IEEE 802.22 MAC/CC Overview

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Authors:

Name	Company	Address	Phone	email
Gwang-Zeen Ko	ETRI	Korea	+82-42-860-4862	gogogo@etri.re.kr
Byung Jang Jeong	ETRI	Korea	+82-42-860-6765	bjjeong@etri.re.kr
Sung-Hyun Hwang	ETRI	Korea	+82-42-860-1133	shwang@etri.re.kr
Jung-Sun Um	ETRI	Korea	+82-42-860-4844	korses@etri.re.kr
Antony Franklin	ETRI	Korea	+82-42-860-0752	antony@etri.re.kr

Abstract

This contribution summarizes the MAC and Cognitive Capability (CC) features developed in the 802.22-2011 Standard.

Contents

MAC Introduction(1)

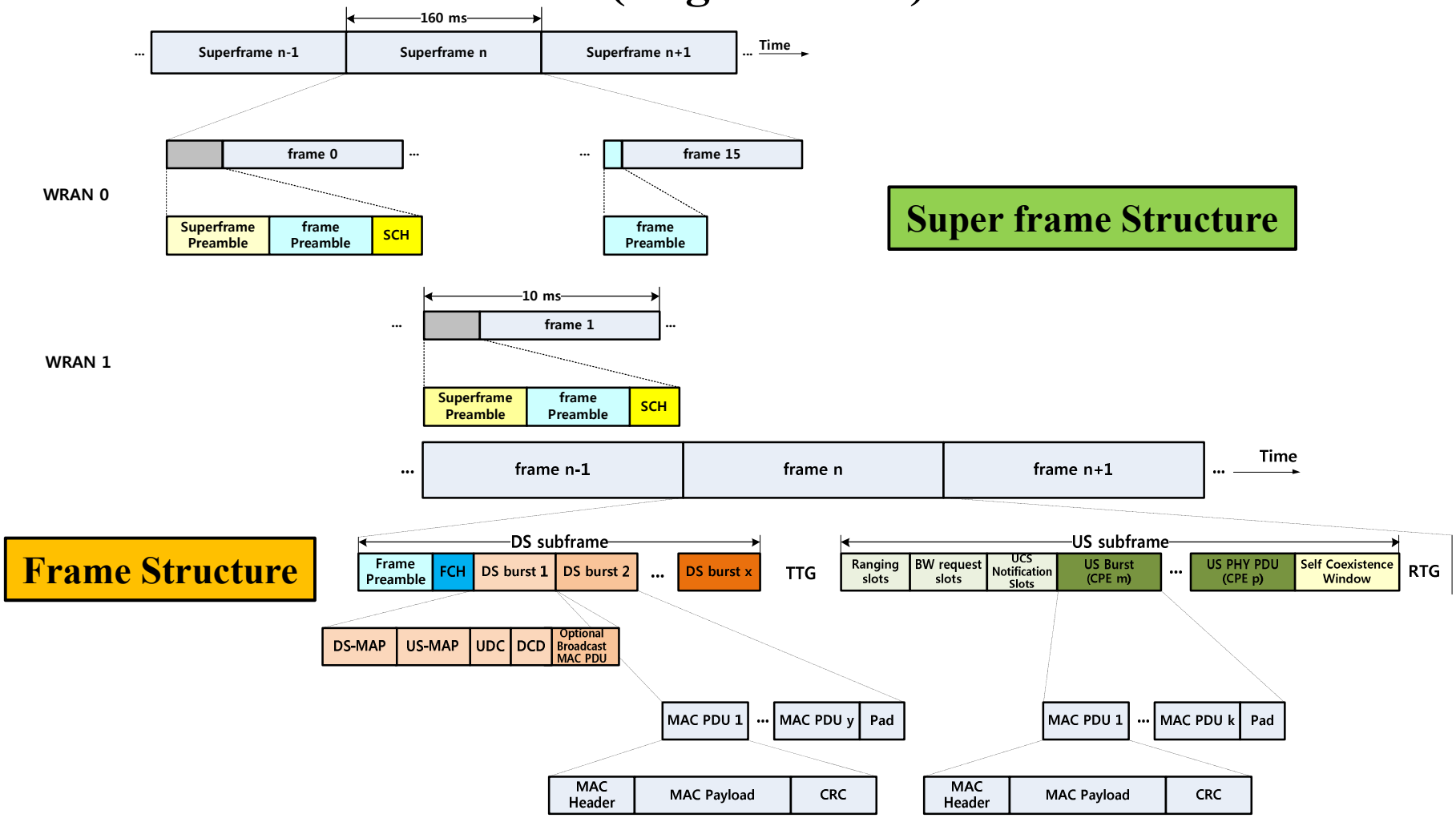
- **Some aspects of IEEE 802.22-2011 have been inspired by the IEEE 802.16 MAC standard**
- **Combination of polling, contention and unsolicited bandwidth grants mechanisms**
- **Support of Unicast/Multicast/Broadcast for both management and data**
- **Connection-oriented MAC**
  - **Connection identifier (CID) is a key component**
    - **IEEE 802.22-2011 CID can be constructed from Station ID(SID) and Flow Identifier (FID) [1]. This new CID definition can reduce overhead and storage requirements[2].**
  - **Defines a mapping between peer processes**
  - **Defines a service flow (QoS provisioning)**

MAC Introduction(2)

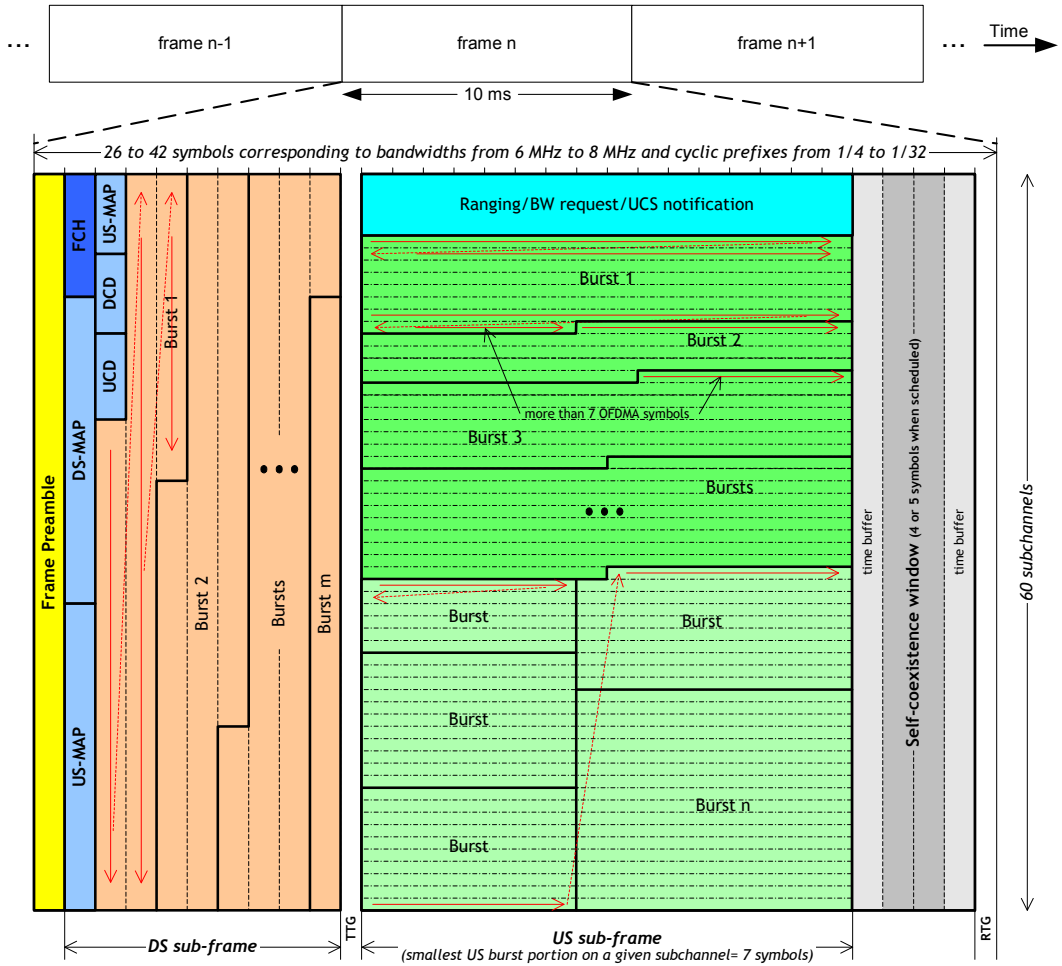
- **However, major enhancements have been made**
  - **Support of Cognitive functionality;**
    - **Dynamic and adaptive scheduling of quiet periods**
    - **Various incumbent user detection and notification methods**
  - **Coexistence with both incumbents and itself (self-coexistence);**
    - **Measurements (incumbents and itself)**
    - **Spectrum management (time, frequency and power)**
    - **The Coexistence Beacon Protocol (CBP)**
    - **The Incumbent Detection Recovery Protocol (IDRP)**
    - **Wireless microphone beacon mechanism(IEEE 802.22.1)**
  - **Support of Self-coexistence mechanism;**
    - **Spectrum Etiquette**
    - **On-demand Frame Contention**

IEEE 802.22 Frame Structure

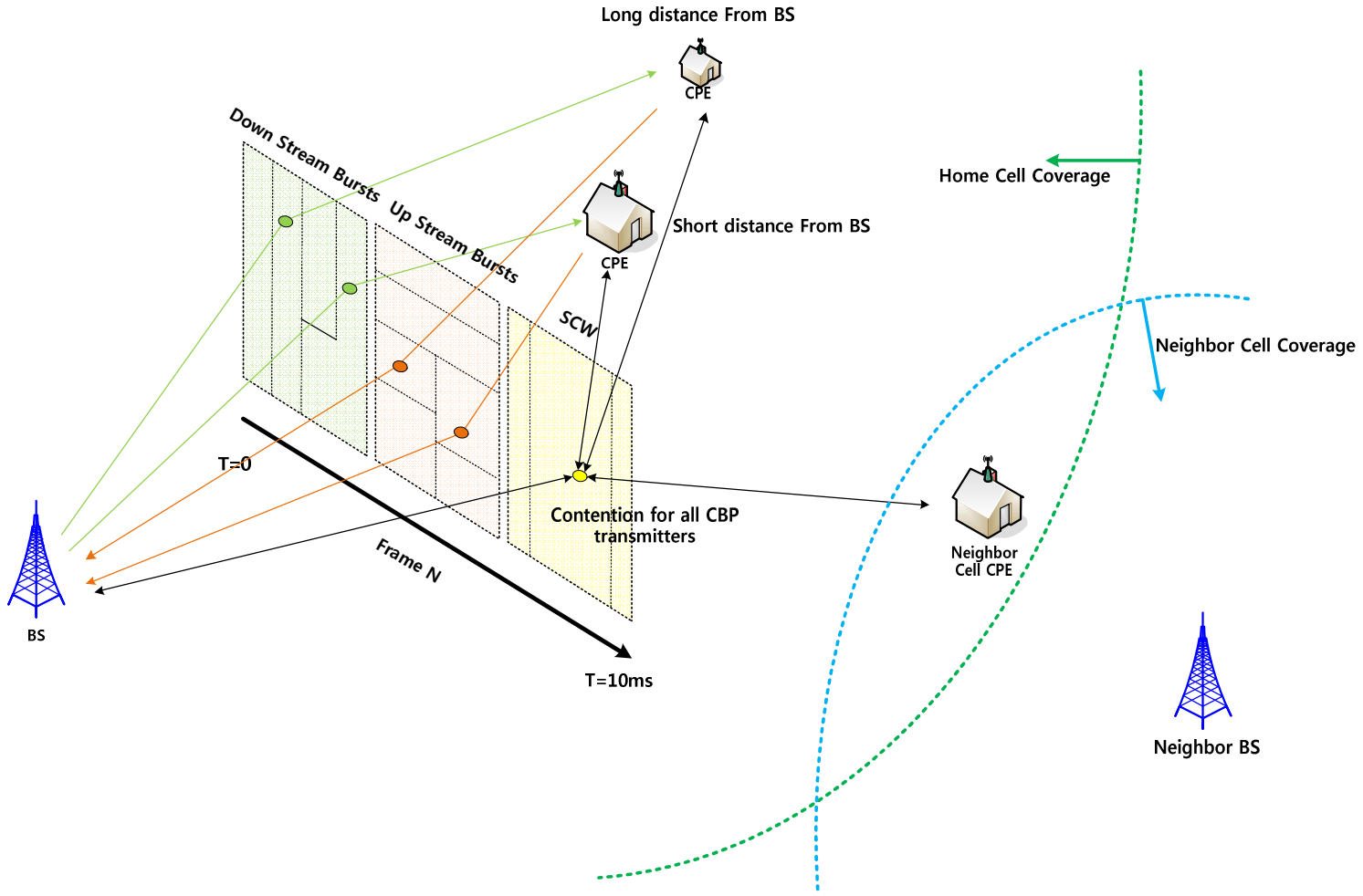
(Logical View)



IEEE 802.22 Frame Structure
(Physical View)



Concept of 802.22 Frame Operation

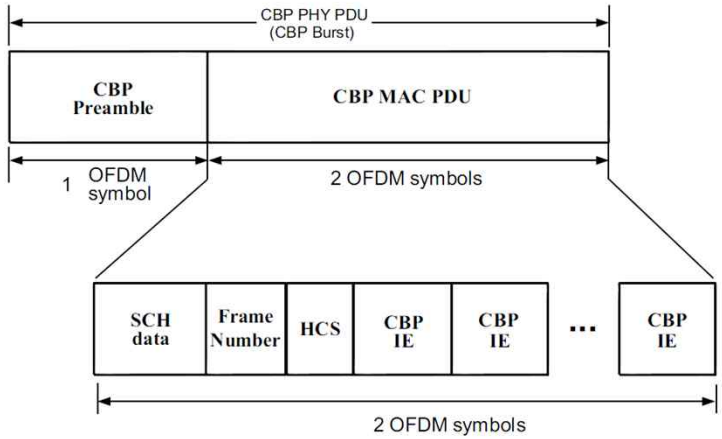


SCH and CBP Features

- **The Super-frame Control Header(SCH) provides information about the 802.22 cell**
  - **Support coexistence with incumbents**
  - **Support the intra-frame and inter-frame quiet periods management mechanisms for sensing**
  - **Support self-coexistence mechanisms**
- **A SCH can include various CBP(Coexistence Beacon Protocol) IEs such as;**
  - **Backup channel information**
  - **Frame Contention information**
  - **Terrestrial Geo-location information**
  - **CBP frame security(Signature IE, Certificate IEs)**
- **Using SCH, WRAN BS can intelligently manage the operation of its associated CPEs**
- **Also, using CBP (Extended version of SCH), WRAN BS can intelligently manage the operation of neighboring WRAN cell under co-existence situation**

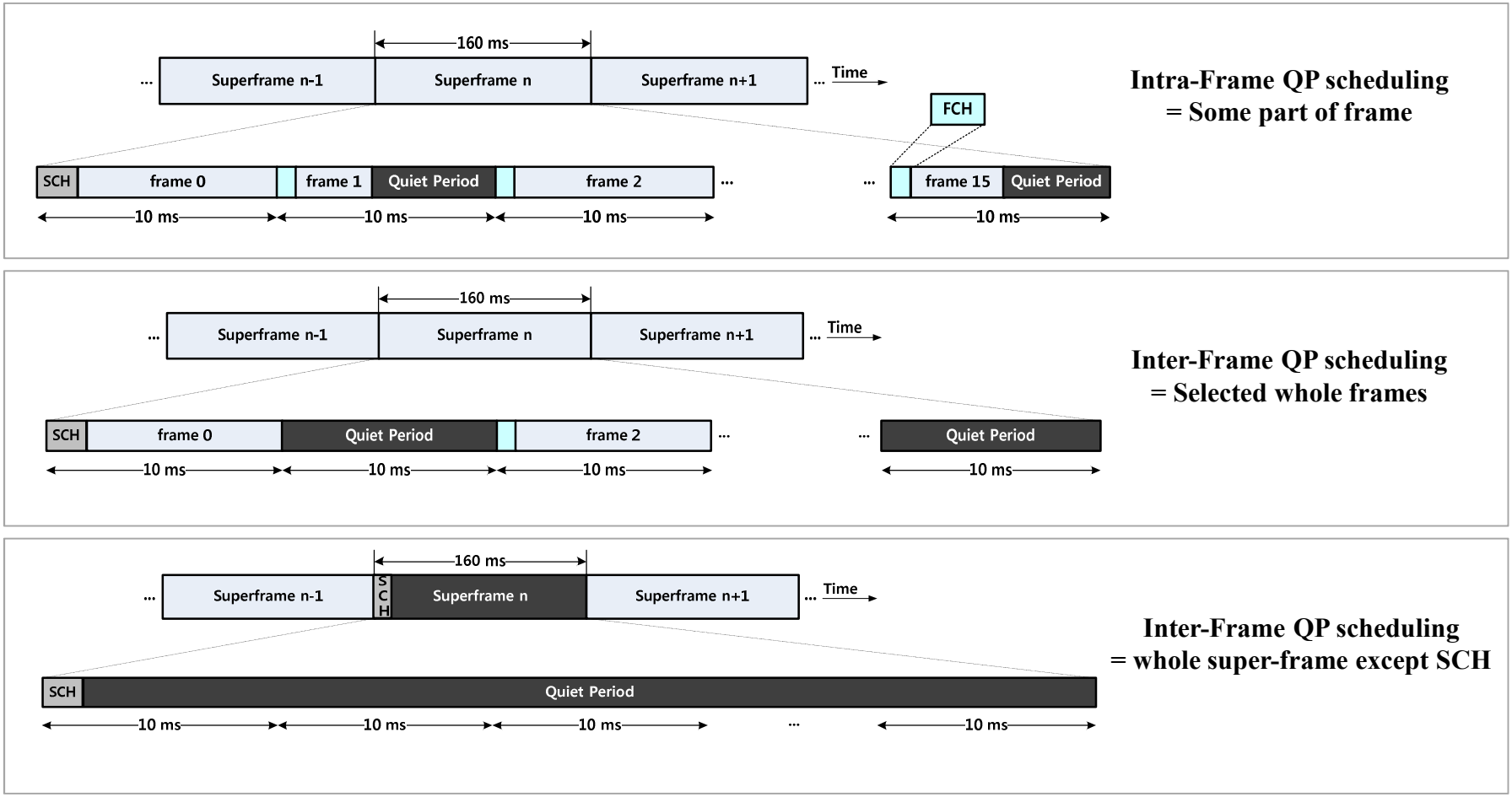
CBP Summary

- **An SCH is transmitted using DS burst whereas a CBP packet is transmitted using SCW**
- **CBP is fully controllable by the BS that decides who sends/listens and when to send/listen for CBP packets(Refer [3])**
  - **The source of a CBP packet can be either a BS or CPE**
- **CBP packets carry control information only (no data)**



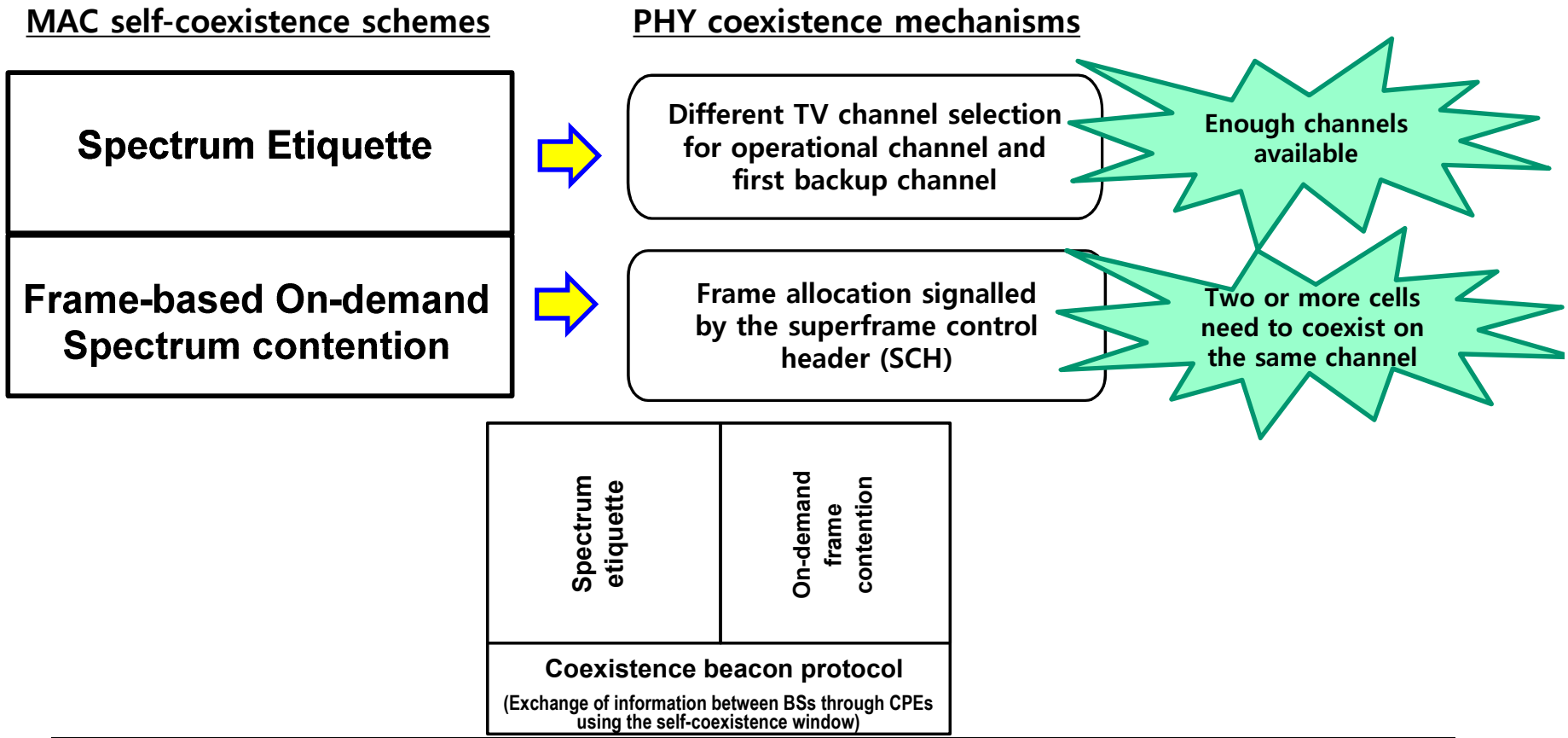
Structure of a CBP packet

Dynamic Quiet Period Scheduling



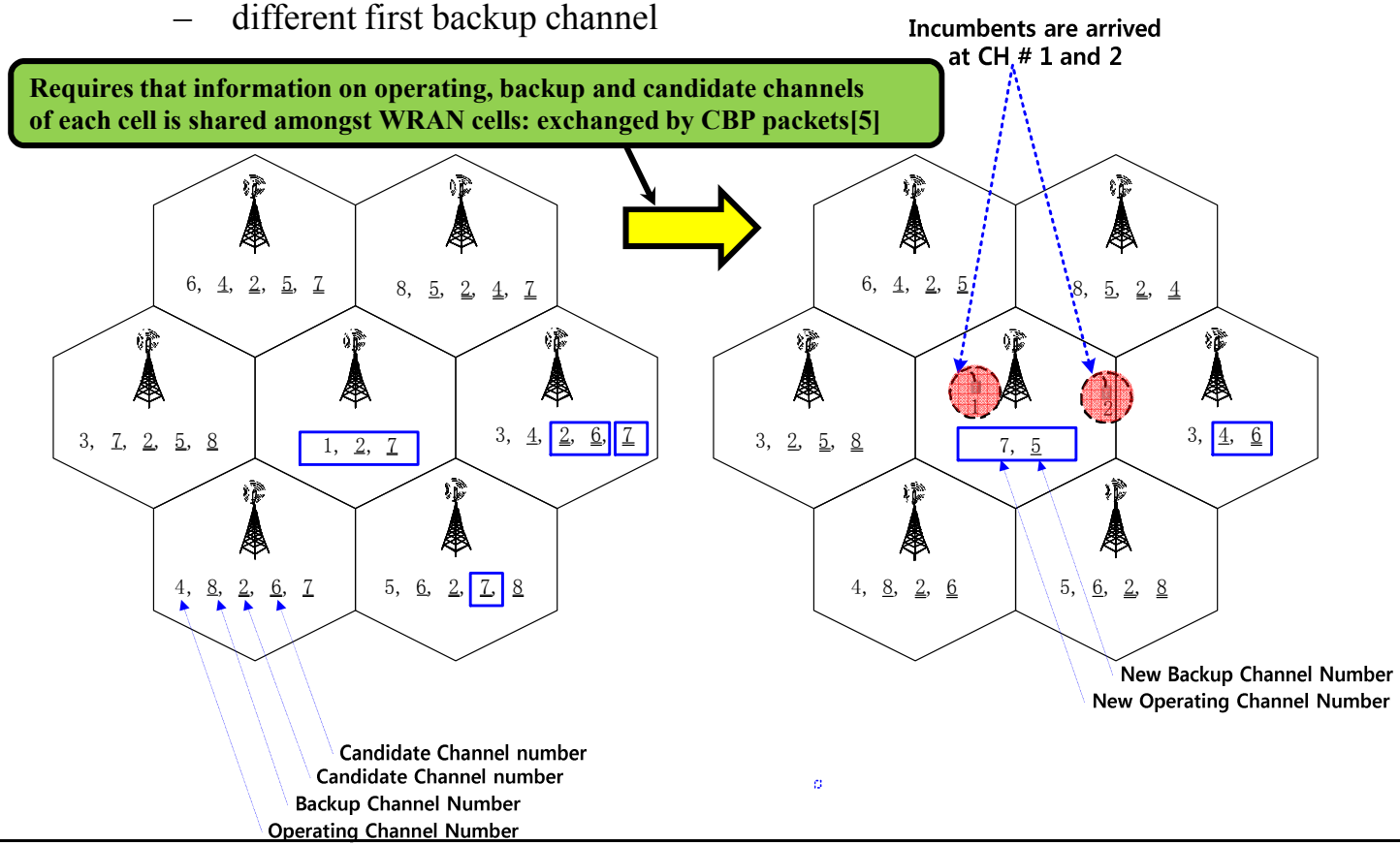
Self-Coexistence Mechanism(1)

- **Self-Coexistence: Among WRAN Systems[4]**



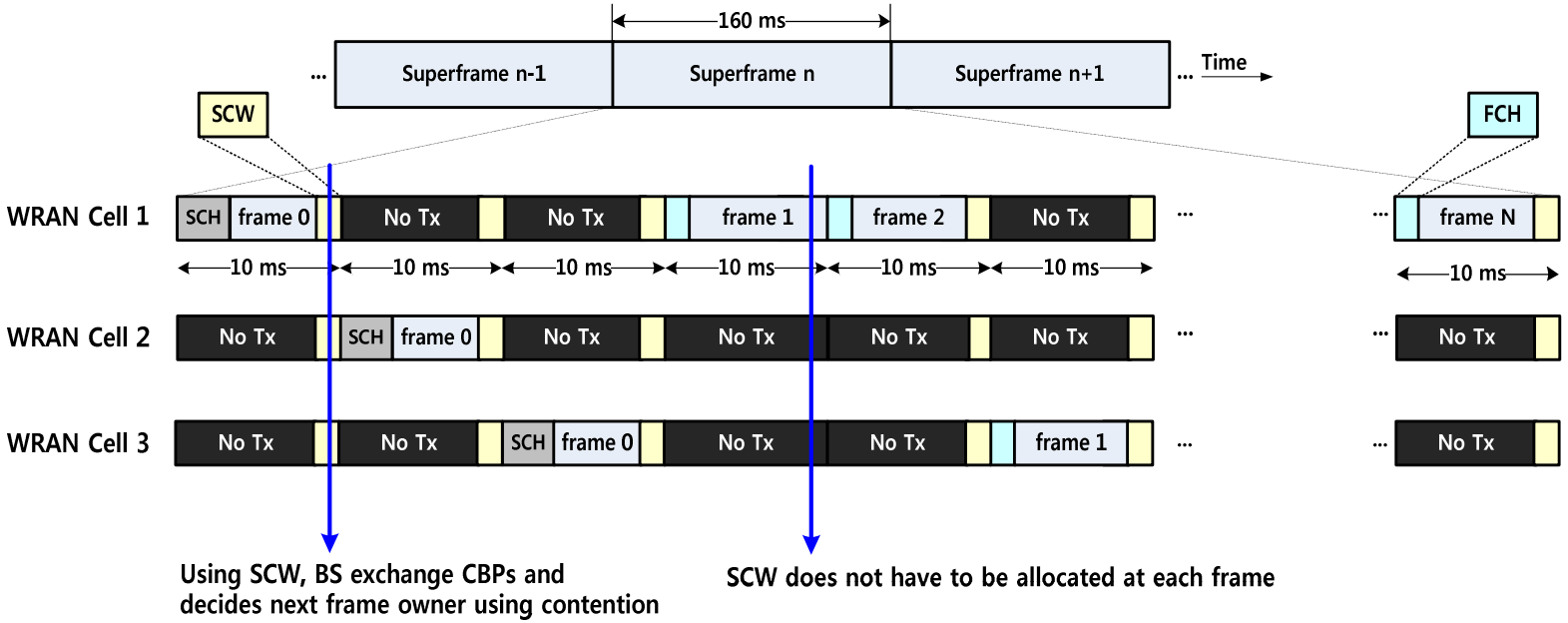
Self-Coexistence Mechanism(2)

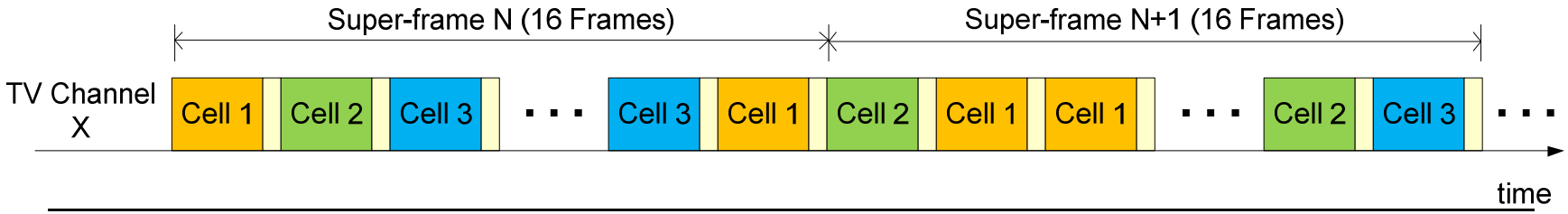
- **Spectrum Etiquette[4]:**
  - Orthogonal channel assignment scheme between adjacent cells
    - different operating channel for overlapping or adjacent cells
    - different first backup channel



Self-Coexistence Mechanism(3)

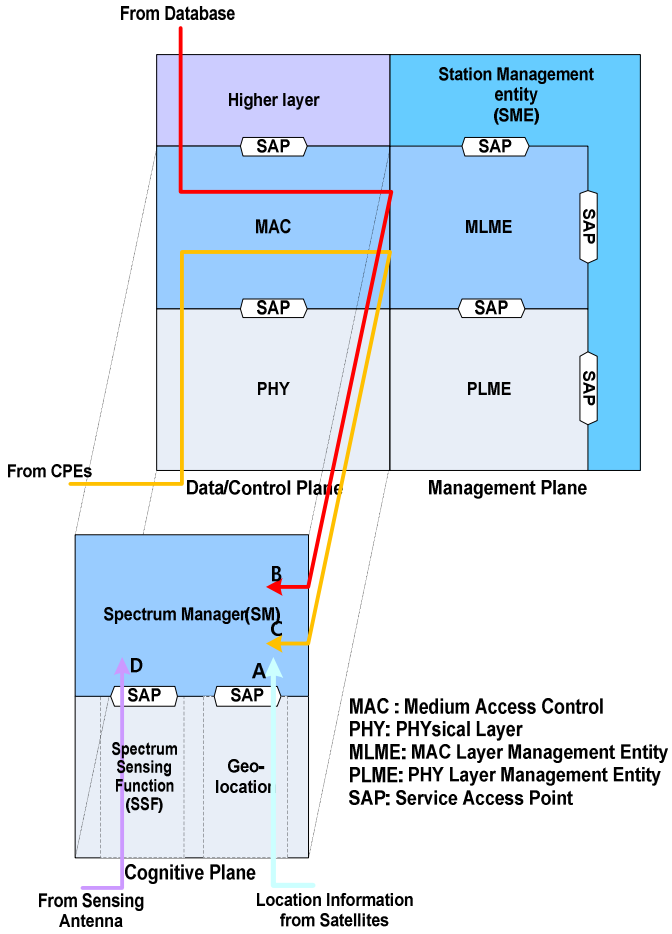
- **On-demand Frame Contention:**
  - Two or more cells need to co-exist on the same channel



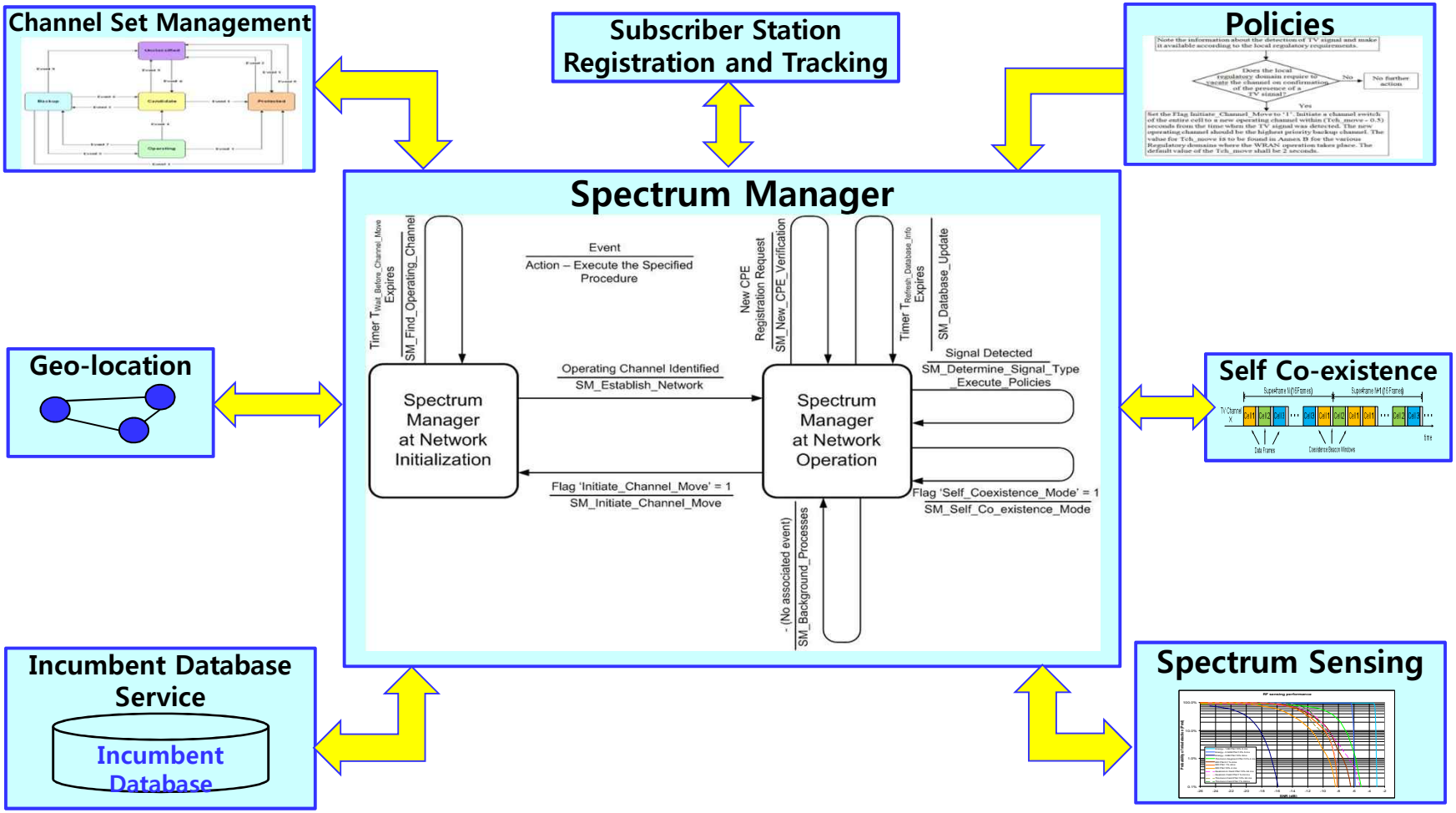


Cognitive Capability Overview

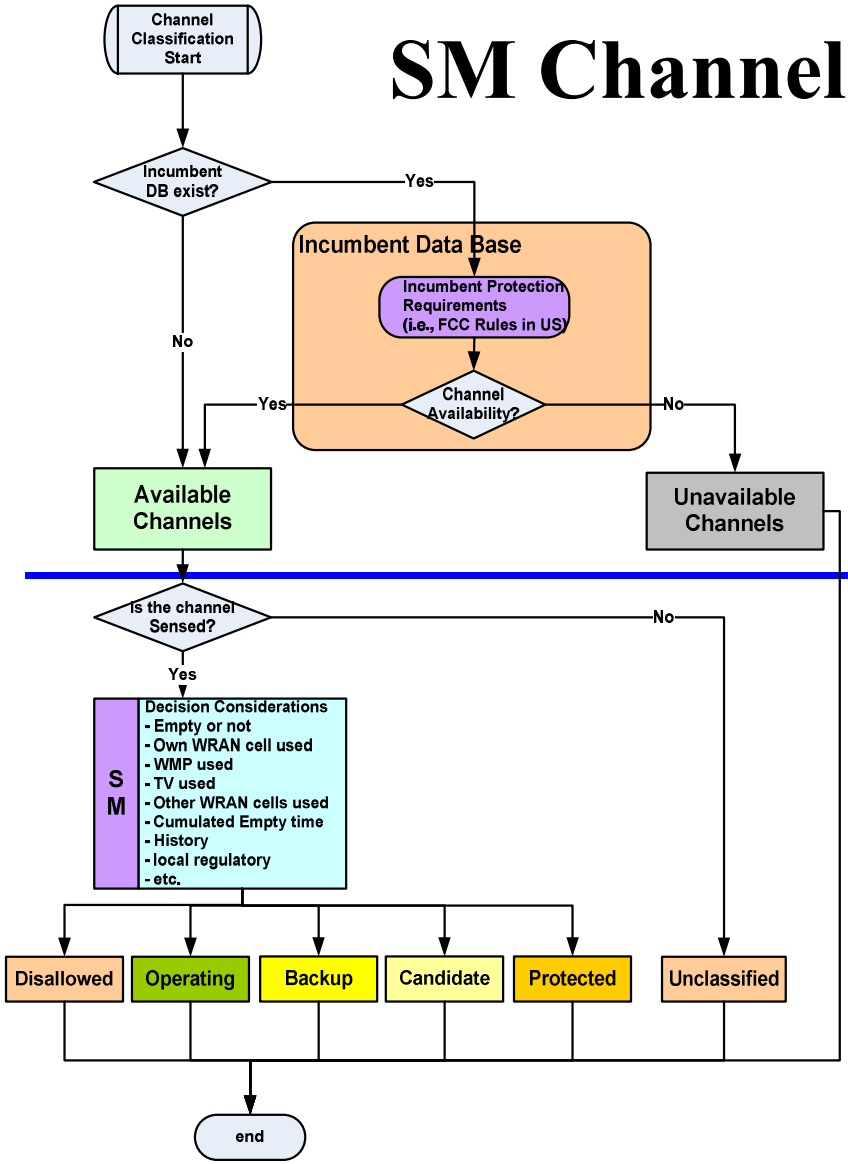
- **Collection of Spectrum Information**
  - **Geo-location information(A)**
  - **TVWS Database(B)**
  - **CPE Spectrum Sensor(C)**
  - **BS Spectrum Sensor(D)**
- **Cognitive Engine(Decision Maker)**
  - **Spectrum Manager (BS)**
  - **Spectrum Automation(CPE)**
- **Configurable Communication System**
  - **802.22 PHY**
  - **802.22 MAC**



Summary of Spectrum Manager[4]



SM Channel Classification[5]

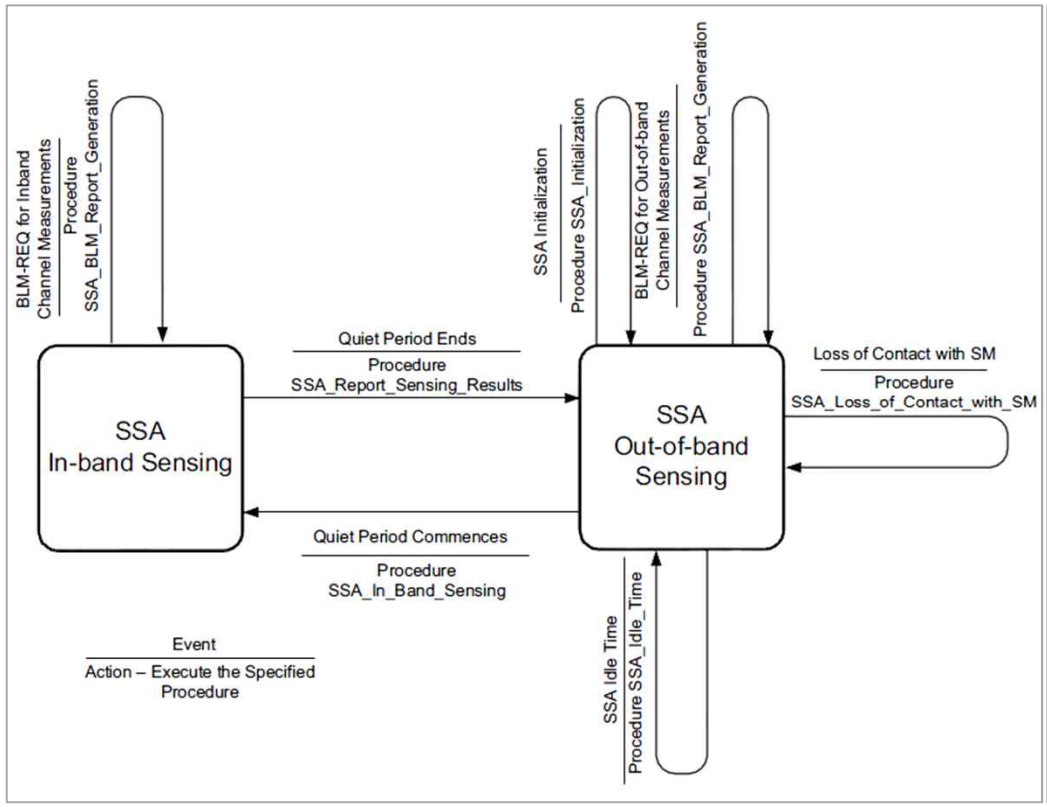


- Two step channel decision
- External IEEE 802.22
- Internal IEEE 802.22

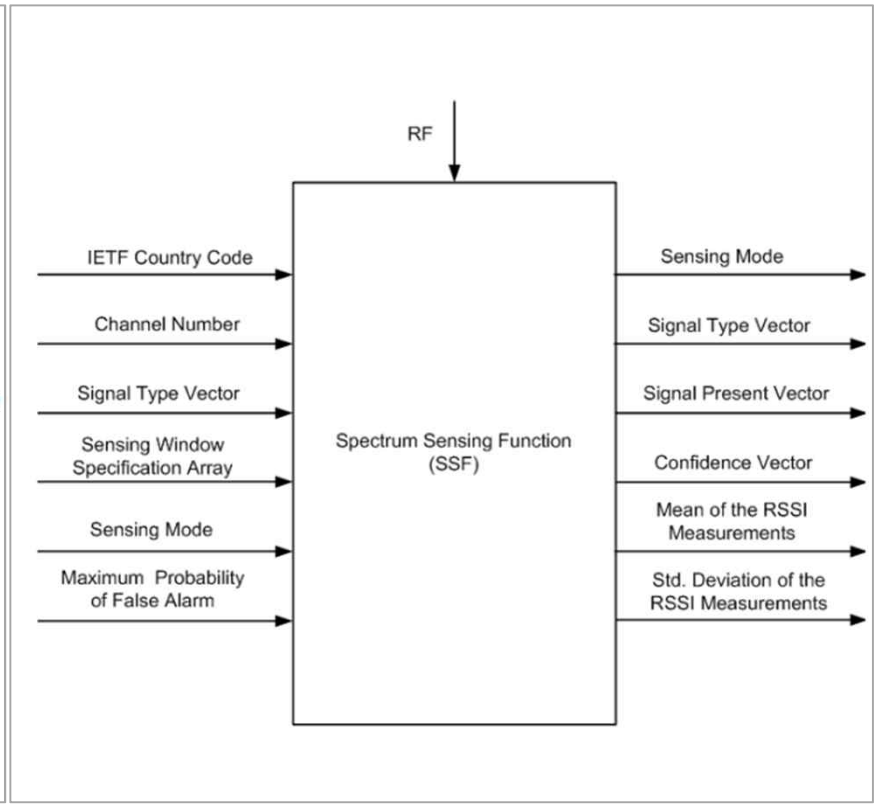
Spectrum Sensing[6]

- **IEEE 802.22 support to spectrum sensing capability by using SSA and SSF**
- **Spectrum Sensing Automation(SSA, sensing manager)**
  - **All the IEEE 802.22 devices (BS and CPEs) shall also have an entity called the Spectrum Sensing Automaton (SSA). The SSA interfaces to the Spectrum Sensing Function (SSF) and executes the commands from the SM to enable spectrum sensing.**
- **Spectrum Sensing Function(SSF, sensor)**
  - **Spectrum sensing is the process of observing the RF spectrum of a television channel to determine its occupancy (by either incumbents or other WRANs).**
  - **The base station and all CPEs shall implement the Spectrum Sensing Function (SSF).**
  - **The SSF shall be driven by the SSA. The SSF shall observe the RF spectrum of a television channel and shall report the results of that observation to the SM (at the BS) via its associated SSA.**

Spectrum Sensing[6]



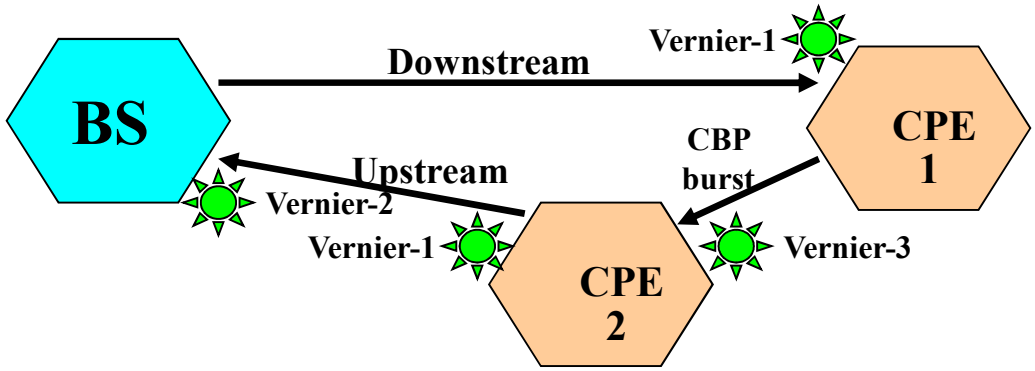
Spectrum Sensing Automation state machine Operation



Input/Output of the Spectrum Sensing Function

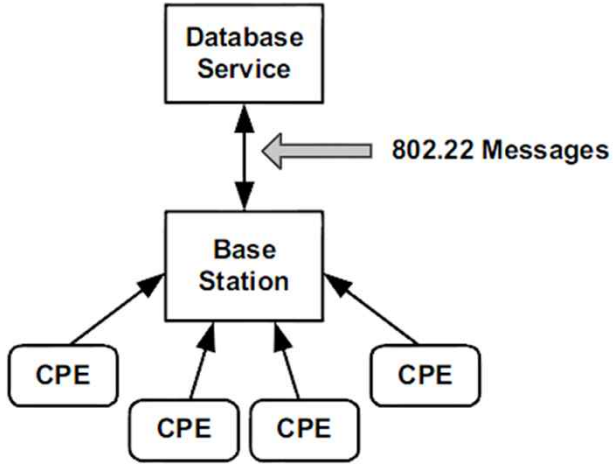
Geo-Location

- **Satellite based geo-location[7]**
  - **Requires GPS antenna at each terminal**
  - **NMEA 0183 data string used to report to BS**
  - **Poor accuracy in Northern hemispheres**
- **Terrestrial based geo-location[4]**
  - **Besides satellite-based geo-location, the 802.22 standard includes terrestrial geo-location using inherent capabilities of the OFDM based modulation and the coexistence beacon protocol bursts transmitted and received among CPEs**
  - **Propagation time measured between BS and its CPEs and among CPEs of the same cell using *Fine Time Difference of Arrival: TDOA***



DB Access

- **WRAN DB access [6]**
  - **802.22 WG defined DB access structure**
  - **Interfaces was defined between DB and BS**
- **Defined DB access primitives are;**
  - **M-DB-AVAILABLE-REQUEST**
  - **M-DB-AVAILABLE-CONFIRM**
  - **M-DEVICE-ENLISTMENT-REQUEST**
  - **M-DEVICE-ENLISTMENT-CONFIRM**
  - **M-DB-AVAILABLE-CHANNEL-REQUEST**
  - **M-DB-AVAILABLE-CHANNEL-INDICATION**
  - **M-DB-DELIST-REQUEST**
  - **M-DB-DELIST-CONFIRM**
  - ***etc***



Structure of the IEEE 802.22 WRAN access to the database service

References

- [1] 22-10-0137-02-0000, Additional text to implement new connection identifier management approach
- [2] 22-09-0112-05-0000, New connection identifier approach
- [3] 22-07-0136-00-0000, Overview of CBP
- [4] 22-10-0121-02-0000, 802.22 Coexistence Aspects
- [5] " Channel Management in IEEE 802.22 WRAN Systems," IEEE Communication Magazine, vol.48, No.9, Sept. 2010
- [6] IEEE P802.22-2011 Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands, July 2011
- [7] 22-10-0073-03-0000, IEEE 802.22 Wireless Regional Area Networks