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Re:	IEEE 802.16 Working Group Letter Ballot #26b as announced in IEEE 802.16-08/006
Abstract	This document proposes the addition of optional outer-coding for MBS services.
Purpose	To be discussed and adopted by 802.16 Rev2.
Notice	
Release	
Patent Policy	

Optional outer-coded data mode for MBS

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1. Introduction

In order for the current MBS solution in 802.16 to achieve packet error rates that are viable for broadcast video and audio applications, a network must use overly robust and inefficient MCS or must somehow employ a retransmission scheme such as would be used to transfer a file rather than for real time consumption of the MBS service.

By adding optional outer-coding that adds significant time-diversity, we can operate at a higher MCS and achieve roughly a 45% increase in MBS throughput in a typical 1 to 1.5 km cell while not impacting any existing implementations of the existing MBS. While different outer-codes have different performances under different circumstances, we need a standardized solution for at least one basic outer-code to avoid the emergence of incompatible proprietary solutions.

2. Proposed Solution

2.1 Overview of the Proposed Solution

Introduce an outer-coding capability that significantly improves the spectral efficiency of MBS services. It will

- require no PHY changes;
- be backwards compatible with existing MBS implementations;
- provide convergence sublayer support to outer-coding for MBS services
- co-exist with the current 16e bi-directional data service, and have no impact on it

All the concepts of the current MBS remain – MBS Zones, the MBS Map, etc. apply unchanged.

In order to increase the level of protection and make more extensive use of time diversity than what is practically feasible with (PHY) FEC encoding alone, the proposal adds outer coding on the MBS application data packets before being passed to the 802.16 MAC/PHY air interface, as shown in Figure 1 . The outer-coding enables operation at SINRs that would otherwise result in PERs that are both unacceptable for real-time consumption (no unicast retransmissions) of video services and inefficient for broadcast services. Due to the addition of the outer-coding function, the data packets into 802.16 MAC, i.e., the MAC SDUs, are outer-coding encoded data packets, which requires a simple Convergence Sublayer (CS) to provide the interface to the 802.16e MAC. Such a CS is referred as the Outer-Coded Data CS (OCD-CS). Note that the outer coding is above the CS/MAC, so it can be out of scope of the 802.16 Air Interface specification. However, to facilitate interoperability, the proposed changes provide support for a basic Reed-Solomon outer-code that provides a 45% bandwidth/capacity improvement over no outer-coding and also provides a mechanism to specify application layer specific outer-coding.

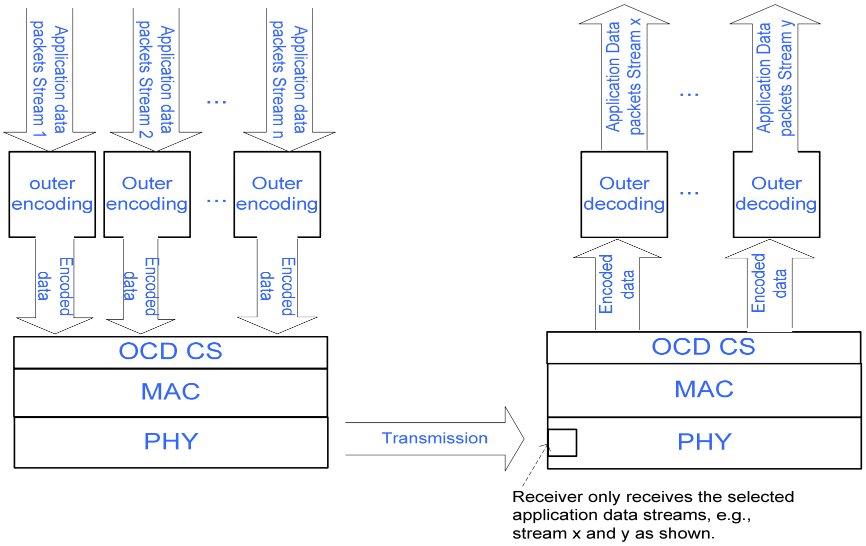

Figure 1 Outer Coding Overview

The outer-coded MBS data packets are transmitted in the MBS regions as is currently the case with existing MBS data.

The contents of an MBS zone typically consists of multiple streams of data packets, each stream represents an application content, e.g., a TV channel, a data service program, etc. An example of a stream is an AAC/H.264 encoded audio / video data packet flow.

Figure 2 shows an overview of outer-coded MBS operations. The outer-coding function defines a span of time over which the MBS service data payloads are grouped together to form an outer-coded packet. The typical time span of outer coding is 100s of ms up to 2 seconds, trading off delay for coding gain. In order not to unnecessarily weaken the outer-code, it is critical that the outer-coded data be mapped to the MAC and PHY such that information that does not benefit from outer-coding is either very robustly coded (in the MBS_MAP) or is not necessary for retrieving the outer-coded data. The typical information added by the MAC or PHY after the outer-coding would be the GMH, subheaders, and CRC-16. So, the data that is outer-coded during the outer-coding interval combined with any other coding dependant information (the outer-coder packet in Figure 2) shall be passed to the MAC in PDUs that map to the PHY FEC blocks such that information that is not outer-coded, i.e., the GMH and CRC-16 is in deterministic locations and of deterministic size.

The MBS_MAP message specifies the outer-coded MBS allocations using the MBS OUTER CODED DATA IE TLV which is similar to the MBS DATA Time Diversity IE which, along with the MBS_MAP structure, is left unchanged for backwards compatibility.

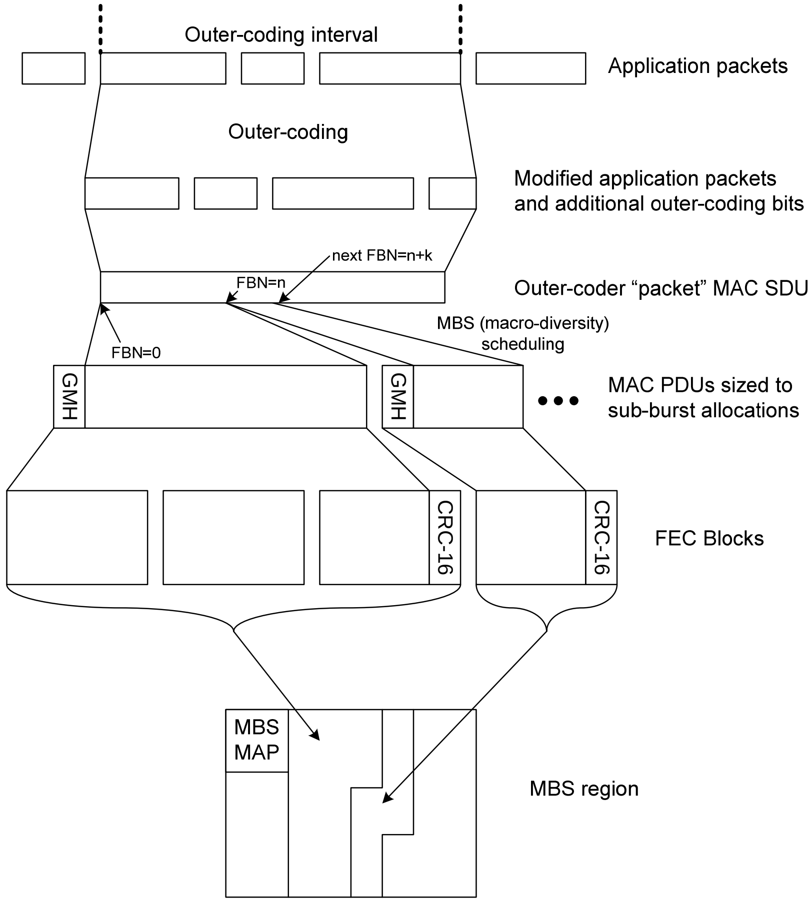

Figure 2 An overview of MBS outer-coding

2.2 Convergence Sublayer (CS) Support for MBS Outer-Coding

At the transmitter, i.e., the BS, the required CS support for MBS outer-coding includes:

- accepting the outer-coded data packets;
- performing classification of the received data packets based on the stream and mapping to the appropriate MCID;
- passing the data packets and the associated signaling information to the MAC CPS (Common Part Sublayer).

At the receiver, i.e., the MS, the OCD-CS transparently passes the received data packets and their stream indications to the upper layer, i.e., the outer coding decoding function.

2.3 MAC Support for MBS Outer-coding

The preferred MAC support for the MBS outer-coding operations would have included adding a new IE in the MBS_MAP message, called MBS_OUTER_CODED_DATA_IE, as shown in the modified version of table 155.

Table 155 —MBS_MAP message format

Syntax	**Size (bit)**	**Notes**
MBS_MAP Message format() {	—	—
Management Message Type = 62	8	62
MBS_DIUC_Change_Count	8	—
#MBS_DATA_IE	4	The number of included MBS DATA IEs
for (i=0; i<n; i++) {	—	n = #MBS DATA IEs
MBS_DATA_IE	*variable*	—
}	—	—
#Extended_MBS_DATA_IE	4	The number of included Extended MBS DATA IEs
for (i=0; i<k; i++) {	—	k = #Extended MBS DATA IEs
Extended_MBS_DATA_IE()	*variable*	—
}		—
# MBS_DATA_Time_Diversity_IE	4	The number of included MBS DATA Time Diversity IEs
for (i=0; i<m; i++) {	—	m = # MBS DATA Time Diversity IEs
MBS_DATA_Time_Diversity_IE ()	*variable*	—
}	—	
# MBS_OUTER_CODED_DATA_IE	4	The number of included MBS OUTER CODED DATA IEs
for (i=0; i<p; i++) {	—	p = #MBS DATA OUTER CODED IEs
MBS_ OUTER_CODED_DATA_IE()	*variable*	—
}	—	—
If(!byte boundary){	—	—
Padding Nibble	4	—
}		—
TLV encoded element	—	—
}	—	—

Unfortunately, since the IEs for inclusion in the MBS_MAP were designed without length fields, this method is not backwards compatible with existing MBS implementations. So, the proposed method, which meets the goal of backwards compatibility with existing MBS implementations, instead adds the MBS OUTER CODED DATA IE TLV in the MBS_MAP message. The parsing rules take a complex form using the precedence set in table 575 for the United (Unified? – there is a discrepancy between tables 573 and 575) TLV encoding for Power Saving Class Parameters.

3. Suggested Changes in Rev2/D6a

3.1 Remedy – part 1

In Rev2/D6a, on page 45, insert a new section 5.4 Outer-Coded Data CS as follows:

5.4 Outer-Coded Data CS (OCD-CS)

The Outer-Coded Data CS (OCD-CS) provides support for transmission of outer-coded data blocks. Each outer-coded data block constitutes one OCD-CS SDU, and is passed to the BS via the OCD-CS SAP. Each OCD-CS SDU shall be delivered to the OCD-CS with an indication of the MBS Zone ID, Stream ID, and a set of outer coding parameters that identifies the parameters applied to the outer coding (such as number of data columns and parity columns; see 6.2.22.7 and 11.22.1.1 for details). The BS shall classify each received outer coded data block onto an MBS connection. At the SS, the MAC SDUs received shall be passed as one outer-coded data block to the upper layer together with the Stream ID and the outer coding parameters.

5.4.1 OCD-CS Parameters

The OCD-CS uses the OCD-CS SAP, an instance of the logical CS SAP. The OCD-CS SAP parameters enable the upper layer protocols to pass outer coded data blocks to the OCD-CS. The parameters are relevant for SAP data path primitives, OCD-CS_DATA.request and OCD-CS_DATA.indication as described in sections 5.4.2 and 5.4.3, respectively.

MBS_ZONE_ID: A 7-bit MBS zone identifier.

OUTER_CODING_PARAMETER_SET_LENGTH: The length, in bytes, of the outer coding parameter set.

OUTER_CODING_PARAMETER_SET: The parameters applied to the outer coding.

STREAM_ID: A 12-bit identifier that uniquely identifies a stream in an MBS zone.

LENGTH: Number of bytes in DATA.

DATA: The payload delivered by the MBS upper layer to the OCD-CS, or by the OCD-CS to the upper layer.

5.4.2 OCD-CS_DATA.request

Function:

This primitive defines the transfer of data from the upper layer to the OCD-CS.

Semantics of the service primitive:

The parameters of the primitive are as follows:

OCD-CS_DATA.request (
MBS_ZONE_ID,
OUTER_CODING_PARAMETER_SET_LENGTH,
OUTER_CODING_PARAMETER_SET,

STREAM_ID,

LENGTH,

DATA

)

The parameters of the OCD-CS_DATA.request are described in section 5.4.1.

When generated:

This primitive is generated by an upper layer protocol when an MBS outer coded data block is to be transferred to peer entities.

Effect of receipt:

The receipt of this primitive causes the OCD-CS to map the DATA to an MBS connection and pass the OUTER_CODING_PARAMETER_SET to the lower sub-layers of the MAC. OCD-CS invokes MAC functions, for example the MAC SAP to effect transfer of the DATA in a MAC SDUs to the MAC CPS sub-layer.

5.4.3 OCD-CS_DATA.indication

Function:

This primitive defines the transfer of data from the Broadcast CS to an upper layer protocol.

Semantics of the service primitive:

The parameters of the primitive are as follows:

OCD-CS_DATA.indication (

MBS_ZONE_ID,

OUTER_CODING_PARAMETER_SET_LENGTH,

OUTER_CODING_PARAMETER_SET,

STREAM_ID,

LENGTH,

DATA

)

The parameters of the OCD-CS_DATA.request are described in section 5.4.1.

When generated:

This primitive is generated by OCD-CS whenever an OCD-CS SDU is to be delivered to an upper layer protocol.

Effect of receipt: The effect of receipt of this primitive by the upper layer protocol entity is outside the scope of this standard.

3.2 Remedy – part 2

In Rev2/D6a, on page 256, line 17 make the following changes to section 6.2.2.3.52:

The following TLVs may be included in the MBS_MAP message:

Downlink Burst Profile

Downlink Burst Profile is used for the definition of MBS DIUC. The MBS DIUC overrides the DIUC in DCD message for the MBS portion of the frame. If MBS DIUC is not defined by MBS MAP message, DIUC in DCD message shall be used instead. See Table 156, Table 157, and Table 158.

MBS_OUTER_CODED_DATA_IE TLV

The MBS_OUTER_CODED_DATA_IE TLV describes the allocation for outer-coded MBS streams in the MBS region defined by this MBS_MAP. See section 11.22.1. The MBS OUTER CODED DATA IE TLV is present only when MBS for outer-coded services is provided. The MBS sub-bursts indicated by the MBS OUTER CODED DATA IE TLV are encoded in the same way as HARQ, but do not need acknowledgement from the MS and there are no retransmissions.

3.3 Remedy – part 3

In Rev2/D6a, on page 483, line 57, add the following new section:

6.2.22.5 Performance enhancement with outer-coding

A service being transported over multicast and broadcast connections may have outer-coding applied before the data is passed to the MAC layer in order to allow an increase in the efficiency of the MCS used for the transmission of the MBS data. Outer-coding is performed over a time interval that is sufficient to realize additional gain (time diversity, spreading of errors, etc.) or other benefits at lower overhead than can be achieved when limited to a single OFDMA frame and can span up to 512 OFDMA Frames. The selection of the time span over which outer-coding is performed is outside the scope of the standard. In order not to weaken the gain of the outer-coding by introducing dependencies on information that is not outer-coded, the outer-coded data shall be mapped to MAC PDUs and PHY FEC blocks such that each sub-burst contains only a single MAC PDU, including the GMH, but no sub-headers or CRC-32, and a single CRC-16, guaranteeing that information that is not outer-coded is in deterministic locations and of deterministic size.

Since outer-coding can recover from missing the reception of an entire MAC PDU fragment of the outer-coder packet, unlike conventional fragmentation of SDUs into MAC PDUs, it is important to know which bytes were lost rather than merely that a particular fragment was lost. Moreover, this information must be sent as robustly as either the MBS_MAP or the outer-coded data. So, the fragmentation of outer-coder packets (MAC SDUs for the outer-coding function) into MAC PDUs shall not use the fragmentation or packing subheaders, but shall use a fragmentation byte number (FBN) in the MBS_OUTER_CODED_DATA_IE TLV in the MBS_MAP to indicate which byte of the outer-coder packet maps to the first byte of an allocation for the MCID. Additionally, to avoid dependence on the length field in the GMH to determine the number of padding bytes in the last sub-burst allocated for an outer-coder packet, at the end of the outer-coder interval the number of sub-burst padding bytes is included in the MBS_OUTER_CODED_DATA_IE TLV. This allows the MAC layer to use this information to strip the padding bytes before delivery to higher layers.

The process of mapping outer-coded application data to allocations is shown in Figure 152a.

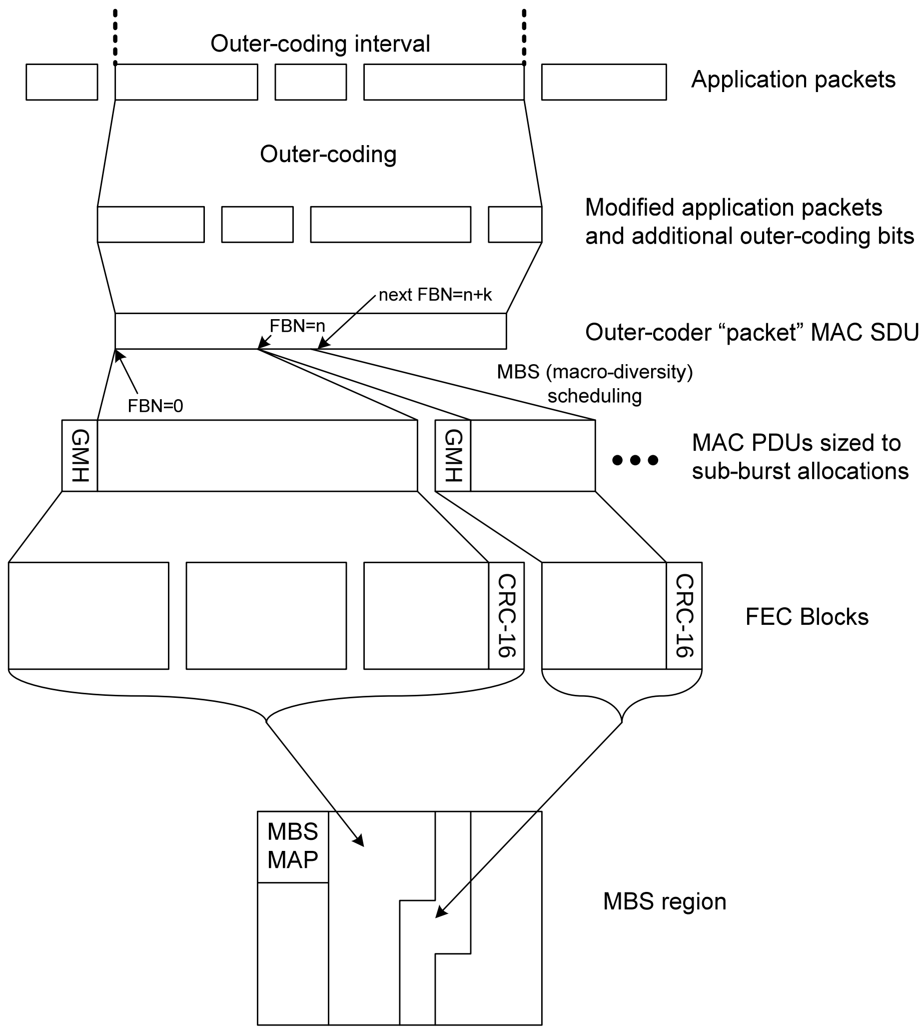

Figure 152a —Deterministic mapping of MBS outer-coded data to the MAC and PHY

Due to variation of data rates over time, the outer-coder may have parameters (e.g., boundary between data and parity) that vary from one outer-coding interval to another and are necessary to decode the data. This information is included in the Outer-coding Parameter Set field (see section 11.22.1.1) which is included in the MBS OUTER CODED DATA IE TLV described in section 11.22.1.

The following modes are currently defined for MBS data transmitted in bursts indicated by the MBS OUTER CODED DATA IE:

0 – no outer-coding
1 – Basic Reed-Solomon outer-coding

3.4 Remedy – part 4

In Rev2/D6a, on page 483, line 57, add the following

new section:

6.2.22.7 Basic Reed-Solomon outer-coding mode

All receivers capable of performing the basic Reed Solomon outer-code mode shall be able to perform Reed-Solomon decoding on blocks of length up to 255 (in each row) with different possible combinations of systematic data and parity bytes having up to 64 parity bytes. This will allow for support of different Reed-Solomon combinations where the total number of data bytes plus the number of parity bytes (including possible puncturing) is less than or equal to 255.

In the Basic Reed-Solomon outer-coding mode, each row of the outer code block is a Reed-Solomon (RS) codeword. RS codewords shall be generated on a GF(256) finite field with field generator polynomial:

$$p(x) = x^8 + x^4 + x^3 + x^2 + 1 .$$

The code generating polynomial is:

$$g(x) = \prod_{i=0}^{2\lceil p/2 \rceil - 1} (x + \lambda^i) ,$$

where $\lambda = 2$ and p is the number of parity bytes.

The codeword $RS(N, K)$ represents a codeword of length N with K data bytes (including a possible RS padding byte). If $N < 255$, the codeword is a shortened Reed-Solomon codeword. Note that the number of parity bytes, i.e., $P = N - K$, shall always be an even number, but the last byte may be punctured, i.e., generated by the encoder, but not available at the decoder.

To generate a shortened Reed-Solomon codeword, the systematic bytes of the codeword shall be prefixed with $255 - N$ 0x00 bytes. The encoder generates a $RS(255, 255 - N + K)$ codeword of length 255 and drops the leading $255 - N$ 0x00 bytes. The shortened codeword is the resulting N bytes of the codeword which includes the original K systematic bytes and $P = N - K$ parity bytes.

At the sender, the application layer packets are written into the Reed-Solomon code block vertically as shown in Figure 152b, effectively interleaving the packets across multiple Reed-Solomon codewords. They are preceded by a control block that aids in packet delineation without error propagation. The control block format is shown in Table 200a. RS padding bytes are added to the last few bytes of the data section of the table if necessary to fill the data section of the table. These shall have the value 0x00 and shall not be transmitted over the air.

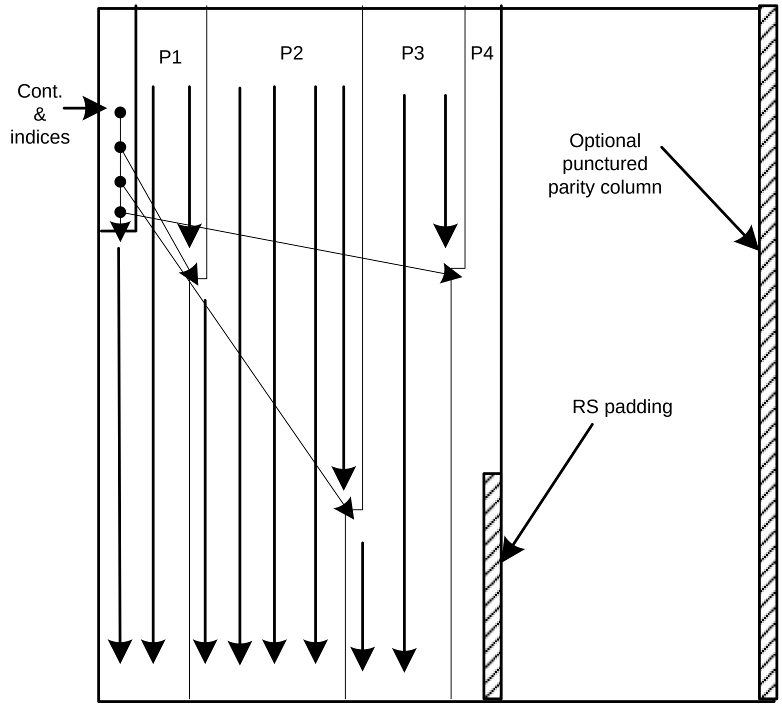

Figure 152b —Application packets in a RS code block

Table 200a —Basic RS outer-code control information format

Field	**Size (bits)**	**Description**
RS outer-code control info (){		
Reserved	2	
Application packet CRC present	2	0b00 – no application CRC 0b01 – CRC-32 0b10-0b11 – *reserved*
First packet status	2	0b00 – unfragmented packet 0b01 – fragment of previous packet 0b10-0b11 – *reserved*
Last packet status	2	0b00 – unfragmented packet 0b01 – fragment of packet 0b10-0b11 – *reserved*
Number of application packets in outer-coding table	8	—
For(i=0; i<n; i++){		n = Number of application layer packets in outer-coding table
Index of i^{th} application layer packet	16	The location in the RS code block corresponding to the first byte of the packet (see Figure 152b). Location 0x0000 is the byte in the top of the leftmost column. Location indices increment when moving down a column and when moving from the bottom of a column to the top of the column next to it to its right.
}		
}		

The data from the Reed-Solomon code block is transmitted vertically, ensuring that the Reed-Solomon codewords are interleaved in time. At the sender, if column shuffling is on, the bytes in each column (including the parity columns) of the Reed-Solomon table shall be shuffled prior to delivery of the SDU to the MAC layer for transmission. Shuffling is described in the context of de-shuffling below.

At the receiver, the data for any column in an outer coding interval where the column shuffling is on shall be de-shuffled before being written to the Reed-Solomon code block. The exception is that a column containing pad bytes is not shuffled. The process of de-shuffling is shown in Figure 152c.

If the index of a particular column in the Reed-Solomon table for a particular outer-coded data block is denoted by i, where i=0 for the first column, and the number of rows in the column is denoted by N, then the Shuffling Length of the column is given by $P_i = i \bmod N$. To de-shuffle the i^{th} column, the first P_i bytes of the shuffled column shall be removed and appended to the end of the column to form the de-shuffled column. The de-shuffled column is then written to the Reed-Solomon table.

1A	1B	1C	1D	1E
2A	2B	2C	2D	2E
3A	3B	3C	3D	3E
4A	4B	4C	4D	4E
5A	5B	5C	5D	5E

received data with columns shuffled

de-shuffle →

1A	2B	3C	4D	5E
2A	3B	4C	5D	1E
3A	4B	5C	1D	2E
4A	5B	1C	2D	3E
5A	1B	2C	3D	4E

table after columns are de-shuffled

Figure 152c —Column de-shuffling – MS side

The basic Reed-Solomon outer-coding mode uses a Reed-Solomon table. The number of data and parity columns is given in the Basic Reed-Solomon outer-code information (see section 11.22.1.1) in the MBS_OUTER_CODED_DATA_IE TLV in the MBS_MAP. Additionally, the total number of bytes transmitted that are included in the Reed-Solomon Block (RSDB Bytes), including both data and parity, are specified in the Basic Reed-Solomon outer-code information. The number of rows in the table is calculated as:

$$\text{Number of rows} = \left\lceil \frac{\text{No. of RSDB bytes}}{\text{No. of data columns} + \text{No. of parity columns}} \right\rceil .$$

The bytes of the received outer-coder packet shall be written, with de-shuffling if indicated, starting from the upper left corner of the table (first byte of the first row of the table). The received bytes are written vertically to the table such that consecutive bytes of the data are written to consecutive rows of the Reed-Solomon table. When data reaches the last row of a column in the table, it wraps around and continues from the first row of the next column. Received bytes are written to the data section of the table first and then to the parity section skipping the RS padding locations in the last column of the data section of the table. The value at the RS padding locations shall be considered to be 0x00 for decode purposes, and they are not received over the air. The number of RS padding bytes in the last data column of the table is calculated using:

$$\text{Number of RS padding bytes} = \text{Number of rows} \times (\text{No. of data columns} + \text{No. of parity columns}) \\ - \text{No. of RSDB bytes}$$

The delineation between data and parity bytes is given by:

$$\text{Number of parity bytes} = \text{Number of rows} \times \text{No. of parity columns}$$

$$\text{Number of data bytes} = \text{No. of RSDB bytes} - \text{Number of parity bytes}$$

After filling up the data section of the table, the parity section of the table shall be filled in the same manner. Received bytes will continue to be written to the parity section of the table in a vertical manner and the last received byte of the outer-coder packet for this outer-coding interval shall be written to the last byte of the table (bottom right corner of the parity table). This reconstructs the table shown in Figure 152b.

3.4 Remedy – part 5

In Rev2/D6a on page 1333, line 31, add the following new section 11.22:

11.22 MBS_MAP encodings

Note that the MBS_MAP (see section 6.2.2.3.52) specifies the use of the Downlink Burst Profile TLV from the DCD message (see section 11.4.4). In tables 218, 270, 449, and 567 the Downlink Burst Profile TLV has a type field value of 1. In table 451, an alternate form appears with the type value of 153. MBS_MAP TLV encodings shall avoid the reuse of TLV type values already used to indicate the DL Burst Profile TLV.

11.22.1 MBS_OUTER_CODED_DATA_IE TLV formats

Name	Type	Length (bytes)	Value	Scope
MBS OUTER CODED DATA IE	2	variable	Compound field including nested TLV	MBS_MAP

Table 609a —Contents of the MBS_OUTER_CODED_DATA_IE TLV

Syntax	Size (bit)	Notes
MBS Burst Frame Offset	2	This indicates the burst located by this IE will be shown after MBS Burst Frame offset + 2 frames.

OFDMA symbol offset	8	This indicates starting position of the region of MBS bursts with respect to start of the next (MBS Burst Frame offset + 2)-th frame. The region begins from the first subchannel of the OFDM symbol and in this region MBS bursts, indicated by MBS OUTER CODED DATA IE at the same MBS MAP message, are allocated in a frequency-first, one-dimensional way in the order of MBS OUTER CODED DATA IE at a MBS_MAP message.
# of Multicast CID Allocations	3	The number of multicast CIDs with data sub-bursts with the same frame offset
For(i=0; i<n; i++){		n = # Multicast CID Allocations
Multicast CID	12	12 LSBs of CID for multicast. The same MCID may appear more than once if different size allocations are present for it in this MBS region.
# of Data Sub-bursts for this MCID	8	The number of consecutive sub-burst with the same structure within this frame offset for this MCID
N_{EP} code	4	Each sub-burst for this instance of this MCID has the same N_{EP} and N_{SCH} parameters
N_{SCH} code	4	Each sub-burst for this instance of this MCID has the same N_{EP} and N_{SCH} parameters
Outer-coder packet FBN	18	Fragmentation byte number index into outer-coder packet (see Figure 152a) indicating the first byte of the first sub-burst for this allocation for this MCID.
Outer-coding interval start	1	When set to 1, indicates that this MBS MAP IE describes the Sub-bursts containing the first information for a new outer-coding interval for this MCID.
Outer-coding interval end	1	When set to 1, indicates that this MBS MAP IE describes the Sub-bursts containing the last information for a new outer-coding interval for this MCID.
Outer-coding interval params present	1	When set to 1, indicates that this MBS MAP IE contains outer-code specific parameters that are needed by the receiving device for the next outer-coding interval.
Next MBS MAP change indication	1	When set to 1, indicates that the size of MBS MAP message of next MBS frame for this multicast CID will be different from the size of this MBS MAP message.
Next MBS frame offset	8	A relative value from the current frame number in which the next MBS MAP message for this MCID will be transmitted.

Next MBS OFDMA Symbol offset	8	The offset of the OFDMA symbol in which the next MBS portion starts, measured in OFDMA symbols from the beginning of the DL frame in which the MBS_MAP is transmitted.
If (Next MBS MAP change indication = 1) {	—	—
Next MBS No. OFDMA symbols	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for this MCID.
Next MBS No. OFDMA subchannels	6	It is to indicate the size of MBS_MAP message in Next MBS portion where the BS shall transmit the next MBS frame for this MCID.
}	—	—
If (Outer-coding interval end = 1) {		
No. of Sub-Burst Padding Bytes	12	The No. of Sub-Burst Padding Bytes parameter indicates the number of padding bytes transmitted at the end of an outer-coding interval to fill up the last sub-bursts at the end of the data transmitted for that MCID. This allows the MAC layer to strip these bytes without relying on the GMH.
}		
If (Outer-coding interval params present = 1) {		
Outer-Coding Mode	5	Specifies the outer-coding mode to use. See table 609b in section 11.22.1.1
Outer-Coding parameter set length	8	Length, in bytes of the Outer-Coding parameter set
Outer-Coding parameter set	*variable*	Outer-coding mode specific information needed by the receiving device for the next outer-coding interval for this MCID.
}	—	—
reserved	*variable*	1-7 bits to ensure TLV byte alignment
}	—	—

11.22.1.1 Outer-coding parameter set formats

The outer-coding mode takes one of the values shown in Table 609b.

Table 609b — Outer-code modes

Outer-code mode	**Outer-code Name**	**Outer-coding parameter set**	**Outer-coding parameter set length (bytes)**

0	No outer-coding information	No additional information is needed when no outer-coding is applied. The outer-Coding parameter set length is set to 0.	0
1	Basic Reed-Solomon outer-code information	A compound field as defined in Table 609c	4
2-30	*reserved*	*Reserved for future outer codes*	*N/A*
31	Vendor-specific outer-code information	Information for a vendor-specific outer-code outside the scope of the standard.	*variable*

Table 609c —Basic Reed-Solomon outer-code information

Field	**Size (bits)**	**Description**
No. of parity columns	7	The total number of parity columns in the Reed-Solomon table (excluding the punctured parity column, if applicable)
No. of data columns	8	The total number of data columns in the Reed-Solomon table
No. of RSDB bytes	17	The total number of bytes transmitted over the air in all sub-bursts, both data and parity, for this outer-code block. This excludes any sub-burst padding bytes in the last transmitted sub-burst and untransmitted RS padding bytes in the Reed-Solomon table. It also does not include any MAC added GMHs or PHY added CRC-16s.