Multiplexing and Coding for MAP Transmission in IEEE 802.16m

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Venue:
IEEE 802.16m-08/005, “Call for Contributions on Project 802.16m System Description Document (SDD)”.
Target topic: “Downlink Control Structure”.

Base Contribution:
None

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

Multiplexing and Coding for MAP Transmission in IEEE 802.16m

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March, 2008

About This Presentation

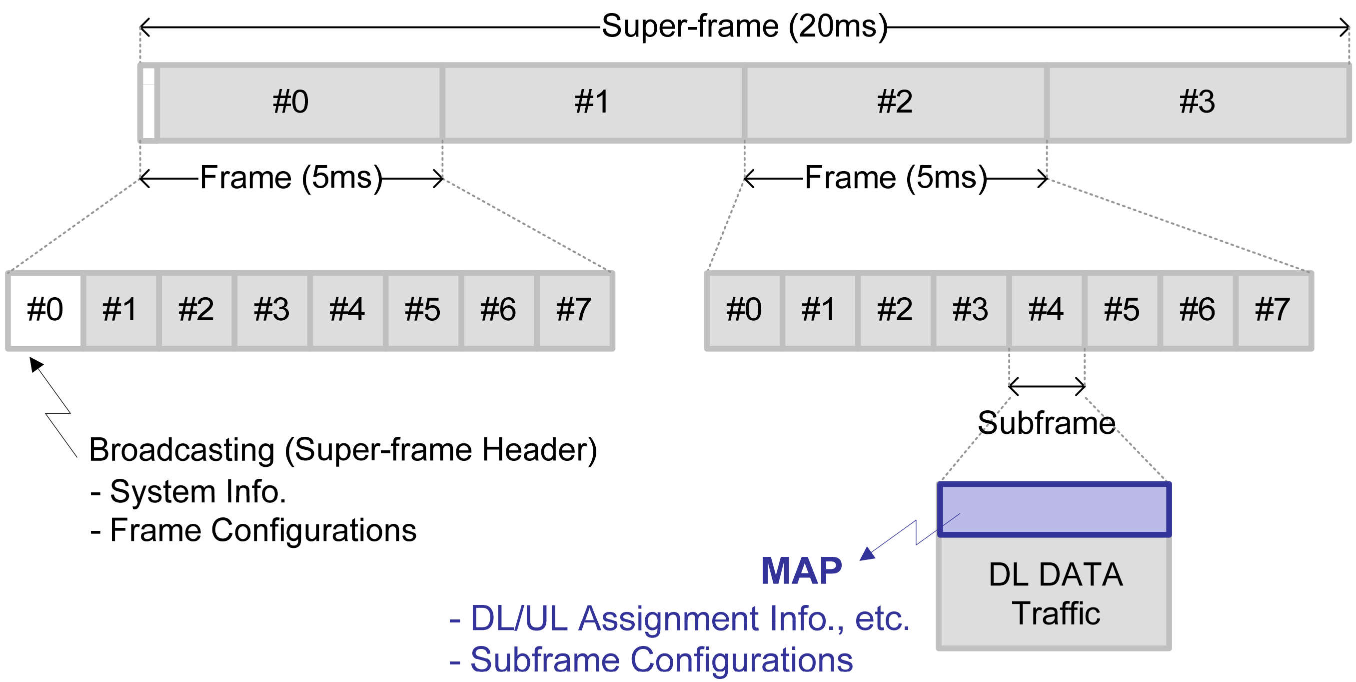
- **Scope and Goal**
  - Design of an efficient MAP transmission scheme suitable for 802.16m frame structure (i.e. sub-frame based frame structure)

- **Major Issues and Approaches**
  - Coding: **Joint** vs. **Separate**
  - Multiplexing: **FDM** vs. **TDM**
  - Analyze the system level performance in point of throughput / overhead / outage

- **Propose to use FDM with Separate coding**

DL Control Channel Structure

- **Frame structure and DL control channels** [IEEE C802.16m-08/062r1]



- **Considerations for MAP Design**
  - **Overhead** → Verify through system level performance evaluation
  - Coverage ↗
  - Flexibility, complexity, etc.

Issues for MAP Design

- **Focusing on Multiplexing & Coding**

	L1		L2
TARGET:	**COVERAGE ↑ & L1 OVERHEAD ↓**		**L2 OVERHEAD ↓**
	MAP Transmission Schemes	Indication Methods	Message Field

MAP Transmission Schemes

- **MUX btw MAP and Data:** **FDM / TDM**
- **Coding:** **Separate / Joint**
- **Adaptation: Power / Rate**
- MCS Level
- Resource Block Structure
- TX Antenna Scheme
- …

Indication Methods

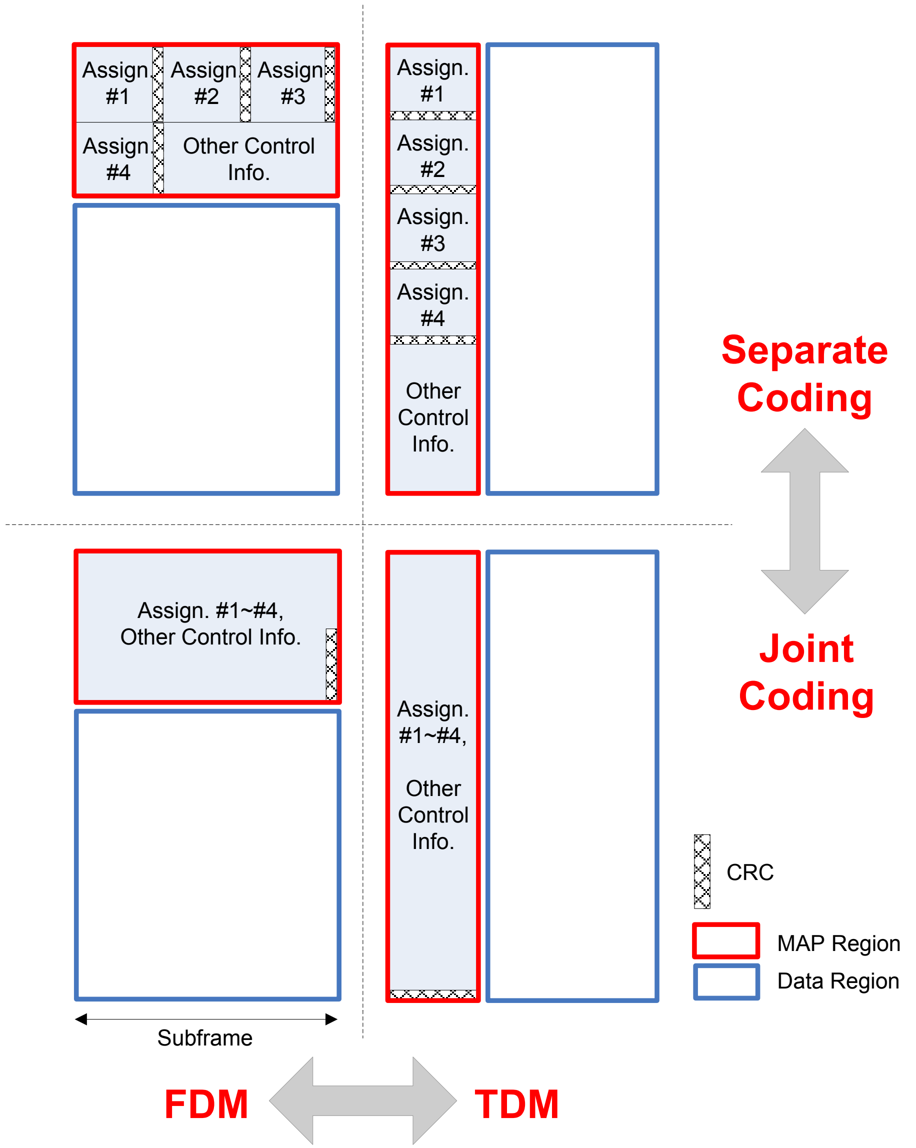
- MAP Size Indication
  - Dynamic/Semi-static
- …
- Resource Indication Schemes
  - Bitmap/Tree/Start-length/…

Message Field

- Message
  - Contents/# of bits/…

Multiplexing / Coding

- **Multiplexing Between MAP & Data**
  - FDM vs. TDM
- **Coding**
  - Separate
    - Per user (or CID), an assignment message is encoded with CRC
    - Per user (or CID) power control
  - Joint
    - All assignment messages are encoded together
    - Robust coding or power boosting



Coding - Joint vs. Separate

		Separate Coding	Joint Coding	Note
Signaling Bit Overhead	CID	▪ Possible to eliminate CID overhead	▪ Per assignment message	▪ Separate: CRC masked by CID, scrambling using CID, etc
	CRC	▪ Per assignment message	▪ One CRC field	
Performance	Coding gain (Length)	▪ Smaller	▪ Larger	
	Link adaptation gain	▪ Larger ▪ Individual user	▪ Smaller ▪ (Worst geometry user)	
Resource indication scheme		▪ Limited ▪ Not suitable to bitmap (overhead) ▪ Not applicable to run length	▪ Flexible	▪ Joint coding can be also limited when other schemes are considered such as synchronous HARQ, persistent allocation, etc

→ **In respect to total Overhead** (spectral efficiency),
Separate coding has more gain than Joint coding
(Link adaptation gain >> Coding gain)

Multiplexing - FDM vs. TDM

	FDM	TDM	Note
Processing time (Latency)	▪ Longer	▪ Shorter	▪ In TDM, there's trade off between CH. est. performance (time averaging) and benefit of latency
Power saving: Micro-sleep in one mini-frame	▪ Not support	▪ Support	▪ In TDM, there's trade off between CH. est. performance (time averaging) and benefit of micro-sleep ▪ Small gain is expected in TDM with short-length frame
Resolution of MAP size change (1-D MAP region)	▪ Larger (if resource block is not too large)	▪ Smaller (especially for short-length frame)	

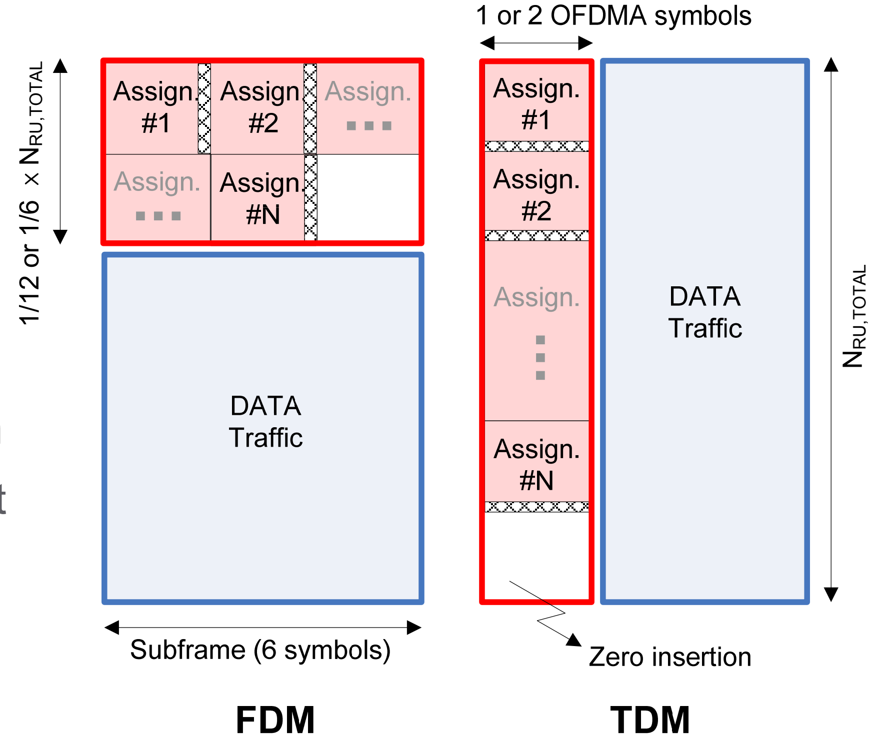
→ **In respect to Overhead** (spectral efficiency),
this contribution will provide system level performance evaluation with specific frame structure

System Level Performance Evaluation

- **Comparison between TDM and FDM**

- **Major Assumptions**
  - Separate coding
    - Per user power control
  - 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

System Level Performance Evaluation

- **Simulation Environments/Assumptions**

Index	Value
Deployment Scenario	EVM baseline [IEEE 802.16m-07/037r2]
MCS for MAP	QPSK, 1/2
HARQ	Synchronous (No assignment message for retransmission)
Scheduler	Proportional fairness
# of Users per Sector	10
# of Scheduled Users	2, 3, 4, 5 per mini-frame (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%, Veh A-30kmph-30%, Veh A-120kmph-10%)
Channel Estimation	Real channel estimation (Equal impairment for both TDM and FDM)
Other Simulation Assumptions	EVM baseline

System Level Performance Evaluation

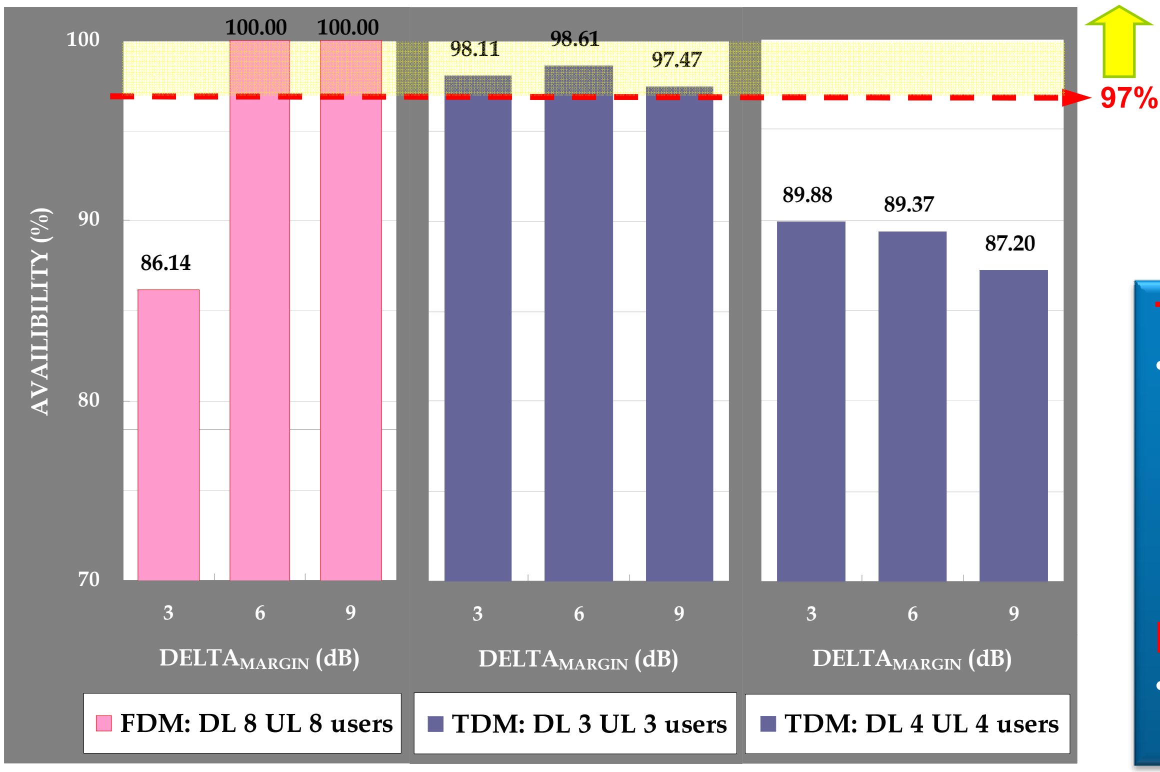
- **Performance Metrics**
  - **Sector Throughput** with satisfying MAP outage requirement
  - **MAP Outage** requirement: Distribution of user whose BLER is larger than 1% < 3% of total users

- **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
    - Δ_{MARGIN}: Margin value to accomplish required MAP outage

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 Δ_{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 Δ_{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%

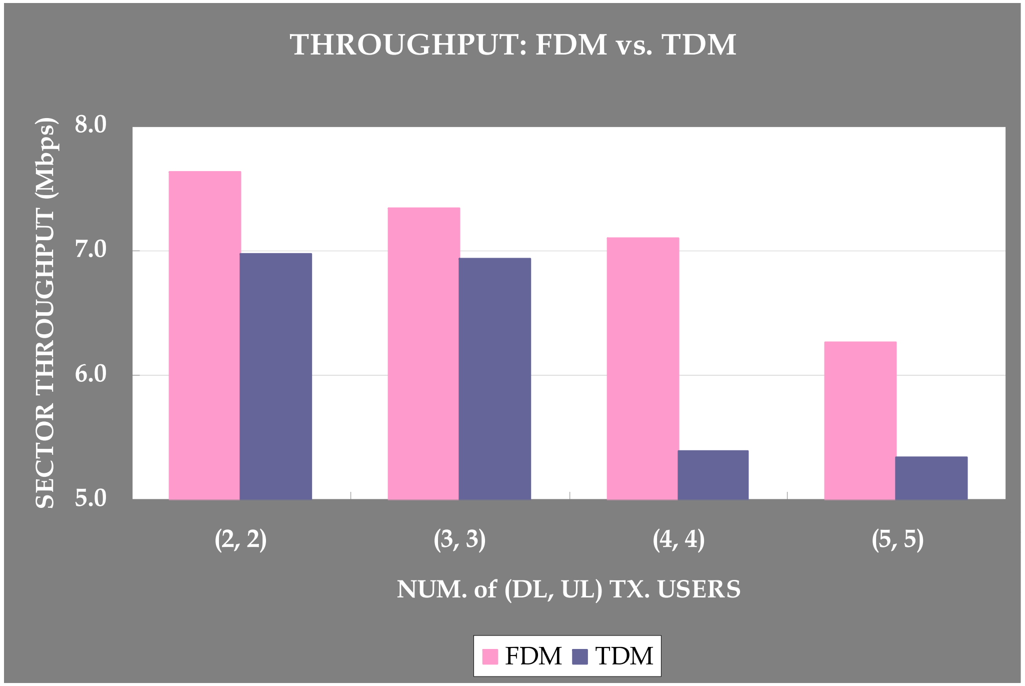
FDM

- 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 Δ_{MARGIN}
    - FDM: controlled by Δ_{MARGIN}

MUX	# of Users (DL, UL)	Orthogonal Resource Overhead	Δ_{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)

Text Proposal to 802.16m SDD

Insert the following text into Physical Layer clause (Chapter 11 in [IEEE 802.16m- 08/003])

--Text Start--

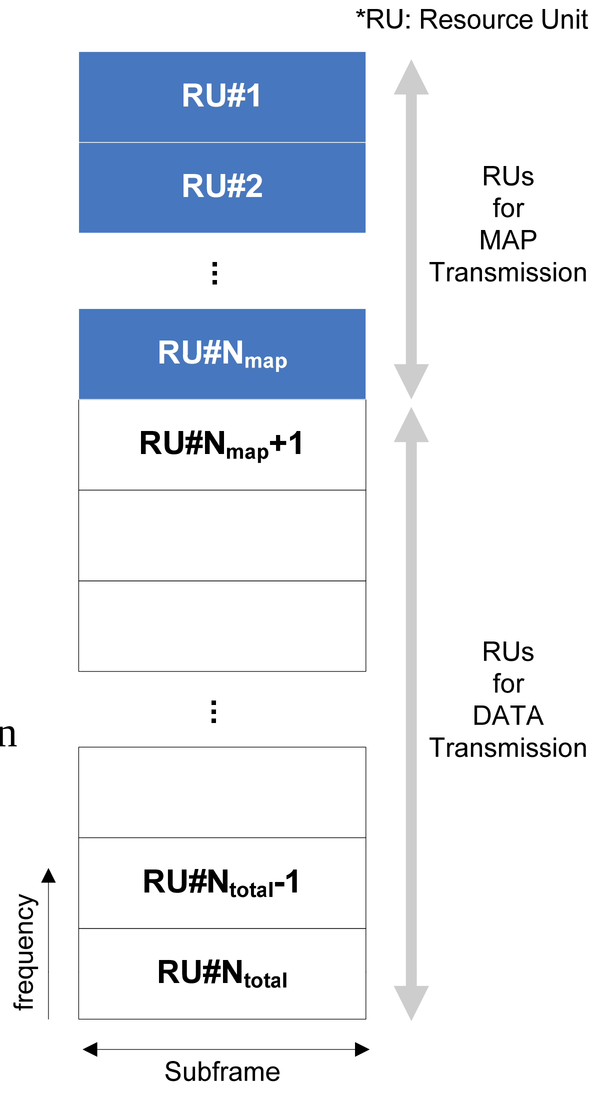
11 Physical Layer

11.x DL Control Channels

11.x.x MAP

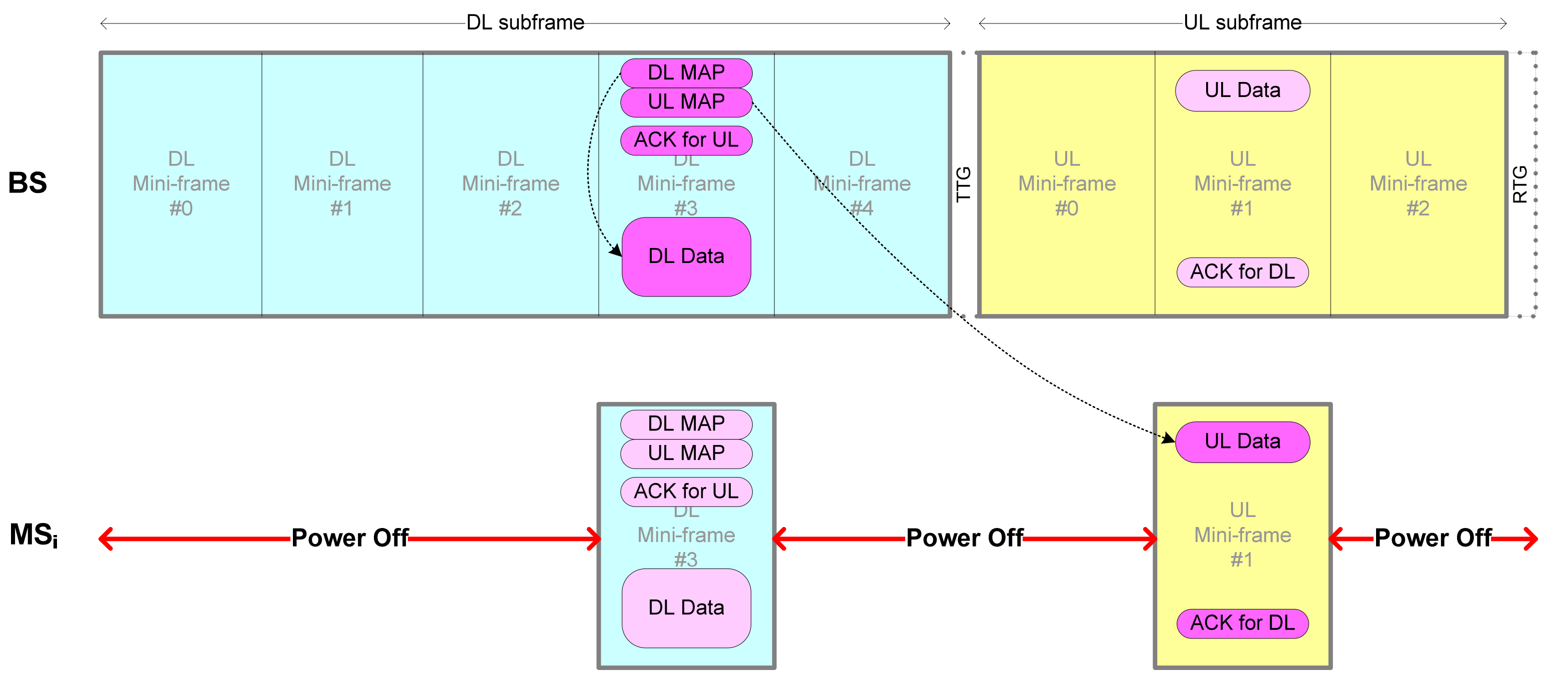
MAP transmission block is composed of multiple assignment blocks. Each assignment block shall carry information for one CID (one or multiple users) and be encoded separately. The power of each assignment block can be controlled by BS. In each subframe on downlink, the MAP transmission block is multiplexed with DL data traffic in a FDM manner.

--Text End---------------------------------------



Annex: Power Saving with Sync HARQ

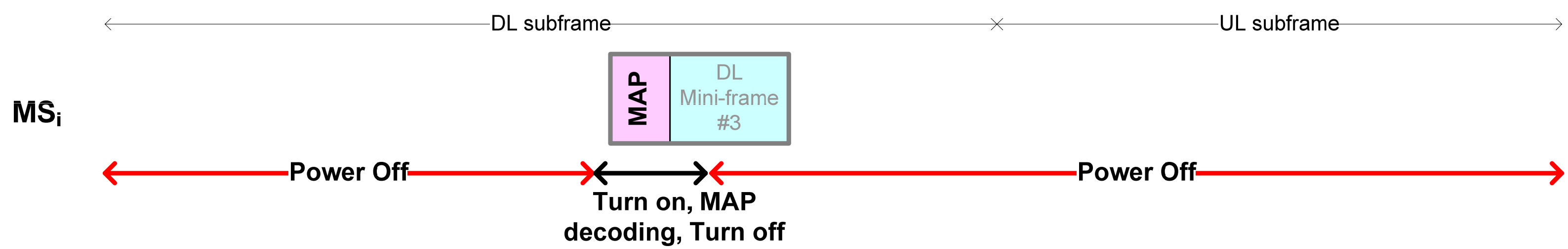
- **Synchronous H-ARQ**
  - Pre-determined feedback and Re-Tx timings
  - The periodic Tx feature (HARQ interlace) can be exploited for Power Saving
  - One of HARQ interlaces is pre-assigned to a MS as a default interlace, then the MS may go sleep mode during other interlace periods



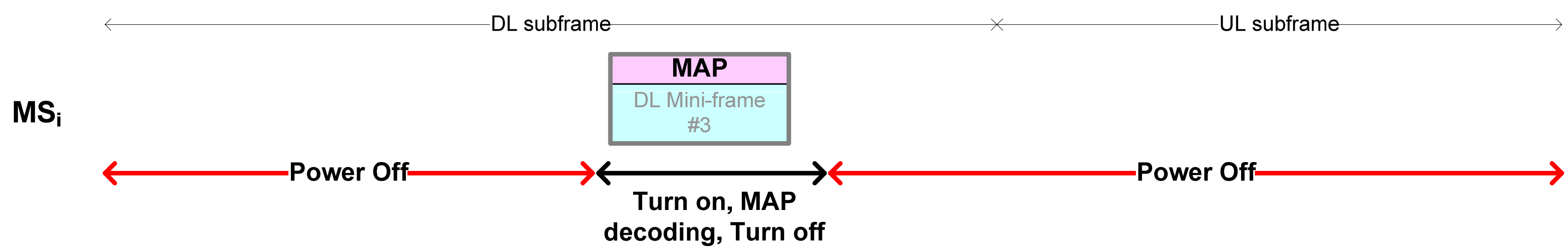
Annex: Power Saving with Micro-Sleep

How much Micro-Sleep Gain in a system with Synchronous H-ARQ?

- **Power off period**
  - With Micro-sleep (for TDM of MAP and data)



  - Without Micro-sleep (for FDM of MAP and data)



➢ **Not significant gain, with Synchronous H-ARQ**