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Fiber Demarcation for Small Cells and Wi-Fi

By Ty Estes

Service Providers are deploying carrier Wi-Fi and small cells as part of the Mobile Network Operator (MNO) heterogeneous network (HetNet) strategy to complement macro cell towers, and meet the growing bandwidth demands of smart phones and tablets.

Sprint, T-Mobile, AT&T and Verizon have launched Wi-Fi calling, and millions of Wi-Fi Access Points (AP) are being deployed as a cost-effective method to offload data and video traffic from 3G and 4G networks. The recent advances in Wi-Fi technology augment the deployment of the cellular networks using cost-efficient wireless access points in unlicensed spectrum.

Deployment of small cell hosted sites will grow dramatically in the coming years. Infonetics Research forecasts the small cell market to grow from a very small base to $2.8 billion by 2018.

The research firm Mobile Experts projects that 70% of small cells will have integrated Wi-Fi by 2017, indicating the two technologies will be converging in the next few years.

Both carrier Wi-Fi and small cells use Carrier Ethernet backhaul circuits. The Metro Ethernet Forum and Carrier Ethernet 2.0 certification makes Ethernet the protocol of choice for backhaul services. Ethernet offers comprehensive operations, administration and maintenance (OAM) tools to ensure backhaul services meet or exceed Service Level Agreements (SLA).

The Carrier Ethernet Network Interface Device (NID) is required for the demarcation in Carrier Ethernet services, and provides a user to network interface (UNI) that manages one or more "flows" of traffic. The NID enables SLAs with rate-limiting, and traffic classification features.

Fiber backhaul and Carrier Ethernet demarcation provide long distance connectivity, Quality of Experience (QoE) and low-latency data traffic, but Service Providers face several challenges when providing backhaul services to MNOs:

- Providing Service Level Agreements for backhaul services
- Deploying Carrier Ethernet demarcation devices across diverse network topologies
- Reducing wireless backhaul OPEX and CAPEX
- Powering small cells and Wi-Fi Access Points
- Migrating from Wi-Fi hotspots to Carrier Wi-Fi
- Timing synchronization

Providing Service Level Agreements for Backhaul Services

The Metro Ethernet Forum (MEF) announced Carrier Ethernet 2.0 as the next generation in the evolution of Ethernet services. The Carrier Ethernet 2.0 multiple classes of service (Multi-CoS) enables services within an EVC to be differentiated, prioritized and assigned unique bandwidth profiles (rate limiting). The MEF further defines Multi-CoS as standardized classes of service that are associated with MEF-defined performance objectives and performance tiers.

The MEF 23.1 specification introduced the industry's first standardized Multi-CoS performance objectives (MPOs) with new SLA metrics for specific applications, including mobile backhaul. In addition to the ITU Y.1731 performance metrics of frame delay (latency), inter-frame delay variation (jitter) and frame loss ratio; MEF 23.1 adds mean frame delay and frame loss range.

In Figure 1, a 4G/LTE backhaul service is transported over EVC 100 with four Classes of Service (CoS). Each class of service flow is differentiated with a priority and bandwidth profile.

The CE 2.0 certified compliant NID enables Multi-CoS SLAs within a service, and flows to different devices can be assigned to the appropriate ports. The NID supports Y.1731 performance monitoring for each CoS to enable value added services with SLA assurance.

Figure 1 – Carrier Ethernet 2.0 Multi-CoS Performance Monitoring

The CE 2.0 certified compliant NID also supports the IEEE 802.1ag connectivity fault management and 802.3ah link OAM with dying gasp. Service providers use 802.1ag to monitor and isolate faults for end-to-end services across multiple networks.

802.1ag connectivity fault management and Y.1731 performance monitoring are designed for Layer 2 networks like metro Ethernet access networks. The IETF Two-Way Active Measurement Protocol (TWAMP) defines a standard for measuring Layer 3 and Layer 4 round-trip two-way network performance metrics between any two devices that support the TWAMP protocols. The TWAMP-control protocol is used to set up performance measurement sessions, and to send and receive performance-measurement probes. NIDs that support TWAMP deliver a flexible method for accurately measuring performance between two end-point devices, regardless of the type of networks the service traverses.

Deploying Demarcation Devices Across Diverse Network Topologies

Service providers operate several disparate network topologies, including active Ethernet, PON and wavelength division multiplexing, as illustrated in Figure 2. The ability to deploy a single NID device across all these network topologies simplifies deployments and streamlines equipment inventories. By installing different types of Small Form Pluggable (SFP) transceivers, the same NID can be installed in active and passive networks, and support data rates from 10 Mbps to 10 Gbps.

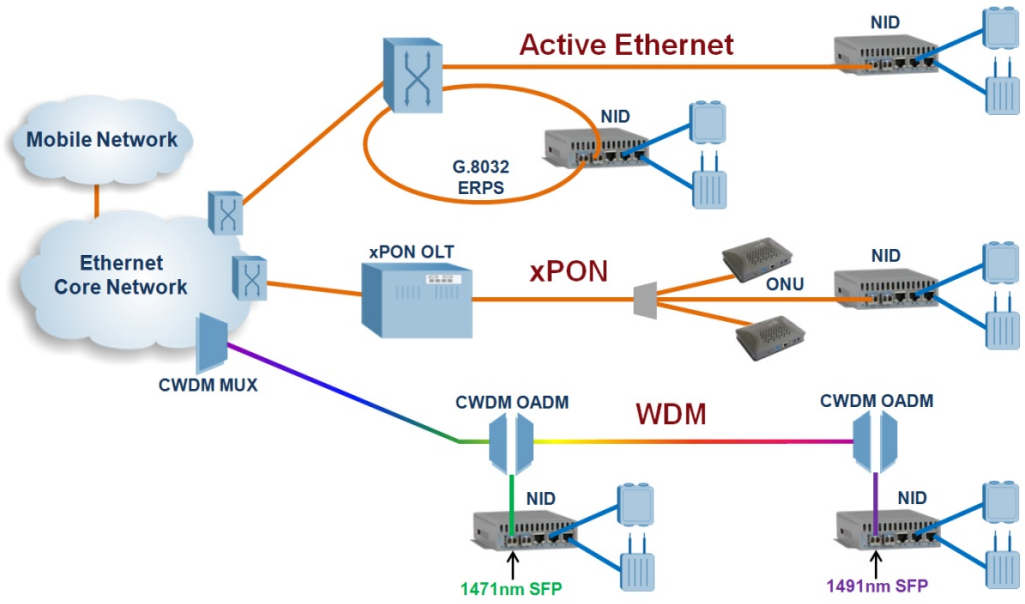

Figure 2 – Unified Demarcation for Diverse Network Topologies

NIDs can be deployed in a variety of active Ethernet network topologies, including point-to-point, hub and spoke, protected rings and redundant links. NIDs installed on fiber rings that support ITU-T G.8032 Ethernet Ring Protection Switching (ERPS) provide resiliency to protect network services, and multiple EVCs. G.8032 ERPS supports complex ring architectures with multi-ring and sub-ring protection that enables Service Providers to build reliable and scalable Layer 2 networks with sub 50ms failover protection.

NIDs that support ITU-T G.8031 Ethernet Linear Protection Switching (ELPS) provide resiliency to protect services in point-to-point network topologies with sub-50 ms failover.

FTTx technologies such as EPON, GPON, and XGS-PON will compete for network upgrade dollars in 2016. Service Providers are expected to deploy point-to-multipoint networks for residential triple play services, and point-to-point networks for mobile backhaul/fronthaul, small cell/carrier Wi-Fi backhaul and business Ethernet services.

To deliver SLA-assured CE 2.0 services, Service Providers may choose a CE 2.0 compliant SFP NID if

the Optical Network Unit (ONU) is a standalone device, or a compact standalone CE 2.0 NID if the ONU is a SFP plug-in module. Uptick in SLA assured services over the xPON may drive equipment vendors to integrate the CE 2.0 features and a unified management for provisioning the services.

WDM access networks utilize several wavelengths transported over fiber, and are deployed where fiber is scarce. There are a variety of WDM topologies deployed by Service Providers to preserve fiber infrastructure. Figure 2 shows a Coarse Wavelength Division Multiplexing (CWDM) multiplexer installed at the head of a single-mode fiber run to insert up to 16 wavelengths. Each wavelength transports a backhaul service. Add+drop multiplexers (OADM) are installed at small cell/Wi-Fi locations to filter out (drop) one wavelength and transparently pass the other wavelengths to other locations. At each location, a NID is installed with a CWDM SFP that matches the wavelength being dropped off by the OADM. Longer wavelengths (higher nm) are used for the longer distances on the fiber run.

Reducing OPEX with Automated Provisioning and Testing

Carrier Ethernet enables flexible mobile backhaul, with different service types that have both port-based and VLAN-based (multiplexed) services. In addition, there are a wide variety of service attributes and Service OAM parameters. Configuring NIDs with these complex parameters can make provisioning and turning up Carrier Ethernet services costly and time consuming. This complexity also creates issues with human error and mis-configuration that can further delay service activation, and require additional testing and troubleshooting.

Zero Touch Provisioning (ZTP) enables quick and easy service turn-up, and reduces costs associated with expert technicians having to manually provision demarcation devices. It also reduces expertise required by installers and technicians and centralizes management at the Network Operations Center (NOC).

Carrier Ethernet mobile backhaul services deliver sync, voice, video and data. Service activation testing provides the methodologies to quickly test and validate SLA metrics prior to handing off the backhaul service to the MNO. Current methods of testing services are time consuming, and require truck rolls with expensive test equipment.

NIDs with integrated ITU-T Y.1564 and RFC 2544 test heads eliminate expensive test equipment CAPEX and the OPEX of truck rolls, while expediting service activation testing, turn up, and enabling validation of CE 2.0 service assurance with application-oriented Multi-CoS performance objectives.

The SFP NID is a small form pluggable (SFP) gigabit optical NID that enables Service Providers to deliver low-latency, SLA-guaranteed backhaul services in a variety of network topologies. The SFP NID supports many of the functions of a standalone NID, including performance monitoring, fault management, service activation testing and timing synchronization.

The SFP NID can be installed directly into a small cell, saving CAPEX by eliminating the need for a standalone demarcation device, and saving OPEX by reducing power consumption, space, installation and maintenance costs.

Powering Small Cells and Wi-Fi Access Points

Power over Ethernet (PoE) is a technology that enables the safe transfer of DC electrical power along with data over standard unshielded twisted pair (UTP) network cabling. Both the data and the power may share the same wire, and each is independent and unaffected by the other.

PoE is deployed where access to electrical power is inconvenient, expensive or infeasible to supply; which applies to many indoor/outdoor small cell and Wi-Fi deployments. The cost of bringing electrical power to each device is eliminated by powering the equipment through the UTP cable. This is why many small cells and Wi-Fi APs are powered by PoE. But this requires the installation of PoE power injectors, such as PoE switches or midspans, which increase equipment costs and the footprint at the antenna site.

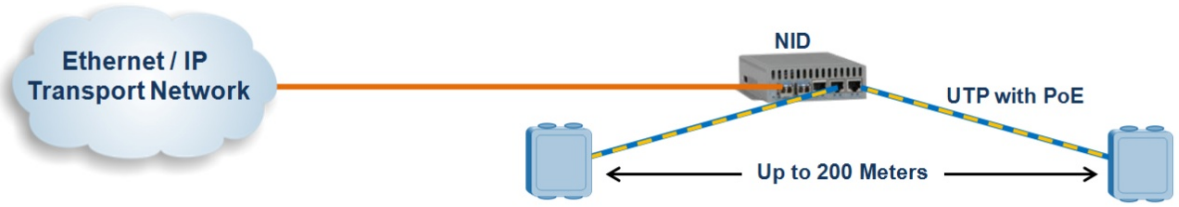

Figure 3 – NID with Power over Ethernet

NIDs with power over Ethernet are classified as Power Sourcing Equipment (PSE) can power multiple Powered Devices (PDs), including Wi-Fi APs and small cells, as illustrated in Figure 3. NIDs with PoE provide fiber connectivity to the backhaul link and inject PoE through the RJ-45 ports. This lowers CAPEX by eliminating the need for midspans or bulky PoE switches, and resolves the power and size issues. The PDs can be installed up to 100 meters away from the NID (the maximum distance of copper UTP cabling), and two small cells or Wi-Fi APs can be installed up to 200 meters apart from each other using the same NID.

PoE NIDs support a variety of PoE power levels; up to 60W PoE per RJ-45 port for multi-stream wireless access points.

- IEEE 802.3af PoE (15.4W)
- IEEE 802.3at PoE+ (34.2W)
- IEEE 802.3bt (60W PoE) – ratification expected in 2017.

Migrating from Wi-Fi Hot Spots to Carrier Wi-Fi

Service providers, especially Cable MSOs, are rolling out millions of Wi-Fi hotspots to provide best-effort internet access as a value-added service and to reduce churn. Although some revenue is generated by providing 3G and 4G offloading for MNOs, Wi-Fi has not been fully monetized so it is critical to reduce deployments costs. One way to reduce CAPEX is to deploy low-cost fiber media converters that provide Power over Ethernet.

In this sports arena Wi-Fi example, as illustrated in Figure 4, PoE media converters provide SFP ports for fiber access, and inject PoE, PoE+ or 60W PoE through the RJ-45 ports. As Wi-Fi deployments evolve to transport voice calls, QoE and Carrier Ethernet backhaul will be required. This can be achieved by installing SFP NIDs in the media converters. This provides a low-cost initial equipment investment and a low-cost upgrade path to carrier Wi-Fi with voice calling.

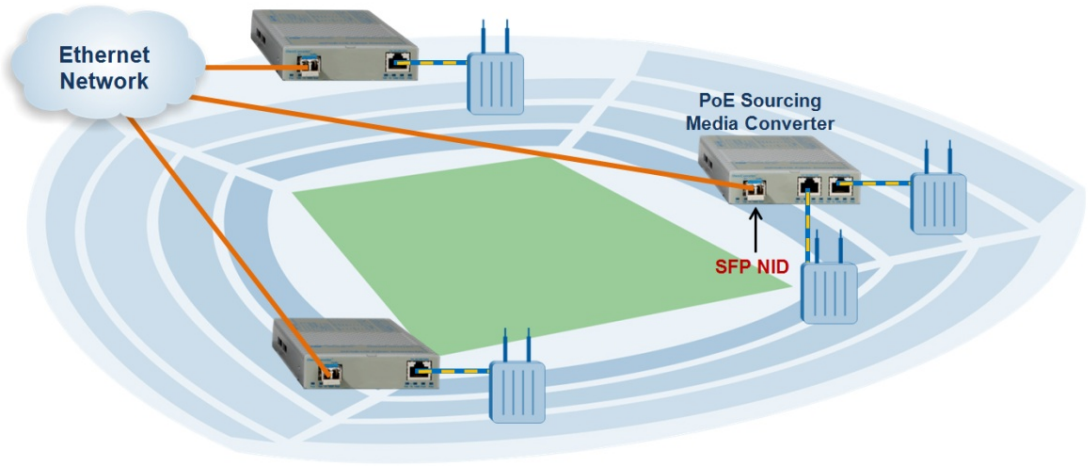

Figure 4 – Carrier Ethernet Backhaul with PoE Media Converters + SFP NIDs

Timing Synchronization

Cellular base stations and small cells require frequency and/or phase synchronization. There are a number of different technologies available to allow frequency, phase and time synchronization between base stations. Some of these are network based, while others are satellite or radio based techniques.

It should be noted that while synchronization as a service is a new concept that is not well defined, MEF 22.1 has included frequency synchronization as part of its definition of Ethernet services for mobile backhaul.

NIDs that support synchronous Ethernet (SyncE), network time protocol (NTP) and IEEE 1588v2 will enable Service Providers to deliver timing synchronization to MNOs. Combining the various synchronization methods will help improve reliability and accuracy, while addressing the weakness of each individual technique.

Conclusion

Service providers are spending billions to deploy millions of Wi-Fi APs and small cells to provide value added services, offload cellular data, and supplement the coverage of wireless networks.

Service providers have to deliver SLAs to MNOs, install equipment and provide power, and provision services; all while keeping costs in check to maintain profitability.

Ethernet NIDs enable Carrier Ethernet 2.0 backhaul for small cells and Wi-Fi APs with Multi-CoS SLAs by supporting industry standards for service activation testing, performance monitoring, fault management and protection.

Service providers can simplify inventories and reduce CAPEX by deploying the same NID for WDM, HFC, active Ethernet and EPON/DPoE access networks. Service providers can reduce OPEX by automating provisioning and streamline service testing to enable plug-and-play installations.

As Service Providers monetize Wi-Fi services, media converters with PoE can reduce deployment costs of best effort Ethernet backhaul, and upgrade to Carrier Ethernet with SLAs for carrier Wi-Fi voice services by installing an SFP NID in the media converter.

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