Possible Approach for Flexible Downstream Coding for Burst Mode

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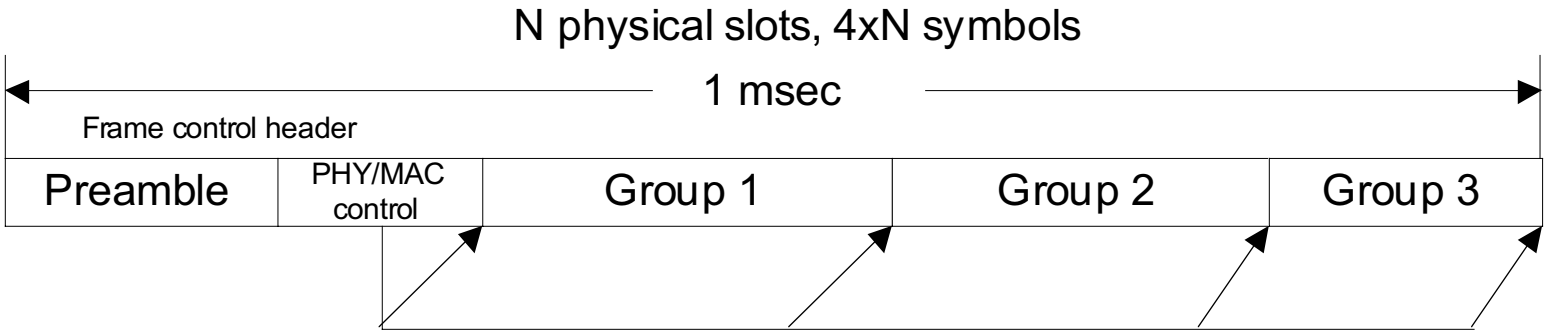
Purpose:

This set of slides is intended to foster some discussion regarding the FEC options for the 802.16.1 Physical layer specification.

Possible Approach for Flexible Downstream Coding for Burst Mode

- Based upon the various submission to the FEC subcommittee, there appears to be a desire to have some flexibility in the coding for the burst mode of operation (FDD with adaptive modulation, FSDD, or TDD).
- There is currently no method defined to support this variability other than having the receiver automatically detect the code rate used.
- This presentation suggests a possible approach that can be considered in order to provide the desired level of flexibility and allow for optional coding techniques that can be used to enhance future deployments.

Possible Approach for Flexible Downstream Coding for Burst Mode



Frame structure for FDD with adaptive modulation

Possible approach:

•Treat the PHY/MAC control data as a separate group from the user data portion of the frame, which has a clearly defined coding scheme.

•Use the PHY/MAC control portion of the frame to transmit any pertinent information to the subscribers in order to allow them to enter the network (synchronization information, registration portion of upstream frame, etc.)

•Divide the rest of the frame into different FEC/Mod groups, and allow each user group to have different modulation and/or coding structures. The frame should still have the modulation levels increase from QPSK to 16-QAM to 64-QAM, but the coding schemes could be allowed to vary.

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MAC management messages are required in order to configure the different FEC/Mod groups. An example of a possible message structure is given below:

FEC/Mod Group	**Modulation Type**	**FEC Type**	**RS Information bytes**	**RS Error Correction**	**Row information bits**	**Column information bits**
1-N	1 = QPSK 2 = 16-QAM 3 = 64-QAM	1 = RS only 2 = RS + P 3 = RS + BCC 4 = PTC	K=8-253 (ignored for FEC type 4)	T=0-16 (ignored for FEC type 4)	6-58 (ignored for FEC type 1-3)	6-58 (ignored for FEC type 1-3)

The configuration of the FEC parameters could either be made highly flexible, as shown above, or limited to a select few options for simplicity.

FEC/Mod Group Configuration Message

Upon entering the network, each user would be assigned to an FEC/Mod group. As the channel changes, the users can be moved to different FEC/Mod groups. In addition, the configuration of the FEC/Mod groups can also change.

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The Downstream Allocation MAP would change slightly to identify the different user groups rather than the different modulation types. This MAP would contain the following information:

FEC/Mod Group	**Start Allocation**
1	Start Physical Slot Number
2	Start Physical Slot Number
…	…

The number of elements in the MAP could be limited to the number of active users, or contain a place holder for all possible user groups.

FEC Coding for the PHY/MAC control portion of the frame

The PHY/MAC control messages should immediately follow the preamble and should have fairly strong error protection for the following reasons:

1. These messages are more sensitive to errors than the user data and may need to have stronger coding.

2. These messages are relatively short, and therefore lower rate codes will not significantly degrade channel capacity.

3. If stronger coding schemes are desired for the user data portion, then it would be desireable not be limited by the coding on the PHY/MAC control portion of the frame.

FEC Coding for the PHY/MAC control portion of the frame

Below are a couple of options for protecting the PHY/MAC control portion of the frame that allows for short packets sizes and a relatively simple implementation.

FEC Scheme	**Code Rate**	**Eb/No for 10^{-9}**
RS(69,53)+Parity[1]	0.6828	6.23
RS(72,53)+BCC(24,16)[2]	0.49	5.62
…		

[1] Qian Hongyi (Centre for Wireless Communications, Singapore)
[2] Alok Gupta (Ensemble)

These are just a couple of examples. We should probably choose one clearly defined scheme and keep it fixed rather than having it flexible. Also, if a low rate code is used, we also need to revisit the impacts on the preamble length.

FEC Coding for the user data portion of the frame

For the user data portion of the frame, I would suggest that we have the following mandatory FEC schemes supported:

1. RS only based on GF(256)
2. RS based on GF(256) + (9,8) Parity

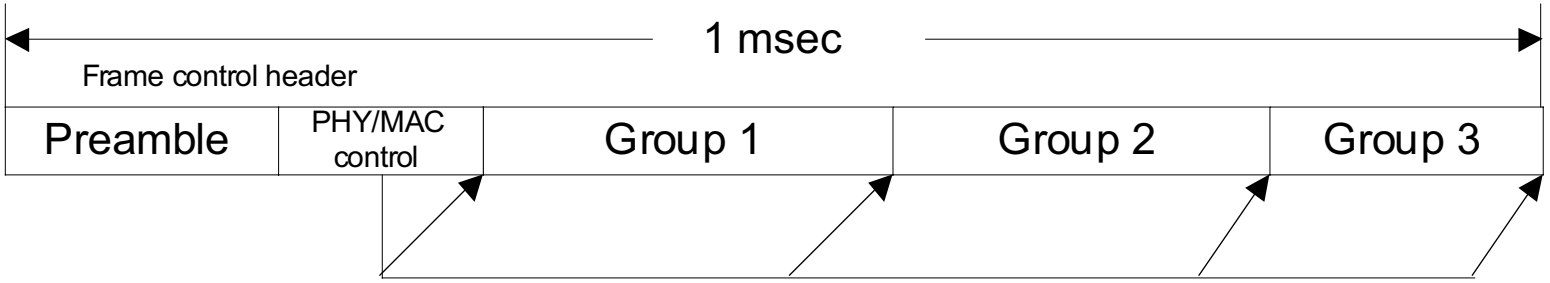
(3. RS + BCC only if it's decided that the PHY/MAC control portions use this format)

and the following option:

1. Product Turbo Code based on (64,58) Extended Hamming Code.

Note that similar concepts could be supported for the upstream. The MAC layer may also need to support a capability set exchange message for the base station to know what the subscriber station supports.

Example configuration for Downstream frame



Frame Portion	**Modulation Type**	**FEC**	**Rate**	**Eb/No**	**C/N (min)**	**C/N (min) from RS(140,128)+P code[1]**
PHY/MAC control	QPSK	RS(69,53) + P(9,8)	0.6828	6.23	7.57	9
Group 1	QPSK	RS(189,159)+ P(9,8)	0.7477	5.53	7.26	9
Group 2	16-QAM	PTC (63,56) x (63,56)	0.79	7.5	12.5	16
Group 3	64-QAM	PTC (63,56) x (63,56)	0.79	12	18.76	22

[1]Jay Klein, et. al., IEEE 802.16.1pc-00/20, "PHY layer proposal for BWA".

In this case, the cell radius would be limited by the PHY/MAC C/I, and the rings supporting 16-QAM and 64-QAM would be greatly widened by using PTC.

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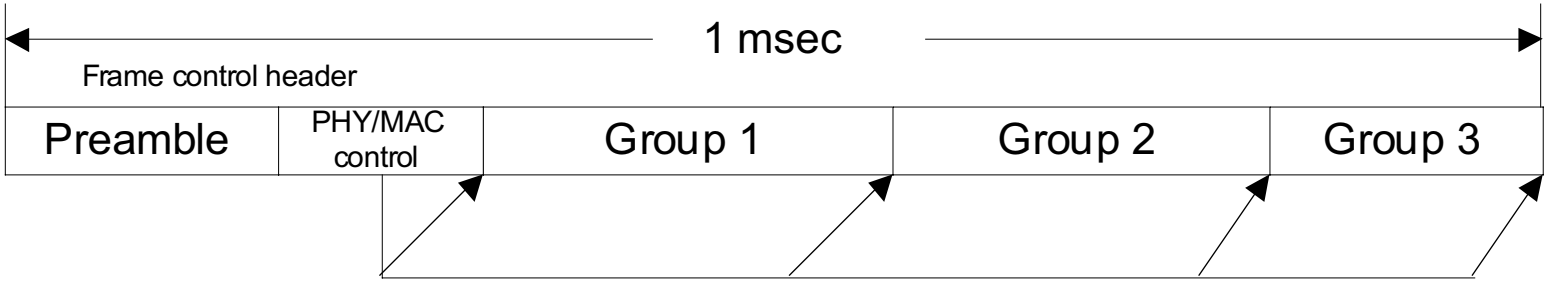

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PHY/MAC control	QPSK	RS(72,53) + BCC(24,16)	0.49	5.62	5.522	9
Group 1	QPSK	PTC (63,56) x (63,56)	0.79	4.3	6.28	9
Group 2	16-QAM	PTC (63,56) x (63,56)	0.79	7.5	12.5	16
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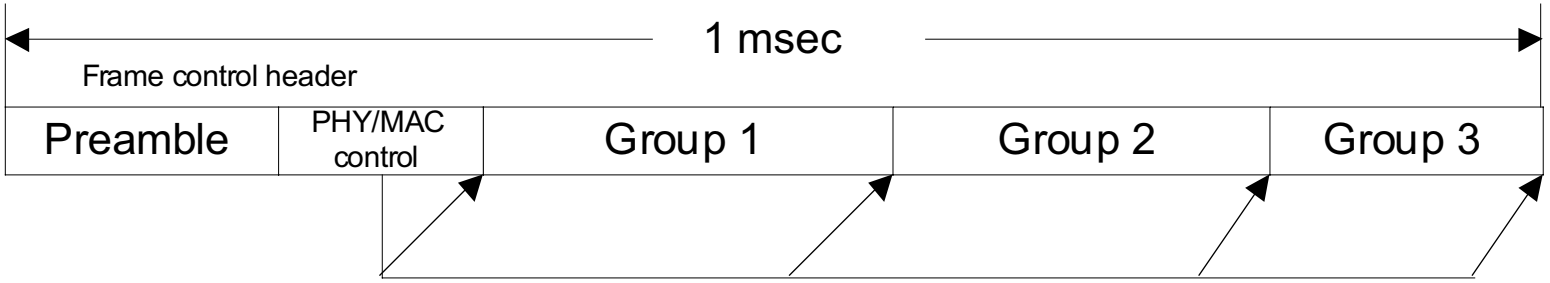
In this case, the cell radius would be increased by using PTC for the QPSK data portion while still maintaining stronger protection for the PHY/MAC control data.

Example configuration for Downstream frame



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In this case, the cell radius would be increased by using strong coding for the QPSK data and provides higher rates for users with PTC capability as it becomes available in products.

Conclusions

- Note that the previous examples showed 3 groups, but there is no reason why it can be limited to 3.
- It's possible to have a flexible coding scheme in the downstream channel for the burst mode of operation (Mode B).
- Having this flexibility allows for low complexity implementations in the near term and helps foster the new PTC technology and the potential benefits that it may provide as it matures.