

ZebOS®
Advanced Routing Suite

ZebOS Advanced Routing Suite

INTELLIGENT NETWORK SOFTWARE FOR ENHANCED IP SERVICES

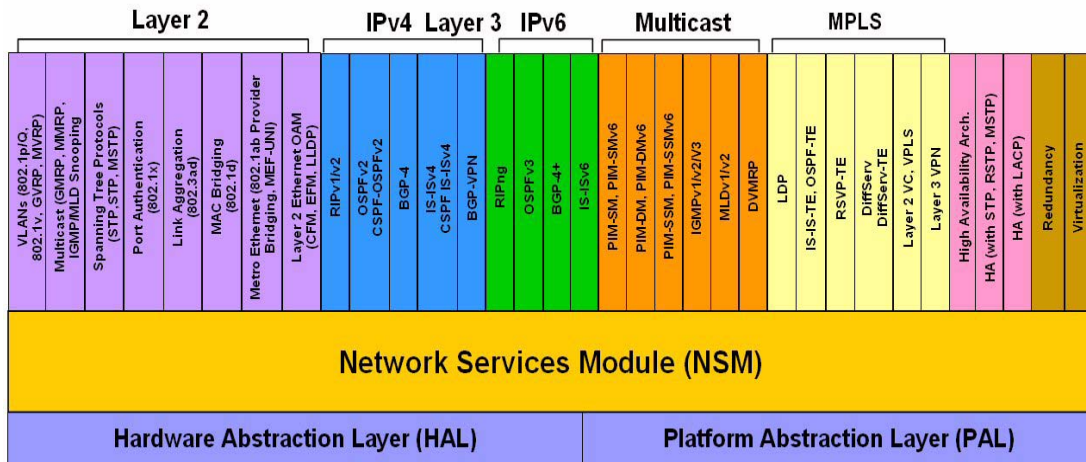
Overview

IP Infusion's ZebOS® Advanced Routing Suite is a scalable, robust and standards-based Layer 2 and Layer 3 carrier-class routing and switching software solution that allows OEMs to rapidly add 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 ARS supports industry-standard and best-of-breed operating systems, control plane and data-plane processors. Although ZebOS ARS is a control plane network software solution, it has been architected to take advantage of separate dataplane processors (NPUs and ASICs) to support highly-modular and scalable communications equipment. The ZebOS ARS is targeted at vendors building or enhancing access, enterprise, edge, core and enhanced IP services products.

ZebOS ARS encompasses these key features

- IPv4 and IPv6 Unicast Routing
- IPv4 and IPv6 Multicast Routing
- IPv4-to-IPv6 Transition Software
- MPLS Traffic Engineering and MPLS-VPN (Layer 2, Layer 3)
- 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)
- 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)



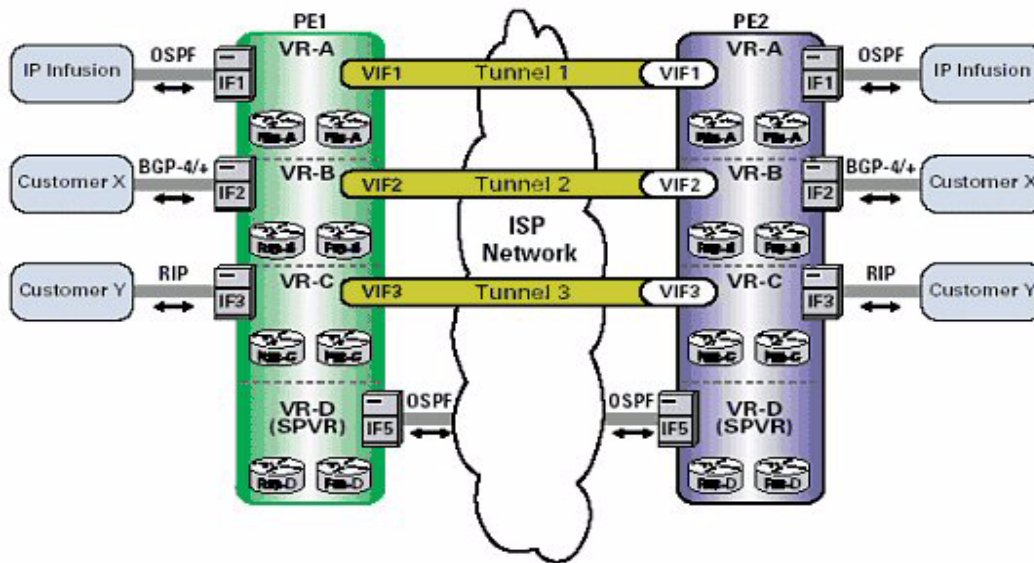
ZebOS Modular Routing and Switching Software Building Blocks

ZebOS Architecture

The ZebOS ARS 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 ZebOS ARS to be deployed 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), which is the base module that simultaneously and independently communicates with every ZebOS ARS routing and switching process. The ZebOS NSM manages both the route table and each of the enabled protocols; performs route conversion and redistribution; and manages the interface state, routing policies and filtering tasks. The 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 provides a command line interface and an SNMP (Simple Network Management Protocol) capability that can be used as-is by vendors, or can be integrated into the vendors' existing management infrastructure. The 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.



MPLS-VPN and Transparent LAN Services

Routing Protocols

IPv4 AND IPv6

IP Infusion is the leading provider of integrated IPv4 and IPv6 routing protocols in the market. The ZebOS Advanced Routing Suite supports the most recent Internet Engineering Task Force (IETF) drafts and specifications for both IPv4 and IPv6 versions of OSPF, BGP, IS-IS and RIP. In addition to standard IPv4 and IPv6 routing protocols, the ZebOS ARS 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 ARS also supports its own TCP/IP module, which is 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 virtual routing 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 tunnelling 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, multicast and VLAN software packages that provide advanced Layer 2 functionality for vendors building routing and switching equipment. Each Layer 2 protocol module leverages the command line interface and the kernel management of the ZebOS Network Services Module. The ZebOS Layer 2 modules are complementary to our Layer 3 routing protocol software solutions and are built on a common architecture. The Layer 2 family includes a full set of solutions for

- Ethernet MAC bridging
- Spanning Tree Protocol (STP), Multiple and Rapid Spanning Tree Protocols (MSTP and RSTP); all of which support Port mirroring, Broadcast Storm Recovery and 802.3x Flow Control
- VLAN and hardware forwarding APIs

- Multiple VLAN Registration Protocol (MVRP)
- Multicast capabilities, including Internet Group Management Protocol (IGMPv1/v2/v3), Multicast Listener Discovery (MLDv1/v2) and Multiple Multicast Registration Protocol (MMRP)
- IGMP and MLD Snooping and Proxy
- GARP Multicast Registration Protocol (GMRP)
- GARP VLAN Registration protocol (GVRP)
- Multiple VLAN Registration Protocol (MVRP)
- Port and Protocol VLAN classification (802.1v) and VLAN Stacking
- 802.1x Port Authentication
- Link Aggregation (802.3ad) and Link Aggregation Control Protocol (LACP)
- Layer 2 Operations, Administration and Maintenance (OAM)
- Metro Ethernet Features

Traffic Engineering and VPN Support

The ZebOS Multiprotocol Label Switching (MPLS) modules comprise a complete solution for the rapid integration of MPLS functionality into enterprise or provider access, edge and core communications equipment. ZebOS supports both MPLS Traffic Engineering (TE) and MPLS VPN (Virtual Private Network) capabilities, as well as extensions for the support of DiffServ and DiffServ Traffic Engineering. The 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 Border Gateway Protocol (BGP) VPN extensions (RFC2547)
- Virtual Private LAN Service (VPLS with Martini)
- DiffServ and DiffServ-TE Extensions

Traffic Engineering extensions use the RSVP-TE and DiffServ-TE dynamic signaling protocols to communicate to the ZebOS MPLS Forwarder or a third-party MPLS forwarder. The RSVP-TE extension enables MPLS to scale into large and complex IP-based communications equipment. In addition, ZebOS ARS supports the Constrained Shortest Path First. Using a Traffic Engineering Database and pre-existing Label Switched Paths (LSP), the CSPF module calculates—on demand—an optimum Explicit Route (ER) based on the specified constraints. The resulting ER is used by a signaling protocol, either RSVP-TE or LDP, to set up Label Switched Paths (LSP).

Providing Virtual Private Network (VPN) services can add significant value to provider edge equipment. These solutions enable the security needed by VPN service providers, while at the same time building a scalable infrastructure that can take advantage of IP routing, traffic engineering (TE) and MPLS switching features. The Advanced Routing Suite offers both Layer 2 and Layer 3 VPN modules. Through the ZebOS MPLS Forwarder and LDP modules, the ZebOS ARS offers a Layer 3 MPLS-VPN solution by tightly integrating BGP-VPN extensions; it provides address space and routing separation through the use of per-VPN routing tables (VRF) and MPLS switching in the core.

Optional MPLS Layer 2 VPN and Virtual Private Lan Services (VPLS) protocol modules that enhance MPLS by providing transparent LAN access between VPN sites are available. 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. The ZebOS VPLS includes MPLS Layer 2 VC, but also implements draft-lasserre-vkompella-ppvprn-vpls-04, adding support for hub-and-spoke VPN and mesh VPN topologies. It combines the benefits of MPLS Layer 2 VC with the flexibility and scalability of multipoint-to-multipoint VPN.

In order to provide a flexible DiffServ over MPLS solution, the ZebOS DiffServ module is available as an extension to the ZebOS RSVP-TE module. The ZebOS DiffServ module enables network traffic to be specified and prioritized by class so that certain kinds of traffic, for example voice traffic, get precedence over other types of traffic. DiffServ employs a sophisticated policy to determine how to forward network data, so it is more advanced than earlier Quality of Service (QoS) or Type of Service (ToS) protocols. 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. The ZebOS DiffServ-TE module 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 and achieve fine-grained optimization of transmission resources.

Multicast

The ZebOS ARS includes support for both IPv4 and IPv6 multicast protocol modules. This includes support for Protocol Independent Multicast-Sparse Mode (PIM-SM and PIM-SMv6) and Protocol Independent Multicast-Dense Mode (PIM-DM and PIM-DMv6). ZebOS PIM-SM routes multicast packets to multicast groups and is designed to efficiently establish distribution trees across wide area networks (WANs). PIM-SM is termed “protocol independent” because it can use the route information that any routing protocol enters into the multicast Routing Information Base (RIB), or, as it is known in Windows terminology, the multicast view. The PIM-SM protocol is designed 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.

The ZebOS PIM-DM module is a data-driven multicast routing protocol, which builds source-based multicast distribution trees that operate on the flood-and-prune principle. It requires unicast-routing information but does not depend on a specific unicast routing protocol. It is designed to effectively distribute 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.

In addition, ZebOS 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. It is a distributed protocol that dynamically generates IP multicast delivery trees using a technique called Reverse Path Multicasting (RPM).

Virtual Routing

Virtual Routing (VR) logically subdivides a physical router into multiple virtual routers and allows each virtual router to execute separate instances of the routing protocol software and network management software (for example, SNMP or the CLI). Each virtual router can be independently monitored and managed by the user. 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 considered to be an add-on feature of virtual routing.

The ZebOS ARS offers optional Virtual Routing for both the IPv4 and IPv6 routing protocol modules. It provides support for multiple Routing Information Bases (RIBs) and Forwarding Information Bases (FIBs) per

physical router. Each VR consists of an OSPFv2, BGP-4(+), or RIP/RIPng Protocol, each with its own RIB and FIB.

Integration Platforms

ZebOS ARS contains an advanced Hardware Abstraction Layer (HAL) interface which isolates all of the hardware-platform-specific interaction into a compact set of well-defined function calls for NSM. This allows ZebOS ARS protocol modules and control plane applications to be totally independent of the hardware platform and the Operating System (OS) while allowing easy and rapid integration with any dataplane solution. These include popular network processors like the Intel IXP425 and IXP2400, silicon switching solutions like the Broadcom StrataSwitch and StrataXGS and Marvell Prestera series. IP Infusion's ZebOS Advanced Integration Suite (AIS) Hardware Integration Platform (HIP) product provides integration and optimization of ZebOS ARS software with both switching/routing hardware platforms and an OS of choice. Using ZebOS AIS HIPs and ZebOS ARS protocol modules, original device manufacturers (ODMs) and original equipment manufacturers (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 (IMI) and IMI Shell modules
- CLI and CLI APIs
- SNMP and SNMP APIs

The ZebOS Integrated Management Interface (IMI) and IMI Shell (IMISH) modules provide complete, unified management for the ZebOS NSM and the individual ZebOS ARS routing protocols. ZebOS IMI allows a system administrator to configure and monitor all of the ZebOS daemons through one centralized user connection. An industry-standard CLI and CLI API manages and configures the ZebOS NSM and each of the protocol modules. Further, SNMP and SNMP API support is available to allow network management agents, as well as billing and provisioning applications, to pull important data from the ZebOS software and its associated protocol modules for all standard defined MIBs. ZebOS also has extensive logging capabilities to log system events and errors. Finally, ZebOS IMI also provides tools and utilities to configure and monitor many features that are available in the Linux/Unix operation systems. These features include DNS, DHCP, ACL, NAT, and the IPv6 to IPv4 transition protocols ISATAP, GRE and IP-in-IP.

Development, Documentation and Support

All ZebOS ARS modules are written in the portable ANSI C programming language. ZebOS ARS is delivered with extensive documentation including: Command Reference Manuals, Developer Guides, and 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 email support. The technical support staff is composed of highly-skilled network engineers developing, supporting, and operating advanced IP networks.

Additional Information

Individual protocol module data sheets 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 or 408.794.1500, or visit our Web site at www.ipinfusion.com.