# Multiplexing for Unicast Service Control Channels in IEEE 802.16m

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IEEE C80216m-08/297, “Call for Comments on DL Control Rapportuer Group Contribution ”.

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Base Contribution:

None

Purpose:

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

# Multiplexing for Unicast Service Control Channels in IEEE 802.16m

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# Multiplexing

- **3 Options**

| | |
|---|---|
| ***Option 1: Combination of FDM and TDM*** | [DL control channels and data are multiplexed in a subframe using a combination of TDM and FDM.]<br>[The control zone occupies x subcarriers in the first y (y<6) OFDM symbols in a subframe. 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.] |
| ***Option 2: TDM*** | [Control and data channels are multiplexed using TDM.] |
| ***Option 3: FDM*** | [DL control channels and data are multiplexed in a subframe using FDM. Subframe format indicator channel is always transmitted through distributed resource to get frequency diversity. Subframe format indicator channel provides the information about resource partition and permutation setting within a subframe. In addition, this channel also provides information about decoding DL/UL control blocks. In different permutation zone, DL/UL control blocks have different permutation type. e.g. in localized zone, DL/UL control blocks also are localized.]<br>[Control channels and data are multiplexed using FDM. Both control and data channels are transmitted on logical resource units (LRU) that span all OFDM symbols in a subframe.]<br>[Control and data are FDM within sub-frame and TDM across sub-frames.] |

***Keep option 3 and Delete option 1 and option 2.***

⟶ **This contribution gives the reason why we should adopt FDM**

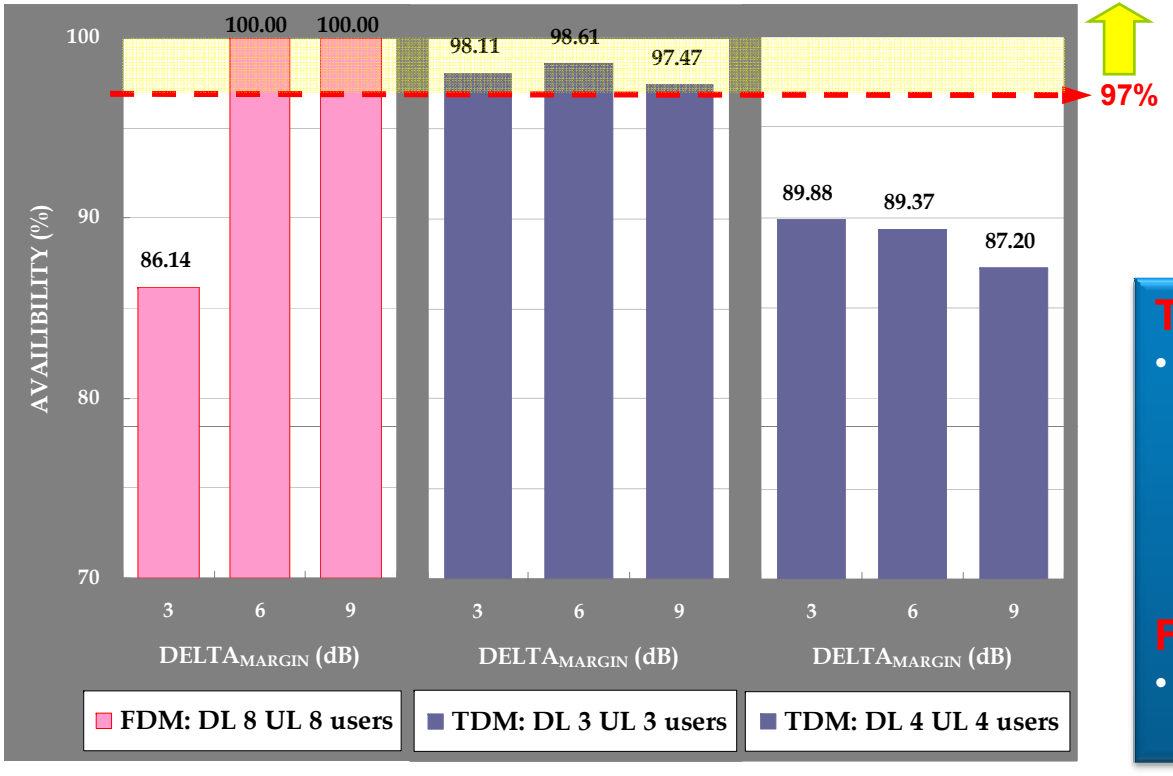
# Multiplexing - FDM vs. TDM

| Performance Metrics | FDM | TDM | Note |
|---|---|---|---|
| **Granularity of ratio btw control and data (1-D MAP region)** | ▪ Higher | ▪ Lower (especially for short-length subframe) | ▪ ***Refer to SLS results*** |
| **Coverage (MAP Outage)** | ▪ Better | ▪ Worse | |
| **Spectral efficiency (Sector Throughput)** | ▪ Better | ▪ Worse | |
| **Other sector interf. for MAP (in case of partial traffic loading)** | ▪ Smaller (averaged by permutation) | ▪ Larger (collision between MAPs) | ▪ Synchronous BS environment |
| **Processing time (Latency)** | ▪ Longer | ▪ Shorter | ▪ In TDM, there's trade off between CH. est. performance and benefit of latency |
| **Power saving: Micro-sleep (in one subframe)** | ▪ Not support | ▪ Support<br>▪ Small gain is expected in TDM with a subframe | ▪ In TDM, there's trade off between CH. est. performance and benefit of micro-sleep<br>▪ Another ***power saving concept is proposed for FDM*** in the later slide |

# Comparisons btw TDM and FDM

- **Performance Metric**
  - With fixed resource overhead, **How many users can be supported** with satisfying MAP outage requirement (<3%)?
  - MAP outage is controlled by $\Delta_{MARGIN}$

**Availability (%) = 100 – MAP outage**




| MUX | Orthogonal Resource Overhead |
|---|---|
| FDM | 16.7% |
| TDM | 16.7% (1 OFDMA symbol) |

*16.7%: Enable to support Maximum DL8 UL8 assignment blocks

**TDM**

- Even if $\Delta_{MARGIN}$ is increased, TDM cannot support more than DL3, UL3 users with 16.7% resource OH
  → From DL4, UL4 users, OH jumps to 33.3%

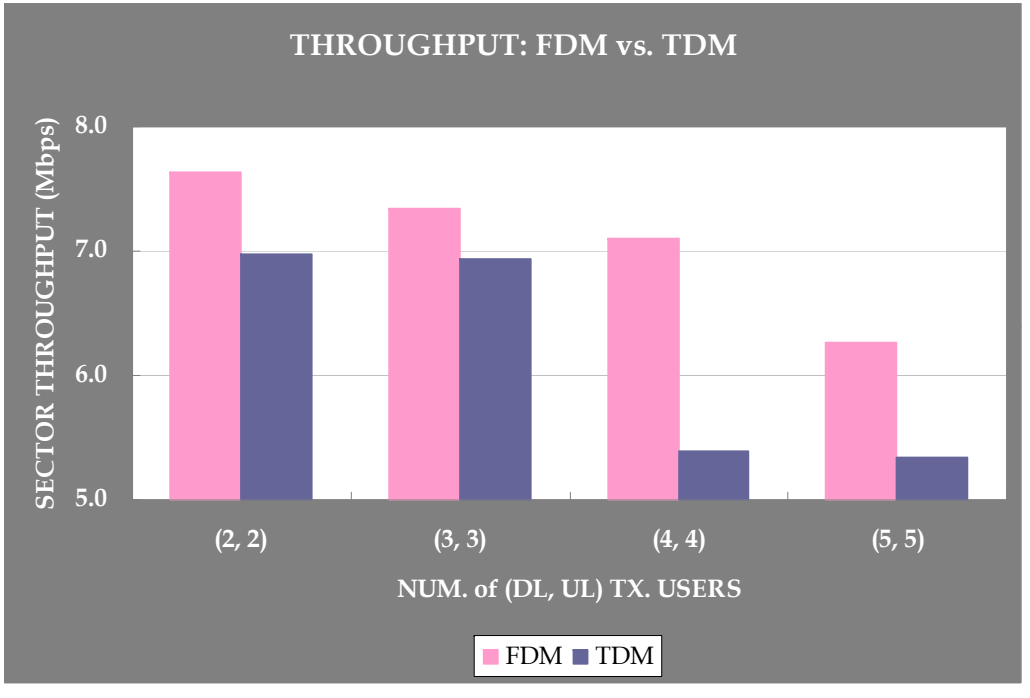
**FDM**

- Enable to support DL8, UL8 users without change of resource OH

# Comparisons btw TDM and FDM

- **Performance Metric**
  - Maximum **Sector Throughput** with satisfying MAP outage requirement (<3%)
  - MAP outage
    - TDM: controlled by orthogonal resource (# of OFDMA symbols) and $\Delta_{MARGIN}$
    - FDM: controlled by $\Delta_{MARGIN}$

| MUX | # of Users (DL, UL) | Orthogonal Resource Overhead | $\Delta_{MARGIN}$ |
|---|---|---|---|
| FDM | (2, 2) | 8.3% | 6dB |
| | (3, 3) | 8.3% | 5dB |
| | (4, 4) | 8.3% | 5dB |
| | (5, 5) | 16.7% | 5dB |
| TDM | (2, 2) | 16.7% | 4dB |
| | (3, 3) | 16.7% | 4dB |
| | (4, 4) | 33.3 % | 2dB |
| | (5, 5) | 33.3 % | 4dB |




**FDM**
- More flexible power control
  → Higher Throughput

**TDM**
- Limit on power control
- Large resolution of MAP size change
  → ***Lower Throughput*** (especially for large number of users)

# Power Saving: Micro-Sleep in TDM

- **Power-On Interval of not-allocated users in a subframe**

| | Required Time | |
|---|---|---|
| FFT | 1 symbol | |
| MAP Region | p symbols | p=1 |
| Channel Est. | q symbols | q=2 |
| MAP Decoding | Minimum 1 symbol | |
| Turn-off + Turn-on | $x_0$, $x_1$, $x_2$ | |

**< Power Saving Gain>**

$$PSG \le \sum_{i=0}^{2} \frac{5 - Max(p,q) - x_i}{6} \times z_i \times G_i \ \%$$

$$= 4.92\ \%$$

***Power saving gain by Micro-sleep is NOT significant***

| Parts | Portion of Power Consumption | | Time for turn-off + turn-on | | Power Saving Gain (%) | |
|---|---|---|---|---|---|---|
| Baseband Modem (BB TX/RX, Vocoder, CPU) | $z_0$ | 0.1 | $x_0$ | 1 symbols | $G_1$ | 50 |
| RF Parts (TX/RX, Power amp.) | $z_1$ | 0.65 | $x_1$ | 2 symbols | $G_2$ | 30 |
| Display Device | $z_2$ | 0.25 | $x_2$ | - | $G_3$ | - |

We expect actual value is smaller

# Power Saving

***Micro-sleep in a subframe CANNOT provide significant power saving gain***

↓

***If MAP is transmitted every 2 subframes for micro-sleep, Separate coding becomes less efficient***

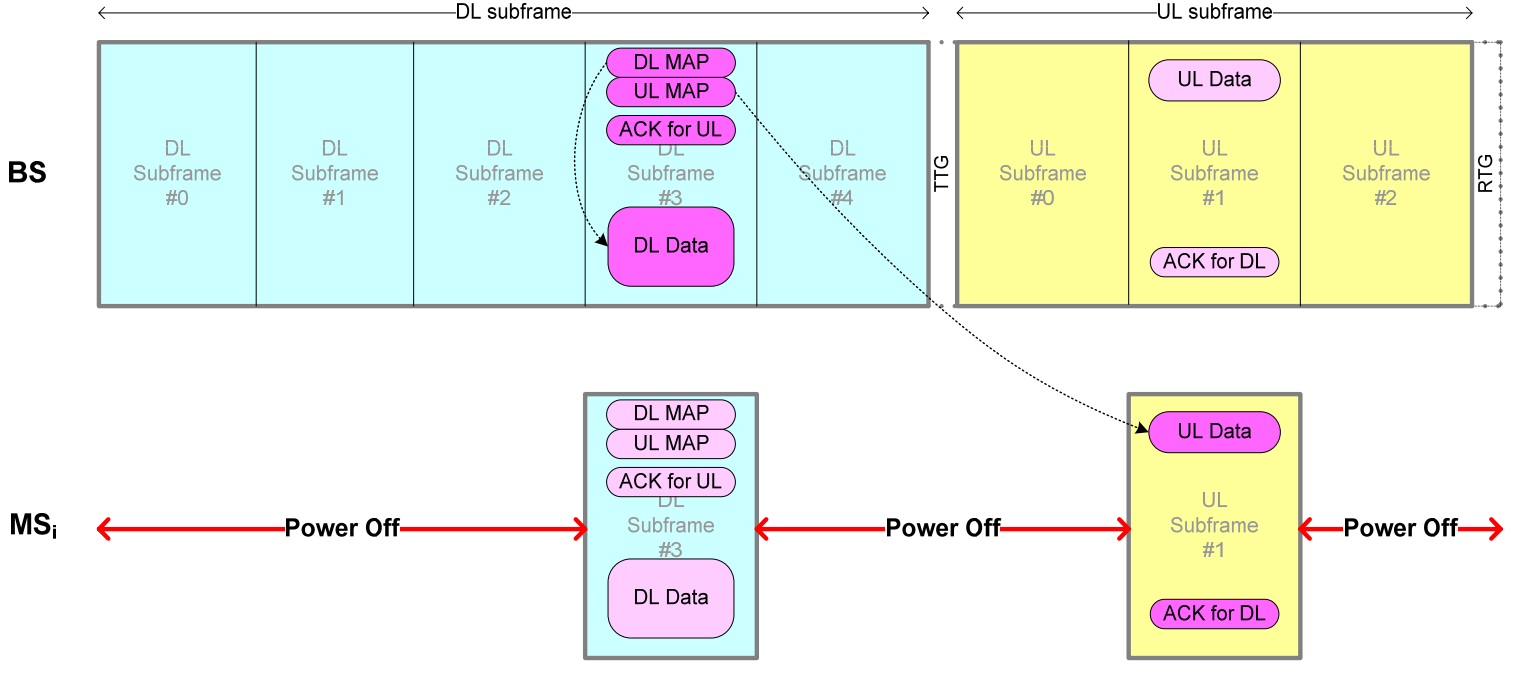
*(Merits of separate coding become smaller as the number of scheduled user Increases. Performance gap with other schemes may decrease)*

↓

***Propose another power saving concept*** ▶ ***Next slide***

# Power Saving: Default Subframe Concept

- **Default Subframe Concept**
  - Pre-determined feedback and Re-Tx timings
  - The periodic Tx feature can be exploited for Power Saving
  - One of subframe is pre-assigned to a MS as a default subframe, then the MS may go sleep mode during other subframe



# Summary

- **Metric: Sector Throughput**
  - *FDM > TDM*

- **Metric: Power Saving**
  - Micro-sleep gain in a subframe is small
  - Micro-sleep with subframe bundling (n≥2) makes separate coding to be less efficient
  - Default subframe concept can provide power saving without degrading separate coding performance → *FDM can support power saving*

- **Adopt *FDM* as multiplexing scheme of unicast service control channels and data**

# Annex: System Level Simulation (1)

- **Performance Metrics**
  - **Sector Throughput** with satisfying MAP outage requirement
  - **MAP Outage** requirement: Distribution of user whose BLER is larger than 1% < 3% of total users

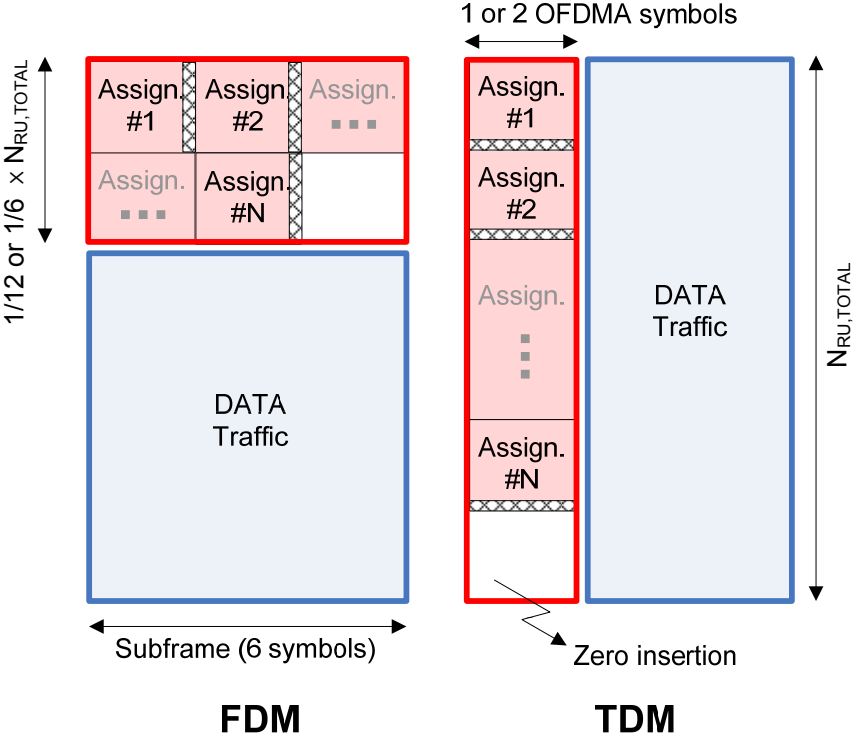
- **Per User Power Control**
  - $P_{MAPIE}[i] = SINR_{REQ} – SINR(CQI)[i] + \Delta_{MARGIN}$
    - $SINR_{REQ}$: SINR value required to satisfy 1% BLER
    - SINR(CQI)[i]: i-th user SINR set by CQI feedback value
    - $\Delta_{MARGIN}$: Margin value to accomplish required MAP outage

# Annex: System Level Simulation (2)

- **Comparison btw TDM and FDM**

- **Major Assumptions**
  - Subframe structure
    - [IEEE C802.16m-08/062r1]
  - Only assignment block in MAP region
    - 48 bits (including CRC) per assignment block
  - 1-D MAP region indication

| MUX | Orthogonal Resource Overhead |
|---|---|
| FDM | 8.3 or 16.7 % |
| TDM | 16.7 or 33.3 % |




* 8.3%: Maximum DL4 UL4 assignment blocks
  16.7%: Maximum DL8 UL8 assignment blocks
  33.3%: Maximum DL16 UL16 assignment blocks

# Annex: System Level Simulation (3)

- **Simulation Environments/Assumptions**

| Index | Value |
|---|---|
| Deployment Scenario | EMD baseline [IEEE 802.16m-07/037r2 ] |
| MCS for MAP | QPSK, 1/2 |
| HARQ | Synchronous<br>(No assignment message for retransmission) |
| Scheduler | Proportional fairness |
| # of Users per Sector | 10 |
| # of Scheduled Users | 2, 3, 4, 5 per mini-frame<br>(4, 6, 8, 10 for both DL and UL) |
| MAP Error Effects | Resource loss for MAX retransmission |
| Antenna Configuration | SIMO 1x2 |
| Channel Model | Mixed (Ped B-3kmph-60%,<br>Veh A-30kmph-30%, Veh A-120kmph-10%) |
| Channel Estimation | Real channel estimation<br>(Equal impairment for both TDM and FDM) |
| Other Simulation Assumptions | EMD baseline |