

# ZebOS<sup>®</sup>

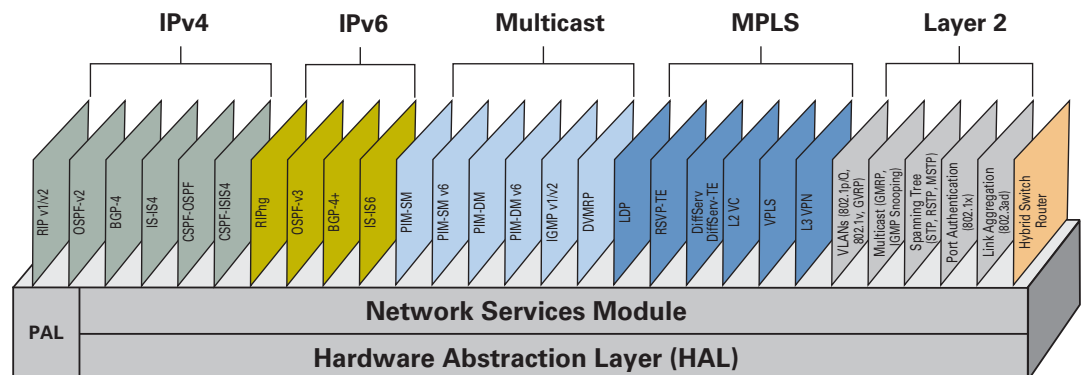
## Advanced Routing Suite

### Intelligent Network Software for Enhanced IP Services

IP Infusion's ZebOS<sup>®</sup> 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 Advanced Routing Suite (ARS) supports industry standard and best-of-breed operating systems, control, and dataplane processors. Although 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 contains a number of key features:

- IPv4 and IPv6 Unicast Routing
- IPv4 and IPv6 Multicast Routing
- IPv4 and IPv6 Transition Software
- MPLS Traffic Engineering & MPLS-VPN (L2, L3)
- Advanced L2 and VLAN Switching
- Virtual Routing for Provider Edge Solutions
- Industry Standard Command Line Interface and Management
- Integration with Industry Leading Silicon (Broadcom, Marvell and Intel) using the ZebOS Hardware Integration Platform products
- Support for Industry standard operating systems (Linux and VxWorks)

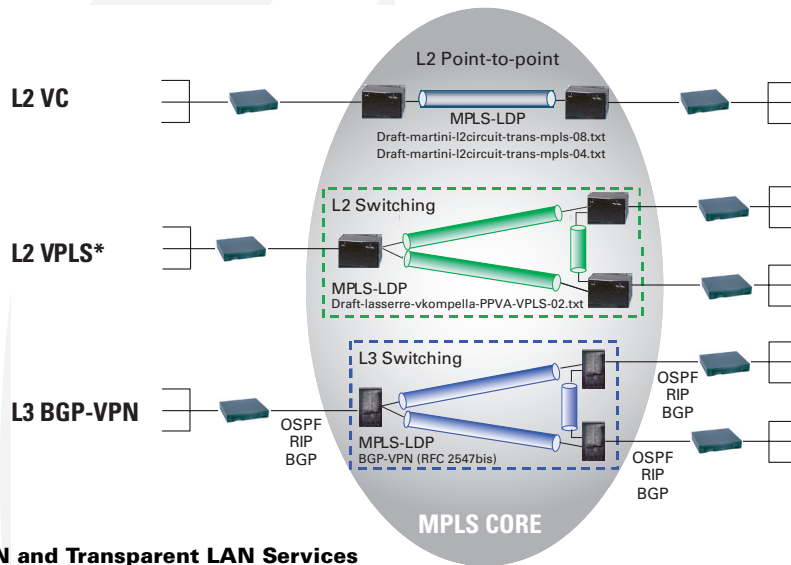


**Figure 1 ZebOS Modular Routing and Switching Software Building Blocks**

### 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 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 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. The 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 SNMP capability that can be used as is by vendors, or can be integrated into the vendors existing management infrastructure. The IMI and IMI-shell provide a persistent, industry standard mechanism for managing the network configuration and operations, as well as unix-like facilities for command and output redirection and logging.



**Figure 2 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 Advanced Routing Suite supports the most recent drafts and specifications of both IPv4 and IPv6 versions of OSPF, BGP, IS-IS and RIP. In addition to the standard IPv4 & IPv6 routing protocols, ARS offers virtual routing support, as well as Traffic Engineering (TE) extensions and a Constrained Shortest Path First (CSPF) topology support for the OSPF and IS-IS Protocol Modules. ZebOS 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. This TCP/IP stack is ideal for real-time operating system vendors that require dual-stack and virtual routing extensions for their products.

Additionally, IP Infusion offers a set of IPv4 to IPv6 transition software packages, including 6to4, ISATAP, GRE, and IPIP tunneling support. These protocols offer a mechanism for vendors to provide their users with methods for simultaneously supporting both IPv4 and IPv6.

### Advanced Layer 2 and VLAN Switching

The ZebOS L2 and VLAN 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 (NSM). The Layer 2 Modules are complementary to our Layer 3 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 (MSTP, RSTP)
- VLAN and hardware forwarding APIs
- IGMP Snooping
- GARP Multicast Registration Protocol (GMRP)
- GARP VLAN Registration protocol (GVRP)
- Port and Protocol VLAN classification (802.1v) and VLAN Stacking
- Port mirroring, Broadcast Storm Recovery, and 802.3x Flow Control
- 802.1x Port Authentication
- Link Aggregation (802.3ad)

In addition to the individual protocol modules, the ZebOS Layer 2 family offers a number of bundled L2 solutions. These include:

1. The Core Bundle includes the Rapid Spanning Tree Module and the VLAN & Prioritization with SVL and IVL Module.
2. The Advanced Bundle includes the Multiple Spanning Tree Module, IGMP Snooping Module, and the GMRP Module.
3. The Advanced VLAN Bundle includes the Port and Protocol VLAN Classification Module, GVRP Module, and VLAN Stacking Module.

### MPLS Traffic Engineering and VPN Support

The ZebOS MPLS switching modules provides a complete solution for the rapid integration of MPLS functionality into enterprise, edge, and core communications equipment. ZebOS supports both MPLS Traffic Engineering and MPLS VPN 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)
- Constraint-based Routing-Label Distribution Protocol (CR-LDP and LDP)
- Interior Gateway Protocol Constrained Shortest Path First (CSPF for OSPF and IS-IS)
- MPLS-VPN using BGP VPN extensions (RFC2547)
- Virtual Private LAN Service (VPLS with Martini)
- DiffServ and DiffServ Traffic Engineering Extensions

The Traffic Engineering (TE) extensions use RSVP-TE and CR-LDP dynamic signaling protocols to communicate to the ZebOS MPLS Forwarder or a third party MPLS forwarder. The RSVP-Traffic Engineering extension enables MPLS to scale into large and complex IP-based communications equipment. In addition, ZebOS ARS supports Constrained Shortest Path First (CSPF) algorithm. Using Traffic Engineering Database and pre-existing LSPs, 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 CR-LDP, to set up Label Switched Paths (LSP).

Providing VPN services can add significant value to provider edge equipment. These solutions give 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 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 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.txt* and *draft-ietf-12circuit-encap-mpls-04.txt* and provides a point-to-point layer 2 virtual circuit that allows extension of a LAN segment across a MPLS cloud. The ZebOS VPLS (virtual private LAN services) Module includes MPLS Layer 2 VC, but also implements *draft-lasserre-vkompella-ppvpn-vpls-04.txt*, adding support for hub and spoke VPN and mesh VPN topologies. It combines the benefits of MPLS Layer 2 Virtual Circuit (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 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 fined-grain 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 RIB, or, as it is known in Windows terminology, the multicast view. Sparse mode protocol is designed for situations where multicast groups are thinly populated across a large region. Although it can operate in LAN environments, they are most efficient over WAN environments. PIM-DM 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), 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.

## Virtual Routing

Virtual Routing 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 ARS offers optional Virtual Routing (VR) support for both the IPv4 and IPv6 routing protocol modules. It provides support for multiple Routing Information Bases (RIBs) and multiple Forwarding Information Bases (FIBs) per a physical router. Each VR consists of an OSPFv2,

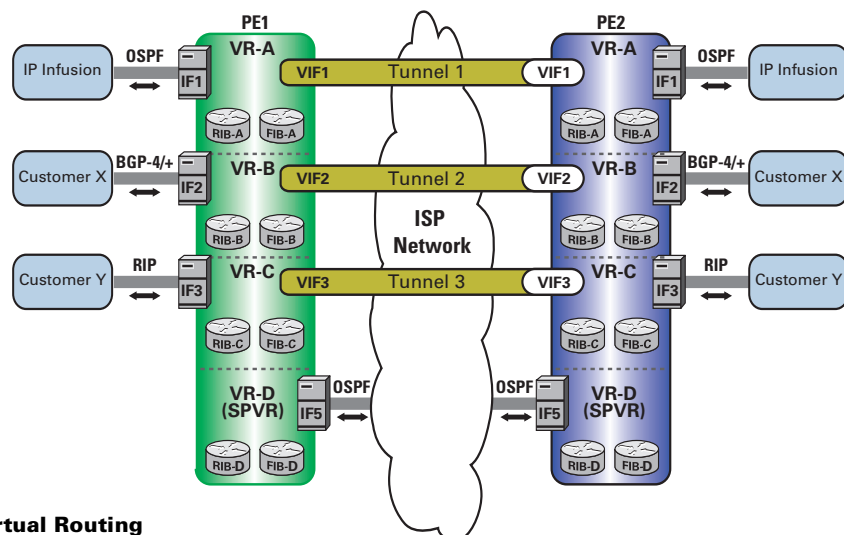


Figure 3 Example of Virtual Routing

BGP-4(+), or RIP Protocol, each with its own Route Information Base (RIB) and Forwarding Information Base (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 call for NSM. This allows ZebOS ARS protocol modules and control plane applications to be totally independent of hardware platform and 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 ZebOS Hardware Integration Platform product provides integration and optimization of ZebOS ARS software with both switching/routing hardware platforms and Operating System of choice. Using Hardware Integration Platforms and 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: 1) ZebOS Integrated Management Interface (IMI) and IMI Shell Modules, 2) CLI and CLI api, 3) SNMP and SNMP api, and 4) Web Element Manager. The ZebOS Integrated Management Interface (IMI) and IMI Shell 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 Network Services Module and each of the protocol modules. Additionally, 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. Furthermore, ZebOS has extensive logging capabilities to log system events and errors. In addition, 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, IPv6 to IPv4 transition, ISATAP, GRE, and IP-in-IP tunneling protocols. The Web Element Manager Module is a Java-based application that enables the configuration and management ZebOS Layer 2 protocols and provides complete Operations, Administration, Maintenance and Provisioning (OAM&P) of the protocols, down to a single bridge/router system. Accessible from anywhere with a standard Web browser, the Web Element Manager empowers the customer with network-wide control and visibility, as well as complete navigation and configuration functions. Additionally, the Web Element Manager enables you to not only design your system with an embedded web-based manager but also to greatly reduce the end customer's manual effort in managing their networks.

Lastly, the Hybrid Switch Router Module facilitates the design of a hybrid Layer 2/Layer 3 switch router system and enables ZebOS L2 and L3 protocol modules to run simultaneously and inter-dependently in an integrated L2/3 switch router system. A hybrid L2/L3 switch router system, typically deployed for distribution and core layer aggregation, offers L3 forwarding with the high speed performance associated with traditional L2 switch. Higher capacity switch fabric and distributed switching and routing in hardware are used to mix L2 and L3 switching for large number of high speed ports and to avoid performance degradation and oversubscription of the backplane.

## 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, Installation and Configuration Guide. 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 spec sheets are available that contain more details on features, platforms, and requirements. For these or any other additional information, please contact us at [sales@ipinfusion.com](mailto:sales@ipinfusion.com), or 408.794.1500, or visit our website at [www.ipinfusion.com](http://www.ipinfusion.com).



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