# Design of Resource Allocation Unit Structure for IEEE 802.16m

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Taeyoung Kim, Jeongho Park, Junsung Lim, Jaeweon Cho, David Mazzarese
Hokyu Choi, Jaehee Cho, Heewon Kang, Yungsoo Kim, DS Park
Samsung Electronics Co., Ltd.
416 Maetan-3, Suwon, 443-770, Korea

Voice: +82-31-279-0202
E-mail: ty33.kim@samsung.com

Venue:

IEEE 802.16m-08/005, “Call for Contributions on Project 802.16m System Description Document (SDD)”.
Target topic: “Downlink Physical Resource Allocation Unit”, “Pilot Structures as relevant to downlink MIMO”.

Base Contribution:

None

Purpose:

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

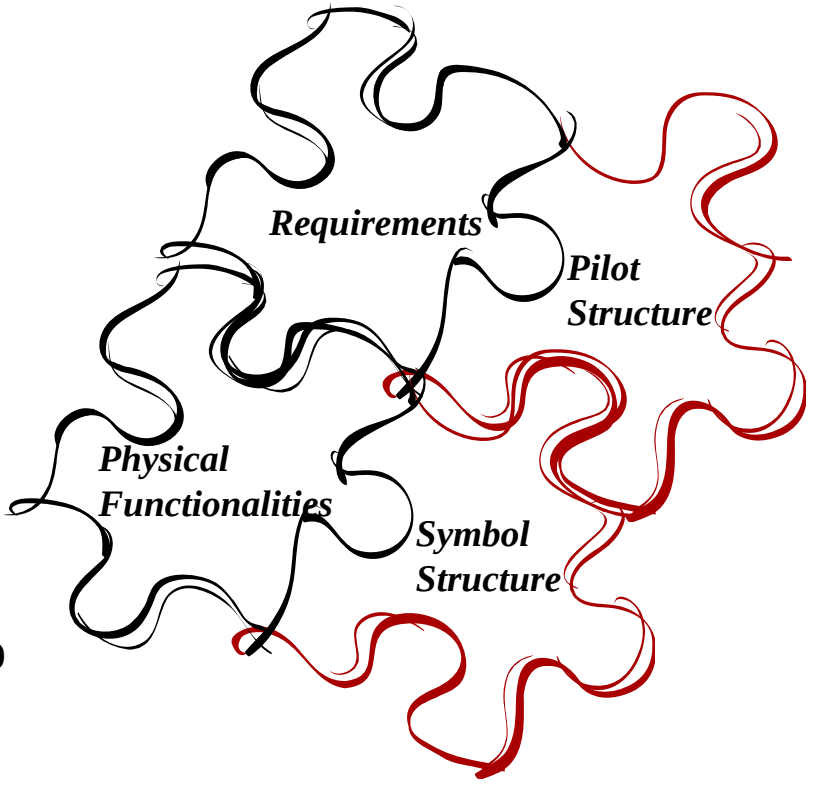
# Outline

- Scope and Goal
- Requirements
- Rationale
- DL Resource Allocation Unit Design
- Proposed RU structure
- Proposed DL Subchannelization
- Proposed DL reference signal
- Proposed text for SDD
- Annex A, B

# Scope and Goal

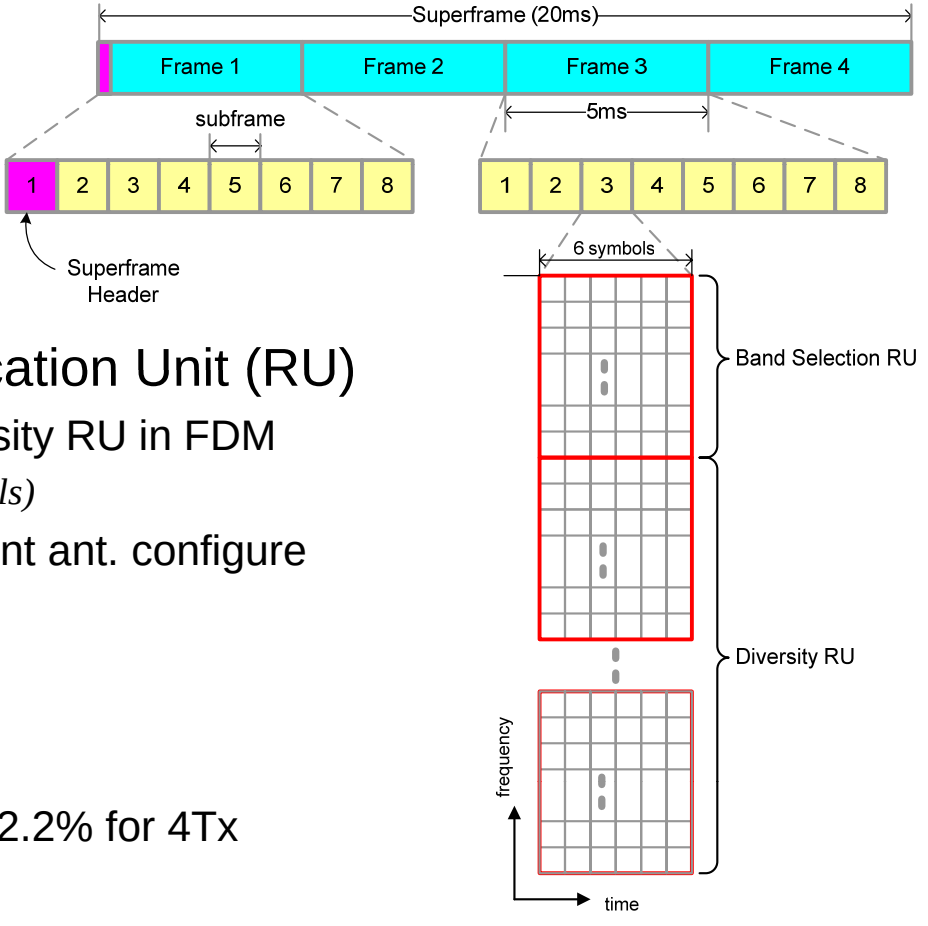
- Scope
  - This contribution is about symbol and pilot structure.
  - It is desirable to determine symbol and pilot structure considering each other based on various requirements and physical functionalities

- Goal
  - To Propose *Integrated Symbol and Pilot Structure* which is viable to support physical functionalities and to meet requirements



# Requirements for RU Structure

- Frame and Subframe Structure
  - Hierarchical frame structure
    *(Refer to C802.16m-08/118r1)*




- Requirements for Resource allocation Unit (RU)
  - To support band selection and diversity RU in FDM
    *(Refer to C802.16m-08/187 for further details)*
  - To support OL/CL-MIMO with different ant. configure

- Requirements for Pilot Structure
  - Pilot overhead : <17.0% for 2Tx, < 22.2% for 4Tx
    *(Refer to Annex A for further details)*
  - Adjacent pilot distance : < 4 tones & < 6 symbols
    *(Refer to Annex B for further details)*

# Rationale for RU Structure (1/3)

- Categorize subchannelization in terms of ***pilot type*** and the ***size of a block*** for a RU
  - A block is defined as a physically contiguous group of X subcarriers by Y symbols.
  - Pilot type: common pilot vs. dedicated pilot
  - Block size: large vs. small (even including a tone)

| | Large block | **Small block** |
|---|---|---|
| Common | | **necessary** |
| Dedicated | | **?** |

- Necessity for Small Block
  - To support small packet with full frequency diversity gain
    - such as DL control channel (including MAP), TCP ACK, VoIP
- Why NOT Dedicated Pilot for Small Block?
  - Inefficiency to incorporate a number of pilots within a small block
  - Low channel estimation performance due to restriction of pilot number

The support of ***Small Block with Common pilot*** should be ***mandatory*** for reliable transmission of essential DL control signal

# Rationale for RU Structure (2/3)

- Necessity for Large Block
  - Efficient to support band selection subchannel (e.g. AMC in legacy system)
  - Efficient to utilize CL-MIMO (e.g. Precoding, Beamforming)
  - Eligible to contain sufficient number of pilots within one block

- Which Type of Pilot is more Suitable to Large Block ?
  - Case I : Large block with common + mandatory
  - Case II : Large block with dedicated + mandatory

| | **Large Block** | Small Block |
|---|---|---|
| Common | **case I** | mandatory |
| Dedicated | **case II** | |

*Note that Large Block doesn't preclude to be used as diversity resource allocation unit*

# Rationale for RU Structure (3/3)

- Comparative Analysis

| | | Case I | Case II |
|---|---|---|---|
| Utilization of common pilot on channel estimation | | High | Mediocre |
| Overhead | Need of BF/code book index indication | Yes | No |
| | Burden for 4Tx pilots | High | Low |
| | Additional common pilot/midamble for CQI/PMI | No | Yes |
| | Need of De-boosting power level indication for data(1) | Yes | No |
| Interference estimation accuracy | | Low | High |

(1) : Assuming that MAP is multiplexed with data in FDM manner. Separate coding and power boosting is applied.
*See contribution IEEE C802.16m-08/185 for more details*

***Case II*** is more well-matched to ***mandatory*** compared to Case I.

We propose to use ***small block with common pilot*** and ***large block with dedicated pilot*** to effectively support for DL data traffic and control message.

# DL Resource Allocation Unit Design

- Proposed Resource Allocation Unit (RU)
  - Size
    - 18 subcarriers x 6 OFDMA symbols (freq x time)
    - 108 subcarriers for data and pilot
  - Type
    - Diversity RU structure (large block and small block)
    - Band selection RU structure (large block only)
    - Large block has the size of 18 subcarriers and 6 symbols

- Pilot Patterns

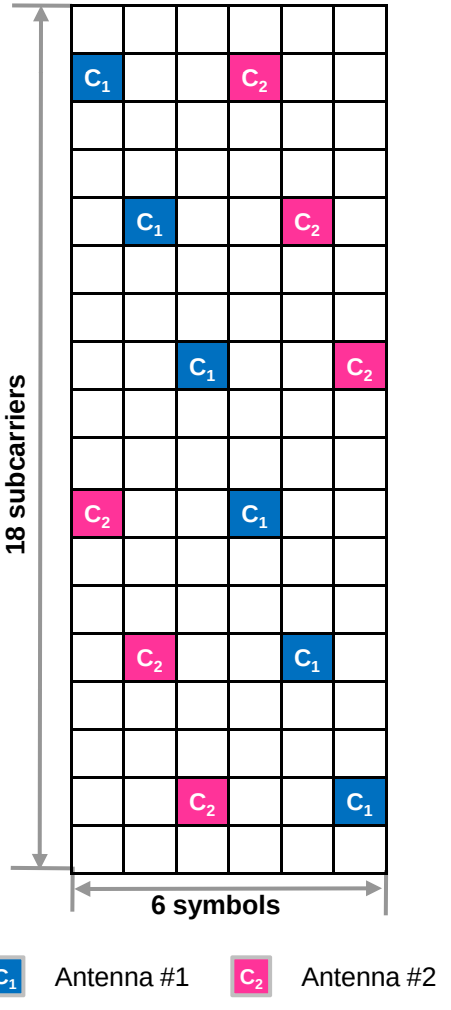
| | Block size | Pilot type | Total Pilot OH | Tx Ant. |
|---|---|---|---|---|
| Pilot Pattern A | Small | Common | 11.1% | 2 Tx |
| Pilot Pattern B | Large | Dedicated | 11.1% | 2 Tx |
| Pilot Pattern C (Low density) | Large | Dedicated | 11.1% | 4 Tx |
| Pilot Pattern D (High density) | Large | Dedicated | 22.2% | 4 Tx |

*Note that the pilot patterns is allowable to be changed for optimization*

# Proposed RU Structure (1/2)

- Pilot Pattern A

| Parameter | Value |
|---|---|
| # of total usable subcarriers | 864 |
| # of RUs per subframe | 24 @ 5MHz BW<br>48 @ 10MHz BW<br>96 @ 20MHz BW |
| # of data tones per RU | 96 |
| Pilot Type | *Common pilot* |
| Pilot OH per antenna | 5.55 % |

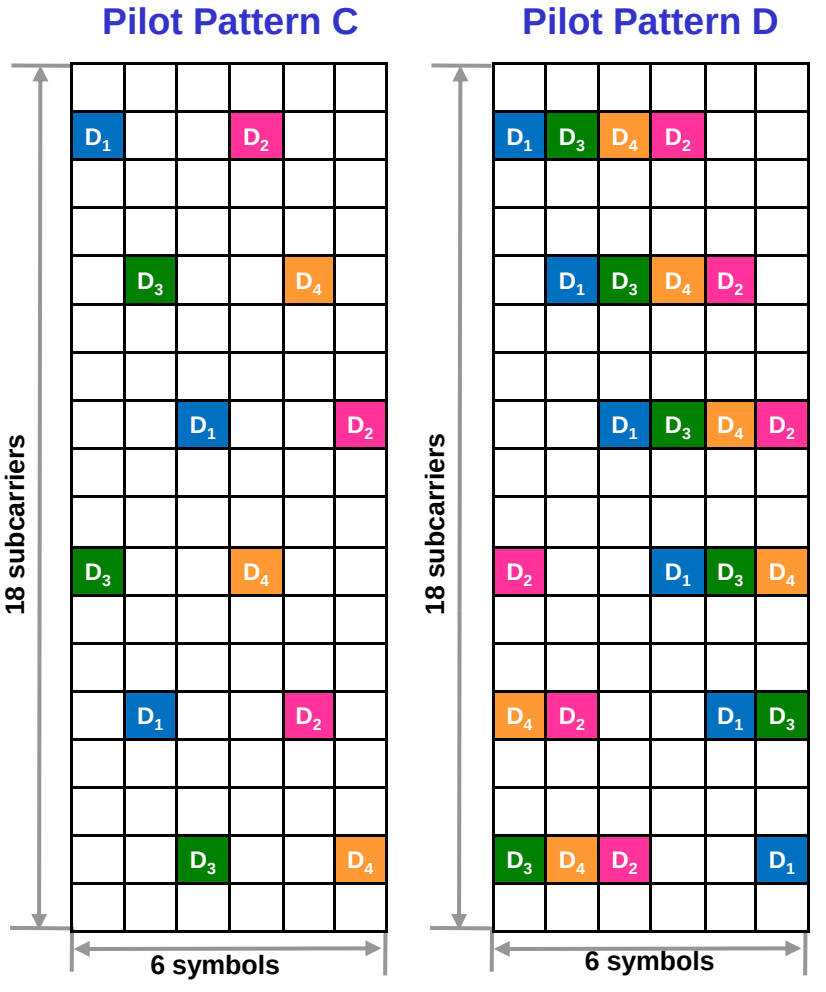


# Proposed RU Structure (2/2)

- Pilot Pattern B:
  - Same as Pilot pattern A except that pilot type is dedicated one

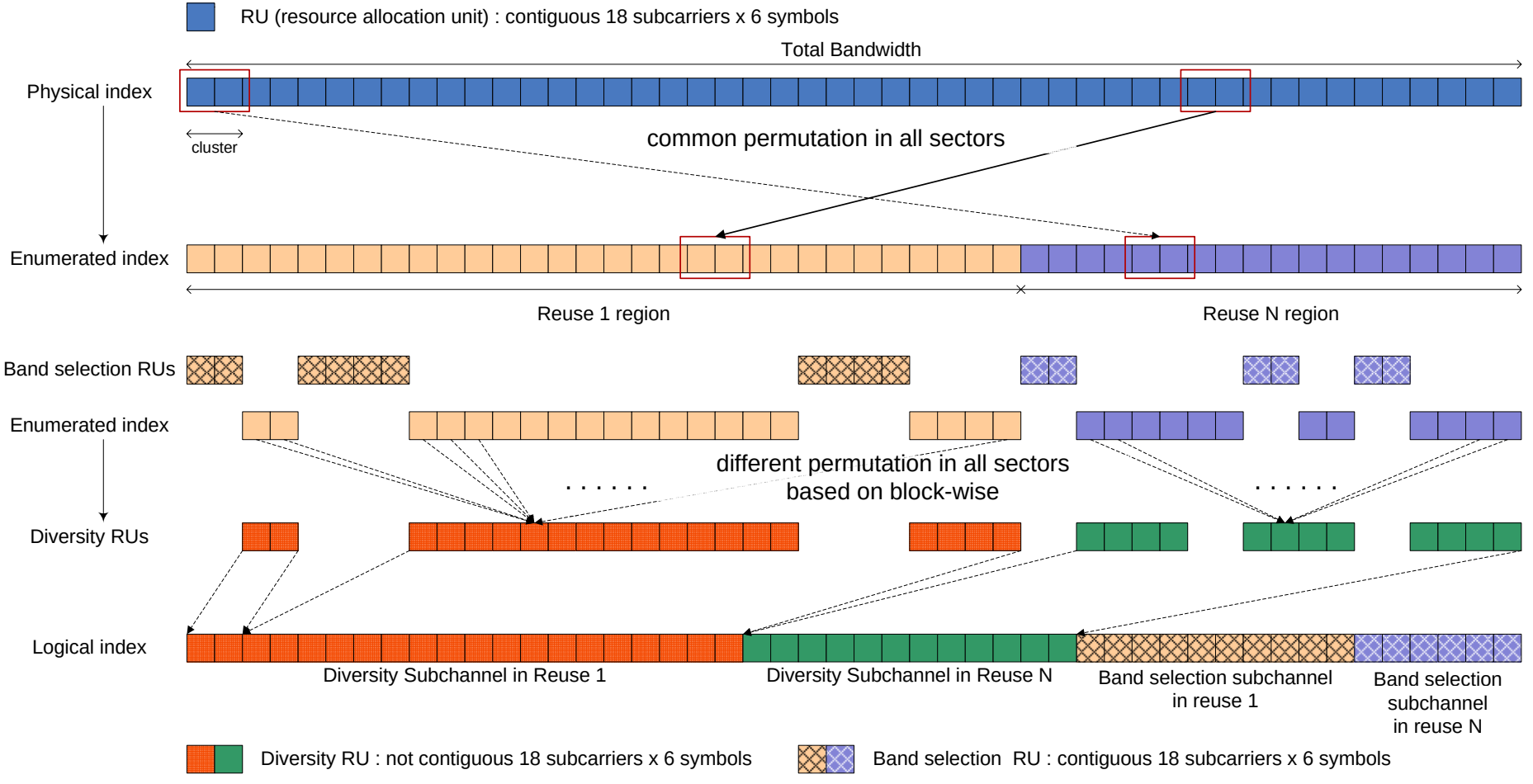
- Pilot Pattern C, D:

| Parameter | | Value |
|---|---|---|
| # of total usable subcarriers | | 864 |
| # of RUs per subframe | | 24 @ 5MHz BW<br>48 @ 10MHz BW<br>96 @ 20MHz BW |
| # of data tones per RU | Pilot pattern B, C | 96 |
| | Pilot pattern D | 78 |
| Pilot Type | | *Dedicated pilot* |
| Pilot OH per antenna | Pilot pattern B | 5.55 % |
| | Pilot pattern C | 2.77 % |
| | Pilot pattern D | 5.55 % |



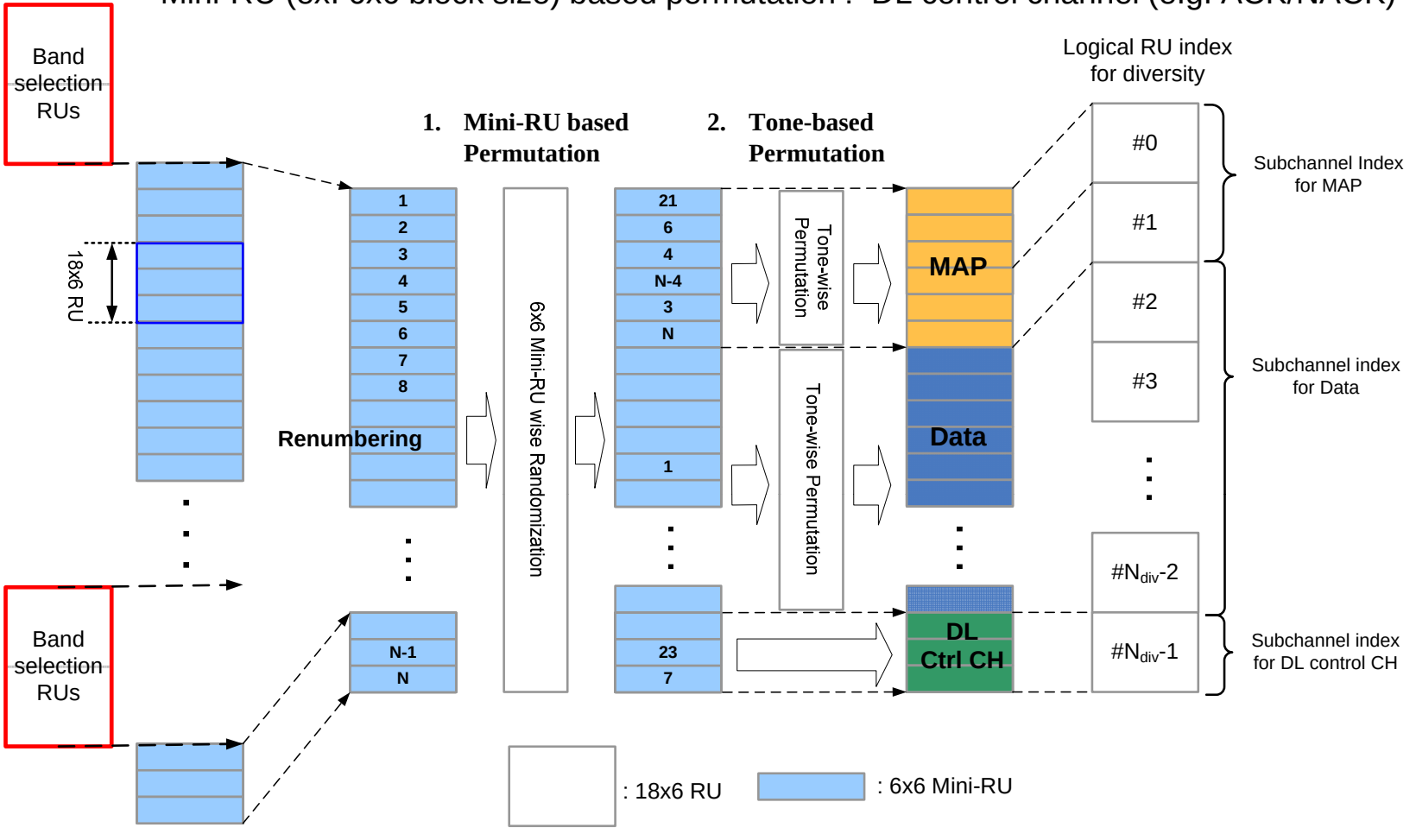
# Overall Subchannelization Procedure

- Support
  - FFR of [Reuse 1, Reuse N] x FDM of [Diversity, Band selection]



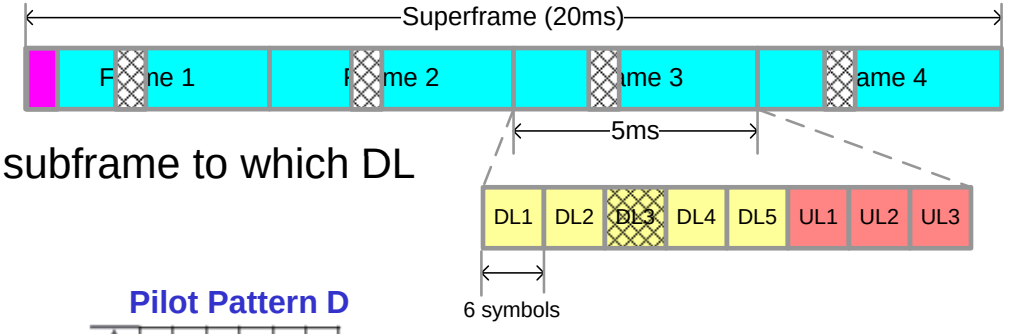
# Diversity Subchannelization Procedure

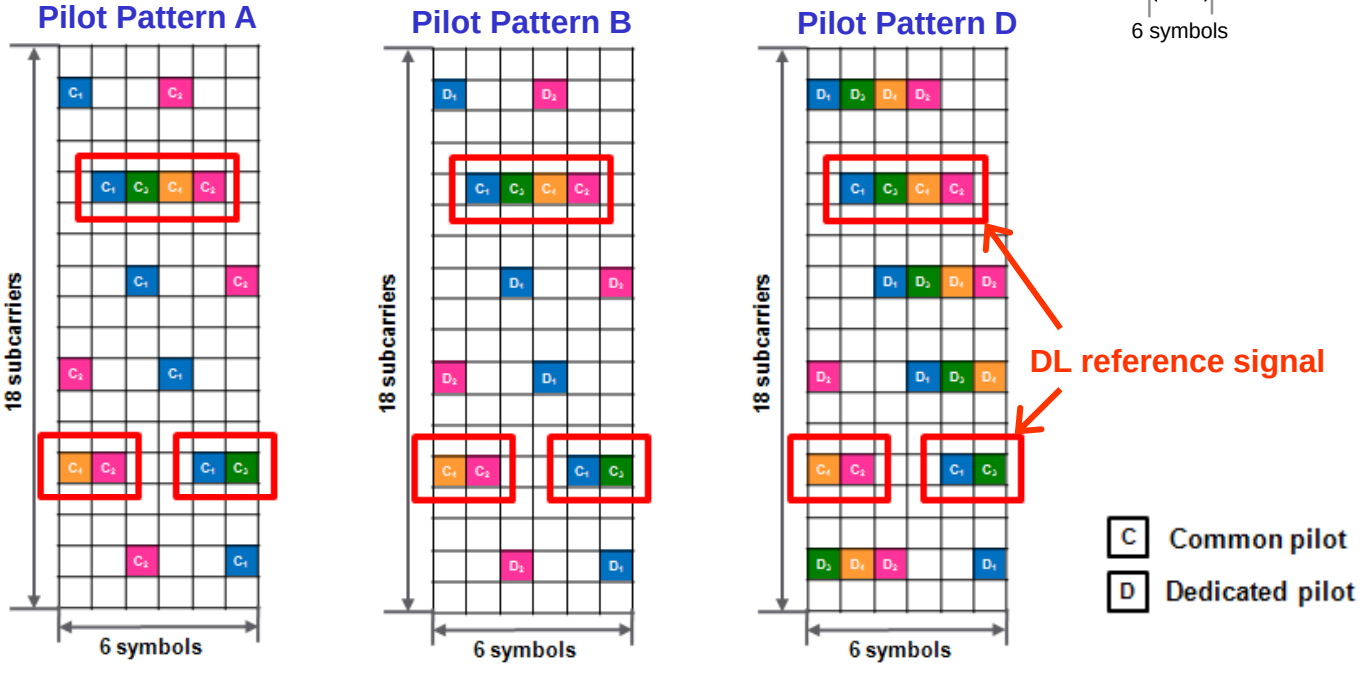
- Example
  - Diversity RU with small block
    - Tone (ex. 1x1 block size) based permutation : MAP and small size packet
    - Mini-RU (ex. 6x6 block size) based permutation : DL control channel (e.g. ACK/NACK)



# DL Reference Signal

- Transmission for CQI and PMI feedback
  - Periodicity: Once a frame (5ms)
  - Reference signal should be able to support maximum number of Tx stream.
- Example
  - DL:UL = 5:3
  - Pilot pattern C is not used in the subframe to which DL reference signal belongs



# Summary

- Proposed Symbol and Pilot Structure

<table>
<tr><td colspan="4">Multiplexing of diversity and band selection subchannel</td><td colspan="2">FDM</td></tr>
<tr><td colspan="4">Resource allocation unit size</td><td colspan="2">18 tones x 6 symbols</td></tr>
<tr><td rowspan="6">DL Data</td><td rowspan="3">Diversity subchannel</td><td colspan="2">Block size for permutation</td><td>Small (TBD)</td><td>Large (18 x 6)</td></tr>
<tr><td colspan="2">Pilot type</td><td>Common</td><td>Dedicated</td></tr>
<tr><td rowspan="2">Pilot overhead per Ant.</td><td>2Tx</td><td>5.55%</td><td>5.55%</td></tr>
<tr><td>4Tx</td><td>2.77%</td><td>Low : 2.77%<br>High : 5.55%</td></tr>
<tr><td rowspan="3">Band selection subchannel</td><td colspan="2">Pilot type</td><td colspan="2">Dedicated</td></tr>
<tr><td rowspan="2">Pilot overhead per Ant.</td><td>2Tx</td><td colspan="2">5.55%</td></tr>
<tr><td>4Tx</td><td colspan="2">Low : 2.77%<br>High : 5.55%</td></tr>
<tr><td rowspan="3">DL control</td><td>MAP</td><td colspan="2">Block size for permutation</td><td colspan="2">Small (TBD)</td></tr>
<tr><td>etc</td><td colspan="2">Block size for permutation</td><td colspan="2">Small (TBD)</td></tr>
<tr><td colspan="3">Pilot type</td><td colspan="2">Common</td></tr>
<tr><td colspan="3" rowspan="2">Reference signal for CQI</td><td>Tx frequency</td><td colspan="2">200Hz</td></tr>
<tr><td>Overhead</td><td colspan="2">0.23% per Antenna</td></tr>
<tr><td colspan="4">Supportable physical functionality</td><td colspan="2">FFR, OL/CL MIMO</td></tr>
</table>

# Proposed Text for SDD (1/3)

***Insert the following text into SDD Section 11 in IEEE 802.16m-08/003***

- Section 11.x: DL Symbol Structures

  DL resource allocation unit (RU) should have the size of 18 contiguous or non-contiguous subcarriers and 6 symbols. Therefore, it should contain 108 subcarriers including data and pilot tones.

  DL resource allocation unit (RU) should be composed of one block or multiple blocks. A block is physically contiguous group of X subcarriers by Y symbols.

  The size of a block should be variable according to the type of resource allocation unit.

- Section 11.x: Diversity Resource Allocation Unit

  Diversity RU should be composed of multiple blocks which are spread out whole frequency band.

- Section 11.x: Band Selection Resource Allocation Unit

  Band selection RU should be a block which has the size of 18 subcarriers by 6 symbols.

# Proposed Text for SDD (2/3)

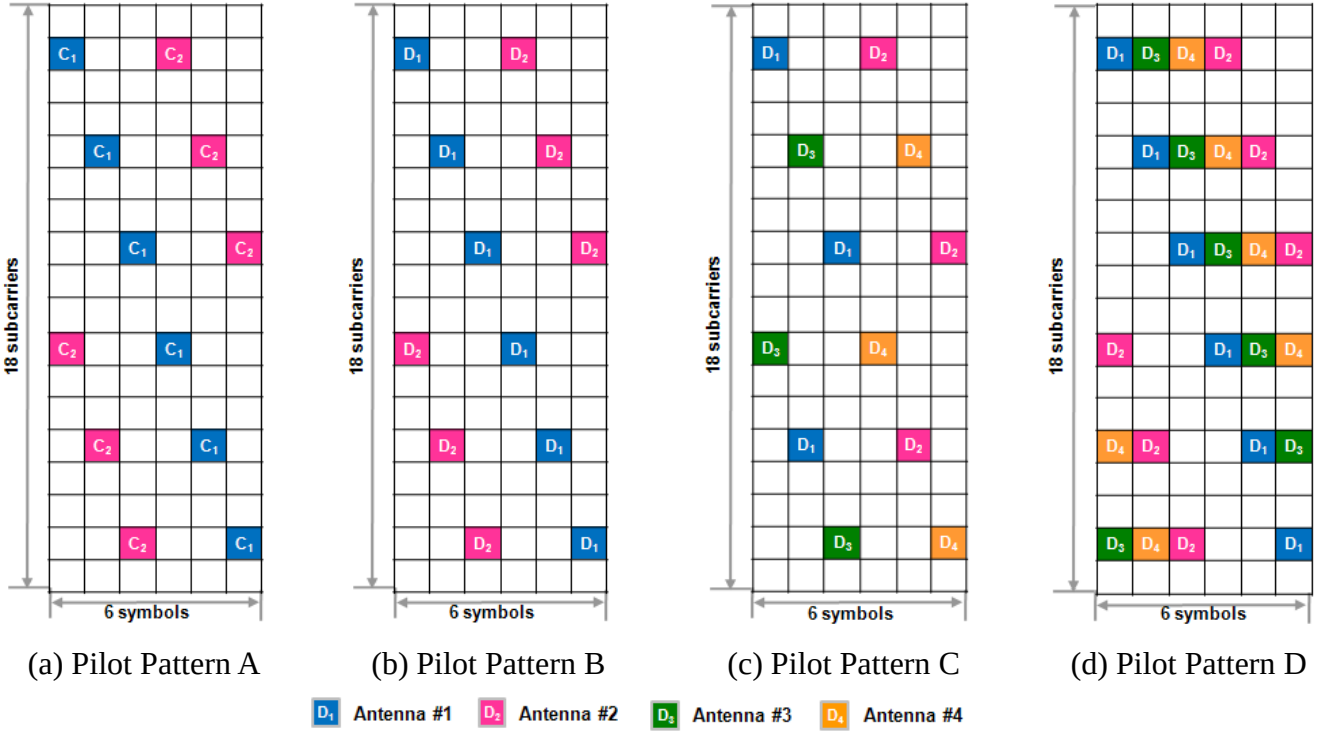
- Section 11.x: DL Pilot Pattern

  There are 4 pilot patterns according to pilot type and available number of transmit antennas.

  Pattern A and B should be used for 2 transmit antennas. Pattern C and D should be used for 4 transmit antennas.

  Pattern A should be used as the common pilot in diversity RU. Pattern B, C and D should be used as the dedicated pilot in diversity and band selection RU.

  ***(Add figures of pilot patterns as following.)***




(a) Pilot Pattern A (b) Pilot Pattern B (c) Pilot Pattern C (d) Pilot Pattern D

# Proposed Text for SDD (3/3)

- Section 11.x: DL Subcarrier Mapping to Resource Allocation Unit

  Overall procedure of DL subcarrier mapping to RU should be like below :

  1. Common permutation with cluster (A cluster is the multiples of a block with the size of 18 x 6)
  2. Divide total clusters into reuse 1 region and reuse N region exclusively
  3. Reserve clusters for band selection RU in each reuse region
  4. Sector permutation with the required block size
  5. Logical indexing for all diversity RU and band selection RU

  ***(Add the figure at page 11 in this slide).***

- Section 11.x: DL reference signal

  DL reference signal should be transmitted on one of the DL subframes once a frame (5msec).

# Annex A: Normalized peak data rate

- TGm SRD requirement (*6.1 in SRD-80216m-07_002r4*)

| Requirement type | Link direction | MIMO configuration | Normalized peak data rate (bps/Hz) |
|---|---|---|---|
| Baseline | Downlink | 2x2 | 8.0 |
| Target | Downlink | 4x4 | 15.0 |

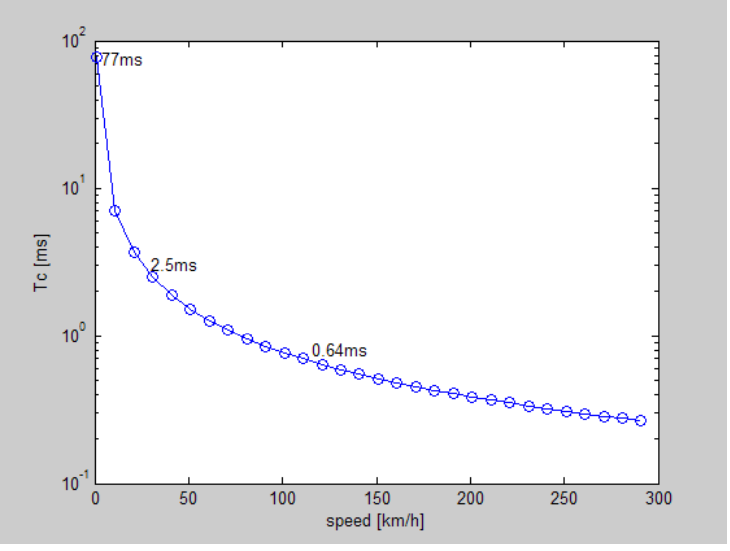
- Proposed symbol and pilot structure

| Overhead | 2x2 (Type A, B) | 4x4 | |
|---|---|---|---|
| | | Type C | Type D |
| Guard band OH | 5.5 % | | |
| CP OH (1/8) | 11.1 % | | |
| Superframe header OH | 3.09 % | | |
| Pilot OH | 11.1% | 11.1% | 22.2% |
| Idle time OH | 1.26 % | | |
| Total OH | 28.55% | 28.55% | 37.48% |
| **Normalized peak data rate (bps/Hz)** | **8.6** | **17.1** | **15.0** |

*Assumption : 64QAM, code rate 1, and the other features are based on C802.16m-08/062r1*

# Annex B: Mobility support

- TGm SRD requirement *(7.3 in SRD-80216m-07_002r4)*




"- Optimized for Stationary, Pedestrian 0 - 10 km/h
- Graceful degradation as a function of vehicular speed for Vehicular 10 - 120 km/h"

**MS Speed and coherence time (Cor > 0.5)***

| km/h | 1 | 10 | 30 | 100 | 120 | 200 | 250 | 300 |
|---|---|---|---|---|---|---|---|---|
| Tc (ms) | 77 | 70 | 2.5 | 0.77 | 0.64 | 0.38 | 0.31 | 0.27 |
| symbol | 770 | 680 | 24.3 | 7.5 | 6.2 | 3.7 | 3 | 2.6 |

* Steele, R. Ed., Mobile Radio Communications, IEEE Pres, 1994

**3~4 symbol-distance is desirable for Cor >> 0.5**

**Delay profile and coherence BW****

| tap / profile | coherence BW | | # of tones | recommended distance (tone x symbol) |
|---|---|---|---|---|
| | Cor.> 0.9 | Cor.>0.5 | | |
| Ped A | 430kHz | 4300kHz | 39.3 | (16 x 3) |
| Ped B | 31.65kHz | 316.5kHz | 2.9 | (3 x 3) |
| Veh A | 53.48kHz | 534.8kHz | 4.9 | (4 x 3) |

** Lee, W.C.Y., Mobile Cellular Telecommunications Systems, McGraw Hill Publications, New York, 1989

**Proposed symbol and pilot structure**

| | 2Tx | | 4Tx |
|---|---|---|---|
| Pattern A | (3 x 3) | Pattern C | (6 x 3) |
| Pattern B | | Pattern D | (3 x 1) |

**39 tone (PedA), 3~5 tone (PedB, VehA) - distance is desirable for Cor > 0.9**