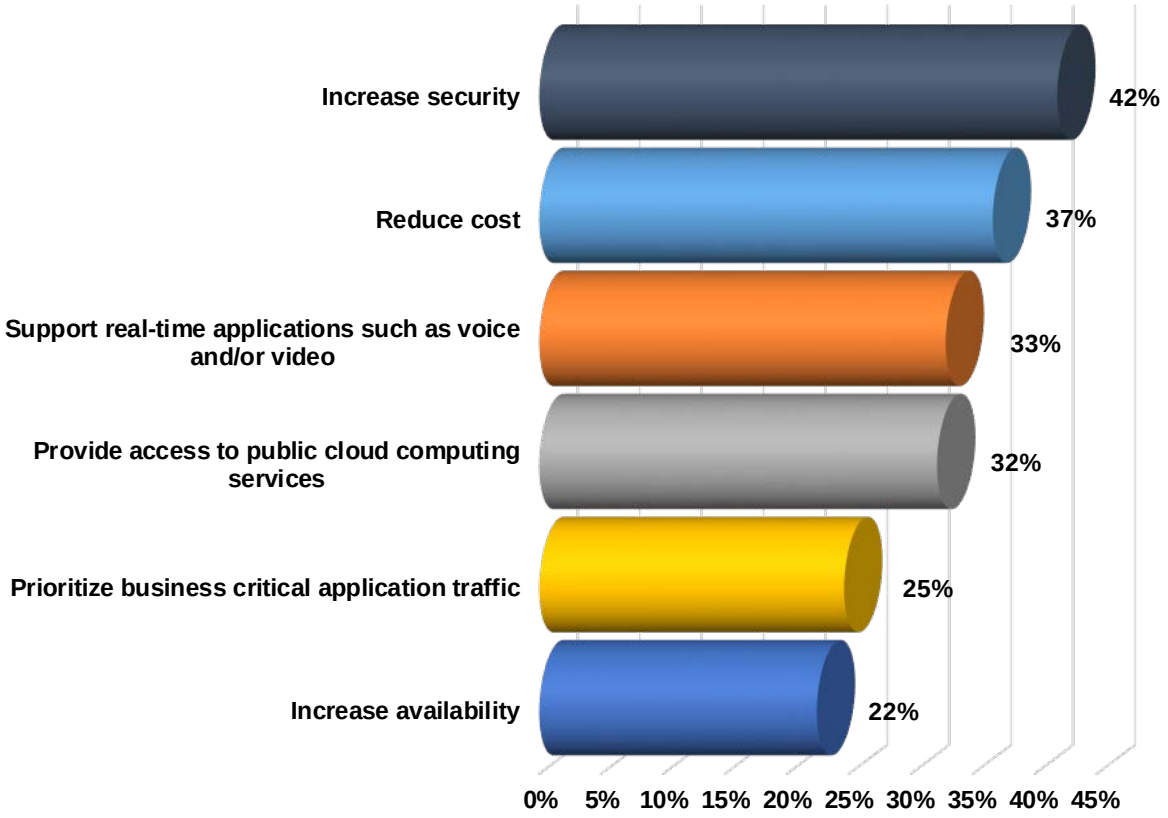
academic institutions to share scholarly documents. A number of emerging applications also use peer-to-peer WANs. This includes Spotify which uses a peer-to-peer network along with streaming servers to stream audio and video to their clients. It also includes Bitcoin and other alternative currencies such as Peercoin and Nxt.

Why is this important?	For the foreseeable future there will not be a WAN solution that is optimal for all organizations. The optimal WAN solution will depend on a number of factors, including the use case(s) it has to support. 

Factors Impacting the WAN

The Survey Respondents were presented with fifteen factors and asked to choose the three factors that would likely have the most impact on their WAN over the next twelve months. The factors that were the most important are shown in **Figure 2**.

Figure 2: Top Five Factors impacting WAN



If there is a mild surprise in **Figure 2** it is that a third of The Survey Respondents indicated that providing access to public cloud services is one of the top factors impacting their WAN. This is a bit of a surprise only because unlike the other factors in **Figure 2**, until recently providing access to public cloud services was seldom mentioned as a factor driving change in the WAN.

It was not surprising that eighteen percent of The Survey Respondents indicated that supporting mobile users is one of the top factors impacting their WAN. However, an important and somewhat surprising result that is not shown in **Figure 2** is that sixteen percent of The Survey Respondents indicated that supporting the IoT was one of the top factors impacting their WAN. This is surprising only in that the vast majority of companies are just beginning to feel the impact of the IoT and this impact will likely increase significantly over the next few years.

Why is this important?	In order to justify the cost and the risk of implementing a new WAN solution, that solution must enable organizations to respond to at least some of the challenges shown in **Figure 2**.

Concerns with WAN Services

As discussed in *The 2015 Guide to WAN Architecture and Design*, network organizations currently make relatively little use of wired WAN services other than MPLS and the Internet and the use they do make of those other services is decreasing somewhat rapidly. That report also identified the concerns that network organizations have with those two services. Those concerns are shown in **Table 1** in descending order of importance.

Table 1: Concerns with WAN Services

Concerns with MPLS	Concerns with the Internet
Cost	Security
Uptime	Uptime
Latency	Latency
Lead time to implement new circuits	Cost
Security	Packet loss
Lead time to increase capacity on existing circuits	Lead time to increase capacity on existing circuits
Packet loss	Lead time to implement new circuits
Jitter	Jitter

Wireline services are not the only WAN services that have limitations. Some of the limitations that are associated with cellular services include:

- Variable signal coverage;
- Link setup latency;
- Constantly evolving specs (3G, 4G, LTE, XLTE, 5G);
- Security;
- Supporting multiple carriers simultaneously.

Why is this important?

In order to provide value, any WAN solution that is comprised of multiple WAN services, whether they are wired or wireless services, must maximize the advantages of each service while simultaneously minimizing their disadvantages.

Satisfaction with the Current WAN Architecture

The Survey Respondents were asked to indicate how satisfied their organization was with their current WAN architecture. Their responses are shown in **Figure 3**.

Figure 3: Satisfaction with current WAN architecture

Why is this important?

As shown in **Figure 3**, only a third of organizations are either very satisfied or completely satisfied with their current WAN architecture. This indicates that a large portion of the WAN marketplace would likely be receptive to alternative WAN architectures.

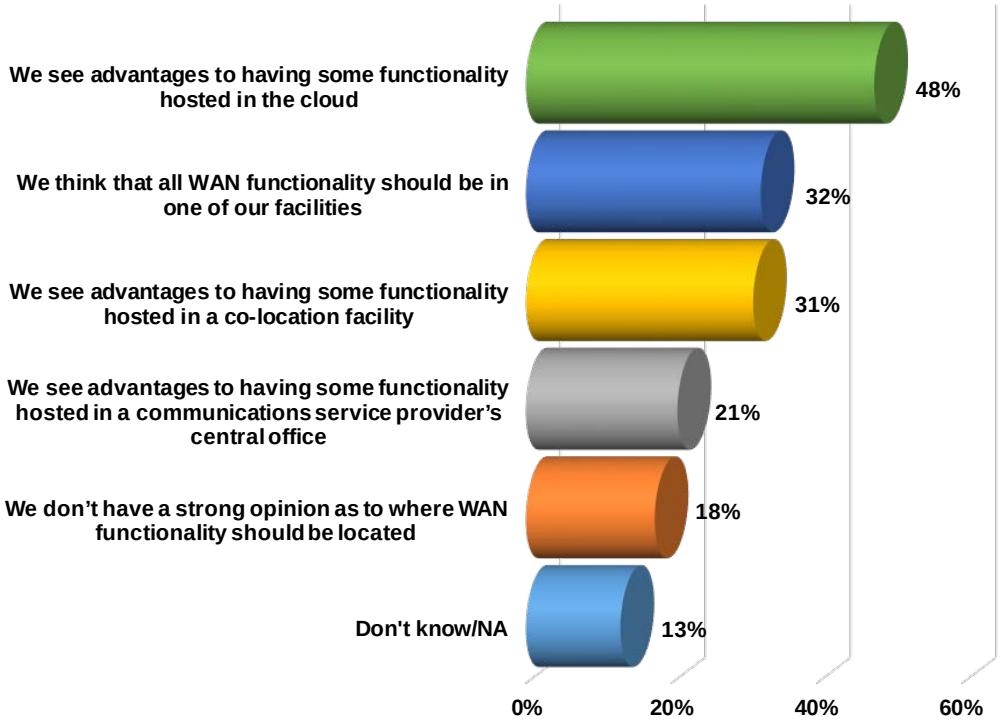
Location of WAN Functionality

In contrast to traditional WAN architectures, in the emerging WAN architectures there are a number of places to host functionality such as orchestration, control and security. Those locations include:

- At the customer's branch offices;
- In a service provider's central office;
- At the customer's regional office or data centers;
- In a cloud site provided by a vendor;
- At a co-location facility;
- At a public cloud provider's facility.

The Survey Respondents were asked to indicate where their organization thinks that WAN functionality such as control, optimization and security should be located, and they were allowed to indicate multiple places. Their responses are shown in **Figure 4**.

Figure 4: Location of WAN Functionality



Why is this important?

Figure 4 indicates that a sizeable percentage of The Survey Respondents either didn't know where their organization believes that key WAN functionality should be hosted or they worked for an organization that didn't yet have a strong opinion. However, looking just at those organizations that have an opinion shows that many network organizations are receptive to a range of options relative to where WAN functionality is hosted. It also shows a strong interest in having some WAN functionality hosted in the cloud.

Choice of Implementation Options

When network organizations evaluate new WAN solutions they have a variety of implementation options to consider. This includes:

- Do-it-Yourself

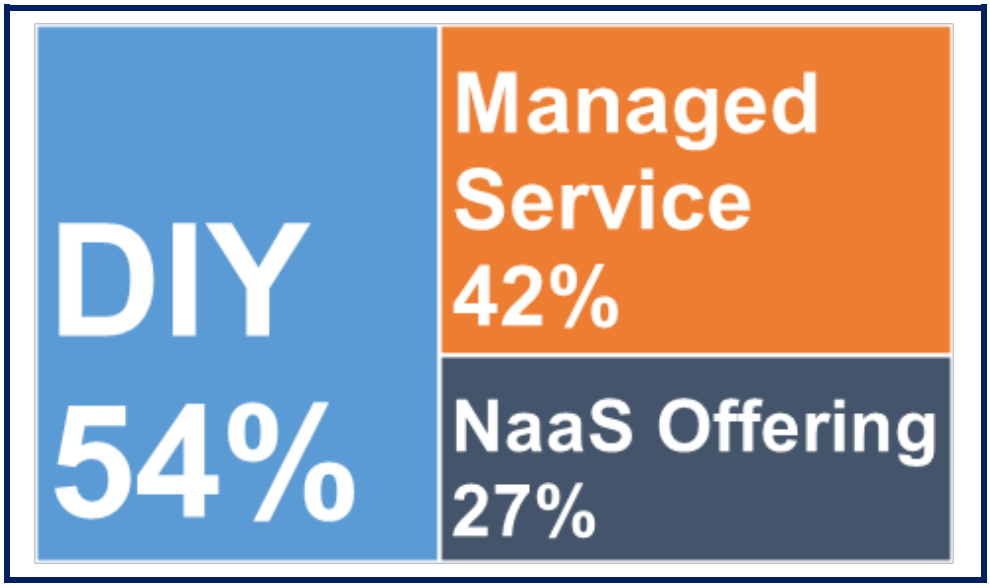
  In the Do-it-Yourself (DIY) option, network organizations are responsible for all facets of the lifecycle of a WAN solution, including the planning, designing, implementing and ongoing management of the solution.

- Managed Service

  In this option a vendor such as a Communications Service Provider (CSP), systems integrator or value added reseller takes on the responsibility for all facets of the lifecycle of a WAN solution.

- Numerous CSPs have either already launched or have announced their intention to launch a Network-as-a-Service (NaaS) offering based on Software Defined Networking (SDN) and/or Network Functions Virtualization (NFV).

The Survey Respondents were asked to indicate which implementation option their organization was most likely to implement and they were allowed to indicate multiple choices.



Why is this important?

One way to look at the survey results is that the DIY option is the preferred option by a relatively wide margin. However, another way to look at the survey results is to observe that the combination of a managed service and a NaaS solution are preferred over the DIY option by a relatively wide margin. In either case, the responses to this question provide further evidence that there isn't a WAN solution that is optimal for all organizations.

Choice of Vendors

Whenever there is a transition point in IT there is the potential that some vendors will gain market share and that some will lose market share. After more than a decade with little change in the available WAN products and services, the emergence or a broad range of new WAN related products and services marks the beginning of a major transition in the WAN market.

The Survey Respondents were asked to indicate how their organization would likely approach the selection of a WAN vendor and they were allowed to indicate multiple choices. Their responses are shown in **Figure 5**.

Figure 5: Interest in Looking for New Vendors

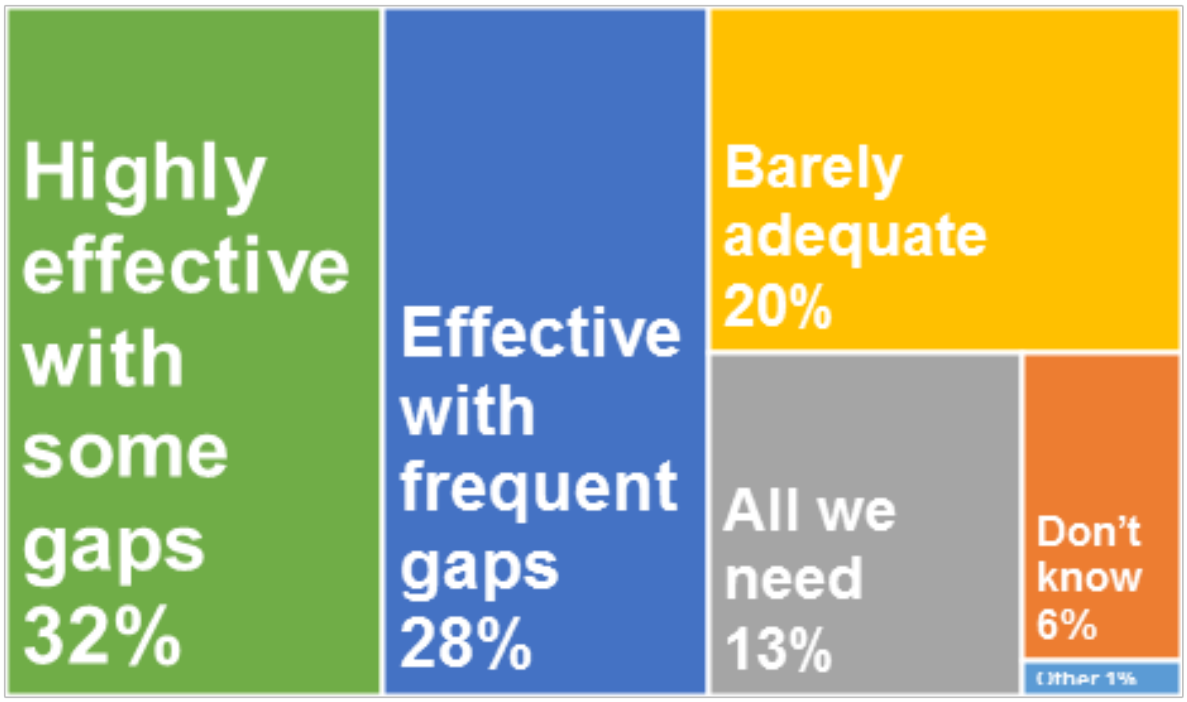
Why is this important?

The fact that only 6% of The Survey Respondents indicated that they would definitely stick with their incumbent vendor(s) and that an additional 13% indicated that it was unlikely that they would stick with their incumbent vendor indicates that many network organizations are receptive to changing WAN vendors.

WAN Management

The Survey Respondents were asked to rate the visibility that their network organization has into their WAN for troubleshooting problems related to network and/or application performance degradation. Their responses are shown in **Figure 6.**

Figure 6: WAN Troubleshooting Visibility



The survey results indicate that only a small percentage of network organizations have all of the visibility they need to effectively troubleshoot WAN performance problems.

As companies continually increase their reliance on the WAN in order to support critical business processes, the inability of the network organization to effectively trouble shoot the WAN will increasingly have a negative impact on those critical business processes. The deployment of new WAN solutions is an opportunity for network organizations to improve their ability to troubleshoot the WAN and hence improve their ability to support the company's critical business processes. The deployment of new WAN solutions also presents network organizations with a challenge. That challenge is that network organizations must have a tool that can effectively manage the new WAN solution throughout its lifecycle. Having such a tool significantly reduces the risk that is associated with adopting a new WAN solution.

As noted, if network organizations want to implement new WAN solutions they need an effective management tool before, during and after that implementation. To exemplify why that is the case, consider the situation in which a hypothetical network organization is interested in potentially adopting a Software Defined WAN (SD-WAN) solution. Prior to beginning its evaluation of SD-WAN solutions, the network organization needs to have an effective management tool that enables the organization to baseline the performance of its WAN and the performance of the business critical applications that transit the WAN. This is necessary so that

the organization has the performance data it needs so that it can evaluate the impact of implementing one or more SD-WAN solutions.

Before deciding to adopt an SD-WAN solution the network organization decides to run a proof of concept (POC) of one or more SD-WAN solutions. The primary goal of conducting a POC is to determine whether or not the solution will provide the promised benefits. The sites that are included in the POC must be chosen in such a way that if the solution is effective there then it will likely be successful in the remaining sites. An effective management tool can help the organization to choose the appropriate sites for the POC based on factors such as application and network usage. An effective management tool also provides insight that helps the network organization determine whether or not the solution provides the promised benefits. Because it provides this insight, the output of an effective management tool is a key input into the analysis that the network organization does to determine if it makes sense to adopt an SD-WAN solution.

While conducting a POC provides insight into the performance of an SD-WAN solution, the amount of insight increases as the network organization begins to implement the solution and more sites and more applications are supported by the solution. Using an effective management tool during the implementation phase of adopting an SD-WAN solution enables the network organization to fine tune its use of that solution. For example, the network organization may use the data generated by that tool to decide to change its policy about which WAN links an application can transit.

Unfortunately, the adoption of new WAN architectures, such as an SD-WAN, has the potential to further complicate the task of ongoing WAN management. As a result, adopting a new WAN architecture further increases the importance of having an effective management tool. One of the reasons why adopting an SD-WAN further complicates ongoing management is because SD-WANs introduce a new device into the WAN which must be managed. That device is referred to as a controller and its role is to support the central management of policy that enables network-wide policy definition and enforcement. One of the management challenges associated with the controller is that under heavy load the controller can add excessive delay. Another challenge is that the communications between the controller and the end devices must now be managed.

Another reason why the adoption of SD-WANs has the potential to further complicate the task of WAN management is that many SD-WAN solutions feature dynamic load balancing of traffic over multiple WAN links. Hence, network organizations that are trying to troubleshoot performance problems with an SD-WAN have a new management question they need to be able to answer. That question is: Which link or links did the traffic transit and how did that change over time?

Why is this important?	Having effective WAN management solutions significantly reduces the risk that is associated with adopting new WAN solutions and it enables network organizations to better support the company's critical business processes. 

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Jim Metzler has a broad background in the IT industry. This includes being a software engineer, an engineering manager for high-speed data services for a major network service provider, a product manager for network hardware, a network manager at two Fortune 500 companies, and the principal of a consulting organization. In addition, he has created software tools for designing customer networks for a major network service provider and directed and performed market research at a major industry analyst firm. Jim's current interests include cloud networking and application delivery.

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