

IEEE 802.22 MAC/CC Overview

IEEE P802.22 Wireless RANs

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Abstract

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

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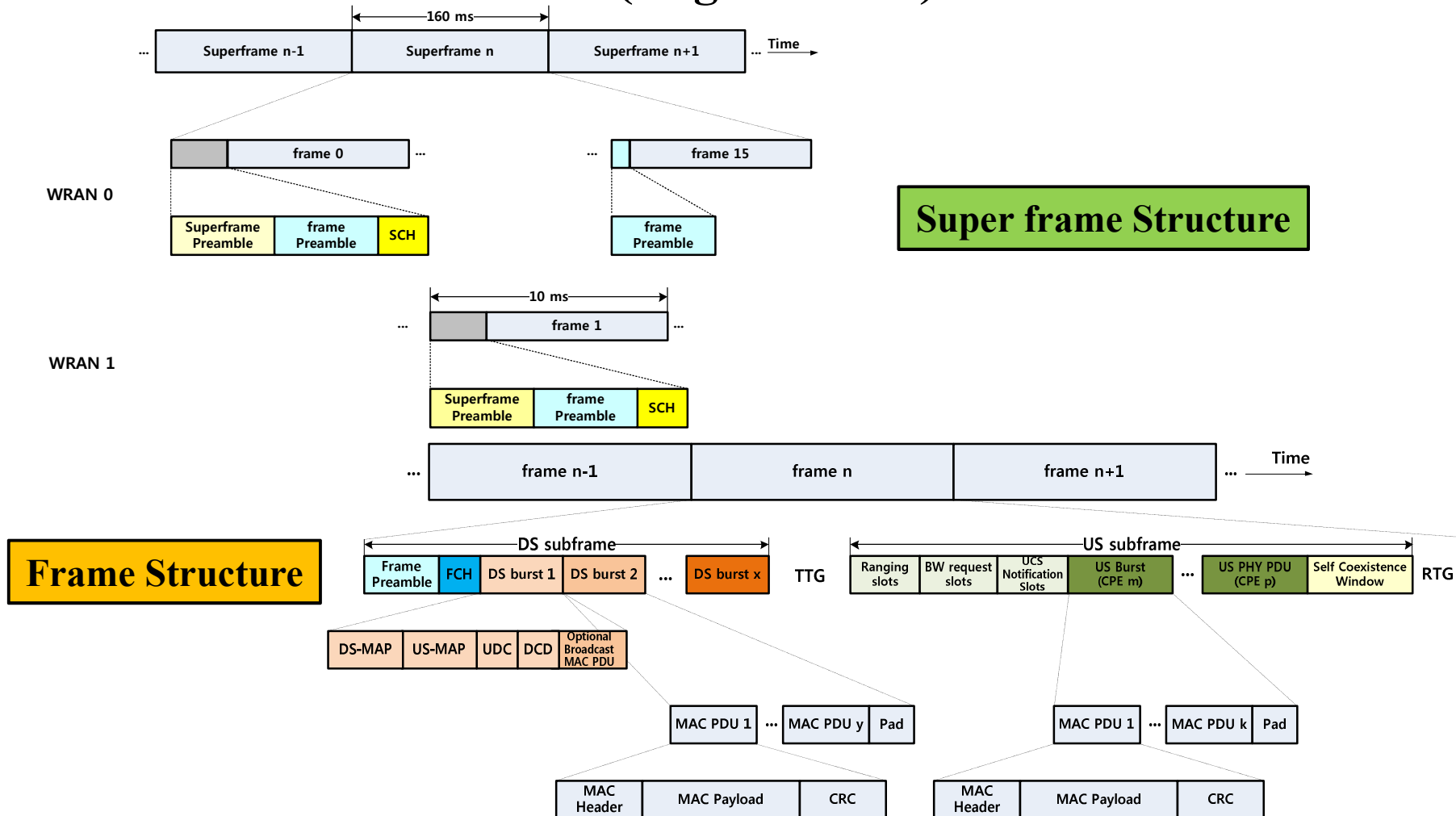
MAC Introduction(1)

- **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)**

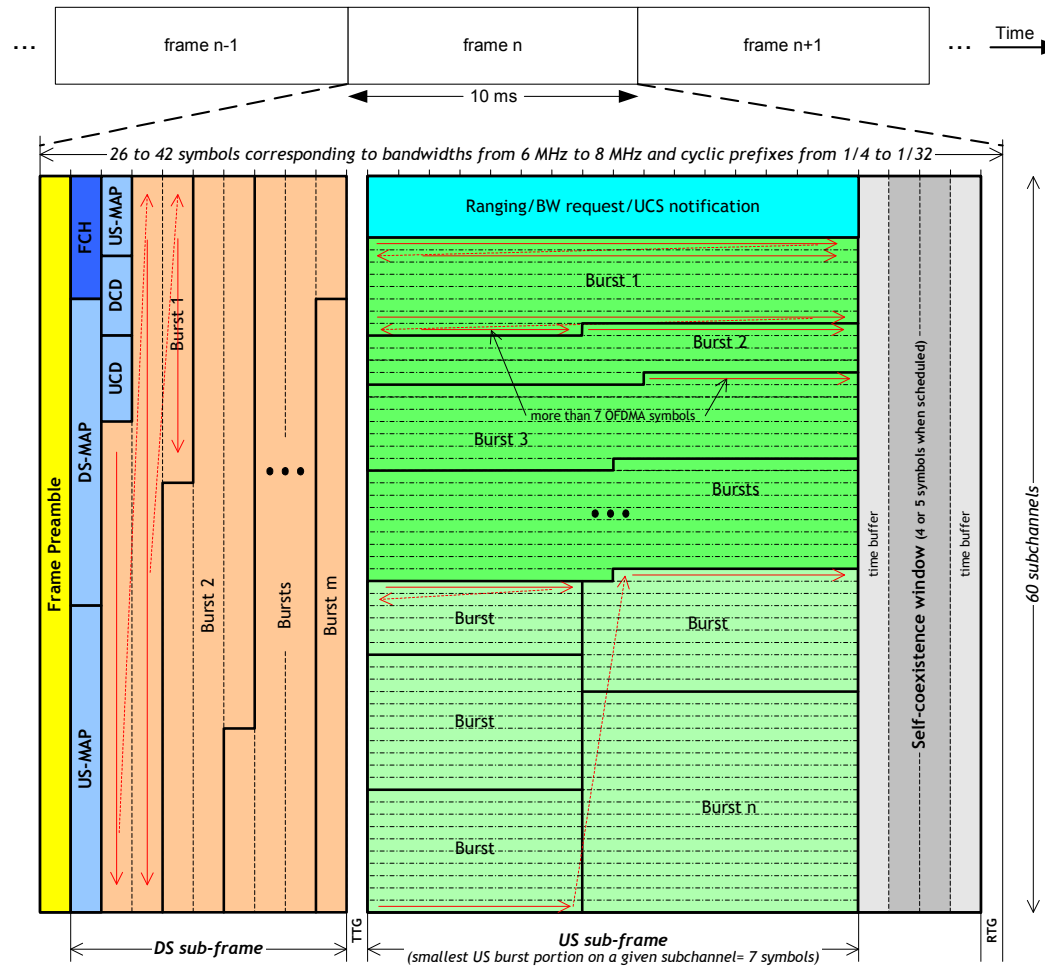
MAC Introduction(2)

- **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**

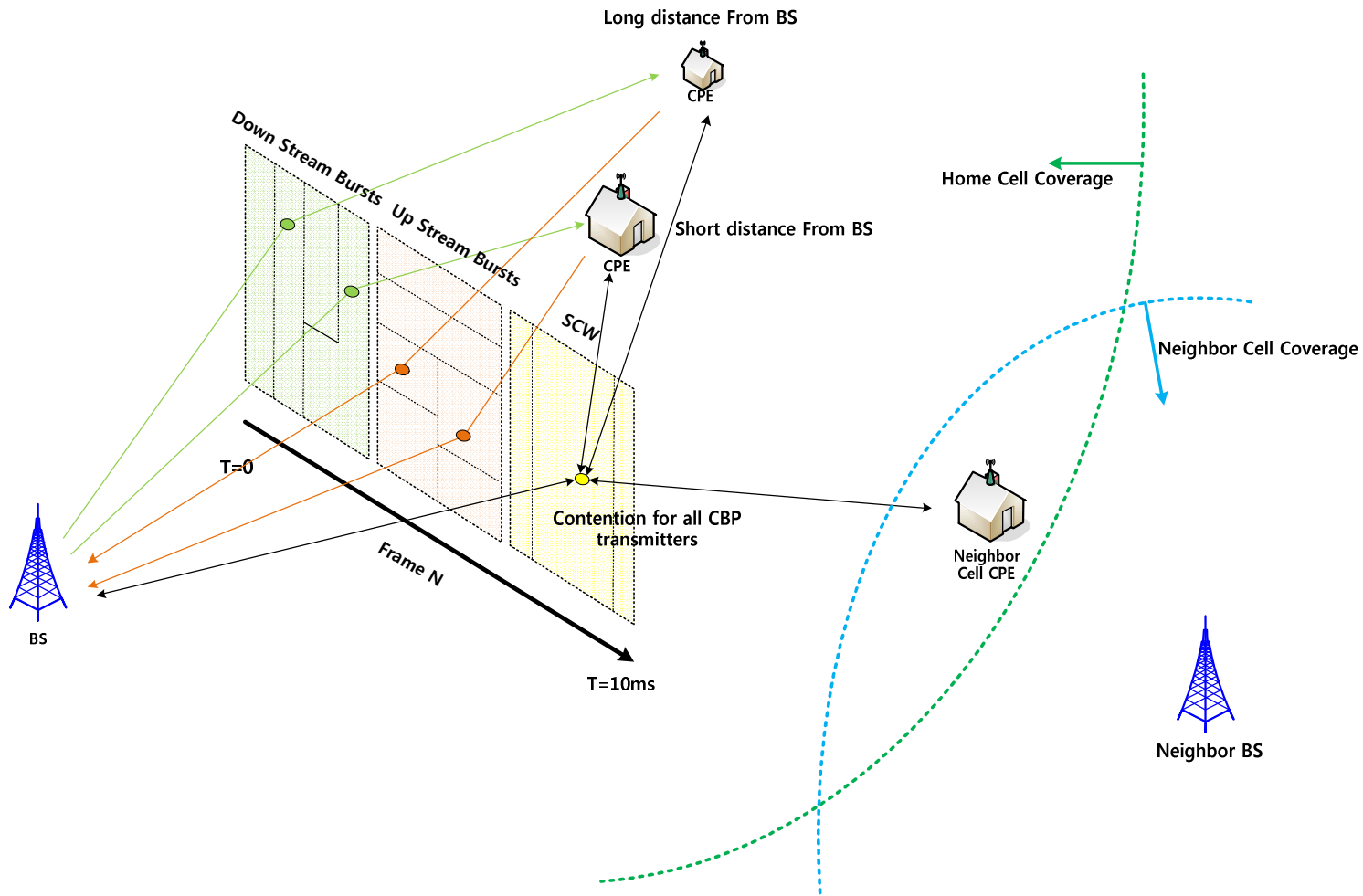
IEEE 802.22 Frame Structure (Logical View)



IEEE 802.22 Frame Structure (Physical View)



Concept of 802.22 Frame Operation

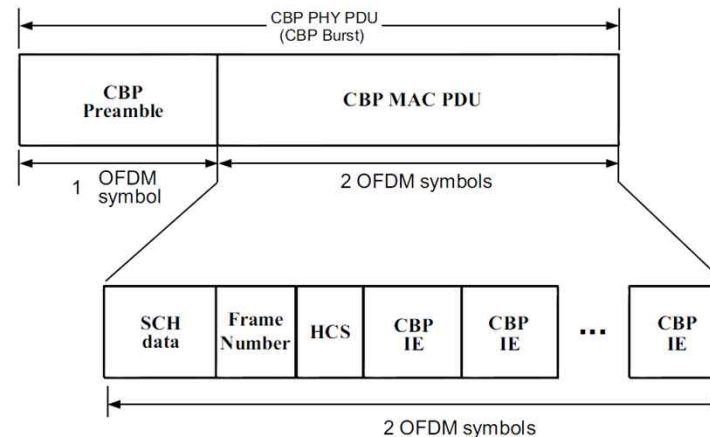


SCH and CBP Features

- **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**

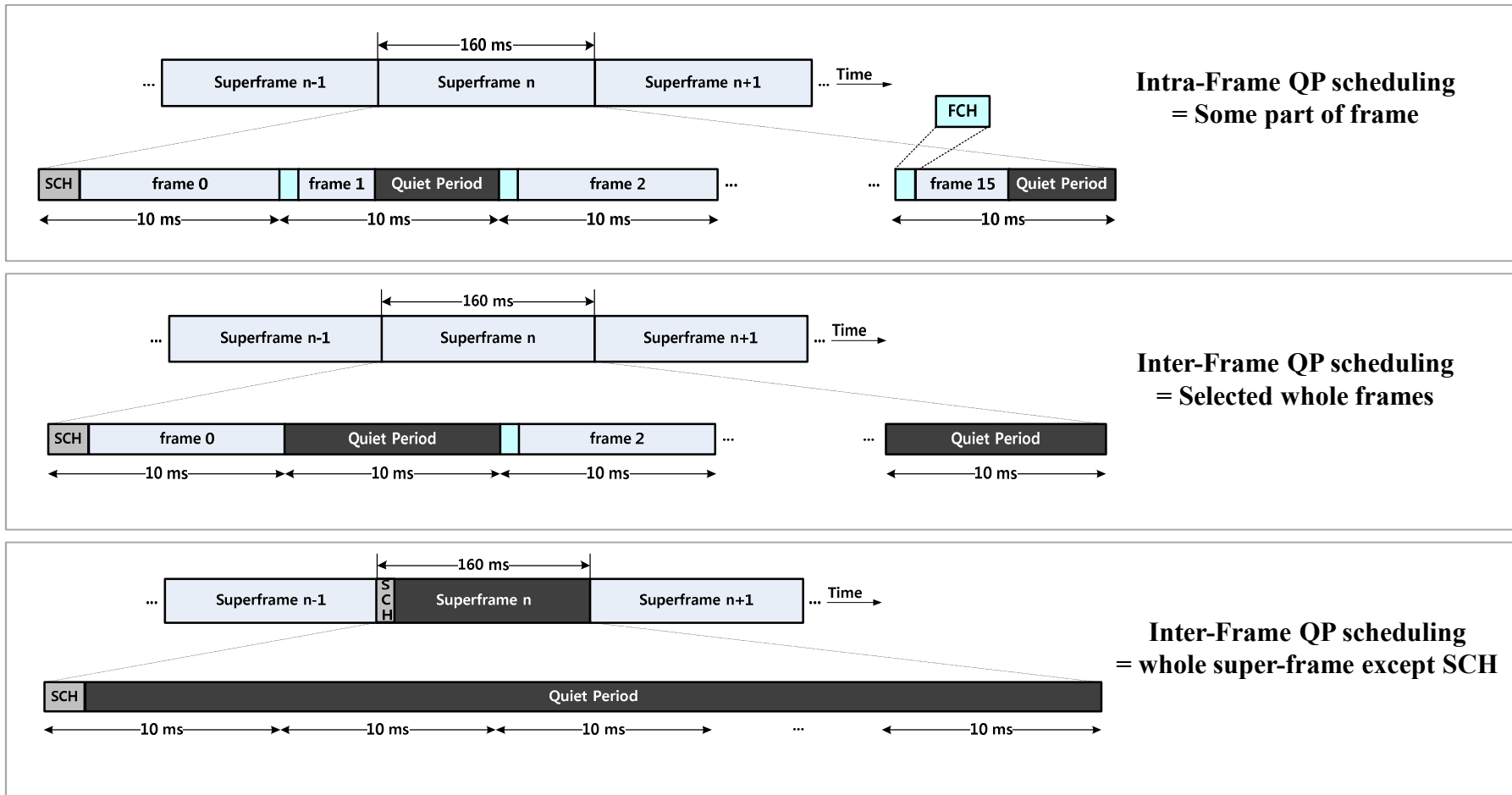
CBP Summary

- 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)



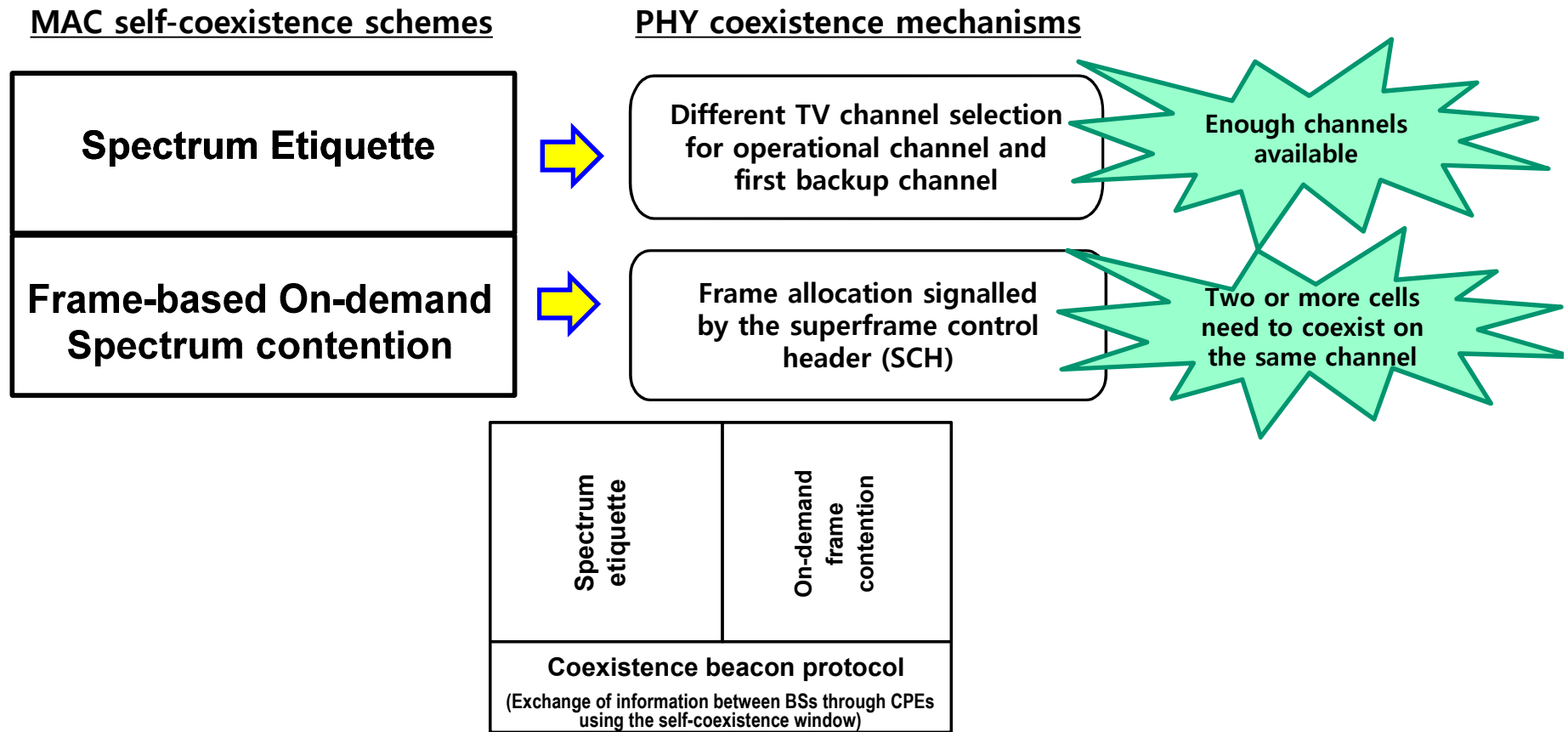
Structure of a CBP packet

Dynamic Quiet Period Scheduling



Self-Coexistence Mechanism(1)

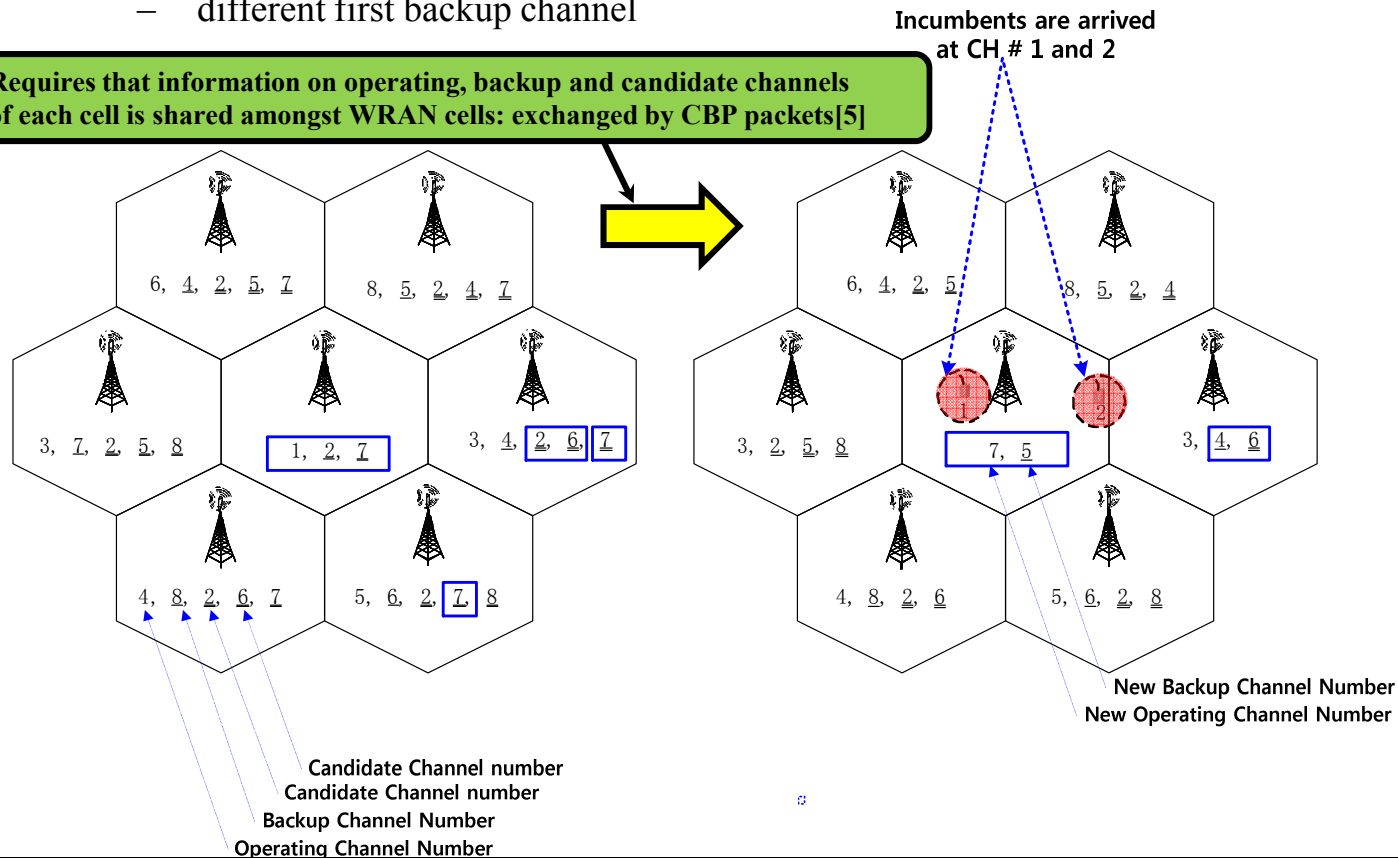
- Self-Coexistence: Among WRAN Systems[4]



Self-Coexistence Mechanism(2)

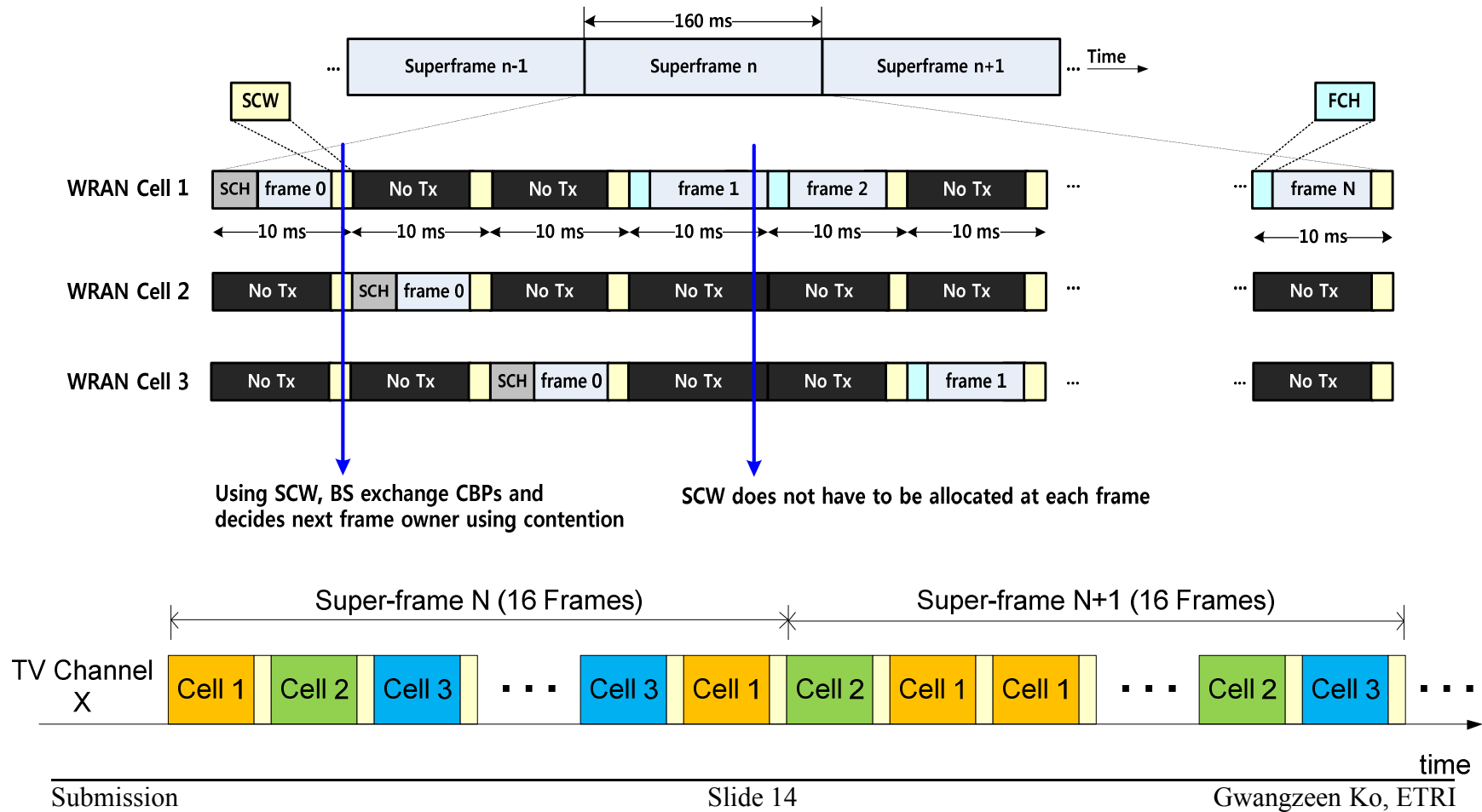
- **Spectrum Etiquette[4]:**
 - Orthogonal channel assignment scheme between adjacent cells
 - different operating channel for overlapping or adjacent cells
 - different first backup channel

Requires that information on operating, backup and candidate channels of each cell is shared amongst WRAN cells: exchanged by CBP packets[5]



Self-Coexistence Mechanism(3)

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

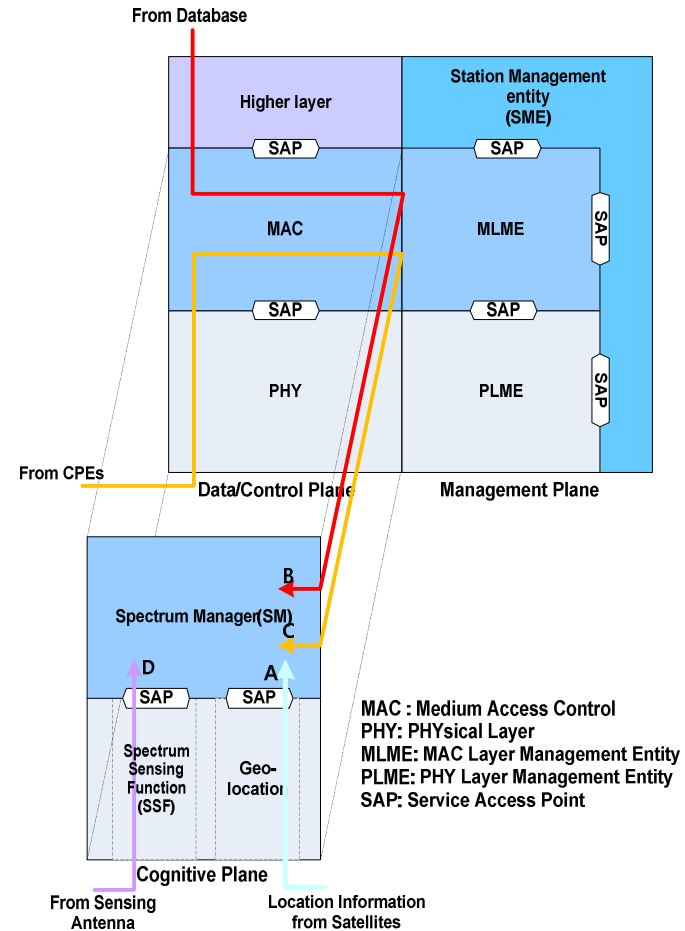


Cognitive Capability Overview

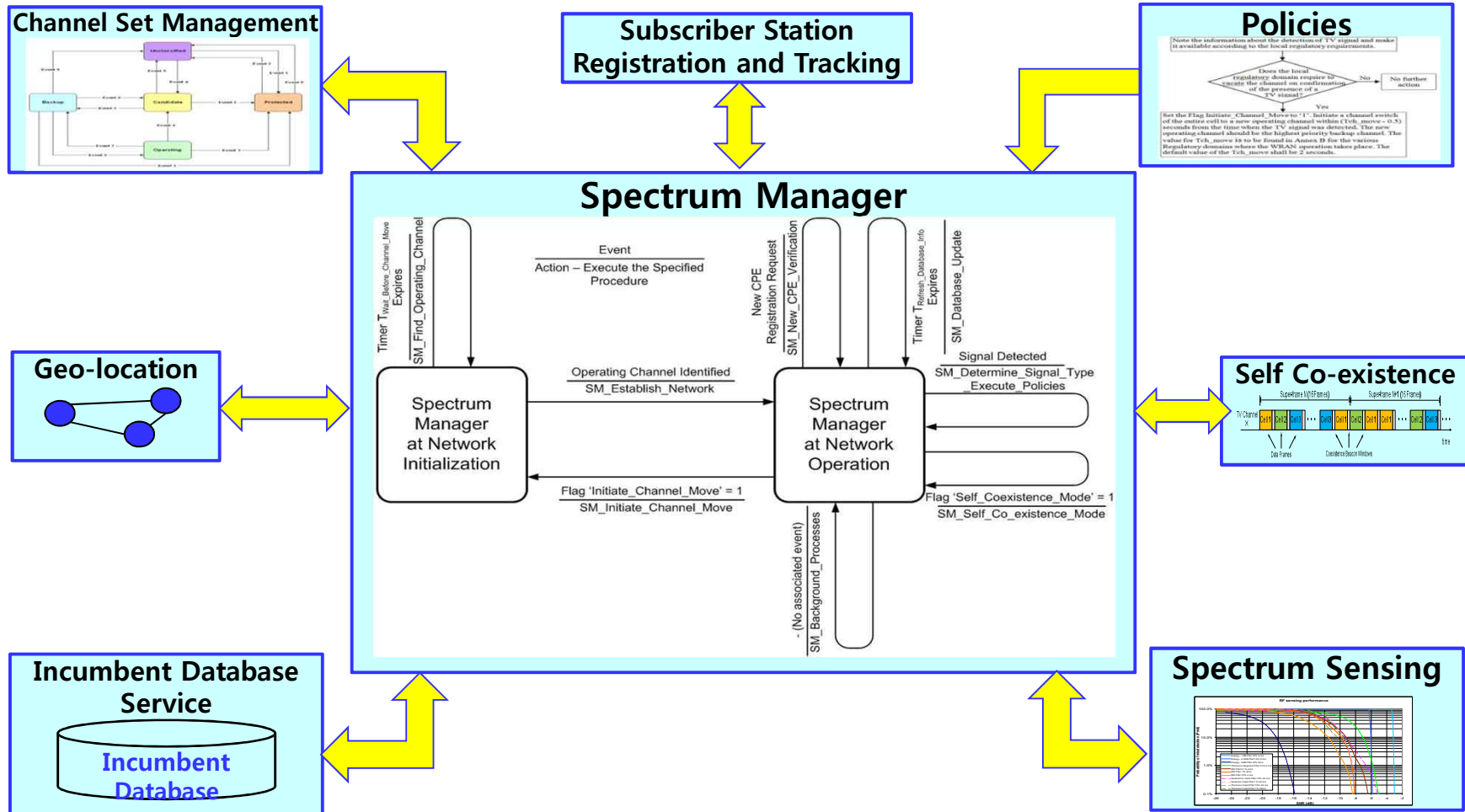
- **Collection of Spectrum Information**
 - Geo-location information(A)
 - TVWS Database(B)
 - CPE Spectrum Sensor(C)
 - BS Spectrum Sensor(D)

- **Cognitive Engine(Decision Maker)**
 - Spectrum Manager (BS)
 - Spectrum Automation(CPE)

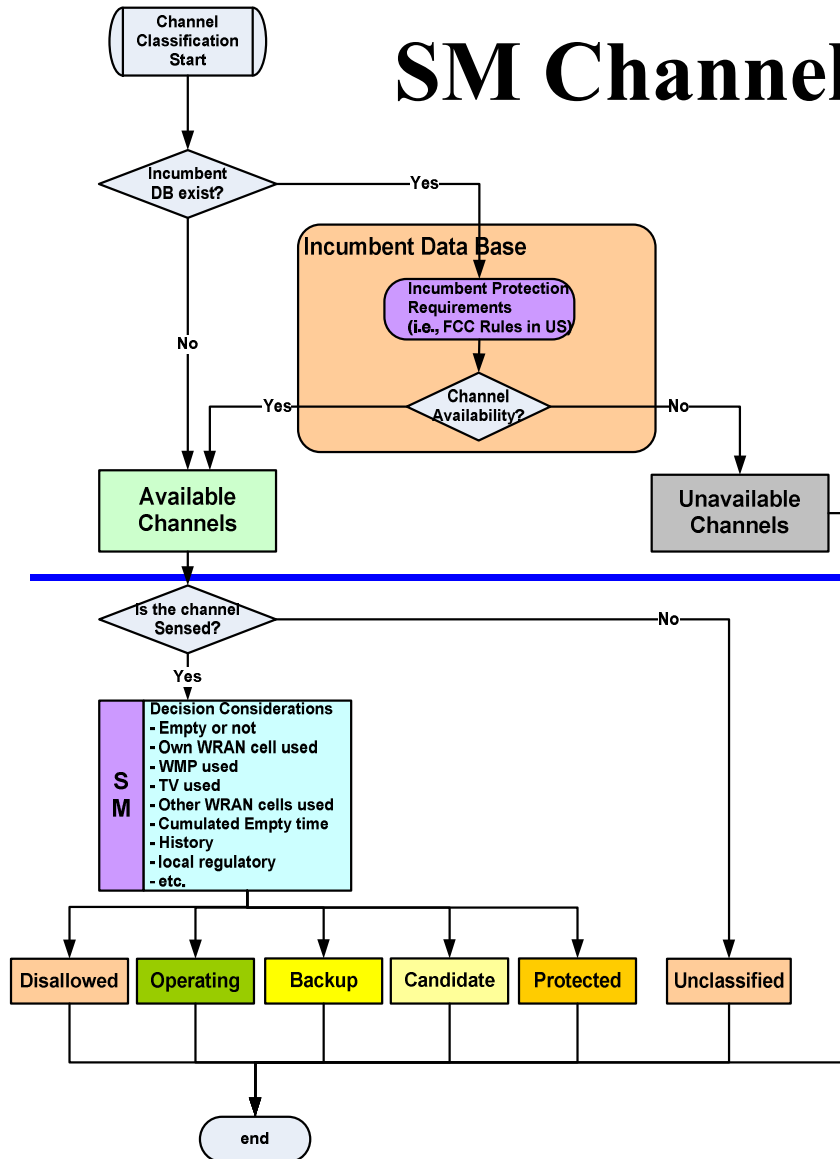
- **Configurable Communication System**
 - 802.22 PHY
 - 802.22 MAC



Summary of Spectrum Manager[4]



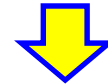
SM Channel Classification[5]



• Two step channel decision



• External IEEE 802.22

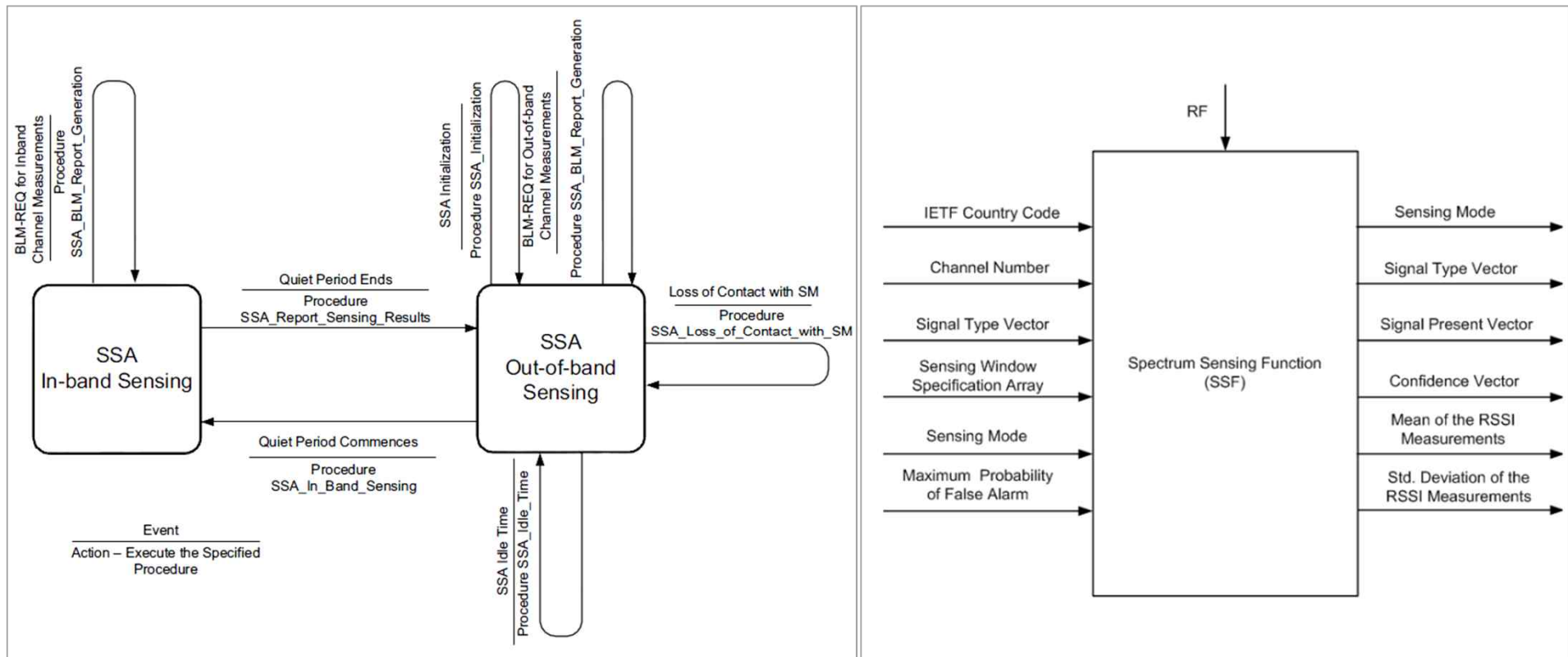


• Internal IEEE 802.22

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]

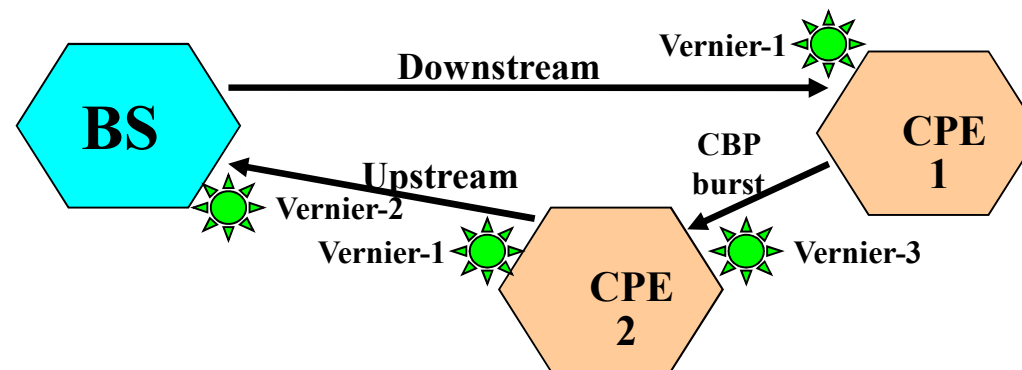


Spectrum Sensing Automation state machine Operation

Input/Output of the Spectrum Sensing Function

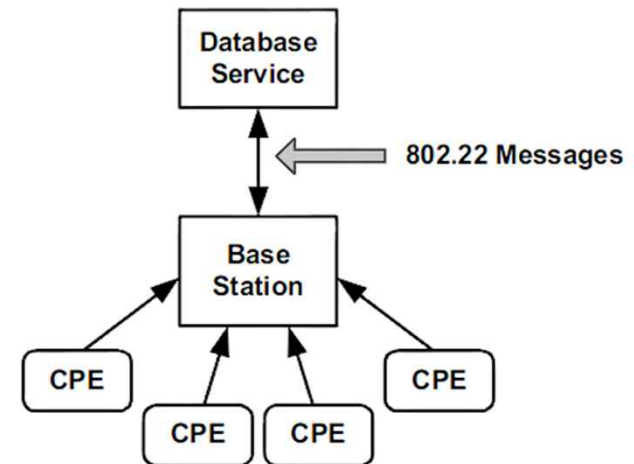
Geo-Location

- **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**