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Ericsson Builds Integrated Site Edge Router With Carriers In Mind

Hands-on evaluation of company's ISER focuses on high performance, security, resiliency and interoperability



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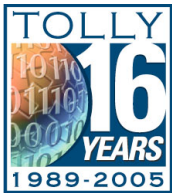
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Ericsson Builds Integrated Site Edge Router With Carriers In Mind

New Paradigm for Net Operators

Driven by a decade of telecommunications legislation and regulatory reform, network operators have managed to survive, and even thrive, by working smarter and more cost efficiently.

Technological advances have enabled creation and provisioning of new services in a more cost-efficient way. The emergence of wireless, in fact, has spawned an entire new mobile network market. Meanwhile, while new opportunities such as mobile networks exist, the stark reality is that investment money has become more scarce as new waves of players enter the market and new technologies vie for investment dollars.

In response to changing market conditions, network operators have become more focused on looking at the cost structures of providing these services to ensure their offerings are competitive. At the same time, network operators are luring new business with attractive new service options that deliver the level of quality tailored for user needs.

Lastly, network operators are intent on finding a safe way to migrate into the new technology arena by choosing a future-proof, scalable, open standards-based solution and a reliable partner with the right core competences.

Potential telecommunication partners not only need a savvy platform, they must offer network operators a technology platform to reduce time to market with new services in an effort to reduce churn and attract new business.

Marriage of IP with Traditional Services

Ericsson's Integrated Site is a framework for hosting multiple heterogeneous, decoupled applications that are no more interrelated than classical telecommunications network elements.

This approach, which makes use of open-standard network interfaces and off-the-shelf technology, is similar to that used for introducing blade servers a few years ago. Autonomous blade systems provide complete user and network services. The blade systems in Ericsson's Integrated Site framework, for instance, retain their autonomy while making use of common resources. These common resources, in turn,

can be packaged as a blade system that is made available at the chassis level where a collection of blade systems can share them. The blade systems interact with one another via a passive backplane.

Ericsson's Integrated Site Edge Router (ISER) is an edge router blade that fits within the Integrated Site chassis. It delivers an abundance of IP-based services and can serve as the driver for mobile- and fixed-network operators to blend in IP services alongside traditional telephony offerings to ensure voice/data convergence to users.

ISER is a standards-based network router that delivers a diverse set of IP routing functions, differentiated services and security gateway functions for attached application hosts and servers. Network operators will find it is an ideal platform from which to support IPv4 unicast routing, data encryption and key management, Quality of Service (QoS) handling, tunnel support and filtering, and more.

Ericsson commissioned The Tolly Group in August 2005 to examine with a high degree of precision the key performance characteristics exhibited by ISER, as well as verify the operation of key functions and features. Tolly Group engineers tested ISER over a two-week period over which engineers conducted more than 71 tests at Ericsson facilities in Raleigh, NC.

What emerged from that exercise was clear evidence that ISER offers the standards, the network services, and the performance and feature sets necessary for network operators to deploy a rich set of IP services from within the Ericsson Integrated Site framework.

While this white paper does not delve into the results of all 71 tests in detail (Appendix A maps out the high-level results for readers), the report does offer a tour of ISER's architecture, as well as a summary of the key hands-on test results, focusing on such pivotal IP service areas as IP forwarding performance, Layer 3 resiliency, routing protocol interoperability with comparable devices from Cisco Systems and Juniper Networks, an examination of virtual routing and Layer 3 tunneling capabilities, a summary of Quality of Service offerings, and a spot check of the key security and IPSec functions resident on ISER.

However, before we delve into the hands-on test results, readers would benefit from a primer on how ISER is designed to provide high-performance IP service and what impact that architecture has on the IP services and capabilities offered.

ISER Architecture

Ericsson's ISER provides IP routing functions, differentiated services and security gateway functions for attached application hosts and servers.

ISER is a blade system that delivers broad functionality including: IPv4 unicast routing, data encryption and key management, Quality of Service (QoS) handling, tunnel support and filtering. The ISER has virtual routing capabilities, enabling the device to appear as several virtual routers residing on the same hardware platform. In conjunction with another ISER blade IP-level connectivity redundancy is supported.

The ISER system consists of a single blade with an Intel IXP 2850 network processor dedicated for data plane processing, a Motorola MPC190 security processor for IKE acceleration and a Motorola MPC8540 Power QUICC III processor for control plane processing.

From a connectivity standpoint, ISER provides four optical Gigabit Ethernet (GbE) interfaces on the front panel, each supporting Small Form Factor Pluggable (SFP) connectors.

ISER also features four GbE interfaces on its backplane, as well. Those interfaces are arranged as a single aggregated link to serve an attached private LAN. Link aggregation and supervision is controlled dynamically via Link Aggregation Control Protocol (LACP).

Resiliency is evident in the ISER. ISER blade systems are normally deployed in pairs to ensure availability. Usually, ISER pairs operate in backup mode, whereby each device operates at most half of the 4GB of available bandwidth so the blade has the capacity to handle traffic from its paired blade in the event of an outage or disruption.

ISER also takes resiliency a step further by supporting VRRP. The standard VRRP as specified in RFC 3768 is enhanced with sub-second failure detection. When a host's default router fails, sub-second VRRP provides rapid switchover to an alternate default router. During the switchover, traffic destined to that host may experience packet loss for a brief duration during the routing convergence time.

In addition, ISER provides load-balancing support for hosts connected via multiple Layer 3 links to the ISER configured as a default IP gateway using Equal Cost Multi-Path (ECMP).

Hardware Design

ISER is based upon a novel hardware design that relies upon the flexibility of network processors, as opposed to application-specific integrated circuits (ASICs). Each of the blade's network processors

Services ISER can provide:

- Virtual routing
- Unicast routing & forwarding
- Layer 3 tunneling
- IPsec and security
- DiffServ & QoS
- Resiliency
- Interfaces
- IP termination services
- OAM capabilities

The ISER blade utilizes three state-of-the-art processors and a switching chip:

- Intel IXP 2850 network processor dedicated for data plane processing.
- Motorola MPC190 security processor for IKE acceleration.
- Motorola MPC8540 Power QUICC III processor for control plane processing.
- Vitesse VSC7384 - 12-port Gigabit Ethernet switch to provide OAM VLAN and payload VLAN separation. The OAM VLAN traffic is switched to the Control Processor and the data plane traffic is switched to the network processor.

handles a portion of the overall blade activity. By taking this approach, Ericsson ensures that packet processing continues unabated while control traffic rides across a separate data plane. (More on that in the software section.)

ISER's motherboard consists of an Intel IXP2850 network processor (NP) and a Motorola MPC8540/1 control processor (CP). The IXP2850 processor consists of an array of microprocessors (called micro-engines) that are designed to handle packet handling and an onboard auxiliary RISC processor (called an XScale). The micro-engines and the XScale both can access the control memories that the micro-engines use for packet processing. This cooperative approach to packet processing enables the XScale to update the route table entries that the micro-engines access when a route lookup is needed.

Software that Says, "Standards"

ISER's software architecture divides functionality into three distinct layers:

Service Layer: All the router control plane application entities (for example, IP routing) reside in this layer. The Service Layer entities run on the CP.

Forwarding Control Layer: The Forwarding Control Layer (FCL) is comprised of the software components responsible for dynamic programming of the underlying data plane layers' firmware. The FCL interfaces upward with service layer elements via a set of Ericsson enhanced and Network Processor Forum initiated (NPF) Service APIs (SAPs) and downward via a set of Functional APIs (FAPs). FCL runs on the CP, as well.

Dataplane Layer: The data plane layer actually is a collection of sublayers: configuration managers, the slow path and the fast path. The slow-path processing is mapped to Intel IXP2850 NPs and an on-board XScale RISC processor handling rapid packet processing. The configuration managers terminate FAPI interfaces from the FCL and also run on the XScale. The fast-path processing is comprised of firmware mapped to on-board micro-engines for wire-speed forwarding.

Software in the control plane and XScale processors run the MontaVista Linux operating system version 3.1.

There are a dynamic set of interactions that occur within ISER's core software elements. Control software primarily runs on the ISER's CP and supports emerging Network Processor Forum (NPF) standards

and IETF Forces working group's drafts. A Service Layer contains Operation, Admin and Maintenance (OAM) functionality, routing protocols, IPSec, non-IP transport components, Differentiated Services and QoS. These Service Layer elements use the NPF Service Application Program Interface (SAPI) to program the logical functional blocks within the ISER data plane.

An important design concept for ISER is the allocation of the packet processing functions between the control plane and the network processor. In general, the OAM, routing, signaling and general control functions run on the control plane, while the FAPIs and data plane functions run on the network processor. The control plane and network processor are interconnected via a PCI bus running Ethernet over PCI to handle packet flow.

As part of its software design, ISER supports a number of software services:

Unicast Routing and Forwarding

The routing function relies upon standard routing protocols such as OSPF, ISIS and BGP for the establishment and maintenance of Layer 3 forwarding information. Forwarding mainly involves lookup of correct routes based on destination IP address information in an IP packet, although filtering, policy-based routing (PBR) etc. can influence forwarding decisions.

IP Security/IKE

IPSec enables ISER to protect, and authenticate, traffic that is forwarded, originated, or terminated by ISER. IPSec encryption/authentication protocols protect IP traffic only at Layer 3. ISER supports the Internet Key Exchange (IKE) protocol to negotiate and maintain IPSec services. ISER also supports the Encapsulating Security Protocol (ESP) encryption and ESP authentication for transport and tunnel mode operations.

Encryption can be accomplished through the application of DES, 3DES, AES, and NULL algorithms, while MD5, SHA-1, and NULL HMAC algorithms are available for ESP authentication.

ISER enables users to write IPSec policies to specify how various traffic types should be protected.

The policies can be applied to traffic based on either the source or destination IP address (IP header), the protocol field (IP header), or the source and destination port (TCP/UDP header).

ISER's IPsec support also accounts for IPsec Security Associations (SAs). These may be configured manually, or ISER can be configured for IKE to configure SAs on the fly.

DiffServ and QoS

ISER's support for DiffServ gets right to the heart of the router's support for Quality of Service. ISER's DiffServ system supports QoS, DiffServ and stateless packet filters. Use of the DiffServ Codepoint (DSCP) field of the IP header enables users to mark packets for traffic classification purposes.

ISER Supported Interfaces:

- Untagged LAN interfaces (Layer 2)
- Tagged VLAN interfaces (Layer 2)
- VRRP interfaces (Layer 2)
- IPv4 interfaces (Layer 3)
- Tunnel (GRE, IPv4-in-IPv4) interfaces (Layer 3)
- Special virtual interfaces: loopback interfaces used internally by ISER virtual router instances (Layer 3)

Interface Support

In addition to its varied services, ISER supports an array of interfaces. There are interfaces defined for unicast routing, IKE/security, OAM, data plane and forwarding control layer, DiffServ/QoS and various driver interfaces.

ISER supports two network interface types: physical ports (Layer 1) and logical interfaces (Layer 2 and Layer 3).

ISER's GbE physical interfaces provide Layer 2 transport connectivity to and from uplink and downlink directions according to IEEE standard 802.3-2002. Further, the function supports VLAN tagging (IEEE 802.1Q).

Operation, Admin and Maintenance

Ericsson has a comprehensive built-in Operation, Administration, and Maintenance (OAM) function for the ISER blade. OAM functions supported include blade configuration, fault management (e.g., alarm reporting), performance management, security management, and software upgrade.

ISER's OAM facility provides a Command Line Interface (CLI) for configuration of the blade independent of the graphical configuration solution provided within the OAM framework.

Beyond Network Services

Aside from the multitude of network services present in ISER, the router offers two very important capabilities: Resiliency and Traffic Separation.

Built-in Resiliency

Any enterprise router in today's converged networks must provide 24x7 availability and the capability to recover from outages without service disruption.

ISER relies upon network-level protocols, such as VRRP, to provide such recovery.

VRRP is a redundancy protocol designed to run over shared interfaces (eg. Ethernet). VRRP enables a Layer 3 interface to be backed up by another Layer 3 interface and hides the redundancy details from the host that uses the IP address associated with the Layer 3 interface as its default gateway address. The backup interface is on a different router. Hosts on a LAN have their default routers backed up by VRRP so that hosts always find a default router irrespective of the failure of some routers.

ISER supports VRRP according to RFC 3768 (VRRP), meaning it supports failover times of not less than three seconds. VRRP support, when used with another ISER can be used to achieve sub-second switchover for faster recovery.

In addition to VRRP support, ISER is designed to handle the graceful restart of routing protocols. As mentioned in the Architecture section ISER supports separate control plane and data plane activities. Consequently, packet processing is unaffected when a protocol process must be restarted on the control plane. Graceful restart alleviates any routing instability caused by a protocol restart. It allows a routing protocol to inform neighbors on the control plane that it went down and came back up, so that all that is required is to synchronize the routing state.

A third mechanism available to hosts is Equal-cost multipath (ECMP), RFC 3272. ECMP protects against next-hop failures since there are other next hops to which the packets can be diverted. It also protects against link failures on the ISER in cases where an ECMP route points to different physical interfaces. In this case the packets can continue flowing through the ISER even when a physical interface goes down.

Traffic Separation

ISER supports various methods of traffic separation. The router supports VLANs on all interfaces for the logical partitioning of traffic. At Layer 3, the router supports virtual routers to segregate traffic, as well as support for Layer 3 tunnels. Users may configure ISER to support more than one VLAN per VR.

Hands-on Testing

ISER Hands-on Test Key Findings:

- Achieves bidirectional zero-loss throughput ranging from 2.85 Gbps when handling 64-byte packets to 4 Gbps when handling 512- and 1,518-byte packets
- Recovers from triggered outage in 0.277 seconds using Ericsson enhanced sub-second VRRP and supports up to 32 standard VRRP groups in a configuration involving two or more ISER blades
- Interoperates via IPSec with both a Cisco 7505 Router and Juniper Networks NetScreen-SA 100 firewall
- Passes 10 Mbps of legitimate traffic and properly updated routes learned from the adjacent router using OSPF while under an ICMP DoS attack while being flooded with 1.48 million pps of PING flood packets
- Reads and modifies DSCP QoS markings from Cisco and Juniper devices tested
- Demonstrates interoperability and exchange of routing table info with Cisco and Juniper devices tested while supporting OSPF, BGP, IS-IS and RIP

Tolly Group engineers conducted 71 tests on an Ericsson Integrated Site Edge Router running software version ISER CSA 113 38/1 R1A ISER Version IS_0.50.0. ISER was equipped with four Gigabit Ethernet front panel ports and four Gigabit Ethernet backplane ports, which can be aggregated into groups.

ISER was connected to a SmartBits 6000B traffic generator on one side and to a Cisco Catalyst 6500 router on the WAN side, which provided connectivity to two other devices utilized for interoperability testing. The other devices were a Cisco Systems, Inc. 7505 Router, running IOS Version 12.2(8)T4 and configured with four interface slots supporting a FEIP2 controller (2 Fast Ethernet interfaces) and two VIP2 R5K controllers (four Fast Ethernet interfaces). The Cisco 7505 employed a Cisco RSP8 (R7000) 250-MHz processor (Implementation 39, Rev 2.1) with 262144K/8216 Kbytes of memory.

The Tolly Group also tested the ISER for interoperability with a Juniper Networks M20 multiservice Layer 2-3 edge router. The Juniper M20 was running software version 7.2R1.7 and came configured with support for four FPC (Flexible Physical Interface Card Concentrator) slots with 3.2 Gbps of full-duplex throughput per slot, and a total of 16 PICs per chassis.

Tests focused upon several key areas: IP forwarding performance, Layer 3 resiliency, IP interoperability with popular routers from Cisco Systems, Inc and Juniper Networks, virtual routing/Layer 3 tunneling, Layer 2/3 Quality of Service, Security and IPSec.

The following sections convey the key findings from those tests.

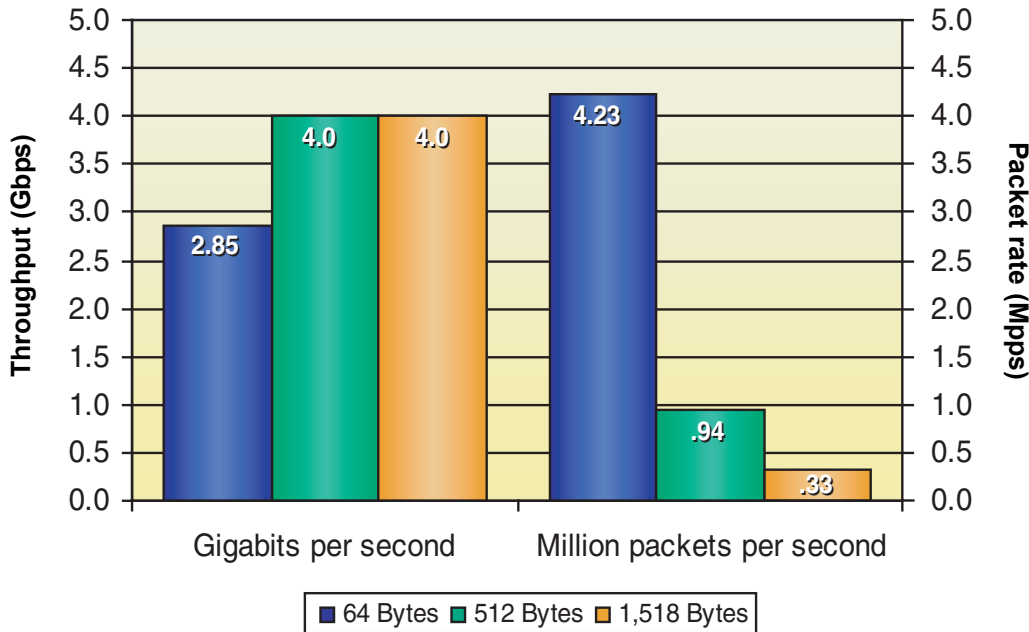
IP Forwarding Performance

Tolly Group engineers measured the Layer 3 zero-loss throughput of the Ericsson ISER for 64-, 512- and 1,518-byte packets. ISER was able to sustain bidirectional zero-loss throughput ranging from 2.85 Gbps when handling taxing 64-byte packets to 4 Gbps when handling 512- and 1,518-byte packets. (See Figure 1.) ISER also achieved a maximum forwarding rate of 4.23 million packets per second (Mpps) for the small packet size of 64 bytes.

Engineers next tested the average store-and-forward latency of ISER. Latency ranged from a low of 10.4 μ sec for 64-byte packets to 29.7 μ sec for 1,518-byte packets. Results demonstrate that for the packet sizes tested, ISER exhibits very low latency, well below Ericsson's 200 μ sec threshold.

Figure 1

Ericsson Integrated Site Edge Router (ISER) Layer 3 Aggregate Throughput in a Four-Port Gigabit Ethernet Configuration as Reported by Spirent SmartFlow 4.60



Tolly Group engineers then sought to verify that ISER's average jitter is within the tolerance required ($\leq 400 \mu\text{sec}$) and set by Ericsson. ISER recorded sub-second jitter of $0.7 \mu\text{sec}$ when handling a G.711 VoIP stream of 218 bytes, with 3.27 Mpps of 64-byte background traffic.

IP Forwarding Methodology

The test bed consisted of a Spirent SmartBits 6000B traffic generator with four ports on LAN 3321A cards connected to four ports on the ISER using gigabit fiber links. The four ports were configured on a different subnet and a VLAN, in a full-mesh network with each port configured with 10 flows. Maximum aggregate throughput was measured for 64-, 512- and 1518-byte sizes, with an acceptable packet loss of less than 0.001%.

Average store-and-forward latency was measured for packet sizes of 64-, 512- and 1518-bytes at 60% of maximum load. The test was run three times to ensure repeatability, and the result averaged to arrive at the final test results.

For jitter tests, the test bed consisted of a Spirent SmartBits 6000B traffic generator with four ports on LAN 3321A cards for the background traffic generation and two ports on LAN3101A card for the emulated G.711u VoIP stream rate generation for the jitter measurement. Two ports on LAN3321A were connected to two ports on the ISER using gigabit fiber links. The other two ports on LAN3321A were connected to two ports on a Cisco Catalyst 6500 using gigabit fiber links. The two ports on LAN3101A were connected to the Cisco Catalyst 6500 using Fast Ethernet links. The four ports were configured on a different subnet and a VLAN, in a full-mesh network. The Jitter measurement was done on the LAN3101A port using SmartBits SmartVoIPQoS application. The SmartVoIPQoS generated 200 emulated G.711 VoIP flows (100 flows one direction and 100 flows the other direction) across the Catalyst-DUT-Catalyst and measured the jitter. Average store-and-forward latency was

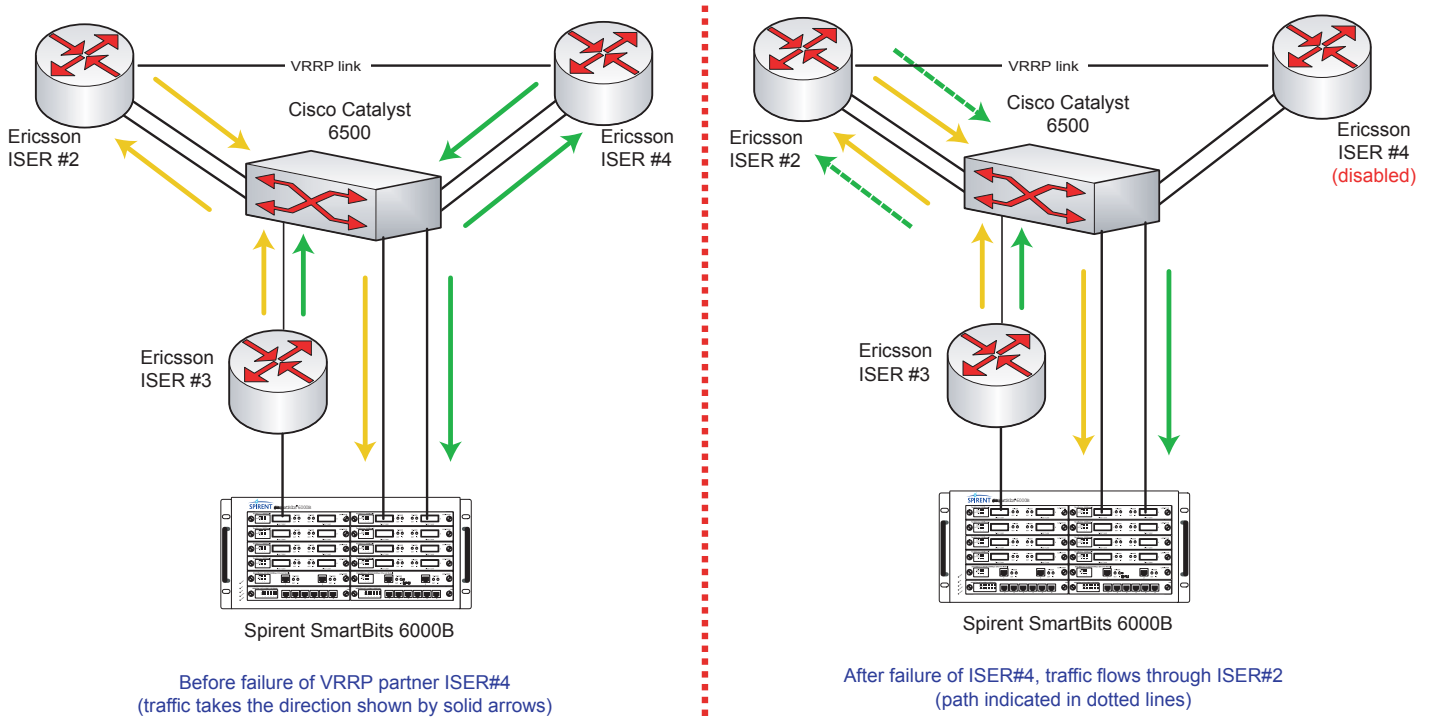
measured for packet sizes of 64-, 512- and 1518-bytes at 60% of maximum load. The test was run three times to ensure repeatability, and the result averaged to arrive at the final test results.

Layer 3 Resiliency

The Tolly Group conducted a bevy of tests aimed at demonstrating ISER's resiliency. Engineers first exercised ISER's support for the Virtual Router Redundancy Protocol (VRRP), identifying the ISER's failover time when VRRP is applied. Tests show ISER rebounds from an outage in 0.277 seconds. This demonstrated that the ISER supports VRRP groups with 50 msec advertisement timer, and the failover times observed were well below one second. See figure 2.

Figure 2

Impact of VRRP on Traffic Flows Between ISER Blade Routers



Note: ISER #2 and ISER #4 were configured with two sub-interfaces, each in turn configured with two VRRP Master groups, and two VRRP Slave groups. The VRRP Master groups on ISER #2 have their Slave VRRP counterparts on ISER #4, and vice versa.

Next, engineers sought to verify that traffic continues to flow across ISER and peering is maintained during a graceful restart of BGP under load. This test showed that no packets were lost by ISER during the restart period provided that no topology changes were made in the network.

Engineers also tested graceful restart of BGP in a network with the Cisco 7505 Router and the Juniper M20. Engineers verified that traffic continued to flow and peering was maintained while interoperating with the Cisco and Juniper routers during graceful restart of BGP under load.

Engineers verified graceful restart of OSPF under load. The test verified that traffic continued to flow and peering was maintained during graceful restart of OSPF under load. No packets were lost during the restart period provided that no topology changes were made in the network. Engineers also tested the graceful restart of OSPF in a network with the Cisco 7505 Router and the Juniper M20. Engineers verified that traffic continued to flow and peering was maintained while interoperating with the Cisco and Juniper routers during graceful restart of OSPF under load.

In the final resiliency test, engineers measured the maximum total VRRP groups supported per ISER. Tests show the ISER supports up to 32 VRRP groups. During the test, ISER supported eight VRRP sub-second groups and 24 one-second groups. The average failover time was 2.588 seconds when tested at 96% of line rate.

Layer 3 Resiliency Methodology

During the resiliency test, two ISER routers were connected to each other using resilient links and the test traffic was input to the ISER routers using two SmartBits ports. Traffic was generated from SmartBits ports with 128-byte packets at line rate. While traffic was being transferred bidirectionally at line rate, the BGP daemon on one of the ISER routers was killed. The daemon immediately restarted, and while it was restarting, engineers displayed the BGP neighbors table and observed there were no neighbors until the graceful restart completed. During this time, engineers checked the SmartCounters to verify there were no dropped packets. Graceful restart-time was set at 120 seconds, and the stalepath-time was set at 120 seconds. A 300-second timer value was tried, and there was no loss. This same methodology was used for graceful restart of OSPF.

















During the maximum VRRP support group test, a total of 32 VRRP groups were configured per ISER, with eight sub-second groups and 24 one-second groups. Traffic was generated at 96% of line rate and passed from a SmartBits port to one of the ISER routers, which split the traffic evenly between two ISER routers configured as VRRP Master and Backup, which then forwarded the test traffic to a destination ISER router connected to the SmartBits. While the traffic was flowing, the physical interface on one of the VRRP partners was shut down, and the traffic was observed to be routed

to the ISER router acting as the VRRP backup. The failover time was calculated based on the number of packets lost. The failover scenario was repeated by failing each VRRP partner ISER alternatively. The average of the three failover times was calculated.

Routing Protocol Interoperability

In these tests, the Tolly Group sought to verify that the ISER offers interoperability for RIP, OSPF, BGP and ISIS with popular Cisco 7505 Router and Juniper Networks M20 Internet Router. Engineers configured IS-IS, RIP, OSPF and BGP on the ISER, as well as the Cisco 7505 Router and the Juniper M20. Next they redistributed all routes on all the routers.

Figure 3

Ericsson Integrated Site Edge Router (ISER) Interoperability with Cisco and Juniper Routers ¹		
Feature	Interoperability with	
	Cisco Catalyst 7505	Juniper M20
IS-IS interoperability		
RIP interoperability		
OSPF interoperability		
BGP interoperability		
Graceful restart of BGP	not supported by Cisco	
Graceful restart of OSPF	not supported by Cisco	
IPSec interoperability		
DSCP send/receive interoperability		
GRE/IP-IP interoperability		

¹IPSec interoperability testing was conducted between ISER and a Juniper NetScreen-SA 100.

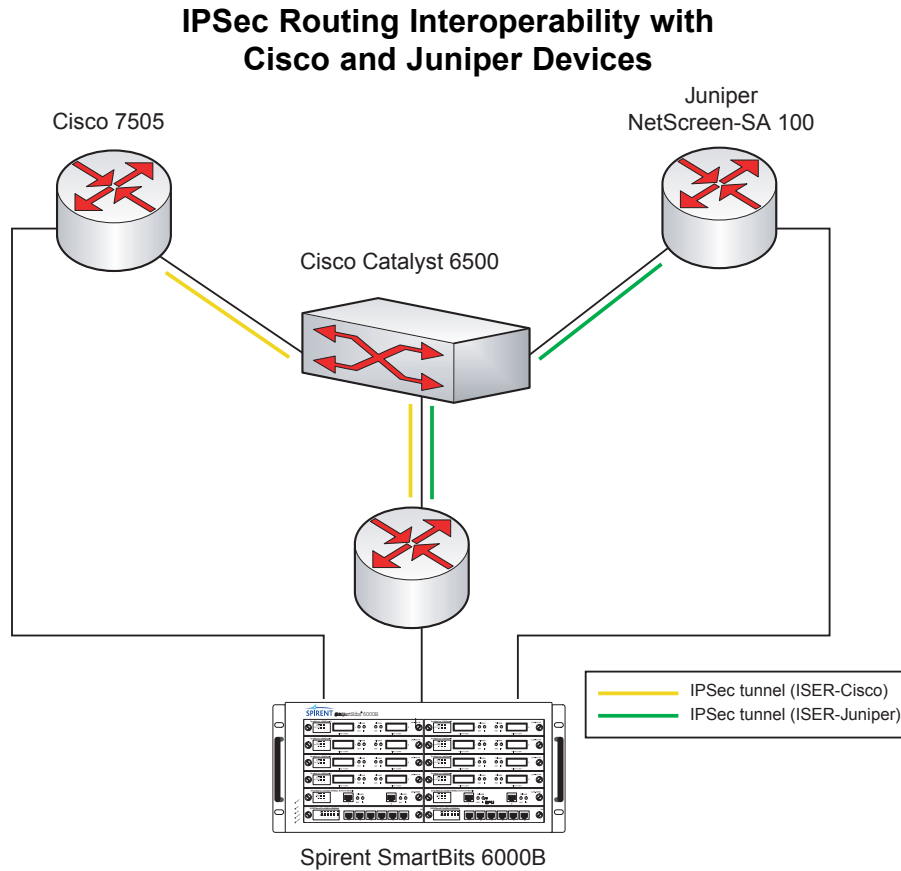
A check of the routing tables showed that the ISER was interoperating with the Cisco 7505 Router and the Juniper M20 using IS-IS, RIP, OSPF and BGP. (See Figures 3 and 4.) Tests also show that the ISER obtained over 500 routes from the Cisco and Juniper devices. The test proves that ISER can interoperate with Cisco and Juniper routers using IS-IS, RIP, OSPF and BGP and that routing tables are exchanged and updated with peers accurately.

Interoperability Methodology

Engineers connected the Cisco 7505 and the Juniper M20 running IS-IS to the test bed. The Cisco 7505 Router was configured with 250 static routes redistributed into IS-IS, and the Juniper M20 was configured with eight virtual routers with a total of 250 static routes redistributed into IS-IS. The ISER router was connected to 10 peers, with both L1 and L2 adjacencies, resulting in a total of 20 adjacencies. Using SmartWindows, 260 flows were configured to be sent to ISER to be routed to the Cisco 7505 Router (10 flows) and Juniper M20 (250 flows). Engineers verified that the traffic was successfully routed by the ISER to both Cisco and Juniper devices. A check of the routing

tables on the ISER confirmed that there were 500 routes in total acquired from the Cisco and Juniper devices.

Figure 4



Virtual Routing and Layer 3 Tunneling

Tolly Group engineers verified that MAC addresses are appropriately utilized to ensure traffic separation between virtual routers on the same physical interface in the same tagged/untagged VLAN. ISER passed this test which shows that even though eight virtual routers were configured on each physical interface, each VR could be distinguished based on its unique MAC address and VLAN tag.

In an IP address separation test, engineers verified IP address separation on various interfaces on the virtual router. The test demonstrated that even though two virtual routers had overlapping IP addresses and subnets, the traffic can be forwarded to the correct interface based on its unique MAC address, thus showing that the virtual router IP addresses are separated.

Engineers also performed a virtual router BGP protocol separation test to verify that multiple virtual routers running BGP can exist on the same physical network at the same time, and still have independent routing tables. The ISER passed this test, too. Another protocol separation test was conducted for OSPF. ISER passed that test, as well. Again, the test confirms that ISER can support multiple virtual routers running OSPF on the same physical network at the same time, and still have independent routing tables.

Next, engineers checked to verify that the ISER can apply DiffServ Policy-Based Routing on a per-virtual router basis. Indeed, the ISER passed the test, demonstrating that it applied the service policy in the source interface for both virtual routers. Thus, test results show that for both virtual routers, ISER routed the traffic based on the DSCP values defined in the service policy.

On the Layer 3 tunneling side, engineers verified the maximum throughput through GRE/IP-IP tunnels. Tests show the ISER forwards 3 Gbps of traffic for 1,400-byte packets and 2 Mpps for 64-byte packets over the GRE/IP-IP tunnels. Engineers also verified GRE/IP-IP interoperability with the tested Cisco and Juniper devices. Tests show that the Ericsson ISER interoperates with Cisco 7505 Router and Juniper M20 routers/switches while passing traffic through GRE/IP-IP tunnels.

Virtual Routing Methodology

For the test of untagged ports on the ISER, each port on the ISER was configured with eight virtual routers, each with four sub interfaces on different subnets. A SmartBits port was PINGed from each virtual router and it was verified that the packet capture on the SmartBits port showed that the PING packets from each virtual device carried a unique MAC address. The same test set up was used to check for the tagged ports test.

In the IP address separation test, each port on the ISER was configured with eight virtual routers. The IP address configured on each virtual router was duplicated on another virtual router with the same IP subnet mask. A SmartBits port was PINGed from each virtual router and engineers verified that the packet capture on the SmartBits port showed that the PING packets from each virtual router carried a unique MAC address, even though they came from different virtual routers with the same IP address and IP subnet mask.

For the DiffServ Policy-Based Routing test, engineers created two virtual routers on the ISER. Each virtual router included all four ports in the DUT and all front panel ports were connected to the SmartBits ports in a hub-and-spoke configuration. Each virtual router was configured to support one source and three destinations. Initially, without policy-based routing, the SmartBits traffic arrived at the three destinations evenly for each virtual router. The first

three streams had DSCP value 10 and the second three streams had DSCP value 50. They were destined for three different SmartBits ports. Then, engineers applied the service policy in the source interface for both virtual routers and verified that for both virtual routers the ISER routed the traffic based on the DSCP values, defined in the service policy.

Figure 5

Ericsson Integrated Site Edge Router (ISER) Quality of Service (QoS) Features	
Feature	
Packet filtering - Stateless Inspection Deny	
Packet filtering - Stateless Inspection Permit	
Policing and shaping	
Policy-based routing	
DSCP send/receive with Cisco and Juniper routers	
Maximum ACL rules = 16,485	
Max traffic classes per physical interface = 8	

Layer 2/3 Quality of Service

The Tolly Group tested a number of Quality of Service features on the ISER. While there are too many tests to recount in this report, one of the more important tests verified DSCP interoperability between the ISER and the Cisco 7505 Router and the Juniper M20. That means ISER can read and modify DSCP info from Cisco or Juniper devices and vice versa.

Engineers also tested ISER to determine the maximum number of ACL rules that can be

configured using PMAP and PFilter. Tests show that ISER supports as many as 16,485 ACL rules. (See Figure 5.)

QoS Methodology

For the maximum ACL rules tests, engineers created 1,024 ACL-pf and 1,204 acl-pmap. They applied packet filters in the access policy both inbound and outbound for all four ports - each port representing one VLAN. Next, engineers applied pmap in the service policy both inbound and outbound of for all four ports and their corresponding VLANs. $(1,024*2*4) + (1,024*2*4) = 16,485$.

Security and IPSec

Engineers tested to verify that ISER can establish an IPSec tunnel with the Cisco 7505 Router and a Juniper NetScreen-SA 100 firewall using both manual keying and automatic keying using Internet Key Exchange (IKE) protocol. Tests prove that the ISER, indeed, can support an IPSec tunnel to the Cisco 7505 Router switch and the Juniper NetScreen-SA 100.

Next, engineers verified that ISER can pass legitimate traffic while under an ICMP DoS attack. While ISER received PING flood packets at the rate of 1.48 million packets per second, engineers verified that the device passed 10 Mbps of legitimate traffic and properly updated the routes learned from the adjacent router using OSPF. This test proves that ISER can perform basic routing functions and forward 10 Mbps of legitimate traffic while it is under the gigabit rate PING flood attacks.

Next, it was time to learn how ISER would respond to a SYN Flood attack. Engineers unleashed SYN Flood packets at the rate of 1.48 million packets per second upon the ISER and verified that the device passed 10 Mbps of legitimate traffic and properly updated the routes learned from the adjacent router using OSPF.

In the final security test, engineers measured the maximum number of IPSec tunnels supported under load. Tests show that ISER established 500 IPSec tunnels.

Security/IPSec Methodology

During the IPSec interoperability test with the Cisco 7505 Router, engineers connected the SmartBits to the ISER and the Cisco 7505 router. Next, they established the IPSec VPN tunnel in between the ISER and the Cisco 7505 Router using 3DES/SHA-1 and generated bidirectional traffic from the ISER to the Cisco router across the IPSec tunnel. Engineers captured the packets between the two devices and verified that the packets were encrypted.

For the ICMP Ping/Echo Reply Flood Attack test, engineers sent 1.48 million packets per second of PING flood packets to the ISER and verified that the device was still able to transport 10 Mbps of legitimate traffic and properly updated the routes learned from the adjacent router using OSPF. This same methodology was used for the SYN Flood attack test.

For the maximum IPsec tunnel test, engineers configured three ISER units in a hub-and-spoke configuration. Next, they established 250 IPsec tunnels between the hub router and the spoke router 1 and in between the hub and the spoke 2, so that the hub router has 500 IPsec tunnels established.

Testers passed some verification traffic over the tunnel and subsequently captured packets between two ISERs and checked whether the captured packets were encrypted.

Flexibility Translates into Benefits

As this white paper demonstrates, Ericsson's ISER is based upon a wealth of standards, and a hardware design that utilizes flexible network processors.

ISER's design, covered in detail in this report, will prove extremely beneficial for mobile and fixed network operators alike who deploy a complete telecom site network consisting of IP applications, collapsed in a chassis requiring Layer 3 IP gateway functionality.

ISER is based upon a plethora of standard network protocols (OSPF, BGP and IS-IS) that positions Ericsson's Integrated Site as an ideal IP network infrastructure framework for pioneering IP-centric applications. Moreover, support for standards makes ISER very scaleable and enables it to interact with other blades to support key new IP-based applications. And ISER's high availability makes it a safe platform for critical IP applications.

ISER, for instance, is an ideal host for session border gateway operations and also as an Ethernet DSL access multiservice access node.

For more information on these emerging IP applications and ISER's role in supporting them, check out the Ericsson document, "Ericsson's Integrated Site Concept" on the Web at:

http://www.ericsson.com/about/publications/review/2005_01/files/2005014.pdf

Platform for Rapid Response

In today's market, network operators need to respond to the needs for converged network services. Traditionally telephony service must reside

alongside IP-based data and video service, as well as Voice over IP. That calls for a network operator platform that offers high performance, a high degree of resiliency and the ability to support multiple differentiated services harmoniously alongside one another.

Ericsson's Integrated Site concept provides a framework that yields flexibility and short time to market. Thanks to native support for aggressive use of third-party technologies, open-source codes, and standard protocols, it enables operators to introduce a layered framework for application nodes.

Within that Integrated Site framework, Ericsson's ISER blade system is the keystone to supporting IP-based services.

Ericsson's liberal use of network processors makes the ISER design self sustaining by separating the control plane functions from the forwarding plane operations. Moreover, it provides a level of extended life – as technology evolves network processors may be reprogrammed, as opposed to alternative solutions based upon application-specific integrated circuits (ASICs) which would required wholesale replacement.

Hands-on testing demonstrates that ISER offers a unique blend of high performance, resiliency and routing protocol interoperability with installed devices from both Cisco Systems, and Juniper Networks.

And ISER's broad support for industry-standard protocols and open interfaces ensures that the router will evolve gracefully as standards and technology evolve in parallel. ISER's broad protocol support also makes it an ideal IP network infrastructure framework for pioneering IP-centric applications. Moreover, support for standards makes ISER very scaleable and enables it to interact with other blades to support key new IP-based applications. And ISER's high availability makes it a safe platform for critical IP applications.

The reality for mobile and fixed network operators is that IP-based network services - supporting data, video and voice applications – are here to stay. That means network operator infrastructures must evolve rapidly to offer such services in a competitive and timely manner.
















Ericsson's ISER blade system demonstrates all of the capabilities network operators need to support a rich set of IP network services to users. It provides exactly the type of IP services needed to bring IP-based services to market quickly and efficiently, enabling network operators to be among the first to meet the market window for new services, increase the value of their own services and reduce user churn. In the end, that's a hard recipe to beat.



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Appendix A. Test Details

ISER Test by Test Results			
Parent test	Permutation	Test result ( = pass)	Proof point
Routing Protocol Support: Unicast Routing and Forwarding	All routing protocols on same VLAN interface		This test proves that the ISER can accommodate multiple protocols on a single VLAN interface. The routing tables were updated correctly with the peers.
Routing Protocol Support: Unicast Routing and Forwarding	ECMP - Four hops or less (per VR)		The ISER supports Equal Cost Multi Path (ECMP) forwarding with four or less hops to the common destination, and with ECMP and round-robin load-sharing enabled, the traffic to the common destination is forwarded equally on the ECMP routes.
Routing Protocol Support: Unicast Routing and Forwarding	Maximum zero-loss throughput		The ISER demonstrated a maximum Layer 3 aggregate throughput of 4 Gbps per large packet sizes (512- and 1,518-byte packets), and 2.86 Gbps for the 64-byte size packets. The ISER also achieved a maximum forwarding rate of 4.23 Mpps for the small packet size of 64 bytes.
Routing Protocol Support: Unicast Routing and Forwarding	Average store-and-forward latency		The ISER demonstrated an average store and forward latency as low as 14.4 μ sec for the 64-byte packet size, and as high as 71 μ sec for the 1518-byte packet size. This shows that for the packet sizes tested, the ISER exhibits very low latency, well below Ericsson's 200 msec threshold.
Routing Protocol Support: IS-IS	IS-IS interoperability with Cisco and Juniper devices		Proves that the ISER can interoperate with Cisco and Juniper routers using IS-IS. The routing tables were exchanged and updated with the peers accurately.
Routing Protocol Support: IS-IS	Maximum IGP Routes - IS-IS		Proves that the ISER supports in excess of 500 routes per VR routing table while running IS-IS, and does so while interoperating with Cisco and Juniper routers.
Routing Protocol Support: RIP	RIP Interoperability with Cisco and Juniper		Proves that the ISER interoperates with Cisco and Juniper routers using RIP v1 and v2.
Routing Protocol Support: OSPF	QAR OSPF_2QARs suites		Verifies OSPF protocol conformance: tested using the OSPF 2QARs suites of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF_2QARs_broadcast_only suites		Verifies OSPF protocol conformance: tested using the ospf_2qars_broadcast_only suites of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF 2QARs_point_to_multi_only suites		Verifies OSPF protocol conformance: tested using the ospf_2qars_point_to_multi_only suites of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF_3QARs suite		Verifies OSPF protocol conformance: tested using the OSPF 3QARs suite of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF_2Areas suite		Verifies OSPF protocol conformance: tested using the OSPF 2Areas suite of Agilent QARobot
Routing Protocol Support: OSPF	OSPF interoperability with Cisco and Juniper		Proves that the ISER can interoperate with Cisco and Juniper routers using OSPF. The routing tables are exchanged and updated with the peers accurately.
Routing Protocol Support: OSPF	Maximum IGP Routes - OSPF		Proves that the ISER supports in excess of 500 routes per VR routing table while running OSPF, and does so while interoperating with Cisco and Juniper routers.
Routing Protocol Support: OSPF	QAR OSPF_Stress suites		Verifies OSPF protocol conformance: tested using the OSPF Stress suite of Agilent QARobot

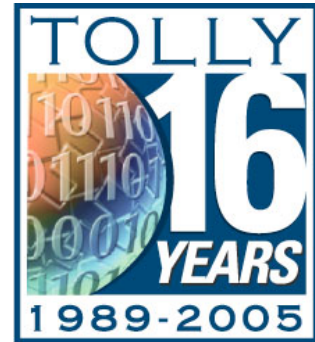
Parent test	Permutation	Test result ( = pass)	Proof point
Routing Protocol Support: OSPF	QAR OSPF_Opaque suite		Verifies OSPF protocol conformance: tested using the OSPF Opaque suites of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF_Opaque_Stub suites		Verifies OSPF protocol conformance: tested using the ospf_opaque_stub suites of Agilent QARobot
Routing Protocol Support: OSPF	QAR OSPF_Stub suites		Verifies OSPF protocol conformance: tested using the ospf_stub suites of Agilent QARobot
Routing Protocol Support: BGP	QAR bgp_rfc_1997 suite		Verifies BGP protocol conformance: tested using the RFC 1997 suites of Agilent QARobot. Passed RFC 1997 conformance test, except for the route aggregation.
Routing Protocol Support: BGP	QAR bgp_rfc_1997_aggreg suite		Verifies BGP protocol conformance: tested using the RFC 1997 suites of Agilent QARobot. Passed RFC 1997 conformance test, except for the route aggregation.
Routing Protocol Support: BGP	QAR bgp_rfc_1997_append suite		Verifies BGP protocol conformance: tested using the RFC 1997 suites of Agilent QARobot. Passed RFC 1997 conformance test, except for the route aggregation. Passed RFC 1997 conformance test, except for the route aggregation.
Routing Protocol Support: BGP	QAR bgp_rfc_1997_noadvertise suite		Verifies BGP protocol conformance: tested using the RFC 1997 suites of Agilent QARobot. Passed RFC 1997 conformance test, except for the route aggregation. Passed RFC 1997 conformance test, except for the route aggregation.
Routing Protocol Support: BGP	BGP interoperability with Cisco and Juniper		Verifies base iBGP, eBGP and mixed e/iBGP interoperability with Cisco and Juniper. Test proves that the ISER interoperates with Cisco and Juniper routers while running BGP. The routing tables are exchanged and updated accurately.
Routing Protocol Support: BGP	Maximum BGP Routes per VR		Test proves that the ISER supports in excess of 500 routes per VR routing table while running BGP, and does so while interoperating with Cisco and Juniper routers.
Routing Protocol Support: BGP	QAR bgp_rfc_1997_noexport suite		Verifies BGP protocol conformance: tested using the RFC 1997 suites of Agilent QARobot. Passed RFC 1997 conformance test, except for the route aggregation.
Routing Protocol Support: BGP	QAR bgp_rfc_3065_1 suite		Verifies BGP protocol conformance: tested using the RFC 3065 suites of Agilent QARobot. Passed RFC 3065 conformance test, except for one of the AS_PATH modification rules (Section 6.1C, 2).
Routing Protocol Support: BGP	QAR bgp_rfc_3065_2 suite		Verifies BGP protocol conformance: tested using the RFC 3065 suites of Agilent QARobot. Passed RFC 3065 conformance test, except for one of the AS_PATH modification rules (Section 6.1C, 2). Passed RFC 3065 conformance test, except for one of the AS_PATH modification rules (Section 6.1C, 2).
Routing Protocol Support: BGP	QAR bgp_rfc_3065_3 suite		Verifies BGP protocol conformance: tested using the RFC 3065 suites of Agilent QARobot. Passed RFC 3065 conformance test, except for one of the AS_PATH modification rules (Section 6.1C, 2).
Routing Protocol Support: BGP	QAR bgp_rfc_2796_1 suite		Verifies BGP protocol conformance: tested using the RFC 2796 suites of Agilent QARobot. Passed RFC 2796 conformance test, except for one of Implementation Considerations (Section 8, P.6).

Parent test	Permutation	Test result ( = pass)	Proof point
Routing Protocol Support: BGP	QAR bgp_rfc_2796_2 suite		Verifies BGP protocol conformance: tested using the RFC 2796 suites of Agilent QARobot. Passed RFC 2796 conformance test, except for one of Implementation Considerations (Section 8, P.6).
Routing Protocol Support: BGP	QAR bgp_rfc_2796_3 suite		Verifies BGP protocol conformance: tested using the RFC 2796 suites of Agilent QARobot. Passed RFC 2796 conformance test, except for one of Implementation Considerations (Section 8, P.6).
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_1 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_2 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_3 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_4 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_5 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_6 suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Routing Protocol Support: BGP	QAR draft_ietf_idr_bgp4-10_bcast suite		Verifies BGP protocol conformance: tested using the IETF IDR Draft suites of Agilent QARobot. Passed draft-ietf-idr-bgp4-14 conformance test except for the Section 9.1.1, p.40 and route aggregation.
Resiliency	VRRP sub-second failover		Demonstrates that the ISER supports VRRP groups with 50 msec advertisement timer, and the failover times observed were well below one second. The recovery times were of the order of a couple of hundred milliseconds.
Resiliency	Graceful Restart BGP		Demonstrates that the ISER can gracefully restart while running BGP, and no traffic is lost during the restart process, assuming no network topology changes have occurred during the restart period.
Resiliency	Graceful Restart OSPF		Demonstrates that the ISER can gracefully restart while running OSPF and no traffic is lost during the restart process, assuming no network topology changes have occurred during the restart period.
Resiliency	Graceful Restart BGP with Cisco and Juniper		Demonstrates that the ISER can gracefully restart while running BGP and interoperating with Cisco and Juniper peers. No traffic is lost during the restart process, assuming no network topology changes have occurred during the restart period.
Resiliency	Graceful Restart OSPF with Cisco and Juniper		Demonstrates that the ISER can gracefully restart while running OSPF and interoperating with Cisco and Juniper peers. No traffic is lost during the restart process, assuming no network topology changes have occurred during the restart period.

Parent test	Permutation	Test result ( = pass)	Proof point
Resiliency	Maximum VRRP sub-second groups per ISER		ISER supports up to eight subsecond VRRP groups at a given time.
Resiliency	Maximum total VRRP groups per ISER		ISER supports upto 32 simultaneous VRRP groups, with up to eight of them being subsecond VRRP groups.
Security and IPSec	IPSec manual key tunnel mode		ISER establishes IPSec tunnel using manual key
Security and IPSec	IKE negotiated tunnel mode		ISER establishes IPSec tunnel using auto IKE
Security and IPSec	IPSec interoperability with Cisco		ISER establishes IPSec tunnel with Cisco 7505
Security and IPSec	IPSec interoperability with Juniper NetScreen-100		ISER establishes IPSec tunnel with a NetScreen-100
Security and IPSec	ICMP Ping/Echo Reply Flood Attack		Proves that ISER can perform basic routing functions and forward 10 Mbps of legitimate traffic while it is under the gigabit-rate Ping Flood attacks.
Security and IPSec	SYN Flood Attack		Proves that ISER can perform basic routing functions and forward 10 Mbps of legitimate traffic while it is under the gigabit-rate SYN Flood attacks.
Security and IPSec	Maximum IPSec throughput		ISER forwarded 1.16 Gbps for 1,450-byte packets and 1 MPPS for 64-byte packets over the IPSec tunnel.
Security and IPSec	Maximum IPSec tunnels		ISER established 500 IPSec tunnels
Quality of Service	Packet Filtering - Stateless Inspection Deny		ISER allows only particular traffic flows using ACL
Quality of Service	Packet Filtering - Stateless Inspection Permit		ISER denies only particular traffic flows using ACL
Quality of Service	Policing and shaping		ISER supports traffic policing and shaping
Quality of Service	Policy Based Routing: Next Hop and out sub-int		ISER made routing decision based on the set policy
Quality of Service	DSCP send/receive with Cisco and Juniper		Proves that ISER exhibits DSCP interoperability with Cisco 7505 and Juniper NetScreen-SA 100
Quality of Service	Maximum ACL rules		ISER was able ACL to support up to 16,485 ACL rules
Quality of Service	Max traffic classes per physical interface		ISER supported up to six different traffic classes.
Virtual Routers	VR VLAN MAC separation		Shows that even though eight VRs were configured on each PHY, each VR could be distinguished based on its unique MAC address and VLAN tag.
Virtual Routers	VR IP address separation		Shows that even though two VRs have overlapping IP addresses, the traffic can be forwarded to the correct interface based on its unique MAC address, thus showing that the VR IP addresses are separated.

Parent test	Permutation	Test result (✓ = pass)	Proof point
Virtual Routers	VR IP Subnet separation		Shows that even though two VRs have overlapping IP addresses, the traffic can be forwarded to the correct interface based on its unique MAC address, thus showing that the VR IP addresses are separated.
Virtual Routers	VR BGP Protocol separation		Test verifies that multiple VRs running BGP can exist on the same PHY at the same time, and still have independent routing tables.
Virtual Routers	VR OSPF protocol separation		Test verifies that multiple VRs running OSPF can exist on the same PHY at the same time, and still have independent routing tables.
Virtual Routers	VR DiffServ PBR separation		Test verifies DiffServ policy-based routing takes place per VR
Virtual Routers	Maximum routes per VR		ISER supports at least 1,000 routes per VR.
Virtual Routers	VR performance: Maximum BGP \ instances		Tests show the maximum BGP instances is 4 per ISER, and one per VR
Virtual Routers	VR performance: Maximum IGP instances		The maximum OSPF instances is eight per ISER, and one per VR. The maximum IS-IS instances is eight per ISER, and one per VR.
Layer 3 Tunneling	Maximum GRE/IP-IP throughput		ISER forwarded 3 Gbps of traffic for 1,400-byte packets and 2 MPPS for 64-byte packets over the GRE/IP-IP tunnels.
Layer 3 Tunneling	GRE/IP-IP interoperability with Cisco and Juniper		Tests show that the ISER achieved GRE/IP-IP interoperability with the Cisco 7505 and the Juniper M20.

Information technology is an area of rapid growth and constant change. The Tolly Group conducts engineering-caliber testing in an effort to provide the internetworking industry with valuable information on current products and technology. While great care is taken to assure utmost accuracy, mistakes can occur. In no event shall The Tolly Group be liable for damages of any kind including direct, indirect, special, incidental, and consequential damages which may result from the use of information contained in this document. All trademarks are the property of their respective owners.



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