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Cable Modem IPv4 and IPv6 eRouter Specification

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Contents

1	SCOPE.....	1
2	REFERENCES	2
2.1	NORMATIVE REFERENCES	2
2.2	INFORMATIVE REFERENCES	4
2.3	REFERENCE ACQUISITION.....	4
3	TERMS AND DEFINITIONS.....	5
4	ABBREVIATIONS, ACRONYMS AND CONVENTIONS.....	6
4.1	ABBREVIATIONS AND ACRONYMS	6
4.2	CONVENTIONS	7
5	THEORY OF OPERATION	8
6	EROUTER INITIALIZATION	11
7	IPV4 PROVISIONING	12
7.1	DHCPv4 FIELDS USED BY THE EROUTER.....	13
7.2	ROUTER DHCPv4 SERVER SUB-ELEMENT	14
7.2.1	<i>DHCPv4 Server Function Goals</i>	<i>14</i>
7.2.2	<i>DHCPv4 Server Function System Description</i>	<i>14</i>
7.2.3	<i>DHCPv4 Server Function Requirements.....</i>	<i>15</i>
8	IPV6 PROVISIONING	16
8.1	OBTAIN LINK-LOCAL ADDRESS	17
8.2	PERFORM ROUTER DISCOVERY	17
8.3	OBTAIN IPV6 ADDRESS AND OTHER CONFIGURATION PARAMETERS	17
8.4	USE OF T1 AND T2 TIMERS.....	18
8.5	<i>IPV6 PROVISIONING OF CPE DEVICES</i>	<i>19</i>
8.6	<i>DHCPv6 REQUIREMENTS FOR EROUTER.....</i>	<i>19</i>
9	IPV4 DATA FORWARDING AND NAPT OPERATION.....	21
9.1	INTRODUCTION	21
9.1.1	<i>Assumptions</i>	<i>21</i>
9.1.2	<i>Overview.....</i>	<i>21</i>
9.2	SYSTEM DESCRIPTION	21
9.2.1	<i>Overview.....</i>	<i>21</i>
9.3	IPV4 ROUTER	23
9.4	NAPT.....	24
9.4.1	<i>Dynamically Triggered NAPT Translations</i>	<i>25</i>
9.4.2	<i>ALGs (Application Layer Gateways).....</i>	<i>25</i>
9.4.3	<i>Multicast NAPT</i>	<i>26</i>
9.5	ARP	26
9.6	IPV4 MULTICAST.....	26
9.6.1	<i>IGMP Proxying.....</i>	<i>27</i>
9.6.2	<i>IPv4 Multicast Forwarding</i>	<i>28</i>
9.6.3	<i>IPv4 Multicast Forwarding Example</i>	<i>28</i>

10	IPv6 DATA FORWARDING	31
10.1	OVERVIEW.....	31
10.2	SYSTEM DESCRIPTION	32
10.3	IPv6 MULTICAST.....	34
10.3.1	MLD Proxying	34
10.3.2	IPv6 Group Membership Database.....	35
10.3.3	IPv6 Multicast Forwarding	35
10.3.4	IPv6 Multicast Forwarding Example	36
11	QUALITY OF SERVICE	38
11.1	DOWNSTREAM QUALITY OF SERVICE OPERATION.....	38
11.2	UPSTREAM QUALITY OF SERVICE OPERATION	38
ANNEX A	SNMP MIB OBJECTS SUPPORTED BY THE ERROUTER.....	39
A.1	eROUTER INTERFACE NUMBERING	39
ANNEX B	CONFIGURATION OF ERROUTER OPERATIONAL PARAMETERS.....	40
B.1	eROUTER SNMP CONFIGURATION	40
B.2	ECM PROXY MECHANISM FOR CONFIGURATION OF eROUTER	46
B.3	eROUTER CONFIGURATION ENCODINGS	46

Figures

FIGURE 5-1 - LOGICAL COMPONENTS OF AN EDOCSIS DEVICE WITH AN IPv4 eROUTER.....	8
FIGURE 5-2 - LOGICAL COMPONENTS OF AN EDOCSIS DEVICE WITH AN IPv6 eROUTER.....	9
FIGURE 5-3 - LOGICAL COMPONENTS OF AN EDOCSIS DEVICE WITH AN IPv4 + IPv6 eROUTER	9
FIGURE 7-1 - IPv4 PROVISIONING MESSAGE FLOW	12
FIGURE 8-1 - IPv6 PROVISIONING MESSAGE FLOW	16
FIGURE 9-1 - eROUTER IPv4 FORWARDING BLOCK DIAGRAM	22
FIGURE 9-2 - eROUTER IPv4 MULTICAST FORWARDING BLOCK DIAGRAM	27
FIGURE 9-3 - IPv4 MULTICAST FORWARDING EXAMPLE.....	29
FIGURE 10-1 - eROUTER IPv6 FORWARDING BLOCK DIAGRAM	31
FIGURE 10-2 - eROUTER IPv6 MULTICAST FORWARDING BLOCK DIAGRAM	34
FIGURE 10-3 - IPv6 MULTICAST FORWARDING EXAMPLE.....	36

Tables

TABLE 6-1 - eROUTER MODES	11
TABLE 7-2 - eROUTER DHCP RETRANSMISSION INTERVAL.....	13
TABLE 7-3 - DHCPv4 SERVER OPTIONS.....	15
TABLE B-1 - vacmViewTreeFamilyTable	40
TABLE B-2 - SNMPv1v2c COEXISTENCE CONFIGURATION MAPPING.....	41
TABLE B-3 - SNMPCommunityTable.....	42
TABLE B-4 - SNMPTargetAddrTable.....	42
TABLE B-5 - SNMPTargetAddrExtTable	43
TABLE B-6 - vacmSecurityToGroupTable	44
TABLE B-7 - vacmAccessTable.....	44
TABLE B-8 - SNMPv3 ACCESS VIEW CONFIGURATION ENCODING	45
TABLE B-9 - vacmViewTreeFamilyTable	46

1 SCOPE

This standard defines a core set of features that enable multiple subscriber devices to gain access to operator provided high speed data service using DOCSIS. This core set of features allow for both IPv4 and IPv6 enabled devices to gain connectivity to the Internet.

The eRouter is specified as an Embedded Service/Application Functional Entity (eSAFE) device as defined in [SCTE 107] that is implemented in conjunction with a DOCSIS Cable Modem device.

The core set of features defined in this standard includes the ability to provision multiple CPE devices, a description of how to forward data to and from CPE devices and also the ability to forward IP Multicast traffic to CPE devices.

2 REFERENCES

2.1 Normative References

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2.2 Informative References

This document uses the following informative references.

[OSSIv3.0] SCTE 135-4 2007, DOCSIS 3.0 Part 4: Operations Support System Interface

2.3 Reference Acquisition

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IETF Standards, Internet Engineering Task Force (IETF) Secretariat c/o Corporation for National Research Initiatives, 1895 Preston White Drive, Suite 100, Reston, VA 20191-5434, Phone 703-620-8990, Fax 703-620-9071, Internet: <http://www.ietf.org/>

3 TERMS AND DEFINITIONS

This standard uses the following terms:

Customer-Facing Interface	An eRouter interface used for connecting CPE devices.
Customer-Facing IP Interface	An IP Interface connected to the eRouter which is not necessarily mapped one-to-one to with the number of Customer-Facing ports on the eRouter.
Customer-Facing Logical IP Interface	A logical Interface connected to the eRouter which is not necessarily mapped one-to-one to with the number of Customer-Facing ports on the eRouter.
eRouter	An eSAFE device that is implemented in conjunction with the DOCSIS Embedded Cable Modem.
Multicast Subscription Database	A simple table of entries for the IPv4 or IPv6 Multicast Group Membership information maintained by the eRouter on respective interfaces. Implementation details for storage of records is completely Vendor defined.
Operator-Facing Interface	The eRouter interface which is connected to the Embedded Cable Modem.
Operator-Facing IP Interface	IP Interface that is connected to the Embedded Cable Modem and is provisioning with an IP Address provided by the Operator.

4 ABBREVIATIONS, ACRONYMS AND CONVENTIONS

4.1 Abbreviations and Acronyms

This standard uses the following abbreviations:

ALG	Application Layer Gateway
ARP	Address Resolution Protocol
ASN.1	Abstract Syntax Notation One
CPE	Customer Premises Equipment
CM	Cable Modem
DAD	Duplicate Address Detection
DNS	Domain Name Service
DUID	DHCP unique identifier
EAE	Early Authentication and Encryption
eSAFE	Embedded Service/Application Functional Entity
EUI	Extended Unique Identifier
FTP	File Transfer Protocol
ID	Identifier
IP	Internet Protocol
IRT	Initial Retransmission Times
LAN	Local Area Network
ND	Neighbor Discovery
MAC	Media Access Control
MIB	Management Information Base
MLD	Multicast Listener Discovery
MRC	Maximum Retransmission Count
MRD	Maximum Retransmission Duration
MRT	Maximum Retransmission Time
NAT	Network Address Translation
NAPT	Network Address Port Translation
OID	Object ID
OUI	Organization Unique Identifier
RFC	Request For Comment
RA	Router Advertisement
RD	Router Discovery
SIP	Session Initiation Protocol
TCP	Transmission Control Protocol
TLV	Type/Length/Value
TTL	Time To Live
UDP	User Datagram Protocol

4.2 Conventions

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

"MUST"	This word means that the item is an absolute requirement of this document.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this document.
"SHOULD"	This word 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 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.

5 THEORY OF OPERATION

The eRouter device is intended to provide home networking functionality in conjunction with a DOCSIS eCM in an eDOCSIS device.

This document defines a set of features for an IPv4 eRouter and a set of features for an IPv6 eRouter. Both sets of features can be implemented together as an IPv4 + IPv6 eRouter.

The figures below depict implementations of eDOCSIS devices with an IPv4 eRouter, an IPv6 eRouter and an IPv4 + IPv6 eRouter.

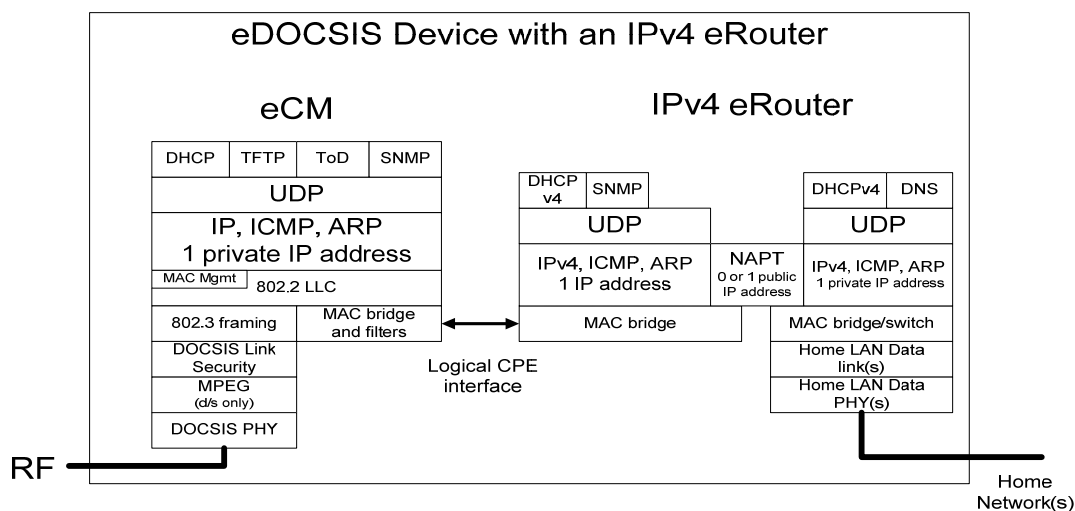


Figure 5-1 - Logical Components of an eDOCSIS device with an IPv4 eRouter

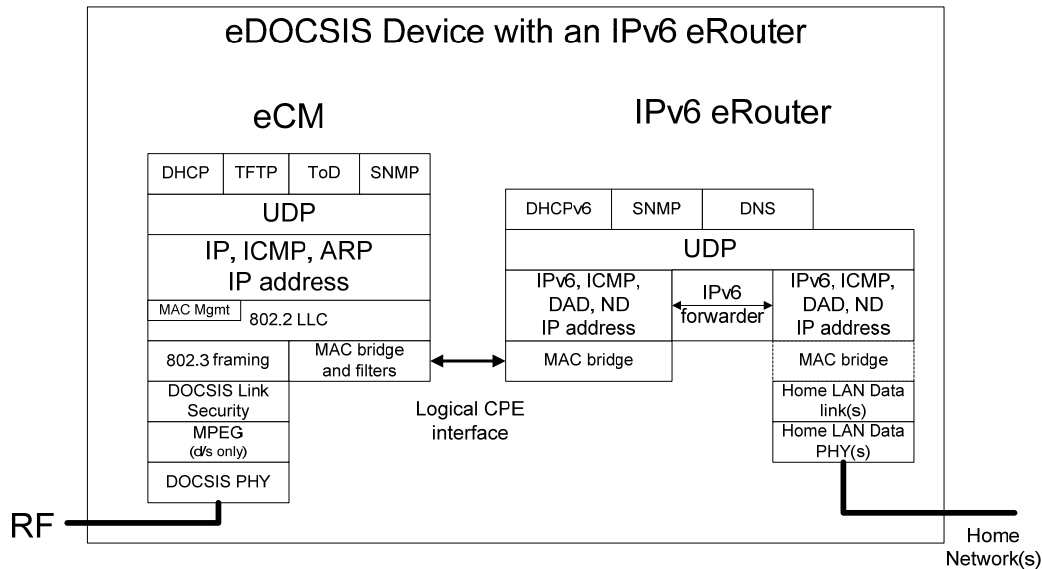


Figure 5-2 - Logical Components of an eDOCSIS device with an IPv6 eRouter

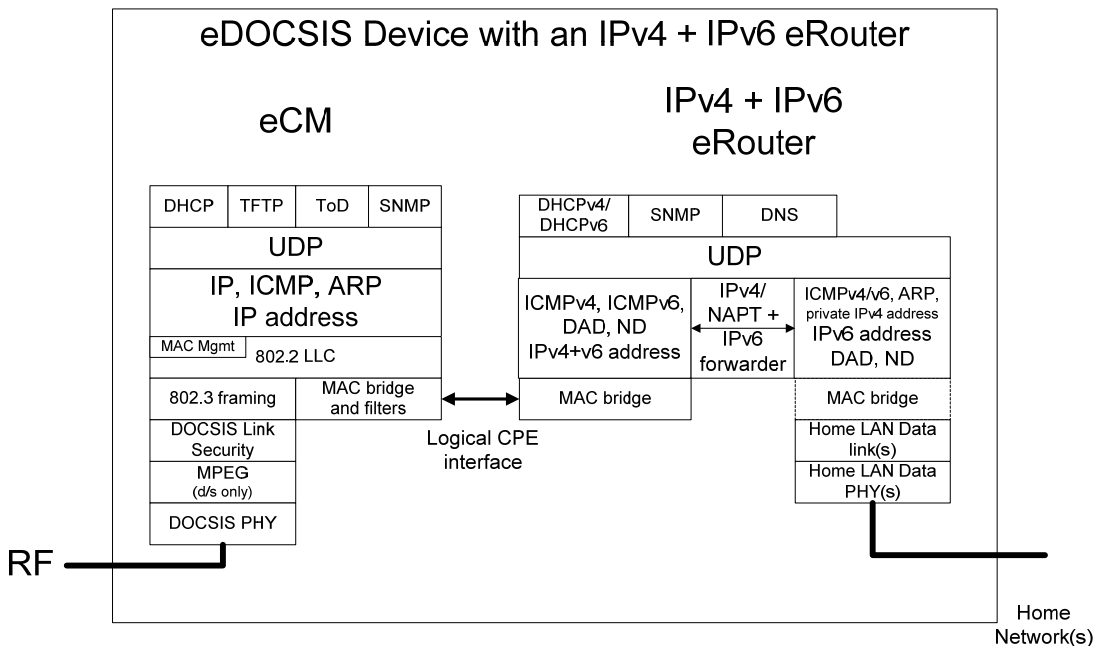


Figure 5-3 - Logical Components of an eDOCSIS device with an IPv4 + IPv6 eRouter

The primary function of the eRouter device is allow subscribers to connect multiple CPE devices to the operator provided DOCSIS high-speed internet service. DOCSIS specifications allow subscribers to directly connect multiple CPE devices to the Cable Modem; however, that requires operators to provide provisioning to each of the CPE devices. The eRouter takes over the provisioning aspect of multiple CPE devices at the subscriber end.

Depending on which version of the eRouter is included with the eDOCSIS implementation, the eRouter allows provisioning of IPv4 CPEs, IPv6 CPEs or both IPv4 and IPv6 CPEs simultaneously.

This document defines the core set of functions that are performed by the eRouter however in most implementations vendors would include additional features that would enhance the eRouter device. This may include additional home-networking features as well as the ability to provision and manage the eRouter from the subscriber side.

The standard defines a) CPE provisioning with IPv4 and IPv6 addresses, b) IPv4 data forwarding with NAT and IPv6 data forwarding, c) Ability to forward IP Multicast traffic and d) Preserve IP QoS markings on IP data to and from the CPE devices.

This standard uses the terms Customer-Facing Interface and Operator-Facing Interface as defined in the Terms and Definitions.

This standard defines requirements for an eRouter device with a single Operator-Facing IP Interface. This document defines requirements for an eRouter device with a single Customer-Facing logical IP Interface which is not necessarily mapped one-to-one to with the number of Customer-Facing ports on the eRouter. Though it is possible that an eRouter could have multiple Customer-Facing IP interfaces, it is vendor specific how to forward traffic between Customer-Facing Interfaces and the Operator-Facing IP Interface when there are multiple Customer-Facing IP interfaces.

6 eROUTER INITIALIZATION

Prior to its initialization, the eRouter is enabled or disabled through the TLVs in Annex B. The eRouter may operate in any one of four possible modes – Disabled, IPv4 Protocol Enabled, IPv6 Protocol-Enabled or Dual IP Protocol-Enabled, summarized in Table 1. The eRouter MUST support the Disabled Mode and at least one other Mode. The eRouter MAY support the IPv4 Protocol Enabled Mode. The eRouter MAY support the IPv6 Protocol Enabled Mode. The eRouter MAY support the Dual IP Protocol Enabled Mode.

Table 6-1 - eRouter Modes

Mode	IPv4	IPv6
Disabled	CM bridges all traffic per MULPI spec.	CM bridges all traffic per MULPI spec.
IPv4 Protocol Enabled	eRouter forwards IPv4 traffic with NAPT.	eRouter does not forward IPv6 traffic.
IPv6 Protocol Enabled	eRouter does not forward IPv4 traffic.	eRouter forwards IPv6 traffic.
Dual IP Protocol Enabled	eRouter forwards IPv4 packets using NAPT.	eRouter forwards IPv6 packets.

In Disabled Mode, the eRouter transparently forwards all traffic directly between its Customer-Facing Interface and its Operator-Facing Interface. In this mode, it appears as if there is no eRouter present. The CM bridges all traffic (regardless of IP protocol version) to the CPE ports that would have been behind the eRouter had it been enabled. In this mode, the eRouter specification is irrelevant – the interfaces become part of the cable modem. All behavior will occur according to the DOCSIS specifications.

When configured to operate in IPv4 Protocol Enabled Mode, the eRouter performs IPv4 provisioning and forwards IPv4 traffic between its Customer-Facing Interface and its Operator-Facing Interface. The eRouter operating in IPv4 Protocol Enabled Mode will not perform any IPv6 provisioning. An eRouter configured to operate in IPv4 Protocol Enabled Mode will not forward any IPv6 traffic. The IPv4 traffic is forwarded using NAPT according to section 9.

When configured to operate in IPv6 Protocol Enabled Mode, the eRouter performs IPv6 provisioning and forwards IPv6 traffic between its customer-facing interface and its operator-facing interface. The eRouter operating in IPv6 Protocol Enabled Mode will not perform any IPv4 provisioning. An eRouter configured to operate in IPv6 Protocol Enabled Mode will not forward any IPv4 traffic.

In Dual IP Protocol Enabled Mode, the eRouter is configured to forward both IPv4 and IPv6 traffic between its customer-facing interface and its operator-facing interface. IPv4 traffic is forwarded using NAPT, according to section 9. IPv6 traffic is forwarded according to section 10.

7 IPV4 PROVISIONING

The normative requirements of this section are mandatory for an eRouter that implements the IPv4 Protocol Enabled Mode and/or the Dual IP Protocol Enabled Mode as defined in section 6.

After the CM has completed provisioning, if the eRouter is configured to route IPv4 packets, the eRouter **MUST** use DHCPv4 [RFC 2131] via its Operator-Facing Interface in order to obtain an IP address and any other parameters needed to establish IP connectivity, as illustrated in Figure 7-1.

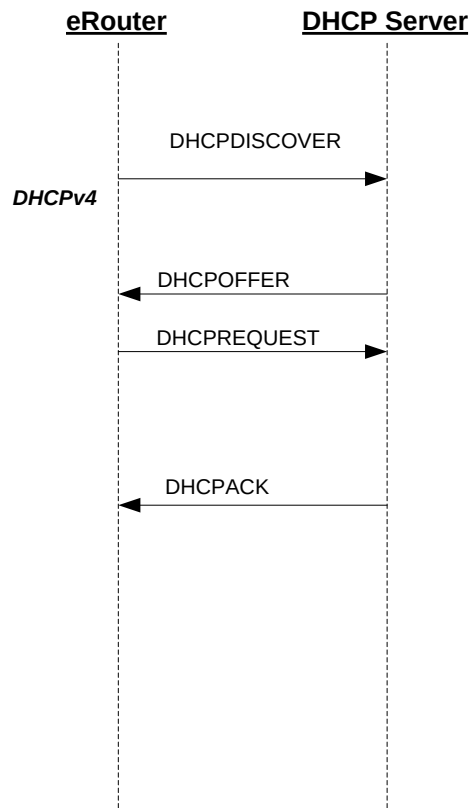


Figure 7-1 - IPv4 Provisioning Message Flow

The eRouter may receive multiple DHCPOFFER messages in response to its DHCPDISCOVER message. If a received DHCPOFFER message does not include all of the required DHCPv4 fields and options as described in section 7.1, the eRouter **MUST** discard the DHCPOFFER message and wait for another DHCPOFFER message. If none of the received DHCPOFFER messages contain all the required DHCPv4 fields and options, the eRouter **MUST** retransmit the DHCPDISCOVER message.

The backoff values for retransmission of DHCPDISCOVER messages **SHOULD** be chosen according to a uniform distribution between the minimum and maximum values in the rows of Table 7-2.

Table 7-2 - eRouter DHCP Retransmission Interval

Backoff Number	Minimum (sec.)	Maximum (sec.)
1	3	5
2	7	9
3	15	17
4	31	33
5	63	65

The eRouter SHOULD also implement a different retransmission strategy for the RENEWING and REBINDING states, as recommended in [RFC 2131], which is based on one-half of the remaining lease time.

The eRouter MUST limit the number of retransmissions of the DHCPDISCOVER and DHCPREQUEST messages to five or fewer. The eRouter MUST NOT forward IPv4 traffic between its Customer-Facing Interface and its Operator-Facing Interface until it has completed IPv4 provisioning, including the successful receipt of a DHCPACK message. The eRouter MUST NOT forward IPv4 traffic if, at any time, it does not have an IPv4 address for its Operator-Facing Interface.

The eRouter MUST be able to accept a unicast response from the DHCP server/relay agent.

[RFC 3203] describes an extension to DHCPv4 that allows a server to send a FORCERENEW message that forces a client to renew its lease. The eRouter MUST ignore all received FORCERENEW messages.

7.1 DHCPv4 Fields Used by the eRouter

The eRouter MUST include the following fields in the DHCPDISCOVER and DHCPREQUEST messages:

- The hardware type (htype) MUST be set to 1.
- The hardware length (hlen) MUST be set to 6.
- The client hardware address (chaddr) MUST be set to the 48 bit MAC address associated with the IPv4 CM-facing interface of the eRouter.
- The Broadcast bit MUST NOT be set.
- The client identifier option MUST be included, using the format defined in [RFC 4361].
- The parameter request list option MUST be included. The following option codes (defined in [RFC 2132] and [RFC 4361]) MUST be included in the list:

Option code 1 (Subnet Mask)

Option code 3 (Router Option)

Option code 6 (DNS Server Option)

Option code 60 (Vendor Class Identifier) [eRouter1.0]

Option Code 43 (see [SCTE 107])

Option 55 Parameter Request List