Downstream Bit Loading Procedure

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Outline of DS Bit Loading

- Load bits according to the bit loading profiles.
- The bit loading profile is defined in transmitted subcarrier domain.
- The bit loaded symbols are subject to time and frequency interleaver.
- The scattered pilot pattern changes for each OFDM symbol, which needs to be taken into account during bit loading.
- A placeholder has to be reserved for scattered pilot during bit loading

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Bit Loading and Interleaving

- Diagram from DOCSIS 3.1

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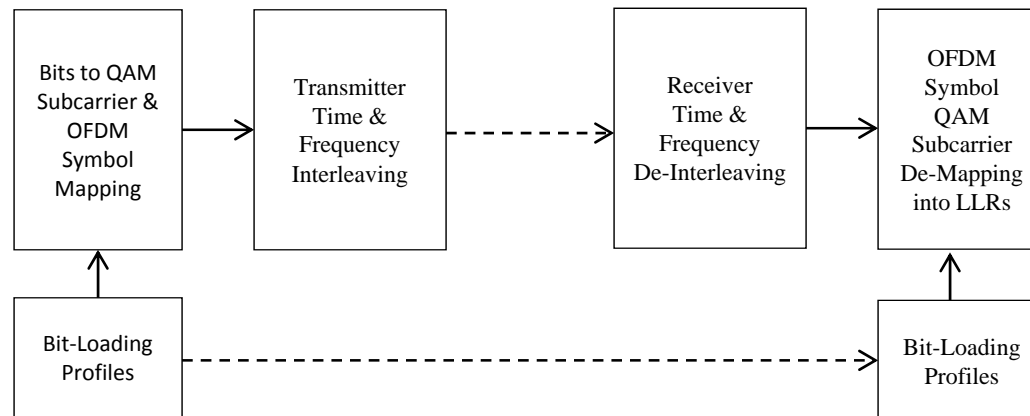
Summary for DS Bit Loading Procedure

- Profile i: $A_i(k)$, k=0, …, N-1, N=4096/8092
- Let N_l be the set of all indexes excluding continuous pilots, exclusion subcarriers, PLC subcarriers, $B_i(k)$ represents profile for k=0, …, N_l.
- Let $C_i(k)=P^{-1}(B_i(k))$, where P is the frequency interleaver. P^{-1} is the inverse function of P.
- Let D(k, j)=1 denote the presence of scattered pilots at subcarrier k and OFDM symbol j before the frequency interleaver. Note: D(k,j) varies for different OFDM symbols.
- Load each of N_l subcarrier of OFDM symbol j with $C_i(k)$ bits, k=0, …, N_l, Whenever hitting D(k,j), that subcarrier is skipped from loading bits.
- D(k,j) needs to be tracked for each frame.

Outline of FDD Bit Loading Profile Update

- Single Modulation Profile for DS FDD (TD #19)
- Each CNU generates different MER measurements, corresponding to different profiles.
- CLT should discretionally choose the single modulation profile that meets the capability of all CNUs, for example, LCD for all profiles.
- The particular bit loading algorithm should be implementation specific.
- The MER measurement is transmitted through the US PHY link channel upon request by CLT.
- The modulation profile is transmitted to each CNU through DS PLC.

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When to Update the Bit Loading Profile

- New CNU registration.

- Request from CLT management plane

- CNU may also need to initiate the bit loading profile update for various reasons, for example: bad frame loss ratio

  - CNU is passive, only responds to the instruction from CLT.
  - Use MAC Report message? No, MAC cannot see frame loss.
  - CLT needs to periodically read FER from each CNU.

  CNU_FER[7:0]: $a_2a_1a_0e_4e_3e_2e_1e_0$ represent

  $0.1a_2a_1a_0*2^{\wedge}(-e_4e_3e_2e_1e_0)$

CLT Bit Loading Profile Update

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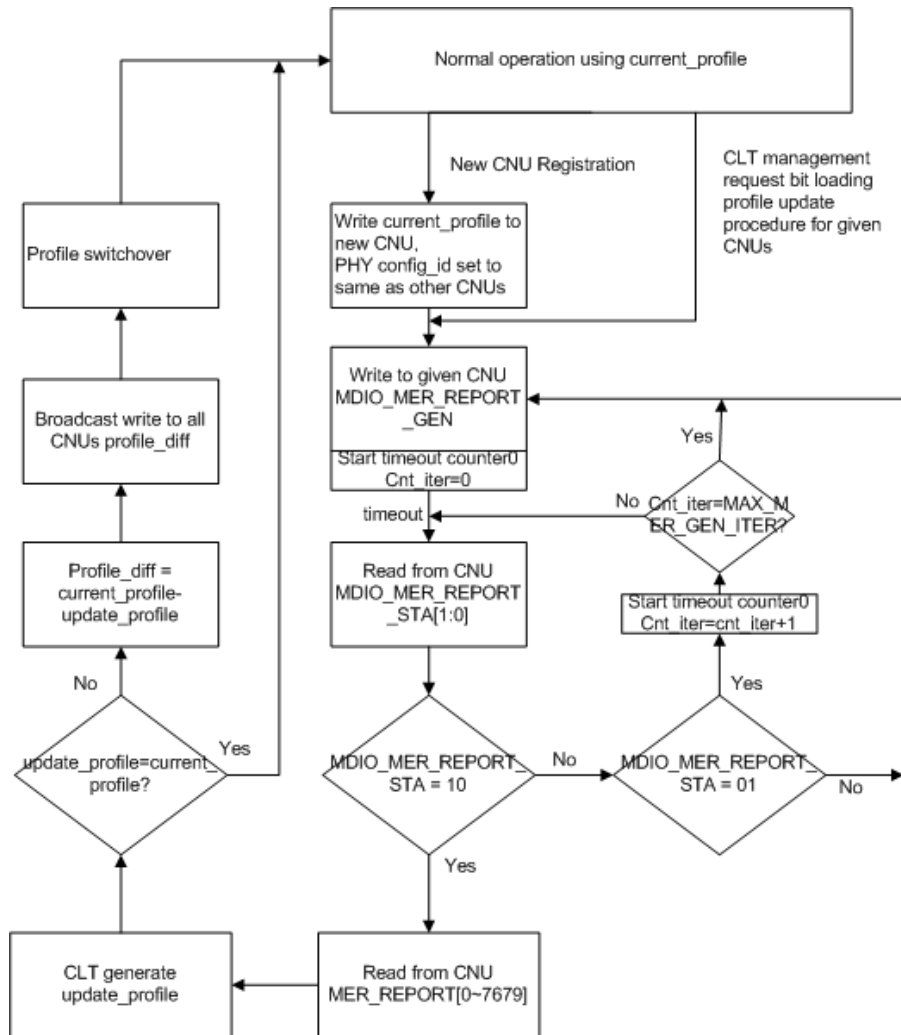
Data Format of Profile

Code	Modulation	Code	Modulation
0000	OFF	1000	256-QAM
0001	BPSK	1001	512-QAM
0010	QPSK	1010	1024-QAM
0011	8-QAM	1011	2048-QAM
0100	16-QAM	1100	4096-QAM
0101	32-QAM	1101	8192-QAM(optional)
0110	64-QAM	1110	16384-QAM(Optional)
0111	128-QAM		

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Instruction to Write Profile

- Use PLC write instruction
- Each profile needs 7680/4=1920 words. (For 8192FFT)
- CNU needs to maintain two profiles
  - CNU_DS_Profile_A[0~N-1][15:0]
  - CNU_DS_Profile_B[0~N-1][15:0]
  - N = 1920 for 8192 FFT, N = 960 for 4096 FFT
- May have a lot of consecutive carriers with same modulation order
- Use two modes to send bit loading profile
  - Direct Mode: PROFILE_WRITE_MODE=0, the address specify the subcarrier index. Can write 32*4=128 subcarriers for one write command
  - Block Mode: PROFILE_WRITE_MODE=1, the first address specify the start subcarrier index, then followed by the number of subcarriers in a block, the bit loading size for the whole block.

Direct Mode Operation

PLC Instr.	Register	Length (bits)	Count (0~31)	Value	Note:
1	PROFILE_WRITE_MODE	1	0	0	Direct mode
2	CNU_DS_Profile_A/B[k]	13	0~31	vary	Send up to 128 profile element

Block Mode Operation

PLC Instr.	Register	Length (bits)	Count (0~31)	Value	Note:
1	PROFILE_WRITE_MODE	1	0	1	Block mode
2	PROFILE_WRITE_BLOCK_START	13	0	vary	Start index
3	PROFILE_WRITE_BLOCK_SIZE	13	0	vary	Size of the block of profile elements
4	PROFILE_WRITE_VALUE	4	0	vary	The value of the profile block.

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FDD CNU MIDO Registers

MDIO Registers	Description
CNU_DS_Profile_A[0~N-1][15:0] CNU_DS_Profile_B[0~N-1][15:0]	DS profiles, N = 1920 for 8192 FFT, N = 960 for 4096 FFT. A/B profiles used for hitless switch
MER_REPORT_GEN	1: Start generation of MER report for CNU 0: Not start
MER_REPORT_STA[1:0]	Status of MER reporting 00: Not start 01: Generating a new MER report 10: New MER report ready 11: Error when generating MER report
MER_REPORT[0~Nc-1][15:0]	MER report. 8 bits for each carrier. Each word contains two subcarriers. xxxxxx.xx dB, 0~63.75dB Nc=3840 for 8192FFT Nc=1920 for 4096FFT

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FDD CNU Diagram of Bit loading

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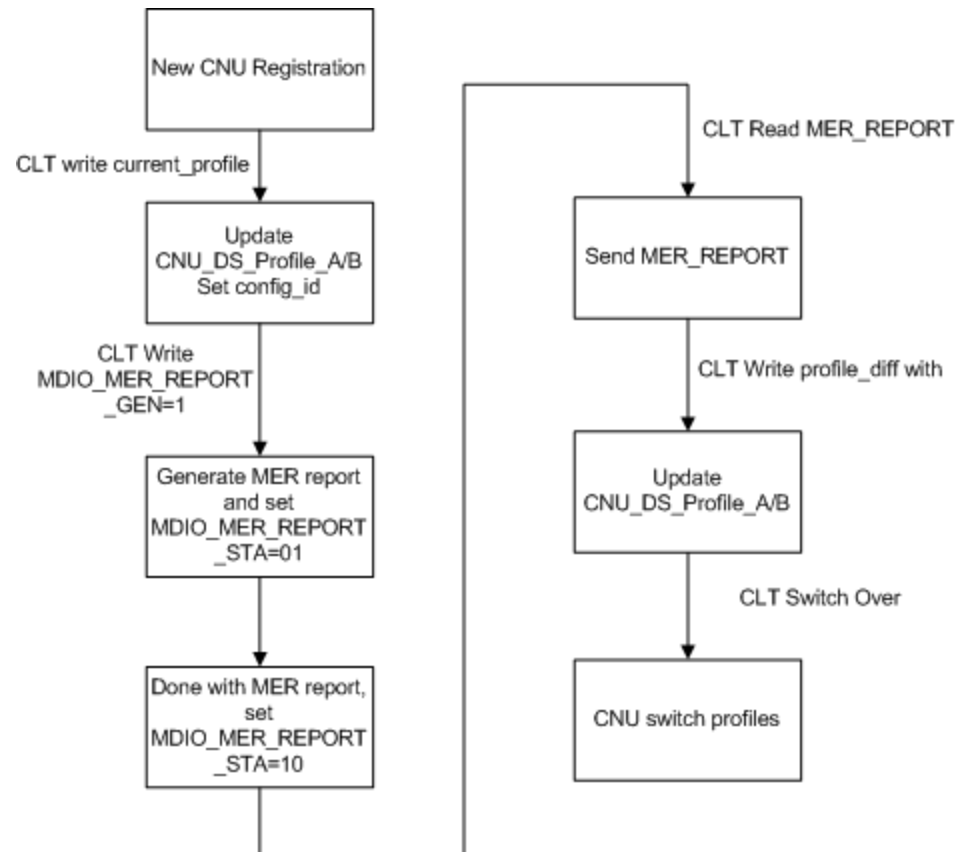
Outline of TDD DS Bit Loading Profile Update

- Support MMP for TDD DS, because TDD DS is in nature bursty. (TD #19)

- CLT maintains up to Nprofile different DS profiles, including one broadcast profile (default profile), and Nprofile-1 individual profiles.

- CLT assigns each CNU in one of Nprofile-1 CNU sets.

- It is implementation specific for CLT to choose the number of active profiles, the CNU sets, and each profile.

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CLT Behavior for Bit Loading Profile Update

- Upon new registration, the CLT needs to send broadcast profile (default profile) to new CNU.
- CLT shall enable the MER reporting for new CNU.
- After obtaining MER report from CNU, the CLT shall decide
  - Change of active profiles
  - Change of CNU set.
  - Notify each CNU of changed set with profile_update.
- CLT maintains Nprofile profiles, including:
  - DS_Profile_0: broadcast profile also default profile
 - DS_Profile_1~DS_Profile_i: active profiles, i<Nprofile

CLT Diagram for Bit Loading Profile Update

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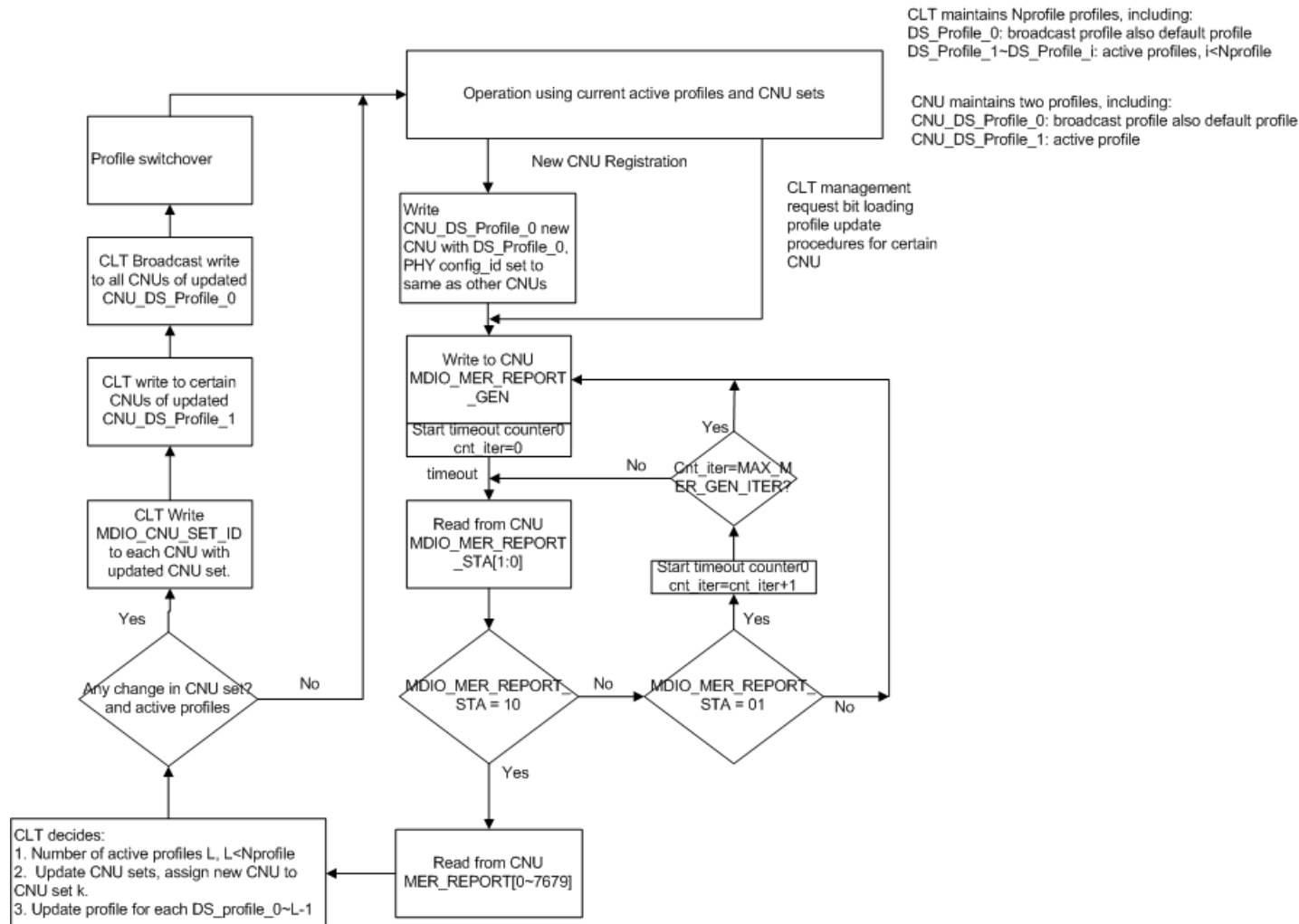
TDD CNU MIDO Registers

MDIO Registers	Description
CNU_DS_Profile_0A[0~N-1][15:0] CNU_DS_Profile_0B[0~N-1][15:0] CNU_DS_Profile_1A[0~N-1][15:0] CNU_DS_Profile_1B[0~N-1][15:0]	DS profiles, N = 1920 for 8192 FFT, N = 960 for 4096 FFT. A/B profiles used for hitless switch. CNU_DS_Profile_0x is used for broadcast, and CNU_DS_Profile_1x is used for unicast
MER_REPORT_GEN	1: Start generation of MER report for CNU 0: Not start
MER_REPORT_STA[1:0]	Status of MER reporting 00: Not start 01: Generating a new MER report 10: New MER report ready 11: Error when generating MER report
MER_REPORT[0~Nc-1][15:0]	MER report. 8 bits for each carrier. Each word contains two subcarriers. xxxxxx.xx dB, 0~63.75dB Nc=3840 for 8192FFT Nc=1920 for 4096FFT
CNU_SET_ID_A[2:0]	CNU_SET_ID corresponds to the

TDD CNU Diagram for Bit Loading

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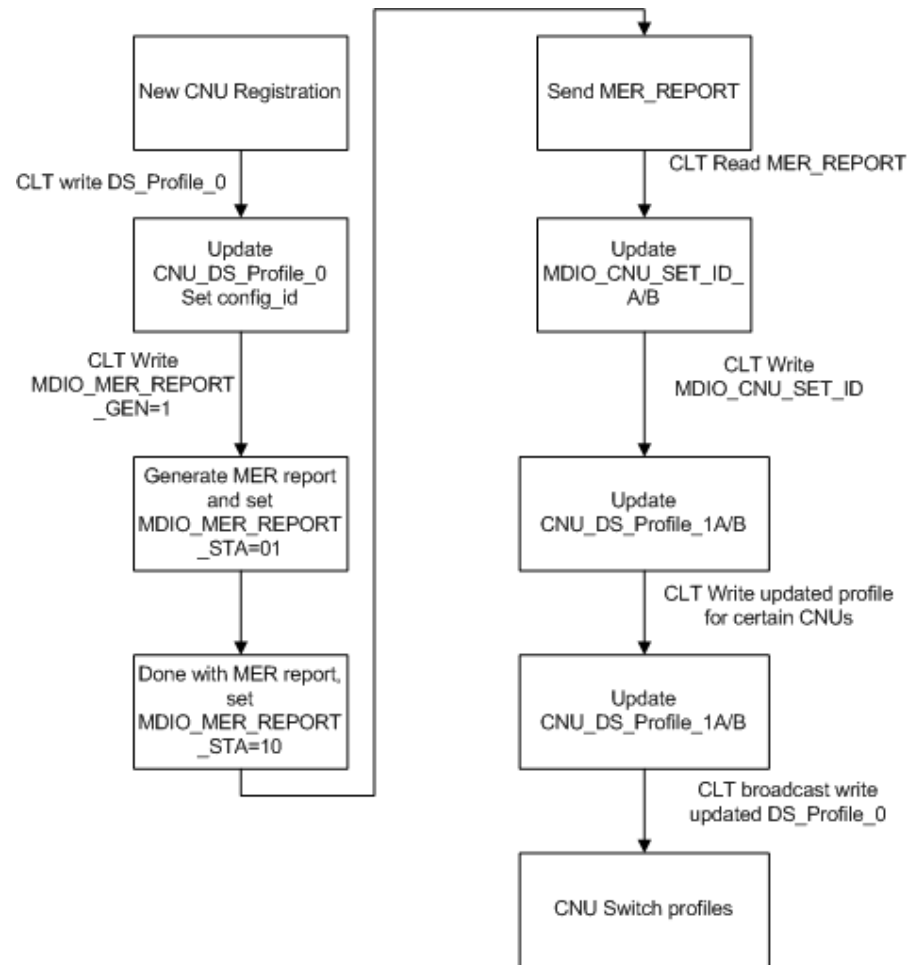
Conclusions

- The EPoC bit loading procedure is similar to that in DOCSIS 3.1.
- Without much help from MAC management message, the bit loading profiles need to be maintained through PLC.
- Instruction sequence regarding the generation and updating of bit loading profiles need to be specified in the standard.
- The implementation of bit loading profile generation at the CLT and MER report generation at CNU are beyond the scope of this TF.

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Proposed Motion (New Slide)

- Adopt zhang_3bn_02a_1113 page 5~18 as a starting point towards baseline proposal for the procedure of updating the bit loading profiles for DS.
- Yes
- No
- Abstain