ACK channel design for 802.16m HARQ

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Venue:

Re: PHY: text; in response to the TGm Call for Contributions and Comments 802.16m-08/033 for Session 57

Base Contribution:

This is the base contribution.

Purpose:

To be discussed and adopted by TGm for the 802.16m SDD

Introduction

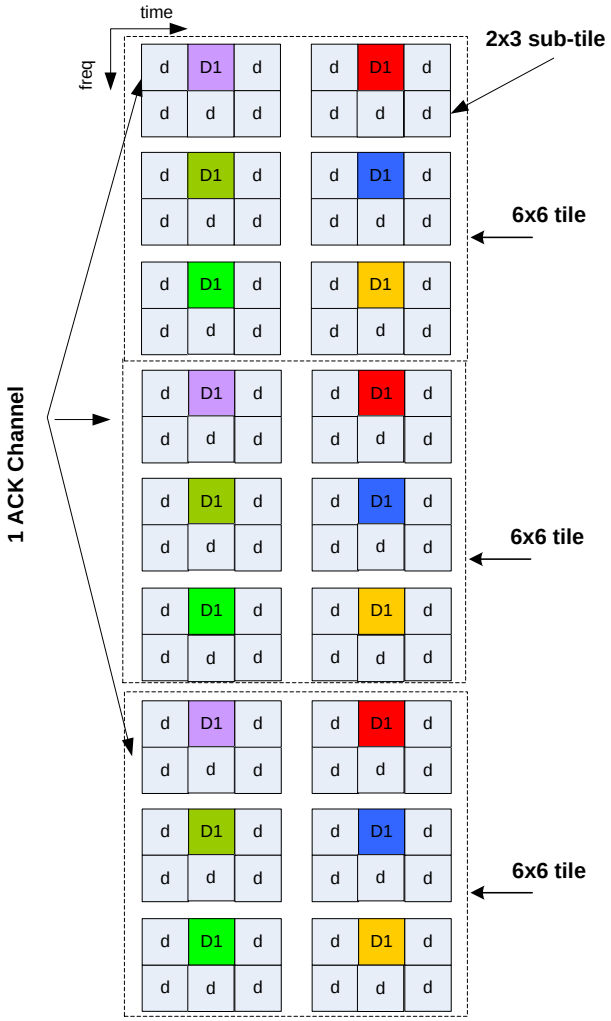
- In IEEE 802.16m Denver meeting, design requirements and comparison criteria for UL control channels are discussed and adopted by TGm [1].
- General requirements and design considerations for all UL control channels is
  - Cell coverage for 95% of users, optimized for cell sizes up to 5km…;
  - Mobility support optimized for pedestrian speeds of 0 - 10 km/hr; graceful degradation for vehicular speeds of 10 - 120 km/hr…;
  - Overhead reduction as far as feasible without compromising overall performance and ensuring proper support of system features.
  - If applicable, can be easily supported and fit into the PHY structure defined by PHY RG.
- ACK channel (ACKCH) for HARQ is one important UL control channel.
  - In [2], we propose ACKCH design for 802.16m type-1 subframe with 6 OFDMA symbols
  - There are two types of subframes depending on the size of CP: 1) the type-1 subframe which consists of 6 OFDMA symbols (some of which may be idle symbols) and 2) the type-2 subframe that consists of 7 OFDMA symbols.
  - ***In this material, we provide the ACKCH design for subframes with 5, 6 or 7 OFDMA symbols and performance evaluation.***

The ACKCH design proposed in [2]

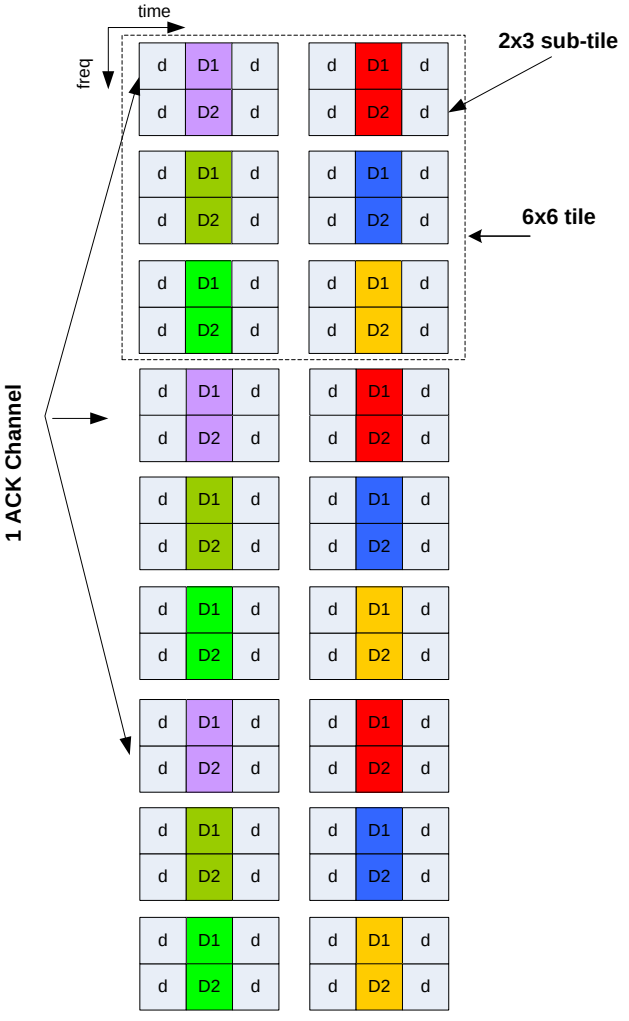
- The **6*N_{sym} tile** has been adopted as the basic physical resource unit in 802.16m UL distributed resource allocation in 16m SDD [3].
  - Each LDRU (logical distributed resource unit) is made up of 3 tiles, which are distributed in frequency domain.
- In [2], we propose ACKCH design based on the 6*6 UL tile for the subframe with 6 OFDMA symbols.
  - One 6*6 UL tile is divided into 6 pieces of 2*3 (frequency-time domain) sub-tile.
  - Each LDRU are divided into 6 ACK channel. Each ACKCH is made up of 3 sub-tiles, one sub-tile from each tile of the LDRU.
  - Both single Tx antenna and double Tx antennas structure are supported. See the figures in the next slide.

The ACKCH design proposed in [2]

- “D1” and “D2” are the pilot transmitted over the Tx antenna 1 and Tx antenna 2
- “d” is the data subcarrier
- One color means one ACKCH



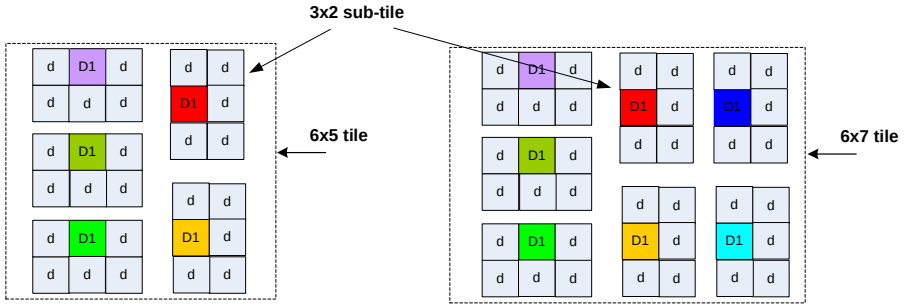
One LDRU is divided into 6 UL ACKCHs, Single Tx Antenna



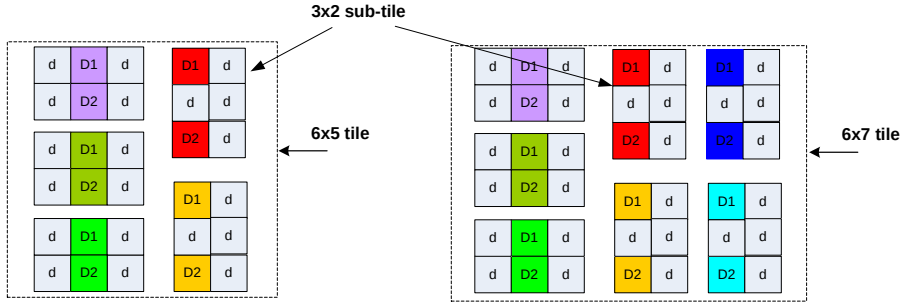
One LDRU is divided into 6 UL ACKCHs, Double Tx Antennas

Proposed ACK channel for subframes with 5 or 7 OFDMA symbols

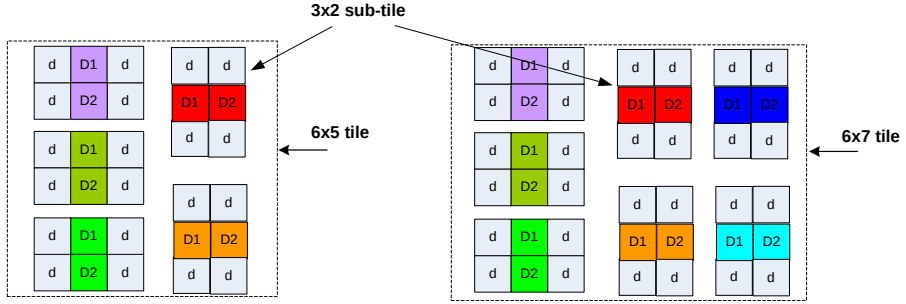
- Due to the presence of idle symbol for DL/UL guard time, or due to the length of CP, one subframe could contain 5 or 7 OFDMA symbols. In these cases, the ACKCH design in [2] can not be applied.
- We propose that one 6*5 (or 6*7) tile is divided into 2*3 sub-tiles and 3*2 sub-tiles.
  - The sub-tile structure is defined in the figure, with the proposed pilot pattern.
    - For 2 Tx antenna, there are two optional pilot patterns, denoted as case I and case II. Case I has less power fluctuation across OFDMA symbols; while case II has better performance (will be verified by simulationg).
    - For 2 Tx antenna, the Alamouti scheme is used.
  - For 5 OFDMA symbol case, one LDRU could be divided into 5 ACKCHs. Each ACKCH is made up of 3 sub-tiles, one sub-tile from each tile of the LDRU.
    - 3 ACKCHs are made up of 2*3 sub-tiles; the other 2 ACKCHs are made up of 3*2 sub-tiles.
  - For 7 OFDMA symbol case, one LDRU could be divided into 7 ACKCHs. Each ACKCH is made up of 3 sub-tiles, one sub-tile from each tile of the LDRU.
    - 3 ACKCHs are made up of 2*3 sub-tiles; the other 4 ACKCHs are made up of 3*2 sub-tiles.



The tile structure of UL ACKCH for the subframe with 5 or 7 OFDMA symbols, Single Tx Antenna.



The tile structure of UL ACKCH for the subframe with 5 or 7 OFDMA symbols, Double Tx Antennas, Pilot pattern case I.



The tile structure of UL ACKCH for the subframe with 5 or 7 OFDMA symbols, Double Tx Antennas, Pilot pattern case II.

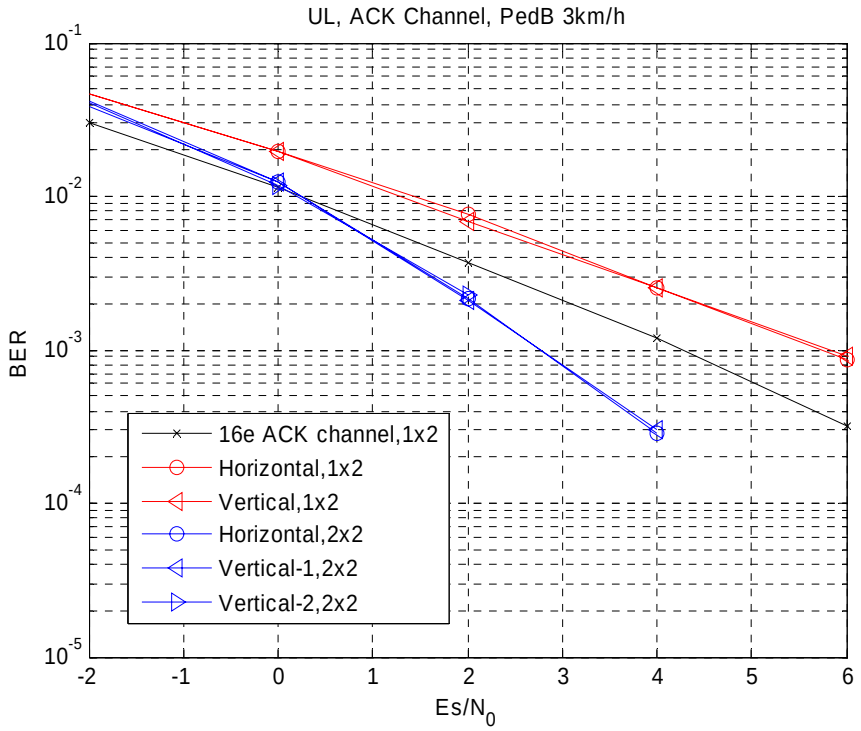
Modulation Scheme for the ACK channel

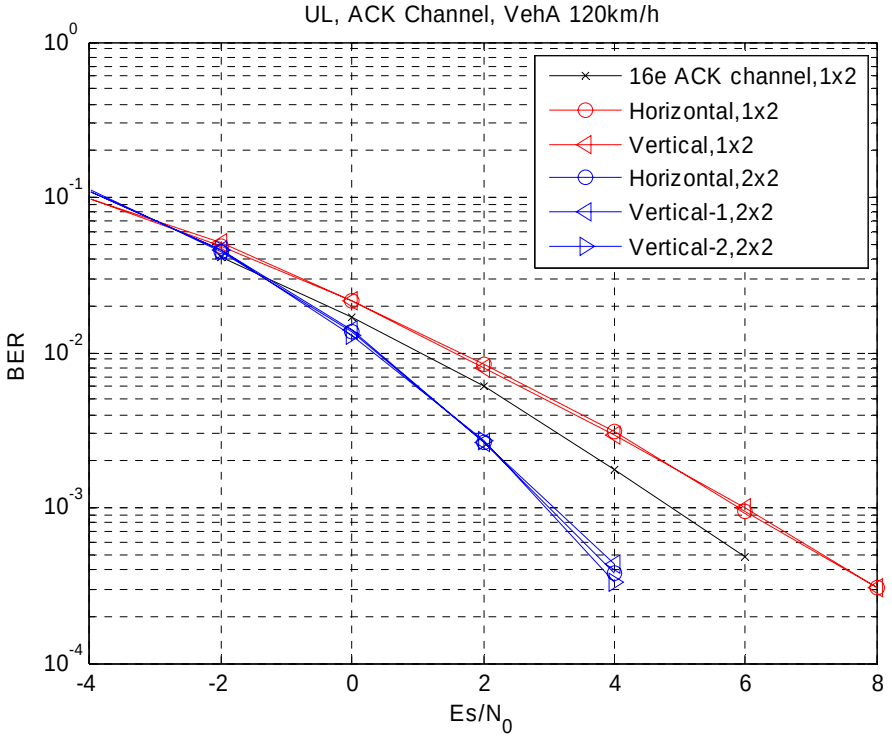
- In the proposed ACKCH, there are two types of ACKCH
  - the ACKCH made up of three 2*3 sub-tiles, denoted as horizontal ACKCH;
  - the ACKCH made up of three 3*2 sub-tiles, denoted as vertical ACKCH.
- For both types, each ACKCH contains 15 data subcarriers for the single Tx antenna case, and 12 data subcarriers for the double Tx antenna case.
- The 1-bit ACK/NAK information is modulated to the data subcarriers.
  - To transmit ACK, $\frac{\sqrt{2}}{2}(1+j)$ is transmitted over all the data subcarriers;
  - To transmit NAK, $-\frac{\sqrt{2}}{2}(1+j)$ is transmitted over all the data subcarriers.
  - This simple modulation method could ensure the maximum Euclidean distance between ACK and NAK signaling.

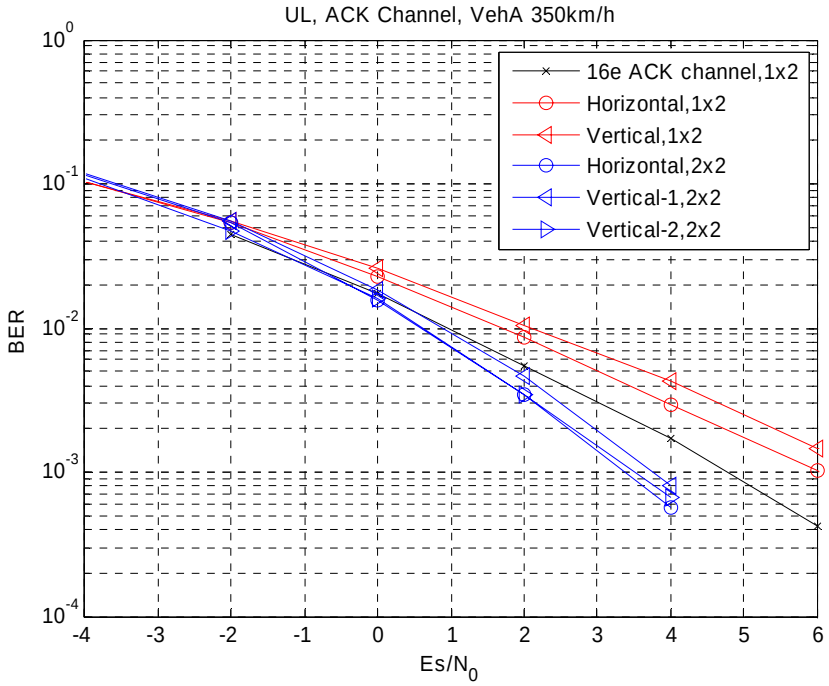
Performance evaluation

- The performance of the two types of ACKCH is verified by simulation, and compared with the performance of 16e ACKCH.
- Note that one 802.16e ACKCH consumes 36 OFDMA subcarriers; while, our proposal consumes 18 OFDMA subcarriers. Thus, our proposal is twice efficient in bandwidth.
- The simulation results are pasted in the next slide.

Simulated Cases:	Horizontal ACKCH Vertical ACKCH 802.16e ACKCH
Channel:	PedB 3km/h, VehA 120km/h, VehA350km/h
Antenna Config.	[1Tx, 2Rx, SIMO] [2Tx 2Rx, Alamouti STBC]
Pilot Boosting	3dB
Max Simulation Number	100,000


UL, ACK Channel, PedB 3km/h
BER
Es/N0
16e ACK channel,1x2
Horizontal,1x2
Vertical,1x2
Horizontal,2x2
Vertical-1,2x2
Vertical-2,2x2


UL, ACK Channel, VehA 120km/h
BER
Es/N0
16e ACK channel,1x2
Horizontal,1x2
Vertical,1x2
Horizontal,2x2
Vertical-1,2x2
Vertical-2,2x2


UL, ACK Channel, VehA 350km/h
BER
Es/N0
16e ACK channel,1x2
Horizontal,1x2
Vertical,1x2
Horizontal,2x2
Vertical-1,2x2
Vertical-2,2x2

Conclusions

- **The proposed ACKCH could be applied to 802.16m subframe of arbitrary number of OFDMA symbols.** The reason is that each UL tile contains $6*N_{sym}$ subcarriers. Both two types of proposed sub-tile structures contain 6 subcarriers. Therefore, one tile could always be divided into N_{sym} sub-tiles (of the two types mixed), if only $N_{sym} > 1$. See the example in slides 4-5 for $N_{sym} = 5$, 6 or 7. This point allows that even for the case of $N_{sym} = 4$ or other values due to the presence of other UL control channel (like sounding), our proposal could be used.
- Compared with 16e ACKCH (16e ACKCH only has 1 Tx)
  - With single Tx antenna, the proposed ACKCH has 1dB performance degradation.
  - With double Tx antennas, the proposed ACKCH outperforms by 1 dB.
  - Note the proposed ACKCH consumes only half the subcarriers, i.e. **twice bandwidth efficient**.
- The proposed ACKCH with 3*2 tile has the same performance the proposed ACKCH with 2*3 tile.
- For 3*2 tile with 2 Tx antenna, there are two pilot patterns, denoted as case I and case II.
  - Case I has less power fluctuation across OFDMA symbols.
  - Case II has little better performance in very high mobility case.

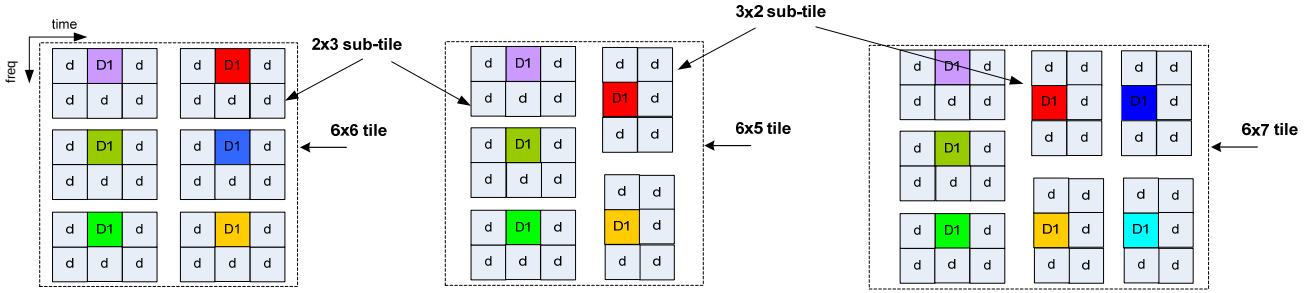
Proposed SDD text

[Insert the following section in 16m SDD]

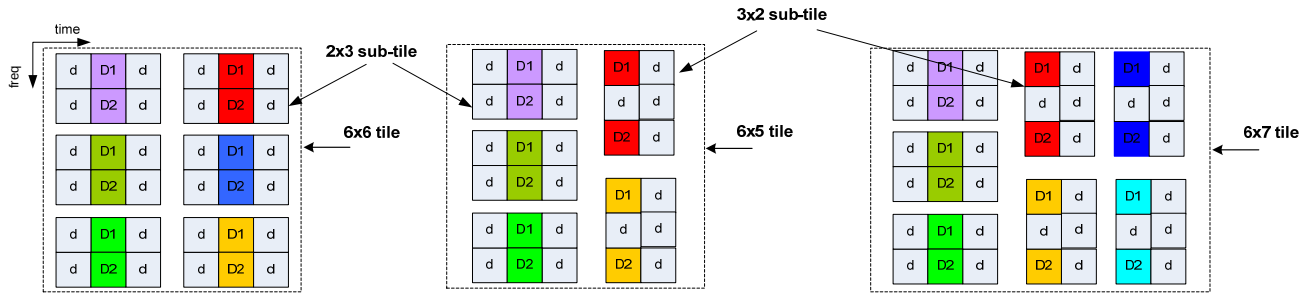
11.9.2.2 UL HARQ Feedback Channel

11.9.2.2.2 PHY structure

HARQ ACK/NAK feedback channel is defined in distributed resource. Each LDRU are divided into N_{sym} ACK channel, where N_{sym} is the number of OFDMA symbols per subframe. One $6*N_{sym}$ tile could be divided into 2*3 sub-tiles and 3*2 sub-tiles, depending on the value of N_{sym}. Each ACKCH is made up of 3 sub-tiles, one sub-tile from each tile of the LDRU. The tile and sub-tile structure and the pilot pattern for the ACK/NAK channel are provided in the following figure.



The tile structure of UL ACKCH, Single Tx Antenna.



The tile structure of UL ACKCH, Double Tx Antenna.

Reference

- [1] IEEE C802.16m-08/726r2, "Project 802.16m UL Control Structure Rapporteur Group Chairs' Report"
- [2] IEEE C80216m-08/396r1, "Proposal for IEEE 802.16m Uplink Physical Resource Allocation Unit in Green-field"
- [3] IEEE 802.16m-08/003r4, "Draft IEEE 802.16m Requirements,"