CMTS and CM Impairment Mitigation Techniques 2/28/18

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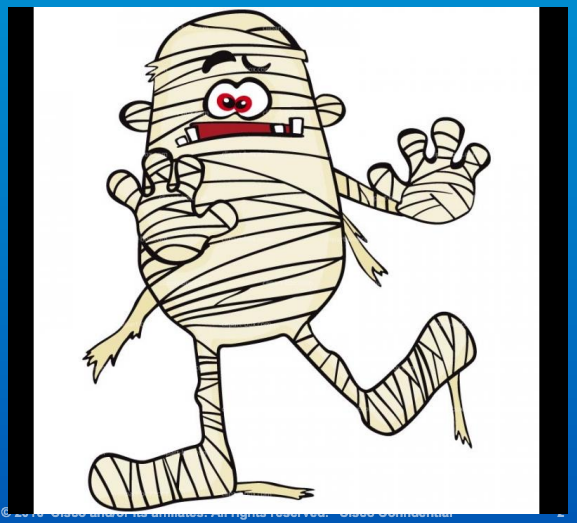
Band-Aids are OK,

Complete Mummification, not so Much



John Downey circa 2018

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Preface

- Band-Aids mask issues
  - ✓Proactive monitoring is a must
- **NOT** using everything at your disposal to keep end-customers happy is like “cutting off your nose to spite your face”
- Everything has pros and cons
  - ✓Must learn to compromise
- Ignoring little things eventually turns into much bigger things

Impairment Increase vs Reporting

	CNR	MER(SNR)	Corr FEC	Uncorr FEC
AWGN	Bad	Bad	Bad	Eventually Bad
CW Carrier	Bad	Ok	Ok	Ok
Impulse Noise	Bad	Ok	Ok	Bad
Group Delay / Micro-Reflections	Ok	Bad	Bad	Eventually Bad
Laser Clipping No traffic Distorted traffic	Ok, ish	 Ok Bad	 ---- Bad	 ---- Eventually Bad

- Ingress cancellation will cancel some CPD
- CPD resembles AWGN when all DSs are

Agenda

- Embedded Technology
  - ✓Ingress Cancellation & Pre-EQ
  - ✓Dynamic US Interleaving
  - ✓Full Bandwidth Capture & PNM
- Self Healing Features
  - ✓DS - Resiliency (partial mode & RBGs), CM Status Messages, LB max failures
  - ✓US - 3-Level Dynamic Modulation, Partial Mode (SM & Data Burst MER)
  - ✓D3.1 - Graceful Profile Management, Resiliency, exclusion, ZBL, mixed profiles
- Best Practices
  - ✓Mod profiles, US pwr level, pwr adjust, max ch pwr offset, avoidance (freq hopping?, cm steering), T4 multiplier
- DPON – RF over Glass (RFoG)
- References

Introduction

- Provide brief overview of CMTS and CM technology as provided by DOCSIS certified/qualified equipment
- List cBR-8 features that provide “self-healing” functionality in regards to ingress and customer CM service disruption
- Provide best practices and optimization in regards to physical layer attributes
- Recommendations and deviations from default settings are based on typical cable plant architectures & design
- Recommendations may not apply in some scenarios

Embedded Technology

Embedded Technology

- Ingress Cancellation
- Pre-EQ
- Dynamic US Interleaving
- Full Bandwidth Capture & PNM

Ingress Cancellation

- Great for stead-state, narrow ingress
  - ✓CB, ham radio, CW, shortwave,…
- **Note**: DS even has ingress cancellation, but not talked about
- `(config-if)# cable upstream 0 ingress-noise-cancellation ?`
  - ✓`<10-3000>  trigger interval in milliseconds`
  - ✓100 msec default

US Equalization

- CMTS Internal Adaptive EQ
  - ✓ Works regardless if Pre-eq enabled or not, done on short, long, a-short, a-long & a-ugs bursts
  - ✓ 8-tap blind equalizer for all CM types
  - ✓ Helps TDMA as well as ATDMA
  - ✓ Bottom line is internal EQ does not harm Pre-eq but may compliment it
- Pre-EQ
  - ✓ Alleviates group delay and micro-reflection issues
    - ➢ Groups delay near bandedges (filters), but also from suckouts (fake filters), step attenuators, filters and padded taps
  - ✓ Original PNM usage
  - ✓ Not on by default and uses IM and SM bursts
  - ✓ D2.0 increased EQ tap length from 8 to 24
    - ➢ Good reason to uses ATDMA mode even if still using 16-QAM at 3.2 MHz also avoids D1.x CMs to register/range
    - ➢ Cisco CMTS has direct load feature – 3 dB drop within SM period triggers it

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Dynamic US Interleaving

- Impulse noise not be “seen” by US chip
- MER is averaged and would report fine
- Many packets or codewords could be dropped leading to uncorrected FEC
- Dynamic US interleaving in atdma modulation profile may help convert uncorr to corr

Cable Global Commands

Cable Global Commands

- Flap-list
- Remote Query
- DOCSIS Restricted LBGs
- DS Resiliency Bonding Groups
- CM Status Messages
- Modulation Profiles

Flaplist

- Flaplist tracks US SM bursts
  - ✓Reason to use 16-QAM
  - ✓When to place in flaplist, how long, and how many
    - `cable flap-list power-adjust threshold 3`
    - `cable flap-list aging 86400`
    - `cable flap-list size 8191`

Remote Query

- Great for lab and initial install, but not suggested for production network
- Suggested usage with large timer
  - ✓`cable modem remote-query 1800 public`
- Use “real-time” command for troubleshooting
  - ✓`show cable modem “mac address” remote update “community”`
- Remote–query needed for some fields to populate for `scm phy` command

Restricted Load Balance Group Example (85 MHz US)

- Assuming 8 US chs, USs 0-3 are < 42 MHz, 8-ch & 4-ch US BGs created
-
```
cable tag 1
 name 42MHz
 tlv ufrs 0 (1 means extended)
 docsis-version docsis20
```
-
```
cable load-balance docsis-group 10003
 restricted
 downstream Integrated-Cable 1/0/0 rf-channel 0-15
 upstream Upstream-Cable 1/0/0 us-channel 0-3
 tag 42MHz
```
- **Note**: Be sure D3.0 CMs placed in RLBGs have all DSs assigned for bonding
- **Note**: Verify proper tag was assigned after CM re-registration
  - ✓Tags are assigned from top down in show run and only one tag

Wideband Resiliency – DS Ch Bonding Partial Mode

- Global config to move ALL DS SFs to PC when impairment present
  - ✓ `(config)#cab rf-change-trigger percent 50 count 10 secondary`
- DS resiliency depends on CMs sending CM-STATUS messages to CMTS
  - ✓ Use `sh cab rf-status, scm "mac" cm-status, & scm "mac" wide rcs-status` to see
- Also have: `(config)#cable rf-change-dampen-time ?`
  - ✓ `<1-65535>  # of seconds NP RF status change must persist`
- CM will report `p-online` and fwding interface gets changed
- **Note**: Do not "`shut`" DS on CMTS side to test DS resiliency, but feature to allow `mute` to test
- Resiliency Bonding Groups (RBGs)
  - ✓ `cable resiliency ds-bonding`
  - ✓ `interface wideband-cable x/y/z:a`
    `cable ds-resiliency`

CM-Status Messages & CMs Stuck P-online

- CM-status messages use contention Req and normal US BW minislot allocation
  - ✓ **Tip**: Since size of message ~ 34B, an “a-short” burst profile most likely used and maybe use more robust modulation for this burst
- `10k(config)#cab cm-status 1 holdoff ?`
  - ✓ `<1-65535>  holdoff timer value in increment of 20 ms`
  - ✓ Default of 50 increments of 20 msec = 1000 msec = 1 sec
  - ✓ Controls how frequent repeated cm-status messages sent for same transaction ID
- `10k(config)#cab cm-status 1 holdoff 50 reports ?`
  - ✓ `<0-255>  reports value with default of 2`
  - ✓ Controls how many cm-status messages sent for same Transaction ID
- **Warning**: Maximum Reports Count of zero (0) allows CM to continue sending CM-Status messages as long as event condition is "on" and is enabled for reporting
- **Tip**: `cable cm-status x holdoff 100 reports 10`
  - ✓ Gives 20 sec total; x can be specific cm-status message or “all”
- **Note**: cm-status ack supported in 16.6 IOS, but only for D3.1 CMs

Modulation Profiles

```
Cab modulation-prof 222 atdma request 0 16  0 22 qpsk  scram 152 no-diff 32  fixed qpsk0 1 2048
Cab modulation-prof 222 atdma initial 5 34  0 48 qpsk  scram 152 no-diff 384 fixed qpsk0 1 2048
Cab modulation-prof 222 atdma station 5 34  0 48 qpsk  scram 152 no-diff 384 fixed qpsk0 1 2048
Cab modulation-prof 222 atdma a-short 4 76  7 22 qpsk  scram 152 no-diff 64  short qpsk0 1 2048
Cab modulation-prof 222 atdma a-long  9 232 0 22 qpsk  scram 152 no-diff 64  short qpsk0 1 2048
Cab modulation-prof 222 atdma a-ugs   9 232 0 22 qpsk  scram 152 no-diff 64  short qpsk0 1 2048

Cab modulation-prof 223 atdma request 0 16  0 22 16qam scram 152 no-diff 32  fixed qpsk1 1 2048
Cab modulation-prof 223 atdma initial 5 34  0 48 16qam scram 152 no-diff 384 fixed qpsk1 1 2048
Cab modulation-prof 223 atdma station 5 34  0 48 16qam scram 152 no-diff 384 fixed qpsk1 1 2048
Cab modulation-prof 223 atdma a-short 4 76  7 22 16qam scram 152 no-diff 64  short qpsk1 1 2048
Cab modulation-prof 223 atdma a-long  9 232 0 22 16qam scram 152 no-diff 64  short qpsk1 1 2048
Cab modulation-prof 223 atdma a-ugs   9 232 0 22 16qam scram 152 no-diff 64  short qpsk1 1 2048

Cab modulation-prof 224 atdma request 0 16  0 22 16qam scram 152 no-diff 32  fixed qpsk1 1 2048
Cab modulation-prof 224 atdma initial 5 34  0 48 16qam scram 152 no-diff 384 fixed qpsk1 1 2048
Cab modulation-prof 224 atdma station 5 34  0 48 16qam scram 152 no-diff 384 fixed qpsk1 1 2048
Cab modulation-prof 224 atdma a-short 6 76  6 22 64qam scram 152 no-diff 64  short qpsk1 1 2048
Cab modulation-prof 224 atdma a-long  9 232 0 22 64qam scram 152 no-diff 64  short qpsk1 0 2048
Cab modulation-prof 224 atdma a-ugs   9 232 0 22 64qam scram 152 no-diff 64  short qpsk1 1 2048
```

Note: Dynamic US interleave turned ON for a-long burst for more protection to impulse noise; if deemed unnecessary or causes problems, change 0 back to 1

Cable Controller Configurations

Cable Controller Configurations

- **Note**: controller synonymous with connector
- Upstream Controller
  - ✓3-level dynamic modulation
  - ✓Pre-equalization
- Integrated Controller
- **Note**: Modular was used for 3G60 on uBR10K
- Downstream-Cable Controller
  - ✓New for remote phy

Controller Upstream-Cable 1/0/0

```
us-channel 0 frequency 25000000
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 uncorr-fec 1
! This is default command, so won't show
us-channel 0 threshold hysteresis 4
us-channel 0 docsis-mode atdma
us-channel 0 minislot-size 2
us-channel 0 modulation-profile 224 223 222
us-channel 0 equalization-coefficient
no us-channel 0 shutdown
```

Cable Interface Configurations

Cable Interface Configurations

- Power-adjust continue
- Upstream max-channel-power-offset
- Upstream balance-scheduling
- 4 & 2-ch upstream bonding
- US bonding partial mode (SM & data burst MER thresholds)
- T4 multiplier
- Service flow movement
- SID cluster
- Map-advance dynamic

Cable Interface Configurations

```
interface Cable1/0/0
load-interval 30
down Integrated-Cable 1/0/0 rf-ch 0
down Integrated-Cable 1/0/0 rf-ch 8
up 0 Upstream-Cable 1/0/0 us-channel 0
up 1 Upstream-Cable 1/0/0 us-channel 1
up 2 Upstream-Cable 1/0/0 us-channel 2
up 3 Upstream-Cable 1/0/0 us-channel 3
cab up 0 power-adjust continue 6
cab up 1 power-adjust continue 6
cab up 2 power-adjust continue 6
cab up 3 power-adjust continue 6
cab up balance-scheduling
cab up ranging-init-technique 2/3 (better D3.0 DS LB)
cab up max-channel-power-offset 6
cab up ranging-poll t4-multiplier 2
cab upstream resiliency sf-move RTPS
cab up resiliency sf-move NRTPS
cab up resiliency sf-move UGS
cab up resiliency data-burst snr 24 ufec 1 cfec
0 hysteresis 4
```

```
cab upstream bonding-group 1000
  upstream 0
  upstream 1
  upstream 2
  upstream 3
  attributes 80000000
cab upstream bonding-group 1001
  upstream 1
  upstream 2
  attributes 80000000
cab bundle 1
cab map-advance dynamic 800 600
cab sid-cluster-group num-of-clust 2
cab sid-cluster-switching max-req 4
cab cm-status enable 3 9-10 16 20-24
cab reduction-mode mta-battery enable
cab reduction-mode energy-manage enable
```

Potential US Bonding Issues

- Power level issues during registration
  - ✓ `cab up n power-adjust continue 6` used for D2.0 and keepalive every 15 secs
  - ✓ `cab up max-channel-power-offset 6` introduced for D3.0 CMs
- US bonding could have higher utilization on first US (US 0 typically) than other USs in BG
  - ✓ Could negatively affect D2.0 LB on that US
  - ✓ `cable upstream balance-scheduling` introduced to distribute minislots evenly
- Changes introduced to improve scalability & CPU performance
  - ✓ Could have effect of slower per-CM throughput
  - ✓ **Note**: It may be necessary to configure `cable sid-cluster-group num-of-cluster 2` to achieve desired US bonded speeds
  - ✓ Another solution is large US Max Traffic burst in cm file, such as 30 kB
  - ✓ DOCSIS 3.0 uses Continuous Concatenations and Fragmentation (CCF)
    - ➢ No need to change Max Concat field from default of 3044, but 8K suggested in case it registers in D2.0 mode

US Bonding Partial Mode

- **Note**: US resiliency on by default & controlled on per-CM basis
- US partial mode dynamic, no need for extra configured BGs
  - ✓**Note**: US ch state dictated by SM burst at 16-QAM vs data at 64-QAM
  - ✓New feature has configurable threshold for per-cm tracking of FEC & MER
    - ➢`cab up resiliency data-burst snr 24 ufec 1 cfec 0 hysteresis 4`
- Possible suggestion: `cab up ranging-poll interval 15000 t4-multiplier 2`
- Move and retain secondary flows during US partial mode
  - ✓`cab upstream resiliency sf-move RTPS`
  - ✓`cab upstream resiliency sf-move NRTPS`
  - ✓`cab upstream resiliency sf-move UGS`

Map Advance Dynamic "Safety" "Max-Delay"

- Goal is to have map advance dynamic as low as possible for better per-cm US speed, but > ~ 2500 for VoIP and US bonding concerns along with `misses` in the flaplist from missed station maintenance
- "Safety" can probably be set to about 600-800 and calculate "max-delay" (cap) based on fiber plant length
- MAP advance can be tricky
  - ✓If large HFC plant, then cap of 600 may be too little and can result in late/expired MAPs at CM/eMTAs
- If it is known that HFC plant is shorter/smaller, then cap of 600 should be fine

DOCSIS 3.1 DS &US Profile Management

D3.1 DS Graceful Profile Management

- Dynamically adjusts each CM's DS data profile
- Use RxMER to calculate recommended data profile
  - ✓Use fixed and scattered pilots with 6 dB correction
- Upgrade/Downgrade automatically
- Avoid profile thrashing by only upgrading when new RxMER data collected from CM (configurable period with 60 min default)
- CM remains online
- cBR makes selection intelligently
  - ✓e.g. CM-STATUS report of lower unfit modulation pre-empts selection of any higher modulation
- DBC might be triggered for best DS data profile
- "Catch all" is to utilize CM-STATUS message reporting for unfit/fit data profile

Baseline Scenario

- CM comes online and cBR picks data profile (256-QAM)
- Configure 4-5 data profiles and reset CM
- CM will use best recommended data profile (4096-QAM)
- Upgrade is automatic
- Suggested 12, ¼ dB offset = 3 dB & 10% subcarrier ignore
- 4K, 2K, 1K, 1K/256 mixed, 256-QAM data profile

D3.1 Partial Mode

- Can reset `p-online` D31 CMs automatically through configuring partial-service-reset-timer
  - ✓Not enabled by default
  - ✓After LCSO, checks for any D31 CMs `p-online` and auto-resets
  - ✓If `p-online` due to other CM issues, then it may stay `p-online`
- `CBR8(config)#cable lcha partial-service-reset-timer ?`
  - ✓`<1-300>  D31 modem partial service reset timer in seconds`
  - ✓`EDT: %CBR-4-RECONCL_RESET_D31_CM_FINISH: Reconciliation reset partial D31 CM for slot 1 finished: D3.1 Online 10, D3.1 DS partial 0, D3.1 US partial 0, D3.1 both partial 0. D3.0 DS partial 0, D3.0 US partial 0, D3.0 both partial 0`

DPON

DPON – RF over Glass (RFoG)

- All CMs do initial ranging on US 0
  - ✓Legacy CMs pushed to US 0 and US 0 must be “up”
- All USs in mac domain need same parameters and USs need to be in numeric order (0, 1, 2, 3)
- DOCSIS 3.0 CMs granted evenly across all USs
  - ✓No need for `US balance-scheduling` command
- Interface config for dpon:
  - ✓`(config-if)#cab upstream ?`
    - ➢`dpon  Configure Docsis over Passive Optical Network`
- **Note**: once configured, it is used for entire linecard
  - ✓Use “`term mon`” to see warnings
  - ✓3.18 made it per domain, but not backported to 10K
- **Note**: make sure max-ports set for exact # of USs in 10K domain

Relatively New Features

- US Data Burst MER – more advanced US bonding partial mode
- 16 USs per mac domain – but still only 12 SC_QAMs per connector pair
- Energy Management mode (uses RBGs)
- DPON/RFoG per mac domain
- D3.1 US module 5-204 MHz (Leoben 3)

References

References

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- cBR-8 Visios
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  - ✓ http://cmtswiki.cisco.com:8080/display/battlestar/cBR8+Troubleshooting+Guide
- Product Demo: Kaon demo for cBR-8
  - ✓ Interactive 3D virtual demo to show cBR-8 demo on laptops & tablets
  - ✓ Get access through Cisco 3D catalog app together or go to link below
    - ➢ Password protected (1984)
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- Google Hangout - #1 DOCSIS Podcast (we're the only one)
  - ✓ http://volpefirm.com/
  - ✓ https://plus.google.com/u/0/+Volpefirm/videos

Metaphors

One more ingress spike affect on Analog AM lasers

AM Laser in HFC Plant


CISCO