Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**TDM Downlink Mini-frame Control Channel Structure**
Date Submitted	**2008-03-18**
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Re:	IEEE 802.16m-08/005: Call for Contributions on Project 802.16m System Description Document (SDD). Target topic: "Downlink Control Structures".
Abstract	Proposal for IEEE 802.16m downlink control structures
Purpose	For discussion and approval by TGm
Notice	
Release	
Patent Policy	

Objectives

- In contribution IEEE C802.16m-08/210r2, we express our views on the downlink control information hierarchy in a 16m system
- In contributions IEEE C802.16m-08/081r1 and IEEE C802.16m-08/212, we described an enhanced FDM based control design in a mini-frame
- In this contribution, we describe an enhanced TDM based control design in a mini-frame
- We would like to propose that both approaches be studied thoroughly during the SDD development

Current DL Control/Data Multiplexing Schemes

- TDM option
  - Pro
    - Allow MSs to micro-sleep
    - Slightly shorter HARQ/PC timeline
    - Slightly less buffer at MS
  - Con
    - Loses flexibility in power domain, as a result, needs more control message transmission formats and more blind decoding of control channel
    - Finite granularity in resource allocation
- FDM option
  - Pro
    - Better dealing of near-far effect in power domain with continuous granularity
    - Limited number of transmission formats and blind decoding
  - Con
    - No micro-sleep
    - Slightly longer HARQ/PC timeline
    - Slightly more buffer required at MS

Proposed Control and Data Multiplexing Scheme within a Data Mini-frame

- Control zone occupies x subcarriers in the first 2 OFDM symbols
  - To gain the benefits of TDM based control structure
- Data zone occupies the remaining usable subcarriers in the first 2 OFDM symbols
  - To enhance bandwidth and power efficiency by adding FDM
  - The Control zone size (x) is modulated on Common Pilots in the control zone
- 3rd to 6th OFDM symbols are used for data zone
  - Cleaner design for the data zone and pilot structures
    - C802.16m-08/214 and C802.16m-08/215 provides more details on pilot structures

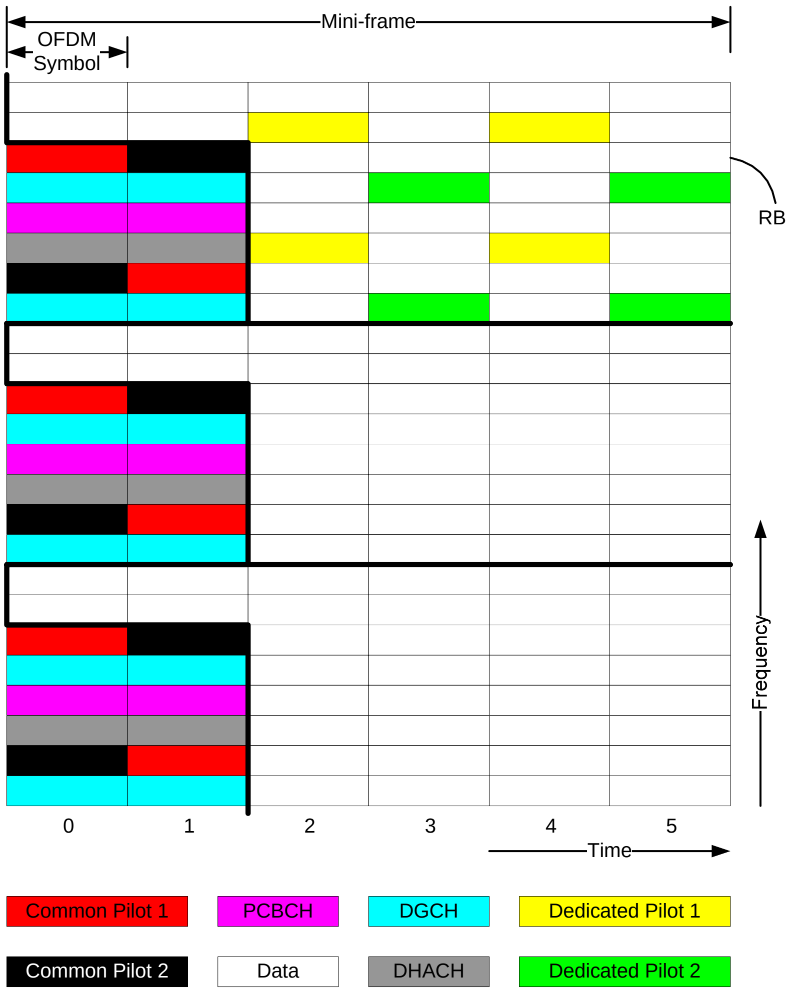


FIG. X: Example of Downlink Control Structure

Control Zone within a Data Mini-frame (1/2)

The control zone includes:

- 1st and 2nd Tx Antenna Common Pilots
  - Modulated with Control zone size information by using 4~6 possible sequences for Common Pilots
  - Using orthogonal subcarriers for the first 2 Tx antennas
- Power Control Bitmap Channel (PCBCH)
  - To broadcast the PC bits for MS UL power control
    - One bit is used as 3rd&4thAntCommonPilotPresence Flag to indicate the presence or absence of the common pilots in the control zone for the 3rd and 4th Tx antennas
  - A variable length (12~40 bits) bitmap plus 12-bit CRC for 10 MHz bandwidth
  - Super-frame Header or System Information message [1] indicates the bitmap size and what MIMO scheme is used on PCBCH (and other control channels) for improving cell edge coverage
- DL HARQ ACK Channel (DHACH)
  - To provide HARQ ACK/NACK for the UL data channel
  - ACK/NACK signals are carried by orthogonal sequences over shared resource block called DHACH group

[1] IEEE C802.16m-08/210r2

Control Zone within a Data Mini-frame (2/2)

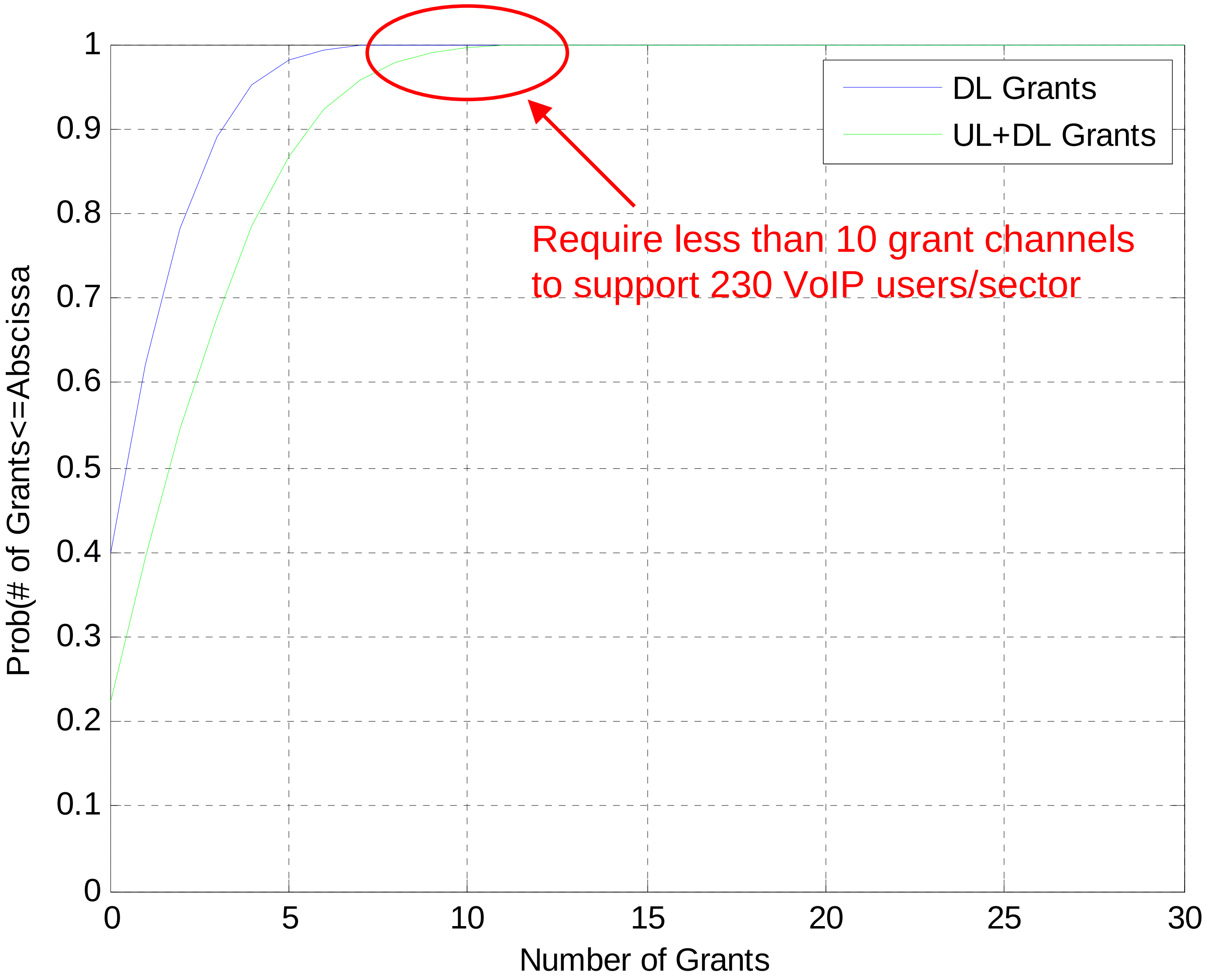
- 3rd and 4th Tx Antenna Common Pilot
  - If 3rd&4thAntCommonPilotPresence Flag is on, some subcarriers in the control zone are used as common pilots for the 3rd and 4th Tx antennas; otherwise these subcarriers are used for additional control channels
    - The BS may group MSs that can benefit from the 3rd and 4th Tx antennas into some mini-frames so that the BS can turn off the 3rd and 4th Tx antenna common pilots in the other mini-frames in order to reduce common pilot overhead
- DL Grant Channel (DGCH) to send DL/UL scheduling grant and system acquisition grant messages
  - The subcarriers in the first 2 OFDM symbols excluding Common Pilots, PCBCH, and DHACH are grouped into basic control resource blocks (CRBs)
  - Each DGCH can be unicasted or broadcasted and can use different aggregations of 1, 2, 4, or 8 CRBs to combat the near-far effect
  - Blind decoding of DGCHs is performed by each MS
    - Prefer to have one payload size for the grant messages with message header to indicate the grant type
  - FFS: Group grant mechanism for VoIP

Simulation Assumptions (802.16m EVM)

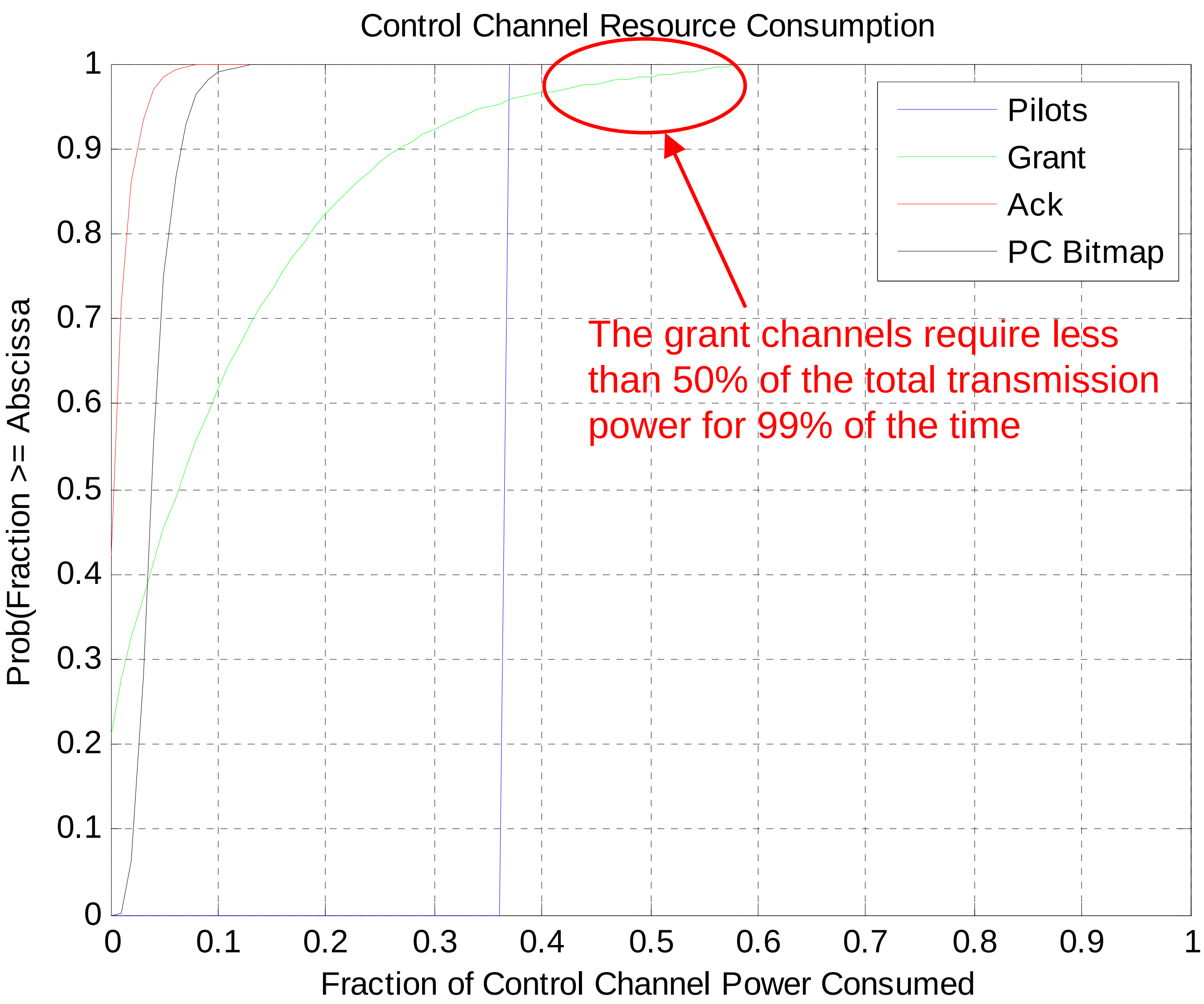
Simulation Assumptions	
DL Traffic Type:	VoIP (simplified AMR)
Number of VoIP Users / Sector	230
Scheduler Type:	Persistent VoIP Allocations for 1st Transmissions; Scheduled Allocations for Retransmissions

See more detailed simulation assumptions in the appendix

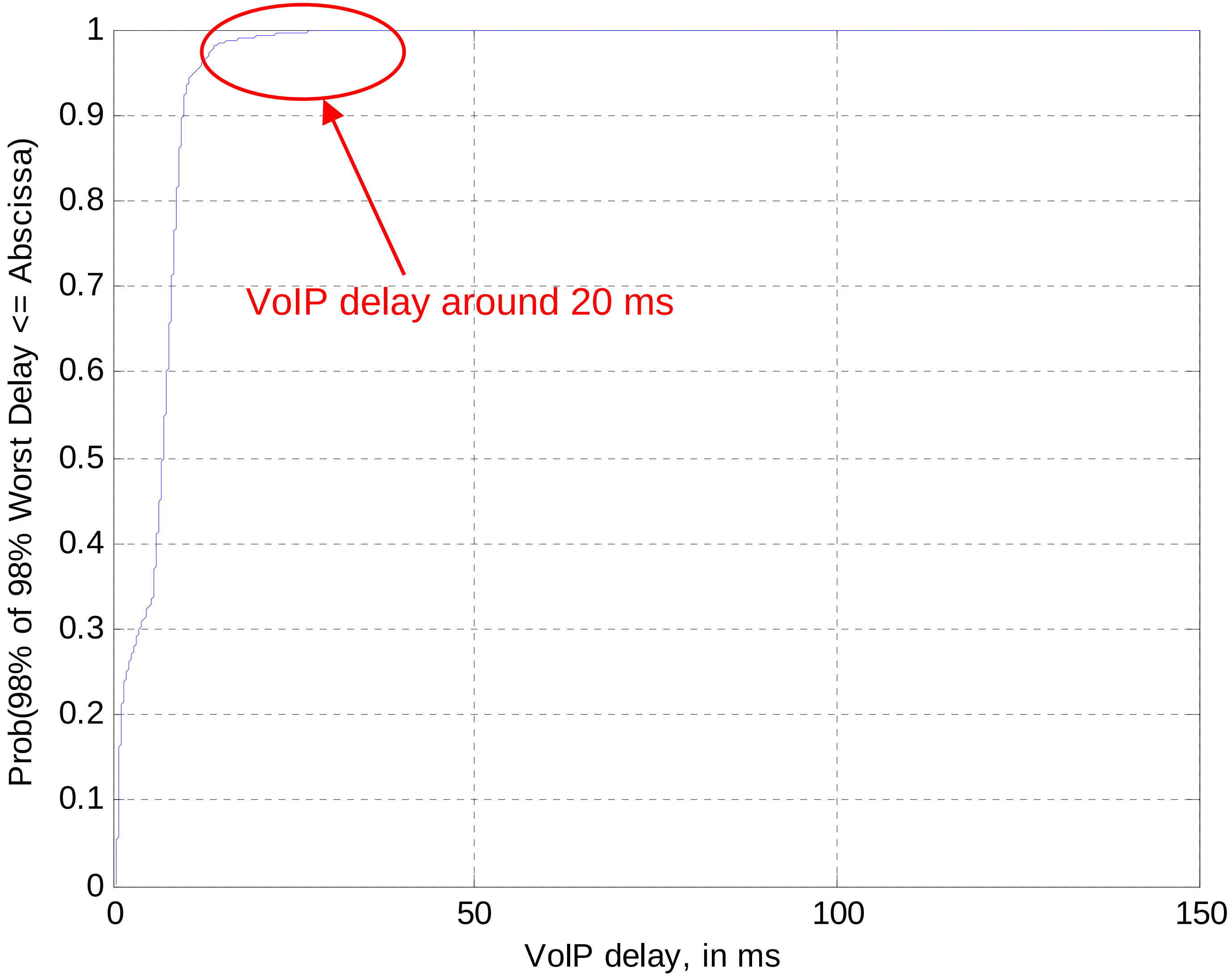
Simulation Results



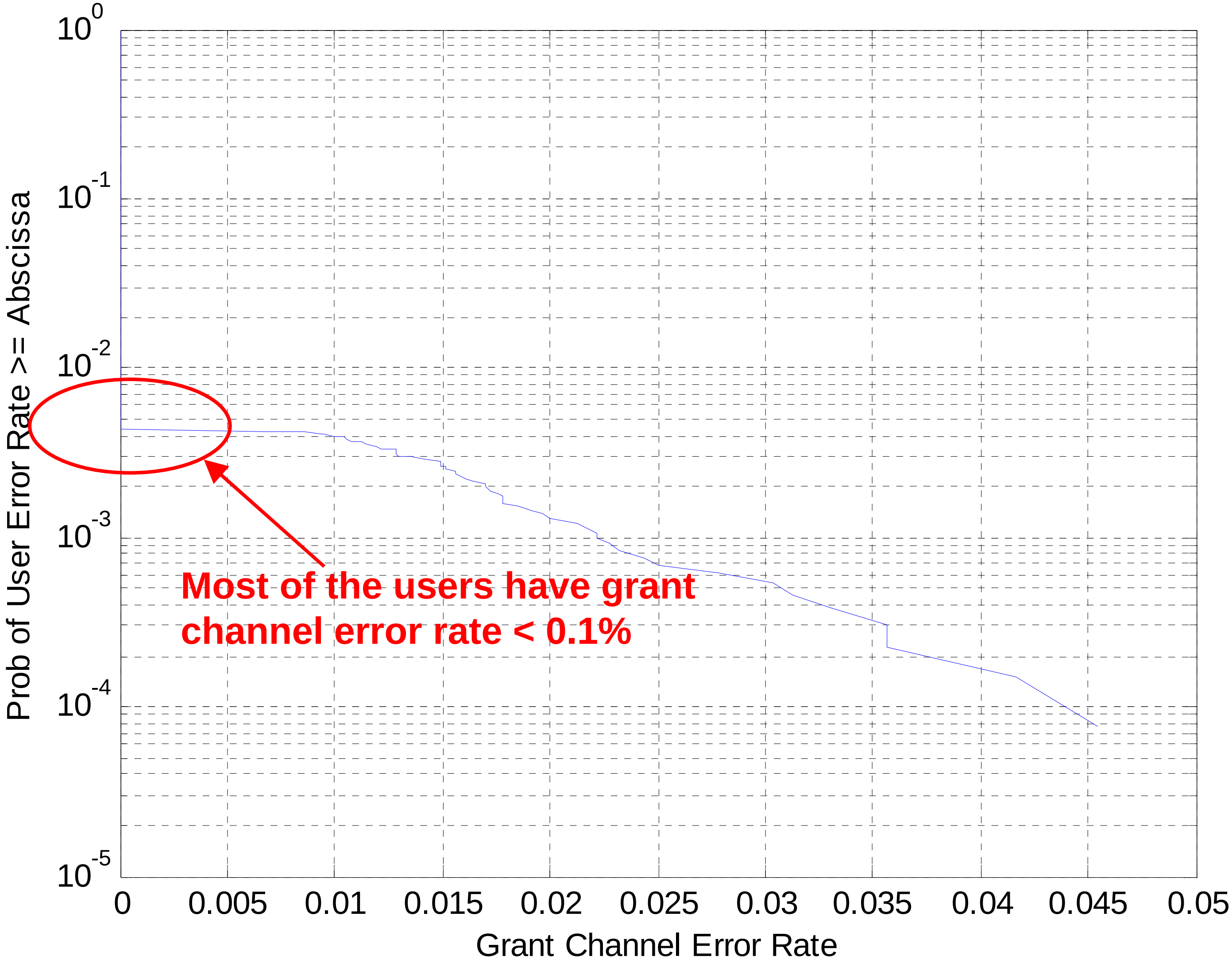
Simulation Results



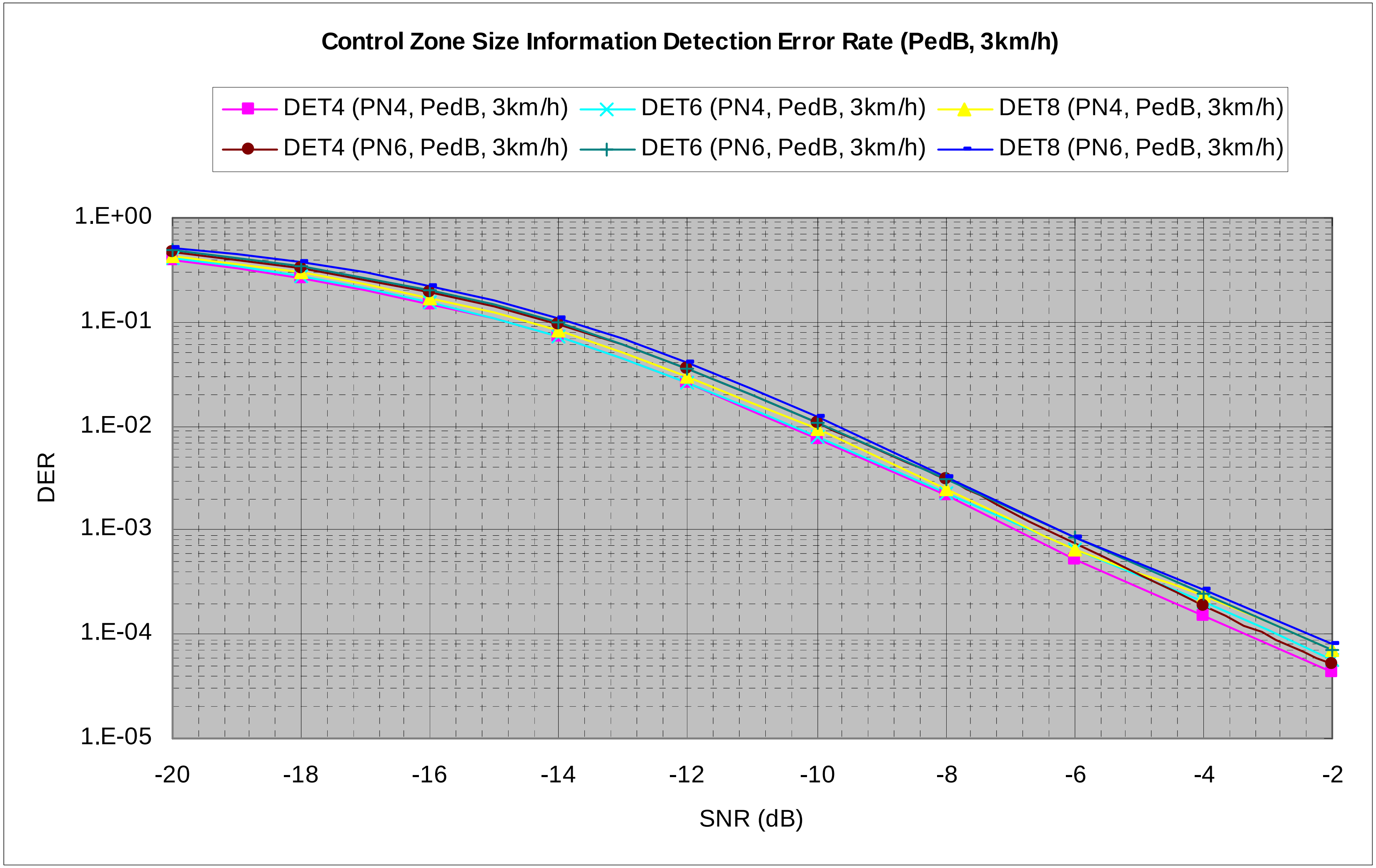
Simulation Results



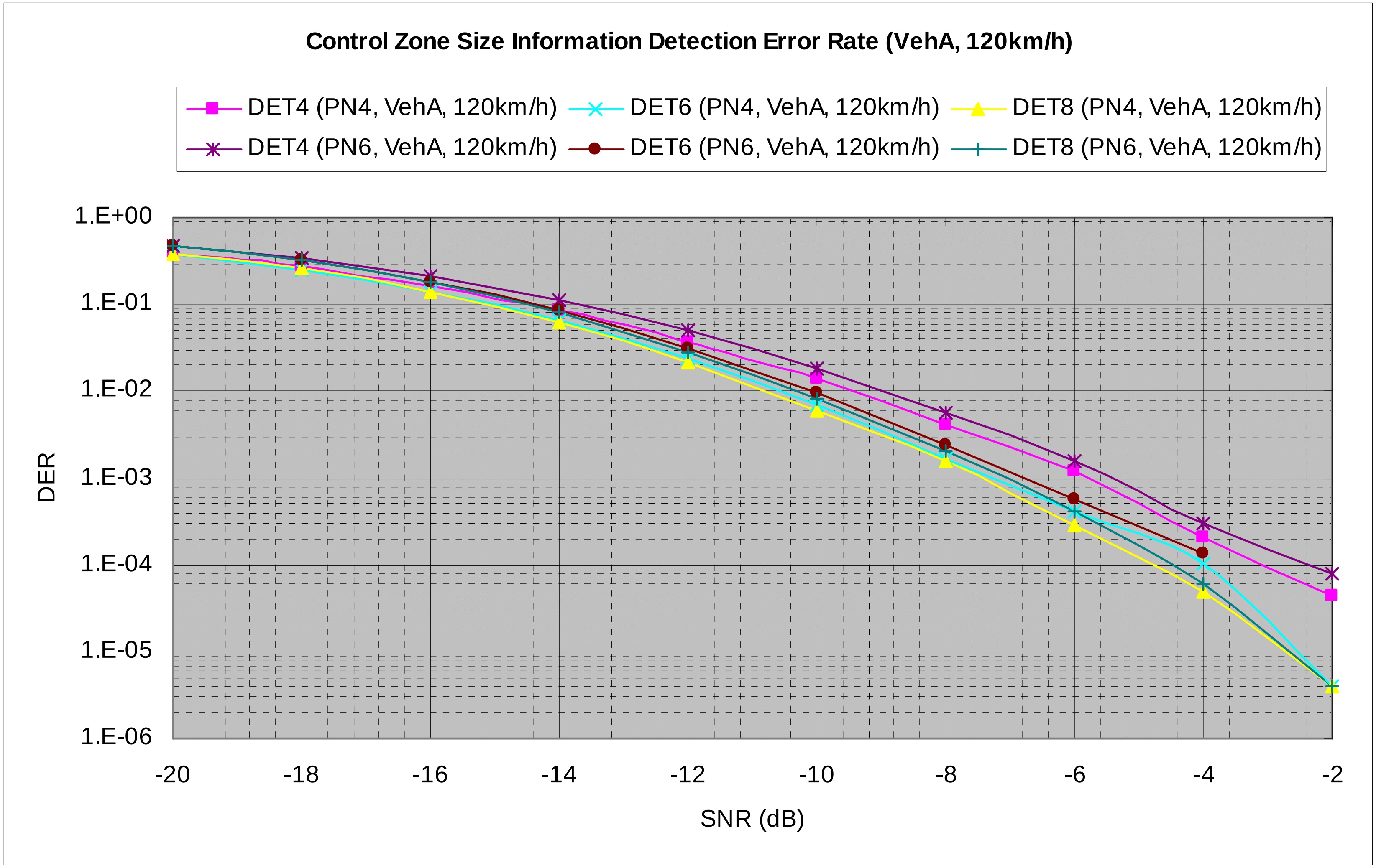
Simulation Results



Control Zone Size Detection Performance (1)



Control Zone Size Detection Performance (2)



Text Proposal

Insert the following text into Physical Layer sub-clause (C802.16m-08/003)

11.Y TDM Based Data Mini-frame Structure

Figure X shows an example of TDM based data mini-frame structure, including control and data multiplexing in a data mini-frame and various types of control channels in the control zone in a data mini-frame.

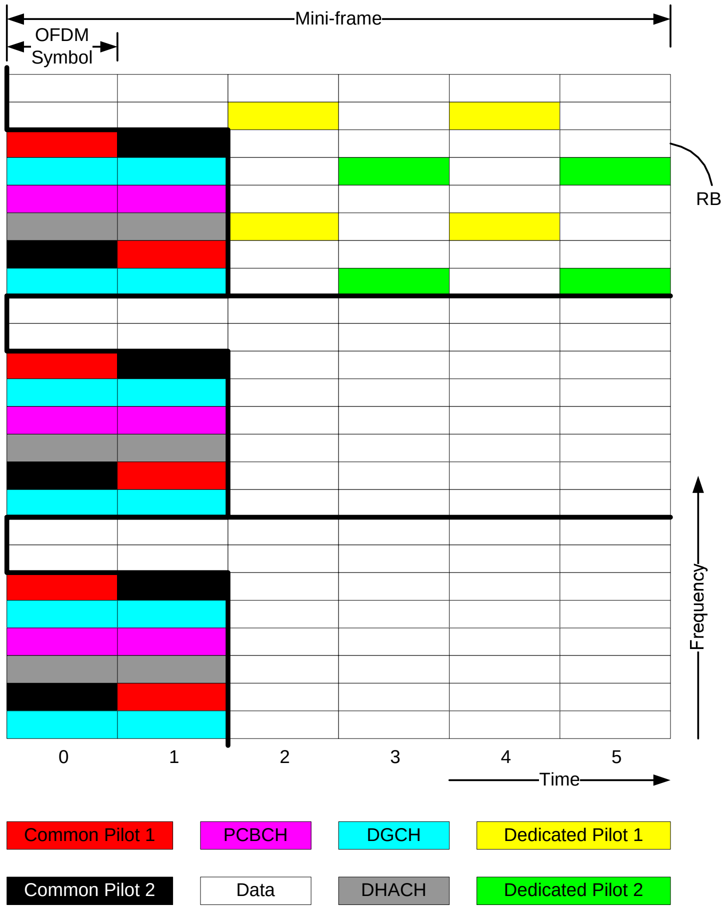


FIG. X: Example of Downlink Control Structure

Text Proposal (continued)

Insert the following text into Physical Layer sub-clause：

11.Y.1 Control and Data Multiplexing in a Data Mini-frame

Control and Data should be multiplexed in a Data Mini-frame using a combination of TDM and FDM. The control zone occupies x subcarriers in the first y (y<6) OFDM symbols in a data mini-frame. The data zone occupies the remaining usable subcarriers in the first y OFDM symbols. The data zone also occupies the remaining (6-y) OFDM symbols. The value of y can be standardized. The value of x is indicated and modulated on the common pilots in the control zone of a data mini-frame.

Text Proposal (continued)

Insert the following text into Physical Layer sub-clause：

11.Y.2 Control Zone

The control zone includes:

- Common Pilots for the 1st and 2nd Tx Antennas
- Control zone size information
  - Can be modulated on the Common Pilots for the 1st and 2nd Tx Antennas
- Power Control Channel to indicate the PC bits for MS UL power control
- One bit AdditionalAntennaCommonPilotPresence Flag to indicate the presence or absence of the common pilots in the control zone for the additional Tx antennas (such as the 3rd and 4th Tx antennas)
  - Can be combined with power control channel
- Common Pilots for additional Tx Antennas
  - If AdditionalAntennaCommonPilotPresence Flag is on, some subcarriers in the control zone are used as common pilots for the additional Tx antennas (such as the 3rd and 4th Tx antennas)
- Downlink HARQ ACK Channel to provide HARQ ACK/NACK for the UL data channel
- Downlink Grant Channel to send DL/UL scheduling grant and system acquisition grant messages

Appendix - Simulation Assumptions

Simulation Assumptions (802.16m EVM) (1)

Layout Model	
Network Topology:	**19cell, 3sectors/cell, wraparound**
BS-BS Distance:	**1.5 km**
Center Frequency:	**2.5 GHz**
Channel Bandwidth:	**10 MHz**
Frequency Reuse:	**1**
Base Station Model	
Max TX Power Per Sector:	**46 dBm**
BS Height:	**32 m**
Sector Antenna Pattern:	**3 dB beamwidth of 70^{o}; 20 dB F/B Ratio**
Sector Gain:	**17 dBi**
Cable Loss:	**2 dB**
Penetration Loss:	**10 dB**
Number of TX Antennas:	**2**

Simulation Assumptions (802.16m EVM) (2)

MS Model	
MS Height:	1.5 m
MS Noise Figure:	7 dB
MS Antenna Pattern:	Omni-directional
MS Antenna Gain:	0 dBi
Number of MS antennas:	2
Propagation Model	
Pathloss Model:	Loss (dB) = 130.62+37.6*log10(R, km)
Lognormal Shadow Fading:	μ=0 dB, σ=8 dB
Shadow Fading Correlation:	100% inter-sector, 50% inter-BS, 50 m corr. distance
Channel Model:	Modified ITU Ped B, 3 km/hr (60% of users) Modified ITU Veh A, 30 km/hr (30% of users) Modified ITU Veh A, 120 km/hr (10% of users)

Simulation Assumptions (802.16m EVM) (3)

PHY Assumptions	
Frame Duration:	5 ms
Superframe Duration:	20 ms
Number of mini-frames/Frame:	8 (4 DL & 4 UL)
Transmission Scheme:	2x2 STC
PHY Abstraction:	RBIR
Channel Estimation:	Real
HARQ Type:	Chase Combining (Maximum of 4 TX)
Control MCS:	48 bits including CRC, QPSK, rate ½
Data MCS:	Adaptive

Simulation Assumptions (802.16m EVM) (4)

MAC Assumptions	
DL Traffic Type:	VoIP (simplified AMR)
Number of VoIP Users / Sector	230
Scheduler Type:	Persistent VoIP Allocations for 1st Transmissions; Scheduled Allocations for Retransmissions
Packing & Fragmentation:	Off

Simulation Assumptions for Control Zone Size Detection

- Carrier frequency: 2 GHz
- System BW: 10 MHz
- Ped. B with 3km/h and Veh. A 120km/h
- Antenna Configuration: 1x2
- Pilot tone is boosted with 3dB over data tone and located every 9th subcarrier on first 2 OFDMA symbol
- There are 96 pilot tones per OFDMA symbol
- Common Pilot Sequence: Preamble sequence of 16e preamble
- PN4: 4 candidate sequences to indicate 4 possible control zone sizes
- PN6: 6 candidate sequences to indicate 6 possible control zone sizes

Detection Method for Control Zone Size Information

$$DecisionValue(i) = \sum_{l=0}^{L-1} \left| \sum_{t=0}^{1} \sum_{k=0}^{N-1} Pilot(t, k + l \cdot N) \cdot PN_i(t, k + l \cdot N) \right|^2$$

- Pick the sequence PN_i having largest $DecisionValue(i)$ among candidates
- $N_p = L \cdot N$, where N_p is number of pilot per OFDMA symbols
- N is coherent summing length per OFDMA symbol
- $Pilot(t, k)$ is k-th pilot tone in t-th OFDMA symbols
- $PN_i(k)$ is k-th bit of i-th PN sequence in t-th OFDMA symbols
- DET3: L=3
- DET4: L=4
- DET6: L=6
- DET8: L=8