# DC-BR3800-01 BLE Module Deployment Guide

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# DC-BR3800-01 BLE Module Deployment Guide

## What Makes Bluetooth Low Energy (BLE) Modules Work?

The DC-BR3800-01 BLE Module is a Cisco-Certified 3rd Party Expansion Module that extends the capabilities of a Cisco 3800 series access point by providing the ability to capture BLE transmissions from BLE beacons and forward that information to a third-party analytics platform to determine that beacon's proximity to a single reader or location as determined by multiple readers.

# Minimum Software Requirements for the BLE Module

- **Web Browser** – The function of this software is to manage an individual BLE module through its GUI interface.
- **BLE Management Platform** – The function of this software is to configure and manage the BLE modules
- **Aggregator Platform** – The function of this software is to receive the information from the BLE modules and then calculate the location. The aggregator platform can be developed using the BLE Module integration guide, or purchased through a solution provider such as DeCurtis Corporation.
- In addition to these components**,** you will also need a DHCP server (on the same or different subnet as the Cisco 3800 series access point).

# Minimum Hardware Requirements for the BLE Module

- Suitable Cisco WLC such as the 3504, 5520 or 8540 running 8.7.102.0 or later
- Cisco 3800 Series Access Point (e.g. AIR-AP3802i, AIR-AP3802e, AIP-AP3802p)
- PoE+ (30W) Power Injector or Switch
- DC-BR3800-01 BLE Module
- BLE Module 2.4GHz Omni-directional antenna

# BLE Module Feature Introduction

The BLE Module has the ability to read any Bluetooth Low Energy (BLE v4x and v5x) standard beacons and forward that information to an analytics platform to determine a beacon's proximity to a single reader or location among multiple readers. As part of an RTLS (real time location services) platform, it makes possible the ability to accurately track users and assets indoors and provide enhanced user experiences such as indoor wayfinding.

## Location Concepts

**Beacon:** A combination of identifying (UUID, major, minor, mac address, etc.) and location metadata (geom field, point) representing a single Beacon. The design assumption is that the (UUID, major, minor, mac addresss) will be unique to a single device.

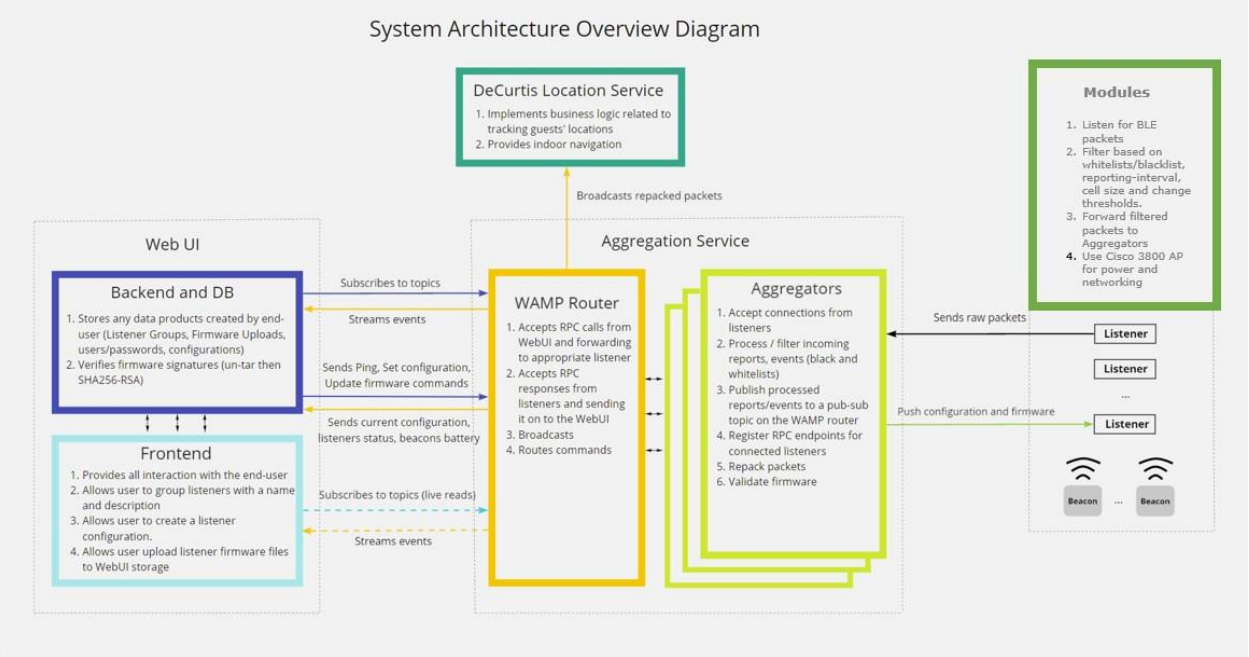
**BLE Module (Reader):** A combination of identifying (MAC address) and location metadata (geom field, point) representing a single reader hardware device (e.g. BLE Module). A design assumption for readers is that their self-reported MAC field will be unique to a single reader device and that their geographic location will be accurately specified in the web interface, admin panel, or location service software interface.

## Loosely-Coupled Architecture

The BLE Module and Access Point operate in a "loosely-coupled architecture", where the host AP is a physical connection point which provides power and an uplink to a larger network. The module is a self-contained device that operates independently of the host AP. The module does not rely on any host AP resource except for power and an optional upstream connectivity.

Module firmware or application software runs on the module independently and does not require the host AP's compute resources. The BLE Module requires its own IP Address, which can be provided in the same or different VLAN and subnet of the Cisco 3800 Series access point.

## Components




### Beacons

Any Bluetooth Low Energy (BLE) v4 or v5 standard beacon can be read by the BLE Module, including iBeacons™, Eddystone or proprietary beacons. Some optional enhancements to iBeacon™ protocol are supported:

- Battery level advertisement. At programmable intervals, the beacon can transmit the current battery life percentage.
- Longer Intervals. For some applications the 100ms max advertisement interval specified by iBeacon™ is not ideal. Beacons can be programmed to advertise at intervals between 20ms and 10000ms (10 seconds) so that the OEM may choose between increased battery life or increased location accuracy.
- Security for access control. A special version can be used for access control solutions, providing a highly-secure, connectionless solution for "frictionless" access control.

### DC-BR3800-01 BLE Module

The BLE Module monitors the BLE advertisement channels for BLE-compatible packets. Beacon distance and power is filtered and aggregated by the reader before being forwarded to the location service at configurable intervals.

Filtering options include whitelisted beacons, blacklisted beacons, reporting intervals, cell sizing, and change thresholds.

The BLE Module packet format is documented in the DC-BR3800-01 Module Packet-Format document.

## Cisco 3800 Series Access Point

The 3800 Series carries forward the modular architecture first introduced with the Aironet 3600 Series, providing unparalleled investment protection for forward-looking modular solutions. The 3800 Series delivers an enhanced second-generation modular architecture by:

- **Moving the module connection from the bottom to the side of the access point.** This allows for easier addition and removal of a module without having to dismount the access point and also allows for flexibility in module design with respect to size and appropriate antenna placement.
- **Increasing the power available to a module to 18W**, providing additional flexibility for future module solutions.

Cisco Wireless LAN Controllers provide centralized monitoring and management to Cisco 3800 access points.

### BLE Management Console

The BLE Module Management Console provides centralized monitoring and management for the BLE Modules. It is segmented logically into the aggregation service (which includes one or more aggregators and a WAMP Router), and the Web UI, (which includes the frontend, backend, and database.) The BLE Module Management Console is outside the scope of this document.

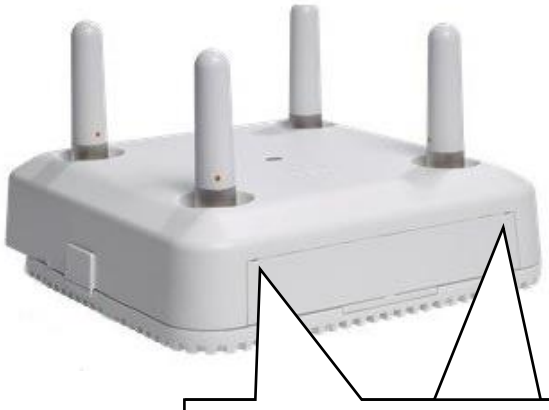
## Location Service

The Location Service works in conjunction with the BLE Management Console to implement business logic related to tracking a beacon's location. An example service would include providing indoor navigation. The Location Service is outside the scope of this document.

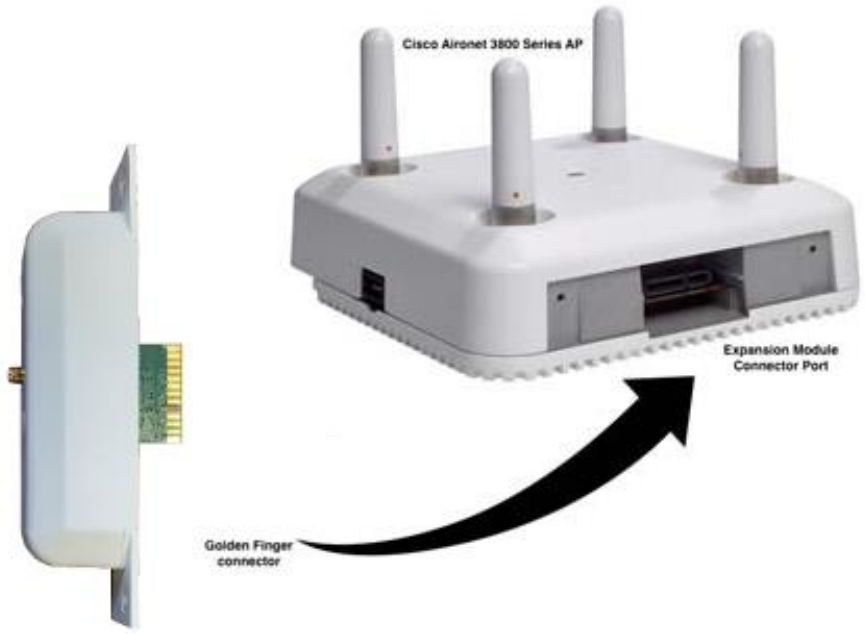
# Physically Installing the BLE Module

To physically install the module into a Cisco 3800 Series access point:

- Step 1: Remove the plastic covering using a flathead screwdriver.
- Step 2: Insert the module into the access point by aligning the Golden Finger connector with the Expansion Module Connector Port.
- Step 3: Secure module with supplied hand-screws.



Using a small flathead screwdriver, release the snaps at both locations to remove the cover.




Take Note

When a module is removed or inserted into the access point while the access point is turned on, the access point will reboot automatically. This is expected behavior.

# BLE Module Antenna

The BLE Module is certified for use with a 2.4GHz 5dBi weatherproof IP67 omnidirectional antenna with RP-SMA connector.

Screw-Mount / "Through-hole mount" on back of antenna

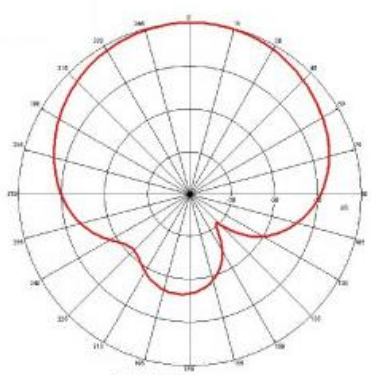
Compact, puck shaped antenna for band 2.4GHz Bluetooth frequencies.

- Mount on any panel or board that you can drill a hole through, such as a ceiling panel, wall or drywall.
- Easily mounts in a ceiling tile, by drilling a hole in the tile of the same diameter. Antenna has a nut and washer to mount the antenna on a ceiling mount.
- Mount on ceiling or wall panel so that the antenna faces down from the ceiling, or horizontally from the wall.
- Can be mounted securely inside or outside, with its 22mm long screw thread.
- **Dimensions**:
  - Largest diameter: 78mm
  - Smallest diameter of antenna body: 63mm
  - Depth (or height): 23mm.
  - Diameter of through-hole mount: 11/16 inch (17mm) including outer part of threads.

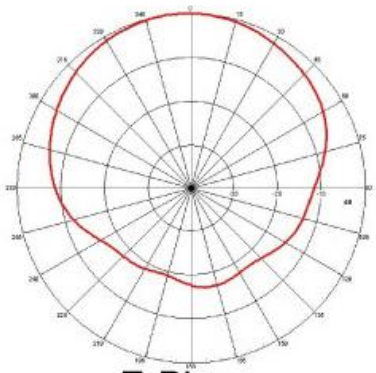
Waterproof**:** Totally sealed IP67 casing, with rubber seal gasket to prevent risk of water ingress.

**Specifiations:**

- Technology: Bluetooth
- Frequency: 2.4GHz to 2.5GHz (2400MHz to 2500MHz)
- Gain: 5 dBi
- Polarization: Vertical
- Impedance: 50 ohm
- Style: Puck
- Connector: RP-SMA (Reverse Polarity SMA)
- Cable
  - Type: LMR-100 equivalent cable, double-shielded for minimal signal loss.
  - Cable Length: 2 meter cable to RP-SMA-male connector.



H-Plane



E-Plane

# Module LED Status Lights

The DC-BR3800-01 BLE Module features three LED lights. The state of the LEDs can provide indication of the module's state. The three main options will be:

- No lights (no power)
- Solid red light (power, not booted)
- Solid blue light (booted)

If the module does not display any LED lights, this indicates the module is not receiving power. Check to see if the access point is powered on and associated to the WLC.

- If the access point is not powered on, power on and fully boot the access point, then check the module's LED lights.
- If the access point is powered on, remove the module and re-insert the module.

***Note:*** *When a module is removed or inserted into the access point while the access point is turned on, the access point will reboot automatically. This is expected behavior.*

If the module displays a solid red light, it indicates the module is receiving power, but has either not fully booted up, or is disabled.

By default, the extended module port is disabled.

A solid blue light indicates the module is receiving power and is fully booted. This typically indicates normal operation.

# Enabling the Module From the WLC

By default, the external module port is disabled on the access point.

If the module is not part of a group, it can be enabled individually through the WLC (GUI).

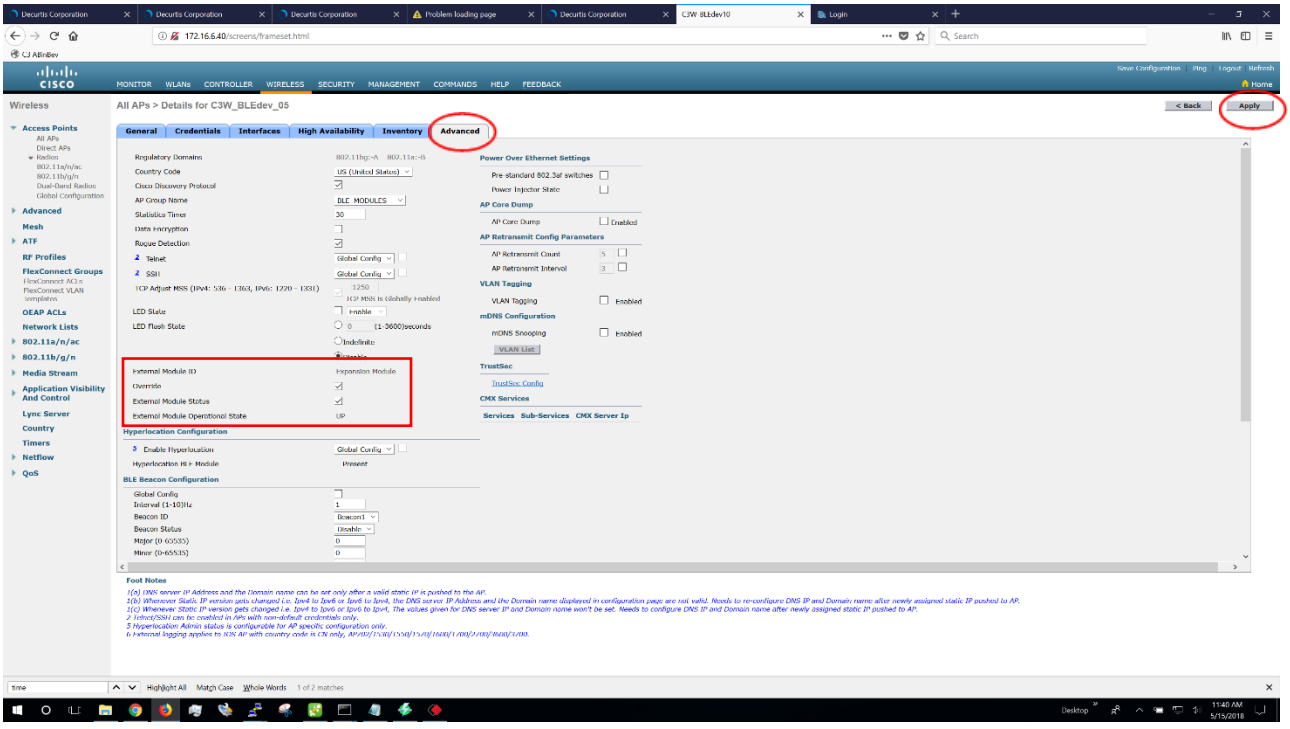
**Procedure**

- Step 1: Select the Access Point to which the module is attached.
- Step 2: Select the Advanced tab
- Step 3: Select the Override checkbox
- Step 4: Select the External Module Status checkbox
- Step 5: Apply the settings

It will take about 30 seconds for the Module to fully boot once enabled. The Module's LED lights should change from Red to Blue during the boot process.

The module will send network traffic through the management VLAN if not assigned to a group.

Once the Module has been enabled and has fully booted, the External Module Operational State should change from DOWN to UP.



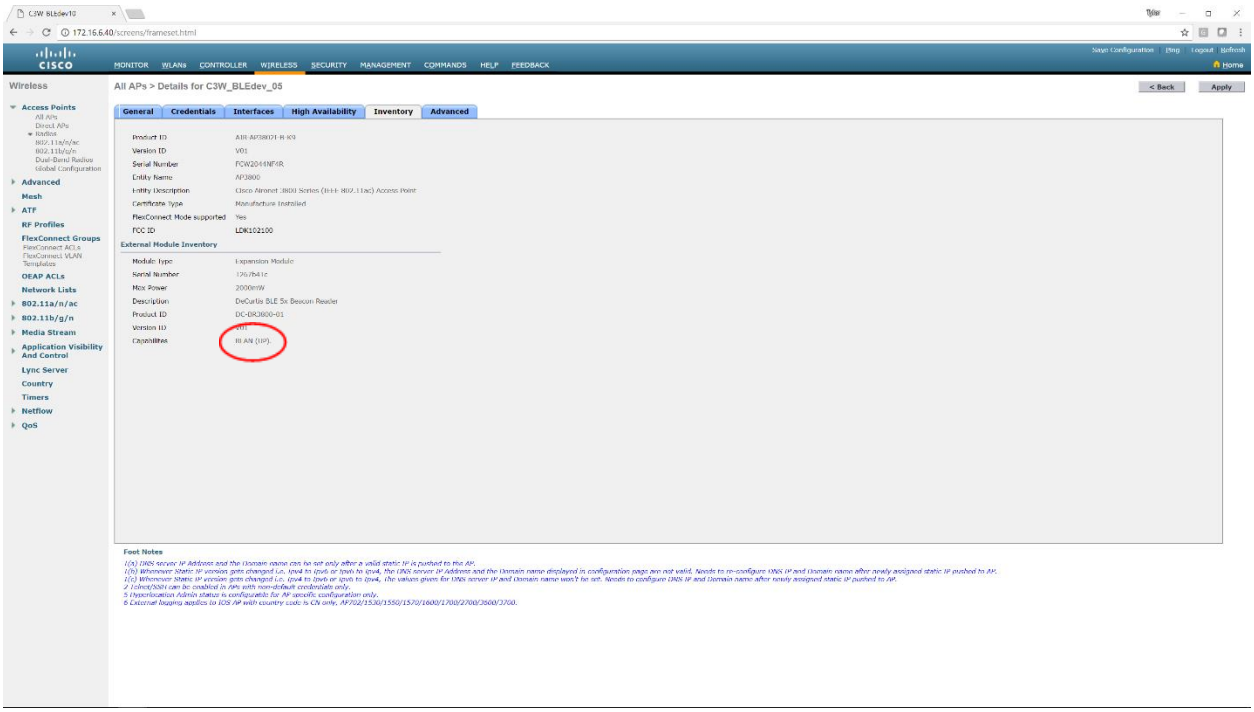
## Enable or Disable the BLE Module from the WLC (CLI)

To enable or disable a module through the WLC CLI, enter the following command:

**config ap ext-module {enable | disable} ap-name** (where ap-name is the host name of the access point to which the module is attached)

## AP Inventory

Information about the Module can be seen from the **AP > Inventory** tab. To confirm the module is fully operational, verify the **Capabilities** field shows **RLAN (UP)**.



# Configuring the WLC for Large Scale Module Deployments

To avoid having to deploy and configure Modules individually when implementing networks with multiple Modules, typical deployments require knowledge of WLC concepts including VLANs, Dynamic Interfaces, AP Groups, RLANs and Local Mode vs. FlexConnect Mode. For more information please refer to the Cisco Wireless Controller Configuration Guide, Release 8.7 found here:

https://www.cisco.com/c/en/us/td/docs/wireless/controller/8-7/config-guide/b_cg87.html

Only steps needed to support BLE Module configuration are included. Please refer to Cisco Wireless Controller Configuration Guide, Release 8.7 for additional configuration information.

## BLE Module RLAN

The external module connector on the Cisco 3800 series access point works similarly to an Ethernet port on the access point. In a Cisco WLC, a remote LAN (RLAN) interface is used for Port-to-VLAN mappings, and in this case Module-to-VLAN mapping. The RLAN entry on the WLC will be used to create a logical definition which will be applied to the external module on the AP.

Module traffic can be bridged locally at the AP's Ethernet port, or centrally switched on the WLC – the control of which will be handled on the RLAN configuration. Ensure the trunk configuration on the AP switchport is correct, and the proper VLANs are defined and allowed. Also verify the FlexConnect VLAN support and VLAN mapping information for the Flexconnect APs is correct prior to configuration. If VLAN support and the Native VLAN configuration on the AP is not correct, it might result in improper handling of the network traffic.

In order to map an RLAN to the Module, complete these steps:

Step 1: Create an RLAN entry on the WLC
Step 2: Choose whether module traffic on the RLAN will switch centrally at the WLC or be bridged locally on the AP's Ethernet port.
Step 3: If the traffic from the Module to which the RLAN will map should switch locally at the AP, enable FlexConnect Local Switching on the RLAN and supply the VLAN ID.
Step 4: Create an AP Group.
Step 5: Add the AP to which the module is attached to the AP Group.
Step 6: Add the Module RLAN to the AP Group
Step 7: Configure the RLAN-to-Module mapping on the AP Group.

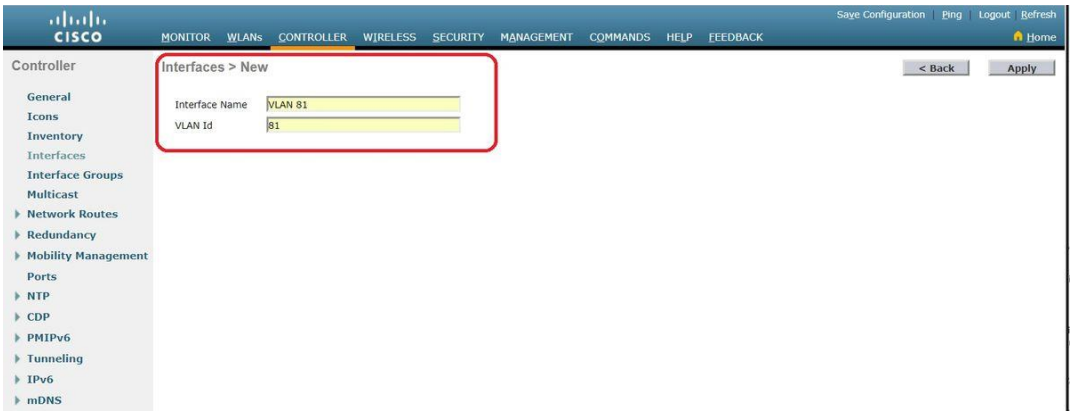
If FlexConnect Local Switching is enabled on the RLAN, but the AP is in Local Mode, data will centrally switch on the WLC to the dynamic interface on which the RLAN is mapped.

# Creating a Separate WLC BLE Module RLAN Interface

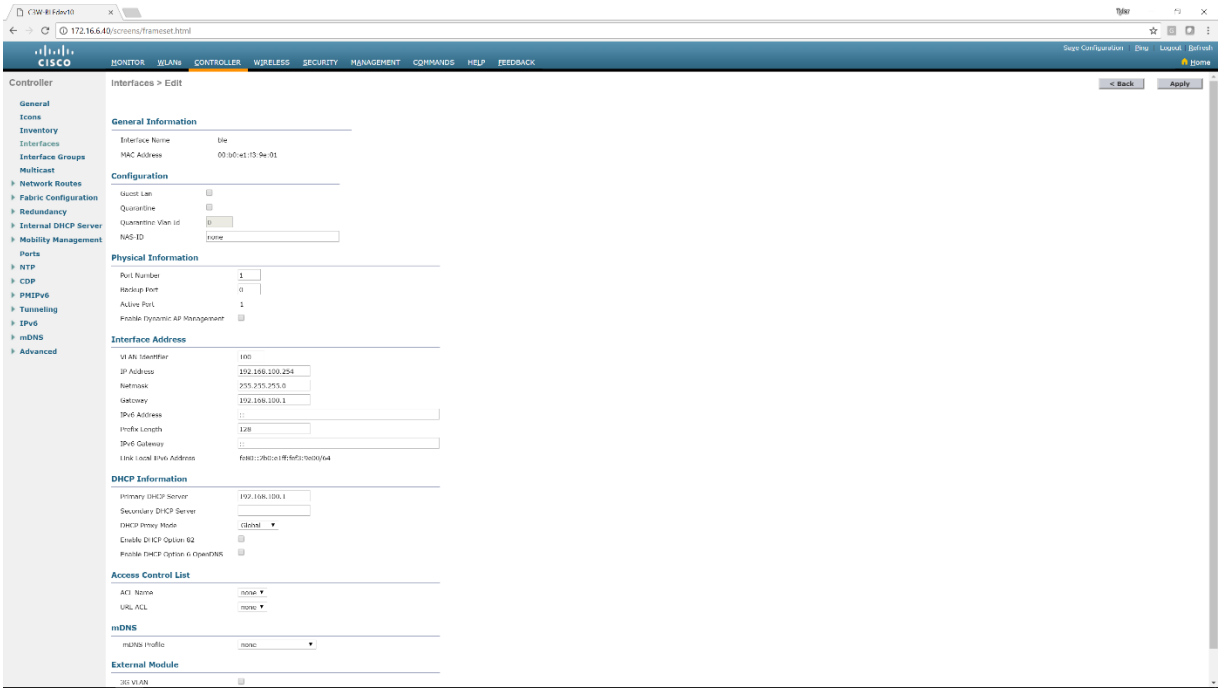
While the Module RLAN can send traffic through the management interface, in many cases administrators will want to segment the Module RLAN network traffic to a different VLAN. This is accomplished by creating a new dynamic interface on the WLC and mapping it to a specific VLAN.

**Procedure**

Step 1: In **Controller > Interfaces**, click **New**.
Step 2: Enter the **Interface Name**. (Example: Module-RLAN)
Step 3: Enter the **VLAN ID**, and then click **Apply**. (Example: 100)




Step 4: In the **Port Number** box, enter the WLC interface that connects to the LAN distribution switch. (E.g. 1)
Step 5: In the **IP Address** box, enter the IP address to assign to the WLC interface. (E.g. 192.168.100.254)
Step 6: Enter the **Netmask** (E.g. 255.255.252.0)
Step 7: In the **Gateway** box, enter the IP address of the VLAN interface (E.g. 192.168.100.1)
Step 8: In the **Primary DHCP Server** box, enter the IP address of the DHCP server (E.g. 192.168.100.1)

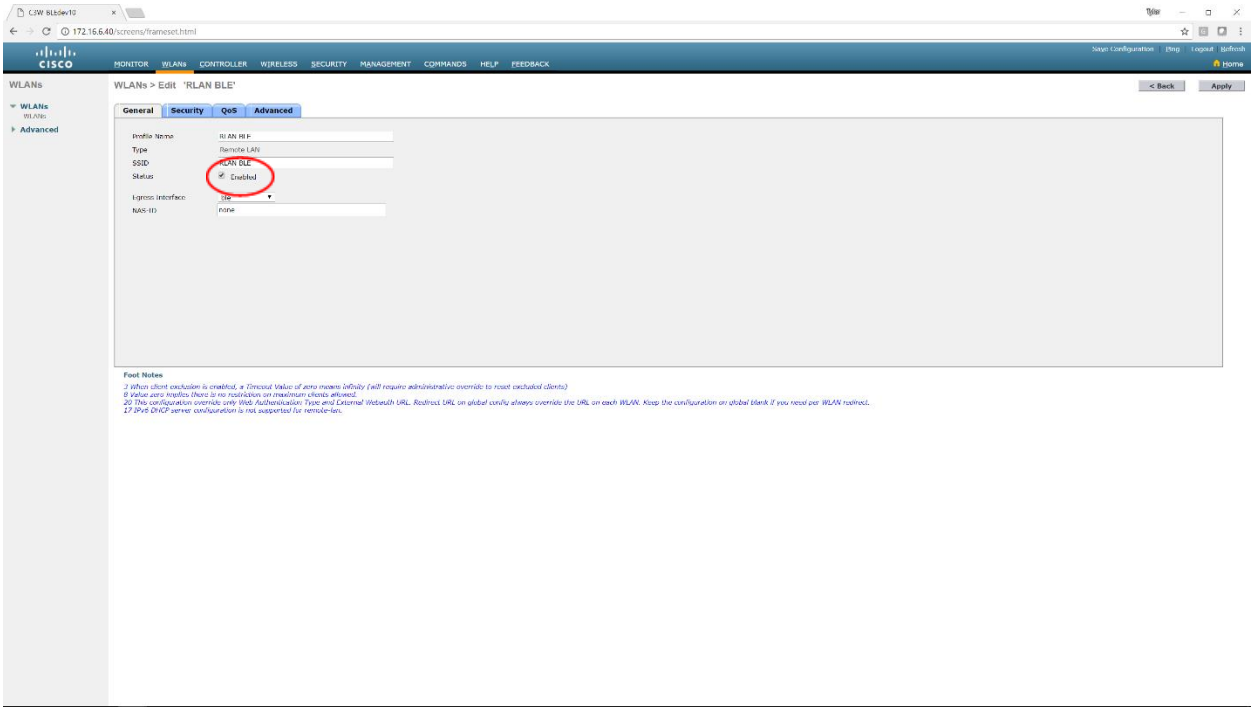


# Configuring the BLE Module RLAN

**Procedure**

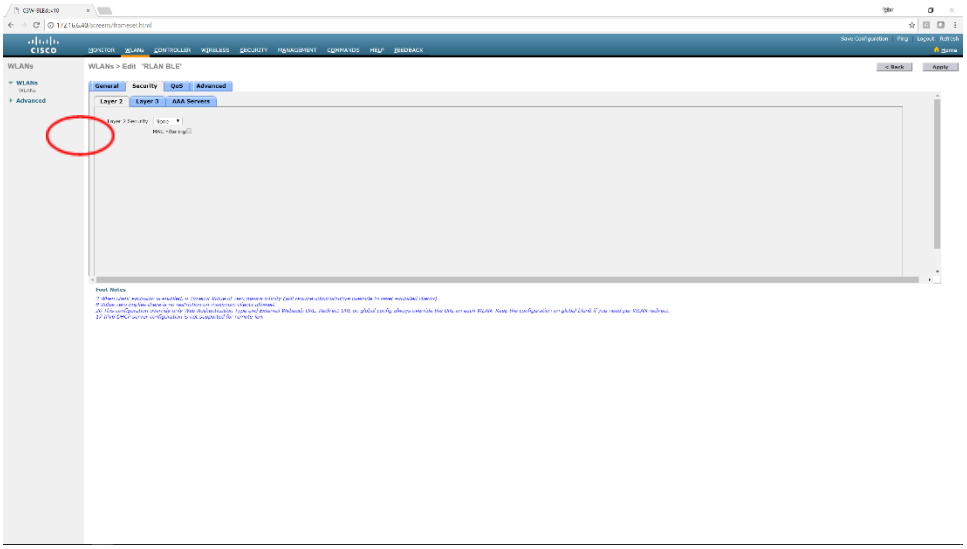
Step 1: In **WLANs**, click **New**
Step 2: For Type, choose Remote LAN
Step 3: Enter the **Profile Name**. (Example: Module-RLAN)
Step 4: Enter the **ID**, and then click **Apply**.

Step 5: Select the RLAN on the WLC
Step 6: **Enable** the RLAN

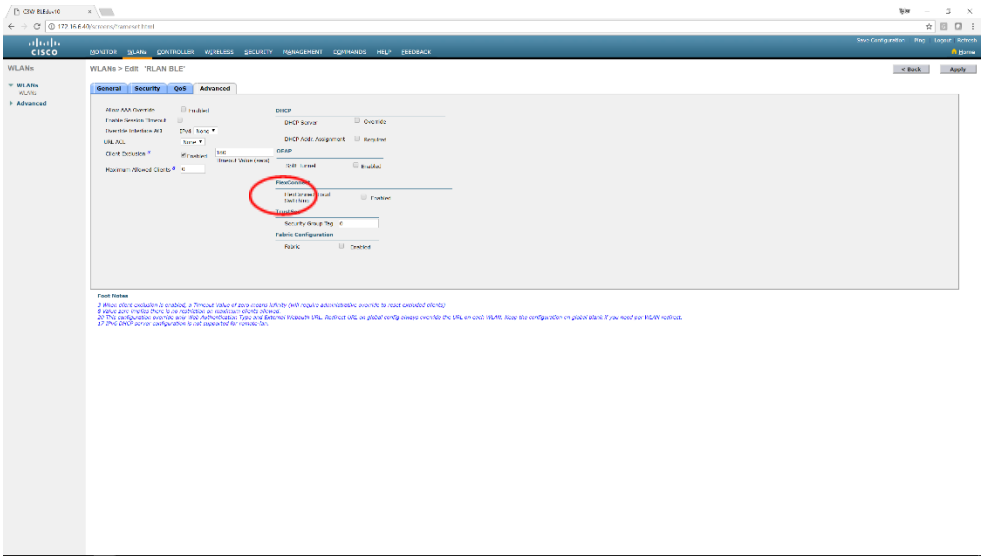


Step 7: Select the **Security Tab**
Step 8: Disable **MAC filtering**

MAC filtering is enabled by default when a new RLAN is created.



Step 9: Select the **Advanced** tab
Step 10: If you are using **FlexConnect Local Switching**, select the FlexConnect Local Switching checkbox.
Step 11: In the **VLAN ID** field, enter the VLAN ID
Step 12: Click **Apply** in order to save changes.



If FlexConnect Local Switching is enabled on the RLAN, but the AP is in Local Mode, Module network traffic will centrally switch on the WLC to the dynamic interface on which the RLAN is mapped.

If Local Switching is enabled on the RLAN, the Module network traffic will always be mapped to the VLAN ID supplied on the Advanced tab. If AP-Specific FlexConnect VLAN Support mapping is configured on the AP, or at FlexConnect Group level, the VLAN ID configured on the RLAN will always take precedence.

# Configuring BLE Modules Through Groups

When installing a large number of BLE Modules in a single system, you can assign BLE Module configuration parameters to groups of access points by creating an RLAN and assigning it to an AP Group.

If you want to assign BLE Module network traffic to a different VLAN than the management VLAN, you must first place any access point hosting a BLE Module into a group other than the "default group".

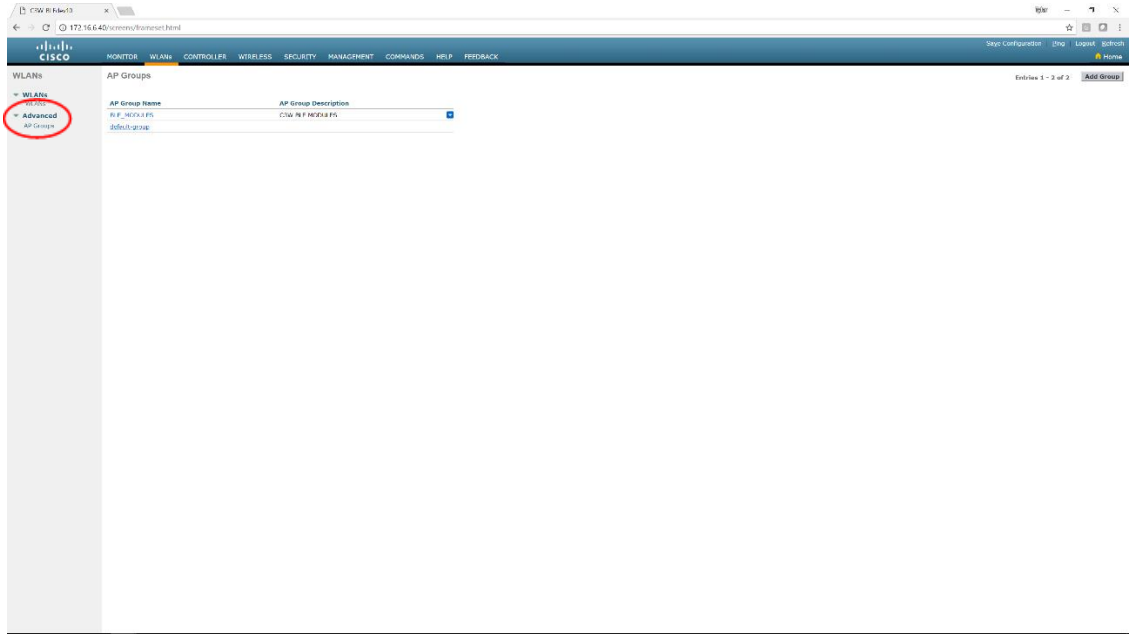
# Creating Access Point Groups (GUI)

**Procedure**

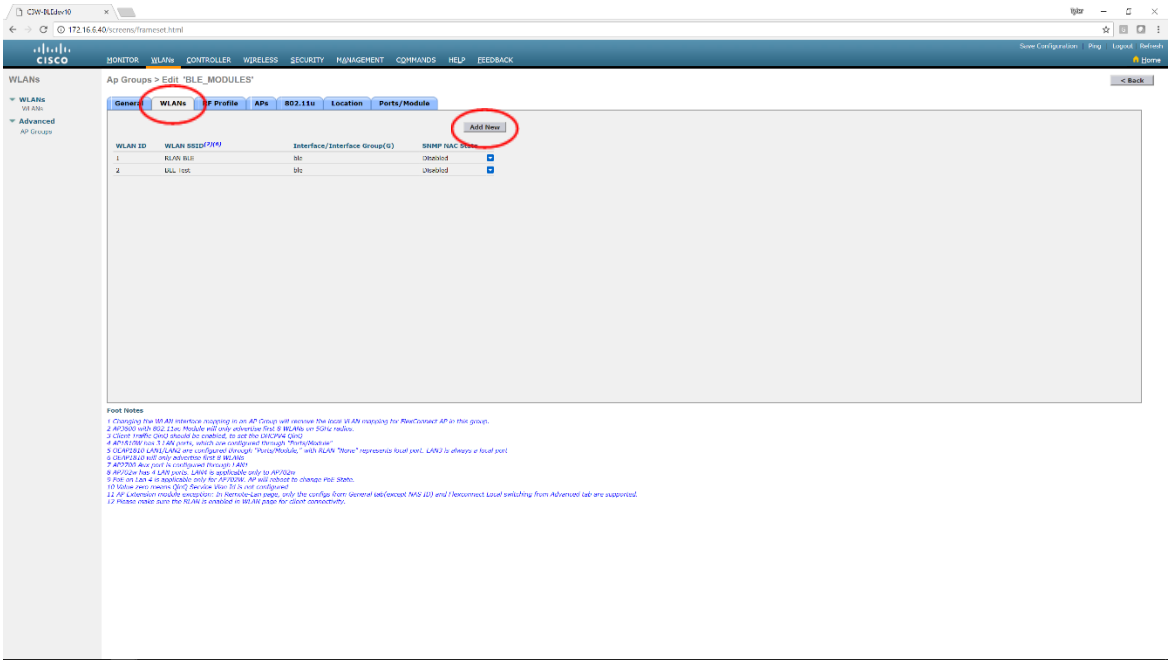
Step 1: Choose **WLANs > Advanced > AP Groups** to open the AP Groups page.

This page lists all the access point groups currently created on the controller. By default, all access points belong to the default access point group "default-group," unless you assign them to other access point groups.

Step 2: Click **Add Group** to create a new access point group. The Add new AP Group section appears at the top of the page.
Step 3: In the **AP Group Name** text box, enter the group's name.
Step 4: In the **Description** text box, enter the group's description. (E.g. Module RLAN Group)
Step 5: Click **Add**. The newly created access point group appears in the list of access point groups on the AP Groups page.



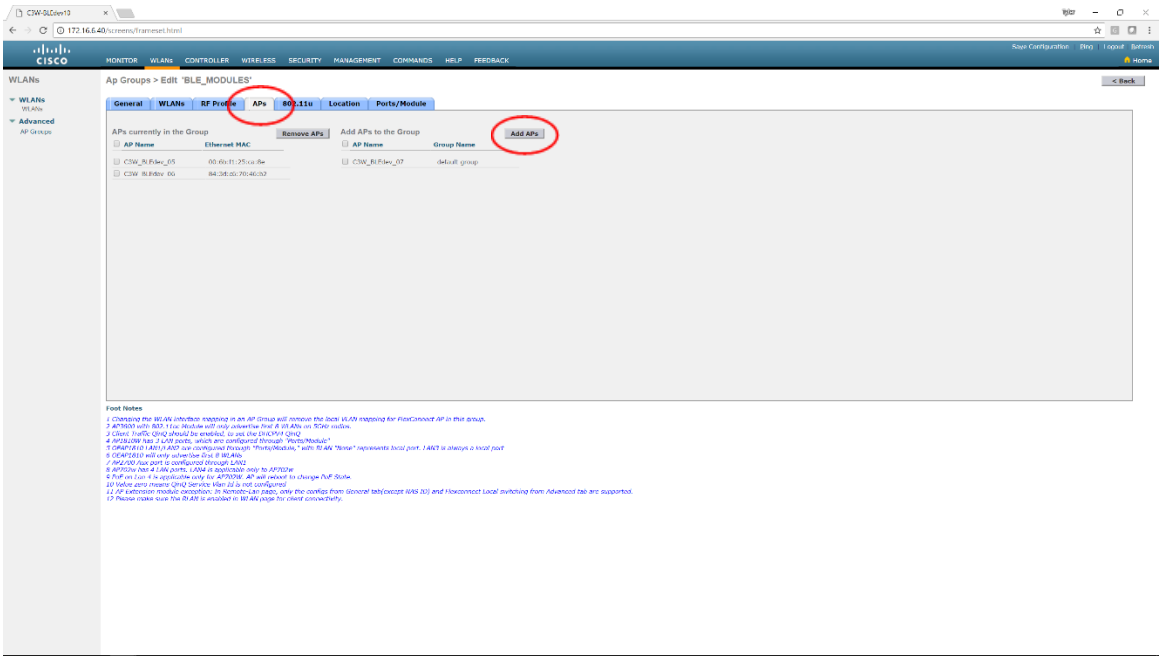
Step 6: Select the newly created **AP Group**
Step 7: Select the **WLANs** tab
Step 8: Add the RLAN by selecting **Add New**



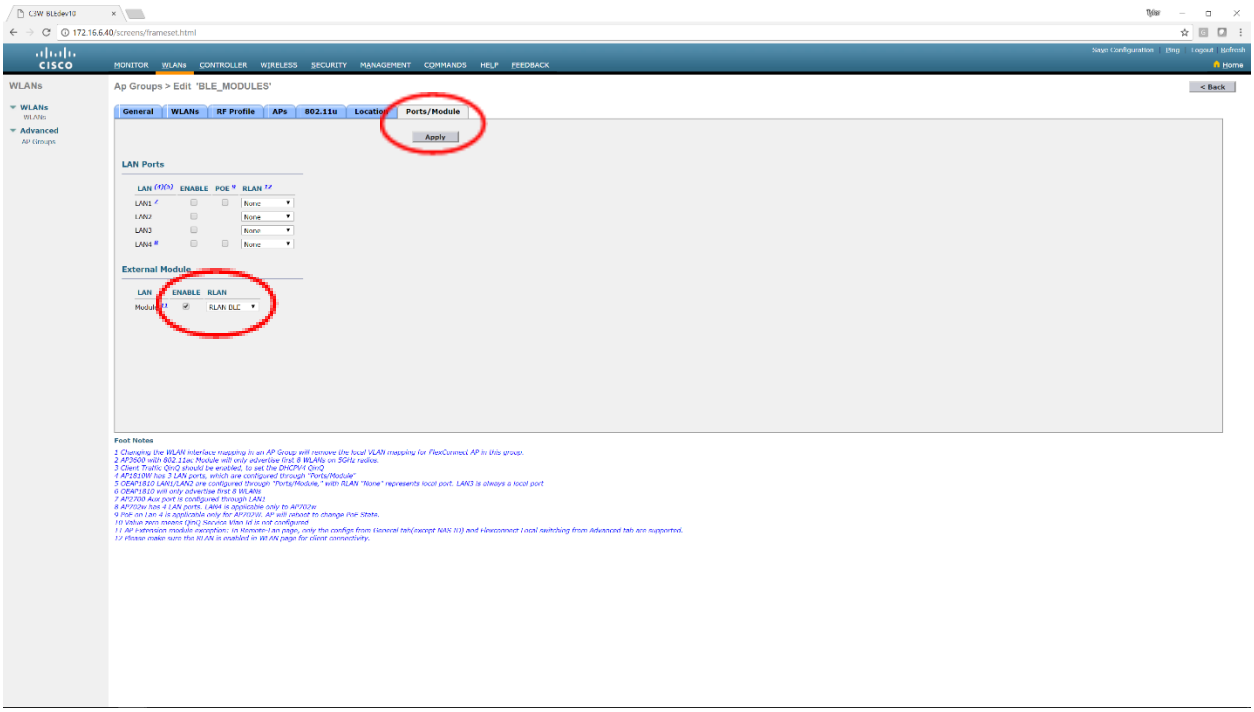

Step 9: Click **Add** once the proper RLAN is added
Step 10: Select the **APs** tab
Step 11: Add all appropriate access points with Modules attached to the AP Group by selecting **Add APs**

Take Note

Moving an AP from one group to another (including the default group) will cause the AP to reboot.



Step 12: Select the **Ports/Module** tab
Step 13: Under the External Module section, select the **ENABLE checkbox**
Step 14: Choose the Module RLAN from the **RLAN dropdown box**
Step 15: Select **Apply** to save changes.




## Assigning IP Addressing Through DHCP

The BLE Module requires a TCP/IP connection to forward data collected at the BLE Module to a management platform and/or analytics server. The network address can be statically configured or assigned automatically through a DHCP server.

In addition to the network address, the Module supports the ability to configure the server IP address and port through DHCP using DHCP Option 43 and 60. Also, the BLE Module can use Option 43 to automatically update its firmware by comparing its current firmware with the version described in the Option 43 configuration.

While using DHCP Option 43 and 60 is not required, most large scale implementations will want to take advantage of the benefits provided to configure the BLE Modules. To use DHCP Option 43 and 60, the DHCP server must support these options.

The semantics of DHCP server configuration vary based on the DHCP server vendor. Consult the vendor documentation for instructions on vendor specific options.

Basic DHCP Concepts are beyond the scope of this document. For more information about how to configure DHCP, please refer to Cisco IOS IP Configuration Guide, Release 12.2 or similar support guide.

https://www.cisco.com/c/en/us/td/docs/ios/12_2/ip/configuration/guide/fipr_c/1cfdhcp.html

# DHCP Option 60

DHCP Option 60 is used to define VCI (Vendor Class Identifier) on the DHCP server and it is the same VCI which is included in the initial DHCP discover message that a DHCP client broadcasts in search of an IP address. Option 60 is used by DHCP clients in order to identify itself to the DHCP server.

DHCP Option 60 can support multiple VCIs on the DHCP server. Cisco often uses DHCP Option 60 to identify Cisco access points to a WLC. So, defining a VCI for a Cisco access point, and also defining a VCI for the DC-BR3800-01 Module will allow the DHCP Server to distinguish between the two devices when providing different configuration options.

The DHCP Option 60 VCI for the DC-BR3800-01 Module is "**DC-BR3800-01**". Most DHCP Servers use HEX strings rather than ASCII characters. The HEX string is "**44432d4252333830302d3031**".

# DHCP Option 43

On the DHCP server, the vendor specific information is mapped to VCI text strings. When the DHCP server sees a recognizable VCI in a DHCP discover from a DHCP client, it returns the mapped vendor specific information in its DHCP offer to the client as DHCP Option 43. On the DHCP server, option 43 is defined in each DHCP pool (Scope) that offers IP addressing to the BLE Modules.

RFC 2132 defines that DHCP servers must return vendor specific information as DHCP Option 43. The RFC allows vendors to define encapsulated vendor-specific sub-option codes between 0 and 255. The sub-options are all included in the DHCP offer as type-length-value (TLV) blocks embedded within Option 43. The definition of the sub-option codes and their related message format is left to the vendors.

When DHCP servers are programmed to offer BLE Modules as Option 43 the sub-option TLV block is defined in this way:

**OPTION 43 (TLV = Type[Option Number]+Length[Based on Option type]+Value [Server Address, etc.])**

**Type** - Option Number (E.g. Option 1, Option 2, etc.) in HEX.

**Length** – A count of the string of the HEX numbers in the Value field.

**Value** – The server address, port number, minimum firmware version, or firmware server URL (in HEX).

**Example HEX String:**

**0104 ac10a007** 0202 270f 0306 18302e352e34 043d 687474703a2f2f3137322e31362e3136302e333a383030302f 6333636973636f2d66772d302e352e342d757067726164652e62696e2e7369677061636b

**01 04 ac10a007**

**01** = Option 1 (Beacon Server IP)
**04** = Length of 4 HEX numbers
**ac10a007** = ASCII 192 168 100 3 (IP Address 192.168.100.3)

## Module Options

**Option 1** – Management Server IP Address

**Option 2** – Management Server Port

**Option 3** – Minimum Firmware Version

**Option 4** – Firmware Server URL

***Note:*** *When performing ASCII to HEX conversions, do not include periods for IP Addresses.*

***Note:*** *The URL used for the Firmware Server (Option 4) should be as short as possible to avoid the HEX translation being longer than the BLE Module can understand.*

## Example Configuration

The following Option 43 configuration would be used to configure the BLE Module with the following paramaters:

- (Option 1) Management Server IP address of 192.168.100.3
  - HEX = c0 a8 64 03
- (Option 2) Management Server Port of 9999
  - HEX = 27 0f
- (Option 3) Minimum Module Firmware Version of 0.5.4
  - HEX = 18 30 2e 35 2e 34
- (Option 4) Firmware Server URL of http://192.168.100.3:8000/c3cisco-fw-0.5.4-upgrade.bin.sigpack
  - HEX = 68 74 74 70 3a 2f 2f 31 39 32 2e 31 36 38 2e 31 30 30 2e 33 3a 38 30 30 30 2f 63 33 63 69 73 63 6f 2d 66 77 2d 30 2e 35 2e 34 2d 75 70 67 72 61 64 65 2e 62 69 6e 2e 73 69 67 70 61 63 6b

## Option 43 HEX

**0104**c0a864030**2022**70f**0306**18302e352e34**043e**687474703a2f2f3139322e3136382e3130302e333a383030302f6333636973636f2d66772d302e352e342d757067726164652e62696e2e7369677061636b

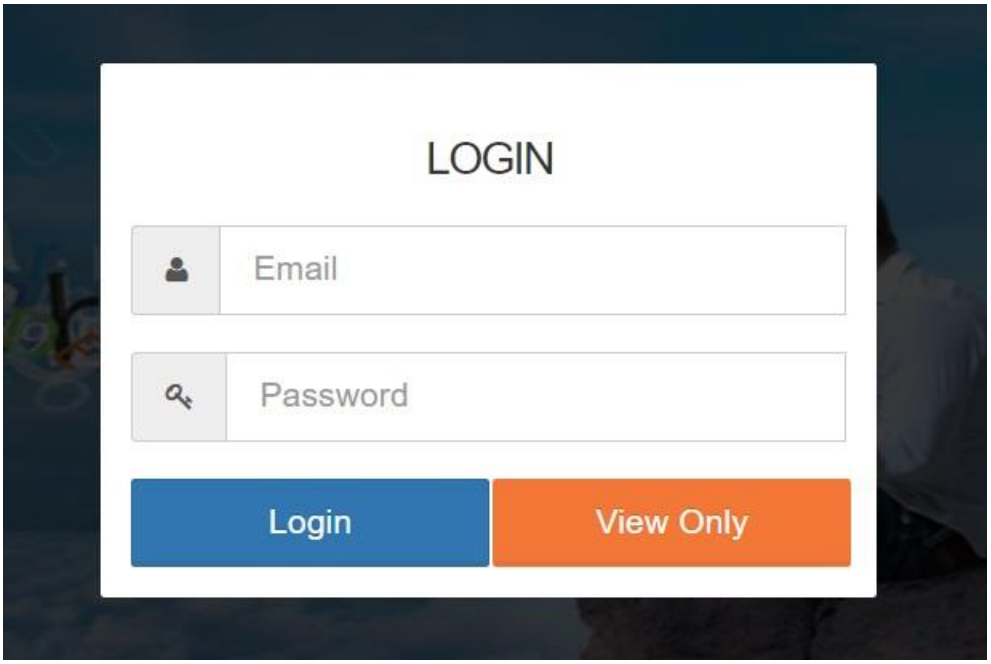
The Type and Length fields are bolded followed by the value (from each option above).

# DC-BR3800-01 Module Configuration

### GUI Login

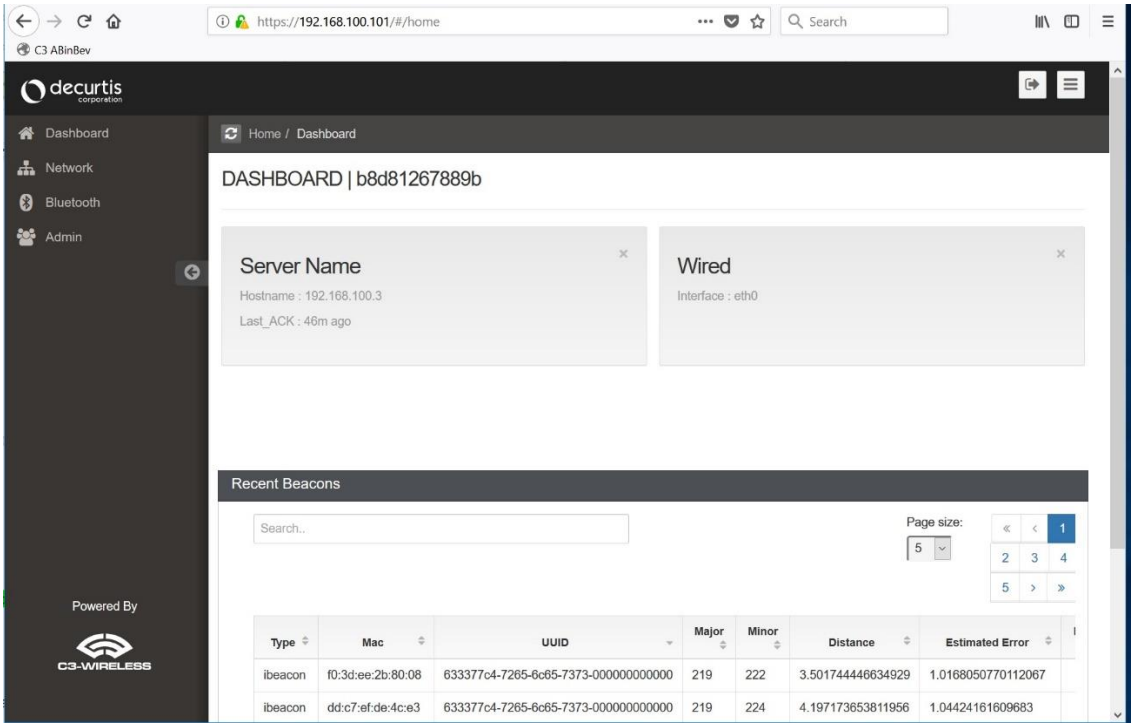
To access the BLE Module's GUI interface, enter its assigned IP address into a valid Web Browser (Chrome recommended). You will be presented with a login screen.

Default administrative credentials are:
Username: "root"
Password: "dcletmein".

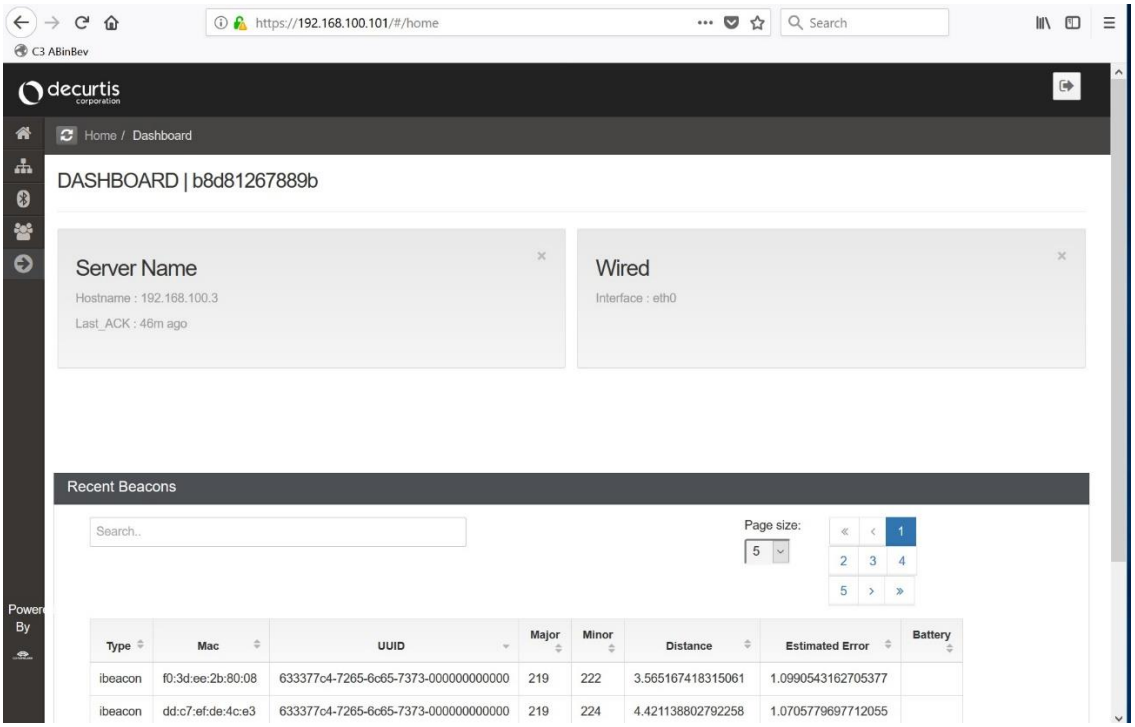


# GUI Layout

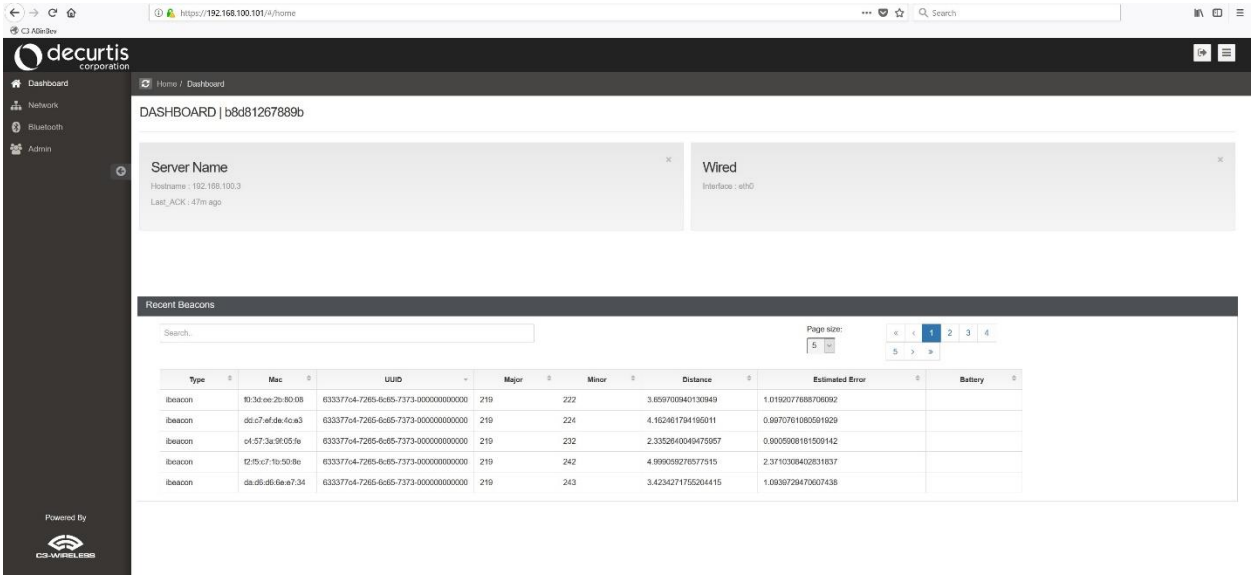
The GUI layout consists of a left menu pane, top right menu pane, and bottom right information pane. **Note:** the left menu pane can be minimized to allow more space for the information pane.




**Minimized left menu pane:**



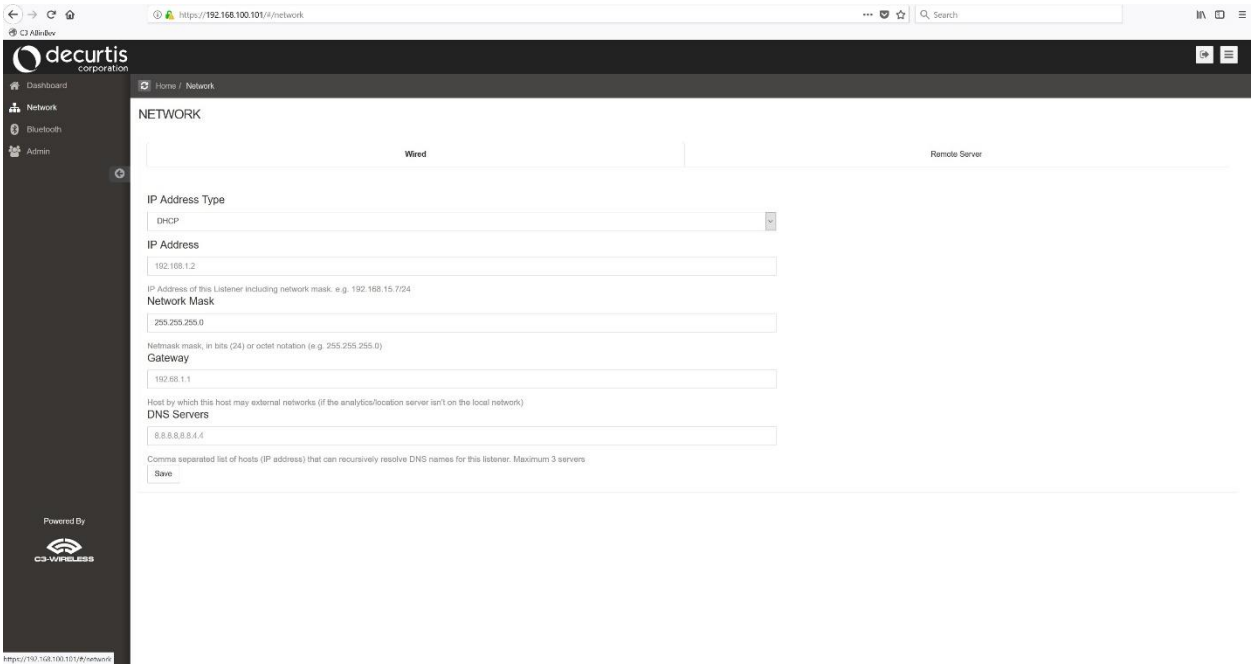
## Dashboard view




The dashboard provides the following information of the BLE Module:

- Host name (MAC address by default)
- Location
- IP address of the BLE Module Management Platform
- Network information assigned to the BLE Module's Ethernet address
- Live view of the most recent beacons seen. Details include:
    - Beacon type (e.g. iBeacon)
    - MAC Address
    - UUID, Major, Minor (if an iBeacon)
    - Estimated distance of the beacon from the module
    - Estimate error
    - Battery life (optional, must be supported by the beacon)

## Network View




The network view has two tab options: (Wired tab and Remote Server tab).

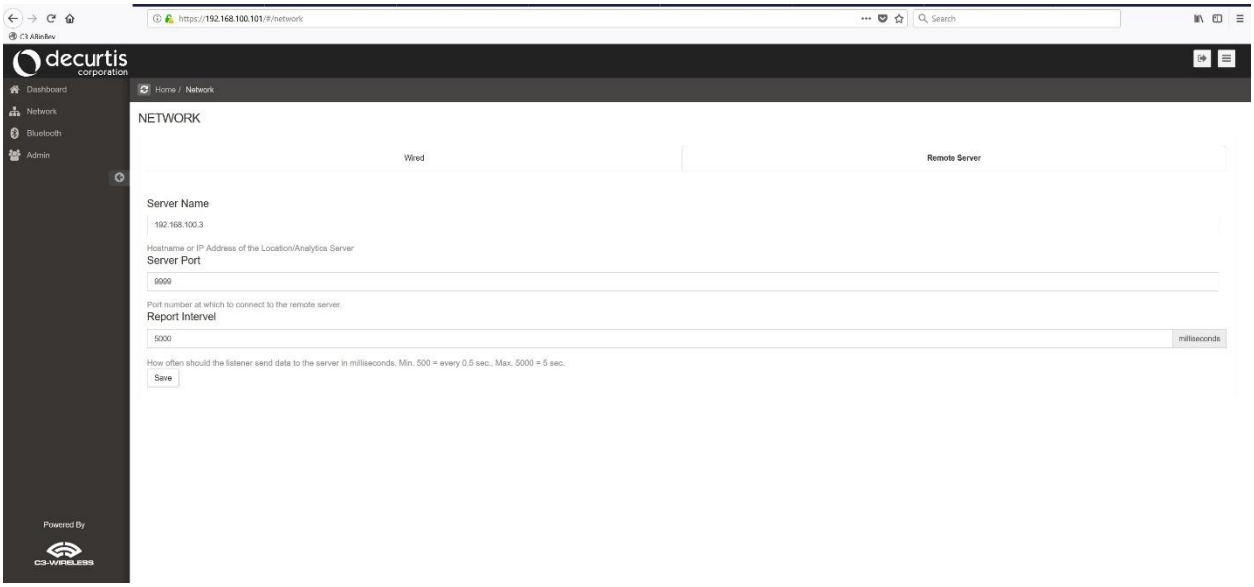
## Wired tab

From the Wired tab you can configure the following:

- IP Address Type (Static or DHCP)
- IP Address
- Network mask
- Gateway
- DNS Servers

When DHCP is selected, the additional options are greyed out.

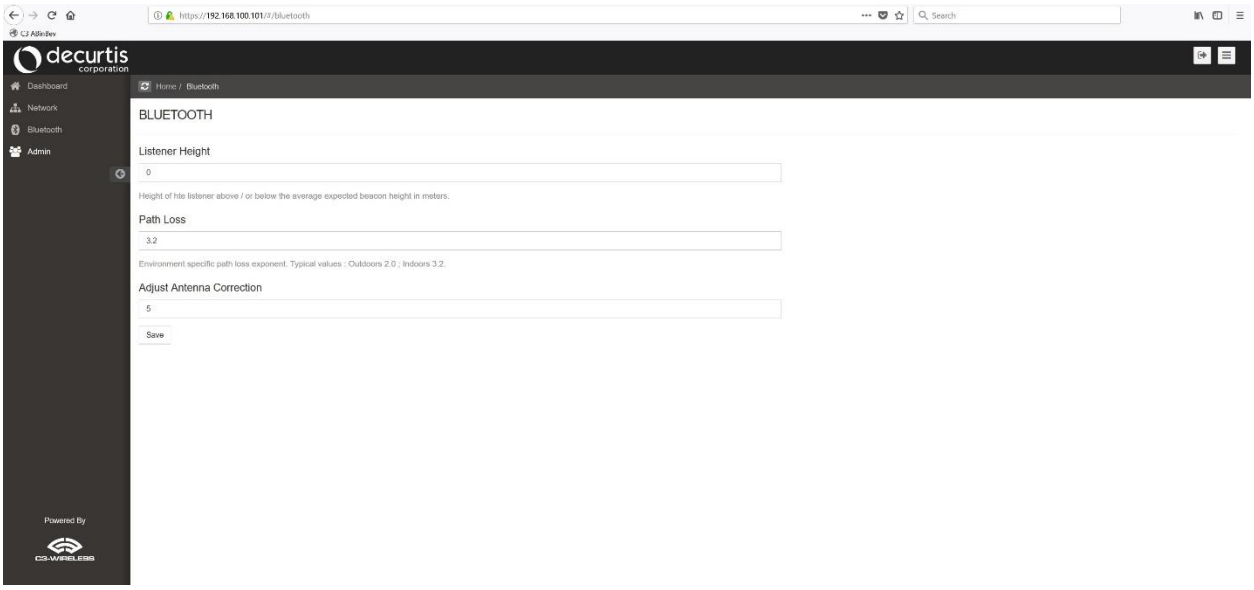
## Remote Server Tab




The remote server tab allows you to configure the following:

- IP Address or URL of the BLE Module Management Platform (Server).
- Management Platform port.
    - Default is “9999”.
- Report Interval
    - This determines how often the module transmits queued data to the management platform (in milliseconds)
    - Default is every five (5) seconds.
- Keep alive packet (Not shown)
    - The listener will transmit a keep alive packet to the server at this interval so it may distinguish between listener failure and simply no beacons near the listener.

## Bluetooth View

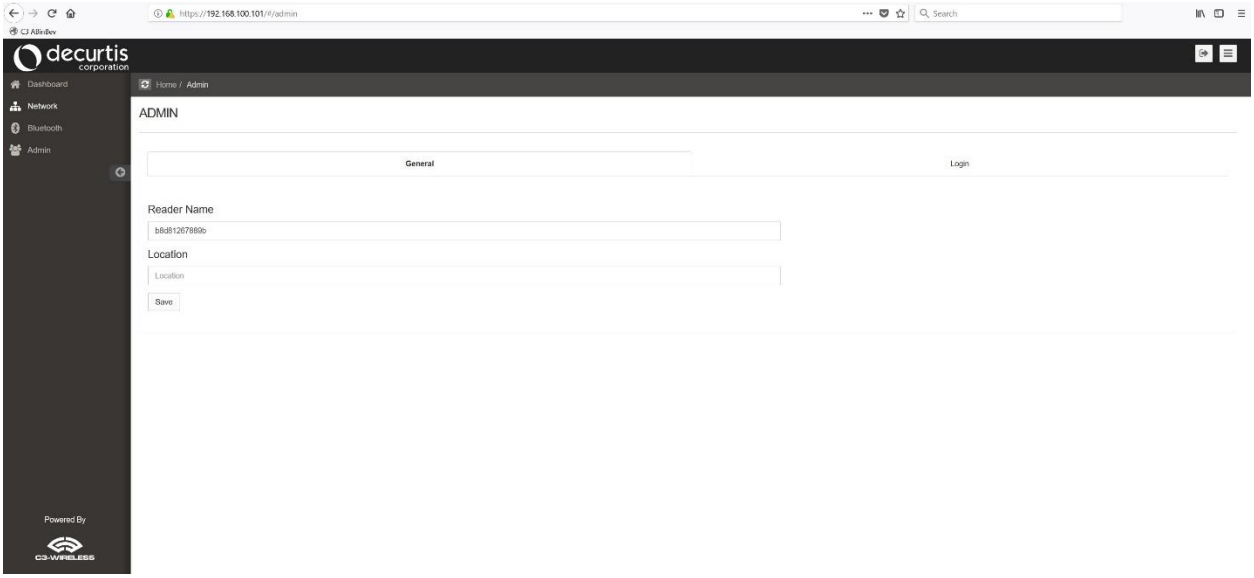



In order to provide accurate beacon distance estimations, several environmental variables must be configured, including the BLE Module's antenna height, environmental path loss, and adjustments made for the type of antenna and antenna cable used.

The following options are configurable:

- Path Loss
    - The RSSI model used for determining beacon distance needs a path loss component to summarize the RF characteristics of the local environment. In clear, outdoor environments this is often below 2.0, indoors in office environments it is sometimes over 4.0.
    - Default is "4"
- Module antenna HAAB (Height above average beacon)
    - Default is "0"
- Antenna gain correction
    - If a high gain antenna is used, signal levels reported for beacons will be higher than the advertised dBm@1m. This value is added to RSSI before distance is calculated. High gain antennas will require a positive value, electrically compromised antenna will require negative values.
    - Default is "0"

### Admin View




The admin view has two tabs, (general tab and login tab).

From the General tab, you can configure the following:

- BLE Module name
  - Host name of the BLE Module
  - Default is the module's MAC address
- Location
  - Where the module is located
  - Default is blank

The login tab allow configuration of user accounts for accessing or administering the BLE Module.

# Privilege / Authorization Model

Users are the authentication units. Only users have authentication credentials (password and/or associated API keys.) There are two types of users:

- **Admin Users**. Admin users may login to the admin panel, but their actual access therein is limited by permissions specified by Superusers/ Admin users.
- **Normal Users**. Normal users may not access the admin panel, and all API results / Web views are filtered to only include objects owned by groups of which they are members.

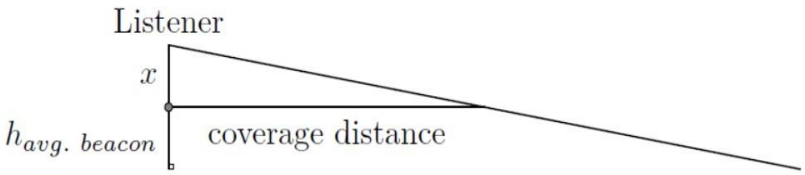
# BLE Module Tuning

## BLE Module Antenna Positioning

The BLE Module antenna has a null looking directly into the point of the antenna and maximum gain between 40°–80° off axis.

Avoid placing the listener such that most common expected beacon paths will dwell directly underneath it.

The ideal height for maximum gain is:




$$\tan 80° \approx 5.7 = \frac{\text{coverage distance}}{x}$$

$$x = \frac{\text{coverage distance}}{5.7}$$

$$\text{ideal height} = x + h_{\text{avg. beacon}} = \frac{\text{coverage distance}}{5.7} + h_{\text{avg. beacon}}$$

For example, for a BLE Module expected to cover a 8m radius, the ideal height assuming a mean expected beacon height of 1.5m above the floor is $\frac{8\,\text{m}}{5.7} + 1.5\,\text{m} \approx 2.9\,\text{m}$ above the floor.

What does *ideal height* mean? In this context, it means that the largest and most uniform portion of the antenna gain is oriented to receive signals from the largest portion of the wanted coverage area.

**Recommended best practice:**

- Mount the BLE Module antenna on the ceiling.
- Avoid placing the antenna directly above the expected position of beacons.
- If you have a choice of mounting heights, the best location results can be found near the ideal height.
- Larger areas can be covered by placing the BLE Module antenna higher, at the cost of widening the null zone directly underneath the BLE Module antenna.

The equation for *x* above, represents ideal HAAB (Height above average beacon). BLE Modules may be informed of their actual HAAB via the BLE Module config file. This value may need tuning in the BLE Module software configuration. See the section on HAAB.

## Antenna Positioning

- Position the antenna perpendicular to and level with the expected plane of beacons.

**Note:** This will normally be 90 degrees to the floor.

- Position the antenna point toward the plane of expected beacons.

## HAAB (Height Above Average Beacon)

Positioning BLE Module antennas above obstacles can improve reception / received power of beacon transmissions, but will also increases the non-planar distance the beacon signal must travel (more distance is traveled vertically rather than horizontally).

Imagine that you are holding a beacon and standing directly underneath a BLE Module antenna mounted 4 meters above you on the ceiling. The BLE Module would report that the beacon is 2-3 meters away, but if viewed on a map, you'd rightfully expect the beacon should be geographically co-located at the BLE Module antenna.

This can be corrected by use of the Pythagorean Theorem.

$$a2 + b2 = c2$$

Where HAAB is one side of a right triangle and RSSI derived distance is assumed to be the hypotenuse path of the signal; the planar distance can be calculated.

For the above example; let $a$ = 3m (HAAB), $b$ = $b$ (unknown planar distance to beacon, in meters), and $c$ = 3m (signal path distance)

$$3^2 + b^2 = 3^2$$

$$b^2 = 0$$

$$b = \sqrt{0} = 0\,\mathrm{m}$$

If we move away from the BLE Module and the signal path distance is reported as 6m, the HAAB correction reduces the planar distance to:

$$3^2 + b^2 = 6^2$$

$$b = \sqrt{27} \approx 5.2\,\mathrm{m}$$

In general, other error sources (multipath propagation, dynamic path loss, lobes in antenna pattern) dominate the total system error. However, in some environments with high ceilings or small rooms where beacons are expected to be mostly underneath the BLE Module antenna, tuning this value may be desired.

## Antenna Gain

BLE Modules are generally shipped with a 2.4GHz 5dBi antenna with RP-SMA connector. This unit/antenna combination is the one against which reference beacon signal strength is calculated.

If a different antenna is substituted, or if an antenna extension cable is added, it will be necessary to modify the module antenna_correction. High-gain / directional antennas will require a negative value, electrically compromised antenna will require positive values in order to produce accurate location data.

The units of antenna_correction are dBm. For calibration of unknown antenna; a beacon may be placed a known distance the listener / antenna and the antenna_correction may be adjusted until the reported distance is equal to the known distance. Increasing values of antenna_correction result in a decrease in reported distance, reducing antenna_correction results in a larger reported distance.

# Cisco WLC and Access Point External Module-Related CLI Commands

## WLC

| Command | Description |
|---|---|
| config ap ext-<br>module {enable \| disable} *ap-name* | Enable/disable the module |
| show ap module summary all | Summary of all APs connected to the WLC that are attached to the external module. Also, displays details of the module type. |
| show ap module summary *ap-name* | Summary of the external module parameters for the specified AP including:<br>- Module Type<br>- Serial #<br>- MaxPower<br>- Description<br>- Product ID<br>- Capability |
| show ap inventory {all \| *ap-name*} | Summary of modules attached to the AP(s) |

## Access Point

| Command | Description |
|---|---|
| show interface wired-em | Statistics and state of the interface when the module is connected to the AP |
| show inventory | Module status and description when it is connected to the AP |
| show client summary | Displays information about the client behind the module and AP radio/WLC client summary |
| debug traffic ext-module<br>all<br>ip<br>tcp<br>udp | Enable the External Module debug to display the traffic dump of:<br>*All* packets sent between the module and AP<br>All *IP* packets sent between the module and AP<br>All *TCP* packets sent between the module and AP<br>All *UDP* packets sent between the module and AP |