Availability, performance and flexibility, in a small form factor for delivering carrier-class IP services in next generation networks

As networks for broadband deployment continue to evolve service providers are finding that they need a device that will allow them to design their networks to deliver advanced IP services closer to the customer. They need to do this to deliver content and services in a manageable manner, while reducing traffic across the core, reducing latency and providing quality of service with high availability and high performance.

The Redback® SmartEdge® 400 is a multi-service routing platform that delivers the necessary performance and features for next generation broadband in a small form factor. The small size allows the SmartEdge 400 Router to be deployed in remote POPs where it can perform multiple functions such as IP edge routing and VPN termination for residential and business customers. These services can be delivered with superior performance, advanced quality of service and with the highest reliability because of the advanced ASIC technology and availability capabilities of the SmartEdge 400.

Improving service availability is becoming increasingly important as customers become intolerant of unreliable IP services and demand predictable service levels. The increase in IP service demand has introduced new requirements for scaling the network. This involves not only distributing services closer to customers, as well as increasing network capacity and packet-forwarding rates, but also ensuring that the operating software that supports routing protocols and packet forwarding processes is also scalable, robust, and highly resilient. Margin requirements and competitive pressures are motivating interest in IP services beyond basic Internet access, but service providers need the right device to allow them to deliver these services.

The SmartEdge 400, a member of the SmartEdge family of carrier-grade networking platforms, is targeted at dedicated IP access services, Layer 3 and Layer 2 VPNs, and multicast delivered close to the customer. The product is distinguished by a number of features for providers focused on delivering highly available IP services today, and having flexibility to support new IP services in the future.

**KEY BENEFITS**

- **Small Form factor: Performance in a 5 RU chassis.** Brings services close to the customer by installing in small POPs.
- **Routing protocols:** Built from the ground up, with a focus on high availability, scalability and support for new protocols such as MPLS.
- **Highly redundant hardware:** Engineered to carrier standards for deployment in carrier networks worldwide.
- **High performance programmable packet forwarding:** Based on a Packet Processing ASIC (PPA) developed by Redback.
- **Familiar Command Line Interface:** Simplifies provisioning and speeds time to service.
System Architecture

The SmartEdge 400 is engineered for deployment in the most demanding network environments. All common equipment and line cards are hot swappable and critical components such as the Route Processor can be implemented in redundant configurations. The operating system enables fast failover to a hot standby Route Processor with no interruption to forwarding. Near hitless software upgrades are made possible by the modular software architecture. The packet switching mesh employs high-performance ASICs developed by Redback and is distributed to every line card, thus having no single point of failure. There is a dedicated processor for time critical I/O functions such as fault and performance monitoring and alarms. Power and return lines are diversely routed across the backplane to every slot in the chassis. The SmartEdge 400 packs considerable performance into a 5 RU form factor with a packet mesh that delivers 80 Gbps of sustained packet forwarding. There are 6 slots in the chassis, two for route processors and four for line cards. High port densities allow providers to maximize the use of rack space and conserve power—both of which are significant contributors to operational expense.

Purpose built hardware with high thermal efficiency.

Redback has focused on building highly resilient hardware and software for the SmartEdge 400. The product was designed with availability, scalability, programmability, and high performance in mind. It supports 99.999% reliability, scales both physically and logically to thousands of sessions. It can forward packets at line rate with features enabled and is flexible enough to be continuously upgraded to support new services. It provides the highest performance per rack unit. The SmartEdge 400 uses a unique front to side cooling method that provides the highest levels of thermal efficiency and allows units to be stacked and racked closer together for the highest densities.

High-performance switching and programmable forwarding. The SmartEdge 400 employs a high-performance packet mesh, where every card is interconnected to every other card. The packet mesh has 80 Gbps of switching capacity that is delivered by ASICs developed by Redback. The packet forwarding functions in the SmartEdge 400 are implemented with Redback’s specialized network processors, called Packet Processing ASIC (PPA). The SmartEdge 400 uses a dedicated PPA on every line card for input packet processing and another dedicated PPA on every line card for outgoing packet processing. With these dedicated packet processors for incoming and outgoing traffic, the SmartEdge 400 can support high-performance forwarding, with a rich set of packet processing features (ACLs, rate limiting, etc.) turned on, both on the access side (toward the customer) and the backbone side. The PPA is fully programmable so enabling new services is as straightforward as reprogramming the hardware. The PPA preserves investments in hardware since new features can be enabled with new software on the existing hardware.

The SmartEdge 400 packs considerable performance into an extremely compact form factor.

<table>
<thead>
<tr>
<th>Interface Type</th>
<th>Ports per Slot</th>
<th>Ports per Chassis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch OC-12 to DS3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Ch OC-12 to DS1/DS3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Ch DS3 (slots 3-4 only)</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>Clear Channel DS3</td>
<td>12</td>
<td>48</td>
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<tr>
<td>Ch STM-1</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Ch E1</td>
<td>24</td>
<td>96</td>
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<tr>
<td>OC-12c/STM-4</td>
<td>4</td>
<td>16</td>
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<tr>
<td>OC-3c/STM-1</td>
<td>8</td>
<td>32</td>
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<tr>
<td>OC-12c/STM-4 ATM</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>OC-3c/STM-1 ATM</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>DS3 ATM (slots 3-4 only)</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>10/100TX Ethernet</td>
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<tr>
<td>Gigabit Ethernet</td>
<td>4</td>
<td>16</td>
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</tbody>
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**Advanced features that maximize Route Processor availability.**

The SmartEdge 400 hardware and software support a hot standby Route Processor with fast failover and minimal interruption to forwarding. An Active Component Upgrade feature allows individual routing protocols to be upgraded in crisis situations, with no interruption to forwarding.

**Distributed forwarding.** Forwarding functions on the SmartEdge 400 are distributed on every line card and handled by the PPA. A failure of one line card has no impact on packet forwarding on any other line card. In contrast to most existing platforms, the forwarding path of the SmartEdge 400 is fully programmable, so it can forward any packet type, with any encapsulation, without intervention by the Route Processor. Thus, there is no central point of failure for packet forwarding, even for specialized packet types.

**Non-stop forwarding and separation of routing and forwarding.** The SmartEdge 400 can support non-stop forwarding by continuing to forward packets even when the control plane is adversely affected by network instability or a protocol crash or restart. This is because routing and forwarding functions are strictly separated. The Route Processor is dedicated exclusively to processing route updates and calculating routes. Business customer traffic and SLAs are not affected by control plane transitions; instead, the network remains available.

**Routing designed for availability, scalability, and flexibility.** Recognizing that all of the routing protocol suites available in the open market lack high availability and high scalability characteristics, the SmartEdge OS was built from the ground up. The code is optimized for high availability and engineered for scalability to support next-generation requirements for peering and edge aggregation. It is also designed to accommodate new protocols such as MPLS and IPv6 with new encapsulations and Address Families.

**Software modularity and process restartability.** The SmartEdge OS is highly modular to improve system reliability. Every protocol such as BGP, OSPF, IS-IS, and RIP is implemented as a separate process. The Routing Information Base (RIB) and configuration UI are also separate processes. Failure of one process has no impact on any other process. For example, if a network event crashes BGP it does not affect any other protocols and does not cause a system crash. If a routing protocol fails it can be restarted without affecting any other protocol.

**Graceful restart.** The SmartEdge 400 supports graceful restart for BGP, OSPF, LDP and IS-IS. Graceful restart is a mechanism that promotes high availability in the network and minimizes the impact of restarting routing protocols. Normally, when a protocol is restarted, a systems peers detect that a session went down and cause reconvergence throughout the network. The resulting route recomputation and networkwide routing updates consume processing resources and potentially cause packet loss in transient forwarding loops. When graceful restart is supported, the SmartEdge system’s peers do not immediately cause networkwide reconvergence. The restarting SmartEdge is given the opportunity to re-establish routing sessions and download fresh routes. Graceful restart works in tandem with the forwarding plane stability introduced by non-stop forwarding to support a new measure of control plane stability.

**Value added features.** The SmartEdge 400 has a full complement of packet processing features that can be used to enable IP services. These include extensive packet classification or filtering capabilities based on ingress port/circuit, source/destination IP address and/or TCP port or protocol. Packets can be marked per the DiffServ specification or the Type of Service bits can be set. Access Control Lists are supported to permit or deny packets based on the same filter criteria.

Quality of Service functions include ingress policing and egress shaping, whereby incoming and outgoing traffic are conditioned to meet a mutually agreed upon traffic profile, typically a sustained bandwidth value plus a burst tolerance. The SmartEdge 400 also supports sophisticated queuing and scheduling. There are up to 1k queues available per line card and the number and use of the queues is configurable.
Support for multiple contexts. The SmartEdge 400 delivers a full suite of subscriber management features for broadband service aggregation. The SmartEdge 400 supports the provisioning, aggregating, and managing of broadband subscribers simultaneously with other applications such as VPNs and multicast content delivery. Subscribers get access to these other applications, enabling the creation of services such as DSL subscriber VPNs and subscriber-enabled content delivery. Many methods of subscriber encapsulation are supported, such as RFC 1483, RFC 1490, PPP over ATM and PPP over Ethernet. L2TP wholesaling is also available.

Support for multiple contexts. A unique service enabling capability of the SmartEdge 400 is support for multiple routing contexts, which allow a provider to partition a chassis with software to create “contexts” or virtual systems. Each context appears to the service provider (and end customer) as a full-featured system with a console along with all of the monitoring and configuration features they would expect to see in a dedicated system. The use of contexts in combination with MPLS or GRE VPNs provides a powerful VPN model that allows for increased customer visibility into VPNs.

Virtual private network support. Virtual private networks (VPNs) allow carriers to offer new services that leverage existing infrastructure investments. The SmartEdge 400 supports both Layer 2 and Layer 3 VPNs in conjunction with multiple contexts to create a flexible and powerful service offering. Each VPN gets its own IP address space, routing table, protected network traffic, user authentication, and other attributes. VPNs can be built across a carrier network with a variety of different technologies, including BGP/MPLS (RFC 2547), Layer 2 MPLS (draft-martini), and GRE tunneling. The customer can be terminated into the VPN with a variety of different methods, including ATM, frame relay, Ethernet, and leased line. Because of the SmartEdge 400’s support of virtual interfaces, customers can be easily switched between different types of VPNs with only one configuration line change.

Routing protocol interoperability and scaling. The Delivering IP services requires a complete set of scalable interior and exterior gateway routing protocols equipped with the latest feature extensions. The SmartEdge 400 supports BGP, IS-IS, OSPF, RIP, and IGMP. BGP features include Route Aggregation, MDS Authentication, Route Reflection, Route Flap Dampening, Confederations, Communities, Peer Groups and new extensions such as BGP Refresh, Outbound Route Filtering, and BGP Graceful Restart. Interior Gateway Protocol (IGP) features supported include: multiple levels, multiple instances (with redistribution between instances), load balancing and authentication. For any combination of route table size and peers, the routing protocols will offer unmatched convergence times.

The SmartEdge 400 also supports a complete suite of multicast routing protocols: IGMP, MSDP, PIM-SM, SSM. These protocols together with the hardware assisted multicast forwarding make for a superior multicast implementation, supporting very high fanouts. To protect link bandwidth and preserve the quality of multicast streams, network providers can also limit the number of members in a multicast group on a per-port basis.

Bulkstats. Bulkstats provides a more efficient alternative to SNMP as a means of gathering network accounting statistics from the SmartEdge 400. The system samples and stores system, network and traffic statistics at specified sampling intervals. The data are then sent at specified intervals as a text file via FTP to a network management station, allowing for easier network management.

Traffic mirroring. Traffic mirroring is a powerful tool for troubleshooting and lawful interception. Packets can be mirrored or sampled from any circuit in the system, at ingress or egress, and then sent to any other circuit on the system. Up to seven classes of packets can be specified, with each class being mirrored to a different output circuit.

Cross connect support. The cross connect features on the SmartEdge 400 allow network providers to offer premium services to end customers while minimizing both equipment expenditures and customer downtime. The SmartEdge can locate specific packets within an end customer traffic flow and direct them toward separate networks. All PPP Over Ethernet packets can be sent to one network for standard Internet service, and all IPv4 and IPv6 packets can be directed toward a premium services network. Additionally, disparate media such as ATM and Ethernet can be cross-connected together so ATM PVCs could be aggregated into Gigabit Ethernet trunks.
**IP Aggregation**

The SmartEdge 400 Router supports channelized interfaces to deliver DS1/E1 and DS3/E3 port density for dedicated access services. Channelized OC-12c interfaces support up to 336 DS1s or 12 DS3 terminations in a single slot. A high-density Channelized DS3 line card also delivers 336 DS1s and clear channel DS3/E3 modules offers 12 ports for POPs where an optical handoff is not available. Frame Relay termination is supported over DS1/E1, DS3/E3, and POS interfaces. DS3, OC-3c/STM-1 and OC-12c/STM-4 ATM support termination of thousands of VCs per port.

**Virtual Private Networks (VPNs)**

VPNs allow carriers to offer new services that leverage existing infrastructure investments. The SmartEdge 400 Router supports VPNs that can be provisioned across a network in multiple ways, including BGP/MPLS (RFC 2547), Layer 2 (draft-martini), and GRE tunneling. The SmartEdge 400’s support of virtual interfaces allows customers to be easily switched between different types of VPNs. VPNs work in conjunction with multiple contexts to support separate IP address space, routing table, protected network traffic, and user authentication for each VPN. The customer can be terminated into the VPN with a variety of different methods, including ATM, frame relay, Ethernet, and leased line.

**Multicast Content Delivery**

Multicast allows carriers to deliver multi-media broadcast content to the customer with a high quality of service, while reducing replicated traffic across the core. The SmartEdge 400 Router provides high performance ASICs for data replication and supports a rich suite of features including PIM-SM, IGMP v1, v2, v3, SSM, MBGP, and MSDP. Multi-cast is supported over MPLS and GRE VPNs.
### Hardware

#### Chassis
- -8.75”(H) x 17.5” (W) x 16” (D) for 5 RU DC version
- -9” chassis per 2 rack for 5 RU DC Version
- -10.5”(H) x 17.5” (W) x 16” (D) for 6 RU AC version
- -8 chassis per 2 rack for 6 RU AC Version
- 19” and 23” rack mountable (front or mid-mountable)
- 6 slots, 2 for Route Processors; 4 slots for line cards.
- Front to side airflow for optimum cooling.
- Weight: 28 lbs for basic chassis; fully loaded chassis approx. 47 lbs
- Connectors on chassis: Power A, B; dual BITS
- DS3 cards with BNC connectors on the back
- Redundant chassis power inputs for both
- Restartable routing processes
- Hot standby route processors

#### Route Processor Module
- 2 per chassis (1 working + 1 hot standby)
- Power PC 750
- 768 MB memory per Route Processor
- PC card slot for 1 GB Microdrive for secondary storage
- BITS clock sources (2) for external stratum clock inputs
- Stratum 3 Oscillator
- Management ports: 2 craft ports: DB-9 RS-232
- Stratum 3 Oscillator

#### Line Cards
- Dual Packet Processing ASICS (PPA); 1 for ingress processing, 1 for egress processing
- Packet mesh ASICS
- DS3 cards with BNC connectors on the back panel must be installed in either slots 3 or A.
- There are 24 total BNC connectors available.

#### Card Types
- 1 port Channelized OC-12 to DS3
- 1 port Channelized OC-12 to DS1/DS3 (336 channels)
- 12 port Channelized DS3 (336 channels)
- 12 port Clear Channel DS3
- 3 port Channelized STM-1 (336 channels)
- 24 port Channelized E1
- 1 port OC-48c/STM-16
- 4 port OC-12c/STM-4
- 8 port OC-3c/STM-1
- 1 port OC-12c/STM-4 ATM
- 4 port OC-3c/STM-1 ATM
- 12 port DS3 ATM
- 12 port 10/100TX Ethernet
- 4 port Gigabit Ethernet

#### Redundancy
- 1+1 for all common CPUs, clock and independent power to each line card
- Hot standby route processors
- Restartable routing processes
- Redundant chassis power inputs for both DC and AC versions.

### Operating Environment
- Temperature: 0-40 degrees long term
- SC to 55C degrees short term
- Humidity: 5-90% RH
- Power: -48 VDC +/- 20% (-38.4V to -57.6V)
- AC 90-254 VAC
- Typical system power = 525 W
- Maximum system power = 700 W
- Actual system power consumption is dependent on the type and number of line cards installed.

### Compliance
- NEBS Level III in process, CE Mark, UL 1950, GR-63 Core, GR-1089 Core, ETS 300 386-2
- FCC Part 15, EN15022 class A, Ethernet 10/100TX
- Forwarding performance of 80 Gbps or 65 Mpps

### Security
- Reverse Path Forwarding (RPF) check, SSH, MD5 support for routing protocols, key rollover, RADIUS, TACACS+; Administrative ACLs
- Subscriber Awareness
  - Subscriber Name, Session, IP Address

### Address Management
- DHCP Relay, DHCP Proxy, IPCP parameter negotiation
- MPLS Traffic Engineering

### Advanced Features
- Multi-contexts with intercontext routing
- Premium Service Insertion
- Cross connect support
- Access Control Lists
- Bulkstats
- Network Address Translation (NAT)
- Virtual Service Gateway System Redundancy Protocol (VRRP)
- Dynamically Verified Static Routing (DVSR)
- Policy routing
- Traffic mirroring
- Access Control Lists

### Protocols
- BGP-4 (RFC 1771), IS-IS (RFC 1195 & ISO/IEC 10589), OSPF v2 (RFC 2328)
- PIM-SM (RFC 2362), IGMP v1, v2, v3 (RFC 3376), SSM (IETF Draft), MBGP (IETF Draft), MSDP (IETF Draft)
- MPLS-TE, RSVP (RFC 3209), LDP (RFC 3036)
- BGP/MPLS VPNs (RFC 2547), Layer 2 VPNs (IETF draft)

### Configuration and Network Management
- Industry familiar Command Line Interface (CLI) support via telnet or Secure Shell (SSH)
- Multiple user groups or access levels with definable access privileges
- Transaction based configuration against a configuration database including commits, aborts and ability to roll back unintended changes
- NetQoE EMS support for event logs, SNMP traps, interface statistics for troubleshooting and performance monitoring, port views and chassis views.

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