Building E2E IP networks for the 5G and cloud era

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Thanks to their strengths of reachability, interoperability, and flexibility, IP networks have grown over the past 30 years to become the foundation of ICT information networks.

Today, all Internet traffic is connected using the large-scale distributed router system. However, improving the utilization rate of IP networks and realizing new congestion-free, high-availability IP networks for the 5G and cloud era is a key goal for operators.

Congestion-free, high-availability

In its earliest design form, the router was developed as part of the US Department of Defense's Advanced Research Projects Agency Network (ARPANET), with its main function being to interconnect heterogeneous networks. It also reroutes traffic during network failures, and is ultimately designed to support a highly accessible distributed interconnected system.

IP networks forward traffic based on a destination IP address. Paths between nodes and global network topology are calculated with standardized IGP or BGP. Routing tables are updated based on changes in network routing. Since the standard routing system uses the shortest path tree algorithm, it's easy for the IP load on IP networks to become unbalanced. On the same network at the same time, the load on some links may exceed 90 percent, while on others it's just 10 percent. Just as with the road network system, this kind of situation is likely to cause some network utilization to be too high, resulting in congestion and packet loss, while utilization of other links is very low, leading to wasted network resources.

To solve this problem, traffic engineering technology was developed, and today traffic tuning algorithms are being continuously optimized. Manually planning network configuration supports scheduling and O&M of the routing system.

The advent of the 5G and cloud era will bring higher demands on the network from various service applications. There's an urgent need to rethink the design of router network architecture. AI can be harnessed to create a semi-distributed, semi-centralized system on top of the traditional distributed system. This will better support requirements for traffic engineering, QoS, high utilization, and the high self-healing capabilities of 5G and cloud era networks.

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5G and cloud services will place demands on networks in three main respects.

First, the emergence of VR/AR and 4K/8K live broadcast will require 10x more network capacity, but network construction costs must not change significantly. Meanwhile, with telecom service cloudification accelerating, a large amount of telecom cloud deployment has moved down the network, and cloud network convergence has become a problem that operators must face in network deployment.

The key is a simplified network core in the target network architecture design. When improving network capacity, existing IP network architecture needs to be simplified and the node functions integrated to realize cloud-network synergy.

Second, according to *Huawei's Global*

Industry Vision 2025, the number of global connections will reach 100 billion by 2025. At the same time, there will be an explosion in growth of not only north-south traffic but also east-west traffic, due to the large number of enterprises migrating to the cloud. Various interactive experience services and financial private lines will also impose more stringent demands on latency.

This will pose a considerable challenge on the scheduling capability of IP networks. Manually configured networks based on traditional traffic engineering and traffic optimization technologies cannot meet network optimization requirements for high levels of complex traffic. Solving this requires adopting AI-oriented global traffic engineering and queue management to realize network-wide, global service scheduling through network-wide automation.

Third, with the rapid development of 5G and cloud services and increased bandwidth, the complexity of service traffic and latency requirements will rise, and network complexity will grow. The traditional command-line user interface-based O&M model cannot meet the future requirements of network O&M. There is an urgent need for automated, smart O&M systems to enable smart O&M through network self-healing.

In Huawei's view, the key to solving the above problems lies in building a comprehensive IP network for the 5G and cloud era that boasts high availability, non-blocking, automated, smart, and self-healing capabilities. Such an IP network will support the development of 5G and cloud line services, fast service innovation, and efficient intelligent O&M, enabling operators to enter the fully-connected intelligent era.

New IP networks for the 5G era with four new features

Huawei proposes reshaping IP networks with new architecture, new interfaces, new protocols, and new O&M.

New interfaces: The traditional networking interfaces are GE, 10GE, and 100GE. With the continued advance of chip technology, optical-electrical (PAM4) technology has reduced cost per bit by more than 30 percent, thereby further lowering operator network construction costs. With PAM4 technology maturing, 50GE, 200GE, and 400GE have been defined as new standards for the next-generation of Ethernet network interfaces by the IEEE. Huawei's full range of routers support new 50GE, 200GE, and 400GE series interfaces. They have passed testing by the international authority ETANC, and are widely used in operator networks, helping to significantly reduce networking costs.

New architecture: With advances in chip technology, single-chip SOC has a capacity of 1.2 Tbit/s, making it possible to simplify the network layer. At the same time, the growth of 5G and telecom cloud services are placing higher requirements on network bandwidth and latency. Operators universally hope to simplify the network layer, integrate node functions, and implement comprehensive service-independent bearer capabilities.

In backbone networks, Huawei has enabled P+PE and MDS (multi domain system) capabilities using integrated backbone solutions. FBB/MBB/private line networks are integrated through physical devices, while still enabling logical partition management, significantly reducing IP backbone network construction costs.

At the metro network level, Huawei introduced the Metro Fabric solution, which is based on its Fabric architecture. The solution decouples the network bearer layer and service layer, so that the bearer network can be expanded on demand, providing high-capacity, non-blocking integrated bearer capabilities.

As for telecom cloud solutions, Huawei proposed a cloud network architecture with separate forwarding and control planes based

on actual needs, which solves the three challenges: low resource utilization, complex management and maintenance, and slow service provisioning.

CU-separated architecture separates the BRAS into two parts: vBRAS-CP (control plane) and vBRAS-UP (user plane). The vBRAS-CP is centrally deployed like a telecom cloud to fully utilize the computing power of the cloud, and the vBRAS-UP uses high-performance hardware. This supports large-bandwidth and low-latency services (like Cloud VR) and enables forwarding capability in the Tbit range per router.

At the same time, thanks to telecom cloud sharing and powerful computing capabilities, the architecture can pool network resources, improving resource utilization by 50 percent. The cloud-based CP can carry millions of users, TTM is increased by 5 to 6 times, and O&M configuration is reduced by 90 percent.

By reducing network layers, integrating node functions, and migrating some functions to the telecom cloud, a simplified target network architecture for the 5G and telecom cloud era has started to take shape based on this.

New protocols: After 30 plus years of routing protocol development, the problem with traditional network protocols is that there are so many and they have complex configurations. In particular, there are numerous difficulties with mechanisms in implementing traffic engineering, automated configuration, and network self-healing.

This is why SR and SRv6 emerged. SRv6 unifies over 10 existing complex protocols into a forwarding plane with the capability to program the source address router and path. This reduces protocol configuration and O&M complexity. Application-driven service paths can also be configured with SRv6. Whole-network Traffic Engineer optimization and AI-based queue management capabilities, including automated TI-LFA, micro-loop avoidance, and distributed and centralized traffic engineering, enable changes to traditional router Traffic Engineer, QoS, and protection solutions at the mechanism level, creating a new high-availability, congestion-free IP network.

Huawei's SRv6 solution is based on NP-programmable architecture, which protects network investment. Existing hardware can be upgraded to support SRv6 series features, so an SRv6-ready network can be implemented, helping operators to smoothly evolve from IP/MPLS networks to SRv6 networks.

New O&M: Telecom cloud and SRv6 have enabled some network functions to be centralized at the control layer and automated network configuration to be implemented through an open and programmable centralized control plane. Meanwhile, the use of big data and AI has optimized network intelligence.

Huawei's innovative NCE is the first in the industry to integrate management, control, and analysis functions. It comprises four engines – intent, automation, intelligence, and analysis – which form an automated, smart full-lifecycle system. By collecting and aggregating massive

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network data using telemetry and deep learning and analysis based on AI algorithms, big data analysis can be performed on network capacity, loads, faults, and alarms. This enables global traffic engineering and fault location and ultimately supports congestion-free, fault-free self-healing networks.

Through in-depth collaboration with operators using the NetCity mechanism, Huawei has already developed high-value use cases in the 5G bearer domain, including automated site addition, automated clock management, alarm correlation analysis, and group management.

Exploring new IP networks with partners

In the process of moving towards congestion-free, high-availability IP networks, Huawei is also working with upstream and downstream players to drive industry maturity. This includes industry standards, joint innovation, and commercial pilots. The aim is to build a comprehensive new IP network for the 5G and telecom cloud era.

In the IP interface domain, together with the industry, Huawei is promoting the standardization of new PAM4-based IP interfaces. Huawei is the chair of three of the four standards working groups for 50G PAM4 technology, set up by the IEEE (IEEE 802.3bs, IEEE 802.3cn, and IEEE 802.3ct), and the editor of one (IEEE 802.3cd).

To build up the industry chain, Huawei has organized three 50GE PAM4 technical and industry forums and released a 50G PAM4 technical white paper to foster the maturity of the PAM4 industry chain. Today, the industrial chain is complete, with chips, optical modules, and test instruments.

In commercial deployment, Huawei became the first to pass China Mobile Research Institute testing of 50 GE in September 2017. By the end of 2018, Huawei had completed more than ten 50 GE commercial deployments around the world.

In the sphere of IP protocols, Huawei has over 20 top experts engaged in research in fields relating to SRv6. Many hold key positions in the IETF in sub-fields relating to SRv6, including chamber and chair positions, and have produced dozens of related IETF standards and drafts. Huawei is a main contributor to SRv6 standards and drafts. Huawei also spearheaded the establishment of an SRv6 global industry alliance, and helped organize the first SRv6 industry forum to bring together industry expertise, create consensus, and accelerate the commercial adoption of SRv6.

Looking to the future, Huawei has partnered with leading operators to explore IP network service scenarios based on new interfaces, new architecture, new protocols, and new O&M through the NetCity joint innovation mechanism. By the end of 2018, Huawei had carried out joint innovation on 5G bearing with more than 20 operators across the world. Huawei is also helping to build 5G bearer solutions for more than 10 operators globally. Huawei will work with operators and industry partners around the world to implement a new IP era and together build a fully connected, intelligent world.