Point-to-Multipoint Broadband Fixed Wireless

Session WMT-230

Overview

• Headend can support one downstream and four upstream channels
• Subscriber supports one downstream and upstream channel pair
• Downstream and upstream channels may have bandwidths of 1.5, 3 and 6 MHz
• Headend and subscriber both support antenna diversity
Overview

- Full-duplex data in the licensed MDS/MMDS band (2.15–2.162 and 2.500–2.690 GHz) and unlicensed U-NII (5.725–5.825 GHz)
- Consists of Headend (HE) and Subscriber Units (SU)
- Provides a fixed wireless link from a single headend site to multiple subscriber sites
- Each headend site can be designed and configured to broadcast in a single sector or in multiple sectors
Features

• Small-cell and single-cell deployment
• Multipath robustness
• Adjusts transmit power of subscribers to maintain desired signal levels at headend
• Loopbacks (IF and RF)
• Performance metrics

Features

• Marginal RF links can be configured to improve performance
• End-to-end IP-based technology using a variety of protocols and media
• Open interfaces—part of Cisco’s dedication to open architectures
• Highly efficient MAC protocol, based on the industry standard DOCSIS MAC
Specification

- **Headend**
  - MMDS 2500–2690 MHz
  - MDS 1 and 2 2150–2162 MHz (upstream only)

- ** Subscriber Unit (high power)**
  - MMDS 2500–2690 MHz
  - MDS 1 and 2 2150–2162 MHz (upstream only)

- ** Subscriber Unit (standard power)**
  - MMDS 2500–2690 MHz
  - MDS 1 and 2 2150–2162 MHz (upstream only)

### Table

<table>
<thead>
<tr>
<th>Channel Bandwidth</th>
<th>HE ODU</th>
<th>SU HP ODU</th>
<th>SU SP ODU</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 MHz</td>
<td>2W (33dBm)</td>
<td>1W (30dBm)</td>
<td>0.1W (20dBm)</td>
</tr>
<tr>
<td>3 MHz</td>
<td>2W (33dBm)</td>
<td>2W (33dBm)</td>
<td>0.2W (23dBm)</td>
</tr>
<tr>
<td>1.5 MHz</td>
<td>4W (36dBm)</td>
<td>2W (33dBm)</td>
<td>0.4W (26dBm)</td>
</tr>
</tbody>
</table>

2 Watts Is Maximum Permissible Output Power for SU Per FCC Regulations
P2MP Complete System

Components—HE
Components—HE

- A Cisco router (Cisco uBR7223, uBR7246, or uBR7246 VXR universal broadband router)
- Wireless modem card installed in the router
- A power feed panel
- Wireless transverter (2 for diversity)
- Duplexer (1 for each wireless transverter)
- Antenna (diversity requires two antennas)

Wireless Line Card

- Provides the control and data interface between the system’s digital motherboard and the Radio Frequency (RF) subsystem in the wireless transverter
- Also provides the up/down conversion from baseband to Intermediate Frequency (IF)
- Consists of the following components:
  - Connection for the optional 10-MHz external reference clock
  - Monitor and power feed panel connectors (main and diversity)
  - Light-emitting diodes (LEDs) that provide a visual indication of the state of the modem card
Wireless Line Card

Power Feed Panel

- Provides
  - DC power input ports (DC Supply separate)
  - Transmit and receive IF signals
- Contains circuit breakers for the DC power
- Secondary lightning protection circuitry for the IF cables
Power Feed Panel

Transverter

- The ruggedized wireless transverter is the control and data interface to the indoor subsystems.
- It provides up/down conversion from IF to RF frequencies and power amplification.
Components-SU

- A Cisco Router 2600 or Cisco 3600 series access routers
- A wireless network module installed in the router
- DC Injector and DC power supply
- Wireless transverter (2 for diversity)
- Duplexer (1 for each wireless transverter)
- Antenna (diversity requires two antennas)
**26xx/36xx**

- The point-to-multipoint wireless feature is supported on following platforms:
  - Cisco 2610
  - Cisco 2611
  - Cisco 2612
  - Cisco 2613
  - Cisco 2620
  - Cisco 2621
  - Cisco 3620
  - Cisco 3640
  - Cisco 3661
  - Cisco 3662

---

**Network Module**

- Provides the control and data interface to the system’s digital motherboard and the Radio Frequency (RF) subsystem in the wireless transverter
- Also provides the up/down conversion from baseband to Intermediate Frequency (IF)
- Consists of:
  - Digital motherboard
  - IF analog board
  - Two power injector connectors (main and diversity)
- Supports up to two wireless transverters (main and diversity)
Network Module

Power Injector

- Serves as an interconnection device between the network module, a –48V (+24V) DC power supply, and the wireless transverter
- Output signal to the wireless transverter combines DC power, control signals, and transmit IF signal
- Also receives the incoming IF signals from the wireless transverter
- Contains circuit breakers for the DC power
- Each DC Injector supports one wireless transverter
**Wireless Transverter**

- Provides up/down conversion from IF to RF frequencies and power amplification
- The standard power subscriber transverter can be an integrated unit; i.e. antenna and transverter combined

**Network Planning**

- Three basic approaches to providing point-to-multipoint fixed wireless communications to a geographic area
  - Single large cell—supercell
  - Few medium-sized cells—minicells
  - Large number of small cells—microcells
Supercell

- Up to 20 miles in diameter, with a single headend, or hub at the center
- Least popular but simplest method of installing a wireless point-to-multipoint network
- Divided into sectors extending from the hub at the center to the edge of the cell
- All the broadcasts originate from the same central point

A Supercell with 3 Sectors
Supercell

- Needs only one broadcast hub at the center
- A supercell hub may need to transmit with more power to ensure clear, continuous communication with the subscribers farthest from the hub
- System capacity is related to no. of available frequency channels and can limit the number of subscribers

Minicells

- Second most popular method of installing a fixed wireless point-to-multipoint network
- Each minicell from four to ten miles in diameter and divided into sectors
- The hub of a minicell may not require high transmission power
- It can serve more subscribers than a supercell
- Due to frequency reuse, the same number of available frequency channels can service more users
Microcells

- The most popular method of installing a wireless point-to-multipoint network
- Each microcell up to two miles in diameter and divided into three or more sectors
- May not require high transmission power at the hub
- Allows the maximum number of subscribers within a given area
- Subscribers in the microcell can use lower transmission power
- Requires the most number of hub sites
Microcells

Microcells Each with 3 Sectors

Network Considerations

- Selection of a network design depends upon
  - User density in a geographic area
  - Total no. of users in the system
  - Antenna heights (both HE and SU)
  - Link obstructions
  - Tx power of the equipment
  - Available frequency bandwidth
  - Customer throughput requirement
  - Future expansion
RF Network Planning Issues

- Complete RF network planning should be done in advance for the deployment to be scalable
- A detailed site survey helps in RF planning
- Areas with the greatest risk of problems in maintaining a good signal path with potential subscribers include:
  - Locations at the edge of a cell
  - Locations at the edge of a sector
  - Uneven terrain
  - Dense foliage

Fade Margin

- Fade margin is the “extra” signal power added to a given radio link to ensure that the link will continue working if it suffers anomalous signal propagation effects (such as fading)
Fade Margin

- To calculate the required Fade Margin
  \[ F = -10 \log_{10} \left( \frac{(100\% - \text{Availability} \%) / (2.5 \times a \times b \times f \times D \times 10^{-6})}{2} \right) \]
  
  Where:
  - \( F \) = Fade margin in dB
  - \( D \) = Path length in miles
  - \( f \) = frequency in GHz
  - \( a \) = terrain factor
    - 4 for very smooth terrain over water, flat desert
    - 1 for average terrain with some roughness
    - 0.25 for mountains, very rough or very dry terrain
  - \( b \) = Climatic factor
    - 0.5 for hot, humid coastal areas
    - 0.25 for normal, interior temperature or subarctic areas
    - 0.125 for mountainous or very dry but non-reflective areas

Receiver Sensitivity

- Receiver sensitivity— is an indication of the ability of the microwave receiver to detect the proper signal
- Expressed as a negative dBm value for a particular Bit Error Rate (BER)
Free Space Path Loss

- It is the signal energy lost in traversing a path in free space only, with no other obstructions

  Attenuation in dB = 96.6 + 20 \log_{10} D + 20 \log_{10} F

  Where:
  - D is the Path Length in miles
  - and F is the frequency in GHz

Antenna Gain

- The antenna manufacturer provides the information

- Expressed in dBi
Cable Loss

- RF energy is carried between the antenna and the radio equipment through a coaxial cable
- Always results in loss
- The amount of loss is directly proportional to the length of the cable, and is inversely proportional to the diameter of the cable
- Also proportional to frequency

Rx Signal at SU

- Tx Antenna Gain = 18 dBi
- Free Space Path Loss = 126 dB
- Rx Antenna Gain = 24 dBi
- Cable Loss = 1 dB
- Distance Between Antennas = 11.5 miles
- Tx Power = 33 dBm
- Rx Power = ? dBm
Rx Signal at HE

Rx Antenna Gain = 18 dBi  Free Space Path Loss = 126 dB  Tx Antenna Gain = 24 dBi

Distance Between Antennas = 11.5 miles

Rx Power = 7 dBm  Tx Power = 23 dBm

Link Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter (MHz)</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
<td>Upstream</td>
</tr>
<tr>
<td>Transmitter power (dBm)</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
<td>-33.0</td>
</tr>
<tr>
<td>Rx Antenna Gain (dBi)</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Cable Loss (dB)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Parameter (MHz)</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Unavailability (%)</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Distance (miles)</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Frequency (MHz)</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Data Rate (Mbps)</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
<td>128.0</td>
</tr>
<tr>
<td>Rx Antenna gain (dBi)</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

Extra Margin

Required Power (dBm)                   | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  | -33.0  |
Required Fade Margin (Linear)          | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 | 0.04883 |
Required Fade Margin (dB)              | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    | 1.0    |

Notes:
- Very Rough Terrain: 10 dBm or less
- Very Dry Terrain: 15 dBm or less
- Very Reflective Terrain: 20 dBm or less
- Very Dry but Nonreflective Terrain: 25 dBm or less
- Very Rough or Very Dry Terrain: 30 dBm or less
- Very Reflective Terrain: 35 dBm or less
- Very Rough or Very Dry Terrain: 40 dBm or less
- Very Reflective Terrain: 45 dBm or less
**Frequency Reuse Patterns**

- For the downstream broadcast, there are a variety of repeated microcell patterns; these include:
  - Four by three (4/3), four cells, each with three sectors
  - One by six (1/6), one cell with six sectors
  - Three by three (3/3), three cells, each with three sectors
  - Three by four (3/4), three cells, each with four sectors

- In a good network plan, no adjacent cells or sectors will ever use the same frequency, or frequencies that could interfere with each other

---

**Four by Three (4/3) Pattern**

- One of the most common deployments
- Basic grouping of 4 microcells in an almost square layout in the center of the area to be covered
- Each microcell is divided into 3 sectors
- A different broadcast frequency is used in each of the 12 sectors
- The same pattern of 4 microcells with 3 sectors each is then repeated
Four by Three (4/3) Pattern

One by Six (1/6) Pattern

- This plan repeats a single microcell with 6 sectors
- A different broadcast frequency is used in each of the 6 sectors
One by Six (1/6) Pattern

Microcells with Six Sectors

Three by Three (3/3) Pattern

- This plan repeats a pattern of three microcells, each with three sectors, totaling nine different sectors
- A different broadcast frequency is used in each of the 9 sectors
Three by Three (3/3) Pattern

Microcells with 3 Sectors

Three by Four (3/4) Pattern

- Basic grouping of 3 microcells
- Each microcell is divided into four sectors, resulting in a total of 12 sectors
- A different broadcast frequency is used in each of the 12 sectors
- The same pattern of 3 microcells with 4 sectors each is then repeated
Three by Four (3/4) Pattern

Adjacent-Channel Interference

- Caused by another RF signal that is using a frequency immediately adjacent to the channel that you are using
- Your own network can be a cause of this type of interference without careful planning
Co-Channel Interference

- Caused by another RF signal, using the same channel frequency that you are using
- Your own network can be a cause of this type of interference without careful planning
- Happens when same frequency is used more than once in a cell, or
- When the sector using a frequency in one cell, meets a sector using the same frequency in another cell
Initial Configuration—HE

- Before proceeding to configure a HE wireless line card, following information will be needed:
  - Number of receive antennas (2 for diversity operation)
  - Duplexer information
  - Transmit and receive frequencies
  - Required transmit power
  - Target receive power
  - Modulation profile settings (upstream and downstream)
  - Dynamic Host Configuration Protocol (DHCP) server address

- **Radio receive-antennas**—to configure the number of receive antennas in use
  - This command will take effect on the next no shut
    
    radio receive-antennas \{1 \mid 2\}
  
  - Use the no version of the command to set the number of receive antennas to the default value (1)
    
    no radio receive-antennas
Initial Configuration—HE

- **Radio transmit-power**—to set the transmit output power level for the HE RF in dBm
  
  ```
  radio transmit-power power_level
  power_level = number representing power stated in dBm
  ```

  Tx Power range for MMDS = 15 to 38 dBm
  Tx Power range for UNII = -5 to 15 dBm

  - This command will take effect on the next no shut
  - To display the current transmit power settings, use the command
    ```
    show controllers radio slot/port rf
    ```

Initial Configuration—HE

- **Radio downstream frequency**—to configure the downstream channel frequency and the bandwidth
  
  ```
  radio downstream frequency [freq] width [width]
  [freq] is the frequency in KHz
  [width] is the bandwidth in MHz
  ```

  - Enter the RF center frequency and bandwidth for the whole downstream channel group
  - The headend linecard supports a single downstream
  - The frequency group must be positioned within the Tx passband of the RF duplexor
Initial Configuration—HE

- The allowable frequency ranges can be displayed by using the command
  
  `show controller radio [slot]/[port] rf`

- The frequency is **unspecified** by default

- The interface cannot be no-shut unless a frequency is specified

- The default width is 6.0 MHz

---

MMDS Frequency Plan (US Only) (6 MHz)

<table>
<thead>
<tr>
<th>MMDS Channel</th>
<th>MHz</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>Start</td>
<td>Center</td>
</tr>
<tr>
<td>A1</td>
<td>2500</td>
<td>2503</td>
</tr>
<tr>
<td>B1</td>
<td>2506</td>
<td>2509</td>
</tr>
<tr>
<td>A2</td>
<td>2512</td>
<td>2515</td>
</tr>
<tr>
<td>B2</td>
<td>2518</td>
<td>2521</td>
</tr>
<tr>
<td>A3</td>
<td>2524</td>
<td>2527</td>
</tr>
<tr>
<td>B3</td>
<td>2530</td>
<td>2533</td>
</tr>
<tr>
<td>A4</td>
<td>2536</td>
<td>2539</td>
</tr>
<tr>
<td>B4</td>
<td>2542</td>
<td>2545</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MMDS Channel</th>
<th>MHz</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>Start</td>
<td>Center</td>
</tr>
<tr>
<td>C1</td>
<td>2548</td>
<td>2551</td>
</tr>
<tr>
<td>D1</td>
<td>2554</td>
<td>2557</td>
</tr>
<tr>
<td>C2</td>
<td>2560</td>
<td>2563</td>
</tr>
<tr>
<td>D2</td>
<td>2566</td>
<td>2569</td>
</tr>
<tr>
<td>C3</td>
<td>2572</td>
<td>2575</td>
</tr>
<tr>
<td>D3</td>
<td>2576</td>
<td>2581</td>
</tr>
<tr>
<td>C4</td>
<td>2584</td>
<td>2587</td>
</tr>
<tr>
<td>D4</td>
<td>2590</td>
<td>2593</td>
</tr>
</tbody>
</table>
# MMDS Frequency Plan (US Only) (6 MHz)

<table>
<thead>
<tr>
<th>MMDS Channel US</th>
<th>MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>2596-2599-2602</td>
</tr>
<tr>
<td>F1</td>
<td>2602-2605-2608</td>
</tr>
<tr>
<td>E2</td>
<td>2608-2611-2614</td>
</tr>
<tr>
<td>F2</td>
<td>2614-2617-2620</td>
</tr>
<tr>
<td>E3</td>
<td>2620-2623-2626</td>
</tr>
<tr>
<td>F3</td>
<td>2626-2629-2632</td>
</tr>
<tr>
<td>E4</td>
<td>2632-2635-2638</td>
</tr>
<tr>
<td>F4</td>
<td>2638-2641-2644</td>
</tr>
</tbody>
</table>

# MMDS Duplexer Options

<table>
<thead>
<tr>
<th>Cisco Part Number</th>
<th>Channel Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBR-ODD-01A</td>
<td>C1 to D4 (2548 MHz to 2590 MHz)</td>
</tr>
<tr>
<td></td>
<td>G1 to G4 (2564 MHz to 2606 MHz)</td>
</tr>
<tr>
<td>UBR-ODD-02A</td>
<td>A1 to B4 (2500 MHz to 2548 MHz)</td>
</tr>
<tr>
<td></td>
<td>E1 to F4 (2536 MHz to 2584 MHz)</td>
</tr>
<tr>
<td>UBR-ODD-03A</td>
<td>D1 to B4 (2544 MHz to 2592 MHz)</td>
</tr>
<tr>
<td></td>
<td>F4 to G4 (2638 MHz to 2686 MHz)</td>
</tr>
<tr>
<td>UBR-ODD-04A</td>
<td>A1 to B4 (2500 MHz to 2512 MHz)</td>
</tr>
<tr>
<td></td>
<td>A4 to B4 (2535 MHz to 2546 MHz)</td>
</tr>
<tr>
<td>UBR-ODD-05A</td>
<td>E1 to F1 (2596 MHz to 2608 MHz)</td>
</tr>
<tr>
<td></td>
<td>E4 to F4 (2632 MHz to 2644 MHz)</td>
</tr>
<tr>
<td>UBR-ODD-06A</td>
<td>C4 to F2 (2584 MHz to 2620 MHz)</td>
</tr>
<tr>
<td></td>
<td>H1 to G4 (2650 MHz to 2686 MHz)</td>
</tr>
</tbody>
</table>
U-NII Duplexer Options

<table>
<thead>
<tr>
<th>Band Plan</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band Plan 1 Downstream</td>
<td>5727–5751 MHz</td>
</tr>
<tr>
<td>Band Plan 1 Upstream</td>
<td>5775–5799 MHz</td>
</tr>
<tr>
<td>Band Plan 2 Downstream</td>
<td>5751–5775 MHz</td>
</tr>
<tr>
<td>Band Plan 2 Upstream</td>
<td>5799–5823 MHz</td>
</tr>
</tbody>
</table>

Initial Configuration—HE

- **Radio modulation-profile**—use this command in Global Configuration mode. It creates, modifies, and deletes “modulation profiles”

- Modulation profiles can be applied to one or more upstream or downstream channels

  ```
  radio modulation-profile <n> bandwidth <bandwidth in MHz> throughput <throughput in Mbps> multipath-robustness <high|standard> burst-size medium
  
  <n> is a number indicating the profile to act upon (1-32)
  ```
Initial Configuration—HE

- Bandwidth is the bandwidth assigned in MHz (1.5, 3 or 6)
- Throughput is the maximum physical layer throughput in Mbps; application throughput expected to be less
- Lower throughput settings will employ more FEC coding
- Multipath robustness level also known as delay spread tolerance
- Burst size is the duration of OFDM burst

The negative form of the command will delete the modulation profile

no radio modulation-profile <n>
Initial Configuration—HE

- Various modulation profile options can be viewed by using the command
  
  \texttt{show radio capability modulation-profile}

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Throughput (Mbps)</th>
<th>Multipath Robustness</th>
<th>Burst Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>4.2</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>1.5</td>
<td>3.2</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>1.5</td>
<td>1.6</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>10.0</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>7.6</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>5.1</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>8.6</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>6.6</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>4.4</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>22.0</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>17.0</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>12.0</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>19.0</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>14.0</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>11.0</td>
<td>high</td>
<td>medium</td>
</tr>
</tbody>
</table>
### Initial Configuration—HE

**UPSTREAM**

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Throughput (Mbps)</th>
<th>Multipath Robustness</th>
<th>Burst Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>4.3</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>1.5</td>
<td>3.2</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>1.5</td>
<td>1.4</td>
<td>standard</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>8.1</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>6.3</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>3.0</td>
<td>4.4</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>19.0</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>15.0</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>6.0</td>
<td>11.0</td>
<td>high</td>
<td>medium</td>
</tr>
</tbody>
</table>

**Modulation profiles can be verified using the command**

```
show radio modulation-profile
```

**Example:**

<table>
<thead>
<tr>
<th>Mod</th>
<th>Bandwidth</th>
<th>Throughput</th>
<th>Multipath Robust</th>
<th>Burst Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0</td>
<td>6.6</td>
<td>high</td>
<td>medium</td>
</tr>
<tr>
<td>8</td>
<td>3.0</td>
<td>6.3</td>
<td>high</td>
<td>medium</td>
</tr>
</tbody>
</table>
Initial Configuration—HE

- **Radio downstream subchannel modulation-profile**—this command creates a downstream in a subchannel configures it to use a particular modulation-profile

- Use it in radio interface mode

  ```
  radio downstream subchannel <sc> modulation-profile <p>
  ```

  - `<sc>` is a number corresponding to the subchannel map (1-7)
  - `<p>` refers to the index of a profile defined with the radio modulation-profile command (1-32)

---

**Diagram**

- Center Frequency
- Subchannel (SC)
- Width in MHz
Initial Configuration—HE

- **Radio upstream frequency**—to configure the upstream channel frequency and the bandwidth

  \[ \text{radio upstream frequency [freq] width [width]} \]

  [freq] is the frequency in KHz

  [width] is the bandwidth in MHz

---

Initial Configuration—HE

- Enter the RF center frequency and bandwidth for the whole upstream channel group

- Individual upstreams may then be populated in one or more of the subchannels in the map

- The group must be positioned within the Rx passband of the RF duplexer

- The width specified in the profile must match that of the subchannel that this upstream is being assigned to

- The upstream must not overlap spectra with any other existing upstreams
Initial Configuration—HE

• **Radio upstream subchannel modulation-profile**—This command creates an upstream in a subchannel and configures it according to the specified modulation profile

  ```
  radio upstream <n> subchannel <sc> modulation-profile <p>
  ```

  <n> is a logical index chosen by the user (0-3)
  <sc> indicates the subchannel assignment (1-7)
  <p> refers to the modulation profile to use (1-32)

• To remove an upstream channel

  ```
  no radio upstream <n>
  ```

Initial Configuration—HE

• This command is used to set the desired target receive power level of various upstreams at HE

  ```
  radio upstream <n> target-receive-power <power_level>
  ```

  <n> is a logical index chosen by the user (0-3)
  <power_level> -100 dBm through -30 dBm

  This command will take effect at the next no shut

  ```
  radio upstream 0 target receive-power -70
  ```
Initial Configuration—HE

- Target Receive Power is the Minimum Detectable Signal (MDS) plus the fade margin
- If the channel has multipath reflections or fades, a higher average signal strength will be necessary to yield the same codeword error rate

Initial Configuration—HE

- The best tradeoff between safety margin above MDS and maximum range is approximately 15 dB
- The table summarizes the recommended TRPs for each upstream data mode

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Throughput (Mbps)</th>
<th>1 ANTENNA MDS (dbm)</th>
<th>TRP (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1.4</td>
<td>-92</td>
<td>-77</td>
</tr>
<tr>
<td>1.5</td>
<td>3.2</td>
<td>-87</td>
<td>-72</td>
</tr>
<tr>
<td>1.5</td>
<td>4.3</td>
<td>-71</td>
<td>-66</td>
</tr>
<tr>
<td>3</td>
<td>4.4</td>
<td>-89</td>
<td>-74</td>
</tr>
<tr>
<td>3</td>
<td>5.3</td>
<td>-84</td>
<td>-79</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>-60</td>
<td>-55</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>-50</td>
<td>-71</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>-52</td>
<td>-57</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>-77</td>
<td>-62</td>
</tr>
</tbody>
</table>
Initial Configuration—HE

- Radio cable-loss—use this command to enter the effective cable loss (measured in dB) of the cable between the wireless modem card and the specified wireless transverter, including the power feed panel, connectors, and lightning protection

radio cable-loss{auto|<antenna_num><tx_loss> <rx_loss>}

  antenna_num - Enter 1 for main antenna or 2 for diversity antenna
  tx_loss - Positive number less than or equal to 15 dB reflecting effective transmit cable loss
  rx_loss - Positive number less than or equal to 15 dB, reflecting effective receive cable loss

- Use the no version of the command to remove the setting
  no radio cable-loss

- To display the current settings, use the command
  show running-configuration interface radio slot number/port number
Initial Configuration—HE

<table>
<thead>
<tr>
<th></th>
<th>Wireless Modem Card to PFP</th>
<th>PFP to Primary Lightning Suppression</th>
<th>Primary Lightning Suppression to Trans</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Length</strong></td>
<td>4 Feet</td>
<td>250 Feet</td>
<td>50 Feet</td>
</tr>
<tr>
<td><strong>Cable Type</strong></td>
<td>RG142</td>
<td>LMR400</td>
<td>LMR400</td>
</tr>
<tr>
<td><strong>Loss per 100 feet</strong></td>
<td>8 dB @ 400 Mhz</td>
<td>2.7 dB @ 400 MHz</td>
<td>2.7 dB @ 400 MHz</td>
</tr>
<tr>
<td><strong>Connectors</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Loss per Connector</strong></td>
<td>.25 dB</td>
<td>.25 dB</td>
<td>.25 dB</td>
</tr>
<tr>
<td><strong>Equipment Loss</strong></td>
<td>1.2 dB (PFP)</td>
<td>0.2 dB (Lightning Suppression)</td>
<td>—</td>
</tr>
<tr>
<td><strong>Loss per Segment</strong></td>
<td>2.02 dB</td>
<td>7.45 dB</td>
<td>1.85 dB</td>
</tr>
</tbody>
</table>

Total Loss = 11.32 dB

Initial Configuration—HE

- Configure the ip address for the radio interface
  
  `ip address <ip address> <subnet mask>`
Initial Configuration—HE

To set the DHCP server, use the following set of commands in global configuration mode:

```
ip dhcp excluded-address <ip address of the HE radio interface>
tftp-server slot0:gold13.cm
ip dhcp pool <pool name>
network <network address> <subnet mask>
bootfile gold13.cm
option 2 hex 0000.0000
lease <days|hours|minutes> | <infinite>
```

Initial Configuration—HE

- To enable upstream data traffic
  ```
  no radio upstream <n> shutdown
  ```
- To disable upstream data traffic
  ```
  radio upstream <n> shutdown
  upstream <n> can be abbreviated as u<n>
  Default is shutdown mode
  ```
SU State Machine

### Subscriber State Machine

- **Power-on Reset**
- **Hunt for Downstream Channel**
  - **TS NOT Achieved**
  - **OFDM PHY Synchronization**
  - **PHY Sync NOT Achieved**
- **TS Achieved**
- **Listen to MAP and UCD Messages**
- **Ranging Process Contends on “Ranging Minislots”**
- **Registration Process**
- **Begin Data Transmission**

### Process Details:
- **Registration Failed**
- **TS NOT Achieved**
- **PHY Sync NOT Achieved**
- **PHY Sync Achieved**
- **TS Achieved**

### Tasks:
- IP address retrieval
- Security association establishment
- Access time of day via RTC server
- Retrieve subscriber configuration file using TFTP protocol
- Receive data SIDs (note that voice SIDs are dynamically assigned)
- Establish a QoS for each SIDs, i.e. transmission rate, CBR or VBR and etc.
- Establish a filtering criteria for data packets (multicast and Unicast and broadcast control)

### Time Frames:
- **Synchronization**
  - **Time Stamp Synchronization**
  - **Upstream TDMA**
  - **Hunt for Downstream Channel**

### Fixed Wireless Services:

Point-to-Multipoint Broadband Fixed Wireless

Session WMT-230
Please Complete Your Evaluation Form

Session WMT-230