

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [MAC review of baseline document]

Date Submitted: [January 15, 2008]

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Re: [In response to TG3c Call for Proposals (IEEE P802.15-07-0586-02-003c)]

Abstract: [Merged proposal of enhancement of MAC for mmWave system proposal]

Purpose: [To be considered in TG3C baseline document.]

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Review of baseline document: Enhancement of MAC for mmWave System Proposal

Jan 15, 2008

Outline

1. Changes at Atlanta meeting
2. MAC function of baseline document
3. Comparison with AV-OFDM MAC
4. Issues to be addressed

Summary of the changes at Atlanta

802.15.3cMAC baseline document was changed at Atlanta meeting

1. The beacon period (BP) was removed.

- A) Optional beacon extension in 15.3b for multiple beacon supported in 15.3c
- B) Remove related parameters for BP.

2. MAC sublayer parameters are changed.

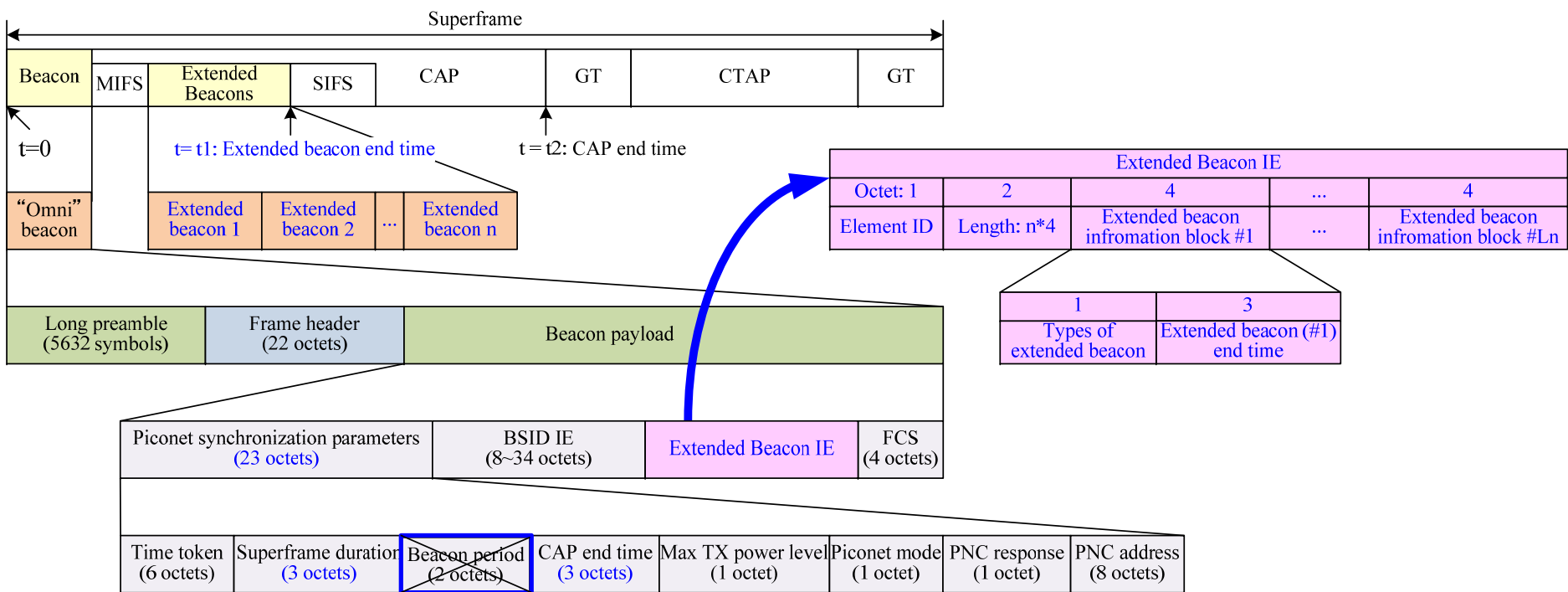
- A) mMaxNumValidDEVs is changed from 16 to 243 defined in 802.15.3b to keep consistency

*; “omni” means to cover all directions by omni antenna or part of omni antenna coverage which is planned to be covered by the directional antenna (beam forming or sector antenna)

The beacon period (BP) removed

The beacon period (BP) in our proposal was removed to keep consistency with 15.3b. Optional extended beacon in 15.3b is used to realize multiple beacon support in 15.3c

- A) An 802.15.3c superframe contains an **“omni” beacon** and **optional extended beacons** (for beamforming) for SC or OFDM
- B) **Extended beacon information element (IE)** was newly defined to transmit extended beacon information to DEVs



MAC sublayer parameters changed

- A) mMaxBPDduration (256us) was eliminated because beacon period is not supported any more
- mMaxBPDduration was newly defined parameters for variable length beacon period in our proposal.
- B) mMaxNumValidDEVs was changed from 16 to 243 defined in 802.15.3b to keep consistency
- mMaxNumValidDEVs is an existing parameters that determines maximum numbers of associated DEVs for a piconet

Summary

MAC – Difference and Addition from 3b

Features of 802.15.3c MAC

1. Superframe structure

- Improved time resolution for superframe timing control

2. Frame aggregation

- Frame aggregation with dedicated subheader
- Definition of Blk-ACK for aggregation

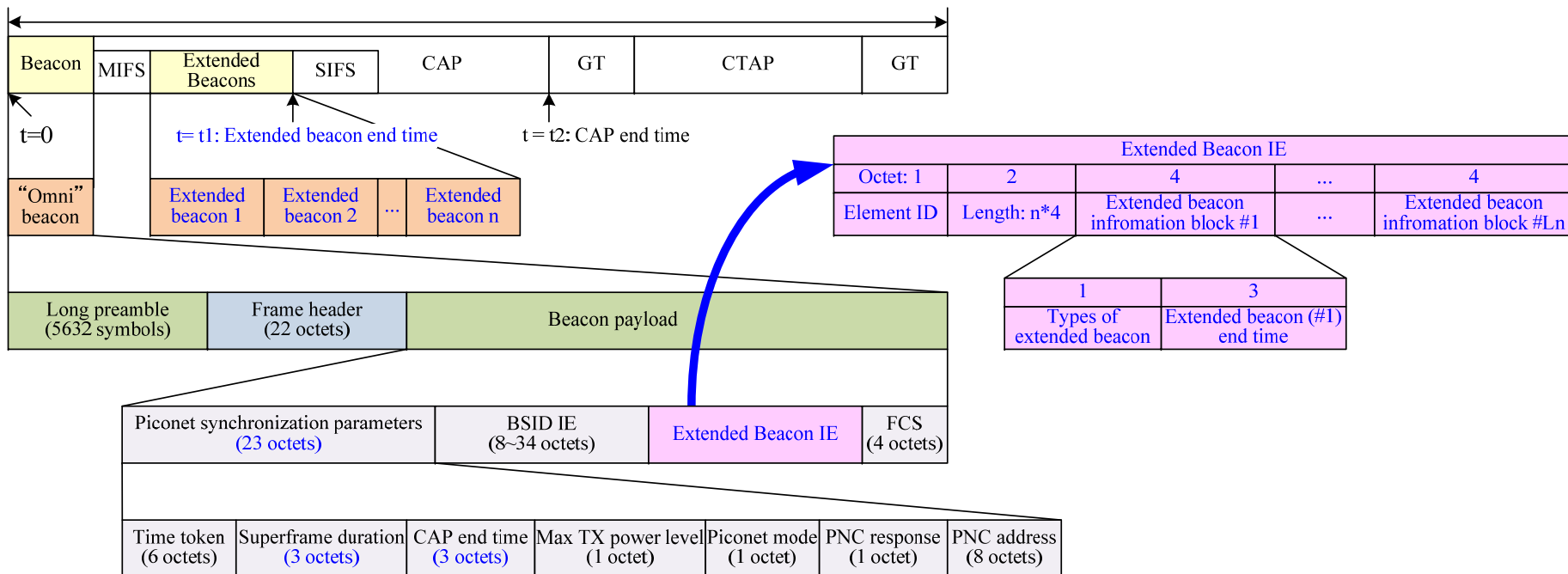
3. Five new procedures to realize 15.3c functions

- Option : Beamforming, Channel probing, DEV-DEV directional communications, UEP, Transit switched diversity

Superframe structure

- Contention Access Period (CAP) based on CSMA/CA
- Channel Time Allocation Period (CTAP) based on TDMA
- Improved time resolution of 9ns (16symbols/1.728Gbps) for superframe timing control
 Modification of piconet synchronization parameters
 - Superframe duration (3 octets from 2 octets in 15.3b)
 - CAP end time (3 octets from 2 octets in 15.3b)
- Optional beacon extension in 15.3b for multiple beacon supported in 15.3c

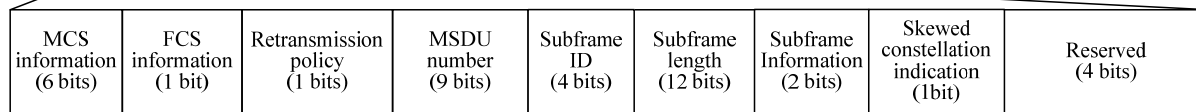
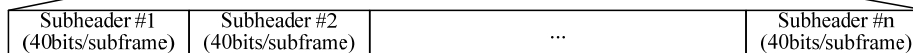
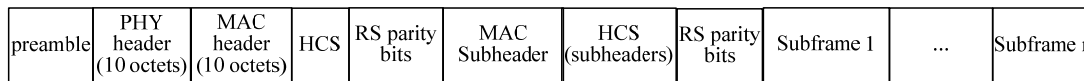
“Omni”: meaning to cover all directions by omni antenna or part of omni antenna coverage which is planned to be covered by the directional antenna



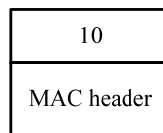
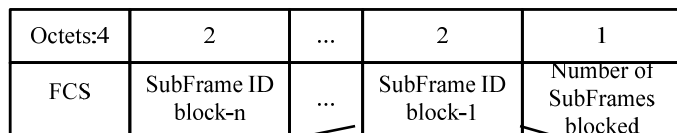
Aggregation and Blk-ACK

- Frame aggregation for High throughput
 - Subheader for each subframe protected by HCS
 - Subframe information and FCS information in subheader for UEP
- Newly defined Block ACK (Blk-ACK)
 - Selective retransmission for each subframe
 - Support partial subframe retransmission for UEP

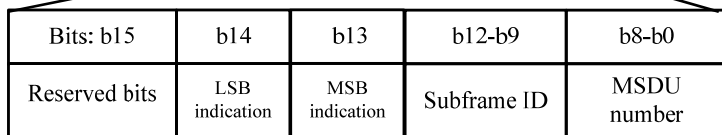
Subheader



Block ACK



•MSB subframe
 •LSB subframe
 •MSB and LSB combined subframe



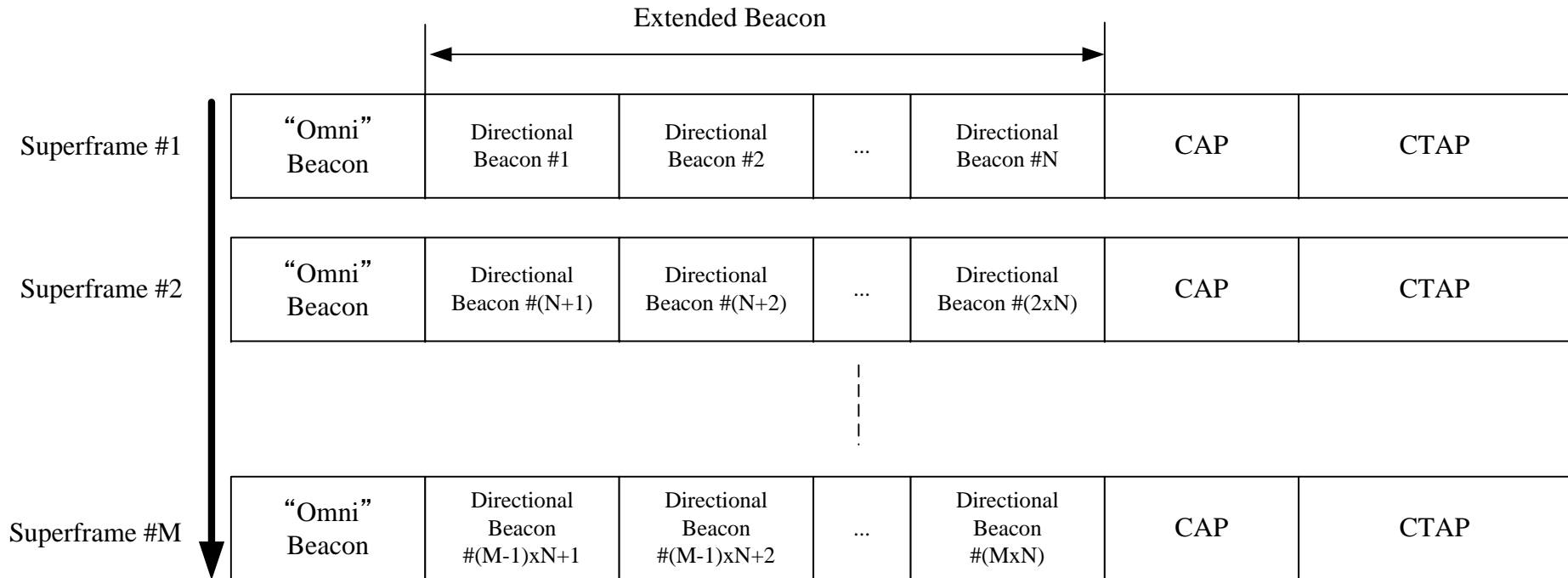
MAC New operation procedures and primitives

Four procedure additions

- **Beamforming (Option)**
 - Beamforming by receiving beam training sequence
- **Channel probing (Option)**
 - Determination of most suitable PHY transmission mode
 - Forward and backward channel probing by transmitting channel probing sequence
- **DEV-DEV directional communications (Option)**
 - DEV-DEV beamforming, channel probing and streaming
 - Peer discovery for capability confirmation
- **UEP (Option)**
 - MCS (modulation and coding scheme) control by the subheaders

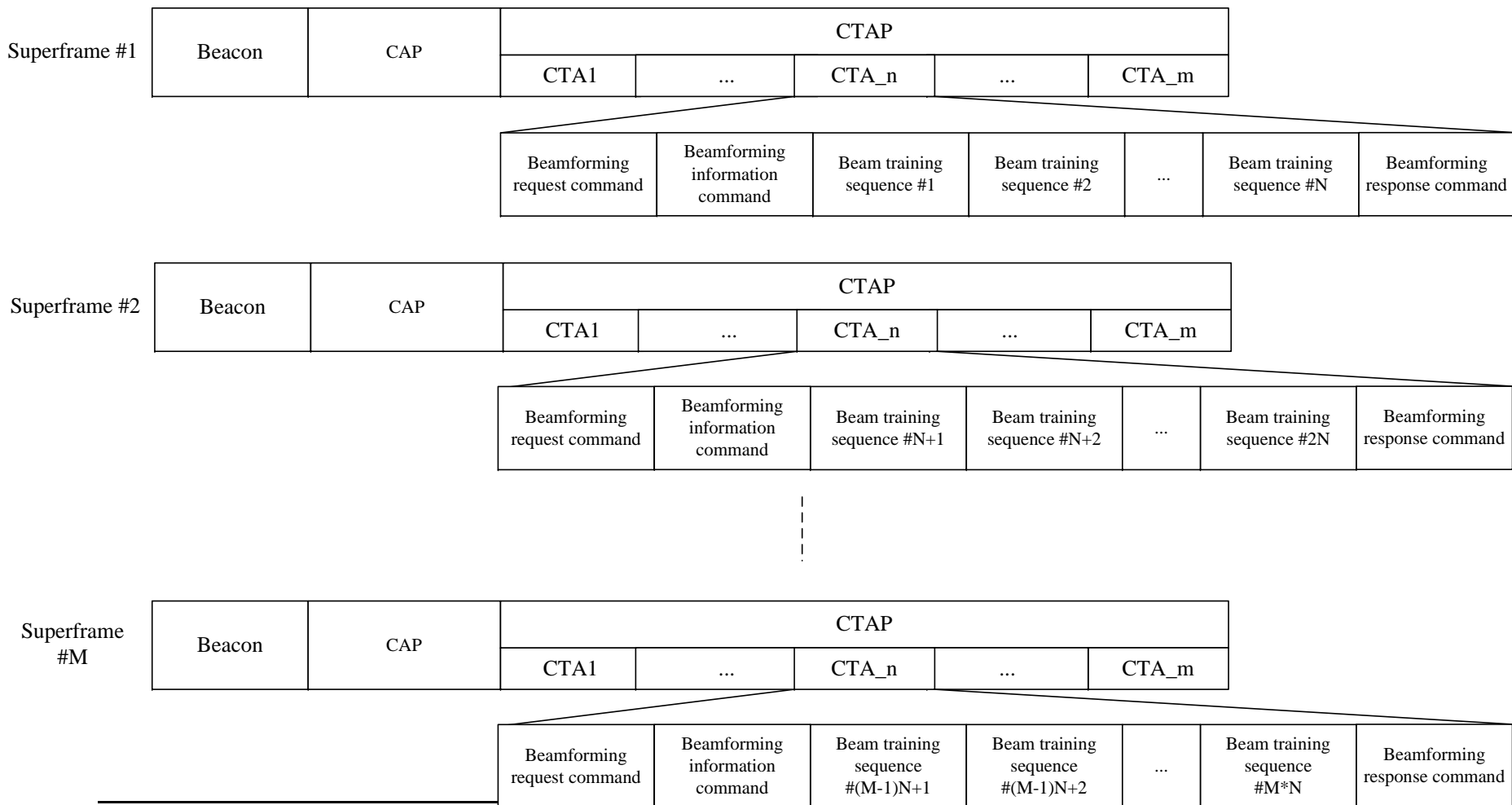
Beamforming (1/2)

- **Two types of beamforming** are defined
 - **Type 1 : PNC and DEV beamforming by using “omni” and directional beacons in beacon period**



Beamforming (2/2)

– Type 2 : DEV and DEV beamforming by beam training sequences in CTA



Channel probing

- **Channel probing** is defined to find the highest data rate transmission mode
 1. **Channel probing between PNC and DEV by beacon**
 2. **Channel probing between DEVs in CTA**
 - DEV request intended DEV to send channel probing sequence in allocated CTA
 - DEV measure channel status by processing channel probing sequence from intended DEV
 - DEV informs the measurement result to the intended DEV in the same CTA

Unequal Error Protection (UEP) (1/3)

– Three types of UEP are defined

- UEP 1
 - MSB data or LSB data occupies a whole subframe
 - MSB subframes and LSB subframes can be aggregated into one frame
 - Different MCS and FCS can be selected subframe by subframe
 - 6bits in subheader to indicate different MCS
- UEP 2
 - MSB and LSB data are separately put into different aggregated frame
 - MSB and LSB frames are allowed to be transmitted on different antenna (using transmit switched diversity)
 - One bit in subheader to indicate the aggregated frame is MSB data or not

UEP (2/3)

• UEP 3

- Two UEP schemes are available: UEP mapping and UEP coding
- Two bits in subheader to indicate using UEP mapping or coding
- Additional transmission mode (MCS) for UEP

Transmission Mode	PHY-SAP data rate	Modulation	Constellation	MSB coding	LSB coding
SC Mode	2040 Mbps	QPSK	normal	LDPC (576,288)	LDPC (576,432)
SC Mode	2562 Mbps	QPSK	normal	LDPC (576,432)	LDPC (576, 504)

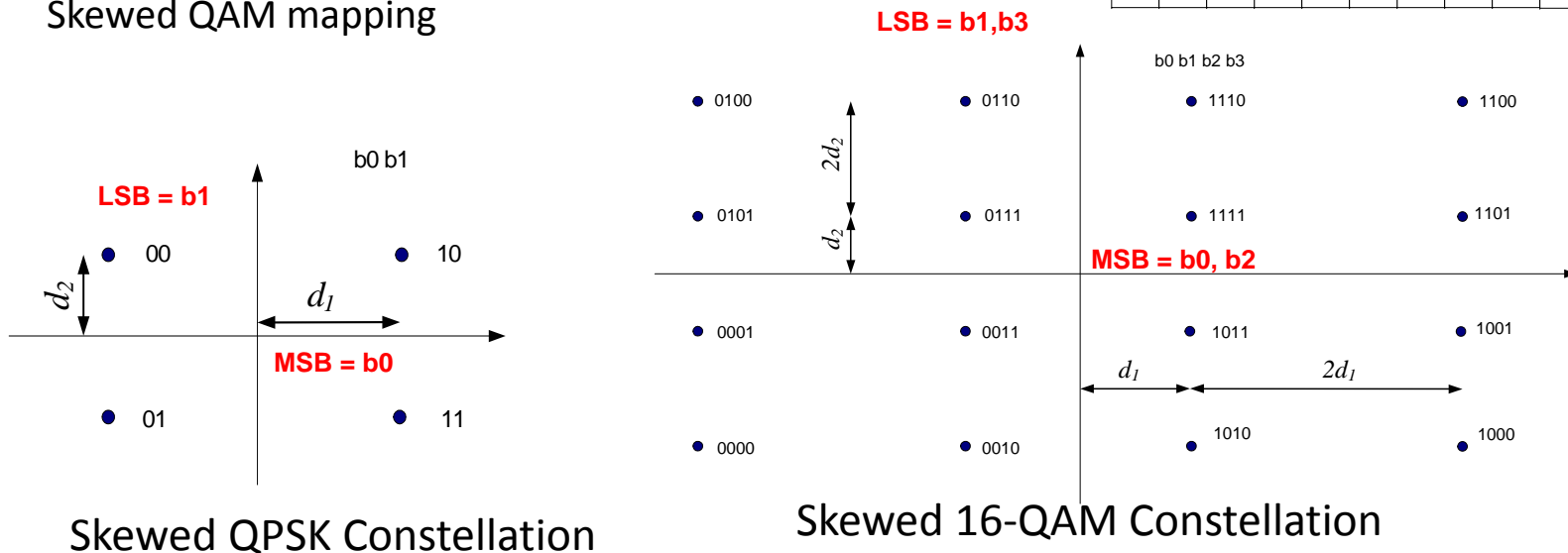
• Interleaver for UEP mapping

– Bit interleaving pattern

- A,B,C and D denote output of any FEC encoder for MSB's
- E,F,G and H denote output of any FEC encoder for LSB's

A1	C3	A5	B1	D3	B5	C1	A3	C5	D1	B3	D5
B2	D4	B6	C2	A4	C6	D2	B4	D6	A2	C4	A6
E1	G3	E5	F1	H3	F5	G1	E3	G5	H1	F3	G5
F2	H4	F6	G2	E4	G6	H2	F4	H6	E2	G4	E6

• Skewed QAM mapping



UEP (3/3)

- UEP information request command : This command is sent by any DEV to other DEV including PNC to request UEP scheme supported and UEP MCSs supported at the target DEV

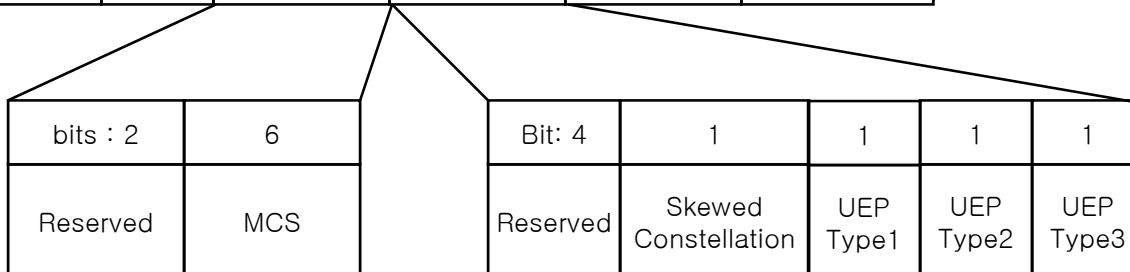
2	2
Length=Ln	Command type

Fig. UEP information request command format

- UEP information response command : This command is sent by the target DEV in response to originating DEV's request to let the originating DEV know which UEP schemes are supported and which UEP MCSs are supported at the target DEV.

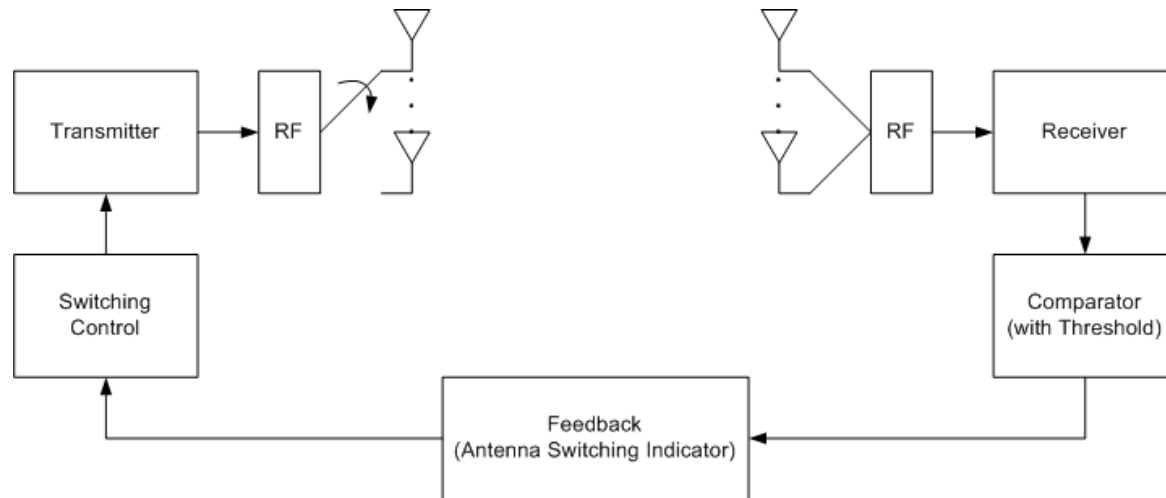
Octets : 1	...	1	1	2	2
UEP MCS Block-n	...	UEP MCS Block-1	UEP information	Length=Ln	Command type

Fig. UEP information response command format



Optional Transmit Switched Diversity

- Transmit antenna switch diversity may be used to achieve diversity gain from shadowing or blockage.



- Transmitter will inform the receiver of the number of antennas, L .
- At first transmission, transmitter arbitrarily selects one antenna from L transmit antennas.
- At each stage, receiver will compare the received SNR with a predetermined threshold, γ .
- If the SNR is larger than γ , receiver will feedback a “no switch” signal.
- If the SNR is smaller than γ , receiver will feedback a “switch” signal.
- If the SNR for all L available antennas, is less than γ , the receiver will then feedback the antenna number with largest SNR. The transmitter will use this antenna for transmission.

Comparison of MAC between AV-OFDM and CoMPA proposal

Differences (I)

- SCAN
 - AV-OFDM : 12 LRP channel scanning
 - CoMPA : 4 channel scanning
 - SNR difference of ~13dB due to received filter
- Starting PN
 - How to determine channel for beacon?
 - AV-OFDM: select from 12 channels
 - ComPA : select from 4 channels
- Association
 - No impact for procedure.
 - Command transmission in CAP
 - AV-OFDM : LRP channel?
 - CoMPA: Common rate

Differences (II)

- Channel probing
 - Channel estimation sequence in Beacon?
 - SNR for estimation
 - Command transmission in CAP
 - AV-OFDM : LRP channel?
 - CoMPA: Common rate
- Streaming
 - Command transmission in CAP
 - AV-OFDM : LRP channel?
 - CoMPA: Common rate
 - Aggregation
 - AV-OFDM: mandatory aggregation (Maximum size : 7M octets)
 - CoMPA: optional operation is available (Maximum size : 64k octets)
- DEV-DEV directional communication
 - No definition in AV-OFDM

Question to understand AV-OFDM MAC

- What is specific point in AV-OFDM MAC compared with 15.3b MAC?
- How to scan LRP and HRP channel?
- How to select channel for communication?
 - HRP and LRP
- Does AV-OFDM have directional beacon?
- What is transmission mode for CAP duration?
- What is difference in omni LRP and directional LRP?
- How to use directional LRP?
- How to re-transmission for aggregation?
 - Definition of ack group
 - Usage of block-ack
- How to make a DEV-DEV link?
 - LRP channel for streaming ACK
- Please make an example of procedure for AV-OFDM
 - From power on to streaming