Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Proposed Text of DL PHY Control Structure Section (BCH) for the IEEE 802.16m Amendment**
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Re:	IEEE 802.16m-08/053r1, “Call for Contributions for Project 802.16m Amendment Working document Text” Target topic: “DL PHY control structure”
Abstract	The contribution proposes the text of DL PHY control structure section to be included in the 802.16m amendment.
Purpose	To be discussed and adopted by TGm for the 802.16m amendment.
Notice	
Release	
Patent Policy	

Proposed Text of DL PHY Control Structure Section for the IEEE 802.16m Amendment

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Contents

1 Introduction

The contribution proposes text for the DL control structure section to be included in the 802.16m amendment. The proposed text is developed so that it can be readily combined with IEEE P802.16 Rev2/D7 [1], it is compliant to the 802.16m SRD [2] and the 802.16m SDD [3], and it follows the style and format guidelines in [4].

The proposed text is limited to the PHY aspect of BCH. This contribution, however describes the details of DL control structure including the operation procedure and information elements required to support the proposed text.

2 Design Requirements

This section addresses design requirements for BCH design which are subsets of 802.16m SRD. The design requirements are based on the general requirements, the functional requirements, the baseline performance requirements, and the operational requirements.

Table 1 summarizes the design requirement for system optimization.

Table 1 – Design requirement

Topic	Requirement
BW	Minimum 5 MHz
DL MIMO	Minimum 2 x 2
Intra-frequency HO latency	27.5 ms
Mobility	Pedestrian
Cell coverage	5 Km (i.e. 8.6 Km ISD)
Synchronization	Synchronized timing and frame counters across entire systems

2.1 Operating bandwidths

Scalable bandwidth is ability to operate with different bandwidth allocations. IEEE 802.16m shall support scalable bandwidths from 5 to 40 MHz.

2.2 Multiple antenna configurations

The minimum is consistent with a 2x2 downlink configuration.

2.3 Handover interruption time

The handover interruption times specified in Table 2 apply to handover of IEEE 802.16m MS between IEEE 802.16m BSs operating in the absence of legacy MSs under normal operating conditions.

Table 2 – Handover interruption times

Handover type	Max. interruption time (ms)

Intra-frequency		27.5
Inter-frequency	Within a spectrum band	40
	Between spectrum bands	60

2.4 Mobility

Mobility shall be supported across the IEEE 802.16m network.

Table 3 summarizes the mobility performance.

Table 3 – Mobility support

Mobility	Performance
Stationary, pedestrian 0 – 10 km/h	Optimized
Vehicular 10 – 120 km/h	Graceful degradation as a function of vehicular speed
High speed vehicular 120 – 350 km/h	System should be able to maintain connection

2.5 Cell coverage

IEEE 802.16m shall support the deployment scenarios captured in Table 4 in terms of maximum cell range.

Table 4 – Deployment scenarios

Cell range	Performance target
Up to 5 km	Optimized
5 – 30 km	Graceful degradation in system/edge spectral efficiency
30 – 100 km	System should be functional (thermal noise limited scenario)

2.6 Synchronization

IEEE 802.16m shall support the ability to synchronize frame timing and frame counters across the entire system deployed in given geographic area, including synchronization among all BSs and MSs operating on the same or on different carrier frequencies and among neighboring IEEE 802.16m system, whether operated by the same operator or not.

3 Preparation for Ranging: General Flow

MS needs ranging when MS performs the initial access, handover and while exiting idle mode. Figure 1 shows the general operation flows to prepare for ranging.

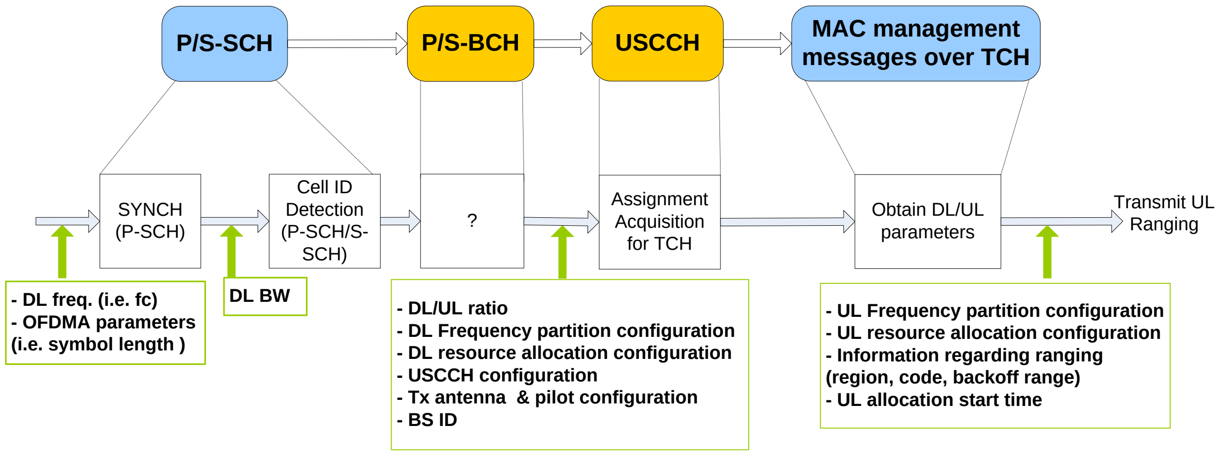

Figure 1 – General operation flow: preparation for ranging

Table 5 shows the information required for the preparation for ranging.

Table 5 – Information contents

	Information
DL Parameters	DL carrier frequency
	OFDM symbol length
	DL BW
	Cell ID
	DL/UL ratio*
	# of Tx antennas**
	DL Subband allocation count (SAC)
	DL Frequency partition configuration (FPC)
	DL Resource configuration (e.g. ratio of CRU and DRU)
	USCCH configuration (e.g. size, MCS level, location)
	Superframe number
	System descriptor change count
UL Parameters	UL carrier frequency/BW (needed for FDD)
	UL Subband allocation count (SAC)+
	UL Frequency partition configuration (FPC)+
	UL Resource configuration (e.g. ratio of CRU and DRU)+
	UL start timing
	Information related initial ranging (e.g. codes/backoff range/interval/region)
	Information related HO ranging (e.g. codes/backoff range/region)
	Information related exiting idle mode (e.g. codes/backoff range/ region)

4 PHY Structure

The superframe header (SFH) includes PBCH and SBCH, and is located in the first subframe of a superframe.

Table 6 summarizes the PHY structure which this contribution suggests.

Table 6 – Suggested PHY structure

Topic	value
PRU configuration	Type-1 subframe with 5 symbols
Resource Units	DRU
BW Occupancy	5 MHz
Tx diversity	SFBC
Channel coding	CC
Target coverage	8.6 km ISD with 98 % coverage
Repetition # within a superframe	{PBCH, SBCH} = {8 (up to 24), 8}

4.1 Superframe header structure

The superframe header (SFH) is the first DL subframe of the superframe and uses 6 OFDMA symbols. The SFH consists of BCH and SCH (P-SCH or S-SCH). Additionally, other bursts such as USCCH and data may be included in the SFH. Within the same subframe, PBCH/SBCH is TDM with SCH and is FDM with other channels. Figure 2 shows the superframe header structure.

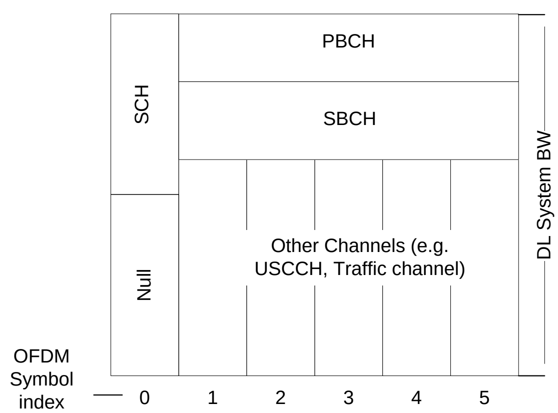

Figure 2 – Superframe header structure

4.2 Transmission format

4.2.1 Target SINR Coverage

The 16m SRD specifies that the system should be optimized for cell ranges up to 5km (i.e. 8.67 km ISD). The 16m EVM also mentions the mandatory cell size being 0.87 km (i.e.1.5 km ISD) for the baseline configuration.

Figure 3 shows the CDF of the SINR for two cell ranges with frequency reuse of 1 and frequency reuse of 3. The test environments and associated configurations for this system level simulation are based on 16m EVM.

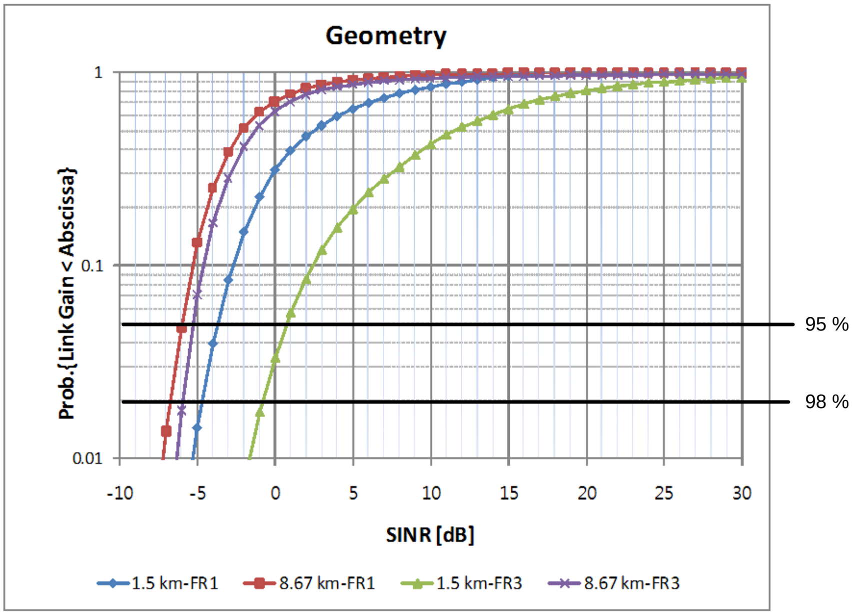

Figure 3 – SINR distribution

In order to evaluate the SINR coverage, we can consider the points on the plot corresponding to the 98% and 95 % coverage. Based on simulation results, we can make the following observations regarding the Target SINR:

Table 7 – Target SINR [dB]

Cell size / Coverage	1.5 Km ISD		8.7 Km ISD	
	FR-1	FR-3	FR-1	FR-3
98 %	-5	-1	-7	-6
95 %	-3.5	1	-6	-5

The target SINR is a minimum threshold which represents the average SINR that must be experienced by a stationary user in order to obtain the required percentage of coverage in the cell.

It should be noted that frequency reuse of 3 isn't helpful for 8.67 km ISD cell. So, the design of 16m BCH shall be optimized for 8.67 km ISD cell (as specified in 16m SRD), but with a frequency reuse of 1.

4.2.2 MIMO transmission

Simulation results show that with 2 Tx pilot pattern, SFBC is better than 1 stream transmission. So, the transmit diversity scheme for BCH is SFBC (i.e. M = 2 streams) using the 2 Tx rate-1 mode.

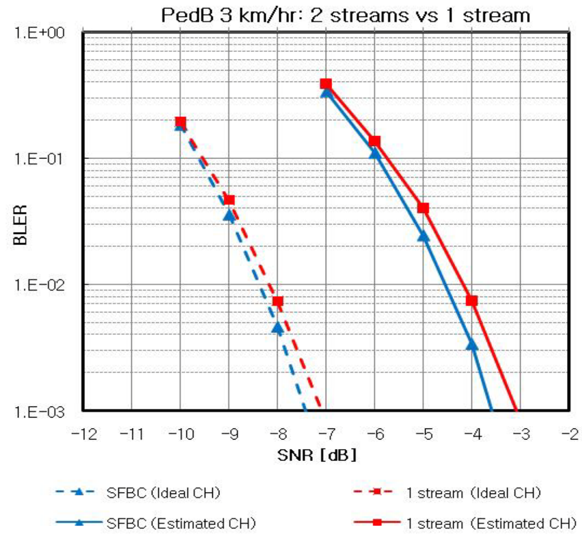

Figure 4 – Link performance: 2 streams vs 1 stream

4.2.3 Coding rate

Link performance to achieve the above target SINRs were evaluated using LLS. The following parameters are used.

- BW/FFT : 5 MHz / 512
- Tx diversity: SFBC
- Information bits: 48 bits /96 bits
- Channel coding: CC or CTC
- PedB 3 km/hr
- Channel estimation: PRU based MMSE
- Resource unit: DRU

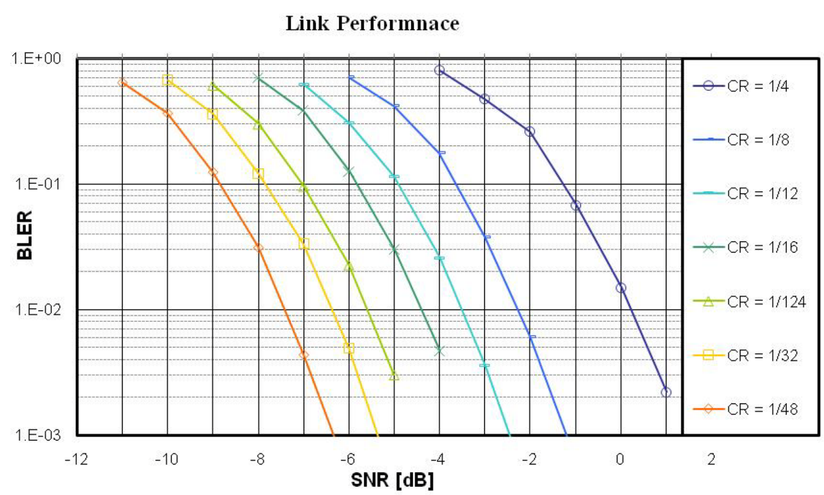

Figure 5 – Link Performance with various coding rate

Based on these simulation results, we can make the following observations.

- The coding rate with 1/16 can achieve the target SINR for 98 % coverage of 1.5km ISD cell with a target BLER of 1%.
- The coding rate with 1/48 can achieve the target SINR for 98 % coverage of 8.67km ISD cell with a target BLER of 1%.

For robustness, the coding rate for 8.67 km ISD cell should be equal to or less than 1/48, and the coding rate for 1.5 km ISD cell should be equal to or less than 1/16.

4.2.4 Available information size

To compute the available information size, we consider the following:

- The pilot structure uses 2 stream pilot patterns.
- 5 Symbols are available symbols for BCH as described in section 4.1.
- PBCH and SBCH occupy no more BW than 5 MHz.

Based on the foregoing, the size of available resource is 1920 tones.

To achieve the target SINR with 98 % coverage for 8.67 km ISD cell with the frequency reuse of 1, we consider the following three approaches:

According to the first approach, the whole information block is transmitted every superframe. This requires a code rate of 1/48 to achieve the aforementioned requirement

According to the second approach, the whole block is repeated over multiple superframes to get a lower code.

The third approach combines the first and the second approach.

Next we look at the number of repetitions required in case of the second and third approaches. A code rate of 1/16 is required to achieve the target SINR with 98 % coverage for 1.5 km ISD cell with the frequency reuse of 1. We propose that the information block with the code rate of 1/16 is transmitted during 4 consecutive superframes. This facilitate MSs within 1.5 km ISD coverage to get faster access and conserve power, while the coverage requirement is met for the MSs further away .

Considering QPSK modulation and 16-bit CRC, the aforementioned three approaches imply the following:

- Approach # 1: For a code rate of 1/48, 24 repetitions are needed. So, we need to find X satisfying 24X = 1920.
  - X = 80, i.e. the size of the available information bits is 64 bits
- Approach # 2: For a code rate of 1/16, 8 repetitions are needed. So, we need to find Y satisfying 8Y = 1920.
  - Y = 240, i.e. the size of the available information bits is 224 bits

- Approach # 3: The information is divided into 2 blocks. One block (X bits) is transmitted using approach #1 and another block (Y bits) is transmitted using approach #2. So, we need to find both X and Y satisfying 24X + 8Y = 1920. Illustrative values can be:
  - X=48 (i.e. information = 32 bits), Y = 96 (i.e. information = 80 bits). The size of the available information bits is 112 bits
  - X=56 (i.e. information = 40 bits), Y = 72 (i.e. information = 56 bits), i.e. the size of the available information bits is 96 bits.
  - X=64 (i.e. information = 48 bits), Y = 48 (i.e. information = 32 bits), i.e.the size of the available information bits is 80 bits.

Similarly, we also consider the target SINR with 95 % coverage. This requires code rate of 1/32 and 1/12.

- Approach # 1: For a code rate of 1/32, 16 repetitions are needed. So, we need to find X satisfying 16X = 1920.
  - X = 120, i.e. the size of the available information bits is 104 bits.
- Approach # 2: For a code rate of 1/12, 6 repetitions are needed. So, we need to find Y satisfying 6Y = 1920.
  - Y = 320, i.e. the size of the available information bits is 304 bits
- Approach # 3: The information is divided into 2 blocks. One block (X bits) is transmitted using approach #1 and another block (Y bits) is transmitted using approach #2. So, we need to find both X and Y satisfying 16X + 6Y = 1920. Illustrative values can be:
  - X=48 (i.e. information = 32 bits), Y = 192 (i.e. information = 176 bits), i.e. the size of the available information bits is 208 bits
  - X=72 (i.e. information = 56 bits), Y = 128 (i.e. information = 112 bits), i.e. the size of the available information bits is 168 bits (i.e.)
  - X=96 (i.e. information = 80 bits), Y = 64 (i.e. information = 48 bits), i.e. the size of the available information bits is 128 bits

In deciding the final approach, the information bit should be agreed first.

4.2.5 Channel coding

The channel coding depends on the size of the information block.

Based on simulation results, convolutional code should be considered for information block size less than 96 bits while CTC should be considered for information block size is equal to or larger than 96.

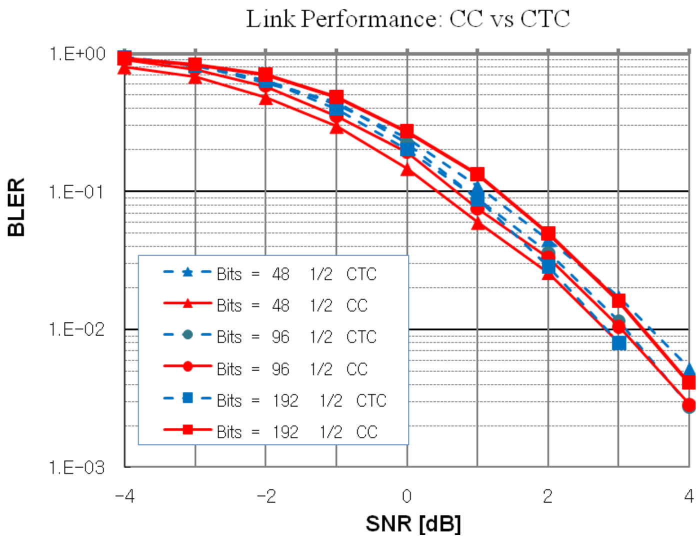

Figure 6 – Link Performance: CC vs CTC

Since the information size considered is equal to or less than 96 bits, convolutional code seems to be the appropriate choice for BCH transmission.

5 References

[1] IEEE P802.16 Rev2 / D7, "Draft IEEE Standard for Local and Metropolitan Area Networks: Air Interface for Broadband Wireless Access," Oct. 2008.

[2] IEEE 802.16m-07/002r4, "802.16m System Requirements"

[3] IEEE 802.16m-08/003r5, "The Draft IEEE 802.16m System Description Document"

[4] IEEE 802.16m-08/043, "Style guide for writing the IEEE 802.16m amendment"

[4] IEEE 802.16m-08/050, "IEEE 802.16m Amendment Working Document"

6 Text proposal for inclusion in the 802.16m amendment

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3. Definitions

Insert the following at the end of section 3:

3.xx superframe header: The first DL subframe of the superframe.

3.xx superframe prefix message: A data structure that contain information regarding superframe.

3.xx downlink channel prefix message: A data structure that contain information regarding downlink channel.

4. Abbreviations and acronym

Insert the following at the end of section 4:

BCH	broadcast channel
PBCH	primary broadcast channel
SBCH	secondary broadcast channel
SFP	superframe prefix
DLCP	downlink channel prefix

Insert a new section 15:

15.3.x Broadcast Channel (BCH) in Superframe Header(SFH)

The superframe header (SFH) is the first DL subframe of the superframe and uses 6 OFDMA symbols. The SFH consists of BCH and SCH (P-SCH or S-SCH). Additionally, other bursts such as USCCH and data may be included in the SFH.

Except SCH, the SFH uses the distributed resource unit which is described in section 15.3.5 in IEEE 802.16m-08/050[5]. The frequency reuse for the resource allocation is predetermined. $N_{FR, SFH}$ indicates the value of frequency reuse and is set to 1 (or FFS).

Figure1 shows the superframe header structure.

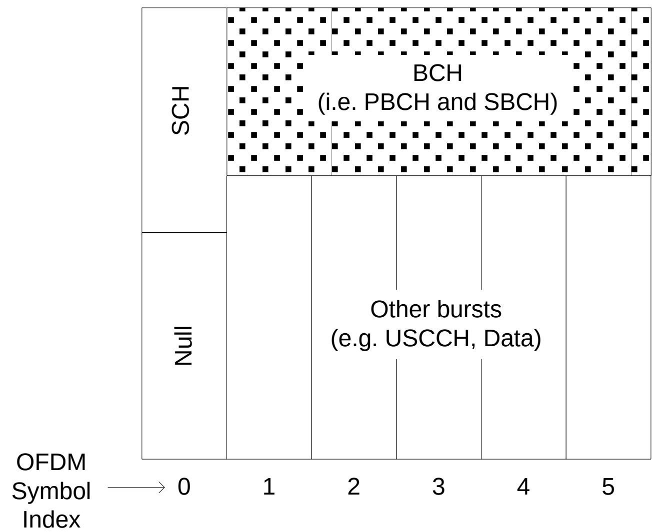

Figure 1 – Superframe header structure

15.3.x.1. BCH

The BCH is divided into two parts: PBCH and SBCH. The PBCH carries the superframe prefix (SFP) message and the SBCH carries the downlink channel prefix (DLCP) messages.

Figure 2 shows the structure of the BCH.

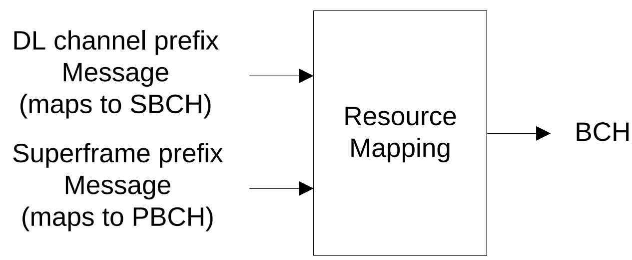

Figure 2 – Structure for BCH

The BCH is sent on the first N_{BCH} subchannels (i.e. logical subchannel number with 0 to N_{BCH} -1). The value of N_{BCH} is TBD.

The DLCP message shall be mapped to the first N_{DLCP} subchannels (i.e. logical subchannel number with 0 to N_{DLCP} -1) in the BCH. The value of N_{DLCP} is TBD.

The SFP message immediately follows the DLCP message after repetition code is applied. The SFP message shall be mapped to N_{SFP} subchannels (i.e. logical subchannel number with N_{DLCP} to N_{DLCP} + N_{SFP}-1) in the BCH. The value of N_{SFP} is TBD.

Note that $N_{BCH} = N_{DLCP} + N_{SFP}$, where N_{BCH}, N_{DLCP}, and N_{SFP} represent the number of subchannels for BCH, DLCP message and SFP message, respectively.

15.3.x.2. Downlink Channel Prefix(DLCP) Message

The DLCP message is a data structure transmitted during $N_{period,\ DLCP}$ consecutive superframes. The DLCP message starts in superframes which satisfy $n_{superframe\ number}$ mod $N_{period,\ DLCP} = 0$, where $n_{superframe\ number}$ is the superframe number and $N_{period,\ DLCP}$ represents the number which the DLCP message is transmitted over multiple superframes repeatedly. The value of $N_{period,\ DLCP}$ is TBD (e.g. 4).

The DLCP message contains information regarding the DL carrier and is mapped to the SBCH. The DLCP message format is TBD.

The DLCP message is generated as shown in figure 3.

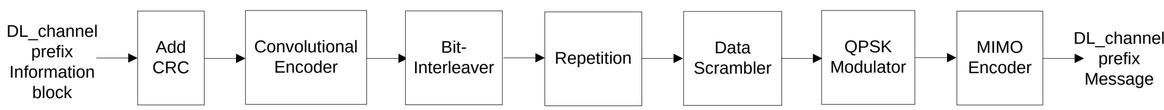

Figure 3 – Generation of the DLCP Message

15.3.x.2.1 Channel Coding

The DLCP information shall be appended with a CRC of length $N_{CRC,\ DLCP}$. $N_{CRC,\ DLCP}$ is TBD (e.g. 16 bit).

The resulting sequence of bits shall be encoded by the convolutional encoder and then interleaved by the bit-interleaver. The convolutional encoder and the bit-interleaver are defined in section 8.4.9 in IEEE P802.16 Rev2 / D7 [1]. A coding rate of 1/2 is used.

The block of channel encoded bit sequences shall be repeated $N_{repetition,\ DLCP}$ times. The value of $N_{repetition,\ DLCP}$ is TBD (e.g. 8).

15.3.x.2.2 Data Scrambler

The block of repeated bit sequences shall be scrambled with a cell-specific sequence. The scrambling sequence is TBD.

15.3.x.2.3 Modulation

The block of scrambled bit sequences shall be modulated using QPSK.

15.3.x.2.4 MIMO Encoder

The block of modulated symbols shall be mapped to 2 streams using SFBC matrix.

15.3.x.3. Superframe Prefix (SFP) Message

The SFP message is a data structure transmitted in each superframe.

The SFP message contains information regarding the current superframe and is mapped to PBCH. The SFP message format is TBD.

The SFP message is generated as shown in figure 4.

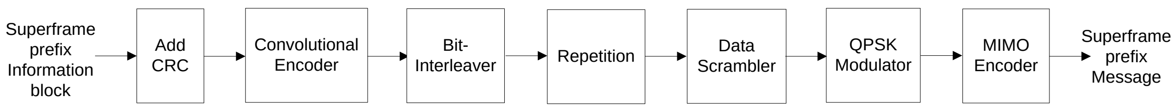

Figure 4 – Generation of the SFP Message

15.3.x.3.1 Channel Coding

The SFP block shall be appended with CRC. A CRC length of $N_{CRC,\ SFP}$ shall be used, where $N_{CRC,\ SFP}$ is TBD. (e.g. 16 bit)

The resulting sequence of bits shall be encoded by the convolutional encoder and then interleaved by the bit-interleaver. The convolutional encoder and the bit-interleaver defined in section 8.4.9 in IEEE P802.16 Rev2 / D7 [1]. A coding rate of 1/2 is used.

The block of channel encoded sequences shall be repeated $N_{repetition,\ SFP}$ times. The value of $N_{repetition,\ SFP}$ is up to 24.

15.3.x.3.2 Data Scrambler

The block of repeated bit sequences shall be scrambled with a cell-specific sequence. The scrambling sequence is TBD.

15.3.x.3.3 Modulation

The block of scrambled bit sequences shall be modulated using QPSK.

15.3.x.3.4 MIMO Encoder

The block of modulated symbols shall be mapped to 2 streams using SFBC matrix.

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