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PBB-TE: A Carrier Ethernet Technology

contents

Introduction

The last few years have witnessed a rapidly increasing demand for data services. In keeping with this trend, Carriers are looking for new, less expensive ways to transmit data services, while still ensuring guaranteed end-to-end connections and SLAs. Ethernet, the most successful networking technology ever invented, is leading this charge. Carrier Ethernet, a new variety of Ethernet, is positioned to dominate emerging business and residential networks.

Limitations of Conventional Ethernet

The Ethernet that works so well in the office is far removed from a carrier-grade, connection-oriented technology that service providers need to support guaranteed data services. The primary issues with conventional Ethernet are poor scalability, lack of OAM features and poor restoration times.

Metro Ethernet Forum (MEF) has defined five specific attributes that distinguishes Carrier Ethernet from Conventional Ethernet:

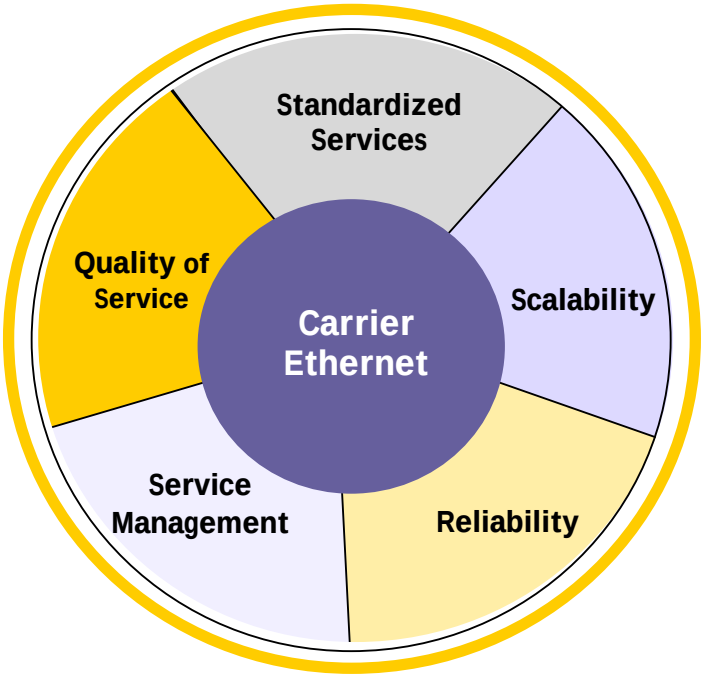

Figure 1: Carrier Ethernet Attributes (Source: MEF)

PBB-TE (Provider Backbone Bridges - Traffic Engineered), the latest enhancement to Ethernet Standard, achieves these five objectives for Carrier Ethernet. PBB-TE is widely expected to become the dominant technology for guaranteed, connection-oriented data transport in the aggregation and transport portion of metropolitan networks.

PBB-TE: An Evolution from Conventional Ethernet

This section details the various additions that were applied to the Conventional Ethernet standard leading up to PBB-TE.

1. IEEE 802.1Q: VLAN

VLAN (Virtual Local Area Network) tags are used by switching devices to differentiate traffic with a VLAN identifier (0 to 4095). This allowed for QoS and traffic separation functions on a shared media.

Figure 2: IEEE 802.1Q Frame Format

2. IEEE 802.1ad: Provider Bridge

VLAN tags have a maximum of 4096 IDs, which is sufficient for LANs, but not enough for carriers with multiple routes and subscribers. To improve the scalability of VLANs, Provider Bridge (also known as Q-in-Q) defined stacked VLAN tags. An additional tag is inserted in an already tagged frame, creating an inner tag (C-Tag) and an outer tag (S-Tag). This allowed service provider to add tags specific to their networks without modifying the tags already in the frame inserted by the customer.

Figure 3: IEEE 802.1ad Frame Format

3. IEEE 802.1ah: Provider Backbone Bridge

At the edge of the PBB network, customer Ethernet frames are encapsulated into carrier Ethernet frames. Within a PBB network, frames are switched according to the destination backbone switch MAC. The main advantage of this approach is the complete separation of customer and carrier domains, enabling the customer's Ethernet frames to be transparently transported in the carrier's Ethernet frames. This greatly reduces the complexity of the switch-forwarding tables, as the entries are limited to the carrier's network switches.

PBB added a unique field called I-Tag, which allows the carrier to assign QoS parameters and define a unique customer identifier (I-SID). Since the I-SID is 24 bits long, it can support millions of service identifiers.

PBB also incorporates a new feature called Backbone VLANs (B-Tag). Backbone VLANs allow a carrier to define a few "super highways" between major network ingress and egress points. As new customers and services are added to the network, they can simply be assigned to existing Backbone VLAN tunnels. Using B-Tag eliminates the need to manually provision each and every service flow across intermediary nodes on the network.

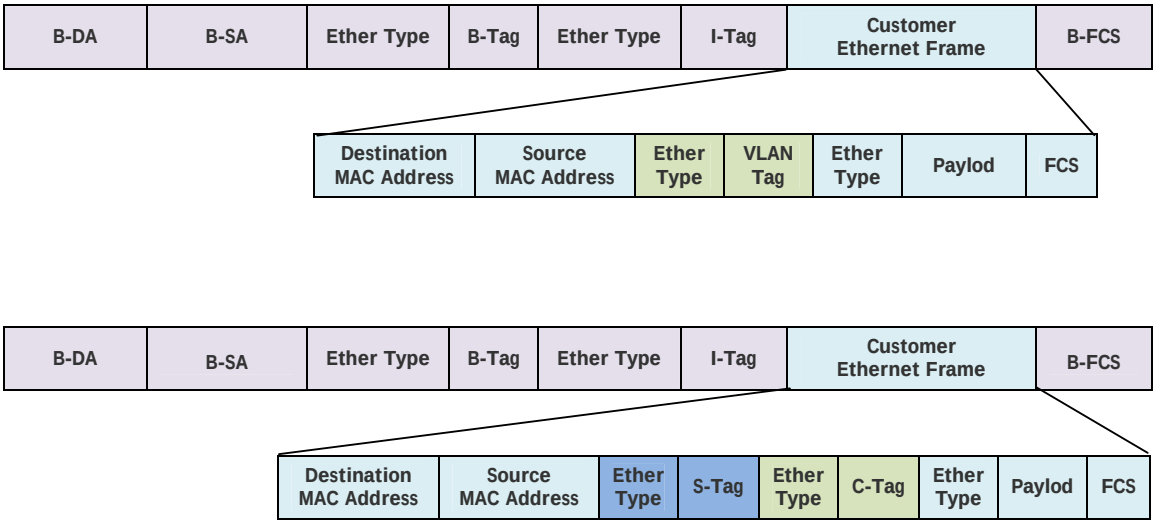

Figure 3: IEEE 802.1ah Frame Format

4. IEEE 802.1ag: Connectivity Fault Management

Connectivity Fault Management (CFM) provides both active and passive mechanisms for monitoring end-to-end Ethernet flows. The three major components of CFM are: loopback messages, link-trace messages and continuity-check messages.

Loopback messages are analogous to the Layer 3 "ping" capability and are a passive mechanism initiated by an end point. This is a one shot test to check connectivity to a known MAC address.

Link-Trace messages are analogous to the Layer 3 "traceroute" capability and are also a passive mechanism initiated by an end point. This test finds the exact path taken through the Layer 2 network to reach a destination end point.

Continuity Check Messages are an active mechanism where each end point send out periodic "hello" messages to other devices in the maintenance domain and maintain a table of active devices. This feature also includes a provision to send an alarm indication signal in the event of a failure.

5. IEEE 802.1Qay: Provider Backbone Bridge – Traffic Engineered

Provider Backbone Bridging solved most of the Carrier Ethernet problems, but left a few undesirable issues in the core. If MAC filter table updates, unknown packet flooding, and long protection times due to RSTP are so problematic, why not simply turn these mechanisms off? This is exactly what is done with the new PBB-TE (802.1Qay) standard. By turning off these legacy Ethernet functions, there needs to be an alternative method to provision the MAC filter tables, backbone tunnels and Ethernet service parameters. PBB-TE simply states that these functions can be provisioned by an external management system.

PBB-TE: Architecture

1. Netwok Elements

A typical PBB-TE network is composed of two main devices, the PBT edge switch and the PBT backbone (or core) switch.

The edge switch is the interface between the customer network and the service provider network. This device is responsible for the encapsulation or de-encapsulation of the customer's Ethernet frames within the PBB frame. The PBB frames are switched within the PBB-TE network based on the backbone destination MAC address (B-DA) and the backbone VLAN ID (B-VID). The I-Tag is used to identify QoS levels as well as the customer carried by the PBB frames via the I-SID.

The backbone switch is responsible for the forwarding of PBB frames within the PBB-TE network using predefined routes according to the B-VID.

2. Frame Forwarding

In legacy Ethernet, switches perform spanning tree and flooding to discover neighboring switches, thus creating dynamic forwarding routes. In Learning mode, a switch forwards frames with unknown destination MAC addresses to all ports. These addresses are then added to the switch table once an incoming frame with that source MAC is detected at a port. Broadcast frames are processed and forwarded by the switch to all ports.

In PBB-TE, switches are configured with static routes by the network operator, ensuring that frames take predetermined paths within the network.The user must configure all the backbone switches in the forwarding table using external management software. In such a situation, frames with destination MAC addresses not yet associated in the switch table will be dropped. Since broadcast frames are not supported in PBB-TE networks, they will also be dropped by the backbone switches.

3. Network Resiliency

In legacy Ethernet, the spanning tree learning process would automatically discover the network interruption and elect new routes based on calculations.These mechanisms disrupt the flow of traffic until the learning and calculation process is completed, this is typically 3 to 5 seconds for RSTP.

In PBB-TE, since spanning tree is disabled and routes are configured by the network operators, network resiliency also becomes a configurable item. The network can contain at least two paths, a working path and a protection path. The working path consists of the main path taken by frames under normal operation while the protection path is the backup path taken by frames in case the main path is broken. Path assignment is based on the B-VID assigned to the frames during their encapsulation at the edge switch. Therefore, the network operator must determine the working and protection VLANs as well as configure the routes that each VLAN must take on the network.

For PBB-TE, path issues are determined by IEEE 802.1ag Connectivity Fault Management (CFM) continuity check messages, which should be received at specific intervals. In the event that a backbone or core device does not receive a CFM message after a specific interval, a failure in

the link is assumed. Frames are then automatically forwarded using the protection path within 50 ms.The PBB-TE recovery times are therefore within the sub-50 ms requirement of traditional transport networks while providing deterministic paths for frames.

Carrier Ethernet @L&T Infotech

L&T Infotech has always ensured that it is up to date on emerging technologies and paradigms, and Carrier Ethernet is no exception. L&T Infotech has been actively following Carrier Ethernet developments in various standards bodies, apart from providing insight into the subject at various forums and conferences.

Further, L&T Infotech has been engaged in the implementation of commercial products incorporating various Carrier Ethernet Technologies. We have experience of working on following Carrier Ethernet technologies: IEEE 802.1q (VLAN), IEEE 802.1ad (Q-in-Q), IEEE 802.1ah (MAC-in-MAC), IEEE802.3ah (EFM: Ethernet OAM) and IEEE1588 (PTP)

We at L&T Infotech are well equipped to help customers in the Carrier Ethernet domain by leveraging our extensive experience in Transport Technologies as well as our rich experience in development of switching and routing systems.

Abbreviations and Acronyms

CFM	Connectivity Fault Management
EFM	Ethernet in First Mile
MEF	Metro Ethernet Forum
OAM	
PBB-TE	Provider Backbone Bridges- Traffic Engineered
PTP	Precision Time Protocol
QoS	Quality of Service
RSTP	Rapid Spanning Tree Protocol
SID	Service ID
SLA	Service Level Agreement
VID	VLAN ID
VLAN	Virtual Local Area Network

References

IEEE Standards	http://www.ieee.org/
MEF Standards	http://metroethernetforum.org/
Various Carrier Ethernet Vendors	Ciena (http://www.ciena.com) Extreme Networks (http://www.extremenetworks.com) EXFO (http://www.exfo.com) Fujitsu (http://www.fujitsu.com) Nortel (http://www.nortel.com) Tejas Networks (http://www.tejasnetworks.com)

About the author(s)

Nitin Jain has an experience of around 10 years in the execution and management of software development projects in the wireline and wireless telecom infrastructure domain. One of his areas of technical interest is wireline transport, especially Carrier Ethernet . He has been associated with L&T Infotech since 1999.

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