

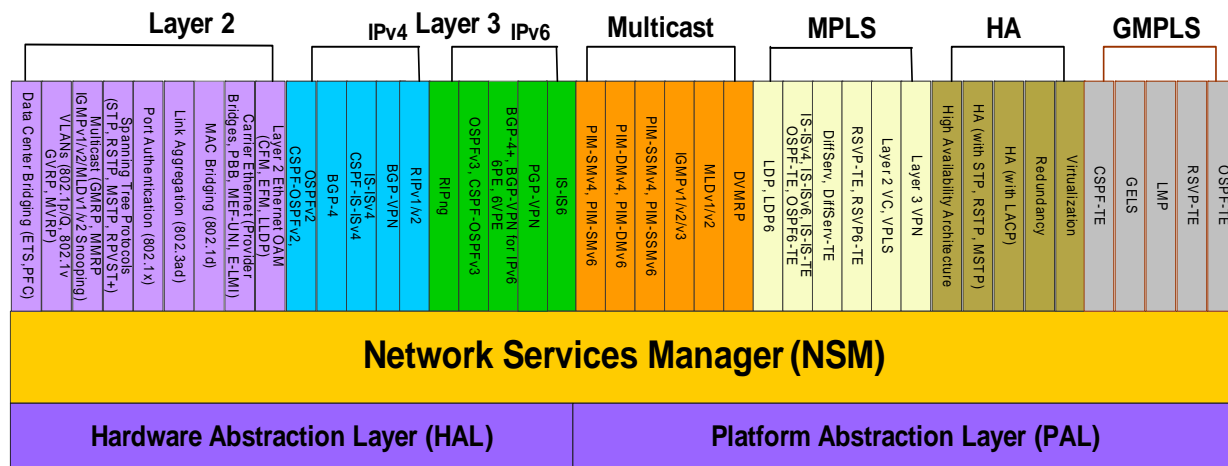
ZebOS®  
Network Platform

## ZebOS Network Platform

### Intelligent Network Software for Enhanced IP Services

IP Infusion's ZebOS® Network Platform is a scalable, robust and standards-based Layer 2 and Layer 3 carrier-class routing and switching software solution that allow OEMs add to rapidly networking capabilities to their new and existing lines of communication products. Its modular, platform-independent architecture enables OEMs to pick from amongst an impressive array of protocols and solutions to add to their equipment.

The ZebOS Network Platform supports industry-standard and best of breed operating systems, control-plane and data-plane processors. Although ZebOS is a control-plane network software solution, its architecture takes advantage of separate data-plane processors (NPUs and ASICs) to support modular and scalable communications equipment. The target for the ZebOS Network Platform is vendors building or enhancing access, enterprise, edge, core and enhanced IP services products.



### ZebOS Modular Routing and Switching Software Building Blocks

#### Key Features

- IPv4 and IPv6 Unicast and Multicast Routing
- IPv4-to-IPv6 Transition Software
- MPLS Traffic Engineering and MPLS-VPN (Layer 2/Layer 3)
- Generalized MPLS
- Advanced Layer 2 and VLAN Switching
- Robust Layer 3 Routing Capabilities for IPv4 and IPv6 Implementations
- A High Availability Solution for Managing Recovery from Failover

- Virtual Routing (VR) for Provider Edge (PE) Solutions
- Industry Standard Command Line Interface (CLI) and Integrated Management Interface (IMI)
- Integration with industry-leading silicon (Broadcom and Intel) using the ZebOS AIS Hardware Integration Platform (HIP) products
- Support for industry-standard operating systems (Linux and VxWorks)

## ZebOS Network Platform Architecture

The ZebOS Network Platform is a scalable, flexible and platform-independent architecture that provides stability and fine-grained modularity. Protocol modules can be independently licensed, installed and upgraded. This allows customers to deploy ZebOS in smaller and lower-priced access equipment as well as highly-scalable core networking equipment.

Each protocol module is built on the ZebOS Network Services module (NSM), the base module that simultaneously and independently communicates with every ZebOS routing and switching process. The NSM manages both the route table and each of the enabled protocols; performs route conversion and redistribution; manages the interface state, routing policies and filtering tasks. ZebOS NSM communicates through the Platform Abstraction Layer (PAL) to the underlying operating system or network processor for forwarding table updates.

The ZebOS Integrated Management Interface (IMI) provides a command line interface and an SNMP capability that vendors can use as-is, or integrate into an existing management infrastructure. ZebOS IMI and IMI-shell (IMISH) provide persistent, industry-standard mechanisms for managing network configuration and operation, as well as Unix-like facilities for command and output redirection and logging.

## Routing Protocols

### IPv4 and IPv6

IP Infusion is the leading provider of integrated IPv4 and IPv6 routing protocols in the market. The ZebOS Network Platform supports the most recent IETF and IEEE drafts and specifications for both IPv4 and IPv6 versions of OSPF, BGP, IS-IS and RIP. In addition to standard routing protocols, ZebOS offers Virtual Routing (VR) support, Traffic Engineering (TE) extensions and the Constrained Shortest Path First (CSPF) topology support for the OSPF and IS-IS protocol modules.

ZebOS also supports its own TCP/IP module, a dual stack that supports simultaneous use of IPv4 and IPv6 in a variety of configurations. The ZebOS TCP/IP stack is ideal for real-time operating system vendors that require dual-stack and VR extensions for their products. IP Infusion also offers a set of IPv4-to-IPv6 transition software packages, including 6to4, ISATAP, GRE, and IP-in-IP tunneling support. These protocols offer mechanisms for vendors to provide their users with methods for simultaneously supporting both IPv4 and IPv6.

## Advanced Layer 2 and VLAN Switching

The ZebOS Layer 2 and VLAN switching modules are a family of Ethernet bridging, spanning tree, multi-cast and VLAN software packages that provide advanced Layer 2 functionality for vendors building routing or switching equipment. Each Layer 2 protocol module leverages the CLI and kernel management of the ZebOS NSM. ZebOS Layer 2 modules are complementary to our Layer 3 routing protocol software solutions and are built on a common architecture.

The ZebOS Layer 2 family has a full set of solutions for the following:

- **VLAN Modules:** 802.1p/Q, 802.1v, Generic VLAN Registration Protocol (GVRP), and Multiple VLAN Registration Protocol (MVRP)

- **Multicast Modules:** Multiple Registration Protocol (MRP), GARP Multicast Registration Protocol (GMRP), Multiple Multicast Registration Protocol (MMRP), IGMP and MLD Snooping
- **Carrier Ethernet:** 802.1ab, Provider Bridging, MEF-UNI, and Ethernet Local Management Interface (E-LMI)
- **Spanning Tree:** STP, RSTP, MSTP and RPVST+ modules
- **Port Authentication:** VLAN Stacking, 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:** 802.1d
- **Layer 2 OAM Modules:** Link Layer Discovery Protocol (LLDP), Ethernet to the First Mile (EFM) and Connectivity Fault Management (CFM)

## Multi-protocol Label Switching

ZebOS Multi-protocol Label Switching (MPLS) modules are a complete solution for the rapid integration of MPLS functionality into enterprises for provider access, edge and core communications equipment. ZebOS supports both MPLS Traffic Engineering (TE) and VPN capabilities, and extensions for the support of DiffServ and DiffServ-TE. ZebOS MPLS switching modules support the following:

- Resource Reservation Protocol-Traffic Engineering (RSVP-TE)
- OSPF-TE and IS-IS-TE
- Label Distribution Protocol (LDP)
- Interior Gateway Protocol (IGP) Constrained Shortest Path First (CSPF for OSPF and IS-IS)
- MPLS-VPN using BGP VPN extensions in compliance with RFC 2547
- Virtual Private LAN Service (VPLS)
- DiffServ and DiffServ-TE Extensions

## Traffic Engineering

Traffic engineering extensions use the RSVP-TE and DiffServ-TE dynamic signaling protocols to communicate to the MPLS Forwarder or a third-party MPLS forwarder. The RSVP-TE extension enables MPLS to scale to large and complex IP-based communications equipment. ZebOS supports CSPF; using a TE database and pre-existing Label Switched Paths (LSPs), the CSPF module calculates (on demand) an optimum Explicit Route (ER) based on the constraints identified. A signaling protocol (either RSVP-TE or LDP) uses the resulting ER to setup an LSP.

## Virtual Private Networks

Providing VPN services adds significant value to provider edge equipment. These solutions enable the security needed by VPN service providers, while simultaneously building a scalable infrastructure that can take advantage of IP routing, traffic engineering (TE) and MPLS switching features. The ZebOS Network Platform offers both Layer 2 and Layer 3 VPN modules. Through the ZebOS MPLS Forwarder and LDP modules, ZebOS offers a Layer 3 MPLS-VPN solution by tightly integrating BGP-VPN extensions, and providing address space and routing separation using per-VPN routing tables and MPLS switching in the core.

MPLS Layer 2 VPN and VPLS protocol modules enhance MPLS by providing transparent LAN access between VPN sites. The ZebOS MPLS Layer 2 Virtual Circuit (VC) module implements draft-ietf-12circuit-transmpls-08 and draft-ietf-12circuitencap-mpls-04, and provides a point-to-point Layer 2 virtual circuit that allows extension of a LAN segment across an MPLS cloud. ZebOS VPLS includes MPLS Layer 2 VC, but also implements draft-lasserre-vkompella-ppvsn-vpls-04, adding support for hub-and-spoke and mesh VPN topologies. It combines the benefits of MPLS Layer 2 VC with the flexibility and scalability of multi-point-to-multipoint VPN.

## DiffServ and DiffServ TE

In order to provide a flexible DiffServ-over-MPLS solution, the ZebOS DiffServ module is available as an extension to ZebOS RSVP-TE. ZebOS DiffServ allows clients to specify and prioritize network traffic by class so that defined traffic types (for example voice traffic) get precedence over other traffic types. More advanced than QoS or ToS protocols, DiffServ employs a sophisticated policy to determine how to forward network data.

Since DiffServ by itself lacks the ability to efficiently use network transmission resources, IP Infusion has also developed a DiffServ-Aware MPLS Traffic Engineering (DiffServ-TE) module. ZebOS DiffServ-TE performs traffic engineering per DiffServ class rather than at an aggregate level. By combining DiffServ with MPLS Traffic Engineering, routing devices can simultaneously classify and prioritize traffic to achieve fined-grain optimization of transmission resources.

## Generalized Multi-protocol Label Switching

Generalized MPLS (GMPLS) enhances the MPLS architecture by separating the control and data planes of various networking layers. GMPLS provides a family of control plane protocols designed to operate in connection-oriented and traffic-engineering transport networks. The introduction of GMPLS to the ZebOS supports only Packet Switched Networks at this time. Brief descriptions of the ZebOS GMPLS modules are given below.

### Constrained Shortest Path First TE extensions for GMPLS

The CSPF TE extensions for GMPLS support GMPLS TE constraints, path computation over unnumbered links and path computation for bidirectional Label Switched Paths (LSPs). The CSPF algorithm calculates an optimum explicit route (ER), based on specific constraints for LSP. The signaling protocol (RSVP-TE) uses the resulting ER to setup a dynamic LSP.

### GMPLS Ethernet Label Switched

GMPLS Ethernet Label Switching (GELS) allows dynamic creation of the Ethernet LSP. Ethernet LSP is a GMPLS established Provider Backbone Bridge-Traffic Engineering (PBB-TE) TESI having two point-to-point (P2P) Ethernet Switched Paths. The GMPLS Ethernet Label Switched (GELS) path module is based on draft-ietf-ccamp-gmpls-ethernet-pbb-te-03.

### Link Management Protocol

Link Management Protocol (LMP) helps manage the links in control-plane (control-channels) and data-plane (data-links). LMP represents an essential part of the GMPLS protocol family. LMP is a control-plane component of GMPLS, and it provides the functions to support:

- GMPLS routing (OSPF-TE) and signaling protocols (RSVP-TE)
- Neighbor discovery by allowing connected nodes to verify proper connection of their data-links and to correlate those links
- Fault management capability in GMPLS networks

### Open Shortest Path First TE Extensions for GMPLS

Based on RFC 4202 and RFC 4203, the OSPF module supports extensions for GMPLS. The traffic engineering extensions for OSPF provide a way of describing the traffic engineering topology and distributing this information within a given OSPF area. ZebOS OSPF supports GMPLS-TE constraints such as switching capability, encoding type, protection capability, etc. It enables support for interface services for TE links from NSM and populates TE information in traffic engineering database.

### Resource Reservation Protocol extensions for GMPLS

The RSVP-TE (Resource Reservation Protocol-Traffic Engineering) architecture supports packet-switching interfaces. It is designed to support IPv4 or unnumbered data plane links. RSVP-TE relies on NSM for

most of its services, including data link, control link, TE link, control channel, and control adjacency. It also depends on NSM for Label, RIB (FTN/ILM) and QoS. These features support RFC 3471, RFC 3472, RFC 3473 and RFC 3477.

## Multicast

The ZebOS Network Platform includes both IPv4 and IPv6 multicast protocol modules, including Protocol Independent Multicast-Sparse Mode and Protocol Independent Multicast-Dense Mode. ZebOS PIM-SM routes multicast packets to multicast groups and is designed to efficiently establish distribution trees across wide area networks. PIM-SM is protocol-independent, because it can use the route information any routing protocol enters into the multicast RIB. The design of ZebOS PIM-SM makes it ideal for situations where multicast groups are thinly populated across a large region. Although they can operate in LAN environments, multicast groups are most efficient in WAN environments.

ZebOS PIM-DM is a data-driven multicast routing protocol that builds source-based multicast distribution trees to operate on the flood-and-prune principle. These trees require unicast-routing information, but do not depend on a specific unicast routing protocol. ZebOS PIM-DM effectively distributes data to target recipients in a concentrated area. Ideally suited for routers and switches, PIM-DM functionality greatly optimizes the delivery of video conferencing, streaming music and movies, Voice over IP (VoIP) services, distributed downloads, Internet TV, and more, into Local Area Networks.

ZebOS also supports the Distance Vector Multicast Routing Protocol (DVMRP) module. DVMRP is a multicast routing protocol that provides an efficient mechanism for connectionless datagram delivery to a group of hosts across an internetwork. DVMRP is a distributed protocol that dynamically generates IP multicast delivery trees using a technique called Reverse Path Multicasting (RPM).

## Virtual Routing

Virtual Routing logically subdivides a physical router into multiple virtual routers (VR) and allows each one to execute separate instances of routing protocol and network management software (for example, SNMP or the CLI). Moreover, users can independently monitor and manage each virtual router. Many sources refer to virtual routers in terms of their application within virtual private networks. This design interprets the VPN implementation to be a specific application of the overall virtual routing design. As a result, the VPN approach is an add-on feature of virtual routing.

The ZebOS Network Platform contains VR for both IPv4 and IPv6 routing protocol modules. It provides support for multiple RIB and FIB per physical router. Each VR instance consists of an OSPFv2, BGP-4+, or RIPv1/RIPv2 Protocol, each with its own RIB and FIB.

## Integration Platforms

The ZebOS Network Platform contains an advanced Hardware Abstraction Layer (HAL) interface that isolates all hardware-platform-specific interactions into a compact set of well-defined function calls for NSM. This lets ZebOS protocol modules and control plane applications to be completely independent of the hardware platform and the OS while supporting easy and rapid integration with any dataplane solution.

IP Infusion's ZebOS Advanced Integration Suite (AIS) Hardware Integration Platform (HIP) provides integration and optimization of ZebOS software for both switching/routing hardware and an OS of choice. Using ZebOS AIS HIPs and ZebOS Network Platform protocol modules, ODMs and OEMs can rapidly bring full solutions to market without the costly software and hardware development normally associated with complex device development.

## Management and Logging Plus Basic Access and Tunneling Protocols

In order to provide its customers with ease of management, configuration, and operation, IP Infusion has developed various management interfaces:

- ZebOS Integrated Management Interface and IMI Shell
- CLI and CLI APIs
- SNMP and SNMP APIs

The ZebOS Integrated Management Interface (IMI) and IMI Shell (IMISH) provide complete, unified management of ZebOS NSM and individual ZebOS routing protocols. IMI allows a system administrator to configure and monitor all ZebOS daemons through one centralized user connection. ZebOS IMI provides tools and utilities to configure and monitor the many features that are available in the Linux/Unix operating systems, including DNS, DHCP, ACL, NAT, and the IPv6-to-IPv4 transition protocols ISATAP, GRE and IP-in-IP.

An industry-standard CLI and CLI API aids in managing and configuring ZebOS NSM and each protocol module. SNMP and SNMP API support is available to let network management agents, as well as billing and provisioning applications, pull important data from ZebOS software and associated protocol modules for all standard defined MIBs. ZebOS has extensive logging capabilities to record system events and errors.

## **Development, Documentation and Support**

All ZebOS Network Platform modules are written in the portable ANSI C programming language and delivered with extensive documentation including Command Reference, Developer, Installation, and Configuration Guides. IP Infusion provides comprehensive technical support to customers who have purchased support and maintenance contracts for IP Infusion products, including the customers-only online support Web site, product updates and e-mail support. The technical support staff is composed of highly skilled network engineers developing, supporting, and operating advanced IP networks.

## **Additional Information**

Individual protocol module product briefs are available that contain more details on features, benefits and requirements. For these or any other additional information, please contact us at [sales@ipinfusion.com](mailto:sales@ipinfusion.com) or 408.400.1900, or visit our Web site at [www.ipinfusion.com](http://www.ipinfusion.com).