Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Control Phase Length with MMS UWB Packet Configuration 1

Date Submitted: April 29, 2025

Source: Riku Pirhonen (NXP)

Abstract: Start of Ranging packet is used to configure the MMS UWB Packet Configuration. Configuration 1 is for UWB driven MMS and starts with a SYNC+SFD fragment, that can be used for Poll and Response. This way use of poorer performing SP0 (BASIC_PACKET) for Poll and Response can be avoided in use cases where no additional data is needed.

Purpose: Improve UWB driven MMS link budget.

Comment #266

DCN 15-25-0194-00-04ab

Name	Index #	Page	Sub-clause	Line #	Comment	Proposed Change
Pirhonen, Riku Assigned to Billy and Carl	266	80	10.39.4.1	2	In case of UWB driven MMS, the MMS UWB packet has SYNC+SFD fragment, which can be used to estimate carrier frequency offset. Sending separate Poll and *Response* ~~Control~~ packets is not always needed and in that case control phase duration can be set to 0 to indicate that there are no separate physical poll and response frames.	Add text: In case of UWB driven MMS the SYNC+SFD fragment of UWB MMS packet can be used for carrier frequency offset estimation. If there is no other reason to send a dedicated poll and response frame, *macMmsRcpPollNSlots* and/or *macMmsRcpRespNSlots* can be set to 0 to indicate zero length control phase and the SYNC+SFD fragment of the UWB MMS packet serves as the poll or the response.

- CID #266 is the main comment, 267 – 270 are implementation of an approving resolution.

Name	Index #	Page	Sub-clause	Line #	Comment	Proposed Change
Pirhonen, Riku	267	105	10.39.11.1.3.9	7	The minimum value for *macMmsRcpPollNSlots* can be 0	change the range from 1 - 15 to 0 – 15
Pirhonen, Riku	268	105	10.39.11.1.3.9	10	The minimum value for *macMmsRcpRespNSlots* can be 0	change the range from 1 - 15 to 0 – 15
Pirhonen, Riku	269	145	10.39.12	1	The minimum value for *macMmsRcpPollNSlots* can be 0	Change the value range for *macMmsRcpPollNSlots* to 0 – 15
Pirhonen, Riku	270	145	10.39.12	1	The minimum value for *macMmsRcpRespNSlots* can be 0	Change the value range for *macMmsRcpRespNSlots* to 0 – 15

Initialization

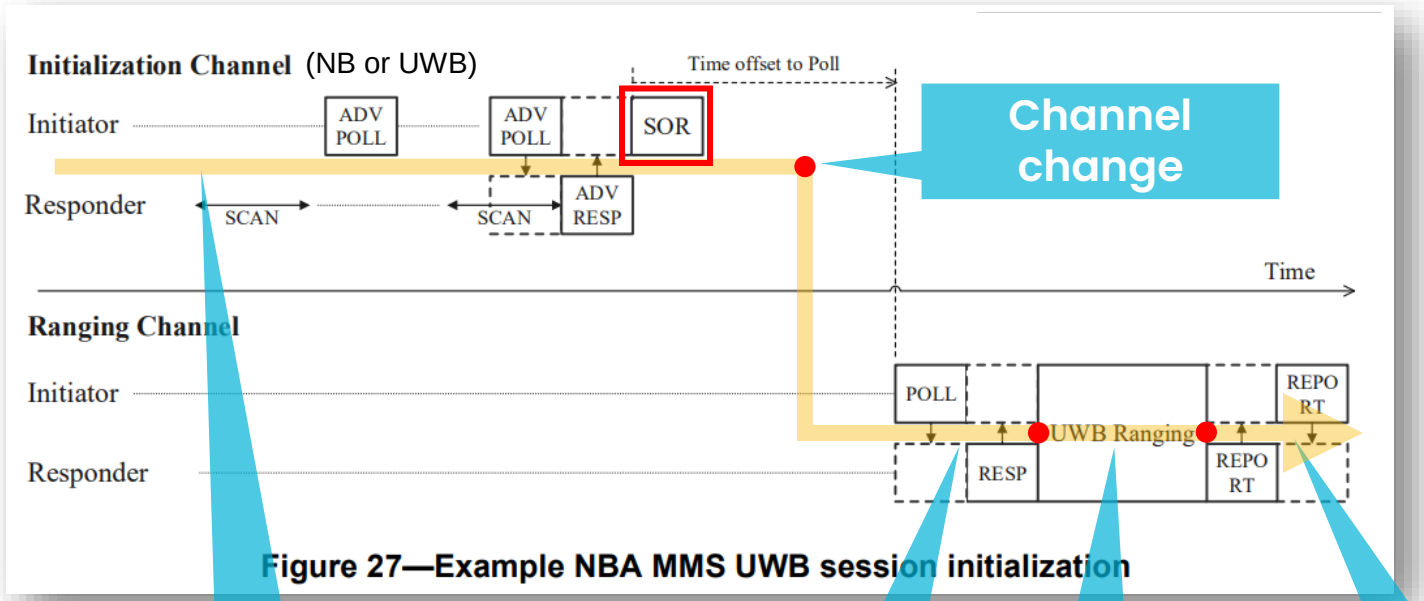

Figure 27—Example NBA MMS UWB session initialization

Channel change

NB or UWB

NB or UWB

UWB

NB or UWB

- Initialization on NB (typical) or UWB
- Advertising Poll and Response negotiate parameters
- SOR frame defines (10.39.11.3.4)
  - Time offset to poll
  - Use of NB (Narrowband Assisted, NBA) or UWB (UWB Driven, UWBD) for poll and response
  - Interleaved (typical) or non-interleaved control and ranging frames
  - Length of Control, Ranging and Report phases etc.

Initialization – Start of Ranging

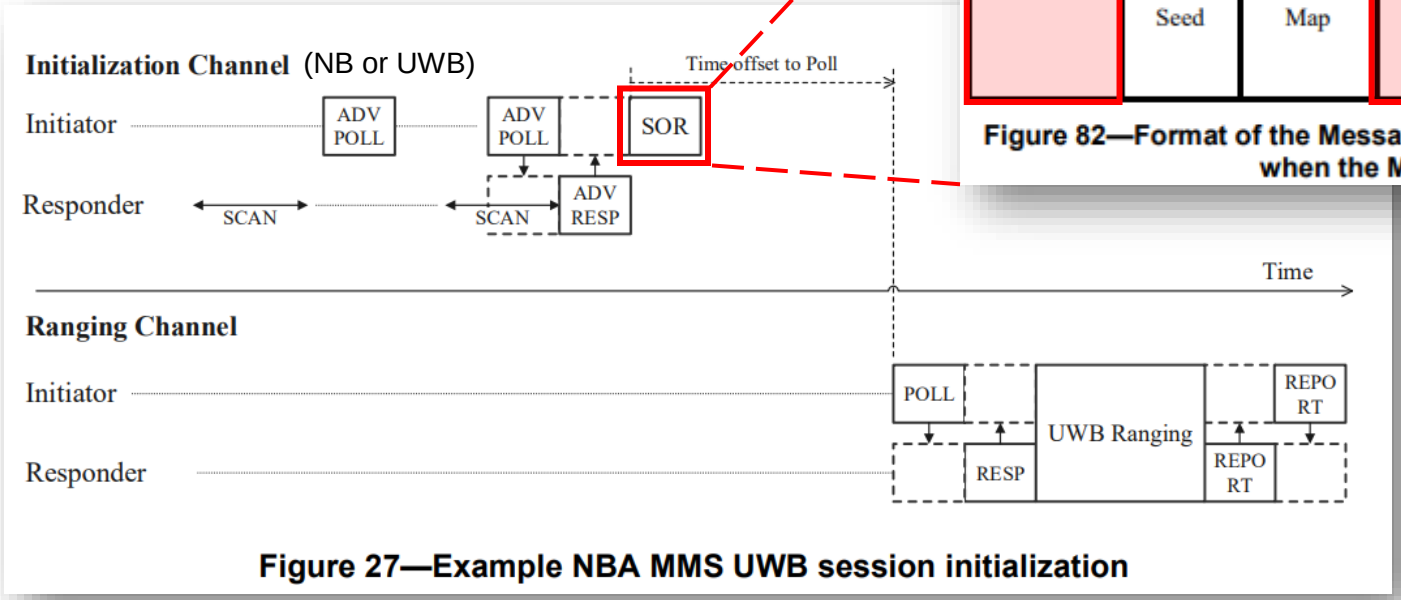

Figure 27—Example NBA MMS UWB session initialization

Octets: 4	1	6	1	8	4	1
Time Offset	NB Channel Seed	NB Full Channel Map	Management PHY Configuration	Management MAC Configuration	Ranging PHY Configuration	MMS Number of Fragments

Figure 82—Format of the Message Content field in the Start of Ranging Compact frame when the Message Control field value is zero

SOR Message Content Field

- Time Offset (10.39.11.1.3.11)
- Management PHY Configuration (10.39.11.1.3.13)
  - Control phase configuration (NB or UWB)
  - Report phase configuration (NB or UWB)
- Management MAC Configuration (10.39.11.1.3.9)
  - Control phase poll slots
  - Control phase response slots
  - Ranging phase duration
  - Report phase duration
  - Interleaved / Non-Interleaved mode
- Ranging PHY Configuration (10.39.11.1.3.7)
  - Sequence Code Index
  - UWB Channel

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SOR – Time Offset to Poll

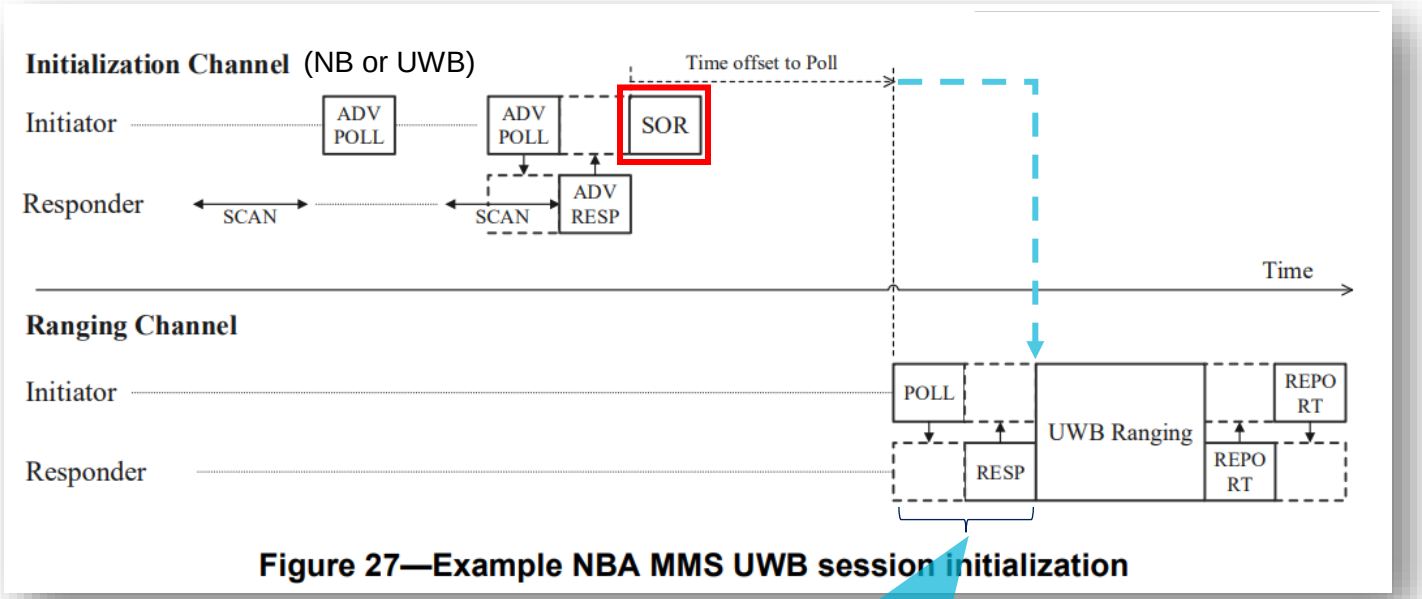

Figure 27—Example NBA MMS UWB session initialization

If *macMmsRcpPollNSlots* and *macMmsRcpRespNSlots* are set to zero, the SP0 frame is skipped and the SOR Time Offset points directly to the SYNC+SFD of the ranging packet

- Start of Ranging (SOR) Time offset to Poll indicates start of its SYNC + SFD
  - Poll can be NB or UWB
- Sending separate Poll and Response packets in Control phase is not always needed.
  - In case of UWBD mode, the SYNC+SFD fragments of MMS UWB Packet can be used for Poll and Response.
- If *macMmsRcpPollNSlots* and *macMmsRcpRespNSlots* are set to zero, Control phase becomes zero length and SOR points directly to the start of the ranging packet
  - More practical to use zero length than make control phase optional.

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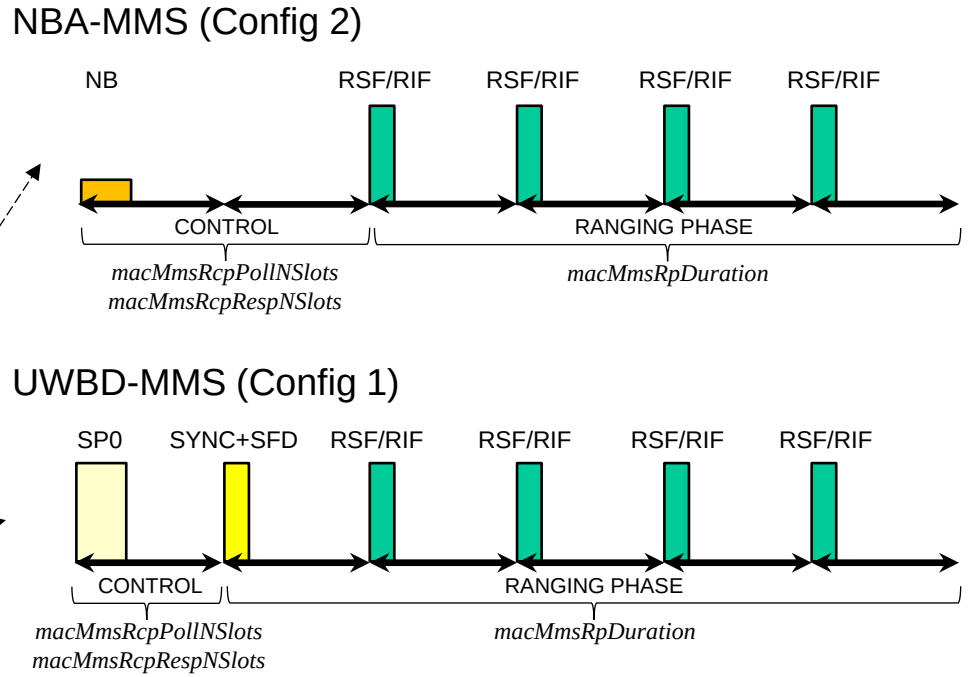
SOR – Management PHY Configuration - MMS UWB Packet Configuration

Bits: 0–3	4–7
Control Phase Config	Report Phase Config

Figure 67—The Management PHY Configuration field

Table 20—Modulation selection for Control and Report phases

Control Phase Config field value, Report Phase Config field value, *macMmsControlPhaseMode* value, *macMmsReportPhaseMode* value	Meaning, modulation to be selected:
1–8	Each value selects the corresponding config # from Table 67 to specify the O-QPSK PHY modulation mode
14	This selects the UWB modulation specified by set #1 from Table 84
15	This selects the UWB modulation specified by set #2 from Table 84
All others	Reserved



- SOR Management PHY Configuration field defines MMS UWB Packet Configuration
  - 1 -8 refers to NBA-MMS, Config 2
  - 14 – 15 refers to UWBD-MMS, Config 1

- Multi-millisecond (MMS) packets
  - NBA-MMS (Narrowband Assisted - Config 2)
  - UWBD-MMS (UWB Driven - Config 1)
- Example with total of 4 RSF/RIF fragments
- Proposed zero length Poll and Response shall apply only to UWB-MMS (Config 1)

SOR – Management MAC Configuration – Control, Ranging and Report Phase

Bits: 0–2	3–10	11–18	19	20	21–24	25–28	29–40	41–44	45–48	49–52	53–55
Ranging Slot Duration	Ranging Round Duration	Ranging Block Duration	Channel Switching	Measurement Report Request	RcpPollSlots	RcpResponseSlots	RpDuration	MrpFirstSlots	MrpSecondSlots	MrpThirdSlots	Non interleaved Mode

Figure 66—The Management MAC Configuration field

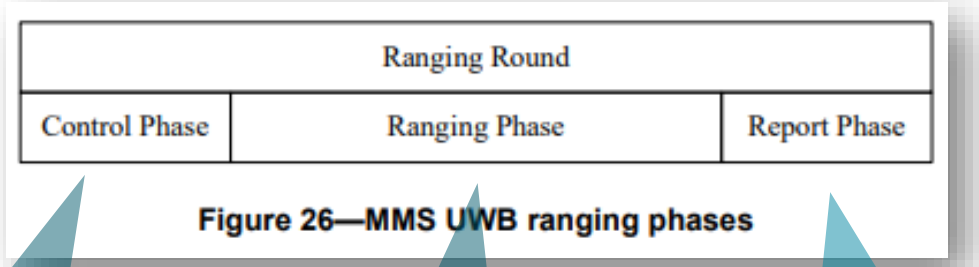


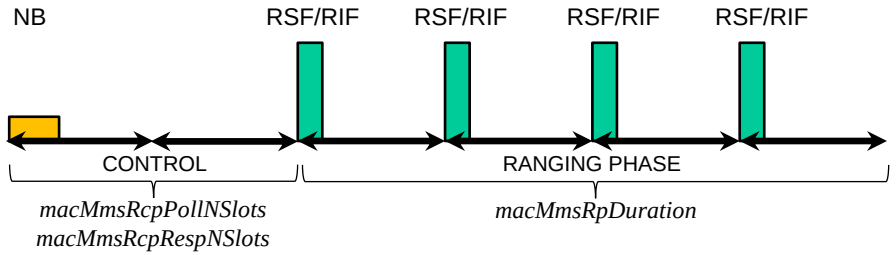
Figure 26—MMS UWB ranging phases

macMmsRcpPollNSlots
macMmsRcpRespNSlots

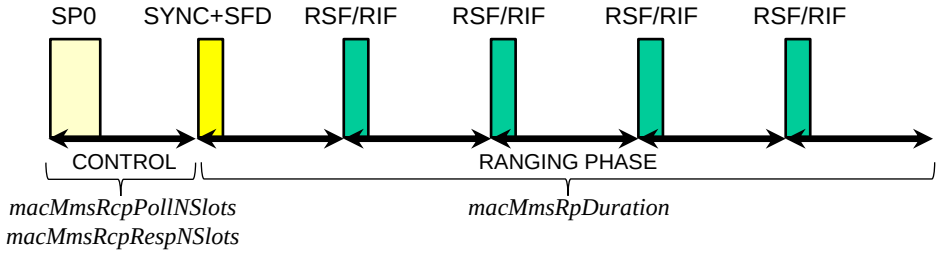
macMmsRpDuration

macMms1stReportNSlots
macMms2stReportNSlots

NBA-MMS (Config 2)



UWBD-MMS (Config 1)



- Control, ranging, and report phase
  - Lengths configured with *macMms* parameters
  - NB poll typically 1.5 & 2 ms before the 1st fragment
  - For UWB SP0 (BASIC_PACKET) 2 ms total control phase length may also be preferred, shown here with 1 ms
  - Proposal: If *macMmsRcpPollNSlots* and *macMmsRcpRespNSlots* are set to zero, Control phase becomes zero.
  - If *macMmsRcpPollNSlots* and *macMmsRcpRespNSlots* are set to value 1 -15, SP0 is in use.

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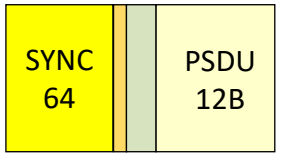
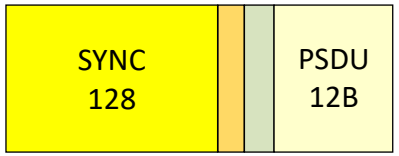
SOR – MMS UWB Packet Configuration 1 - Poll and Response Slots

SP0 (BASIC_PACKET)

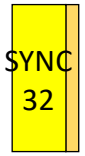


118 µs

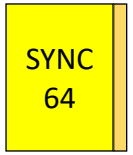


170 µs

SYNC+SFD

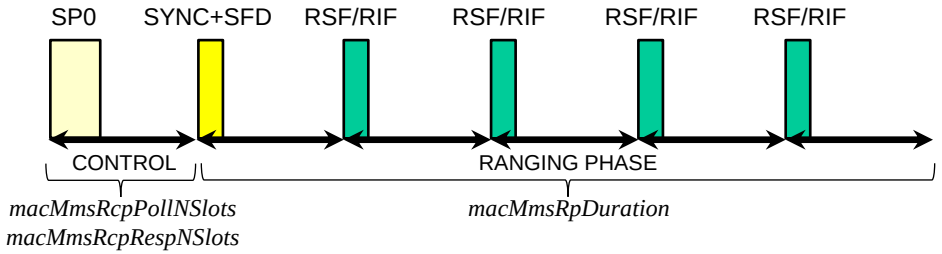


29 µs



52 µs

UWBD-MMS (Config 1)



- Longer SP0 Frame is sent at lower peak power level
- SYNC and SFD are used for Carrier Frequency Offset and timing estimation
  - If SP0 is used for Poll and Response, SYNC and SFD of this longer, lower peak power level packet defines the link budget
  - If SP0 is not needed, higher peak power level of the shorter SYNC and SFD fragment can be used for Poll and Response and defines the link budget
- Higher peak power means better link budget

UWBD-MMS SP0 vs SYNC+SFD acquisition performance comparison

SP0 (Defined by Management PHY Configuration Field)

Table 84—Additional mandatory operating parameter sets for HRP-EMDEV

Set #	SYNC PSR	SFD # per Table 16-11	SFD Length	STS number of Segments	STS Segment Length (units of 512 chips)	Data Rate (Mb/s)	Comments
1	64	2	8	0	-	1.95	TX and RX
2	128	3	16	0	-	1.95	TX only

Short

Long

SYNC+SFD (SHR), defined by the ~~N_MSR~~ fragment length

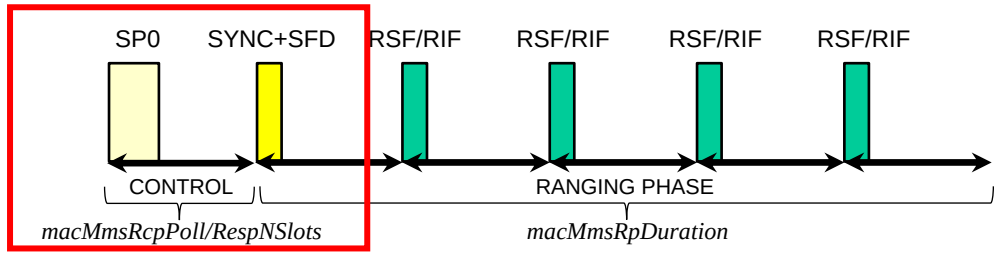
Table 16—SYNC and SFD fragment parameters

N_MSR field value	Selected SYNC PSR	Selected SFD length	Selected SFD # (ref. Table 16-11)
< 64	32	8	2
≥ 64	64	8	2

Short

Long

UWBD-MMS



	SP0 1.95 Mbit/s		SYNC+SFD			
	SP0 short	SP0 long	Length 91 code		Length 127 code	
	PSR64	PSR128	PSR32	PSR64	PSR32	PSR64
SYNC	46.7 µs	93.3 µs	23.3 µs	46.7 µs	32.6 µs	65.1 µs
SFD	5.8 µs	11.7 µs	5.8 µs	5.8 µs	8.1 µs	8.1 µs
PHR	12.8 µs	12.8 µs	N/A			
PSDU	52.3 µs	52.3 µs				
Total	**117.6 µs**	**170.1 µs**	**29.1 µs**	**52.2 µs**	**40.7 µs**	**73.2 µs**

Typical 91-length code cases

- Short SP0 vs short SYNC+SFD, SP0 is 4 x longer / 4.3 x more pulses
- Long SP0 vs long SYNC+SFD, SP0 is 3.3 x longer / 3.4 x more pulses
- Both PSR 64, SP0 is 2.3 x longer / 2.4 x pulses
- This corresponds **to 6.3 dB, 5.3 dB or 3.8 dB** power level difference

SP0 will significantly (~4dB) limit the UWBD-MMS SYNC performance

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SP0 payload

The poll Compact frame (10.39.11.3.5 or 10.39.11.3.9) is used by the responder to estimate the clock frequency offset for the reception of the initiator's subsequent MMS UWB transmissions. Additionally, the poll Compact frame may indicate either short-term operating parameters for the current ranging round or long-term operating parameters for the next and subsequent ranging rounds. The poll may optionally request

10.39.4 MMS UWB control phase

Octets: 3	3	1	variable	2
RPA Hash	RPA Prand	Message ID	Message Content	FCS

Figure 86—One-to-one Poll Compact Frame Content field format

Octets: 2
0x00, 0x00

Figure 87—Format of the Message Content field in the One-to-one Poll Compact frame when the Message Control field value is zero

Poll compact frame content

Octets: 3	1	variable	2
Responder RPA Hash	Message ID	Message Content	FCS

Figure 90—One-to-one Response Compact Frame Content field format

Octets: 5
0x00, 0x00, 0x00, 0x00, 0x00

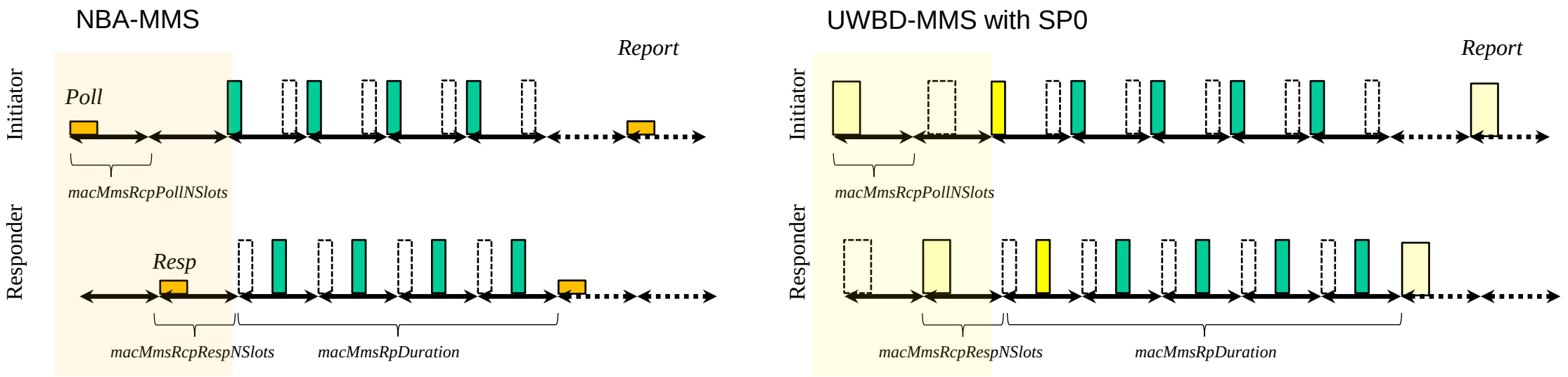
Figure 91—Format of the Message Content field in the One-to-one Response Compact frame when the Message Control field value is zero

Response compact frame content

SP0 (BASIC_PACKET) for control

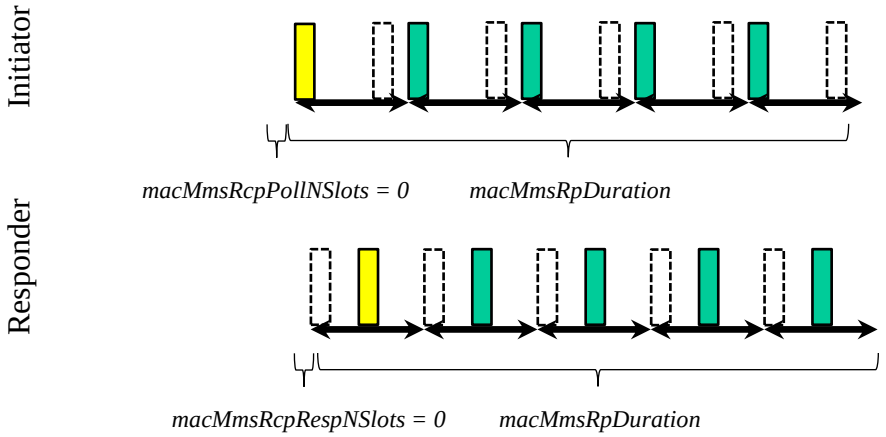
- Poll and Response frames are used to estimate the CFO and timing
- When you want to use SP0 control?
  - When Poll or Response message control field value is not 0.
  - When use case requires Resolvable Private Address (RPA), Public address or Security
  - When setting short-term or long-term operating parameters
- When you don’t want to use SP0 control?
  - For maximum link budget, when only poll and response are needed

Interleaved mode ranging round – NBA vs UWBD with SP0

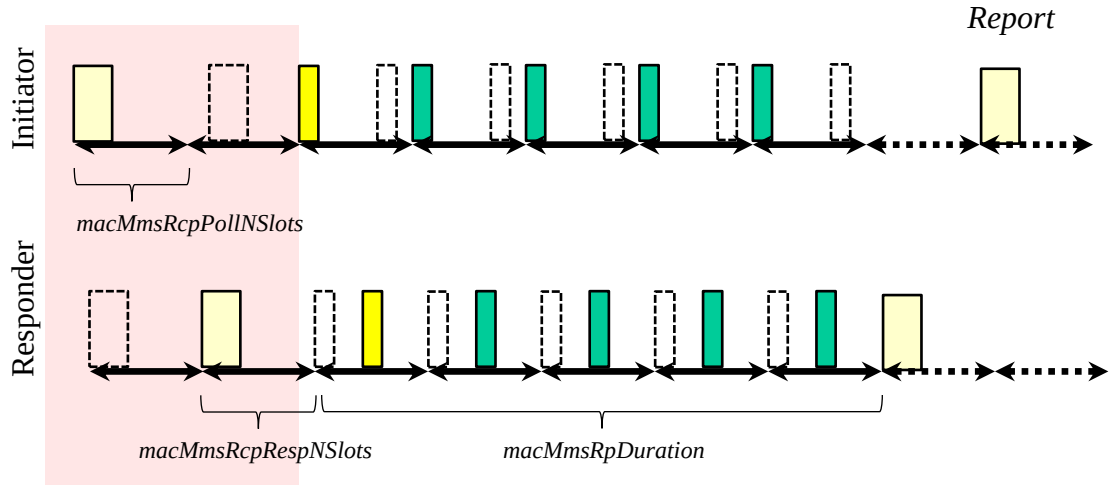


Interleaved mode ranging round – UWBD without SP0 and with SP0

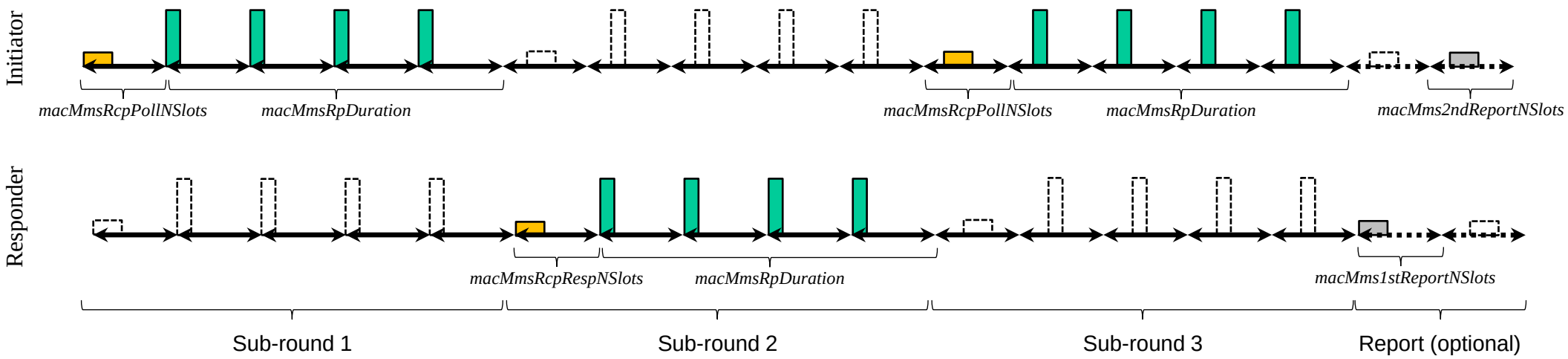
UWBD-MMS without SP0 (*macMmsRcpPoll/RespNSlots* = 0)



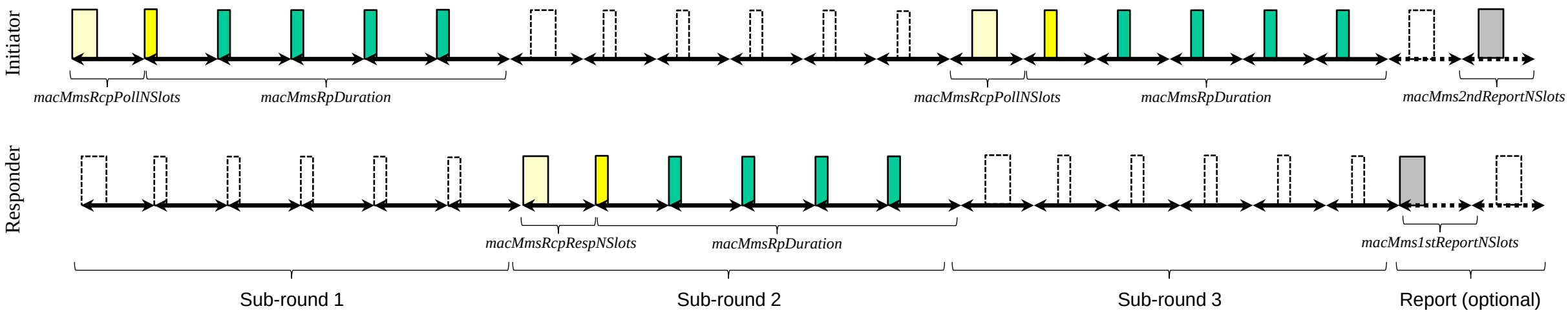
UWBD-MMS with SP0



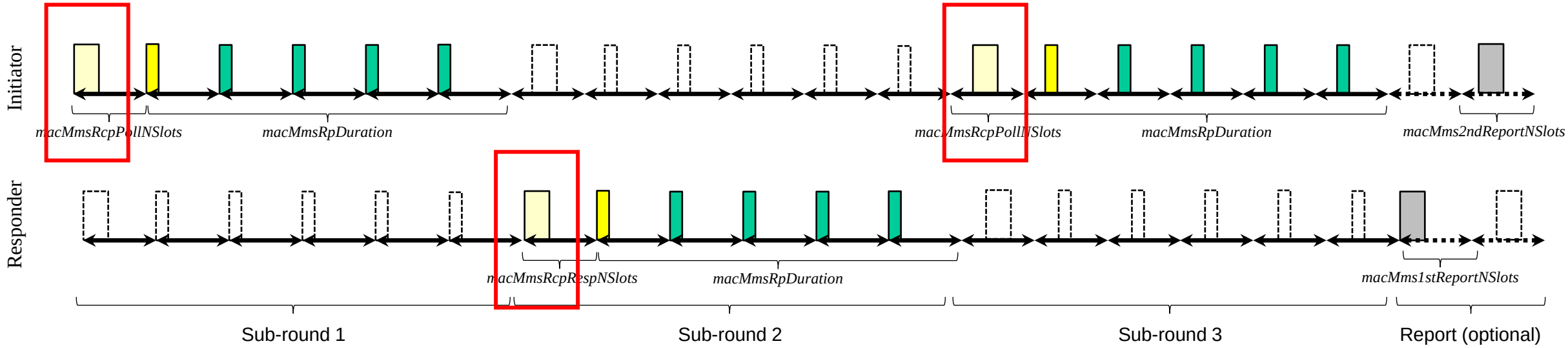
Non-interleaved mode – NBA-MMS
Example with 3 sub-rounds, 4 fragments (10.39.7)



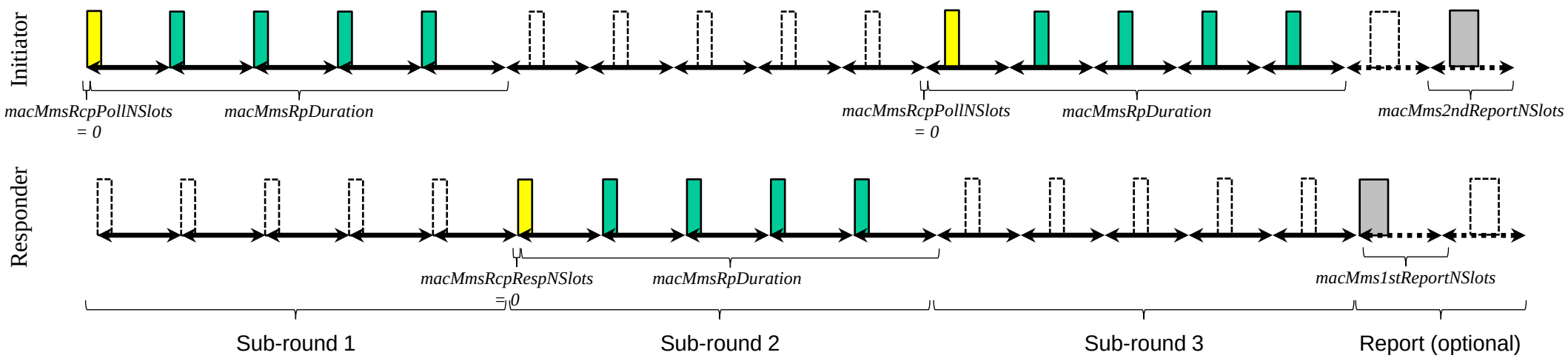
Non-interleaved mode – UWBD-MMS with SP0
Example with 3 sub-rounds, 4 fragments (10.39.7)



Non-interleaved mode – UWBD-MMS with SP0
Example with 3 sub-rounds, 4 fragments (10.39.7)



Non-interleaved mode – UWBD-MMS without SP0
Example with 3 sub-rounds, 4 fragments (10.39.7)



Summary

- Start of Ranging points to the start of SYNC + SFD
- In case of UWBD MMS, the MMS UWB packet has SYNC + SFD
- Poll and Response can be done with higher peak power level SYNC + SFD fragment
- Setting *macMmsRcpPollNSlots* and *macMmsRcpRespNSlots* to zero skips SP0 packets
- SP0 control packets can be used when needed (*Nslots* parameter value 1 – 15)