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A Survey on Wide Area Network Optimization Techniques and it's Applications

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ABSTRACT: It is the network that covers a very large geographical area, the most important examples are the global Internet, and these networks usually cover entire countries or entire continents, and are characterized by a huge number of devices and complex design. "WAN" connects different smaller networks, including local area networks. This ensures that computers and their users somewhere can communicate with many devices and users in other locations. Wide Area Network are often created with corporate leased communication circles, as well as educational and government institutions that used Wide Area Network to transfer data to employees, students, clients, buyers, and suppliers from various locations around the world. In this paper, we provide a survey on the state of the art of WAN optimization or WAN acceleration techniques, and illustrate how these acceleration techniques can improve application performance, mitigate the impact of latency and loss, and minimize bandwidth consumption. We begin by reviewing the obstacles in efficiently delivering applications over a WAN. Furthermore, we provide a comprehensive survey of the most recent content delivery acceleration techniques in WANs from the networking and optimization point of view. Finally, we discuss major WAN optimization techniques which have been incorporated in widely deployed WAN acceleration products - multiple optimization techniques are leveraged by a single WAN accelerator to improve application performance in general. WAN optimization technique works to overcome latency, minimize packet loss and increase network throughput.

KEYWORDS: Geographical area, Global Internet, Wide Area Network (WAN), WAN optimization.

I. INTRODUCTION

WAN optimization also known as WAN acceleration is the category of technologies and techniques used to maximize the efficiency of data's flow across a wide area network (WAN), between organizations' centralized data centers and their remote locations. In an enterprise WAN, the goal of optimization is to increase the speed with which end users can access business-critical applications and information, by overcoming network latency, minimizing packet loss and mitigating capacity limitations.

WAN optimization tools have been around since the early days of enterprise wide area networking, when bandwidth requirements first started to exceed availability. At the time, connectivity options were limited, with organizations relying on expensive MPLS links to connect their branch offices and data centres. WAN optimization helped network managers achieve more efficient bandwidth usage -- improving application performance without dramatically increasing spending with carriers.

Although it has evolved over the past several decades, WAN optimization technology is still in use today. WAN accelerator appliances might be physical or virtual, and they may be sold as stand-alone products or as part of software-defined WAN platforms. Vendors include Blue Coat Systems (acquired by Symantec), Cato Networks, Citrix, Riverbed Technology, Silver Peak Systems, F5 Networks and Fortinet, among others.

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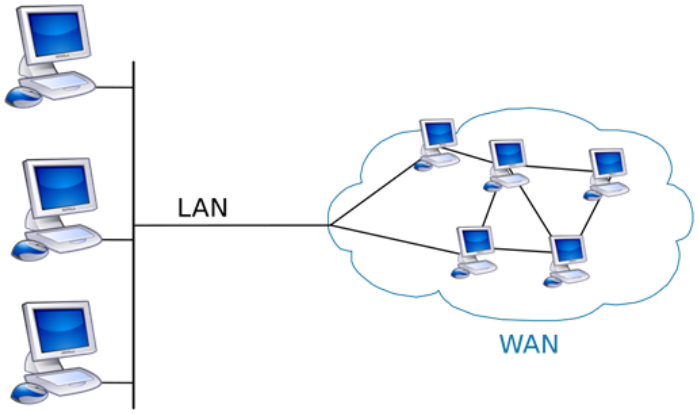

Figure 1: Wide Area Network

WAN optimization works to overcome latency, minimize packet loss and increase network throughput. It accomplishes this via an array of complementary WAN optimization techniques and technologies, including the following:

a. Data caching stores frequently used information on a local host or server for faster access in the future. Because data doesn't have to travel from its point of origin to its destination over and over again, caching lightens the burden on the network.
b. Data duplication identifies and eliminates redundant copies of data. This reduces the amount of information that must be sent across a WAN for remote backups, replication and disaster recovery.
c. Data compression shrinks the size of data to minimize bandwidth use.
d. Network monitoring identifies nonessential traffic. By creating and enforcing rules about downloads and internet use, WAN optimization appliances can prioritize the performance of critical applications over less important ones.
e. Protocol acceleration, or protocol spoofing, minimizes the burden a chatty protocol puts on the WAN. This method works by bundling chatty protocols so they are, in effect, a single protocol -- resulting in fewer packet headers and network handshakes.
f. Traffic shaping prioritizes traffic and allots bandwidth accordingly.

A wide area network (WAN) is a network located within a wide geographical area. “WAN” connects various smaller networks, including local area networks (LAN) and metro area networks (MANs). This ensures that computers and their users somewhere can communicate with multiple devices and users in other locations.

WAN is a type of communication network that may be wired, wireless, or computer network, spanning large geographical areas. WANs are suitable for personal use, organizations or companies operating in different and separate locations spread over large geographical areas, and thus it is necessary for these special sites to connect and communicate with each other in order to share, exchange and manage data or communications between them.

To accomplish this, the company needs a "TSP" telecommunications service provider, which is the abbreviation (Telecommunications service provider) in order to connect the local area networks "LAN" in various locations.

WAN optimization also supports remote and mobile workers. When someone works remotely, they are expanding the WAN and requiring business data to travel further. Without WAN optimization, their connection could be slow. Even simple business processes such as email can become inconvenient to use. If the network is optimized correctly, all employees will be able to access network portals and business information, even if they are connecting remotely. Furthermore, even applications not directly affected by optimization processes can benefit when bandwidth is freed up in relation to other parts of the network. All these benefits increase business efficiency and promote cost savings as a result.

II. WAN VIRTUALIZATION

WAN virtualization combines two or more network connections of any type to create a single, virtual pipe between locations. This enables cost-efficient, high-availability, and high-bandwidth capacity. All aggregated links are active, and the full amount of bandwidth is always available. It can augment or replace expensive private MPLS circuits with low-cost broadband internet links and achieve excellent application performance and reliability, even with congestion events.

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A well-designed WAN virtualization solution will perform dynamic, real-time traffic engineering. It will react subsecond, not only to link failures, but also to congestion-related network problems. WAN virtualization supports both session-based steering and per-packet traffic engineering. The advantage of per-packet traffic engineering is real-time reliability and predictability for all applications. WAN virtualization is more comprehensive than WAN link aggregation. It can easily handle connections with significant differences in bandwidth, latency, jitter, and packet loss. It will also determine where to steer traffic based on current, real-time conditions for each network connection.

WAN virtualization is a term that pre-dates SD-WAN, and has largely been replaced by that term, even though only a small number of today's SD-WAN offerings deliver true WAN virtualization.

WAN optimization is a dual-ended offering that uses a collection of techniques for reducing bandwidth consumption and improving application performance across WANs. WAN optimization as a solution and a market segment was very popular in the 2006-–2016 timeframe as enterprise WAN administrators sought to deal with the limited bandwidth available on frame relay and MPLS WANs in the face of server consolidation at a handful of data centers and/or headquarters. WAN optimization's application-specific proxy technology for Microsoft's CIFS file transfer protocol was useful for improving file transfer performance of older versions of Microsoft's protocol during server consolidation.

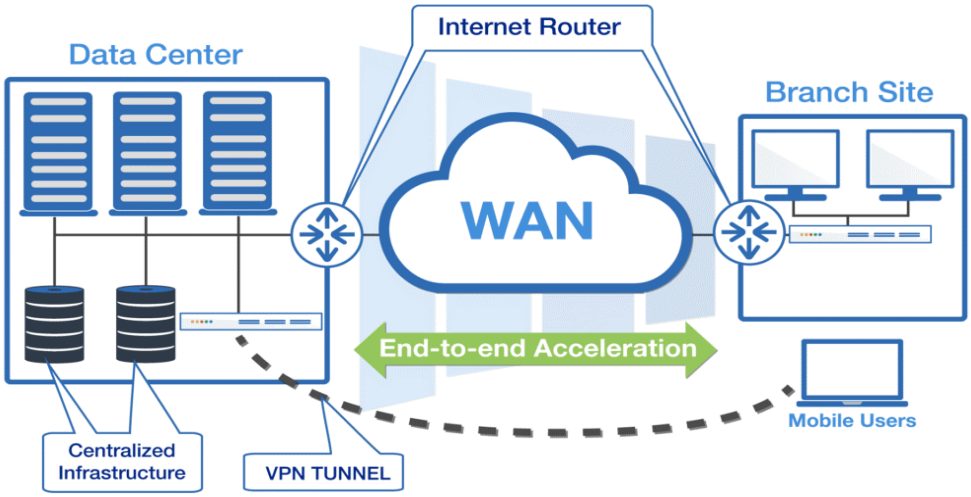

Figure 2: WLAN Virtualization

While there remains a place for WAN optimization technology in a world of high-bandwidth internet links and ever-greater focus on SaaS and cloud access, SD-WANs are generally a better way to solve the problems associated with improving enterprise WANs.

2.1 Optimization Solutions for Office/Data Center Connections

Our solutions are aimed at effective use of WAN. The concept of SDN is applied to WAN in order to integrate physical networks and to enable the virtualization of corporate networks. Then, end user devices of each office are divided into two groups according to the usage priority of the business system. Next, the virtualized corporate network is built while being divided into two categories of priorities - high and regular. Finally the priority controls and bandwidth controls for each virtual network as well as the communication path control for each flow (the packet flow of each business application in the communications between terminals) are carried out. Such functions have achieved the effective usage of bandwidth and optimal efficiency of communication line fee.

Moreover, these solutions achieve network visualization through the centralized control of both physical and virtual networks in order to control traffics per flow-base. This makes it possible to deal with performance incidents much easier, such as deterioration in response time, etc. System maintenance can also be performed easily; thereby operators enable to modify the system without referring to configuration files. This means that operations may be conducted by an operator that has not yet gained advanced technical proficiency. Therefore, our solutions are effective for high-cost communication line.

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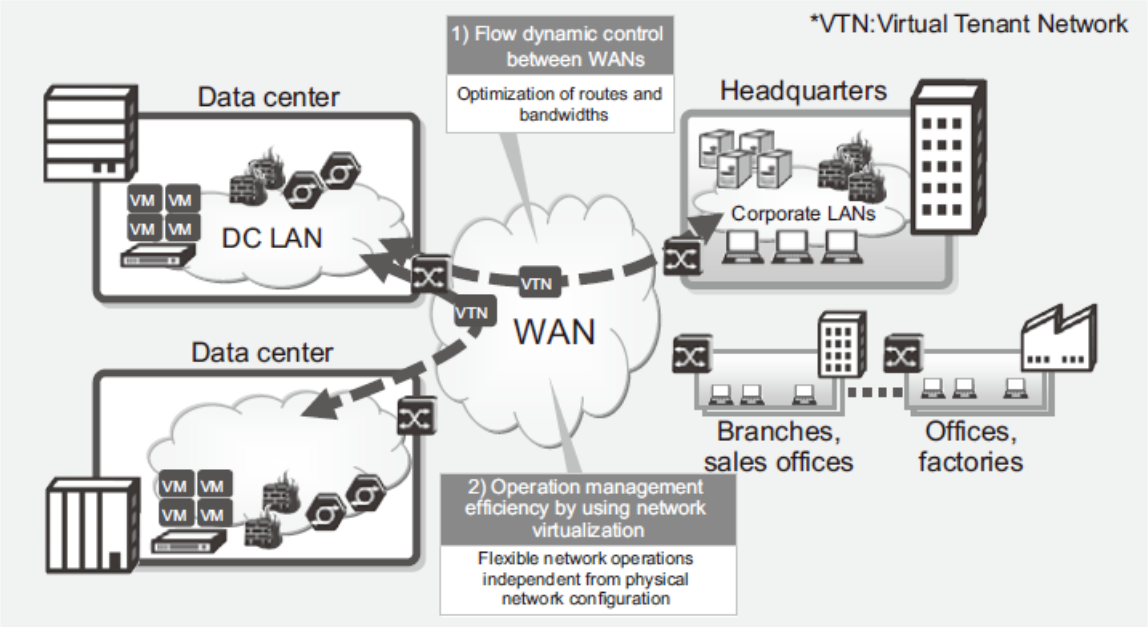

Figure 3: Overview of an optimization solution for an office/data center connection.

III. WAN OPTIMIZATION TECHNIQUES

3.1 SD-WAN and WAN optimization techniques

WAN optimization techniques have helped maximize network throughput for years, while SD-WAN is relatively new. While the two concepts are separate, they can complement each other.

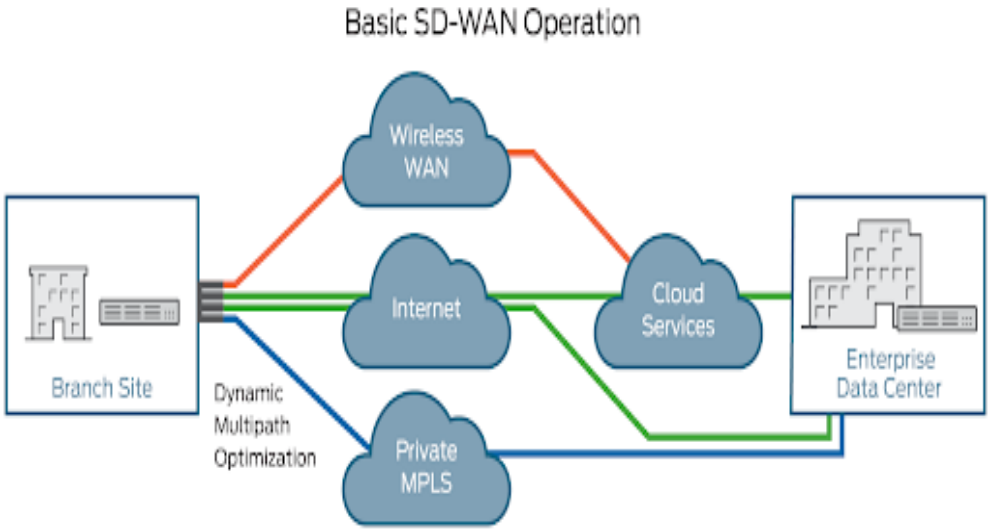

Figure 4: SD-WAN and WAN optimization techniques

3.2 Modern WAN edge services can benefit your network

Modern services could replace legacy routers at the network edge. And while individual WANs have different edge requirements,common needs include flexibility and reliability. As WAN edge infrastructure advances, branch office routers are in danger of losing relevance and agility. By 2023, modernized edge products may replace over half of currently installed branch office routers. According to Gartner's first WAN edge survey of over 60 vendors, routing ceased to differentiate itself from other WAN edge services, and legacy routers are increasingly unable to meet growing business demands. Enterprises may hesitate to transition from traditional network equipment to newer, software-based technologies, due to risk considerations and the paradigm shift. But a new WAN edge market has surfaced since 2014,

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according to Gartner, so networking technology's future lay with these newer technologies. Investing in them now would benefit enterprises in the long run, Gartner said.

Gartner found that investing in modern edge products over branch routers could benefit organizations and redesigning legacy WAN architectures could better support modern products. These products included capabilities from software defined-WAN (SD-WAN), WAN optimization, operations, deployment, small platforms and virtual applications. The survey also highlighted 22 vendors that provide different WAN edge products for regional, global and retail WANs. With these options, organizations are able to implement products thatbest support size requirements of their WAN, which also play a key role as these requirements vary by WAN.

3.3 Modern services available for WAN edge infrastructures

Modern WANs require modern WAN edge products with flexible, customizable and reliable capabilities. The following services offer various deployment and installation options, and they may operate differently for each individual organization.

Routing

Routing is used in integrations for LANs, data centres and carrier environments. While it is a major factor in the network edge, routing is no longer a deciding factor for WAN edge services in branch offices, according to the survey. Most products ranked in the survey met basic routing capability standards, with few vendors offering physical routers as their key WAN edge product.

SD-WAN

SD-WAN streamline and simplifies the number of physical routers needed and allows for a more dynamic edge. SD-WAN include features such as application-based policy configuration, path determination, simplified operational environments and secure provisioning. The key benefits of SD-WAN architectures include better network redundancy, efficient MPLS connections and added flexibility to deploy new services remotely.

WAN optimization

With WAN optimization, features such as TCP optimization, compression and duplication, and application protocol optimization can improve overall application performance. Although some proponents deem WAN optimization unnecessary due to SD-WAN technology it is essential in some WAN edge applications to ensure user expectations are met.

Operations

In its survey, Gartner suggested enterprises use WAN edge services that simplify operational environments compared to the operational environments of traditional branch office routers. Gartner's basic requirements for operational efficiency highlighted configurations that are simple and supportive, use a central controller, are application or business-centric and have zero-touch deployment capabilities.

Deployment

WAN edge services need to have flexible deployment choices such as hardware, software and cloud option because different architectures have different needs. Enterprises with distributed endpoints require reliable connectivity on a network, which leads to a necessity for flexible deployment capabilities.

Small platform and virtual applications

Small platform services need to fit scalability requirements in other words, the service molds to enterprise needs. Also, enterprises can automatically create customizable segments for specific network applications or virtual applications based on performance, connectivity and deployment requirements. These two environment types offer flexibility for different use cases, such as location services, guest Wi-Fi and customer loyalty applications.

3.4 The size of your WAN

Gartner noted three WAN use cases: regional, global and retail WANs. Each has varying requirements for its edge infrastructure. The regional, or midsize, WAN typically supports 50 sites or fewer across a particular region. The global WAN is for multinational organizations that support around 250 to 1,000 different sites. The retail WAN comprises several small footprint locations, such as gas stations and convenience stores. Despite the different sizes, each WAN requires visibility across the network and control over its applications.

However, the WAN edges have their differences. For example, global WANs might require more WAN optimization to lower latency, while regional WANs may not. Global and regional WANs also have to support more sites and applications than retail WANs, so enhanced reliability weighs heavier for them.

3.5 Importance of WAN optimization

Businesses are increasingly facing pressures on their WAN setups due to increased use of cloud computing, applications, and other network-wide technologies such as web portals. The associated increase in traffic across the WAN makes WAN optimization even more important, as network slowdowns can become a major issue if you don’t proactively manage this complexity and volume.

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Numerous different business processes are affected by a slow network. Even simple actions, like employees accessing files, can become unacceptably slow. If the network is dragging, it might take their business-wide file manager a while to load, and then even longer to open the file. Even though it seems like a small, two-minute task, these problems quickly add up.

Meanwhile, admins may have trouble effectively managing and monitoring their network and ensuring network security if they're fighting against inefficient, high-latency network infrastructure. WAN optimization can potentially allow admins and their software tools to more effectively protect all devices and end-users.

IV. APPLICATIONS

Deduplication

Eliminates the transfer of redundant data across the WAN by sending references instead of the actual data. By working at the byte level, benefits are achieved across IP applications.

Compression

Relies on data patterns that can be represented more efficiently. Essentially compression techniques similar to ZIP, RAR, ARJ etc. are applied on-the-fly to data passing through hardware (or virtual machine) based WAN acceleration appliances.

Latency optimization

Can include TCP refinements such as window-size scaling, selective acknowledgements, Layer 3 congestion control algorithms, and even co-location strategies in which the application is placed in near proximity to the endpoint to reduce latency. In some implementations, the local WAN optimizer will answer the requests of the client locally instead of forwarding the request to the remote server in order to leverage write-behind and read-ahead mechanisms to reduce WAN latency.

Caching/proxy

Staging data in local caches; Relies on human behavior, accessing the same data over and over.

Forward error correction

Mitigates packet loss by adding another loss-recovery packet for every "N" packets that are sent, and this would reduce the need for retransmissions in error-prone and congested WAN links.

Protocol spoofing

Bundles multiple requests from chatty applications into one. May also include stream-lining protocols such as CIFS.

Traffic shaping

Controls data flow for specific applications. Giving flexibility to network operators/network admins to decide which applications take precedence over the WAN. A common use case of traffic shaping would be to prevent one protocol or application from hogging or flooding a link over other protocols deemed more important by the business/administrator. Some WAN acceleration devices are able to traffic shape with granularity far beyond traditional network devices. Such as shaping traffic on a per user AND per application basis simultaneously.

Equalizing

Makes assumptions on what needs immediate priority based on the data usage. Usage examples for equalizing may include wide open unregulated Internet connections and clogged VPN tunnels.

Connection limits

Prevents access gridlock in and to denial of service or to peer. Best suited for wide open Internet access links, can also be used links.

Simple rate limits

Prevents one user from getting more than a fixed amount of data. Best suited as a stop gap first effort for remediating a congested Internet connection or WAN link.

An organization that lets its network connection run unmonitored won't have much connectivity after a short while. Optimization of WANs needs to be done so it has the following advantages:

1. Make sure the transmission speeds are optimal.
2. Compress data packets or redirect them to the shortest possible route for the least latencies.
3. Ensure all connected network devices are correctly configured to perform as well as they should.
4. Keep data secure and ensure that complete packets make it to the intended destination safely.

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V. CONCLUSION

In this paper, we have provided a detailed discussion on performance enhancement techniques over a WAN, especially with the focus on WAN optimization, also known as WAN acceleration. WAN optimization is the category of technologies and techniques used to maximize the efficiency of data's flow across a wide area network (WAN), between organizations' centralized data centres and their remote locations. In an enterprise WAN, the goal of the optimization is to increase the speed with which end users can access business-critical applications and information, by overcoming network latency, minimizing packet loss and mitigating capacity limitations.

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