Juniper Networks
G1 CMTS

Functional Description
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About This Manual

This section describes important information about the design of this document.

Purpose

The purpose of this document, G1 CMTS Functional Description, is to provide technical explanations, and physical and electrical specifications, of the G1 Cable Modem Termination System (CMTS).

The intended audience for this information is technical personnel in management or operational positions. This document also serves as a resource to system administrators, engineers, and technicians who install and operate a G1 CMTS.

Organization

This document is organized as follows:

- Chapter 1, “Introduction”—A brief technical introduction to the G1 CMTS.
- Chapter 2, “Architecture”—An overview of the functional architecture of the G1 CMTS.
- Chapter 3, “Chassis”—Technical descriptions of the chassis, connectors, LEDs, power supply, and cooling fans.
- Chapter 4, “DOCSIS Module”—A functional description is provided.
- Chapter 5, “Chassis Control Module”—A functional description is provided.
- Chapter 6, “System Management”—Overview of tools and applications used to manage and operate the G1 CMTS.
Document Conventions

The following document conventions are used in this manual:

Table 1: Document Conventions

<table>
<thead>
<tr>
<th>General Conventions</th>
<th>Italic font</th>
<th>Denotes a) emphasis, b) first use of a new term, or c) a document title.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Name font</td>
<td>Denotes a) the on-screen name of a window, dialog box or field, or b) keys on a keyboard.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software Conventions</th>
<th>Computer font</th>
<th>Font denotes code or messages displayed on-screen.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Bold font</td>
<td>Font denotes literal commands and parameters that you enter exactly as shown.</td>
<td></td>
</tr>
<tr>
<td>&lt;Computer italic&gt; font</td>
<td>Font denotes parameter values that require a user-defined input. The value strings are enclosed in angle brackets &lt;...&gt;.</td>
<td></td>
</tr>
<tr>
<td>[parameter]</td>
<td>Square brackets denote optional parameters.</td>
<td></td>
</tr>
<tr>
<td>{parameter}</td>
<td>Braces denote required parameters.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical bars separate parameters in a group from which you must choose only one.</td>
<td></td>
</tr>
</tbody>
</table>

Notes, Cautions, and Warnings

A note indicates information that might be helpful in a particular situation, or information that might otherwise be overlooked.

A caution indicates a situation that requires careful attention. Failure to observe a cautionary note could result in injury or discomfort to yourself, or serious damage to the product.

A warning is intended to alert the user of the presence of uninsulated dangerous voltage within the product’s enclosure that may present a risk of electric shock.

G1 CMTS Document Set

- **G1 CMTS Installation and Operation**
- **G1 CMTS Functional Description**
- **G-series CMTS CLI and SNMP Reference**
Part 1
Overview and Component Descriptions

- Introduction on page 3
- Architecture on page 11
- Chassis on page 17
- DOCSIS Module on page 25
- Chassis Control Module on page 31
- System Management on page 35
Overview

This chapter provides an introduction to the G1 Cable Modem Termination System (CMTS).

The G1 CMTS manages Internet data and voice. It functions as the interface between the service networks—Internet, public switched telephone network (PSTN)—and the hybrid fiber/coax (HFC) network of subscribers, as shown in Figure 1 on page 3. This is the “last mile” of broadband service, with the CMTS typically located in the cable headend or distribution hub. It is targeted at the following data and voice aggregation applications:

- Medium CATV Hub Sites—DOCSIS multi-service, residential, and commercial IP network access over HFC networks maintained by cable television (CATV) multiple service operators (MSOs) needing enhanced integrated data, voice, and video in large metropolitan areas.

- Small CATV Hub Sites—Smaller hub sites aggregated over metropolitan fiber rings.

Figure 1: Typical CMTS Location
G1 CMTS Features and Functions

The G1 CMTS provides true multi-service support, including the ability to simultaneously support DOCSIS IP services and VoIP services.

Features and Benefits

Innovative features of the G1 CMTS include:

- Scalable, high-density 1U chassis that contains a single DOCSIS Module that supports up to 2 downstream channels at 64 and 256 QAM, and up to 8 upstream channels at QPSK and 16 QAM.
- Architecture that supports up to 32K service flows per chassis.
- Logical allocation of up to 8 upstream channels to any of the four upstream ports on the chassis. This allows channels to be provisioned by the command-line interface (CLI), SNMP commands, or a network management system (NMS) without the need for physical node recombining.
- Operator-configurable logical grouping of upstream and downstream channels into cable interfaces. This allows adding capacity on-the-fly to serve a growing subscriber base.
- Real-time scanning of the entire 5 MHz – 42 MHz return path for conditions such as ingress noise or channel overload. Under these conditions, the G1 CMTS can dynamically change the modulation type, resize a channel (change a symbol rate), move a channel to a new carrier frequency, and move an arbitrary number of modems from one channel to another without the need for modem re-registration.
- Advanced upstream scheduling and a queuing algorithm that efficiently allocates resources to satisfy multiple service flows with the most stringent quality of service requirements (class of service for DOCSIS 1.0). Per-flow QoS with Diff-Serv ensures end-to-end management of SLAs.

The G1 CMTS delivers the following benefits:

- DOCSIS services—DOCSIS 1.0, DOCSIS 1.1, EuroDOCSIS 1.0, EuroDOCSIS 1.1, bandwidth and channel management beyond DOCSIS 1.1 requirements
- Industry-leading RF performance—Signal-to-noise ratio (SNR) performance, efficiency, and configuration flexibility.
  - Noise cancellation—Suppresses narrowband ingress noise in the return path.
  - Upstream pre-equalization—Used to issue pre-equalization coefficients to a cable modem to compensate for various distortions present in the return path.
- Standard Fast Ethernet interfaces—One for network traffic, one for management
Advanced diagnostics

- Flap list—Used to assist an operator with troubleshooting and locating CMTS and CM configuration issues, and problems in the HFC plant without impacting throughput and downstream performance, and without creating additional packet overhead throughout the HFC network.

- Debug commands—Sends informational messages to the console whenever an enabled debug event occurs.

- Local event logging and reporting—CLI commands are provided for the control and access of the local event log defined in the DOCSIS Cable Device MIB (RFC2669).

- Support for ServiceGuard Management System—Optional application that provides spectrum monitoring and automatic impairment identification.

Cable modem (CM) management

- show cable modem commands—Extensive set of CLI commands that display various packet, physical layer, and ranging statistics associated with CMs, and provide the ability to query CM entities through SNMP.

- Rogue CM management—Problematic CMs can be statically or dynamically declared as rogue. An operator can force rogue CMs to use a specified configuration file and TFTP server.

Quality-of-service—Advanced DOCSIS scheduler for Voice-Over-IP and other applications.

- Call admission control—Policies can be defined to configure the maximum allowable ratio of the aggregate minimum reserved traffic rate (MRTR) for all admitted service flows to the channel bandwidth. In addition, the tolerated grant jitter for real-time service flows can be specified or enforced within the call admission control policy.

- Service classes—Service classes can be created and applied to unclassified traffic, encrypted multicast traffic, and traffic on VPNs. Class parameters include traffic priority, maximum sustained traffic rate (MSTR), maximum traffic burst, MRTR, and maximum latency.

- Traffic scheduling—Policies can be defined and applied to upstream and downstream channels. Traffic scheduling policy parameters include the traffic policing algorithm for packets that exceed the MSTR and the scheduling discipline for traffic classes.

- Congestion management—The random early detection (RED) algorithm can be applied to upstream and downstream channels to avoid traffic congestion.

- Range-time upstream load balancing—The CMTS assigns an upstream channel to which a CM is assigned in proportion to the available bandwidth amongst available upstream channels.

- Dynamic optimization of contention slots—A special algorithm to optimize the allocation of contention slots (initial ranging and requests) in the upstream. This optimization makes use of collision statistics to control both the rate of these contention slots, and the window start and end parameters of the truncated binary exponential backoff algorithm specified in DOCSIS.
- Fragmentation—The Broadband Cable Processor ASIC supports the reassembly of fragmented packets sent by CMs. The fragmentation of large packets into smaller ones reduces latency in the case of head-of-line blocking by a large packet.

- Concatenation—Provides efficient utilization of upstream bandwidth by sharing the DOCSIS PHY overhead and a MAC header across multiple, concatenated MAC frames.

- Initial maintenance alignment—Initial maintenance opportunities occur at the same time across all upstream channels on the DOCSIS Module. This ensures that all initial ranging attempts by CMs occur during initial maintenance grants regardless of the upstream channels selected by the CMs.

- ARP proxy—The G1 CMTS can reply to ARP requests from its ARP cache.

- Address authentication—ARP and IP packets are checked against an address authentication table. This addresses the problem of spoofing of hosts on a DOCSIS Module interface. Invalid and unverifiable addresses can be logged and reported as SYSLOG messages and SNMP traps.

- Layer 2 MAC rewrite feature—The source MAC address of a packet originating from a CM (or a host behind it) that is destined for the network side interface (NSI) is rewritten with the MAC address of the cable interface in which the CM resides. This reduces the number of MAC addresses seen by a network device to a maximum of four per DOCSIS Module. Accordingly, the destination MAC address of a packet destined for the MAC address of a DOCSIS Module’s cable interface is rewritten with the MAC address of the destination CM (or a host behind it).

- IGMP snooping—Internet Group Management Protocol (IGMP, v1 or v2) membership report messages received on an upstream channel are monitored in order to determine the multicast group memberships on the associated downstream channel. The multicast group memberships are saved in a table that is used to forward multicast traffic only to those downstream channels that belong to the multicast group.

- Virtual private network (VPN)—VPNs are implemented using 802.1Q VLAN tags. A CPE can be assigned to a VPN, in which case a tagged packet from the CPE must match its assigned VPN for the packet to be forwarded. A CM can also be provisioned as a member of a VPN within its configuration file. VPNs can span multiple DOCSIS Modules and MAC domains.

- Multicast encryption
  - Cable VPN—Broadcast and multicast packets on a cable VPN can be assigned to a DOCSIS security association ID (SAID). Subscribers within a VPN who have BPI enabled in their modem configuration have all traffic encrypted with DOCSIS SAIDs, including multicast and broadcast packets.
  - Security associations—A security association can be defined and applied to IP multicast addresses. Security association parameters include the type (static or dynamic), the data encryption algorithm, and MAC addresses of CMs that have access to this security association.
  - Broadcast domains—802.1Q VLAN tags are used to implement broadcast domains in which broadcast and multicast packets are flooded. Multiple MAC domains can be part of a broadcast domain.
Subscriber groups—DHCP server provisioning can be defined on a subscriber group basis which allows cable modems and CPE devices on the same cable interface to be provisioned by different service providers (open access). Up to four subscriber groups can be defined per cable interface.

Software and feature upgrades—Software upgrades by FTP, SFTP, or TFTP can be performed to add the latest features and functions. Multiple software images are maintained to allow testing to be performed prior to committing to the upgrade.

Environmental monitoring—the Chassis Control Module monitors the internal chassis temperature. SNMP message generation and event logging inform the operator of thermal warnings.

Management interfaces

- Extensive CLI command set accessible through the local console, Telnet, or secure shell (SSH). SSH supports secure copy server functionality (**scp** host command) and secure FTP (**sftp** host command).
- RADIUS and TACACS+ client support for remote user authentication.
- SNMPv3 and OSSlv1.1 MIB (Management Information Base) support.
- FTP and TFTP transfers can be initiated on the CMTS.

Subscriber account management interface—Implemented as specified in DOCSIS OSSlv1.1, this interface specification is defined to enable operators to develop an operations and business support system (OBSS) for the deployment of different classes of service with accompanying usage-based billing.

The G1 CMTS is compliant with, and in many cases exceeds, the following industry specifications:

- DOCSIS 1.0
- DOCSIS 1.1
- EuroDOCSIS 1.0
- EuroDOCSIS 1.1
**Functional Overview**

The G1 CMTS is usually connected directly to a router that is part of an MSO’s core network. It receives network side packet streams originating from the Internet, media gateways or video servers, then processes them into DOCSIS-compatible digital signals (MPEG) that are modulated onto an RF carrier for transmission downstream over the HFC network to the subscribers’ cable modems.

Upstream signals consist of protocol data units (PDUs) in data bursts from the cable modems. The G1 CMTS uses advanced scheduling algorithms to optimize the timing of these transmissions. The packets are processed to recover the payload data then routed, as IP packets, to the appropriate destinations through the network side interface.

The G1 CMTS’s high capacity of 2 downstream and 8 upstream channels, and other innovative features, are accomplished by the Broadband Cable Processor ASIC (application-specific integrated circuit).

**Broadband Cable Processor ASIC**

The Broadband Cable Processor ASIC provides all-digital processing of the return path. This, plus advanced noise cancellation and equalization algorithms, enables modulation rates beyond QPSK and allows traditionally problematic frequency ranges of the upstream spectrum to be utilized. All-digital processing also accommodates full spectrum analysis by capturing statistics of the upstream band in real time.

The Broadband Cable Processor ASIC incorporates key DOCSIS MAC (media access control) functions such as concatenation, fragmentation, encryption, and decryption. Accelerating these functions in hardware provides a high-performance, scalable CMTS solution that can process thousands of simultaneous DOCSIS service flows.

Advanced timing and digital signal processing algorithms allow more efficient use of the RF spectrum resulting in increased channel capacity.

**G1 CMTS Components**

The two modules of the G1 CMTS are described below. See Figure 2 on page 9 for a graphical depiction of the data flow through the modules in a chassis.

- **DOCSIS Module**—Performs all data processing functions. Processes IP data into DOCSIS packets. Converts and modulates data for RF transmission. Reverses these processes for upstream data. Supports the Fast Ethernet port for the network side data, and supports the F-connectors for the HFC cabling.

- **Chassis Control Module**—Provides management interface. Controls redundant protection functions and supplies software image to the DOCSIS Module. Runs the SNMP agent and environmental monitoring.
G1 CMTS Management

The G1 CMTS supports the following system management applications and tools:

- **CLI**—The command-line interface provides the most comprehensive controls and is instrumental for installation, configuration, and upgrade tasks.

- **NMS**—The G1 CMTS can interact with SNMPv2c and SNMPv3-based network management systems using DOCSIS 1.0 and DOCSIS 1.1 MIBs, and G1 CMTS enterprise MIBs. Events can conditionally be reported as SYSLOG messages or SNMP traps.

- **ServiceGuard Management System**—This optional advanced diagnostics application with a Java GUI provides a rendition of a spectrum analyzer for acquiring data on upstream transmission cable performance. It incorporates an integrated Impairment Identification tool that allows for unattended monitoring of statistics to characterize compromised performance to a potential cause (such as impulse or burst noise, narrowband ingress, or microreflections).
This chapter describes the architecture of the G1 CMTS.

The G1 CMTS relays traffic between RF interfaces (DOCSIS) and the network side interface (Fast Ethernet). It has a comprehensive set of features supporting access through DOCSIS cable modems.

**Main Elements**

The G1 CMTS high-performance architecture is composed of these main elements:

- **DOCSIS Module**—Combines the high-density Broadband Cable Processor ASIC with multiple 500 MHz MPC7410 processors for high-performance network edge processing in an asymmetric multiprocessing architecture. The 60x system bus connecting the MPC7410s has a data rate of 8 Gigabits/second. This module contains 384 MB of RAM, 128 KB of NVRAM, and 1.5 MB of flash memory.

  It runs DOCSIS MAC protocols, the scheduler, and all data path processing such as packet filtering, rate-limiting, traffic shaping, and 802.1D bridging. The Broadband Cable Processor ASIC provides hardware assist for the following functions: MAC protocol, scheduling, concatenation, fragmentation, encryption and decryption, spectrum analysis, noise cancellation, pre-equalization, and per-SID (service identifier) statistics.

- **Chassis Control Module**—Provides the following chassis management interfaces:
  - LEDs
  - Console port
  - Ethernet management port
  - Telnet
  - Secure shell (SSH)
  - RADIUS and TACACS+ client support
  - Command-line interface
  - SNMP
  - OSSIv1.1MIBs
This module supports a command-line interface (CLI) designed for familiarity with commonly used CLIs, and it runs all the advanced diagnostics applications. It contains a 1.13 GHz Pentium processor, 572 MB of RAM, a 256 MB CompactFlash, and supports a 40 GB hard drive.

Figure 3 summarizes the relationship between the main elements. This illustration assumes that two cable interfaces have been configured for the DOCSIS Module.

The Chassis Control Module’s Fast Ethernet management port provides Telnet, SSH, and SNMP access to the chassis system. In addition, this module downloads software to the DOCSIS Module whenever it requires initialization.

Management and Control Plane

The G1 CMTS management and control planes are distributed over the Chassis Control Module and the DOCSIS Module (see Figure 4 on page 13).

- The Chassis Control Module provides all management interfaces such as the CLI (accessible through the console, Telnet, and SSH) and the SNMP MIBs. These communicate with a Common Management/Monitoring Framework that controls the DOCSIS Module through the Control Interface.

- The DOCSIS Module contains a bridging-type data path and uses a flood-forwarding algorithm between an RF interface and the Fast Ethernet interface. Configuration and management messages are exchanged over an internal Fast Ethernet interface that connects the Chassis Control Module to the DOCSIS Module in the chassis.
Figure 4: Management and Control Planes
Data Path Processing

One of the MPC7410 processors in the DOCSIS Module is dedicated to data path processing. All traffic through Fast Ethernet port DATA is forwarded to both MAC domains (0 and 1). The path exists for the downstream and upstream channels.

Downstream Path

The downstream path, shown in Figure 5, consists of the following processes:

1. Fast Ethernet (FE) ingress (Rx)—Downstream packets enter the DOCSIS Module from the network side interface (NSI). The Fast Ethernet port behaves like a switch port.
2. Subscriber management MIB packet filter—Incoming packets are processed from the switch port. Subscriber management MIB packet filters, defined by MIB objects, implement an inbound packet filter.
3. Bridging—Packets are bridged by a destination MAC address to one of two downstream ports. Packets can also be bridged from the upstream data path for peer-to-peer communications within the broadcast domain defined by the RF interface (RFI). This is upstream turnaround.
4. Classification and subscriber management MIB packet filter—Flow classification is performed based on IP header information. At the same time, a second set of filters can be applied in implementing a subscriber management MIB outbound packet filter.
5. Rate-limiting—The downstream maximum rate limit associated with the DOCSIS SFID (service flow identifier) is enforced.
6. RED (random early detection)—Congestion avoidance mechanism is applied. RED and rate-limiting are features for managing QoS in the downstream.
7. DOCSIS egress (Tx)—Downstream packets exit the DOCSIS Module to the RFI.

Figure 5: Downstream Data Path
**Downstream Scheduler**

The scheduler supports delay, minimum rate, and maximum rate processing for service flows provisioned using the DOCSIS 1.1 QoS parameter set. The primary benefits are support for VoIP applications, tiered services, and congestion management of best-effort traffic using RED.

The scheduler performs the rate limiting, reserved rate, and output priority scheduling for up to 8K service flows per DOCSIS MAC domain. Each RF interface supports strict priority scheduling. This guarantees that the highest priority packets are transmitted first and that there is no packet reordering as a result of the output classification. All classes of traffic are subjected to RED.

Figure 6 illustrates the service flow classifier and priority queuing that occurs in the downstream.

**Figure 6: Downstream Classifier and Queuing**

**DOCSIS 1.1 QoS Encoding:**
- MDL - Maximum Downstream Latency
- MRTR - Minimum Reserved Traffic Rate
- MSTR - Maximum Sustained Traffic Rate
**Upstream Path**

The upstream path, shown in Figure 7, consists of the following processes:

1. **DOCSIS ingress (Rx)**—Upstream packets enter the DOCSIS Module from the RFI. SID/SFID information is present in the receive packet header from the Broadband Cable Processor ASIC; therefore, packets are pre-classified before filtering.

2. **Subscriber management MIB packet filter (inbound)**—Upstream packets are passed through a subscriber management MIB inbound packet filter.

3. **Bridging**—After filtering, packets are bridged via destination MAC address to the Fast Ethernet port. Packets can also be bridged from the upstream channel to one of two downstream ports for peer-to-peer communications within the broadcast domain defined by the RFI. This is called upstream turnaround.

4. **Subscriber management MIB packet filter (outbound)**—Upstream packets are passed through a subscriber management MIB outbound packet filter.

5. **DOCSIS egress (Tx)**—Upstream packets exit the DOCSIS Module to the NSI. DOCSIS rate-limiting is performed by the upstream scheduler managing bandwidth grants. The upstream scheduler is the primary means of managing QoS in the upstream.

![Figure 7: Upstream Data Path](image-url)
Chapter 3

Chassis

This chapter describes the chassis of the G1 CMTS. The following topics are discussed:

- Physical and Operational Characteristics on page 19
- Rear Connectors on page 20
- LEDs on page 21
- Power Supply on page 22
- Cooling and Fans on page 23

Figure 8 on page 18 illustrates the front of the G1 CMTS chassis, and Figure 9 and Figure 10 on page 18 illustrate the rear of the AC and DC versions, respectively.

The chassis is a rack mountable, 19-inch wide, 1U high housing that contains two modules, a power supply, and six fans. The major components of the G1 CMTS chassis are listed below and discussed in detail in the following chapters.

- DOCSIS Module—Provides the core functionality and features of the G1 CMTS.
- Chassis Control Module—Performs the management and monitoring functions for the G1 CMTS.
- Power Supply—A single 250W AC or DC power supply.
- Fans—Four chassis fans plus two power supply fans that provide the airflow for cooling the system components.
Figure 8: G1 CMTS Chassis—Front View

Figure 9: G1 CMTS Chassis—Rear View, AC Power

Figure 10: G1 CMTS Chassis—Rear View, DC Power
Physical and Operational Characteristics

Chassis physical specifications are shown in Table 2 and environmental specifications are shown in Table 3 on page 20.

The G1 CMTS chassis is constructed of plated sheet metal. It is designed to fit into a 19-inch equipment rack that complies with EIA standard RS-310-C. Installation into a 23-inch EIA rack can be accomplished by attaching additional mounting brackets to the sides of the chassis. Additional rail and bracket mounting holes are provided to support installation into non-standard racks.

Threaded nuts for chassis ground are located on the rear of the chassis (see Figure 9 on page 18).

Table 2: Chassis Physical Specifications

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Height</td>
<td>1.75 in. (44 mm)</td>
</tr>
<tr>
<td></td>
<td>Equivalent to 1U</td>
</tr>
<tr>
<td>Width</td>
<td>17.1 in. (434 mm)</td>
</tr>
<tr>
<td></td>
<td>Excluding mounting brackets</td>
</tr>
<tr>
<td>Depth</td>
<td>22.5 in. (572 mm)</td>
</tr>
<tr>
<td>Weight</td>
<td>20 lb (9.1 kg)</td>
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Figure 11 provides a top view of the chassis and its major components.

Figure 11: Top View of Chassis
Table 3: Chassis Environmental Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tr>
<td>Ambient Temperature Range (Operational)</td>
<td>0° to +40°C (0° to +104°F)</td>
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<tr>
<td>Ambient Temperature Range (Non-operational)</td>
<td>-35° to +60°C (-31° to +140°F)</td>
</tr>
<tr>
<td>Altitude</td>
<td>60 m (197 ft.) below sea level to 1800 m (5,905 ft.)</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>10% to 90% non-condensing</td>
</tr>
<tr>
<td>Vibration (Operational)</td>
<td>5 Hz to 100 Hz and back to 5 Hz, at 0.1 g (0.1 oct/min)</td>
</tr>
</tbody>
</table>

Rear Connectors

The G1 CMTS distributes signals from the functional modules to the rear of the chassis. This locates the chassis cable connections on the backside of the chassis rather than the front.

The G1 CMTS has two RJ-45 Fast Ethernet connectors in the rear. Fast Ethernet connector DATA is dedicated to carrying traffic between the DOCSIS Module and the network side interface. Fast Ethernet connector MGT is the interface to the Chassis Control Module that is used to manage the G1 CMTS. Serial port COM in the rear can also be used as a management port. The Fast Ethernet connectors contain LEDs that indicate the status of these ports. Table 6 on page 21 summarizes the definitions of these LEDs.

The chassis has two downstream F-connectors (DS0 and DS1) and four upstream F-connectors (US0 through US3) for routing traffic between the DOCSIS Module and the HFC network.

See Figure 12 for an illustration of the G1 CMTS connectors. Table 4 on page 20 summarizes the rear connectors on the G1 CMTS chassis.

Figure 12: G1 CMTS Connectors

Table 4: G1 CMTS Connectors

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM</td>
<td>RS-232 – DB-9 connector for serial interface for G1 CMTS management</td>
</tr>
<tr>
<td>DATA</td>
<td>10/100 Ethernet – RJ-45 connector for G1 CMTS network traffic</td>
</tr>
<tr>
<td>MGT</td>
<td>10/100 Ethernet – RJ-45 connector for G1 CMTS management</td>
</tr>
<tr>
<td>DS0 – DS1</td>
<td>F-connectors for downstream ports 0 and 1, respectively</td>
</tr>
<tr>
<td>US0 – US3</td>
<td>F-connectors for upstream ports 0 through 3, respectively</td>
</tr>
</tbody>
</table>
LEDs

The two LEDs on the front of the G1 CMTS chassis provide an indication of the operational status of the system. See Figure 13 for an illustration of these LEDs. Table 5 summarizes the meaning of these LEDs.

The Fast Ethernet connectors on the rear of the chassis contain LEDs that indicate the status of these ports. Table 6 on page 21 summarizes the definitions of these LEDs.

The AC and DC power supplies also contain an LED that indicates the status of the power supply. Table 8 summarizes the definition of this LED.

Figure 13: G1 CMTS Front LEDs

Table 5: G1 CMTS Front LEDs

<table>
<thead>
<tr>
<th>Left LED</th>
<th>Right LED</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>Off</td>
<td>No power</td>
</tr>
<tr>
<td>Green</td>
<td>Green</td>
<td>Normal operation</td>
</tr>
<tr>
<td>Yellow</td>
<td>Yellow</td>
<td>Chassis Control Module is powering up</td>
</tr>
<tr>
<td>Yellow</td>
<td>Yellow</td>
<td>Minor fault—Corresponds to Warning event priority (applicable only after bootup)</td>
</tr>
<tr>
<td>Red</td>
<td>Yellow</td>
<td>Major fault—Corresponds to Error event priority</td>
</tr>
<tr>
<td>Red</td>
<td>Red</td>
<td>Critical fault—Corresponds to Emergency, Alert, or Critical event priority</td>
</tr>
</tbody>
</table>

Table 6: Fast Ethernet Port LEDs

<table>
<thead>
<tr>
<th>LED</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>On—Link is present (DATA port only)</td>
</tr>
<tr>
<td></td>
<td>Off—Link is not present (DATA port only)</td>
</tr>
<tr>
<td></td>
<td>Blinking—Activity on link</td>
</tr>
<tr>
<td>Amber</td>
<td>On—100Base-T mode</td>
</tr>
<tr>
<td></td>
<td>Off—10Base-T mode</td>
</tr>
</tbody>
</table>
**Power Supply**

The chassis contains a single AC or DC 250W power supply. The user must specify a model when ordering a G1 CMTS. Table 7 contains the output specifications for the AC and DC power supplies.

Table 7: Power Supply Output Specifications

<table>
<thead>
<tr>
<th>Output Voltage</th>
<th>Maximum Output Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 VDC</td>
<td>12 A</td>
</tr>
<tr>
<td>+3.3 VDC</td>
<td>16 A</td>
</tr>
<tr>
<td>+12 VDC</td>
<td>10 A</td>
</tr>
<tr>
<td>-12 VDC</td>
<td>0.5 A</td>
</tr>
<tr>
<td>+5 V Standby</td>
<td>2 A</td>
</tr>
</tbody>
</table>

The AC power supply has a standard IEC 15-amp receptacle with a three-prong male plug for connecting to a power source. The DC power supply has a terminal block with barrier guards for single lug connections to the source and return. The DC terminal block provides inputs for a second power source which provides DC power source redundancy.

The power supply output is monitored by the Chassis Control Module. If the output voltage differs by more than 10% from its nominal level, an SNMP message is sent to the NMS, and an entry is written to the local event log (if enabled).

The power supply contains an over-temperature shutdown mechanism that causes it to shutdown if its internal temperature reaches 45° C. A power supply LED provides an indication of this condition, and others, as defined in Table 8.

Table 8: Power Supply LED

<table>
<thead>
<tr>
<th>LED State</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green, blinking</td>
<td>Standby mode</td>
</tr>
</tbody>
</table>
| Amber              | Over-current
|                    | Over-temperature
|                    | Over-voltage               |
A G1 CMTS requires a maximum of 360 watts from an external power source. Its typical power consumption is approximately 205 watts. Table 9 provides the input requirements for the power source.

### Table 9: Power Source Input Requirements

<table>
<thead>
<tr>
<th>Power Supply Type</th>
<th>Voltage</th>
<th>Current Requirements</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>100 to 240 VAC 47 to 63 Hz</td>
<td>1.3 A Nom (230 V, 70% efficiency)</td>
<td>290 W (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.8 A Max (200 V, 70% efficiency)</td>
<td>360 W (Max)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5 A Nom (115 V, 70% efficiency)</td>
<td>290 W (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.6 A Max (100 V, 70% efficiency)</td>
<td>360 W (Max)</td>
</tr>
<tr>
<td>DC</td>
<td>-38 to -72 VDC</td>
<td>6.0 A Nom (-48 VDC, 70% efficiency)</td>
<td>290 W (Typ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.5 A Max (-38 VDC, 70% efficiency)</td>
<td>360 W (Max)</td>
</tr>
</tbody>
</table>

### Cooling and Fans

The G1 CMTS has six fans in the rear of the chassis—four chassis fans plus two power supply fans. If enabled, when one of the four chassis fans fails, an SNMP message is sent to the NMS, and an entry is written to the local event log.

The Chassis Control Module monitors the internal temperature of the chassis. User-defined high and low temperature thresholds can be set by the CLI to determine when SNMP messages are sent to the NMS to warn that the internal temperature has crossed one of these thresholds.

The G1 CMTS is designed to direct the air flow from the front air intake of the chassis, across the DOCSIS Module and the Chassis Control Module, then out of the fans in the rear of the chassis.

We recommend that the G1 CMTS be installed in an open rack to ensure adequate air flow.
Chapter 4

DOCSIS Module

This chapter describes the DOCSIS Module of the G1 CMTS. The DOCSIS Module contains the circuits, devices (including the Broadband Cable Processor ASIC) and code that provide the core functionality and features of the G1 CMTS.

The DOCSIS Module connects with the rear of the chassis to provide access to the HFC network (F-connectors) and the network side interface (Fast Ethernet). This keeps the cabling in the back of the chassis. See “Rear Connectors” on page 20 for more discussion.

As referenced by the CLI commands, the DOCSIS Module is considered to be in slot 2 of the G1 CMTS. See the G-series CMTS CLI and SNMP Reference for details regarding the CLI.

Functional Characteristics

All network-side traffic and HFC-side traffic transmitted and received by the DOCSIS Module passes through the connectors in the rear of the chassis. Thus, no external connections to the DOCSIS Module are required from the front of the chassis.

Downstream data flow comes to the DOCSIS Module from the rear Fast Ethernet connector in the form of Internet data in IP packets. The module performs various processes as described in “Data Packet Processing” on page 26. The data is encapsulated first into DOCSIS frames then into an MPEG transport stream. The transport stream is modulated onto an RF signal by the integrated upconverter for downstream distribution to subscribers’ cable modems.

The upstream data flow is contained in PDUs (protocol data units) of varying length transmitted as TDMA bursts on specifically allocated frequencies. This process is controlled by advanced timing algorithms.

The DOCSIS Module also has a number of other innovations to achieve high levels of density and performance. Fast processing is accomplished with high speed busses, multiple processors and fast memory. Repetitive processing tasks have been moved to the Physical and MAC layers of the protocol stack.

The DOCSIS Module contains the proprietary Broadband Cable Processor ASIC, which in the G1 CMTS supports up to 2 downstream and 8 upstream channels. The Broadband Cable Processor ASIC enables the implementation of QPSK and 16 QAM modulation on upstream channels with very low packet loss in the presence of noise. This allows tighter scheduling of packets, thereby efficiently utilizing more of the RF spectrum. Downstream modulation uses 64 QAM or 256 QAM. See “Introduction” on page 3 for more discussion of features.
Figure 14 shows a block diagram of the DOCSIS Module and Figure 15 on page 27 shows the packet processing flow. Technical descriptions follow the illustrations.

**Figure 14: DOCSIS Module Block Diagram**

This section provides general descriptions of the major processing functions performed at the Physical, MAC, and higher protocol layers for DOCSIS 1.1 and EuroDOCSIS 1.1 compliance. Figure 15 on page 27 illustrates these functions. See the DOCSIS specifications for more details.
Figure 15: Packet Processing Layers

**Higher Layer Functions**

- Packet filter and forward—Filters layers 2, 3, 4, and above based on DOCSIS 1.1 filter functionality.
- CMTS Management—SNMP, MIBs, and CLI (command-line interface).
- Network side interface—IP data and VoIP interfaces.
**MAC Layer Functions**

- Classifier—Classifies upstream data frames into higher layer packet flows; classifies downstream frames into corresponding service flows using SFIDs (DOCSIS service flow ID).
- Frame Generator—Encapsulates downstream packets into DOCSIS frames.
- Encryption—Encrypts downstream data frames in accordance with the DOCSIS baseline privacy and baseline privacy plus standards.
- Decryption—Decrypts upstream data.
- Fragmentation/concatenation—Reassembles upstream fragmented MAC frames and deconcatenates concatenated MAC frames.
- Frame parser—Parses DOCSIS MAC header, identifies packet as data or management, and routes accordingly. Verifies HCS (header checksum) and CRC (cyclical redundancy checking).
- MAC management—Provides cable modem, service flow, and RF management functions. Performs resource allocation scheduling of requests, service flows, quality of service, and other items. Handles cable modem and service flow admission control.

**Physical Layer Functions**

- Downstream transmission convergence (DTC) sublayer
  - Manages the use of internal or external clock in MPEG transport stream; inserts timestamp.
  - Examines packets for DOCSIS PID (packet identifier) and MPEG null PID, and multiplexes queued data packets into available MPEG packets.
  - Re-stamps DOCSIS PID with MPEG null PID if no data is queued for transmission.
- Physical media dependent (PMD) sublayer
  - Frames downstream MPEG packets by substituting synchronization byte with parity checksum.
  - Implements FEC (forward error correction) and interleaving downstream; descrambles data and decodes FEC upstream.
  - Modulates to IF baseband and upconverts to RF for downstream traffic; demodulates upstream traffic.
  - Monitors upstream performance characteristics such as timing, frequency offset, BER (bit error rate), and RF spectrum.
**Modem Management**

The DOCSIS Module exercises functional management over MAC layer and cable modem processes.

**MAC Layer Scheduling**

Management at the MAC layer includes the following scheduling functions:

- Queue upstream requests.
- Transmission opportunity allocation based on MAC messages from cable modems.
- QoS scheduling requirements, which have priority over normal service flows.
- Prioritize service flows for least delay.
- Maintenance opportunity allocation, including initial maintenance alignment (see the `cable aligned-insertion-interval` command in the *G-series CMTS CLI and SNMP Reference*).

**Cable Modem Management**

The DOCSIS Module performs the following cable modem management functions:

- Registration of cable modems by SID (service identifier) assignments, and recording time and address failures.
- Ranging by adjusting timing offset, transmit power, carrier frequency, and transmit equalizer taps.

**Enhanced Bridging Features**

The G1 CMTS provides enhanced bridging features that provide additional value to MSOs (see the *G-series CMTS CLI and SNMP Reference* for details about the commands):

- ARP proxy (see the `cable proxy-arp` command).
- Address authentication for ARP and IP packets (see the `cable arp-verify` and `cable source-verify` commands).
- Layer 2 MAC rewrite (see the `cable mac-rewrite` command).
- Cable VPNs (see the `cable vpn` command).
- Broadcast domains (see the `cable broadcast-domain` command).
- Encrypted multicast (see the `cable multicast-map` command).
This chapter describes the Chassis Control Module of the G1 CMTS. The following topics are discussed:

- Functional Characteristics on page 31
- Configuration, State, and Alarm Data on page 32

The Chassis Control Module performs management and monitoring functions for the G1 CMTS, and it provides a single access point for operational and maintenance functions.

The Chassis Control Module supports a Fast Ethernet port and a serial port at the rear of the chassis for G1 CMTS management. See “Rear Connectors” on page 20 for more discussion. Communication between the Chassis Control Module and the DOCSIS Module is achieved through an internal Fast Ethernet connection.

As referenced by the CLI commands, the Chassis Control Module is considered to be in slot 1 of the G1 CMTS. See the G-series CMTS CLI and SNMP Reference for details regarding the CLI.

**Functional Characteristics**

The Chassis Control Module is the single access point to the G1 CMTS for a command-line interface or SNMP management application from a remote location. The Fast Ethernet port (10/100Base-T) MGT is used for this purpose. For connecting to the Chassis Control Module locally, use the RS-232 serial COM port in the rear of the chassis.

The primary functions of the Chassis Control Module are as follows:

- Store and report configuration and alarm status for the DOCSIS Module and itself.
- Supply software images to the DOCSIS Module.
- Serve as the SNMP agent for the CMTS.
- Provide the command-line interface.
- Support the subscriber account management (SAM) interface.
- Monitor the state of the power supply and the four chassis fans (see “Cooling and Fans” on page 23).
**Configuration, State, and Alarm Data**

The Chassis Control Module stores configuration files for the DOCSIS Module and itself. When the DOCSIS Module boots up, the Chassis Control Module sends a configuration file to that module. A configuration file is ASCII text in a format readable by the command-line interface. Users can edit this file on the CMTS with the `edit` command, or on an external host with any standard text editor (followed by uploading it to the CMTS). The Chassis Control Module also provides configuration data to management applications.

The Chassis Control Module polls the DOCSIS Module for state information, then stores that data. This includes ranging and registration data on the cable modems, and a backup of the modules’ memory and tables. Polling occurs at regular intervals to keep the data current. Users can set the polling rate with the command-line interface or with SNMP commands.

The Chassis Control Module collects and stores events from itself, the chassis and its environment, and the DOCSIS Module within the local event log. It uses this information to control the front LEDs (see “LEDs” on page 21) and provides this data to management applications.

The Chassis Control Module monitors the fans for failures. If any one of the four chassis fans fails, the module conditionally sends an SNMP message to the NMS and adds an entry to the event log.

The power supply output is monitored by the Chassis Control Module. If the output voltage differs by more than 10% from its nominal level, an SNMP message is sent to the NMS, and an entry is written to the local event log (if enabled).

**Security**

The Chassis Control Module supports several features for secure access to the CMTS, including secure shell (SSH), remote authentication, and secure FTP (SFTP).

**Secure Shell**

The Chassis Control Module supports secure remote login sessions through a secure shell server (SSH). If it is enabled on the CMTS, you can access the SSH server by issuing the `ssh` command from a host client. The SSH server supports:

- Ciphers `3des-cbc`, `blowfish-cbc`, `twofish128-cbc`, and `aes128-cbc`.
- Message authentication codes (MACs) `hmac-sha1` and `hmac-sha1-96`.
- Key exchange method `diffie-hellman-group1-sha1`.

The SSH server security feature supports the following from a host client:

- Secure server copy functionality with the equivalent of the `scp` UNIX command.
- The SFTP protocol for secure access to the CMTS through the `sftp` command.

See the `ip ssh-enable` command and its related commands in the *G-series CMTS CLI and SNMP Reference* for more details.
Remote Authentication

The Chassis Control Module maintains a local user and password database that is used for user authentication by default. In addition, RADIUS and TACACS+ clients are supported for remote user authentication. The CMTS can be configured to use one of these clients for authentication, with an option to fall back to the local database if an authorization server does not respond. See the remote-authentication command and its related commands in the G-series CMTS CLI and SNMP Reference for more details.

Subscriber Account Management

The Chassis Control Module supports the subscriber account management (SAM) interface specification as defined in DOCSIS OSSlv1.1. This interface specification is defined to enable operators to develop an operations and business support system (OBSS) for the deployment of different classes of service with accompanying usage-based billing. SAM is disabled by default. You enable it with the billing enable command.

The Chassis Control Module maintains a billing file (in compressed format) comprising subscriber usage billing records that adhere to the IP detail record (IPDR) standard as extended for XML format cable data systems subscriber usage billing records. In this role, the CMTS acts as the IPDR recorder (IR). Billing records contain packet statistics for each service flow and subscriber.

Upon demand from a collection system (mediation server or billing system), the Chassis Control Module transfers the billing file by means of the FTP or SFTP protocol (GET command). These protocols support three modes of user authentication—local database, RADIUS, and TACACS+. A user must have a group-privilege of bi-rw and fs-rw to access the billing file from an external server (a user logged into the CMTS cannot access the billing file through the CLI).

When the billing file is no longer needed, the collection system deletes it (DELETE command). The Chassis Control Module polls to determine when the file has been deleted and creates a new billing file. If the billing file reaches 75% or 100% of its fixed allotment before being deleted, a corresponding event is generated.
Chapter 6
System Management

The G1 CMTS is designed to accommodate the following management applications to provide usable management, maintenance, and troubleshooting capabilities:

- Command-Line Interface on page 35
- Network Management System on page 36
- ServiceGuard Management System on page 36

Specific instructions on the use of these applications are in the *G1 CMTS Installation and Operation* manual.

These applications generally run on a PC and communicate with the G1 CMTS over a LAN. A PC can be connected directly to the chassis through the rear serial port that leads to the Chassis Control Module.

**Command-Line Interface**

The CLI can be operated by connecting a PC remotely through a Telnet or secure shell using the IP address of the chassis, which is the address of the Chassis Control Module. A PC can also be connected directly to the serial port on the Chassis Control Module using a terminal emulator such as HyperTerminal that comes with Windows® operating systems.

The G1 CMTS includes an extensive set of commands that are used for the configuration of the CMTS. They can also be used for troubleshooting and maintenance tasks, as well as direct management of the CMTS. This command set was developed to be similar to existing CLIs common in the broadband cable industry, so operators will find it familiar.

The commands are fully documented in the *G-series CMTS CLI and SNMP Reference* manual. Instructions for using commands to accomplish specific tasks is covered in the *G1 CMTS Installation and Operation* manual.

Commands are sent as plain text strings to the Chassis Control Module where they are parsed and processed into code that can be understood by the operating system of the other modules. Commonly used groups of commands include those for configuring modules, debugging problems, and showing current settings and statistics. Security policies allow the operator to define who has access to which commands.
Network Management System

The G1 CMTS uses SNMPv2c and SNMPv3 in conjunction with various Management Information Bases (MIB). This enables the G1 CMTS to work with the user’s existing Network Management Systems (NMS). DOCSIS and enterprise MIBs are supported by the G1 CMTS and are provided by Juniper Networks. See the G-series CMTS CLI and SNMP Reference for details on MIB support and SNMP communications.

The G1 CMTS appears as a single managed object to an NMS. Cable modems can also be managed with an NMS.

Events are recorded in the local event log in the G1 CMTS and in the SYSLOG in the NMS. Other SNMP-based communications between the chassis and the NMS include MAC and PHY statistics, as well as traps, informs, and notifications.

ServiceGuard Management System

The ServiceGuard Management System is an optional application purchased separately that provides an advanced diagnostic system that adds unique capabilities for monitoring and analyzing the return path in the HFC network. The application retrieves measurements and statistics collected by the CMTS such as noise power spectrum and SNR. It then analyzes that data to synthesize critical performance information and identify potential impairments such as noise ingress, common path distortion, and microreflections. The ServiceGuard Management System can also cross-check performance criteria against user-defined thresholds to generate alarm events.

This information is presented to technicians in a Java-based GUI, which enables them to take preventive actions before service degrades. The plots display is modeled after the screen display of a spectrum analyzer.

The ServiceGuard Management System includes the following features:

- Noise monitoring under active carriers.
- Monitors multiple ports simultaneously.
- User-configurable per-channel and global thresholds.
- Automatically diagnoses common return path impairments.
- Full-featured alarm log.
- Data collected: modulation error rate (MER), signal-to-noise ratio (SNR), noise power spectrum, noise power density spectrum, and codeword error rate (CER).
- Impairments identified: ingress, impulse, channel distortion, micro-reflections.
- Automated discovery of manageable G1 CMTS.
- Systems can be grouped to fit organizational alignments.
- SNMP-based interface to Juniper Networks G1 CMTS MIBs.
The ServiceGuard Management System has an integrated impairments identification tool. When a technician analyzes the performance of a specific channel, this tool suggests common network problems to investigate. It does this by comparing MER, SNR, and CER to their respective thresholds and to each other. These relationships are analyzed by the impairments identification tool which then indicates potential causes of the problem.

The components of this system are the Broadband Cable Processor ASIC, the DOCSIS Module agent, and the ServiceGuard Management System.

The ServiceGuard Management System application must be purchased separately from the G1 CMTS.
Part 2
Appendixes

- Agency Certifications on page 41
Appendix A
Agency Certifications

This appendix lists agency compliance and certifications for the G1 CMTS.

Safety

- UL 60950 (US, Canada)

  Warning
  - This equipment is intended only for installation in a restricted access location within a building.
  - This equipment is intended for indoor use only.
  - This equipment does not have a direct copper connection to the outside plant.

  Caution
  Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries according to the instructions.

- EN 60950 (Europe)

EMC

- FCC Part 15, Class A (US)

  Note
  This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
  (1) This device may not cause harmful interference, and
  (2) this device must accept any interference received, including interference that may cause undesired operation.

- ICES-003, Class A (Canada)

- EN 55022, Class A (Europe)
Immunity

- EN 55024
- EN 61000–4–2 (ESD)
- EN 61000–4–3 (RF Field, AM)
- EN 61000–4–4 (EFT)
- EN 61000–4–5 (Surge)
- EN 61000–4–6 (RF Conducted Continuous)
- EN 61000–4–11 (Voltage Dips and Interrupts)
- EN 61000–3–3 (Flicker)
Part 3

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