Cisco 12000 Series Gigabit Switch Routers

Introduction

The Internet is rapidly becoming an electronic agent for commerce, entertainment, communication, and information retrieval. New network-enabled intranet applications and powerful desktop computers are driving an exponential increase in network traffic. Service providers and enterprises are rapidly deploying packet-switching infrastructures to handle this tremendous growth in data traffic.

The Cisco 12000 series gigabit switch router (GSR) is the premier routing product family from Cisco designed and developed for the core of service provider and enterprise IP backbones. The Cisco 12000 GSR family includes three models: the Cisco 12008, 12012 and 12016.

The Cisco 12008 has eight slots that can be used to support up to 84 DS3, 28 OC-3c/STM-1c, and 28 OC-12c/STM-4c or 7 OC-48c/STM-16c interfaces.

The Cisco 12012 has 12 slots that can be used to support up to 132 DS3, 44 OC-3c/STM-1c, 44 OC-12c/STM-4c, or 11 OC-48c/STM-16c interfaces.

The Cisco 12016 has 16 slots that can be used to support up to 180 DS3, 60 OC-3c/STM-1c, and 60 OC-12c/STM-4c or 15 OC-48c/STM16c interfaces, with support for 15 OC-192c/STM-64c interfaces in the future.

The Cisco 12000 series GSR products are architected to meet the bandwidth, performance, services, and reliability requirements of today's IP core backbones.

Scalable Bandwidth

Modular, multigigabit crossbar switching fabric allows bandwidth to scale in flexible increments: 40 Gbps for the Cisco 12008, 60 Gbps for the Cisco 12012, and 80 Gbps for the Cisco 12016.

- High-density, high-speed interfaces from DS3 to OC-48c/STM-16c can be added as needed, with support for OC-192 in the future
- Dynamic Packet Transport (DPT) ring interfaces at 2 x 622 Mbps (OC-12c/STM-4c)
- Packet over Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH) (PoS) interfaces at 155-Mbps (OC-3c/STM-1c), 622-Mbps (OC-12c/STM-4c), and 2.5 Gbps (OC-48c/STM-16c) data rates
- Asynchronous transfer mode (ATM) interfaces at 155-Mbps (OC-3c/STM-1c) and 622-Mbps (OC-12c/STM-4c) data rates
- LAN interfaces at 1-Gbps (Gigabit Ethernet) and 100-Mbps (Fast Ethernet)
- Frame-based interfaces (Point-to-Point Protocol [PPP], Frame Relay) at 45 Mbps (DS3), 155 Mbps (OC-3c/STM-1c), and 622 Mbps (OC-12c/STM-4c)

CISCO SYSTEMS

Figure 1 Cisco 12000 Series

Scalable Performance

- Innovative switch fabric design supports virtual output queues (VoQs) that eliminate head-of-line blocking (HOLB) and increase overall system efficiency, and it supports partial fulfillment for multicast traffic when replication of multicast traffic is performed by the switch fabric.
- Distributed architecture delivers scalable Layer 3 switching performance through intelligent line cards (LCs) that can be added incrementally.
- Microprogrammable application-specific integrated circuits (ASICs)-based queuing provides line rate forwarding for unicast and multicast traffic that fills SONET/SDH transmission facilities to capacity, ensuring best return on investment on expensive bandwidth.

Scalable Services

- Industry-leading Cisco IOS® software
- State-of-the-art queuing and congestion management techniques—Random Early Detection (RED), Weighted RED (WRED), and distributed round robin (DRR)—that provide an enhanced Weighted Fair Queuing (WFQ) mechanism
- Multiprotocol Label Switching (MPLS) Tag Switching support to deliver scalable traffic engineering features

Carrier-Class Design

- Redundancy in all key system components—processors, switch fabric, LCs, power, and cooling—to minimize network disruption in the event of a failure.
- Hot-swap capability enables components to be added or removed without service disruption.
- Switch fabric redundancy provides fail-over to backup fabric with no data or user session loss.
- Automatic protection switching (APS)/multiplex section protection (MPS) enables SONET/SDH resiliency capabilities for providing interface redundancy.

Network Equipment Building System (NEBS) and European Telecommunications Standards Institute (ETSI) compliance enables installation in service provider central offices.

Cisco 12000 GSR Architecture

System Level

The Cisco 12000 GSR is based on a high-speed distributed routing architecture combined with a state-of-the-art switching core that delivers Layer 3 routing at gigabit speeds.

The Cisco 12000 GSR is optimized for performing routing and packet-forwarding functions to transport IP datagrams across a network. The routing function is performed in the gigabit route processor (GRP) responsible for running the routing protocols and building the routing tables from the network topology. This information is then used to build the forwarding tables distributed to the LCs. In addition, the GRP is also responsible for the system control and administrative functions.

The packet-forwarding functions are performed by each of the LCs. A copy of the forwarding tables computed by the GRP is distributed to each of the LCs in the system. Each LC performs an independent lookup of a destination address for each datagram received on a local copy of the forwarding table, and the datagram is switched across a crossbar switch fabric to the destination LC.

All cards are installed from the front of the chassis and plugged into a passive backplane. This backplane contains serial lines that interconnect all the LCs to the switch-fabric cards as well as other connections for power and maintenance functions. Each slot in the GSR has up to four serial line connections (1.25 Gbps), one to each of the switch-fabric cards (see below) to provide a total capacity of 5 Gbps per slot (2.5 Gbps full-duplex).

The major components of the GSR are the switch fabric, GRP, and LCs.

Switch Fabric

At the heart of the Cisco 12000 GSR is a multigigabit crossbar switch fabric that is optimized to provide high-capacity switching at gigabit rates. The crossbar switch enables high performance for two reasons: connections from the LCs to a centralized fabric are point-to-point links that can operate at very high speeds and multiple bus transactions can be supported simultaneously, increasing the aggregate bandwidth of the system. A GSR system can be configured as 40 Gbps for the Cisco 12008, 60 Gbps for the Cisco 120012, and 80 Gbps for the Cisco 12016.

The switch fabric includes two card types: switch-fabric cards (SFCs) and clock and scheduler cards (CSC). Each GSR must have at least one CSC in the chassis. The CSC handles requests from LCs, issues grants to access the fabric, and provides a reference clock to all the cards in the system to synchronize data transfer across the crossbar. The SFCs receive the scheduling information and clocking reference from the CSC cards and perform the switching functions.

It provides the following key functions:

- Gigabit speed interconnections between LCs (5 Gbps per slot)
- State-of-the-art scheduling algorithm combined with virtual output queues to eliminate head-of-line blocking, achieving 99-percent efficiency
- Hardware-based multicast
- High availability via redundancy (1:4 for SFC, 1:1 for CSC) with lossless fail-over and hot-swap capability

Gigabit Route Processor

The GRP is a high-performance engine that provides the routing intelligence for the Cisco 12000 GSR family. It is dedicated to determining the network topology and calculating the best path across the network. The GRP has the following hardware characteristics:

- 200-MHz R5000 CPU
- Optionally up to 256-MB CPU DRAM (default 128 MB)
- 512-KB Layer 2 cache
- 512-KB configuration nonvolitile RAM (NVRAM)
- 8-MB boot Flash
- Two PCCard Type II software upgrades
- Ethernet (RJ-45 and MII connectors) for network management access
- Local console and modem ports (DB-25/EIA/TIA-232c)

The GRP provides the following key functions:

- Processes interior gateway protocols (IGPs) such as Intermediate System-to-Intermediate System (IS-IS), Interior Gateway Routing Protocol (IGRP), Open Shortest Path First (OSPF), and Enhanced IGRP (EIGRP) to determine the network topology
- Processes external gateway protocols (EGPs) such as Border Gateway Protocol (BGP)
- Creates and maintains the routing table (up to one million route entries)
- Distributes and updates Express Forwarding (EF) tables on the LCs and maintains copies of the tables of each LC for card initialization
- Handles general maintenance functions such as diagnostics, console support, and LC monitoring
- Processes in-band management through Simple Network Management Protocol (SNMP), Management Information Base (MIB), Telnet, BOOTP, and Trivial File Transfer Protocol (TFTP)

Line Card

LCs connect the GSR to other devices via electrical or optical media. The LCs are designed for the transmission of IP packets over DPT, PPP, Frame Relay, or ATM interfaces. The features and functions of the LCs are interface specific.

Dynamic Packet Transport

DPT interfaces on the GSR enable connections to other Cisco 12000 GSRs or other Cisco routers such as the Cisco 7500, via dual counter-rotating optical rings. DPT rings can be provisioned over dark fiber, wave-division multiplexing (WDM), or SONET/SDH infrastructure. The GSR currently offers the following DPT interfaces:

- Single-ring OC-12c/STM-4c LC

Table 1 shows key features of the DPT interfaces.

Table 1 Key Features of the DPT Interfaces

Interface Type	Density/LC	Physical Layer
OC-12c/STM-4c ring	Single ring per LC (dual fiber)	Transceiver—multimode ring Connector—SC Transceiver—intermediate-reach ring Connector—SC Transceiver—long-reach ring Connector—SC

Key features of the DPT LC include the following:

- Spatial Reuse Protocol (SRP) Media Access Control (MAC)
- SRP fairness algorithm
- Intelligent protection switching (IPS) with enhanced pass-through capabilities
- Multicasting
- Multiple packet priority levels
- Ring bandwidth multiplication
- "Plug-and-play" provisioning and configuration
- MAC-level counters and MAC-based packet filtering

Packet over SONET/SDH

Packet over SONET (PoS) interfaces on the GSR enable connections to other Cisco 12000 GSR or other Cisco routers such as the Cisco 7500 or 7200, via optical interfaces. These interfaces can be circuit provisioned over a SONET/SDH infrastructure or dark fibers, connections, or wavelength WDM systems. The Cisco 12000 GSR offers the following PoS interfaces:

- Four OC-3c/STM-1c ports per LC
- One OC-12c/STM-4c port per LC
- Four OC-12c/STM-4c ports per LC
- One Channelized OC-12c port (to DS3) per LC
- One Channelized OC-12c/STM-4c port (to STS-3c/STM-1c) per LC
- One OC-48c/STM-16c port per LC

Table 2 outlines some of the key features of the PoS interfaces.

Table 2 Key Features of the PoS Interfaces

Interface Type	Density/LC	Physical Layer	SONET/SDH Layer	Packet Layer
OC-3c/STM-1c	Four per LC	Transceiver—Multimode Connector—SC Transceiver—single-mode, intermediate-reach Connector—SC Transceiver—single-mode, long-reach Connector—SC	Standards-compliant interface SONET/SDH alarm processing SONET/SDH APS/MPS Support for SONET overhead bytes for seamless network interoperability	RFC 1619, PPP over SONET/SDH RFC 1662, PPP in HDLC-like framing Multiple virtual output queues to eliminate HOLB Packet buffer memory (both transmit and receive) expandable to 128 or 256 MB (card dependent) Forwarding table memory expandable to 256 MB Forwarding table that accommodates up to one million forwarding entries ASIC-based queuing QoS support
OC-12c/STM-4c	One per LC	Transceiver—multimode connector—SC Transceiver—single-mode, intermediate-reach Connector—SC		
OC-12c/STM-4c	Four per LC	Transceiver—multimode connector—SC Transceiver—single-mode, intermediate-reach Connector—SC		
OC-48c/STM-16c	One per LC	Transceiver—single-mode, intermediate-reach Connector—SC or FC Transceiver—single-mode, long-reach Connector—SC or FC		

Asynchronous Transfer Mode

ATM interfaces on the Cisco 12000 GSR enable connections to other Cisco 12000 GSRs or other Cisco routers such as Cisco 7500 or 7200, via ATM networks. The GSR offers the following ATM interfaces:

- Four OC-3c/STM-1c ports per LC
- One OC-12c/STM-4c port per LC

Table 3 shows some of the key features of the ATM interfaces.

Table 3 Key Features of the ATM Interfaces

Interface Type	Density/LC	Physical Layer	SONET/SDH Layer	ATM Layer
OC-3c/STM-1c	Four per LC	Transceiver—multimode connector—SC Transceiver—single-mode, intermediate-reach Connector—SC	Standards-compliant interface SONET/SDH alarm processing SONET/SDH APS/MPS Support for SONET overhead bytes for seamless network interoperability	Segmentation and reassembly (SAR) based on ATM adaptation layer 5 (AAL5) Permanent virtual circuits (PVCs) RFC 1483—Multiprotocol Encapsulation over AAL5 Logical Link Control (LLC)/Subnetwork Access Protocol (SNAP) and MUX IP PVC (LLC encapsulated for routed protocols) Multiple virtual output queues to eliminate HOLB Packet buffer memory (both transmit and receive) expandable to 128 MB Forwarding table memory expandable to 256 MB Forwarding table that accommodates up to one million forwarding entries ASIC-based queuing
OC-12c/STM-4c	One per LC	Transceiver—multimode connector—SC Transceiver—single-mode, intermediate-reach Connector—SC		

Ethernet

Gigabit Ethernet (GE) and Fast Ethernet (FE) interfaces on the GSR enable connections to other Cisco 12000 GSR or other Cisco routers such as Cisco 7500 or 7200. The Cisco 12000 GSR offers the following Ethernet interfaces:

- Eight-port FE LC
- One GE port per LC

Table 4 shows some of the key features of the Ethernet interfaces.

Table 4 Key Features of the Ethernet Interfaces

Interface Type	Density/LC	Physical Layer	Ethernet Layer	Packet Layer
GE	One per LC	Transceiver—multimode connector—SX Transceiver—single-mode, intermediate-reach Connector—LH	MAC with full-duplex operation 8 /10-MB encoding/decoding 1000BaseSX multimode interface, compliant with IEEE 802.3z specifications 1000BaseLH single-mode interface, compliant with IEEE 802.3z specifications Hot Standby Router Protocol (HSRP)	Multiple virtual output queues to eliminate HOLB 512-KB burst buffers to smooth out arriving packet bursts 128-MB packet buffer memory (both transmit and receive) Forwarding table memory expandable to 256 MB Forwarding table that accommodates up to one million forwarding entries ASIC-based queuing
FE	Eight per LC	Transceiver—multimode SC 100BaseFX Transceiver—RJ-45 connector for 100BaseTX	MAC with full-duplex operation 8/10-MB encoding/decoding 100BaseFX multimode interface, compliant with IEEE 802.3u specifications 100BaseTX copper interface, compliant with IEEE 802.3u specifications HSRP	Multiple virtual output queues to eliminate HOLB 512-KB burst buffers to smooth out arriving packet bursts 128-MB packet buffer memory (both transmit and receive) Forwarding table memory expandable to 256 MB Forwarding table that accommodates up to one million forwarding entries ASIC-based queuing

Table 5 Technical Specification

Specification	Cisco 12008	Cisco 12012	Cisco 12016
System Level Specifications			
System Bandwidth	40 Gbps	60 Gbps	80 Gbps
Chassis Slots	GRP, line cards: 8 slots Switch fabric: 5 slots	GRP, line cards: 12 slots Switch fabric: 5 slots	GRP, line cards: 15 slot Switch fabric: 5 slots
Gigabit Route Processor	Processor: R5000, 200 MHz Memory: 64- to 256-MB EDO 20-MB Flash	Processor: R5000, 200 MHz Memory: 64- to 256-MB EDO 20-MB Flash	Processor: R5000, 200 MHz Memory: 64- to 256-MB EDO 20-MB Flash
Physical Specifications			
Dimensions (h x w x d)	24.0 x 17.3 x 21.2 in. (61.0 x 43.9 x 53.8 cm)	56.0 x 17.3 x 21.0 in. (142.2 x 43.9 x 53.3 cm)	71.5 x 17.25 x 22 in. without power shelf rack-mount flanges or cable management system (181.6 x 43.8 x 55.9 cm) 72.5 x 18.75 x 24.0 in. with power shelf, rack-mount flanges and cable management system (184.2 x 47.6 x 61.0 cm)
Weight (maximum)	187 lb (84.8 kg)	380 lb (172.3 kg)	390 lb (177 kg)
Shipping Dimension (h x w x d)	35.5 x 25.0 x 39.5 in. (90.2 x 63.5 x 100.3 cm)	67.0 x 24.88 x 39.39 in. (170.2 x 63.2 x 100 cm)	82.5 x 33.5 x 40.5 in. (need metric translation)
Shipping Weight	220 lb (99.8 kg)	492 lb (223 kg)	580 lb (need metric translation)
Power Specifications			
DC Input Voltage	–40.5 to –75 VDC	–40.5 to –75 VDC	–40.5 to –75 VDC
AC Input Voltage	180 to 264 VAC (47 to 63Hz)	180 to 264 VAC (47 to 63Hz)	180 to 264 VAC (47 to 63Hz)
DC Input Current	33.75A max. at –48 VDC 27A max. at –60 VDC	49.6A max. at –48 VDC 39.7A max. at –60 VDC	43.9A max. at –48 VDC 35.1A max. at –60 VDC
AC Input Current	9.7A max. at 200 VAC 8.1A max. at 240 VAC	7.4A max. at 200 VAC 6.1A max. at 240 VAC	12.4A max. at 200 VAC 10.3A max. at 240 VAC
Power Supply Configuration	DC: 1 min., 2 for 2N redundancy AC: 1 min., 2 for 2N redundancy	DC: 1 min., 2 for 2N redundancy AC: 2 min., 3 for N+1 or 4 for 2N redundancy	DC: 2 min., 4 required for 2N redundancy AC: 2 min., 3 required for N+1 redundancy
Input Power	DC: 1620W AC: 2000 VA	2259 VA max.	2477 VA max.
Output Watts*	1560W	1794W max.	3234W
Heat Dissipation	DC: 1620 VA (5530 Btus/hr) AC: 2000 VA (6828 Btus/hr)	2259W (7712 Btus/hr)	2477W (8456 Btus/hr)
Environmental Specifications			
Nonoperating Temperature	–40 to 149ºF (–20 to 65ºC)	–40 to 149ºF (–20 to 65ºC)	–4 to 149F (–20 to 65ºC)
Operating Temperature	32 to 104ºF (0 to 40ºC)	32 to 104ºF (0 to 40ºC)	32 to 122ºF (0 to 50ºC)
Nonoperating Relative Humidity (noncondensing)	5 to 95%	5 to 95%	5 to 95%
Operating Relative Humidity (noncondensing)	10 to 90%	10 to 90%	10 to 85%
Nonoperating Vibration	5 to 200 Hz, 1 g (1 oct/min) 200 to 500 Hz, 2 g (1 oct/min)	5 to 200 Hz, 1 g (1 oct/min) 200 to 500 Hz, 2 g (1 oct/min)	3 to 500 Hz, 1.0 g
Operating Vibration	5 to 200 Hz, 0.5 g (1 oct/min)	5 to 200 Hz, 0.5 g (1 oct/min)	3 to 500 Hz, .35 g

*Output power will vary depending upon configuration. Value will generally be lower for typical configurations.

Regulatory Specifications

Cisco 12000

Safety
- UL 1950
- CSA 22.2-No 950
- EN 60950/IEC60950
- EN60825/IEC60825 (Cisco 12016)
- EN41003
- AUSTEL TS001
- AS/NZS 3260
- EN60825 Laser Safety (Class 1)

EMI
- FCC Class A
- AS 3548 Class A
- EN55022 Class A
- VCCI Class 1
- ICES-003 Class –A—Cisco 12016
- EN55022 Class B (to 1 GHz)—Cisco 12016
- VCCI Class B (to 1 GHz)—Cisco 12016
- AS/NZS 3548 Class B—Cisco 12016

Immunity
- IEC-1000-4-2 ESD
- IEC-1000-4-3 radiated immunity
- IEC-1000-4-4 EFT
- IEC-1000-4-5 surge
- IEC-1000-4-6 low-frequency common immunity
- IEC-1000-4-11 voltage dips and sags
- IEC-1000-3-2 power-line harmonics
- EN300386 (EMC for network equipment)—Cisco 12016

NEBS
- SR3580: NEBS: criteria levels (Level 3 compliant)
- GR-63-Core: NEBS: physical protection
- GR-1089-Core: NEBS: EMC and Safety

ETSI
- ETS-300386-2 switching equipment

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