Congestion Avoidance/Mitigation and Capacity Concerns

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Agenda - Layers 1-7 of OSI Model

- Layer 1 - Physical
- Layer 2 – Data Link
  - ✓Ethernet Frames, Switching
- Layer 3 – Network
  - ✓IP Packets, Routing
- Layer 4 – Transport
  - ✓TCP/UDP
- Layers 5, 6 & 7 – Session, Presentation & Application
- Layer 8 = COST!
- **Note**: Over 1 year of traffic growth in less than 1 month!
- Play recording - password: 29mAcwPA

Top Seven Steps

Service Group (SG) = 1 Fiber Node (FN)	US Segmentation Physical Node Splits (2x2 RPD)
Verify No Uncorr FEC and “Clean” Plant	
Run Highest US and DS Modulation and Ch Widths	Utilize D3.1 as much as possible More spectrum allocation – maybe “steal” from video Utilize/exploit “Powerboost”; DS and US
Eliminate Overhead	Eliminate some primary DSs Less US chs per MAC domain (maybe more MAC domains) Remove “stale” service flows

Top Seven Steps (cont)

Control Abusers and DoS Attacks

Optimize CMTS Efficiency

Load balancing

D3.1 graceful profile management & US/DS resiliency/partial mode

Implement Cache Servers

Layer 1 – Physical Layer

Split Node	
Segment US	• BDR/EDR makes this easier • May need to double mac domains for 1:2 architectures
Add More DOCSIS Channels	
Add/Increase D3.1	• Increase DS OFDM ch width & implement higher modulation • Activate D3.1 US OFDMA
Distributed Access Architectures (DAA) Complement D3.1	• Digital fiber links improve US & DS RxMER • No laser clipping!

More Speed

Use D3.1 (DS & US)

Note: More speed does not mean less latency!

D3.1 US may exhibit even more latency with ping tests

Less Overhead

Decrease primary DSs & fewer USs/SG

Trade Video QAMs for More Data Spectrum

Take Advantage of Powerboost

Typical 10% over-provisioning done to negate differences between layer 2 & layer 3 speed reporting

Peak-rate and Powerboost can be used to alleviate

Name trademarked by Comcast

Utilize CM peak-rate TLV

US Powerboost

Can exploit US Max Traffic Burst for US Powerboost

Capacity Overhead

- 256-QAM, Annex B raw rate = 42.88 Mbps
- "Usable" refers to layer 2 speed reporting — "Primary" = 37.5 (I-CMTS) 36 Mbps (M-CMTS) 46 Mbps Annex A
- Each US in mac domain can decrease usable by ~.4 Mbps — Worse if no data traffic since all DS MPEG-2 encapsulated
  Note: D3.1 is not MPEG-2 encapsulated
- Layer 3 reporting could be 5 - 10% less if average frames < 1518B
- "Secondary-only" will be 37.5 Mbps (no DOCSIS overhead)
- Multicast sent down each "Primary" — Can be removed with; `cable downstream dsg disable` on Integrated/Modular interfaces
- Per-CM speed is very different from aggregate speed — Many variables come into play, especially for US REQ/Grant cycle
- "Powerboost" and peak-rate TLV affect

CMTS Suggestions

CMTS Global Config & General Suggestions

Throttle

Throttle CM Ranging

- `[no] cable throttle-modem init-rate <1-1000> holdoff-time <5-100> flush-rate <100-1000>`
- Suggested values; 32 CM/s; 45 sec; 300 CM/s
- `cab up rate-limit-bwreq exempted-priority <priority>`
- `Sh cab throttle-modem`

Prioritize

Prioritize Pre-Registration Traffic

- `(config)#cable qos pre-registration us-priority [0-7]`
- DS – "`cable service flow priority`" (EDCS-1524683)
- **Note**: Setting all BE flows > priority 0 can lead to issues

Utilize

Utilize nRTPS for Call Signaling

- Non-contention request guarantees call signaling during high congestion

CMTS Global Config & General Suggestions (cont)

“Stale” Service Flows

```
cab service flow activity-timeout 300
```

Add to CMTS global config so flows with no activity > 300 seconds are torn down if CM/eMTA does not do it automatically

DOCSIS 3.0 Voice Bearer Traffic Steering

```
cab docsis30-voice downstream req-attr-mask 0 forb-attr-mask 80000000
```

By default D3.0 DS VoIP is bonded & may cause DS latency or jitter

Note: Some CPE exhibit low speed test if VoIP flow present at same time

Note: US voice traffic is never bonded (nor are other scheduled flows)

Manage Service Tiers

When adding faster service tiers be sure to delete old slower ones that are obsolete!

Warning: Slow to fast ratio cannot be more than 1:1000. If it is, the slower rate can constrain the faster rate!

Cable Interface Config Suggestions

Limit Primary DSs	• `down Integrated-Cable 1/0/0 rf-ch 0 4`
Evenly Distribute US Bonded Traffic	• `cab up balance-scheduling`
Re-acquire Layer 3 Faster after DS LB & Limit Contention Ranging for D3.0 CMs	• `cab up ranging-init-technique 2`
Help CM Max Tx Issues	• `cab up max-channel-power-offset 6` • `cab up n power-adjust cont  6`
Provide Faster CM US Updates of Pre-EQ, Levels & MER	• `cab up ranging-poll t4-multiplier 2`

Cable Interface Config Suggestions (cont)

Allow

- Allow VoIP Calls to Stay Online if CM Enters US Partial Mode
  - `cab upstream resiliency sf-move UGS` (NRTPS & RTPS)

Allow

- Allow Fair Sharing of US Traffic Between D3.1 & 3.0 CMs
  - `cable upstream qos fairness`

Activate

- Activate US Partial Mode Based on Data Burst MER Readings
  - `cab up resil data-burst snr 24 ufec 1 cfec 0 hyst 4`

Adjust

- Adjust CM Insertion Interval & CM Ranging Opportunities
  - `cab insertion-interval auto 120 1000 or (60 480)`

Minimize

- Minimize US Collisions w/ Range & Data Back-off Changes
  - `cab up x range-backoff 3 6`
  - `cab up x data-backoff 3 5`

Customer Examples

One Customer's Mitigation Plans

Add Extra 3.2 MHz, 64-QAM Ch	Adds ~13 Mbps
Split MAC Domains	Cumbersome due to outside plant/node & hub cabling
Convert 1 or 2 ATDMA to OFDMA	Could be issue with lack of D3.1 CPE
Implement Subscriber Traffic Management (STM)	Can track "heavy" users Potentially limit speed for everyone automatically during certain times

Adding D3.1 OFDMA US

Tested 3 SC-QAM US carriers with 14 MHz OFDMA

Placed OFDMA as high as possible in low-split

Tested larger carrier with exclusion for SC-QAMs

Found ch impacted due to poor performance of low spectrum and reduced ability to get 1K, 2K QAM

Also tried two OFDMA carriers to allow low spectrum to change modulation independent of upper spectrum

Decided that 14 MHz of continuous spectrum was best due to overhead of 2 chs and overall performance

Also tested with 8-10 actives deep

Another Customer's Goals and Plans

Perform as few node splits as possible	
Deployed 96 MHz D3.1 DS OFDM and will add another 96 MHz in congested nodes	• **Note**: OK to ignore correctable codeword errors
Added OFDMA at bottom end of US spectrum	• With exclusion band for DSG
Considering 204 MHz split with analog or DAA	• Good luck with analog ☺
Considering DMIC to reduce theft of service	

Adding More US Channels

US Capacity Increase – Adding 5th US Ch

US Max Tx drops by 3 dB once you exceed 4 US chs in TCS

Note: Max Tx is based on modulation of first ch ranged

Note: Bonding done at service flow level, could have some CMs reporting 5-ch TCS

4-ch BG for BE flow & single-ch BG for nRTPS or other flow in cm file

Assuming good amount of 8-ch US capable CMs, suggest 5-ch US BG and just 4-ch BG with 4 best US freqs (chs)

US Capacity Increase - Things to Keep in Mind

More USs in mac domain creates more DS map overhead

~.4 Mbps per US

Moving to every 4th DS as Primary helps

Could run out of US SC-QAM resources

D3.1 TaFDM not advised because of inefficiencies

CMTS processes new CM TLVs (54-56) for US and DS spectrum capability

Note: Some CMs could have capability, but not report it and CMTS will not let it register on intended BG

CM US Freq Limit (cont)

Utilized DOCSIS RLBGs and key off US freq or MTC TLVs

Doesn’t help with good CMs with in-house device that cuts off freq

Also requires lots of RLBG configs on every SG

Abandon SC-QAMs above expected freq cutoff & allocate for D3.1 OFDMA

Still potential issue for D3.1 CMs in house with external bad devices

Setting initial ranging (IR) for D3.1 OFDMA much high than expected freq cutoff may help it **not** range and relegate it to D3.0 lower US BG

- Not guaranteed since IR is BPSK!

85 MHz US - What Happens with **D2.0** CMs That Range on US > 42 MHz?

5 Best case; register on US freqs < 42 MHz

Next case; range on US > 42 MHz, but fail & then register on US freq < 42 MHz

Worst case; range on US freq > 42 MHz, have enough Tx power to overcome roll-off, pre-eq makes up for in-ch tilt and grp delay, but MER suffers

One fix would be DOCSIS Restricted LBGs to force them < 42 MHz
- More work and complexity

Suggest 3-level dynamic modulation so US can automatically drop down if need be and go back when valid

Drop first US ch past 42 MHz may eliminate need for RLBGs

Make sure first ch above 42 is well above, like 58 MHz start freq

Gives enough spectrum for 4, 6.4 MHz chs for an 85 MHz system

85 MHz US - What Happens with **D3.0** CMs That Range on US > 42 MHz?

4-ch and 42 MHz filtered CMs can just go to partial mode, but that's not optimum either

Make sure first ch above 42 is well above, like 58 MHz start freq

See later slides - Ways to Avoid Issues with CM US Freq Limit

Even D3.1 solution has some drawbacks in this situation because initial ranging(IR) is so robust at BPSK and fine ranging (FR) at QPSK that CM will register in 3.1 US mode with poor performance

New code will drop to partial mode based on uncorr FEC errors now

OSI Layer 1 - Physical

Power

Power – Black and Brown Outs

- Check outside plant standby power supplies
- If CPE have functional backup batteries, remotely check condition and backup functionality (if possible)

Identify

SC-QAM: Identify chs with pre-FEC and post-FEC errors

- Fix causes of post-FEC errors first, since they = packet loss
- Find/fix causes of pre-FEC errors, before becoming post-FEC errors

Identify & fix

OFDM: Identify & fix causes of uncorr codeword errors

- **Note**: OK to ignore correctable codeword errors

OSI Layer 1 – Physical (cont)

Optimize HE/hub RF levels, outside plant active device adjustment

Optimize DS & US analog optical fiber link performance

May be able to achieve improved RxMER through optical links, which can lead to support for higher modulation orders

More short-term emphasis on leakage and ingress management

Improve signal quality on ingress-impacted channels

Ways to Avoid Issues with CM US Freq Limit

Low-split CMs on mid/high-split plant - global config may help:

`cable us-freq-use-cm-cap`

Config is supported on 16.7 and 16.10 releases and disabled by default

- Uses CM capability TLV 5.20 to determine if CM supports standard US freq range or ext

Can view TLV 5.20 under scm verbose

```
sh cab modem <MAC> verbose | s US Frequency Range Capability
```

Note: Command above almost always says 5-85 MHz even when it can do higher or is setup to do lower

4800.33ef.3ebe doing 204 MHz but shows 5-85 MHz

14c0.3e0a.08fd doing 42 MHz but shows 5-85 MHz

cBR-8 does not let 14c0.3e0a.08fd on OFDMA which runs to 85 MHz so knows capabilities

`Command "scm <mac> ver | i MHz"` will show that info

CM US Freq Limit (cont)

Command limits TCS assigned by CMTS to CM to US chs within supported freq range reported by CM

- CM supporting only standard US freq range should not attempt to range on US chs above 42 MHz/65 MHz
- Will not help CMs with external devices in house limiting US spectrum

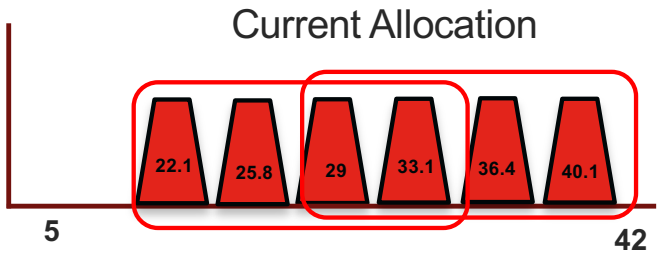
Utilized DOCSIS RLBGs and key off US freq or MTC TLVs

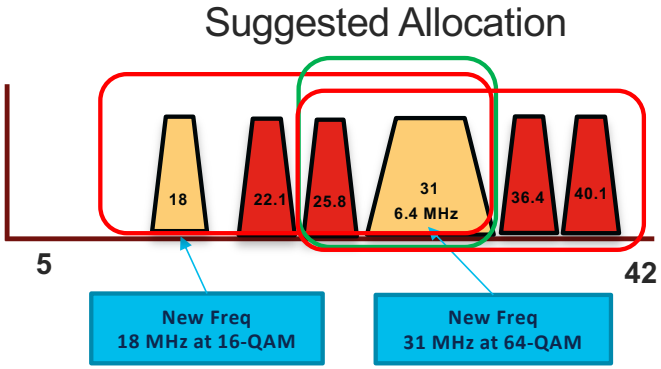
- Doesn't help with good CMs with devices in house that cut off freq
- Also requires lots of RLBG configs on every SG; may have limited LBGs

Abandon SC-QAMs above expected freq cutoff & allocate for D3.1 OFDMA

- Still potential issue for D3.1 CMs in house with external bad devices
  - To address this, try setting initial ranging (IR) for D3.1 OFDMA much high than expected freq cutoff so devices that experience issue will never range and would be relegated to D3.0 mode and lower US BG
  - Note: One customer found this to not be the case

Example of Customer US Spectrum Allocation





- More USs = more DS overhead Map traffic, especially if all DSs are primary!
- Wasted money since license is for ch regardless of modulation or ch width
- Use of `cable upstream 0 rate-limit` can make US appear erratic and not smooth
  - Suggest default `cable upstream 0 rate-limit token bucket shaping`
- Suggest +3 dBmV config for 6.4 MHz ch
  - MER same as 3.2 MHz chs
  - +3 for 1, 6.4 MHz chs is not much added total power when looking at 22.4 MHz of spectrum
  - Total power would be an increase of .67 dB
- Using middle freq will help with less cable attenuation and "cleaner" plant
- Aggregate speed is not much higher, but D3.0 US bonded speed is much more
  - 4-ch US bonding goes from 4*13 (52 Mbps total) to 3*13+27 = 66 Mbps
  - 27% increase ((66-52)/52)

OSI Layer 2 – Data Link

Ethernet Frames and Switching	
Denial of Service (DoS)	Cloning – DMIC, BPI+, “Hotlist” Over Use/Abuse • Deep Packet Inspection (DPI) • Subscriber Traffic Management (STM) Arp Attacks, IGMP Joins? • Filters/Access Lists (ACLs), SBRL Expiring Certs • Allow/Deny Lists
More Speed - Actual and Perceived (Powerboost)	D3.1 (DS & US) Less Overhead - Decrease Primary DSs, Fewer USs/SG Trade Video QAMs for More Data Spectrum
Note: More speed does not mean less latency!	D3.1 US may exhibit even more latency with ping tests

Disable Cable Modem Ranging / Registration

- Can stop specific CM from registering with hotlist command
- (config)#cab privacy hotlist ?

```
Cm              Add cm hotlist
Manufacturer    Add manufacturer hotlist
```

✓(config)#cab privacy hotlist cm ?

```
H.H.H           CM mac address H.H.H
```

✓(config)#cab privacy hotlist manufacturer ?

```
LINE            Certificate serial number
```

- ubr#show cable privacy hotlist cm

```
MAC Address          Last Ranged          Type          Interface
0000.cadb.2f56       Dec 10 17:06:45      Permanent     C5/0/0
0019.47a0.6038       Dec 10 16:58:26      Permanent     C5/0/0
```

OSI Layer 3 - Network

Network	IP Packets Routing
CPU	SUP Linecard
SNMP	
More Efficient Usage	Load Balance Resiliency/Partial Mode Encapsulation (WIFI, VPN)

Route Processor CPU

- Sh Proc cpu sorted 5sec | ex 0.00%

```
CPU utilization for five seconds: 16%/4%; one minute: 13%; five minutes: 12%
 PID Runtime(ms)   Invoked      uSecs   5Sec   1Min   5Min TTY Process
 149    19869308   3436820       5781  4.15%  3.85%  3.85%   0 CR10K5 Radian Pr
   8      529960     89389       5928  1.19%  0.15%  0.08%   0 Check heaps
  91      109352    785150        139  0.87%  0.46%  0.12%   0 DHCPD Receive
  52      617204   2730778        226  0.63%  0.49%  0.48%   0 Net Background
 126     1804728   8159135        221  0.63%  0.39%  0.33%   0 CR10K Request di
 134     3804712    616039       6176  0.63%  0.67%  0.67%   0 CR10K5 BCM84754
 401      841576   8034391        104  0.47%  0.55%  0.52%   0 L2TP mgmt daemon
  33       69472    203568        341  0.47%  0.13%  0.03%   0 ARP Input
 139      905896  28229452         32  0.31%  0.24%  0.18%   0 C10K BPE IP Enqu
 122       87156    191293        455  0.31%  0.23%  0.11%   0 CMTS SID mgmt ta
 102       29500   1755589         16  0.15%  0.11%  0.10%   0 Fault Manager
 202      104796   5155843         20  0.15%  0.11%  0.05%   0 IP Input
 261      201244    624036        322  0.15%  0.11%  0.10%   0 c10k_periodic_st
 343      442032    130862       3377  0.15%  0.09%  0.10%   0 DiagCard0/-1
 201       48672     91222        533  0.07%  0.10%  0.03%   0 IP ARP Adjacency
 105       59072    360437        163  0.07%  0.11%  0.10%   0 Environment Moni
 101       59572    151075        394  0.07%  0.03%  0.02%   0 HC Counter Timer
 249       40204   7507403          5  0.07%  0.05%  0.07%   0 DEPI Application
 464       55576   1615671         34  0.07%  0.06%  0.02%   0 ReqXmt 7/1: defa
 399       56536    756496         74  0.07%  0.10%  0.08%   0 CMTS ACFE Proces
```

Route Processor Memory

- Sh processes memory sorted

```
Processor Pool Total: 3390117548 Used:  751121156 Free: 2638996392
      I/O Pool Total:  159383552 Used:   62036192 Free:   97347360
Transient Pool Total:   16777216 Used:      30180 Free:   16747036

 PID TTY  Allocated      Freed    Holding    Getbufs    Retbufs Process
   0   0  760830360   27206128  672439072          0          0 *Init*
 128   0  110234512     986256  108885136          0          0 C10K SPUMONI SPA
 122   0   32768076   46005896    3308964          0          0 CMTS SID mgmt ta
 109   0    2589136          0    2596284          0          0 Dynamic Services
   0   0  537102124  589493248    2437636   17463660       8504 *Dead*
 126   0 2433801428 3674990568    2189772          0          0 CR10K Request di
 193   0    4214988    2101072    2175064          0          0 TurboACL
 139   0  221939668          0    1913036          0          0 C10K BPE IP Enqu
 401   0 1857459388 1473683796    1841232          0          0 L2TP mgmt daemon
 163   0    6844604    5007556    1816608          0          0 tENM
 249   0 4243166060  329932572    1111396          0          0 DEPI Application
  28   0    1113848        940     713584          0          0 IPC Seat Control
   0   0          0          0     705312          0          0 *MallocLite*
 201   0    1902088    1544888     590920          0          0 IP ARP Adjacency
  39   0     650224     123800     533572          0          0 Entity MIB API
   9   0     652284    1291868     506648     524232     726180 Pool Manager
 403   0  126282500  126518952     500088          0          0 HCCP_LC_CTRL
 345   0     489472       3744     471328          0          0 SEA main process
 332   0    8329980   10927544     369296          0          0 CMTS Multicast Q
   1   0     468508    1293972     358704          0          0 Chunk Manager
 241   0    1101504     785128     329524          0          0 IP RIB Update
```

Linecard CPU

- Sh contr c7/1/0 proc-cpu sorted | ex 0.00%

```
CPU utilization for five seconds: 27%/20%; one minute: 26%; five minutes: 26%
 PID Runtime(ms)   Invoked      uSecs   5Sec   1Min   5Min TTY Process
  16    13824104    271753      50870  2.55%  2.12%  2.04%   0 WBCMTS critical
 181     7443208    318825      23345  1.19%  1.19%  1.18%   0 SNMP bg sync col
  90      715652    272553       2625  0.79%  0.21%  0.50%   0 CMTS MAC Parser
  64     4937492    770983       6404  0.79%  0.84%  0.84%   0 DOCSIS Load bala
 143      784280   9031731         86  0.23%  0.17%  0.17%   0 IP Input
  61      533944    214191       2492  0.23%  0.14%  0.11%   0 CMTS CM MONITOR
  77      102584   3671944         27  0.23%  0.22%  0.23%   0 CMTS MAC Timer P
  70      171924    350503        490  0.15%  0.08%  0.08%   0 CMTS CHAN STATS
 196      442056    112250       3938  0.07%  0.07%  0.07%   0 Compute load avg
  65      700052   2055111        340  0.07%  0.13%  0.16%   0 CR10K Request di
 198      148408   2272590         65  0.07%  0.07%  0.07%   0 ReqXmt 5/1: defa
 205        9448    570609         16  0.07%  0.06%  0.07%   0 HCCP_DATA_KA
```

- sh contr c8/0/0 proc-cpu sorted | ex 0.00%

```
CPU utilization for five seconds: 10%/7%; one minute: 10%; five minutes: 10%
 PID Runtime(ms)   Invoked      uSecs   5Sec   1Min   5Min TTY Process
 184     5927116    217342      27270  0.95%  1.01%  1.01%   0 SNMP bg sync col
  64     2741024    745642       3676  0.71%  0.70%  0.71%   0 DOCSIS Load bala
  16     4265644    271864      15690  0.39%  0.47%  0.49%   0 WBCMTS critical
  61      358108    114380       3130  0.15%  0.05%  0.05%   0 CMTS CM MONITOR
  77       59508   3523622         16  0.07%  0.05%  0.07%   0 CMTS MAC Timer P
 199      438176    108543       4036  0.07%  0.07%  0.07%   0 Compute load avg
  70      219028    317086        690  0.07%  0.07%  0.07%   0 CMTS CHAN STATS
 146      267164   4109077         65  0.07%  0.04%  0.05%   0 IP Input
```

Linecard Memory

- sh contr c8/0/0 memory

```
               Head    Total(b)     Used(b)     Free(b)   Lowest(b)  Largest(b)
Processor    C73EF00   1769738496   454869920   1314868576   1301932116   1299960636
      I/O   75F00000   167772160   107608068    60164092    59910688    56092732

          Processor memory

 Address      Bytes     Prev     Next Ref     PrevF    NextF Alloc PC  what
0C73EF00 0000065540 00000000 0C74EF34 001  -------- -------- 028542EC  MallocLite
0C74EF34 0000065540 0C73EF00 0C75EF68 000  285FEC2C 0        0294D170  (coalesced)
0C75EF68 0000065540 0C74EF34 0C76EF9C 001  -------- -------- 024D2840  SID_INST_CHUNK
0C76EF9C 0000065540 0C75EF68 0C77EFD0 001  -------- -------- 023B8BB0  CM_MCTX_CHUNK
0C77EFD0 0000000356 0C76EF9C 0C77F164 001  -------- -------- 023FFCD0  CM Flap Info
0C77F164 0000005764 0C77EFD0 0C780818 001  -------- -------- 02751228  CMTS_PARSEINFO
0C780818 0000007204 0C77F164 0C78246C 000  287414DC 0        02751228  (fragment)
0C78246C 0000000356 0C780818 0C782600 001  -------- -------- 023FFCD0  CM Flap Info
0C782600 0001159332 0C78246C 0C89D6D4 000  28625354 C8A7BA0  02891078  (coalesced)
0C89D6D4 0000000356 0C782600 0C89D868 001  -------- -------- 023FFCD0  CM Flap Info
0C89D868 0000040972 0C89D6D4 0C8A78A4 000  0        0        02CE609C  (coalesced)
0C8A78A4 0000000716 0C89D868 0C8A7BA0 001  -------- -------- 02F7B47C  CMTS MAC Parser
0C8A7BA0 0012280984 0C8A78A4 0D45E068 000  C782600  0        02891078  (coalesced)
0D45E068 0000020004 0C8A7BA0 0D462EBC 001  -------- -------- 0223D8B4  Manage Chnk Q Elemen
```

SNMP & Security

- Change polling method to “get exact” wherever possible, for optimal performance
  - ✓ Router(config)#Access-list 199 permit udp host xxx.xxx.xxx.xxx any eq snmp
    - ➢ One line for each device polling the box
  - ✓ You then create you class and policy maps:
  - ✓ Router(config)#class-map match-all snmp
  - ✓ Router(config-cmap)#match access-group 199
  - ✓ Router(config-cmap)#policy-map snmp
  - ✓ Router(config-pmap)#class snmp
  - ✓ Router(config)#police 56000 8000 10000 conform-action transmit exceed-action drop
  - ✓ Router(config)#interface GigabitEthernet1/0/0
  - ✓ Router(config-if)#service-policy input snmp
- Recommended ACLs for general security of cable access networks
- IP Unreachables/ICMP Unreachable Rate-Limiting: Blocks IP unreachables / prevents too many sequential ICMP unreachables from being sent when an outside node scan pings subnets and there are addresses that are not being used or users offline.
  - ✓ Router(config)#interface cable 5/0/0
  - ✓ Router(config-if)#no ip unreachables
  - ✓ Router(config)# ip icmp rate-limit unreachable 10000
- Cable ARP Filters: Helps control # of ARP replies and requests being transmitted on cable interfaces. Can be caused by bad devices as well as viruses and worms
  - ✓ Router(config)#interface c5/0/0
  - ✓ Router(config-if)#cable arp filter request send 2 2

1. Configure D2.0 Global Settings

- `cab load-balance d20-ggrp-default method utilization`
- `cab load-balance d20-ggrp-default policy pure-ds-load`
- `cab load-balance d20-ggrp-default init-tech-list 4`
- `cab load-balance d20-ggrp-default interval 45`
- `cab load-balance d20-ggrp-default threshold load 15`
- `cab load-balance d20-ggrp-default docsis-policy 1`
- `cab load-balance docsis-enable`
- `cab load-balance modem max-failures 20`
- `cab load-balance method-utilization min-threshold 50`
- `cab load-balance method-utilization cm-hold 900`
- `cab load-balance rule 1 disable-throughput-lower us 100`
- `cab load-balance rule 2 disable-throughput-lower ds 500`
- `cab load-balance docsis-policy 1 rule 1`
- `cab load-balance docsis-policy 1 rule 2`

D2.0 LB Step-by-Step Suggestions

2. Make proper RLBGs if necessary
3. Configure any “exclude” statements needed
4. Config `load-interval 30` on all Cab, I, M, & W interfaces
5. Configure all fiber nodes
6. Use: `cab load-balance d20 GLBG auto-generate`
   - ✓**Note**: From exec mode, do `wr mem` afterward to save all LBGs
7. Reboot CMs if already online

Sh Cab load-balance docsis-group 800 all | in 36

```
DOCSIS load-balancing load
Interface          State Grp  Utilization  Rsvd NBCM  WB/UB Flows Weight
Mo8/0/0:0 (477 MHz)  up   1    10%(10%/92%)  0%   3     9     3     36.0
Mo8/0/0:1 (483 MHz)  up   1    5%(5%/92%)    0%   2     9     2     36.0
Mo8/0/0:10 (537 MHz) up   1    0%(0%/92%)    0%   2     10    3     36.0
Mo8/0/0:11 (543 MHz) up   1    0%(0%/92%)    0%   2     10    2     36.0
Mo8/0/0:12 (549 MHz) up   1    0%(0%/92%)    0%   2     10    2     36.0
Mo8/0/0:13 (555 MHz) up   1    5%(5%/92%)    0%   2     10    2     36.0
Mo8/0/0:14 (561 MHz) up   1    0%(0%/92%)    0%   2     10    2     36.0
Mo8/0/0:15 (567 MHz) up   1    10%(10%/92%)  0%   2     10    4     36.0
Mo8/0/0:2 (489 MHz)  up   1    10%(10%/92%)  0%   2     9     2     36.0
Mo8/0/0:3 (495 MHz)  up   1    5%(5%/92%)    0%   2     9     2     36.0
Mo8/0/0:4 (501 MHz)  up   1    10%(10%/92%)  0%   2     9     2     36.0
Mo8/0/0:5 (507 MHz)  up   1    5%(5%/92%)    0%   2     9     2     36.0
Mo8/0/0:6 (513 MHz)  up   1    0%(0%/92%)    0%   2     9     2     36.0
Mo8/0/0:7 (519 MHz)  up   1    5%(5%/92%)    0%   2     9     2     36.0
Mo8/0/0:8 (525 MHz)  up   1    0%(0%/92%)    0%   2     10    2     36.0
Mo8/0/0:9 (531 MHz)  up   1    0%(0%/92%)    0%   1     10    2     36.0
```

- Utilization based on “load-interval” with default of 300 sec and suggested lowest setting of 30
  - Cable interface setting affects US utilization; Modular/Integrated affects DS utilization
- Policy pure-ds-load recommended when doing DS utilization LB
  - Removes US utilization for DS LB decisions

1. Configure D3.0 Global Settings

- `cable load-balance d30-ggrp-default policy pure-ds-load`
- `cable load-balance d30-ggrp-default init-tech-list 4`
- `cable load-balance d30-ggrp-default threshold load 20`
- `cable load-balance d30-ggrp-default interval 30`
- `cable load-balance d30-ggrp-default docsis-policy 1`
- `cable load-balance docsis-enable`
- `cable load-balance docsis30-enable`
- `cab load-balance modem max-failures 20`
- `cab load-balance method-utilization min-threshold 50`
- `cable load-balance method-utilization cm-hold 900`
- `cab load-balance rule 1 disable-throughput-lower us 100`
- `cab load-balance rule 2 disable-throughput-lower ds 500`
- `cab load-balance docsis-policy 1 rule 1`
- `cab load-balance docsis-policy 1 rule 2`

D3.0 LB Step-by-Step Suggestions

2. Make proper RLBGs & “exclude” commands if necessary
3. Config `load-interval 30` on all Cable, I, M, & W interfaces
4. Configure cable interface commands
   - ✓ `cable upstream balance-scheduling`
   - ✓ `cable up ranging-init-technique 2`
5. Configure all fiber nodes
6. Reboot CMs if already online
   - ✓ Wait for modem-count LB and primary distribution
7. Configure;
   - ✓ `cab load-balance d30-ggrp-default method util`
   - ✓ `cab load-balance docsis30-enable dynamic down`
   - ✓ Rebuild all FNs or change all auto-generated D3.0 LBGs to method utilization
8. Reboot CMs if already online (may not be needed)

D3.0 Modems Registered in D2.0 Mode

```
10k#show cable modem wideband registered-traditional-docsis
MAC Address    IP Address  I/F        MAC          Prim RCC MD-DS-SG/
                                      State        Sid  ID  MD-US-SG
1859.3353.0b18 10.10.0.29  C7/1/1/U0  online(pt) 1270 1   1 / 1
1859.3353.09b0 10.10.0.18  C7/1/1/U1  online(pt) 1253 1   1 / 1
1859.3353.0adc 10.10.0.21  C7/1/1/U3  online(pt) 1255 1   1 / 1
1859.3353.0ad6 10.10.0.28  C7/1/1/U2  online(pt) 1245 1   1 / 1
```

- D3.0 CMs "`online`" are basically in D2.0/single-ch mode
- May not complain because CM is online, but QoS will suffer
- CMs will participate in D2.0 LB
  - Can wreak havoc on load balance
- CMs with high level QoS will "eat" limited capacity and potentially "starve out" legitimate D2.0 CMs
- **Note**: CMs could be `w-online` but D2.0 on US
  - Lose mtc-mode CCF, but gain US LB

Partial Mode & Wideband CM Distribution

- `Scm partial-mode`
- `Scm partial-service`
- `Scm cm-status`
- `Show cable resiliency`
- `Show cable modem resiliency`
- `Scm wide ch`
- `Show cable mac-domain cx/y/z rcc`
- `Scm <mac> wide rcs ver`

DS Partial Mode

- “Trigger” command needed to even process cm-status messages
  - cab rf-change-trigger percent 50 count 10 secondary
  - This was first attempt at resiliency - very limited in that CMs in p-online were either sending all their traffic down their primary or forcing everyone to go to less DSs once thresholds were met
  - All CMs in p-online leading up to threshold will still be sending their traffic down their primary and only CMs after threshold will actually do subset
  - CMs can come out of p-online automatically when a cm-status message reports “good” and can go back to w-online without intervention
  - Plus, it is easier to track CMs listed as p-online
- 10k(config-if)#cab cm-status enable ?
  - <grouplist> CM-STATUS event list to enable
  - 3 Sequence out of range
  - 6 T4 timeout
  - 7 T3 re-tries exceeded
  - 8 Successful ranging after T3 re-tries exceeded
  - 9 CM operating on battery backup
  - 10 CM returned to A/C power
  - Only 3 is on by default depending on IOS

Resilient Bonding Groups (RBGs)

- Feature was added in SCG IOS and works in conjunction with “trigger” command
  - Much more flexible
  - Recommend higher threshold for “trigger” command
  - Need to keep eye on CMs “thrashing” and CPU affect
- (config)#cable resiliency ds-bonding
- (config)#interface wideband-cable x/y/z:a
  - (config-if)#cable ds-resiliency
- **Note**: Without “trigger or RBG, CMs should cycle on and off when cm-status bad
  - DDTS – CSCur93878
  - Potential work-around - no cable cm-status enable 3
- Once CM picks BG, RBG will not intervene and place it in bigger BG later
  - BGs must be created properly manually and CM should pick biggest it can handle assuming steered properly, if need be
  - When CM locks on primary DS, CM only “sees” BGs that primary is part of

DS Resiliency and Partial Mode

- `(config)#cab rf-change-trig percent 75 count 10 second`
- `(config)#cab cm-status all holdoff 500 reports 5`
- `(config)#cab rf-change-dampen-time 60`
- `(config)#cab acfe enable`
- `(config)#cab acfe period 60`
- `(config)#cab acfe guar-bw-sync-period 240`
- `(config)#cab resiliency ds-bonding`
- Configure 4-6 RBGs per controller (more if battery mode used)
  - ✓ `(config)#interface wideband-cable x/y/z:63`
    `(config-if)#cable ds-resiliency`

US Partial Mode

- On by default
- Much easier for CMTS to control on US vs DS
  - CMTS schedules minislots and can mark per-CM US up or down
- `scm 1859.334e.82c4 ver`

```
MAC Address                          : 1859.334e.82c4
IP Address                           : 10.10.0.210
Prim Sid                             : 62
Host Interface                       : C7/1/4/UB
MD-DS-SG / MD-US-SG                  : 1 / 1
Primary Wideband Channel ID          : 2726 (Wi7/1/1:5)
Primary Downstream                   : Mo7/1/1:10 (RfId : 2050)
Wideband Capable                     : Y
UDC Enabled                          : N
Extended Upstream Transmit Power     : 0dB
Multi-Transmit Channel Mode          : Y
Number of US in UBG                  : 4
Upstream Channel                     : US0        US1        US2        US3
Ranging Status                       : sta        sta        sta        sta
Upstream SNR (dB)                    : 39.7       39.8       39.3       37.89
Upstream Data SNR (dB)               : --         --         --         --
Received Power (dBmV)                : 0.00       0.00       0.00       -0.50
Reported Transmit Power (dBmV)       : 32.00      32.00      32.00      32.00
Peak Transmit Power (dBmV)           : 51.00      51.00      51.00      51.00
```

SCM Partial-Mode & Service

- 10k#show cable modem partial-mode

```
MAC Address    IP Address   I/F         MAC           Prim RCC UP-reason/
                                        State         Sid  ID  Failed-tcs
1859.3353.0b3e 10.10.1.169  C7/1/6/UB   p-online(pt)  72   2   N/A
38c8.5cb6.63ca 10.10.1.255  C7/1/6/UB   p-online(pt)  78   2   N/A
1859.3353.0a18 10.10.0.228  C7/1/7/UB   p-online(pt)  2    1   N/A
1859.3353.09c2 10.10.0.219  C7/1/7/UB   p-online(pt)  5    1   N/A
```

- 10k#show cable modem partial-service

```
MAC Address    IP Address  I/F       MAC          DSxUS Impaired   Impaired
                           State     State              DS          US
54d4.6ffb.2e1b 40.4.58.23  C7/1/0/p  p-online(pt) 3x1   Mo1/3/0:1  0,1
                                                    Mo1/3/0:2
1859.3353.0b3e 10.10.1.169 C7/1/6/UB p-online(pt) 4x4   7/1/2:16
                                                        7/1/2:17
                                                        7/1/2:18
                                                        7/1/2:19
1859.3353.0a18 10.10.0.228 C7/1/7/UB p-online(pt) 7x3   7/1/2:12
```

- 10k#show cable modem 38c8.5cb6.63ca primary-channel

```
MAC Address    IP Address   Host        MAC           Prim Num Primary    DS
                            Interface   State         Sid  CPE Downstream RfId
38c8.5cb6.63ca 10.10.1.255  C7/1/6/UB   p-online(pt)  78   0   Mo7/1/2:7  2071
```

SCM “mac” Wide RCS-Status

- 10k#scm 38c8.5cb6.63ca wide rcs-status

```
CM   : 38c8.5cb6.63ca

RF   : 7/1/2 4
  Status                    : UP
  FEC/QAM Failure           : 0
  Dup FEC/QAM Failure       : 0
  FEC/QAM Recovery          : 0
  Dup FEC/QAM Recovery      : 0
  MDD Failure               : 0
  Dup MDD Failure           : 0
  MDD Recovery              : 0
  Dup MDD Recovery          : 0
  Flaps                     : 0
  Flap Duration             : 00:00

RF   : 7/1/2 5
  Status                    : UP
Flap Duration             : 00:00

RF   : 7/1/2 6
  Status                    : UP
  Flap Duration             : 00:00
```

Note: Primary DS not shown

```
RF   : 7/1/2 16
  Status                    : DOWN
  FEC/QAM Failure           : 1   Mar 25 18:37:15
  Dup FEC/QAM Failure       : 0
  FEC/QAM Recovery          : 0
  Dup FEC/QAM Recovery      : 0
  MDD Failure               : 0
  Dup MDD Failure           : 0
  MDD Recovery              : 0
  Dup MDD Recovery          : 0
  Flaps                     : 1
  Flap Duration             : 12:40
RF   : 7/1/2 17
  Status                    : DOWN
  FEC/QAM Failure           : 1 Mar 25 18:37:15
  Flaps                     : 1
  Flap Duration             : 12:40
RF   : 7/1/2 18
  Status                    : DOWN
  FEC/QAM Failure           : 1 Mar 25 18:37:15
  Flaps                     : 1
  Flap Duration             : 12:40
RF   : 7/1/2 19
  Status                    : DOWN
  FEC/QAM Failure           : 1 Mar 25 18:37:15
  Flaps                     : 1
  Flap Duration             : 12:40
```

Verify Bonded Service Flows

- CMTS bonds the service flow, not modem
- CM can report 8x4 when doing scm wide ch command, but that is the physical chs it is using, not necessarily actual bonding taking place
  - Need to look at service flow ver to verify if BE flow is doing full ch bonding or you have 2 flows using 2, 4-ch BGs
- 10k#sh cab modem 1855.0ff0.17bd wide ch
  - MAC Address IP Address I/F MAC DSxUS Primary
  - State WB
  - 1855.0ff0.17bd 10.10.2.11 C8/0/0/UB w-online(pt) 16x4 Wi8/0/0:0
- 10k#sh cab modem 1855.0ff0.17bd service-flow ver | in Forward
  - Forwarding interface: Wideband-Cable8/0/0:0
- 10k#sh cab modem 1855.0ff0.17bd service-flow ver | in Bonding
  - Upstream Bonding Group : UBG-800

Show Cable Upstream Service-Flow Summary

Interface	Static Upstream Service Flow							Dynamic Upstream Service Flow					Descrip
	Total	PRI	BE	UGS	UGS-AD	RTPS	N-RTPS	BE	UGS	UGS-AD	RTPS	N-RTPS	
C6/0/0/UB1	17	17	0	0	0	17	0	0	0	0	0	0	Cell-1
C6/0/0/UB2	17	17	0	0	0	17	0	0	0	0	0	0	Cell-2
C6/0/0/U0	8	4	4	0	0	4	0	0	0	0	0	0	N/A
C7/1/1/U0	7	7	7	0	0	0	0	0	0	0	0	0	
C7/1/1/U1	7	7	7	0	0	0	0	0	0	0	0	0	
C7/1/1/U2	8	8	7	0	0	0	0	0	0	0	0	0	
C7/1/1/U3	7	7	7	0	0	0	0	0	0	0	0	0	
C7/1/1/UB0	1	1	1	0	0	0	0	0	0	0	0	0	
C7/1/4/U0	8	8	8	0	0	0	0	0	0	0	0	0	
C7/1/4/U1	8	8	8	0	0	0	0	0	0	0	0	0	
C7/1/4/U2	8	8	8	0	0	0	0	0	0	0	0	0	
C7/1/4/U3	8	8	8	0	0	0	0	0	0	0	0	0	
C7/1/4/UB714	16	16	16	0	0	0	0	0	0	0	0	0	
C7/1/6/U0	15	15	15	0	0	0	0	0	0	0	0	0	
C7/1/6/U1	15	15	15	0	0	0	0	0	0	0	0	0	
C7/1/6/U2	17	17	17	0	0	0	0	0	0	0	0	0	
C7/1/6/U3	17	17	17	0	0	0	0	0	0	0	0	0	
C7/1/6/UB716	2	2	2	0	0	0	0	0	0	0	0	0	
C7/1/7/U0	10	10	10	0	0	0	0	0	0	0	0	0	
C7/1/7/U1	11	11	11	0	0	0	0	0	0	0	0	0	
C7/1/7/U2	11	11	11	0	0	0	0	0	0	0	0	0	
C7/1/7/UB717	16	16	16	0	0	0	0	0	0	0	0	0	
C8/0/0/U0	7	7	7	0	0	0	0	0	0	0	0	0	
C8/0/0/U1	8	8	8	0	0	0	0	0	0	0	0	0	
C8/0/0/U2	8	8	8	0	0	0	0	0	0	0	0	0	
C8/0/0/U3	9	9	8	0	0	0	0	0	0	0	0	0	
C8/0/0/UB800	17	17	17	0	0	0	0	0	0	0	0	0	
Total:	305	305	303	0	0	0	0	0	0	0	0	0	

Show Cable Modem TCS Summary

Interface	Cable Modem							
	Total	Reg	Oper	Unreg	Offline	Wideband	TCS	USCB
C5/0/0/U0-1	32	32	32	0	0	32	768	1
C5/0/0/U2-3	94	94	94	0	0	94	3072	2
C5/0/0/U4-5	32	32	32	0	0	32	12288	3
C5/0/0/U6-7	50	50	50	0	0	50	49152	4
C7/1/1/U0.0,1.0,2.0,3.0	16	16	16	0	0	16	3840	711
C7/1/1/U0.0	7	7	7	0	0	0		
C7/1/1/U0.1	1	1	1	0	0	0		
C7/1/1/U1.0	7	7	7	0	0	0		
C7/1/1/U2.0	7	7	7	0	0	0		
C7/1/1/U3.0	8	7	7	1	1	0		
C7/1/7/U0-2	16	16	16	0	0	16	1792	717
C7/1/7/U0	10	10	10	0	0	0		
C7/1/7/U1	11	11	11	0	0	0		
C7/1/7/U2	11	11	11	0	0	0		
C8/0/0/U0-3	17	17	17	0	0	17	3840	800
C8/0/0/U0	7	7	7	0	0	0		
C8/0/0/U1	8	8	8	0	0	0		
C8/0/0/U2	8	8	8	0	0	0		
C8/0/0/U3	9	8	8	1	0	0		
Total:	321	313	313	8	2	67		

SID Depletion

CMTS has 8175 SIDs per mac domain

Every US service flow uses a separate unique SID

Assuming an average of 2.3 SIDs per CM

Some are dynamic flows & others nailed up for signaling & BE
That could be limited to ~3500 CMs per service group

D3.0 US bonding can use same SID, but sid cluster setting may allow more

In worst case scenario; 8 USs in mac domain, utilizing DSG for settop boxes with typical 2 STBs & 1 D3/3.1 CM per house with stale service flows & SID Cluster 2

SID exhaustion could be realized
Note: We have a customer today with 2300 devices using 7200 SIDs

CMTS Utilization Display

- `cbr8#sh int c1/0/2 mac-scheduler`

```
DOCSIS 1.1 MAC scheduler for Cable1/0/2/U0 : rate 30720000
  wfq:None
  us_balance:ON
  dps:OFF
  fairness:OFF
  Adv Phy Short Grant Slots 155176, Adv Phy Long Grant Slots 6038475
  Adv Phy UGS Grant Slots 0
  Avg upstream channel utilization(%data grants) : 1%
  Avg upstream channel utilization in 30 sec : 0%
  Avg percent contention slots : 98%
  Avg percent initial ranging slots : 1%
```

- Contention percent is (99 - current data %), which means; what is available for contention, not current percentage of contention
- Contention % & Data % should add up to 99%
  - Have seen in past with Rate-Adapt (not available on cBR-8) and maybe with DPS (not officially supported yet) where this did not occur
  - **Note**: Got around misreporting of Data % when Rate-Adapt was activated by taking current bps and dividing by estimated “usable” bandwidth for A-Long IUC
- **Side Note**: Some people call this user bandwidth vs channel bandwidth
  - Actual traffic rate in percentage form vs ch usage based on time allocation (minislots)

Device Count

One original suggestion was no more than 150 to 200 CMs per US

- If doing VoIP, you may want to cut this in half
- However, advances in DOCSIS Phy technology may allow greater US aggregated bandwidth allowing more CMs per US than currently recommended
- Devices such as a digital settops requiring low bandwidth may also be installed and allow more devices to be installed

We also suggested keeping total devices under 1500 per mac domain (cable interface) because of SID space and ranging concerns

- **Note**: Recently modified since we have many Primary DSs per SG

Historically, we had ranging (station maintenance (SM)) at every 20 sec and T4 timer in CM is 30 sec; This only gave 10 sec as worst case scenario for linecard failovers

- After seeing issues in field, we changed SM from every 20 sec to every 15 sec when linecard HA configured
  - Gives 15 sec worst case coverage, but creates more SM on DS; but not much traffic to worry about
- Side Note: CMs with ! on US Rx level as seen on CMTS are at max TX power and can create fast polling and much more SM messages, which is why I suggest no more than 5% with ! (max Tx)

Utilization Tracking

SNMP polling interval for calculating RF ch utilization

- `(config)#cab util-interval ?`
  - `<1-86400>  The time interval in seconds (300 default)`

CMTS MIB to monitor DS usage

- CISCO-CABLE-WIDEBAND-MIB > ccwbRFChannelTable > ccwbRFChannelUtilization
- Reports average DS utilization across xx secs of “load-interval”
  - Default of 300, but recommend 30 sec
- Remember, no minislots in DS
- For M-CMTS solution with Annex B, 6 MHz ch width using 256-qam, use 36 Mbps as usable rate to figure out what to divide by
- When using this MIB, configure “cab util-interval <n>” value to same value or lower before actual snmp polling interval
  - Ex. If snmp polling set to 10 min, can use 9 or 10 for cab util-interval value
  - Setting cab util-interval cmd updates interval for ccwbRFChanUtilInterval

Use CMTS MIB to monitor US usage:

- Can use cdxIfUpChannelAvgUtil to monitor avg US channel utilization
- May need to monitor minislot utilization instead since US BW could be available, but no available minislots to send
  - cdxIfUpChannelAvgContSlots
- BW utilization is typically in Mbps, so divide by:
  - 9 Mbps for 16-qam, 3.2 MHz
  - 27 Mbps for 64-qam, 6.4 MHz

Utilization Tracking (cont)

Other similar MIB to monitor DS/US usage	• Use docsIfCmtsChannelUtUtilization to monitor avg US/DS ch utilization
	  • US utilization percent reports minislots utilized on physical ch
	  • DS utilization percent reports percent of ratio between bytes data transmitted vs total number of bytes transmitted in raw BW of mpeg ch
	• Setting cabl util-interval <n> will update utilization interval for docsIfCmtsChannelUtilizationInterval

In SCF and later, MIB ccwbRFChannelUtilization used for polling RF DS ch utilization for 3Gx60, 20x20V, 8x8V, 3G SPA & WB SPA	• Use ccwbFiberNodeTable to query cable interfaces and RF ch snmp if index
In SCE and later, MIB docsIfCmtsChannelUtUtilization can be used for polling legacy linecards; 5x20, 20x20, WB SPA for RF ch utilization	• MIB ccwbFiberNodeNBIfIndex pointed to DS or US ch of cable interface or integrated/modular cable snmp if index

Battery Mode (BM) Introduction

When feature enabled and CM power outage, CM will enter battery backup mode

Bonding downgraded to one DS by one US ch

Battery 1x1 mode (BM)

Reduces power usage when CM running on battery

Longer backup for VoIP and low traffic

When CM returns to AC power mode, ch bonding returns to original configuration

Battery 1x1 Mode Feature Description

CM use CM-STATUS to report event 9 “CM on battery backup” and event 10 “CM returned to AC power” to CMTS

Single-ch US BG & 1-ch DS grp needed to move CM to 1x1

For US, each US ch has default single-ch BG

For DS, RBGs need to be configured

Feature uses DBC to move CM from original BG to 1x1

CMTS uses saved info to restore CM to original BG when power restored

Energy Management Feature Description

Low power mode referred to as "Energy Management 1x1 Mode“

- CM must support feature & be enabled in cm file along with user-configurable thresholds
- CMTS uses DBC to instruct CM to enter/exit Energy Management 1x1 Mode
- EM feature uses Resilient BGs for DS and default single-ch US BGs for US
  - CMTS selects one available US BG which has max BW available

CM instructed by CMTS via DBC to switch to RCS containing single DS ch & TCS containing single US ch to operate in EM 1x1 Mode during "idle" times

- Data rate demand of that user can be satisfied by available capacity on single US and DS ch pair it is assigned

When CM requires higher data rate, CMTS instructs CM to return to original RCS/TCS set

When CM enters EM mode, CMTS saves original wideband interface and US TCS

When CM exits EM mode, it returns to original wideband interface and US ch sets

Note: Battery Backup 1x1 Mode is independent, more simplified feature from EM mode & requires cm-status messages 9 & 10 to be processed

Show Controller Output

- cBR8#sh contr integrated-Cable 2/0/0 counter rf-channel

```
Control  RF   MPEG       MPEG       MPEG  Sync       MAP/UCD    User
         Chan Packets    bps        Mbps  Packets    Packets    Mbps
              Tx                           Tx         Tx
2/0/0    0    11233773307 38809667  38.80  43539665  1743367624 35.68
2/0/0    1    11233556286 38809667  38.80  0         217697     37.81
......
2/0/0    7    11233556282 38809667  38.80  0         217697     37.81
2/0/0    8    11233773068 38809667  38.80  43539665  1742875987 35.68
2/0/0    9    11233556295 38809667  38.80  0         217696     37.81
2/0/0    10   11233556291 38809667  38.80  0         217697     37.81
.....
2/0/0    31   11233556299 38809667  38.80  0         217697     37.80
```

- cBR8-CPoC#sh contr integrated-Cable 2/0/0 counter ofdm-ch

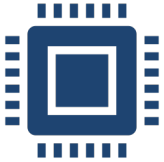
```
Contro Ch# Profile/PLC  Packets  Bytes    Rate(Mbps) Utilization(%)
2/0/0  158 Total        5443178  82278447 1512.226   100.0
2/0/0  158 0            4571485  31129641 0.005720   0.0
2/0/0  158 1            5441574  82273356 1512.133   100.0
2/0/0  158 2            2222428  91837370 0.001600   0.0
2/0/0  158 PLC-MMM      6530949  58560842 0.010761
2/0/0  158 PLC-EM       0        0        0.000000
2/0/0  158 PLC-TR       0        0        0.000000
```

Controller Upstream-Cable 1/0/0

- us-channel 0 frequency 16000000
- us-channel 0 channel-width 6400000 6400000
- us-channel 0 threshold snr-profiles 24 19
- us-channel 0 threshold corr-fec 0
- us-channel 0 threshold hysteresis 4
- us-channel 0 docsis-mode atdma
- us-channel 0 minislot-size 2
- us-channel 0 modulation-prof 224 223 222
- us-channel 0 equalization-coefficient
- no us-channel 0 shutdown
- **Note**: upstream channels 1 2 & 3 at 22500000, 29000000, 35500000

Going Forward

OSI Layer 4-7 Considerations



Strategic Usage of Cache Servers

TCP/UDP

Ack Suppression

TCP Windowing

Note: Over-the-Top (OTT) video uses adaptive bit rate (ABR) and is TCP-based

Netflix, YouTube, etc. may eliminate 4K video & also drop quality encoding 25% to save BW

Miscellaneous

CableLabs' Guidelines for In-Home WIFI Performance

- https://www.cablelabs.com/tips-to-improve-your-home-wi-fi-performance?utm_campaign=TL%20%7C%20Inform%5BED%5D%20Blog&utm_source=hs_email&utm_medium=email&utm_content=85664616&_hsenc=p2ANqtz--DQiVygwYckmbJuuXdqZKVZgaQV_ndqdVdvHxSyOU6QLtqNYfGErgOSez4msJ_4h_UgMTCdw27Jfy69n8jWV4Uk6Z2bQ&_hsmi=85664616

Ask subscribers to check tightness of F connectors on CPE and tighten if loose

- Avoids tech needing to go inside house
- Been found to improve/resolve some US noise/ingress issues

Going Forward & Planning for Next Inevitable Event

Implement subscriber-based subscription model	For quick activation of more channels/capacity
Have segmentable nodes	Future segmentation for quick activation
Implement DAA	Better performance and complementary to D3.1

Laser Clipping Theory

High US Utilization, Types of Applications, & Laser Clipping

More US utilization (Ring doorbell, gaming,…) coupled with applications not using UGS like Vonage, Skype, Zoom and other BE VoIP will increase probability of Request collisions

Suspect customers with audio-only will have more contention requests vs piggyback requests

Video calls would increase US throughput requirements and piggybacking would probably occur more often

DS OTT video and its TCP acks that must be sent on US could be exacerbating the issue

These collisions could lead to laser clipping and dropped packets

Note: Laser clipping would not occur on digital fiber links in distributed access architectures (DAA) like remote-PHY

Verifying BW Request Counters

Following commands used to verify BW requests (contention or piggybacked)

- Cannot tell when contention requests actually contend/collide

```
cbr8#sh int cx/y/z sid n count ver | inc BW
```

- `BWReqs {Cont,Pigg,RPoll,Other} : 8306, 3243, 0, 0`
- **Note**: Could use this command to test theory of which applications create more contention Reqs
- Intended for specific CM

```
cbr8#sh contr cx/y/z up n | in Request|Bytes
```

- `Bandwidth Requests = 2776290`
- `Piggyback Requests = 1077964`
- `Invalid BW Requests= 195 (more info in notes view)`
- `Bytes Requested = 256264277`
- `Bytes Granted = 1626995783`
- Command to show per-US counters

Example

500 homes in SG/FN

10% doing some sort of teleconferencing

40% of them are doing audio-only
- Half of them actually have collisions
- Gives 500*.1*.4*.5 = 10 potential Req collisions

10*log(10) = 10 dB potential power spike

Note: To add power perfectly, signals need to be same freq, amplitude & phase

At US laser input, signals will be same freq and power, but phase is based on timing/distance

CMs have time offsets to keep tight timing alignment, so phase should be aligned as well

Laser Clipping Traits

"See" artifacts like second and third order harmonics above diplex filter region

One way to prove signal is an artifact is to turn off original "real" signal or watch spectrogram view, which is time in Z axis

See if artifacts disappear same time signal below 42 MHz disappears or fluctuates

Sometime DS signal leaks on US, so it's actually ingress and not harmonics

Look below 5 MHz and make sure AM or HAM radio not getting into node

Have seen in past where node used special port for power insertion and it wasn't as good as we thought for RF choking

- Installed power inserter on RF leg and issue solved

CM Ranging Causing Power Spikes

CM on low value tap will normally only need to transmit maybe 35 dBmV and if it ranges it could go as high as 57 dBmV

HE test CMs notorious for this if no proper attenuation added

Utilizing flexible solution taps (FST) with built-in EQs helps alleviate this since CMs all Tx between 40-50 dBmV and will not have large range to ramp up

Note: Concern about CMs in “hotlist” as they will still range

Never show init(r1), but ramping up on every UCD and trying all day long

Could be better to let them register & give them cm file with network access disabled

Stick with double minislot from default like we suggest and never quadruple it

If so, more time on wire wasted

Dropping it to default minislot of 1 when using 6.4 MHz ch width will not save us anything and could affect US concatenation and per-CM US speed

Contention Requests and Laser Clipping

Contention % is amount available for contention

Not amount of contention happening
Should be 99-utilization %

If Cont and Utilization % don't add up to 99%, then it's a problem

Monitor Cont Requests

If low, make sure util + cont = 99%

If it doesn't add up, then track specific CMs and figure out why

If low and does add up properly, then not much you can do since heavy US traffic is "real"

Work-around to laser clipping

Install RPD 😊 – Digital optical link has no laser clipping

Decrease levels into laser by 3-6 dB with expected lower MER!

- Pad movement from HE to node
- CMTS config change (-3 to -6 dBmV vs default of 0)
- Pad and CMTS change (3 dB pad movement from HE to node and -3 dBmV on CMTS)

References

References – Internal BNE Web Page

- http://stugots.cisco.com/SystemTest/BNE-Library.shtml
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Misc_PPTs/CBR-8_Lessons_Learned_7-28-16.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Misc_PPTs/CMTS_&_CM_Impairment_Mitigation_Technigues_2-28-18.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Misc_PPTs/CMTS_&_RF_Troubleshooting_10-19-16.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Misc_PPTs/CMTS_Operation_Monitoring_11-18-16.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/D3%230__DS_Bonding/DS_Resiliency_1-23-2020.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Misc_PPTs/One_Domain_per_SG_vs_Two_2-7-2020.pptx
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/Throughput/DOCSIS_DS&US_Speed_Playbook_8-5-16.ppt
  - Many of other resources under Throughput Section
- http://stugots.cisco.com/rr/BNE-KnowledgeBase/D3%231/cBR-8_OFDMA_Configuration_3-2020.pptx
  - Many of other resources under D3.1 Section
- Understanding US Ranging
  - http://stugots.cisco.com/rr/BNE-KnowledgeBase/Articles/CM_Upstream_Ranging_4-22-17.doc
  - http://stugots.cisco.com/rr/BNE-KnowledgeBase/Articles/Modem_Provisioning_3-20-2020.doc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