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

Submission Title: [NICT's MAC Proposal In Response to Call For Contribution]
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Re: [Response to call for contribution of 15.8 PAC

Abstract: [MAC proposal for IEEE802.15.8]

Purpose: [This document is to provide a MAC mechanism]

NICT's MAC Proposal
In Response to Call For Contribution

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Common Mode Proposal

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Common Mode in TGD

As described per TGD:

- *Common mode (e.g., for discovery and communication) shall be supported for interoperability.*

- *Common mode used in different frequency bands needs not necessarily be the same.*

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Proposed Common Mode (1)

- There shall be one and only one common mode at each frequency band that is dedicated to PAC.

- A common mode shall use a assigned fixed RF channel, and have fixed PHY parameters including modulation, channel coding, and data rate.

- All PDs shall be able to operate at the common mode.

Reason: Fixed RF channel and PHY parameters guarantee interoperability among PDs.

Proposed Common Mode (2)

Common mode shall give the highest priorities for the following operation.

- Broadcasting/sending emergency message.

  – *IEEE 802.15.8 shall support prioritized services including emergency services with highest priority*.

- Initiating a PAC group through sending short signal/message.

  – *Energy-efficient discovery(e.g. low duty cycle)*
  – *Support high PD density and high discovery traffic*
  – *Prioritized access to discovery*

Proposed Common Mode (3)

- Any PD is allowed to send emergency message through common mode.

- Any PD is allowed to send short signal/message (TS: triggering signal) to initiate a PAC group.

  - *To support a fully distributed, decentralized, and self-organized system.*
  - *To provide a fully distributed scheduling mechanism.*
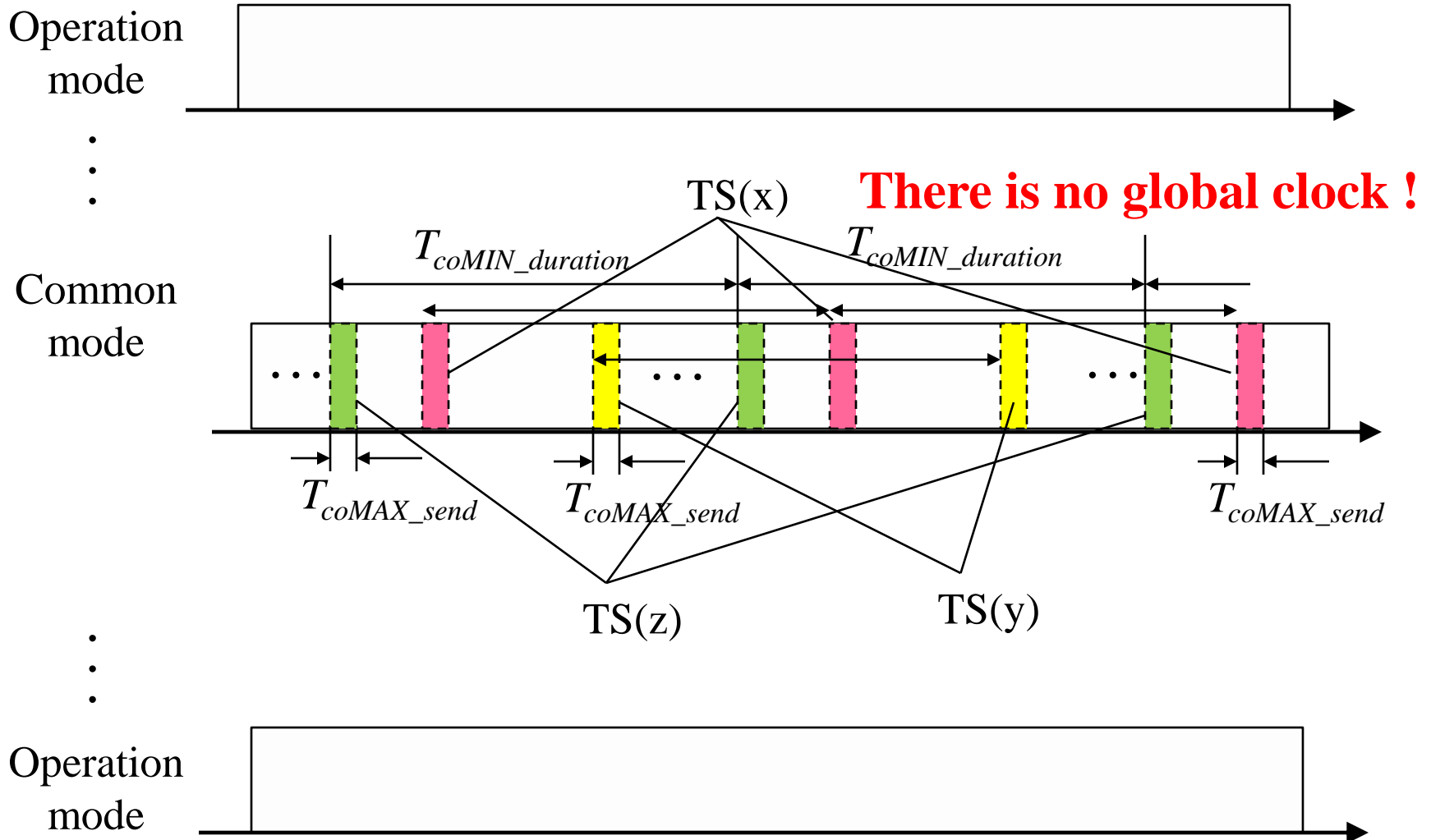
Management of Common Mode

Policy of Using Common Mode

- Besides emergency message transmission, to decrease scanning latency, it is desired to use common mode only for starting discovery, or for initiating a PAC group.

- Common mode should not be used in operations or communications for an established PAC group.

Management of Common Mode (Discovery signal)

1. There is no global clock for common mode. An initiator PD (I-PD) broadcasts a short signal/message on its own clock. Hereafter, we refer to the short signal/message broadcasted over common mode as a trigger signal (TS).

2. Length of a TS that is broadcasted via the common mode shall be within the maximum length T_{coMAX_send}. Re-broadcasting of a TS shall be after a minimum duration $T_{coMIN\_duration}$.

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Illustration of Constraint 2

Operation mode

Common mode

There is no global clock !

TS(x)

$T_{coMIN\_duration}$

$T_{coMIN\_duration}$

T_{coMAX_send}

T_{coMAX_send}

T_{coMAX_send}

TS(z)

TS(y)

Operation mode

Management of Common Mode (continue) (Active discovery Scan)

3. An I-PD shall perform CCA before broadcasting a TS. The minimum CCA time is T_{coMIN_cca}.

   A) When CCA reports a clear channel at time t_k, the I-PD shall start broadcast of a TS at $t_k + T_{coMIN\_duration}$ and stop broadcast after broadcasting the last TS at $t_k + N_{co\_send} \times T_{coMIN\_duration}$.

   where, N_{co_send} is an integer randomly selected within [1, N_{coMAX_send}], and N_{coMAX_send} is the maximum number that a TS can be repeatedly broadcasted in an iteration. After an iteration, N_{co_send} is reset for the next iteration.
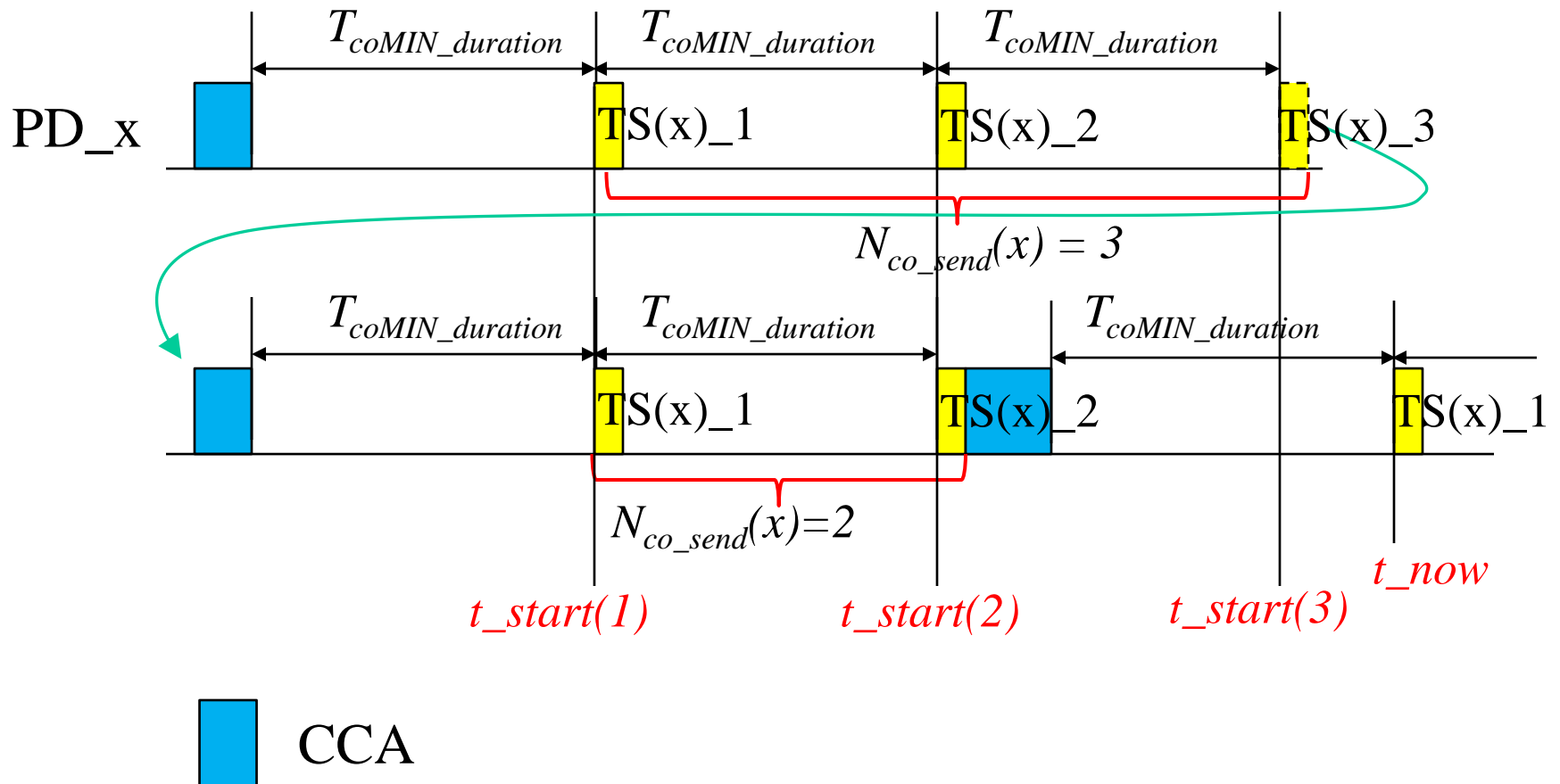
Illustration of Constraint 3 A)

PD_x

$T_{coMIN\_duration}$ $T_{coMIN\_duration}$ $T_{coMIN\_duration}$

TS(x)_1   TS(x)_2   TS(x)_3

$N_{co\_send}(x) = 3$
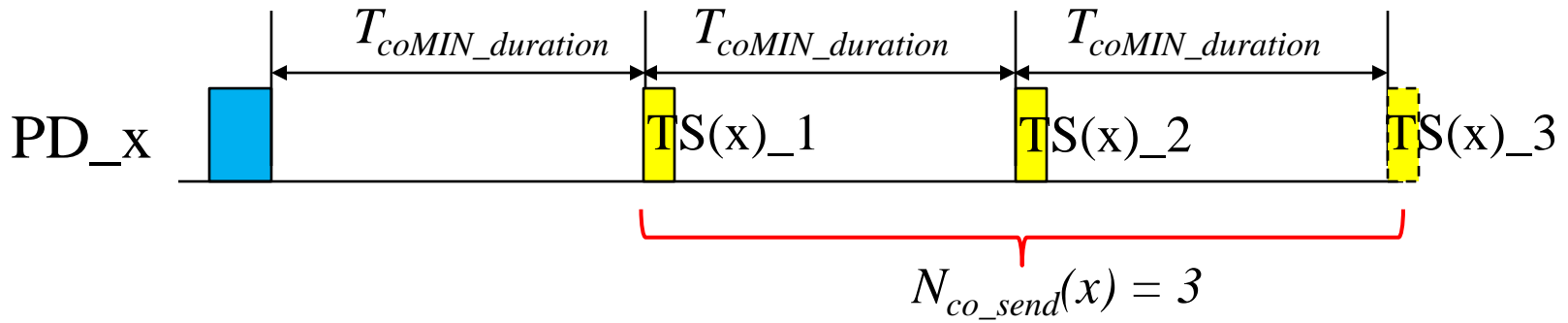
CCA

Management of Common Mode (continue) (Active discovery scan - continue)

B) After 3A), the I-PD shall perform CCA again before further broadcasting. When CCA reports a clear channel, the I-PD repeats (iteration) procedure 3A) again.

C) Procedure of 3B) will be iterated until the upper layers stop the iteration.

D) In each iteration, the group clock provides the information of start time, t_start, of TS which is synchronized to the first broadcasted TS, as well as the information of the current TS time, t_now. The latter is the start time of TS in the current iteration.

Illustration of Constraint 3B, 3D

$T_{coMIN\_duration}$ $T_{coMIN\_duration}$ $T_{coMIN\_duration}$

PD_x

TS(x)_1   TS(x)_2   TS(x)_3

$N_{co\_send}(x) = 3$

$T_{coMIN\_duration}$ $T_{coMIN\_duration}$ $T_{coMIN\_duration}$

TS(x)_1   TS(x)_2   TS(x)_1

$N_{co\_send}(x) = 2$

t_start(1)   t_start(2)   t_start(3)   t_now

CCA

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Emergency Message

- − PD shall broadcast emergency message directly via common mode under constraints 2-3 when required (e.g., asked by upper layer).

- − An emergency message could have a maximum length of T_{coMAX_send} multiplied by m (integer).

- − The repetition interval of an emergency message could be $T_{coMIN\_duration}$ divided by k (integer).

- ✓ E.g., 1 ≤ m ≤ 3 and 2 ≤ K ≤ 4.

Superframe Proposal

Proposed Superframe Structure
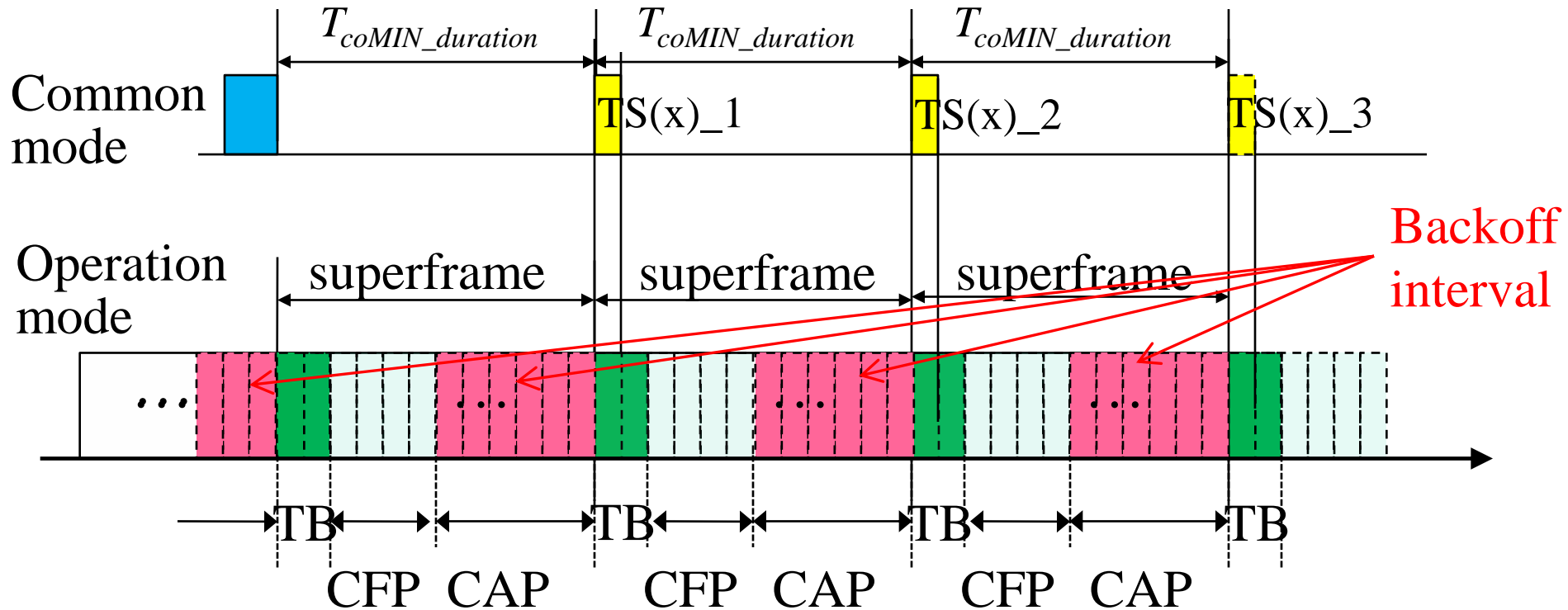
- Operation within an operation mode is based on a superframe structure, which includes a temporary beacon (TB), CFP, and CAP. The clock of TB is synchronized to the first TS.
- **The length of a superframe is equal to $T_{coMIN\_duration}$**

Association Procedure

Association Procedure

i.   The I-PD broadcasts an invitation (active scanning) with TS including information of necessary IDs, selected operation mode (including channel), and a group clock.

ii.   When a joiner PD (J-PD) scans the invitation (passive scanning) at common mode, it moves to the selected operation mode announced in (i). Accounting from the start of TS, the joining PD waits for a duration of TB+CFP. Then, it sends joining request including its ID information with a random backoff within a duration of CAP.

Association Procedure (continual)

iii. When a J-PD scans the TS in an iteration, it should calculate the difference between t_now and t_start. If t_start is within a CAP, the J-PD takes random backoff between t_start and the end of CAP and sends joining request. If t_start is out of a CAP, it waits until the next CAP before sending request.

iv. I-PD scans the selected operation mode (passive scanning), registers the J-PDs and distributes a list of the registered PDs within the temporary beacon (TB) at the selected operation mode.

v. J-PDs that had sent joining requests but are not included in the distributed PDs list should repeat the process of (ii) and (iii).

Illustration of Constraint (iii)
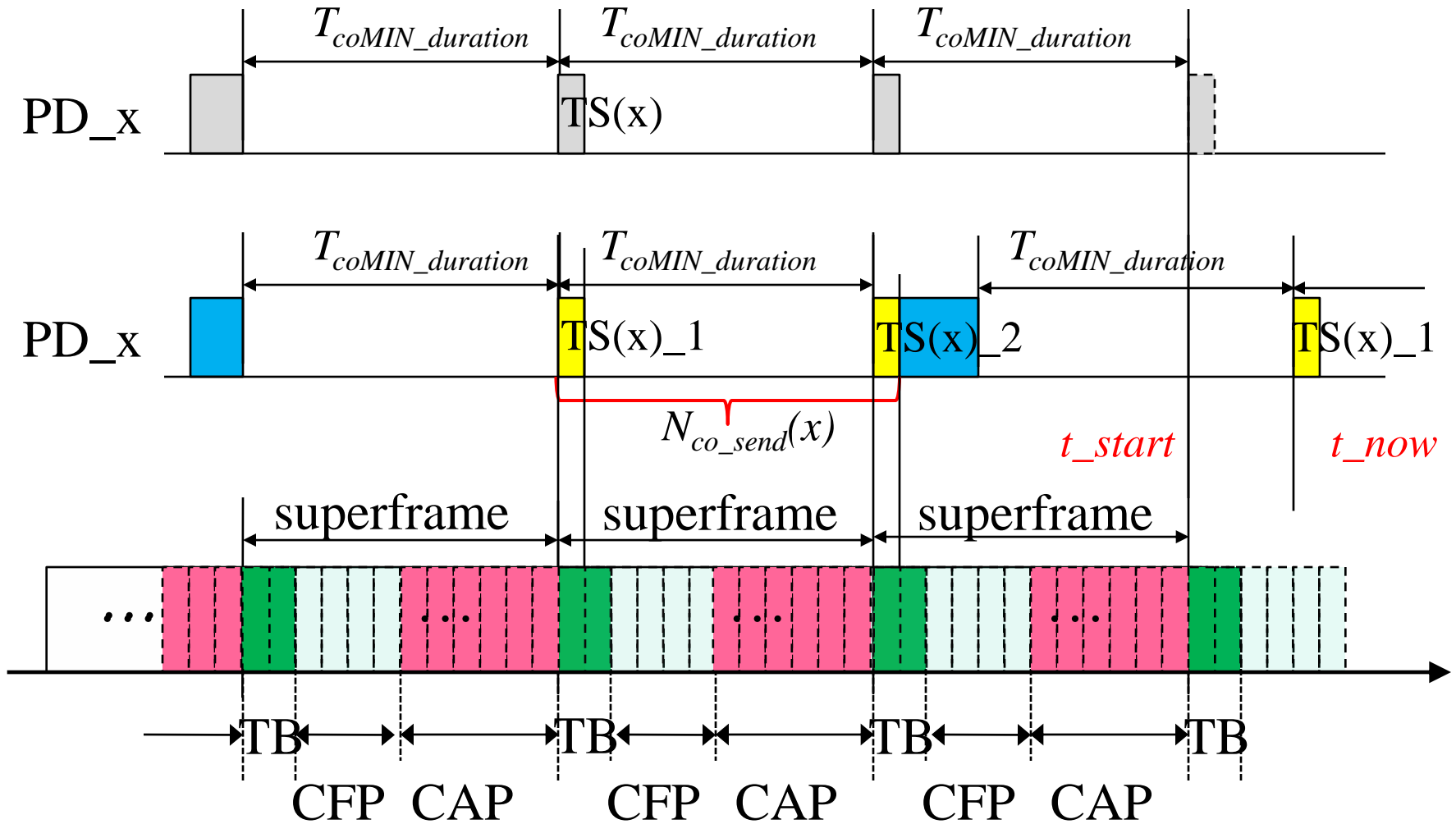
Group Operation

Group Operation

① Any I-PD that initiated a group will act as a temporary leader of the formed group (***distributed and self-organized control***). Moreover, the role of leader can be changed among PDs in the group.

② Communications within the formed group are undertaken using an selected mode and can move to the other selected modes.

③ Coordination may performed among neighbor groups for channel sharing or interference avoidance.

Illustration of Group Forming
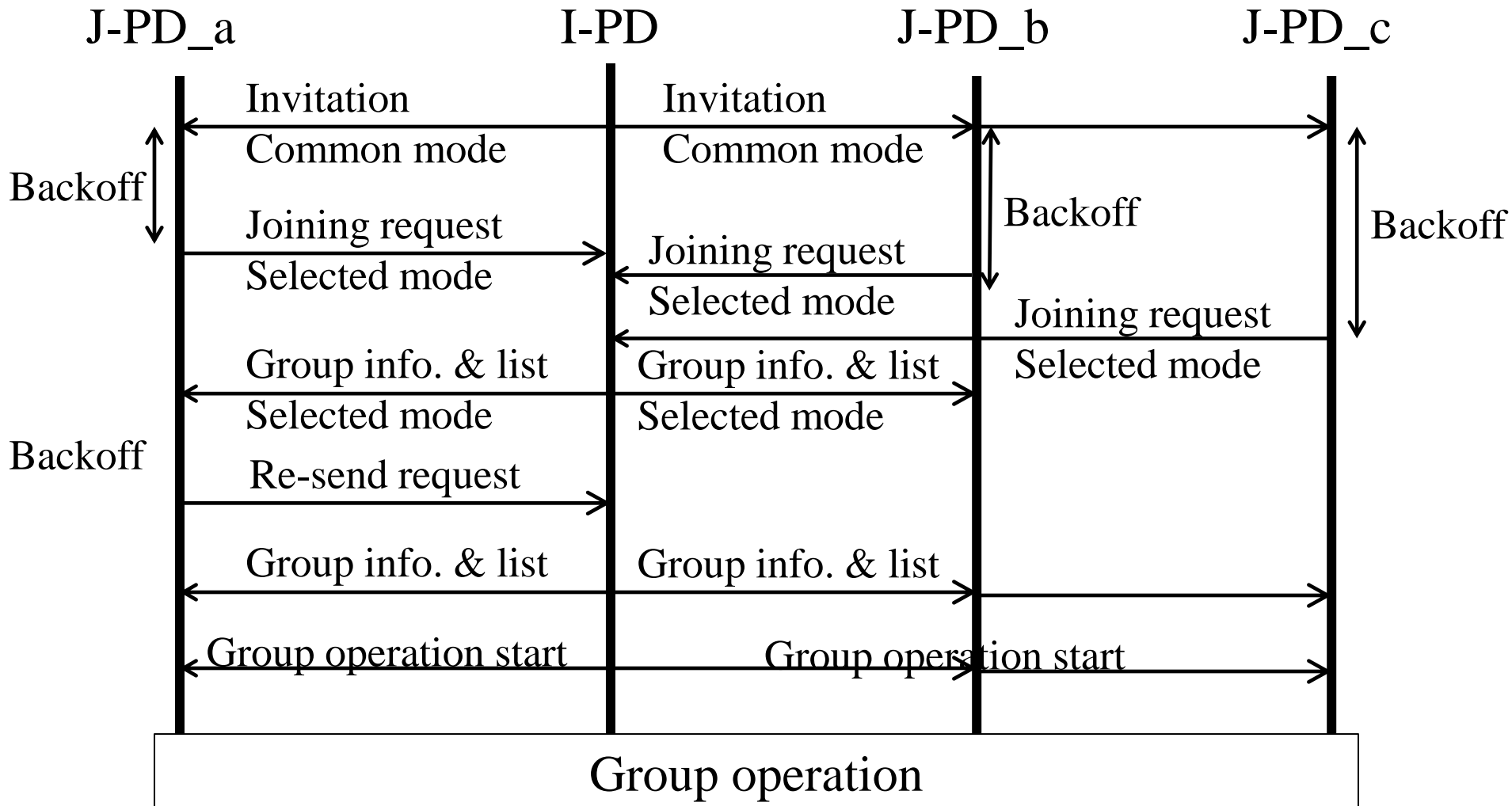
Group Operation Example

- With the selected operation mode, a temporary leader broadcasts temporary beacon (TB) to coordinate group operation.

    – The clock of TB is synchronized to the TS.

    – TB should have similarity with TS and the length of TB is larger than TS.

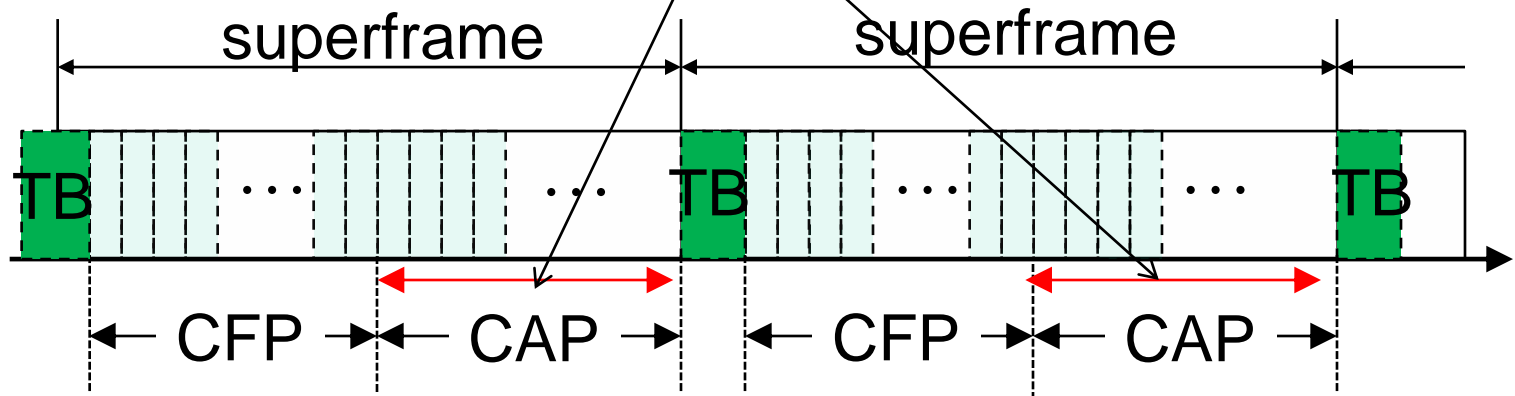   – The temporary leader updates the group list and broadcast within the TB.

Superframe Structure Example

Group forming:
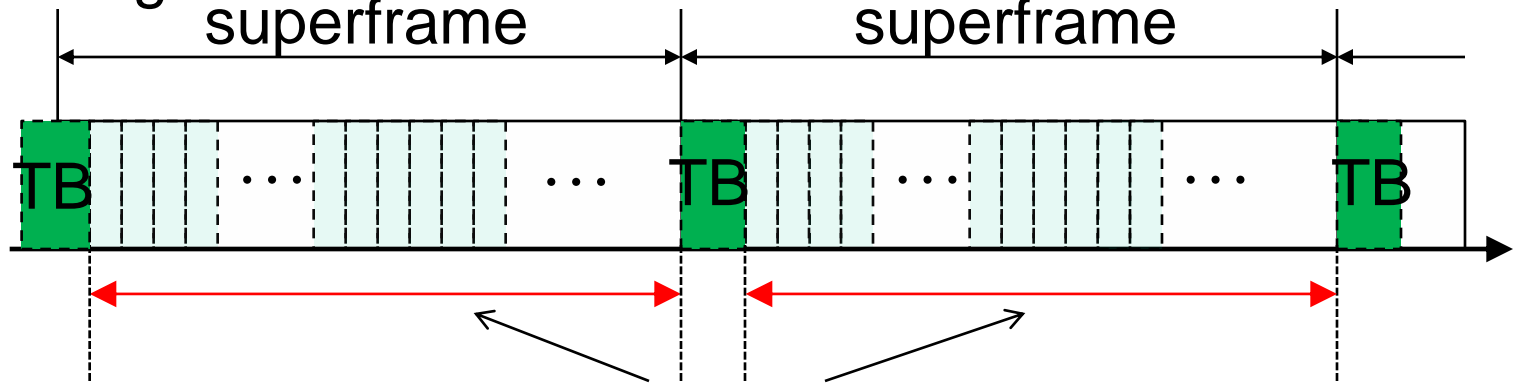
Group operation:

Joining requests backoff interval

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Advertisement Procedure

a. Advertising PD broadcasts information of operation mode, clock, category of advertisement, etc. within TS via common mode under constraints 2-3.

b. Receiving PDs scan the advertising information with own filters via the common mode.

c. Advertising PD broadcasts advertisement message via the selected operation mode.

d. Receiving PDs receive the advertisement message via the selected operation mode.

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Illustration of Advertisement Procedure

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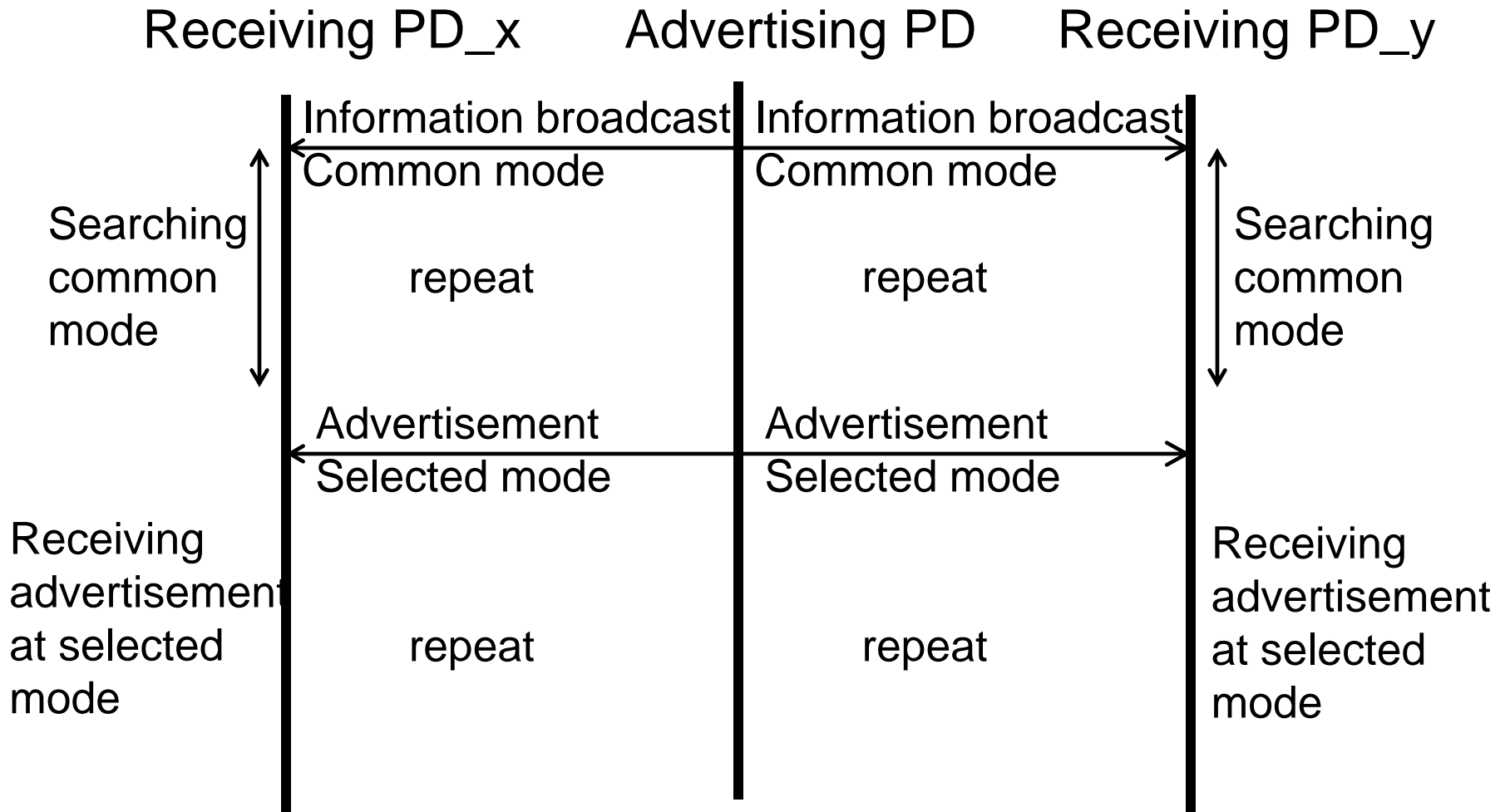
Conclusion Remarks

- Proposals are given for
  - Common mode
  - Common mode management
  - Superframe structure
  - Discovery
  - Association
  - Group operation