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

Submission Title: Toshiba Proposal for IEEE802.15.3e CFP (Full Proposal)
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Abstract: This document presents an overview of the full proposal and a MAC proposal for HRCP.

Purpose: To propose a full set of specifications for TG 3e.

Contents

◆ Part 1 - Overview

◆ Part 2 – MAC Structure

Part 1 - Overview

◆ Merits of Close Proximity

◆ Limiting operation to Close Proximity

◆ Mobile and handheld usages

◆ 60 GHz frequency band

◆ Coordination

◆ Superframe

◆ Other management aspects

◆ Data exchange

◆ Appendix: Evaluation criteria listing

Merits of Close Proximity

◆ P2P (Point-to-Point) connectivity is easily implemented

◆ Touch-based connectivity is easily achieved
  – Quick, simple and intuitive operation for everyone
  – No setup procedures needed to establish connection

Short connection time made possible by:

→ quick link setup
→ quick link release
→ data integrity at MAC level

◆ Low latency using simple MAC
  – Removal of unnecessary processes not essential for P2P connectivity
  – Required processes are streamlined for dedicated P2P operation

◆ Robustness against errors and fluctuations
  – No serious throughput degradation nor stability problems

Limiting operation to Close Proximity

◆ Establish nominal operational coverage
- – Implementation dependent
- – Distance coverage of 10 cm when operating at minimum rate (details TBD)
- – Automatic system switch-on function based on fast setup time under 2 msec.

◆ Data rate and connection time
- – Maximum PHY SAP rate per 2.16GHz bandwidth shall exceed that of 15.3c (ie., more than 5.775 Gbps using 64 QAM)
- – Must satisfy the conditions for maximum connection time while also capable of achieving 100 Gbps using at least one mode.

Requirement at 0 cm separation
-- *"touch"* –
→ Data rate = no less than 100 Gbps ←
using 256 QAM with 4x4 MIMO for 2 channels

◆ No interference or co-existence issues
- – Because of the close proximity nature of the wireless propagation, there are no interference or co-existence issues.

Mobile and handheld usages

◆ **Small device form factor**

– Antenna(s) must be small enough to fit inside a small mobile device, such as a smartphone.

◆ **Efficient design**

– System shall achieve efficiency of communications (high throughput, low latency, etc) by keeping the overall design simple.

◆ **Energy efficiency**

– Mobile and handheld systems should be energy-efficient to allow normal operation using battery power.

60 GHz frequency band

◆ Out of the four channels defined for the 60GHz ISM band, channels 1, 2 and 3 should be used for HRCP, either individually, bonded or aggregated (ie., channels 1+3), as these three base channels are allowed by the major regulatory domains (US, EU, Japan, Korea).
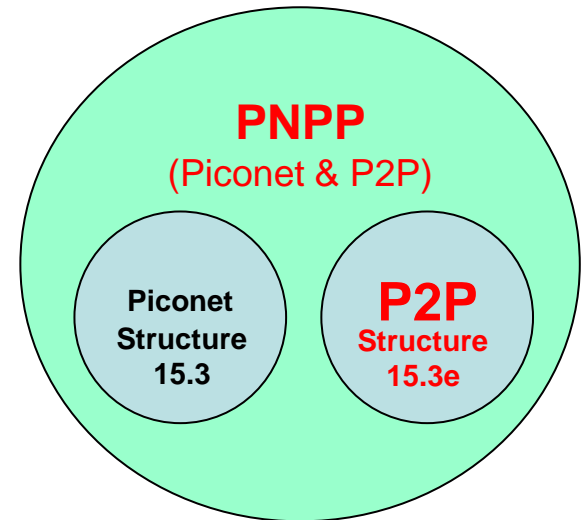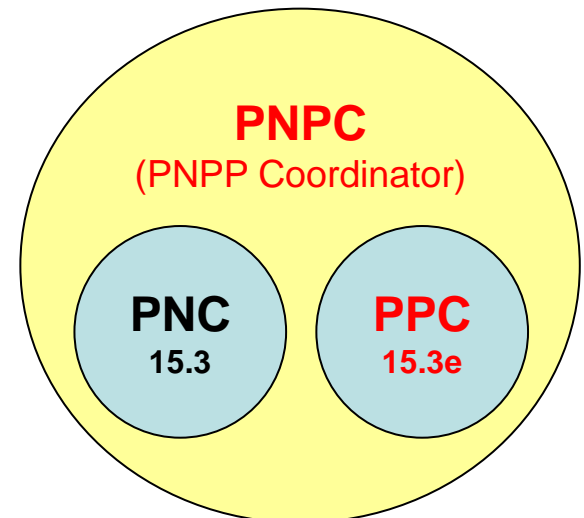
Coordination
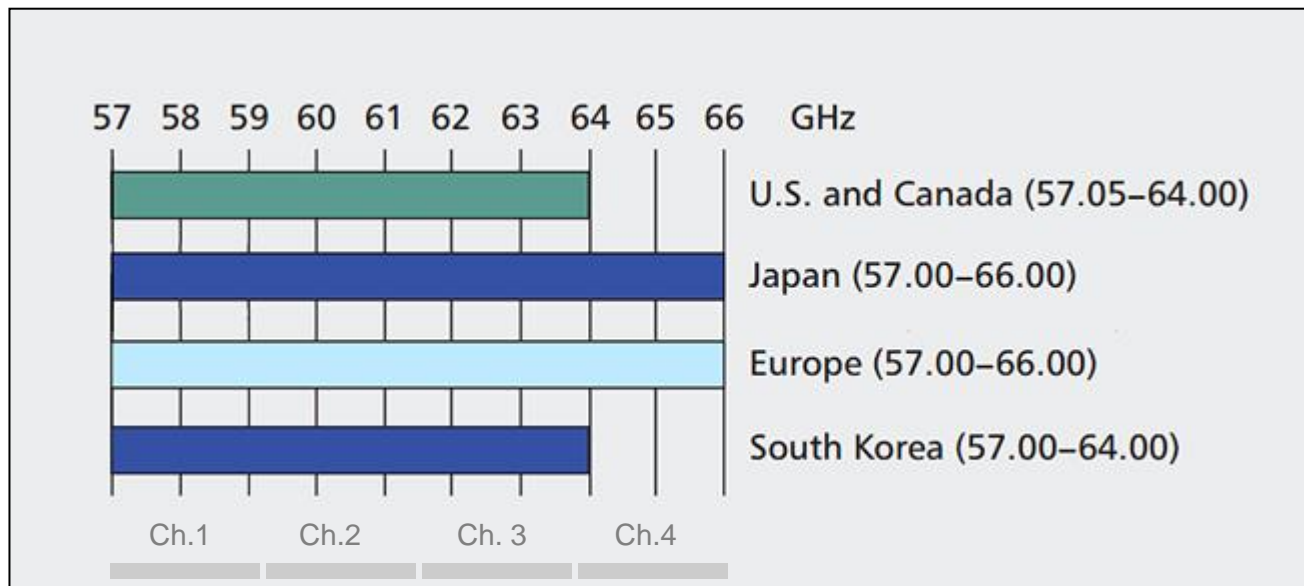
System structure definition

◆ Since the topology is limited to P2P,
   it is not a "piconet" but just a P2P structure
   – Not a PNC but a PPC (P2P Coordinator)

◆ Redundant processes can be removed to
   optimize for P2P connectivity:
   – No coordinator handover
   – No child piconet
   – No neighbor piconet
   – No parent piconet
   – No PNC shutdown
   – No parameter changes in system
   – No periodic exchange of management frames

To realize the aesthetics and purity of P2P, we must
discard redundant processes and procedures.
(This is the spirit of *Wabi-Sabi*.)

PNPP
(Piconet & P2P)

Piconet Structure 15.3

P2P Structure 15.3e

Coordinator definition

PNPC
(PNPP Coordinator)

PNC 15.3

PPC 15.3e

Superframe

◆ No Beacons are sent once connection is established
- No handover or transfer of the coordinator
- No new DEV will join
- No system parameter modifications
- Full bandwidth available

◆ No CTA
- CAP only
- Can have access to full bandwidth since the communications is P2P and there is no need to assign any time division

Other management aspects

◆ No information <u>discovery</u> after connection is established
– Data transfer can start immediately.
◆ No <u>dynamic</u> channel selection
– Default channel is predefined to achieve short connection setup time.
◆ No <u>peer</u> information retrieval and no channel status request
– Fixed P2P connection reduces connection time.
◆ No information <u>announcement</u> to peers and no remote scan
– No need to transmit since the single peer device remains constant.
◆ No <u>stream</u> management
– Short connection time is optimized for a single unique transaction.
◆ No <u>second exchange</u> in Association procedure
– Capability negotiation limited to single exchange to achieve short setup time
◆ <u>Setup</u> time
– Time from first successful reception of all necessary information from the management frame(s) to completion of association by both devices.
◆ No <u>Piconet</u> identifiers
– No exchange of PNID for each session

Data exchange

◆ No Carrier Sense (no CSMA)
  – Close proximity P2P will always have full access to entire bandwidth
◆ No Delayed or Implied ACK
  – Derived from throughput and data integrity considerations
    ◆ Upper layer throughput will be degraded since TX will have to wait for a response
    ◆ Applicable only for isochronous data streams (which are not supported)
◆ No selective repeat (No Block ACK)
  – Derived from throughput and data integrity considerations
◆ Data throughput
  – Shall be calculated at the MAC SAP.

PHY criteria

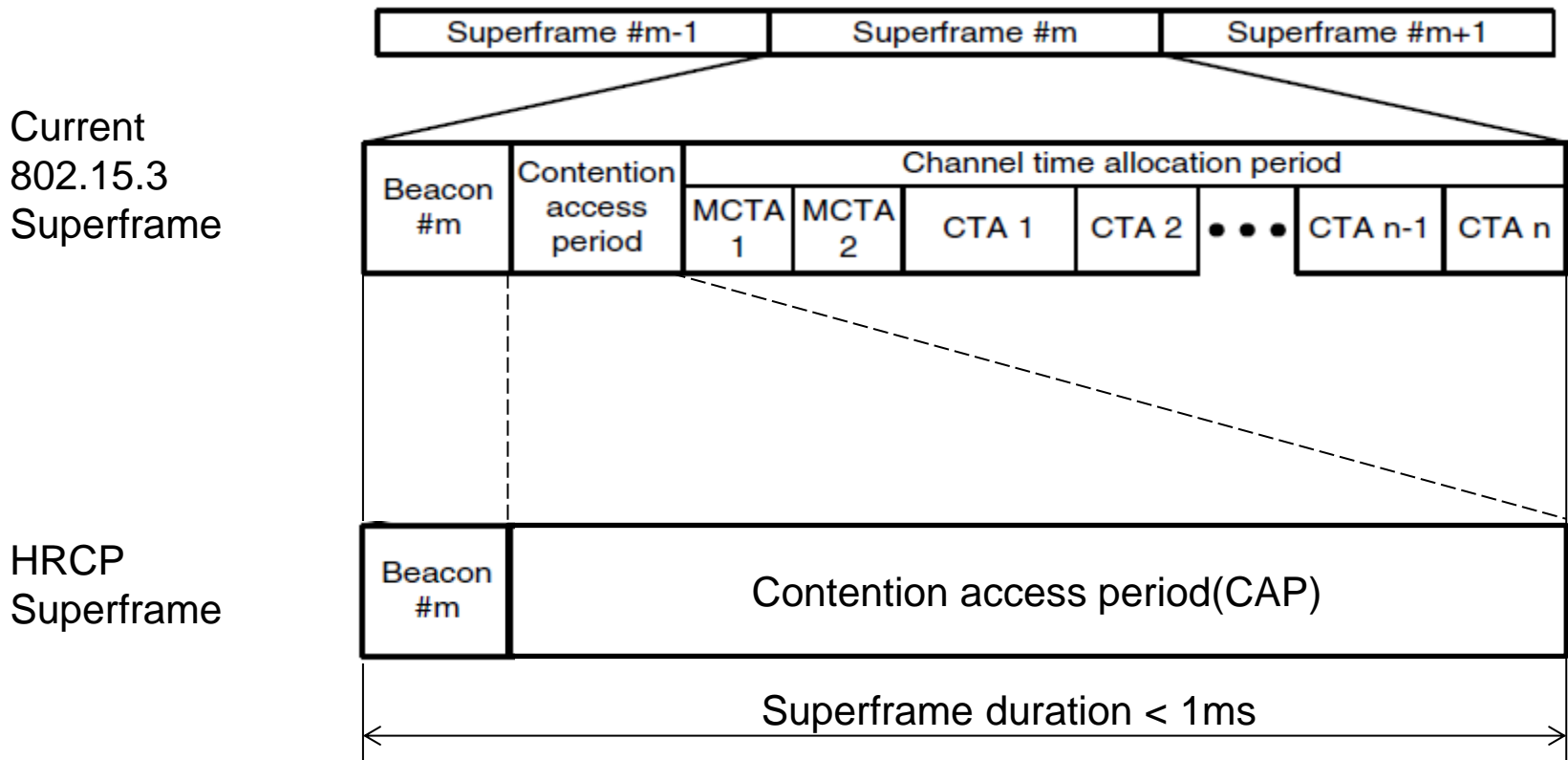|		Location
1	**Communication distance:** Must demonstrate link budget values at a distance of 10 cm based on simulation.	Slide 5
2	**Frequency**: Shall operate within the 60GHz unlicensed band	Slide 7
3	**Interference**: Shall be able to operate in dense environments without mutual interference among 3e devices	Slide 5
4	**Coexistence**: Shall be able to coexist with other systems in the same band when operating without any beamforming technology	Slide 5
5	**Data Rate:** Calculated at the PHY SAP: At least one mode shall be capable of achieving 100 Gbps satisfying the common frequency regulations of US, EU, Korea, and Japan	Slides 5, 7
6	**Antenna form factor:** The antenna used for satisfying the other PHY criteria shall be small enough for placement and operation inside a mobile device, including smartphones.	Slide 6

MAC criteria

		Location
1	**Connection setup time:** less than 2 ms	Slide 5
2	**Definition of "Connection setup time"**: time from first successful reception of all necessary information from the management frame(s) to completion of association by both devices.	Slide 10
3	**P2P**: Operation shall be limited to point-to-point connection between two devices only	Slide 4
4	**No identifiers**: Connection setup shall be performed without exchanging network identifiers (PNID) for each session	Slide 10
5	**NO CSMA:** No Listen before Talk (or CSMA) shall be used prior to transmission	Slide 11
6	**Management frames:** No periodic management frames shall be transmitted after completion of association	Slide 8
7	**Data throughput**: Shall be calculated at the MAC SAP	Slide 11
8	**Error detection and correction**: In the presence of random and burst errors, there shall not be serious throughput degradation nor falling into unstable states	Slide 4

System criteria

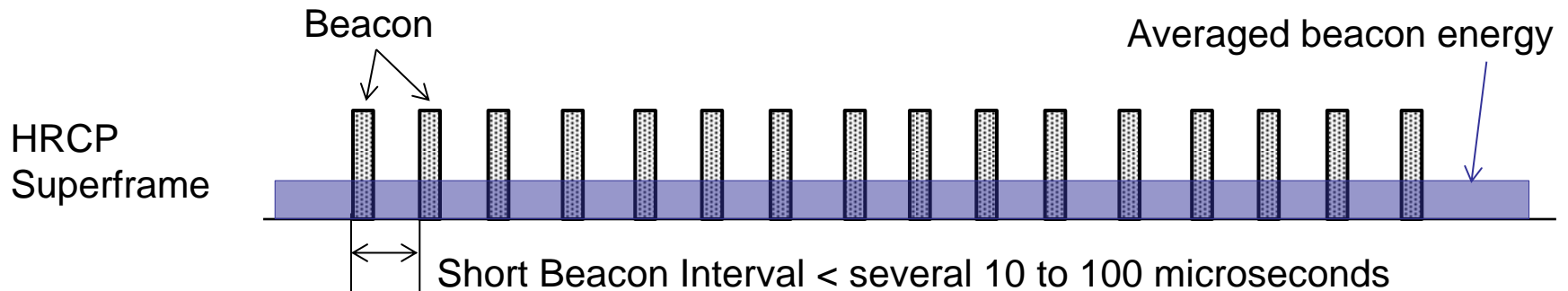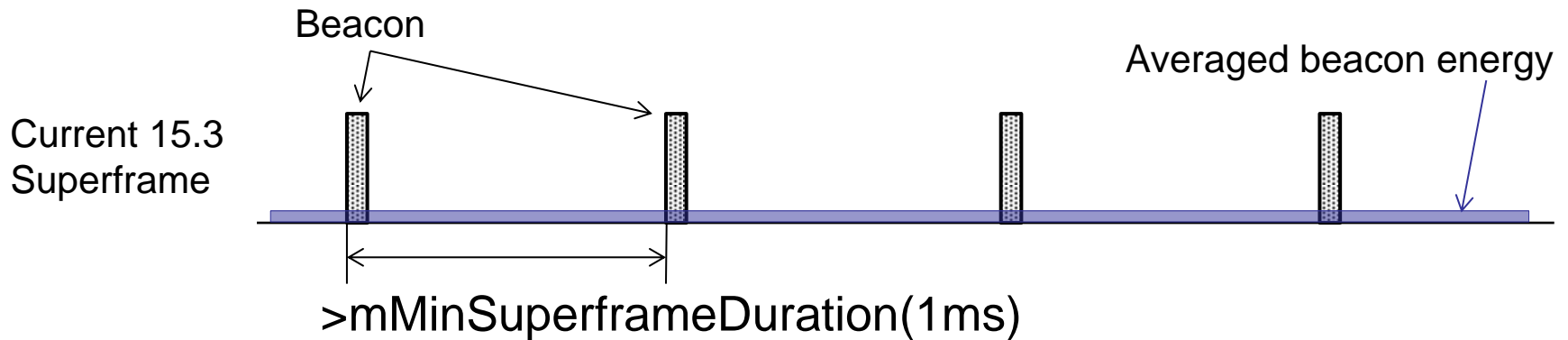|		Location
1	**Touch action**: Bringing the antennas to within about 1 cm shall trigger the two devices to establish connection. Accurate spatial alignment shall not be required.	Slide 4
2	**Disconnection**: Shall be able to disconnect promptly when devices draw apart beyond 10 cm	Slide 5
3	**Efficient design**: System shall achieve high throughput and low latency using simple design.	Slide 6
4	**Mobile** devices should be energy-efficient.	Slide 6

Part 2 - MAC Structure

◆ New HRCP Superframe structure

◆ Shortened beacon interval

◆ Proposed setup procedure without exchange of DevID

◆ Proposed Association/Disassociation procedures

◆ Proposed DevID exchange sequence

◆ Next DevID field in beacon

New HRCP Superframe Structure

Shortened beacon interval

Beacon

Averaged beacon energy

Current 15.3
Superframe

>mMinSuperframeDuration(1ms)

Beacon

Averaged beacon energy

HRCP
Superframe

Short Beacon Interval < several 10 to 100 microseconds

Relatively high energy density from the beacons allows high energy detection
wakeup when the device approaches another.
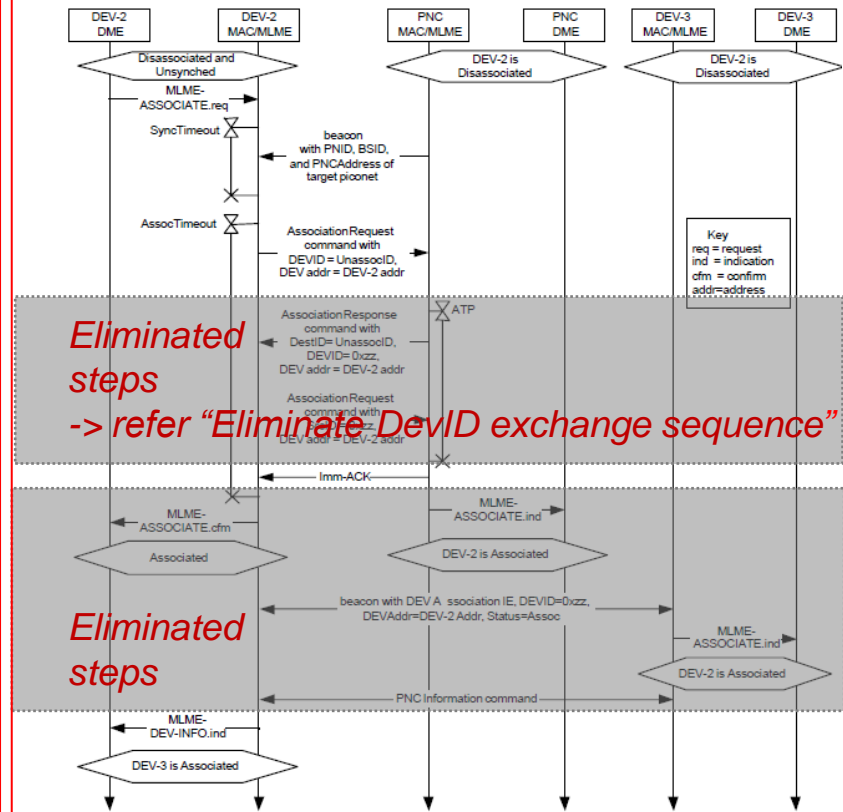→ This makes possible ultra low standby power architecture.
→ Short beacon interval also realizes short setup time. (*See association*).

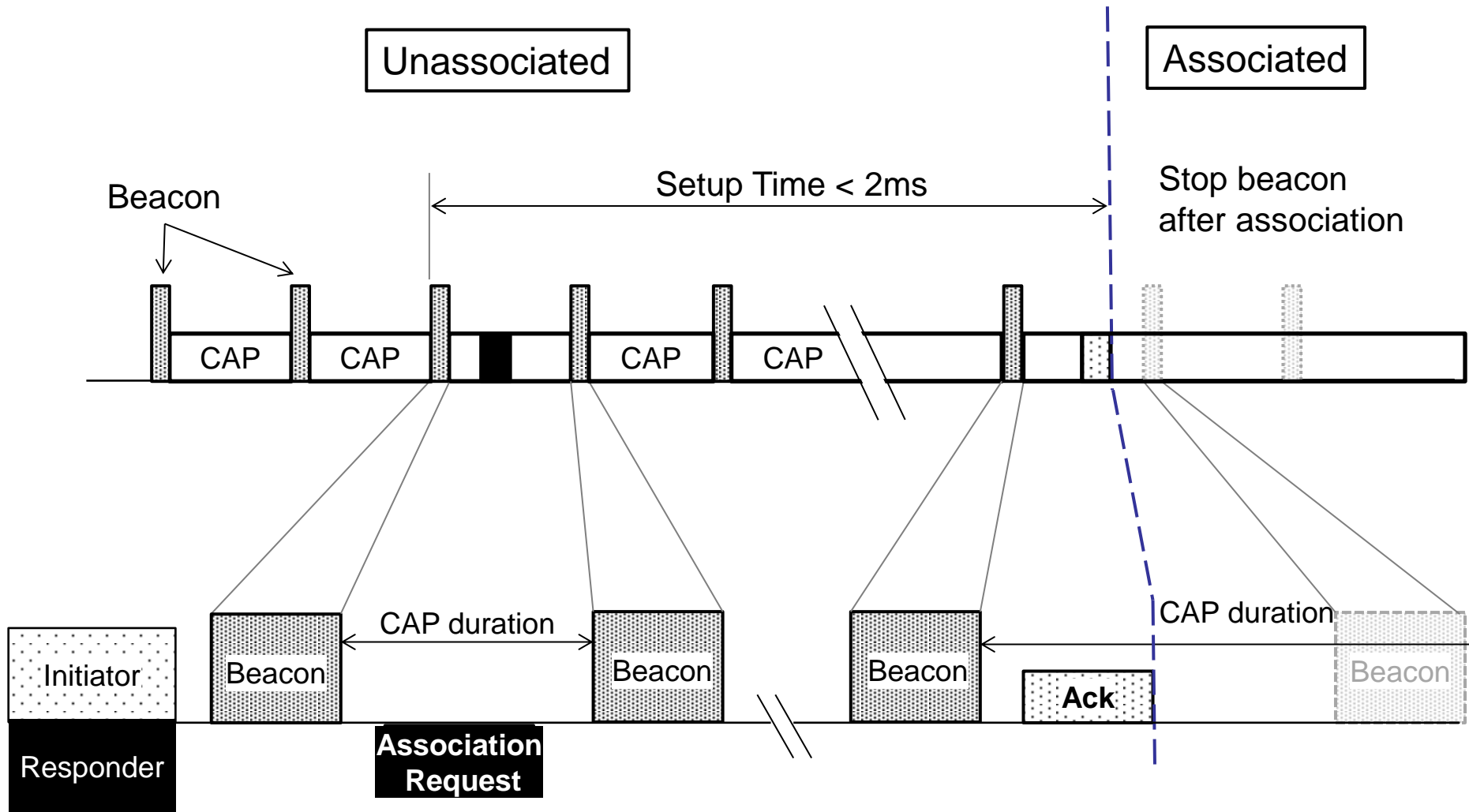# Proposed setup procedure without exchange of DevID

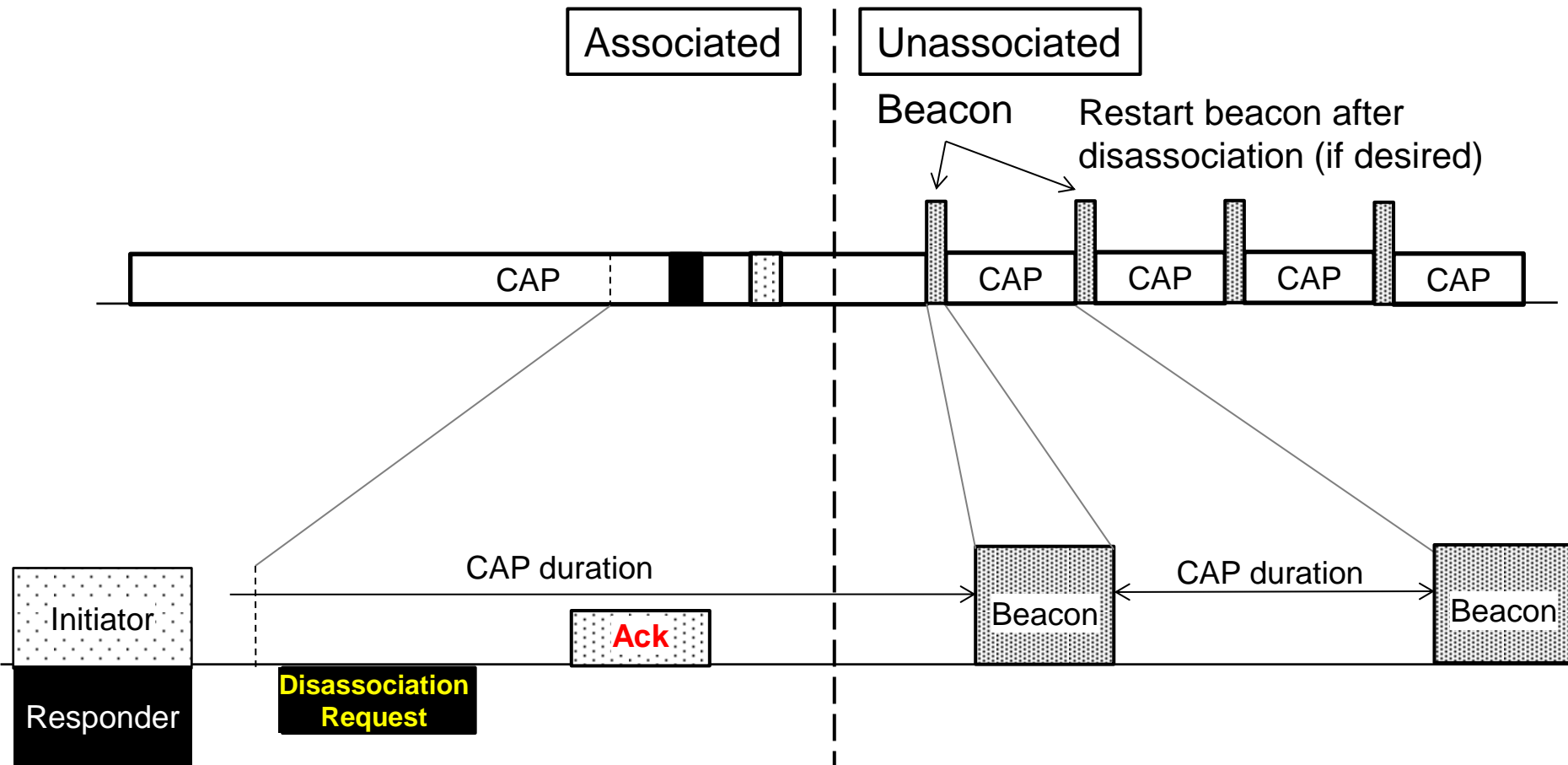*Current procedure:*
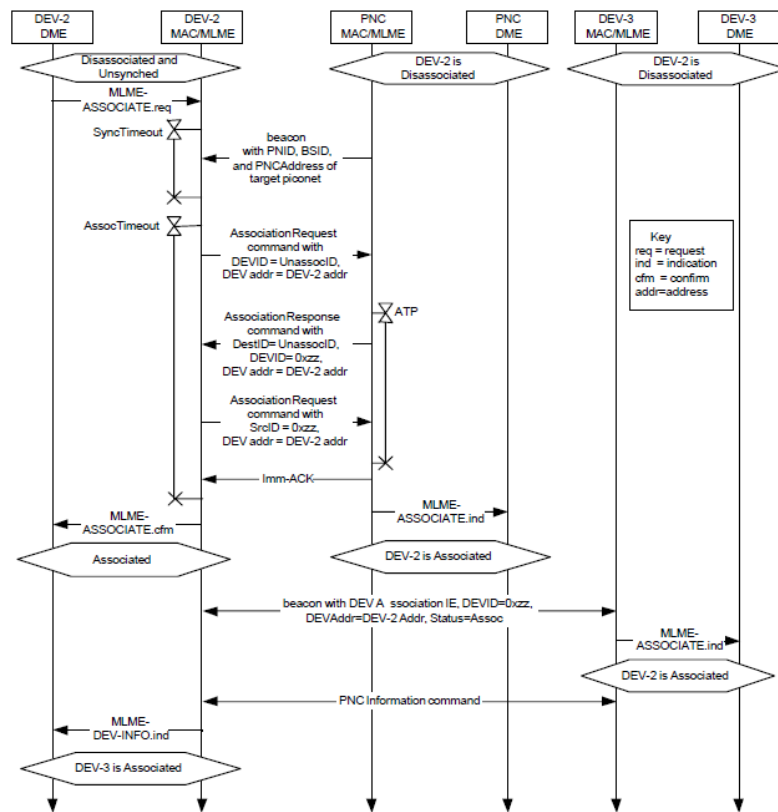
Proposed new simplified procedure:

Eliminated steps
-> refer "Eliminate DevID exchange sequence"

Eliminated steps

Eliminated steps are shown in shade

Proposed Association procedure

Proposed Disassociation procedure
- *Explicit* case -

Associated

Unassociated

Beacon

Restart beacon after disassociation (if desired)

CAP

CAP

CAP

CAP

CAP

CAP duration

CAP duration

Initiator

Ack

Beacon

Beacon

Responder
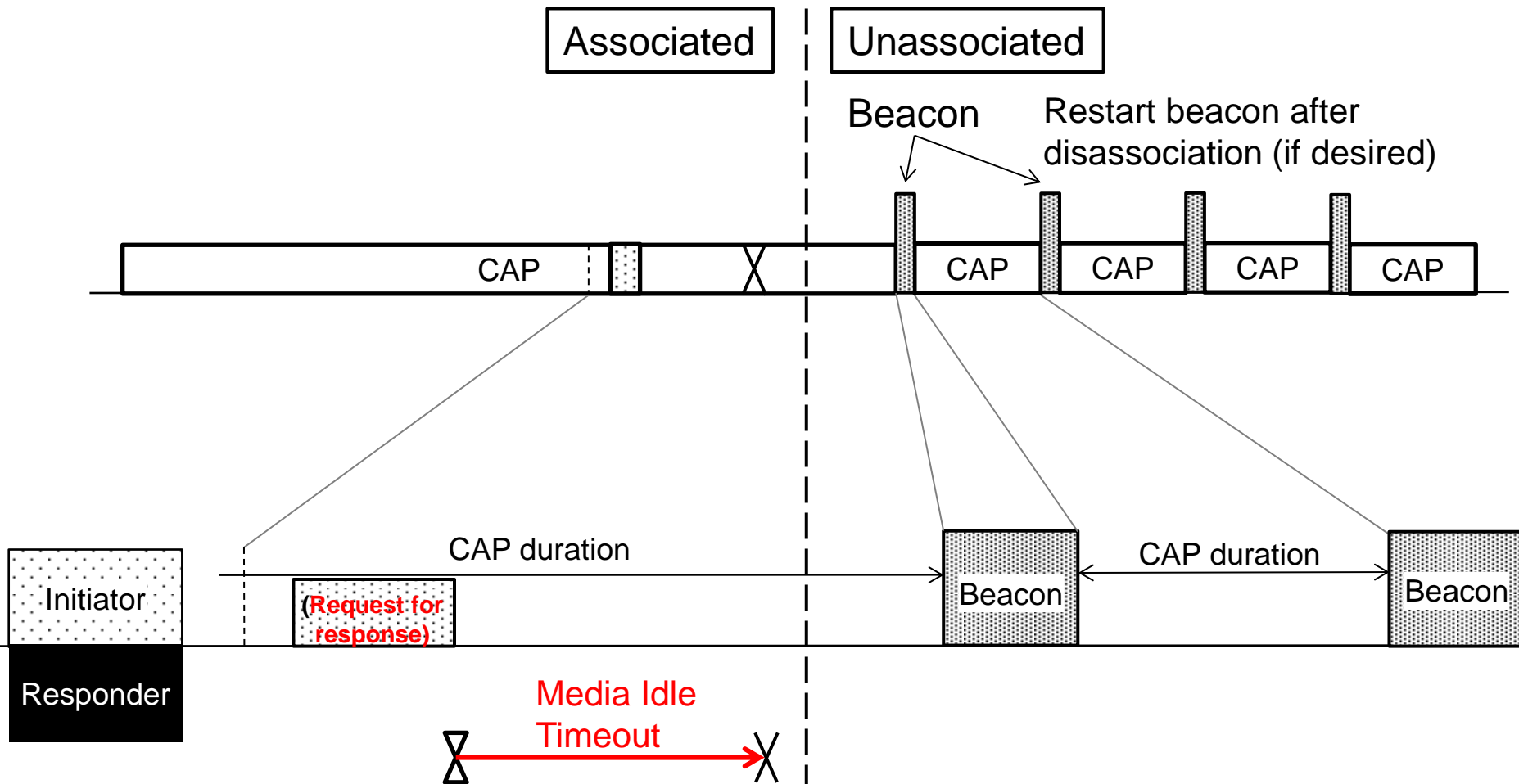
Disassociation Request

Proposed Disassociation procedure
- *Responder* *timeout* -
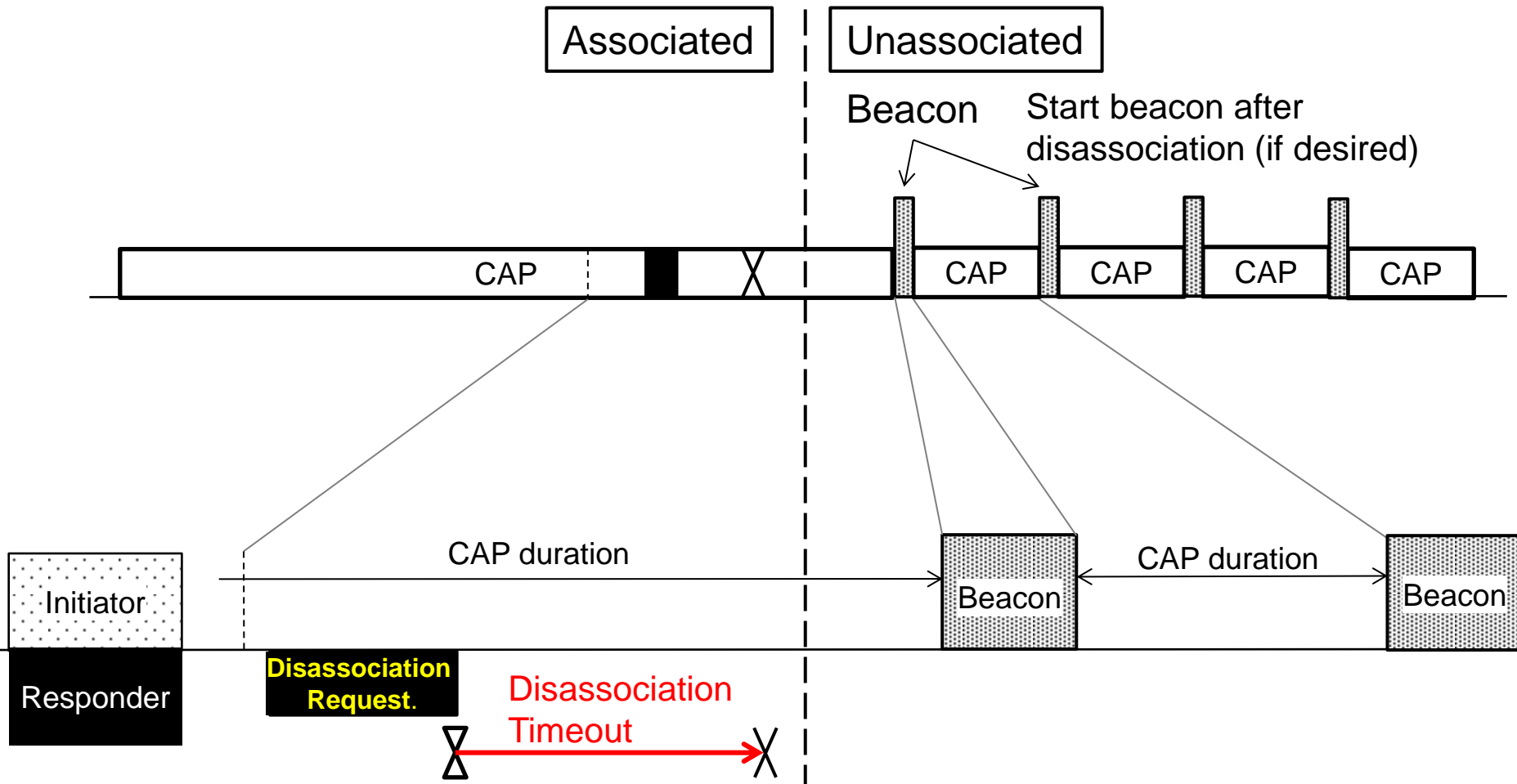
Proposed Disassociation procedure
- Device *disappears* *-*

Proposed DevID exchange sequence

◆ We eliminate some of the association steps in order to realize fast setup time, including DevID exchange sequence.

◆ To achieve this, we introduce a new scheme that notifies the DevID to be used for the next session before the association procedure by means of a new IE in the beacon.

◆ This scheme satisfies the following restriction on DevID reuse as stated in section 8.3.1 of 802.15.3:

– "After the PNC sends a Disassociation Request command, as described in 7.5.1.3, to a DEV, the PNC shall not reuse the same DEVID of that DEV until at least two times the ATP duration for that DEV has passed."

Next DevID field in beacon

◆ Add a "Next DEVID" (1 Octet) field in the beacon frame. This Next DEVID value shows the DEVID which will be assigned to the next associating device.

◆ A device which would like to be associated by PPC shall explicitly assign its DEVID as "Next DEVID" field value by itself.

◆ After association, the beacon carrying the "Next DEVID" field is turned off.

◆ If the associated device disappears within a certain period, the session is unassociated by PPC

◆ When PPC creates a new session, the "Next DEVID" in the new beacon shall increment by one for this next session. The newly associated device is assigned this incremented DEVID by itself.

◆ In case the old device tries to come back to PPC, since the DestID field in PPC's packet frame has already incremented, PPC will refuse the packet of the old SrcID field and reconnection will be blocked.

Blocking a reconnection

New Session after "DevID=N" has disappeared

New Beacon
[Next DevID=N+1]

PPC

Beacon
[Next DevID=N]

PPC

0

Session
Closed

0

association

Reconnection
Refused

associated

DevID=[]

DevID=N

DevID=N+1

[ ]

N

N

N+1

Device

disappeared

New Device

Old Device

N