Testing Challenges for Next Generation Metro/Edge Routing Devices.

The new Metro/Edge Device

Service providers have invested very heavily to increase capacity in their core network in response to industry predictions that bandwidth demand would soon exceed supply in the network core. In reality, traffic growth estimates were hugely inflated, resulting in excess bandwidth and equipment capacity in the network core.

The ´if you build it - they will come´ philosophy, and assumption that a high-capacity network is all you need to attract business has proved wrong, resulting in fierce competition amongst service providers, and significant industry consolidation. Service providers are now searching for ways to both:

- reduce operating expenses and
- capitalize on their considerable investment by offering new revenue-generating, network-differentiating services and applications over their core infrastructure.

This has fuelled investment in, and development of, a new breed of metro/edge devices that promises to satisfy both service provider objectives.

Characteristics of Metro\Edge Routing Devices

Traditionally, edge aggregation devices have offered service aggregation capabilities, while IP service switches and routers have delivered the actual IP services. The superior service aggregation capabilities of new metro/edge devices enable service providers to consolidate network equipment and simplify network management by replacing multiple edge/aggregation devices with a single, powerful device. Ultimately, these new devices will integrate these super-aggregation capabilities with the revenue-generating service delivery of an IP service switch or router, into a single, multi-purpose device.

Service Aggregation

These new devices reduce network-operating expenses through powerful service aggregation. These platforms are equipped with the range of interfaces and features to aggregate large numbers of channels and transport types sourced from multiple service concentration devices and enterprise routers. For example, a typical metro/edge device combines the transport aggregation capabilities of a channel bank (which, for example, multiplexes several T-1 channels onto a single channelized OC-3 interface) with the forwarding and routing capabilities of a router, into a single, comprehensive multi-service platform. Replacing multiple network elements with a single multi-feature device reduces capital and maintenance expenditures, equipment integration and management complexity, and streamlines and simplifies the delivery of new technologies, services and applications across the network.

Service Delivery

In addition to 'traditional' router features and capabilities, these devices are being enhanced with the protocols and technologies that will enable them to leverage excess capacity in the IP core to deliver data-driven services at a very cost-effective price. Today, most corporate networks are connected via leased-lines (dedicated and expensive facilities interconnecting a corporation's remote sites). The aggregation and sophisticated service features of metro/edge devices will provide a vehicle for migrating corporations onto the public Internet. Service providers can generate new revenue by selling corporate customers connectivity services, such as virtual private networks (VPNs) and multicast tunneling, at a lower cost, and with more features (such as security and virtual LAN connectivity), than their current leased-line connection.

The evolving metro/edge device is thus an extremely versatile and increasingly sophisticated creature. These new devices must support a wide range of transport technologies and interface speeds to provide aggregation and connectivity between different network topologies and elements. They must also support an increasing number of complex protocols and packet encapsulations in order to manage diverse network topologies, and deliver new services and applications.

Testing Challenges

The sheer intricacy of modern metro\edge devices, coupled with the immaturity of the underlying technologies driving many new services and applications, makes testing them an essential yet challenging task. Ultimately, these devices must be capable of aggregating and delivering multiple business-critical services and applications with carrier-class reliability and predictability, which requires a test solution capable of thoroughly testing service aggregation and service delivery, from product development though to deployment.

Testing Service Aggregation

Managing and multiplexing different service channels can be a demanding task. Take, for example, a metro\edge device with channelized DS3 interfaces on the 'pre-aggregation' side, and channelized OC-48 POS interfaces on the 'post-aggregation' side. Each channelized OC-48 POS interface is capable of carrying 48 DS3 channels. Each of these channels acts as a single point-to-point link, and must support individual routing peering sessions, as well as Quality of Service (QoS) delivery for each traffic stream within the channel. The system under test (SUT) must manage thousands of concurrent routing peering sessions as channels are provisioned and manipulated, and perform process-intensive traffic conditioning and scheduling activities for the thousands of service streams being aggregated. Testing the stability, scalability, and performance of the service aggregation process is a considerable endeavor that addresses several critical measurements including:

- The impact of provisioning a single channel on the other channels
- The maximum number of channels that can be provisioned and multiplexed before forwarding performance and QoS delivery begins to deteriorate
- The verification of channel integrity from aggregation/de-aggregation
- The reliability and responsiveness of failover switching and backup path provisioning

Testing the service aggregation capabilities of a metro/edge routing device requires a test solution capable of generating multiple wire-speed traffic streams, each representing a different service type or class, over the number of channels and range of interfaces characteristic of these devices. Quality of service measurements for each traffic stream must be delivered in real time to determine whether the device is truly capable of performing traffic grooming, conditioning and scheduling activities across thousands of converging streams and channels.

Testing Service Delivery

Emerging IP services are responsible for reliably and securely delivering aggregated traffic streams across the network core through VPN services and packet encapsulating/tunneling techniques. Testing the service delivery of metro/edge devices is a complex procedure, and can be approached in two stages: protocol performance measurements and service performance measurements.

Protocol Performance Measurements

Services delivered by metro/edge metro/ edge routing devices are frequently driven by new and immature technologies. Before service performance can be measured, it is necessary to first verify the performance of each supported protocol on the metro/edge platform. Protocol performance testing includes testing the conformance, interoperability, scalability and stability of the service protocols, and all underlying protocols necessary to deliver today's hot services and applications. For example, to deliver MPLS VPN services through the core, the metro\edge routing device must support a multitude of interacting protocols, including (at a minimum) an internal gateway protocol (IGP) such as OSPF or IS-IS with traffic engineering (TE) extensions, the multi-protocol internal border gateway protocol (MP-iBGP), and an MPLS signaling protocol such as RSVP-TE or LDP/CR-LCP. The conformance, interoperability, scalability and stability of all these protocols will impact the ultimate performance of the VPN service.

Testing the performance of protocols driving hot metro/edge services and applications requires a test solution with the breadth and scale of protocol emulations typically supported on evolving metro\edge devices, including L2TP, IP SEC (IKE), MP-iBGP, LDP/CR-LDP, RSVP-TE, ISIS-TE, OSPF-TE, RIP, IGMPv3, IPv6 and PIM-SM. The test solution should complement protocol emulations with automated conformance and stress test suites to ensure these measurements are executed thoroughly, to the industry standard, and in a timely manner. In order to achieve protocol scalability and stability measurements, protocol emulations on the tester must exceed the performance of protocol implementations on the SUT. A test solution must possess all of these features in order to achieve critical protocol measurements, including:

- The verification of each protocol to the industry standard
- The interoperability of each protocol with other vendor implementations
- The maximum number of VPN routing and forwarding tables (VRFs) that the SUT can support
- The maximum number of entries each VRF can support
- The maximum number of label-switched paths (LSPs) the SUT can support
- The maximum rate at which LSPs can be set-up
- The maximum number of L2TP or IP SEC (IKE) tunnels the SUT can establish and manage
- The maximum rate at which L2TP or IP SEC (IKE) tunnels can be set-up or torn-down
- The maximum number of multicast groups the router can support

Service Performance Measurements

Once protocol performance expectations are met, service performance measurements can finally be executed. This stage of testing simultaneously stresses both the protocols (control plane) and traffic (data plane) of the device to determine whether it can truly manage all underlying protocols and deliver service traffic effectively. Therefore, testing service performance requires a test bed that realistically reflects the network topology, services and traffic characteristics that the routing device must manage once deployed. For example, measuring MPLS VPN service performance requires the simulation of the remote customer networks, and the service provider network, around the SUT. This simulation is achieved using a variety of routing protocol emulations. The MPLS label-switched path that will carry the VPN traffic is then simulated over the service provider topology using a signaling protocol. Finally, the VPN routing and forwarding table (VRF) containing VPN membership and reachability information is advertised to the SUT using multiprotocol I-BGP (MP-iBGP). Once the underlying topology is simulated, label-stacked traffic must then be generated into the SUT to measure its ability to effectively deliver MPLS VPN traffic between customer sites, and achieve important performance measurements including:

- The impact of VRF stability on VPN traffic forwarding
- Whether the device can push the correct labels onto traffic destined for different customer sites
- How well the device can manage VPN traffic with overlapping address space
- Whether the device can maintain QoS guarantees while forwarding IP and labeled traffic between different customer sites

Similarly complex test configurations and measurements must be repeated for each supported technology, service and application on the metro\edge device. Thoroughly testing the service performance of a device therefore requires a test solution capable of concurrently emulating all underlying protocols and services and generating realistic service traffic through the metro\edge device. To effectively represent the traffic mix that this type of device must manage in a real- live network, a test solution must support a variety of service traffic types (i.e. L2TP, IP, VPN, RTP, etc.), packet encapsulations (i.e. IPv6 tunneling, multicast tunneling, PPPoA, etc.) and transport technologies (i.e. ATM transport over MPLS, MPLS over IP/GRE, etc.). The test solution must be capable of varying the mix and load of these service streams on the fly, and dynamically manipulating the simulated topology while real-time QoS performance metrics are delivered. Wire-speed service streams must be generated into the device along with thousands of protocol updates to determine how routing instability and different traffic configurations affect forwarding performance and service delivery. It is only under these extreme, yet realistic conditions that the ultimate service performance of a next generation metro\edge device can be ascertained.

Conclusion

Testing the performance of a metro\edge routing device, from product development to deployment, requires a test solution capable of satisfying all of the above test objectives. In order to thoroughly test the service aggregation capabilities and service delivery of this emerging multi-purpose device, a comprehensive test solution should possess the following features:

- A wide range of channelized and concatenated interface types and speeds
- Protocol emulations that exceed the performance of the protocol implementations on the device (including OSPF-TE, ISIS-TE, BPG-4, RIP, IGMPv3, PIM-SM, IP SEC (IKE), MP-iBGP, L2TP, RSVP-TE, and LDP/CR-LDP)
- Automated test scripts for executing protocol stress and conformance tests
- Wire-speed service traffic generation and real-time QoS analysis
- The ability to dynamically manipulate traffic configurations and simulated topologies during performance measurements

For additional information relating to test equipment that can perform these type of tests please email iptest@agilent.com

Specifications subject to change.
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