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Taking Advantage of the Opportunities and Overcoming the Challenges of Carrier Ethernet Networks

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Wide scale deployment of broadband services is driving the deployment of Ethernet in carrier networks. Multiple Protocol Label Switching-Transport Profile (MPLS-TP), and Provider Backbone Bridging (PBB) will improve the scalability of Ethernet networks, while Ethernet/MPLS Operations, Administration, and Maintenance (OAM) features enable fault and performance management in wide area networks. With Precision Time Protocol (PTP) and Synchronous Ethernet, timing and synchronization services can be carried over packet switched networks. Finally, High Speed Ethernet and Optical

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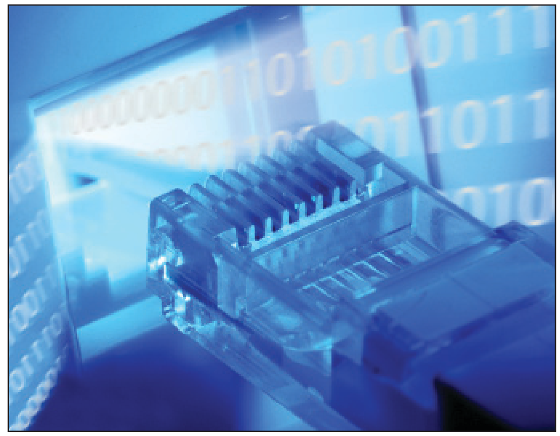

Transport Networks (OTNs) enable cost effective transport of high-bandwidth data services over metro core networks. It is important to take a careful approach to managing the complexities of deploying these services – this includes considerations such as a comprehensive suite of instruments, systems and software to provide an end-to-end approach for testing and evaluation of emerging Carrier Ethernet features in the lab and field. This article takes a close look at those key challenges and some best practices for successful Carrier Ethernet deployment.

One clear signal being sent from the market today -

the time is right to get Carrier Ethernet right, now: so much rides on its success. Consider the magnitude of the following - the expansion in the number of broadband Internet users and the growing use of multimedia applications is causing backbone Internet traffic to increase at a rate approaching 100% per year. Meanwhile, enterprises are asking for the ability to tie their sites together with simple and cost effective Ethernet services. Increasing broadband service penetration demands a transport network that delivers significantly lower cost-per-bit than traditional circuit switched networks. Ethernet provides the benchmark for cost-efficient transport technology so it should come as no surprise that Carrier Ethernet networks are emerging as key components in business Voice over Internet Protocol (VoIP), disaster recovery, video conferencing and wireless backhaul applications as well as consumer Triple-Play service delivery.

Improved OAM capabilities

The Ethernet community has been continuously adding capabilities to native Ethernet in order to deliver a carrier-grade transport alternative to legacy time division multiplex (TDM) technologies. Provider Backbone Bridge/Provider Backbone Transport (PBB/PBT), Transport Multi-Protocol Label Switching/Multi-Protocol Label Switching Transport Profile (T-MPLS/MPLS-TP), Ethernet OAM, Synchronous Ethernet, and Time Division Multiplexing over IP (TDMoIP) are some examples of major Carrier Ethernet initiatives. MPLS-TP is based on the same layered networking principles that are used in familiar transport network technologies like SDH, SONET and OTN so it aligns well with existing management processes and work procedures. PBB adapts Ethernet technology to carrier class transport networks using the layered Virtual Local Area Network (VLANS) tags and MAC-in-MAC encapsulation with connection oriented features and behaviors that are also inspired by SDH/SONET. The result is that Carrier Ethernet networks facilitate service aggregation and work in concert with network infrastructure and tunneling technologies that provide Quality of Service (QoS), redundancy and scalability across the network.

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The new standards will provide improved OAM capability to the customer premises demarcation point, potentially reducing operating expenses (OPEX) by more than half. Multiple standards deliver building blocks for managing the access layer:

- 802.3ah OAM addresses managing the physical layer from the provider edge (PE) to the media access control (MAC) layer of the remote device
- Metro Ethernet Forum (MEF) Ethernet Local Management Interface (E-LMI) addresses managing the User Network Interface (UNI) of the remote device
- 802.1aj Two-Port MAC Relay (TPMR) addresses managing a customer demarcation device

The Ethernet First Mile (EFM) 802.3ah provides link layer OAM functionality in the first and last mile. It is media independent and operates at a slow rate of 10 frames per second. Ethernet OAM packet data units (OAMPDU) only work in point-to-point full-duplex networks and are not forwarded by peer devices. They require minimal configuration and deliver following functions:

- Device discovery
- Remote failure indication
- Remote loopback
- Link monitoring

During the network initialization, adjacent devices exchange identification information and OAM capabilities. Network devices can notify peer devices in the event of failures. The remote loopback is a link-layer mechanism that operates at the frame level. Link monitoring delivers event notifications, such as status and diagnostics information.

The IEEE 802.1ag Connectivity Fault Management (CFM) standard specifies protocols and protocol entities within the architecture of VLAN-aware bridges that enable the detection, verification, and isolation of connectivity failures in virtual bridged LANs (VBLANs). These capabilities can be used in networks operated by multiple independent organizations, each with restricted management access to each other's equipment. This standard specifies protocols, procedures and managed objects

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in support of connectivity fault management. It allows verification of the path through bridges and LANs taken from frames addressed to and from specified network users and enable detection and isolation of a connectivity fault to a specific bridge or LAN. The standard defines maintenance domains, maintenance associations, their constituent maintenance points and the managed objects required to create and administer them. It also describes the protocols and procedures that maintenance points use to detect and diagnose connectivity faults within a maintenance domain (MD).

Timing and synchronization functionality

TDM services require various timing and synchronization functions. For example, wireless end nodes of Global System for Mobile Communications (GSM)/Universal Mobile Telecommunications System (UMTS) retrieve their reference frequency from the network. To avoid interference and hand-over problems, they require a frequency stability of 50 to 250 parts per billon. TDM networks such as SONET/SDH are based on technologies that can natively carry a frequency reference at the physical layer. But packet switched networks such as Ethernet are nondeterministic so they impose delay and delay variation on packets.

PTP, also known as IEEE standard 1588v2, provides one solution to this problem by accurately distributing time over packet-based networks. PTP uses a Grandmaster clock at the server that ports timing information to isolated slave clocks that in turn deliver traditional TDM T1 timing to the installed equipment. Network delays and latency are greatly reduced by measuring the round-trip delay between the master and slave clock, using a technique where the master and slave communicate with short messages to each other in order to measure and cancel out delay and latency inaccuracies. Alternatively, expensive GPS-based clocks are used at each cell site to obtain the timing synchronization required for CDMA services when using IP backhaul. PTP, on the other hand, requires only a central Grandmaster clock at the mobile switching center (MSC) and low-cost PTP slave clocks at the cell sites, which greatly lowers both capital and operating costs.

Synchronous Ethernet provides a mechanism for transferring frequency over the Ethernet physical layer, which is then traceable to an external source such as a network clock. Synchronous Ethernet interfaces can operate in sync or non-sync mode. In sync mode, the transmitter is locked to 4.6 parts per million. The receiver recovers it and passes it to the system/transmitter clock. In this mode, the interface does not work over native Ethernet interfaces. To enable communications between various nodes, Synchronous Ethernet provides an Ethernet Synchronization Status Messaging channel, similar to SONET/SDH Synchronization Status Messaging (SSM) bytes, that allows nodes to deliver their synchronization status to downstream nodes.

Optical Transport Networks

Profitably meeting the increasing demand for broadband services requires a transport technology with a lower cost per bit than traditional circuit switched technology. Optical transport network (OTN) technology reduces transport costs and enhances network and performance management functions. Forward error correction (FEC) algorithms improve the reach of transmission links, helping to reduce regenerators and optimize spectral efficiency. OTN reduces OPEX and capital expenditures (CAPEX) because it is simpler to operate than SONET/SDH, scales to higher rates, extends reach between difficult nodes and offers transparent delivery of client signals. An OTN provides a much simpler transport protocol than SONET/SDH and is optimized for transport applications and not burdened with SONET/SDH provisioning-intensive switching layer functionality. OTN services are also better suited for the transparent mapping and transport of native client traffic through metro and long-haul networks.

Test equipment helps meet the challenge

Carrier-grade Ethernet networks facilitate service aggregation and work in concert with different network infrastructures and tunneling technologies that provide common QoS, traffic engineering, OAM, redundancy and scalability across the enterprise. The result is a complex mix of parameters and requirements that present many challenges to network equipment manufacturers (NEMs) and service providers. Verification of network elements, reduction of installation times and assurance of service availability are all required to deliver the high QoS needed to ensure customer retention.

In order for operators and NEMs to address these challenges, they must possess a suite of instruments, systems and services provides an integrated, end-to-end approach to testing carrier-based Ethernet. For example, a rugged handheld 10-GE multifunction tester streamlines the installation and maintenance of Carrier-grade Ethernet services. It supports applications ranging from Ethernet and IP SLA verifications including VPLS/MPLS to verification of PBB/OAM functionality to ensure compliance with Carrier Ethernet SLAs.

Innovative test applications simplify the complexity of installing, troubleshooting and maintaining carrier Ethernet networks. They probe, discover and record the health and reliability of the network by characterizing the transport layers and the higher-layer TCP/IPT based flows that impact applications and services. The test information is delivered in simplified summary format to simplify results interpretation. Technicians at all levels can make informed configuration changes on their own, without having to involve more senior technicians, based on industry best practices, improving the speed and efficiency of problem resolution. The net result is that service organizations can reduce operating expenses by expediting network fault resolution and circuit installation.