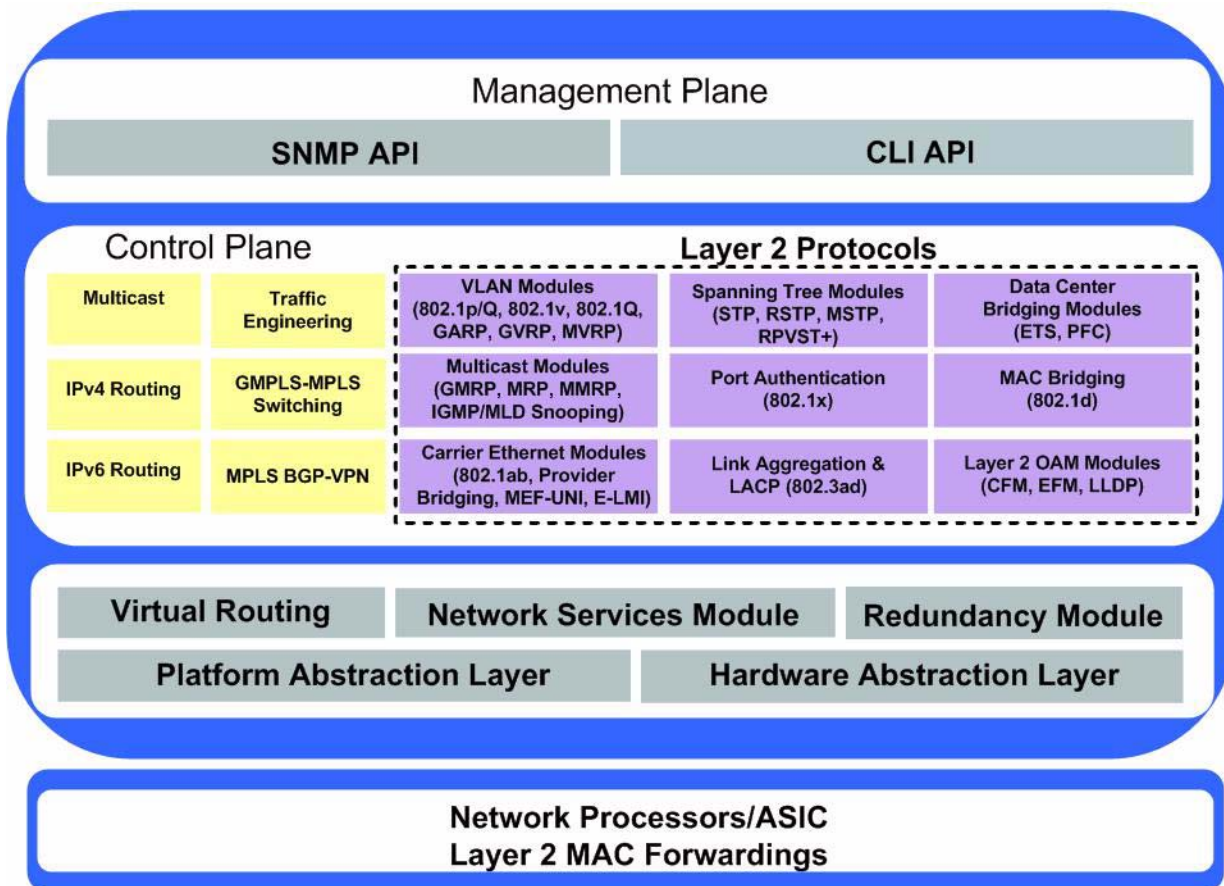


ZebOS®  
Network Platform

## Layer 2 Protocol Modules

### Overview

The ZebOS® Network Platform Layer 2 Protocol Modules are a family of Ethernet bridging, spanning tree, multicast, and VLAN software packages that provides advanced Layer 2 functionality for vendors building routing and switching equipment. ZebOS Layer 2 Protocol Modules leverage the command line interface and the kernel management of the ZebOS Network Services Module (NSM). Because of their seamless integration with leading operating systems and other ZebOS protocols, the ZebOS Layer 2 Protocol Modules offer the ideal Layer 2 framework for both new and existing IP Infusion customers. IP Infusion's Layer 2 Protocol Modules support Carrier Ethernet and advanced multicasting demands, including Voice over IP (VoIP), Video on Demand (VOD), IP television (IPTV), and online gaming.



Layer 2 Protocol Modules in the ZebOS Architecture

## ZebOS Layer 2 Protocol Modules

The ZebOS Layer 2 family includes the following protocol modules:

- [VLAN Modules](#) — 802.1p/Q, 802.1v, Generic VLAN Registration Protocol (GVRP), and Multiple VLAN Registration Protocol (MVRP), VLAN Stacking
- [Multicast Modules](#) — Multiple Registration Protocol (MRP), GARP Multicast Registration Protocol (GMRP), Multiple Multicast Registration Protocol (MMRP), IGMP and MLD Snooping
- [Carrier Ethernet](#) — 802.1ad Provider Bridging, MEF User-to-Network Interface (UNI), Provider Backbone Bridges (PBB), Ethernet Local Management Interface (E-LMI)
- [Spanning Tree](#) — STP, RSTP, MSTP and RPVST+ modules
- [Port Authentication](#) — 802.1x Port Authentication
- [Link Aggregation](#) — Link Aggregation (802.3ad) and Link Aggregation Control Protocol (LACP)
- [Data Center Bridging](#) — Enhanced Transmission Selection (ETS) and Priority-based Flow Control (PFC)
- [MAC Bridging](#) — IEEE 802.1d
- [Layer 2 OAM](#) — Link Layer Discovery Protocol (LLDP), Ethernet to the First Mile (EFM) and Connectivity Fault Management (CFM)

In addition, the ZebOS Layer 2 family offers core and advanced VLAN bundled options.

### VLAN Modules

**Virtual LAN** — The ZebOS Layer 2 Modules support 802.1p/Q Virtual LAN (VLAN) bridging. VLAN bridging allows network devices to segment into virtual LANs, regardless of their physical location. The ZebOS Layer 2 Core Module also includes 802.1p priority signaling for prioritization of traffic at the data-link layer.

**Port and Protocol VLAN Classification** — Port and Protocol VLAN Classification is an amendment (802.1v) to 802.1Q that describes enhancements to allow for classification of incoming packets by methods other than source port. It defines rules for classification based on data-link-layer protocol identification.

**Generic Attribution Registration Protocol (GARP)** — GARP provides a generic framework for bridges to register and de-register attributes, such as VLAN identifiers and multicast group membership.

**GARP VLAN Registration Protocol (GVRP)** — GVRP provides 802.1Q VLAN pruning and dynamic VLAN creation. A switch can exchange VLAN configuration information with other GVRP switches, prune unnecessary broadcast and unknown unicast traffic, and dynamically create and manage VLANs.

**Multiple VLAN Registration Protocol (MVRP)** — MVRP registers multiple VLANs and provides for the rapid healing of network failures without interrupting services to unaffected VLANs. In addition, MVRP improves the convergence time of the GVRP module.

### Multicast Modules

**Multiple Registration Protocol (MRP)** — MRP specifies the protocol, procedures, and managed objects required to support multiple registrations, thus allowing participants in an MRP application to register attributes with other participants in a Bridged LAN.

**Multiple Multicast Registration Protocol (MMRP)** — MMRP manages group Media Access Control (MAC) addresses. In addition, MMRP improves the convergence time of the GMRP module.

**GARP Multicast Registration Protocol (GMRP)** — GMRP provides multicast pruning and dynamic group membership for multicast. A switch can exchange multicast group information with other GMRP switches, prune unnecessary broadcast traffic, and dynamically create and manage multicast groups.

**Internet Group Multicast Protocol (IGMP) Snooping** — A switch supporting IGMP snooping can passively snoop on IGMP packets to learn the IP Multicast group membership. With IGMP snooping multicast traffic of a group is only forwarded to ports that have members of that group. IGMP snooping generates no additional network traffic.

**Multicast Listener Discovery (MLD) Snooping** — A switch supporting MLD snooping can passively snoop on MLD packets to learn the IP Multicast group membership. With MLD snooping, multicast traffic is only forwarded to ports that request receipt of packets from the source. MLD snooping generates no additional network traffic.

### **Carrier Ethernet**

ZebOS Carrier Ethernet software delivers the extensions to Ethernet required to enable providers to support Ethernet services to customers and to use Ethernet technology in their networks.

**Provider Bridging**—Provider bridging enables a service provider to use the architecture and protocols of IEEE standard 802.1Q to offer the equivalent of separate LANs, Bridged LANs, or Virtual Bridged LANs to multiple customers, while requiring no active cooperation between their customers and only minimal cooperation between individual customers and the service provider.

**Provider Backbone Bridging (PBB)**—PBB resolves issues between the customer service instances and MAC address scalability by supporting a completely new or separate Provider Backbone MAC address space that can support up to sixteen million service instances.

**MEF-UNI**— The MEF UNI supports the Metro Ethernet Forum's (MEF) User Network Interface (UNI) requirements, framework, and functional model for how a UNI reference point operates in a Metro Ethernet Network (MEN).

**Ethernet Local Management Interface (E-LMI)**—E-LMI is an Ethernet OAM protocol used for communications between two User Network Interfaces (that is, UNI-C and UNI-N). E-LMI provides both UNI and EVC (Ethernet Virtual Connection) status information to customer edge (CE) devices. This information enables automatic configuration of CE operation based on the Metro Ethernet Network configuration.

### **Spanning Tree**

The following highlights the features of IP Infusion's Spanning Tree modules.

**Spanning Tree Protocol (802.1D)** —The ZebOS Spanning Tree Protocol (STP) module enables devices to avoid bridge loops by exchanging BPDU (bridge protocol data unit) messages and includes standard Management Information Base (MIB) support for RFC 1493 and RFC 2674. The Spanning Tree Algorithm calculates the best path and prevents multiple paths between network segments. IP Infusion's implementation of STP supports IEEE 802.1D and RFC 4188 for the Bridge Management MIB.

**Rapid Spanning Tree Protocol (802.1w)** — The Rapid Spanning Tree Protocol (RSTP) accelerates the reconfiguration and restoration of a spanning tree after a link failure. IP Infusion's implementation of RSTP optimizes convergence time, and supports IEEE 802.1D and RFC 4318. IP Infusion's RSTP module has also been optimized for faster convergence times.

**Multiple Spanning Tree Protocol (802.1s)** — The Multiple Spanning Tree Protocol (MSTP) is a supplement to the IEEE 802.1Q standard. It allows VLAN bridges to use multiple spanning trees, by providing the ability for traffic belonging to different VLANs to flow over potentially different paths within a virtual bridged LAN. IP Infusion's MSTP module has also been optimized for faster convergence times to support the MSTP MIB requirements.

**Rapid per VLAN Spanning Tree Plus (RPVST+)** — RPVST+ builds an individual spanning-tree topology for each VLAN defined on a bridge; that is, each VLAN runs its own independent spanning-tree instance. In addition, RPVST+ bridges can have different spanning-tree topologies for different VLANs within an autonomous switching domain.

### Port Authentication

**Port Authentication** — The ZebOS Layer 2 802.1x module provides port-based network access control for LAN devices. The IEEE 802.1x standard offers centralized control of user authentication and access.

### Link Aggregation

**Link Aggregation** — Link Aggregation (802.3ad) allows one or more links to be aggregated together to form a Link Aggregation Group (LAG), such that a MAC Client can treat it as if it was a single link.

**Link Aggregation Control Protocol (LACP)** — LACP allows bundling of multiple physical interfaces to form a single logical channel providing enhanced performance and redundancy. The aggregated interface is viewed as a single link to each switch and to the spanning tree. When there is a failure in one physical interface, the remaining interfaces stay up, so there is no disruption.

### Data Center Bridging

**Priority-based Flow Control (PFC)** — The PFC standard specifies protocols, procedures and managed objects that enable flow control per traffic class on IEEE 802 full-duplex links. Priority-based flow control helps eliminate frame loss due to congestion by operating on individual priorities. Along with other Data Center Bridging technologies, PFC helps the flow of higher-layer protocols, which are highly loss sensitive, while not affecting traditional LAN protocols that utilize other priorities.

**Enhanced Transmission Selection (ETS)**— The ETS standard supports the allocation of bandwidth amongst traffic classes. When the available load in a traffic class does not use its allocated bandwidth, ETS allows other traffic classes to use the available bandwidth.

### MAC Bridging

IEEE 802.1d defines MAC (Media Access Control) Bridging, which allows multiple Local Area Networks (LANs) to connect together. MAC bridging filters data sent between LAN segments to reduce network congestion and to allow networks to partition for administrative purposes.

### Layer 2 OAM

**Link Layer Discovery Protocol (LLDP)** — LLDP (802.1ad) defines a set of managed objects used to discover the physical topology of adjacent stations in LANs, as defined in IEEE 802.3.

**Ethernet to the First Mile (EFM)** — EFM (802.3ah) describes subscriber access technologies and the physical layer specifications for subscriber access. In subscriber access networks, this requires implementation of only the far-end OAM features, including:

- Remote failure detection
- Remote loopback
- Link Monitoring

**Connectivity Fault Management (CFM)** — CFM (802.1ag) refers to the service Operations and Management (OAM) of the Ethernet OAM, and addresses the per-customer and per-service OAM granularity required to manage Layer 2 Ethernet services. CFM can operate over Service VLAN (S-VLAN), Customer VLAN (C-VLAN), Border VLAN (B-VLAN), or I-SID service instances, and LAN segments. Support for enhanced CFM OAM, as defined in IEEE 802.1ag, fulfills the requirements of the ITU-T Y.1731 standard by affording periodic, on-demand, and asynchronous messaging.

## Features

- Robust and reliable implementation of Layer 2 protocols
- Conformance to IEEE and IETF standards and tested interoperability with leading Layer 2 vendors
- Industry-standard CLI management
- Software-based MAC forwarding engines for Linux that handle exception packets for network processors or ASICs, or forward traffic for CPU-based systems
- Transparent forwarding of report and report suppression

## Benefits

- Complements the ZebOS Layer 3 routing protocols
- Includes hardware APIs to streamline integration with ASICs and network processors
- Reduces the time and associated costs of developing Layer 2 applications

## Standards Supported

The lists below group standards applicability for each of the major subjects discussed in this product brief.

### Layer 2 Protocols

- **Spanning Tree Protocol (STP)** — IEEE 802.1D (2004); RFC 4188: Definitions of Managed Objects for Bridges
- **Rapid Spanning Tree Protocol**— IEEE 802.1D (2004) clause 17; RFC 4318: Definitions of Managed Objects for Bridges with Rapid Spanning Tree Protocol
- **Multiple Spanning Tree Protocol (MSTP)** — IEEE 802.1Q (2005): Clause 13
- **Rapid Per-VLAN Spanning Tree Plus (RPVST+)** — ZebOS implementation of the Cisco version of Spanning Tree/Rapid Spanning Tree
- **Virtual LANS (VLANs)**— IEEE 802.1Q (2003); RFC 4363: Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions
- **Generic Attribute Registration Protocol (GARP)** — IEEE 802.1Q (2003)
- **Generic Multicast Registration Protocol (GMRP)** — IEEE 802.1Q (2003)
- **Generic VLAN Registration Protocol (GVRP)** — IEEE 802.1Q (2003)
- **Multiple Registration Protocol (MRP)** — IEEE 802.1ak/D4.0
- **Multiple Multicast Registration Protocol (MMRP)** — IEEE 802.1ak/D4.0
- **Multiple VLAN Registration Protocol (MVRP)** — IEEE 802.1ak/D4.0
- **Link Layer Discovery Protocol** — IEEE 802.1AB 2005
- **Port Authentication** — IEEE 802.1X (2004); draft-ietf-bridge-8021x-01.txt (IEEE8021-PAE-MIB)
- **Internet Group Management Protocol (IGMP) (Version 1, 2, and 3) Snooping/Proxy**, RFC 4541— Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches
- **Multicast Listener Discovery (Version 1, 2) Snooping/Proxy**— RFC 4541: Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches

### Carrier Ethernet Protocols

- **Provider Bridging** — IEEE 802.1ad/D6.0
- **Provider Backbone Bridging** — IEEE 802.3ah/D4.1, IEEE 802.1ap/D3.2 clause 17.5.8, IEEE 802.1Qay/D4.5

## MEF Specifications

- **MEF 2** — Requirement and Framework for Ethernet Service Protection
- **MEF 11** — User Network Interface (UNI) Requirements and Framework (UNI Type 1 and 2 only). Includes:
  - MEF 20 Section 8 — UNI Type 2 Discovery and Configuration
  - MEF 20 Section 9 — Supporting E-LMI for UNI Type 2
  - MEF 20 Section 10 — Supporting Ethernet OAM (Link and Service level OAM)
  - MEF 10.1 — UNI and EVC per UNI Service Attributes
  - MEF 10.1 — EVC Service attributes
- **MEF 16** — Ethernet Local Management Interface (E-LMI)
- **MEF 17** — Service OAM Framework and Requirements

## Ethernet OAM

- **Ethernet Link OAM** — IEEE 802.3ah - 2004 clause 57; RFC 4878: EFM MIB
- **Ethernet Service OAM** — IEEE802.3ah - 2004 clause 57, ITU-T Y.1731/05-2006, IEEE 802.1ag - 2007 amendment 5, IEEE 802.1Qay/D4.5 - clause 26.9
- **Ethernet Protection Switching** — IEEE 802.1Qay/D4.5 clause 26.10, ITU-T G.8031 - 06/2006, ITU-T G.8031 Amendment 1 - 10/2007, ITU-T G.8032, 06/2008
- **Link Aggregation** — Static aggregation, IEEE 802.3-2002 clause 43, IEEE 802.3 LAG-MIB

## Data Center Bridging

- **Enhanced Transmission Selection (ETS)** — 802.1Qbb
- **Priority-based Flow Control (PFC)** — 802.1Qaz

## Standard Deliverables

- Source Code (written in ANSI compliant C)
- Installation Guide
- Configuration Guides
- Command Reference Guides
- Developer Guides

## Special Considerations

The ZebOS Layer 2 Modules require either software- or hardware-based forwarding for Layer 2 data plane support.