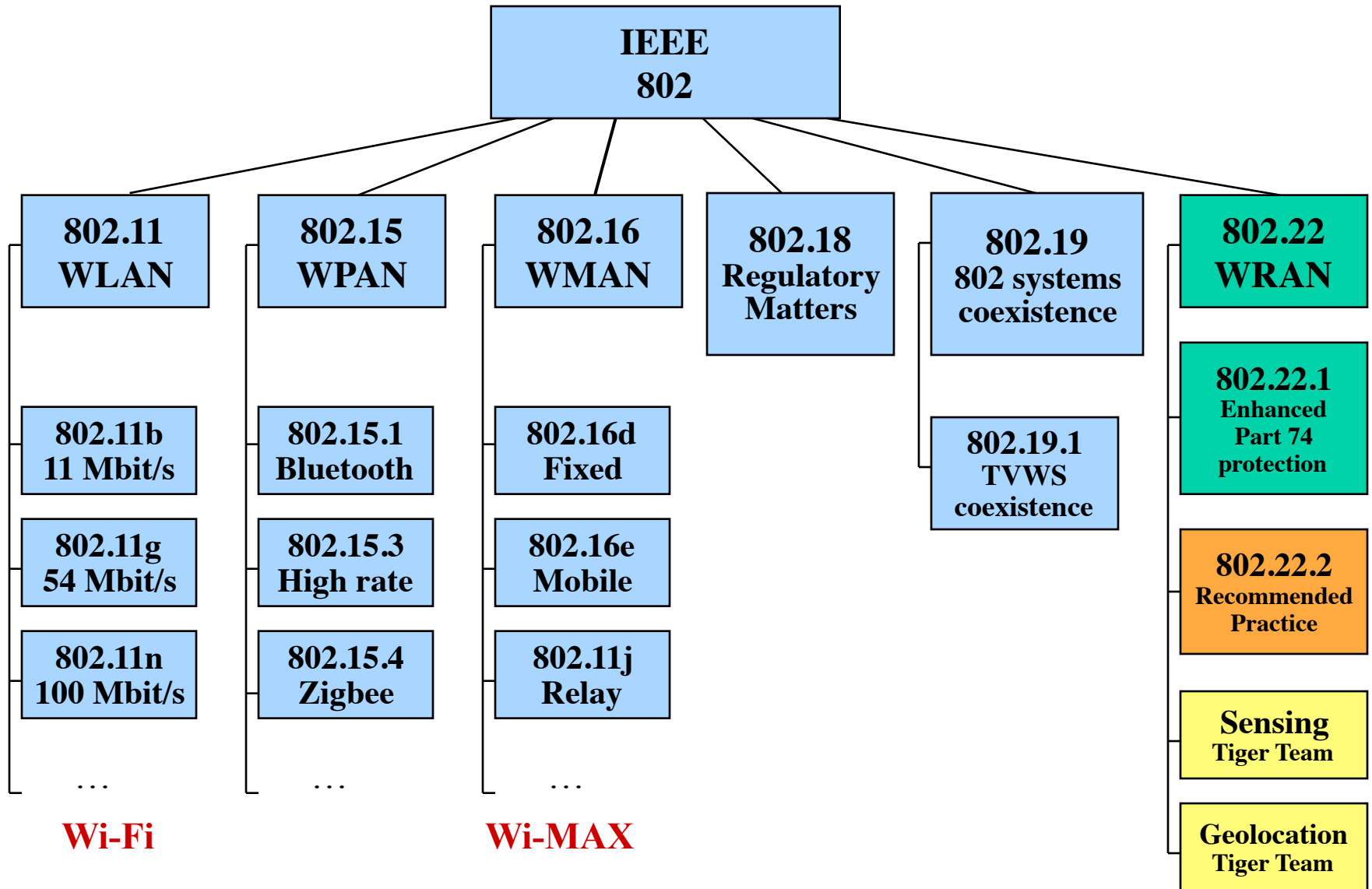# The IEEE 802.22 WRAN Standard and its interface to the White Space Database
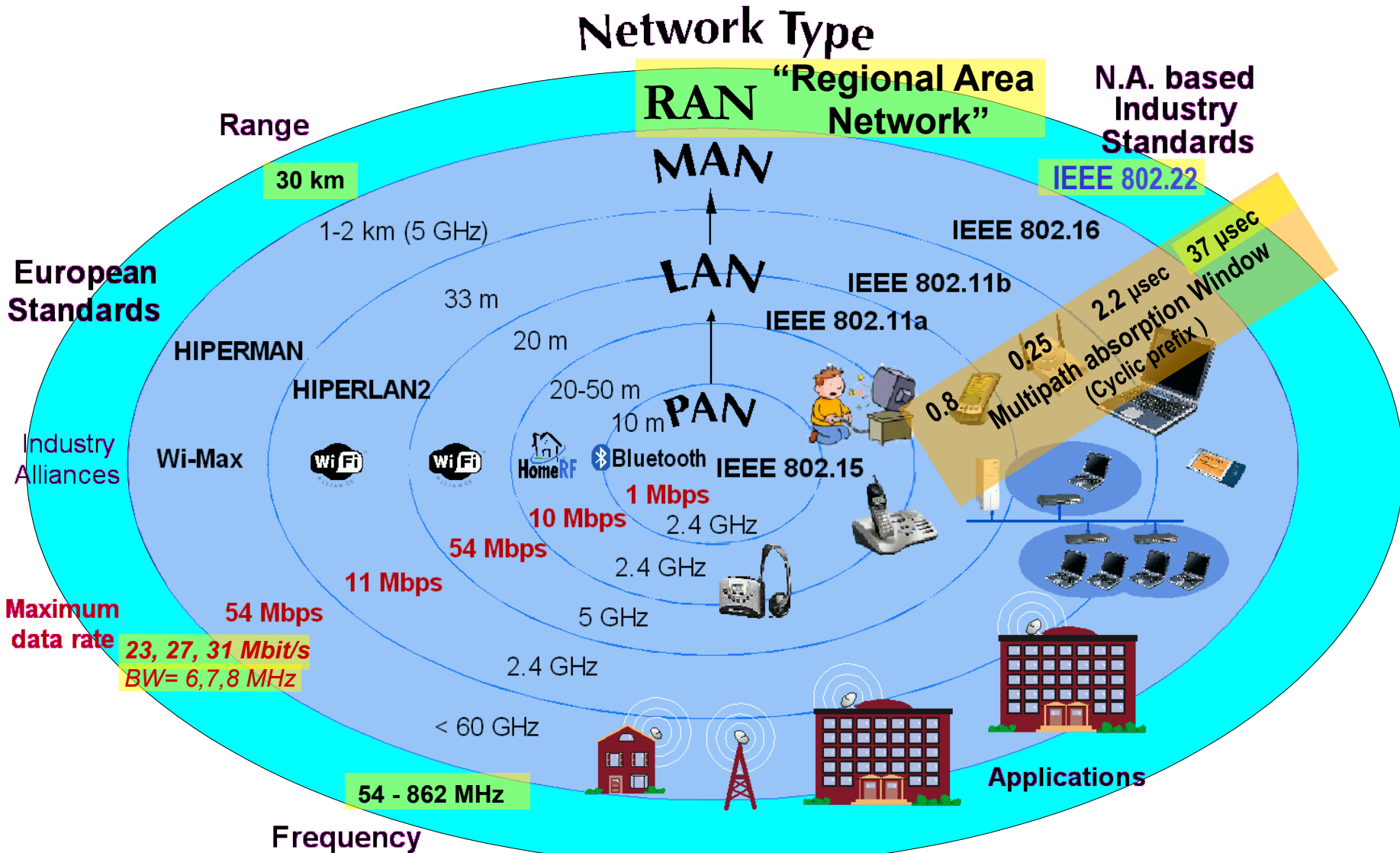
IETF PAWS
Working Group Meeting
Québec City
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IEEE 802 Standards Process

IEEE 802 Standards

Network Type

RAN — "Regional Area Network"

MAN

LAN

PAN

Range
- 30 km
- 1-2 km (5 GHz)
- 33 m
- 20 m
- 20-50 m
- 10 m

N.A. based Industry Standards
- IEEE 802.22
- IEEE 802.16
- IEEE 802.11b
- IEEE 802.11a
- IEEE 802.15

European Standards
- HIPERMAN
- HIPERLAN2
- Wi-Max

Industry Alliances
- Wi-Fi
- Wi-Fi
- HomeRF
- Bluetooth

Maximum data rate
- 54 Mbps
- 11 Mbps
- 54 Mbps
- 10 Mbps
- 1 Mbps
- 23, 27, 31 Mbit/s BW= 6,7,8 MHz

Frequency
- < 60 GHz
- 2.4 GHz
- 5 GHz
- 2.4 GHz
- 2.4 GHz
- 54 - 862 MHz

0.8   0.25   Multipath absorption Window   2.2 μsec   37 μsec   (Cyclic prefix)
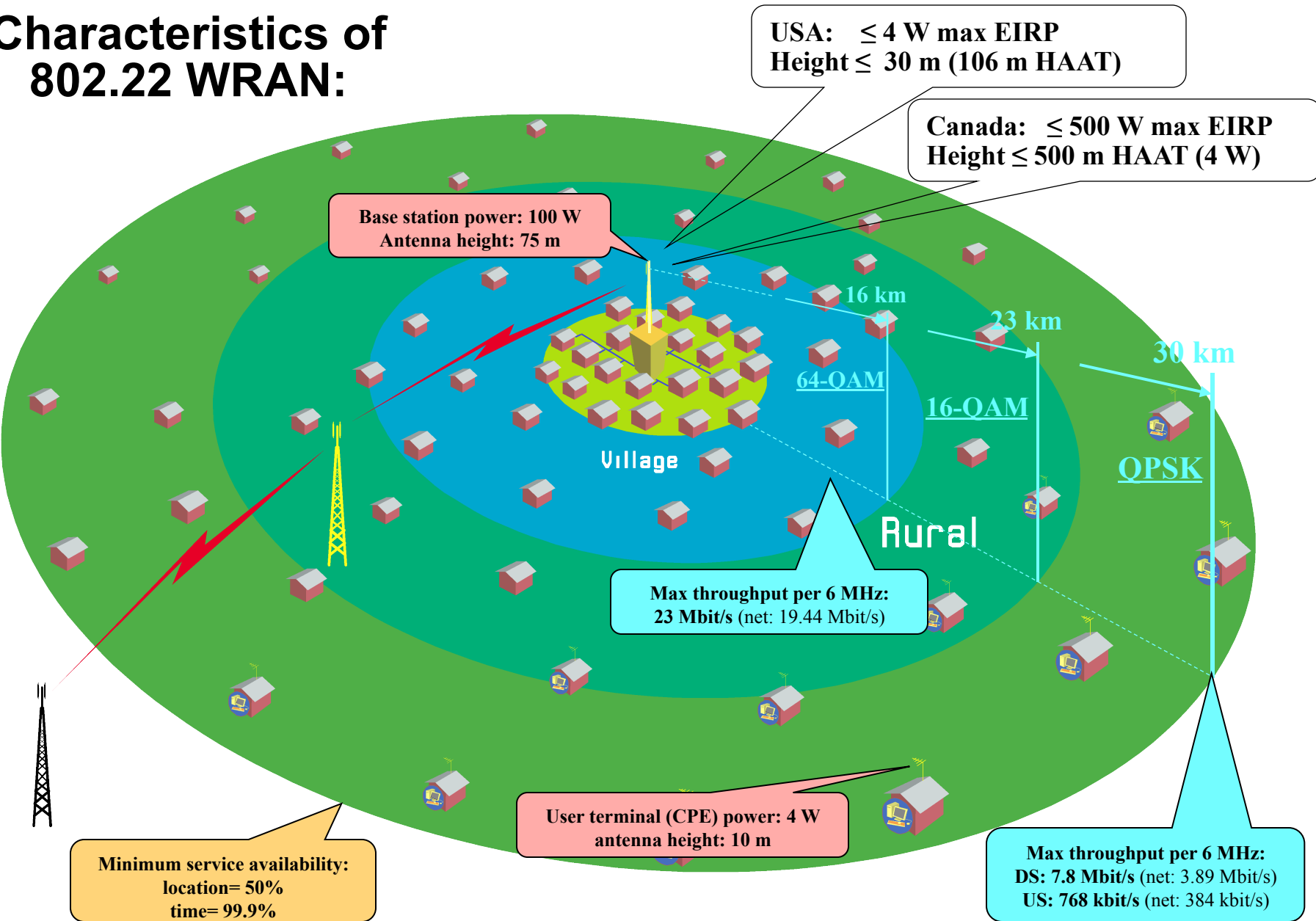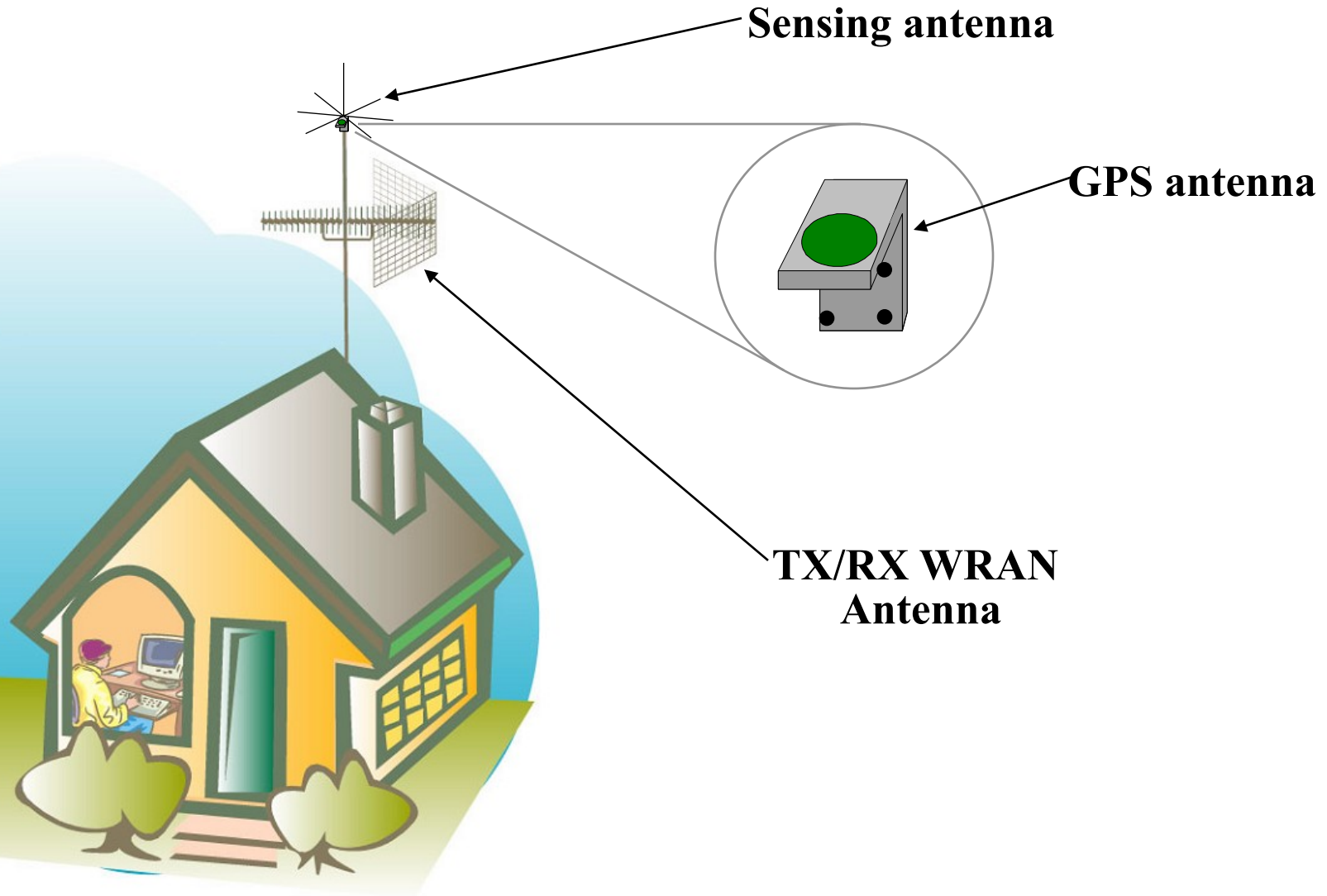
Applications

Slide 3

IEEE 802.22 WRAN Standard
Key features

- WRAN: Wireless Regional Area Network
  - Aimed at bringing broadband access to hard-to-reach, low population density areas, typical of rural environments and developing countries

- Operate in vacant channels in TV broadcast bands to take advantage of better signal propagation at lower frequencies

- Operate as license-exempt equipment although the base station (BS) and possibly the customer premise equipment (CPE) have to be professionally installed

- Point-to-multipoint network topology
  - Base station connected to the Internet through a backhaul
  - Base station provides service to up to 512 CPEs (fixed or portable) and controls all their RF characteristics ("master-slave")

- Use cognitive radio capabilities to avoid interference to broadcast incumbents and other WRAN systems
  - Access to databases
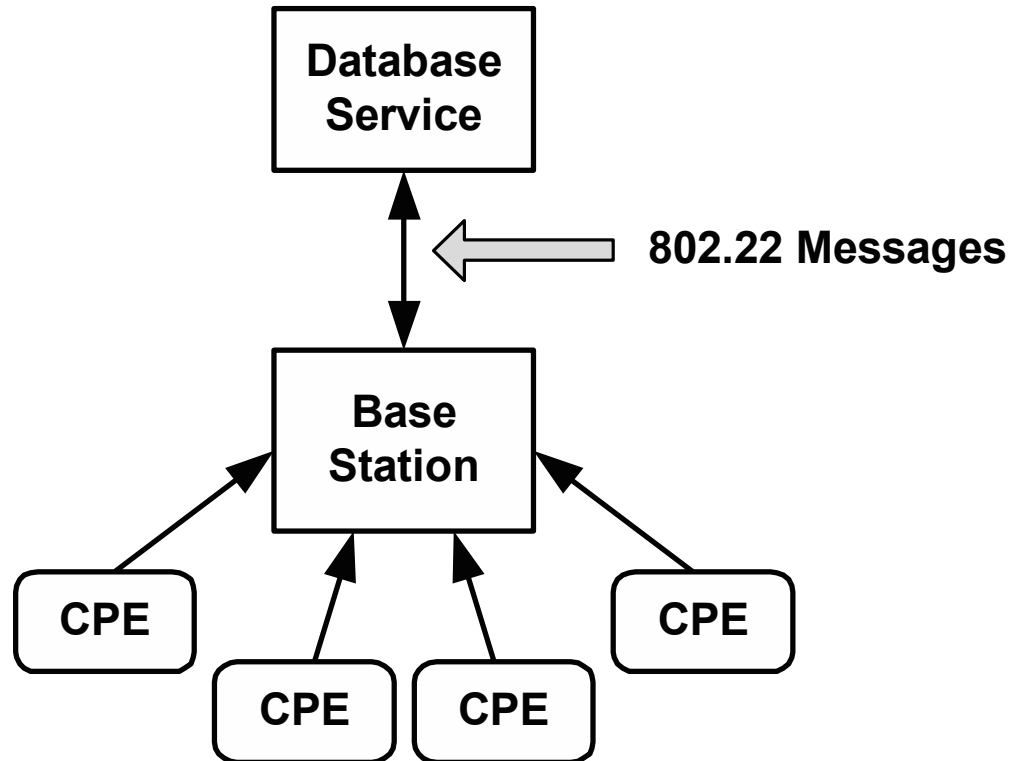 - RF sensing

Characteristics of 802.22 WRAN:

USA: ≤ 4 W max EIRP
Height ≤ 30 m (106 m HAAT)

Canada: ≤ 500 W max EIRP
Height ≤ 500 m HAAT (4 W)

Base station power: 100 W
Antenna height: 75 m

16 km

23 km

30 km

64-QAM

16-QAM

QPSK

Village

Rural

Max throughput per 6 MHz:
23 Mbit/s (net: 19.44 Mbit/s)

User terminal (CPE) power: 4 W
antenna height: 10 m

Minimum service availability:
location= 50%
time= 99.9%

Max throughput per 6 MHz:
DS: 7.8 Mbit/s (net: 3.89 Mbit/s)
US: 768 kbit/s (net: 384 kbit/s)

Typical CPE installation

Sensing antenna

GPS antenna

TX/RX WRAN Antenna

802.22 database interface model

To comply with the FCC R&O 08-260, the IEEE 802.22 interface to the database will take place entirely between the database service and the BS rather than with its individual CPEs (BS has to find the channel that is common to all its CPEs rather than the CPEs doing it individually (MO&O 10-174: 15.711(e)).

```
          ┌─────────────┐
          │  Database   │
          │  Service    │
          └─────────────┘
                 ↕         ⇐  802.22 Messages
          ┌─────────────┐
          │    Base     │
          │   Station   │
          └─────────────┘
        ↗      ↑     ↑      ↖
    ┌─────┐          ┌─────┐
    │ CPE │          │ CPE │
    └─────┘          └─────┘
        ┌─────┐  ┌─────┐
        │ CPE │  │ CPE │
        └─────┘  └─────┘
```

802.22 database interface procedure

- The BS will initially enlist with the database service as a fixed device. It will also enlist all its associated CPEs with their geographic location, device identification, etc., as obtained at association on a real time basis.

- On an ongoing basis, the BS will then query the database (at least once every 24 hours) using the M-DB-AVAILABLE-CHANNEL-REQUEST message so that it can retrieve the channel availability information.

- The database service could also send any update relevant to the BS operation through 'push' internet technology since the network address of the base station is provided as part of the messages (*this will allow better reaction time than the 24 hours minimum access time while keeping the database traffic to a minimum*).

Security of the database interface

- SSL will be supported on the link between the database service and the BS to provide transport layer security:
  - to allow authentication of the database service provider as well as the WRAN system querying the service
  - to avoid the message exchange being altered on the backhaul connection
- protocols used for device and database service authentication and for interacting with the database:
    EAP-TLS or EAP-TTLS
- database service primitives are exchanged between the CPE/BS and the database service via Attribute Value Pairs of EAP messaging
- formatting of these messages should conform to the authentication service that the database service employs: (e.g., RADIUS/RFC 2865 or DIAMETER/RFC 3588).

Database service primitives

1. **M-DB-AVAILABLE-REQUEST**: Message that allows the BS to verify that it is connected to the database service in order to receive channel availability and maximum allowed EIRP updates.

2. **M-DB-AVAILABLE-CONFIRM:** Message that allows the database service to confirm that the BS is connected to the database service.

3. **M-DEVICE-ENLISTMENT-REQUEST:** Message that allows the BS to enlist with the database service a device that has joined its WRAN network.

4. **M-DEVICE-ENLISTMENT-CONFIRM:** Message that allows the database service to confirm to the BS that the new device has been successfully registered.

Database service primitives

5. **M-DB-AVAILABLE-CHANNEL-REQUEST:** Message by which the BS requests a list of available channels and maximum allowed EIRP per channel from the database service for the specified type of device at the particular location.

6. **M-DB-AVAILABLE-CHANNEL-INDICATION:** Message that is used to return to the BS the list of available channels as provided by the database service in the form of channel number, maximum allowed EIRP, and availability schedule.

7. **M-DB-DELIST-REQUEST:** Message that allows the BS to request the database service to remove the enlistment of a device that was associated with that base station.

8. **M-DB-DELIST-CONFIRM:** Message that is used to inform the BS whether its request to remove the enlistment of a device that was associated with that base station was successfully received and executed by the database service.

M-DB-AVAILABLE-REQUEST

Name	Type	Length	Description
Base station-ID Length	Integer	2 bytes	Length of Base station-ID field (number of characters)
Base station-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Database Service URL Length	Integer	2 bytes	Length of database service URL field (number of characters). This is used to set the Locator for the Database service
Database Service URL	Character String	Variable	A fully qualified URL starting with, http:// or https://
Base Station Database Service Access URL Length	Integer	2 bytes	Length of Base Station Database Service URL filed (number of characters)
Base Station Database Service Access URL	Character String	Variable	A fully qualified URL. This is used to set the Locator for the Base Station Access by the Database Service
Base Station Management URL Length	Integer	2 bytes	Length of Base Station Management URL field (number of characters)
Base Station Management URL	Character String	Variable	A fully qualified URL. This is used to set the Locator for the BS Management Service
Timestamp Length	Integer	2 bytes	Length of Timestamp field (number of characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Timestamp of the present request at time of transmission and as encoded in the $ZDA substring of the NMEA 0183 string

M-DB-AVAILABLE-CONFIRM

Name	Type	Length	Description
Base station-ID Length	Integer	2 bytes	Length of Base station-ID field (number of characters)
Base station-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Timestamp Length	Integer	2 bytes	Length of Timestamp field (numberof characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Copied from the timestamp in the M-DB-AVAILABLE-REQUEST

M-DEVICE-ENLISTMENT-REQUEST (a)

Name	Type	Length	Description
Device Type	Integer	1 byte	The value identifies the type of device obtained as part of its process to associate 0x00 = Fixed base station 0x01 = Fixed CPE 0x02 = Personal/portable mode 0x03–0xFF = *Reserved*
Device-ID Length	Integer	2 bytes	Length of Device-ID field (number of characters)
Device-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Proxy Device-ID Length	Integer	2 bytes	Length of Proxy Device-ID field (number of characters)
Proxy Device-ID	Character String	Variable	This element is the device ID for the device (most likely the controlling BS) that is acting as the proxy to the database service. (In US, this is the FCC-ID.)
Proxy Serial Number Length	Integer	2 bytes	Length of Proxy Serial Number field (number of characters)
Proxy Serial Number	Character String	Variable	This element is the serial number for the device (most likely the controlling BS) that is acting as the proxy to the database service.
Location Data String Length	Integer	2 bytes	Length of Location Data String field (number of characters)
Location Data String	Character String	NMEA 0183	The value identifies the location of the device (latitude, longitude).
Responsible Party Name Length	Integer	2 bytes	Length of Responsible Party Name field (number of characters)
Responsible Party Name	Character String	Variable	
Antenna height	Integer	1 byte	Antenna height above ground level in meters.

M-DEVICE-ENLISTMENT-REQUEST (b)

Name	Type	Length	Description
If (Device Type = 0x00 or 0x01) {			
Contact Name Length	Integer	2 bytes	Length of Contact Name field (number of characters)
Contact Name	Character String	Variable	
Contact Physical Address Length	Integer	2 bytes	Length of Contact Physical Address field (number of characters)
Contact Physical Address	Character String	Variable	
Contact Email Address Length	Integer	2 bytes	Length of Contact Email Address field (number of characters)
Contact Email Address	Character String	Variable	
Contact Telephone Number Length	Integer	2 bytes	Length of Contact Telephone Number field (number of characters)
Contact Telephone Number	Character String	Variable	
}			
Base Station Database Service Access URL Length	Integer	2 bytes	Length of Base Station Database Service URL field (number of characters)
Base Station Database Service Access URL	Character String	Variable	A fully qualified URL. This is used to set the Locator for the Base Station Access by the Database Service.
Database Service URL Length	Integer	2 bytes	Length of Database Service URL field (number of characters)
Database Service URL	Character String	Variable	A fully qualified URL starting with, http:// or https://

M-DEVICE-ENLISTMENT-REQUEST (c)

Name	Type	Length	Description
If (wranIfDatabaseServiceBS AntennaInformationSupportedMib) {			
Antenna information	Character String	72 bytes	Antenna directionality information of the device in dB relative to the main lobe maximum gain for every 5 degree azimuth clockwise starting from the direction of the maximum antenna gain expressed in unit of 0.25 dB over the range −63.75 dB (encoded 0x00) to 0 dB (0xFF). (to allow the database calculation of the channel availability and the maximum allowed EIRP values at the registering location)
Antenna azimuth	Integer	2 bytes	Antenna azimuth in degrees, clockwise from true North
}			
}			
Timestamp Length	Integer	2 bytes	Length of Timestamp field (number of characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Timestamp of the present request at time of transmission and as encoded in the $ZDA substring of the NMEA 0183 string

M-DEVICE-ENLISTMENT-CONFIRM

Name	Type	Length	Description
Device-ID Length	Integer	2 bytes	Length of Device-ID field (number of characters)
Device-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Timestamp Length	Integer	2 bytes	Length of Timestamp field (number of characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Copied from the timestamp in the M-DB-AVAILABLE-REQUEST

M-DB-AVAILABLE-CHANNEL-REQUEST

Name	Type	Length	Description
Device Type	Integer	1 byte	The value identifies the type of device at the geolocation registering 0x00 = Fixed base station 0x01 = Fixed CPE 0x02 = Personal/portable mode 0x03–0xFF = *Reserved*
Device-ID Length	Integer	2 bytes	Length of Device-ID field (number of characters)
Device-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Location Data String Length	Integer	2 bytes	Length of Location Data String field (number of characters)
Location Data String	Character String	NMEA 0183 Character String	The value identifies the location of the device (latitude, longitude)
Timestamp Length	Integer	2 bytes	Length of Timestamp field (number of characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Timestamp of the present request at time of transmission and as encoded in the $ZDA substring of the NMEA 0183 string

M-DB-AVAILABLE-CHANNEL-INDICATION

Name	Type	Length	Description
Device-ID Length	Integer	2 bytes	Length of Device-ID field (number of characters)
Device- ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial number	Character String	Variable	
Number of Channels Available	Integer	1 byte	
{ If(Number of Channels Available > 0)			If the number of channels is equal to 0, this means that the device cannot operate.
For (i=1; $i\leq$ Number of Channels Available; i++) { Channel_Number Max_Allowed_EIRP (dBm) Availability schedule }	Vector of 2×N bytes and a number of pairs of NMEA 0183 $ZDA strings	Variable	List of available channel numbers and corresponding maximum allowed EIRP expressed in dBm over the range −64 dBm (encoded 0x00) to +63.5 dBm (encoded 0xFF) as well as the availability schedule (start and stop date/time) for each channel in Universal date and time system
}			
Status Message	Character String	Variable	Various status messages coming from the database service (e.g., unapproved device flag)
Timestamp Length	Integer	2 bytes	Length of Timestamp field (number of characters)
Timestamp	Character String	NMEA 0183 $ZDA string	Copied from the timestamp in the M-DB-AVAILABLE-CHANNEL-REQUEST

M-DB-DELIST-REQUEST

Name	Type	Length	Description
Device-ID Length	Integer	2 bytes	Length of Device-ID field (number of characters)
Device-ID	Character String	Variable	In US, this is FCC-ID
Serial Number Length	Integer	2 bytes	Length of Serial Number field (number of characters)
Serial Number	Character String	Variable	
Responsible Party Name Length	Integer	2 bytes	Length of Responsible Party Name field (number of characters)
Responsible Party Name	Character String	Variable	
Location Data String Length	Integer	2 bytes	Length of Location Data String
Location Data String	Character String	NMEA 0183 Character string	The value identifies the location of the device (latitude, longitude)

M-DB-DELIST-CONFIRM

Name	Type	Length	Description
Device-ID	Character String	Variable	In US, this is FCC-ID
Serial Number	Character String	Variable	
Responsible Party Name	Character String	Variable	
Location Data String Length	Integer	2 bytes	Length of Location Data String field (number of characters)
Location Data String	Character String	NMEA 0183 Character string	The value identifies the location of the device (latitude, longitude)

References

1. *IEEE Std 802.22-2011^{TM}, 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*

2. *U.S. FCC, ET Docket 08-260, "Second Report and Order and Memorandum Opinion and Order in the Matter of Unlicensed Operation in the TV Broadcast Bands," November 14, 2008.*

3. *U.S. FCC, ET Docket 10-174, "Second Memorandum Opinion and Order in the Matter of Unlicensed Operation in the TV Broadcast Bands," September 23, 2010.*

4. *NMEA 0183, Interface Standard of the National Marine Electronics Association, Version 4.00* http://www.nmea.org/content/nmea_standards/nmea_083_v_400.asp.

5. *IETF RFC 2865, "Remote Authentication Dial In User Service (RADIUS)," June 2000.*

6. *[B1] DIAMETER/RFC 3588, "Diameter Base Protocol," September 2003.*

7. *IETF RFC 3748, "Extensible Authentication Protocol (EAP)," June 2004.*