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.
Contents

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

• Cognitive Capability Overview
  – Spectrum Manager
  – Channel Classification
  – Spectrum Sensing
  – Geo-location
  – DB Access
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)

Superframe Structure

Frame Structure

IEEE 802.22 Frame Structure
(Logical View)
IEEE 802.22 Frame Structure
(Physical View)

- DS sub-frame
- TTG
- RTG
- US sub-frame

26 to 42 symbols corresponding to bandwidths from 6 MHz to 8 MHz and cyclic prefixes from 1/4 to 1/32

Frame Preamble
FCH
DS-MAP
Burst 1
DCD
Burst 2

Self-coexistence window (4 or 5 symbols when scheduled)

Burst 1
Burst 2
Burst 3

more than 7 OFDMA symbols
Burst
Burst

Bursts
Bursts
Bursts

frame n-1
frame n
frame n+1

... Time ...
10 ms
Concept of 802.22 Frame Operation

- Long distance from BS
- Short distance from BS
- Home cell coverage
- Neighbor cell coverage
- Contention for all CBP transmitters
- Frame N
- T=10ms
- BS
- CPE
- Neighbor cell CPE
- Neighbor BS

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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)
Dynamic Quiet Period Scheduling

Intra-Frame QP scheduling
= Some part of frame

Inter-Frame QP scheduling
= Selected whole frames

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

- Different TV channel selection for operational channel and first backup channel
- Frame allocation signalled by the superframe control header (SCH)

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

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