IEEE 802.22 Wireless Regional Area Networks (WRANs)

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Audio/Video recordings of this lecture are available at:

http://www.cse.wustl.edu/~jain/cse574-10/

Overview

❑ IEEE 802.22: Key Features

❑ IEEE 802.22 Superframe/Frame Structure

❑ IEEE 802.22 Channel Management

❑ Configuration/Security/Power Management

❑ Co-Existence Beacon Protocol (CBP)

❑ Geolocation/Database

IEEE 802.22: Key Features

- Uses 54 MHz-862 MHz TV Band
- Designed to share spectrum when TV broadcast is off
- 17 km to 30 km radius (100 km in good conditions)

100 km
QPSK

30 km
16 QAM

17 km
64QAM
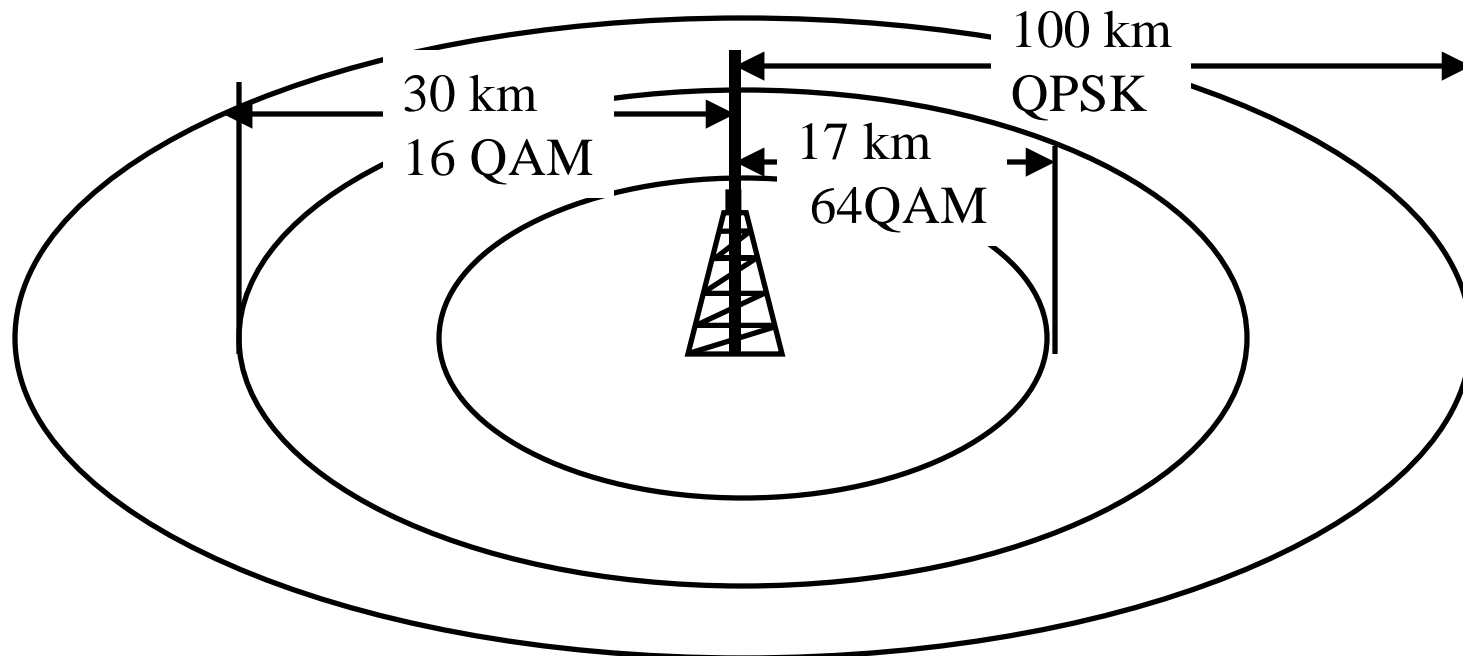
IEEE 802.22: Key Features (Cont)

❑ 1.5 Mbps Down, 384 kbps Up.

❑ Coverage: 50% locations in the fringe areas and 99.9% time

❑ 2 bps/Hz $\Rightarrow$ 12 Mbps in 6 MHz channel
   $\Rightarrow$ 255 users with 40:1 over-subscription

# Characteristics of Wireless Standards
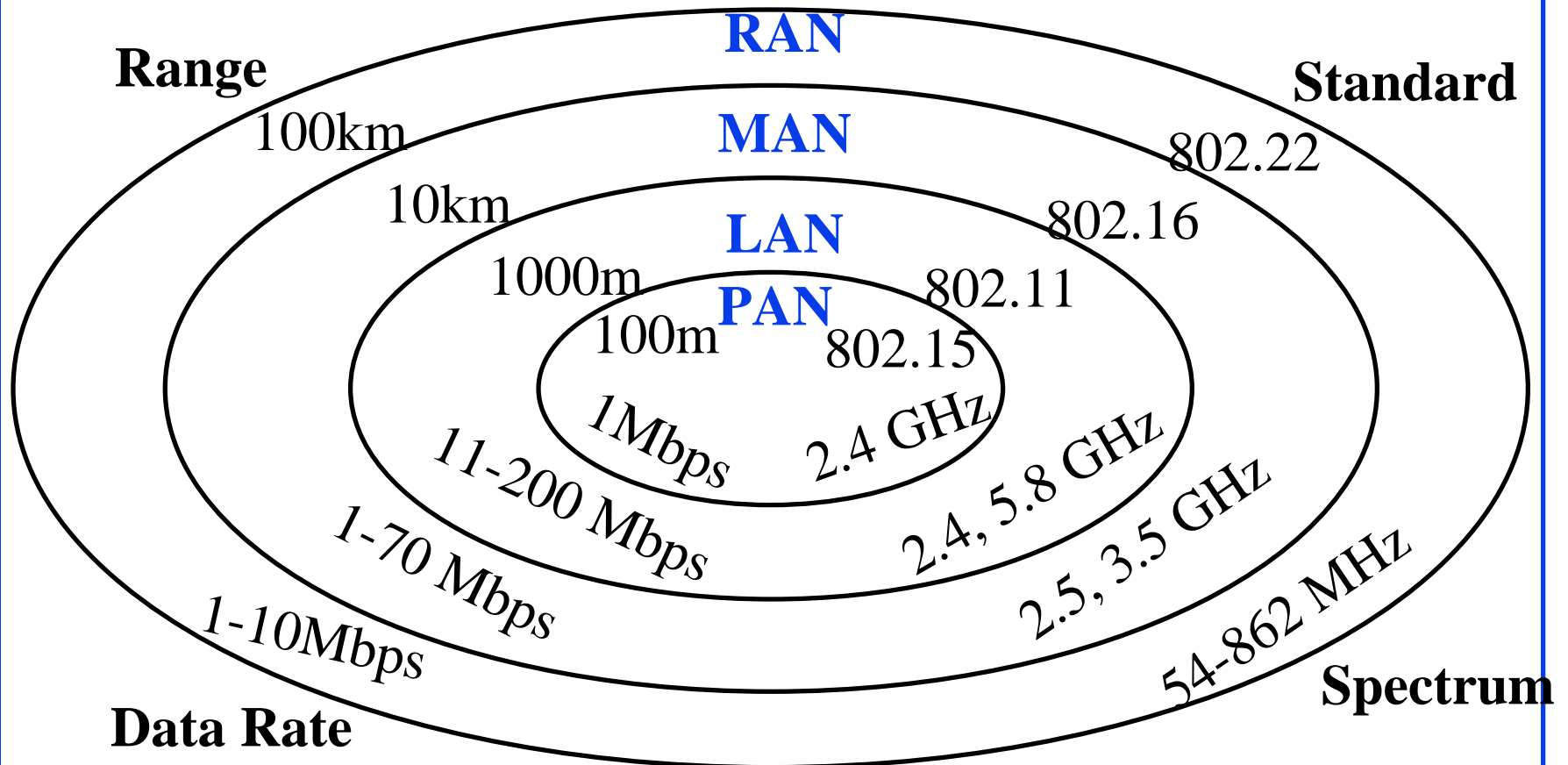
Similarities Between 802.16 and 802.22

❑ Centralized allocation at BS

❑ Service classes: UGS, rtPS, nrtPS, BE

❑ QoS parameters, Peak/sustained rates, max latency, jitter

❑ OFDMA, Slots, DS subframe, US subframe, Bursts
 DL/UL is called DS/US. SS is called CPE.

❑ Connections, 12-bit connection ID (CID), Basic, Primary
   management, Secondary management connections

❑ Ranging request/response

❑ Contention: Ranging, BW request

❑ MAC subheaders: BW request, fragmentation, grant
   management, packing, ARQ feedback, fast feedback

IEEE 802.22 Concepts

❑ Spectrum sensing: Check if TV/WRAN signal is present

❑ In-band: Operating TV Channel N and the first adjacent
channels (N+1 and N-1).

❑ Out-of-band: Any TV channel that is not in-band

❑ Geo-location: Latitude and longitude

❑ Waypoint: Any WRAN device whose location is known.
Used for geolocation.

IEEE 802.22 Superframe Structure

❑ Superframe: Group of 16 frames, with a superframe preamble and superframe control header (SCH).

❑ First frame payload is reduced by two symbols to compensate for Superframe preamble and superframe control header

Superframe n-1	Superframe n	Superframe n+1

← 160 ms →

	Frame 0			Frame 1	•••		Frame 15

Superframe Preamble	Frame Preamble	Superframe Control Header	Frame Preamble
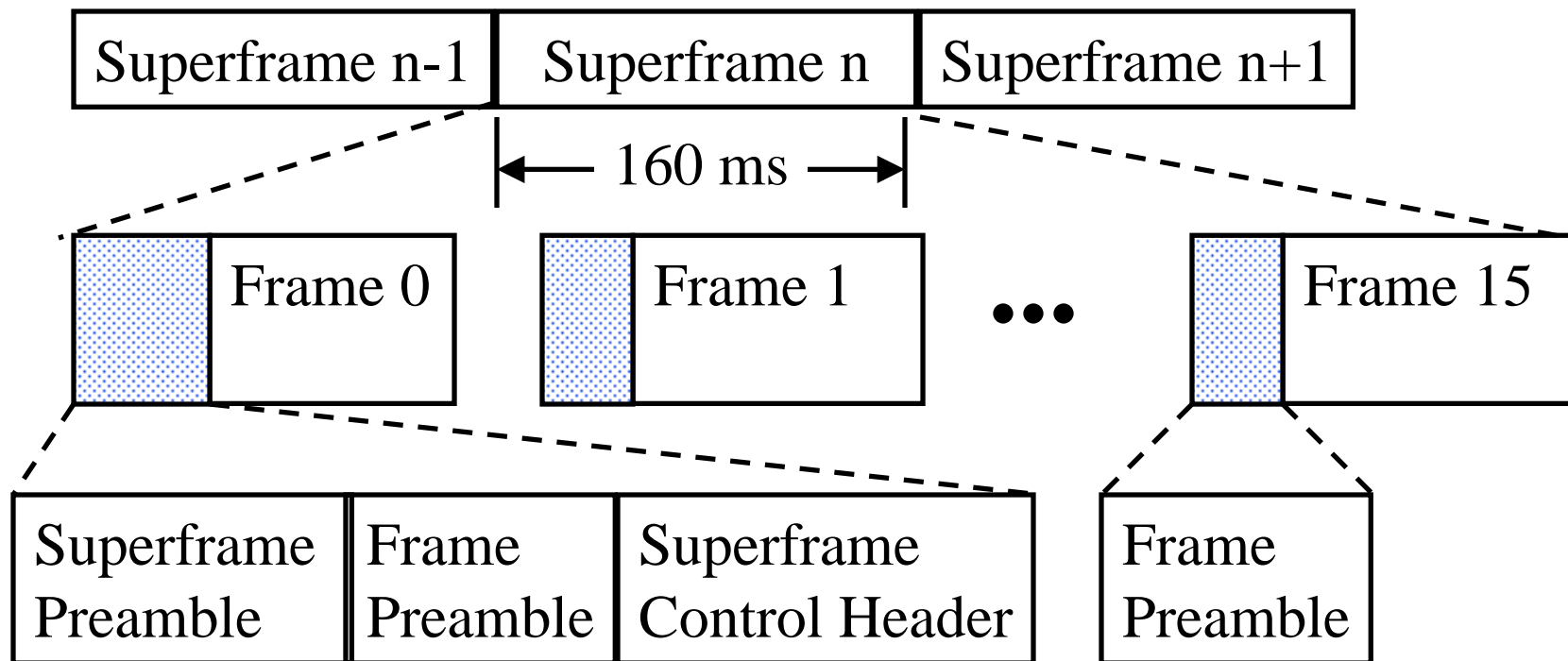
IEEE 802.22 Frame Structure

❑ SCH indicates whether a frame or coexistence beacon follows it.

❑ It also indicates the position and duration of quiet period for inter-frame sensing.

❑ DS:US boundary is adaptive

❑ DS bursts are vertical, US bursts are horizontal

❑ Urgent Co-existence situation (UCS) notification
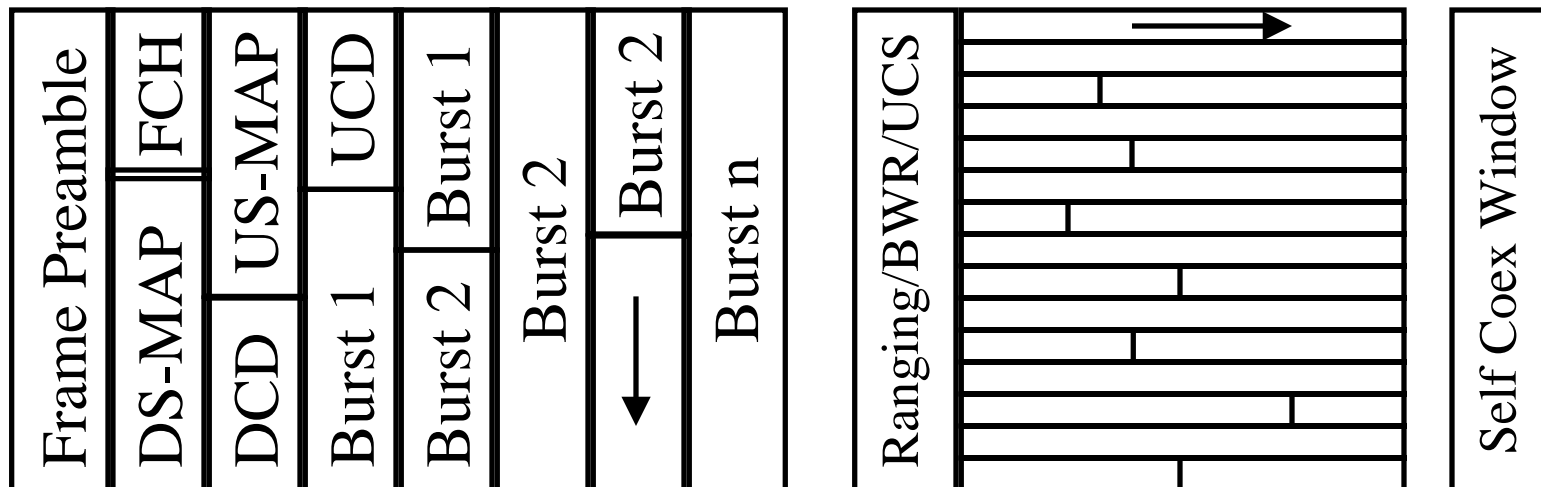
Channel Classifications and Selection

❑ Available: Not occupied by TV transmitters

  ➢ Disallowed: Local regulation

  ➢ Operating: Used by this BS

  ➢ Backup: In backup list of this BS

  ➢ Candidate: For backup

  ➢ Occupied: By other WRANs

  ➢ Unclassified: Don't know

❑ Unavailable: Occupied by TV transmitters

IEEE 802.22 Channel Management

❑ Channel Termination req/resp

❑ Announced by BS if incumbent comes back

❑ Channel Add req/resp to add TV channels to the BS channels

❑ Channel Switch req/resp

❑ Channel Quiet Request/resp
(to perform measurement)

❑ Channel Occupancy update

❑ BS may get the list of incumbents from a database

Measurements Management

❑ Bulk measurement request:
Sent by BS to unicast/multicast/broadcast address
Includes number of repetition and report frequency

❑ Measurement response

❑ Stop measurement request

❑ Location configuration measurement request

Configuration Management

❑ SW Upgrade TFTP server
❑ TFTP complete message

Security Management

❑ Privacy key management req/reply reject/ack

❑ PKM EAP start/transfer

❑ PKM SA-TEK challenge

Power Management

❑ 802.22 stations (BS or CPE) are not allowed to operate on active TV channel (N) or the adjacent channel (N$\pm$1)

❑ Maximum EIRP is limited when operating on alternate channels (N$\pm$2 and beyond)

IDRP

❑ Incumbent Detection Recovery Protocol

❑ BS transmits a channel switching req (CHS-REQ)

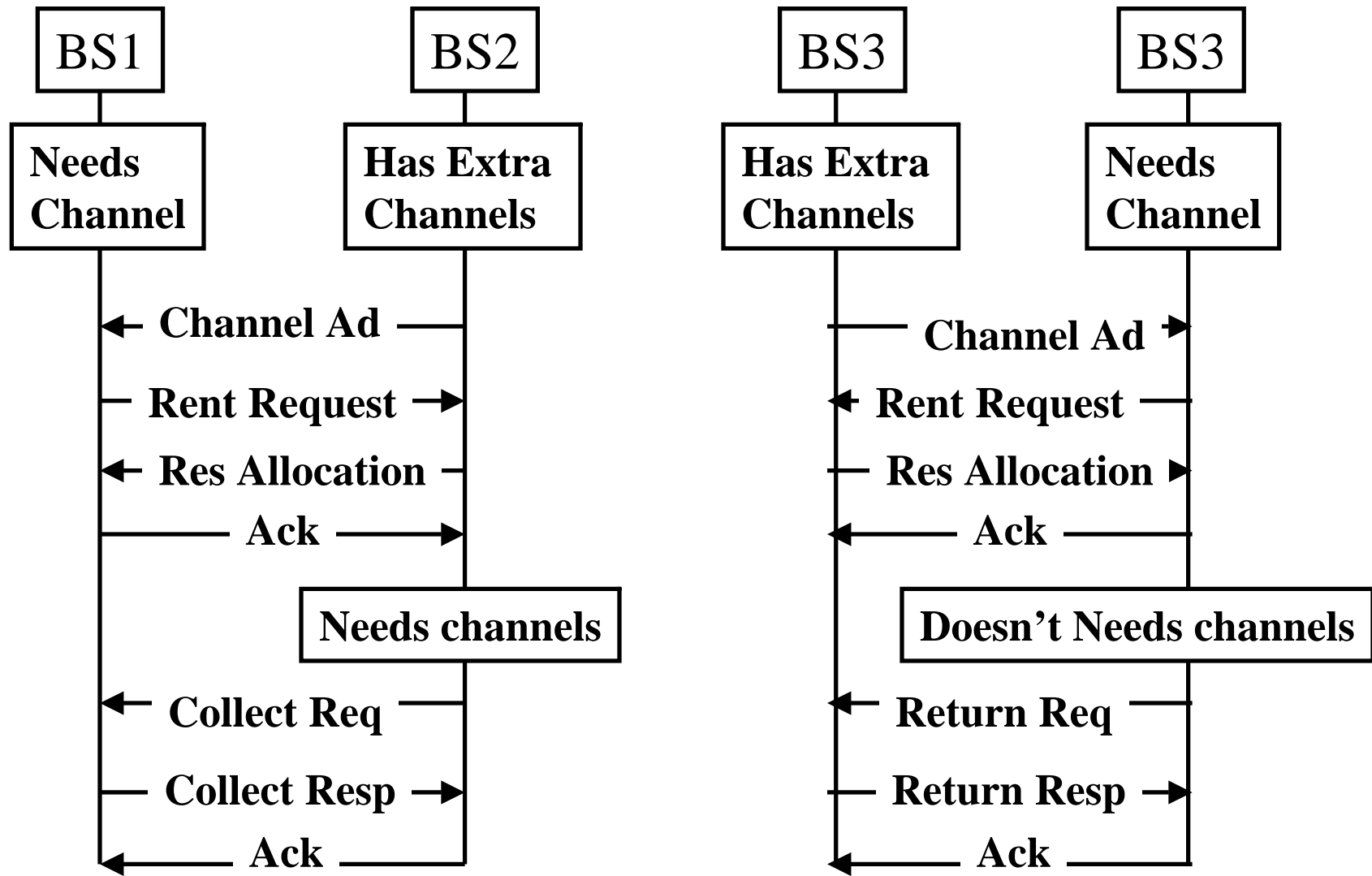❑ If a CPE misses the CHS-REQ, it times out if it does not hear from BS, CPE then moves to the next backup channel

Co-Existence Beacon Protocol (CBP)

❑ For signaling to adjacent and overlapping WRAN cells and for geolocation

❑ CBP bursts are transmitted by selected CPEs at the end of US subframe.

❑ CPEs decode CBP packets from CPEs in cells operating on the same TV channel or adjacent channels.

❑ 14 types of CBP packets including CPE beacons.

❑ CPE beacons are transmitted by the CPEs and contain the TV channel #, backup channel #s, BS ID, CPE ID.

❑ CBP packets are used for coexistence and Geolocation

Self-Coexistence

❑ Two or more 802.22 networks in the same space/time/frequency

1. Spectrum Etiquette: Do not hog the channels

2. Interference Free scheduling: Do not allocate slots which interfere with neighboring cell's CPEs

3. Dynamic Resource Renting and Offering: Less loaded BSs rent spectrum to more loaded BSs.

4. Adaptive On-Demand Channel Contention (AODCC)

Dynamic Resource Renting and Offering

BS1	BS2	BS3	BS3
Needs Channel	**Has Extra Channels**	**Has Extra Channels**	**Needs Channel**

← **Channel Ad** ── ── **Channel Ad** →

─ **Rent Request** → ← **Rent Request** ─

← **Res Allocation** ─ ─ **Res Allocation** →

─ **Ack** → ← **Ack** ─

Needs channels	**Doesn't Needs channels**

← **Collect Req** ─ ← **Return Req** ─

─ **Collect Resp** → ─ **Return Resp** →

← **Ack** ─ ← **Ack** ─

Dynamic Resource Renting (Cont)

❑ Resource advertisement:
Time for which the channel is available for rent

❑ Rent Request: Bid, start time, end time

❑ Resource allocation Response:
Satisfaction or dissatisfaction

❑ Resource Allocation Ack

❑ Resource collection request/response/ack

❑ Returning request/response/ack

AODCC

❑ Adaptive On-Demand Channel Contention

❑ A CPE sends a CBP with channel contention (CC) request.

❑ CC request contains id of the source and destination operator and BS IDs.

❑ CPE runs the contention resolution and sends CC response.

❑ The Contention source then sends a CC ack to indicate that it is going to use that channel.

AODCC (Cont)

❑ Two Cells for the same Operator:

  ➢ Draw random numbers.

  ➢ Whoever gets a higher number wins.

❑ Two Cells from Different Operator:

  ➢ BS1 bids "Credit Tokens" to BS2 with a start time and duration

  ➢ BS2 computes its own "Credit Tokens" to BS1.

  ➢ Whoever bids higher wins.

Synchronization

❑ Neighboring cells on the same frequency need to synchronize their transmission

Spectrum Sensing Function (SSF)

❑ Both BS and CPEs have SSF

❑ There are message for BS to ask CPEs to sense and respond back

Geolocation/Database

❑ GPS based - CPE's send their GPS coordinates

❑ Ranging is done between BS and CPEs

❑ BS can also ask other CPEs to listen to ranging and determine their distances from a CPE

Summary
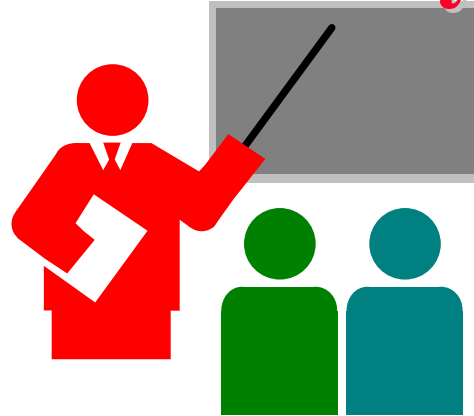
- IEEE 802.22 wireless regional area network covers large rural areas using unused TV channels

- Similar to IEEE 802.16: OFDMA

- Coexistence with incumbent TV operator requires periodic sensing

- Multiple IEEE 802.22 networks can co-exist in the same area on the same channel => Need self-coexistence methods

- Spectrum sharing, renting rules

- Adaptive on-demand channel contention

802.22 Documents

❑ IEEE 802.22/WDv0.4.7, "Draft 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," March 2008, 372 pp. (Available only to working group members)

❑ P802.22.1-D6, "Part 22.1: Enhanced Protection for Low-Power, Licensed Devices Operating in Television Broadcast Bands," February 2009. (Available only to working group members)

❑ 802-22_PAR, "IEEE 802.22 PAR," Sept 23, 2004, 3 pp.

Homework 13

❑ Read the IEEE 802.22 specs and draw a flow chart of the channel contention procedure at the contention source CPE. No need to draw the contention resolution at the destination.

Related Wikipedia Articles

❑ http://en.wikipedia.org/wiki/IEEE_802.22

❑ http://en.wikipedia.org/wiki/Dynamic_frequency_hopping

❑ http://en.wikipedia.org/wiki/Cognitive_radio

❑ http://en.wikipedia.org/wiki/White_spaces_(radio)

List of Acronyms

- AODCC   Adaptive On-Demand Channel Contention
- BS   Base Station
- BW   Bandwidth
- CBP   Co-Existence Beacon Protocol
- CPE   Customer Premises Equipment
- GPS   Global Positioning System
- ID   Identification
- MHz   Mega Hertz
- OFDMA   Orthogonal Frequency Division Multiple Access
- PAR   Project Authorization Request
- PKM   Public Key Management
- SSF   Spectrum Sensing Function
- SW   Software
- UCS   Urgent Co-existence situation
- WRAN   Wireless Regional Area Network