Carrier Ethernet Global Interconnect

Service Provider Test and Showcase

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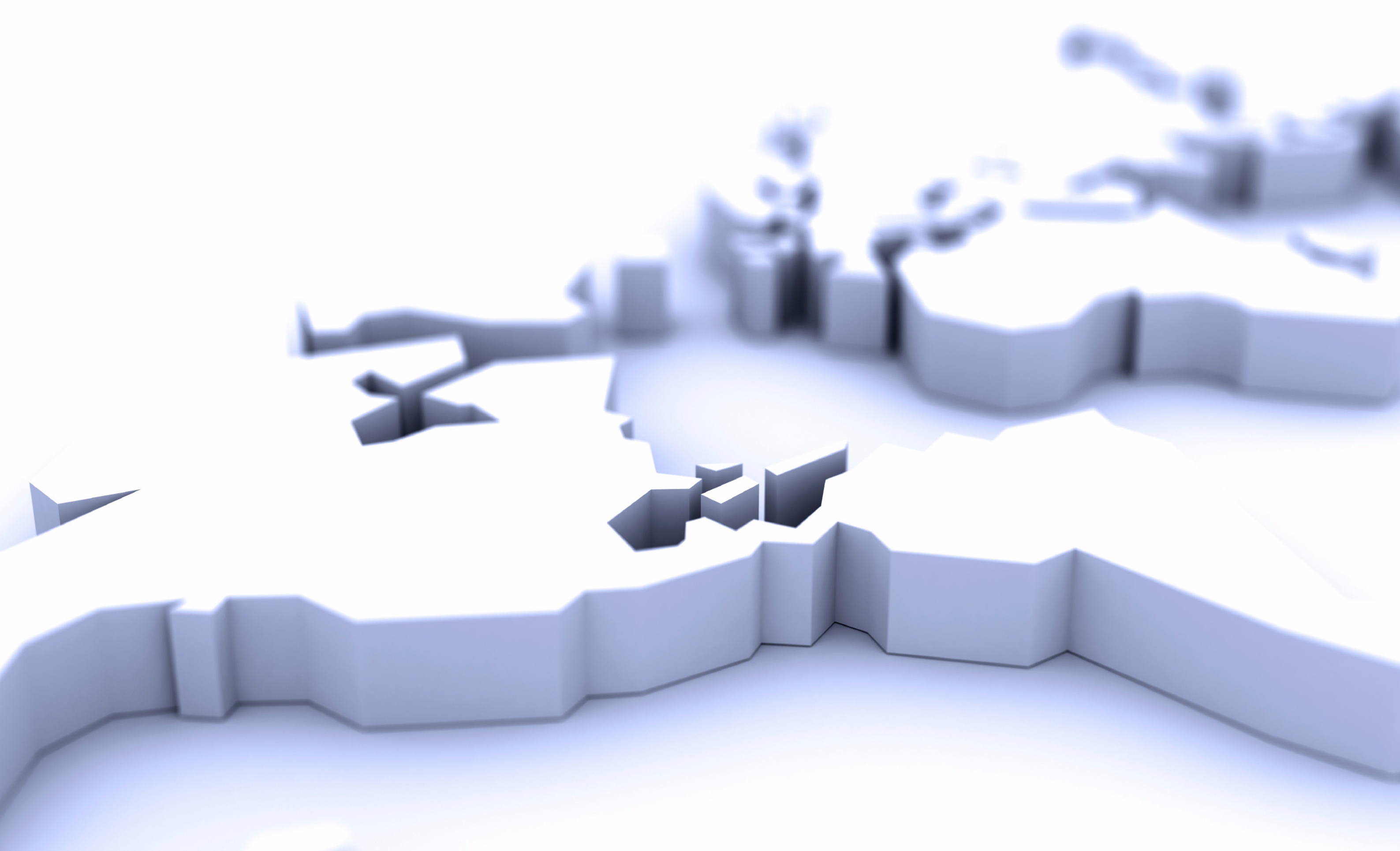
light reading's ethernet europe 2011

examining ethernet's evolution



Editor's Note

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The MEF has touted the horn for Carrier Ethernet Global Interconnection — the linkage of Carrier Ethernet service segments to achieve global coverage — just for around one year now. The relevant MEF standard, ENNI, has been ratified in January 2010.

In a young, very active and growing market, we have completed the fourth round of neutral interoperability tests in live service provider production networks. This whitepaper discloses the results. With the participating service providers Abovenet, Level 3, Teragate and Tinet, our Carrier Ethernet exchange partner Equinix and the three vendor sponsors MRV Communications, Omnitron Systems and RAD Data Communications, we completed the tests successfully and are happy to showcase the results in London.

The good news is: Interconnection of basic point-to-point services is not a technical issue. The services worked once the service providers had completed provisioning.

For the first time, we successfully tested E-LAN multipoint services across two service providers, Level 3 and Tinet. The services worked fine in this initial validation.

Virtually all of the 14 operators we evaluated in the last five quarters had issues getting bandwidth profiles and class of service mappings correctly configured in accordance with their own service descriptions. This time, it took several weeks to iron out the end-to-end service activation issues across the test bed. Most problems were caused by communication failures — lack of common understanding across providers and users — and configuration errors. The MEF has recognized that more efforts are required for education (see the MEF Carrier Ethernet Certified Professional program) and in aligning provi-

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Participants

Operators	Service Names
AboveNet	eWan
Level3	EPL — Ethernet Private Line VPLS — Layer 2 VPN services
TeraGate	TeraGate IntelligentEthernet EVPLAN
Tinet	Ethernet Extension — EPL EVPLAN

Carrier Ethernet Exchanges
Equinix

Vendor Sponsors	Devices
MRV Communications	OS904, OS906
Omnitron Systems	GM3, HybridNID
RAD Data Communications	ETX-204A

sioning methods.

The participating Network Interface Device (NID) vendors provided equipment to terminate circuits and to monitor their performance. This worked great, and the NIDs were reliable endpoints. They could just not help much to troubleshoot the cumbersome service activation since providers supported in-band management which was typically unavailable while services were provisioned.

At EANTC, we have always felt that differentiated classes of service and OAM performance monitoring will eventually be key differentiators for Carrier Ethernet wholesale access services. Simple point-to-point OVCs (Operator Virtual Circuits) seem to be the low-hanging fruit reachable for everyone, and competition for these commodity services is likely to be pricing-based.

At this point, it is up to enterprise users of Carrier Ethernet services to demand for more. After all, one big selling point of Ethernet has typically been its perceived competitive pricing. On the other hand, only proper class of service support will enable parallel voice over IP, storage and interactive applications across the network for example. Only performance monitoring will allow service providers and enterprises to enter into strict service level agreements.

A Word from Equinix

The need to interconnect autonomous networks is growing proportionately alongside the demand to serve customers across a global landscape. While many networks are already interconnected, more interconnects will be required to meet the demand for services and to consistently serve customers no matter where they happen to locate their business. This is especially true as the customer applications require increasing amounts of bandwidth and hence the emphasis on Ethernet based interconnects.

Now that we've completed the fourth phase of Global Interconnect testing, 1 year since the ratification of MEF 26, it is plain to see that the industry is making great progress towards solving the technical challenges surrounding Ethernet interconnection. This interconnection testing proves not only that the Ethernet equipment of today is quite robust and capable, it is further evidence that connections between two or more autonomous Ethernet networks are viable. In addition, the challenges associated with mapping CoS and implementing Ethernet OAM are being addressed by MEF as well as the Ethernet Exchange providers. Ethernet Exchanges are growing in popularity and "many-to-many" interconnection is poised to aid in meeting the demand for extended services.

The technical challenges may increase as more services and more interconnects come into the fold. A standardized approach and proven interoperability will drive more streamlined interconnection. We look forward to working with both the equipment vendor and service provider communities to continue to address and test service capabilities. Not to devalue the technical challenges, but is it hopeful that a streamlined technical solution will free up more time to address the business and commercial challenges facing the industry.

Introduction

It is no longer appropriate to consider Carrier Ethernet standards, or the respective products on the market, immature. Of course there is still more work to be done here, however given the progress the MEF has shifted focus on the next phase of this problem — Global Interconnect. How can services be defined in a manner which is comparable amongst providers? How can two (or more) operators be interconnected to form an end-to-end service where neither of them have complete coverage? The customer-facing User Network Interface (UNI) has been standardized since

2005, and in January 2010 the MEF ratified the External Network-Network Interface (ENNI) specification, defining details for Carrier Ethernet service interconnection across network operators. The goal is to provide a common ground and understanding for services and their interfaces, improving interoperability of Carrier Ethernet across operators and customers. We set up this test program with exactly this goal: To validate and improve ENNI inter-working across network operators worldwide.

This white paper concludes the fourth phase of EANTC tests, the first of which kicked off the test program in January 2010. Since then, we have validated fourteen operators for a range of aspects of their Ethernet services including ENNI connectivity across Ethernet Exchanges and resiliency against link failures, evaluation of remote locations all across Europe and North America, MEF specified ENNI and Class of Service (CoS) mapping and the associated bandwidth profile expectations, and finally verifications of Ethernet OAM and performance monitoring. Previous reports can be found at www.eantc.de/cegi2010. In this phase we aimed to continue these topics where applicable, and tested multipoint-to-multipoint services in addition (E-LAN).

Test Scenario

In our scenario, both point-to-point services and multipoint-to-multipoint services were enabled throughout the participating operator networks. For point-to-point services, we simulated two separate customers ("Customer A" and "Customer B") with points of presence in various locations in Europe and USA. These customers each purchase multiple Ethernet Virtual Private Line (EVPL) services from a wholesale provider, who implements these services by leasing Operator Virtual Circuits (OVC) from different operators and constructing the service from these segments. Each Ethernet Virtual Private LAN (EVPLAN) service was configured to span all operators. The wholesale provider also operates Network Interface Devices (NIDs) which terminate the end-to-end service and use them to monitor the availability of the service through Connectivity Fault Management (CFM). We put ourselves in the shoes of such a wholesale provider.

We implemented Carrier Ethernet services between multiple providers, interconnecting them either at Equinix's London location (LD4) or their Frankfurt location (FR2), based on where the operators had equipment. Abovenet then provisioned a service to connect the two Equinix hubs.

Operator Network

We verified EVPL and EVPLAN services from several Carrier Ethernet providers during the tests. For consistency, we referred to these networks as "Operator MEN", while the term "Provider" was reserved for the emulated wholesale provider implementing the multisegment end-to-end services. Abovenet, Level3, Teragate and Tinet participated as Operator MENs, connecting to connecting to one or more of the Equinix exchanges. In addition, Abovenet provided a connection between the exchanges with a dedicated Gigabit Ethernet link.

Each operator configured a set of multiple OVCs in their network in accordance with the interconnection plan defined by EANTC. Operator MENs had to establish mapping of specific S-VLAN IDs at one of the customer ports and the port facing the interconnection facility to the same OVC. The actual mechanism of how the frame forwarding was implemented in the provider's network was not in scope to the tests.

Exchange / Interconnect MEN

The interconnection facility concept plays an important role in our scenario, as it allows a flexible configuration of the interconnection service between two providers. Instead of arranging the VLAN and CoS mapping parameters for each pair of providers, and providing a separate Ethernet link between them, the interconnection facility may become a central "meeting point" for Carrier Ethernet providers, by arranging interconnections between multiple providers' services. The interconnection facilities used were administrated by Equinix, one being in London, and one in Frankfurt. Equinix's solution provided simultaneous interconnection between all attached services by mapping specific SVLAN IDs on the ports facing providers to desired port and SVLAN ID used by the peering partner. In addition, the switch provided a solution for the operators whose equipment lacked full ENNI functionality; allowing, for example, connection between those supporting 802.1ad and those not.

Many providers support different CoS classes in their networks, and in most cases they are defined and encoded differently. For services implemented across multiple providers, it is crucial to support a common scheme between the providers in order to maintain correct QoS definitions across the entire service. MEF23 defines such a scheme for CoS and frame color, and specifies the mapping to be used and it is important that Ethernet Exchanges are able to map these definitions appropriately.

Ethernet Network Interface Devices (NIDs)s

Ethernet Network Interface Devices ("NIDs") were used to terminate the end-to-end services at the customer ports of the operator MENs and assist the testing in several ways. Ethernet NIDs from three different vendors were used: MRV OS904 and OS906, Omnitron GM3 and HybridNID, and RAD ETX-204A.

The NIDs were located throughout Europe and North America - completely based on the operators' preference, and the NID vendors ability to ship to that location. In all cases the NID vendor was able to ship a NID to the location of choice with a pre-configured management port in order to reach the NID from remote. All three NID vendors also continued to support and debug when and where necessary.

First, in order to test with emulated customer traffic, we put the NIDs in Ethernet loopback mode, causing them to return all traffic received from the MEN back to the source. This way we could generate traffic, and make measurements, from our test equipment which

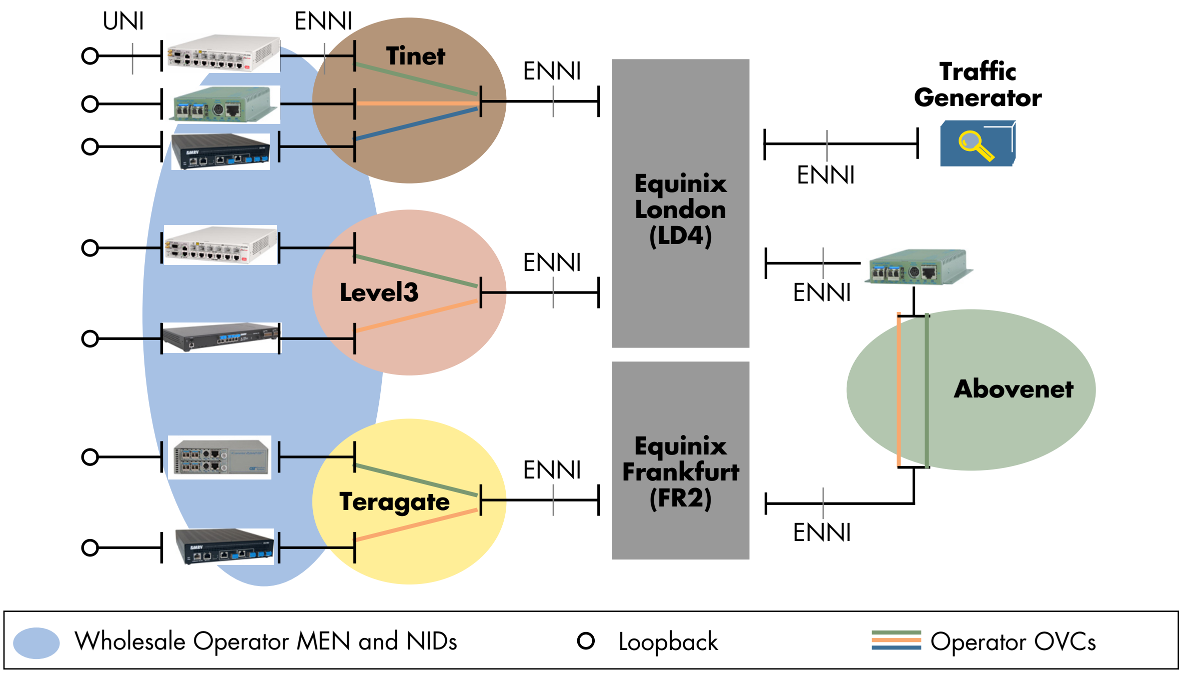

Figure 1: Test Setup

was located at the Equinix location in London. Alternatively, in some cases, we simply captured and compared the interface counters.

Operator	Service Termination Points
AboveNet	London, Frankfurt
Level3	New York
TeraGate	Frankfurt, Munich
Tinet	London, Frankfurt

Then, in cases where traffic needed to be generated from the NID side, the NIDs themselves played active role by generating traffic using their RFC2544 tests. Finally, we asked the NID vendors to configure Ethernet Service OAM instances on the NIDs in order to continuously monitor, and actively measure, end-to-end connectivity and performance.

Test Results

Since the goal of the test was not to create a competitive performance analysis amongst providers as much as it was to evaluate the state of the art, what we present as results is what we were able to achieve in the three weeks of testing amongst the multiple parties. Naturally, performance metrics were nevertheless recorded for internal documentation and as a sanity check.

We were reminded of the range of time it can take to establish a service amongst several parties. The act of coordinating equipment allocation and service provisioning across multiple providers in multiple locations and time zones proved to be a time consuming exercise. Without agreed-upon interconnect agreements among the providers defining the service configuration and service level agreements in advance, completing any testing in just a couple of weeks would likely have been impossible.

The results show that there is still progress to be made, but things are moving. ENNI availability is increasing, both for E-LAN and E-Line services. OAM tools are however not deployed everywhere, and bandwidth profiles prove to be a challenge.

Individual OVC Verifications

In order to ensure correct configuration of the entire test bed, we first performed simple connectivity tests with each individual OVC that was configured by the providers.

Equinix implemented the interconnection using internal VPLS — multipoint-to-multipoint connections providing switching between 2 or more Service Access Points (SAPs). In order to include the tester into setup, we defined new SAPs on the switch port connected to the analyzer for each of the point-to-point and multipoint-to-multipoint service defined in our global scenario. By transmitting traffic with the appropriate SVID value on the traffic generator port, frames could be injected into each selected service. A test frame with an arbitrary destination MAC not learned by the interconnection switch would be flooded and transmitted to all endpoints of the service. This was however not an issue as we enabled the Layer 2 loopback function on the NID where we wanted our traffic to go to. By swapping the MAC addresses and transmitting the frame back, the NID automatically mimics a host with the MAC address we sent the frame to. This causes the interconnection switch, and also the switching function of the multipoint-to-multipoint OVCs to learn this MAC address and from now on forward the test traffic to this destination only. This type of interconnection allowed us to maintain just one single configuration of the interconnection switch, suitable for all tests.

E-LAN — Multipoint Connectivity

A new addition to the tests, compared to previous phases of this test program, was the inclusion of multipoint-to-multipoint services, or Ethernet LAN (E-LAN) services.

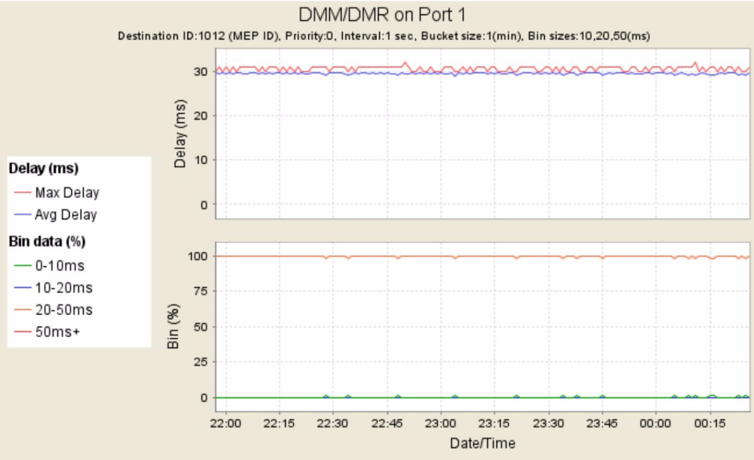

Figure 2: End-to-end Delay Measurements — Omnitron GM3

Each E-LAN service spanned all four participating operators. We were able to successfully verify multipoint connectivity within Level3 and Tinet networks both via the test equipment deployed at Equinix, and with the NIDs deployed in remote locations. The NIDs were used to generate traffic via their RFC 2544 tests from only one direction, thus intentionally causing a flood situation where we expected and indeed measured frames being received at all other endpoints of the service.

In addition, point-to-point Ethernet OAM instances were configured over both the E-LAN services by all three NID vendors as defined by IEEE 802.1ag Connectivity Fault Management (CFM), with performance monitoring enabling performance monitoring features from ITU-T Recommendation Y.1731. This enabled both easy status checks and performance monitoring of the services. The figures show how these performance metrics were graphed from various services and displayed by the NIDs.

Bandwidth Profiles

After hearing once again how important Service Level Agreement (SLA) assurance and bandwidth profile testing is, it was not much of a choice as to whether or not we would repeat such tests in this phase of the program, as conducted in previous phases. Operators offered a variety of different bandwidth profiles. In Abovenet's case, a dedicated Gigabit Ethernet link was provided to facilitate the tests which traversed their network. Teragate and Tinet were successfully tested for MEF 23 mapping, as well as Committed and Excess Information Rates and Burst Sizes (CIR/EIR and CBS/EBS). Level 3 provided us with their standard service definition, which also had metrics defined for all seven differentiated service classes, and our tests proved the drop priority and bandwith policing metrics which were defined.

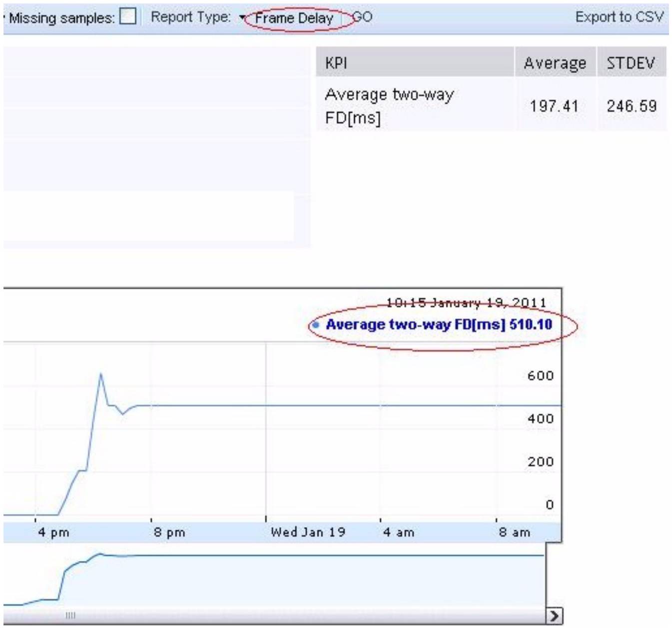

Figure 3: End-to-end Delay Measurements — RAD Data Communications ETX-204A

About EANTC

The European Advanced Networking Test Center (EANTC) offers independent telecom network test services for manufacturers, service providers and enterprise customers. Business areas include interoperability, conformance and performance testing for IP, MPLS, Mobile Backhaul, VoIP, Carrier Ethernet, Triple Play, and IP applications.

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