Proposal for IEEE 802.16m Uplink PHY Structure with Legacy Support

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Venue:

IEEE 802.16m-08/016r1, “Call for Contributions on Project 802.16m System Description Document (SDD)”.

Target topic: “Uplink Pilot Structures”; “Uplink Physical Resource Allocation Unit (Resource blocks and Symbol Structures)”.

Base Contribution:

This is the base contribution.

Purpose:

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

Notice:

Release:

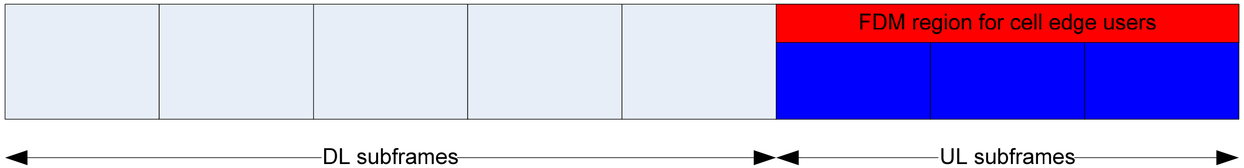
Patent Policy:

Introduction

- This contribution presents our considerations for 802.16m UL PHY design considering legacy support. The following topics are discussed:
  - Multiplexing 16m with 16e
  - Pilot pattern optimization
  - ACK/NAK channel optimization
- Our 16m UL PHY design for green-field is provided in another contribution: C80216m_08/396

Multiplexing 16m with 16e

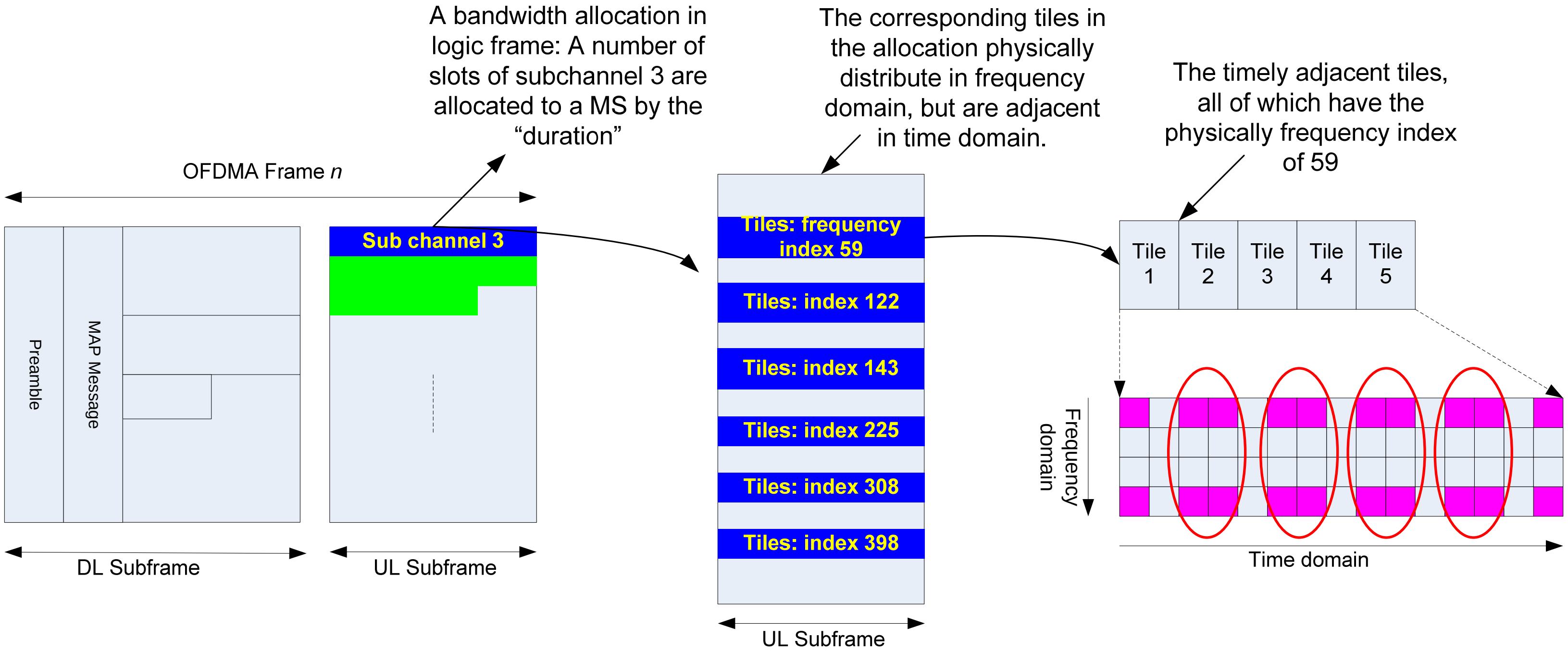
- FDM between legacy system and 16m system in UL should be supported
  - 802.16m system requirement: An IEEE 802.16m BS shall be able to support a legacy MS while also supporting IEEE 802.16m MSs on the same RF carrier, at a level of performance equivalent to that a legacy BS provides to a legacy MS.
  - Coverage will be an issue for the both 16e and 16m cell-edge users, if 16e and 16m systems are multiplexed by TDM. A good discussion was provided by C80216m-08_063r1.
    - Even in a 16m only network, cell-edge 16m users should be able to multiplex with other users in FDM manner.
    - FDM will be a constraint to 16m system design
    - The constraint is especially large when 16e users in the FDM region are doing PUSC/OPUSC.
      - 16m UL subchannelization scheme for distributed resource allocation (including the tile size, etc.) needs to be same with 16e.
    - The constraint is comparatively small when 16e users in the FDM region are doing AMC.
      - 16m UL basic PHY resource unit (RU) should be compatible to 16e AMC structure. An 2*3-bin AMC structure is mandatory according to WiMAX profile. Therefore, the UL basic PHY RU should have the size of 18*6 (freq*time) subcarriers, also considering the subframe structure.
    - **In either case, 16m performance shall be optimized.**



- TDM between legacy system and 16m system in UL should also be supported. In this case, 16m system will behave the same as in green-field.
  - In green-field, the 16m system could be designed much more freely.
  - Regarding the basic UL PHY RU
    - We prefer a 18*6 UL PHY RU, since it is symmetric with our proposed DL PHY RU and is compatible to the mandatory 16e AMC structure.
    - For distributed resource allocation, a UL PHY RU is further split into “tiles”.
    - More details for green-field design are referred to C80216m_08/396.

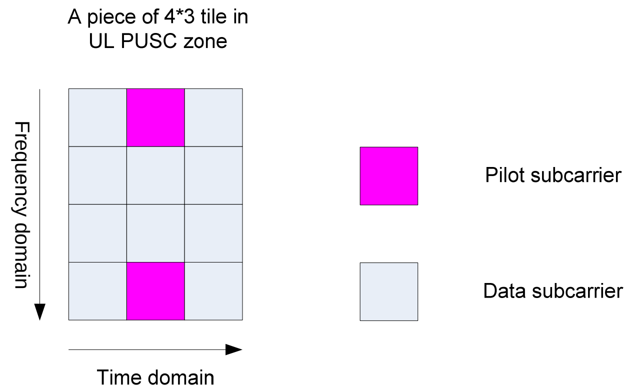
Issues of 16e PUSC Pilot Pattern

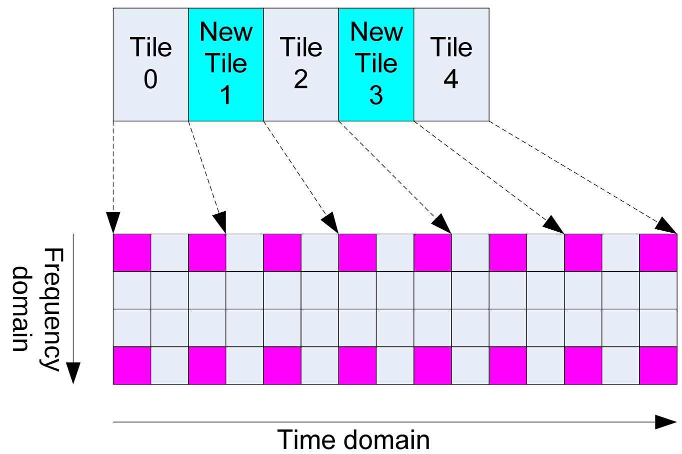
- In the case that 16m and 16e are using FDM and 16e is using PUSC, we propose that 16m also uses the 16e tile structure (4*3 block in freq-time domain) and 16e UL PUSC permutation.
  - When "subchannel rotation" is disabled, the bandwidth allocation is shown in the figure using the subchannel example in section 8.4.6.2.3 of the 802.16 standard.
  - Time-domain adjacent pilots (in the same frequency subcarrier) are somehow redundant.



Pilot Pattern Optimization for Single Tx Antenna

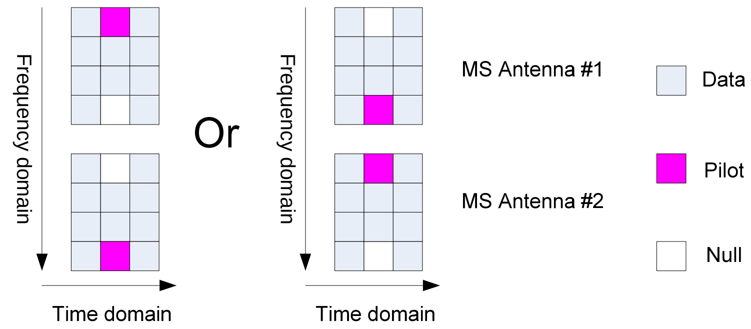
- Assume n (>2) tiles are adjacent in time domain and occupy the same subcarriers in frequency domain. Each of the n tiles has an natural index k, k=0,1,…,n-1.
- Define a new pilot pattern for the tile.
- For the tiles whose index $k=2j+1$, $j=0,1,\cdots,\lfloor(n-1)/2\rfloor-1$, the new pilot pattern is used. The new pilot pattern saves two pilot subcarriers per tile for data.
- For other tiles, the 802.16e pilot pattern is used.
- Then, pilots distribute evenly in the whole bandwidth allocation.
- See the example in the lower figure for n=5.
  - In this example, the improvement in spectrum efficiency in terms of available data subcarriers is **4/40=10%**.
- The analysis on the performance of the new pilot pattern could be found in backup slides. Conclusion: **there is minor performance degradation, but an obvious improvement in bandwidth efficiency**.

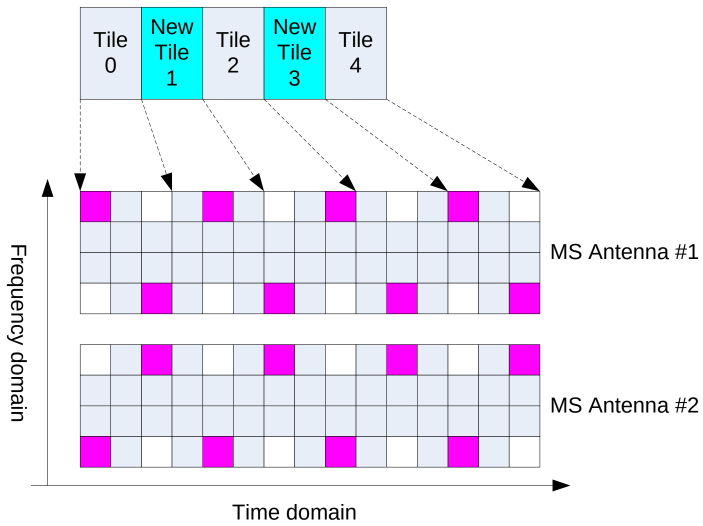




Pilot Pattern Optimization for Double Tx Antenna

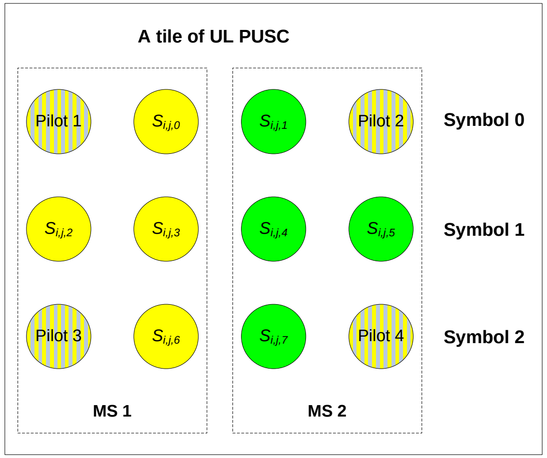
- The tile with new pilot pattern when 2 transmit antennas are defined in the upper figure.
- We use the pilot patterns for 2 UL Tx antennas of a MS when *n*=5 (5 timely-continuous tiles are allocated to one MS's UL) as an example.
  - The location of the tiles with new pilot pattern keeps to the same rule with the case of single transmit antenna.
  - The 2nd and 4th tiles use the new pilot pattern.
  - The 1st, 3rd and 5th tiles use the 802.16e UL PUSC pilot pattern (section 8.4.8.1.5) with the modification that in the 3rd tile antenna #1 and #2 exchange the pilot positions.
  - The improvement in bandwidth efficiency is same with single antenna scenario.



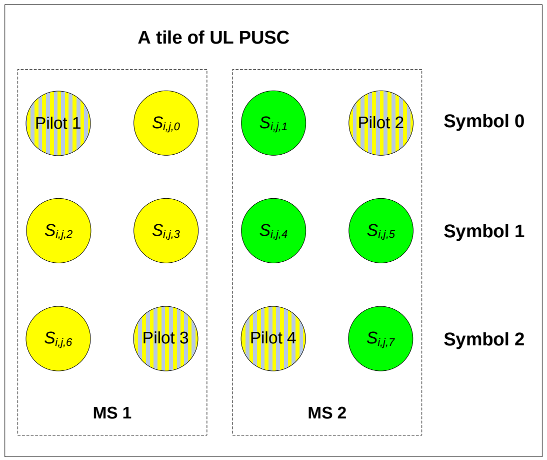


ACK/NAK channel optimization

- The coding/modulation scheme of 16e ACK/NAK channel is borrowed directly from the CQICH design without optimization.
- In the case of 16e PUSC, we have two directions to improve the 802.16 ACK channel:
  - Improving the ACK channel's efficiency without performance degradation (proposal I): we propose to allow two MSs to share one ACK channel (half a slot of 16e PUSC), as shown in the figure.
  - Improving the ACK channel's performance by using the best possible coding/modulation scheme (best ACK coding in brief) (proposal II)



2 MSs sharing one ACK channel
Option 1: pilot pattern same with 16e PUSC



2 MSs sharing one ACK channel
Option 2: pilot pattern different with 16e PUSC

ACK/NAK channel optimization

- The proposed Coding/Modulation Scheme is shown in a similar manner with the ACK/NAK channel defined in 802.16e spec.:
  - 2 MSs sharing one ACK channel (P0 and P2 have the same definition with 16e.)

ACK/NAK from two MSs	Coding/modulation scheme (Index of new tile vectors)
MS 1, ACK	0,0,0
MS 1, NAK	1,1,1
MS 2, ACK	2,2,2
MS 2, NAK	3,3,3

Tile index	$S_{i,j,0}, S_{i,j,1}, \cdots, S_{i,j,7}$
0	*P0, X, P0, P0, X, X, P0, X*
1	*P2, X, P2, P2, X, X, P2, X*
2	*X, P0, X, X, P0, P0, X, P0*
3	*X, P2, X, X, P2, P2, X, P2*

  - The "best ACK channel coding" using one 16e ACK/NAK channel (half a slot).

ACK 1-bit symbol	Index of new tile vectors
ACK	0,0,0
NAK	1,1,1

Tile index	$S_{i,j,0}, S_{i,j,1}, \cdots, S_{i,j,7}$
0	*P0, P0, P0, P0, P0, P0, P0, P0*
1	*P2, P2, P2, P2, P2, P2, P2, P2*

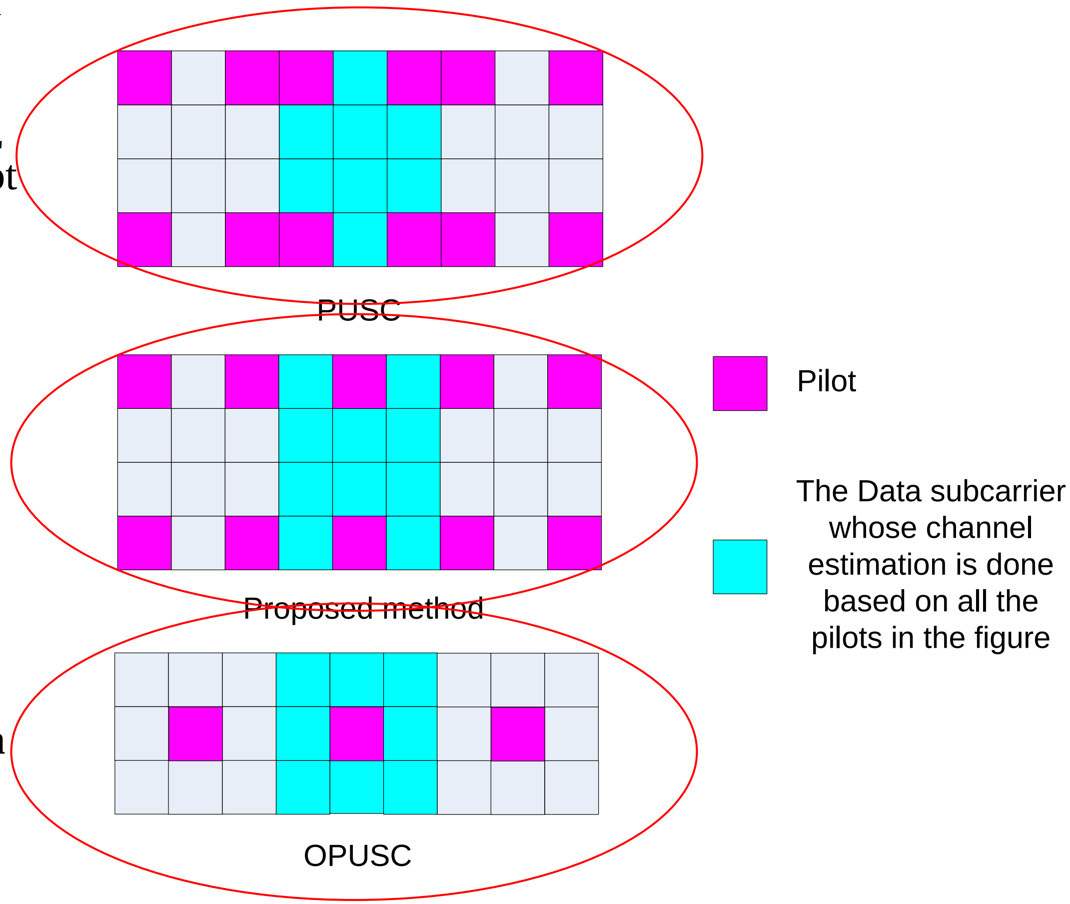
  - The performance of the proposals have been verified by simulation results in the backup slides. Conclusion: Proposal I significantly improves the efficiency of ACK channels by allowing two MSs to share one ACK channel to transmit two ACK feedbacks simultaneously, with ~ 1dB performance degradation; Proposal II improves the BER performance by 1~2dB.

Proposed text changes for 802.16m SDD

- Section 11.x: Uplink PHY Structure
  - Section 11.x.x: Uplink PHY Structure with legacy support
    - Both FDM and TDM between legacy system and 16m system in UL should be supported.
    - In the case that 16m and 16e are using FDM and 16e is using PUSC, we propose that 16m also uses the 16e tile structure (4*3 block in freq-time domain) and 16e UL PUSC permutation.
      - The new pilot pattern for PUSC. (Add the figures in slides 5-6 here.)
      - The new ACK/NAK channel for PUSC. (Add the figures in slides 7-8 here.)

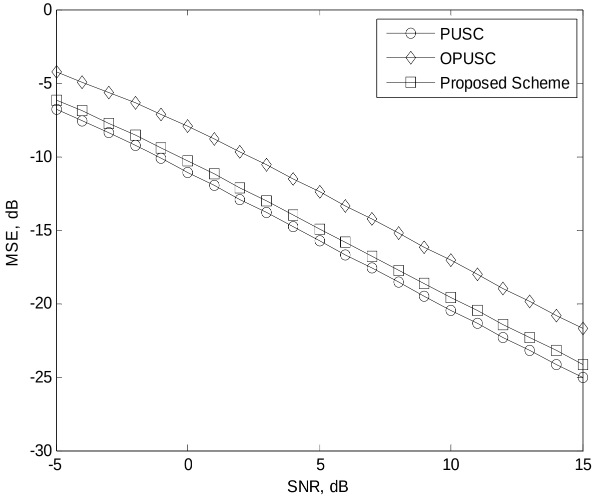
Backup Slides Part I: Analysis on performance degradation due to the reduction of pilots, channel estimation: Time-Freq. 2-D Wiener filter

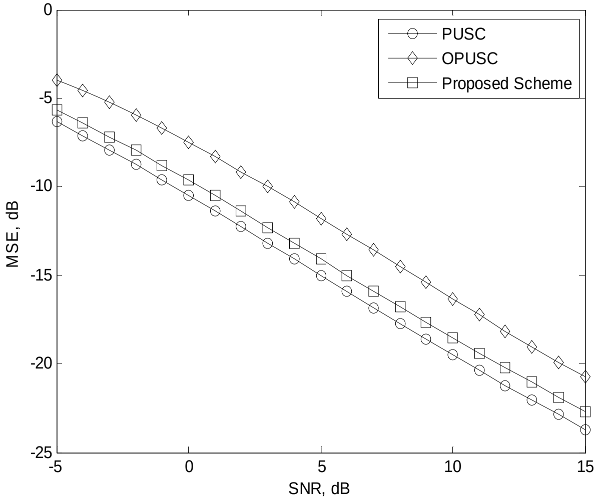
- Arbitrary number of pilots could be used in the channel estimation of 2-D Wiener filter.
- The normalized channel estimation MSE of the “blue” subcarriers of the three pilot patterns is compared under different channel models.
- **Note that in the comparison all the pilots in the right figure are utilized to do the channel estimation. Which means**
  - PUSC: 12 pilots are used
  - OPUSC: 3 pilots are used
  - Proposed method: 10 pilots are used
- **The conclusion is: the proposed method has a minor degradation in channel estimation MSE (< 1dB) compared with PUSC. Compared with OPUSC, it’s MSE is much better.**



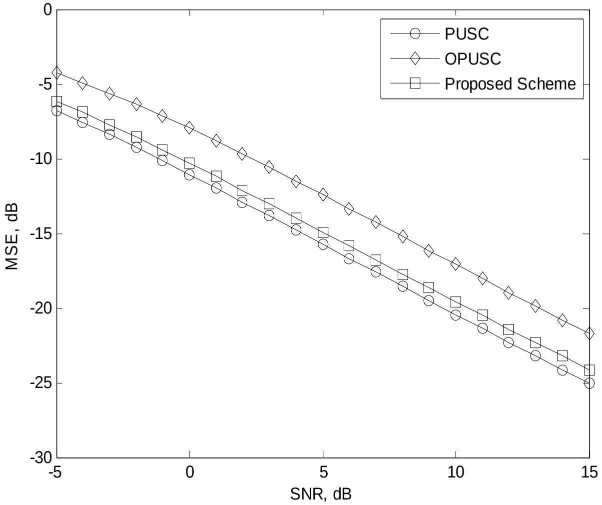
Backup Slides Part I: the proposed pilot pattern Channel estimation performance in MSE

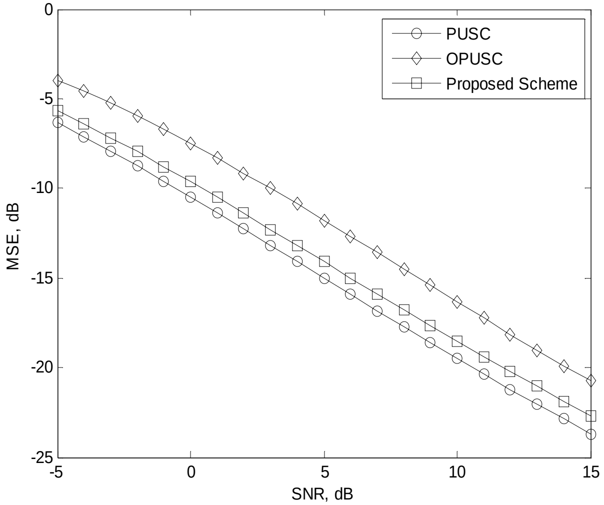
- Veh A: 30 km/h   120 km/h





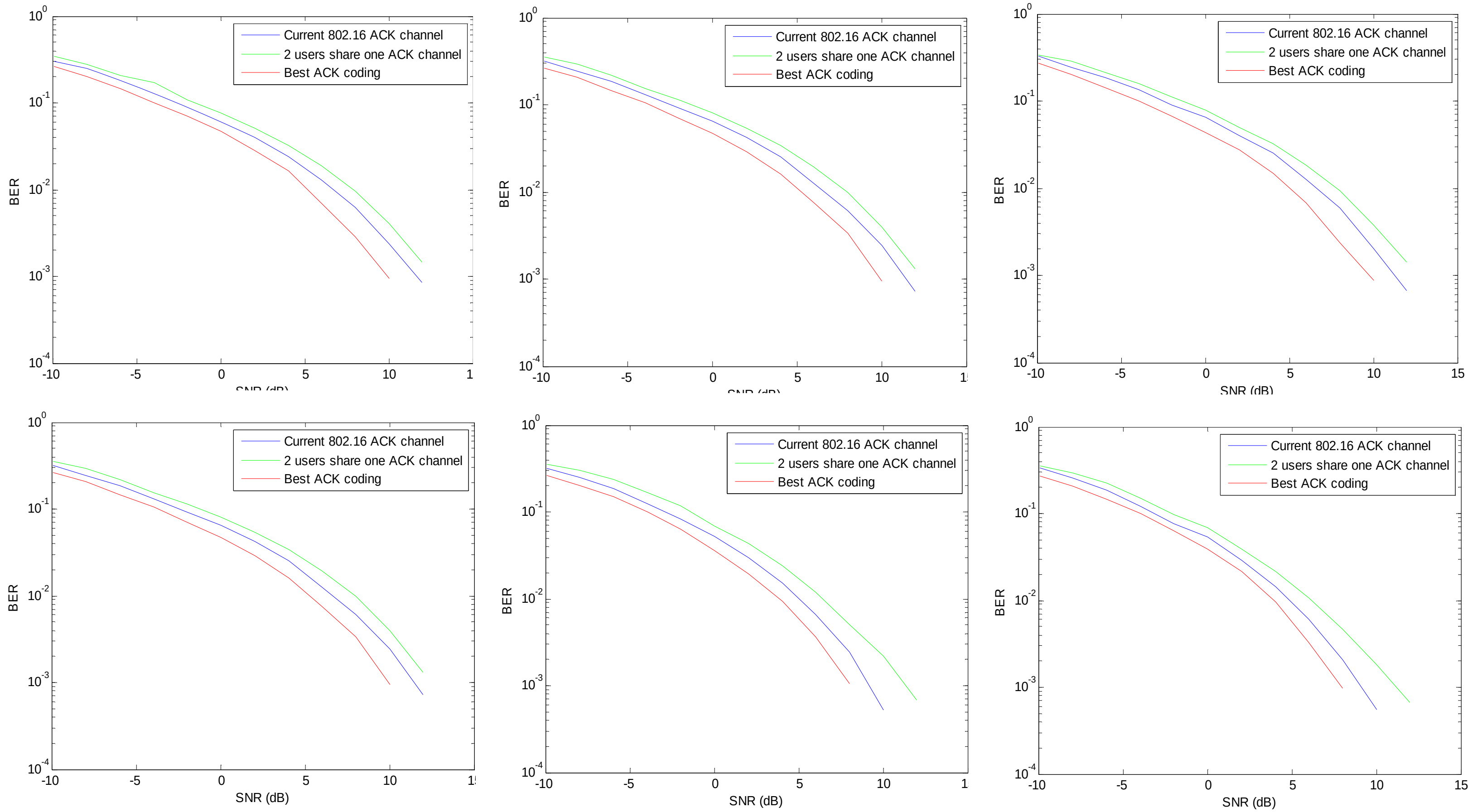
- Veh B: 30 km/h   120 km/h





Backup Slides Part II: Analysis on performance of the proposed ACK channel

- Velocity 30km/h 60km/h 150km/h
- Veh-A
- Veh-B



– By using proposal I to obtain the twice efficiency over Veh-A channel, we will have a ~ 1dB performance degradation in the considered BER range. If the channel model changes to Veh-B, the degradation is enlarged to less than 2 dB.

– Proposal II always outperforms the current 802.16 ACK CM by 1~2 dBs.