

Project: IEEE 802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [P802.15.4.e Preliminary proposal : AFA provisioning]

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Re: [IEEE P802.15-08-0373-01-004e-call-for-proposals]

Abstract: [Additional AFA(Adaptive Frequency Agility) functionalities, for future provisioning of IEEE802.15.4 PHY/MAC.]

Purpose: [This submission is a proposal of MAC amendment responding to CFP of IEEE802.15 TG-4e.]

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Purposes of Proposal

Purposes include variety of aspects

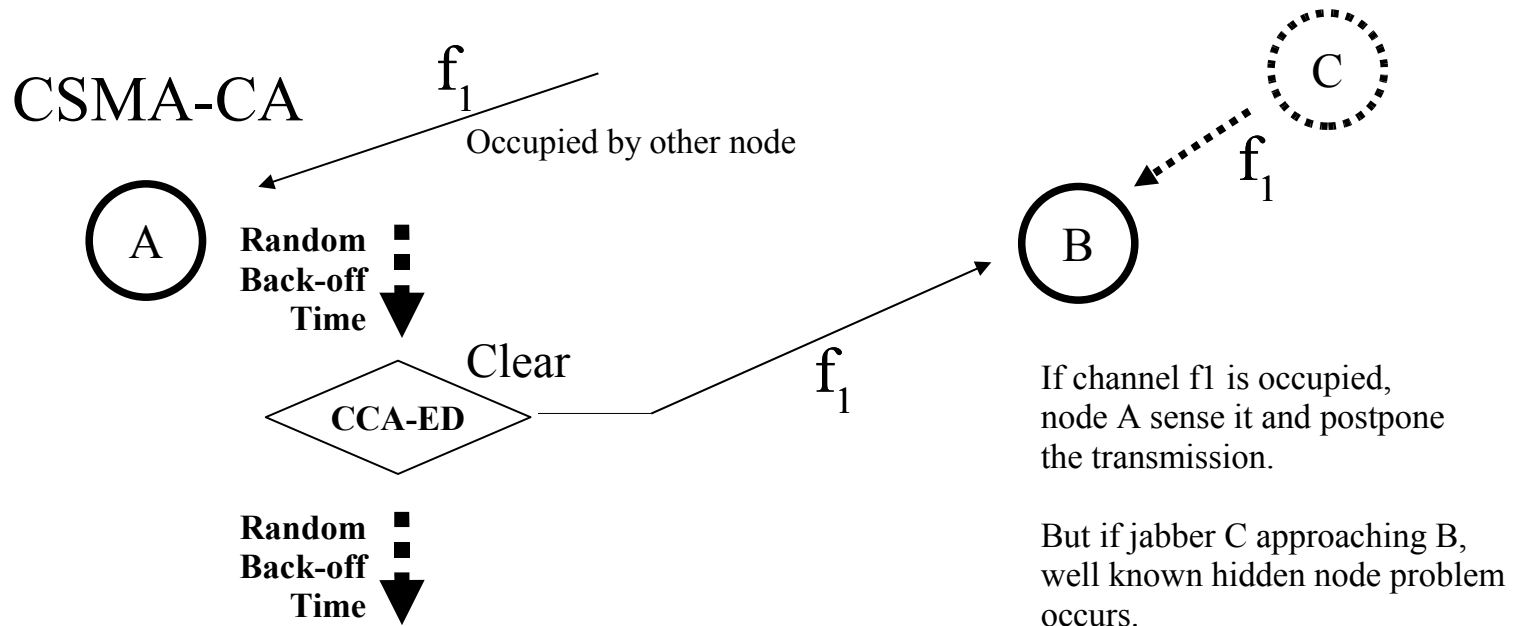
AFA (cross layer multi-channel) functions,
using PHR-extension, new MAC Primitives,
and NHL channel-coordination,
are able to provide,

- (1) Collision Avoidance
- (2) Frequency Agility and/or Selection
- (3) Adaptive Channel Usage
- (4) Channel Blacklisting
- (5) Fault localization and/or Isolation

Conventional 802.15.4 Mechanisms

Conventional Art (1)

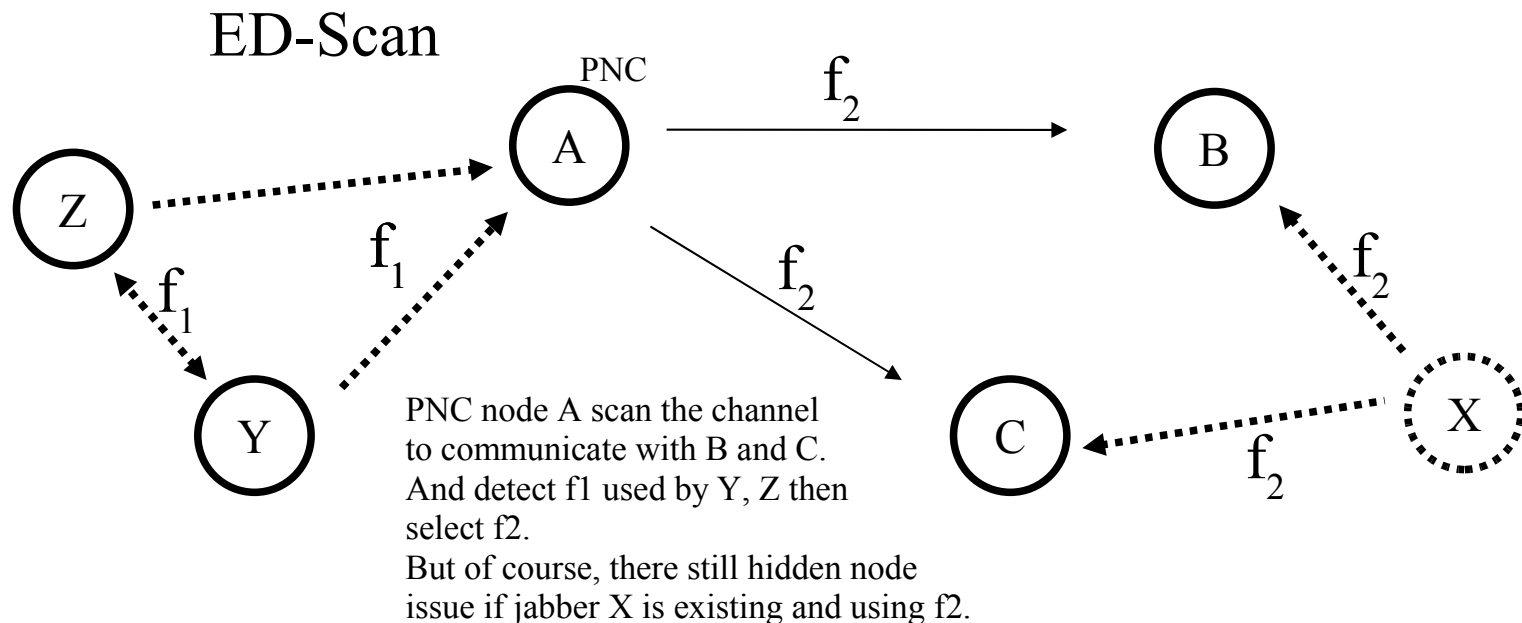
Collision Avoidance by CSMA-CA



- Sufficiently effective mechanism if traffic is low enough.
- Time-critical, reliable and deterministic applications need more.

Conventional Art (2)

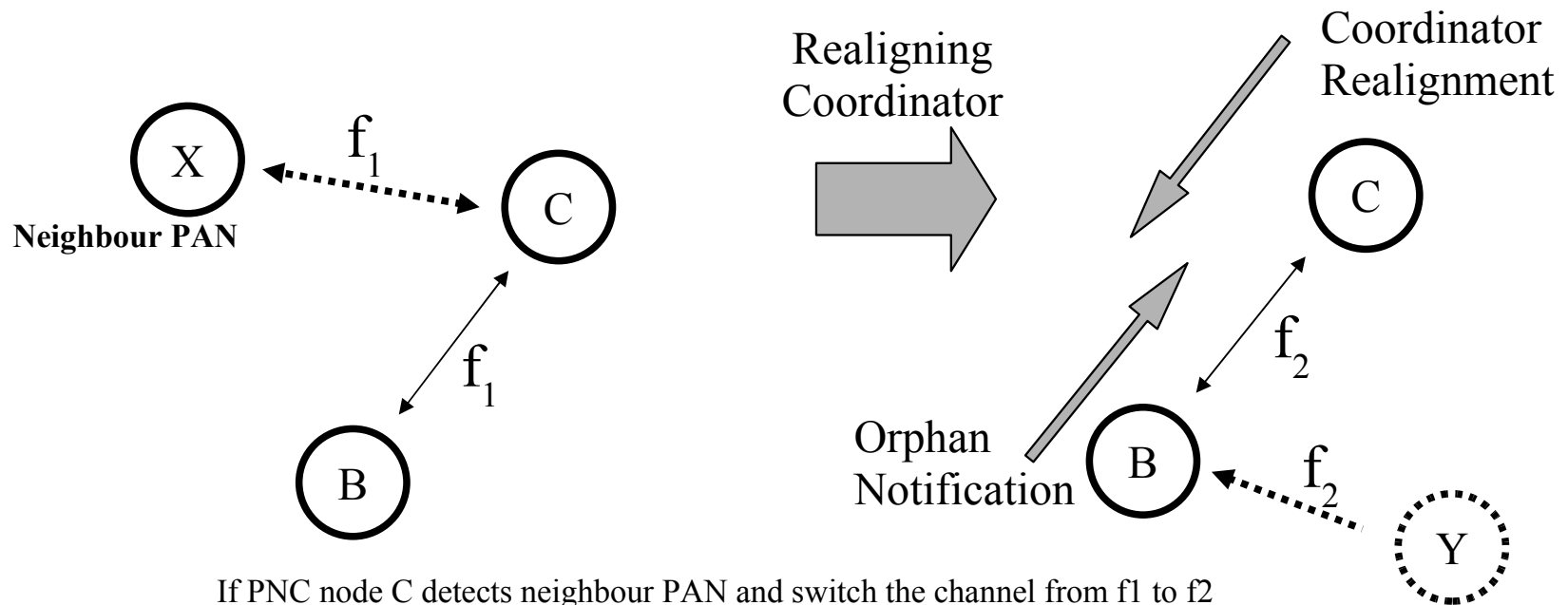
Frequency Channel Selection using ED-Scan



- Sufficiently effective mechanism if node density is sparse enough.
- Reliability Conscious applications need more to select channel.

Conventional Art (3)

Channel switching by Orphan Scan



If PNC node C detects neighbour PAN and switch the channel from f_1 to f_2 node B gets lost and Orphan scan mechanism is initiated.

But again if jabber Y is locating near node B, channel switching doesn't work properly.

- Sufficiently effective mechanism if altered channel is proper.
- Reliability Conscious applications prefer more to select channel.

Summary of Proposal

PHY Header Extension for AFA

PHY Header Extension for AFA in case of 802.15.4d (1)

Modification of PHR Length Field

Current : Length 7 bits + Reserved 1 bit

Modification : Length 7 bits + PHR Extension 1 bits

Addition in PHR structure

TX Channel Table

→ Length : 3 Octets + 1 Octet Control bits

→ 24 Entry for each 200kHz 1mW/10mW sub-channel

→ 1 bits for each entry

→ Value: 1bit, indicating

Clear/Busy , or AFA scheduled TX channel, or other

Favourable Usage

→ Inform status on other TX channels or TX schedule to Peer nodes

PHY Header Extension for AFA in case of 802.15.4d (2)

		Octets			
		1	3	1	variable
Preamble	SFD	Frame length (7 bits)	Extension Exist (1 bit)	TX Ch. Table 24 Ch. x (1 bit)	Control bits (8)
SHR		PHR		PHY payload	

- TX Channel Table : In case of Japanese 950MHz PHY, sub-channel number indicates a 200kHz BW channel as the way shown in 15-08-0109-02-004d, e.g. increasing number means increasing frequency.

Octet Number	1								2								3							
Sub-channel Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Clear/Busy	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit

- Control Field : Define the meaning of TX ch. Table, or other messages.

Std. Control field (1bit)	Control bits (6bit)	Reserved (Further Extension Exist)
0	Standard definition	(1 bit) Usually "0"
1	Reserved	

Control bits	Meaning
0	Channel clear/Busy
1	Scheduled TX
2	Acknowledged
3-63	Reserved

Usage of PHY Header Extension for AFA

- Remote CCA

Result of multichannel CCA performed by peer node can be recognized and collected.

- Forecasting scheduled TX on peer node without CCA

If peer node is programmed to work in synchronous TX or TDMA without CSMA-CA scheme, PHR extension can be used to notify the channel may be occupied without CCA.

- Link layer Ack History

If a node have been performed successful transaction at least once, PHR extension can be used to indicate no fault of TRX on the channel. Adversely, indicating it have never performed acknowledged transaction, suggests a possible malfunction if Ack have been sent by peer nodes (observing nodes).

MAC Primitives for AFA

PHY Channel Coordination Functions

PHY Management Services

PLME-Peer-AFA-TX ; Perform CCA on each channel & TX on PHR-Ex
PLME-Peer-AFA-RX ; Collect AFA information in PHR on Peer frames

PIB

phyChannelsOccupied

- Type: array ; Indicates CCA history of performed LBT
- Value: Ratio and latest time stamp of Clearance

phyChannelsActivated

- Type: array ; Indicates Transmitting Channel to Peer nodes
- Value: Scheduled TX (including TDMA), Simulcast, Duplicate TX

phyCurrentChannel ; Currently using sub-channels

- Type: array
- Value: Arbitrary combination of channels, specified by number 1-24

MAC Primitives

MAC Management Service Primitive using PHR-Extension

MLME-CCA-Announce ; Perform CCA on each channel & inform peer nodes

.request (Type, CCAA_Channels, CCAA_Duration, ChPage, CCAA_Level, Persistence)

.confirm (StatusTxNumber, ChPage, CCAA_ResultListSize, CCA_ResultList)

MLME-Peer-CCA-Survey ; Collect CCA information on each CH & Peer

.request (Type, CCAS_Channels, CCAS_Duration, ChPage, Persistence)

.indication (StatusRxNumber, ChPage, ResultPeerListSize, CCA_ResultPeerList)

MLME-Scheduled-TX-Announce ; Inform peer nodes of scheduled TX-CH

.request (Type, STxA_Channels, ChPage, STxA_ListSize, STxA_List, STxA_Persist)

.confirm (StatusTxNumber, StxA_Channels, ChPage, STxA_PeerList)

MLME-Acked-CH-Announce ; Inform of Acknowledged Channels

.request (Type, AckA_Channels, ChPage, AckA_ListSize, AckA_List, AckA_Persist)

.confirm (StatusTxNumber, ChPage, AckA_ListSize, AckA_List)

MAC Primitives Appropriate Usage & Effects

MLME-CCA-Announce ; Issued by NHL to perform CCA on each channel and to inform peer nodes the status of CCA at specified detection level.

MLME successively update CCA result during specified duration and confirm the result persist as the history of surrounding radio-sphere as long as the elapsed time of each CCA result is within the persistence limit.

MLME-Peer-CCA-Survey ; Issued by NHL to collect CCA information of each of peer on each channel and to organize the resulting Peer CCA table.

MLME inform NHL of the organized result table through indication. This result is persisting until and been updated by within specified persistence time. This effects during the specified duration of operation.

MLME-Scheduled-TX-Announce ; Issued by NHL to inform peer nodes of any of expected or scheduled transmission on each channel without CCA, which is resulted by Channel Switching, TDMA or Channel Hopper.

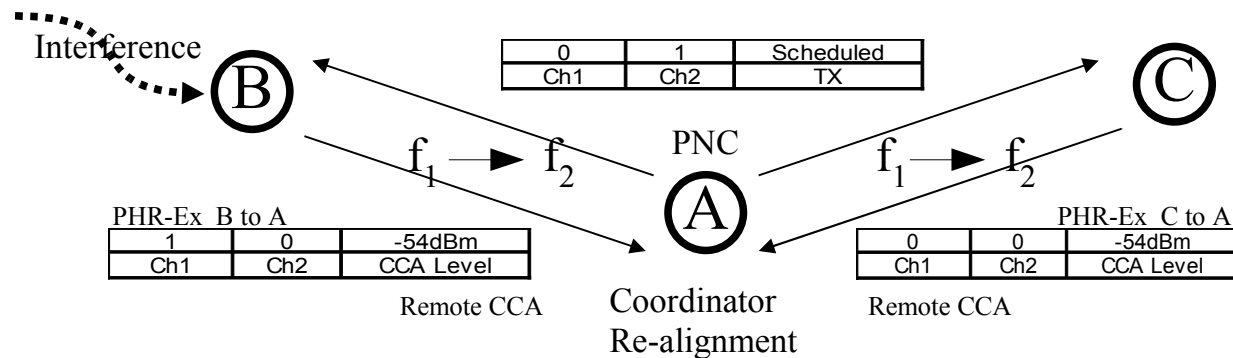
MLME-Acked-CH-Announce ; Issued by NHL to inform peer nodes of all of the channels which was recently acknowledged and the communication have been completed successfully. This confirm the health of both Tx & Rx and adversely possible asymmetry fault if permanent negative.

The information have to be updated within appropriate time duration.

AFA Scenario

2 channel asynchronous AFA (Frequency Switching) Scenario

Node A, B, C are pre-defined to use Ch.1(f_1), Ch.2(f_2), and are using Ch.1, then switching to Ch.2 in this figure below.



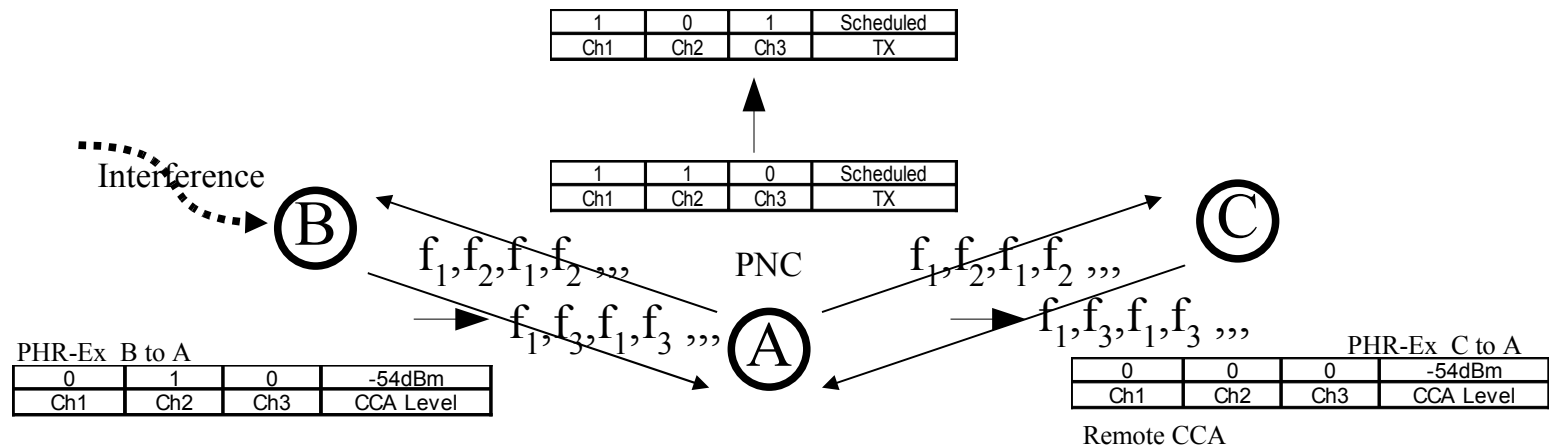
All node is using Ch.1 and node B is getting distracted due to interference, for example. PNC node A is collecting the remote CCA information from both node B and C periodically and detect the remote interferences at each node. If NHL decide to switch to alternate frequency channel of f_2 i.e. Ch.2, in this case, conventional Coodinator Re-alignment can work. Before this decided channel switching, PNC can use PHR-Ex of scheduled TX on Ch.2.

Note: Before AFA, NHL can set the CCA level of each nodes

Multi-Channel asynchronous AFA Scenario

TX node may always transmits duplicate information on multiple channel redundantly.

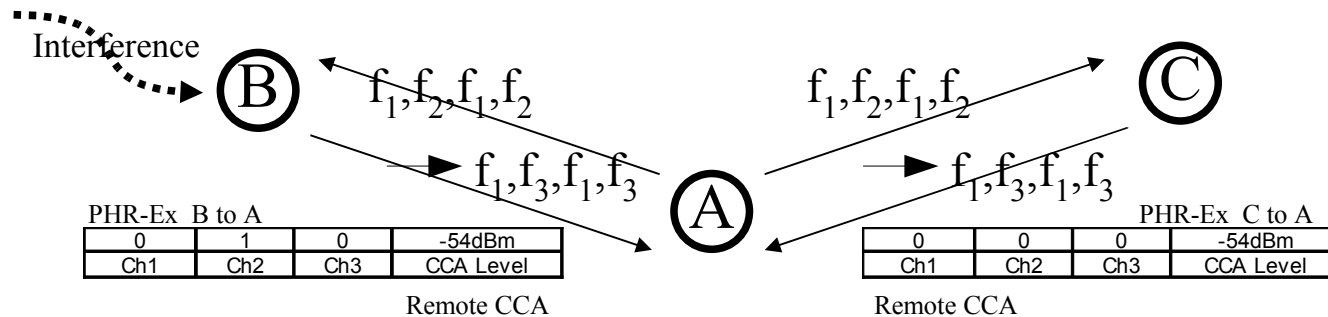
All nodes are able to play the overlaid double Piconet and each leaf nodes can work either on Ch.1 or Ch.2.



All nodes can take redundant opportunity to communicate on Ch.1 and Ch.2, and node B is getting interfered. PNC node A decides to switch channel by remote CCA and starts announcing the scheduled TX on Ch.1 and Ch.3. This alleviates the possibility of orphan generation.

2 channel synchronous AFA (Frequency Switching) Scenario

Node A, B, C are using f_1 and f_2 alternately, that is minimum multiple channels.

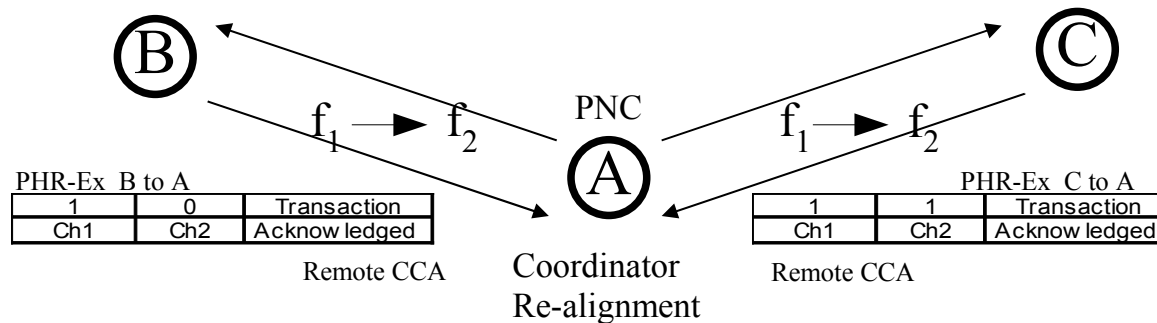


All TX node must follow the pre-defined TX channel order to send, in this case, AFA means alternating order. PNC node A is collecting remote CCA information and detect remote busy of node B on Ch.2.

Simplest AFA can be the tactics of yielding the channel usage to avoid remote collision. If the remote CCA busy is sustaining, Ch.2 may be changed to and substituted by Ch.3, for example in this case.

Multichannel AFA (Fault Isolation) Scenario

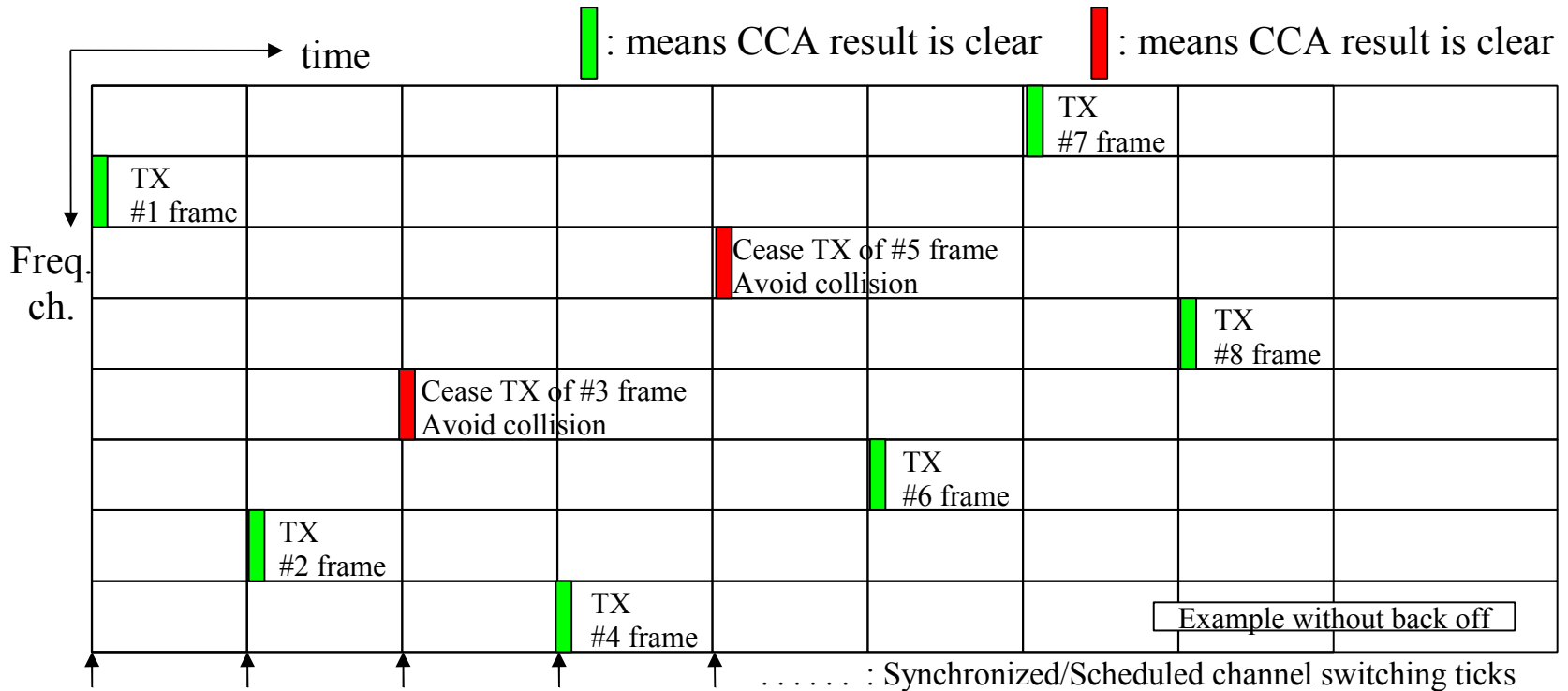
NHL is able to have Acknowledged status on each leaf nodes by receiving Ack'ed information on PHR-Ex.



PNC is able to take action if sustaining No Acknowledged transaction on Node B. This may occur on a specific channel of Node B, or entire channel of Node B, and the information can be used to detect harmful Asymmetric Fault on the peer node.

AFA with distributed CCA in each time slot

TX node to decide the transmission of each channels using CCA.

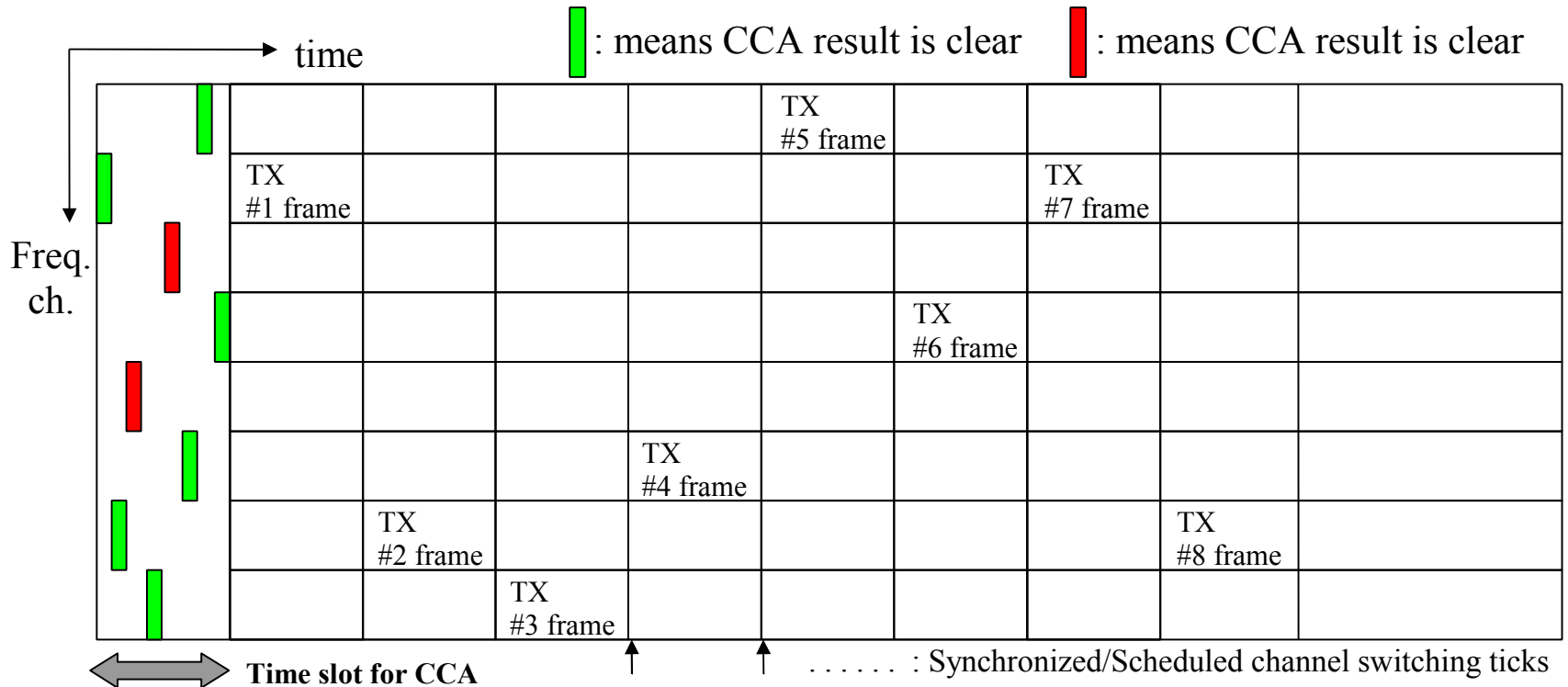


Then TX node must follow the pre-defined TX channel order to send. In this case, AFA means just CA, i.e., collision avoidance.

In case of the reliability conscious APP, it's better for TX node to inform the decision of transmission regarding entire channels to RX nodes.

AFA with congregated CCA in a designated time slot

TX node to decide the transmission of each channels and its order to send.



TX node must ensure at least a frame is following the previously scheduled channel and time slot unchanged to inform the new transmission channels and its order to send. Adaptive utilization of channels according to CCA is possible.

References

- 15-08-0373-01-004e-call-for-proposals.doc
- 15-08-0030-01-004e-AFA-functionality-in-reliability-conscious-applications.pdf
- 15-08-0109-02-004d-WW-BPSK-with-AFA-provisioning.pdf

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