Proposed 802.16m Frame Structure

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Venue:

IEEE 802.16m-07/047, "Call for Contributions on Project 802.16m System Description Document (SDD)".

Target topic: "Proposed 802.16m Frame Structure with special attention to legacy support".

Base Contribution:

IEEE C802.16m-08/062

Purpose:

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

Proposed 802.16m Frame Structure

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Outline

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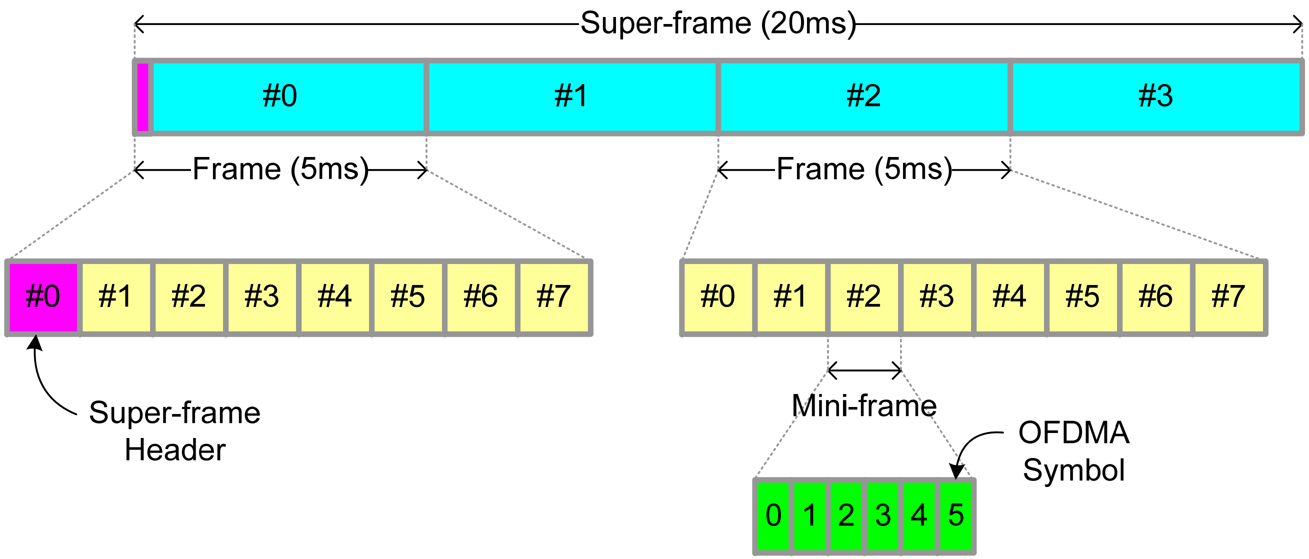
- Rationale for the Proposal
  - A Unified Structure for FDD, H-FDD, and TDD modes
  - Efficient Legacy Support
  - Low Data Latency
- Text Proposal for Inclusion in SDD

Proposed 802.16m Frame Structure

Key Features of Proposed Structure

- A unified frame structure for various modes and scenarios
  - FDD, H-FDD, TDD
  - Legacy support configuration
- High throughout and low latency (meet/exceed requirements in SRD)
  - Low data latency by adopting mini-frame concept
  - Reduce system overhead by adopting super-frame concept
- Fully support backward compatibility
  - Support backward compatibility without legacy performance degradation
  - Efficient legacy turn-off feature in support of green field deployment
  - Maximum commonality of 16m design in 16m/legacy-mixed and 16m-only deployment scenarios

Generic Frame Structure



- Super-frame/frame/mini-frame structure:
  - Super-frame (20ms) : 4 frames
  - Frame (5ms) : 8 mini-frames
  - Mini-frame : A number of OFDMA symbols (default: 6 for 1/8 CP)
- Super-frame header appears in the 1st mini-frame of every super-frame

Super-frame Header

- Super-frame header is …
  - A set of dedicated physical channels to broadcast system information
- Benefit $\Rightarrow$ System overhead reduction, simple network entry procedure
  - Efficient handling of slow varying information, no need of assignment for it
- Position and Structure
  - Located in the 1st mini-frame of every super-frame
  - Structure: SCH (Synchronization Channel) + BCH (Broadcasting Channel)
- Basic functions
  - SCH: Synchronization, Acquisition, BS identification, …
  - BCH: Rx configuration Info. (E.g. DL/UL ratio, mini-frame configuration, etc.),
    Network configuration Info. (E.g. BS loading, Self Organization, etc.),
    16m/legacy mixed mode ratio indication, …

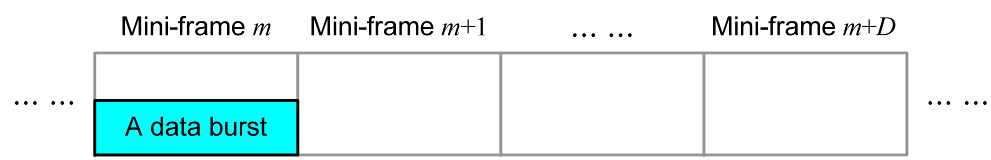
Mini-frame Approach

- Data transmission on mini-frame basis
  - Data burst occupies a portion of DL/UL subframe (i.e. One or a few mini-frames)

    ⇒ Enable fast HARQ operation in 5ms frame

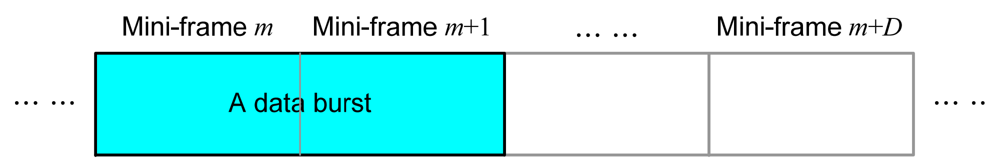
- Various TTI (transmission time interval) options for different purposes
  - Default option: TTI = One mini-frame

For low latency,

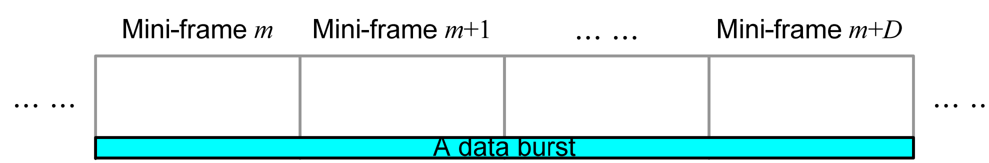


  - Additional option: TTI = Multiple contiguous mini-frames

For a large FEC packet Tx,



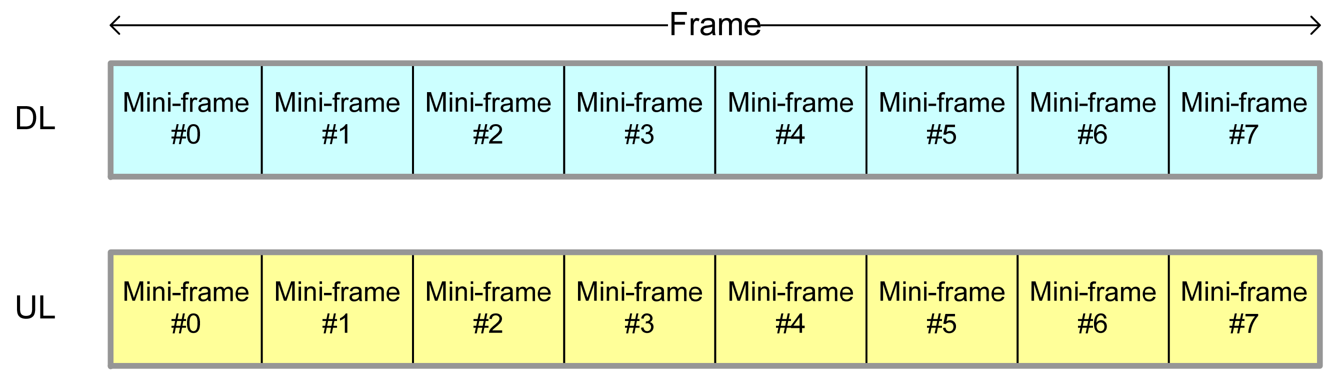
For better link budget,



Rationale for the Proposal

1. **A Unified Structure for FDD, H-FDD, TDD**
2. **Efficient Legacy Support**
3. **Low Data Latency**

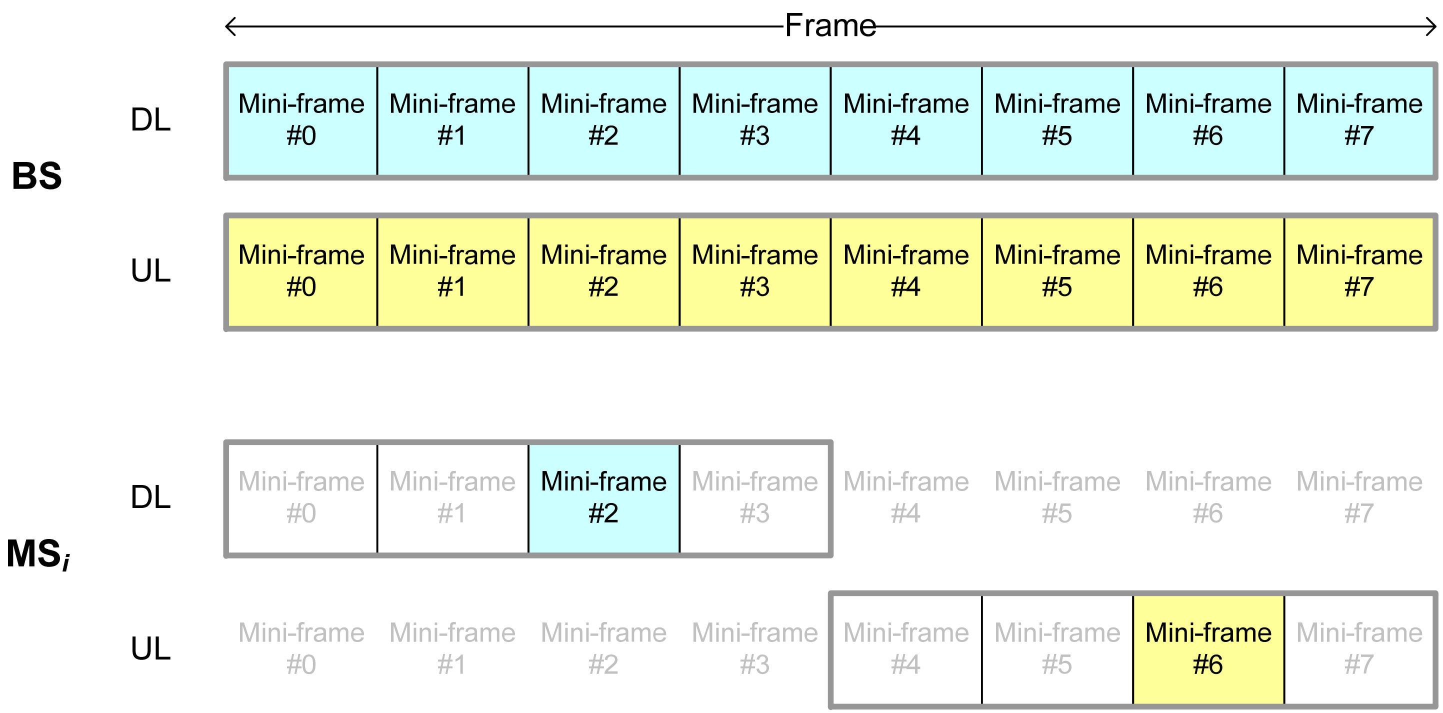
FDD Frame Structure



- A data burst may span over one or multiple consecutive mini-frames
- Each DL mini-frame carries DL/UL resource assignment (MAP)
- Synchronous HARQ operation with the pre-determined interlace structure

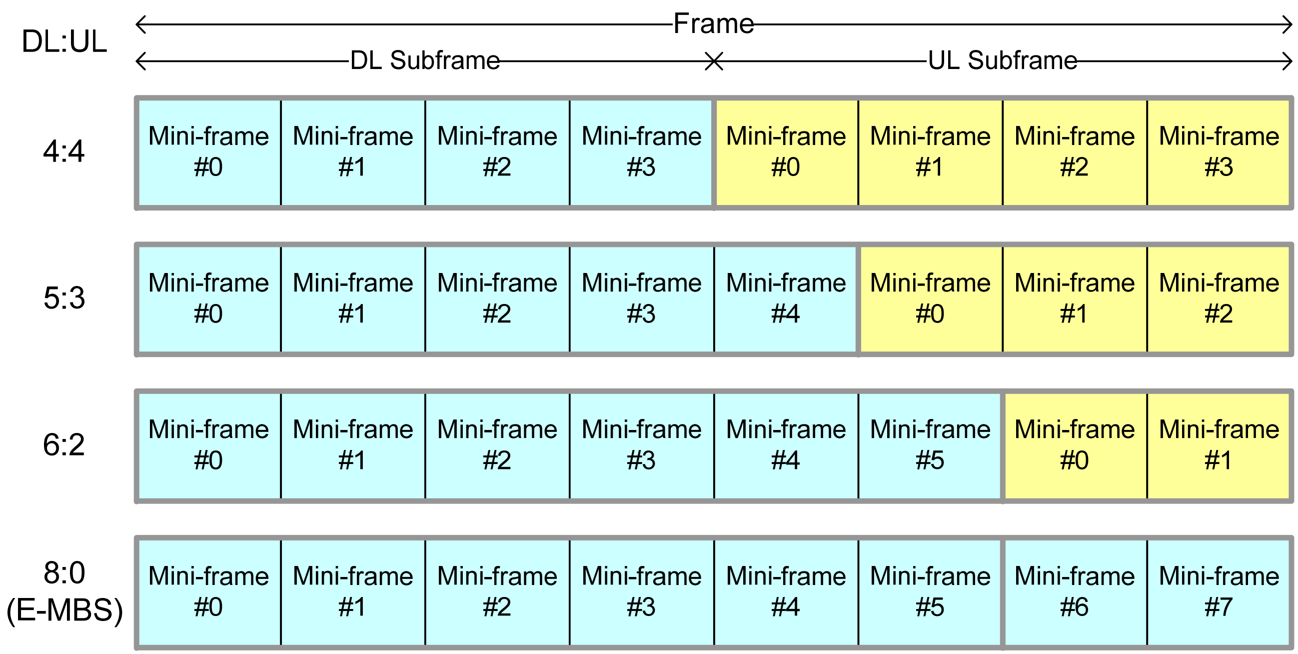
⇒ Common to FDD, H-FDD, TDD and legacy support mode

H-FDD Frame Structure



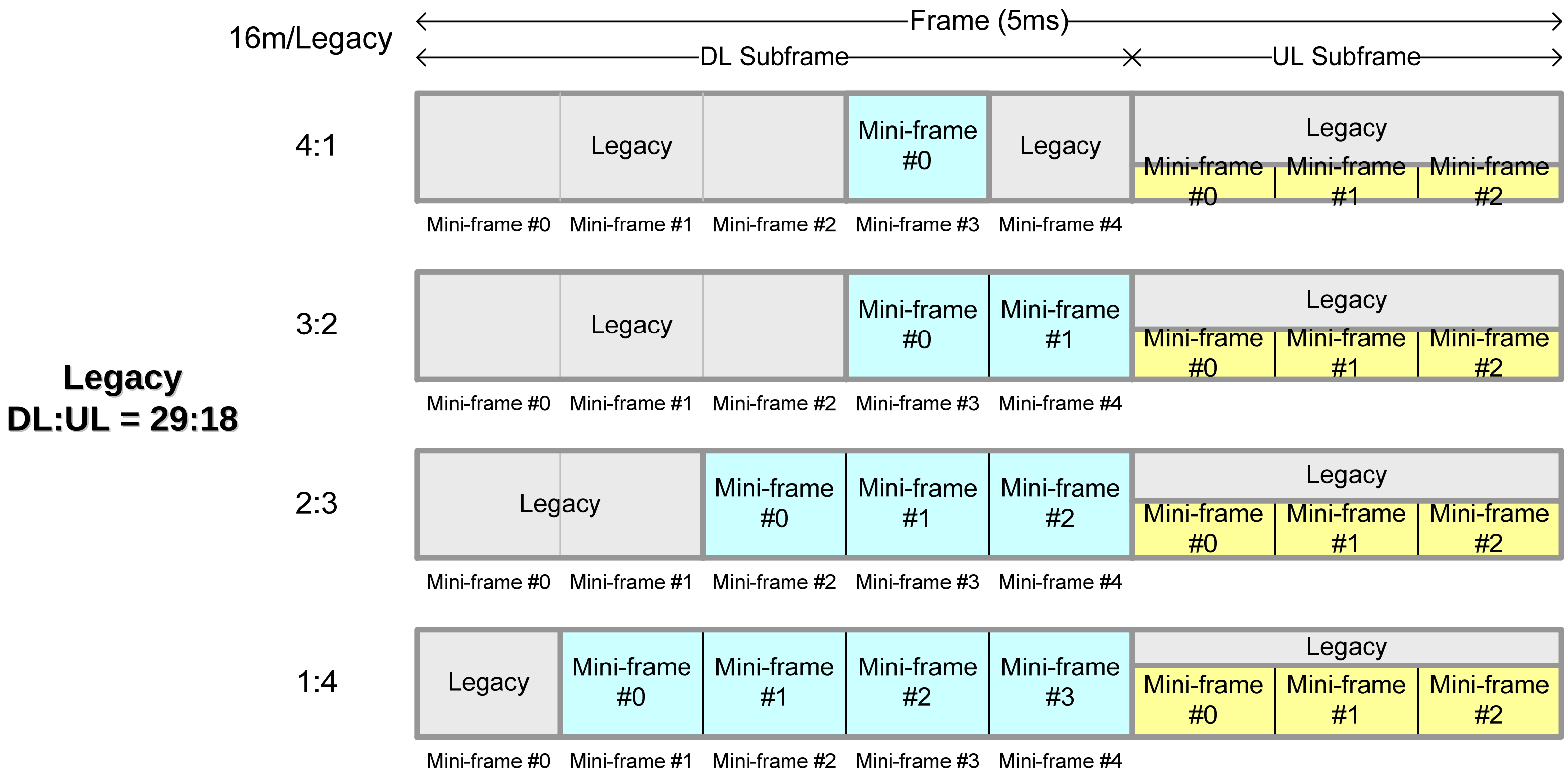
- Able to co-operate with FDD
  - From BS point of view, the same frame structure as FDD
  - From MS point of view, a half set of collected HARQ interlaces

TDD Frame Structure



- Single switching point (DL/UL and UL/DL) per 5ms frame
- Support various DL/UL partitions
  - DL:UL = 4:4, 5:3, 6:2, and 8:0 (e.g. E-MBS) in units of mini-frames
- Synchronous HARQ operation similar to FDD

Legacy Support Configuration



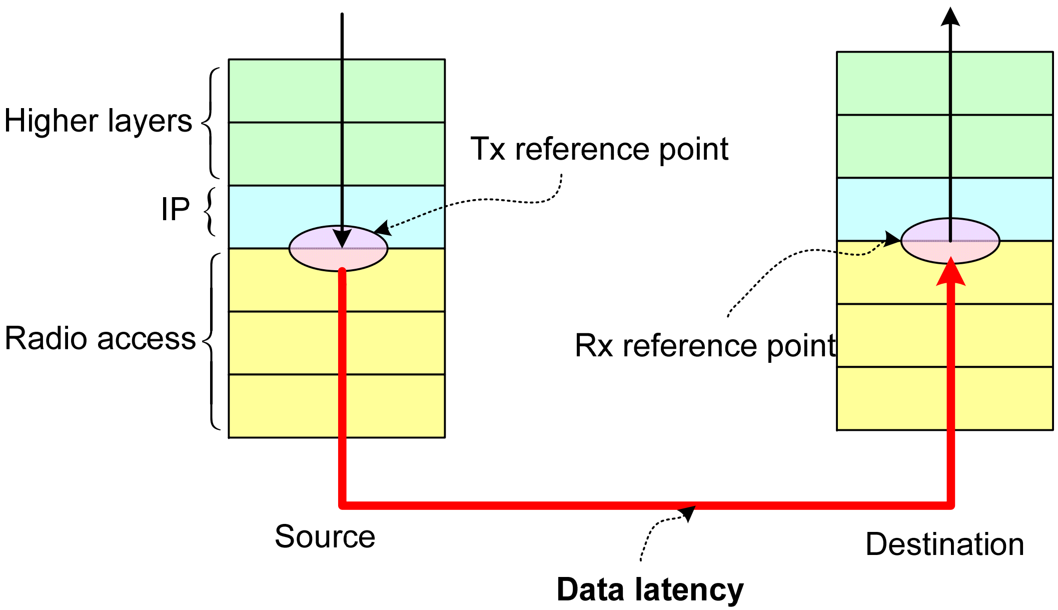
- Support large combinations of 16m:Legacy ratios
  - 16m:Legacy = 4:1, 3:2, 2:3, 1:4 in the example above

For more detailed explanation on legacy support, see input contribution IEEE C802.16m-08/063.

Data Latency

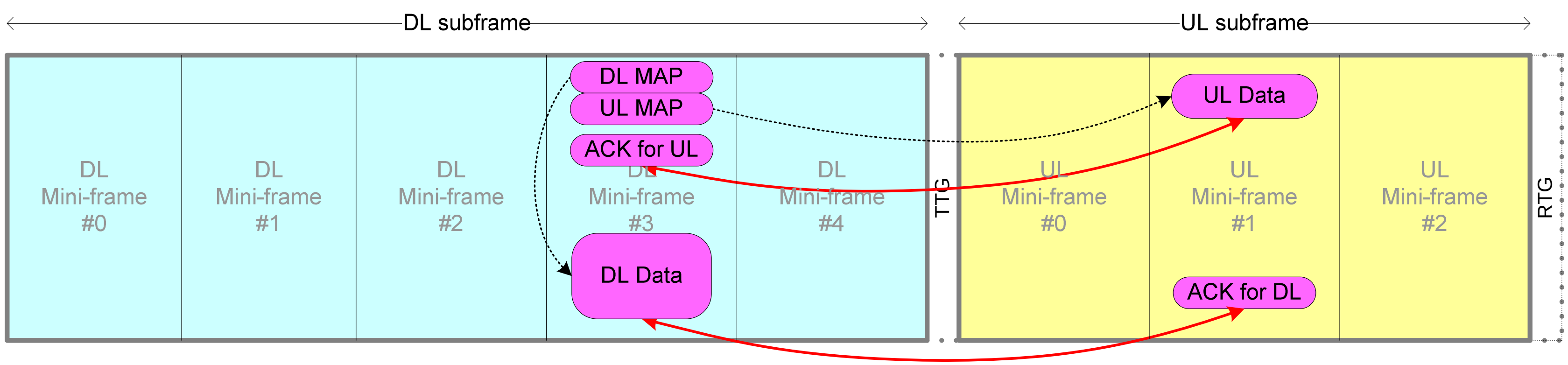
- Data latency requirement specified in 16m SRD < 10ms
- Definition of the data latency

  "One way transit time between a packet being available at the IP layer (Tx) in either the MS/Radio Access Network and the availability of this packet at IP layer (Rx) in the Radio Access Network/MS, under unloaded condition."



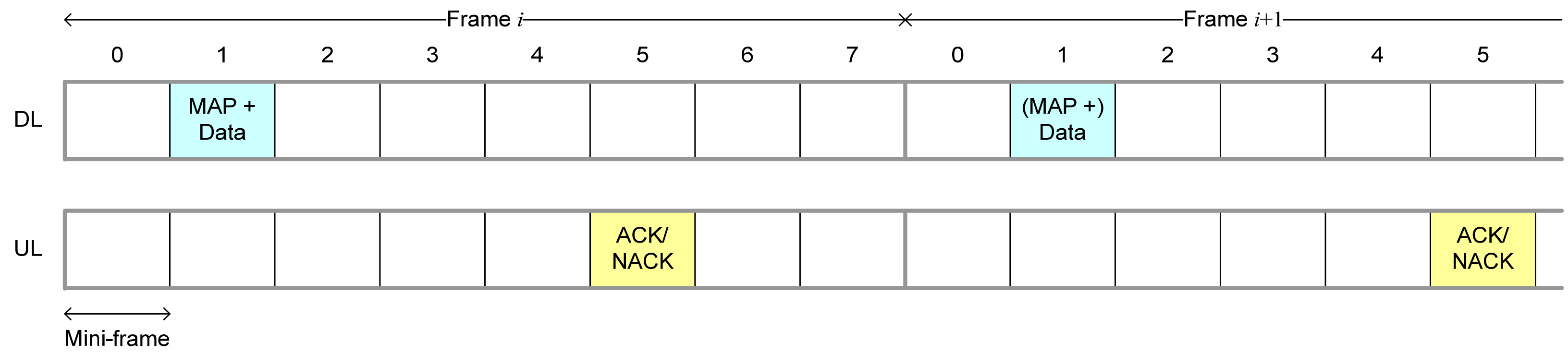
How to Make the Latency Low?

- Short TTI (transmission time interval)
  - Data burst transmission on mini-frame basis
  - TTI for delay-sensitive service is set to one mini-frame
- Fast HARQ operation within 5ms frame
  - Associate a data transmission and HARQ feedback in the same frame in consideration of Rx processing time and re-Tx processing time
- Example – TDD 5:3



HARQ Interlace – FDD DL

- Synchronous HARQ



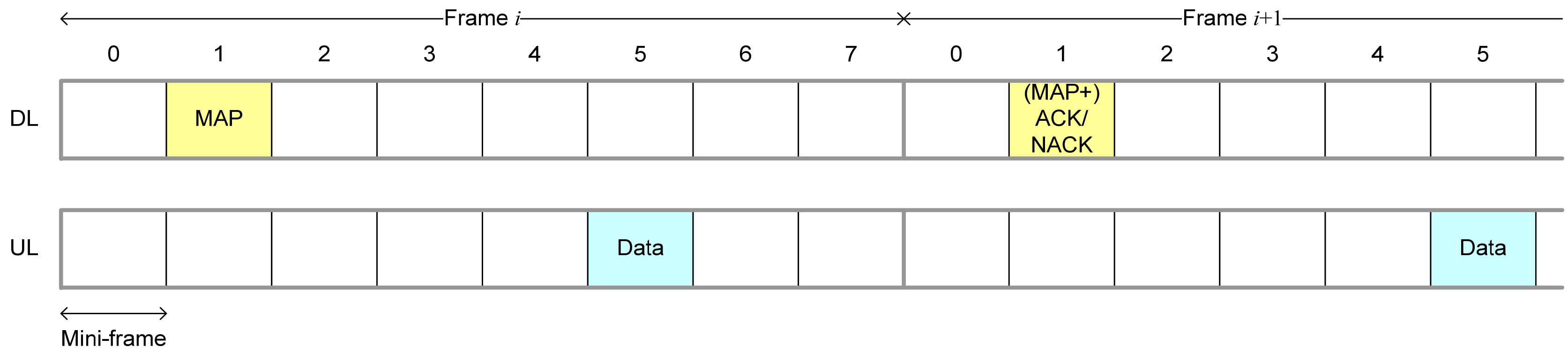
- Structured transmission timing of data and feedback

Type	Direction	Frame index	Mini-frame index
MAP + Data Tx	DL	i	m
ACK Tx	UL	$(i + \text{floor}((m+4)/8)) \bmod 4$	$(m+4) \bmod 8$
Data ReTx	DL	$(i + 1) \bmod 4$	m

$i = 0\sim3,\ \ m = 0\sim7$

HARQ Interlace – FDD UL

- Synchronous HARQ



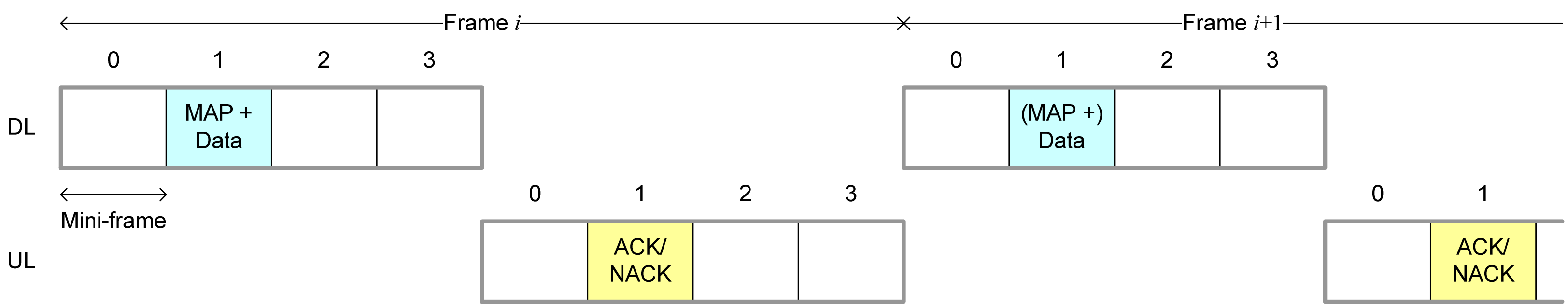
- Structured transmission timing of data and feedback

Type	Direction	Frame index	Mini-frame index
MAP	DL	i	m
Data Tx	UL	$(i + \text{floor}((m+4)/8)) \bmod 4$	$(m+4) \bmod 8$
ACK Tx	DL	$(i + 1) \bmod 4$	m
Data ReTx	UL	$(i + 1 + \text{floor}((m+4)/8)) \bmod 4$	$(m+4) \bmod 8$

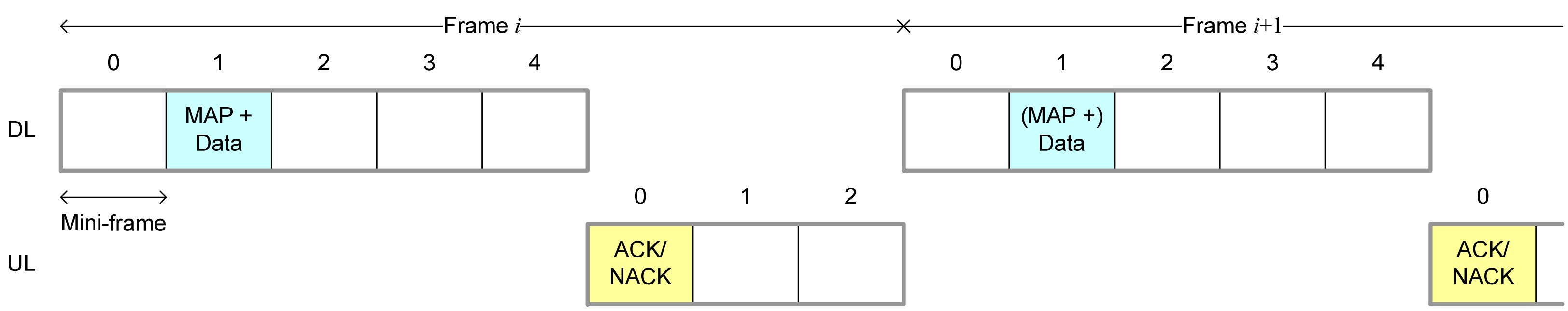
$i = 0 \sim 3, \; m = 0 \sim 7$

HARQ Interlace – TDD DL (1/2)

- Synchronous HARQ
- TDD (D:U = 4:4)

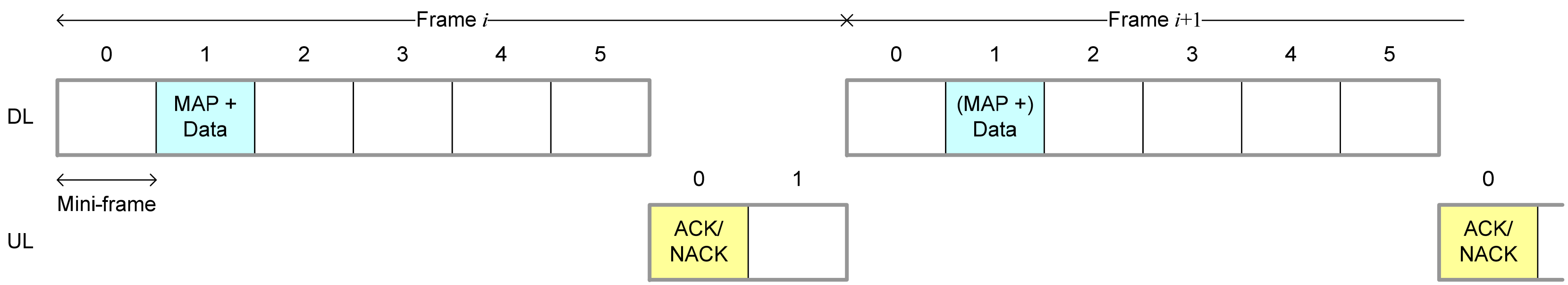


- TDD (D:U = 5:3)



HARQ Interlace – TDD DL (2/2)

- TDD (D:U = 6:2)
  - A slow interlace (ReTx Frame → i+2) may be applied to data Tx in DL mini-frame #0 or #5



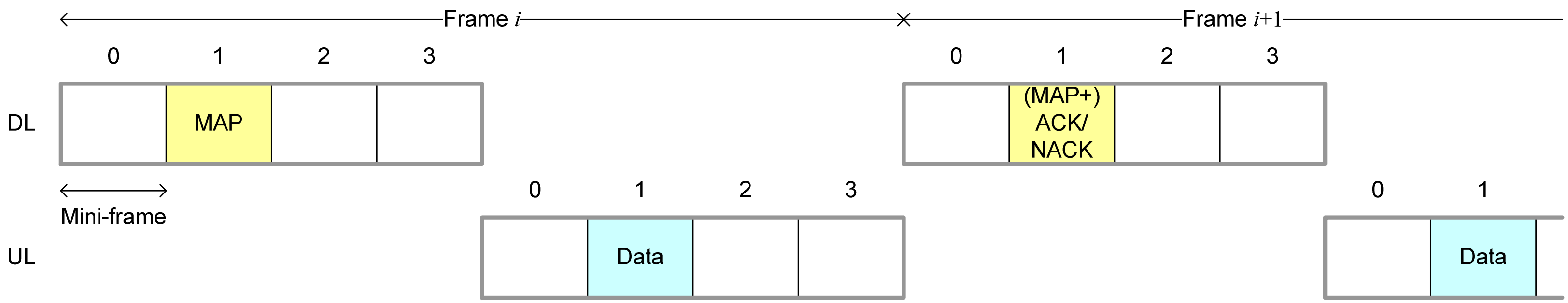
- Structured transmission timing of data and feedback

Type	Direction	Frame index	Mini-frame index
MAP + Data Tx	DL	i	m
ACK Tx	UL	i	floor(m/K)
Data ReTx	DL	$(i + 1) \bmod 4$	m

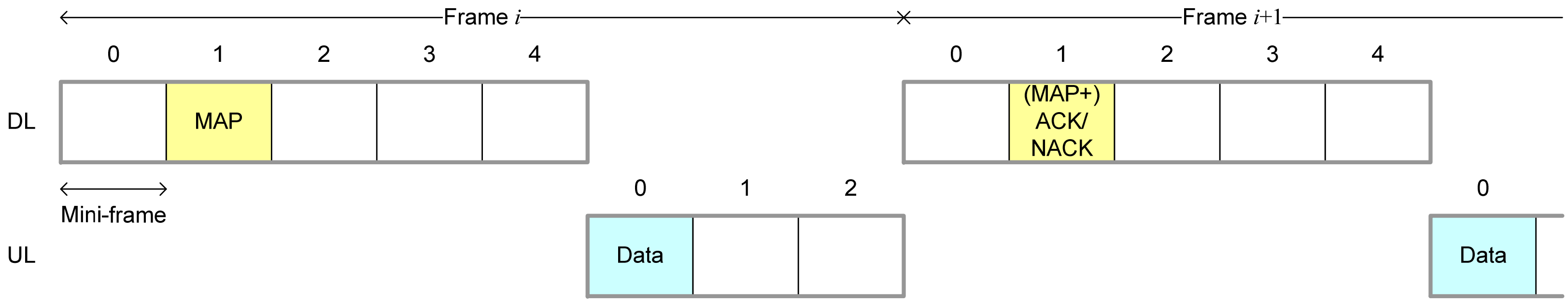
i = 0~3, m = 0~D-1, K = D/U

HARQ Interlace – TDD UL (1/2)

- Synchronous HARQ
- TDD (D:U = 4:4)

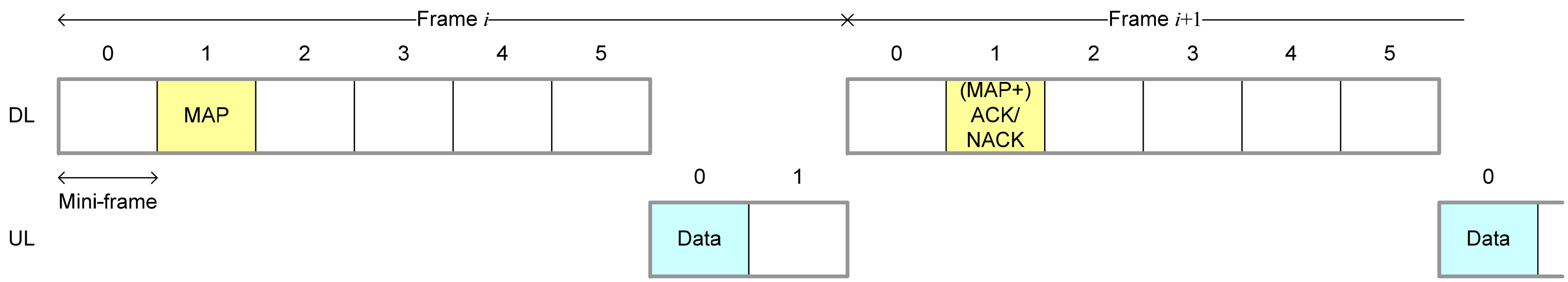


- TDD (D:U = 5:3)



HARQ Interlace – TDD UL (2/2)

- TDD (D:U = 6:2)
  - A slow interlace (ReTx Frame → i+2) may be applied to UL data Tx assigned by MAP in DL mini-frame #0 or #5



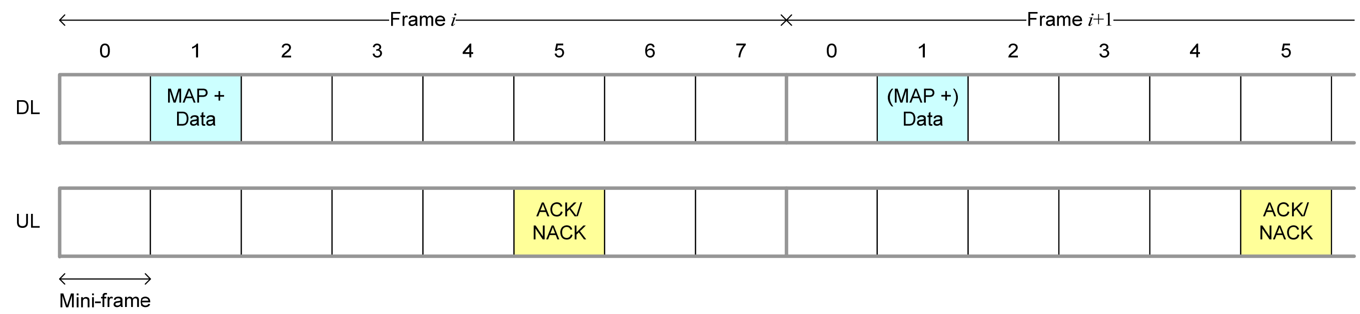
- Structured transmission timing of data and feedback

Type	Direction	Frame index	Mini-frame index
MAP	DL	i	m
Data Tx	UL	i	floor(m/K)
ACK Tx	DL	$(i + 1) \bmod 4$	m
Data ReTx	UL	$(i + 1) \bmod 4$	floor(m/K)

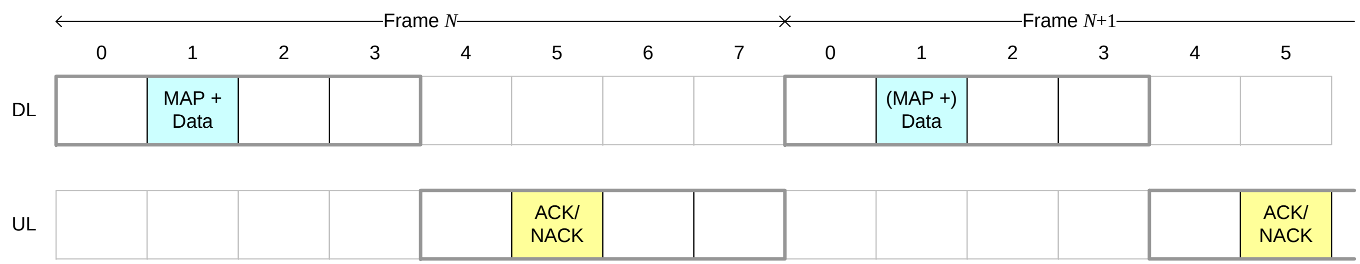
i = 0~3, m = 0~U-1, K = D/U

Single HARQ Structure

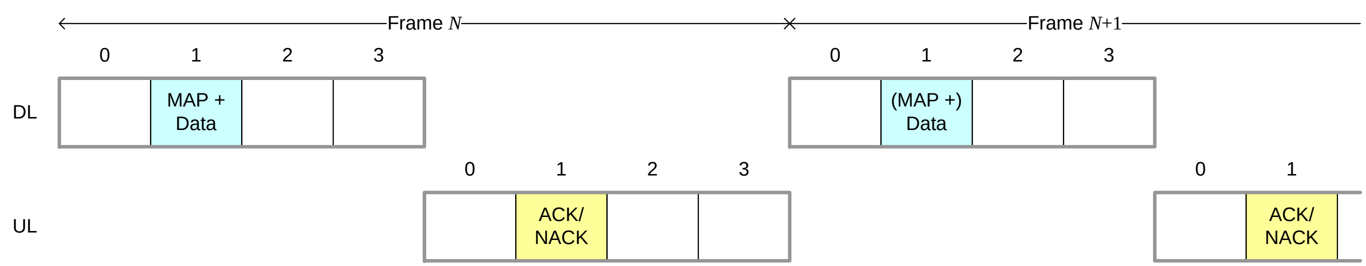
- A common structure of HARQ interlace
- FDD_{DL}



- $H\text{-}FDD_{DL}$

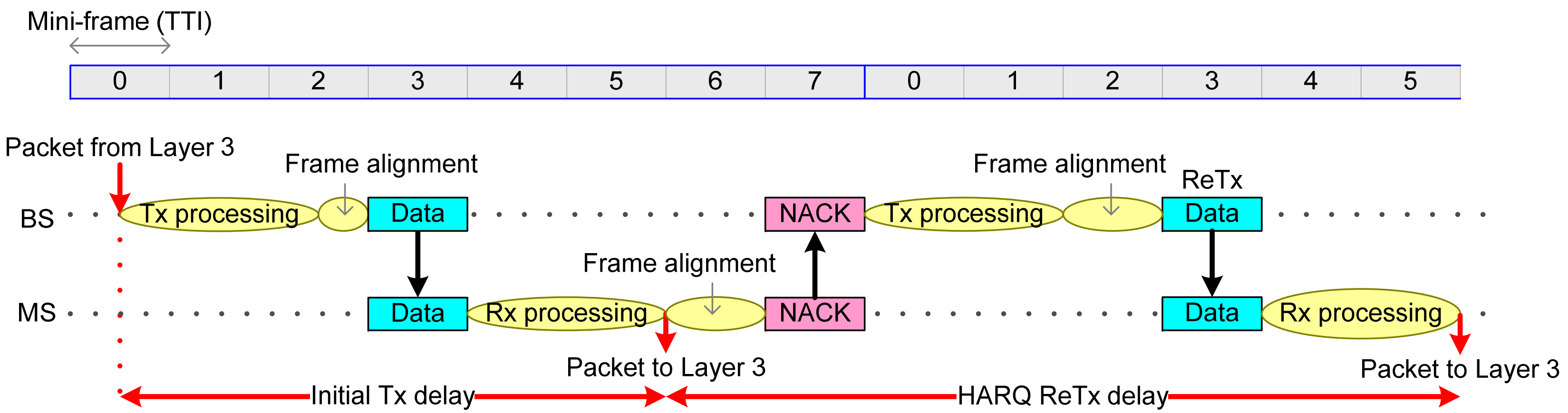


- $TDD\ 4{:}4_{DL}$



Data Latency Calculation (1/2)

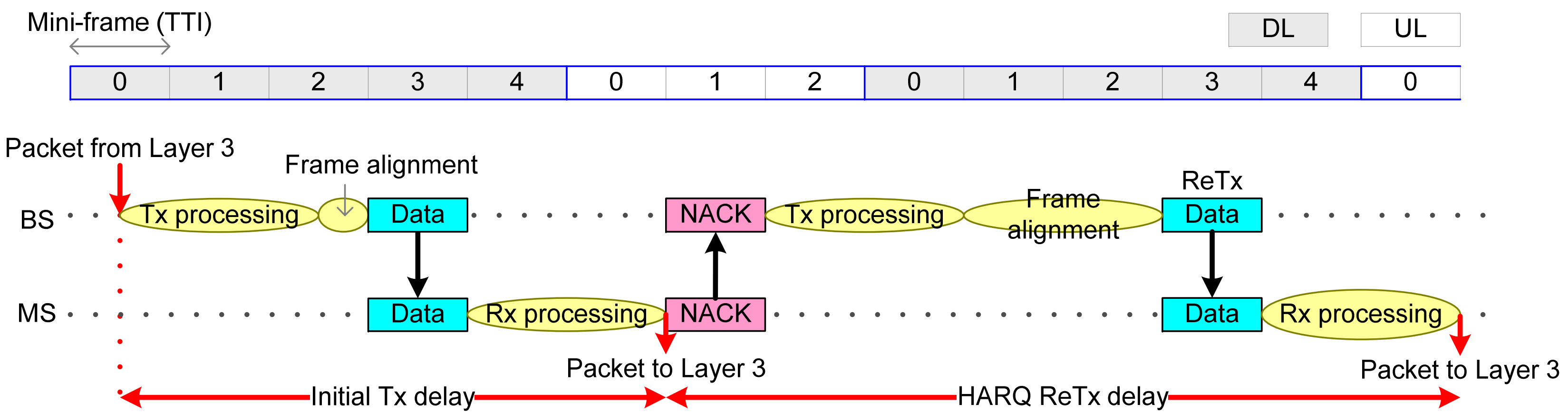
- Calculation Equation [Ref: 3GPP TS 25.912]
  - Data Latency = Initial Tx delay + Pr(ReTx) x HARQ ReTx delay = *function* (TTI, …)
- Data latency for FDD DL



Delay type		Value
Initial Tx Delay	Tx Processing Delay	2 TTI
	Frame Alignment Delay	0.5 TTI
	Transmission Interval	1 TTI
	Rx Processing Delay	2 TTI
HARQ ReTX Delay		8 TTI
Data Latency with TTI = 0.617ms, Pr(ReTX) = 30%		**5.5 TTI + Pr(ReTx) x 8 TTI = 4.87ms**

Data Latency Calculation (2/2)

- Data latency for TDD 5:3 DL
  - Case: a packet arrives in DL mini-frame #0 and it is transmitted at DL mini-frame #3



Delay type		Value
Initial Tx Delay	Tx Processing Delay	2 TTI
	Frame Alignment Delay	0.5 TTI
	Transmission Interval	1 TTI
	Rx Processing Delay	2 TTI
HARQ ReTX Delay		8 TTI
Data Latency with TTI = 0.617ms, Pr(ReTX) = 30%		**5.5 TTI + Pr(ReTx) x 8 TTI = 4.87ms**

Latency Performance of the Proposal

- Latency results[1), 2)] for all cases even with Pr(ReTx) = 30% < 10 msec!

	Latency with Pr(ReTx) = 0%		Latency with Pr(ReTx) = 30%	
	DL	UL[3)]	DL	UL[3)]
FDD	3.39 msec		4.87 msec	
TDD 4:4	4.17 msec		5.65 msec	
TDD 5:3	3.86 msec	4.55 msec	5.34 msec	6.03 msec
TDD 6:2	3.63 msec	5.01 msec	5.85 msec[4)]	6.49 msec

1) With the assumption of Tx/Rx processing delay = 2 mini-frames (2TTI), TTI = 0.617ms.
2) The averaged value for L3 packets whose arrivals are uniformly distributed over 5ms frame.
3) Pre-scheduling such as UGS service is assumed.
4) The slow interlace such that re-transmission timing is extended to the frame after the next, is considered for data transmission in DL mini-frame #0 or #5 .

Text Proposal for Inclusion in SDD

Proposed Text

Insert the following text into Physical Layer Clause (i.e. Chapter 11 in IEEE C802.16m-07/320r1):

------------------------------ Text Start ---

11.1. Framing Structure

11.1.1 Generic frame structure

The generic frame structure, which shall apply to TDD as well as FDD mode of operation, is defined on the basis of a super-frame as illustrated in Figure xx. The super-frame shall be built up using four 5ms frames. Each 5ms frame in the super-frame shall comprise eight mini-frames. A mini-frame is either dedicated to downlink or uplink.

A single burst may span across more than one contiguous mini-frames.
[Note: The maximum number of contiguous mini-frames that a burst may span is TBD].

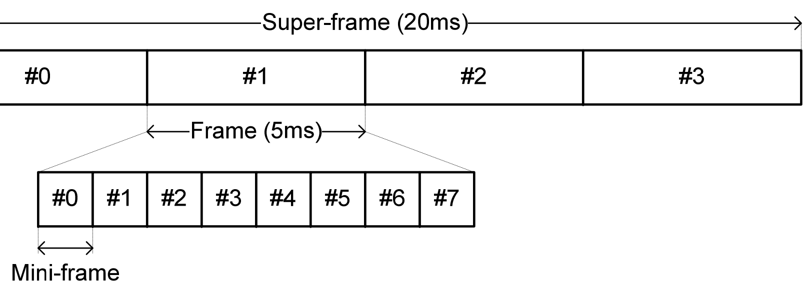


Figure xx Generic frame structure

For TDD mode, the ratio of DL mini-frames to UL mini-frames shall be one of 8:0, 6:2, 5:3 or 4:4.

11.1.2 Super-frame header

Every super-frame shall contain a super-frame header. The super-frame header shall be located in the first downlink mini-frame of the super-frame. A super-frame header shall include synchronization sequence and system configuration information.

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