

IEEE 802.22 Wireless Regional Area Networks (WRANs)

Raj Jain
Professor of Computer Science and Engineering
Washington University in Saint Louis
Saint Louis, MO 63130
Jain@cse.wustl.edu

Audio/Video recordings of this lecture are available at:
<http://www.cse.wustl.edu/~jain/cse574-08/>

Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-1



- ❑ 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

Washington University in St. Louis

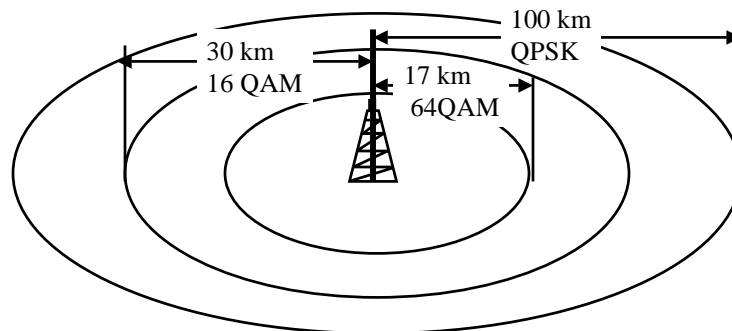
CSE574S

©2008 Raj Jain

13-2

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)



Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-3

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

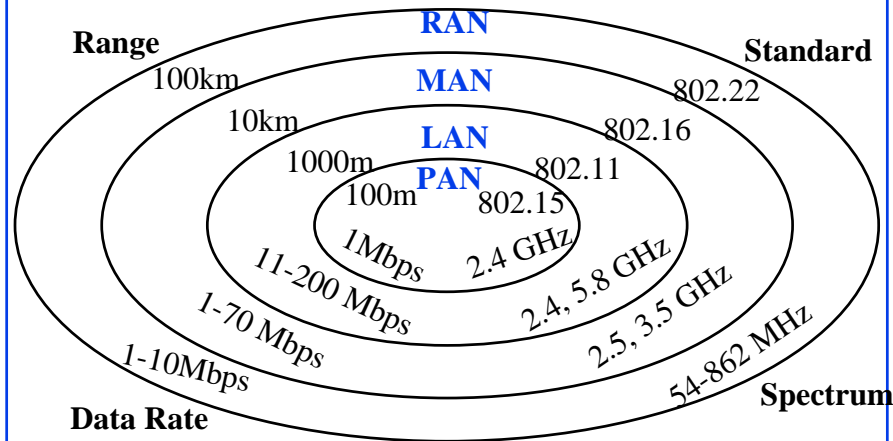
Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-4

Characteristics of Wireless Standards



Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-5

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

Washington University in St. Louis

CSE574S

©2008 Raj Jain

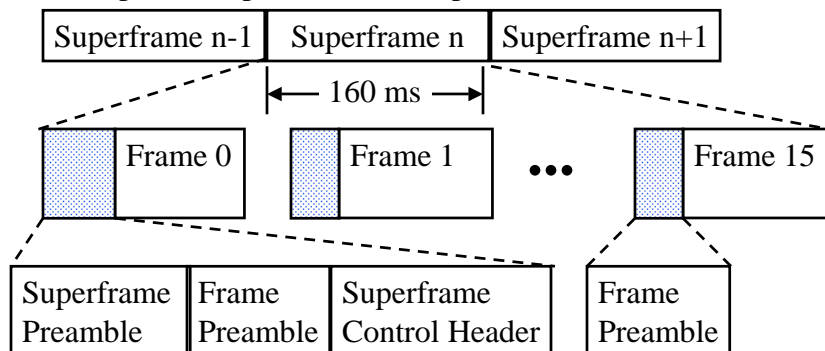
13-6

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.

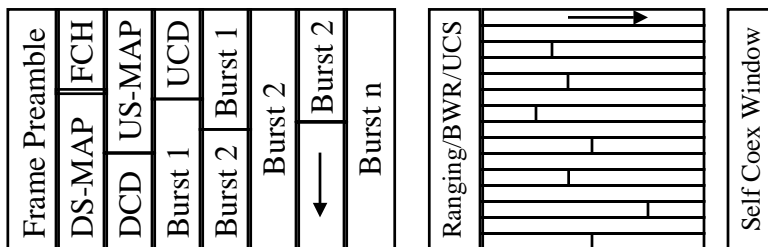
IEEE 802.22 Superframe Structure

- 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



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



Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-9

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

Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-10

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

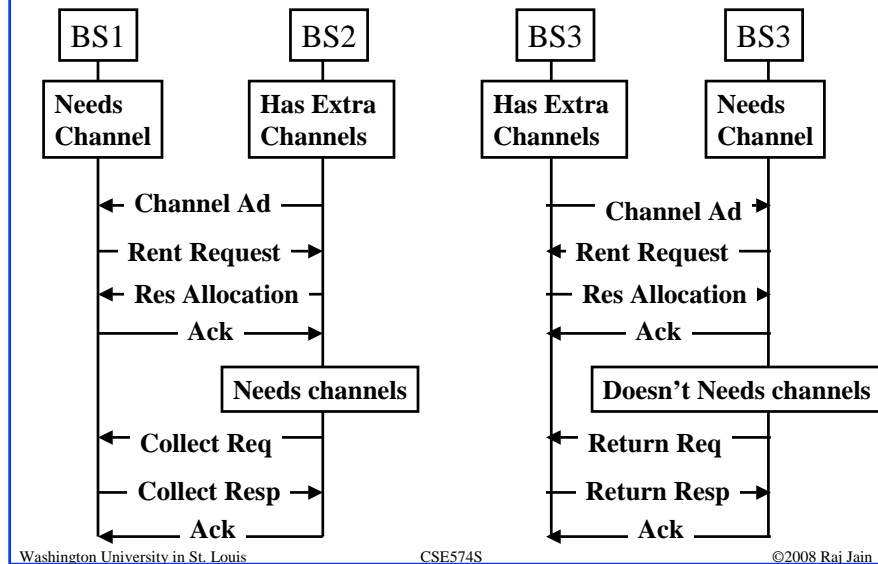
Co-Existence Beacon Protocol (CBP)

- ❑ 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



13-19

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

Washington University in St. Louis

CSE574S

©2008 Raj Jain

13-20

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-D2, "Part 22.1: Enhanced Protection for Low-Power, Licensed Devices Operating in Television Broadcast Bands," October 2007. (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.