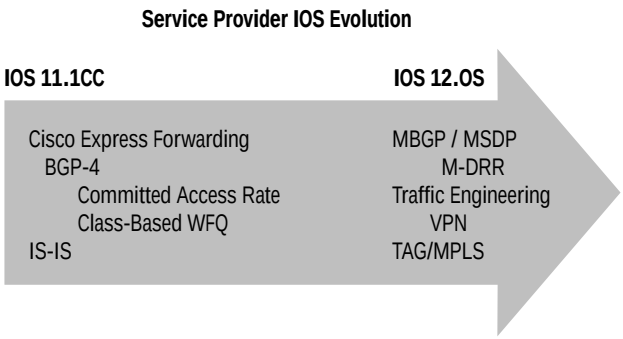
Cisco IOS: Empowering SP Networks

Internet has become the primary vehicle for delivering public data services. Applications such as E-Commerce, Video, and VPNs are driving carriers to ramp their service offerings from traditional narrow band T1/E1 services to broadband DS3/E3, OC3/STM1, OC12/STM4, OC48/STM16 and beyond. To support these emerging applications, many Tier 1 ISPs are required to double their backbone capacity every six to nine months. It is this voracious demand for bandwidth that is driving the requirement for an "Optical Internet."

As service providers attempt to scale their networks to support this explosion in demand for bandwidth, the challenge will be to not only provide raw bandwidth, but to do so while enhancing their new revenue generating service offerings. Key to achieving this goal will be the adoption of an Internet software architecture that address the following critical areas:

- Network scalablity
- Redundancy & Serviceability
- Advancements in Routing Protocols
- MPLS
- Value-Added Services Support

Figure 1 IOS 12.OS Leverages 11.1CC to Deliver a Service Provider Specific Platform



CISCO SYSTEMS

Cisco IOS 120S: Designed for Service Providers

Networks, the size and scale of the Internet have unique requirements. Not only do they require extremely high speed switching, but also must remain stable in a very dynamic environment. In recognition of this, Cisco has improved upon much of its traditional routing technology with a goal to develop an entirely new architecture.

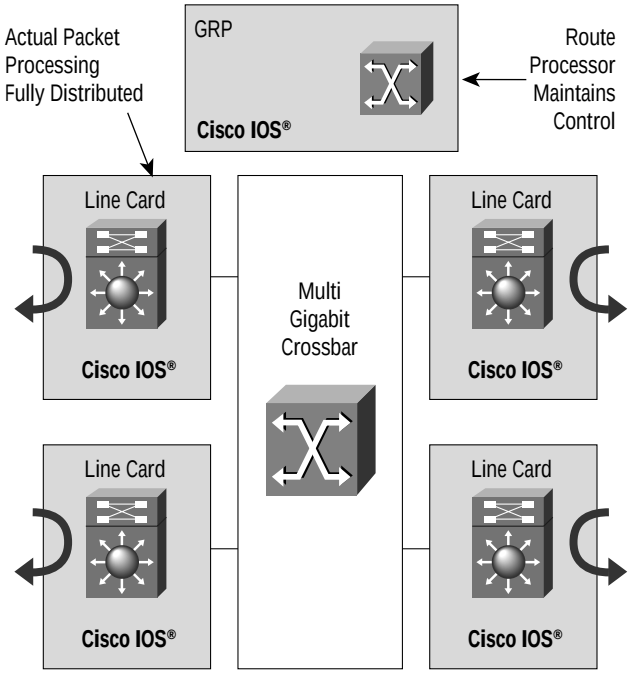
Over the last 24 months, Cisco has worked with the top 20 ISPs and Content Providers on the refinement of Cisco IOS 11.1CC, an ISP specific release which has become the basis for many IP, BGP, and value-added-service enhancements. 11.1CC was the first platform to deploy Cisco Express Forwarding (CEF), a new routing technology designed to scale internet performance while forming the foundation for service application.

The culmination of all of this work is 120S. IOS 120S leverages the experience gained through the deployment of IOS 11.1CC to build a new Internet core software platform. Tailored for Service Providers and the choice platform for the GSR 12000, IOS 120S mixes the maturity and stability of industry proven protocols, such as Cisco's BGP-4 implementation, with the functionality required to scale next generation backbones. While competitive software architectures can support one function (i.e. forwarding packets), they do not have the flexibility to do so while providing "high-touch" services. Moving forward, it will be a rich assortment of features such as MPLS-VPN, QoS, Traffic Engineering, and additional "high-touch" features that will enable ISPs to offer differentiated, value-added revenue generating services in the face of increasing competition.

IOS 120S: Scalability

The key to exploiting scalable distributed architectures like the Cisco 12000 GSR is in the control functions embedded in the software. Internet core routers like the Cisco 12000 GSR are mission specific pieces of equipment. Fundamentally, they require support for up to thousands of interfaces, specific application performance optimization (network protocol convergence), and fully distributed operation. IOS 120S has a distributed architecture that can distribute processing load across all the line cards of the Cisco 12000 GSR. Furthermore, IOS 120S has the control framework in place (distributed Cisco Express Forwarding (dCEF), for example) to leverage the power of future generations of higher-speed forwarding engines.

Figure 2 Cisco's Distributed Architecture Allows Each Line Card to Forward Packets and Apply Services Autonomously



Cisco IOS 120S also utilizes sophisticated prioritization and preemption techniques to guarantee resource availability during sub-optimal conditions (e.g. rapid topology change)

IOS 120S High Availability

As mission critical applications continue to be deployed over the Internet, any amount of network downtime can cause serious repercussions. In order to support a "Zero Downtime" environment, key redundancy and serviceability attributes must be present throughout the backbone. Below is a list of the key redundancy and serviceability features supported in IOS 120S:

- OIR (Online Insertion and Removal): While hot-swapping line cards, fabrics, and GRPs, IOS 120S can dynamically bring cards in and out of service without affecting the performance of other system components
- APS/MSP (Automatic Protection Switching): SONET/SDH brings many redundancy features to the table. For example, APS and MSP allow the routers to communicate link status information to the SONET/SDH network, providing for 1:1 link restoration.
- H.S.A. (High System Availability): IOS 120S incorporates support for redundant route processors (GRPs). A warm-standby backup GRP can take over in the event of a primary GRP hardware failure

IOS 120S Routing Protocol Enhancements for ISPs

Internet Service Providers depend on BGP for core routing maintenance. BGP provides a standards based approach to inter-domain routing that can scale to Internet levels. While broadly supported throughout the industry, the BGP standard is particularly valuable when complemented by the range of extensions that are unique to the Cisco IOS BGP implementation. Following are some of the key Cisco IOS 120S extensions that Service Providers are using today to deploy large networks.

- Carrying full Internet routes—When coupled with Cisco Express Forwarding technology, IOS 120S's BGP-4 implementation can scale to upwards of 1 million routes. While the Internet today carries approximately 90,000 routes, the ability to carry full internet tables from multiple different providers can aid in both manageability and aggregate network convergence times.
- NetFlow Autonomous System (AS) Matrix—This matrix enables aggregate traffic flow analysis based on volume between source and destination networks (using Autonomous System numbers). The ability to tightly couple BGP-4 routing information with NetFlow statistics gathering is unique to Cisco's implementation.
- Multi-path load-balancing—When a single border router peers multiple times with the same provider, Cisco's BGP-4 implementation can load balance the traffic across all peering points. Up to six parallel peering paths are supported.

IOS 120S MPLS Extentions for ISPs

While MPLS in an of itself is a standard, Cisco IOS 120S integrates many unique MPLS extensions that allow service providers to differentiate themselves amongst the competition. Following are some example of how these extensions may be deployed in large MPLS networks today:

- MPLS Traffic Engineering (RRR)—ATM users have become accustomed to being able to traffic engineer their cores. Routing with Resource Reservation (RRR) leverages MPLS's ability to de-couple the layer-3 control plane from the forwarding function. Utilizing RRR, Service Providers can continue to traffic engineer their networks to ensure the highest level network throughput.
- MPLS Fast Re-Route (FRR)—Service providers can setup multiple MPLS TE tunnels between source and destination that can not only support different Classes of Services (CoS) but also provide "real-time tunnel failover" capability whereby one MPLS tunnel can serve as a warm-standby backup tunnel that can take over in the event of a link or path failure of the primary MPLS tunnel. Tunnel failover can be accomplished in less than 50 msec—the SONET/SDH standard for APS protection switching.
- MPLS Connection Services—When migrating to MPLS, there will be a period of transition for many customers depending on classic layer-2 services like Frame Relay and ATM. Supporting Frame Relay and ATM switching over an MPLS infrastructure allows the service provider to continue to offer these traditional layer-2 services simultaneously with next generation IP services over MPLS networks.
- MPLS based IP-VPNs—Service Providers can offer highly scalable and secure VPN services over their Layer 3 infrastructure by combining MPLS switching, MPLS RRR, MPLS FRR, the concept of distinct Forwarding Information Base (FIB) Tables (based on CEF) per VPN and the infinite scalability of Multi-protocol BGP to provide a standards based solution that can scale to 1000's of VPNs with 1000's of sites each in a secure way.

IOS 120S: Enhancements for Value-Added ISP Services

As mentioned earlier, forwarding packets only solves half of the equation. Equally important is the ability to provide services while scaling the backbone. By leveraging its inherent distributed nature, IOS 120S is able to maintain high levels of performance while simultaneously supporting many 'high-touch' services. Features such as Extended Access Lists (X-ACL), NetFlow, and Committed Access Rate (CAR) run on each individual line card. Adding new line cards to a router provides the additional processing capacity required to deliver these enhanced services to new customers.

- IP CoS—This feature uses three prededence bits in the IP header to support up to eight Classes of Services (Cos). This value is set at the edge of the network and enforced in the core.
- (X)ACL—Extended Access lists provide a first line security measure that scales to gigabit levels.
- CAR—The Committed Access Rate feature aids service providers in many critical areas: Traffic Policing (particularly useful for contract enforcement), Sub-Rate service offering, and QoS packet 'coloring'
- IP Multicast—Multicast offers service providers an efficient method for deploying applications such as IP steaming video.
- NetFlow—Coupled with BGP, NetFlow provides a powerful tool for monitoring and analyzing network traffic that can be useful for traffic engineering, network provisioning and billing applications.

IOS 120S Delivers

Service Providers are constantly struggling to scale their infrastructure. The adoption of the Internet as the de-facto public data network will only increase the drive for additional bandwidth. However, while performance is critical, it is important not to lose sight of the services that customers require networks to provide. By adopting Cisco IOS 120S in combination with the GSR 12000, service providers can scale their network backbone requirements while at the same time delivering highly differentiated services at high performance levels. Ultimately this combination will become critical to the long term success of any Network Service Provider.

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems Europe s.a.r.l.
Parc Evolic, Batiment L1/L2
16 Avenue du Quebec
Villebon, BP 706
91961 Courtaboeuf Cedex
France
http://www-europe.cisco.com
Tel: 33 1 69 18 61 00
Fax: 33 1 69 28 83 26

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Headquarters
Nihon Cisco Systems K.K.
Fuji Building, 9th Floor
3-2-3 Marunouchi
Chiyoda-ku, Tokyo 100
Japan
http://www.cisco.com
Tel: 81 3 5219 6250
Fax: 81 3 5219 6001

Cisco Systems has more than 200 offices in the following countries. Addresses, phone numbers, and fax numbers are listed on the

Cisco Connection Online Web site at http://www.cisco.com/offices.

Argentina • Australia • Austria • Belgium • Brazil • Canada • Chile • China • Colombia • Costa Rica • Croatia • Czech Republic • Denmark • Dubai, UAE Finland • France • Germany • Greece • Hong Kong • Hungary • India • Indonesia • Ireland • Israel • Italy • Japan • Korea • Luxembourg • Malaysia Mexico • The Netherlands • New Zealand • Norway • Peru • Philippines • Poland • Portugal • Puerto Rico • Romania • Russia • Saudi Arabia • Singapore Slovakia • Slovenia • South Africa • Spain • Sweden • Switzerland • Taiwan • Thailand • Turkey • Ukraine • United Kingdom • United States • Venezuela

12/99 LW