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 in the IEEE 802.22-2011 Standard.
Contents

• 802.22 MAC Features
  – Introduction
  – Super-frame/Frame Structure
  – CBP summary and Coexistence schemes
    • Dynamic QP Scheduling
    • Self-Coexistence Schemes

• Cognitive Capabilities in 802.22
  – Spectrum Manager
  – Channel Classification
  – Spectrum Sensing
  – Geo-location
  – DB Access
MAC Introduction (1)

• Some aspects of IEEE 802.22-2011 MAC have been inspired from 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 other 802.22 systems (self-coexistence)
    - Measurements (incumbents and 802.22 operation)
    - 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)
  - Self-coexistence mechanisms
    - Spectrum Etiquette
    - On-demand Frame Contention
IEEE 802.22 Frame Structure
(Logical View)
IEEE 802.22 Frame Structure
(Physical View)

- Frame Preamble
- FCH
- DS-MAP
- Burst 1
- DCD
- Burst 2
- US-MAP
- Burst 3
- Burst 4
- More than 7 OFDMA symbols
- Burst n
- Burst m
- Ranging/BW request/UCS notification
- Frame n-1
- Frame n
- Frame n+1
- 10 ms
- 26 to 42 symbols corresponding to bandwidths from 6 MHz to 8 MHz and cyclic prefixes from 1/4 to 1/32
- Self-coexistence window (4 or 5 symbols when scheduled)
- Time
The allocation of burst could be based on distance of CPE from BS in order to compensate the delay of arrival.

Contention for all CBP transmitters.
SCH and CBP Features

- **The Super-frame Control Header (SCH)**
  - Provides the control information for a WRAN cell
  - Support the intra-frame and inter-frame quiet periods management mechanisms for sensing
  - Support coexistence with incumbents and other WRAN cells (self coexistence)
- **An SCH can include various CBP (Coexistence Beacon Protocol) IEs**
  - Backup channel information IE
  - Frame Contention information IE
  - Terrestrial Geo-location information IE
  - Signature IE, Certificate IEs (CBP frame security)
- **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

- CBP is used to communicate the operating parameters from one WRAN cell to another WRAN cell
- CBP packet is transmitted using SCW which contains the SCH of its own WRAN cell
- 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 a CPE
- CBP packets carry only control information (no data)
Dynamic Quiet Period Scheduling

Intra-Frame QP scheduling
(Some part of super-frame)
QP < 1Frame

Inter-Frame QP scheduling
(whole super-frame except SCH)
Self-Coexistence Mechanism (1)


- MAC self-coexistence schemes
  - Spectrum Etiquette
  - Frame-based On-demand Spectrum contention

- PHY coexistence mechanisms
  - Orthogonal channel selection for operating channel and first backup channel
  - Frame allocation signalled by the super-frame control header (SCH)

- Coexistence beacon protocol
  (Exchange of information between BSs through CPEs using the self-coexistence window)

- Enough channels available
- Two or more cells need to coexist on the same channel
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

Using SCW, BS exchange CBPs and decides next frame owner using contention

SCW does not have to be allocated at each frame
Cognitive Capability

- **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]

Summary of Spectrum Manager [4]

Channel Set Management

Subscriber Station Registration and Tracking

Policies

Spectrum Manager

Incumbent Database

Geo-location

Self Co-existence

Spectrum Sensing

Incumbent Database Service
SM Channel Classification [5]

Two step channel decision

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External to IEEE 802.22 System

Internal to IEEE 802.22 System
Spectrum Sensing[6]

- IEEE 802.22 supports 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

Input/Output of the Spectrum Sensing Function
Geo-Location

• Satellite based geo-location [7]
  – Requires GPS antenna at each device
  – NMEA 0183 data string used to represent geo-location
  – 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 are defined between DB and BS
- **Defined number of primitives for DB access**
  - M-DB-AVAILABLE-REQUEST
  - M-DEVICE-ENLISTMENT-REQUEST
  - M-DB-AVAILABLE-CHANNEL-REQUEST
  - M-DB-AVAILABLE-CHANNEL-INDICATION
  - M-DB-DELIST-REQUEST
  - *Etc.*

Structure of the IEEE 802.22 WRAN access to the database service
References