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**Edge Resource Manager Interface for Modular Cable
Modem Termination Systems**

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SCOPE

1.1 Introduction and Overview

This standard specifies interfaces that are used by Edge QAM devices (EQAMs), Edge Resource Managers (ERMs) and M-CMTS cores within the context of a Modular Cable Modem Termination System (M-CMTS). This is one of several standards that together define and specify a complete M-CMTS system (see Section 1.3). The basic architecture of a complete M-CMTS system is shown in Figure 2–1.

Three interfaces are specified in this standard:

ERMI-1: A registration interface between an ERM and an EQAM. This interface is used to register and unregister EQAM resources (i.e., QAM channels) with an ERM.

ERMI-2: A control interface between an EQAM and an ERM. This interface is used by an ERM to request QAM channel resource from an EQAM, and by an EQAM to deliver resources to an ERM.

ERMI-3: A control interface between an M-CMTS core and an ERM. This interface is used by the M-CMTS core to request specific QAM channel resources from the ERM, and by the ERM to respond to such requests with the location of QAM channel resources.

The interfaces specified in this standard are shown in Figure 2–2 in Section 1.2.

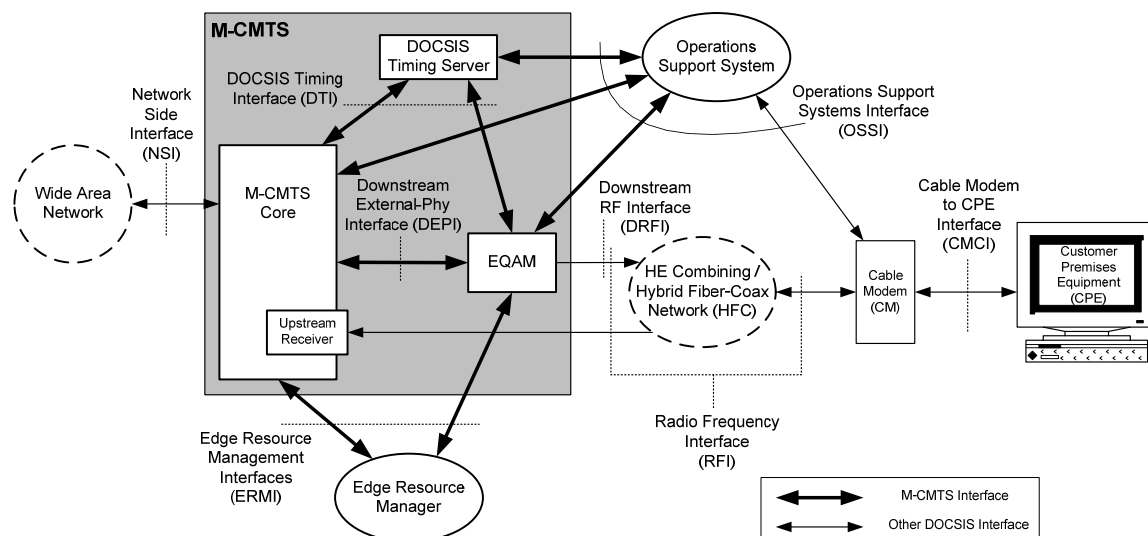


Figure 2–1 – M-CMTS Reference Architecture

1.2 Assumptions

In developing this standard, the following assumptions were made concerning the implementation and deployment of M-CMTS systems:

The system must function in the absence of an ERM.

In the absence of an ERM, all the interfaces to and from the ERM (i.e., the interfaces specified in this standard) are necessarily absent. Therefore, we assume that they will be replaced by a static configuration in which:

- The M-CMTS core is provisioned or otherwise configured with sufficient information to send data to EQAMs, and has sufficient knowledge of the resources available on each EQAM to access those resources without further information;

- The EQAMs are capable of co-operating with an M-CMTS core, even though they have not registered their resources with an ERM;
- The operator has configured the system in such a way that no unintended conflicts for resources arise.

The system will be compatible with Euro-DOCSIS [SCTE 79-1].

QAM channel identifiers (TSIDs) will be unique per head-end. In practice, this means that a TSID must be unique within the administrative domain that includes both the DOCSIS and VOD systems.

The system will be compatible with the Digital Set-top Gateway (DSG) specification [SCTE 106].

A QAM channel resource will register with, and be controlled by a single ERM at any one time.

A QAM channel is used by one MAC Domain at any one time.

Only one CMTS may use the primary QAM channel (the QAM channel that carries the MAC control messages when DOCSIS channel-bonding is used).

Multiple ERMs may exist in a single system and the following are beyond the scope of this standard:

- Communication between ERMs;
- Resource aggregation using data from multiple ERMs;
- The method by which a session manager chooses the ERM with which to communicate.

A single ERM may manage both DOCSIS and VOD resources.

The M-CMTS system must function with DOCSIS 1.x and 2.0 cable modems (which do not provide feedback to the CMTS as to which downstream channels they can receive).

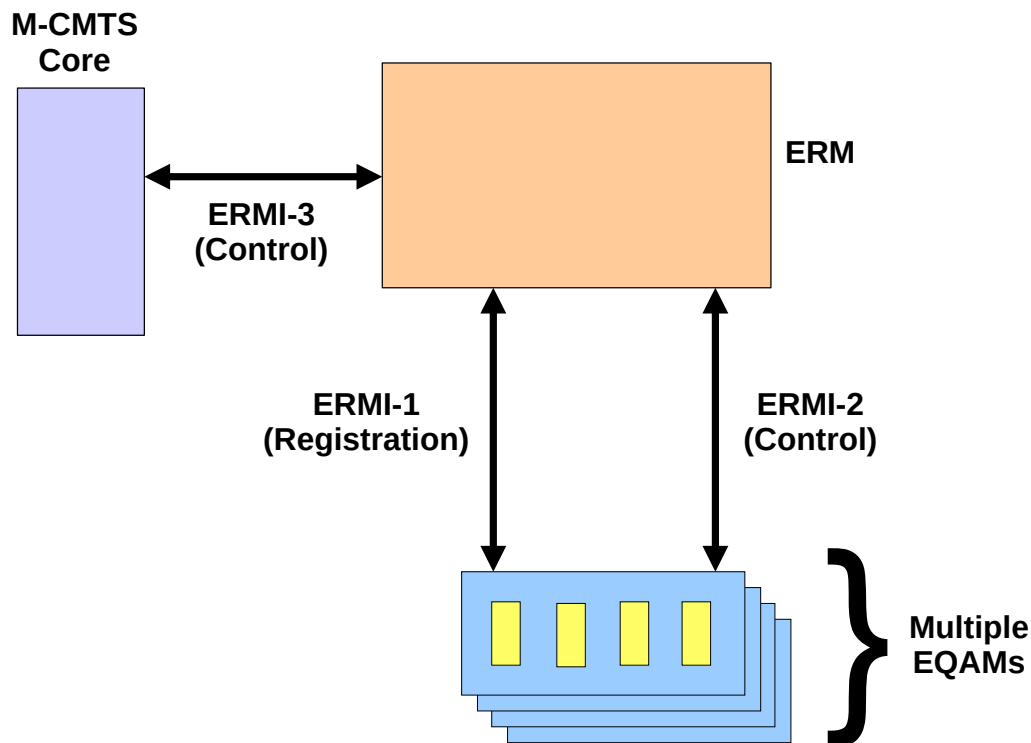


Figure 2-2 - ERM Interfaces

1.3 Modular CMTS Interface Standards

A list of the standards in the Modular CMTS Interface Specifications family is provided in Table 2–1.

{Editor’s note: Update with SCTE designations, when known}

Table 2–1 – M-CMTS Interface Specifications

Designation	Title
SCTE 137-2 2007	DOCSIS Downstream External PHY Interface for Modular
SCTE 137-1 2007	DOCSIS Timing Interface for Cable Modem Termination Systems
SCTE 139 2007	Edge Resource Manager Interface for Modular Cable Modem Termination Systems
SCTE 133 2007	Downstream RF Interface for Cable Modem Termination Systems

1.4 Requirements and Conventions

Throughout this standard, the words that are used to define the significance of particular requirements are capitalized. These words are:

“MUST”	This word or the adjective “REQUIRED” means that the item is an absolute requirement of this standard.
“MUST NOT”	This phrase means that the item is an absolute prohibition of this standard.
“SHOULD”	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
“SHOULD NOT”	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
“MAY”	This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 REFERENCES

All references are subject to revision; users of this specification are therefore encouraged to investigate the possibility of applying the most recent edition of the standards and other references listed below.

2.1 Normative References

{Editor's note: The DSS references need to be updated to SCTE standards references, when known}

[CMTS-NSI]	Cable Modem Termination System – Network Side Interface Specification, SP-CMTS-NSI-I01-960702, July 2, 1996, Cable Television Laboratories, Inc.
[SCTE 137-2]	DOCSIS Downstream External PHY Interface for Modular, 2007.
[SCTE 133]	Downstream RF Interface for Cable Modem Termination Systems, 2007.
[SCTE 106]	ANSI/SCTE 106 2007, DOCSIS Set-Top Gateway (DSG) Specification.
[SCTE 139]	Edge Resource Manager Interface for Modular Cable Modem Termination Systems, 2007.
[ISO 8601]	ISO 8601:2004, Data elements and interchange formats – Information interchange – Representation of dates and times
[J.83]	ITU-T Rec. J.83, (04/97) Digital multi-programme systems for television sound and data services for cable distribution.
[RFC 1123]	STD 3, RFC 1123, Braden, R., "Requirements for Internet Hosts – Application and Support" October 1989, Internet Engineering Task Force.
[RFC 2068]	RFC 2068, R. Fielding et al., "Hypertext Transfer Protocol – HTTP/1.1", January 1997, Internet Engineering Task Force.
[RFC 2131]	RFC 2131, R. Droms, "Dynamic Host Configuration Protocol", March 1997, Internet Engineering Task Force.
[RFC 2326]	RFC 2326, H. Schulzrinne; et al, Real Time Streaming Protocol (RTSP), April 1998, Internet Engineering Task Force.
[RFC 2373]	RFC 2373, Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", July 1998, Internet Engineering Task Force.
[RFC 3219]	RFC 3219, J. Rosenberg, H. Salama and M. Squire, "Telephony Routing over IP (TRIP)," January 2002, Internet Engineering Task Force.
[SCTE 79-1]	ANSI/SCTE 79-1 2007, DOCSIS 2.0 Part 1: Radio Frequency Interface

2.2 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027; Phone 303-661-9100; Fax 303-661-9199; Internet: <http://www.cablelabs.com>
- Internet Engineering Task Force (IETF), <http://www.ietf.org>
- International Telecommunication Union – Telecommunication Standardization Sector (ITU-T), <http://www.itu.int/itu-t/>
- International Organization for Standardization (ISO), <http://www.iso.org>

3 TERMS AND DEFINITIONS

This standard defines the following terms:

Edge QAM	A head-end or hub device that receives packets of digital video or data from the operator network. It re-packetizes the video or data into an MPEG transport stream and digitally modulates the transport stream onto a downstream RF carrier using QAM.
MAC domain	A grouping of layer 2 devices that can communicate with each other without using bridging or routing. In DOCSIS, a MAC domain is the group of CMs that are using upstream and downstream channels linked together through a MAC forwarding entity
Service Group	An HFC service group (also known as a service group) is a portion of an HFC access network used to deliver a set of services to a population of cable modems that share a common spectrum of RF channels.

4 ABBREVIATIONS AND ACRONYMS

This standard uses the following abbreviations and acronyms:

CM	Cable Modem
CMTS	Cable Modem Termination System
DEPI	DOCSIS External PHY Interface
DOCSIS	Data-Over-Cable-Service-Interface Specifications
DOCSIS-MPT	Traditional DOCSIS MPT Mode
DOCSIS-PSP	DOCSIS-Packet-Streaming-Protocol
DRRP	DOCSIS Resource Registration Protocol
DS	Downstream
DTI	DOCSIS Timing Interface
ERM	Edge Resource Manager
ERMI	Edge Resource Manager Interface(s)
FQDN	Fully Qualified Domain Name
FSM	Finite State Machine
HFC	Hybrid Fiber Coax
IP	Internet Protocol
M-CMTS	Modular Cable Modem Termination System
MAC	Media Access Control. Layer 2 of the ISO seven-layer model.
MPEG	Motion Picture Experts Group
MPEG-TS	Motion Picture Experts Group Transport Stream
PHY	Physical Layer. Used to refer to the downstream QAM transmitters and the upstream burst demodulators
PSP	Packet Streaming Protocol
QAM	Quadrature Amplitude Modulator (or Modulation)
RF	Radio Frequency
TRIP	Telephony Routing over IP
TSID	MPEG2 Transport Stream ID
UDP	User Datagram Protocol
URL	Uniform Resource Locator
VOD	Video On Demand

5 TECHNICAL OVERVIEW

5.1 Registration Interface

The registration interface (ERMI–1) allows EQAMs to register their QAM channel resources with an ERM.

5.1.1 Goals, Scope and Constraints

The Registration interface was designed to meet the following goals:

- Enable EQAMs to register their resources with an ERM
- Help the ERM to detect when failures occur in resources that it manages

The protocol used on this interface is based on TRIP [RFC 3219]. TRIP was designed to assist networks to locate voice-over-IP gateways and to route voice-over-IP traffic to an appropriate egress gateway. TRIP is a policy-driven protocol for advertising the reachability of telephony destinations between location servers, and for advertising attributes of the routes to those destinations.

Some EQAM resource registration protocols used in VOD systems are based on TRIP. Using a similar protocol to implement DOCSIS downstream resource allocation simplifies EQAM design.

When a VOD application needs a downstream QAM channel resource, it will request a downstream QAM channel resource from the ERM. When a DOCSIS application needs a downstream QAM channel resource, it will request a downstream QAM channel resource from the ERM.

5.1.1.1 Registering QAM Channels

Each ERM is responsible for managing the resources of one or more EQAMs. In order for an ERM to manage an EQAM's resources, it must first obtain an inventory of the resources associated with that EQAM. It must also obtain IP and/or RF addressing information associated with the EQAM and those resources in order to determine how to communicate with them. For example, an EQAM contains one or more QAM channels, each of which has associated RF properties (for example, the carrier frequency) and an RF address (the MPEG-2 Transport Stream ID (TSID)).

In order to allocate a particular QAM channel to a DOCSIS MAC domain, an ERM must know the following properties associated with that QAM channel:

- TSID
- QAM configuration, Capability, and QAM grouping
- Service Group
- Total available bandwidth

EQAMs use the Registration Interface to advertise available resources to an ERM. The ERM may use this information to populate a database of available resources.

5.1.2 Overall Architecture

The Registration Interface allows an EQAM to advertise to an ERM, information about the location and properties of resources under its control. The ERM may use this information to populate a database of the resources that have been reported to it by multiple EQAMs. The ERM may use this data to formulate responses to incoming requests for resources.

The Figure 5–1 shows the Registration component architecture. The Registration Interface between an ERM and an EQAM carries messages conforming to the DOCSIS Resource Registration Protocol (DRRP), as specified in Section 6.2.

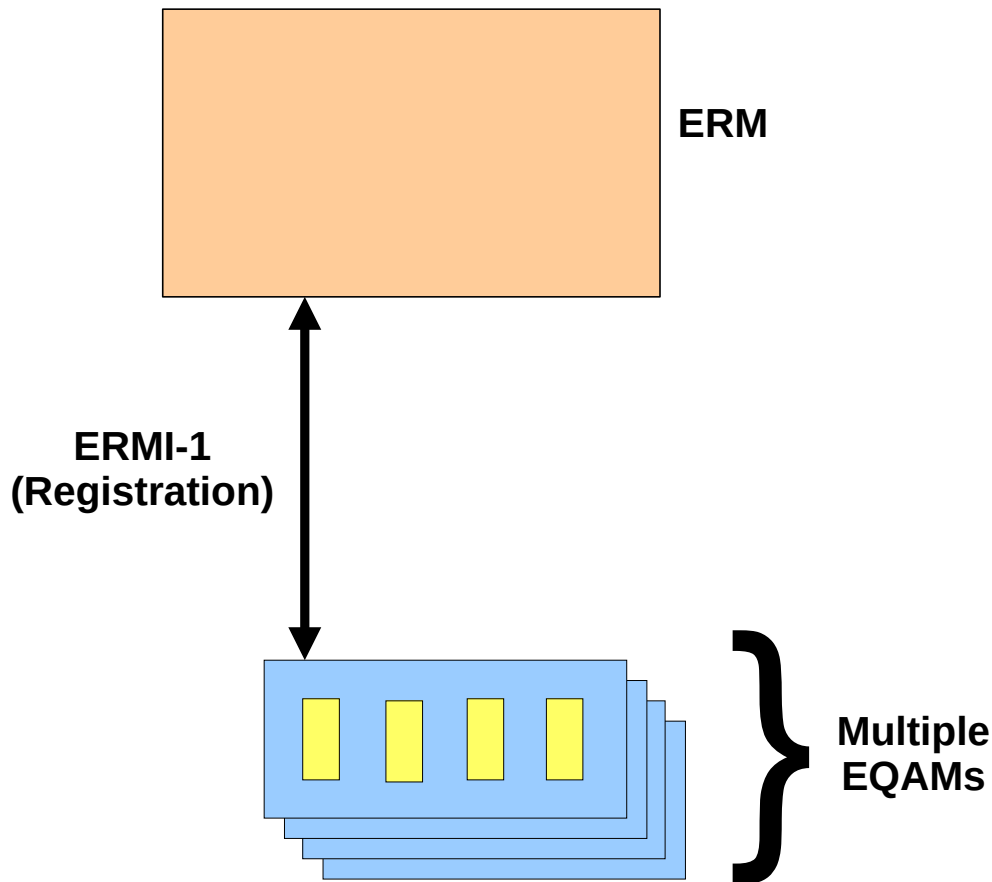


Figure 5–1 - Registration Interface and Components

An ERM normally manages multiple EQAMs, as shown in the Figure 5–1. An EQAM requires an ERM IP address in order to contact the ERM. An EQAM may use a DNS query to obtain an ERM IP address. An EQAM may also be configured to communicate with a secondary ERM in the event that it can no longer communicate with the primary ERM. However, a single QAM channel is controlled by a single ERM at a time.

Messages sent using the DRRP protocol are carried over a TCP/IP connection that may be initiated by either the EQAM or the ERM.

In this standard, the term “DRRP node” (or simply “node”) is sometimes used to refer to a generic entity that participates in exchanges of DRRP messages.

Because the device control interface for an EQAM is based on RTSP (see Section 7), the EQAM advertises an RTSP URL, in addition to the IP address. This RTSP URL is used to establish an RTSP transport connection with the EQAM. This allows the ERM to send device control messages to the EQAM to request QAM channel resources.

In normal use, an M-CMTS core requests a QAM channel resource from an ERM, (*i.e.*, during the process of creating a DOCSIS MAC domain (over ERMI-3)). The resources previously advertised by EQAMs (over ERMI-1) are used by the ERM to select a suitable QAM channel resource to meet the requirements of an incoming request. The ERM checks with the EQAM (over ERMI-2) that the resource is available, and that the ERM returns addressing information for that resource (over ERMI-3), to the requesting M-CMTS core.

In addition to an initial advertisement, the EQAM sends additional advertisements whenever an attribute of a resource under its control changes. For example, if a QAM channel within an EQAM changes its carrier

frequency, the EQAM will transmit the new information to the ERM. Also, if an EQAM detects a fatal failure in one of its QAM channels, it will inform the ERM.

5.1.3 DRRP Operation

This section describes how EQAMs use DRRP to register a QAM channel resource with an ERM and how ERMs use DRRP to obtain information about QAM channel resources, in order to build a database of available resources.

5.1.3.1 DRRP Addressing

A DRRP advertisement provides the mapping from an application-specific address field (in our case, a URL) of an advertised resource to an IP signaling address where control messages for that resource should be sent. The application-specific address identifies the individual resource being advertised.

When it boots, the EQAM advertises the application-specific addresses (*i.e.*, URLs) of its available QAM channel resources to the ERM. When an M-CMTS core sends a suitable request to the ERM, the ERM will select a QAM channel resource from its database. The ERM then sends an RTSP request to the EQAM to bind this QAM channel resource. After the EQAM receives a resource allocation request from the ERM, the EQAM verifies that the resource is available and that the QAM channel can be configured as requested. The EQAM then marks the resource as being in use and responds to the ERM request with an indication of success.

For each QAM channel resource that the EQAM wishes to advertise, it sends a DRRP ReachableRoute attribute to the ERM, embedded in a DRRP UPDATE message. To withdraw a QAM channel from service, the EQAM sends a WithdrawRoute attribute¹ (see Section 6.2.3.1).

The application-specific address passed in the DRRP Route attribute is the RTSP URL (*i.e.*, a URL whose protocol portion is rtsp:) of the particular resource that is being advertised.

DRRP advertisements include the IP address of the EQAM (to which RTSP signaling requests are sent) in a NextHopServer attribute. The syntax and semantics of the DRRP NextHopServer attribute are described in Section 6.2.3.3.

5.1.3.2 RTSP URLs

An RTSP URL identifies the protocol to be used to access the resource as RTSP, and contains two additional fields: hostname and abs-path, separated by a virgule: rtsp://hostname[:port]/abs-path.

The hostname field may contain either a FQDN or an IP address. In either case, it may include an optional TCP port number. The value identifies the address of the server that receives RTSP requests. In the context of the ERMI-2 interface, the ERM is an RTSP client and the EQAM is an RTSP server.

The abs-path field is used to further distinguish the entity upon which a subsequent RTSP request will operate. For example, suppose that an EQAM supports multiple QAM channels controlled by a single logical RTSP server in the EQAM. In order to control an individual QAM channel within an EQAM, an ERM must be able to identify the individual QAM channel to which a particular RTSP request applies. Because the hostname field in a URL identifies only a particular network device, it cannot identify an individual QAM channel within that device. Therefore, the abs-path field is used within an RTSP request to identify the individual destination QAM channel for the request.

Table 5–1 shows the URL format used by EQAMs when advertising QAM channels. In the table, the hostname field in the URL is represented by the string “hostname”. The abs-path field contains the ASCII-encoded TSID of the QAM channel.

¹ The names of the Route, ReachableRoute and WithdrawRoute attributes are drawn from TRIP. Although this document retains these names, it may help the reader to think of them instead as Resource, UsableResource and WithdrawResource.

Table 5–1 - URL Formats for QAM Channels

Component	Sub-Component	URL Format	abs-path encoding
EQAM	QAM Channel	rtsp://hostname[:port]/<QAM ID>(e.g., rtsp://192.168.0.2/1234)	QAM ID Value (which is the ASCII encoding of the TSID value for the QAM channel)

5.1.3.3 DRRP Timers

DRRP uses two timers, the Hold Timer and ConnectRetry Timer.

5.1.3.3.1 Hold Timer

Whenever a DRRP node receives a message, it resets and starts the Hold Timer. If the Hold Timer fires before it receives another message, then it sends a NOTIFICATION message which causes the DRRP connection to be closed. The duration of the Hold Timer, which is called the Hold Time, is negotiated by the DRRP nodes when the DRRP connection is established. KEEPALIVE messages should be sent at an interval of 1/3 of the Hold Time, in order to ensure that the Hold Timer does not fire.

5.1.3.3.2 ConnectRetry Timer

The ConnectRetry Timer is used during the process of establishing a DRRP connection. After the DRRP node initiates the TCP connection to the remote DRRP node, it starts the ConnectRetry Timer and waits for a response from the remote node. If the ConnectRetry Timer expires before receiving a response from the remote node, the DRRP node will retry to establish the TCP connection.

5.1.3.4 DRRP Attributes

In a DRRP UPDATE message, EQAMs may advertise the following DRRP attributes (for each QAM channel) to the ERM. Each of these attributes is specified in detail in Section 6.2.3.

- **DEPI Control Address:** This attribute identifies the destination IP address used by control packets to communicate with the QAM channel.
- **DOCSIS Capability:** This attribute identifies the type of configuration and DOCSIS modes in which the QAM channel is capable of operating.
- **NextHopServer:** This attribute identifies the EQAM to which signaling messages should be sent.
- **Port ID:** This attribute identifies the RF port of the QAM channel. (i.e., the RF port to which the QAM channel is connected).
- **QAM Configuration:** This attribute identifies the current configuration of the QAM channel.
- **QAM ID:** This attribute identifies a QAM channel resource within the headend.
- **Reachable Routes:** This attribute identifies resources that are being advertised as available by the EQAM.
- **Service Status:** This attribute describes the current operational state of the QAM channel.
- **Total Bandwidth:** This attribute identifies the rate at which the QAM channel is capable of consuming data from the network.
- **WithdrawnRoutes:** This attribute identifies resources that are being withdrawn from service by the EQAM.

5.2 Resource Allocation Signaling

5.2.1 Resource Allocation Components and Interface

Figure 5-2 shows the components involved in the resource allocation interfaces.

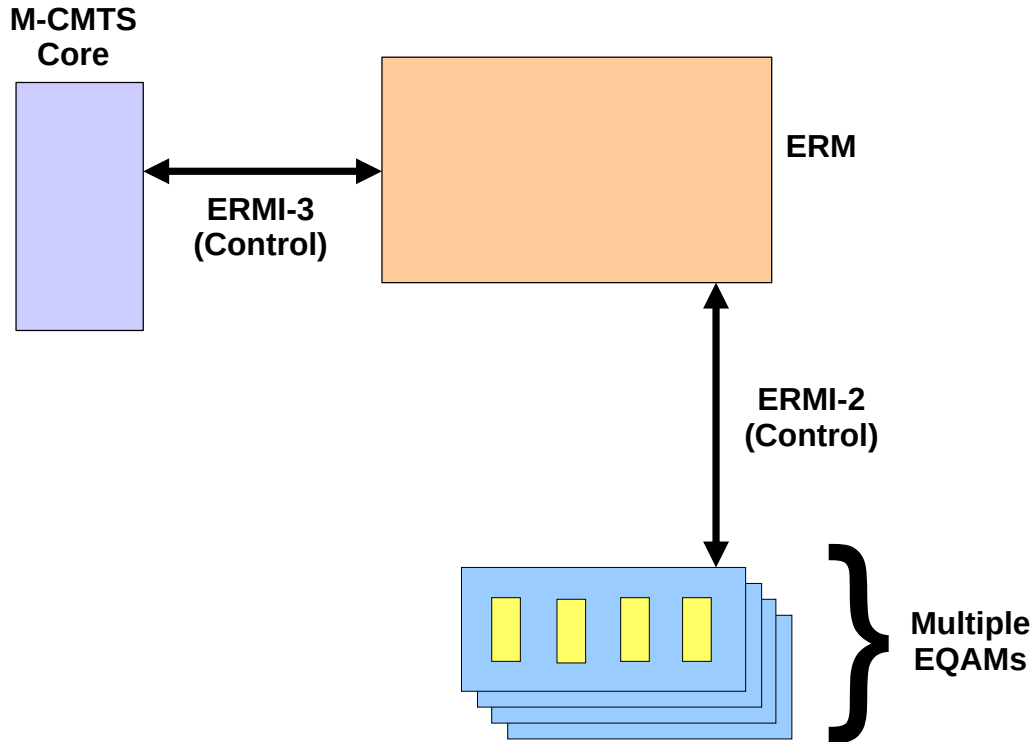


Figure 5-2 - Resource Allocation Interfaces and Components

The M-CMTS core initiates a QAM resource transaction with the ERM when it requests or releases a QAM channel resource. When a MAC domain is being created, for example, the M-CMTS core provides the ERM with details of the desired service group, bandwidth, and QAM channel capability. The ERM then consults its database of available resources, verifies that the resources are available, and returns the contact information for an appropriate QAM channel, if one is available.

An EQAM is a device which has a pool of QAM channels that may be allocated to DOCSIS, or to other applications (such as video). A particular QAM channel may support only a subset of all possible DOCSIS capabilities. For example, some QAM channels may support only certain interleave settings; or some QAM channels may not support the DOCSIS PSP mode specified in [SCTE 137-2]. The capabilities of each individual QAM channel are advertised to the ERM when the EQAM advertises that particular QAM channel.

The ERM may apply operator-dependent policies when selecting a QAM channel. Such policies may take into consideration factors such as: QAM channel load balancing; whether DOCSIS bonded traffic may share a QAM channel with VOD traffic; and the existence of QAM channels that have been reserved for future DOCSIS traffic, etc.

In an EQAM, QAM channels are physically connected to RF ports. A single RF port may be associated with multiple QAM channels. The RF port may impose limitations on the configuration of associated QAM channels. For example, all the QAM channels associated with a single RF port may be required to be configured identically. Although a QAM channel used by a video application and one used by DOCSIS may have the same carrier frequency and modulation type, they may have different interleave settings. To allow an individual QAM channel to switch between operating in a mode compatible with video and one compatible with DOCSIS, the EQAM should be able to control the configuration of a single QAM channel without affecting the configuration of any other QAM channels.

This standard specifies two resource-allocation interfaces. ERMI-2 is an interface between an ERM and an EQAM, and is used to bind QAM channel resources selected by the ERM. ERMI-3 is an interface between an M-CMTS core and an ERM, and is used to request and return QAM channel resources.

5.2.2 Service Groups

The mapping between a QAM channel and its associated service group is determined by the physical wiring of the RF network. **Figure 5-3** is a simplified depiction showing a small network of three QAM channels (QAMC1 through QAMC3), and three fiber nodes (FN1 through FN3). In **Figure 5-3**, QAMC1 and QAMC2 are cross-connected to FN1 and FN2. QAMC1 and QAMC2 therefore, belong to service group A. QAMC2 and QAMC3 are both connected to FN3. These two QAM channels therefore, belong to service group B. QAMC2 belongs to both service group A and to service group B.

A service group is identified by a list of QAM channels (or, an equivalent list of frequencies). Each QAM channel is identified by a QAM ID, which is a 16-bit MPEG Transport Stream ID (TSID), configured at the EQAM so as to be unique for each QAM channel in the head-end. TSIDs are inserted (inband) into video streams by QAM channels; it is convenient to use the same identifier for QAM channels in DOCSIS applications. In our example, QAMC1, QAMC2, and QAMC3 will be identified by TSID1, TSID2, and TSID3 respectively. Therefore, service group A is identified by the set {TSID1, TSID2}, and service group B by the set {TSID2, TSID3}.

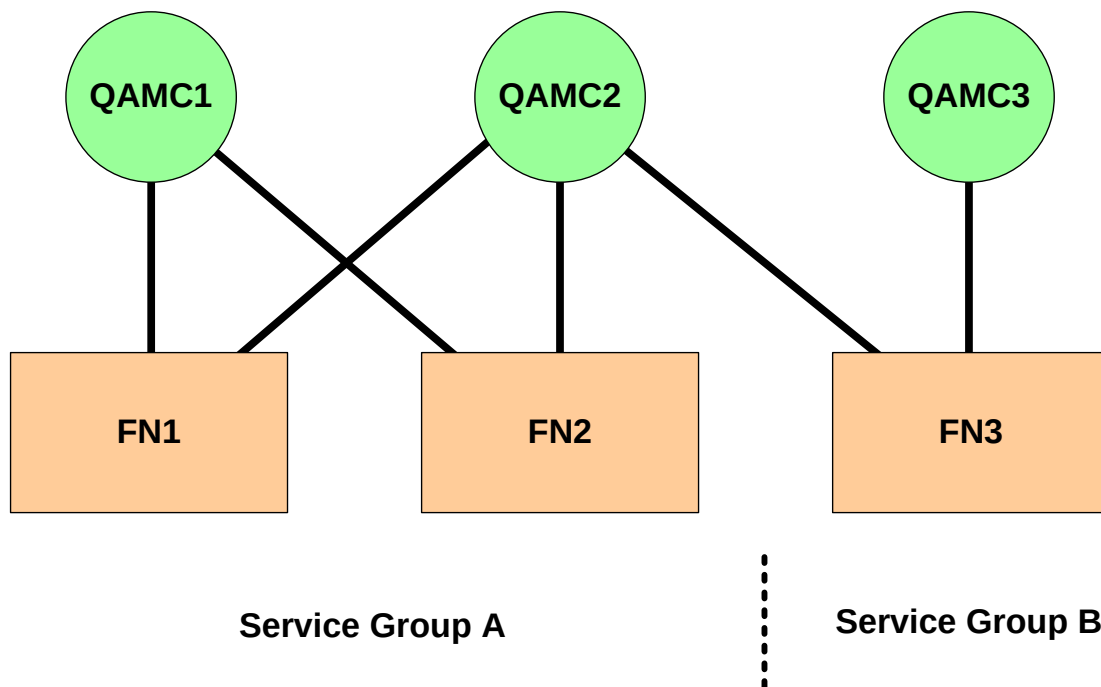


Figure 5-3 - Service Group Example

The mapping between QAM channel and service group can be learned either dynamically or through static configuration. In VOD applications, the subscriber's Set-Top Box scans the frequency spectrum to discover the list of visible QAM channels and their associated TSIDs. The list of visible TSIDs is passed to a VOD Session Manager. The Session Manager then forwards this list to the ERM. The method used to perform service group discovery in DOCSIS is outside the scope of this standard. If the service group information is not discovered automatically, it must be configured or otherwise made available to the M-CMTS core by some means not specified in this standard.

The ERM allocates QAM channel resources based on the requested QAM ID list, bandwidth, and DOCSIS capability. The M-CMTS core includes a list of QAM IDs in its request for a resource; the ERM searches the list to find the “best” available QAM channel that meets the requirements for bandwidth and the DOCSIS channel capability and is consistent with local policy.

5.2.3 Signaling Protocol

The protocol used for the resource allocation interfaces (ERMI-2 and ERMI-3) is the Real Time Streaming Protocol, RTSP [RFC 2326]. RTSP is an application-level client/server protocol designed to control the delivery of real-time data. RTSP provides an extensible framework to enable controlled, on-demand delivery of such data. The protocol is intended to control multiple simultaneous data delivery sessions, to provide a means for choosing delivery channels, and to provide a way to choose among multiple delivery mechanisms.

The client initiates an RTSP session by sending a SETUP message containing a request for resources. The server allocates the resources for the session and replies by identifying a suitable resource that meets the client's request. In ERMI-2, the ERM is an RTSP client and the EQAM is an RTSP server. In ERMI-3, the M-CMTS core is an RTSP client and the ERM is an RTSP server.

An RTSP message is either a request or a response. A request contains an RTSP method, the object on which the method is operating, and any parameters necessary to further define the operation. Depending on the RTSP method, the direction of an RTSP request can be from client to server or *vice versa*.

In a VOD application, RTSP is extended with new methods and headers to support the VOD application. In the DOCSIS application specified in this standard, additional headers are defined. Naturally, in order for an ERM/EQAM pair to function correctly in both VOD and DOCSIS applications, both devices must support the (different) RTSP extensions used by the two applications.

RTSP allows considerable variations in the capabilities supported by conformant implementations. This standard indicates the subset of RTSP requirements that must be supported by the RTSP components in the ERMI resource allocation interfaces (ERMI-2 and ERMI-3). In addition, extensions needed for the DOCSIS application are also specified herein.

5.2.4 Selecting an ERM

There may be multiple ERMs in the operator's head-end network. The M-CMTS core selects the correct ERM with which to communicate by means that are outside the scope of this standard. For the simplest case, this can be achieved by static configuration. In a more dynamic network, ERMs may report resources to an aggregation point by means that are outside the scope of this standard. Such an aggregation point may serve as a proxy to locate the correct ERM.

5.3 Static Partitioning

In current head-end networks, the QAM channel resources used by video applications and those used by DOCSIS applications are separate and distinct. In order to allow resources to be switched easily between these two types of application, common interfaces should be used within the ERM for registration, allocation, and control. In order to provide a relatively simple migration path, QAM channel resources may initially be partitioned by using static configuration.

Some EQAMs may control QAM channels that are capable of supporting both video and DOCSIS applications. It is permissible to provision statically, some of the QAM channels in the EQAM for video service and the rest for DOCSIS data applications.

5.3.1 Simplified Architecture for Static QAM Resource Sharing

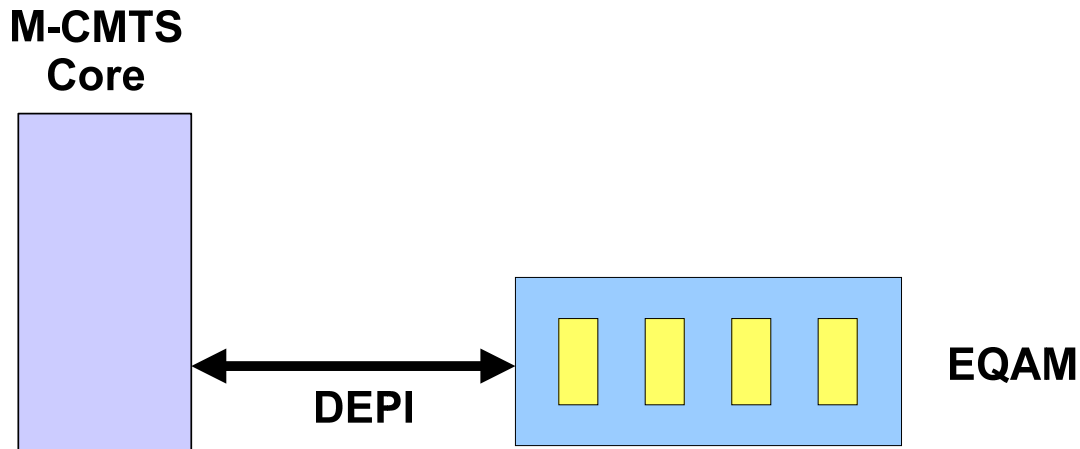


Figure 5–4 - Simplified Framework for Static QAM Partitioning

Figure 5–4 shows an architecture suitable for partitioning QAM channels statically between video and DOCSIS applications. In this simple architecture, the ERM is not used at all by DOCSIS applications.

The EQAM is configured so that only video QAM channels are advertised to the ERM (since the ERM is used only by video applications).

5.3.2 Operation

When the M-CMTS core needs a QAM channel resource, such as in the case of creating a new MAC domain, it selects a QAM channel from the appropriate service group. The M-CMTS core obtains the IP address of the QAM channel from its configuration database. The M-CMTS core then uses the DEPI protocol to establish a control channel to this IP address. Once this channel is in place, the M-CMTS core negotiates the physical settings for the QAM channel, as specified in [SCTE 137-2].

5.4 Device Configuration

The ERMI components, EQAM and M-CMTS core, must be properly configured for ERMI to function as intended. The configuration for dynamic signaling and static partitioning is slightly different. The differences are noted below.

Each QAM channel in the EQAM is configured with:

- QAM ID;
- IP address, (this is the IP address used by the M-CMTS core to communicate with the QAM channel as specified by [SCTE 137-2]). UDP ports acceptable for DEPI data sessions communicating with this QAM channel can be optionally configured;
- Modulation type;
- Channel bandwidth;
- Interleave setting (I, J);
- J83 annex;
- Carrier frequency;
- Power;
- QAM capability;

- Resource allocation mode (ERM, or non-ERM);
- ERM IP address (only needed for dynamic signaling);

In the M-CMTS core, the following are configured:

- Mappings between QAM IDs and service groups;
- QAM ID for each QAM channel;
- IP address for each QAM channel (only needed for static portioning);
- IP address of ERM (only needed for dynamic signaling);
- QAM capability for each QAM channel;

as specified in the [SCTE 137-2] specification.

6 DOCSIS RESOURCE REGISTRATION PROTOCOL (DRRP) SPECIFICATION

6.1 Relationship with TRIP [RFC 3219]

DRRP shares many similarities with the protocol described in [RFC 3219]. It has similar procedures and a similar Finite State Machine for connection establishment. It also shares the same format for messages. DRRP nodes are also conformant TRIP nodes, although they perform only a subset of the messaging described in [RFC 3219].

DRRP supports four messages that may be exchanged between nodes: OPEN, UPDATE, NOTIFICATION, and KEEPALIVE:

- The OPEN message is used to initiate a DRRP connection between nodes. The OPEN message is used exactly as specified in [RFC 3219].
- The UPDATE message is used by an EQAM to advertise resources under its control to an ERM.
- The NOTIFICATION message is used by a DRRP node to inform the far end that an error has occurred. DRRP connections are closed after a NOTIFICATION message is sent or received. The NOTIFICATION message is used exactly as specified in [RFC 3219].
- DRRP includes a periodic bidirectional KEEPALIVE message whose frequency is negotiated by the two sides when the DRRP connection is established. The KEEPALIVE message is used as specified in [RFC 3219].

If the ERM does not receive a KEEPALIVE message within the agreed-upon period, it assumes that the EQAM has failed and updates its database accordingly, by marking the associated resources as no longer available. The ERM may try to re-establish the DRRP connection to that EQAM before removing that EQAM from its resource pool. The ERM can also discover a change in a QAM channel resource through receipt of an UPDATE message. Failures of QAM resources and indications of the availability of new QAM resources are conveyed to an ERM through the WithdrawnRoutes and ReachableRoutes attributes of the UPDATE message.

6.2 DRRP

This section documents the subset of [RFC 3219] used by the M-CMTS architecture, as well as the additional attributes that are used to advertise QAM channel resources. Instead of referring to the applicable sections of [RFC 3219], this section includes normatively, the relevant sections of [RFC 3219]. The resultant protocol is known as DRRP, the DOCSIS Resource Registration Protocol.

6.2.1 Establishing a DRRP Connection

DRRP messages MUST be carried over a TCP/IP connection. A DRRP node MUST listen on TCP port 6069 for incoming connections that will be used to carry DRRP traffic.

The DRRP connection may be initiated by either of the DRRP nodes.

A DRRP node MUST conform to the DRRP state machine specified in Section 6.2.7. A DRRP node begins in the [Idle] state and goes through several state transitions before reaching the [Established] state, after which point the EQAM SHOULD advertise its resources that are operational to the ERM.

6.2.2 Message Formats

Incomplete received DRRP messages MUST be ignored. The total size of a transmitted DRRP message MUST NOT exceed 4096 octets. The recipient MUST be able to process DRRP messages up to 4096 octets in size. Within a DRRP message, octets MUST be transmitted with most significant octet first and, within an octet, most significant bit first. This is commonly known as “network order”.

6.2.2.1 Message Header

Every DRRP message MUST begin with a 3-octet header, specified below. There may or may not be a data portion following the header, depending on the message type. The layout of the header fields is shown in Figure 6-1:

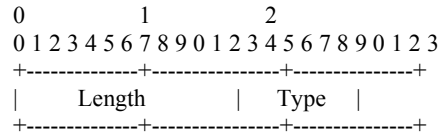


Figure 6-1 - DRRP Header Format

Length

This 2-octet unsigned integer indicates the total length of the message, including the header, in octets. Thus, it allows the recipient to locate the beginning of the next message in the message stream. The Length field MUST be present. The value of the Length field MUST be in the range $3 \leq \text{Length} \leq 4096$. The value may be further constrained by the message type. The stream of DRRP messages MUST NOT contain padding between messages.

Type

This 1-octet unsigned integer encodes the type of the message. The Type field MUST be present. The value of the field MUST be one of the values identified in Table 6-1:

Table 6-1 - DRRP Message Types

Type	DRRP message
1	OPEN
2	UPDATE
3	NOTIFICATION
4	KEEPALIVE

6.2.2.2 OPEN Message

The first DRRP message sent by a node MUST be either an OPEN message or a NOTIFICATION message sent in response to a received OPEN message.

If the OPEN message is acceptable to the recipient node, a KEEPALIVE message confirming the OPEN MUST be returned.

The minimum length of the OPEN message is 17 octets (including the message header). OPEN messages not meeting this minimum requirement are handled as defined in Section 6.2.4.2.

Following the fixed-size DRRP header, the OPEN message contains the following fields:

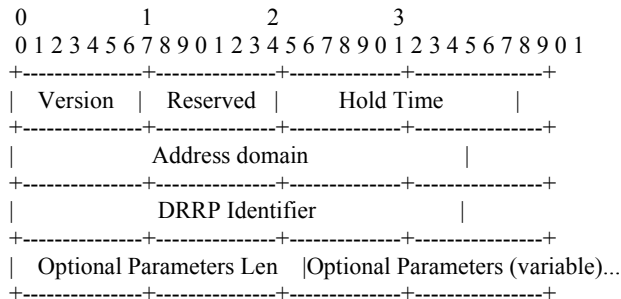


Figure 6-2 - DRRP OPEN Header

Version

This 1-octet unsigned integer indicates the protocol version of the message. The Version field **MUST** be present. The Version field **MUST** contain the value 1.

Hold Time

This 2-octet unsigned integer indicates the number of seconds that the sender proposes for the value of the Hold Timer. The Hold Time field **MUST** be present. Upon receipt of an OPEN message, a DRRP node **MUST** calculate the value of the Hold Timer, T_H , by using the smaller of its configured Hold Time (if any), and the value of the Hold Time field in the OPEN message. The value of the Hold Time field in an OPEN message **MUST** be either 0 or greater than two. The configured Hold Time (if any) **MUST** be either 0 or greater than two. A recipient **SHOULD** reject connections if the value of the Hold Time field does not meet local policy. The calculated value of T_H is the maximum number of seconds that may elapse between the receipt of successive KEEPALIVE and/or UPDATE messages (see Section 6.2.2.4 and Section 6.2.2.3).

Address domain

This 4-octet unsigned integer indicates the address domain number of the sender. The Address domain field **MUST** be present. Two DRRP nodes **MUST** have the same address domain in order to establish a DRRP connection, unless one has the reserved address domain number of zero.

The value of the Address domain field **MUST** be less than or equal to 255.

An Address domain field that contains the value 0 **MUST** be interpreted by the recipient to mean that the advertised address can be reached from any address domain.

DRRP Identifier

This 4-octet unsigned integer indicates the DRRP Identifier of the sender. The DRRP Identifier field **MUST** be present. The value of this field **MUST** uniquely identify this node within its address domain. A given node **MAY** set the value of its DRRP Identifier to an IPv4 address assigned to that node. The value of the DRRP Identifier of a DRRP node is configured on the node. The DRRP node **MUST** use the same value for the DRRP Identifier field in all OPEN messages sent to other nodes.

Optional Parameters Len

This 2-octet unsigned integer indicates the total length of the Optional Parameters field in octets. The Optional Parameters Len field **MUST** be present. If the value of this field is zero, the Optional Parameters field is absent.

Capability Code

This is a 2-octet field, used to identify individual capabilities. The Capability Code field **MUST** be present.

Capability Length

This 2-octet unsigned integer contains the length of the Capability Value field in octets. The Capability Length field **MUST** be present.

Capability Value

This is a variable-length field that is interpreted according to the value of the Capability Code field and Capability Length field. A single capability, as identified by the value of its Capability Code field, may appear more than once in the Optional Parameters field.

The value of the Capability Code field **MUST** be one of the values identified in Table 6–2.

Table 6–2 - Capability Codes

Capability Code	Capability
1	Route Types Supported
2	Send Receive
32768	DRRP Version

6.2.2.2.1.2 Route Types2 Supported

The Route Types Supported capability lists the route types supported by the transmitting node. A node **MUST NOT** use route types that are not supported by the remote node. If the route types supported by the remote node are not supported, a node **SHOULD** terminate the DRRP connection.

The format for a Route Type is shown in Figure 6–5:

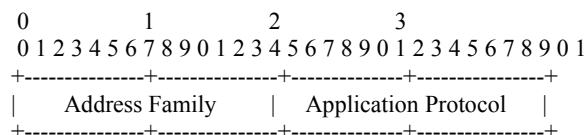


Figure 6–5 - Route Type Format

The Address Family and Application Protocol fields are specified in Section 6.2.3.1.1.1. The Address Family field identifies the address family of the resource within the ReachableRoutes attribute. The Address Family field **MUST** be present. The Application Protocol field identifies the application for which the resource may be used. The Application Protocol field **MUST** be present.

For example, a Route Type for DRRP could be <URL, ERMI>, indicating a URL for the ERMI resource signaling interface to the EQAM.

The Route Types Supported capability may contain multiple Route Types in the capability. The number of Route Types listed in the capability is limited only by the value of the Capability Length field.

² As before, we maintain the nomenclature used in [RFC 3219].