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

Submission Title: [AFA functionality in reliability conscious applications]
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Source: [Shusaku Shimada] Company [Yokogawa Co.]

Address [2-9-32 Nakacho-town Musashinoshi-city Tokyo, 180-8750 Japan]
Voice:[+81-422-52-5543], FAX: [+81-55-7311], E-Mail:[shusaku@ieee.org]

Re: [Doc. 15-07-0936-00-004e-call-applications-tg4e]

Abstract: [WPAN applications users emphasize the network reliability with cost effectiveness keep growing due to strong efficiency needs in the market segments like Energy, Medical/health-care and Social infrastructure. Therefore, the reliable usage of a congested frequency band shared by multiple systems has been focused, and as a feasible solution in the link level, each regulatory organizations commenced to recommend AFA(Adaptive Frequency Agility) function aiming better co-existence scenario. Possible link level supports for higher layer AFA are exemplified.]

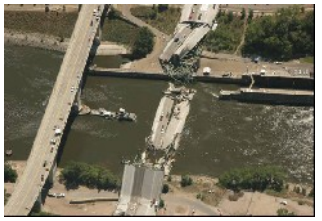
Purpose: [The purpose of this submission is to respond to CFA of IEEE802.15 TG-4e.]

Demand & Requirement in Reliability Conscious Application

- Demand of Energy Efficiency market in plant & transportation
  Strong with long term QoS stability

- Demand reflecting the distending Medical/health-care expense
  Steady in Low Physical Risk use-cases

- Necessity to ensure the social infrastructural services
  Emerging, for mitigate Disaster Risk,
  with long term QoS stability



Reliability of WPAN is essential factor due to risk of malpractice

AFA as the solution for reliability be considered in WPAN SDO.

CSMA and AFA (Adaptive Frequency Agility)

Clear definition of AFA is still ambiguous

- CSMA by others and CCA is a part of AFA and its base function

- Back off mechanism is either a part of AFA or out of use

  Switch the frequency channel to avoid collision
  (1) after Back Off mechanism
  (2) without Back Off

- CCA information have to be collected for peer nodes

FH (Frequency Hopping) and AFA

Clear definition of AFA is still ambiguous

- FH or Frequency Selection is the base function of AFA

- Pre-configured hopping patterns are either a part of AFA or out of use

  Switch the frequency channel to avoid collision
  (1) using fixed pattern
  e.g. Costas Sequence, Latin tile etc.
  (2) using opportunistic way,
  e.g. Algorithmic manner or Episodic fashion

- Time synchronization in network level have to be ensured for peer nodes

Cognitive Radio and AFA

Clear definition of AFA and Cognitive Radio are still ambiguous

- Adaptive Frequency Selection is the base function of AFA
- Cognitive capability using additional information of other STA from stored database or remote one via network is either a part of AFA or out of use

Switch the frequency channel to avoid collision

(1) in a way of reflex
using own CCA result and peer one
e.g. Costas Sequence with skip channels

(2) in a way of cognitive
using co-existing system allocation in location and frequency band
e.g. Partly pre-configured pattern selection

- Peer receiving nodes have to know TX frequency

Channel Scan Operation using CCA

- Distributed CCA during series of transmission or CCA at designated time slot is a part of AFA and its base function

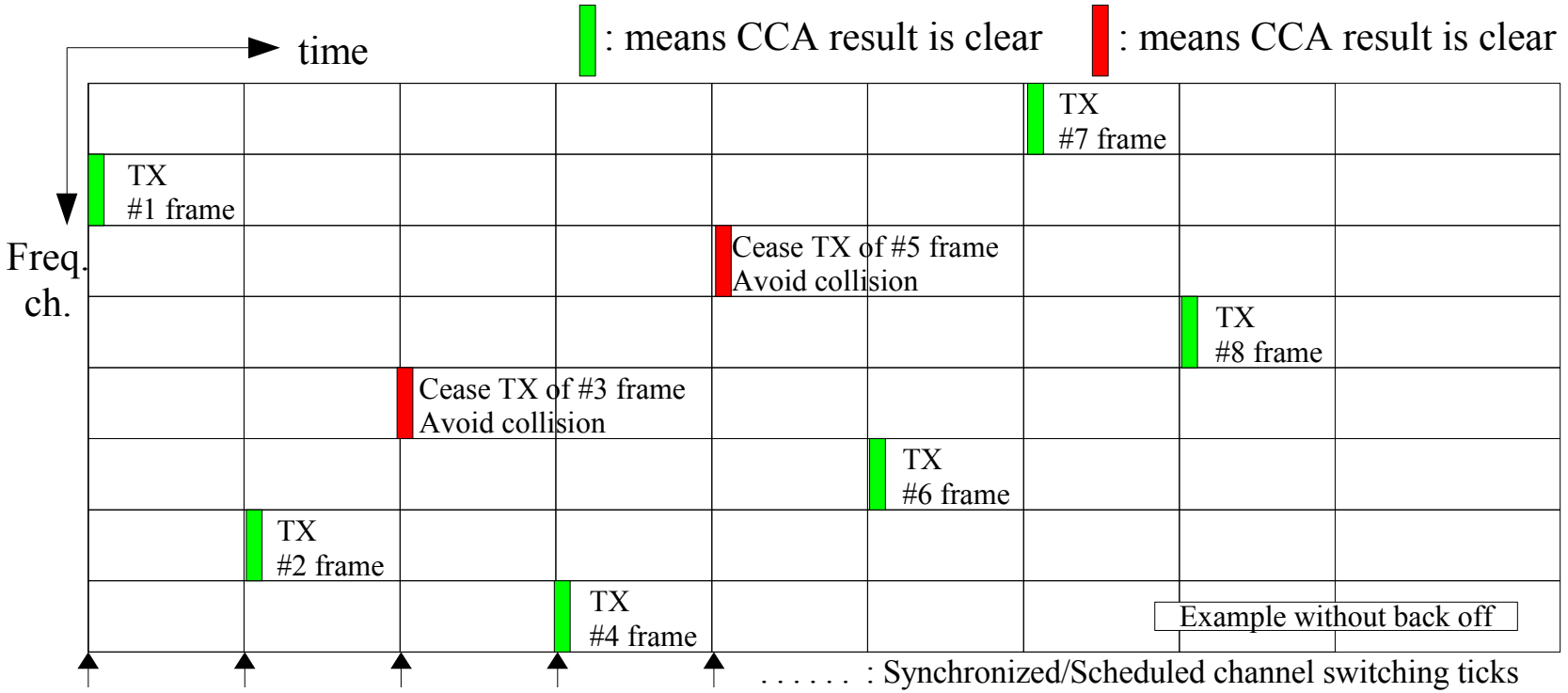
- Channel Scan using CCA and transmission of resulting information are network independent function in PHY/MAC

  But the frequency channel selection is correlated issue
  (1) Depend on network topology and interference
  (2) Cross Layer issue with PHY, MAC and NWK

- Due to inevitable congested frequency usage, channel scan operation and resulting peer CCA information are crucially important in every forms of AFA implementations.

AFA with distributed CCA in each time slot

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

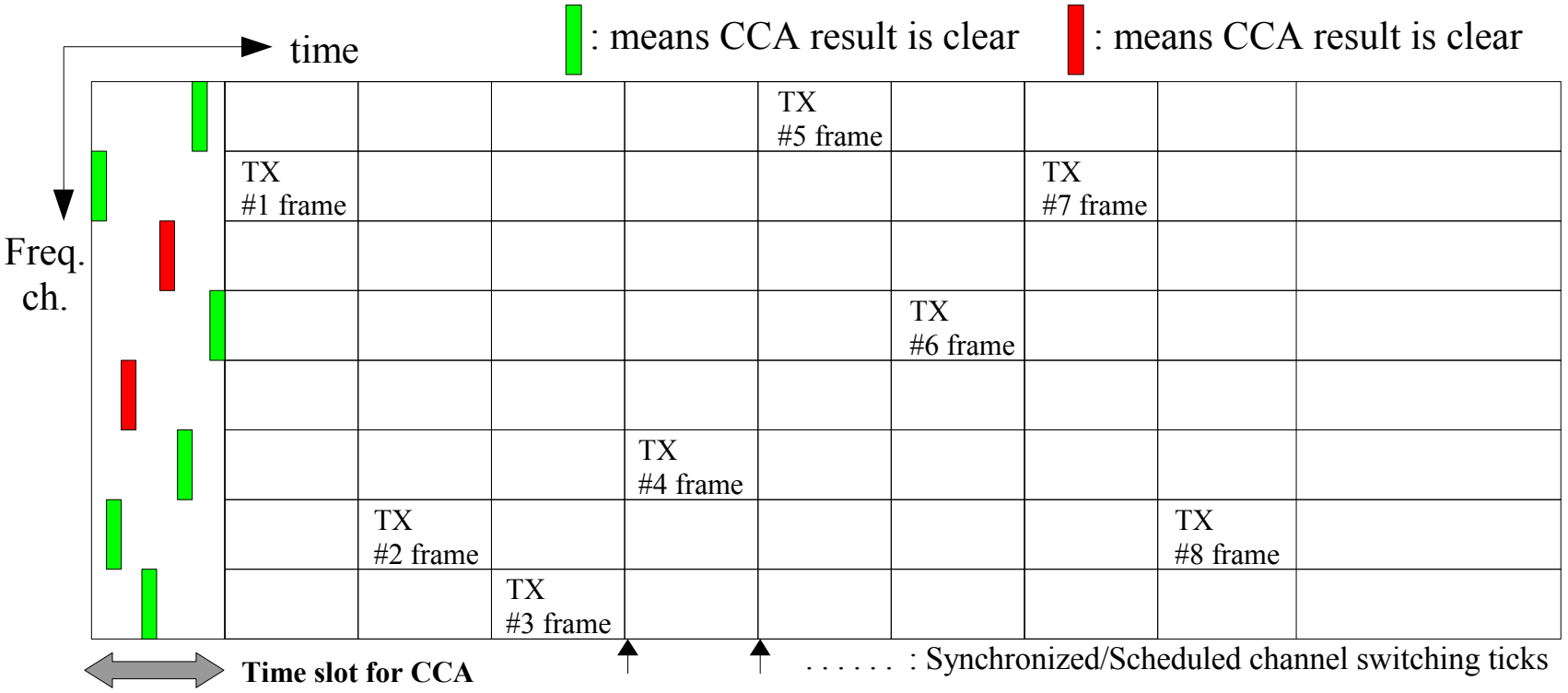


Then TX node must follow the pre-defined TX channel order to send. In this case, AFA means just CA, i.e., collision avoidance.

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

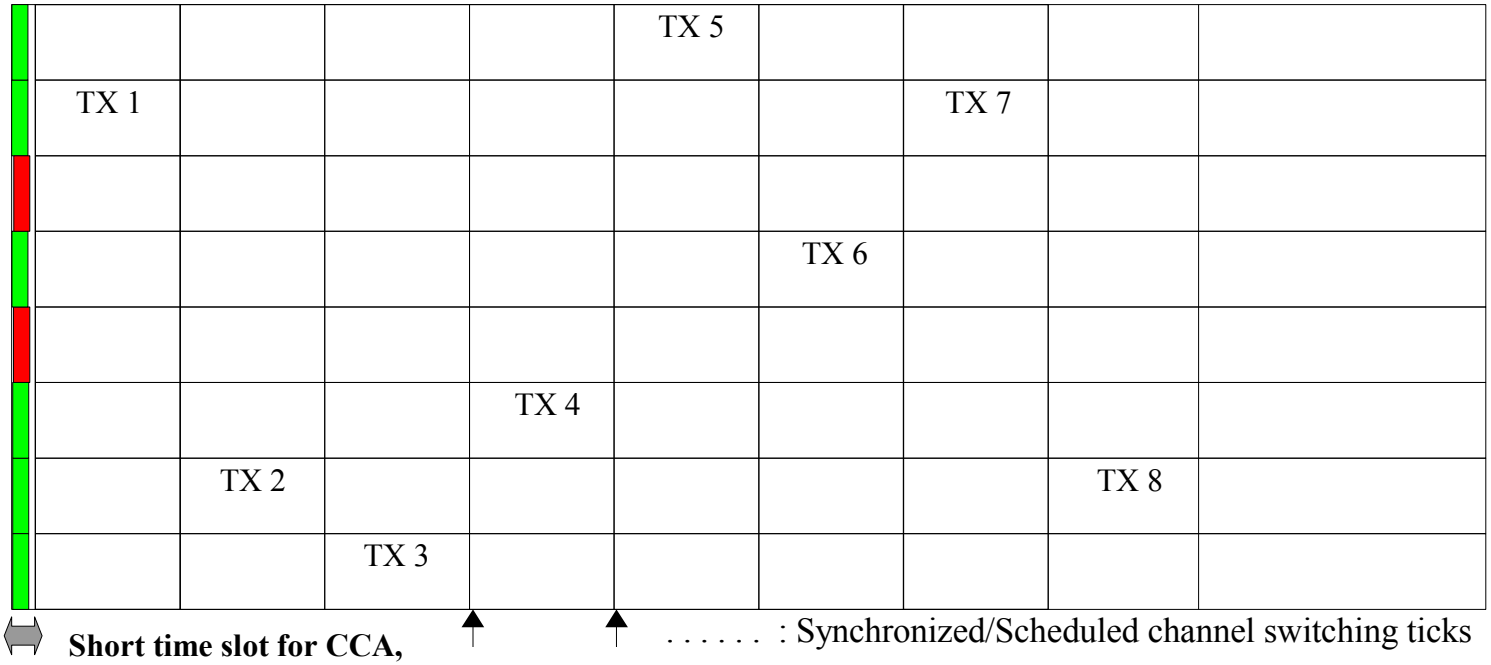
TX node to decide the transmission of each channels and its order to send.



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.

AFA with Simultaneous CCA in a designated time slot

As a future provisioning, it may be considered TX node decide the channel usage more adaptively based on wider band receiver like OFDM transceiver.



Even in this uncertain future scenario, TX node is supposed to include at least TX side information of channel usage by which RX node is able to be ensured if intended frame transmission have succeeded or failed. Simultaneous reception of multichannel at RX node would greatly improve the reliability of AFA.

Feedback or Acquisition of CCA information on each channel

Link layer ACK as a courier of RX side CCA information

Naturally implying bad CCA due to occupation on other channels to be sent

Acquisition of the transmission frames to other RX node by other TX node

Promiscuous acquisition of received frame and collection of CCA information are required to utilize this for AFA at own node when it start transmitting.

CCA status at Peer (potential RX node) is PHY level information ?

Clearly utilization of collected information have to be available at MAC or higher layers including the application layer.
Nevertheless in the case of promiscuous acquisition without any Peer MAC information, PHY header seems to be an adequate place to accommodate.

Header overhead have to be minimized provided the extension is able to carry the required information for TX node to include.

Example of 802.15.4d PHY Proposal : PHR Extension (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 : 4 Octets
→ 8 Entry for each 600kHz 1mW channel
→ 4 bits for each entry
→ Value: Clear/Busy 1bit, TX order/CCA-ED 3 bits

Favourable Usage

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

Example of 802.15.4d PHY Proposal : PHR Extension (2)

		Octets			
		1		4	variable
Preamble	SFD	Frame length (7 bits)	**Extension Exist** (1 bit)	TX Channel Table 8 Channels x (4 bits)	PSDU
SHR		PHR		PHR Extension	PHY payload

TX Channel Table

Channel	Clear/Busy	TX order/CCA-ED
1	(1bit)	(3 bits)
2	(1bit)	(3 bits)
3	(1bit)	(3 bits)
4	(1bit)	(3 bits)
5	(1bit)	(3 bits)
6	(1bit)	(3 bits)
7	(1bit)	(3 bits)
8	(1bit)	(3 bits)

Clear/Busy	Meaning of TX order/CCA-ED
0	TX Order (3 bits)
1	CCA-ED/Ack'ed (3 bits)

TX Order	Meaning
0	Clear/TX channel
001-111	TX Order

CCA-ED/Ack'ed	Meaning
000	Ack'ed
001	Reserved
010	Reserved
011	Reserved
100-111	ED Value

End