DOCSIS 3.0 USCB

2010.5.14

USCB Overview 12.2.33SCC

DOCSIS 3.0 Upstream Channel Bonding

- Bonds multiple, physical upstream transmit channels to form a larger, logical upstream channel.
- DOCSIS 3.0 required that CM must have 4 or more upstream channel transmitters. This translates into the possibility of 100Mbps+ upstream rate…
- Removed DOCSIS 2.0/1.x single request-grant cycle bottleneck.
- Bonded Flows allow multiple outstanding BW-REQ.
- BW can be requested on any of the bonded upstream channels
- Requests can be granted on any of the bonded upstream channels
- Reduced upstream latency (TCP ACK) also increases DS throughput. [TCP application]

Upstream channel bonding terms

- SID Cluster - A group of SIDs containing one and only one SID for each upstream channel within an upstream bonding group and treated the same from a request/grant perspective.
- SID Cluster Group - The set of all SID Clusters associated with a specific service flow.
- MTC Mode - Multi-transmit channel mode.
- Transmit Channel Configuration

  TLV settings in Registration and DBC MAC Management Messages

  Define operations such as addition, deletion, change, replacement, or re-ranging of one or more upstream channels in the Transmit Channel Set of a cable modem.
- Transmit Channel Set

  Set of upstream channels that a CM is configured to use for upstream transmission

  Each upstream service flow of the cable modem may be associated with some or all of the channels in the Transmit Channel Set (TCS)

  The TCS of a cable modem is conveyed from a CMTS to a cable modem through the Transmit Channel

  Configuration (TCC) field in the Registration Response message

Upstream channel bonding terms

- Upstream Service Group

  The complete set of Upstream Channels (UCs) within a single CMTS potentially reachable by the transmission of a single Cable Modem

  In an HFC deployment, a USSG corresponds to the physical combining of the upstream reverse carrier path signal from one or more Fiber Nodes reaching a single CMTS.

- MAC Domain Upstream Service Group

  The subset of an Upstream Service Group (US-SG) which is confined to the Upstream Channels of a single MAC Domain

  An MD-US-SG differs from a US-SG only when multiple MAC domains are defined per US-SG.

- T4 Timeout Multiplier

  Value added by CMTS to RNG-RSP messages to modems in MTC mode.

  Helps reduce overhead associated with scheduling RNG-REQ slots and processing RNG-RSP messages

- CCF – Continuous Concatenation and Fragmentation

- Ambiguity Resolution

Legacy Request/Grant Mechanism

- The CM requests for either a single packet or a concatenation of packets
- Once the CM has transmitted a request, it must wait until it receives a grant allocating all of that bandwidth before requesting additional bandwidth for that same service flow.
- These restrictions attempt to prevent the CM and CMTS from getting out of request/grant alignment under most circumstances.
- The request is in mini-slots including the physical layer overhead.
- The request size is limited to 255 mini-slots due to the 1-byte length field.
- The maximum bandwidth per flow is limited by request/grant latency since the CM can have only one request outstanding per service flow.
- With an upstream throughput potential of 100Mbps, the CM needs to request more bandwidth within a given timeframe than possible with legacy requesting mechanisms.

Multiple Transmit Channel Mode Request Mechanism

- Multiple Transmit Channel Mode uses a larger request field with provisionable granularity
  - Need to be able to request for more bandwidth in a single request
  - Programmable to allow tradeoff of granularity vs. request field length
- The CM requests for queue depth.
- Legacy requesting in mini-slots including the PHY overhead is not efficient for multiple channel operation.
  - For multiple upstream channels, the CMTS would have to convert the mini-slot with PHY overhead request back to a MAC-layer byte estimation and then reconvert to mini-slots on the selected upstream channel(s) using the burst parameters on the selected channel(s).
  - Estimation error exists due to rounding to the nearest mini-slot and filling FEC codewords or shortened last codewords.
- The CM request is in bytes (or multiples of bytes).
  - Multiplier configured per service flow (default of 4)
  - CM's request does not include PHY overhead.
  - Requesting in bytes without the PHY overhead removes estimation errors when granting on channels other than requesting channel.
- The CM can have more than one request outstanding per flow. This is called "multiple requests outstanding".

Multiple Outstanding Requests

- Without a heavy penalty for the mismatch between requests and grants, the CM can request additional bandwidth before the previous request is granted in full.
- The CM can piggyback for NEW packets at any time (only restricted by service flow parameters).
- To determine when to re-request, the CM monitors the ACK time (as in legacy DOCSIS) to determine if the CMTS should have received the request. If the ACK time “expired” and no grant pending is present, the CM re-requests and is free to include bandwidth for any NEW packets.
- The net effect is to allow multiple requests outstanding without requiring each and every outstanding request to be on a different SID.

Why Multiple Requests Outstanding?

- Multiple Requests Outstanding removes issues regarding request arrival time vs. MAP creation time.

  Without multiple requests outstanding, if a request arrives immediately after MAP creation, the CM can end up getting a grant every other MAP.

  With multiple requests outstanding, the CMTS has more requests pending for the CM and can send a grant every MAP.

- Multiple Requests Outstanding allows the CM to send enough requests to fill the bonded upstream providing the QoS parameters allow this.

- Multiple Requests Outstanding allows the CMTS a more up-to-date view of bandwidth requirements even when sending partial grants.

  The CMTS doesn't have to fully satisfy previous requests before seeing next requests.

- Multiple Requests Outstanding matches the bursty nature of upstream traffic.

  As soon as the CM has more traffic to send, it transmits a piggyback request for new bandwidth.

SID Clusters

- DOCSIS uses a Service Identifier (SID) in the bandwidth allocation messages (MAPs) to identify which service flow on which CM may use the allocated bandwidth.
- In order to simplify the CMTS for multiple upstream channel support, a service flow may be assigned a different SID for each upstream channel.
- A set of SIDs used to represent a service flow across all channels within a bonding group is called a SID Cluster.

SID Cluster	US#1 SID	US#2 SID	US#3 SID	US#4 SID
Cluster_0	58	479	85	1001

- The SID assigned to a service flow must be unique for its corresponding channel.

SID Cluster	US#1 SID	US#2 SID	US#3 SID	US#4 SID
Cluster_0	22	58	22	65

- A service flow must have at least one SID Cluster but may have more than one.

Legacy Upstream Bandwidth Scheduling

- The upstream is TDMA, ATDMA, or sCDMA, all of which state multiple access
  - The upstream is defined in terms of minislots.
  - A mini-slot is a specified number of bytes, typically 16.
- The CMTS provides a MAP that describes which minislot is owned by which SID and for what purpose.
  - MAPs are sent ahead of time (“Map Advance Time”). Typically 5 ms.
  - MAPs represent a period of time. Typically 2 ms.
  - MAPs also contain the backoff parameters for contention slots (request and ranging)
- Less MAP advance time and shorter MAPs provide a shorter REQ-GNT round trip time, and this higher upstream throughput per CM

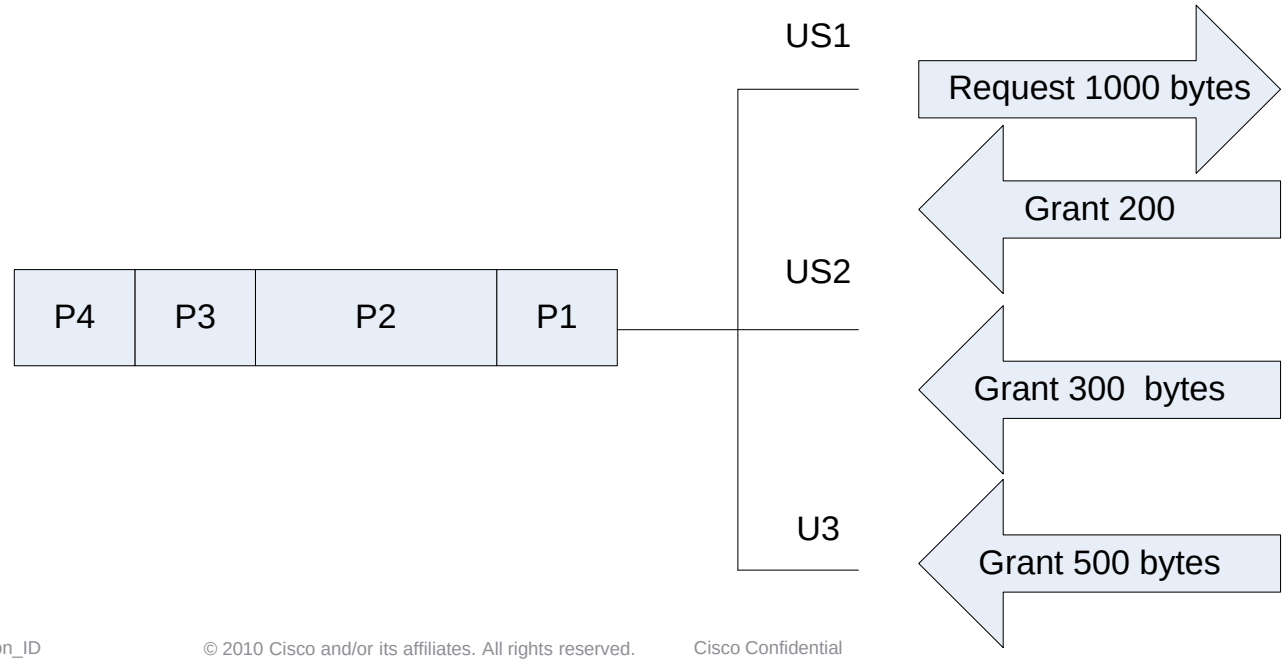
D3.0 Upstream Channel Bonding

- Upstream bonding

  Single flow can consume all BW on multiple USs

- Continuous Concatenation & Fragmentation (CCF)

  Improved form of concatenation and fragmentation that is needed for DOCSIS 3.0 operation



Upstream MAC: Channel Bonding

- CMTS is free to use all burst profiles for data

  Thanks to CCF, and to the fact that requests are made in bytes, the CMTS is free to use any IUC to grant data (IUC5,6,9,10,11) – this opens the path to new forms of spectrum management and reduces the need for logical channels.

- The CMTS will also use SID Clusters

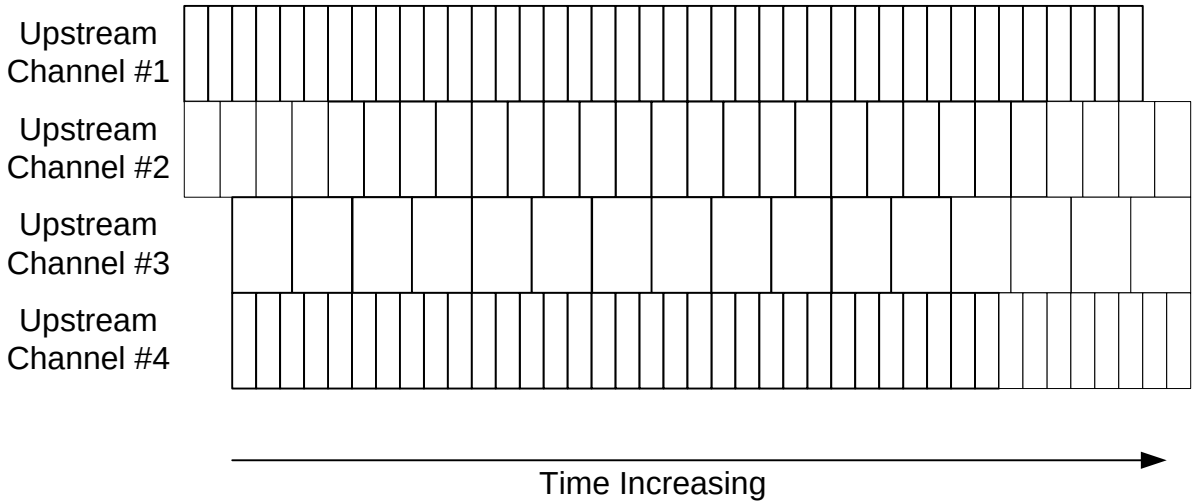
  The CMTS is NOT required to assign the same SID numbers across all upstreams. This set of those single SIDs that are spread across the upstreams is called a “SID Cluster”

- SID Cluster Group

  A group of several SID clusters used to request bandwidth

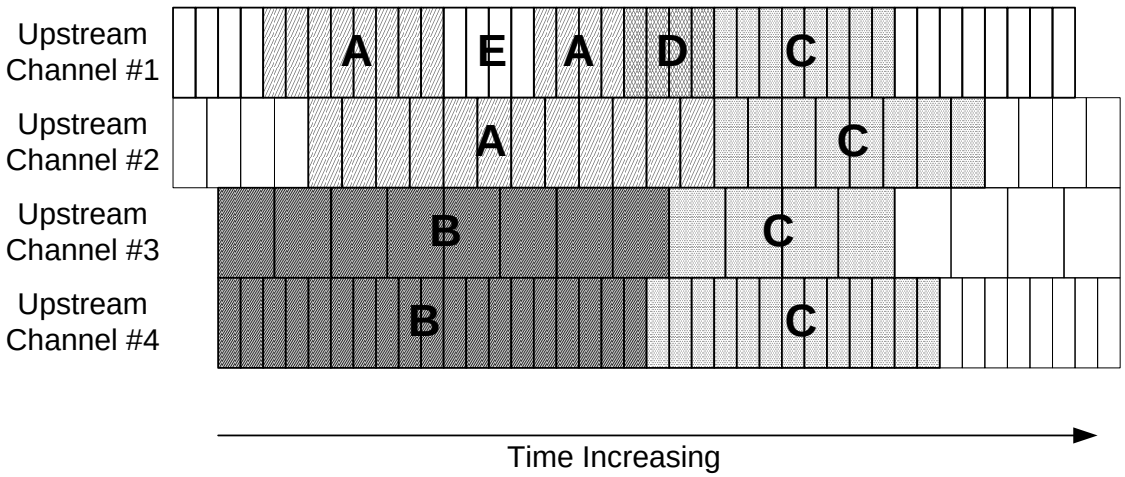
- Requests made based on bytes, not minislots.

How Do We Split the Traffic?



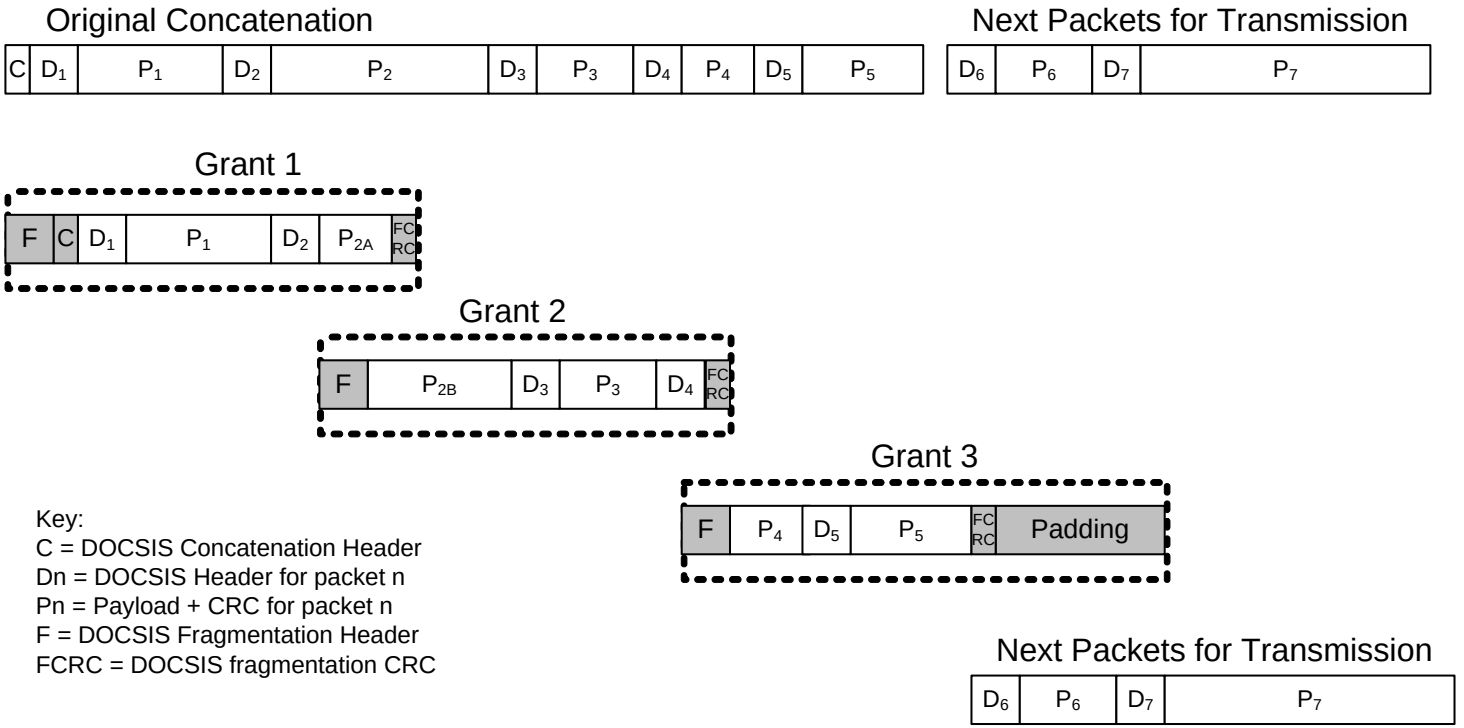
- The upstream is a shared medium where spectrum is shared in time with TDMA or space with SCDMA.
- Each upstream channel may have different properties (TDMA/SCDMA, data rate, mini-slot size, etc.)
- Each burst requires a preamble for the CMTS receiver to acquire signal.
- Protocol must support small bursts as well as longer bursts.
- Dynamic bandwidth assignment is required due to the bursty nature of the traffic.

Basic Traffic Segmentation



- Traffic is divided into segments where a segment is a grant of a contiguous block of mini-slots on a particular channel using a particular burst profile. (Same as a grant in legacy DOCSIS.)
- Traffic for a service flow can be sent on any number of channels within the bonded group.
- The CMTS controls the location of the segments.
- The CMTS has the freedom to put segments on any channels associated with the service flow.

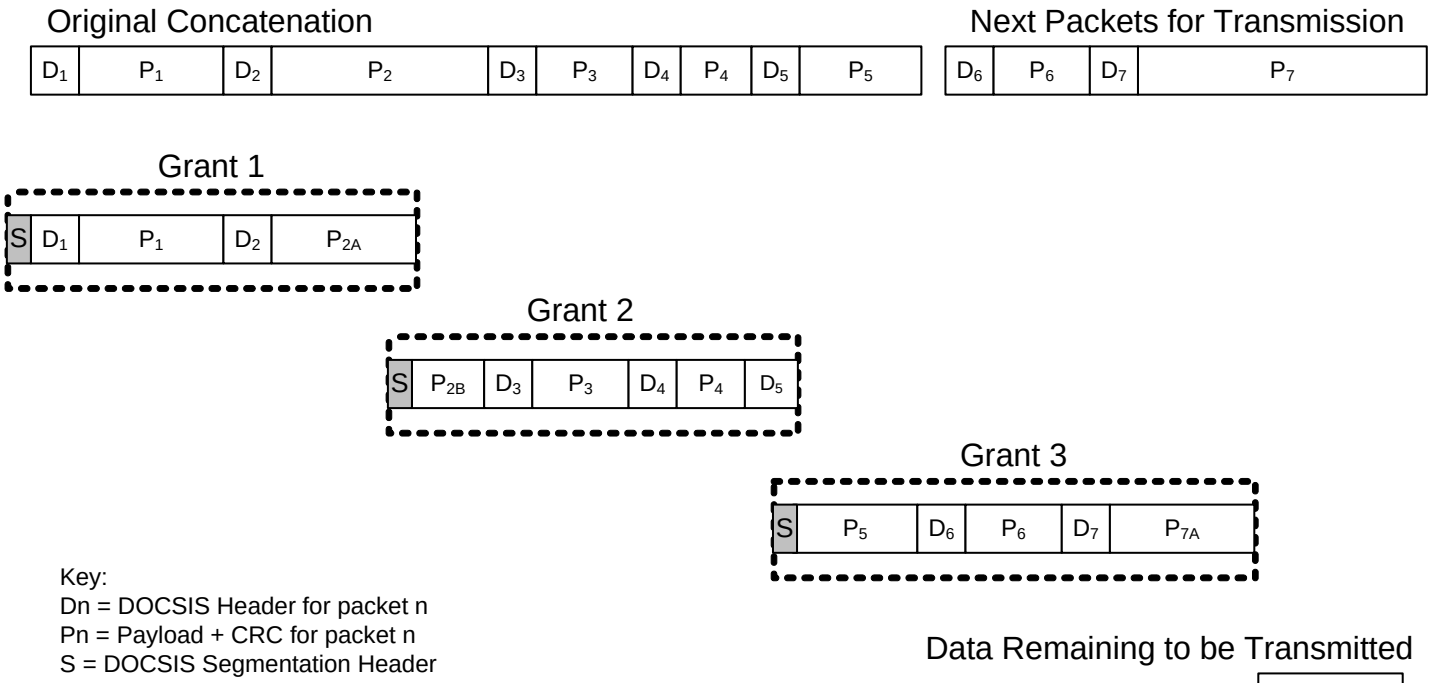
Legacy DOCSIS Concat & Frag



- Legacy DOCSIS encapsulates each fragment with a fragment header and fragment CRC adding 16 bytes to each fragment.
- Multiple packets can only be combined through concatenation.
- Fragments cannot be combined with other fragments or whole PDUs in a burst.
- Inefficient whenever packets are split across grants.

CCF with Segment Headers

- With this continuous stream of traffic, the CMTS MAC will need a mechanism to find packet boundaries in the event that a burst is lost.
- The use of segment headers for dividing traffic provides a more efficient mechanism than the legacy encapsulation of fragments.
- The segment header contains a sequence number and a pointer that points to the first DOCSIS header within the segment.



Segment Header

PFI (1bit)	R (1bit)	Pointer Field (14 bits)	Sequence # (13 bits)	SC (3 bits)	Request (2 Bytes)	HCS (2 Bytes)

- CCF operates on a segment basis
- a segment is an individual data grant to a service flow
- CCF packs the grants with data in a streaming manner
- The segmentation with CCF is performed on a per-service flow basis

Segment Header OFF operation

- Segment headers add unnecessary overhead for applications such as UGS where packets should never span segment boundaries.
- For this reason, the use of segment headers can be disabled on a service flow basis.
- Segment Header Off operation allows the use of continuous concatenation, but not fragmentation so that packets do not span segment boundaries.
- Segment Header Off operation is limited to single channel operation because it does NOT guarantee packet ordering across channels. (No sequence number for re-sequencing at the CMTS!)

Segment Header OFF

Request/Transmission Policy

Bit #9 The Service Flow MUST NOT use segment headers. When set to zero, the Service Flow MUST use segment headers

```
uBR10K#scm 10.1.21.5 qos ver
Sfid                                  : 76
Current State                          : Active
Sid                                   : 38
Minimum Packet Size                        : 0 bytes
Admitted QoS Timeout                       : 200 seconds
Active QoS Timeout                         : 0 seconds
Scheduling Type                            : Unsolicited Grant Service
Unsolicited Grant Size                     : 232 bytes
Nominal Grant Interval                     : 20000 usecs
Grants per interval                        : 1
Tolerated Grant Jitter                     : 2000 usecs
Request/Transmission policy                : 0x21F
IP ToS Overwrite[AND-mask, OR-mask]     : 0xFF, 0x0
Current Throughput                         : 0 bits/sec, 0 packets/sec
```

```
uBR10K#sh int c5/0/0 service-flow
Sfid  Sid   Mac Address     QoS Param Index   Type  Dir   Curr    Active   DS-Forwlf/
                            Prov  Adm  Act                State   Time     US-BG/CH

73    35    001a.c3ff.e4ce  5     6    6       P     US    act     01:18    BG 500
76    38    001a.c3ff.e4ce  7     8    8       S(s)  US    act     01:18    CH 1
74    N/A   001a.c3ff.e4ce  9     10   10      P     DS    act     01:18    Wi5/0/0:0
```

UGS & UGS-AD only

Initialization

SG Discovery and Initial ranging

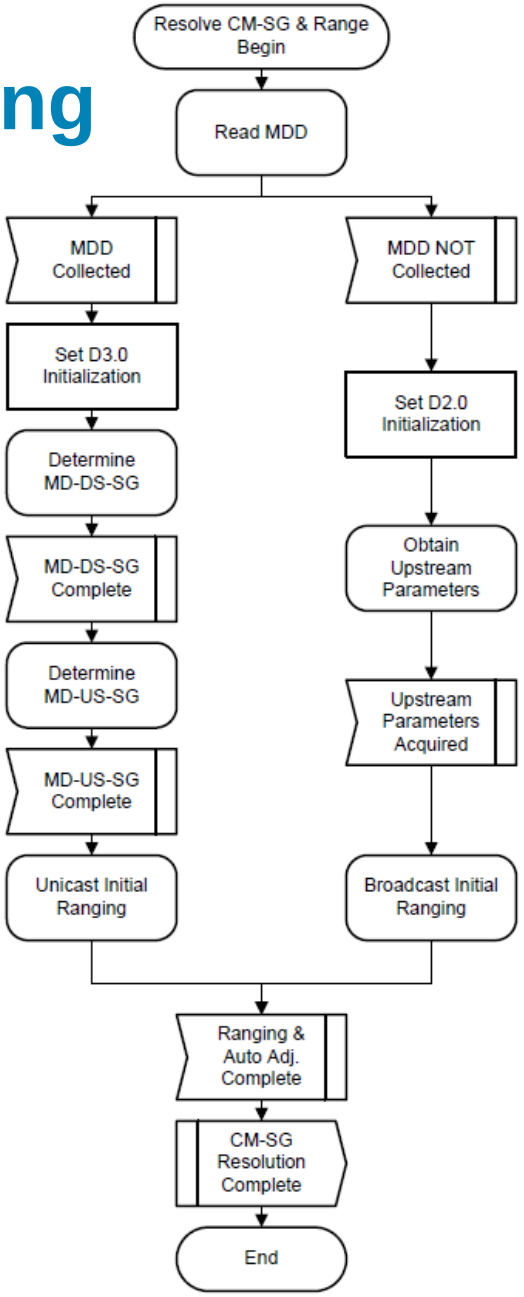
CM MUST attempt to determine its MAC Domain Downstream Service Group ID (MD-DS-SG-ID) if an MDD is present on the downstream.

If successful, the CM MUST provide the MD-DS-SG-ID it has selected to the CMTS in the Bonded Initial Ranging Request (B-INIT-RNG-REQ) message.

If the CM could not determine its MD-DS-SG-ID then it MUST send a B-INIT-RNG-REQ with the MD-DS-SG-ID set to zero.
The CMTS replies to the B-INIT-RNG-REQ with a RNG-RSP message.

In order to resolve the upstream service group (MD-US-SG) associated with this CM, the CMTS may include an Upstream Channel Adjustment in this RNG-RSP message.

If this occurs, the CM MUST tune to the new channel and sends an Initial Ranging Request (INIT-RNG-REQ) message. The CMTS responds with a RNG-RSP message, possibly including another Upstream Channel Adjustment.



MDD US Topology resolution

- Active Upstream Channel List
- Upstream Ambiguity Resolution Channel List
- Upstream Frequency Range

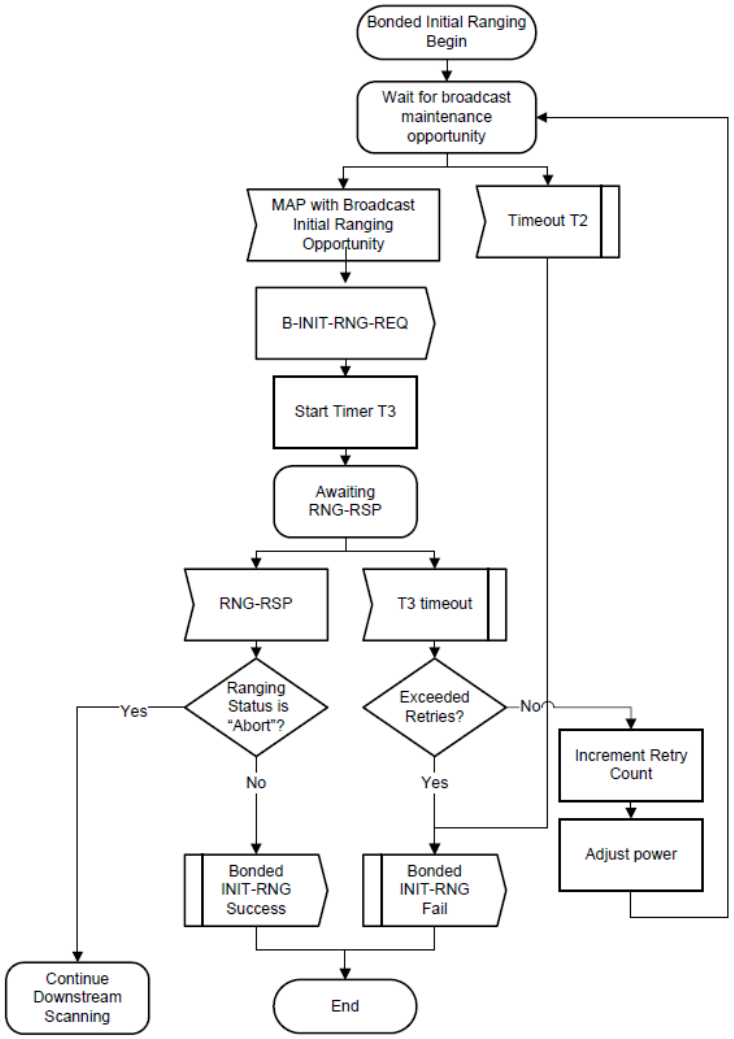
Table 6–42 - Field definitions for Active Upstream Channel List TLV

Type	Length	Value
7	Total number of bytes (including type and length) contained in all sub-TLVs	Contains sub-TLVs as defined in Table 6–43. Each sub-TLV has a one-byte "type" field and one-byte "length" field.

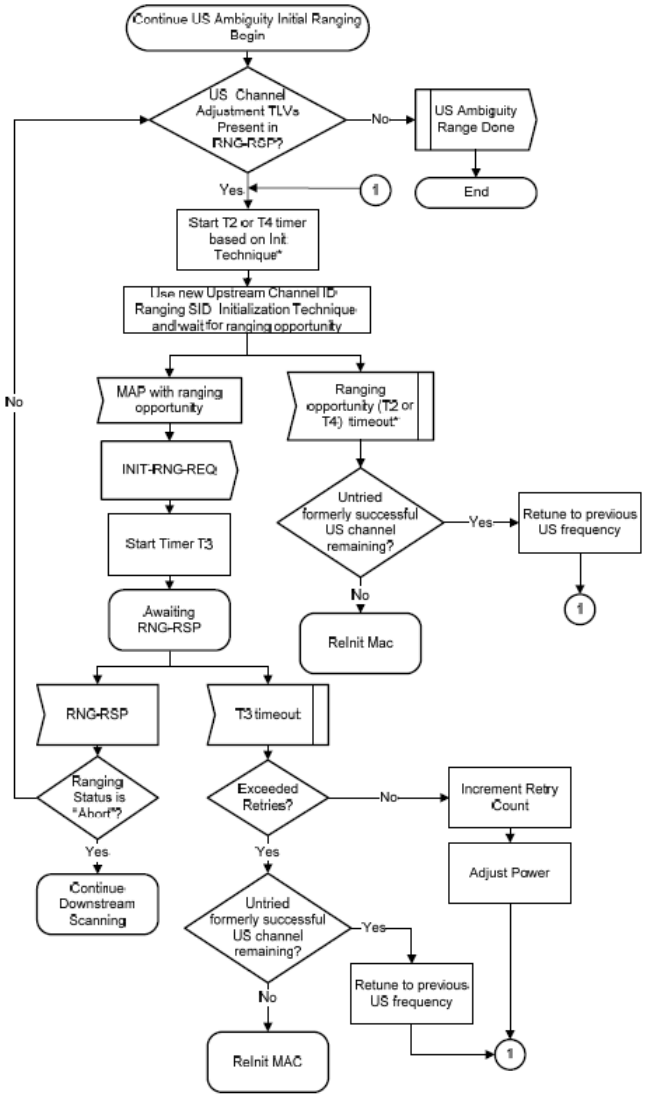
Table 6–43 - Sub-TLVs for Active Upstream Channel List TLV[131]

Type	Length	Value
7.1	1	The upstream channel ID for a channel being listed.
7.2	2	CM-STATUS Event Enable Bitmask: 2 bytes. Each bit in this field represents the enable/disable for a particular event for which status may be reported via the CM-STATUS message. If a bit is 1, CM-STATUS reporting is enabled for the corresponding event. The CMTS MAY include this TLV. If a bit is zero, CM-STATUS reporting is disabled for the corresponding event. If the TLV is omitted, then all events listed below are disabled. The details of CM-STATUS message functionality are described in Section 10.4.3. The following bit fields are defined: 0 - Reserved (unused) 1-2 - Reserved (used for downstream specific events) 3 - Reserved (used for non-channel-specific events) 4-5 - Reserved (used for downstream specific events) 6 - T4 timeout 7 - T3 re-tries exceeded 8 - Successful ranging after T3 re-tries exceeded 9-10 - Reserved (used for non-channel-specific events) 11-15 - Reserved for future use[132]

Ranging



Bonded Initial Ranging



Continuous Ambiguity Initial Ranging

Ranging Changes

- With Multiple Transmit Channel Mode, a Ranging SID is assigned to the CM for each upstream channel. This ranging SID may or may not be one of the SID values already assigned to a SID Cluster for the CM.
- With Multiple Transmit Channel Mode, there are topologies where the ranging characteristics of a CM using one channel should be very similar to that same CM using a different channel.
- Similarly, with Multiple Transmit Channel Mode, there may be occasions when the CMTS sees a ranging adjustment is needed on one channel and the CMTS knows that a similar adjustment would be needed on another channel as well.
- To facilitate this, the ranging parameters were expanded to include a reference channel, and timing, power, and frequency offset adjustments for another channel.

Registration

•The CM sees REG-RSP message with a Transmit Channel Configuration.

•The CM begins storing MAPs and UCDs for the channels in the TCC, and attempts to range (using separate transmitters) on these channels.

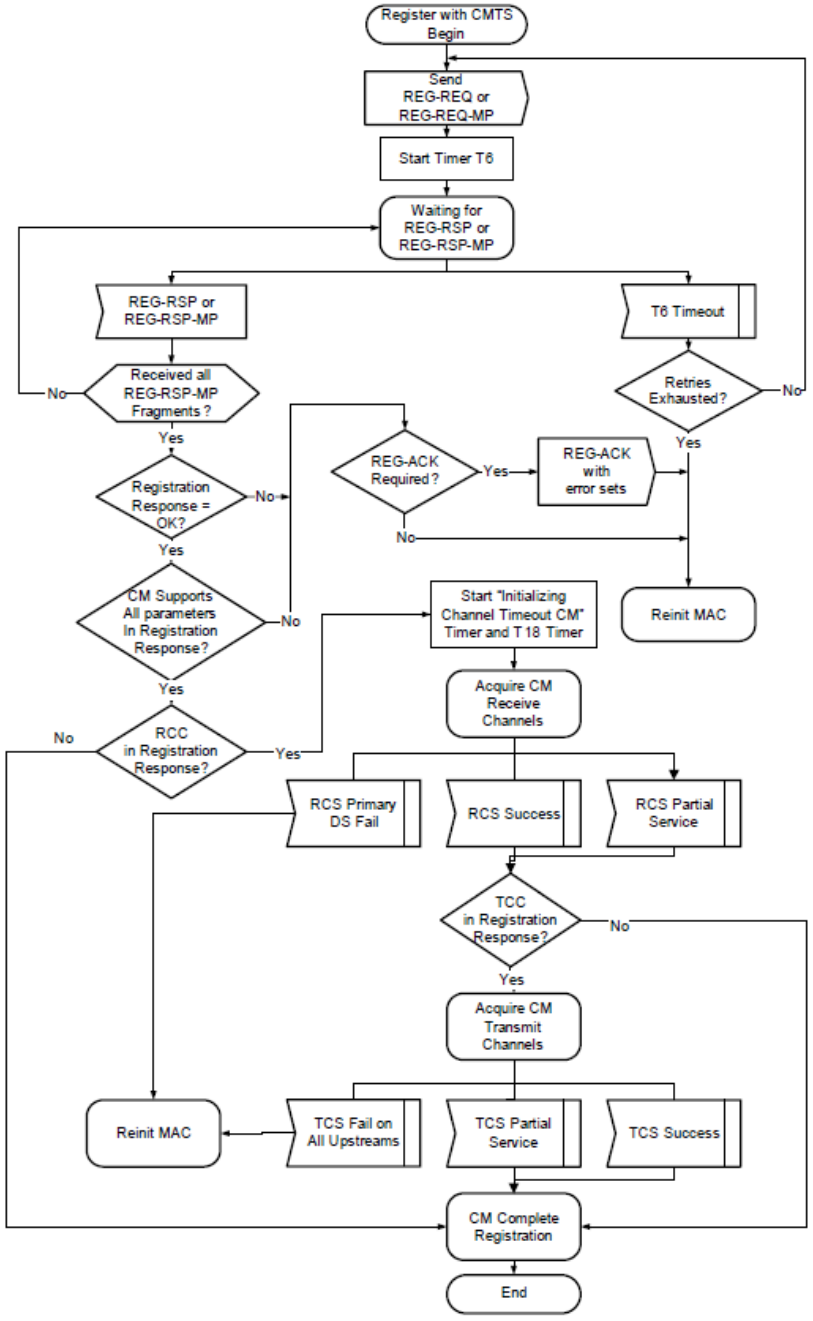
•Once the CM has completed its attempts to range on all channels in the TCC, the CM checks to see if Multiple Transmit Channel Support is Enabled in the REG-RSP.

If Multiple Transmit Channel Mode is not enabled, the CM continues operating in legacy upstream mode and sends a legacy request for the bandwidth to transmit the REG-ACK.

If Multiple Transmit Channel Mode is enabled, the CM switches operation to using queue-depth based requesting and segmentation beginning with the request for bandwidth for transmitting the REG-ACK. When the grant arrives, the CM uses segmentation to transmit the REG-ACK.

•The CMTS waits for a queue-depth based request from the CM in Multiple Transmit Channel Mode. If it receives a legacy request from the CM, it ignores it.

•The CMTS sees a queue-depth based request from the CM, grants the request using Multiple Transmit Channel Mode, and the CM sends up the REG-ACK.



Debug registration

May 6 22:14:09.114: Found Modem Capabilities TLV
May 6 22:14:09.114: Concatenation Support : 1
May 6 22:14:09.114: DOCSIS Version : 3
May 6 22:14:09.114: Fragmentation Support : 1
May 6 22:14:09.114: Payload Header Suppresion Support : 1
May 6 22:14:09.114: Privacy Support : 1
May 6 22:14:09.114: Downstream SAID Support : 24
May 6 22:14:09.114: Upstream SID Support : 8
May 6 22:14:09.114: Tx Equalizer Taps Per Symbol : 1
May 6 22:14:09.114: Tx Equalizer Taps Support : 24
May 6 22:14:09.114: DCC Support : 1
May 6 22:14:09.114: Expanded Unicast SID Support rejected
May 6 22:14:09.114: Ranging Holdoff Support : 0x1
May 6 22:14:09.114: L2VPN Support : 0
May 6 22:14:09.114: US Freq Band Support : 0
May 6 22:14:09.114: US Symbol Rate Support : 56
May 6 22:14:09.114: Selectable Active code Support rejected
May 6 22:14:09.114: Code Hopping mode Support rejected
May 6 22:14:09.114: US MTC_MODE Support : 4
May 6 22:14:09.114: US MTC_MODE_512 Support : 4
May 6 22:14:09.114: US MTC_MODE_256 Support : 4
May 6 22:14:09.114: MAX_SID_CLUST Support : 40
May 6 22:14:09.114: MAX_SID_CLUST_PER_SF Support: 2
May 6 22:14:09.114: DS Receive Support : 4
May 6 22:14:09.114: Max DSID Support : 32
May 6 22:14:09.114: Max Resequence Context Support : 16
May 6 22:14:09.114: Max Num of Multicast DSID Support : 24
May 6 22:14:09.114: Multicast DSID Forwarding Mode Support : 2
May 6 22:14:09.114: FCType 10 Forwarding Support : 1
May 6 22:14:09.114: Docsis Path Verify Support rejected
May 6 22:14:09.114: Max USG service flow support : 24
May 6 22:14:09.114: Map UCD Receipt Support : 1
May 6 22:14:09.114: Upstream Drop Classifier Support : 64
May 6 22:14:09.114: IPv6 Support : 1

May 6 22:14:09.114: Vendor Id:
May 6 22:14:09.114: 0x0000: 00 40 7B
May 6 22:14:09.114: Found RCP TLV
May 6 22:14:09.114: RCP ID:
May 6 22:14:09.114: 0x0000: 00 10 00 00 02
May 6 22:14:09.114: Found RCP TLV
May 6 22:14:09.114: RCP ID:
May 6 22:14:09.114: 0x0000: 00 10 00 00 03
May 6 22:14:09.114: Found RCP TLV
May 6 22:14:09.114: RCP ID:
May 6 22:14:09.114: 0x0000: 00 10 00 00 04
May 6 22:14:09.114: Found RCP TLV
May 6 22:14:09.114: RCP ID:
May 6 22:14:09.114: 0x0000: 00 10 00 00 05

May 6 22:14:09.114: Selected RCC 1 with total current cms 6 for Cable5/0/0 4 channel modem 001a.c3ff.e3d4, (4 rcc rfs) BG 257
May 6 22:14:09.114: Performing admission control check for MTC CM 001a.c3ff.e3d4
May 6 22:14:09.114: Assign the candidate TCS to 001a.c3ff.e3d4: 0xF
May 6 22:14:09.134: 0x0280: 02 02 00 27 03 01 01 03 13 01 01 01 02 04 00 00
May 6 22:14:09.134: 0x0290: 00 00 03 04 00 00 00 00 04 02 00 00

```
May  6 22:14:11.482: Found RCC TLV ...
May  6 22:14:11.486: RCC ID:
May  6 22:14:11.486: 0x0000: 00 10 00 00 04
May  6 22:14:11.486:    RCC Module Index: 1
May  6 22:14:11.486:    RCC Module First Freq: 759000000
May  6 22:14:11.486:    RCC Channel Index: 1
May  6 22:14:11.486:    RCC Connectivity : 0x40
May  6 22:14:11.486:    RCC Center Freq: 759000000
May  6 22:14:11.486:    RCC Primary Chan Indicator: 1
May  6 22:14:11.486:    RCC Channel Index: 2
May  6 22:14:11.486:    RCC Connectivity : 0x40
May  6 22:14:11.486:    RCC Center Freq: 765000000
May  6 22:14:11.486:    RCC Primary Chan Indicator: 0
May  6 22:14:11.486:    RCC Channel Index: 3
May  6 22:14:11.486:    RCC Connectivity : 0x40
May  6 22:14:11.486:    RCC Center Freq: 771000000
May  6 22:14:11.486:    RCC Primary Chan Indicator: 0
May  6 22:14:11.486:    RCC Channel Index: 4
May  6 22:14:11.486:    RCC Connectivity : 0x40
May  6 22:14:11.486:    RCC Center Freq: 777000000
May  6 22:14:11.486:    RCC Primary Chan Indicator: 0
May  6 22:14:11.486: Found DSID TLV ...
May  6 22:14:11.486:    DSID: 524992
May  6 22:14:11.486:    Unrecognized DSID Encoding: Subtype:2 Len:1
May  6 22:14:11.486: DSID Resequencing: 1
May  6 22:14:11.486: Found DSID TLV ...
May  6 22:14:11.486:    DSID: 585729
May  6 22:14:11.486:    Unrecognized DSID Encoding: Subtype:2 Len:1
May  6 22:14:11.486:    Unrecognized DSID Encoding: Subtype:4 Len:6
```

```
May  6 22:14:11.486: Found TCC TLV
May  6 22:14:11.486:    TCC Reference ID 0
May  6 22:14:11.486:    TCC ACTION 2
May  6 22:14:11.486:    TCC US Channel ID 0
May  6 22:14:11.486: Found TCC TLV
May  6 22:14:11.486:    TCC Reference ID 1
May  6 22:14:11.486:    TCC ACTION 1
May  6 22:14:11.486:    TCC US Channel ID 2
May  6 22:14:11.486:    TCC Ranging SID 29
May  6 22:14:11.486:    TCC Init_Tech 1
May  6 22:14:11.486:    TCC Ranging Reference Channel ID 1
May  6 22:14:11.486:    TCC Timing Offset, Integer Part -256
May  6 22:14:11.486:    TCC Timing Offset, Fractional Part 0
May  6 22:14:11.486:    TCC Power Offset 0
May  6 22:14:11.486: Found TCC TLV
May  6 22:14:11.486:    TCC Reference ID 1
May  6 22:14:11.486: Found TCC TLV
May  6 22:14:11.486:    TCC Reference ID 2
May  6 22:14:11.486:    TCC ACTION 1
May  6 22:14:11.486:    TCC US Channel ID 3
May  6 22:14:11.486:    TCC Ranging SID 29
May  6 22:14:11.486:    TCC Init_Tech 1
May  6 22:14:11.486:    TCC Ranging Reference Channel ID 1
May  6 22:14:11.486:    TCC Timing Offset, Integer Part -256
May  6 22:14:11.486:    TCC Timing Offset, Fractional Part 0
May  6 22:14:11.486:    TCC Power Offset 0
May  6 22:14:11.486: Found TCC TLV
May  6 22:14:11.486:    TCC Reference ID 2
May  6 22:14:11.510: Found TCC TLV
May  6 22:14:11.510:    TCC Reference ID 3
May  6 22:14:11.510:    TCC ACTION 1
May  6 22:14:11.510:    TCC US Channel ID 4
May  6 22:14:11.510:    TCC Ranging SID 29
May  6 22:14:11.514: Update SFID 61 Designate SID to 29
May  6 22:14:11.514: Parsing CM's Reg Info Complete
May  6 22:14:11.514: Printing Upstream Info
May  6 22:14:11.514: For srv flow 0 SFID = 61
May  6 22:14:11.514: Printing Downstream Info
May  6 22:14:11.514: For srv flow 0 SFID = 62
```

Configuration and Commands

Fiber-Node

- Fiber-node CLI now must include upstream connector commands for Channel bonding
- Upstream connector command is expanded upon from legacy usage for shared spectrum groups
- If frequency stacking used, you only include the connectors you are actually using

```
!
cable fiber-node 50
  downstream Integrated-Cable 5/0/0 rf-channel 0-3
  upstream Cable 5/0 connector 0-3
!
```

Upstream Bonding Group / MTC mode

```
!
interface Cable5/0/0
 cable mtc-mode                                          /* enable USCB
 cable upstream bonding-group 500                        /* Configure Upstream Bonding group
  upstream 0
  upstream 1
  upstream 2
  upstream 3
  attributes 80000000                                    /* Default attribute – automatically created
 cable sid-cluster-group num-of-cluster 2                /* best practice for higher US throughput
 cable sid-cluster-switching max-request 1
 cable sid-cluster-switching max-outstanding-byte 0
 cable sid-cluster-switching max-total-byte 0
!
```

Show commands

Show cable modem

```
uBR10K#show cable modem
                                                          D
MAC Address    IP Address     I/F        MAC          Prim RxPwr  Timing Num I
                                         State        Sid  (dBmv) Offset CPE P
001a.c3ff.e3d4 10.1.21.12     C5/0/0/UB  w-online      29   0.00   1304   0   N
0023.be83.1c8a 10.1.21.15     C5/0/0/UB  w-online      30   0.00   1060   0   N
0022.ce9c.8398 10.1.21.8      C5/0/0/UB  w-online      32   -0.50  1301   0   N
001a.c3ff.e46a 10.1.21.9      C5/0/0/UB  w-online      33   0.00   1306   0   N
001a.c3ff.e4ce 10.1.21.5      C5/0/0/UB  w-online      35   -0.50  1305   0   N
```

Show cable modem wideband

```
uBR10K#show cable modem wideband
MAC Address    IP Address     I/F              MAC          Prim   RCC    MD-DS-SG/
                                               State        Sid    ID     MD-US-SG
001a.c3ff.e3d4  10.1.21.12     C5/0/0/UB        w-online     29     1      1 / 4
0023.be83.1c8a 10.1.21.15     C5/0/0/UB        w-online     30     1      1 / 4
0022.ce9c.8398 10.1.21.8      C5/0/0/UB        w-online     32     1      1 / 4
001a.c3ff.e46a  10.1.21.9      C5/0/0/UB        w-online     33     1      1 / 4
001a.c3ff.e4ce  10.1.21.5      C5/0/0/UB        w-online     35     1      1 / 4
```

Show cable mac-domain upstream-service-group

```
uBR10K#sh cable mac-domain c5/0/0 upstream-service-group
Cable MD 5/0/0
  US-SG-ID  : 4           US-Chan : U0,1,2,3
  Primary-DS: 5/0/0:0   US-SG-ID: 4
    MDD US-List      : U0,1,2,3
    MDD Ambiguity : U0,1,2,3
```

Show command – show interface upstream bonding-group

```
uBR10K#show interfaces c5/0/0 upstream bonding-group
Cable5/0/0: Upstream Bonding Group 500
    715681 packets input, 83615326 octets input
    Segments: 508915 valid, 0 discarded, 7 lost
    Reserved Bandwidth Max : 0 bits/sec
    Reserved Bandwidth     : 0 bits/sec
    Available Bandwidth    : 122880000 bits/sec
    Total Service Flows On This Bonding Group: 7
Cable5/0/0: Upstream Bonding Group 65536
    30 packets input, 5134 octets input
    Segments: 0 valid, 0 discarded, 0 lost
    Reserved Bandwidth Max : 0 bits/sec
    Reserved Bandwidth     : 0 bits/sec
    Available Bandwidth    : 30720000 bits/sec
    Total Service Flows On This Bonding Group: 0
Cable5/0/0: Upstream Bonding Group 65537
    0 packets input, 0 octets input
    Segments: 0 valid, 0 discarded, 0 lost
    Reserved Bandwidth Max : 0 bits/sec
    Reserved Bandwidth     : 0 bits/sec
    Available Bandwidth    : 30720000 bits/sec
    Total Service Flows On This Bonding Group: 0
Cable5/0/0: Upstream Bonding Group 65538
    0 packets input, 0 octets input
    Segments: 0 valid, 0 discarded, 0 lost
    Reserved Bandwidth Max : 0 bits/sec
    Reserved Bandwidth     : 0 bits/sec
    Available Bandwidth    : 30720000 bits/sec
    Total Service Flows On This Bonding Group: 0
Cable5/0/0: Upstream Bonding Group 65539
    0 packets input, 0 octets input
    Segments: 0 valid, 0 discarded, 0 lost
    Reserved Bandwidth Max : 0 bits/sec
    Reserved Bandwidth     : 0 bits/sec
    Available Bandwidth    : 30720000 bits/sec
    Total Service Flows On This Bonding Group: 0
```

Show cable modem verbose

```
uBR10K#scm 10.1.21.15 ver
MAC Address                     : 0023.be83.1c8a
IP Address                      : 10.1.21.15
IPv6 Address                    : ---
Dual IP                         : N
Prim Sid                        : 30
Host Interface                  : C5/0/0/UB
MD-DS-SG / MD-US-SG             : 1 / 4
MD-CM-SG                        : 0x104
Primary Wideband Channel ID     : 257
Primary Downstream              : In5/0/0:0 (RfId : 240)
Wideband Capable                : Y
RCP Index                       : 3
RCP ID                          : 00 10 00 00 04
Multi-Transmit Channel Mode     : Y
Upstream Channel                : US0     US1     US2     US3
Ranging Status                  : sta     sta     sta     sta
Upstream Power (dBmV)           : 47.05   47.05   47.05   47.05
Upstream SNR (dB)               : 36.12   36.12   36.12   36.12
Received Power (dBmV)           : 0.00    -0.50   0.00    -0.50
Reported Transmit Power (dBmV)  : 46.50   46.50   46.50   47.25
Peak Transmit Power (dBmV)      : 51.00   51.00   51.00   51.00
Minimum Transmit Power (dBmV)   : 24.00   24.00   24.00   24.00
Timing Offset          (97.6 ns)  : 1855   1855    1856    1056
Initial Timing Offset           : 800     800     800     1056
Rng Timing Adj Moving Avg(0.381 ns) : 16  8       -248    -256
Rng Timing Adj Lt Moving Avg    : 5204    4553    4341    -235
Rng Timing Adj Minimum          : 0       0       -256    -256
Rng Timing Adj Maximum          : 270080  270080  270336  0
Pre-EQ Good                     : 0       0       0       0
Pre-EQ Scaled                   : 0       0       0       0
Pre-EQ Impulse                  : 0       0       0       0
Pre-EQ Direct Loads             : 0       0       0       0
Good Codewords rx               : 24275   24232   24232   24349
Corrected Codewords rx          : 0       0       0       0
Uncorrectable Codewords rx      : 0       0       0       0
Phy Operating Mode              : atdma*  atdma*  atdma*  atdma*
```

Deubg for Complete Ranging detail

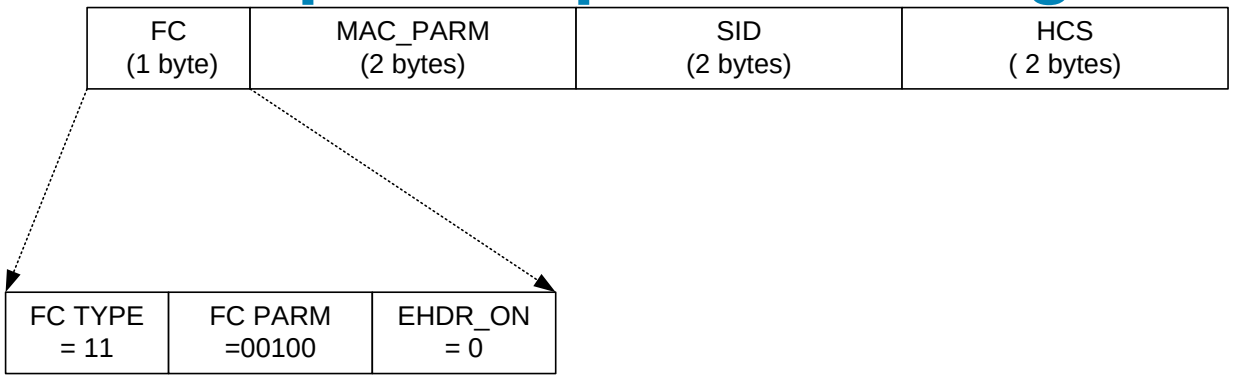
debug cable range
debug cable interface c5/0/0 mac-address H.H.H
debug cable md-sg
debug cable range protocol

```
May  6 23:15:44.141: Bonding Initial Ranging request from 001a.c3ff.e3d4, SID 0 [16383] on Interface
Cable5/0/0/U0: MD-DS-SG-ID 1, Cap flags 192Src sap 197
May  6 23:15:44.141: Initial Ranging: Downstream channel ID is 1 (CGD host DS chan Id 1)
May  6 23:15:44.141: Reusing old primary sid 29 for modem 001a.c3ff.e3d4
May  6 23:15:44.141: cmts_tcc_uschan_add: CM 001a.c3ff.e3d4 tcs 0 chan 0 tech 2 ref 0
May  6 23:15:44.141: Modem 001a.c3ff.e3d4: Host Ca5/0/0/U0: ds_channel_id 1, rfid 240
May  6 23:15:44.141: Ambiguity Resolution Validate Candidate: (B_INIT_RNG_REQ) found[ 1 ] uschan = 0xF,
reachable = 0x1, failed = 0x0.
May  6 23:15:44.141: Ambiguity Resolution: Done with sg_id = 4, (tcs 0x1).
May  6 23:15:44.141: Ambiguity Resolution: B_INIT_RNG_REQ notified. ucid  1 (tcs 0x1).
May  6 23:15:44.141: CM Ambiguity Resolution Done SG_ID=4
May  6 23:15:44.141: Timing error 1305, power error 0.00dB, freq error -168(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:44.141: Ca5/0/0/U0: Send RNG-RSP (1) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:45.141: Ranging CM 001a.c3ff.e3d4, SID 29 iuc 4 mslot 13 on I/f Cable5/0/0/U0
May  6 23:15:45.141: MSCHED_SM: 44768 msecs elapsed since last Rng Poll for 001a.c3ff.e3d4.
May  6 23:15:45.141: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 255 min load 0
May  6 23:15:45.141: Ranging request from 001a.c3ff.e3d4, SID 29 [29/1/240] on Interface Cable5/0/0/U0
May  6 23:15:45.141: Timing error 0, power error 0.00dB, freq error -166(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:45.141: Ranging successful.
May  6 23:15:45.141: Ca5/0/0/U0: Send RNG-RSP (0) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:49.993: 001a.c3ff.e3d4: initial P load 3
May  6 23:15:49.993: cmts_tcc_uschan_add: CM 001a.c3ff.e3d4 tcs 1 chan 1 tech 1 ref 1
May  6 23:15:49.993: cmts_tcc_uschan_add: CM 001a.c3ff.e3d4 tcs 3 chan 2 tech 1 ref 1
May  6 23:15:49.993: cmts_tcc_uschan_add: CM 001a.c3ff.e3d4 tcs 7 chan 3 tech 1 ref 1
May  6 23:15:50.981: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 7 min load 3
May  6 23:15:50.981: Ranging request from 001a.c3ff.e3d4, SID 29 [16383/1/240] on Interface Cable5/0/0/U2
May  6 23:15:50.981: RNG-REQ from 001a.c3ff.e3d4: state 1
```

```
May  6 23:15:50.981: Multi-Channel Initial Ranging
May  6 23:15:50.981: Timing error 256, power error 0.00dB, freq error -307(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:50.981: Ranging adjustments needed.
May  6 23:15:50.981: Ca5/0/0/U2: Send RNG-RSP (1) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:51.161: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 7 min load 3
May  6 23:15:51.161: Ranging request from 001a.c3ff.e3d4, SID 29 [16383/1/240] on Interface Cable5/0/0/U3
May  6 23:15:51.161: RNG-REQ from 001a.c3ff.e3d4: state 1
May  6 23:15:51.161: Multi-Channel Initial Ranging
May  6 23:15:51.161: Timing error 256, power error 0.50dB, freq error -405(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:51.161: Ranging adjustments needed.
May  6 23:15:51.161: Ca5/0/0/U3: Send RNG-RSP (1) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:51.341: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 7 min load 3
May  6 23:15:51.341: Ranging request from 001a.c3ff.e3d4, SID 29 [16383/1/240] on Interface Cable5/0/0/U1
May  6 23:15:51.341: RNG-REQ from 001a.c3ff.e3d4: state 1
May  6 23:15:51.341: Multi-Channel Initial Ranging
May  6 23:15:51.341: Timing error 256, power error 0.50dB, freq error -219(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:51.341: Ranging adjustments needed.
May  6 23:15:51.341: Ca5/0/0/U1: Send RNG-RSP (1) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:51.981: Ranging CM 001a.c3ff.e3d4, SID 29 iuc 4 mslot 13 on I/f Cable5/0/0/U2
May  6 23:15:51.985: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 7 min load 3
May  6 23:15:51.985: Ranging request from 001a.c3ff.e3d4, SID 29 [29/1/240] on Interface Cable5/0/0/U2
May  6 23:15:51.985: Timing error 0, power error 0.50dB, freq error -302(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:51.985: Ranging successful.
May  6 23:15:51.985: Ca5/0/0/U2: Send RNG-RSP (0) for 001a.c3ff.e3d4, SID 29, DS RFID 240
May  6 23:15:52.161: Ranging CM 001a.c3ff.e3d4, SID 29 iuc 4 mslot 13 on I/f Cable5/0/0/U3
May  6 23:15:52.165: 001a.c3ff.e3d4: dyn pwr status 0 tx lvl 197 ch load 7 min load 3
May  6 23:15:52.165: Ranging request from 001a.c3ff.e3d4, SID 29 [29/1/240] on Interface Cable5/0/0/U3
May  6 23:15:52.165: Timing error 0, power error 0.50dB, freq error -383(thres 2560 adj 0) [sm per 20.0 sec]
May  6 23:15:52.165: Ranging successful.
```

Backup Slides

Queue-Depth Request Message



Field	Usage	Size
FC	FC_TYPE = 11; MAC-Specific Header FC_PARM[4:0] = 00100; MAC request header only; no data PDU following EHDR_ON = 0; No EHDR allowed	1 byte
MAC_PARM	Total number of bytes requested in units of N bytes, where N is a parameter of the service flow for which this request is being made	2 bytes
SID	Service ID (0…0x3DFF)	2 bytes
EHDR	Extended MAC Header not allowed	0 bytes
HCS	MAC Header Check Sequence	2 bytes
	Length of Queue-depth Based Request	7 bytes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