RTT Whitepaper

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Realtime TCP Tunnel (RTT) is a tunneling protocol technology. Appex Networks (“AppEx”) has integrated this tunneling technology into the self-operated SD-WAN network service platform, CloudWAN, which covers the entire globe. The tunnel serves as an SD-WAN overlay, carrying office application traffic for enterprise customers.

1 Why AppEx Develop RTT Tunneling?

Most SD-WAN products in the industry typically use conventional tunneling technologies such as IPSec, SSL, GRE or VxLAN as the SD-WAN overlay tunneling, while AppEx have chosen to develop RTT tunneling for the following reasons.

1.1 Gain Excellent Network Transmission Efficiency

In general, the higher the efficiency of network data transmission, the better the response efficiency and experience of upper-layer applications. However, conventional tunneling technologies like IPSec often have problems with low transmission efficiency and instability, especially in remote or cross-border transmission scenarios, resulting in poor user experience. In order to provide enterprise customers with the best possible transmission quality in various complex network environments, AppEx has abandoned traditional tunneling technologies and instead RTT tunneling technology, which combines ZetaTCP® WAN optimization patented technology and multi-sending and selective receiving optimization technology, with ultimate transmission efficiency.

1.2 Achieve the Real Global Network Coverage

To build a global SD-WAN backbone, it is necessary to balance the available link resources, link quality, and bandwidth costs. In general, developed regions have more high-quality dedicated link resources to choose from, with lower bandwidth costs; Underdeveloped areas, on the other hand, have fewer link resources and even fewer high-quality dedicated link resources available. Pursuing high-quality dedicated links in these areas means extremely high bandwidth costs, which will eventually be passed on to enterprise customers using SD-WAN services. In some extremely underdeveloped areas, there may be no high-quality dedicated line resources available at all, making it a challenge to provide enterprise customers with high-quality SD-WAN backbone access services.

The RTT tunnel, with its ultimate transmission capability, is the key to AppEx's solution to these issues. For underdeveloped areas without high-quality dedicated link resources or with extremely expensive links, the RTT tunnel's ultimate transmission capability enables AppEx to build a backbone network using moderate-quality and lower-cost dedicated or Internet links while still meeting the

quality requirements of enterprise applications. In some usage scenarios where wired link access is not available, AppEx can even provide backbone network access services that meet basic usage requirements by using resources such as 4G/5G mobile network and satellite links.

With the transmission capabilities of RTT, AppEx makes networks a truly global reach.

1.3 Ensure Data Transmission Security

For overall assessment based on cost, efficiency, flexibility, etc., enterprise customers typically access the SD-WAN backbone network service through their existing Internet links using encrypted tunneling technology. If the enterprise office site uses traditional IPSec tunneling technology to access the SD-WAN backbone network, the traffic within an IPSec tunnel needs to be decrypted when it reaches the PoP node on the SD-WAN backbone network. This is necessary so that the user traffic encapsulated inside the tunnel can be routed and matched for the next hop path at the PoP node. Once the next hop path is determined, the user traffic will re-enter the next tunnel. When user traffic needs to run through multiple PoP nodes to reach its destination, this "Decrypting—Encrypting" process occurs multiple times. (Note: in some service provider schemes, if dedicated line resources are used for interconnection between two backbone network PoP nodes on the path, user traffic will directly move in plain text via the dedicated line to the next PoP node). This "Decrypt-Encrypt" process greatly increases the risk of enterprise critical business data being leaked or tampered with when using SD-WAN backbone network services.

To eliminate this risk and ensure the security of enterprise data during transmission, AppEx has implemented "end-to-end encryption" technology in its proprietary RTT tunnel. Enterprise user traffic in the RTT tunnel is encrypted by the CloudWAN CPE deployed in the enterprise office network, and does not require decryption at any CloudWAN PoP node along the path until it reaches the CloudWAN CPE deployed in the destination enterprise office network.

1.4 Switch Path Seamlessly Without Interrupting the Application

When enterprise customer traffic is flowing through the SD-WAN backbone network, there may be situations where a PoP node on the path experiences high load or abnormal faults, which may cause interruptions in user traffic. To ensure the normal operation of enterprise office business, the SD-WAN smart path switching function will generally steer enterprise traffic to other available PoP nodes. However, in the extremely short time during path switching process, SD-WAN solutions based on traditional IPSec tunneling technology often cause a

momentary interruption in the current traffic, which can result in user business interruptions (such as video conferencing) and affect the user experience.

Recognizing this issue with traditional tunneling technology, AppEx has implemented seamless path switching in RTT tunneling, ensuring that user traffic does not interrupt and business is not affected during the transmission path switching process, delivering a smooth network experience for users.

1.5 Adapt to Both High-End and Low-End Equipment

CloudWAN offers versatile usage options to users in enterprise office scenarios. Users can access CloudWAN services by deploying CloudWAN CPEs at office sites, or they can conveniently utilize the services through software clients installed on smart terminals such as computers, mobile phones, and tablets for mobile office scenarios. Additionally, in the enterprise cloud scenario, CloudWAN enables users to access its services by deploying virtualized CPE (vCPE) in the cloud.

Additionally, besides enterprise office scenarios, CloudWAN's system design also considers support for industrial Internet and industrial IoT (IIoT) scenarios. However, in industrial Internet and IIoT scenarios, CPE, vCPE and software client are often not applicable, and CloudWAN services need to be deployed through embedded software.

These various types of scenarios require CloudWAN to have highly adaptable and flexible deployment capabilities on the terminal side. In contrast, using conventional technologies such as IPSec can make it difficult to flexibly adapt to various practical scenarios as IPSec has high requirements to operation systems (OS). RTT tunneling technology fully considers the adaptability to various terminal environments, especially low-resource terminal environments, from the design stage, and can be flexibly deployed in various practice scenarios.

2 RTT Transmission Optimization

RTT primarily ensures its network transmission capabilities through protocol optimization and multi-sending and selective receiving technology.

2.1 Protocol Optimization

RTT incorporates ZetaTCP® patent technology for WAN optimization. ZetaTCP® is a learning-based TCP acceleration technology that uses a dynamic algorithm based on the self-learning of network path characteristics. It continuously observes and analyzes network features in real-time for each TCP connection and adjusts the algorithm according to the learned network features to more accurately determine congestion levels, timelier detect packet loss, and thus appropriately process congestion and recover packet loss more quickly. The learning-based algorithm overcomes the problem of static algorithms that cannot adapt to changes in network path characteristics, ensuring the sustained effectiveness of acceleration in various different network environments, and addressing various frequent changes in network latency and packet loss characteristics. For more detailed information on ZetaTCP® optimization technology, please refer to the "ZetaTCP® Whitepaper".

AppEx integrates ZetaTCP® optimization technology into the RTT tunneling, making the RTT tunnel capable of efficient transmission in various complex network environments around the world, ensuring the timeliness of enterprise application data transmission through the RTT tunnel and ensuring the efficiency and experience of global business operations.

2.2 Multi-Sending and Selective Receiving

Building on top of ZetaTCP® optimization technology, AppEx has further developed the multi-sending and selective receiving transmission optimization technology, bringing RTT's transmission support for enterprise application traffic to the utmost level.

The multi-sending and selective receiving technology replicates a network packet into multiple identical ones at the sending end and sends them simultaneously through multiple different paths of the RTT tunnel. The receiving end considers the transmission successful as long as it receives any one of the multiple network packets, and the remaining duplicate packets that arrive later will be discarded by the receiving end (the receiving end confirms whether the current received network packet is a duplicate packet of a previously received one using the sequence number of the network packet).

The multi-sending and selective receiving technology provides further transmission protection for critical enterprise applications, ensuring that critical applications are not interrupted due to failures in a segment or even the entire network path of the transmission. As multi-sending and selective receiving technology duplicates and transmits the same network packet, it consumes additional network bandwidth resources, so it is usually only enabled for critical applications to provide transmission protection.

3 RTT Transmission Security

The RTT tunnel ensures the security of enterprise application data transmission through end-to-end encryption technology.

Generally, when using SD-WAN backbone network for transmission path optimization, SD-WAN solutions based on traditional IPSec and other tunneling technologies can only use "segmented encryption" to encrypt enterprise application data during transmission. "Segmented encryption" requires "Decrypting—Encrypting" enterprise application data at each PoP node along the pathway, which exposes the risk of enterprise application data being leaked or tampered with.

Compared with "segmented encryption", AppEx RTT tunneling uses "end-to-end encryption" to encrypt enterprise application data during transmission. Under the "end-to-end encryption" mode, enterprise application data is encrypted on the CPE located in the sending end office site network, and is not decrypted until it reaches the CPE located in the receiving end office site network. There is no decryption action at any PoP node along the pathway.

To achieve "end-to-end encryption", the RTT tunnel adopts a dual-layer encapsulation tunnel design. The outer layer encapsulation is used to establish the Overlay path, and the label switching (LS) is used to forward network packets between PoP nodes on the path. The inner layer encapsulation is used for "end-to-end" data encryption. When packets pass through a PoP node, only the packet header of the outer layer encapsulation is parsed. Once the next hop PoP node is identified, the destination IP field in the packet header of the outer layer encapsulation is modified to the IP address of the next hop before forwarding the packet. To ensure the security of enterprise application data transmission through RTT, the PoP node doesn't interfere with the inner layer encapsulation. This is because the encryption key is negotiated and created by the CPEs at both ends, and the PoP node itself lacks the ability to parse the encryption of the inner layer encapsulation.

4 RTT Seamless Path Switching

Our goal is to deliver the highest quality SD-WAN backbone network transmission to enterprise customers. In some situations, where a PoP node on the path is either overloaded or faulty, or when the current path no longer meets the SLA requirements, real-time backbone network path switching may be necessary. Please note that CloudWAN Orchestrator typically handles real-time path switching automatically by issuing operation instructions based on real-time monitoring results of the entire network.

RTT has implemented seamless path switching to ensure uninterrupted enterprise application performance during path switching. This function is designed to make enterprise applications insensitive to path switching, providing a seamless and uninterrupted user experience.

The RTT utilizes a dual-layer tunnel encapsulation to enable seamless path switching. Moreover, the outer layer is comprised of segmented tunnels along the hop-by-hop path, while the inner layer is an end-to-end tunnel established based on the outer layer. Enterprise application traffic flows within this inner tunnel between two CPEs. When a path switch occurs, the outer tunnel splices the new segment tunnels based on the latest path instructions to complete the switch. Meanwhile, the inner tunnel remains insensitive to the path switch. As long as the two endpoints of the starting point and the ending point remain unchanged, the inner tunnel can be considered unchanged. Achieving seamless path switching is possible when the traffic of enterprise applications flowing within the inner tunnel remains completely unaffected by the outer path switching. Therefore, if the inner tunnel remains unchanged, the path switching process does not affect the flow of traffic within it. Analogizing the outer and inner tunnels along with the traffic of enterprise applications to railway tracks, trains, and passengers respectively, we can see that the railway tracks complete path switching through turnouts, while trains remain unaware of the turnout operation. Similarly, as long as the starting and ending stations remain unchanged, the train schedule remains unchanged, and passengers sitting in the carriages remain unaware of the changes in the railway track.

5 RTT Portability

RTT is a highly flexible and lightweight solution that is designed to run on a range of hardware platforms. It can operate on high-end industrial control machine hardware platforms equipped with multi-core high-frequency processors, hundreds of GB of memory space, and capable of up to 40 Gbps traffic throughput per device. Additionally, it can also run on IoT terminals with low-frequency processors and limited memory space of only a few MB. The lightweight and flexible design of RTT has facilitated its successful porting to various system platforms, including x86-based industrial control machines, virtualized cloud hosts, MIPS/ARM-based routers or cameras, vehicle on-board devices, IoT devices, and handheld smart terminals. This adaptability enables RTT to meet the diverse needs of various usage scenarios

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