Proposed Hybrid ARQ Structure (protocol and timing) for IEEE 802.16m

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Venue:

IEEE 802.16m-08/016r1, “Call for Contributions on Project 802.16m System Description Document (SDD)”.
Target topic: “Hybrid ARQ (protocol and timing)”.

Base Contribution:

None

Purpose:

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

Proposed Hybrid ARQ Structure (protocol and timing) for IEEE 802.16m

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Definitions

- Synchronous HARQ (S-HARQ)
  - Fixed location of retransmission without allocation information
- Asynchronous HARQ (A-HARQ)
  - Variable location of retransmission with allocation information
  - It needs additional information in MAP IE for asynchronous operation
    - E.g. HARQ channel indicator (ACID), HARQ ID serial number (AI_SN), and Subpacket identifier (SPID), in 802.16e
- Non-Adaptive HARQ
  - Fixed MCS level (or pre-determined pattern) without allocation information
- Adaptive HARQ
  - Varying MCS level and Tx location in a sub-frame with allocation information

About this Contribution

- Goal and scope of this presentation
  - Propose working assumption for Hybrid ARQ (HARQ) operation
  - Compare key attributes of HARQ operation
  - Focus on the operation timing issue (synchronous vs. asynchronous)
- Key attributes of HARQ operation

Operation in time	**Synchronous**	**Asynchronous**
Operation across Re-Tx	**Non-adaptive**	**Adaptive**
Combining type	**Incremental Redundancy**	**Chase combining**

- Consider an issue of Persistent allocation with Synchronous HARQ
- Proposed working assumption ⇨ Synchronous, Non-Adaptive, IR

Performance Comparison of Synchronous and Asynchronous HARQ Protocols

Synchronous vs. Asynchronous

- A-HARQ over S-HARQ
  - Exploit the channel variation across re-transmissions
  - Pre-empt pending re-transmissions to allow for other transmission
  - But, resource assignment needs to be signalled every transmission
- Advantage of A-HARQ is only a flexibility in scheduling retransmissions
  - How much throughput gain from this flexibility in scheduling ?

Metric	S-HARQ	A-HARQ
Control signaling overhead	Low	High
Flexibility in scheduling retransmissions	Low	High
Packet retransmission delay	Short	Long

DL System Level Simulation

- TDD, D:U = 4:4
- Scheduling algorithm: Proportional Fairness
- Non-adaptive and chase combing HARQ operation
- Downlink SLS parameters (based on 802.16m EMD)

Simulation assumptions	Descriptions
Frequency reuse	1
Ant/ Receiver structure	SIMO (1X2) / MMSE
Channel Estimation	Ideal
CQI report period	1 frame (5ms)
CQI erasure rate	0%
Target PER	10%
Number of user / sector	16
Max number of retransmission	4

Test scenario	Configuration
Site-to-site distance	1.5km
BS Tx power	46dBm
Penetration loss	10dB
Antenna Gain	BS: 17dBi, MS: 0dBi
Pathloss model	Loss(dB)=130.62+37.6log(R)
Lognormal shadowing STD	8dB
Channel mix	ITU Ped B 3km/hr – 60% ITU Veh A 30km/hr – 30% ITU Veh A 120km/hr – 10%

SLS Performance Results

	Throughput without MAP overhead (Mbps)	Latency; average (ms)	Latency; 90%-tile (ms)	Average number of transmissions
S-HARQ	**7.57**	**1.34**	**3.2**	**1.24**
A-HARQ	**7.70 (+1.7%)**	**8.89**	**20**	**1.23**

*** Latency: time duration from the 1st transmission to the successful transmission**

- Even with no additional MAP overhead for A-HARQ,
  - No noticeable difference in throughput between A-HARQ and S-HARQ
  - However, a significant increase in transmission latency with A-HARQ
- A-HARQ signaling overhead includes …
  - MAP IE at every retransmission
  - Additional information in MAP IE for A-HARQ: ACID, AI_SN, SPID

Why So Small Gain by A-HARQ?

- To obtain a throughput gain from the scheduling flexibility of A-HARQ, scheduler shall determine the more favorable retransmission timing
  - It is contradictory because the accurate channel estimation is possible at a low speed environment, where most packets succeed at the 1st Tx
- Even with S-HARQ, most scheduling gain can be obtained
  1. PF scheduling for the 1st Tx packet
     - Tx opportunity at a good channel state is already given to the 1st packet.
  2. Small number of retransmissions (<< 2)
     - Potential gain of A-HARQ is reduced.
  3. Short retransmission time for S-HARQ (5ms)
     - The channel is almost invariant across retransmissions
     - No additional channel sensitivity gain can be obtained by using A-HARQ.

Other Attributes of HARQ Operation

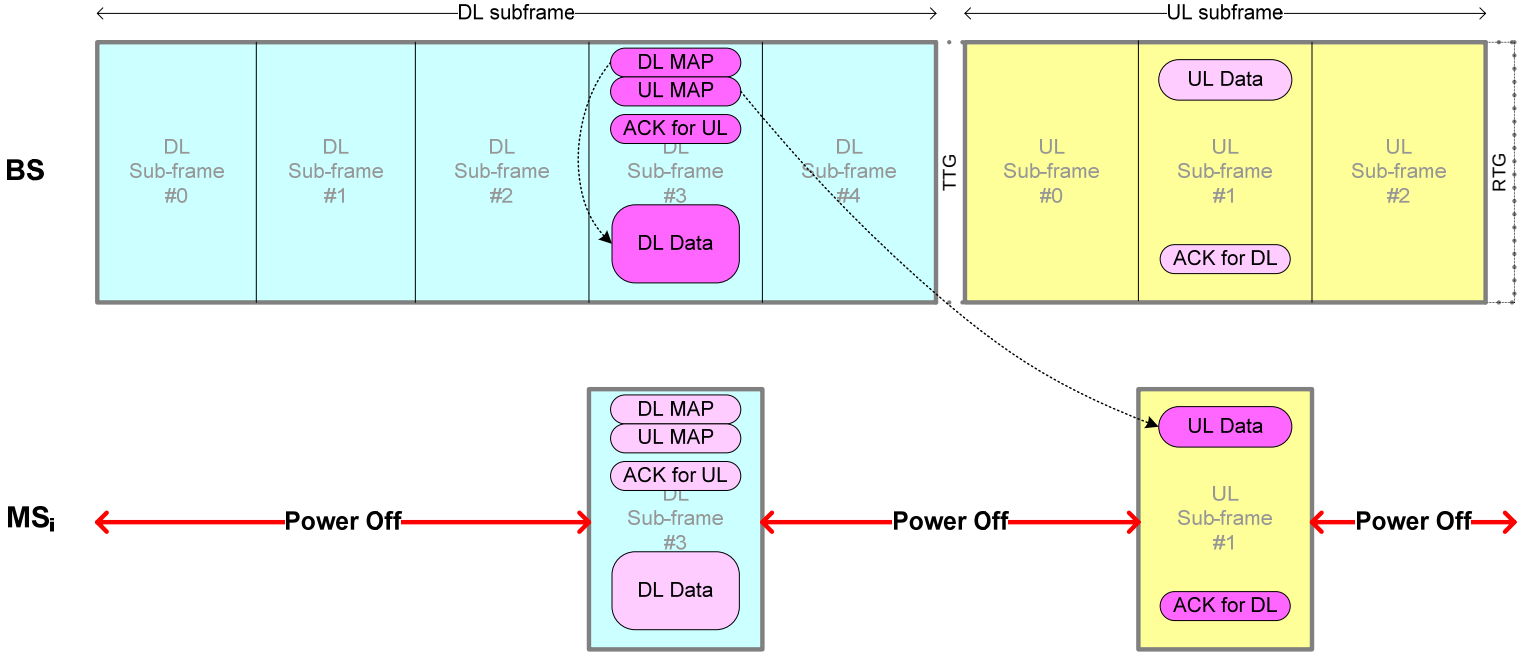
- Non-adaptive vs. Adaptive
  - Not much gain from the adaptive operation across retransmissions
  - The initial transmission is already adaptive, so the probability of having much better channel condition for retransmission is not very likely
  - Preference: Non-adaptive operation
- Incremental Redundancy (IR) vs. Chase Combing (CC)
  - IR provides a coding gain as well as an energy combining gain
  - Preference: Incremental Redundancy

Other Benefits of Synchronous HARQ

Power Saving

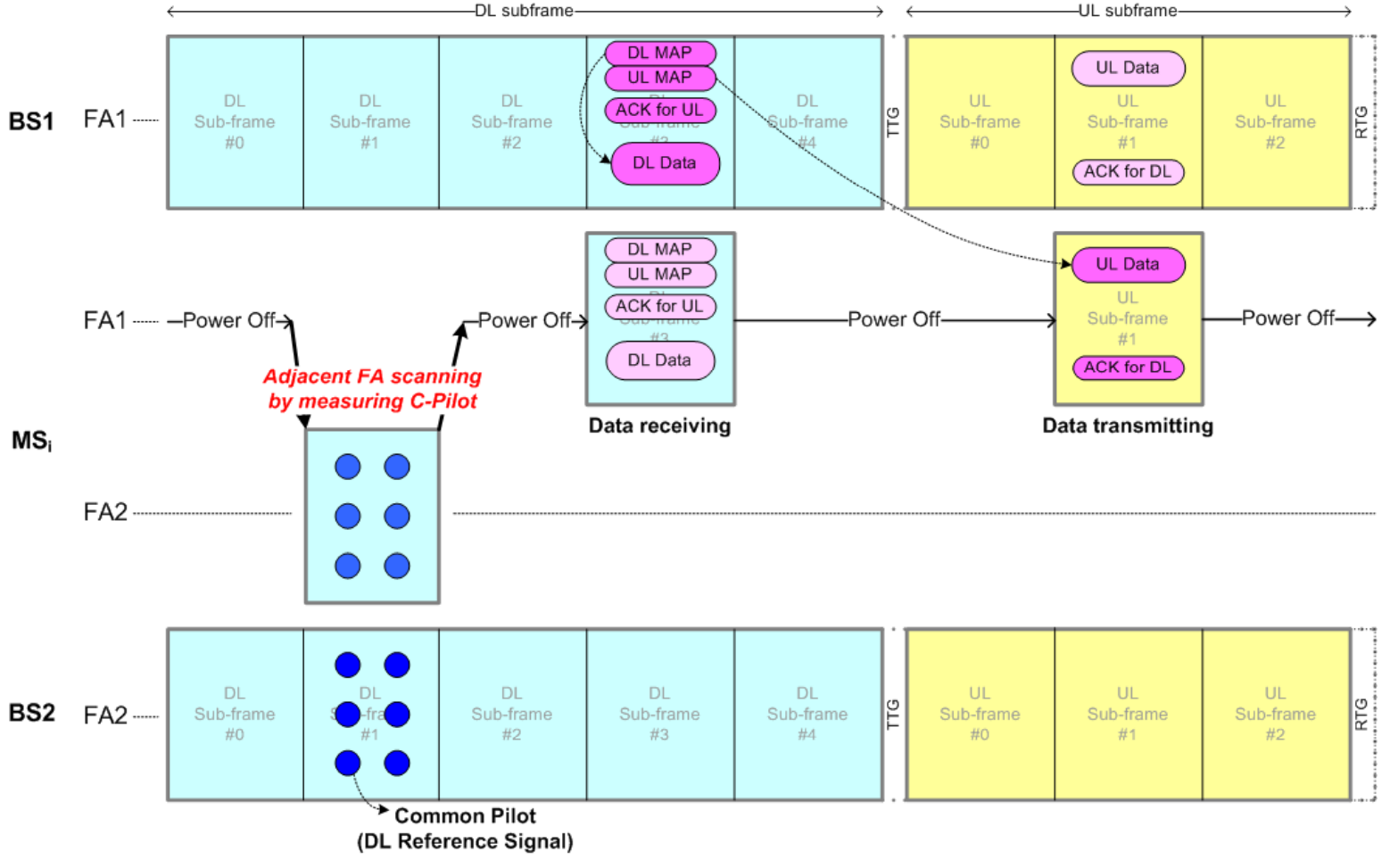
- Default sub-frame concept
  - The periodic Tx timing in S-HARQ can be exploited for Power Saving

    ⇨ implement sleep mode
    - One of sub-frames is pre-assigned to MS as a default
    - Then the MS needs to monitoring *the assigned sub-frame only*
    - Thus, the MS may go sleep mode during other sub-frames



Inter-FA Handover Support

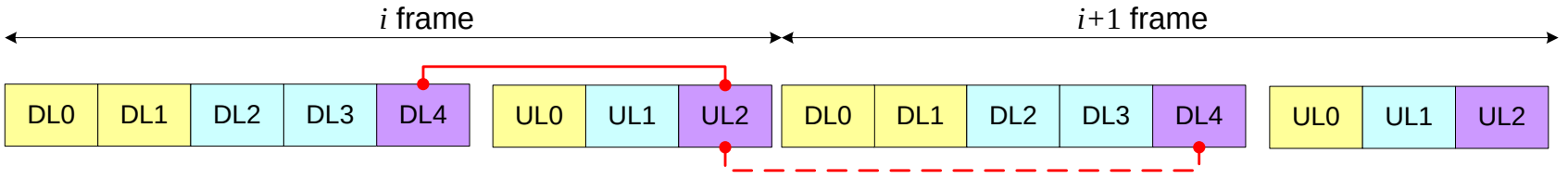
- Adjacent FA scanning for Inter-FA handover during the power off period
  - *Without* interruption to communication *nor* explicit MOB_SCN-Req Msg!



Proposed Structure of Synchronous HARQ

HARQ Timing for Synch Operation

Example – TDD D:U = 5:3

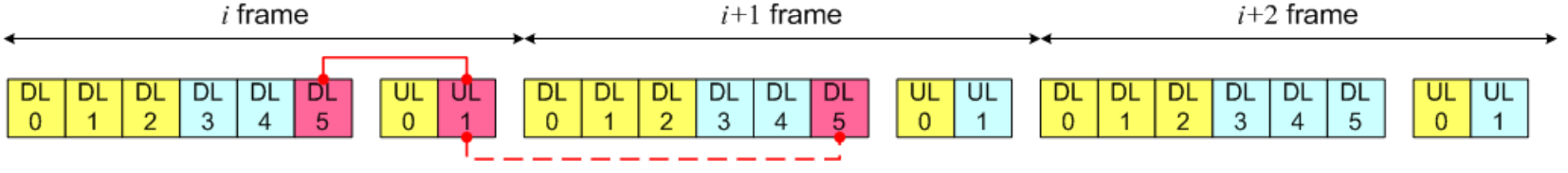


*Each color indicates association between DL and UL subframes for HARQ operation

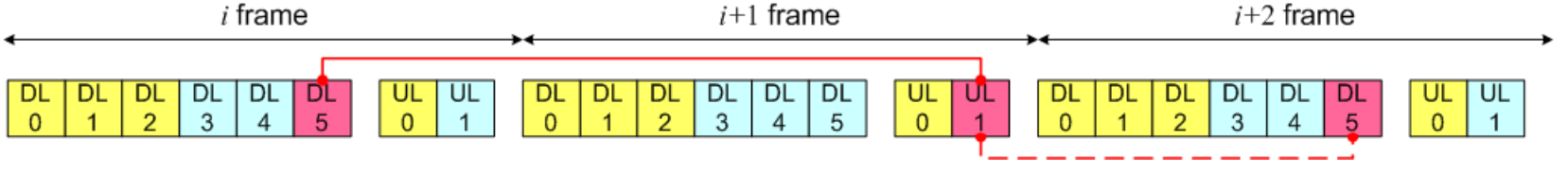
- Timing structure of data and feedback transmissions
  - A common HARQ structure is provided for FDD, H-FDD, and TDD 4:4
  - For more details, see January contribution *IEEE C802.16m-08/062r1*
  - Provides two different timing structures for retransmission in order to relax constraints on processing time for specific cases (see next slide)
  - Support synchronous operation for various TTIs

Two Retransmission Timings

- Fast interlace (default)
  - The interval between initial and subsequent transmissions = 5 ms
- Slow interlace (optional)
  - The interval between initial and subsequent transmissions = 10 ms
- Example – the last DL sub-frame in TDD D:U = 6:2
  - If Rx processing at MS can be done within 1 TTI, the fast interlace is applied



  - Else (i.e. Rx processing delay > 1 TTI), the slow interlace is applied



Data latency (8.5ms) still meets the requirement (10ms); with Pr(Re-Tx) = 30%

Persistent Allocation Support

- Persistent allocation with S-HARQ
  - A pre-fixed resource is used for initial transmission periodically.
  - For S-HARQ Re-Tx, the pre-fixed resource can be used at the next Tx timing without scheduling information if it is not reserved to other users.
- Anticipated problem
  - ① Resource collision: Collision between implicit assignments such as persistent resource and resource for S-HARQ Re-Tx in synchronous manner
  - ② Resource hole: Too small fractions of resource between two persistent resources or resources for S-HARQ Rx-Tx, to assign to other user
- Proposed solution
  - Allow the resource relocation at the time of retransmission, if necessary
  - Details are TBD

Summary and Proposed Text

Summary

- Synchronous HARQ over Asynchronous HARQ
  - Significantly lower MAP overhead
  - Comparable pure throughput performance (without MAP overhead)
  - Significantly lower transmission latency
  - Additional advantages: Power saving, Inter-FA handover support
- Persistent allocation with S-HARQ
  - Allow the resource relocation at the time of retransmission, if necessary
- Proposed HARQ working assumption ⇨ Synchronous, Non-Adaptive, IR

Text Proposal for Inclusion in SDD

Add the following text into Chapter 11 in IEEE 802.16m-08/003r1:

11.x. Hybrid ARQ (HARQ)

HARQ is based on synchronous retransmission, non-adaptive operation, and incremental redundancy (IR).