Cisco Broadband Wireless Gateway Release 2.2 for Cisco IOS Release 12.4(24)YG2

Cisco IOS Release 12.4(24)YG2
09 April 2010

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CONTENTS

CHAPTER 1 **Overview of the Cisco Broadband Wireless Gateway** 1-1

Overview 1-1

Access Service Networks 1-2

Cisco's BWG 1-3

SUP Backward Compatibility 1-4

CHAPTER 2 **Configuring the Cisco Broadband Wireless Gateway** 2-1

New Features in Release 2.2 2-3

New Features in Release 2.0 2-3

Ethernet Convergence Sublayer (CS) 2-4

Ethernet Convergence Sublayer (CS)—R6 Control Only 2-4

Configuring R6 Control Only 2-5

Ethernet CS—Data and Control Both on R6 2-6

VLAN to VRF Mapping for L2-L3 Bridging 2-7

Packet Fragmentation Handling 2-7

Support for Jumbo Frames 2-7

DHCP Option 82 Enhancement 2-7

DSCP Calculation/Marking/Signaling 2-8

DSCP Marking 2-8

Limitations 2-9

WiMAX NWG Specification (1.2.2) Compliant 2-9

L2-L2 Bridging 2-9

Ethernet IP Host 2-10

PPPoE Host 2-10

Transparent VLAN 2-11

CPE Management 2-12

AAA Access for Unauthenticated Subscriber 2-12

New AAA Attributes 2-13

Configuring the SLA Profile 2-15

Multiple SLA Profile Support Per Subscriber 2-16

User Auto-Provisioning 2-18

Session Caching Mechanism 2-19

Support for 20 Hosts Per Subscriber 2-20

Host Mobility Across CPEs 2-20

Support for MS/Host with Statically Assigned IP 2-21
IP CS 2-21
Ethernet CS 2-21
ARP Request from Host 2-22
Uplink Packet from Host 2-22
Limitations 2-22
Other Enhancements 2-22
R6 Protocol Enhancement 2-22
R6 Attachment Request 2-23
R6 Attachment Response 2-23
R6 Data Path Registration Request 2-23
R6 Data Path Registration Response 2-24
EAP Authentication 2-25
Network Admission of an Authenticated User 2-25
Support of Un-Authenticated User 2-26
Configuring AAA to Enable PAP Authentication on BWG 2-27
AAA Access for CPE Using PAP Authentication 2-27
Proxy Realm for CPE Using PAP Authentication 2-27
Auto-Provisioning for Unauthenticated CPE Using PAP Authentication 2-28
Configuring Authentication 2-29
Configuring AAA for Accounting Types 2-29
Configuring Authorization 2-29
Configuring Authentication 2-29
RADIUS Server 2-30
Configuring User Groups 2-31
Verifying the Configuration 2-32
Configuration Examples 2-32
Security Key Exchange 2-33
IP Address Allocation Using DHCP 2-34
Configuring IP Address Allocation 2-34
Multiple Host Support 2-35
Support of Multiple Hosts Behind a SS 2-35
DHCP Option 82 2-36
DHCP Option 82 Enhancement in Release 1.1 2-37
Per-Subscriber DHCP Host Overflow Mechanism 2-37
Service Flow Creation and Management 2-39
Service Flows 2-39
Multiple Service Flow Creation 2-39
Configuring BWG Service 2-40

Sample Configuration 2-40
Verifying the Configuration 2-40
Mapping of Service Flows to DiffServ Classes 2-42
Configuring Service Flows on the BWG 2-43
Configuration Example 2-44
Configuring Service Flow Packet Classification 2-45
Configuration Example 2-45
Critical Service Flow 2-46
Delay the Attachment Response from BWG 2-47
QoS Support 2-48
Configuring QoS 2-49
Configuration Example 2-50
Verifying the Configuration 2-51
User Group Management 2-53
Sample Configuration 2-53
Idle Timer Support 2-54
User Group-Based Maintenance Mode, Show, and Clearing 2-54
Session Timer Support 2-55
Mobile Subscriber Station De-Registration 2-56
AAA Accounting Start-Stop-Interim 2-58
Configuring AAA Accounting 2-61
Accounting Start Response 2-61
Configuration Example 2-62
Verifying the Configuration 2-62
WiMAX Specific VSAs 2-65
AAA-Based Hot-lining 2-65
Hot-Lining Triggers 2-66
AAA Attributes 2-67
Configuring Profile-based Hot-lining 2-68
AAA Packet of Disconnect Message (PoD) 2-70
AAA-based Static IP Address Provisioning 2-71
Handoffs 2-72
Interim Accounting Update During Handoff 2-72
Uncontrolled Handoff 2-73
Controlled Handoff 2-74
Verifying the Configuration 2-75
Security Context Exchange 2-75
Keepalive Support for R6 Interface 2-76
CLI-based Keepalive With reset-bs Option 2-78

show brief Command to Identify a Static or Dynamic Host. 2-79
Session Redundancy 2-79
BWG Session Redundancy and High Availability Infrastructure 2-79
Subscriber Management 2-80
DHCP and AAA 2-80
Dynamic Synchronization 2-81
Configuring Session Redundancy 2-81
Configuration Example 2-82
Authentication 2-83
Accounting 2-84
Subscriber IP Address 2-84
QoS 2-84
Statistics and Counters 2-84
BWG Load Balancing 2-85
Data Path and GRE 2-85
Version Control 2-85
Limitations 2-85
Switchover 2-86
BWG Load Balancing 2-87
BWG Selection 2-88
Modes of Operation 2-88
Configuring Load Balancing 2-89
Load Balancing Configuration Task List 2-89
Configuring Cisco IOS SLB for Load Balancing 2-89
Configuring Real BWG 2-90
Configuring the BWG for Load Balancing 2-90
BWG Configuration Example 2-91
Verifying the Configuration 2-92
Configuration Example 2-92
Configuring a Virtual Server 2-93
Configuring DFP Support 2-95
SLB Stickiness Support 2-95
Configuring SLB Support 2-97
Lawful Intercept 2-97
Configuring the BWG for Lawful Intercept 2-97
Configuring the BWG 2-101
Configuring SNMP on the BWG 2-101
Configuring SNMP Access in Routers 2-102
Configuring SNMP-Server Host 2-103
Configuring SNMP-Server Trap-Source 2-105

Configuration Examples 2-108
SNMP Configuration Examples on the BWG 2-108
MIB Support 2-110
Verifying MIB Support 2-110
Configuration Examples 2-110
MIB Enhancements for BWG Release 1.1 2-114
Restrictions 2-117
Hitless Software Upgrade 2-117
Support Two DHCP Servers Per User Group 2-118

CHAPTER 3 **Proxy Mobile IP** 3-1
Overview 3-1
DHCP Proxy Server 3-2
PMIP Authenticated Network Identifier (PANI) 3-4
Multiple HA Support 3-5
Tunneling Between FA (BWG) and HA 3-5
MIP Host Configuration Extension 3-6
Configuring DNS and Default Gateway 3-6
Client IP Address Allocation 3-7
MIP Registration Revocation from HA 3-7
Co-Existence of PMIP and Simple IP Hosts 3-7
FA Relocation 3-7
Ethernet CS L2-L3 or IPCS 3-8
WiMAX RADIUS Attributes 3-8
Stateful Session Redundancy 3-9
PMIP Profile Configuration 3-9
NAI Configuration 3-11
Verifying the Configuration 3-14

CHAPTER 1

Overview of the Cisco Broadband Wireless Gateway

This chapter provides an overview of the Cisco Broadband Wireless Gateway (BWG), and identifies its function within an end-to-end fixed or mobile IP network.

Overview

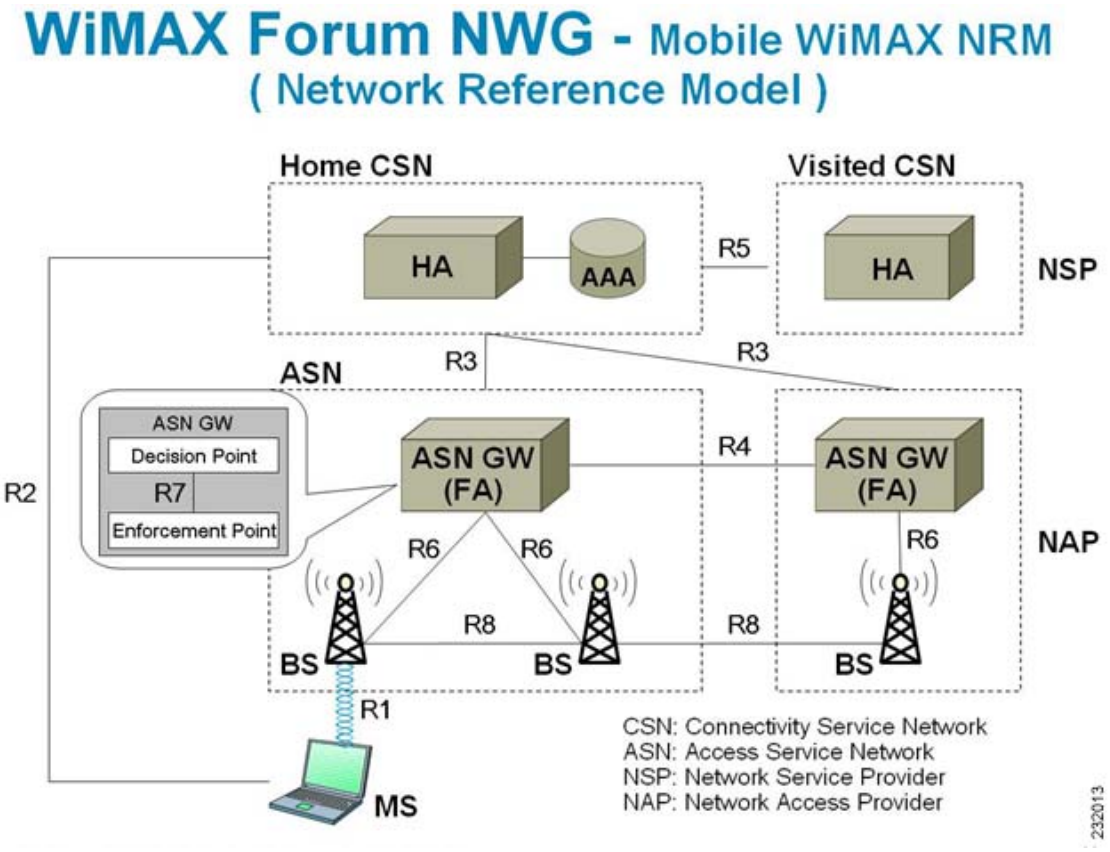
The Cisco BWG functions in the gateway role in WiMax networks, and is designed as part of an end-to-end IP architecture. WiMAX is a standards-based wireless technology that offers high throughput broadband connections over long distances. WiMAX can be used for a number of applications, including “last mile” broadband connections, fixed and mobile cellular service, hotspots and cellular backhaul, and high-speed enterprise connectivity for business.

WiMAX is based on the IEEE 802.16d standard for fixed wireless, and the 802.16e standard for mobile wireless. This standard is appealing to customers because it allows mass production of chipsets that reduce CPE costs, ensure multi-vendor interoperability, and reduce investment risk for operators.

The architectural framework of a WIMAX network consists of the Access Service Network (ASN) and the Core Service Network (CSN). For new, or small deployments addressing the fixed/nomadic markets, only an independent ASN is possible in this release. Release 1.0 and above only addresses the standalone Access Service Network.

Figure 1-1 illustrates the WiMAX Network Reference Model.

Figure 1-1 WiMAX Network Reference Model



Access Service Networks

An Access Service Network is a set of network functions that provide radio access to a WiMAX subscriber. The ASN typically provides functions such as network discovery and selection, connectivity service between the MSS and Core Services network (CSN), Radio Resource Management, Multicast and Broadcast Control, Intra-ASN mobility, Paging and Location Management.

The Wimax architecture consists of both mobile and fixed subscribers, as well as the ASN and CSN. The interface between the ASN and those subscribers is based on the IEEE 802.16 (“d” for fixed and “e” for mobile subscribers). An ASN is comprised of base stations (in one, or more base station clusters), and BWG(s). An ASN may be shared by more than one Connectivity Service Networks (CSN).

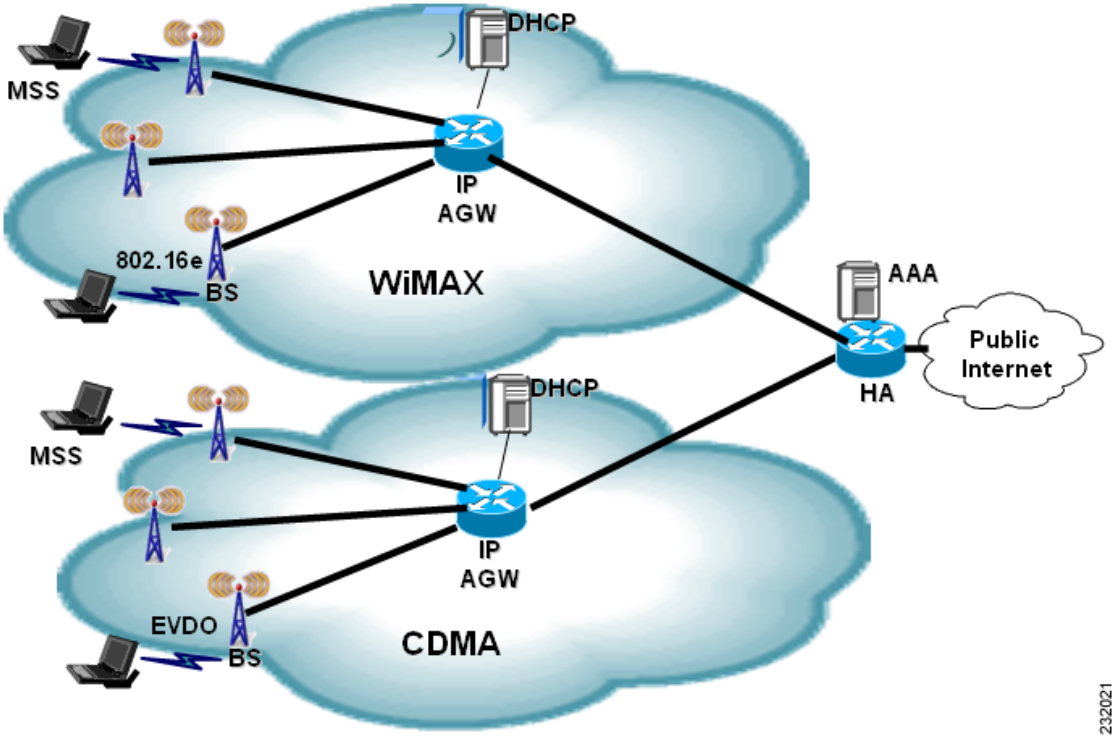
A Network Access Provider (NAP) is a business entity that provides WiMAX radio access infrastructure to one or more WiMAX Network Service Providers (NSPs). A NAP implements this infrastructure using one or more ASNs.

A Connectivity Service Network (CSN) is defined as a set of network functions that provide IP connectivity services to the WiMAX subscriber(s). CSN may comprise network elements such as routers, Home Agent, AAA proxy/servers, user databases, Policy servers, Content Service Gateways, Service Selection gateways, Interworking gateway devices.

With the emergence of an all-IP end-to-end mobile network, there is a need for an all IP Broadband Access Gateway. The IP Access Gateway is radio agnostic and handles mobility and security. It also pushes IP service delivery to the radio network. In short, the BWG allows intelligence to be shared between the Base Station (BS) and the IP network. All radio independent control is part of the BWG, while all radio dependent control is part of the BS.

Figure 1-2 illustrates elements of a WiMAX network.

Figure 1-2 Elements of a Wimax Network



Cisco's BWG

The Cisco BWG provides access gateway functions between the 802.16e wireless domain and the IP network. It is the first hop IP router from the user's perspective and provides NAS and Accounting client capabilities for interaction with AAA servers.

The BWG supports Access Network authentication and security functions.

The BWG provides local mobility anchor capability, so that users can move between base-stations. The BWG also caches authentication and security identification to accommodate fast roaming of users across base-stations or between BWGs.

The BWG is the key to the IP mobility scheme. It provides the termination of the mobility function across base-stations and the foreign agent function. The BWG maps the radio bearer to the IP network. It works with the CSN and the policy servers to control policy on behalf of the user. Additionally, it acts as an IP gateway for the IP host function that is located on the base station. The BWG brings together IP functions performed for the access network including end-to-end Quality of Service, Mobility and Security.

Cisco IOS Release 12.4(24)YG2 is optimized for the Cisco BWG feature on the SAMI card on the Cisco 6500 Catalyst Switch platform and 7600 Series router.

Cisco BWG Release 2.0 and above is supported on the following platforms:

- Cisco Catalyst 6500 Series Switch platform with a SAMI blade installed—Please refer to the following URLs for installation and configuration information:

  Switch Chassis Installation

  http://www.cisco.com/en/US/docs/switches/lan/catalyst6500/hardware/Chassis_Installation/Cat6500/6500_ins.html

  Switch Chassis Module Installation

  http://www.cisco.com/en/US/docs/switches/lan/catalyst6500/hardware/Module_Installation/Mod_Install_Note/78_15767.html

  Release Notes

  http://www.cisco.com/en/US/products/hw/switches/ps708/prod_release_notes_list.html

- Cisco 7600 Series Router platform with a SAMI blade installed—Please refer to the following URL for installation and configuration information:

  http://www.cisco.com/en/US/products/hw/routers/ps368/prod_installation_guides_list.html

  - The Supervisor module (Sup720-3BXL, SUP IOS Release 12.2(33)) on the 7600 supports IOS-SLB functionality, and is enhanced to support BWG selection capability.
  - A maximum of 8 blades can be supported per chassis.
  - The BWG can coexist with CSG2 and the HA on co-located blades.

The Supervisor 720 is supported, both in single and redundant mode. For the Supervisor 720, the 3B and 3BXL versions are supported, with the latter recommended and tested.

The Supervisor 32 is not supported in this release.

Table 1-1 Memory Requirements for the Cisco SAMI on the 6500 Catalyst Switch and 7600 Internet Router

Cisco 6500 Catalyst Switch	BWG Software Feature Set	Sup720-3BXL, SUP IOS Release 12.2(33)	256 MB	512MB	RAM
Cisco 7600 Internet Router	BWG Software Feature Set	Sup720-3BXL, RSP720-3C-GE, and RSP720-3CXL-GE SUP, IOS Release 12.2(33)	256 MB	512MB	RAM

SUP Backward Compatibility

The BWG Release 2.2 on the Cisco 7600 hardware platform requires SUP software version SRE. However, BWG Release 2.2 will work with limited features with older SUP software version SRD.

In order to make BWG 2.2 work with SUP-SRD, configure the following hidden CLI at the global configuration mode:

	Command	Purpose
Step 1	`router(config)# wimax agw sup-backward-compatible`	Specifies that the BWG will work with the SRD Supervisor image.

With SUP-SRD, BWG Release 2.2 will primarily be used for Cisco-R6, PMIP, and other BWG1.x features.

Note If you use the SUP-SRD image, the following features in BWG Release 2.2 are not supported:

- L2-L2 Bridging Support
- SLB Stickiness Support
- NWG R6 in SLB-mode.
- MS Idle Mode Management in SLB-mode.

CHAPTER 2

Configuring the Cisco Broadband Wireless Gateway

This feature module explains and discusses the feature set for the Cisco Broadband Wireless Gateway (BWG). Additionally, this feature module explains how to configure those features and provides sample configurations when appropriate.

This chapter contains information on the following features:

- Ethernet Convergence Sublayer (CS), page 2-4
  - Ethernet CS—Data and Control Both on R6, page 2-6
  - DSCP Marking, page 2-8
- WiMAX NWG Specification (1.2.2) Compliant, page 2-9
- L2-L2 Bridging, page 2-9
- CPE Management, page 2-12
  - AAA Access for Unauthenticated Subscriber, page 2-12
- Support for MS/Host with Statically Assigned IP, page 2-21
  - IP CS, page 2-21
- EAP Authentication, page 2-25
  - Network Admission of an Authenticated User, page 2-25
  - Support of Un-Authenticated User, page 2-26
  - Configuring Authentication, page 2-29
- Security Key Exchange, page 2-33
- IP Address Allocation Using DHCP, page 2-34
  - Configuring IP Address Allocation, page 2-34
  - Multiple Host Support, page 2-35
  - Support of Multiple Hosts Behind a SS, page 2-35
  - DHCP Option 82, page 2-36
- Service Flow Creation and Management, page 2-39
  - Service Flows, page 2-39
  - Multiple Service Flow Creation, page 2-39
  - Configuring BWG Service, page 2-40

  - Mapping of Service Flows to DiffServ Classes, page 2-42
  - Configuring Service Flows on the BWG, page 2-43
  - Configuring Service Flow Packet Classification, page 2-45
  - Delay the Attachment Response from BWG, page 2-47
- QoS Support, page 2-48
  - Configuring QoS, page 2-49
- User Group Management, page 2-53
  - Idle Timer Support, page 2-54
  - Session Timer Support, page 2-55
- AAA Accounting Start-Stop-Interim, page 2-58
  - Configuring AAA Accounting, page 2-61
- AAA-Based Hot-lining, page 2-65
  - Configuring Profile-based Hot-lining, page 2-68
- AAA Packet of Disconnect Message (PoD), page 2-70
- AAA-based Static IP Address Provisioning, page 2-71
- Handoffs, page 2-72
  - Uncontrolled Handoff, page 2-73
  - Controlled Handoff, page 2-74
- Keepalive Support for R6 Interface, page 2-76
- Session Redundancy, page 2-79
  - BWG Session Redundancy and High Availability Infrastructure, page 2-79
  - Subscriber Management, page 2-80
  - DHCP and AAA, page 2-80
  - IOS AAA is not HA-aware at the moment, so the sync of AAA-related information is part of the session replication., page 2-80
  - Dynamic Synchronization, page 2-81
  - Configuring Session Redundancy, page 2-81
  - Authentication, page 2-83
  - Accounting, page 2-84
  - Subscriber IP Address, page 2-84
  - QoS, page 2-84
  - Statistics and Counters, page 2-84
  - BWG Load Balancing, page 2-85
  - Data Path and GRE, page 2-85
  - Version Control, page 2-85
  - Limitations, page 2-85
  - Switchover, page 2-86
- BWG Load Balancing, page 2-87

  - BWG Selection, page 2-88
  - Modes of Operation, page 2-88
  - Configuring Load Balancing, page 2-89
  - Configuring Cisco IOS SLB for Load Balancing, page 2-89
  - Configuring the BWG for Load Balancing, page 2-90
- SLB Stickiness Support, page 2-95
- Lawful Intercept, page 2-97
- Configuring SNMP on the BWG, page 2-101
- MIB Support, page 2-110
  - Verifying MIB Support, page 2-110
- Restrictions, page 2-117
- Proxy Mobile IP
  - PMIP Authenticated Network Identifier (PANI), page 3-4
  - Configuring DNS and Default Gateway, page 3-6

New Features in Release 2.2

The following features are added as part of Release 2.2. They are also cross-referenced in the main features list.

- L2-L2 Bridging
- Interim accounting update during handoff
- PMIP Authenticated Network Identifier (PANI) as the Network Access Identifier (NAI)
- PMIP DHCP proxy support for sending DNS and Default Gateway configuration from local configuration or from AAA server.

New Features in Release 2.0

The following features were added as part of Release 2.0. They are also cross-referenced in the main features list.

- Support for Proxy Mobile IP
- DSCP Marking, page 2-8
- WiMAX NWG Specification (1.2.2) Compliant, page 2-9
- Accounting Start Response, page 2-61
- AAA-Based Hot-lining, page 2-65
- AAA Packet of Disconnect Message (PoD), page 2-70
- AAA-based Static IP Address Provisioning, page 2-71
- SLB Stickiness Support, page 2-95
- Lawful Intercept, page 2-97
- Hitless Software Upgrade, page 2-117

Ethernet Convergence Sublayer (CS)

The Wimax Ethernet Convergence Sublayer (CS) allows a WiMAX network to provide Ethernet Service directly to customers. In comparison with the IP CS, it allows IEEE 802.3 frames (carrying higher layer IP datagrams) to be encapsulated in the 802.16 PDUs. In the Cisco BWG 1.1 release, only two options of Ethernet CS are implemented: BS local switch (enterprise customers), and L2-L3 bridging conversion (residential customers).

As a part of Ethernet CS requirement, the BWG will support statically assigned IP addresses for the CPE/MS/host. This includes the following sub-features for the BWG:

- Enforce a maximum number (8) of active hosts per subscriber/CPE
- Auto-learning of L2/L3 details of the hosts through ARP, or any uplink packet from the host.
- Static host IP verification with Framed-Route from AAA
- A mechanism to age/bump out the idle host.

Ethernet Convergence Sublayer (CS)—R6 Control Only

In the Cisco 12.4(15)XL1 release, the WiMAX R6 interface between the BWG and Base Station (BS) is used for signaling only; the BWG instructs the BS to switch traffic locally. In the absence of GRE encapsulation, the BWG does not receive the bearer traffic from the BS. Instead, the BS must switch or forward the ethernet frames to an externally connected L2 Switch.

Note The R6 Control Plane Only feature should only be used for the Ethernet CS in the Cisco BWG R1.1 release.

Since the data packets no longer go through the BWG in this configuration, the BWG needs the following adjustments:

- Session Idle Timer: The BWG needs to ensure that a session remains open even if no packet is received or sent for the subscriber.
- When AAA sets the session timer to 0, it indicates it is infinite.
- Accounting: The BWG only performs “Accounting Start” and “Accounting Stop”, which corresponds to the service flow creation and deletion. Interim periodic accounting updates are not performed since BWG does not receive bearer traffic in this scenario.

In cases where the BWG does not receive the de-registration request from BS, the absolute session timer is used to de-register the MS on the BWG in order to remove hanging sessions.

The following steps illustrate the sequence of events for the R6 Control Only feature:

Step 1 SS sends a registration message to the BS. The BS forwards it to the BWG.

Step 2 The BWG asks for profile from the AAA server with user_name *MSID*@proxy-realm. Proxy-realm is configured in the user-group.

Step 3 AAA sends the SLA profile back with the following information:

- SS is identified as a business based on the SLA profile (which is configured as **encap-type none** on the BWG); in this case the traffic that is locally switched at the BS identifies this as an Enterprise.

- The VLAN ID (unique for every business SS connected to same BS). For example, the VLAN ID = 250.

Step 4 The BWG sends the Service Flow profiles info to the BS, along with VLAN ID and the Packet Classifications rules. The BS further sends the uplink Packet Classification rules to the SS.

Step 5 Upstream traffic is initiated: this assumes that the CPE router will send uplink .1q tagged traffic, with following VLANs:

- VLAN 10 (Sales)
- VLAN 20 (Voice)

Step 6 If the PCR is such that the SS will put traffic from VLAN 10 into Service Flow 1, this service flow type is BE. If the PCR is such that the SS will put traffic from VLAN 20 into Service Flow 2, this service flow type is UGS. The SS sends traffic to the BS.

Step 7 The BS assigns another .1q tag on incoming traffic for enterprise x (for example VLAN ID = 250). The inner tag is left unchanged. Traffic is switched to the L2 network, and does not go to the BWG.

Step 8 For downstream traffic, the following occurs:

- The BS receives traffic from the L2 switched network.
- Enterprise traffic does not come through BWG.
- The PCR will tell the BS on what SF traffic has to be sent.
- The BS strips the entire outer tag and forwards the remaining packet traffic over the air by SF1 (BE) or SF2 (UGS).

Step 9 The SS receives the traffic and forwards it to the switch. The inner tag is left unchanged.

Additionally, in this scenario the BS, rather than the BWG, terminates the uplink/downlink service flows. The BWG sends the downlink classifiers to the BS so that the BS can choose a proper downlink service flow for a packet. The BS needs the downlink classifiers to select the 802.16e air link connection ID/service flow. The BWG also signals the BS which VLAN tag to use for uplink traffic.

While the BWG design allows the flexibility to perform BS local switching on a flow-by-flow basis, for Release 1.1 all service flows should be configured to be either collectively BS-local switched, or BWG switched for a particular subscriber.

Configuring R6 Control Only

This section provides information on how to configure the R6 Control Only feature on the Cisco BWG. To enable R6 Control Only, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# wimax agw sla profile gold`	Specifies the Service level agreement (SLA) on the BWG. The BWG will enforce a limit for the number of service flows to 4 for each SLA profile. Attempting to exceed the limit will result in a failure.

	Command	Purpose
Step 2	`router(config)# service-flow pre-defined isf profile isf encap-type` **`none`** `vlan 10`	Specifies the initial service flow should be BS local-switched with a VLAN ID set to 10.
Step 3	`service-flow pre-defined secondary profile sec1 encap-type` **`none`** `vlan 10`	The BWG controls the BS's local switching through Data Path Encapsulation Type (NONE) and Data Path ID (Priority + VLAN ID) in the R6 DP Registration Request message. Note that the VLAN ID defined here could be overwritten from AAA.

Note For BWG Release 1.1, the same vlan should be configured in the same SLA profile.

Note When the vlan is downloaded from AAA, it will overwrite the vlans locally configured for all service flows.

The BWG controls the BS's local switching through Data Path Encapsulation Type (NONE) and Data Path ID (Priority + VLAN ID) in the R6 DP Registration Request message. Note that the VLAN ID defined here could be overwritten from AAA. The VLAN Priority (the 3 most significant bits in VLAN tag) comes from DSCP/Precedence defined for the service flow. If DSCP/Precedence is not locally defined, it is calculated based on WiMAX QoS Data Delivery Service Type used for the service flow.

Ethernet CS—Data and Control Both on R6

To align with the WiMAX Forum NWG standard, Cisco's R6 interface supports Ethernet CS with data and control. As noted earlier, only the L2-L3 bridging option for the BWG is supported in this release.

The L2 uplink traffic comes from the host behind the CPE/MS, and these packets are encapsulated 802.16 PDUs and sent to the BS by the CPE through the R1 interface. The BS then encapsulates the Ethernet frame into the GRE packet (the GRE tunnel was established during R6 signaling exchange), and sends it to the BWG. The BWG receives the GRE packet through the R6 data path. After stripping the GRE header and L2 header, the inner IP packet is forwarded to a proper interface configured in the intended VRF.

When the BWG receives the downlink packets, it finds the related host where the L2 information related to the particular host is saved. The L2 information, along with the L3 information carried in the packet, is used to compare with the configured classifiers. As a result, a proper service flow is selected. Once a service flow is selected, the saved L2 information for the host is used to encapsulate the received IP packets.

The host's L2/L3 information is dynamically learned by the BWG through the following mechanisms:

- DHCP procedure from host
- ARP Request from host
- Any uplink packet from host

VLAN to VRF Mapping for L2-L3 Bridging

This feature allows that the uplink L2 traffic with a particular VLAN ID is mapped to a VRF routing domain to forward the IP packets. On the other hand, the downlink IP traffic from a particular VRF will be sent to the MS encapsulated with the same VLAN ID. Note that BWG is designed to support at most one VLAN ID for each host behind MS.

Packet Fragmentation Handling

The virtual template interface on the BWG must be configured with a MTU so that no GRE fragmentation is needed for the R6 data path. The preferable MTU value is less than 1440.

For downlink packets larger than the MTU configured for the virtual template interface, they will be fragmented by IOS, and in doing so, IOS expects to clear the DF bits in the original packets. The BWG receives two IP packets in this scenario. The two IP packets are GRE encapsulated separately, and sent to the BS. The BS transparently passes the two packets to the host where they are assembled and delivered to an application.

For a large uplink packet, the BS clears the DF bits, fragments it into two packets, and sends them to the BWG. The BWG does not reassemble the packets, but forwards them separately.

Support for Jumbo Frames

This feature allows the BWG to support jumbo frames of up to 2000 bytes in payload. Previously, 1500 bytes was the limit beyond which packets are fragmented. The feature raises the Maximum Transfer Unit (MTU) to 2000.

- The mtu has been set for the BWG application to 2000. Configuration in the virtual-template interface allows the change in configuration for mtu, but what is reflected in the virtual-access interfaces is 2000 for BWG.
- The default mtu and ip mtu are respectively 2000 and 1500 in the Virtual-Template interface. So if neither are configured at BWG boot time, the configuration for the virtual-template interface in the running-config will look like the following:

```
Router#sh run | sec Virt
interface Virtual-Template1
 mtu 2000
 ip address 3.3.3.3 255.255.255.0
 ip mtu 1500
 encapsulation agw
```

- Once mtu is configured, ip mtu can be configured to any value less or equal to the mtu and will be reflected dynamically in the virtual-access interface.

A **no ip mtu** will set **ip mtu** in the virtual-access interface to mtu (2000). Any other desired value for **ip mtu** has to be explicitly configured in the virtual-template interface.

DHCP Option 82 Enhancement

In order to allow the BWG to build the L2 header for downlink DHCP packets, the entire L2 header is coded in the Option 82, which is reflected back from the DHCP server. This sub-option only applies between the BWG and DHCP server.

DSCP Calculation/Marking/Signaling

For downlink traffic, the DSCP marking is performed by the BWG. The outer IP DSCP value is obtained in the order of precedence from:

- DSCP/Precedence set for the flow.
- Calculated from SF's Data Delivery Service Type as shown in the following table.

Table 2-1

WiMAX QoS	DSCP
UGS	46
ERT-VR	38
RT-VR	30
NRT-VR	22
BE	0

Note The inner IP's DSCP value is no longer used for marking the outer IP's DSCP.

Note The inner IP value is also marked.

Note The SF QoS to DSCP mapping table is used only when the DSCP is not configured for the SF.

For uplink traffic, the BWG obtains the DSCP value in the same way as for the downlink service flow. The uplink DSCP value is signaled to the BS in the Data Path Info TLV.

Consider that DSCP marking of inner user (uplink) packets cannot be trusted; therefore, the same uplink DSCP value signaled to BS for a service flow is also used to re-mark the R3 uplink packets.

DSCP Marking

In Release 2.0, the BWG supports marking of outer IP DSCP value for downlink data traffic in the following two ways:

- Using DSCP value specified in downlink service-flow profile

  router(config-gw-sf-dir)#set dscp *value*

- Using DSCP value from inbound R3 IP packet

  router(config-gw-sf-dir)#set dscp r3

The BWG supports the marking of R3 IP DSCP value for uplink data traffic in the following three ways:

- Using inner IP DSCP value (default)
- Using outer R6 IP DSCP value

  router(config-gw-sf-dir)#set r3 dscp r6-outer

- Using DSCP value specified in uplink service-flow profile

  router(config-gw-sf-dir)#set r3 dscp *value*

Ethernet Frame Support

The BWG can support Ethernet II, LLC (802.2) and Ethernet SNAP frame types for different hosts. However, one particular host must use the same frame type during its session. In other words, one particular host can only transmit packets with the same Ethernet frame type.

Ethernet VLAN Support

Ethernet packets with a VLAN tag (specifically 802.1Q and Q-in-Q) are also supported.

Ethernet FCS (CRC)

There should be no CRC for both uplink and downlink packets over GRE towards the BWG.

Limitations

The following CS Ethernet limitations exist in Cisco BWG release 1.1 and above:

- Layer 2 broadcast/multicast packets from the MS other than ARP and DHCP are dropped at the BWG.

WiMAX NWG Specification (1.2.2) Compliant

The BWG supports both the Cisco R6 and NWG specification at the same time. No configuration is needed for this feature. The BWG distinguishes Cisco R6 from NWG R6 with the message header "Version" field. This distinction is per-subscriber-based in the BWG. When the first WiMAX R6 message for a session Version = 1, it is designated as NWG R6. Similarly if the first message carries a Version = 0x81, it is Cisco R6. A session must use the same flavor of R6 throughout its session life span except for a handover.

Handover from two BSs with different flavors of R6 is also supported.

L2-L2 Bridging

From Release 2.2, BWG supports L2-L2 Bridging. To configure L2-L2 bridging on BWG, you should be familiar with the integrated routing and bridging (IRB) feature of IOS.

Compared with L2-L3 bridging, L2-L2 bridging allows BWG to pass through the Ethernet CS packets intact.

L2-L2 bridging is enabled separately for each user-group. If the L2-L2 feature is enabled for a user-group, the L2-L3 feature is automatically disabled for that user-group.

To enable bridging on a Wimax user group, the group needs to be first added to a bridge group. When a user-group is added to a bridge-group, a virtual Wimax interface (Wimax<bridge-group>) is created. This virtual Wimax interface represents the user-group in the bridge-group. You cannot add multiple user groups to the same bridge group.

Use the **bridge-group** command to create bridge groups.

The following is a n example of how to configure a bridge group:

```
bridge irb
!
interface Ethernet1/1
  description Interface belong to bridge-group 1
  bridge-group 2
  no bridge-group 2 source-learning
  no ip address
!
bridge 2 protocol ieee
!
wimax agw user group-list wimax
 user-group any
  aaa authentication method-list agw
  aaa accounting method-list agw
  sla profile-name silver
  bridge-group 2
  no bridge-group 2 source-learning
  bridge-group 2 transparent-vlan vlan-tag
```

Ethernet IP Host

For Ethernet IP hosts, a BWG host entry is created based on the pass-through ARP packets, or any other uplink data packets. The host's IP address is captured in the subscriber's host entry table in the BWG.

ARP packets sent to the MS or host are replied to by the BWG (proxy ARP). Packets other than ARP packets —such as downlink broadcast or multicast L2 packets — sent to the Wimax gets dropped.

BWG acts as a layer 2 DHCP relay agent for any DHCP requests generated by the host. BWG adds DHCP option 82 containing circuit-id and remote-id to any upstream DHCP packet. But in the case of bridging, BWG does not have layer 3 network identification and therefore does not set the giaddr field.

PPPoE Host

For a PPPoE host, the BWG intercepts its PPPoE Discovery (signaling) packets. The following is a list of packets that are intercepted:

- PPPoE Active Discovery Initiation (PADI)
- PPPoE Active Discovery Offer (PADO)
- PPPoE Active Discovery Request (PADR)
- PPPoE Active Discovery Session-confirmation (PADS)
- PPPoE Active Discovery Terminate (PADT)

A BWG host entry corresponding to PADS is created only after BWG detects the PADS sent from the network to the client.

You can create a maximum of 20 PPP0E hosts for each subscriber. A new host is only accepted if at least one of the existing host's idle period has exceeded a threshold value. The host that has been idle for the longest period is replaced with a new host. The host idle threshold is 75% of the session idle timer.

BWG also adds a Vendor-specific tag and Relay Session ID tag to every PADI and PADR packets. Vendor-specific tags includes the circuit ID (SF ID) and Remote ID (MSID) sub options. Relay session ID tag is used to insert SFID. BWG removes these tags from the PADO and PADS packets before forwarding them to the PPPoE client.

Transparent VLAN

With L2-L2 Bridging, BWG allows you to configure the L2VPN.

To enable the L2VPN features for enterprises, BWG disables ARP, DHCP and PPPoE intercepting capabilities and allows all L2 packets to pass through without modifications on the uplink and downlink directions. When ARP, DHCP and PPPoE intercepting capabilities are disabled, the BWG cannot perform the ARP proxy function and it cannot learn the host information. Therefore, BWG will not be able to identify whether the packet comes from the CPE, or from the hosts behind it.

The combination of VLAN ID and bridge-group must be unique for each subscriber within o ne BWG context. In a mobile environment, to ensure this uniqueness when MS's mobility event is involved, you must be careful while configuring the AAA VLAN and BWG's bridge-group assignment for a subscriber.

When transparent bridging is enabled, the BWG has an option to vlan-tag all uplink traffic from the subscriber, before sending it to the bridge-group. The VLAN ID comes from the AAA as a Cisco AVP. The VLAN priority value is either explicitly set or mapped from the R6 uplink service flow's QoS Data Delivery Service Type (such as BE, UGS). If AAA does not provide a VLAN ID, the session is rejected.

For downlink packets, the subscriber is identified by a combination of bridge-group ID and VLAN ID. The outer VLAN Tag along with its Ethernet header is used to match the configured packet classification rule and to select a R6 downlink service flow. When it is done, the outer VLAN Tag is removed if the uplink traffic is VLAN Tagged by the BWG.

When transparent bridging is enabled and BWG's VLAN tagging is disabled, all traffic from the subscriber must bear the same VLAN ID.

The following is an example on how to enable transparent bridging on BWG:

```
wimax agw user group-list wimax
 user-group unauthenticated
  aaa accounting method-list agw
  sla profile-name silver
bridge-group 2
bridge-group 2 source-learning
bridge-group 2 transparent-vlan [vlan-tag]
 !
!
```

CPE Management

The CPE Management feature allows the BWG to use AAA to centralize the management of subscribers/CPEs for the overall Cisco WiMax solution. Considering the potential congestion and multiple AAA proxies in a real deployment, it can take up to 10 seconds to receive the RADIUS Access Accept message from AAA. Therefore, the related R6 protocol state machine should be designed to tolerate this AAA response delay.

The unauthenticated CPE management function has been moved to AAA and the BWG. Specifically, it includes the following features:

- User Domain Group Re-assignment
- Service-Level-Agreement (SLA)
- VLAN ID
- Mobile Capability (non-nomadic with a home BS list, and nomadic)
- Static IP Allowed (### whether static IP is allowed for the CPE)
- CPE Type
- CPE Settings
- CPE Auto-Provisioning
- CPE Service State (indicates if a CPE is black-listed)

This section provides information about the following features and functionality:

- AAA Access for Unauthenticated Subscriber, page 2-12
  - New AAA Attributes, page 2-13
- Configuring the SLA Profile, page 2-15
- Multiple SLA Profile Support Per Subscriber, page 2-16
- User Auto-Provisioning, page 2-18
- Session Caching Mechanism, page 2-19
- Support for 20 Hosts Per Subscriber, page 2-20
- Host Mobility Across CPEs, page 2-20

AAA Access for Unauthenticated Subscriber

For Base station/CPE that does not support EAP-based authentication, the BWG provides a PPP/PAP method of authentication using RADIUS. Such CPE generally get classified as Unauthenticated CPE. And for un-authenticated users, we do not get the user name from the CPE.

In this case, the user name, realm and password will be formed based on the following CLI:

```
wimax agw user group-list wimax
 user-group unauthenticated
  aaa authentication method-list xxxx
  proxy realm sprint.com passwd ciscoway
  sla profile-name silver
 !
```

Note The **aaa authentication method-list xxxx** command indicates if the RADIUS Access Request is initiated from the BWG for the group. If the CLI is not configured, AAA query is not required. The respective authentication method list is type PPP, which enables the BWG to perform PAP-based authentication.

Note Reauthentication for PAP users is not supported. The session will be de-registered if reauthentication is attempted by a CPE/MS.

Note The **proxy realm** *sprint.com* **password** *ciscoway* command instructs the BWG how to populate the RADIUS Access Request message. If configured, the user name will be constructed as *mac@realm* (for example, *mac @sprint.com*). If the realm is not configured, the user name will be *mac*. If not configured, *cisco* is used as the password. The method list configured using **aaa authentication method-list** *xxxx* is not used by the BWG in Access-Requests, since PAP authentication uses **default** method list configured globally by the **aaa authentication ppp default** command.

Note These two CLIs are applicable for other user groups (EAP users) as well. However, configuring **proxy-realm** for EAP users serve no purpose.

The reply from the AAA server contains the user's real domain name, which is used for selecting a local user group. The above scheme should not break EAP-authenticated users. In other words, the BWG should allow EAP and non-EAP authenticated users to coexist. For authenticated users, the user name is acquired from CPE through EAP identity request. EAP uses NAI in an Access request to the AAA. If the response from the AAA includes the Service Level Agreement (SLA) Profile Name and the User Domain Name for EAP users, the result from the AAA will override those determined earlier.

New AAA Attributes

To support the CPE management, the following new AAA attributes have been introduced. These new attributes may be returned in the RADIUS Access-Accept message. These attributes are all optional, and are AVPs under cisco_vsa.

Table 2-2 New AAA Attributes

Attributes	Format/Length	Comment
User Domain Name (name_string "User-Name")	String/253	If returned, the subscriber will be re-assigned to the corresponding user group.
SLA Profile Name (name_string "sla-profile-name")	String/253	If returned, the SLA profile corresponding to this name will overwrite the one locally defined in the user group in the BWG.

Table 2-2 New AAA Attributes (continued)

VLAN ID (name_string "vlan-id")	Integer/2	Used to tag the L2 traffic; Overwrite SF's local definition. In case of BS local switch, signaled to BS. **Note** This attribute is applicable to R6 control only sessions.
CPE Type (name_string "cpe-type")	String/253	For diagnostics, not used by BWG except being displayed by: "show wim agw sub" CLI
CPE Mobility (name_string "cpe mobility")	Integer/2	Defines how much mobility the CPE can be: 0 - non-nomadic with a Home BS List 1 – nomadic The default is nomadic.
CPE Settings (name_string "cpe-settings")	Integer/4	These CPE toggle settings are configured in AAA and downloaded into the BWG. The BWG will further use the R6 control protocol to signal BS, where BS further passes the info to the CPE. - bit 31: IngressACL Toggle: Once enabled, the CPE will block some uplink traffic from hosts whose source IP address is not learned by the CPE. - bit 30: Broadcast Filtering Toggle: Once enabled, the CPE will block the uplink broadcast traffic. - bit 29: Rate Limiting Toggle: Once enabled, the CPE will impose rate limiting for uplink traffic such as ICMP and ARP. - bit 0-28: reserved, set to 0 Refer to Cisco R6 Specification
Base Station List (name_string "bs-list")	Binary Hex/253 BSID1:BSID2	This list will be interpreted as a Home BS list if the CPE Mobile Capability equals to "non-nomadic". The BSID could be an IPv4 address or in the format of 802.16 (6 bytes) BSID1 = 1A.01.23.BC

Table 2-2 New AAA Attributes (continued)

Static IP Allowed (name_string "static-ip-allowed")	Integer/4	Used to indicate whether BWG is allowed to learn the CPE/Host's static IP address. This is mainly for security reason: 0 – not allowed 1 – allowed In the absence of this attribute, the default is not allowed.
CPE Service State (name_string "cpe-service-state")	String/253	Indicates if CPE is blacklisted or not. The following are the values defined for this attribute: 0 - Active 1 - Non payment 2 - Reported Stolen 3 - Bad user behavior 4 - Service Temporarily Suspended

Note The above AAA attributes are intended for PAP users, but they should work equally well for EAP users.

Configuring the SLA Profile

To configure the Service Level Agreement on the BWG, perform the following tasks"

	Command	Purpose
Step 1	`router(config)# wimax agw sla profile eth_vlan_pri_sla`	Configure the Service level agreement (SLA) on the BWG. The SLA profile includes all the flows. The BWG will enforce a limit for the number of service flows to 4 for each SLA profile. Attempting to exceed the limit will result in a failure. For Cisco BWG Release 1.1, the same vlan should be configured in the same SLA profile. Different service flows get listed under one SLA profile. You can associate an SLA with a user-group by configuring subcommand **sla profile** *profile name*. Provisioning the SLA allows you to better manage the service flows.

	Command	Purpose

Step 2	`router(config)# service-flow pre-defined isf profile dfault_vlan_sf`
	`  service-flow pre-defined secondary 1 profile vlan_pri_01_sf`
	`  service-flow pre-defined secondary 2 profile vlan_pri_02_sf`
	`  service-flow pre-defined secondary 3 profile vlan_pri_03_sf`
		Different service flows get listed under one SLA profile.

Step 3	`router(config)#wimax agw user group-list wimax`
	` user-group unauthenticated`
	`  aaa accounting method-list agw`
	`  sla profile-name silver`
		Configures the User group list on the BWG. There can be only one user group list allowed on a single processor of the BWG.
		The **no** version of command will remove the user group list. This will create a user group list sub configuration mode to create multiple user groups under the user-group list created.

In the above configuration, the user group's SLA profile acts as a default. The AAA return SLA profile name should take precedence.

Multiple SLA Profile Support Per Subscriber

Previously, SLA profile configuration on the BWG allowed WiMax service providers who defined the service packages efficiently to categorize service offerings (flow types) in a reasonable number of profiles.

For example, the following flows (flow-voice, flow-data, flow-video, flow-hd-video, flow-premium-voice, flow-premium-data) could be defined in 2 packages and sold to subscribers on a package basis.

SLA-regular

- flow-voice,
- flow-data

SLA-premium

- flow-premium-voice,
- flow-premium-data
- flow-hd-video

However, if service providers wanted to offer services in all possible combinations from the above list of flows, they would have to configure as many SLA profiles on BWG.

This feature allows service providers to configure SLA profiles similar to following and package the services to customers in any desirable combination.

SLA-regular data

- Flow-data

SLA-regular voice

- Flow-voice,

SLA premium video

- Flow-hd-video

SLA-premium data flow

- Flow-premium-data

The BWG supports flow creation based on multiple SLA profile names received from AAA. This is in addition to the existing support for a single SLA profile name. AAA can send a list of SLA profile names, separated either by comma, space or semicolon.

- The BWG parses the list to choose a valid, configured SLA profile to create the service flows for session.
- The BWG uses the following sequence of events to create the flows:
- BWG selects only configured SLA profile names from list.
- BWG selects only the unique flows from across the list of SLA profile names. For example, it takes "Union" across all the flows defined under received SLA profile names (with the exception of ISF).
- The current implementation needs only one ISF for successful flow creation. As a result, the BWG selects the ISF based on the order of SLA profile name in list of SLA profile names received from AAA. Even if different ISF profiles are configured for SLA profiles received, it selects the ISF from the first valid, configured SLA profile from the received list.
- The BWG discards all the remaining SLA profiles and SF profiles if the maximum allowed service flows limit is reached.
- The BWG does not check the validity (for example, if SF is configured correctly or not) of the SF under the SLA profile at the time it parses the list received from AAA. As a result, if the SF is found to be invalid or un-configured when the BWG is about to open that SF, then that SF gets dropped and BWG continues with rest of the SF profiles.
- If ISF is not present in SLA profiles coming from the AAA, the session is cleared.

Here is an example of the configuration:

```
wimax agw sla profile silver
service-flow pre-defined isf profile isf
wimax agw sla profile platinum
      service-flow pre-defined secondary 1 profile sec4

wimax agw sla profile gold
      service-flow pre-defined isf profile isf2
      service-flow pre-defined secondary 1 profile sec
      service-flow pre-defined secondary 2 profile sec2
      service-flow pre-defined secondary 3 profile sec3
```

If the SLA list received from AAA is "silver, gold, or platinum" then the session's SLA profile name is set to "silver, or gold", and the following four flows are created on the BWG:

- isf
- sec4
- sec
- sec2

If the above configuration SLA list received from AAA is “platinum, unconfigured, gold”, then the profile name of the session is set to “platinum, gold”, and the following four flows are created:

- isf2
- sec
- sec2
- sec3

The “unconfigured” SLA is discarded by the BWG.

Here is another example:

```
wimax agw sla profile silver
     service-flow pre-defined isf profile isf
wimax agw sla profile platinum
      service-flow pre-defined secondary 1 profile sec
wimax agw sla profile gold
      service-flow pre-defined isf profile isf2
      service-flow pre-defined secondary 1 profile sec
      service-flow pre-defined secondary 2 profile sec2
      service-flow pre-defined secondary 3 profile sec3
```

If the SLA list received from AAA is “platinum, unconfigured, gold”, then the profile name of session will get set to “platinum, gold”, and the following four flows are created:

- isf2
- sec (based on the order in which the SLAs were received, this flow was taken from SLA platinum)
- sec2
- sec3

The “unconfigured” SLA is discarded by the BWG.

In the absence of SLA from AAA, the BWG creates flows according to the SLA profile defined under the session's user group. The BWG still supports the single SLA profile sent by AAA.

User Auto-Provisioning

There are occasions when a user is admitted into the network for a short while even if AAA does not have provisioning for him/her. To enable this feature, the related unauthenticated group should be properly configured. When enabled, the session timer in the user group should be configured to a small value so that the user’s free use of the network is limited.

To configure auto-provisioning, perform the following task:

	Command	Purpose
Step 1	`router(config)# wimax agw user group-list wimax user-group unauthenticated aaa accounting method-list agw sla profile-name silver` **`user auto-provisioning`** `timeout session` **`600`**	Enables users to be auto-provisioned into the network for a configurable time even when AAA does not have provisioning for them.

Note Auto-provisioning is not supported for EAP users. It does not take effect when configured with any user group other than the unauthenticated.

Note Auto-provisioning for hosts with static IP and IPCS is not supported.

Session Caching Mechanism

Occasionally, air-link glitches occur between the MS and BS and the hosts behind the CPE/MS are lost. During an air-link glitch, the original BS may or may not send out the R6 de-registration on behalf of the CPE. After an air-link glitch, the CPE may re-connect to the same or a different BS. Previously, in either case, the session in the BWG was deleted and recreated, thus losing the session and host information. The Session Caching Mechanism preserves, or caches, the session across the CPE glitches. This feature involves two scenarios:

- The original BS sends an R6 De-registration Request to the BWG during a CPE glitch. In this case, the session in the BWG is pushed into the CACHED state. The original session, along with its hosts, are preserved when the CPE re-enters into the BWG while the session is in CACHED state.
- The CPE re-enters (through a Pre-Attachment Request) the BWG (through the same or a different BS) when the BWG has its session in ready state. In this case, the session is re-initialized without losing the host information, and re-entry is allowed.

Before entering the CACHED state, the accounting for both flows and host is stopped. When an R6 Pre-Attachment Request is received, the CACHED session is restored along with its previous hosts. Host accounting is re-started at this point. Thereafter, the normal procedure is followed to create the pre-defined service flows for the subscriber.

Note If you clear a session using the BWG CLI, it will not go into a CACHED state.

The value of the session cache timer is specified under the **user-group** sub-configuration mode. It can be specified as following:

- The session cache timeout value between 1 second and 259200sec (3 days).
- The sub-option **follow-dhcp-lease** sets the session cache timeout value to the maximum of DHCP lease remaining across all dynamic hosts. This is the default option.

Session_Cache_timeout = MAX (DHCP lease remaining for Dynamic Host [0],
DHCP lease remaining for Dynamic Host [1],
……..
DHCP lease remaining for Dynamic Host [n])

By default, the session caching feature is enabled with **follow-dhcp-lease** option, as described above. The detailed **show-subscriber** command displays the session's CACHED state.

Session Caching is enabled by default. Perform either of the following tasks to enable or disable the session cache feature using the following **user-group** commands:

	Command	Purpose
Step 1	`router(config-gw-ugl)# [no] timeout cache-session [1-259200]`	Specifies the session cache timer in seconds. The range is 1-259200.

Or this option:

Step 1	`router(config-gw-ugl)# timeout cache-session follow-dhcp-lease`	Sets the session cache timeout value to the maximum of the DHCP lease remaining across all dynamic hosts.

Support for 20 Hosts Per Subscriber

In Cisco BWG Release 1.3 and above, a CPE can now have up to 20 hosts. However, the total number of hosts for the BWG should not exceed 4 times the total of supported subscribers.

Host Mobility Across CPEs

In BWG Release 1.2, users deployed the BWG in what we termed hot spots. Each hot spot had a WiMAX CPE, and the personal hosts/computers moved around the CPE. These hosts were DHCP hosts. When a host moved away from a CPE, it did not perform DHCP RELEASE. The BWG still maintained information regarding the host despite that it had moved, and that information was not deleted from the BWG until the DHCP lease timer expired. Previously, the DHCP lease was set for 3 days. This caused the BWG to reject new hosts because, from the BWG's perspective, the maximum number of hosts had been reached.

This new feature will address the following scenarios:

- The same DHCP host (based on MAC address) moves from CPE1 to CPE2.

  When this happens, the host may not perform DHCP release through CPE1. Therefore, the BWG still remembers the host associated with CPE1. Previously the host from CPE2 was rejected as long as BWG still remembered the host's association with CPE1.

  In this release, the host's association with CPE1 is removed once the BWG detects the same host is entering the network through another CPE2. The same host can have the same or different IP address when it re-enters the network. Additionally, the same host can re-enter the network with the same or different VRF. Using this approach, the MAC address of the hosts must be unique across the entire network.

  One side effect of this feature is that a spoofed host (with its MAC same as a valid one) through a different CPE can disrupt the normal service of a valid host.

- One host kicks out another host with same VRF and IP address

  In this case, host1 is already in the BWG and associated with a CPE. Host2 (with a different MAC from host1) enters the BWG through the same or different CPE. The network (AAA server through its user-realm => user group => VRF, and DHCP server) assigns host2 with the same VRF and IP address. This should not normally occur because the DHCP server should not re-assign an IP address already in use by host1. However, there may be scenarios where the DHCP server may lose its information (such as a non-graceful restart, or a lease accidentally being deleted through an operator error).

With this new feature functionality, host1 is deleted to avoid network inconsistency and IP routing confusion. And the deleted host cannot get its service back unless it performs the DHCP procedure again.

Support for MS/Host with Statically Assigned IP

The BWG's DHCP mechanism for Ethernet CS is similar to that of IPCS except for an additional sub-option (L2 header) for option 82. Through the DHCP procedure, the BWG is able to capture the host's L2 header (including frame type) and IP address. In addition to the DHCP mechanism, the BWG supports the MS/host with a statically assigned IP address.

The static IP address is handled differently depending if IPCS or Ethernet CS is used.

IP CS

Authenticated Subscriber

For authenticated subscribers, the Framed-Route from AAA response can be used for downlink traffic routing. This feature is already supported in the BWG.

The BWG learns about static hosts in IP CS case through uplink data packets. The BWG does not have any L2 header information, so these static hosts are created without MAC IDs. The aging mechanism described below in the Ethernet CS section also applies to IP CS static hosts.

Note Unauthenticated subscribers are not supported.

Ethernet CS

There are two mechanisms for the BWG to learn the L2 header info and IP address from the statically configured host. The BWG creates its host entry (indexed by table ID—VRF and IP address) and L3 routing entry. The static hosts created in the BWG are limited to 8 active hosts per subscribers. However, a 9th host can be accepted if one of the existing static hosts' idle periods has exceeded a threshold value. In this case, the static host which has been idle the longest is bumped out by the new arrival. The host idle threshold is 75% of session idle timer. A static idle host is removed in the BWG only when a new host is detected by the BWG. DHCP hosts are not aged out.

All of the static IP that are learned are verified with the Framed-Route from the AAA. Currently the BWG supports one framed-route per CPE.

Note You should not disable the route aggregation feature for the user-group. This will prevent too many static host routes to be created or deleted from the routing table, which degrades the performance.

ARP Request from Host

The BWG can always intercept the ARP request packet to learn the host's IP and L2 header info (including frame type). The creation of a static host is subjected to the limits of active hosts per subscriber. If the BWG cannot admit the host, the ARP request will not receive a reply.

The BWG handles ARP packets similar to those for DHCP messages. The ARP reply packet is returned to the same service flow where the request originated. The BWG's MAC address (interface on which the ARP request was received) is used in the ARP reply message to the MS.

The BWG also implements an ARP-rate processing limiting feature to prevent itself from being overwhelmed. ARP packets are dropped if their rate of arrival exceeds what the BWG can handle. Currently the throttling mechanism on the BWG allows one upstream ARP request every 5 seconds.

To be a true ARP proxy, the BWG must be able to intercept a pass-through ARP request packet. These packets have a Target Protocol Address (TPA) different from BWG's IP. In the ARP reply packet, the TPA in the request packet is used.

Uplink Packet from Host

When an uplink packet is received by the BWG without its host entry in the Cisco Express Forwarding (CEF) path, it is rerouted to the process path where it is processed. As a result, a new host may be created. If the host cannot be created (subject to the 8 active host limit), the packet is silently dropped.

The BWG implements a throttle mechanism to prevent rerouting of the packets to the process path from overwhelming the BWG. Currently the throttling mechanism on the BWG reroutes 1 packet every 5 seconds.

Limitations

- A host that was bumped out of the network is not able to receive downlink traffic without first sending some uplink traffic. When this occurs, it indicates that the CPE actually has more than 8 hosts behind it.
- Upstream gratuitous ARPs are dropped by the BWG, and the BWG does not learn from these packets.

Other Enhancements

To support the Cisco BWG Release 1.1 and above features, the BWG is enhanced in the areas of the R6 Protocol, MIB, statistics, SR and CLI.

R6 Protocol Enhancement

The existing R6 protocol is enhanced to accommodate the Ethernet CS requirements.

R6 Attachment Request

CS Capability

The CS capability in the Registration context in the message must be set to the proper value to indicate Ethernet CS by the BS or the BS simulator.

Note The CS Capability included in this message can indicate a single CS type, or a set of CS types with a bitmap supported by the MS. In any case, it shows the MS's capabilities. Please refer to 802.16 for the details CS capability definition.

R6 Attachment Response

This message is sent from the BWG to the BS. The changes to this message are equivalent to the R6 Attachment Request message.

The CS Capability bitmap in this message is encoded to indicate that the BWG supports both IPCS and Ethernet CS.

R6 Data Path Registration Request

This message is sent from the BWG to the BS for normal R6 Data Path setup. The MSINFO TLV contains the following sub-tlvs:

- Anchor GW/DPF ID = IPv4 address of the ASN gateway
- CPE Settings—(optional)
- SF INF
  - SFID
  - CS Type—Specifies IP CS, Eth CS, or VLAN CS for the flow
  - Packet Classification Rule

    Classifier Rule Priority

    Ethernet Src MAC—(optional) for uplink SF, and are sent for downstream in case of control only scenario

    Ethernet Src MAC Mask

    Ethernet Dest MAC—(optional) for uplink SF only

    Ethernet Dest MAC Mask

    EtherType IP

    VLAN-ID

    VLAN Priority Range
  - Data Path Info

    Data Path ID—GRE Key or VLAN ID

    Data Path Encap. Type

    DSCP

The CS Type applies to the particular service flow. It is the intersection between the MS's indicated CS capabilities (in the Attachment Request), as well as the BWG's service flow CLI configuration. If both the CPE and the BWG support both IPCS and Ethernet CS, and the BWG configures both with the same precedence, IPCS is selected.

The Ethernet Src MAC and Ethernet Dest MAC address should be included if they are not configured as **any** in the corresponding BWG CLI configuration. New tag values conform to the Cisco R6 specification.

The Ethernet and VLAN related classifiers will not be signaled for an IPCS service flow. For Ethernet CS, the classifier VLAN-ID and VLAN Priority Range will be signaled to BS if they are locally configured.

The "Data Path ID" is an existing TLV. The VLAN Priority value (the most significant 3 bits of VLAN Tag) for the VLAN Tag comes from the DSCP/Precedence set for the flow, or derived from the QoS Data Delivery Service configured for the flow.

The "Data Path Encapsulation Type" TLV indicates if the encapsulation type should be used to transport the R6 bearer traffic.

0 = None

1 = GRE (Default)

2 = IP-in-IP

3 = VLAN

The tag value for "Data Path Encap Type" must conform to the Cisco R6 specification. For Ethernet CS R6 control-only scenario, this TLV should be set to "none". When "Data Path Encap. Type" is set to "none", the BS interprets the Data Path ID as a VLAN ID. In its absence, use the R6 data path with GRE to transport the data traffic.

The DSCP values signaled to the BS for uplink SF come from either the BWG locally configured for the SF, or, if it is not present, derived from the QoS Data Delivery Service configured for the flow.

In addition, the ISF Path Registration Request signals the newly defined CPE Settings TLV to the BS if it is available through AAA. The CPE settings are under the MS INFO TLV.

R6 Data Path Registration Response

This message is sent from the BS to the BWG during normal data path setup. The changes to the message are equivalent to the R6 Data Path Registration Request message. All the new TLVs defined for Data Path Registration Request messages are available for the Path Registration Response message.

Other R6 Changes

To be consistent, all the R6 signaling UDP packets have a DSCP value of 0x48. In addition, the UDP checksum is already calculated in Release 1.0 and above.

The BWG enforces a limit for the number of service flows to 4, and the number of active hosts to 20 per subscriber. If you attempt to exceed the limit the BWG will fail.

Note The BWG will not allow more than 4 service flows to be configured per SLA profile.

EAP Authentication

The BWG acts as an EAP relay and is agnostic to the EAP method. EAP transport is done between the BWG and the base station as a control exchange. The base station functions as an EAP-relay, converting from Pair-wise Master Key version 2 (PKMv2) to the EAP messages over to the BWG. The BWG is an EAP pass-through, and any key that generates EAP methods is supported in the system.

PKMv2 is used to perform over-the-air user authentication. PKMv2 transfers EAP over the IEEE 802.16 air interface between the MS and the base station. The base station relays the EAP messages to the Authenticator in the BWG. The AAA client on the Authenticator encapsulates the EAP message in AAA protocol packets, and forwards them through one (or more) AAA proxies to the AAA server in the CSN of the home NSP. In roaming scenarios, one (or more) AAA brokers with AAA proxies may exist between the Authenticator and the AAA server. All AAA sessions always exist between the Authenticator and AAA server, with optional AAA brokers providing a conduit for NAI realm-based routing.

Network Admission of an Authenticated User

The following series of events illustrates how the network admits an authenticated user.

1. The authenticator (in BWG) initiates EAP authentication procedure with MS after receipt of Pre-Attachment-Ack message from the Base Station.
2. The authenticator sends EAP Request/ Identity message over Authentication Relay protocol (AuthRelay-EAP-Transfer) to BS.
3. The BS relays the EAP Request/ Identity payload in the PKMv2 EAP-Transfer/ PKM-RSP message to the MS.
4. The MS responds with EAP Response/ Identity message providing NAI. This message is transferred to BS over PKMv2 EAP-Transfer/ PKM-REQ message.
5. The BS relays EAP payload received in PKMv2 EAP-Transfer to the authenticator over Authentication Relay protocol (AuthRelay-EAP-Transfer message).
6. The EAP payload is forwarded to MS' Home AAA server via Visited AAA server (authenticator analyzes the provided NAI for resolving the Home-AAA server location). Authenticator sends EAP Request/ Identity message over Authentication Relay protocol (AuthRelay-EAP-Transfer) to BS.
7. In order to deliver EAP payload received from BS, to AAA server, authenticator forwards EAP message through the collocated AAA client using RADIUS Access-Request message (EAP payload is encapsulated into RADIUS "EAP message" attribute(s).
8. The EAP authentication process (tunneling EAP authentication method) is performed between the MS and the authentication server through the authenticator in the BWG.
9. The EAP payload returned from the AAA server in a RADIUS Access-Challenge message is transferred to the base station in an AuthRelay-EAP-Transfer message. There may be multiple EAP message exchanges between the EAP supplicant, located at the Mobile Subscriber Station, and the EAP Authentication Server, located at the AAA server.
10. The authenticator sends the Key Change Directive message to the base station to indicate completion of the EAP authentication process. The key is computed by BWG using the Master Secret Key (MSK) it received from AAA (in an Access Accept). The Key Change Directive contains the MSINFO TLV with the AK Context sub-TLV, and also the EAP Payload TLV indicating EAP success.
11. In the case of an authentication failure indication is received from the AAA server the subscriber is de-registered from the network using the Normal Mode Network-Initiated Network Exit procedure.

12. The base station acknowledges receipt of Key Change Directive message with a Key Change Acknowledgement message.
13. The base station sends the result of authentication to the Mobile Subscriber Station using a PKMv2 EAP-Transfer message.

Support of Un-Authenticated User

Support of un-authenticated users is required in the following scenarios, and can be used for pre-paid systems, or emergency calls.

- The Mobile Subscriber (MS) can choose to indicate NULL Authentication. This may be a specific type of MS, such as an MS that is limited to emergency calling. This type of MS will indicate NULL Authentication support in the SBC_REQ. The BS relays this through the NetEntry MS State Change Request to the BWG.
- Based on local policy, the BWG can choose to skip authentication, and allow a subscriber to enter the network.
- When the BWG is configured to enable NULL Authentication using the CLI, any Subscriber Station (SS)/MSS requesting NULL authentication will be mapped to a NULL-AUTH user group. DHCP requests from these SS/MSS will only be sent to the configured DHCP server. This enables the operator to control address allocation to the unauthenticated users, as well as apply any restrictions for such users. In addition, Access Control Lists may be configured that would restrict the traffic from the SS/MSS only to certain destinations.

Cisco's BWG Release 1.1 supports EAP authentication. If the BS/CPE does not support EAP authentication then the CPE gets categorized as unauthenticated. The BWG supports a very basic PAP type of authentication for such CPE where the CPE is authenticated based on its MAC ID and password. The RADIUS server should be pre-configured to provision the CPE.

Configuring AAA to Enable PAP Authentication on BWG

To configure the BWG to enable PPP/PAP authentication, perform the following task in global configuration mode:

	Command	Purpose
Step 1	`router(config)# aaa authentication ppp default group {WORD | radius}`	Specifies authentication, authorization, and accounting (AAA) authentication methods for use on serial interfaces that are running PPP.

Here is an example:

```
router(config)#aaa authentication ppp default group radius
```

Here is sample show output to verify the configuration

```
Router#show running-config | include aaa
    aaa new-model
    aaa authentication ppp default group radius
    aaa authorization config-commands
    aaa authorization network default group radius local
    aaa authorization configuration default group radius
    aaa accounting update periodic 1
    aaa accounting network agw start-stop group radius
    aaa session-id common
```

AAA Access for CPE Using PAP Authentication

For the BWG to initiate PAP Access-Request to RADIUS server for an unauthenticated user-group, perform the following task:

	Command	Purpose
Step 1	`router(config-gw-ug)#aaa authentication method-list {WORD | default}`	Indicates if the RADIUS Access Request is to be initiated from the BWG for the user-group. If the command is not configured, the Access-Request is not sent to RADIUS.

Here is an example configuration:

```
router#wimax agw user group-list wimax
       user-group unauthenticated
       aaa authentication method-list xxx
       sla profile-name gold
       timeout idle 100000
       !
```

Proxy Realm for CPE Using PAP Authentication

For un-authenticated users, the BWG does not receive the user name from the CPE. In this case, the BWG provide a mechanism to specify proxy realm and password.

To configure the user name, realm and password, perform the following task:

	Command	Purpose
Step 1	`router(config-gw-ug)#proxy realm {WORD} password {WORD}`	The BWG uses the **proxy realm** coupled with MACID and password as username and password in a PAP Access-Request. It then sends the request to the RADIUS server.

Here is an example of the configuration:

```
router#wimax agw user group-list wimax
    user-group unauthenticated
    aaa authentication method-list agw
    proxy realm cisco.com password cisco
    sla profile-name gold
    timeout idle 100000
```

In this configuration, the BWG sends an Access-Request to the RADIUS server with username set to *MACID@cisco.com* and password set to *cisco.*

If the proxy realm is not configured, the BWG sends an Access-request to the RADIUS server with username set to *MACID* and password set to *cisco* (the default password).

Auto-Provisioning for Unauthenticated CPE Using PAP Authentication

Auto-provisioning provides flexibility, and when configured on the BWG, allows CPE the network entry even if AAA does not have provisioning for that CPE.

Note Auto-provisioning is limited to CPE using PAP authentication.

To configure the unauthenticated user group for auto-provisioning, perform the following task:

	Command	Purpose
Step 1	`router(config-gw-ug)#user auto-provisioning`	Configures an unauthenticated user-group for auto-provisioning. When enabled, the session timer in the user group should be configured to a small value so that the user's free use on the network is limited.

Here is an example of the configuration:

```
router(config)#wimax agw user group-list wimax
    user-group unauthenticated
    aaa authentication method-list agw
    proxy realm cisco.com password cisco
    sla profile-name gold
    timeout idle 100000
    user auto-provisioning
```

Configuring Authentication

This section provides information on how to configure authentication and authorization on the Cisco BWG. To enable authenticated calls between the BWG and a subscriber, perform the following tasks on the BWG:

- Configuring AAA for Accounting Types
- Configuring Authorization
- Configuring Authentication
- RADIUS Server

Configuring AAA for Accounting Types

To configure accounting types on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# aaa session-id {common | unique}`	Specifies either a common or unique session id for different accounting types.
Step 2	`router(config)# aaa new-model`	Enables the NEW access control commands and functions. (Disables OLD commands.) The **no** version of this command resumes the old commands and functions.

Configuring Authorization

To configure authorization on the BWG, perform the following task:

	Command	Purpose
Step 1	`router(config)# aaa authorization network default group {`*server-group-name* `| radius}`	Specifies the server-group to download the configurations from AAA server for a particular authorization list. The **no** version of this command removes the use of server-group.

Configuring Authentication

To configure authentication on the BWG, perform the following task:

	Command	Purpose
Step 1	`router(config)# aaa authentication dot1x {`*authentication-list-name* `| default} group {`*server-group-name* `| radius | tacacs+}`	Specifies the authentication method to be used. The dot1x keyword will be replaced with WiMAX specific keyword.

To specify the configuration download from AAA server, perform following task

	Command	Purpose
Step 1	`router(config)# aaa authorization configuration default group {WORD | radius| tacacs+}`	Specifies the configuration download from the AAA server.

Here is a sample configuration:

```
router(config)#aaa authorization ?
  auth-proxy       For Authentication Proxy Services
  cache            For AAA cache configuration
  commands         For exec (shell) commands.
  config-commands  For configuration mode commands.
  configuration    For downloading configurations from AAA server
  console          For enabling console authorization
  exec             For starting an exec (shell).
  ipmobile         For Mobile IP services.
  multicast        For downloading Multicast configurations from an AAA server
  network          For network services. (PPP, SLIP, ARAP)
  prepaid          For diameter prepaid services.
  reverse-access   For reverse access connections
  template         Enable template authorization

router(config)#aaa authorization conf
router(config)#aaa authorization configu
router(config)#aaa authorization configuration ?
  WORD     Named authorization list (max 31 characters, longer will be rejected).
  default  The default authorization list.

router(config)#aaa authorization configuration de
router(config)#aaa authorization configuration default ?
  group  Use server-group.

router(config)#aaa authorization configuration default gr
router(config)#aaa authorization configuration default group ?
  WORD     Server-group name
  radius   Use list of all Radius hosts.
  tacacs+  Use list of all Tacacs+ hosts.

router(config)#aaa authorization configuration default group radius
```

RADIUS Server

To configure the RADIUS server host on the BWG, perform the following task:

	Command	Purpose
Step 1	`router(config)#` **`radius-server host`** {*`host-name`* | *`ip-address`*} {**`auth-port`** | **`acct-port`**} **`key`**	Configures the RADIUS Server. *ip-address* of RADIUS server **auth-port**—UDP port for RADIUS authentication server (default is 1645). **acct-port**—UDP port for RADIUS accounting server (default is 1646). **key**—per-server encryption key.

Configuring User Groups

To configure a user group on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# wimax agw user group-list` *user-group-list-name*	Configures the user group list on the BWG router. There can be only one user group list allowed on a single processor of the BWG. The **no** version of command removes the user group list. Enabling this command create a user group list sub configuration mode to create multiple user groups under the user-group list created.
Step 2	`router(config)# user-group {any | unauthenticated | domain` *domain-name*`}`	Configures the **user group** under the user group list. This creates a user group sub configuration mode for configuring various parameters of the user group. Three types of user groups are supported: • any—Any user group – In cases where an authenticated user is not found in a user-group based on the domain, the default behavior is to place those users in this category. For example, if you receive a user with NAI *abc@cisco2.com* and do not have a user-group domain for *cisco2.com*, this user will fall into the **any** user group category. • unauthenticated—Un-Authenticated User Group – All un- authenticated users fall into this category of user groups.The **no** version of command removes the user group. • domain—Domain based user groups – In cases where the user is authenticated, the BWG discovers the user based on the domain name part of the NAI received. The NAI received uses the format *userpart@domain*. In order to match a user-group *abc@cisco.com*, you need to configure **user-group domain** *cisco.com* and put all the per domain configuration under this user-group. **Note** For BWG Release 1.0 and above, the presence of user-groups **any** and **unauthenticated** is optional.
Step 3	`router(config)# aaa {authentication | accounting} method-list {`*method-list-name* `| default}`	Configures the authentication or the accounting method list used for the domain. The **no** version of the command removes the user group.

Note AAA server group can be linked with the method list configurations so that different AAA servers can be configured, and thereby map to different user-groups.

Verifying the Configuration

The authentication method of a subscriber displays whether the call was authenticated with EAP, or unauthenticated for the respective user group (**any**, **unauthenticated**, **domain** specific).

For an authenticated call, the Auth Policy and AK Context is also displayed.

To verify your authentication configuration, use the following commands:

	Command	Purpose
Step 1	`router# show wimax agw subscriber msid`	Displays subscriber authentication information.

Configuration Examples

Here is sample output for subscriber information for an unauthenticated call:

```
Router#show wimax agw subscriber msid 1000.0003.0000
 Connection time 000:01:05
 Auth policy 0X0(0)
 Subscriber address 2.2.0.9, type IPv4, organization IETF
 Subscriber address method Dynamic, source DHCP relay
 Subscriber address assigned on flow downlink ID 17
 Subscriber address prefix len allocated 32, aggregate 32
 Subscriber address traffic sent 0 packets, 0 bytes
 Subscriber address traffic received 0 packets, 0 bytes
 Subscriber address DHCP XID 2391, server 0.0.0.0, htype 1
 Subscriber address DHCP client ID 1000.0003.0000, length 6
 Subscriber address DHCP Refresh time 86400 seconds
Number of sessions 1
  Session details:
   FSM in state Ready(7) on last event Rx Attach Ack(14)
   Authentication method unauthenticated
Associated user group **unauthenticated**
Signalling address local 2.2.2.2, remote 10.1.1.82
   Signalling UDP port local 2231, remote 2231
   Idle for inbound 00:01:10, outbound 00:01:10
   Ingress Address filtering 0 packets, 0 bytes
   Number of flows 1
    Flow details ISF(0)
     FSM in state SF Ready(4) on last event Up(1)
     Transaction ID used 0X8001(32769)
     Data ID local 0x9(9), remote 0x2(2)
     Data address local 2.2.2.2, remote 10.1.1.82
     Data traffic sent 2 packets, 656 bytes
     Data traffic received 2 packets, 1208 bytes
     Accounting last record sent Interim(3)
     Idle for inbound 00:01:10, outbound 00:01:10
     Service Flow information Downlink:
      Identifier 17
QoS information:
       Data-delivery-service real-time-variable-rate
       Minimum traffic-rate-reserved 4, Maximum latency 1
```

Here is sample output for subscriber information for an authenticated call:

```
Router>sh wimax agw subscriber msid 1000.0002.0001MSID 1000.0002.0001
 Connection time 000:01:08
 Auth policy 0X12(18), Single-EAP, CMAC
  AK Ctx method C-MAC(1), Lifetime 65535
  AK Ctx Seq No. AK 0, PMK 0
  AK Ctx C-MAC key count 1
 Number of TIDs 1
```

```
 TID Key 10.1.1.82/2.2.2.2/1000.0002.0001
  Peer TID 0X4(4)
    FT MS State Change(9), MT Attachment Request(8)
  Our TID 0x8004(32772)
 Subscriber address 2.2.0.8, type IPv4, organization IETF
 Subscriber address method Dynamic, source DHCP relay
 ….
 Subscriber address DHCP Refresh time 86400 seconds
 Number of sessions 1
  Session details:
   FSM in state Ready(7) on last event Rx Attach Ack(14)
   Username eap-md5-u@eap-md5.com
   Authentication method EAP
AAA session-id length 7, 0x30313233414243
   AAA termination-action 1
   Reauthentication attempts from subscriber 0, ASNGW 0
   Associated user group **any**
   Signalling address local 2.2.2.2, remote 10.1.1.82
   Signalling UDP port local 2231, remote 2231
   Idle for inbound 00:01:09, outbound 00:01:09
   Absolute timeout 1500, remaining 00:23:49
   Idle timeout 600 (both), remaining 00:08:50
   Ingress Address filtering 0 packets, 0 bytes
   Number of flows 1
    Flow details ISF(0)
     FSM in state SF Ready(4) on last event Up(1)
     Transaction ID used 0X8004(32772)
     Data ID local 0x8(8), remote 0x1(1)
     Data address local 2.2.2.2, remote 10.1.1.82
     Data traffic sent 2 packets, 705 bytes
     Data traffic received 2 packets, 1208 bytes
     Accounting last record sent Interim(3)
     Idle for inbound 00:01:09, outbound 00:01:09
     Service Flow information Downlink:
      Identifier 15
```

Security Key Exchange

After EAP authentication of the subscriber, the BWG computes the respective Access Keys (AKs) for each Base-Station. The BWG also caches the PMK for the duration of the authentication, and recomputes additional AKs when the SS/MSS moves to another BS.

Release 1.0 and above supports Re-Authentication triggered from the mobile, and generates a new PMK.

IP Address Allocation Using DHCP

Cisco BWG Release 1.0 and above supports external Dynamic Host Configuration Protocol (DHCP) server-based address allocation.

Note The only mechanism to assign addresses to the SS/MSS is based on DHCP.

The SS/MSS can use DHCP to allocate IP addresses. For Release 1.0 and above there is no MIP or PMIP, because the BWG is only targeting fixed and portable. The DHCP relay is resident in the BWG, and interacts with a DHCP server, provided when the user-groups are on different VRF.

Overlapping of addresses with usergroup is allowed only with VRF.

After successful authentication and setup of the Initial Service Flow, the MS triggers DHCP to acquire an IP address. The DHCP server is configured on the BWG per user-domain group. The DHCP messages are transported transparently over the R6 data path between the BS and the BWG. The addresses can be allocated by the corresponding DHCP server pertaining to the user-domain group. Overlapping addresses across different user-groups are supported. using loop back might be the ideal way, however if the “dhcp gateway address” is not configured the IP of Virtual Template will be used as the gi-address

The initial service flow does not permit any data traffic except DHCP packets. After address allocation is successfully completed, the appropriate classifiers are installed that correspond to the IP address assigned to the SS/MSS.

In order to support multiple hosts behind a Subscriber Station, multiple DHCP requests from subscriber stations will be supported. These requests can be received on the same or alternate service flows.

Configuring IP Address Allocation

To configure IP address allocation using an external-based DHCP server, perform the following task:

	Command	Purpose
Step 1	router# interface Loopback102 ip address 102.0.0.1 255.255.255.0 ! user-group domain eaptls.com2 aaa accounting method-list AAA-ACC1 aaa authentication method-list AAA-AUTHN1 **dhcp gateway address 102.0.0.1** **dhcp server primary 27.0.0.8** sla profile-name silver vrf VRF_2	Configures an external DHCP server to allocate IP addresses. The default ip address allocation time is 300 seconds. **Note** The DHCP server address should not match any local interface address on gateway.

Here is a sample configuration:

```
interface Loopback102
  ip address 102.0.0.1 255.255.255.0
 !
 user-group domain eaptls.com2
  aaa accounting method-list AAA-ACC1
  aaa authentication method-list AAA-AUTHN1
  dhcp gateway address 102.0.0.1
  dhcp server primary 27.0.0.8
  service-flow pre-defined isf profile sf3
  service-flow pre-defined secondary 1 profile sf4
  vrf VRF_2
```

Note The DHCP server and gateway also can be configured under User Group. If you do not configure DHCP server or gateway address under the user group, the global configuration method is used. The DHCP server address should not match any local interface address on gateway

Multiple Host Support

Multiple hosts behind an SS can be supported for IPCS, using DHCP Relay option 82, or option 82 - subscriber ID.

Subscriber-id sub-option of Option 82 could be set to the MSID of the MS/SS and the Circuit-id sub-option can be set to the downlink service flow identifier. A remote ID can be set to the SS/MSS's username for an authenticated user, and the VPNID can be set to the user's VRF name if configured. This includes the new sub option 200 for the L2 header

For example, the DHCP server can allocate a unique IP address for each MAC, to support a multi-host scenario.

Now, the subscriber ID will have the username, and the remote ID will have the MACID of the user.

Note For Release1.0 and above, relay cascading is not supported.

Note The maximum number of hosts allowed behind an MS is 8.

Support of Multiple Hosts Behind a SS

Multiple hosts are also supported over a single SS/MSS

Step 1 CPE (SS) undergoes initial network entry and authentication, and a bearer path is created.

Step 2 A basic R6 bearer path between the BS and the BWG is created. The basic R6 shares a GRE key for uplink/downlink, which may be mapped to the SFID and the corresponding airlink connection.

Step 3 All uplink and downlink packets are sent and received by the CPE for all the hosts on the same service flows (R6 bearer) at the BWG.

DHCP Option 82

DHCP option 82 is applicable for subscribers as well as host. This option is sent in any DHCP messages for any host or subscriber.

Multiple hosts can also be supported using the DHCP option 82. The Relay Agent Information option is inserted by the DHCP relay agent when it forwards client-originated DHCP packets to a DHCP server. Servers that recognize the Relay Agent Information option can use the information to implement IP address, or other parameter assignment policies. Additionally, the L2 header in case of Ethernet CS is also being inserted in option 82

DHCP options 82 appends subscriber id + remote id + circuit id. This is then sent in all DHCP messages toward the server. In case of VRF, VPN ID is also sent. If the DHCP server is not Option 82 aware, and does not echo back the option 82, the BWG drops the messages from DHCP server.

This feature is valuable because it allows you to do the following:

- Identify each subscriber
- Perform subscriber management
- Assign IP addresses based on subscriber info
- Set access control, QoS and security policies

Here is the sequence of events that occur for the DHCP Option 82 feature:

Step 1 Hosts set the client identifier field to the MAC address in the DHCP message.

Step 2 DHCP message communication is done only over ISF for procuring the CPE's IP address, and can be done on any of the flows for procuring the host's IP address. The DHCP packets from BWG are sent out on the same flow as the incoming DHCP message from the host.

Step 3 The BWG inserts the option 82 fields for use by the DHCP server. Option 82 shall be inserted into all DHCP messages towards the DHCP server. For the list of options to insert refer to Table 2-3

Step 4 The DHCP Server could allocate IP address using any of the options in the Option 82 field of the incoming DHCP packet. Once the IP address is allocated, the BWG learns the assigned IP address by monitoring the responses and maps it to the R6 bearer. This process is repeated for each host, and the address is tracked and mapped to the same R6 bearer.

Step 5 The BWG will monitor all DHCP messages, and ensure that the option 82 fields are inserted.

Table 2-3 lists the DHCP Server Options.

Table 2-3 DHCP Server Options

Sub-Option	Code	Length	Sub Value
Circuit ID	1	Variable	Downlink Service Flow ID
Subscriber ID	6	Variable	MSID (MAC-address of SS/MSS)
Remote ID	2	6	User name of the SS/MSS, for an authenticated user

Table 2-3 DHCP Server Options (continued)

Vendor-Specific Relay Information (Ethernet Header)	200		Ethernet CS L2 header
VPN-ID	151	Variable	VRF name, if the user belongs to a VRF.

DHCP Option 82 Enhancement in Release 1.1

In order to allow the BWG to build the L2 header for downlink DHCP packets, the entire L2 header is coded in the Option 82, which is reflected back from the DHCP server. This sub-option only applies between the BWG and DHCP server.

Per-Subscriber DHCP Host Overflow Mechanism

Before this feature was implemented, control over the number of DHCP hosts per subscriber was rigid. Once the maximum was reached, any subsequent host coming into the subscriber was rejected. This rigid control was not good for busy hot spots. The problem became even more serious when the DHCP lease time was long and the host left the CPE did not perform DHCP Release.

Now that a new host overflow mechanism based on LRU (Least Recently Used) is used to address the issue that the number of hosts occasionally exceeds a CPE's limit (20). When a new host enters into the subscriber, if its max is reached, an LRU host (with a minimum idle time applied here to avoid trashing) is selected, and this host is deleted from the active list into the overflow list to make room for the new subscriber. A host in the overflow list can be promoted into the active list once uplink data or DHCP messages are received from the host.

You can enable the feature and configure the size of the host overflow list through the CLI, and by default it is set to 50. The newly added host is always appended at the tail of the list. If the overflow list is full, the oldest overflow host, which is at the list head, gets deleted for the new subscriber.

Once an LRU host in the active list is pushed into the overflow, accounting is stopped (if enabled) for the host. The downlink host route is also removed so the overflow host will not be able to receive downlink data. In addition, there is no DHCP timer running against the overflow host.

To save memory, an overflow host only saves the information which is absolutely necessary for its later restoration into the active list. As a comparison, an active host takes about 300 bytes of memory whereas an overflow host uses less than 40 bytes.

When uplink data or DHCP Renew messages are received for a overflow host, the BWG tries to restore the overflow host into the active list. However, the outcome of this effort depends on two facts:

- If the active list has reached its capacity, or
- If the active list is full, can the BWG find another qualified LRU host from the active list? A qualified LRU host should meet the minimum idle requirement.

If the restoration is successful, the host is removed from the overflow list and added to the active list. The DHCP lease timer is restarted for the host's remaining lifetime as if it has been active all the time. In addition, the host route is restored and host accounting is re-started during this process. If restoration to the active list has failed, the host remains in the cached list.

To summarize, a host is removed from the overflow list under two scenarios:

- Successful restoration into the active list.
- Deleted by another subscriber when it becomes the oldest (at the list head), and the list is full. In this case, DHCP Release is sent to the DHCP server. A host deleted from the cached list can no longer send or receive data unless a DHCP procedure is re-initiated by the host.

In a redundant setup, the overflow host list itself is not synced from the active to standby BWG. However, the information for adding and deleting active hosts is dynamically synced. We expect that this info can be used on the standby side to re-construct its overflow host list. When bulk sync is employed, the standby can no longer re-construct its host overflow list because it has lost the history of how the active hosts got into their position.

The BWG's host overflow feature is not visible to either of the DHCP client or DHCP server. This is a new feature, which allows a CPE to "serve" the number of hosts exceeding its active list.

To make an efficient use of available memory, this feature will be provided on per user group basis. The user-group for hotspot-like CPEs should be explicitly enabled for this feature. By default, this feature is not enabled.

To configure the Per-Subscriber DHCP Host Overflow Mechanism, perform the following tasks:

	Command	Purpose
Step 1	`router(usr-grp)#`**`host-overflow`** `[`**`size`** *`1-100`*`] [`**`min-idle`** *`1- 60`*`]`	Enables the DHCP Host Caching feature and configures the size of the cache list (default 50), and the idle timer (default 5). **min-idle** - establishes the criteria to move a subscriber from the active to the overflow list. The **min-idle** prevents the BWG from frequently moving a host from active host list to overflow list. The **min-idle** value represents minutes.

- Once a data packet is received, since there is no MAC address, the match in the array of records will only be based on IP, and we will not be able to differentiate between dynamic host and spoofing static host. A possible effect would be both actual DHCP host and spoofing host keep on sending traffic with the DHCP host renewing the lease while the spoofing host is "taking advantage". However, there is no change in the existing behavior and this issue exists today. If the real IP host is attached to the CPE and the spoofed CPE can start using same address with the same CPE.
- If static IP is allowed, and the record of a DHCP host removed from CPE is also removed from the array (overwritten by some other record), when the DHCP host comes back, the first data packet intercepted results in opening a static host (since static IP is allowed). If the host never sends a DHCP renewal, it will be treated as static and will not be deleted unless it gets kicked out. However, this is the user's choice, and existing behavior is exactly same.

- If host accounting is enabled, the accounting start/stop for the host can be the overhead.
- The memory requirement is higher per session in cases where hot spot CPE usage is higher in the network.

Perform the following tasks to display the overflow host:

Step 1	`router#` **`show wimax agw subscriber internal`** `router#` **`show wimax agw subscriber msid`** *`msid`* **`overflowed-host`**	Displays the overflow host.

Service Flow Creation and Management

802.16 supports multiple service flows for a given SS. The service flows are identified by mapping a set of classification rules over the packet bearer. Each service flow is a unidirectional flow and can have a different quality of service treatment, both on the airlink and on the network.

In Cisco BWG Release 1.0 and above, service flow creation is supported only when initiated by the network. This service flow creation will provision the classifiers on the SS/MSS as well.

Additionally, pre-provisioned service flow templates are configured on the BWG locally. AAA support for downloading the Service Flow Profile ID is not supported on the BWG.

Service Flows

The BWG manages the service flows for each SS/MSS. Release 1.0 and above only supports network triggered service flows. The BWG allocates SFID for each service flow, and triggers service flow creation. Each service flow also has its respective datapath (for example, GRE key, and the packets corresponding to each service flow are transported accordingly).

All pre-provisioned flows are assumed to be available for the lifetime of the SS/MSS session, and are not deleted.

Multiple Service Flow Creation

When the control plane comes up, the BWG requests the creation of the Initial Service flow with the base station. DHCP IP address allocation and flow creation go in parallel in BWG Release 1.1.

The flows are created one after the other in parallel to DHCP allocation occurring on the ISF. Launching the creation of a service flow happens only after the successful creation of the preceding one. A service flow “fails” to be created if it fails after “*x* retries” of registration request for this SF. If a SF “fails” to be created, it is bypassed (in case it is a secondary SF), or the session is torn down (if it is the initial SF).

For Release 1.0 and above, the BWG supports creating 4 service flows; the initial service flow, and 3 secondary service flow.

If a secondary SF creation fails, then the next flow is attempted and session continues without the failed SF.

Configuring BWG Service

To enable BWG services, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`router(config)# service wimax agw`	Enables WiMAX BWG services.
Step 2	`router(config-if)# encapsulation agw`	Clones a Virtual-Access interface of encapsulation type “ASNGW”. Configure this command in Virtual-Template configuration mode.

Sample Configuration

Here is a sample configuration to clone the Virtual Address:

```
!
interface Virtual-Template1
ipaddress 2.2.2.2 255.255.0.0
encapsulation agw
ip mtu 1440
no keepalive !
```

The Gi address is picked from the Virtual Address by default. You can use the **user-group** configuration to override the Gi address.

Verifying the Configuration

To verify that BWG services are enabled, and to display MS State Change and Data Path statistics, use the **show wimax agw statistics** command in privileged EXEC mode:

```
Message type Deregistration Request(4/0x4)
   Number of messages sent 1
   Number of messages received 11
   Number of messages resent 0
  Message type Deregistration Response(5/0x5)
   Number of messages sent 6
   Number of messages received 1
   Number of messages resent 10
  Message type Deregistration Ack(6/0x6)
   Number of messages sent 1
   Number of messages received 5
   Number of messages resent 0
  Message type Registration Request(12/0xC)
   Number of messages sent 6
   Number of messages received 0
   Number of messages resent 0
  Message type Registration Response(13/0xD)
   Number of messages sent 0
   Number of messages received 6
   Number of messages resent 0
  Message type Registration Ack(14/0xE)
   Number of messages sent 6
   Number of messages received 0
   Number of messages resent 0

Message function type Context Delivery(4/0x4)
  Message type Context Delivery Request(1/0x1)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
```

```
  Message type Context Delivery Report(2/0x2)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0

Message function type Auth Relay(8/0x8)
  Message type EAP Start(1/0x1)
   Number of messages sent 0
   Number of messages received 2
   Number of messages resent 0
  Message type EAP Transfer(2/0x2)
   Number of messages sent 56
   Number of messages received 56
   Number of messages resent 0
  Message type Key Change Directive(5/0x5)
   Number of messages sent 8
   Number of messages received 0
   Number of messages resent 0
  Message type Key Change Confirm(6/0x6)
   Number of messages sent 0
   Number of messages received 2
   Number of messages resent 0
Message type Key Change ACK(7/0x7)
   Number of messages sent 2
   Number of messages received 8
   Number of messages resent 0
  Message type CMAC Key Count Update(8/0x8)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type CMAC Key Count Update Ack(9/0x9)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0

Message function type MS State Change(9/0x9)
  Message type Attachment Response(7/0x7)
   Number of messages sent 6
   Number of messages received 0
   Number of messages resent 0
  Message type Attachment Request(8/0x8)
   Number of messages sent 0
   Number of messages received 6
   Number of messages resent 0
  Message type Attachment ACK(9/0x9)
   Number of messages sent 0
   Number of messages received 6
   Number of messages resent 0
  Message type Pre Attachment Request(15/0xF)
   Number of messages sent 0
   Number of messages received 6
   Number of messages resent 0
  Message type Pre Attachment Response(16/0x10)
   Number of messages sent 6
   Number of messages received 0
   Number of messages resent 0
  Message type Pre Attachment ACK(17/0x11)
   Number of messages sent 0
   Number of messages received 6
   Number of messages resent 0

Message function type Keepalive(20/0x14)
  Message type Keepalive Request(1/0x1)
   Number of messages sent 0
```

```
    Number of messages received 0
    Number of messages resent 0
  Message type Keepalive Response(2/0x2)
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0

Handoff Statistics
  Message type Successful Handoff
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
  Message type Handoff Registration Request
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
  Message type Handoff Registration Response
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
  Message type Handoff Registration Ack
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
Message type Handoff Deregistration Request
  Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
  Message type Handoff Deregistration Response
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
  Message type Handoff Deregistration Ack
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0

Undefined Message Function / Message Type
    Number of messages sent 0
    Number of messages received 0
    Number of messages resent 0
```

Mapping of Service Flows to DiffServ Classes

The BWG maps each individual Service flow to a Diffserv Class. The mapping rules are configured on the router. The mapping rules are designated in Table 2-4:

Table 2-4 Map of Each Individual Service Flow to a Diffserv Class

Service Flow - QoS Class	Applications	Diffserv Class on Network
UGS (Unsolicited Grant Service)	Voice/Video	EF
Real Time Polling Service	Voice/Video	EF
Non-Real Time Polling Service	Interactive Services	AF
Best Effort	Web Traffic	BE

Marking of Packets Corresponding to Service Flows

Each packet is identified and grouped according to the associated service flow. The transport headers corresponding to the packets are then marked with the associated Diffserv Code Point (DSCP) by the BWG based on the above table.

Configuring Service Flows on the BWG

To create service flows on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# wimax agw service-flow profile` *service-flow-profile-name*	Specifies a service-flow profile on the BWG. The **no** version of the command removes the profile. *service-flow-profile-name* is case insensitive. Configuring this command enters service flow configuration mode.
Step 2	`router(config-gw-sf)# direction {uplink | downlink}`	Specifies the direction of the service-flow the configuration is done, and enters service flow direction configuration submode. The **no** version of the command removes the corresponding configuration from the direction specified. The default value is **best** effort.
Step 3	`router(config-gw-sf)# cs-type {ethernet-cs | ip-cs}`	Specifies the cs-type profile under the corresponding direction. The **no** version of the command removes the cs-type information from the corresponding direction. Configuring the command opens a sub configuration mode to configure various cs-type commands.
Step 4	`router(config-gw-sf-dir-cstype)# precedence` *1-2*	Specifies the **precedence** of the cs-type under the direction which it is configured. The precedence gets used as a tie-breaker when an MS can support more than one cs-type. The **no** version of the command removes the precedence information from the corresponding cs-type.
Step 5	`router(config-gw-sf-dir-cstype# vlan {`*2-4095* `| range` *2-4095 2-4095*`} vrf` *vrf-name*	Specifies the vlan to vrf mapping (frames with a particular vlan-id will be mapped to what vrf-name). There is also a provision of specifying the range of vlan-ids mapped to a vrf-name. **Note** This vlan-vrf mapping can be configured for ethernet-cs for direction uplink only.
Step 6	`vrf default` *vrf-name*	Optional configuration command that specifies the default vrf mapping. Uplink frames without a vlan-id, or with a vlan-id that is not configured under this cs-type with a vlan-vrf mapping will be mapped to the vrf-name configured using this command. **Note** The **vrf-default** can be configured for ethernet-cs and ip-cs for direction uplink only.

	Command	Purpose
Step 7	`router(config-gw-sf-dir)# qos-info qos-profile-name`	Specifies which QoS information profile is associated under the corresponding direction. The **no** version of the command removes the QoS information from the corresponding direction.
Step 8	`router(config-gw-sf-dir)# set {dscp | precedence} {precedence-value | dscp-value}`	Specifies what DSCP or TOS marking needs to apply for the subscriber packets in the downstream direction. By default no marking is done.
Step 9	`router(config-gw-sf-dir-cstype)# pak-classify-rule`	Specifies which packet classification rule profile is associated under the corresponding direction. The **no** version of the command removes the packet classification rule from the corresponding direction.

Configuration Example

The following are examples of Service Flow configuration commands:

```
wimax agw service-flow profile isf
 direction downlink
  cs-type ip-cs
   pak-classify-rule isf-classifier-downlink
   precedence 1
  cs-type ethernet-cs
   pak-classify-rule isf-classifier-downlink
   precedence 2
  qos-info isf-qos-downlink
 !
 direction uplink
  cs-type ip-cs
   pak-classify-rule isf-classifier-uplink
   precedence 1
  cs-type ethernet-cs
   pak-classify-rule isf-classifier-uplink
   precedence 2
   vlan 2 vrf vrf_1
   vlan range 3 10 vrf vrf_2
   vrf-default vrf_1
  qos-info isf-qos-uplink

wimax agw service-flow profile 2sf
 direction downlink
  cs-type ip-cs
   pak-classify-rule dn-secondary-01
   qos-info downlink-qos-02
   set dscp ef
   set precedence immediate
  !
 direction uplink
  cs-type ip-cs
   pak-classify-rule up-secondary-01
   qos-info uplink-qos-02
  !
!
```

Configuring Service Flow Packet Classification

To configure a service-flow packet classification rule profile on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# wimax agw service-flow pak-classify-rule profile` *profile-name*	Specifies a service-flow packet classification rule profile on the BWG. These are configured under the predefined service flows that are to be opened for the subscriber. When configured, this command enters into the packet classify rule configuration submode.

Step 2	`router(config-gw-pak-classify-rule-pr)# priority` *0-255*
	IPv4 classifiers===>
	`ip permit {`*0-255* `| gre | tcp | icmp | udp | ip} {`*src-address src-mask* `| any | host` *src-address*`} [range` *src-port-low* `[`*src-port-high*`]` *{dst-address dst-mask* `| any | host` *dst-address*`} [range` *dst-port-low* `[`*dst-port-high*`] [tos` *tos-low tos-mask tos-high*`]`
	Ethernet related classifiers ===>
	`ethernet permit {`*src_mac src_mac_mask* `| any} {`*dst_mac dst_mac_mask* `| any} {`*0-FFFF* `| any | arp | ipv4}]`
	
	VLAN related classifiers ===>
	`vlan permit {`*2-4095* `| any } priority {`*0-7* `| any | range #start #end}`
		Sets the packet classification rule under the profile. Each packet classification rule should have a unique priority associated with it.
		BWG currently supports IPv4, Ethernet and VLAN related rules.

Configuration Example

Here is a sample configuration of the Service Flow Packet Classification configuration commands:

```
wimax agw service-flow pak-classify-rule profile sec1-classifier-uplink
 priority 0
  ipv4 permit ip any any
  ethernet permit any any any
  vlan any priority any
 !
 priority 1
  vlan 300 priority 4 7
 !
 priority 2
  ethernet permit 0032.00AE.0023 ffff.ffff.ffff any arp
 !
 priority 3
  ipv4 permit ip 2.2.2.2 /24 192.168.102.0 /24 tos 0 255 100
 !
 priority 4
  ethernet permit any 0032.00AE.0023 ffff.ffff.ffff 8100
  vlan permit 900 priority 4
 !
 priority 5
  ipv4 permit ip 2.2.2.2 /24 192.168.102.0 /24 tos 0 255 100
  ethernet permit 001C.B046.041B ffff.ffff.0000 0032.00AE.0023 ffff.0000.0000 ipv4
  vlan permit 300 priority range 4 7
```

Note The packet classifiers are viewed collectively for a given user and direction of flow for each packet, and the highest matching priority rule is applied (255 is highest priority). If no classifiers match, the default flow chosen is the ISF in the downlink direction.

Critical Service Flow

Under certain circumstances, one or more secondary flows fail to be created, yet the subscriber session stays up with fewer flows than the subscribers needs. In this situation, the session should be deregistered, so that it can be re-created with all critical flows that the subscriber needs. For example, a customer may want a subscriber to either have all flows (voice, video, and data), or nothing at all. This feature allows a Service Flow (SF) to be marked as critical for the subscriber. The BWG will successfully create subscriber session if and only if every SF marked "Critical" is created.

The BWG allows you to mark a SF as critical while adding it under SLA profile configuration. If the SF is marked critical, then session will fail to open if such critical SF fails to create. The key point is that every critical flow must be created successfully for a session to open. If a SF is not marked to be critical, or if it is ISF, then there is no change in existing behavior.

During Controlled Handover, if the Target-BS fails to include critical flow(s), then the BWG will fail the Handover. The point is to ensure that the "all or none flow(s)" philosophy gets applied to a subscriber all the time.

By default, a SF is not critical, unless specified as "critical" in a SLA-profile.

To configure the BWG to mark service flows as critical, perform the following tasks:

	Command	Purpose
Step 1	`Router(config)#`**`wimax agw sla profile`** *`bronze`* `Router(config-gw-sla)#`**`service-flow pre-defined secondary`** `2` **`profile`** `sec2 critical`	Enables the BWG to mark service flows as "critical" under an SLA profile.

In a SR setup, you must have identical SF-critical configurations on the active and standby BWGs.

The flow details in **show wimax agw subscriber** will indicate if a flow is critical or not.

Here is an example:

```
Router#sh wim agw subs msid <>

MSID 1000.22BA.0001
 CPE is nomadic
 Static IP addresses not permitted
 Subscriber Age 000:00:23
 Base Station ID 0x0A01194B00
.....
…
    Flow details Secondary(2)(Critical)
     SF Profile name sec2
     FSM in state SF Ready(4) on last event Up(1)
     Transaction ID used 0X8003(32771)
     Data ID local 0x3(3), remote 0xD(13)
     Data address local 11.1.25.2, remote 10.1.25.75
     Data traffic sent 0 packets, 0 bytes
     Data traffic received 0 packets, 0 bytes
     Accounting disabled
     Idle for inbound 00:00:31, outbound 00:00:31
     Service Flow information Downlink:
      Identifier 5
```

```
Set DSCP (DDS) 30
QoS information:
 Data-delivery-service real-time-variable-rate
 Minimum traffic-rate-reserved 0, Maximum latency 0
 Unsolicited interval-polling 0, Traffic-priority 0
 Maximum traffic-rate-sustained 0, Request/Transmission-policy 0
 Maximum traffic-burst-rate 0
 Reduced-resources-code 0
 Media-flow-type 05abcd
Classifier information:
 priority 2
  ethernet permit any 1000.2223.0003 FFFF.FFFF.FFFF any
CS Type information:
 Ethernet CS
```

Delay the Attachment Response from BWG

Certain types of Navini's out of the box modems will synchronize and connect to the network at initial power off. During this process, if the Network ID in the Surfer modem is 0xFFFF (factory default), during the REG-RSP message, it will update the new Network ID into the modem's Flash. Once written, this ID cannot be changed and the modem will only enter the network where the BS belongs to the same Network ID.

In Profile C, where the AAA authentication (Accept) may take longer in the case of an unauthenticated modem (such as Surfer), the BWG can send the MS Attachment Response to the BS prior to it receiving the Radius Accept from the AAA. This causes the BS to send a successful REG-RSP to the Surfer modem, and subsequently the modem may fail AAA authentication. The current implementation is for the BS to reset the modem when it finally learns (from the AAA through the BWG) that the authentication failed. The reason to reset the modem is to allow the modem to go to other BS.

The impact of this issue is that:

- A new out of the box modem can lock to a BS that does not belong to the network operator who sold the modem. In this case, the modem is unusable and must be sent back to the operator for reprogramming.
- When the same operator has a live network and a test network with two different Network IDs, the new modem can lock to the wrong network depending on the location where it is powered up for the first time. It will then only work on that network. The first BS it locks on to may not be the intended network.

In order to solve this problem, the BWG is designed to delay transmit of the Attachment response based on a new CLI. This command allows you to configure the timeout value for Attachment response. The default value is set to 4 seconds.

When the timeout value is configured under the user-group, the BWG will start the timer and will take appropriate action. Here are some different scenarios:

1. If the AAA response is received prior to this timeout and,
   - if CPE is authenticated (accepted) and value of service state indicates that the CPE is active, then the BWG continues with the MS Attachment Response immediately.
   - if CPE is authenticated and the value of service state indicates that the CPE is black listed, then the BWG sends Path Deregistration Message with Deregistration Reason TLV

2. If the AAA Response is not received prior to this timeout, then:
   - the BWG sends MS Attachment Response indicating success (not withstanding any TLV errors in the Request).
   - when the AAA Response is received and Service Type attribute indicates that CPE is black listed, the BWG sends Deregistration with the appropriate Reason Code in the Deregistration Reason TLV.
   - when a AAA Response is received and if the Service Type attribute indicates that CPE is active (not blacklisted), then the BWG continues with the Path Registration Request to BS (as in current implementation).

In both the cases, if the BWG receives an "Access-Reject" it continues to open the session if the user is auto-provisioned. The session is deregistered if user is not auto-provisioned.

By default, this BWG is designed to delay the Attachment Response. The BWG supports this feature only for PAP authenticated users.

To configure the delay of the attachment response, perform the following task:

	Command	Purpose
Step 1	`router(config)# user-group unauthenticated` `timeout authentication` *[1-20]*	Configures the delay time of the attachment response. The default value is 4 seconds. This command is only configurable under the "unauthenticated" user-group.

QoS Support

QoS support refers to both airlink QoS as well as mapping on the network. The BWG is responsible for sending the QoS parameters to the BS used to create the appropriate service flows.

Certain hosts can be given additional QoS parameters.

A new R6 bearer (service flow) is created that corresponds to the host's IP address. Multiple hosts can use this service flow.

Mapping of the host to the new R6 service flow is created and communicated to the BS/MS through the RR-Request.

BWG Release 1.0 and above offers the following support:

- Support for pre-provisioned QoS through CLI.
- Support for signaling traffic to be marked as separate class.
- Corresponding to every service flow based on the classifiers, a Diffserv Class would be mapped and used by the BS and the BWG.
- Support for all QoS class of service.

Configuring QoS

To configure QoS on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# wimax agw service-flow profile qos-info` *service-flow-qos-info-profile-name*	Allows the user to configure a service-flow QoS information profile on the BWG. These are associated to predefined service flows that are opened for the subscriber. Configuring the command opens a sub-configuration mode to configure various parameters.
Step 2	`router(config-gw-sf-qos-info)# data-delivery-service {unsolicited-grant|real-time-variable-rate|non-real-time-variable-rate|best-effort| extended-real-time-variable-rate}`	Configures data delivery service associated with certain predefined set of QoS-related service flow parameters. The default value is unsolicited-grant.
Step 3	`router(config-gw-sf-qos-info)# maximum-latency` *maximum-latency-value*	Configures the time period between the reception of a packet by the BS or MS on its network interface, and delivery of the packet to the RF interface of the peer device. If defined, this parameter represents a service commitment (or admission criteria) at the BS or MS, and is guaranteed by the BS or MS. A BS or MS does not have to meet this service commitment for service flows that exceed their minimum reserved rate. The default value is 0.
Step 4	`router(config-gw-sf-qos-info)# maximum-traffic-burst` *maximum-traffic-burst-value*	Configures the parameter that defines the maximum burst size that is accommodated for the service. Since the physical speed of the ingress and egress ports, the air interface, and the backhaul are greater than the maximum sustained traffic rate parameter for a service, this parameter describes the maximum continuous burst the system should accommodate for the service if the service is not currently using any of its available resources. The default value is 0.
Step 5	`router(config-gw-sf-qos-info)# maximum-traffic-rate-sustained` *maximum-traffic-rate-sustained-value*	Configures the parameter that defines the peak information rate of the service.
Step 6	`router(config-gw-sf-qos-info)# media-flow-type` *media-flow-type-hex-string*	Specifies the parameter that describes the application type, used as a hint in admission decisions; for example, VoIP, video, PTT, gaming, or others.
Step 7	`router(config-gw-sf-qos-info)# policy-transmission-request` *policy-transmission-request-value*	Specifies the policy transmission request value for the associated service flow. This value includes options for PDU formation, for uplink service flows, and restrictions on the types of bandwidth request options that may be used. An attribute is enabled by setting the corresponding bit position to 1.
Step 8	`router(config-gw-sf-qos-info)# minimum-traffic-rate-reserved` *minimum-traffic-rate-reserved-value*	Specifies (in bits per second) the minimum amount of data to be transported on behalf of the service flow when averaged over time. The specified rate is only honored when sufficient data is available for scheduling. When sufficient data does not exist, the available data is transmitted as soon as possible.

	Command	Purpose
Step 9	`router(config-gw-sf-qos-info)# **sdu-size** *sdu-size-value*`	Specifies number of bytes in the fixed size SDU. This parameter is used for a UGS service flow when the length of IP packets on the data plane is fixed and known in advance. This is typically the case for flows generated by a specific codec. The default value is 49.
Step 10	`router(config-gw-sf-qos-info)# **tolerated-jitter** *tolerated-jitter-value>*`	Specifies the maximum delay variation (jitter) for the connection.
Step 11	`router(config-gw-sf-qos-info)# **traffic-priority** *traffic-priority-value*`	Specifies the priority assigned to a service flow. For service flows that are identical (except priority), give the higher priority service flow a lower delay and higher buffering preference. For dissimilar service flows, the priority parameter does not take precedence over any conflicting service flow QoS parameter. The specific algorithm to enforce this parameter is not mandated here.
Step 12	`router(config-gw-sf-qos-info)# **unsolicited-interval-grant** *unsolicited-interval-grant-value*`	Specifies the nominal interval between successive data grant opportunities for this service flow. This parameter is used for a UGS and ERT-VR service flow when the inter-arrival time of IP packets on the data plane is known in advance (this is typically the case for flows generated by a specific codec).
Step 13	`router(config-gw-sf-qos-info)# **unsolicited-interval-polling** *unsolicited-interval-polling-value*`	Specifies the maximum nominal interval between successive polling grant opportunities for this service flow.

Configuration Example

Here is a QoS configuration example:

```
wimax agw service-flow qos-info profile isf-qos-downlink
 data-delivery-service real-time-variable-rate
 maximum-latency 1
 maximum-traffic-burst 2
 maximum-traffic-rate-sustained 3
 media-flow-type 012041424344
 minimum-traffic-rate-reserved 4
 policy-transmission-request 5
 sdu-size 6
 tolerated-jitter 7
 traffic-priority 1
 unsolicited-interval-grant 8
 unsolicited-interval-polling 9

wimax agw service-flow qos-info profile isf-qos-uplink
 data-delivery-service unsolicited-grant
 maximum-latency 11
 maximum-traffic-burst 21
 maximum-traffic-rate-sustained 31
 minimum-traffic-rate-reserved 41
 policy-transmission-request 51
 sdu-size 61
 tolerated-jitter 71
 traffic-priority 3
 unsolicited-interval-grant 81
```

```
 unsolicited-interval-polling 91
!
wimax agw service-flow qos-info profile downlink-qos-02
 data-delivery-service real-time-variable-rate
 media-flow-type 05abcd
```

Verifying the Configuration

To verify the QoS values on the BWG, use the **show wimax agw subscriber** command. Here is sample output for QoS statistics:

```
Router>sh wimax agw subscriber
MSID 1000.2228.0001
  Connection time 000:00:14
  Auth policy 0X0(0)
  Number of TIDs 1
  TID Key 10.1.1.70/2.2.2.2/1000.2228.0001
   Peer TID 0X2(2)
     FT MS State Change(9), MT Attachment Request(8)
   Our TID 0x8001(32769)
QoS information:
      data-delivery-service real-time-variable-rate
      minimum-traffic-rate-reserved 4, maximum-latency 1
      unsolicited-interval-polling 9, traffic-priority 1
      maximum-traffic-rate-sustained 3, policy-transmission-request 5
      maximum-traffic-burst-rate 2
      reduced-resources-code 0
     Classifier information:
      priority 0 permit ip host 0.0.0.0 host 0.0.0.0

Service Flow information Uplink:
      Identifier 4
     QoS information:
      data-delivery-service unsolicited-grant
      minimum-traffic-rate-reserved 41, maximum-latency 11
      tolerated-jitter 71, sdu-size 61
      unsolicited-interval-grant 81, policy-transmission-request 51
      reduced-resources-code 0
     Classifier information:
      priority 0 permit ip host 0.0.0.0 host 0.0.0.0
```

Table 2-5 and Table 2-6 identify the QoS Classes and Service Parameters for 802.16.

Table 2-5 QoS Classes in 802.16

QoS Parameter	BE Best Effort Service Flow	ERT-VR	UGS	RT-VR	NRT-VR
Traffic Priority 0-7 Def: 0	Optional	Optional *[a]*		Optional *[a]*	Optional *[a]*
Maximum sustained rate 0-4294967295 bits per second	Optional	Optional *[b]*		Optional *[b]*	Optional *[b]*
Minimum reserved rate 0-4294967295 bits per second		**X**	**X**	**X**	**X**

Table 2-5 QoS Classes in 802.16 (continued)

QoS Parameter	BE Best Effort Service Flow	ERT-VR	UGS	RT-VR	NRT-VR
Maximum Traffic burst 0-4294967295 bits per second		Optional		Optional	Optional
Jitter Tolerance 0-4294967295 msc		Optional *[c]*	Optional *[c]*		
Maximum latency Tolerance 0-4294967295 msc		**X**	**X**	**X**	
Unsolicited Grant Interval 0-65535 msc		**X**	**X**		
SDU Size 0-255 Bytes Def: 49			Optional *[d]*		
Unsolicited Polling Interval 0-65535 msc				**X**	
DSCP					

Table 2-6 QoS Classes and Service Parameters in 802.16

QoS Class	Application	QoS Spec Service Parameter
Unsolicited grant service (UGS)	**VoIP** For real-time, fixed size regularly transmitted packets, e.g., voice codec, ATM CBR, E1/T1 over ATM.	Maximum sustained rate Maximum latency tolerance Jitter tolerance
Real-time polling service (rtPS)	**Streaming Audio, Video** For real-time variable size regularly transmitted packets, e.g., MPEG video, VoIP, streaming.	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Traffic priority
Extended Real-Time Packet Service (ErtPS)	**VoIP (with VAD)**	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Jitter tolerance‘

Table 2-6 QoS Classes and Service Parameters in 802.16

QoS Class	Application	QoS Spec Service Parameter
Non-real-time polling service (nrtPS)	**FTP** For non-real-time service flows, requiring variable size, regular Data Grant Burst, e.g., Internet access, ATM GFR	Minimum reserved rate Maximum sustained rate Traffic priority
Best effort service flow (BE)	**Data Transfer, Web, Browsing**	Maximum sustained rate Traffic Priority

User Group Management

To configure user groups on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)#`**`wimax agw user group-list`** *`user-group-list-name`*	Configures the user group list on the BWG router. The **no** version of command removes the user group list. Enabling this command enters you into user group list sub configuration mode to create multiple user groups under the user-group list created.
Step 2	`router(config-gw-ug)#` **`service-flow pre-defined {isf | secondary`** *`secondary-index`***`} profile`** *`sf-profile-name`*	Specifies the number of pre-defined service flows to be opened for a subscriber. If the **ISF** keyword is configured, the service flow is assumed to be the initial service flow. The **secondary** keyword represents the auxiliary service flows for the subscriber. Currently 1 initial service flow, and up to 3 secondary service flows, are allowed per subscriber.
Step 3	`router(config-gw-ug)#`**`ip static-allowed`**	Allows the creation of static hosts for sessions that are part of this user-group. By default static hosts will not be allowed.

Sample Configuration

The following example illustrates how to configure a user group:

```
!
wimax agw user group-list wimax
 user-group any
  aaa accounting method-list agw
  sla profile-name gold
  dhcp server primary 12.1.1.2
!
user-group domain cisco.com
  aaa accounting method-list agw
  sla profile-name gold
  ip static-allowed
  ip route aggregate auto
!
user-group unauthenticated
```

```
 aaa accounting method-list agw
 aaa authentication method-list agw
 sla profile-name gold
 ip static-allowed
 user auto-provisioning
 proxy realm cisco.com password ciscoway
```

Idle Timer Support

An idle timer is configurable on the BWG for a User group. If there is no data traffic for the duration of the timer, the SS/MSS will be de-registered. Idle timeout can be downloaded from the AAA server during the authentication phase.

Here is a sample configuration:

```
wimax agw user group-list wimax
 user-group any
  aaa accounting method-list agw
  dhcp server primary 11.1.1.93
  service-flow pre-defined isf profile isf
  timeout idle 30
  timeout session 30
 !
 user-group unauthenticated
  aaa accounting method-list agw
  dhcp server primary 11.1.1.93
  service-flow pre-defined isf profile isf
  service-flow pre-defined secondary 1 profile 2sf
 !
!
```

Idle timer support is available for inbound traffic in the ASN.

If an idle timer value is configured in AAA and under an ASN user-group, then AAA is given precedence.

User Group-Based Maintenance Mode, Show, and Clearing

Some customers want to clear all users associated with a particular user group to update an AAA attribute. In doing so, they need a user-group level show and clear command. The maintenance mode allows an operator to block any new CPE from entering a particular user group so that the operator can clear all of the subscribers if needed.

Internally, a user group can keep track of its sessions because it maintains a list of session handles. This handle list is now used for show and clearing.

A user group's maintenance mode is checked against whenever a session is assigned with the user group. Even though a session can be assigned to only one user group at any time, it can come across more than one user group during its entire life time. This is because a non-EAP session is originally assigned to unauthenticated user group and the AAA response can cause BWG to reassign another user group to the session. In this case, the CPE will be rejected if any one of the user groups it has come across has the maintenance mode on.

By default, maintenance mode is disabled. In non-EAP case, every incoming CPE is initially assigned to the unauthenticated user group. Therefore, no new non-EAP CPE can enter the BWG if the maintenance mode is enabled for the unauthenticated user group.

To enable the Maintenance mode feature, perform the following tasks:

	Command	Purpose
Step 1	`router(config-gw-ugl)# service mode maintenance`	Enables the User Group Maintenance mode feature.

Here is a sample configuration:

```
User group domain name unauthenticated
 User-Group overwritten Counter 0
 Service mode operational
 Sessions 2 associated
 IP-GRE Traffic Sent 0 packets, 0 bytes
 IP-GRE Traffic Received 0 packets, 0 bytes
 Eth-GRE Traffic Sent 18 packets, 6138 bytes
 Eth-GRE Traffic Received 18 packets, 10872 bytes
 Ingress Address filtering 0 packets, 0 bytes
 Traffic Received redirected 0 packets, 0 bytes
 Sessions rejected due to service mode not operational 0   // new line
```

Perform the following tasks to display the sessions associated with a user group:

Step 1	router#**show wimax agw user-group name** *user-group-name* [brief] #**show wimax agw user-group any** [**brief**] #**show wimax agw user-group unauthenticated** [**brief**]	Displays the new sessions rejected for the user-group by the BWG during maintenance mode.

To show sessions associated a user group:

```
router#sh wim agw sub user-group name cisco.com br
MSID           Address         Age       Flows Hosts Pkts-Tx    Pkts-Rx
0003.1238.5678 0.0.0.0         000.07.47 1     0     3          3
0003.123A.5678 11.1.0.5        000.02.32 1     0     2          2
0003.123B.5678 11.1.0.6        000.02.00 1     0     2          2
0003.123C.5678 11.1.0.7        000.01.40 1     0     2          2
0003.123D.5678 11.1.0.8        000.01.40 1     0     2          2
0003.123E.5678 11.1.0.9        000.01.40 1     0     2          2
```

Perform the following tasks to clear the sessions:

Step 1	router#**clear wimax agw subscriber user-group name** *group-name* [**local**] router#**clear wimax agw subscriber user-group any** [**local**] router#**clear wimax agw subscriber user-group unauthenticated** [**local**]	Clears sessions associated with a user group.

Session Timer Support

A Session or Absolute timer is configurable on the BWG for a User group. When the timer expires, the subscriber is de-registered. Session timeout can be downloaded from the AAA server during the authentication phase.

Mobile Subscriber Station De-Registration

Cisco BWG Release 1.0 and above supports Network Exit as a result of Path Deregistration messaging.

There are two possible ways to deregister a Mobile Subscriber Station:

Mobile Subscriber Station Initiated De-Registration

Step 1 The SS sends DREG-REQ message to the BS, to start de-registration procedure.

Step 2 The BS sends Data Path De-Reg Request to BWG.

Step 3 BWG sends Data Path De-Reg Response to BS with the action code (set to 0x04) to authorize de-registration procedure.

Step 4 BS sends DREG-CMD to SS to de-register the SS.

Step 5 BS sends Data Path De-Reg Ack to BWG to complete the transaction.

Network-Initiated De-Registration

Step 1 The BWG sends out a Data Path De-Reg Request message to the BS indicating the MS to be deleted.

Step 2 The BS sends out a DSD-REQ over the airlink to deregister the specific Service Flows.

Step 3 BS gets DSD-RSP from SS indicating the termination of the service flow.

Step 4 BS sends Data Path De-Reg Response to BWG indicating the termination of service flow.

Step 5 BWG sends Data Path De-Reg Acknowledgement, to terminate the transaction.

Deregistration Reason TLV in Deregistration Request.

In Release 1.4, the Path Deregistration Request is enhanced to include an additional TLV, Deregistration Reason TLV in addition to the Registration Type TLV based on following logic:

- Authentication failures (i.e. Access-Reject no auto-provisioning, AAA unreachable)
- CPE service state attribute received in Access-Accept indicates that CPE is black listed (not Active)
- Internal Error (i.e., Protection timer timeout, Session timer timeout, etc.)

Please refer to Table 2-7 for a more detailed description of the values of the Deregistration Reason TLV.

Table 2-7 Cisco R6 Deregistration Reason TLV

Type	1010
Length in Octets	4

Table 2-7 Cisco R6 Deregistration Reason TLV (continued)

Value	Enumerator. The values are: 0 - Reserved 1 - Non payment (Service Authorization Failure) 2 - Reported Stolen (Black Listed) 3 – Bad user behavior (Black Listed) 4 – Service Temporarily Suspended (CPE Suspended) 5 - Protection timer expiry (BWG internal error) 6- Address allocation timer expiry (BWG internal error) 7 - AAA server unreachable 8 – 127 – Reserved 128 - Authentication Failed (CPE not found in AAA & No Auto provisioning enabled) 129 – Operator Initiated CPE Deregistration (Network Exit from BWG) 130 – Operator Initiated CPE Reset 131 – Authentication Session Timer Expiry 132 – Idle Session Timer Expiry 133 - Access via non-home BS 134 – ISF Creation failed 135 - User Group in Maintenance Mode
Description	Indicates Deregistration Reason
Message Primitives That Use This TLV	Path Deregistration Request Message

The BWG supports this feature for both EAP and PAP authenticated users.

Note The Deregistration Reason TLV is optional and it will only be included in case of errors that correspond to the values mentioned except 6 and 130.

Note The Address allocation timeout is not supported on the BWG because the deregistration reason codes "6- Address allocation timer expiry" and "130 - Operator Initiated CPE Reset" are not used.

AAA Accounting Start-Stop-Interim

BWG supports per service flow accounting information. Only time based Interim accounting updates are supported. The BWG supports per service flow, and generates a unique set of accounting records for each service-flow tuple (Acct-Session-Id + Acct-Multi-Session-Id + PDFID). Each service flow is uniquely identified by a GRE key. A given MS can have more than one service flow.

Note Per-session accounting is not supported in this release.

For all the accounting records sent by the BWG, the Framed-IP-Address field is set to the mobile's IP address, irrespective of which host behind the mobile the traffic is sent for.

The BWG sends the following messages to the AAA server:

- Accounting Start: The BWG sends this message to the AAA server when a new service flow is created. In case of redundant BWG configuration, a stand-by BWG sends an Accounting Start message only when it becomes active. The trigger for the Accounting Start is the successful creation of the service flows. In case of the initial service flow, the accounting start record is sent only after the IP address is allocated to the users. For the secondary service flow, the accounting record is sent as soon the flow is successfully opened with the BS.

  From BWG Release 2.2, you can configure a delay in sending the Framed-IP-Address field in the accounting start record. Framed-IP is often not included in the accounting start record for flow-accounting. In the case of the initial service flow, the accounting start record is sent at the time of flow creation, before the subscriber host is created. From BWG Release 2.2, you can delay the sending of the accounting start record until a host is created. Use the command **[no] aaa accounting flow start include-framed-ip [delay]** to configure the delay. By default, this feature is disabled. If enabled, the default delay is 3 seconds. The acceptable range of values for the delay is 1 second and 20 seconds.
- Accounting Interim Update: The BWG generates an Accounting Update message if periodic accounting update message is configured. The accounting updates are based on a time trigger, and when configured. The minimum permitted value for the timer is 1 minute.
- Accounting Stop: The BWG sends and Accounting Stop message when the service flow is deleted or when the MS completes the deletion.

The attributes sent in the accounting record are listed in Table 2-8:

Table 2-8 BWG-AAA Authentication Attributes

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
User-Name	1	NAI obtained from the EAP-Response Identity (Outer-NAI)	1	0	0-1	
Service-Type	6	Set to "Framed" for initial authentication and set to "Authenticate-Only" indicating Re-authentication. It may also be set to "Authorize-Only" when used to obtain prepaid quotas mid-session.	1	0	0-1	0

Table 2-8 BWG-AAA Authentication Attributes (continued)

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
Framed-MTU	12	Used by WiMAX, as per RFC3579 in an Access-Request during EAP authentication, this attribute provides the appropriate MTU size to avoid exceeding maximum payload size for PKMv2 (2008 bytes) during EAP exchange (the appropriate fragmentation is assumed in Authentication Server on the EAP application layer). The value of this attribute should be set between 1020 and 2000 bytes (the recommended value is 1400 bytes). In an Access-Accept the use is as per RFC2865.	0-1[m]	0	0-1[m]	0
EAP-Message	79	The EAP message	1-n	1-n	1-n	1-n
Message-Authenticator	80	Provides integrity protection for the RADIUS packets as required by [RFC3579]	1	1	1	1
WiMAX-Capability	26/1	Identifies the WiMAX Capabilities supported by the NAS. Indicates capabilities selected by the RADIUS server.	1	0	0-1[k]	0
NAS-ID	32	FQDN of the NAS	1[b]	0	0	0
NAS-Port-Type	61	Identifies the type of port the request is associated with. Set to WiMAX when coming from a WiMAX ASN. Set to MIPv4 or MIPv6 when coming from an HA.	1	0	0	0
Calling-Station-Id	31	Set to the MAC address of the Device(MS).	1	0	0	0
Device-Authentication-Indicator	26/2	Indicates whether the device authentication was performed, and the result.	0-1[i]	0	0	0
GMT Timezone-Offset	26/3	The offset in seconds from GMT at the NAS.	1	0	0	0
NAS-IP-Address	4	NAS IP Address. Either NAS-IP-Address.	0-1[b]	0	0	0
Error-Cause	101	Error Codes generated during access authentication [RFC3576].	0	0-1	0	0-1
Class	25	Opaque value set by the server used to bind authentication to accounting.	0	0	0-1[h][k]	0
Framed-IP-Address	8	The MIPv4 home address to be assigned to the MN.	0	0	0-1[c][k]	0
Session-Timeout	27	The maximum number of seconds of service to be provided to the user before termination of the session. Associated with the lifetime of the keys	0	0	0-1[d][k]	0
Termination-Action	29	Indicates what action the NAS should take when service is completed.	0	0	0-1[d][k]	0

Table 2-8 BWG-AAA Authentication Attributes (continued)

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
AAA-Session-ID	26/4	A unique identifier in the home realm for this Session.	0-1[e]	0-1	1	0
BS-ID	26/46	Indicates the NAP-ID and BS-ID at the time the message was delivered	0-1[n]	0	0	0
MSK	26/TBD	The Master Session Key derived as the result of successful EAP Authentication.	0	0	1[f]	0
Session-Timeout	27	The maximum number of seconds of service to be provided to the user before termination of the session. Associated with the lifetime of the keys derived from the EAP authentication (i.e., MSK, EMSK and keys derived from EMSK) Session-Timeout in an Access-Challenge packet is used set the EAP-retransmission timer as per RFC3579.	0	0-1	0-1[d][k]	0
CPE-service-state	Cisco VSA	Indicates if CPE is blacklisted or not.	0	0	0-1	0

[b] NAS-ID MUST appear in the Access-Request. NAS-IP-Address may also appear. NAS-ID may be configured on the CLI using the **radius-server attribute 32 include-in-access-req** command.

[c] If this attribute is present then the home address assigned to the mobile must be as specified by this attributes. If this attribute is absent then the home address is derived from MIP procedures or other means (for example, DHCP).

[d] Both Session-Timeout and Termination-Action MUST be present. Termination-Action MUST be set to "RADIUS-Request"(1). This causes the NAS to re-authenticate when the Session-Timeout expires.

[f] The attribute must be encrypted using the procedures in section 3.5 of RFC2868

[h] If more than one class attribute is found in an Access-Accept message, the NAS shall store all of them and send them back in the accounting request packets.

[i] Must appear in the Access-Request associated with the User Authentication phase of the Double EAP Device, user authentication procedure. Otherwise, the attribute MUST not be present in the Access-Request message.

[k] Attributes must not appear in the Access Accept sent associated with the Device Authentication phase of double EAP.

[m] If the Framed MTU appears in an Access-Request during Access-Authentication then it indicates the MTU on the link between the NAS and the MS. As per RFC3579, the RADIUS shall not send any subsequent packet in this EAP conversation containing EAP-Message attributes whose values, when concantenated, exceed the length specified by the Framed-MTU value.

[n] Either the BS-ID or NAP-ID SHALL be provided. If both are provided the receiver SHALL ignore the NAP-ID attribute. In Release 1.0 and above, NAP_ID is not sent to AAA. NAP-ID is 24 (MSB) bits of 48 bit BSID (when BS will send it in future).

Cisco BWG Release 1.4, adds support for the Service State attribute from AAA. The attribute type is "Cisco-VSA" and format is of type "string". This attribute indicates if the CPE is black listed or not.

The following are the values defined for this attribute:

0 - Active

1 - Non payment

2 - Reported Stolen

3 - Bad user behavior

4 - Service Temporarily Suspended

The BWG expects the Service State attribute to be included in an Access-Accept. To facilitate this implementation in the BWG, the AAA is configured to return the Service State attribute with Access-Accept only. When an Access-Reject is sent, the Service Attribute is not included. The BWG supports this attribute for both EAP, as well as PAP authenticated users.

By default the CPE is considered to be active on the BWG.

Configuring AAA Accounting

To enable the accounting feature on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# aaa accounting network {accounting-list-name} {none|start-stop|stop-only} {broadcast|group} {server-group-name|radius}`	Enables the accounting for network services. For WiMAX, an accounting method list name is required.
Step 2	`router(config)# aaa accounting update {newinfo|periodic} {periodic intervals to send accounting updates in minutes}`	Enables the accounting updates at periodic intervals. The **no** version of this command disables the sending of accounting updates.
Step 3	`router(config)# wimax agw user group-list user-group-list-name`	Configures the user group list on the BWG router. Only one user group list is allowed on a single processor of the BWG. The **no** version of command removes the user group list. This command enters a user group list sub-configuration mode to create multiple user groups under the *user-group list* created.
Step 4	`router(config-gw-ug)# aaa accounting method-list {method-list-name| default}`	Specifies the accounting method list used for the domain.

Accounting Start Response

Currently the Accounting Response message is not handled by the BWG. In BWG Release 2.0, whenever flow accounting is enabled, the flow does not start processing traffic unless the Accounting Start response has been received.

This feature is enabled on per user-group basis. By default, this feature is not enabled. To enable the feature, perform the following task:

	Command	Purpose

Step 1	`router(config)# wimax agw user group-list wimax`
	` user-group unauthenticated`
	`  aaa accounting method-list agw`
	`  aaa accounting host enable`
	`aaa accounting start wait-response`
		Enables the BWG to process flow accounting traffic only after an Accounting Start response is received.

Once enabled, if the accounting response from AAA is not received, the session is deleted.

Configuration Example

Here is an example of a user group configuration:

```
wimax agw user group-list wimax
  user-group any
   aaa accounting method-list agw
   aaa authentication method-list agw
!
  user-group domain cisco.com
   aaa accounting method-list agw
   aaa authentication method-list agw
!
  user-group unauthenticated
   aaa accounting method-list agw
```

Here is an example of a AAA and RADIUS configuration:

```
aaa new-model
!
aaa accounting update periodic 15
aaa accounting network agw start-stop group radius
aaa authorization network default group radius
aaa authentication dot1x agw group radius
!
radius-server attribute 32 include-in-access-req format %h.%d.%i
radius-server attribute 55 access-request include
radius-server attribute 25 accounting prefer-preauth
radius-server vsa send accounting wimax
radius-server vsa send authentication wimax
radius-server host 172.19.25.8 auth-port 1645 acct-port 1646 key cisco
radius-server host 1.8.91.8 auth-port 1645 acct-port 1646 key cisco

!
```

Verifying the Configuration

Here is an example of the **show wimax agw subscriber** command, used to verify the accounting configuration:

```
Router#sh wimax agw subscriber msid 1000.0002.0001
 Connection time 000:01:08
 Auth policy 0X12(18), Single-EAP, CMAC
 Number of TIDs 1
 TID Key 10.1.1.82/2.2.2.2/1000.0002.0001
  Peer TID 0X4(4)
    FT MS State Change(9), MT Attachment Request(8)
  Our TID 0x8004(32772)
 Subscriber address 2.2.0.8, type IPv4, organization IETF
 Subscriber address method Dynamic, source DHCP relay
 Subscriber address assigned on flow downlink ID 15
 Subscriber address prefix len allocated 32, aggregate 32
 Subscriber address traffic sent 0 packets, 0 bytes
 Subscriber address traffic received 0 packets, 0 bytes
 Subscriber address DHCP XID 2390, server 0.0.0.0, htype 1
 Subscriber address DHCP client ID 1000.0002.0001, length 6
 Subscriber address DHCP Refresh time 86400 seconds
 Number of sessions 1
  Session details:
   FSM in state Ready(7) on last event Rx Attach Ack(14)
   Username eap-md5-u@eap-md5.com
   Authentication method EAP
```

```
AAA session-id length 7, 0x30313233414243
   AAA termination-action 1
   Reauthentication attempts from subscriber 0, ASNGW 0
   Associated user group **any**
   Signalling address local 2.2.2.2, remote 10.1.1.82
   Signalling UDP port local 2231, remote 2231
   Idle for inbound 00:01:09, outbound 00:01:09
   Absolute timeout 1500, remaining 00:23:49
   Idle timeout 600 (both), remaining 00:08:50
   Ingress Address filtering 0 packets, 0 bytes
   Number of flows 1
    Flow details ISF(0)
     FSM in state SF Ready(4) on last event Up(1)
     Transaction ID used 0X8004(32772)
     Data ID local 0x8(8), remote 0x1(1)
     Data address local 2.2.2.2, remote 10.1.1.82
     Data traffic sent 2 packets, 705 bytes
     Data traffic received 2 packets, 1208 bytes
     Accounting last record sent Interim(3)
     Idle for inbound 00:01:09, outbound 00:01:09
     Service Flow information Downlink: Identifier 15
```

Here is sample RADIUS output for a AAA accounting start:

```
*Aug 11 02:27:21.143: RADIUS(00000006): Send Accounting-Request to
 1.8.91.8:1646 id 1646/61, len 165
*Aug 11 02:27:21.143: RADIUS:  authenticator C4 F4 3F A3 00 1C 01 66 - 78
 DD A4 B4 68 37 F9 5B
*Aug 11 02:27:21.143: RADIUS:  Acct-Session-Id     [44]  10  "00000006"
*Aug 11 02:27:21.143: RADIUS:  Framed-Protocol     [7]   6   noval0
 [0]
*Aug 11 02:27:21.143: RADIUS:  Called-Station-Id   [30]  9   "2.2.2.2"
*Aug 11 02:27:21.143: RADIUS:  Framed-IP-Address   [8]   6   2.2.0.76
*Aug 11 02:27:21.143: RADIUS:  Calling-Station-Id  [31]  19  "10-00-22-
 25-00-01"*Aug 11 02:27:21.143: RADIUS:  Acct-Input-Octets   [42]  6   1208
*Aug 11 02:27:21.143: RADIUS:  Acct-Output-Octets  [43]  6   666
*Aug 11 02:27:21.143: RADIUS:  Acct-Input-Packets  [47]  6   2
*Aug 11 02:27:21.143: RADIUS:  Acct-Output-Packets [48]  6   2
*Aug 11 02:27:21.143: RADIUS:  Vendor, Wimax       [26]  13
*Aug 11 02:27:21.143: RADIUS:   GMT-Time-Zone-Offse[3]   7
*Aug 11 02:27:21.143: RADIUS:   00 00 00 00 00
 [?????]
*Aug 11 02:27:21.143: RADIUS:  Vendor, Wimax       [26]  11
*Aug 11 02:27:21.143: RADIUS:   Packet-Data-Flow-ID[26]  5
*Aug 11 02:27:21.143: RADIUS:   00 00 00
 [???]
*Aug 11 02:27:21.143: RADIUS:  Acct-Session-Time   [46]  6   1630
*Aug 11 02:27:21.143: RADIUS:  Acct-Status-Type    [40]  6   start
 [3]
*Aug 11 02:27:21.143: RADIUS:  NAS-Port-Type       [61]  6   802.16e Wimax
 [27]
*Aug 11 02:27:21.143: RADIUS:  NAS-Port-Id         [87]  11  "WiMAX-AGW"
*Aug 11 02:27:21.143: RADIUS:  Service-Type        [6]   6   Framed
 [2]
*Aug 11 02:27:21.143: RADIUS:  NAS-IP-Address      [4]   6   2.2.2.2
*Aug 11 02:27:21.143: RADIUS:  Acct-Delay-Time     [41]  6   0
*Aug 11 02:27:21.175: RADIUS/ENCODE(00000007):Orig. component type = AGW
*Aug 11 02:27:21.175: RADIUS/ENCODE: NAS PORT sending disabled
*Aug 11 02:27:21.175: RADIUS(00000007): Config NAS IP: 0.0.0.0
*Aug 11 02:27:21.175: RADIUS(00000007): sending
*Aug 11 02:27:21.175: RADIUS/ENCODE: Best Local IP-Address 2.2.2.2 for
 Radius-Server 1.8.91.8
```

Here is sample RADIUS output for a AAA accounting stop:

```
*Feb 18 15:30:29.011: RADIUS(00000006): Send Accounting-Request to
 172.19.25.8:1646 id 1646/24, len 252
*Feb 18 15:30:29.011: RADIUS:  authenticator 6D FC 9B 49 59 28 56 41 - 3F 2E A5
 3C 7B 7A 3A B1
*Feb 18 15:30:29.011: RADIUS:  Acct-Session-Id     [44]  10  "00000008"
*Feb 18 15:30:29.011: RADIUS:  Framed-Protocol     [7]   6   nova10
[0]
*Feb 18 15:30:29.011: RADIUS:  Called-Station-Id   [30]  9   "2.2.2.2"
*Feb 18 15:30:29.011: RADIUS:  Framed-IP-Address   [8]   6   2.2.0.2
*Feb 18 15:30:29.011: RADIUS:  Calling-Station-Id  [31]  19  "06-76-22-24-22-22"
*Feb 18 15:30:29.011: RADIUS:  Vendor, Wimax       [26]  10
*Feb 18 15:30:29.011: RADIUS:   AAA-Session-ID     [4]   4
*Feb 18 15:30:29.011: RADIUS:   00 00
[??]
*Feb 18 15:30:29.011: RADIUS:  User-Name           [1]   23  "eap-md5-u@eap-
 md5.com"
*Feb 18 15:30:29.011: RADIUS:  Acct-Input-Octets   [42]  6   0
*Feb 18 15:30:29.011: RADIUS:  Acct-Output-Octets  [43]  6   0
*Feb 18 15:30:29.011: RADIUS:  Acct-Input-Packets  [47]  6   0
*Feb 18 15:30:29.011: RADIUS:  Acct-Output-Packets [48]  6   0
*Feb 18 15:30:29.011: RADIUS:  Multilink-Session-ID[50]  10  "30313233"
*Feb 18 15:30:29.011: RADIUS:  Class               [25]  21
*Feb 18 15:30:29.011: RADIUS:   63 6C 61 73 73 2D 77 69 6D 61 78 2D 63 68 61 6E
[class-wimax-chan]
*Feb 18 15:30:29.011: RADIUS:   67 65 64
[ged]
*Feb 18 15:30:29.011: RADIUS:  Vendor, Wimax       [26]  13
*Feb 18 15:30:29.011: RADIUS:   GMT-Time-Zone-Offse[3]   7
*Feb 18 15:30:29.011: RADIUS:   00 00 00 00 00
[?????]
*Feb 18 15:30:29.011: RADIUS:  Vendor, Wimax       [26]  17
*Feb 18 15:30:29.011: RADIUS:   BaseStation-ID     [46]  11
*Feb 18 15:30:29.011: RADIUS:   00 0A 01 01 46 00 00 00 00
[????F????]
*Feb 18 15:30:29.011: RADIUS:  Vendor, Wimax       [26]  11
*Feb 18 15:30:29.011: RADIUS:   Packet-Data-Flow-ID[26]  5
*Feb 18 15:30:29.011: RADIUS:   00 05 01
[???]
*Feb 18 15:30:29.011: RADIUS:  Acct-Session-Time   [46]  6   25
*Feb 18 15:30:29.011: RADIUS:  Acct-Terminate-Cause[49]  6   none
[0]
*Feb 18 15:30:29.011: RADIUS:  Acct-Status-Type    [40]  6   Stop
[2]
*Feb 18 15:30:29.011: RADIUS:  NAS-Port-Type       [61]  6   802.16e Wimax
[27]
*Feb 18 15:30:29.011: RADIUS:  NAS-Port-Id         [87]  11  "WiMAX-AGW"
*Feb 18 15:30:29.011: RADIUS:  Service-Type        [6]   6   Framed
[2]
*Feb 18 15:30:29.011: RADIUS:  NAS-IP-Address      [4]   6   172.19.24.88
*Feb 18 15:30:29.011: RADIUS:  Acct-Delay-Time     [41]  6   0
*Feb 18 15:30:29.019: RADIUS: Received from id 1646/23 172.19.25.8:1646,
Accounting-response, len 20
*Feb 18 15:30:29.019: RADIUS:  authenticator 4D 1A 1B 4D C5 0E 39 FD - 36 6B 90 FF 96 21
66 64
*Feb 18 15:30:29.019: RADIUS: Received from id 1646/24 172.19.25.8:1646,
Accounting-response, len 20
*Feb 18 15:30:29.019: RADIUS:  authenticator EB 25 42 F1 48 2C BF 13 - 43 B0 0A 3A 7A 04
F4 1F
```

WiMAX Specific VSAs

The following VSAs are specific to WiMax:

- Wimax Capability—Indicates the WiMAX release, accounting capabilities indication, Hotlining capabilities, and Idle Mode Notification capabilities of the BWG to the AAA in an Access Request.
- GMT Time Zone Offset—The current offset in seconds of the local time at the NAS with respect to GMT time.
- Packet Data Flow-Id (PDFID)—The value of this attribute matches all records from the same packet data flow. PDFID is assigned by the CSN, and remains constant through all handover scenarios. In Release 1.0 and above, the BWG generates the PDFID for a flow in the session.
- Base Station ID—Uniquely identifies a NAP and a base station within that NAP. The BWG forwards the R6 BS ID in this attribute.
- AAA Session ID—A unique per realm identifier assigned to the WiMAX session by the home network during network entry. The value is included in all subsequent AAA packets for that session.

AAA-Based Hot-lining

The Hot-lining feature allows you to address issues with users that would otherwise be unauthorized to access packet data service. When a user is hot-lined, their packet data service is redirected to a Hot-line Application (such as a Cisco ISG) which notifies the user of the reason(s). Once the hot-lining reason is addressed by the user, normal packet data service should be resumed.

A user can be hot-lined at the start of their packet data service, or mid-session with AAA-based Change of Authorization (CoA). The AAA Access Accept is used to hot-line the user's session at the session startup time. If the session receives a AAA CoA with the hot-lining profile details in the middle of the session, the user's data traffic is re-directed. Similarly, hot-lining can be stopped for a session that is currently hot-lined.

The following list identifies the Hot-lining feature support:

- The BWG supports hot-lining of new sessions based on AAA Access Accept attributes.
- BWG supports hot-lining of active sessions based on AAA CoA.
- Uplink traffic as well as downlink traffic is hot-lined, and the BWG supports packet redirection.
- Profile-based Hot-lining is supported.
- The BWG supports Hot-lining on per subscriber from AAA.
- Traffic re-direction only applies for data packets; the signaling packets such DHCP are not subject to redirection.
- IP-Redirection and HTTP-Redirection are supported in this release.

Note Dynamic QoS and packet filtering during Hot-lining are not supported in this release.

Hot-Lining Triggers

There are two methods in which the HAAA indicates that a user is hot-lined:

Profile-Based Hot-lining:

The HAAA sends a hot-line profile identifier in the RADIUS message. The hot-line profile identifier selects a set of rules that are pre-provisioned that cause that user's packet data session to be redirected and/or blocked. The Profile-based approach is supported in this release.

Rule-based Hot-lining:

The HAAA sends the actual redirection-rules (HTTP or IP) and filter-rules in the RADIUS messages that cause the user's packet data session to be redirected and/or blocked.

The difference between these two approaches is where the network intelligence should be located. AAA profile-based Hot-lining dictates that the BWG retain the most of network intelligence with regard to Hot-lining, and the AAA server simply picks a profile to trigger it.

Alternately, AAA will need to specify the detailed actions for the BWG to perform during Hot-Lining in the Rule-based approach. In this scenario the BWG just carries out what AAA dictates.

Note Rule-based Hot-lining is not supported in this release.

Note These two methods cannot be mixed.

In Profile-based Hot-lining, the following conditions apply.

Upstream Flow

When hot-lining is enabled, for the upstream packets the default behavior is to drop the packets. If no filter rule is configured under the hotline profile for the upstream direction, all upstream packets are dropped. You can allow certain packets to pass through the BWG even when the hot-lining is enabled. These packets might include the packets destined for the hot-lining server itself, HTTP, DNS packets, etc. You can specify a URL to indicate to the server which packets need to pass through.

Filter rules for the upstream packets are applied in the following order: IP passthru, HTTP redirect.

Downstream Flow

When hot-lining is enabled, the default behavior for the downstream packets is to drop the packets. If no filter rule is configured for the downstream direction, all the packets are dropped.

The mandatory attributes supported in the Change of Authorization (CoA) message from the AAA server are the User-Name, Calling-Station-Id and AAA-Session-Id attribute. The Calling-Station-Id attribute is used to uniquely identify a particular user on the BWG.

AAA Attributes

There are new attributes associated with AAA Access Accept for the hot-lining feature. These attributes are used to support hot-lining a new session.

Table 2-9

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
Hotline-Profile-ID	26/53	ID to uniquely identify the user's hotline profile	0	0	0-1[a]	0
Hotline-Session-Timer	26/56	Specifies the length of time in seconds that the user would be allowed to remain in the hotline session.	0	0	0-1	0
Hotline-Indication	26/24	Indicates that the flow and host is hotlined	0	0	0-1[b]	0

[a] If Hotline-Profile-ID is included, the HTTP-Redirection-Rule, IP-Redirection-Rule, and Filter-Rule are not included. In cases where these are present, the receiver silently discards the attributes.

[b] If the session is hotlined then this attribute is specified, and the NAS includes this attribute in the accounting messages.

The following new attributes are associated with AAA CoA for the hot-lining feature. These attributes are used to support hot-lining an active session.

Table 2-10

Attribute	Type	Description	COA	COA-ACK	COA-NAK
User-Name	1	The NAI of the MS as received during Access-Authentication.	1	0	0
Calling-Station-Id	31	The MAC address in binary format of the MS.	1	0	0
AAA-Session-ID	26/4	The NAI contained in the User-Name and the AAA-Session-ID forms a unique identifier of the session at the NAS.	1	0	0
Hotline- Profile-ID	26/53	ID to uniquely identify the user's profile	0-1[a]	0	0
Hotline Session Timer	26/56	Contains the length of time in seconds that the user would be allowed to remain in the hotline session.	0-1	0	0
Hotline- Indication	26/24	Indicates that the flow and host is hotlined.	0-1[b]	0	0

[a] If the Hotline-Profile-ID is included, the HTTP-Redirection-Rule, IP-Redirection-Rule, and Filter-Rule are not included. In cases where these are present, the receiver discards the attributes.

[b] The IP address of the MS is included if known by the HAAA.

Configuring Profile-based Hot-lining

To configure the BWG to perform Profile-based Hot-lining, perform the following tasks:

	Command	Purpose
Step 1	`router# wimax agw hotline profile` *profile-name* `ip access-group` *number in | out* `passthru` `http access-group` *number* `redir-url` *url*	Configures the hotline profile on the BWG.
Step 2	`router(config-gw-hotline)# ip access-group` *number in | out* `passthru`	Packets passing the filter rule defined by ACL are allowed to pass. Here the in/out indicate the following: *in* - upstream packet flow *out* - downstream packet flow
Step 3	`router(config-gw-hotline)# http access-group <num> redir-url` *url*	Packets passing the filter rule are dropped and a downstream HTTP packet with the specified URL is sent to the MS.

Here is an example:

```
router#show run | inc hotline
wimax agw hotline profile XYZ
   ip access-group 101 in passthru
   http access-group 102 redir-url www.hotlined.com
   ip access-group 101 out passthru
```

Similar to SLA profile, the AAA server simply selects a hotline profile. To disable hot-lining, the AAA server can choose a special profile name called “hotlining-exit” (case insensitive). Once receiving this special profile name, the BWG resumes the normal traffic for the subscriber. In order to avoid confusion, you should not use this special profile name as a normal hotline profile name.

To enable the CoA handling feature on BWG, perform the following task:

	Command	Purpose
Step 1	`router# aaa server radius dynamic-author` `server-key cisco`	Enables CoA handling feature on BWG.

To properly account for the hot-lining state of the user, the user’s hot-line state should be recorded in the accounting stream. The attribute “Hotlining Indication” received from AAA should be included as a part of the record for accounting start/stop.

Active/Mid Session Hot-lining

Here is the flow for a mid session Hot-lining:

1. During the session setup stage, the BWG initiates a AAA Access request.
2. AAA responds with an Access Accept.
3. An active session is now set up, and AAA wants to hot-line this subscriber.
4. There is a COA request from AAA indicating that the Hotlining Profile-ID should be enforced.

5. There is a CoA Ack to the AAA.
6. The BWG sends an Accounting Stop to AAA for each flow and host.
7. The BWG sends an Accounting start to AAA with Hotlining Indication for each flow and host.
8. The Hotline Session Timer is started. If no value comes from AAA for the Session-Timeout, it is set to a default value of 3600 seconds. If the period indicated by Session-Timeout attribute has elapsed and the session is still hotlined, then session teardown is initiated.
9. The BWG applies the appropriate filter rule specified in the configurations to the upstream or downstream traffic.
10. AAA is now changed to resume the normal traffic flow for the subscriber.
11. There is a COA request from AAA indicating that the Hotline Profile ID = hotlining-exit.
12. There is a CoA Ack to AAA.
13. The BWG sends Accounting Stop to AAA with Hotlining Indication for each flow and host.
14. The BWG sends Accounting Start to AAA for each flow and host.
15. Normal traffic resumes for the subscriber on the BWG.

New Session Hot-lining

1. AAA is provisioned to hot-line this particular subscriber.
2. The BWG sends a AAA Access Request to the AAA server.
3. AAA replies with Access Accept to enforce a hotlining profile.
4. Accounting Start to indicate the session is hotlined.
5. The BWG sets up the session with the appropriate filter rule specified in the configuration to the upstream or downstream traffic.
6. AAA indicates that hot-lining is finished for the session with a COA.
7. The BWG sends back COA-ACK.
8. The BWG stops Hotlining accounting.
9. The BWG starts the normal flow/host accounting.
10. Normal traffic resumes for the user.

Note You should not initiate a Normal Accounting Start for a Hotlined session from the beginning.

AAA Packet of Disconnect Message (PoD)

This feature provides a method for terminating a session that has already been connected. The PoD (Packet of Disconnect) message is a RADIUS Access Request packet, and is intended to be used in situations where the AAA server wants to disconnect the user after the session has been accepted by the RADIUS Access Accept packet.

The data parameters for PoD message are the following RADIUS attributes:

Table 2-11 PoD Message Parameters

Attribute	TYPE	Description	DR	DR-ACK	DR-NAK
User-Name	1	The NAI of the MS as received during Access-Authentication.	1	0	0
Calling-Station-Id	31	The MAC address in binary format of the MS	1	0	0
AAA-Session-ID	26/1	The NAI contained in the User-Name and the AAA-Session-ID forms a unique identifier of the session at the NAS	1	0	0
WiMAX-DM-Action-Code	26/60	Carries the deregistration action code from AAA to the NAS. If the WiMAX-DM-Action-Code is not present in the radius disconnect message then the result will be to use action code 0xffff and the NAS will use Action Code 6. The end result should be that the BS sends the RES-CMD to the MS.			

RADIUS Disconnect-ACK message is sent without any additional parameters.

Here is the attributes of the RADIUS Disconnect NACK Message:

Attribute	ID	AR
Error-Cause	101	1

Once a PoD is received, the session is terminated, and the data path is cleared towards the BS through the R6 Data Path De-registration Request message. The Disconnect-Request packet is sent to UDP port 3799, and identifies the NAS (as well as the user session to be terminated) by including the identification attributes. The NAS responds to a Disconnect-Request packet sent by a RADIUS server with a Disconnect-ACK if all associated session context is discarded (and the user session is no longer connected), or a Disconnect-NAK (if the NAS was unable to disconnect the session and discard all associated session context).

To configure PoD on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`router# aaa server radius dynamic-author server-key string`	Enables the PoD feature on the BWG. **server-key**—Configures the shared-secret text string. *string*-The shared-secret text string that is shared between the network access server and the client workstation. This shared-secret string must be the same on both systems.

To verify and troubleshoot the PoD feature, perform the following task:

	Command	Purpose
Step 1	`router# debug aaa pod`	

AAA-based Static IP Address Provisioning

This feature allows you to specify a list of static IP addresses that can be used by the MS hosts. There is no change to the Framed-Route AAA attribute. If Framed-Route is downloaded from AAA, the static-IP is also verified against it. Additionally, the you must configure the **ip static-allowed** command under the user-group in order to allow static IP hosts.

Here are the attributes for the Static IP Address list:

Table 2-12

Attributes	Format/Length	Comment
Static IP Address List	String/253	The subscriber's hosts will be only assigned to the addresses specified in the list: A0.B0.C0.D0;A1.B1.C1.D1 Up to 10 static IP addresses can be specified in the list; IP address takes in the dot format or hex format; IP addresses are separate by ";" "," or space.
Static IP Allowed	Integer/4	This BWG 1.1 attribute should be no longer sent to BWG from AAA. If it is sent, it will be ignored in BWG 2.0

The BWG must ensure that the same IP address cannot be assigned to more than one host. Duplicate IP address are checked in the same VRF context in case of a AAA provisioning error.

When the Static IP Address list is downloaded from AAA, and the **ip static-allowed** command is configured under the user-group, the **show wimax agw subscriber** command displays the following:

```
MSID 0000.1005.1000
 CPE Type: 201
 CPE is non-nomadic
 Static IP allowed by user-group config
 Static IP address list downloaded
 Subscriber Age 000:17:55
...
```

When the Static IP Address list is downloaded from AAA, and the **ip static-allowed** command is configured under user-group, the **show wimax agw subscriber internal** command displays the following:

```
MSID 0000.1005.1000
 CPE Type: 201
 CPE is non-nomadic
 Static IP allowed by user-group config
 Static IP address list downloaded
 Static IP address list:
  11.11.2.3       11.11.3.4       11.11.1.2       10.1.19.71      11.175.237.86
 Subscriber Age 000:18:24
```

Handoffs

Two forms of handoff are supported for WiMax, inter-base station and inter-BWG. BWG Release 1.0 and above supports only inter-base station handoff.

Inter-BS handoff includes both uncontrolled and controlled handoffs. In the controlled handoffs, the target BS obtains the session information from the serving BS through the R8 interface before the handoff actually occurs. Uncontrolled handoffs occur where information exchange between base stations is not possible before the target BS triggers a handoff at the BWG. Uncontrolled handover is treated in the same manner as Initial Network Entry, but for these kind of handovers, BWG ensures that paths registered with the serving base station are deregistered. From Release 1.0 and above, one attempt is made to send the deregistration message to the serving BS, and the handoff takes place regardless of whether the deregistration handshake between the ASN and SBS is complete or not.

Interim Accounting Update During Handoff

From Release 2.2 and above, you can configure BWG to trigger interim accounting updates during handoffs. When the Mobile Station (MS) does the handoff to another Base Station, an accounting update is sent to the AAA server.

If the interim accounting update feature is enabled, the accounting update will be sent out by the BWG for both flow-based accounting and host-based accounting.

The attributes that are sent as part of interim update will also be part of the accounting update that is sent out during handoff. Additionally, a new Cisco VSA "Handover-Indicator =1", is included. The BS ID is updated to correspond to that of the target Base Station IP address.

The interim accounting updates is not applicable to the following features:

- Hotlining
- PoD

Use the command **aaa accounting update handover** to enable the interim accounting feature.

To configure the interim accounting update during handoff, perform the following tasks:

	Command	Purpose
Step 1	`router#aaa accounting update handover`	Enables the accounting update during handoff. Use the no form of the command to disable the accounting update. By default this command is enabled.
Step 2	`router(config)#aaa accounting update newinfo`	Enables interim accounting updates. By default, this command is disabled.
Step 3	`router(config)#aaa accounting update newinfo periodic 3`	Enables periodic interim accounting updates. Only after configuring the **update handover** and **update newinfo** commands, this command appears in the running configuration.

The following table provides the AAA-Authentication attributes for the interim accounting update:

Table 2-13 AAA-Authentication Attributes for Interim Accounting Update during handoff

Attribute	Type	Description	Start	Interim	Stop
Handover Indicator	Cisco AVP	Indicates that the interim accounting update is triggered by the handover.	0	0-1	0
BS-ID	26/46	An octet string that uniquely identifies the NAP-ID Base Station that serves the MS at the time the UDR is generated. In the case of an accounting update triggered by the handoff, it is replaced with the target BS.	0-1	0-1	0-1

Uncontrolled Handoff

An uncontrolled handover is signaled from the BS to the BWG using a Path Registration Request message. This message contains information for each service flow that is already established with the source BS. It also contains the DP-IDs used for downlink flows.

Note There is no need to re-authenticate the device or the subscriber, as the session is maintained at the same BWG.

Note In uncontrolled handoff, the target BS will trigger a MS network entry in which the MS will get authenticated.

The BWG initiates the deregistration of the path to the old BS. This deregistration will be scheduled by the BWG. It does not necessarily occur directly after successful completion of handoff to the new BS.

There is no requirement to buffer bearer path data during handoff. Downlink data received at the BWG during the handover procedure is discarded.

Any traffic that is “in-flight” through the old path is lost because the device has already moved to the service area of the target BS before to the handoff trigger is received at the BWG.

It is possible that the device may move to a new BS while the handoff procedures between the target BS and the BWG are completed. Because the handover is uncontrolled, the handoff to the current target BS is completed (including R6 message retransmissions, if necessary) before the new handoff event is processed.

The handover exchange comprises three messages (applicable only for controlled handoff):

- Path Registration Request—sent from the Target BS to the BWG—which contains the following:
  - Registration Type
  - SF INFO(s) with SFID, Reservation Action (set to Create), Direction, QoS parameters, Data Path Info and GRE Key (for downlink flows)
  - BS INFO with BSID
- Path Registration Response—sent from the BWG to the Target BS—which contains the following:
  - Registration Type
  - SF INFO(s) with SFID, Reservation Action (set to Success), Direction, Data Path Info & GRE Key (for uplink flows)
  - BS INFO with BSID
- Path Registration Acknowledgement—sent from the Target BS to the BWG—which contains the following:
  - Registration Type

If the BWG cannot accept the handover, it sends the response with “reject cause code TLV”.

If the BWG accepts the handover for only a subset of the desired Service Flows, the handover is rejected.

Handoff will not be rejected if secondary flow is missing, but if primary flow is missing it will be rejected.

The Deregistration Request and ACK sent to SBS will have the registration type as “Handover” while Deregistration response from SBS will have “Network exit”. This is an expected behavior. On receiving this, the BWG does not send the ACK with “reject cause code TLV”.

Controlled Handoff

A controlled handoff occurs when the current and target BSs are able to communicate information and exchange details about service flows, classifiers, and other details, prior to the target BS triggering the handoff at the BWG. This means that the target BS has all relevant information about the mobile device prior to sending the BWG handoff trigger. This trigger occurs when the mobile device has already been connected to the target BS using 802.16e procedures. You can tell a controlled handoff occurred at the BWG by the receipt of a Path Registration Request message from the BS without a previous authentication exchange (which would be observed for a Network Entry event).

The following flow sequence illustrates the events that occur during a controlled handoff:

Step 1 The Target Base Station sends a Path Registration Request to the BWG containing the service flow information received from the Serving Base Station.

Step 2 The BWG responds with a Path Registration Response accepting registration of the data path with the Target base Station.

Step 3 The Target Base Station responds with a Path Registration Acknowledgement.

Step 4 The BWG sends a Path Deregistration Request to the Serving Base Station.

Step 5 The Serving Base Station responds with a Path Deregistration Response.

Step 6 The BWG acknowledges the response with a Path Deregistration Acknowledgement.

Step 7 The Target Base Station sends a Context Report to the BWG.

Step 8 The BWG acknowledges with a Context Acknowledgement.

Step 9 The target BS sends a CMAC Key Count Update message, and the BWG responds with a CMAC Key Count Ack message.

Verifying the Configuration

To view the handoff statistics for the BWG, use the **show wimax agw statistics section handoff** command.

Here is a sample configuration:

```
Router#show wimax agw statistics section handoff
Message type Successful Handoff
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type Handoff Registration Request
   Number of messages sent 0
   Number of messages received 2
   Number of messages resent 0
  Message type Handoff Registration Response
   Number of messages sent 2
   Number of messages received 0
   Number of messages resent 0
  Message type Handoff Registration Ack
   Number of messages sent 0
   Number of messages received 2
   Number of messages resent 0
  Message type Handoff Deregistration Request
   Number of messages sent 2
   Number of messages received 0
   Number of messages resent 0
  Message type Handoff Deregistration Response
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type Handoff Deregistration Ack
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
```

Security Context Exchange

In order for a BS to secure the airlink, it requires keying material from the BWG. A handoff cannot be successful from the perspective of the BS and the device until the data path registration has completed, and the BS receives the keying material. The BS is responsible to initiate both procedures. The BWG treats a context exchange with the BS as an entirely separate event from handover.

A context exchange can occur at any time. The AK transfer protocol is used to transfer the keying material to the BS. This material comprises the AK, AKID, AK Lifetime, AK sequence number and EIK.

If the PMK has expired, then a new PMK must be created.

The security context exchange comprises two messages.

- Context Request—sent from the target BS to the BWG—which contains the following:
  - Context Purpose Identifier
  - BS Info
  - Target BS ID
- Context Report—sent from the BWG to the target BS—which contains the following:
  - MS Info
  - AK Context
  - AKID
  - AK lifetime
  - AK SN
  - CMAC Key count
  - Target BS Info
  - Target BS ID

Keepalive Support for R6 Interface

The Keepalive mechanism is used over R6 interface between the BWG and the Base-Station (BS), which provides each Network Element (NE) the capability to detect failure, or restart of it's peer. The NE, detecting the failure or restart of the peer, may take appropriate actions (for example, clean up the corresponding MS contexts in a controlled way). The Keepalive mechanism is based on the periodic transmission of Keepalive-Req and Keepalive-Rsp messages between the Base Station and the BWG.

Transmission of the Keepalive messages can be enabled or disabled at both the Base Station and the BWG independently.

Note When BWG or BS receive R6 Keepalive-Req message, it must send Keepalive-Rsp reply, even if there are no subscribers on the Base-Station.

For each R6 instance, the Base Station and BWG maintain the following parameters.

Tk: Keepalive timer

N: Number of consecutive keepalive failures. Initialized to 0

M: Permitted maximum number of consecutive keepalive failures.

Pm: Session maturity period. Used to clear session upon detecting peer re-start.

R: Last reset time (LRT). Initialized to restart time of the node.

To enable the Keepalive function, perform the following tasks under base-station group submode:.

	Command	Purpose
Step 1	`router# router(config-wimax-agw-bs)#[no] reference-point r6 keepalive`	Enables keepalive feature on the BWG.
	`router(config-wimax-agw-bs)#reference-point r6 keepalive timeout <Tk-value>`	*Tk* is configurable under base-station group. Range is [30...65535] seconds. Default value is 60.
	`BWG(config-wimax-agw-bs)#reference-point r6 keepalive max-failures-allowed <M-value>`	*M* is configurable under base-station group. Range is [2...255]. Default value is 5.
	`router(config-wimax-agw-bs)#reference-point r6 session-maturity-period <Pm-value>`	*Pm* is configurable under base-station group. Range is [1..30] seconds. Default is 5 seconds.

N and R are variables used in the description below.

The Keepalive statistics are displayed with the following command:

```
router#show wim agw path

Path type Sig-UDP
 State current Ready, old Purging
 Number of sessions connected 1
 Number of old sessions connected 0
 Address local 11.1.27.1(AF_INET), remote 10.1.27.1(AF_INET)
 UDP port local 2231(0x8B7), remote 2231(0x8B7)
 Identification Peer 0x0A011B010000, Our 0x0B011B01
 R6 Version CISCO
 Keepalive Last Reset Time Peer 1244845152, Our 1245156882
 Keepalive timer expires in 00:00:20, timeout 30 secs
 Keepalive consecutive failures max allowed 5, current 0
 Keepalive Request received valid 0, invalid 0
 Keepalive Response received valid 1, invalid 0
 Keepalive Request sent success 2, fail 0
 Keepalive Response sent success 0, fail 0
 IP-GRE traffic sent 18 packets, 2601 bytes
 IP-GRE traffic received 14 packets, 1629 bytes
```

Keepalive Functional Behavior

The Keepalive function is defined as follows:

1. The Base Station or BWG sends a Keepalive-Req and starts timer Tk
2. On receipt of a Keepalive-Rsp, the value of N is reset to **0**.
3. When Tk expires, the node sends the next Keepalive-Req. **N** is incremented if a Keepalive-Rsp for the last Keepalive-Req message was not received prior to expiry of timer Tk.
4. When **N** equals **M**, **N** is reset to **0** and any R6 sessions established with the remote node are terminated using the same procedures as for Network-Triggered MS Network Exit.

BWG Keepalive-sender function works as follows:

- The BWG starts sending Keepalive-Req messages to the BS when the first subscriber (MS) does a network-entry from the BS.
- The BWG stops sending Keepalive-Req messages to a BS, when all subscribers from the BS deregister and exit the network.

- The BWG sends the Keepalive-Req periodically to the BS, as described above.
- The BWG includes the LRT TLV in every Keepalive-Req and Keepalive-Rsp message to the BS, to advertise its last restart time.

The BWG Keepalive-receiver function works as follows:

- The BWG receives a Keepalive-Req from the BS, and replies to the BS with a Keepalive-Rsp.
- The BWG receives a Keepalive-Rsp from the BS for every Keepalive-Req it sends to BS, as described above.
- The BWG extracts the LRT value from Keepalive-Req or Keepalive-Rsp message from the BS. The BWG saves the LRT value when it learns it for the first time.
- In the subsequent Keepalive-Req and Keepalive-Rsp from the BS, the BWG compares the received LRT value with the stored value. If the received LRT value is different from the stored value, the BWG considers the BS as having restarted, and clears all subscriber sessions and stores the new LRT value for the BS. In order to prevent any new sessions getting cleared, all sessions that are older than the Pm are cleared.

The LRT value is synced between SR-active and SR-standby. When the SR-standby becomes active, the keepalive function is resumed seamlessly with the same LRT value.

CLI-based Keepalive With reset-bs Option

Previously, the BS and BWG were occasionally out of sync in terms of sessions. At that time, it appeared that the only way to correct this was to reload the BWG, because a restarted BWG is able to send a keepalive to reset all BSs. However, reloading BWG is considered a drastic operation, which impacts every BS or CPE.

Now, if the BWG gets out of sync with a BS, this feature allows you to reset that specific BS.

To enable the BWG to resync to a specific BS, perform the following tasks:

	Command	Purpose
Step 1	`router#clear wim agw path 10.10.10.10 [reset-bs]` `router#clear wim agw path 10.10.10.10 local [reset-bs]`	Enables the BWG to reset a specific BS.

In the above configuration, 10.10.10.10 is the BS IP address. The **reset-bs** keyword prompts the BWG to clean up all the sessions belonging to the specified BS (if any), but also to send a keep-alive message (with its current reset time) to that BS to indicate that the BWG restarted so that BS is guaranteed to clear its sessions. This special keep-alive will always be sent even if the periodic keep-alive is disabled. Re-transmission is not applied here, so the command can be issued multiple times if needed.

A path for a BS does not exist if there are no subscriber sessions to the BS on the BWG. If this CLI is triggered in absence of a path for a BS then the BWG will not send KA request to BS.

show brief Command to Identify a Static or Dynamic Host.

Hackers tend to use static IP to explore the weakness of the network. This requires the BWG to provide a command to list all hosts with static IP addresses.

This feature leverages the existing **show wimax agw sub brief host** command. At the end of each output line a “D” or “S” is added to indicate if it is dynamic or static host.

Here is an example:

```
Router#sh wim agw sub br host
MSID           Index HostID         Address         DwnLk-SFID Idle Time
1000.2223.0001 1     1000.2223.0002 4.4.0.2         1          00:01:54 D
1000.2223.0001 2     ----.----.---- 4.4.0.3         3          00:00:18 S
```

In the Host Caching feature, the dynamic host is identified with “Idle Time” of “*xxx*”. This is no longer the case, as the dynamic host also needs to remember its idle time for the LRU algorithm.

Session Redundancy

The BWG Session Redundancy architecture provides user session failover capability in a 1:1 redundancy model, with a standby present for every active BWG. The active BWG sends state information to the standby BWG for state synchronization on a as needed basis. When an active BWG failure occurs, the standby BWG has state information needed to provide service to all existing sessions. It then takes over as the active BWG and begins servicing user sessions, thus providing session redundancy. When the previously active BWG comes back online, it takes over as standby for the now active BWG, and obtains state information for all existing sessions from it.

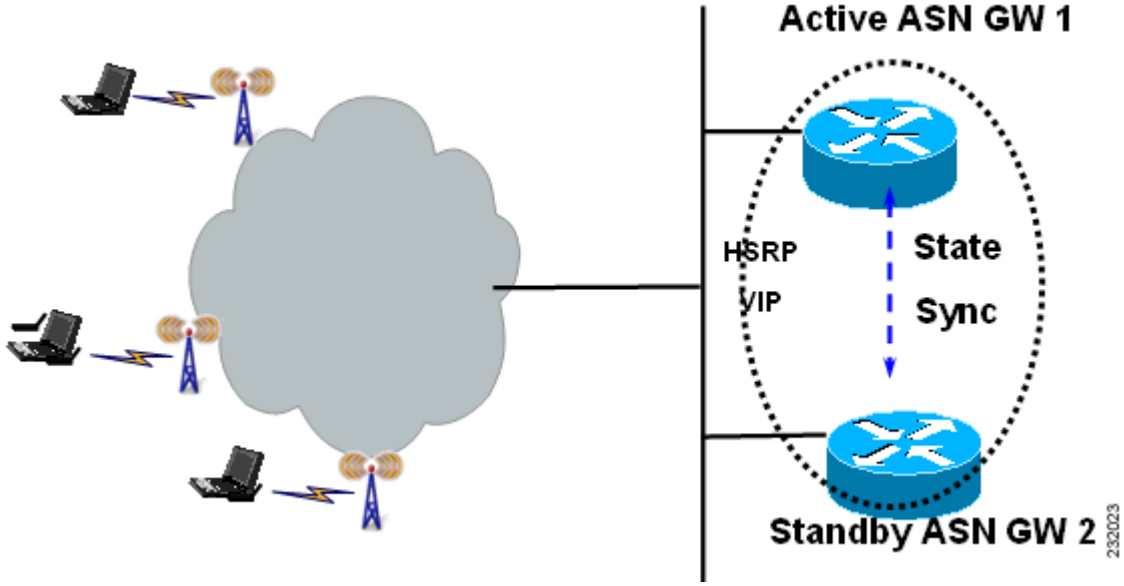
The BWG is hosted on the SAMI blade, and only card to card redundancy will be supported. In other words, failure of a single processor unit on SAMI will result in the entire card being switched over.

Note In Cisco BWG Release 1.1, session redundancy is still supported. However, the configuration on both standby and active should be identical regarding classifier information and CS-Type information for each service flow direction. The new fields introduced for the host data structure are synced from the active to the standby.

BWG Session Redundancy and High Availability Infrastructure

The BWG Session Redundancy is based on the Cisco IOS Hot Standby Routing Protocol (HSRP), the Cisco IOS Check-point Facility (CF) and Redundancy Framework (RF), and Stream Control Transmission Protocol (SCTP) to provide inter-device redundancy and high availability. The Figure 2-1 shows the system view of the BWG SR with relation to the IOS HA infrastructure.

Figure 2-1 Session Redundancy on the BWG



Subscriber Management

Subscriber information includes session and flows associated with a subscriber context, and is created, updated, or eventually deleted.

Subscriber information includes the following details:

- Authentication info (method, keying info, etc.)
- Addressing info (MS MAC, assigned DHCP address, etc.)
- VRF name
- Username
- Session info (signaling address, and associated timers, **etc**.
- Flow info per session (and associated QoS info per flow)

DHCP and AAA

The BWG supports DHCP relay mode and keeps track of client IP addresses allocated by DHCP servers (and the associated server IP addresses) so that it can relay future DHCP messages from clients to the servers. The client IP address and DHCP server IP address are saved in the subscriber context and are synced to the standby. Once the standby becomes active, it continues to relay DHCP messages from a client to the right server (there can be multiple servers configured: primary/secondary).

IOS AAA is not HA-aware at the moment, so the sync of AAA-related information is part of the session replication.

Dynamic Synchronization

In order for the standby to take over processing from the active in case of a failure, information regarding all sessions and flows on the active are dynamically synchronized to the standby at well defined synchronization points. Separate TLVs are used to synchronize session, flow, and path related information. Dynamic syncing happens for new session/flow events after the standby is at hot-standby state, and after bulk-sync is complete.

The following list identifies current synchronization points:

- During initial network entry, session and flow information is synched to standby only after the Initial Service Flow (ISF) is created.
- After the ISF is up, each new flow created on the active is separately synched to the standby.
- Any updates to the service flow will cause the flow to be synched to the standby.
- Every time an address allocation happens, the flow will be synched to the standby.
- Any changes to the path on the active are synchronized to the standby
- During handoff, flow information is synchronized to the standby only after the handoff is complete. Cloned flows are not synched. New flows created on the active as a result of handoff are synchronized to standby by a FLOW UPDATE message that carries modified parameters as result of handoff.
- Flow synchronization after the transmission of an interim accounting request from the active. This causes FLOW UPDATE messages to be sent from active to standby, and the necessary message carries accounting counters that are sent to AAA as a part of interim accounting update.

Configuring Session Redundancy

The following configuration tasks are required before you can configure session redundancy:

- Configure HSRP on the interface.
- Configure redundancy inter-device
- Configure SCTP for RF Check pointing
- Configure Network Time Protocol (NTP) server
- Configure AAA on the active BWG and standby BWG

To configure session redundancy on the BWG, perform the following tasks:

	Command	Purpose

Step 1	`Router#interface FastEthernet0/1`
	`  description BS-If`
	`  ip address 9.11.44.147 255.255.255.0`
	`  standby 100 ip 9.11.44.100`
	`  standby 100 name CORE`
		Configures HSRP on the interface.

Step 2	`Router# redundancy inter-device` `  scheme standby CORE`	Enters inter-device configuration mode, which allows you to enable and protect Stateful Switchover (SSO) traffic.

	Command	Purpose

Step 3	`Router#ipc zone default`
	`association 1`
	`no shutdown`
	`protocol sctp`
	`local-port 5000`
	`local-ip 9.11.44.147`
	`remote-port 5000`
	`remote-ip 9.11.44.159`
		Configures SCTP for RF Check pointing.

Step 4	`Router#config terminal`
	`Enter configuration commands, one per line. End with CNTL/Z.`
	`Router(config)#ntp server 129.237.32.2`
	`Router(config)#^Z`
		(Recommended) - The command **ntp server**, followed by the IP address or hostname of the NTP server, is used to configure your router to use an existing NTP server

Step 5	`Router(config)#ip radius source-interface Loopback` *`Loopback number`*
	
	and configure the loopback interface on your router as follows:
	`interface Loopback0`
	`ip address 192.168.0.250 255.255.255.255`
		Configuring **ip radius source-interface Loopback** on both BWGs enables a AAA server to view two BWGs as a single entity.

Step 6	`Router(config)#` **`wimax agw redundancy`**	Enables session redundancy on the BWG.
Step 7	`Router(config)#` **`subscriber redundancy rate 500 1`**	Specifies the sync rate for SR.

Configuration Example

This configuration is for AAA only.

On the Active BWG

```
------------------------------------------------------------

!
interface Loopback192
 ip address 192.168.0.70 255.255.255.255
!
!
aaa group server radius car-sg
 server 1.8.70.99 auth-port 1812 acct-port 1813
!
aaa authentication dot1x car_auth_list group car-sg
aaa accounting network car_acct_list start-stop group car-sg
!
!
ip radius source-interface Loopback192
radius-server host 1.8.70.99 auth-port 1812 acct-port 1813
radius-server key r6AAA
radius-server vsa send accounting wimax
radius-server vsa send authentication wimax
!
```

On the Standby BWG

```
------------------------------------------------------------


!
interface Loopback192
 ip address 192.168.0.70 255.255.255.255
```

```
!
!
aaa new-model
!
!
aaa group server radius car-sg
 server 1.8.70.99 auth-port 1812 acct-port 1813
!
aaa authentication dot1x car_auth_list group car-sg
aaa accounting network car_acct_list start-stop group car-sg
!
!
ip radius source-interface Loopback192
radius-server host 1.8.70.99 auth-port 1812 acct-port 1813
radius-server key r6AAA
radius-server vsa send accounting wimax
radius-server vsa send authentication wimax
```

Sample Configuration of BWG: Active

```
           interface GigabitEthernet0/0.70
              description to AAA/DHCP
 encapsulation dot1Q 70
 ip address 1.8.70.147 255.255.255.0
 standby 70 ip 1.8.70.70
 standby 70 follow P7_REDUNDANCY
```

Note Please reload the BWG if it suffers a time-zone change.

This configuration example includes information about DHCP:

```
interface Loopback102
    ip address 102.0.0.1 255.255.255.0
  !
   user-group domain eaptls.com2
   aaa accounting method-list AAA-ACC1
   aaa authentication method-list AAA-AUTHN1
   dhcp gateway address 102.0.0.1
   dhcp server primary 27.0.0.8
   service-flow pre-defined isf profile sf3
   service-flow pre-defined secondary 1 profile sf4
   vrf VRF_2
```

Authentication

A subscriber is authenticated using EAP on the active before the sessions/flows are recreated on the standby. The associated MSK, AK context and other credentials need to be transferred to the standby, along with the session stateful data. If geographic redundancy is deployed, this data must be protected. If the standby becomes active after a switchover, and if the same subscriber is re-authenticated on the new active, it follows the same authentication procedure as on the previous active.

Accounting

The accounting start, stop and interim update are only sent from the active. The standby never sends accounting records until it becomes active.

As part of the session/flow recreation on the standby, the IOS AAA database is populated with accounting records for each session/flow. For example, the “class” attribute and accounting session ID are synched from the active to the standby, and are saved to the related accounting record. This ensures that once the standby becomes active, it can send accounting records with the right info.

Synchronization of accounting counters is a function of the AAA interim accounting update feature. If the AAA interim accounting update feature is enabled, then the active BWG sends accounting records to AAA server. And the same event is used as a trigger to initiate a FLOW UPDATE event (which carries accounting counters the same as were sent to AAA server). Conversely, if this feature is disabled on the active, since there is not going to be an accounting update to AAA, there is an absence of triggers to send the accounting update synchronization message to standby. By itself, the BWG SR feature does not implement triggers to synchronize accounting counters.

The accounting session ID is a key attribute used in accounting events (start, stop, interim) and is used to collaborate records on the AAA server. It is a 4-byte unassigned integer, and is assigned uniquely within a ASNWG and increased sequentially until it rolls over. To ensure the new active can continue to generate unique accounting session IDs upon switchover, the new accounting session ID starts from the latest accounting session ID on the prior active.

Subscriber IP Address

Currently, the subscriber IP address is assigned by the DHCP server and a host route is inserted for it. When the standby recreates the subscriber session, the same host route is also inserted on the standby. The standby will not relay any DHCP messages between the DHCP client and the server until it becomes active.

QoS

For BWG Release 1.0 and above, after a flow is created and the QoS parameters for the flow are sent to the BS, the BWG active synchronizes all the QoS parameters to the standby. Out of all of the parameters, the DSCP code for a flow synched to the standby is used to mark the packets once it becomes active.

Statistics and Counters

Statistics and counters are not synched to the standby. Instead, the standby rebuilds them as it processes stateful data from the active to create, modify, and delete sessions/flows. For example, the number of sessions/flows on the standby is updated as the standby processes session/flow creation and deletion. The number of received R6 messages on the standby is accumulated from the moment it becomes active and starts to receive R6 messages.

BWG Load Balancing

When a load balancer is running, it uses the loading information of all the BWGs to select one of them, and forwards an incoming NetEntry message from the BS (with regard to a SS/MS) to the selected BWG.

When Dynamic Feedback Protocol (DFP) is configured, an active BWG periodically sends its loading information to the load balancer. A standby BWG does not send feedback and does not have accurate loading information because it does not process R6 messages and handle user traffic. Once a standby becomes active, it gradually builds accurate load as it processes R6 messages and handles user traffic. So there is an adjusting period before it can send back feedback about its current accurate load.

Data Path and GRE

The data path for a flow is recreated on the standby. The GRE keys for both the upstream and downstream of a flow are synched to the standby. Upon switchover, the new active ensures that any new GRE key allocated locally must not collide with any in-use GRE keys allocated by the previous active.

Version Control

Upgrading from the immediate lower software version to a higher version is supported. Downgrading of software version is not supported. For example, if a redundant pair of BWGs runs on version A, and the next immediate software version is version B, then upgrading from version A to B is supported (but not from B to A). This requires that the higher version understands the stateful data synched from a lower version.

Limitations

The following limitations exist in the Session Redundancy feature on the BWG:

- Synchronization of Accounting Counters

  This is configurable, and depends upon the AAA interim accounting update feature to be enabled. If the AAA interim accounting feature is disabled, then the default behavior of BWG SR is to not synchronize accounting data/payload counters. This may lead to under charging. For example, if a switchover occurs between two consecutive interim updates, the counts accumulated on the active after the previous interim update are lost, since the new interim update sends only the counts that are accumulated on the new active. Additionally, a STOP could be lost right before the switchover.

Note Signaling counters are not synched.

Note For a standalone system, current AAA/Radius counters work accurately. However, when Session Redundancy is enabled, the flow (or session in terms of radius) age can be incorrect if relied upon the current counters. An additional attribute will now be sent from the ASN-GW called "session_elapsed_time" which will reflect the number of seconds since the particular flow started.

- Missing of a Session on the Standby

  Although SCTP provides reliable transport, the stateful data used to replicate a session can be lost due to congestion or max retrials. In this case, the session is not recreated on the standby. In case there is a switchover, this session is lost.

- Stale Session on the Standby

  For the same reason as above, if a stateful data for a session deletion is lost, then the session is not deleted from the standby while it's gone on the active.

  – If there is no switchover before the next session creation of the same subscriber, it's expected that the next synching of creation of a new session for the same subscriber will clean up the stale session.

  – If there is a switchover, then the stale session hangs until cleanup by manual intervention or by features like idle/session timeout.

- Mid-call Abort

  If a call setup is in progression but before reaching the first synching point and if there is a switchover, the call setup is aborted, and the subscriber has to retry the call.

Switchover

When switchover occurs, a trap is generated and sent to the NMS system to indicate that the active unit has failed, and the standby has taken over as active. The following behavior is expected:

- Any new GRE key allocated locally must not collide with any in-use GRE keys allocated by the previous active.
- Any new accounting session ID allocated locally must not collide with any in-use accounting session ID allocated by the previous active.
- DHCP relay for a new session is forwarded to a configured DHCP server.
- Some of the statistics will have a fresh start.
- DFP load is rebuilt and sent to the load balancer.

The following list identifies events which will cause a switchover:

- Router reload/crash because of reasons like software crash, CPU hogging, etc.
- HSRP tracks interfaces based on the configuration. On detecting interface flap <on-off transition> HSRP will enforce reload current active which will cause switchover of activity
- Manual intervention to switch activity from current active router to redundant hot standby. This can be accomplished using the following commands:

  – **redundancy switch-activity force**

    This command is used to switch activity from current active to current hot standby. Issuing the command causes the current router to reload, the current hot standby to become active, and when the current active router comes back up it assumes the role of hot standby.

  – **reload**

    This is normal router reload command that causes switchover. The current active router will reload, and the current hot standby will become active.

BWG Load Balancing

The purpose of load balancing is scalability of the BWG without distributing intelligence across base stations. This scalability is provided by load balancing across a set of BWGs, while representing the cluster as a single BWG from the perspective of the BS. Thus, the base station will have a single point of contact. And any new BWG that is added to the system will not impact the base station provisioning.

Note Server Load Balancing and Session Redundancy are only available on Cisco 7600 SAMI platform.

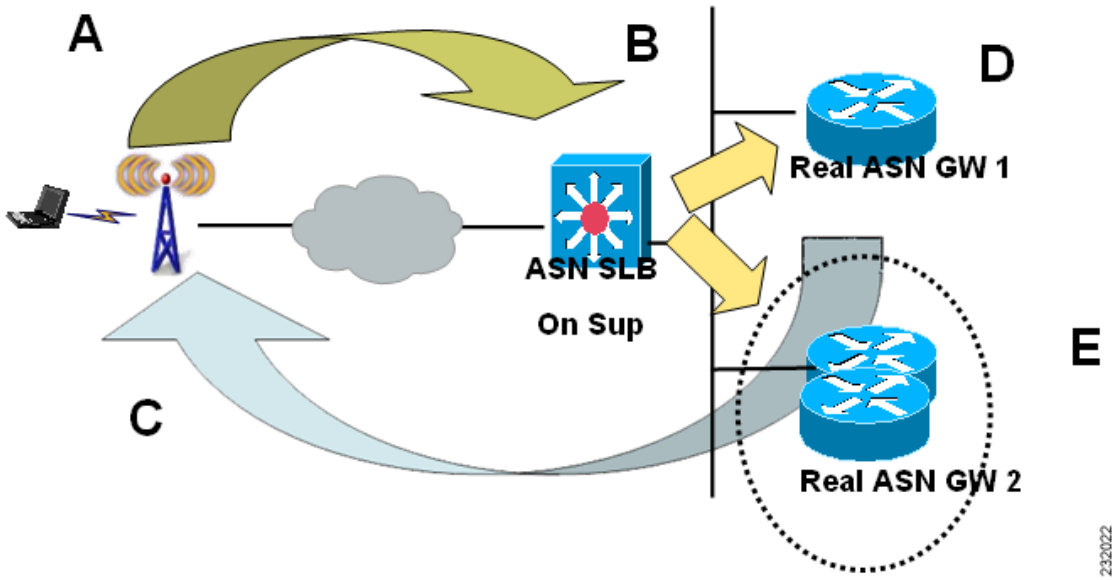
BWG Load Balancing is based on the IOS Server Load Balancing (SLB) feature. BSs are configured with the virtual IP address of the SLB as the BWG ID. The BWG selection flow for load balancing is illustrated below. Both dispatch mode and directed mode are supported. DFP is supported for the SLB to discover the load on the real BWGs.

Note In Release 1.0 and above, the SLB sticky feature and BWG handover call flows are not supported.

The session created on SLB, when the initial context request is processed, is maintained for a configurable time period to handle the re-transmission. During this period, if a re-transmission of context request is detected for a given MS/SS, SLB directs the re-transmission request to the same real BWG, that was selected for the first context request.

DFP is supported for the SLB to discover the load on the real BWGs. Each real BWG has a limit on the number of maximum sessions it supports. Real BWG calculated load on itself is based on the existing number of sessions versus the maximum sessions that it can support, memory usage, and bandwidth usage and reports the load to SLB. SLB directs the initial context request to one of the real BWGs based on either the round robin or least connections method. An BWG will not accept any more sessions if its load as calculated by DFP is 100%. Thus, this mechanism also supports CAC.

Figure 2-2 Server Load Balancing on the BWG



BWG Selection

- During Initial Network Entry phase, the BS sends the NetEntry MS Pre-Attachment Request corresponding to the SS/MSS to the BWG configured as the default.
- This BWG sends the NetEntry MS Pre-Attachment Response to the BS. The response may contain the IP address of an alternate Authenticator ID that can handle subsequent transactions corresponding to the SS/MSS. The BS, on receiving the NetEntry MS Pre-Attachment Response, sends the NetEntry MS State Change Ack to complete the transaction.
- All subsequent transactions corresponding to the SS/MSS occur between the BS and the BWG specified in the NetEntry MS Pre-Attachment Response Message.

Modes of Operation

There are two operation modes on the BWG:

- Dispatched Mode— In this mode packets are sent to the real server without any change to the original packet. A loopback is configured in the real server with an IP equal to virtual IP, and it replies back with virtual IP address as the source address.
- Directed Mode—The packet's destination IP address is rewritten to choose the BWG's IP address, and no loopback with the virtual ip address is configured on the BWG.

In both modes the selected BWG sends the pre-attachment response.

Configuring Load Balancing

This section lists configuration details regarding server load balancing. These configuration details are mainly for Directed Mode unless otherwise specified.

Load Balancing Configuration Task List

This section lists the tasks used to configure load balancing. Required and optional tasks are indicated.

1. On the Cisco IOS SLB, complete the following tasks:
   a. Configuring a Server Farm and Real Server, (Required)
   b. Configuring a Virtual Server, (Required)
   c. Configuring DFP Support, (Optional, but recommended)
2. On the real BWG, complete the following tasks:
   a. Configuring a Loopback Interface for SLB, (Required if using dispatched mode)
   b. Configuring DFP Support on the BWG, (Optional, but recommended)

Configuring Cisco IOS SLB for Load Balancing

This section describes how to configure a Server Farm and a Real Server. To configure a Cisco IOS SLB server farm, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router-SLB(config)# ip slb serverfarm serverfarm-name Router(config-slb-sfarm)#`	Adds a server farm definition to the Cisco IOS SLB configuration, and enters server farm configuration mode.
Step 2	`Router-SLB(config-slb-sfarm)# nat server`	Configures NAT server address translation mode on the server farm.
Step 3	`Router-SLB(config-slb-sfarm)# real` *ip-address* [*port*]	Identifies a real BWG as a member of a server farm, using the IP address of the BWG's virtual template interface, and enters real server configuration mode.
Step 4	`Router-SLB(config-slb-real)# weight` *weighting-value*	(Optional) Specifies the real server's workload capacity relative to other servers in the server farm. **Note** If you use DFP, the static weights you define using the **weight (server farm)** command are overridden by the weights calculated by DFP. If DFP is removed from the network, Cisco IOS SLB reverts to the static weights.
Step 5	`Router-SLB(config-slb-real)# in service`	Enables the real server for use by Cisco IOS SLB.

Sample Configuration

```
ip slb serverfarm ASNGW-SR-SF
       nat server
 probe PINGPROBE
        !
 real 11.11.11.50
   weight 0
          inservice
         !
         real 11.11.11.70
           weight 0
                inservice
```

Configuring Real BWG

Configuring the BWG for Load Balancing

To configure load balancing on the BWG, complete the tasks in the following sections:

- Configuring a Loopback Interface for SLB,
- Configuring the BWG as a DFP Agent, (Optional, but recommended)

Configuring a Loopback Interface for SLB

To enable load balancing, a loopback interface must be configured with the same IP address as the virtual server on the Cisco IOS SLB on each BWG in a farm.

To create a loopback interface, use the following commands, beginning in global configuration mode:

	Command	Description
Step 1	`Router(config)# interface loopback` *number*	Creates a loopback interface. A loopback interface is a virtual interface that is always up
Step 2	`Router(config-if)# ip address ip-address mask`	Assigns an IP address to the loopback interface.

Configuring the BWG as a DFP Agent

To define the port number to be used by the DFP manager (the Cisco IOS SLB in this instance) to connect to the DFP agent; enter the following commands in order, beginning in global configuration mode:

	Command	Description
Step 1	`Router-ASNGW(config)# ip dfp agent agw`	Identifies a DFP agent subsystem and initiates DFP agent configuration mode.
Step 2	`Router- ASNGW(config-dfp)# port` *port-number*	Defines the port number to be used by the DFP manager to connect to the DFP agent.
Step 3	`Router- ASNGW(config-dfp)# inservice`	Enables the DFP agent for communication with a DFP manager. A DFP agent is inactive until both of the following conditions are met: • The DFP agent has been enabled using the **inservice** (DFP agent) command. • The client subsystem has changed the DFP agent

Sample Configuration

```
ip dfp agent agw
    port 5555
    inservice
```

To configure load balancing on the BWG, perform the following task:

	Command	Purpose
Step 1	`Router# virtual x.y.z.m udp port no service asnr6`	Enables load balancing on the BWG. The virtual server configuration commands are extended for ASN support.
Step 2	`Router# idle asnr6 request timer value in seconds`	Sets the idle timer request for the BWG.

BWG Configuration Example

Please note that following sample configuration applies only to SAMI platform.

SLB Related Configuration of Supervisor Card

```
7606-R6-sup720#show running-configuration | section slb
ip dfp agent slb
 port 5555
ip slb probe PINGPROBE ping
 interval 3
 faildetect 3
ip slb serverfarm ASNGW-SR-SF
 nat server
 probe PINGPROBE
 !
 real 11.11.11.50
  weight 0
  inservice
 !
 real 11.11.11.70
  weight 0
  inservice
ip slb vserver V-ASNGW-SR
 virtual 50.70.80.100 udp 2231 service asn r6
 serverfarm ASNGW-SR-SF
 idle asn r6 request 90
 inservice
ip slb dfp
 agent 11.11.11.50 5555 10 0 5
 agent 11.11.11.70 7777 10 0 5
7606-R6-sup720#
```

Sample configuration of a real BWG for above configuration of Supervisor card.

```
bwg-real-s4p5# show running-configuration | section dfp
ip dfp agent agw
 port 5555
 inservice
bwg-real-s4p5#

asngw-real-s4p7#sh runn | section dfp
ip dfp agent agw
 port 7777
 inservice
bwg-real-s4p7#
```

Verifying the Configuration

To verify that load balancing is enabled on the BWG, perform the following tasks:

	Command	Purpose
Step 1	`Router# show ip slb session asnr6 [detail]`	Displays statistics related to load balancing R6 sessions.
Step 2	`Router# show ip slb vserver detail`	Displays vserver statistics in detail.

Configuration Example

Here is a sample configuration for SLB **show** commands on the BWG:

```
7606-R6-sup720#show ip slb sessions asn r6

vserver         MSID             Base Station     real             state
---------------------------------------------------------------------------
7606-R6-sup720#show ip slb sessions asn r6

vserver         MSID             Base Station     real             state
---------------------------------------------------------------------------
V-ASNGW-SR      0000AAAAC38ECCCC 50.35.50.1       11.11.11.50      ASNR6_ESTAB
V-ASNGW-SR      0000AAAAC392CCCC 50.35.50.1       11.11.11.50      ASNR6_ESTAB
V-ASNGW-SR      0000AAAAC396CCCC 50.35.50.1       11.11.11.50      ASNR6_ESTAB
V-ASNGW-SR      0000AAAAC39ACCCC 50.35.50.1       11.11.11.50      ASNR6_ESTAB
V-ASNGW-SR      0000AAAAC39ECCCC 50.35.50.1       11.11.11.50      ASNR6_ESTAB
< S N I P P E D >

7606-R6-sup720#show ip slb vserver detail

V-ASNGW-SR, state = OPERATIONAL, v_index = 7, interface(s) = <any>
  virtual = 50.70.80.100/32:2231, UDP, service = ASNR6, advertise = TRUE
  server farm = ASNGW-SR-SF, delay = 10, idle = 3600
  asnr6: request idle = 90, Parse error pkt drops= 56,
         Number of reject responses = 0
  sticky: <none>
  sticky: group id = 0
  synguard counter = 0, synguard period = 0
  conns = 101, total conns = 509069, syns = 0,  syn drops = 0
  standby group = None
7606-R6-sup720#show ip slb reals

real                  farm name        weight  state          conns
-------------------------------------------------------------------
11.11.11.50           ASNGW-SR-SF      92      OPERATIONAL    83
11.11.11.70           ASNGW-SR-SF      92      OPERATIONAL    18
7606-R6-sup720#show ip slb serv
7606-R6-sup720#show ip slb serverfarms

server farm      predictor           nat   reals   bind id  interface(s)
---------------------------------------------------------------------------
ASNGW-SR-SF      ROUNDROBIN          S     2       0        <any>
7606-R6-sup720#show ip slb sessions asn r6 de
7606-R6-sup720#show ip slb sessions asn r6 detail

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
   state = ASNR6_ESTAB, real = 11.11.11.50
   Key = 0000AAAAC38ECCCC, retry = 1

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
```

```
   state = ASNR6_ESTAB, real = 11.11.11.50
   Key = 0000AAAAC392CCCC, retry = 1

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
   state = ASNR6_ESTAB, real = 11.11.11.50
   Key = 0000AAAAC396CCCC, retry = 1

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
   state = ASNR6_ESTAB, real = 11.11.11.50
   Key = 0000AAAAC39ACCCC, retry = 1

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
   state = ASNR6_ESTAB, real = 11.11.11.50
   Key = 0000AAAAC39ECCCC, retry = 1

V-ASNGW-SR, client = 50.35.50.1:2231, virtual = 50.70.80.100:2231
   state = ASNR6_ESTAB, real = 11.11.11.50

< S N I P P E D >
7606-R6-sup720#
```

Configuring a Virtual Server

To configure a Cisco IOS SLB virtual server, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router-SLB(config)# ip slb vserver virtual_server-name`	Identifies a virtual server, and enters virtual server configuration mode.

Step 2	`Router-SLB(config-slb-vserver)# virtual ip-addr [netmask [group]] {esp | gre | protocol}`
	
	or
	`Router(config-slb-vserver)# virtual ip-addr [netmask [group]] {tcp | udp} [port | any] [service service]`
		Specifies the virtual server IP address, type of connection, and optional TCP or UDP port number, Internet Key Exchange (IKE) Internet Security Association and Key Management Protocol (ISAKMP) or Wireless Session Protocol (WSP) setting, and service coupling.

Step 3	`Router-SLB(config-slb-vserver)# serverfarm primary-farm [backup backup-farm [sticky]] [map map-id priority priority]`	Associates a real server farm with a virtual server. • **backup—**(Optional) Configures a backup server farm • **backup** *backup-farm* [**sticky**]—(Optional) Configures a backup server farm and optionally specifies that sticky connections are to be used in the backup server farm. • **map** *map-id* **priority** *priority*—(Optional) Associates an IOS SLB protocol map to a server farm and defines the priority for that map. Maps are searched based on priority. The lower the number, the higher the priority. **Note** Multiple instances of the **serverfarm** command are allowed if configured with the **map** keyword option. The default server farm (without the **map** keyword option) is limited to a single instance. **Note** To change map configurations the virtual server must be taken out of service. **Note** The NAT modes on the primary and backup server farms for each map must match.
Step 4	`Router-SLB(config-slb-vserver)# idle [request] duration`	(Optional) Specifies the minimum amount of time that Cisco IOS SLB maintains connection context in the absence of packet activity.
Step 5	`Router-SLB(config-slb-vserver)# inservice`	Enables the virtual server for use by Cisco IOS SLB.

Sample Configuration

```
Router-SLB(config)# ip slb vserver V-ASNGW-SR
Router-SLB(config-slb-vserver)# virtual 50.70.80.100 udp 2231 service asn r6
Router-SLB(config-slb-vserver)#serverfarm ASNGW-SR-SF
Router-SLB(config-slb-vserver)# idle asn r6 request 90
Router-SLB(config-slb-vserver)#inservice
```

Configuring DFP Support

You can define Cisco IOS SLB as a DFP manager, as a DFP agent for another DFP manager (such as Distributed Director), or as both at the same time. Depending on your network configuration, you might enter the commands for configuring Cisco IOS SLB as a DFP manager and the commands for configuring Cisco IOS SLB as a DFP agent on the same device or on different devices.

To configure Cisco IOS SLB as a DFP manager, and to identify a DFP agent with which Cisco IOS SLB can initiate connections, use the following commands, beginning in global configuration mode:

	Command	Description
Step 1	`Router-SLB(config)# ip slb dfp [password [0|7] password [timeout]]`	Configures DFP, supplies an optional password, and enters DFP configuration mode.
Step 2	`Router-SLB(config-slb-dfp)# agent ip_address port-number [timeout [retry_count [retry_interval]]]`	Identifies a DFP agent to which Cisco IOS SLB can connect.

Sample Configuration

```
Router-SLB(config) # ip slb dfp
Router-SLB(config-slb-dfp)# agent 11.11.11.50 5555 10 0 5
Router-SLB(config-slb-dfp)# agent 11.11.11.70 7777 10 0 5
```

SLB Stickiness Support

SLB for BWG supports load balancing of any R4 or R6 control plane messages. Release 1.0 and above supports basic load balancing for only the Pre-Attachment Message.

BWG Release 2.0 supports the following features:

- Any Wimax message types towards the BWG with or without sticky entries, both for R4 and R6 reference points.
- If “no sticky entry” is available, all Wimax R6/R4 messages to the Wimax port are load balanced based on the current DFP (or weight algorithms) to the specific “real” BWG.
- If there is a sticky MSID already present, the BWG SLB forwards any Wimax control plane messages to the respective “real” BWG.

Update Sticky

The BWG sends an update notification to the SLB. Once the authentication is completed, the BWG has the user name (NAI) for the MS. As soon as the ISF (first flow) is created, the BWG sends the sticky update to the SLB server, and includes the NAI value.

Deleting Stickiness

The following two scenarios cause the SLB to delete stickiness:

- The BGW signals when a specific subscriber session is deleted to the SLB, so that the sticky entry is removed.
- When the “real” BGW fails, all sticky entries corresponding to the real BWG are deleted.

Stateful Redundancy of SLB

To ensure reliability, the BWG SLB supports stateful switchover of the sticky entries, across the primary and standby supervisors.

Messages Between BWG and SLB

Sticky Update Notification

This message is used by the BWG to notify the SLB about the NAI update for the sticky.

Table 2-14 Sticky Update Notifcation

SRC IP	Virtual Template IP (real IP)	
DST IP	ASNLB's virtual IP	
UDP HDR	SRC_PORT	XXXX (?)
	DST_PORT	XXXX(?)
MSG HDR	MSG_TYPE	1
	MS ID (6 bytes)	(could be max 20 bytes, for the other GWs)
TLV	TYPE	1
	LENGTH	255 (Max)
	VALUE	NAI (abc@cisco.com)

Sticky Deletion Notification

This message is sent when the last PDP in the session gets deleted. This allows the SLB to delete the corresponding sticky entry.

Table 2-15 Sticky Deletion Notification

SRC IP	Virtual Template IP (real IP)	
DST IP	ASNLB's virtual IP	
UDP HDR	SRC_PORT	XXXX (?)
	DST_PORT	XXXX
MSG HDR	MSG_TYPE	2
	MSID (6 bytes)	

Configuring SLB Support

To configure the BWG to perform SLB with Stickiness, perform the following tasks:

	Command	Description
Step 1	`router(config)# wimax agw slb notify {update| delete | …}`	Configures the BWG to send notification to SLB, for example, on CAC failure, etc.
Step 2	`router(config)#wimax agw slb port` *port* `vserver` *vserver-ip-addr* `[next-hop ip` *ip_addr* `vrf` *vrf_name*`]`	Configures the SLB virtual server to which these notifications need to be sent. For session deletion/update notification, this command is required. Both, **next-hop** *ip address* and **vrf** *name*, are optional. In the absence of **next-hop** *ip address*, you must input a static route to reach the virtual server. The allowed port range is 49152-65535.

Lawful Intercept

Lawful Intercept (LI) ensures that Cisco meets worldwide LI requirements, including the support for CALEA (Communications Assistance for Law Enforcement Act).

The packet matching is based on the Mobile Subscriber Identity (MSID) of a given subject.

Configuring the BWG for Lawful Intercept

SNMP Host and User Setup

In order to set or view the variables in a MIB, you must first become an authorized user from an authorized host. Configure the following commands on the BWG to run Lawful Intercept.

1. Create a View Having Access to the Appropriate MIBs

	Command	Description

Step 1	`router#snmp-server view` *view name* `ciscoTap2MIB included`
	
	`snmp-server view` *view name* `ciscoMobilityTapMIB included`
		Configures the BWG to view set or view the variable in a MIB.

2. Create a Group Having Access to the View:

	Command	Description
Step 1	`router#snmp-server group` *group name*`> v3 priv read` *view name* `write` *view name* `notify` *view name*	Configures the BWG create a group that has access to a view.

3. Create a User who is a Member of the Group. You must create a user who has read and write privileges for the new group:

	Command	Description
Step 1	`router#snmp-server user` *`user name group name`* `v3 auth` *`sha/md5 auth password`* `priv` *`3des/aes/des priv password`*	Creates a user to have read and write privileges for a new group.

4. Create a Host from which the User will Connect. You must specify the host from which the user is allowed to connect the BWG:

	Command	Description
Step 1	`router#snmp-server host` *`IP address`* `version 3 priv` *`user name`*	Specifies the host from which the user is allowed to connect to the BWG.

5. Setup the Engine Identifier for testing purposes, even though one may not be required in a production environment:

	Command	Description
Step 1	`router#snmp-server engineID local` *`engine ID`*	Specifies the engine identifier.

Steps to Setup BWG LI

Here are the steps to set up BWG Lawful Intercept:

1. Setup the Mediation Device
2. Setup the generic stream
3. Setup the specific stream
4. Enable the generic stream

Setup Mediation Device

Set the following variables in the CISCO-TAP2-MIB from an authorized host:

Table 2-16 Relevant Mediation Device Variables

OID	Variable Name	Description
.1.3.6.1.4.1.9.9.399.1.1.2.1.2.x	DestAddressType	MD's address type (IPv4 or IPv6)
.1.3.6.1.4.1.9.9.399.1.1.2.1.3.x	DestAddress	The IP address of the MD in hex.
.1.3.6.1.4.1.9.9.399.1.1.2.1.4.x	DestPort	The port on the MD to which to send data.
.1.3.6.1.4.1.9.9.399.1.1.2.1.5.x	SrcInterface	The interface on the intercepting device from which to transmit intercepted data.
.1.3.6.1.4.1.9.9.399.1.1.2.1.10.x	TimeOut	The time at which this row and all related Stream Table rows should be automatically removed, and the intercept function cease. This **MUST** be set to a date in the future. The value should be entered in hex (e.g., 07D8 07 0F 0A 3B 0A 00 = 2008-07-16 10:59:10 00).

Table 2-16 Relevant Mediation Device Variables (continued)

.1.3.6.1.4.1.9.9.399.1.1.2.1.11.x	Transport	The protocol used in transferring the intercepted data to the MD.
.1.3.6.1.4.1.9.9.399.1.1.2.1.12.x	NotificationEnable	Boolean denoting whether this MIB should generate notifications about this table entry.
.1.3.6.1.4.1.9.9.399.1.1.2.1.13.x	Status	The status of the row. Used primarily to create, destroy, or active a given entry.

Other transport options are also available. They may require additional fields to be configured.

Setup Generic Stream

Set the following variables in the CISCO-TAP2-MIB from an authorized host:

Table 2-17 Relevant Generic Stream Variables

OID	Variable Name	Description
.1.3.6.1.4.1.9.9.399.1.2.1.1.2.x.y	Type	Identifies the specific tap type that will be associated with the generic stream.
.1.3.6.1.4.1.9.9.399.1.2.1.1.3.x.y	InterceptEnable	Set to true to activate the tap after a specific stream has been associated with this generic stream.
.1.3.6.1.4.1.9.9.399.1.2.1.1.6.x.y	Status	The status of the row. Used primarily to create, destroy, or active a given entry.

In our case, set the “Status” variable to 5, which denotes the “Create and Wait” status. Then, set the “Type” variable to 4 to denote the Mobility intercept stream. Finally, set the “InterceptEnable” variable to 2, which denotes false, until you associate a specific stream to the tap.

Setup the Specific Mobility Stream

Set the following variables in the CISCO-MOBILITY-TAP-MIB from an authorized host:

Table 2-18 Relevant Mobility Stream Variables

OID	Variable Name	Description
.1.3.6.1.4.1.9.9.672.1.1.2.1.1	CalledSubscriberIDType	The type of identification recorded in the CalledSubscriberID field. Defaults to UNKNOWN. Only UNKNOWN is supported in this release of the BWG.
.1.3.6.1.4.1.9.9.672.1.1.2.1.2	CalledSubscriberID	The identity of the party being contacted. Not supported in this release for the BWG.
.1.3.6.1.4.1.9.9.672.1.1.2.1.3	SubscriberIDType	The type of identification recorded in the SubscriberID. The default value is UNKNOWN, but only IMSI is supported in this BWG release.
.1.3.6.1.4.1.9.9.672.1.1.2.1.4	SubscriberID	The identity of the subscriber, whom we wish to tap.

Table 2-18 Relevant Mobility Stream Variables (continued)

.1.3.6.1.4.1.9.9.672.1.1.2.1.5	StorageType	Denotes whether the user wishes to store this row entry in volatile or nonvolatile memory. Only the VOLATILE option is supported on the BWG.
.1.3.6.1.4.1.9.9.672.1.1.2.1.6	Status	The status of the row. Used primarily to create, destroy, or active a given entry.

Enable the Generic Stream

Set the generic stream's "Status" variable to 1 to activate the row. Finally, set the generic stream's "InterceptEnable" to "true" to activate the tap.

Intercept Provisioning

The Intercepts are provisioned through SNMPv3.The provisioning occurs in three stages. First, the individual placing the intercepts must configure a valid Mediation Device (MD) by configuring the appropriate variables explained in the CISCO-TAP2-MIB. After the MD is configured, you must configure a generic stream, which is also described in the CISCO-TAP2-MIB. Finally, you must choose a specific stream that will be associated with the generic stream.

In the case of the BWG, the Mobility Stream defined by the CISCO-MOBILITY-TAP-MIB is the specific stream. Currently, the BWG only supports tapping based on the Mobile Subscriber ID for the Mobility Stream. Thus, when configuring the Mobility Stream tap, set the SubscriberID field to the desired MSID, whose traffic you want to intercept. Then, set the SubscriberIDType field to "MSID".

Packet Intercept

Conceptually, the Lawful Intercept requirements on the BWG look like packet replication. After a subscriber/host is identified, the packets for this subscriber/host are decapsulated and the IP packets are replicated. The original packet is then sent to the original destination. The replicated and encapsulated packet is sent to the mediation device. The BWG does not look into the type of the packet, just replicates the received packets in either direction and sends the replicated packets to the mediation device. Thus, the BWG could replicate voice as well as data packets.

WiMAX NWG does not define how the replicated packets should be encapsulated. The CISCO-TAP2-MIB allows you to configure the MD to encapsulate and transport the replicated packets using PacketCable UDP, RTP with Nack resilience, TCP with head of line blocking, and SCTP with head of line blocking. The current implementation of the BWG uses UDP (PacketCableTM) as the encapsulation scheme.

SNMP Options Not Currently Supported for Lawful Intercept

Currently the BWG does not support the Debug User options in the CISCO-TAP2-MIB. Specifically, the following objects in the CISCO-TAP2-MIB are not currently supported:

- cTap2DebugUserTable
- cTap2DebugUserEntry
- CTap2DebugUserEntry
- cTap2DebugUserName
- cTap2DebugUserTimeout
- cTap2DebugUserStorageType
- cTap2DebugUserStatus

Configuring the BWG

This section describes various other configuration tasks that you need to perform to make the BWG function properly. It includes the following topics:

- Configuring SNMP on the BWG
- MIB Support

Configuring SNMP on the BWG

This section provides information on how to configure Simple Network Management Protocol (SNMP) on the BWG. It contains the following configuration tasks:

- Configuring SNMP Access in Routers
- Configuring SNMP-Server Host
- Configuring SNMP-Server Trap-Source
- Configuring SNMP Traps

Configuring SNMP Access in Routers

To set up the community access string to permit access to the Simple Network Management Protocol (SNMP), perform the following tasks:

	Command	Purpose
Step 1	`router(config)# snmp-server community string [view view-name] [ro | rw] [ipv6 nacl] [access-list-number]`	Sets up the community access string to permit access to the Simple Network Management Protocol (SNMP). To remove the specified community string, use the **no** form of the command.
	string	Community string that consists of 1 to 32 alphanumeric characters and functions much like a password, permitting access to SNMP. Blank spaces are not permitted in the community string. **Note** The @ symbol is used for delimiting the context information. Avoid using the @ symbol as part of the SNMP community string when configuring this command.
	view	(Optional) Specifies a previously defined view. The view defines the objects available to the SNMP community.
	view-name	(Optional) Name of a previously defined view.
	ro	(Optional) Specifies read-only access. Authorized management stations can only retrieve MIB objects.
	rw	(Optional) Specifies read-write access. Authorized management stations can both retrieve and modify MIB objects.
	ipv6	(Optional) Specifies a IPv6 named access list. (Optional) IPv6 named access list.
	nacl	(Optional) Integer from 1 to 99 that specifies a standard access list of IP addresses or a string (not to exceed 64 characters) that is the name of a standard access list of IP addresses allowed access to the SNMP agent.
	access-list-number	Alternatively, an integer from 1300 to 1999 that specifies a list of IP addresses in the expanded range of standard access list numbers that are allowed to use the community string to gain access to the SNMP agent.

Configuring SNMP-Server Host

To specify the recipient of an Simple Network Management Protocol notification operation, perform the following tasks:

	Command	Purpose
Step 1	`router(config)# snmp-server host host-addr [traps | informs] [version {1 | 2c | 3 [auth | noauth | priv]}] community-string [udp-port port] [notification-type]`	Specifies the recipient of an Simple Network Management Protocol notification operation. To remove the specified host, use the **no** form of this command.

This command is disabled by default. No notifications are sent. If you enter this command with no keywords, the default is to send all trap types to the host. No informs will be sent to this host.

If no **version** keyword is present, the default is version 1. The **no snmp-server host** command with no keywords will disable traps, but not informs, to the host. In order to disable informs, use the **no snmp-server host informs** command.

host-addr	Name or Internet address of the host (the targeted recipient).
traps	(Optional) Send SNMP traps to this host. This is the default.
informs	(Optional) Send SNMP informs to this host.
version	(Optional) Version of the Simple Network Management Protocol (SNMP) used to send the traps. Version 3 is the most secure model, as it allows packet encryption with the **priv** keyword. If you use the **version** keyword, one of the following must be specified: **1 —**SNMPv1. This option is not available with informs. **2c** —SNMPv2C. **3** —SNMPv3. The following three optional keywords can follow the version 3 keyword: • **auth** (Optional). Enables Message Digest 5 (MD5) and Secure Hash Algorithm (SHA) packet authentication • **noauth** (Default). The noAuthNoPriv security level. This is the default if the [auth | noauth | priv] keyword choice is not specified. • **priv** (Optional). Enables Data Encryption Standard (DES) packet encryption (also called “privacy”).
community-string	Password-like community string sent with the notification operation. Though you can set this string using the **snmp-server host** command by itself, we recommend you define this string using the **snmp-server community** command prior to using the **snmp-server host** command.
udp-port *port*	UDP port of the host to use. The default is 162.

notification-type	(Optional) Type of notification to be sent to the host. If no type is specified, all notifications are sent. The notification type can be one or more of the following keywords: • **bgp—**Sends Border Gateway Protocol (BGP) state change notifications. • **config—**Sends configuration notifications. • **dspu—**Sends downstream physical unit (DSPU) notifications. • **entity—**Sends Entity MIB modification notifications. • **envmon—**Sends Cisco enterprise-specific environmental monitor notifications when an environmental threshold is exceeded. • **frame-relay—**Sends Frame Relay notifications. • **hsrp—**Sends Hot Standby Routing Protocol (HSRP) notifications. • isdn—Sends Integrated Services Digital Network (ISDN) notifications. • llc2—Sends Logical Link Control, type 2 (LLC2) notifications. • **repeater—**Sends standard repeater (hub) notifications. • rsrb—Sends remote source-route bridging (RSRB) notifications. • **rsvp—**Sends Resource Reservation Protocol (RSVP) notifications. • **rtr—**Sends SA Agent (RTR) notifications. • **sdlc—**Sends Synchronous Data Link Control (SDLC) notifications. • sdllc—Sends SDLLC notifications. • **snmp—**Sends Simple Network Management Protocol (SNMP) notifications (as defined in RFC 1157). • **stun—**Sends serial tunnel (STUN) notifications. • **syslog—**Sends error message notifications (Cisco Syslog MIB). Specify the level of messages to be sent with the **logging history level** command. • **tty—**Sends Cisco enterprise-specific notifications when a Transmission Control Protocol (TCP) connection closes. • **x25—**Sends X.25 event notifications.

Configuring SNMP-Server Trap-Source

To specify the interface (and the corresponding IP address) that an Simple Network Management Protocol trap should originate from, perform the following task:

	Command	Purpose
Step 1	`router(config)# snmp-server trap-source interface` *interface*	Specifies the interface (and hence the corresponding IP address) that an Simple Network Management Protocol trap should originate from. Use the no form of the command to remove the source designation. The default setting is that no interface is specified. Interface from which the SNMP trap originates. The argument includes the interface type and number in platform-specific syntax.

Configuring SNMP Traps

To enable the router to send Simple Network Management Protocol traps or informs (SNMP notifications), perform the following task:

	Command	Purpose
Step 1	`router(config)# snmp-server enable traps [notification-type] [notification-option]`	Enables the router to send Simple Network Management Protocol traps or informs (SNMP notifications). The **no** form of this command disables SNMP notifications. This command is disabled by default. Most notification types are disabled. However, some notification types cannot be controlled with this command. If you enter this command with no *notification-type* keywords, the default is to enable all notification types controlled by this command (Exception: ATM PVC notifications are not enabled unless the atm pvc keywords are used.)

notification- type	(Optional) Type of notification to enable. If no type is specified, all notifications available on your device are sent. The notification type can be one of the following keywords: • **atm pvc—**Enables ATM permanent virtual circuit (PVC) notifications. When the **atm pvc** keywords are used, you can specify additional *notifcation-option* values (see below). The ATM PVC failure notifcation is defined as "enterprise 1.3.6.1.4.1.9.10.29.2.1; 1 atmIntfPvcFailuresTrap" in the CISCO-IETF-ATM2-PVCTRAP-MIB. ATM PVC failure notifications are sent when a PVC on an ATM interface fails or leaves the UP operational state. Only one trap is generated per hardware interface, within the specified interval defined by the interval keyword (stored as the atmIntfPvcNotificationInterval in the MIB). If other PVCs on the same interface go DOWN during this interval, traps are generated and held until the fail-interval has elapsed. Once the interval has elapsed, the traps are sent if the PVCs are still DOWN. No notifications are generated when a PVC returns to the UP state after having been in the DOWN state. If you need to detect the recovery of PVCs, you must use the SNMP management application to regularly poll your router. • **bgp—**Enables Border Gateway Protocol (BGP) state change notifications. • **config—**Enables configuration notifications. • **entity—**Enables Entity MIB modification notifications. • envmon—Enables Cisco enterprise-specific environmental monitor notifications when an environmental threshold is exceeded. When the **envmon** keyword is used, you can specify a *notification-option* value. • **frame-relay—**Enables Frame Relay notifications. • **hsrp—**Enables Hot Standby Routing Protocol (HSRP) notifications. • isdn—Enables Integrated Services Digital Network (ISDN) notifications. When the **isdn** keyword is used, you can specify a *notification-option* value. • repeater—Enables Ethernet hub repeater notifications. When the **repeater** keyword is selected, you can specify a *notification-option* value. • **rsvp—**Enables Resource Reservation Protocol (RSVP) notifications. • **rtr—**Enables Service Assurance Agent / Response Time Reporter (RTR) notifications.

notification- type	• **snmp [authentication]—**Enables RFC 1157 SNMP notifications. Note that use of the **authentication** keyword produces the same effect as not using the **authentication** keyword. Both the **snmp-server enable traps snmp** and **snmp-server enable traps snmp authentication** forms of this command will globally enable (or, if using the **no** form, disable) the following SNMP traps: – authentication Failure – linkUp – linkDown – coldstart (This behavior is corrected in Cisco IOS Release 12.1(3)T and 12.0(20)S.) • **syslog—**Enables error message notifications (Cisco Syslog MIB). Specify the level of messages to be sent with the **logging history level** command.
notification- option	(Optional) • **atm pvc [interval** *seconds*] [**fail-interval** *seconds*]— The optional **interval** *seconds* keyword/argument combination specifies the minimum period between successive traps, in the range from 1 to 3600. Generation of PVC traps is dampened by the notification interval in order to prevent trap storms. No traps are sent until the interval lapses. The default interval is 30. —The optional fail-interval seconds keyword/argument combination specifies the minimum period for storing the failed time stamp, in the range from 0 to 3600. The default fail-interval is 0. • **envmon** [**voltage | shutdown | supply | fan | temperature**]—When the **envmon** keyword is used, you can enable a specific environmental notification type, or accept all notification types from the environmental monitor system. If no option is specified, all environmental notifications are enabled. The option can be one or more of the following keywords: **voltage**, **shutdown**, **supply**, **fan**, and **temperature**. • **isdn** [**call-information | isdn u-interface**]—When the **isdn** keyword is used, you can specify the **call-information** keyword to enable an SNMP ISDN call information notification for the ISDN MIB subsystem, or you can specify the **isdnu-interface** keyword to enable an SNMP ISDN U interface notification for the ISDN U interface MIB subsystem. • **repeater** [**health | reset**] —When the **repeater** keyword is used, you can specify the repeater option. If no option is specified, all repeater notifications are enabled. The option can be one or more of the following keywords: • **health—**Enables IETF Repeater Hub MIB (RFC 1516) health notification. • **reset—**Enables IETF Repeater Hub MIB (RFC 1516) reset notification.

Configuration Examples

The following example enables the router to send all traps to the host specified by the name "myhost.cisco.com", using the community string defined as "public":

```
snmp-server enable traps
snmp-server host myhost.cisco.com public
```

The following example enables the router to send Frame Relay and environmental monitor traps to the host "myhost.cisco.com" using the community string "public":

```
snmp-server enable traps frame-relay
snmp-server enable traps envmon temperature
snmp-server host myhost.cisco.com public
```

The following example will not send traps to any host. The BGP traps are enabled for all hosts, but the only traps enabled to be sent to a host are ISDN traps (which are not enabled in this example).

```
snmp-server enable traps bgp
snmp-server host bob public isdn

router(config)# [no] logging snmp-authfail
```

Note Using the **logging snmp-authfail** command enables all SNMP authentication failure logging messages. The **no** version of this command will disable the logging of authentication failure messages.

Note If you do not use the SNMP management tools of the router to monitor PPP sessions, you can prevent the virtual-access sub interfaces from being registered with the SNMP functionality of the router and using memory by using the no virtual-template snmp command. For example:
router(config)# [**no**] **virtual-template snmp**

SNMP Configuration Examples on the BWG

Logging

```
=========

!
logging snmp-authfail
logging queue-limit 100
logging buffered 1000000
enable password lab
!
```

Virtual Template

```
==============

!
no virtual-template snmp
!
```

SNMP Traps

==========

```
snmp-server community private RW
snmp-server trap-source GigabitEthernet0/2
snmp-server enable traps snmp authentication linkdown linkup coldstart warmstart
snmp-server enable traps vrrp
snmp-server enable traps ds1
snmp-server enable traps tty
snmp-server enable traps eigrp
snmp-server enable traps casa
snmp-server enable traps cnpd
snmp-server enable traps pw vc
snmp-server enable traps syslog
snmp-server enable traps isdn call-information
snmp-server enable traps isdn layer2
snmp-server enable traps isdn chan-not-avail
snmp-server enable traps isdn ietf
snmp-server enable traps ds3
snmp-server enable traps atm subif
snmp-server enable traps channel
snmp-server enable traps ima
snmp-server enable traps srp
snmp-server enable traps flash insertion removal
snmp-server enable traps hsrp
snmp-server enable traps config
snmp-server enable traps entity
snmp-server enable traps fru-ctrl
snmp-server enable traps cpu threshold
snmp-server enable traps config-copy
snmp-server enable traps envmon
snmp-server enable traps aaa_server
snmp-server enable traps agw
snmp-server enable traps bgp
snmp-server enable traps ospf state-change
snmp-server enable traps ospf errors
snmp-server enable traps ospf retransmit
snmp-server enable traps ospf lsa
snmp-server enable traps ospf cisco-specific state-change nssa-trans-change
snmp-server enable traps ospf cisco-specific state-change shamlink interface-old
snmp-server enable traps ospf cisco-specific state-change shamlink neighbor
snmp-server enable traps ospf cisco-specific errors
snmp-server enable traps ospf cisco-specific retransmit
snmp-server enable traps ospf cisco-specific lsa
snmp-server enable traps pim neighbor-change rp-mapping-change invalid-pim-message
snmp-server enable traps ipmulticast
snmp-server enable traps mvpn
snmp-server enable traps msdp
snmp-server enable traps rsvp
snmp-server enable traps frame-relay
snmp-server enable traps frame-relay subif
snmp-server enable traps ipsla
snmp-server enable traps stun
snmp-server enable traps dlsw
snmp-server enable traps bstun
snmp-server enable traps pppoe
snmp-server enable traps l2tun session
snmp-server enable traps l2tun pseudowire status
snmp-server enable traps ipmobile
snmp-server enable traps frame-relay multilink bundle-mismatch
snmp-server enable traps dsp card-status
snmp-server enable traps dsp oper-state
snmp-server enable traps event-manager
```

```
snmp-server enable traps alarms informational
snmp-server host 171.71.129.34 public
```

MIB Support

The BWG supports a Management Information Base (MIB) that describes objects that enable users and network management to remotely monitor the BWG using SNMP commands. The BWG supports two separate MIBs:

One contains global system information and parameters, base-station information, subscriber, flow, traffic and trap notification information.

The second contains information about the R6 signaling protocol information used between the base-station and the BWG. This includes overall gateway R6 information, and information per base-station.

The BWG MIB variables are not synchronized across a fail-over. Many MIB variables can be recreated on the standby from the synchronized state data. The NMS attempts to handle such a situation, and any inconsistencies in MIB data that result from this approach. The existing RF/CF MIB is also available.

Verifying MIB Support

To display various MIB parameters, perform the following tasks:

	Command	Purpose
Step 1	`router# show wimax agw`	Displays various system parameters, including BWG software version, number of base stations allowed, number of subscribers allowed, and others.
Step 2	`router# show wimax agw stat internal`	Displays BWG internal statistics.
Step 3	`router# show wimax agw stat dhcp`	Displays BWG DHCP statistics.
Step 4	`router# show wimax agw stat`	Displays BWG statistics.
Step 5	`router# show wimax agw user-group`	Displays BWG user group statistics.
Step 6	`router# show wimax agw path`	Displays BWG path statistics.

Configuration Examples

Here is sample output for the **show wimax agw** command:

```
router# show wimax agw
Access network gateway version 0.1, service is enabled

 AGW listening on UDP control port 2231
 Maximum Number of base station 500 allowed
 Maximum Number of subscriber 20000 allowed
  Number of signalling paths created 0
  Number of brearer paths created 0
  Number of subscribers connected 0
  Number of sessions created 0
  Number of flows created 0
  Traffic Sent 0 packets, 0 bytes
  Traffic Rcvd 0 packets, 0 bytes
  Number of framed routes
  Number of subscribers using the framed routes
```

```
  Current number of user auto-provisioned sessions
  The traffic is split for IP CS and ETH CS.
```

Here is sample output for the **show wimax agw user-group** command:

```
router# show wimax agw user-group
AGW User-Group-List
There are 3 user-groups configured in list wimax

User group domain name any
 User-Group overwritten Counter 0
 Service mode operational
 Sessions 0 associated
 IP-GRE Traffic Sent 0 packets, 0 bytes
 IP-GRE Traffic Received 0 packets, 0 bytes
 Eth-GRE Traffic Sent 0 packets, 0 bytes
 Eth-GRE Traffic Received 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes
 Traffic Received redirected 0 packets, 0 bytes


User group domain name cisco
 Service mode operational
 Sessions 0 associated
 Traffic Sent 0 packets, 0 bytes
 Traffic Received 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes


User group domain name unauthenticated
 Service mode operational
 Sessions 0 associated
 Traffic Sent 0 packets, 0 bytes
 Traffic Received 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes

router#show wimax agw user-group brief ?

Name            Sessions  Pkts-Tx   Bytes-Tx  Pkts-Rx   Bytes-Rx  VRF
any             0         0         0         0         0
cisco           0         0         0         0         0
unauthenticated 0         0         0         0         0

router#show wimax agw user-group any ?
  brief  Brief output
  |      Output modifiers
  <cr>

router#show wimax agw user-group any

User group domain name any
--------------------------------------
 Service mode operational
 Sessions 0 associated
 Traffic Sent 0 packets, 0 bytes
 Traffic Recevied 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes


router#show wimax agw user-group any brief
Name            Sessions  Pkts-Tx   Bytes-Tx  Pkts-Rx   Bytes-Rx  VRF
any             0         0         0         0         0
```

```
router#show wimax agw user-group name ?
  WORD  Enter User-group Name

router#show wimax agw user-group name cisco ?
  brief  Brief output
  |      Output modifiers
  <cr>

router#show wimax agw user-group name cisco

User group domain name cisco
-------------------------------------
 Service mode operational
 Sessions 0 associated
 Traffic Sent 0 packets, 0 bytes
 Traffic Recevied 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes


router#show wimax agw user-group name cisco brief ?
  |  Output modifiers
  <cr>

router#show wimax agw user-group name cisco brief
Name            Sessions  Pkts-Tx   Bytes-Tx  Pkts-Rx   Bytes-Rx  VRF
cisco 0         0         0         0         0


router#show wimax agw user-group unauthenticated ?
  brief  Brief output
  |      Output modifiers
  <cr>

router#show wimax agw user-group unauthenticated

User group domain name unauthenticated
--------------------------------------
 Service mode operational
 Sessions 0 associated
 Traffic Sent 0 packets, 0 bytes
 Traffic Recevied 0 packets, 0 bytes
 Ingress Address filtering 0 packets, 0 bytes

asn#sh wimax agw user-group unauthenticated b
asn#sh wimax agw user-group unauthenticated brief ?
  |  Output modifiers
  <cr>

router#show wimax agw user-group unauthenticated brief
Name            Sessions  Pkts-Tx   Bytes-Tx  Pkts-Rx   Bytes-Rx  VRF
unauthenticated    0         0         0         0           0
```

Here is sample output for the **show wimax agw statistics** command:

```
router# show wimax agw statistics
AGW Statistics
Message function type Undefined(0/0x0)

Message function type Data Path(3/0x3)
  Message type Deregistration Request(4/0x4)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
```

```
  Message type Deregistration Response(5/0x5)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type Deregistration Ack(6/0x6)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type Registration Request(12/0xC)
   Number of messages sent 0
   Number of messages received 0
   Number of messages resent 0
  Message type Registration Response(13/0xD)
   Number of messages sent 0
   Number of messages received 0
…
```

Here is sample output for the **show wimax agw statistics dhcp-relay** command:

```
router# show wimax agw statistics dhcp-relay
AGW DHCP Statistics
   Tx to DHCP server Discover 0, Request 0
   Tx to DHCP server Release 0, Decline 0
   Tx to DHCP server Inform 0
   Rx from DHCP server Offer 0, Ack 0
   Rx from DHCP server Nak 0, Unknown 0
```

This output gives the statistics of DHCP messages that are relayed through the BWG. If the BWG happened to initiate any DHCP messages, these counters are not incremented.

Here is sample output for the **show wimax agw statistics internal** command:

```
Router# show wimax agw statistics internal
Last clearing of "show wimax agw statistics internal" counters 3d23h
 Signalling plane related statistics
  Signal packets processed messages 483
  Signal packets has pending messages 0
  Signal packets requeued messages 0
  Signal packets dropped too many pending messages 0
  Signal packets dropped service disabled 0
  Signal packets dropped service not ready 0
  Signal packets dropped no encapsulation interface 0
  Signal packets dropped CAC denied request 0
  Signal packets disposed by agw 0
 Data plane related statistics
  Data packets not ours encapsulation 0
  Data packets not ours encapsulation address 0
  Data packets not ours service disabled 0
  Data packets not ours invalid protocol type 0
  Data packets dropped invalid ip len 0
  Data packets dropped absent key data 0
  Data packets dropped flow not found 21
  Data packets dropped flow path not found 0
  Data packets dropped flow path invalid src address 0
  Data packets dropped session not found 0
  Data packets dropped subscriber not found 0
  Data packets dropped checksum error 0
  Data packets dropped ingress filtering 0
  Data packets dropped sequence number mismatch 0
  Data packets dropped invalid redirect address 0
  Data packets dropped throttling of punts from cef to process 0
  Data packets dropped gateway learning from upstream data packets 0
  Data packets dropped non-ARP and non-DHCP L2 multicast/broadcast data packets 0
  Data packets punted fragmented 0
```

```
 Data packets punted from cef path to process path 0
Other related statistics
 Number of N/w behind MS in usrgrp enabled 0
 Total subscriber created  41
 Total subscriber deleted 45
 Total session created  41
 Total session deleted 45
 Total flow created  4
 Total flow deleted 7
 Total host created  0
 Total host deleted 0
 Total signalling path created  3
 Total signalling path deleted 3
 Total data path created  2
 Total data path deleted 2
 Number of hosts rejected 0
 Number of packets dropped due to Static IP Host not allowed 0
 Number of static hosts aged out 0
 Total sessions rejected due to unapproved BS 0
Configuration related statistics
 Service flow profile not found 0
 QoS profile not found 0
 Classifier profile not found 0
 Sla profile not found 0
Handoff related statistics
 Total handoffs succeeded 0
 Total handoff failed 0
 Total cmac key update succeeded 0
 Total cmac key update failed 0
 Total security key exchange succeeded 0
 Total security key exchange failed 0
Miscellaneous statistics
 Maximum Subscriber exceeded 0
 Maximum BS exceeded 0
```

MIB Enhancements for BWG Release 1.1

The BWG Management Information Base (MIB) is updated to add Ethernet CS related counters of packets/bytes sent/received. The following MIB objects have been updated in BWG Release 1.1:

- Includes the new EthCS related pkt/bytes sent/receive variables.
- Includes a description of packets/bytes sent/receive counters that were modified.

  For example, “The total number of Data Packets received” has been modified to “The total number of IP Data Packets received”

ASN GW Global Statistics

- The total number of IP Data Packets received
- The total number of IP Data Packets Sent
- The total number of IP Data bytes received
- The total number of IP Data bytes sent
- The total number of Ethernet CS Data Packets received
- The total number of Ethernet CS Data Packets Sent
- The total number of Ethernet CS Data bytes received
- The total number of Ethernet CS Data bytes sent
- Total number of hosts rejected
- Total number of static hosts aged out

The MIB also includes new objects for statistics related to ARP (total number of ARP requests received, total number of ARP replies sent, total number of ARP packets dropped), rejected host, and aged out static hosts.

GRE Keying

A GRE key is allocated per service flow in each direction. The GRE keys are exchanged using the RR-Request used to create the Data Path bearer. The GRE keys that correspond to the BWG are allocated by the BWG and sent to the BS during creation of the service flow using the RR-Request. Similarly, the GRE key values corresponding to the BS are allocated by the BS and sent to the BWG using the RR-Response message.

During Inter-BS mobility, new keys are allocated by the Base-station. The BWG keeps the same GRE keys.

The BWG allocates the GRE keys such that the values are not assigned immediately upon release.

VRF Support

A user-group can be configured with virtual route forwarding (VRF) support. This allows you to create an internal VRF entity to connect all traffic to/from the specific user-group.

QoS Support

QoS Support refers to both airlink QoS as well as mapping on the network. The ASNGW is responsible for sending down the qos parameters to the Base-station for creating appropriate service flows.

- Certain hosts can be given additional quality of service parameters
- A new R6 bearer (service flow) may be created corresponding to the hosts IP address. Multiple host can use this service flow
- The mapping of the host to the new R6 service flow is created, and communicated to the BS/MS via the RR-Request.

DSCP Marking Per Service Flow

Each service flow is mapped uniquely to a Diffserv Code Point (DSCP). This DSCP value is used to mark the outer IP header for downstream packets by the BWG, and by the BS for upstream packets.

The inner IP header for upstream and downstream packets is set by the BWG as per the mapping for the service flow, unless explicitly disabled by a CLI.

ACLs

ACLs are supported, and can be configured at a per-user group basis. This applies to all users that connect to the same user-group.

Source IP Address Validation

For all uplink packets, the allocated IP address for the corresponding MS or service flow is validated. If a mismatch is found, those packets are discarded.

To configure this feature, use the **security subscriber address-filtering ingress** command in gateway user group submode.

Support of Split Control and Data End Points for BS

The BS may have different end point IP addresses for the control and the data plane. Depending on the availability of the Data Path End Point ID TLV (sent in path registration response message from the BS for the flow), the BWG can create the GRE path taking the ipv4 from the available TLV.

If the specified TLV is not present, the control plane end point address is used as the remote data end point to create GRE path.

Bearer Accounting

Bearer volume counts are maintained for all service flows. These include the input and output packets and octet counts.

Restrictions

The following restriction apply in Cisco BWG Release 1.0 and above:

- To avoid issues with high CPU usage, we recommend the following configurations:
  - To reduce the CPU usage during bootup, disable logging to the console terminal by configuring the **no logging console** global configuration command.
  - To ensure that the HSRP interface does not declare itself active until it is ready to process a peers Hello packets, configure the delay period before the initialization of HSRP groups with the **standby delay minimum 100 reload 100 interface** configuration command under the HRSP interface.
  - To minimize issues with high CPU usage for additional reasons, such as periods of high PPP PDP processing (creating and deleting), disable the notification of interface data link status changes on all virtual template interfaces of the BWG using the **no logging event link-status** interface configuration command.

```
!
interface Virtual-Template1
description ASNGW-VT
ip unnumbered Loopback0
encapsulation agw
no logging event link-status
access-point-list wimax
end
```

Hitless Software Upgrade

In BWG Release 2.0, new SR attributes are introduced. After the standby upgrades, it does not receive the new BWG 2.0 SR attributes (the active BWG is still running with BWG 1.1/1.2). The standby BWG should set proper default values for these new BWG 2.0 SR attributes not synced from the older BWG (active).

Assuming the following preconditions exist, follow this procedure for a successful software upgrade.

The Active and Standby BWG are running with BWG 1.2 (N-1) software image. To facilitate discussion here, the original Active BWG is designated as Node A and the original standby BWG is called Node B.

Upgrade Procedure:

- Bring up startup-config on Node A and Node B to conform to BWG 2.0. CLI compatibility for BWG 2.0 and its predecessor is maintained, so this procedure is needed only if some BWG 2.0 features are required at the beginning. If this procedure is required, you should **tftp-copy** the existing startup-config file to an external tftp device, manually edit it and tftp-copy back to the BWGs.
- Upgrade the standby (Node B) BWG 1.2 to BWG 2.0 image. The standby BWG 2.0 should still come up as standby BWG. Wait for the bulk sync to finish. Note that all the existing sessions will not have the specific features for BWG 2.0.
- Upgrade Node A to BWG 2.0 image, perform a switchover on node A. Node B (BWG 2.0 image) will become active at this point.
- Wait for the bulk sync to finish. After the bulk sync is over Node A should come up as standby.

Restrictions

The following restrictions apply for the Hitless Software feature:

- BWG 2.0 backwards compatibility is maintained only for the N-1 release.
- Downgrade from BWG 2.0 to N-1 release is not supported.

Support Two DHCP Servers Per User Group

When the BWG is acting as a DHCP relay, it can relay DHCP packets to two DHCP servers. Any DHCP Discover and DHCP Request packets will be sent to both DHCP servers.

To configure two DHCP servers, add this command under the User Group configuration:

#dhcp server primary A.B.C.D backup E.F.G.H

CHAPTER 3

Proxy Mobile IP

This chapter explains and discusses the Proxy Mobile IP feature for the Cisco Broadband Wireless Gateway (BWG). Additionally, this chapter explains how to configure those features and provides sample configurations when appropriate.

Overview

Previous BWG releases implemented the basic functionality of ASN anchored mobility. ASN-anchored mobility occurs when the MS moves between Data Path Functions while maintaining the same anchor FA (BWG) sitting at the northbound edge of the ASN network. The data flow between the CSN and Data Path Functions pivots at the anchor FA/BWG. The CSN is unaware of any mobility that occurs between the ASN Data Plane Functions. A typical example for ASN anchored mobility is inter-BS handover controlled by the same BWG.

CSN anchored mobility mainly addresses the macro-mobility between the ASN and CSN across the R3 reference point. Specifically, in the case of mobile IPv4, this implies re-anchoring the current FA to a new FA, and the consequent binding updates (or MIP re-registration) to update the upstream and downstream data forwarding paths.

BWG Release 2.0 introduces the Proxy Mobile IP (PMIP) feature. In PMIP, the MIP client is implemented in the BWG instead of being in the MS.

The fundamental function for the BWG (PMIP client) is to generate a Mobile IP Registration Request (RRQ) on behalf of the user, send it to the HA and establish the tunnel between FA and HA. In order to accomplish this task, the PMIP client needs to collect the related MIP attributes through an EAP authentication (or Cisco invented AAA access for unauthenticated users) mechanism. The AAA server returns to the BWG with a set of standard Mobility Service attributes. With this info, BWG/PMIP client initiates a MIP RRQ to HA. The HA sends back a Registration Reply (RRP), which contains an assigned IP address (HoA - Home Address) for the MS, back to the PMIP client. As a result of the MIP RRQ/RRP operation, the PMIP client interacts with FA to establish a data path with reversing tunneling capability between FA and HA.

If the MIP registration is successful, BWG further notifies the MS the assigned IP address through the DHCP or ARP mechanism.

The BWG PMIP feature has the following functionality:

- A simplified DHCP proxy server
- Support for Multiple Home Agents (HAs)
- IP-in-IP and GRE tunneling between BWG/FA and HA
- PMIP client to inter-work with different address allocation mechanisms (DHCP, AAA)
- MIP Revocation from HA

- FA Relocation (Network re-entry)
- A hybrid (co-existence) approach of PMIP and simple IP for multiple hosts behind MS
- Support of Radius Attributes (IPv4 PMIP related) for Mobility Service (PMIP IPv4) as specified in WiMAX NWG 1.2.2
- PMIP support for L3-L3 (IPCS) and L2-L3 (Ethernet CS)
- Stateful redundancy for PMIP client/FA

DHCP Proxy Server

With MIP, the client's IP address assignment is from the HA instead of a DHCP server. This requires the BWG to terminate (instead of relay) the DHCP protocol. The following DHCP messages and their options are supported:

DHCP Discover

- 53: DHCP Message Type
- 57: Maximum DHCP Message Size
- 61: Client Identifier
- 50: Requested IP Address
- 12: Host name
- 55: Parameter Request List (Subnet Mask, DNS, DN)

DHCP Offer

- 53: DHCP Message Type
- 54: Server Identifier
- 51: IP Address Lease Time
- 1: Subnet Mask (goes before Router option)
- 3: Router
- 6: DNS
- 12: Hostname

DHCP Request:

- 53: DHCP Message Type
- 57: Maximum DHCP Message Size
- 61: Client Identifier
- 54: Server Identifier
- 50: Requested IP Address
- 51: IP Address Lease Time
- 12: Host name
- 55: Parameter Request List (Subnet Mask, DNS, DN)

DHCP Ack

- 53: DHCP Message Type
- 54: Server Identifier
- 51: IP Address Lease Time
- 1: Subnet Mask
- 12: Hostname

DHCP Release

- 53: DHCP Message Type
- 61: Client Identifier
- 54: Server Identifier

DHCP Decline

- 53: DHCP Message Type
- 61: Client Identifier
- 54: Server Identifier

DHCP NAK

- 53: DHCP Message Type
- 61: Client Identifier
- 54: Server Identifier

Proxy DHCP Server Interacts with PMIP

In BWG Release 2.0, only DHCP Proxy is supported. The following data flow shows the interactions between the DHCP Proxy server and the PMIP client.

1. When an MS enters into the network, the BS and BWG exchange info for the Pre-Attachment Req/Rsp/Ack procedure. The MS/BS can indicate whether Authorization is required.
2. If authorization is required, the BWG initiates the Identity Request procedure.
3. The BWG sends a AAA Access Request.
4. The AAA and the MS start the EAP exchange, if required.
5. The BWG and BS finish the Attachment Procedure.
6. AAA Access Accept is received in the BWG. The message may include the following WiMAX attributes: hHA-IP-MIP4, vHA-IP-MIP4, MN-hHA-MIP4-KEY, MN-vHA-MIP4-KEY, MN-HA-MIP4-SPI, HA-RK-KEY, HA-RK-SPI, and HA-RK-Lifetime. Home attributes are preferred over the visiting ones.
7. If MSK is received, the BWG further derives AK context from MSK and distributes into BS, where the keys are further exchanged with MS through PKMv2. FA-HA AE derivation is based on NWG stage 3, choosing the correct SPI.
8. The BWG starts the DHCP/PMIP protocol state machine, and formulates a MIP RRQ towards the HA. The information for the RRQ message comes from the AAA server and/or the user group configuration, and includes the following information:
   - Flags: user group configuration or default value
   - Lifetime: session timeout from AAA or user-group configuration

- HoA: from AAA's Framed IP address or zero
- Home Agent: from AAA or user group configuration
- Care-of Address: Interface configuration on BWG
- NAI extension included
- Revocation Support extension (I-bit = 0)
- Host-Config. extension if configured in the user group
- MN-HA AE
- GRE-key extension (not in this release)
- FA-HA AE

The virtual access IDB for reverse tunneling for the HA should also be created if it has not been created.

9. The HA interacts with AAA to obtain the MIP keys.
10. The HA validates the MN-HA AE and FA-HA AE with MIP keys from AAA.
11. On successful authentication at the HA, the HA uses it address scheme (local pool, DHCP, AAA, etc.) and assigns a home address for this mobile user. This address is included in the Registration Reply (RRP) message to the BWG. The BWG checks the Identification field and calculates the Mobile-Home Authentication Extension for integrity check. Foreign-Home Authentication Extension is also validated if present. If all validation is successful, a reverse-tunnel is created between the BWG and HA to transport user data.
12. The BWG and BS set up GRE data path. Note that this step should go in parallel with the MIP RRQ/RRP.
13. The MS/Host tries to acquire an IP address by initiating a DHCP DISCOVER.
14. The BWG sends DHCP OFFER to MS/Host.
15. The MS/Host further sends DHCP REQUEST.
16. The BWG sends back DHCP Ack.

Note This procedure deviates slightly from the NWG specification, where the MIP RRQ is triggered by the DHCP Discover message. As long as the MIP RRQ message does not need any info from DHCP Discover, this scenario should operate correctly.

PMIP Authenticated Network Identifier (PANI)

From BWG Release 2.2, BWG supports PMIP Authenticated Network Identifier (PANI). Details of a PANI may be received from a AAA server as part of the Access Accept message. If details of PANI is received, then BWG will use PANI as the Network Access Identifier (NAI) while generating the RRQ to a Home Agent (HA).

The following table provides the AAA-Authentication Attributes for PANI:

Table 3-1 AAA-Authentication Attributes for PANI

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
PMIP Authenticated Network Identifier	26/78	Authenticated identity of the MS as returned by AAA.	0	0	0-1	0

Multiple HA Support

The BWG is designed to communicate with multiple HAs. For each MS, the AAA can provide an HA IP address, or if not available, an IP address from the user-group configuration.

Here is a sample configuration:

```
router(config)#wimax agw pmip profile verizon
       home-agent
          address <home-agent-ip>

router(config)#wimax agw user group-list wimax
 user-group cisco.com
  aaa accounting method-list agw
  sla profile-name silver
    pmip profile-name verizon
 !
```

Only one HA can be configured per user group.

Tunneling Between FA (BWG) and HA

From BWG Release 2.0, both IP-in-IP and GRE tunneling (without GRE key) are supported. IP-in-IP tunneling is the default method (G bit not set in RRQ). If GRE tunneling is desired (with G bit set in RRQ), it can be configured on per user-group basis.

Here is the configuration example:

```
wimax agw pmip profile verizon
       proxy-mn
          gre-tunneling-enable

wimax agw user group-list wimax
 user-group cisco.com
  aaa accounting method-list agw
  sla profile-name silver
    pmip profile-name verizon
```

MIP Host Configuration Extension

The MIP Host Configuration Extension is described in RFC 4332. The default is enabled. It can be disabled explicitly with **no host-config-ext-request** command under the proxy-mn section.

The following parameters from the HA can be passed as DHCP options to the client:

- MIP home network prefix length => DHCP subnet mask (1)
- MIP default gateway => DHCP router (3)
- MIP DNS server => DHCP DNS (6)

To enable this feature, perform the following tasks:

	Command	Purpose

Step 1	`router(config)# wimax agw pmip profile verizon`
	`proxy-mn`
	`host-config-ext-request // RFC 4332`
		Enables Proxy Mobile IP profile on the BWG.

Step 2	`router(config)# wimax agw user group-list wimax`
	`user-group cisco.com`
	`aaa accounting method-list agw`
	`sla profile-name silver`
	`pmip profile-name verizon`
		Configures the User group list on the BWG

Configuring DNS and Default Gateway

BWG allows you to configure the DNS and Default Gateway locally or download from a AAA server.

If the Home Agent does not support RFC4332 (Host Configuration Extensions), you can configure the DNS and Default Gateway in BWG through CLI or configure BWG to download DNS and Default Gateway details from a AAA server. The DNS and Default Gateway details are sent to the CPE as part of the DHCP proxy response.

The order of precedence is:

1. DNS and Default Gateway details received as part of RRP from the HomeAgent.
2. DNS and Default Gateway details received from AAA to the BWG.
3. DNS and Default Gateway configured locally in the BWG.

Use the following commands to configure DNS and Default Gateway:

- [no] dns-server primary <ip address> secondary <ip address>
- [no] default-gateway <ip_address>

The following is an example of the DNS and Default Gateway configuration:

```
wimax agw pmip profile pmip1
  proxy-mn
    dns-server primary  10.1.1.1 secondary 10.1.1.2
    default-gateway 10.1.1.3
```

Table 3-2 AAA-Authentication Attributes for DNS and Default Gateway configuration

Attribute	Type	Description	Access Request	Access Challenge	Access Accept	Access Reject
Default Gateway	Cisco AVP	The IPv4 address of the default Gateway.	0	0	1	0
DNS	26/52	The IPv4 address of the DNS server.	0	0	1-n	0

Client IP Address Allocation

PMIP supports both dynamic and static IP address allocation mechanisms. For a static IP address, the BWG learns the pre-configured IP address in the Mobile Station through ARP. In this case, the BWG authorizes the IP address by verifying that it is in the IP address pool range downloaded from the AAA server. Another static IP address method is based on the BWG obtaining the IP address from the AAA server and leasing it to the MS through DHCP. In both scenarios, the BWG provides the IP address in the MIP registration to the HA, and allows the MS to use the IP address when HA accepts the registration. For dynamic IP address, the BWG does not provide an IP address in the MIP registration and the HA assigns an IP address to the MS/Host based on its own address allocation scheme (AAA, DHCP, local pool, etc.) in the registration reply.

If the BWG has already obtained the IP address before invoking the MIP operation through the means such as from DHCP relay mechanism or from AAA through Framed IP address. In all these cases, the BWG will treat them as if a static IP scenario, i.e., the MIP RRQ will carry the assigned IP to HA as HoA.

MIP Registration Revocation from HA

A MIP revocation from HA is supported. After security associations are verified in the RRP message, the subscriber session is torn down.

Co-Existence of PMIP and Simple IP Hosts

Due to the protocol limitations, a MIP subscriber can only get one IP address. This is a sharp contrast to the current BWG capability of multi-hosts behind a MS. When this happens, only the subscriber's (default) host is assigned the MIP HoA. The rest of hosts will continue to work as a simple IP hosts as if no PMIP has ever existed for the subscriber.

FA Relocation

FA relocation can be triggered when an MS re-enters the network through a different FA/BWG. When this occurs, the PMIP client in the new BWG initiates an RRQ as usual, and the HA revokes the MS’s registration from the old FA/BWG.

The following flow illustrates how FA relocation works:

1. An active session is established between the MS, BS-1, BWG-1 and HA.
2. The MS moves to BS-2, where a network re-entry is needed.
3. As part of network re-entry, the BGW-2 initiates MIP RRQ toward the HA.
4. The HA detects a binding already exists for the MS, so it revokes the MS's old MIP registration.
5. BWG-1 starts to clean up its session for the MS, if it still exists.

6. BWG-1 replies the MIP revocation.
7. MIP RRP with the same HoA to the BGW-2.
8. The MS sends DHCP Discover.
9. BWG-2 offers the HoA as the MS's IP address.
10. The MS sends DHCP Request.
11. The BWG sends back DHCP Ack to confirm the IP address assigned.

Due to mobile IP, the subscriber host will always be assigned to the same IP address by the same HA during macro-mobility. However, the multiple simple IP hosts behind the MS may not be assigned to the same IP address during the macro-mobility. This is determined by the arrangement between the two service providers involved. If the BWG-1 and BWG-2 shares the same DHCP server, the DHCP server may have a mechanism to ensure the same IP address for the simple hosts after the macro-mobility event. On the other hand, if the BWG-1 and BWG-2 uses different DHCP servers, the IP address for the simple IP host can not be ensured to be the same after the macro-mobility event.

Note R4-based FA relocation in idle mode is not supported in this release.

Ethernet CS L2-L3 or IPCS

MIP protocol dictates that the packet tunneled between HA and FA must be an IP packet. In BWG case, either Ethernet CS L2-L3 or IPCS will result in layer 3 IP packets towards CSN (HA). Hence BWG's PMIP support is designed to work with both Ethernet CS L2-L3 and IPCS.

On the other hand, when Ethernet CS L2-L2 bridging is enabled for a user group, the PMIP feature will be automatically disabled for those users. In other words, L2 bridging takes a higher priority than the PMIP feature.

WiMAX RADIUS Attributes

WiMAX Forum NWG 1.2.2 standard attributes will be supported. The following table provides details of the supported WiMAX RADIUS attributes.

Table 3-3 WiMAX RADIUS Attributes

Attribute	Description
hHA-IP-MIP4 (26/6)	HomeAgent Address.
MN-hHA-MIP4-KEY (26/10)	Attribute used to create the Mobile Node—HomeAgent authentication Extension.
MN-HA-MIP4-SPI (26/11)	The SPI associated with MN-HA-MIP4 key.
Session-Timeout	The session timeout (32 bits) is converted to registration lifetime (16 bits) with maximum value of 65534 in time unit of seconds.
Framed-IP address	If present, this attribute is used as HoA in the MIP RRQ.

Table 3-3 WiMAX RADIUS Attributes

Attribute	Description
HA-RK-KEY (26/15)	The key determined during EAP authentication by the RADIUS server and passed to the NAS upon successful EAP authentication. This key is used by the NAS to generate BWG-HA keys.
HA-RK-SPI (26/16)	The SPI used for the HA-RK.
HA-RK-Lifetime (26/17)	The lifetime of the HA-RK and derived keys. Value is between 0 and 65535.

Stateful Session Redundancy

Since the PMIP client/FA does not have its own scheme to perform session redundancy. Its stateful data will be synced as part of BWG's session data. The goal is that when a switchover occurs, the newly active BWG is able to continue the session with a minimal packet loss.

The **ip mobile foreign-agent redundancy** CLI needs to be enabled so that the PMIP stateful session information is synced along with the BWG session data.

PMIP Profile Configuration

In addition to HA address and GRE tunneling, the following is an example for other parameters:

```
router(config)#wimax agw pmip profile verizon
       home-agent
          address <home-agent-ip>
          ha-rk-key <key> spi <spi> lifetime <value>
       proxy-mn
          gre-tunneling-enable
          host-config-ext-request       // RFC 4332
          mn-ha-key <key> spi <spi>
          coa <ip_address>
         local-timezone <tz>
```

Each user group can optionally link to the PMIP profile configured:

```
router(config)#wimax agw user group-list wimax
 user-group cisco.com
  aaa accounting method-list agw
  sla profile-name silver
    pmip profile-name verizon !
```

Note The IP mobile configuration is optional. As long as AAA server has enough per-subscriber provisioning info, the PMIP function can be performed for the subscriber. All (except for gre-tunneling-enable) the user-group configuration serves as default when the corresponding configuration from AAA for a subscriber is not available.

On the BWG side, some basic Mobile IP configuration is required to activate the PMIP support. For example to turn on PMIP service via interface Ethernet 1/3, the following Mobile IP commands is needed:

```
interface Ethernet1/3
  ip address 14.1.1.30 255.255.255.0

ip mobile foreign-agent care-of Ethernet1/3
ip mobile foreign-service reverse-tunnel
ip mobile foreign-service revocation retransmit 3
ip mobile foreign-agent redundancy
```

Note **ip mobile foreign-agent redundancy** CLI is configured for PMIP redundancy.

After PMIP service is enabled through the global commands, MIP can be configured on a per WiMAX user-group basis using the **pmip profile**, and/or configuring the attributes that are provided by the AAA server.

L2-L2 bridging in the BWG does not work with MIP. When the established session is PMIP, L2 bridging is disabled if configured. If the session is PMIP, the L2-L3 option is done for Ethernet CS.

To enable L2-L2 bridging, perform the following tasks:

	Command	Purpose

Step 1	`router(config)# wimax agw user group-list wimax`
	` user-group cisco.com`
	`  aaa accounting method-list agw`
	`  sla profile-name silver`
	`  **bridge-group 1    ! Enable L2-L2 for Ethernet CS**`
		Enables L2-L2 bridging on the BWG.

For IPCS or L2-L3 users, the PMIP feature for a user is indicated through its AAA attributes, or if the AAA attributes are absent, the user-group configuration using **pmip profile**.

The following is a sample configuration of the PMIP profile and the user-group:

```
router(config)#wimax agw pmip profile pmip1
 home-agent
  address 14.1.1.80
  ha-rk-key ascii rootcisco spi decimal 258 lifetime 6000
 proxy-mn
  gre-tunneling-enable
  no host-config-ext-request
  mn-ha-key ascii cisco spi 102 lifetime 3000
  coa-address 14.1.1.100
 !
```

The “host-config-ext-request” is enabled by default.

```
router(config)#wimax agw user group-list wimax
 user-group cisco.com
  aaa accounting method-list agw
  sla profile-name silver
    pmip profile-name pmip1
 !
```

The default flag is:

S-bit = 0

B-bit = 0

d-bit = 0

M-bit = 0

G-bit = configured through gre-tunneling-enable

r-bit = 0

T-bit = 1

x-bit = 0

I-bit = RFC 3543

Note The GRE tunnel should be configured through FA CLIs. Provided that the AAA server supplies enough information for a PMIP subscriber, all the user-group configuration is optional.

The registration lifetime for the session can be obtained in one of the following ways:

- Mn-ha-key lifetime is not configured, session_timeout is not configured, AAA does not send session_timeout:

  In this case, reg_lifetime is assumed to be infinite (65535).

- Mn-ha-key lifetime is not configured, session_timeout is configured > 65535:

  In this case, the session_timeout value is truncated to 65535 and used as reg_lifetime

- Mn-ha-key lifetime is configured > 0 and < 65536 and session_timeout is also configured > 0 and < 65536

  In this case, the configured mn-ha-key lifetime is used as reg_lifetime

- AAA sends session-timeout:

  If it is > 0 and < 65536, then it is used as reg_lifetime. If it is > 65535, then the truncated value of 65535 is used.

NAI Configuration

EAP Authenticated Call

The BWG obtains through the MS's NAI during the initial phase of authentication.

Here is an example of FA interface redundancy configuration through loopback

```
BWG #1

interface Loopback0
 ip address 16.1.1.100 255.255.255.255
!
! HSRP redundancy interface
!
interface Ethernet0/0
 description WiMAX Simulator Interface
 ip address 14.1.1.30 255.255.255.0
 standby 2 ip 14.1.1.100
 standby 2 name AGW-IOU
!
```

BWG PMIP Configuration

```
wimax agw pmip profile <name>
 home-agent
     address 14.1.1.80
     ha-rk-key ascii rootcisco spi decimal 258 lifetime 7200
```

```
   proxy-mn
     host-config-ext-request
     mn-ha-key ascii cisco spi 102 lifetime 7200
     coa-address 16.1.1.100

wimax agw user group-list wimax
 user-group unauthenticated
  aaa accounting method-list agw
  sla profile-name silver
  proxy realm cisco.com
  ip static-allowed
  pmip profile-name <name>
```

Mobile IP Configuration

```
router mobile
! tell FA about the loopback interface
ip mobile foreign-agent care-of Loopback0
!
ip mobile foreign-agent redundancy
ip mobile foreign-service revocation
ip mobile foreign-service challenge
ip mobile foreign-service reverse-tunnel
```

BWG #2

!

The configuration for PMIP is identical on both the active and standby BWGs except that the physical interface is different for HSRP.

HSRP Redundancy Interface

```
interface Ethernet0/0
 description WiMAX Simulator Interface
 ip address 14.1.1.32 255.255.255.0
 standby 2 ip 14.1.1.100
 standby 2 name AGW-IOU
```

Here is an example of the FA interface redundancy configuration via HSRP group address

HSRP Redundancy Interface

```
BWG #1
interface Ethernet0/0
 description WiMAX Simulator Interface
 ip address 14.1.1.30 255.255.255.0
 standby 2 ip 14.1.1.100
 standby 2 name AGW-IOU
```

BWG PMIP Configuration

```
wimax agw pmip profile <name>
  home-agent
     address 14.1.1.80
     ha-rk-key ascii rootcisco spi decimal 258 lifetime 7200
   proxy-mn
     host-config-ext-request
     mn-ha-key ascii cisco spi 102 lifetime 7200
     coa-address 14.1.1.100
wimax agw user group-list wimax
 user-group unauthenticated
  aaa accounting method-list agw
```

```
  sla profile-name silver
  proxy realm cisco.com
  ip static-allowed
  pmip profile-name <name>
!
```

Mobile IP Configuration

```
router mobile
! tell FA about the loopback interface
ip mobile foreign-agent care-of Ethernet0/0
!
ip mobile foreign-agent redundancy
ip mobile foreign-service revocation
ip mobile foreign-service challenge
ip mobile foreign-service reverse-tunnel
```

BWG #2

The configuration for PMIP is identical on both the active and standby BWGs except that the physical interface is different for HSRP.

HSRP Redundancy Interface

```
interface Ethernet0/0
 description WiMAX Simulator Interface
 ip address 14.1.1.32 255.255.255.0
 standby 2 ip 14.1.1.100
 standby 2 name AGW-IOU
```

Verifying the Configuration

Perform the following tasks to verify and troubleshoot PMIP information on the BWG:

	Command	Purpose
Step 1	`router#` **`show wimax agw`**	Displays various system parameters, including BWG software version, number of base stations allowed, number of subscribers allowed, and others. The following information has been added: • Current number of subscribers PMIP enabled
Step 2	`router#` **`show wimax agw subscriber`**	The output is enhanced to reflect the PMIP context information in the BWG. The PMIP tunnel and registry information can be obtained from the standard proxy mobile ip commands. The following information has been added: • Subscriber capability of using PMIP • MIP information such as: – HA Address – Home Address – //if host-config exists, – Home Network Prefix Length – Default Gateway – Primary DNS – Secondary DNS • Details Host – Host PMIP status (whether address allocated using PMIP) • Number of packets dropped due to MIP registration incomplete
Step 3	`router#` **`show wimax agw subscriber internal`**	In addition to the above information the following information has been added to this CLI: • MIP information such as: – MN-HA Key – MN-HA-Spi – HA-RK-Key – HA-RK-Key-Spi – Lifetime Requested – Mip-Flag – AAA-Pmip-Flag – Pmip-Cli-Conf-Flag

	Command	Purpose
Step 4	`router# show wimax agw statistics internal`	The following information has been added: • Number of packets dropped due to Static IP Host not authorized by AAA (previously - Number of packets dropped due to Static IP Host not allowed) • Number of packets dropped due to Static IP Host not authorized by HA • Data packets dropped DHCP packets received during MIP registration • Data packets dropped ARP packets received during MIP registration • Data packets dropped non-ARP and non-DHCP packets received during MIP registration • Total subscriber PMIP enabled created • Total subscriber PMIP enabled deleted • Number of packets dropped due to MIP registration incomplete
Step 5	`router# show wimax agw statistics dhcp-relay`	This command was formerly known as **show wimax agw statistics dhcp**. It displays the number for DHCP messages transmitted and received to/from DHCP server when the BWG acts as a DHCP relay.
Step 6	`router# show wimax agw statistics dhcp-proxy`	This command displays the number for DHCP messages transmitted and received to/from DHCP client when the BWG acts as a DHCP proxy.
Step 7	`router# show wimax agw fsm dhcp-proxy`	This command displays the number of elements currently in the different states of the proxy state machine.

Step 8	`router#show wimax agw statistics internal | inc SLB`
	`Total SLB sticky update notifications succeeded 0`
	`Total SLB sticky update notifications failed 0`
	`Total SLB sticky delete notifications succeeded 0`
	`Total SLB sticky delete notifications failed 0`
		4 counters have been added as part of SLB stickiness support. These counters will keep track of the number of Update and Delete notifications that were sent successfully and that failed.

The following debug commands were added to BWG Release 2.0:

	Command	Purpose
Step 1	`router# debug wimax agw switching pmip`	Displays PMIP switching debugs.
Step 2	`router# debug wimax agw switching pmip errors`	Displays PMIP switching error debugs.
Step 3	`router# debug wimax agw switching pmip events`	Displays PMIP switching event debugs.
Step 4	`router# debug wimax agw switching pmip fsm`	Displays PMIP switching fsm debugs.
Step 5	`router# debug wimax agw switching pmip packet`	Displays PMIP switching packet debugs.
Step 6	`router# debug wimax agw switching pmip fsm errors`	Displays PMIP switching fsm error debugs.
Step 7	`router# debug wimax agw switching pmip fsm events`	Displays PMIP switching fsm event debugs.
Step 8	`router# debug wimax agw switching pmip packet detail`	Displays PMIP switching packet details.

	Command	Purpose
Step 9	**router# debug wimax agw switching pmip packet brief**	Displays PMIP switching packet information.
Step 10	**router# debug ip slb sticky asn msid**	Logs debugs for SLB sticky information.

To Verify the PMIP Registry Table on FA:

```
BWG#show ip mobile proxy registration
Proxy Mobile Node Registrations:

100022240001@cisco.com:
    Registration accepted 06/13/08 05:18:59
    Next Re-registration 00:01:29
    Registration sequence number 1
    Care-of addr 14.1.1.30, HA addr 14.1.1.80, Home addr 5.1.0.2
    Flags sbdmg-T-, Identification CBFC81C3.1108C374
 Lifetime requested 00:50:00 (3000), granted 00:50:00,       remaining 00:26:29
    Revocation negotiated
```

To Verify HA's Binding Table:

```
HA#sho ip mob bind
Mobility Binding List:
Total 4
Total VPDN Tunnel'ed 0
100022230001@cisco.com (Bindings 1):
    Home Addr 5.1.0.1
    Care-of Addr 14.1.1.30, Src Addr 14.1.1.30
    Lifetime granted 00:50:00 (3000), remaining 00:45:16
    Flags sbdmg-T-, Identification CBFC8713.59B6D7F8
    Tunnel0 src 14.1.1.80 dest 14.1.1.30 reverse-allowed
    Routing Options - (T)Reverse-tunnel
    Proxy registration, sequence number 1
    Revocation negotiated - I-bit not set
    Acct-Session-Id: 0x00000004
    Sent on tunnel to MN: 0 packets, 0 bytes
    Received on reverse tunnel from MN: 0 packets, 0 bytes
```

To Verify the Mobile IP Tunnel between HA and FA:

```
BWG#sho ip mobile tunnel
Mobile Tunnels:

Total mobile ip tunnels 1
Tunnel0:
    src 14.1.1.30, dest 14.1.1.80
    encap IP/IP, mode reverse-allowed, tunnel-users 4
    Input ACL users 0, Output ACL users 0
    IP MTU 1480 bytes
    Path MTU Discovery, mtu: 0, ager: 10 mins, expires: never
    outbound interface Ethernet1/3
    FA created, fast switching enabled, ICMP unreachable enabled
    5 minute input rate 0 bits/sec, 0 packets/sec
    5 minute output rate 0 bits/sec, 0 packets/sec
    23106 packets input, 2772720 bytes, 0 drops
    23106 packets output, 2772720 bytes
```

To Verify HA Routing Table for Mobile Node:

```
HA#show ip route mobile
     5.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
M    5.1.0.0/16 is directly connected, Mobile0
M    5.1.0.1/32 [3/1] via 14.1.1.30, 06:24:02, Tunnel0
```

```
M    5.1.0.2/32 [3/1] via 14.1.1.30, 06:21:43, Tunnel0
M    5.1.0.3/32 [3/1] via 14.1.1.30, 06:21:40, Tunnel0
```

Here is a complete sample configuration for the BWG PMIP feature:

```
!
ip vrf voice
 rd 200:1
!
ip vrf sales
 rd 200:1
!
radius-server host 12.12.22.12
radius-server key cisco
! ! Start mobile IP process
router mobile

Specify an interface as the COA used by the MN
ip mobile foreign-agent care-of Ethernet1/3
ip mobile foreign-service reverse-tunnel
ip mobile foreign-service revocation retransmit 3
!
interface Ethernet1/0
Description Interface towards voice switch
 ip vrf forwarding voice
 ip address 15.9.9.1 255.255.0.0
!
interface Ethernet1/3
  ip address 14.1.1.30 255.255.255.0
!
interface Ethernet2/0
 description Interface towards sales department
 ip vrf forwarding sales
 ip address 15.9.9.2 255.255.0.0
!
interface Ethernet3/0
  description VLAN 10 for Voice
   ip address 4.2.4.4 255.255.0.0
   encapsulation dot1q 10
  !
interface Ethernet4/0
  description this interface to be used for FA
  ip address 4.3.4.4 255.255.0.0
!
!
Interface VirtualTemplate1
  ip address 4.4.4.4 255.255.0.0
  encapsulation agw
!
wimax agw service-flow pak-classify-rule profile sec1-classifier-uplink
  priority 1
     ipv4 permit gre 2.2.2.2 224.0.0.0 any
     ethernet permit any all 0032.00AE.0023 ffff.0000.0000 ethernet-type qinq
     vlan permit any priority 0 7
   !
!
wimax agw service-flow pak-classify-rule profile sec1-classifier-downlink
 priority 1
     ipv4 permit gre 2.2.2.2 224.0.0.0 any
     ethernet permit any all 0032.00AE.0023 all ethernet-type qinq
     vlan permit any priority any
    !
!
wimax agw service-flow profile sec1
```

```
    direction downlink
      cs-type eth-cs
          pak-classify-rule sec1-classifier-downlink
     cs-type ip-cs
          pak-classify-rule sec2-classifier-downlink
     qos-info isf-qos-downlink
 !
   direction uplink
      cs-type <eth-cs/ip-cs/vlan-cs>
          pak-classify-rule sec1-classifier-uplink
     qos-info isf-qos-uplink
     set vlan-priority 5
 !
!
wimax agw sla profile silver
    service-flow pre-defined isf profile isf
    service-flow pre-defined secondary 1 profile sec1
!
wimax agw user group-list wimax
 user-group unauthenticated
  aaa accounting method-list agw
  aaa authentication method-list agw
  sla profile-name silver
  proxy realm cisco.com
  ip mobile
   home-agent
     address 14.1.1.80
     ha-rk-key ascii rootcisco spi 102 lifetime 36000
   proxy-mn
     host-config-ext-request
     mn-ha-key ascii cisco spi 102 lifetime 36000
!
```