WiMAX Part III: Mobility and Networking

Raj Jain
Professor of CSE
Washington University in Saint Louis
Saint Louis, MO 63130
Jain@cse.wustl.edu

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

- Network Entry, Ranging, Registration
- Advanced Antenna Support
- Multicast Broadcast Services (MBS)
- WiMAX Network Architecture: ASN Reference Model
- Mobility Management: Handover
- Power-Save Modes

Network Entry

- SS scan for a channel and synchronizes by looking for preamble
- SS looks for DL-MAP, UL-MAP, DCD, UCD messages
  $\Rightarrow$ Gets parameters
- SS sends a RNG-REQ message in the contention ranging period
- BS assigns basic, primary management CIDs.
- SS and BS negotiate capabilities including:
- Bandwidth allocation (H-FDD or FDD), max transmit power for BPSK, QPSK,16-QAM, and 64-QAM, current transmit power, modulations supported, MIMO parameters,
- BS then does a security key exchange
- Registration: SS is allocated a secondary management CID

Connection IDs

- Each SS has a basic CID
- Primary management CID: For MAC and PHY management
- Optional Secondary Management CID:
  For IP level management, e.g., DHCP, SNMP, TFTP
- Transport CIDs: For data transfer
- MAC management messages on basic, broadcast, and initial ranging connections cannot be fragmented or packed

MAC Management Messages

Type	Name	Description	Connection
0	UCD	Uplink Channel Descriptor	Broadcast
1	DCD	Downlink Channel Descriptor	Broadcast
2	DL MAP	Downlink access definition	Broadcast
3.	UL MAP	Uplink access definition	Broadcast
4	RNG-REQ	Ranging Request	Initial or Basic
5	RNG-RSP	Ranging Response	Initial or Basic
6	REG-REQ	Registration Request	Primary
7	REG-RSP	Registration Response	Primary
50	MOB_SLP-REQ	Mobile Sleep request	Basic
51	MOB_SLP-RSP	Mobile Sleep response	Basic
54	MOB_SCN-REQ	Scanning interval allocation req	Basic
55	MOB_SCN-RSP	Scanning interval allocation resp	Basic
62	MBS MAP	MBS MAP	Broadcast

Ranging

- **Goal**: To synchronize clocks and to adjust power
- Initial Ranging and Periodic Ranging
- Initial ranging uses contention ranging slots
- Periodic ranging can use any slots granted to SS
- SS transmits a RNG-REQ message containing DL channel ID, requested burst profile, SS's MAC address, etc.
- BS sends RNG-RSP message containing status (OK or re-try), timing adjustment, power offset, frequency adjustment, assigned Basic CID, primary management CID, MAC address, DL DIUC, frame # in which the RNG-REQ was received, etc.

Registration Request and Response

- REG-REQ Message:

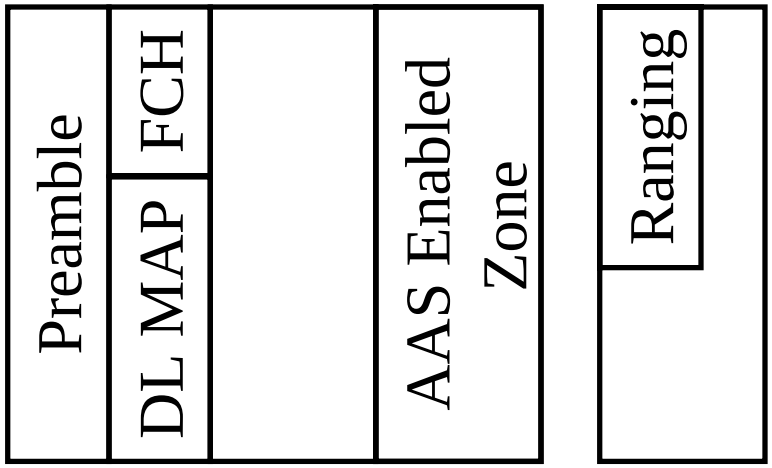
Mgmt Type=6	ARQ Params	SS Mgmt Support	IP Mgmt mode	IP Version

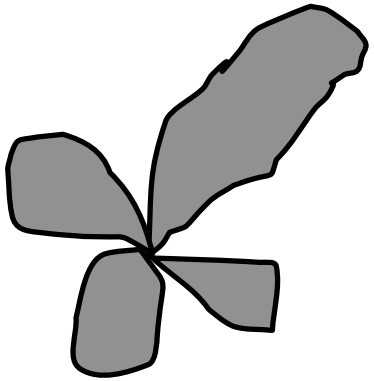
# of UL CIDs supported	SS Capabilities	CS Capabilities

- SS Capabilities: ARQ, CRC, Multicast polling, authorization, Vendor Identification, MAC Version, Max number of supported security associations
- Convergence sublayer (ATM, IPV4, ...)
- In REG-RSP, BS indicates the accepted subset of parameters

Advanced Antenna Support

- Reach can be extended
- Spatial division multiplexing is allowed with beamforming (directional) antennas
  $\Rightarrow$ Multiple users are scheduled at the same time in the same frequency
- Special AAS zone helps achieve this

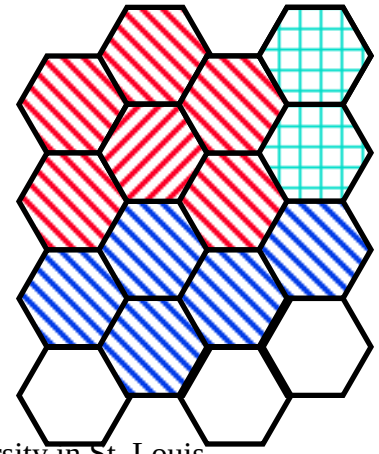


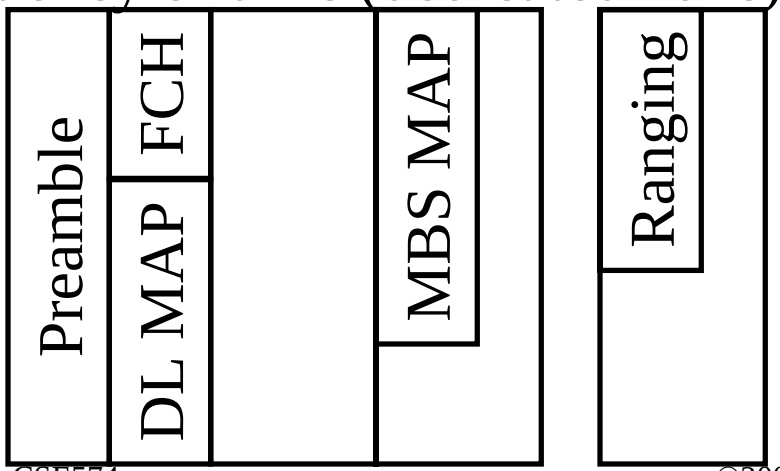


Multicast Broadcast Services (MBS)

- Multiple BS transmit the same information, e.g., TV
- BS transmit at the same time in the same frequency
- BS are grouped in MBS zones
- BS in the zone are time synchronized, use the same CID for MBS, and use the same security association (encryption keys)
- A SS registered with one BS can get the signal from any BS
- BS can use a dedicated frequency or time (dedicated zone)

MBS Zones





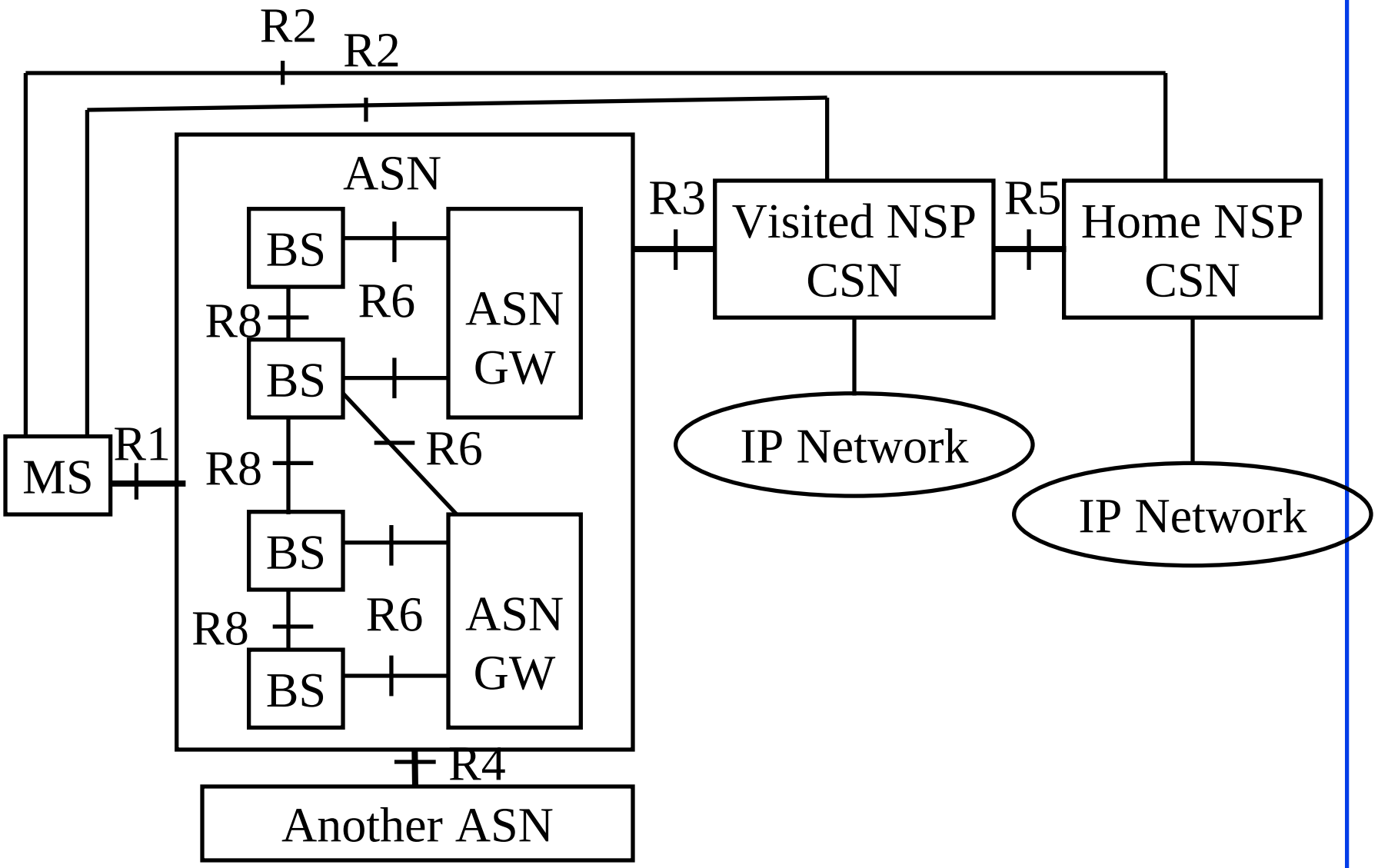
WiMAX MBS Support Features

- Signaling mechanisms for MS to request and establish MBS sessions
- SS access to single or multiple BS
- MBS associated QoS and encryption using a common traffic encryption key
- Separate zone within PHY frame with its own MAP for MBS traffic
- Methods for delivering MBS traffic to idle stations
- Support for macro diversity to enhance MBS delivery

WiMAX Network Architecture

- End-to-end service aspects: QoS, Mobility, Security
- WiMAX Forum's Network Working Group (NWG) followed a 3 stage process:
  - Stage 1: Use case scenarios and service requirements
  - Stage 2: Architecture
  - Stage 3: Protocols
- NWG has finished all 3 stages for Release 1

Network Reference Model



Network Reference Model (Cont)

- Access Service Network (ASN) provides wireless access
- Connectivity Service Network (CSN) provides internet connectivity
- Network Access Providers (NAPs) own ASN
- Network Service Providers (NSPs) own CSN
- Application Service Providers (ASPs) may connect directly to WiMAX or to Internet

ASN Reference Model

- ASN Gateway provides:
  - L2 connectivity
  - Paging and Location Management
  - Relay traffic to CSN
  - Network discovery and selection of preferred NSP/CSN
  - AAA proxy: Credentials to selected NSP's AAA server
  - Policy decision point
- BS Provides:
  - 802.16 PHY and MAC services
  - Resource scheduling to meet QoS
  - Traffic classification
  - Policy enforcement point

ASN Profiles

- Where to put Handover function?
  - In ASN-GW(A) or BS (C)
- **Profile A**: ASN-GW provides handover control, layer 3 path re-route, load balancing between BS
- **Profile C**: BS provides handover control and radio resource management
- **Profile B**: Combines BS and ASN-GW

CSN Reference Model

- CSN provides:
  - Authentication, Authorization, Accounting (AAA)
  - IP Address allocation
  - IP QoS management (diffserv)
  - Mobility support using mobile IP
  - Billing
  - Roaming
- Contain Routers, DNS servers, AAA servers, firewalls

Network Functionality

- Several NSP may share a NAP
- NAP discovery: MS detects the operator ID in DCD
- NSP Discovery:
  MS can use request response to find NSP
- NSP enumeration and selection:
  MS selects appropriate NSP

Mobility Management

- BS allocates time for each MS to measure signals from neighboring BSs.
- BS informs MS about scanning interval and interleaving interval and the number of such periods
- BS also tells MS identity and frequencies of neighboring BSs
- During scanning interval MS measures signal power and SINR for neighboring BSs and may optionally associate with them using initial ranging

Levels of Association

- **Association Level 0**: Scan/association without coordination.
  MS performs contention based ranging
  If successful, MS receives success RNG-RSP
- **Association Level 1**: Scan/association with coordination.
  - Serving BS tells MS ranging code and transmission interval from each of the neighbors
  - MS performs unicast ranging
  - If successful, MS receives success RNG-RSP
- **Association Level 2**: Network assisted association reporting
  - Same as level 1 but MS does not wait for response
  - Neighboring BSs send their responses to serving BS
  - Serving BS aggregates and sends one message to MS

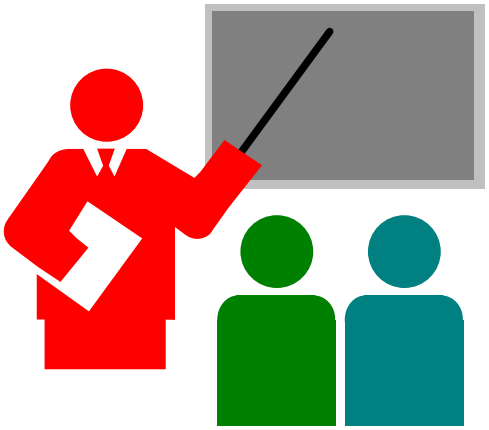
Handover

- **Hard handover**: Break before make
- **Soft handover**: Make before break
- **Fast BS Switching (FBSS):**
  - MS maintains valid connections with all BSs in **Active set**
  - MS communicates only through one BS = **Anchor BS**
  - When necessary, MS reports the new anchor on CQICH
- **Macro Diversity Handover (MDHO):**
  - MS sends packets to all members of **diversity set**
    $\Rightarrow$ Anchor uses selection diversity to select the best copy
  - MS receives packets from all members of diversity set
    $\Rightarrow$ Multiple copies are combined using diversity techniques
- Mobile WiMAX profile requires only hard handover.
  FBSS and MDHO are optional.

Power-Save Modes

- **Sleep Mode**: MS negotiates a sleep time with BS
  - Power Save Class 1: Sleep window is exponentially increased from a min to a max. Typically for BE and nrtPS.
  - Power Save Class 2: Fixed sleep window. UGS.
  - Power Save Class 3: One-time sleep window. Typically for multicast or management traffic.
  - SS can use sleep time to scan for other BSs
- **Idle Mode**: MS is assigned a paging group. Not registered with any one BS. Listens to broadcasts if awake.
  - MS is paged if traffic arrives
  - Saves more power than sleep mode
  - No handover traffic from inactive stations

Summary



- Initial ranging uses contention, periodic ranging using unicast/multicast polling
- Management messages for ranging, sleep mode, handover
- BS, ASN, and CSN. BS handles L1, BS and ASN handle L2, CSN handles L3
- BS helps MS in handover by providing neighbor information and coordination
- Sleep and idle mode for power saving

References: Books

1. Loutfi Nuaymi, "WiMAX: Technology for Broadband Wireless Access," Wiley, Mar-07, 310 pp., ISBN:0470028087.
2. Jeffrey G. Andrews, Arunabha Ghosh, Rias Muhamed, "Fundamentals of WiMAX: Understanding Broadband Wireless Networking," Prentice-Hall, ISBN:0132225522.

Note: Both books are available in Olin library reserve