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

Submission Title: [Automatic Device Discovery for Directional Antenna Devices]

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Re: []

Abstract: [Clarify automatic device discovery time for automatic device discovery of directional antenna devices]

Purpose: [To be considered in 15.3c MAC design]

Summary

- **We clarify automatic device discovery time for automatic device discovery (ADD) of directional antenna devices.**

- **To study automatic device discovery time, we present an example of automatic device discovery for sector switching antenna devices.**

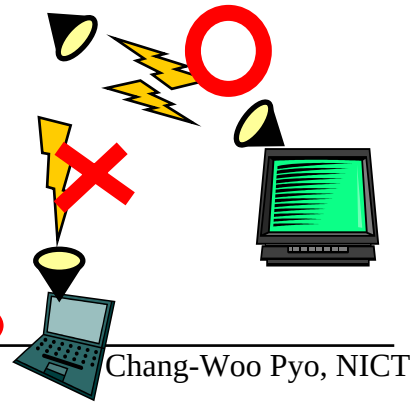
Definition

- **TG3c Usage Model Document: 06/055r21**
- **Device Discovery**
  - Procedure by which a device identifies devices within its potential radio proximity
- **Automatic Device Discovery (ADD)**
  - Procedure by which a device identifies devices within its potential radio proximity without user intervention.

Background

- Automatic device discovery for omni devices is trivial. (Omni devices are assumed in existing IEEE 15.3 MAC)
- However, if TG3c members consider to use directional antenna devices by any reason (see [1] IEEE 802.15-15-06-0018-00-003c), **directional antenna ADD is a big challenge** since the complexity of ADD becomes higher and higher as devices use directional antennas for communication.

ADD Categories		PNC	
		Omni	Directional
DEV	Omni	Easy	Complex
	Directional	Complex	Very Complex

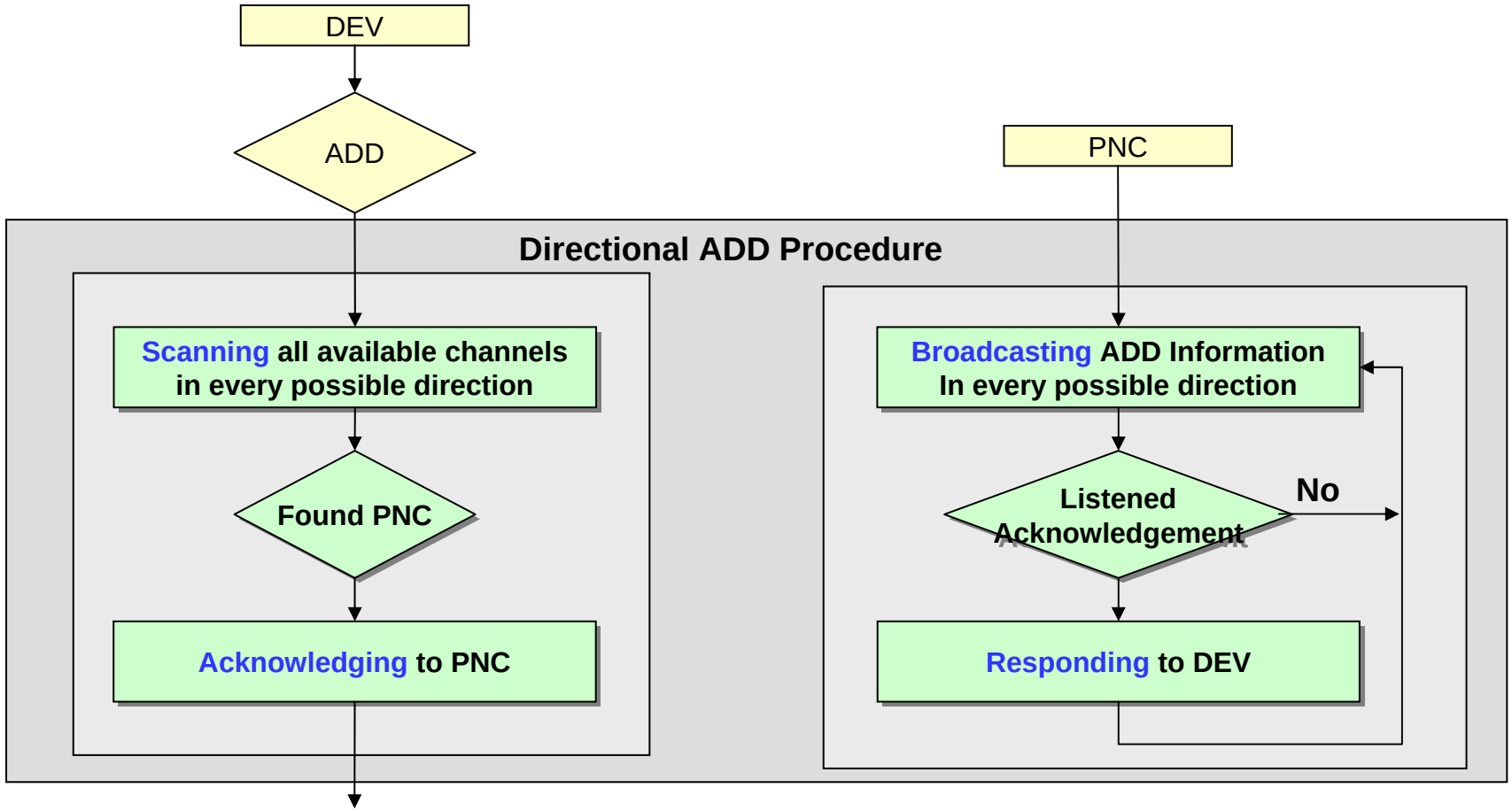


Challenges

- **Directional antenna ADD must be available**
  - **within a reasonable time** and
  - **with a reasonable overhead.**

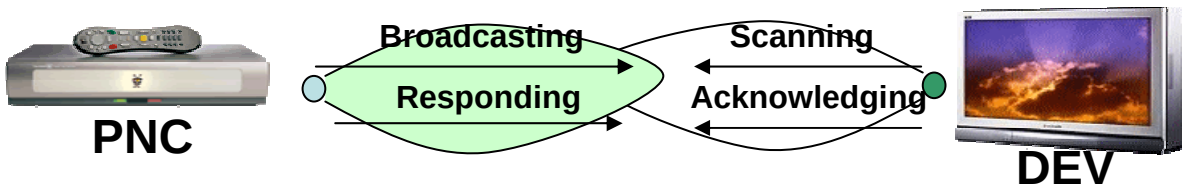
- **"For 1 second data transmission, can you wait for 1 hour to discover devices?"**

Directional Antenna ADD



Procedures and Functions

- ADD includes two (2) procedures and four (4) functions
  - **DEV discovers PNC**
    - PNC **broadcasts** to inform “PNC existence” to around
    - DEV **scans** to detect “PNC existence” in around
  - **PNC discovers DEV**
    - DEV **acknowledges** “PNC discovery” to PNC.
    - PNC **responds** to confirm “ADD” between PNC and DEV.



Example of ADD for Sector Switching Antenna Devices

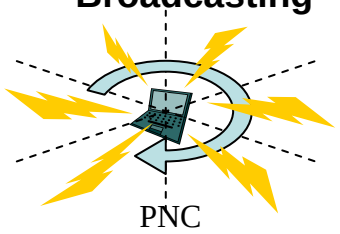
- For an example of controllable directional antenna ADD, **sector switching antenna devices** are assumed for the reference directional antenna devices since the directivity of directional antennas could be easily explained by sector switching antennas.

- For example, omni devices can be expressed as one sector (360°) switching antenna devices.

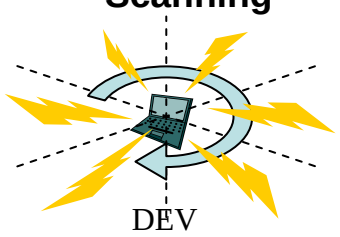
Sector Switching Antenna ADD

ADD Start

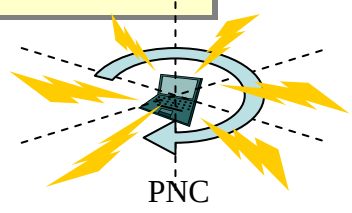
Broadcasting

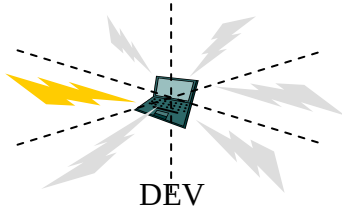


Scanning



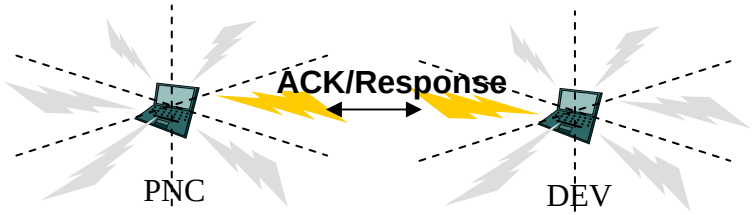
DEV detect PNC





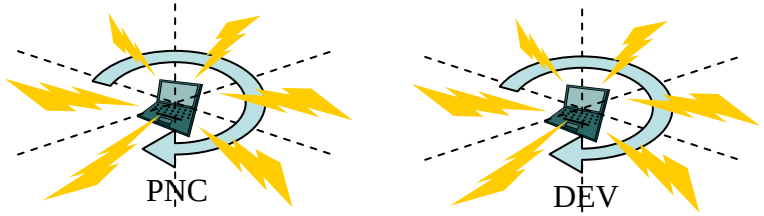
• DEV must scan in each sector and channel over the time that PNC broadcasts ADD information to all available sectors at least once.

PNC detect DEV and ADD Finish



• To finish ADD, it confirms ADD between PNC and DEV by acknowledgement and response

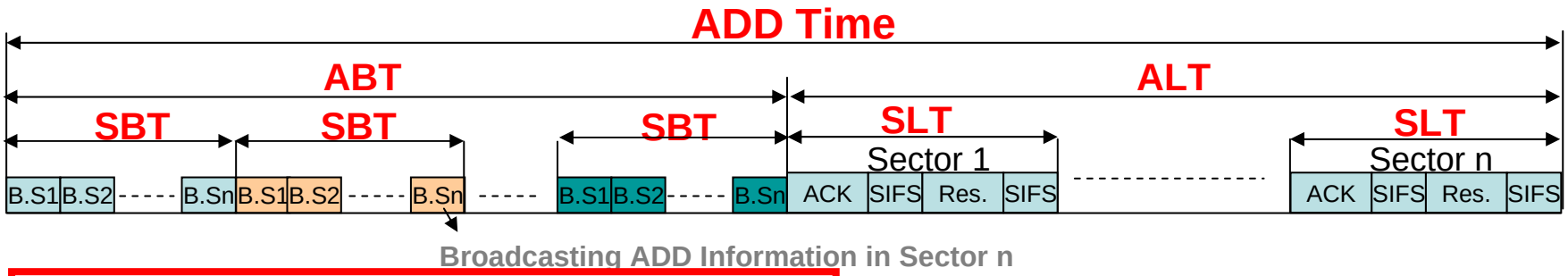
DEV detect PNC



• PNC must broadcast over the time that DEV scans all available sectors.

ADD Time for PNC

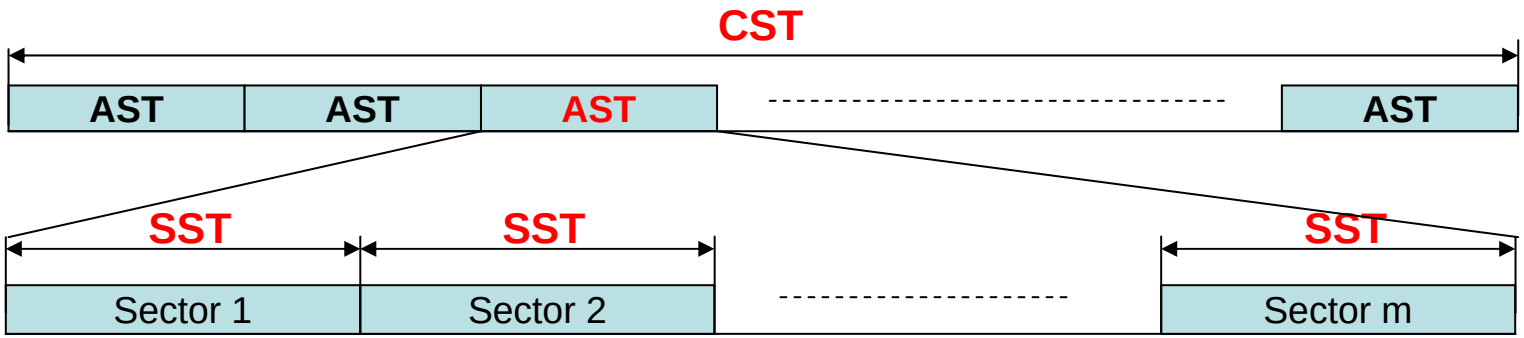
- **PNC contains four (4) main times**
  - **Sector Broadcasting Time (SBT)**
    - The time duration that PNC broadcasts ADD information to all available sectors at least once.
  - **ADD Broadcasting Time (ABT)**
    - It consists of a number of sector broadcasting times.
  - **Sector Listening Time (SLT)**
    - The time duration that PNC stays in a sector to listen to acknowledgement from DEV and to response an ADD result to DEV.
  - **ADD Listening Time (ALT)**
    - ALT contains **n x SLT** for PNC with **n sectors**.
- **ADD time frame for PNC**



This is an example and the time frame is NOT equal to the proposal for ADD.

ADD Time for DEV

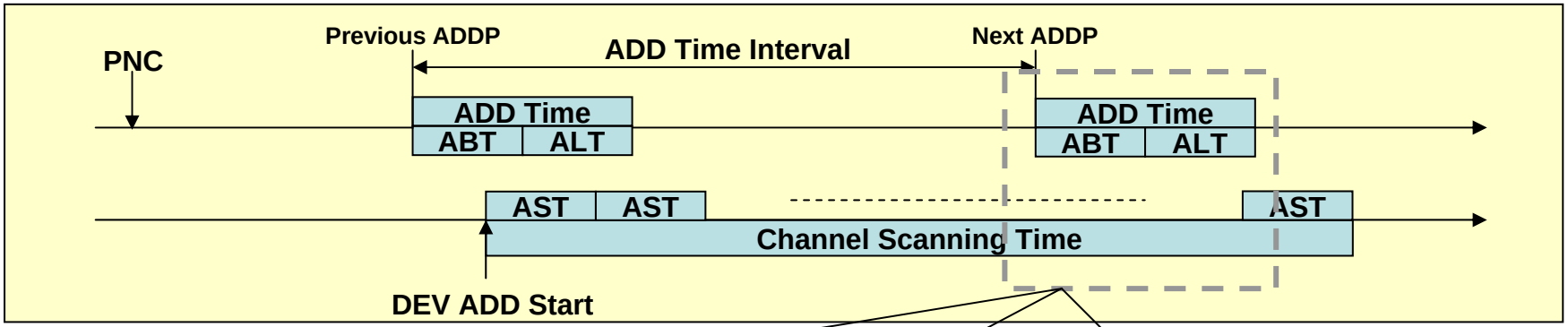
- **DEV contains three (3) main times**
  - **Sector Scanning Time (SST)**
    - The time duration that DEV stays in a sector to scan ADD information per channel.
  - **ADD Scanning Time (AST)**
    - AST contains **m x SST** for DEV with **m sectors**
  - **Channel Scanning Time (CST)**
    - CST includes a number of ADD scanning times.
- **ADD time frame for DEV**

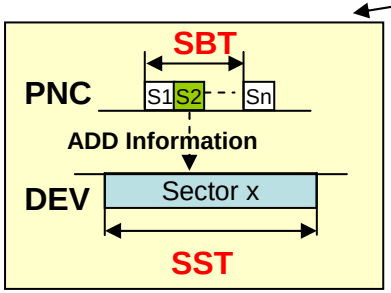


This is an example and the time frame is NOT equal to the proposal for ADD.

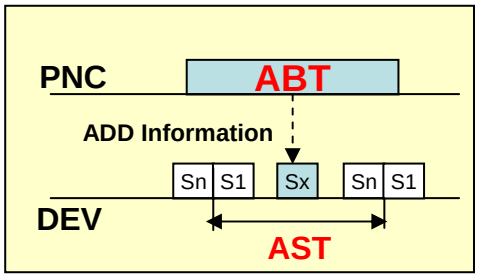
Time Conditions

Condition 1: Channel Scanning Time > ADD Time Interval

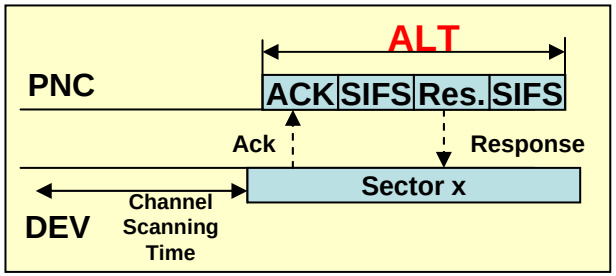




Condition 2:
SST > SBT x # of Channels



Condition 3 :
ABT > AST



Condition 4:
DEV acknowledges within ALT

Time Conditions (conti.)

- Time conditions that DEV discovers PNC
  - Channel Scanning Time > ADD Time Interval
  - SST > SBT x # of Channels
  - ABT > AST
- Time conditions that PNC discovers DEV
  - DEV acknowledges within ALT

Conclusion

- **We clarified automatic device discovery time for automatic device discovery (ADD) of directional antenna devices.**

- **To study automatic device discovery time, we presented an example of automatic devices discovery for sector switching antenna devices.**

References

[1] Chun-Ting Chou, Alireza Seyedi and Rechard Chen, “Medium Access Control (MAC) in Wireless PAN using Directional Antennas,” IEEE 802.15-15-06-0018-00-003c.