Introduction
This document describes the support of protocol 802.11v on a WLC (Wireless LAN controller).

Background Information
802.11v refers to the IEEE (Institute of Electrical and Electronics Engineers) 802.11 Wireless Network Management (Amendment 8).

Stations that support WNM (Wireless network management) can exchange information with each other (Access Points and wireless clients) in order to improve their performance.
AireOS WLC version 8.1 or higher support these WNM services:

- Directed multicast service (DMS)
- BSS (Basic Service Set) Max idle period management
- BSS transition management

**Directed multicast service (DMS):**

Clients that support DMS can request to the AP (Access Point) to send a multicast stream as unicast, like a dynamic media stream function.

For more information for media stream: VideoStream Deployment Guide

Without the use of DMS a client has to wake up every DTIM interval in order to receive multicast traffic. With DMS, the AP (Access Point) buffers the multicast traffic for certain clients, when client wakes up it sends a unicast frame in order to request this traffic. It allows the client to sleep for a longer time and save battery power. Multicast frames are transmitted as unicast over the air, sent at a higher data rate than which it would have been used without DMS.

Wireless clients can send a DMS request-type Add frame in order to ask the AP to send as unicast the traffic of one or more specific multicast streams.

**Management Frame - DMS Request type**
There are three types of DMS request:

**Description Request type value**

- Add 0
- Remove 1
- Change 2
- Reserved 3-255

The DMS request-Add includes a DMS Descriptor.

Inside the DMS Descriptor List there is the TCLAS element, which specifies the multicast traffic stream that the wireless client requests to get as unicast. TCLAS specifies source/destination IP address, source/destination port besides other fields.

The AP sends these traffic streams as unicast to the wireless client and also it continues to send those streams as multicast to any other client in the network that does not support DMS.

Inside a DMS request frame there can be also a TSPEC element (optional), where the wireless client can define the QoS requirements and characteristics of a traffic flow.

**Note:** TSPEC is not supported
In this example the client sent a DMS request (Management frame, Category Code 10: WNM, Action code 23: DMS Request, for the multicast stream IPv4 on group 224.0.0.251, UDP (Protocol 17), destination port 9 (At this document wireshark is not able to completely decode a DMS request).

The AP answers the DMS request with a DMS response, which can be a DMS response-Accept or DMS Response-Deny.

If the AP sends a DMS response-Accept, it also assigns a DMSID to that communication flow.
DMS Request type Change can be used by the wireless client to modify an existent DMSID, for example to request a different TSPEC for a traffic flow.

**Note:** DMS change is not supported

Management Frame - DMS Response type

There are three DMS Response Types:

<table>
<thead>
<tr>
<th>Field Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Accept</td>
</tr>
<tr>
<td>1</td>
<td>Denied</td>
</tr>
<tr>
<td>2</td>
<td>Terminate</td>
</tr>
<tr>
<td>3-255</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

In this example the AP sent a DMS Response-Accept and it assigns a DMS ID 1 to the DMS request sent by the client.
After that if there is a packet with destination group 224.0.0.251 on port 9 it is sent to the air as multicast and it is also buffered on the AP until the client that sent the DMS request is awake is available to receive it as unicast.

This is an example of a packet destination to group 224.0.0.251 on port 9 sent as regular multicast. Notice that the receiver and destination mac address refers to the multicast group.
This is an example of a frame sent as unicast to the client that sent the DMS request. Here the destination and receive address is the mac address of the client and not the multicast mac address. Also the multicast packet is sent as AMSDU.
Once a wireless client no longer wants to receive a multicast stream as unicast it can send a new DMS request to close that flow, it uses the DMS ID that was assigned before by the AP. It is a DMS Request - Remove Type (1)
And the AP confirms this termination with a DMS Response Type Terminate (2)
BSS Max idle period:

When an AP no longer receives frames from a wireless client for a certain period of time it assumes the client left the network and it disassociates it. The BSS Max idle period is the amount of time an AP can keep a client associated without having to receive any frame (client can remain asleep). This value is informed to the wireless client through the association and re-association response frame. This allows the clients to remain asleep for a longer time and save battery power.

BSS Max idle period only appears in association-response or re-association response frames.
The BSS Max Idle Period is specified in units of 1000 TUs (Time units). Every time unit is equal to 1.024 milliseconds.

Idle timeout = 1.024 x BSS Max Idle Period = X seconds

In the example frame:

Idle timeout = 1.024 x 405 = 414.72 seconds

If the Protected Keep-alive Required bit is set to 1, it means that the wireless client must send a RSN protected frame to the AP in order to reset the Idle Timer. If it is set to 0, as this example, the wireless client can send any type of frame (protected or unprotected) to reset the Idle timer at the AP.

**BSS transition management**

802.11v BSS Transition Management Request is a suggestion given to client. Client can make its own decision whether to follow the suggestion or not. The disassociation of a client can be forced if disassociation-imminent function is enabled. It disassociates the client after a period of time if the client does not re-associate to one of the suggested APs.

802.11v BSS Transition is applied to these four scenarios:

**Solicited Request**

Wireless client sends an 802.11v BSS Transition Management Query before they roam for a better option of APs to re-associate with.

**Example of a 802.11v BSS Transition Management Query**
QReason means BSS Transition Query Reason, which is the reason why the client requests the candidate AP list. In this example the client sent a reason 16, which correspond to Low RSSI. For full list of transition query reasons consult Table 8-138 of IEEE 802.11-2012.

After the radio receives this frame, it responds with a BSS Transition Management Request in order to provide the AP candidate list.

Unsolicited Load Balance request

When WLC has load balance feature + BSS transition enabled, the AP no longer sends a
when it is heavily loaded, it sends a BSS transition management request in order to suggest the wireless client another less loaded AP.

For more information about load balance feature: Configuring Aggressive Load Balancing

**Unsolicited Optimized Roaming request**

When WLC has optimized roaming + BSS transition enabled, the AP no longer sends a deauthentication frame to a wireless client when the client does not meet the minimum RSSI (or any other parameter related to optimized roaming), it sends a BSS transition management in order to suggest the wireless client a better AP.

For more information about optimized roaming feature: Cisco Optimized Roaming

**Client steer on FRA AP (Flexible Radio Assignment)**

If a client connects to a less optimum cell within a FRA AP, AP sends out an 802.11v BSS transition Management Request to this client.

When an APs that supports FRA (like 2800 or 3800) uses only 5GHz, there are two cells (micro and macro cell). If a client connects to the macro-cell but micro-cell is more optimal (based on RSSI) then the AP sends a 802.11v BSS transition management request to the client in order to suggest to move the micro-cell and vice versa.

This feature is available since version 8.2.110.0.

For more information about FRA: Flexible Radio Assignment (FRA) and Redundant Radios

**Disassociation Imminent**

Within a BSS transition Management Request, Disassociation Imminent field can be added. This function is to disassociate the client after a period of time if the client does not re-associate to another AP.

When unsolicited optimized roaming request is triggered, the AP sends a BSS Transition Management Request to the client and wait for a certain period (time configured under Optimized Roaming Disassociation Timer), if the client does not roam to a better AP within that period of time, then the AP completes the disassociation of the client.

When Unsolicited Load Balance request is triggered, the AP sends a BSS Transition Management Request to the client and wait for a certain period (time configured under Disassociation Timer), if the client does not roam to a less congested AP within that period of time, then the AP completes the disassociation of the client.

Example of a BSS transition management frame with Disassociation imminent enabled:
BSS Transition Management Response

After a wireless client has received a BSS Transition Management Request, it can or cannot send a BSS Transition Management Response. If the client transitions to another AP it sends it with status code Accept, but if it plans to stay on the same AP due to several reasons it sends it with status code Reject plus the reason of rejection.

Example of a BSS Transition Management Response frame

In this example the wireless client rejects the AP candidate list and does not roam to a different AP. The status code 1 shows the reason why the client leaves the ESS. For full list of status code definitions consult Table 8-253 of IEEE 802.11-2012.

Prerequisites

Requirements

In order to take advantage of 802.11v capabilities of a wlan it is needed to have wireless clients that supports 802.11v.

Components Used

WLC v8.3

Ipod Touch 6th Generation v10.1.1

Configure
Directed multicast service (DMS)

Configuration over WLAN to enable DMS:

CLI config:

> config wlan disable <wlan-id>
> config wlan dms enable <wlan-id>
> config wlan enable <wlan-id>

GUI config (available from version 8.3)

Step 1. Navigate to WLANs > Wlan-ID and click the WLAN to enable DMS.
Step 2. Navigate to Advanced > 11v BSS Transition Support and enable Directed Multicast Service

WLANs > Edit '11v'

BSS Max idle period management

Configuration over WLAN to enable BSS Max Idle period management:

CLI config:

```
> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout(in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable
```
GUI config:

Step 1. Navigate to **WLANs > WLAN-ID** and click the WLAN to set the BSS Max idle period.

Step 2. Navigate to **Advanced > 11v BSS Transition Support** and enable **BSS Max Idle Service**.

Step 3. Navigate to **Advanced > Client User Idle timeout** and set the timeout value in seconds.

**Note**: This GUI options is introduced on version 8.3. For previous versions use command **config wlan bssmaxidle enable <wlan-id>**
BSS transition management

Configuration over WLAN to enable BSS transition management:

**Note**: If only BSS transition is enabled, the only way the Access Points sends BSS transition Management Request frames is if a wireless client sends a BSS Transition Management Query Frame.

**Note**: In order to make the APs to send BSS transition Management Request when they are heavily loaded It is needed to enable BSS transition + load balance.

**Note**: In order to make the APs to send BSS transition Management Request when a wireless client does not have the best RSSI, it is needed to enable BSS transition + optimized roaming.

Solicited request

CLI config:
> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout (in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable

GUI config:

Step 1. Navigate to WLANs > WLAN ID > Advanced and enable BSS Transition.

CLI config:

> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout (in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable

GUI config:

Step 1. Navigate to WLANs > WLAN ID > Advanced and enable BSS Transition and Client Load Balancing.
Unsolicited Optimized Roaming request

CLI config:

> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout (in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable

GUI config:

Step 1. Navigate to WLANs > WLAN ID > Advanced and enable BSS Transition and Coverage
Step 2. Navigate to WIRELESS > Advanced > Optimized Roaming and enable for both band Optimized Roaming Mode. For more information about Optimized Roaming parameters consult this document: High Density Experience (HDX) Deployment Guide, Release 8.0
Disassociation Imminent

CLI config:

> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout (in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable

Step 1. Navigate to WLANs > WLAN ID > Advanced, enable BSS Transition, Disassociation Imminent and set Disassociation Timer and Optimized Roaming Disassociation Timer.

GUI config:
**Note:** Timers are specified in TBTT (Target Beacon Transmission Time) units, which is the interval time between every beacon. By default every beacon is sent every 100ms, so by default 1 TBTT = 100ms. Timers = \( \frac{X \text{ TBTT}}{10} = x \) seconds.

**Verify**

These images show the support of the WLAN (Wireless Local Area Network) and the wireless clients for the different 802.11v services.

**SSID support**

- DMS
IEEE 802.11 Beacon frame, Flags: .......C

IEEE 802.11 Wireless LAN Management Frame

- Fixed parameters (12 bytes)
  - Timestamp: 0x00000000295f28006
  - Beacon Interval: 0.104448 [Seconds]
  - Capabilities Information: 0x1011

- Tagged parameters (267 bytes)
  - Tag: SSID parameter set: tst-80211v
  - Tag: Supported Rates 12(B), 18, 24, 36, 48, 54, [Mbit/sec]
  - Tag: Traffic Indication Map (TIM): DIIM 0 of 0 bitmap
  - Tag: Country Information: Country Code US, Environment Any
  - Tag: QBSS Load Element 802.11e CCA Version
  - Tag: HT Capabilities (802.11n D1.10)
  - Tag: RSN Information
  - Tag: HT Information (802.11n D1.10)
  - Tag: Extended Capabilities (8 octets)
    - Tag Number: Extended Capabilities (127)
    - Tag length: 8
    - Extended Capabilities: 0x00 (octet 1)
    - Extended Capabilities: 0x10 (octet 2)
    - Extended Capabilities: 0x00 (octet 3)
    - Extended Capabilities: 0x04 (octet 4)
      - .......0 = Channel Usage: Not supported
      - .......0 = SSID List: Not supported
      - .......1.. = DNS: Supported
      - .......0... = UTC TSF Offset: Not supported
      - ....0 .... = Peer U-APSD Buffer STA Support: Not supported
      - ...0 .... = TDLS Peer PSN Support: Not supported
      - .0.... = TDLS channel switching: Not supported
      - 0.... .... = Interworking: Not supported
    - Extended Capabilities: 0x01 (octet 5)
    - Extended Capabilities: 0x40 (octet 6)
    - Extended Capabilities: 0x00 (octet 7)
    - Extended Capabilities: 0x40 (octet 8)
  - Tag: Cisco CCX1 CKIP + Device Name
  - Tag: Vendor Specific: Aironet: Aironet DTPC Powerlevel 0x03
  - Tag: VHT Capabilities (IEEE Std 802.11ac/D3.1)
  - Tag: VHT Operation (IEEE Std 802.11ac/D3.1)

• BSS transition management
Client support

- DMS
• BSS transition management
Debug client activity

In order to monitor 11v client activity these commands are available.

> config wlan disable <wlan-id>
> config wlan bssmaxidle enable <wlan-id>
> config wlan usertimeout <seconds> <wlan-id>
> config wlan enable <wlan-id>

<seconds> Client Idle timeout(in seconds) on this WLAN. Range 0,15-100000 secs. 0 in order to disable

Client with DMS capabilities

Client is 11v capable
Client sends a DMS request for group 224.0.0.251 udp port 9 and the AP sends the DMS accept

> show wlan 1

WLAN Identifier................................. 1
Profile Name...................................... 11v
Network Name (SSID)............................... 11v
Status............................................ Enabled

From the AP where the client is connected

AP# debug dot11 dot11v all

> show wlan 1
Number of active DMS Clients..................... 1
DMS ID  Client MAC Addresses
1   a4:f1:e8:58:95:0a

DMS Database is stored in the AP where this client is connected:

AP# show controllers dot11Radio { 0 | 1 } | beg Global DMS

Global DMS - requests:2 uc:130 drop:0
DMS enabled on WLAN(s): 11v

11v

DMS database:
Entry 1: mask=0x55 version=4 dstIp=0xE00000FB srcIp=0x00000000 dstPort=9 srcPort=0 dcsp=0
protocol=17

Once the wireless client closes the DMS flow, it sends a DMS Request Remove

From the AP

*apfMsConnTask_0: Nov 01 22:57:33.990: a4:f1:e8:58:95:0a Got action frame from this client.
*apfMsConnTask_0: Nov 01 22:57:33.990: a4:f1:e8:58:95:0a Received a 11v Action Frame with code [23] from mobile station
*apfMsConnTask_0: Nov 01 22:57:33.990: Received 80211v_DMS_REQ Action Frame
*apfMsConnTask_0: Nov 01 22:57:33.990: WLAN-id : 1 | vap_ip : 1
*apfMsConnTask_0: Nov 01 22:57:33.990: a4:f1:e8:58:95:0a Posting msg of type:
APF_80211v.MSG_DMS_REQ for STA and LRAD:7c:0e:ce:7d:d9:10,slot:0, len:5
*apfMsConnTask_0: Nov 01 22:57:33.990: 11v g_msgQueue = 0x2b415828, osapiMessageSend
rc = 0
*apf80211vTask: Nov 01 22:57:33.991: DMS Request IE processed: State: DMS_REQ_DEL_ACCEPTED
*apf80211vTask: Nov 01 22:57:33.991: DMS ID: 1, DMS Length: 3, Response Type: DMS_RESP_TERMINATE, Last Sequence Control: 65535
*apf80211vTask: Nov 01 22:57:33.991: dmsRequestState = DMS_REQ_DEL_ACCEPTED
*apf80211vTask: Nov 01 22:57:33.991: a4:f1:e8:58:95:0a apf80211vSendPacketToMs: 802.11v Action Frame sent successfully to wlc
*apf80211vTask: Nov 01 22:57:33.991: STA: a4:f1:e8:58:95:0a has dequeued and deleted from the DMS Entry with ID: 1
*apf80211vTask: Nov 01 22:57:33.991: 11v g_msgQueue = 0x2b415828, osapiMessageSend rc = 0

From the AP
**Client BSS Transition Capable**

Client is 11v capable

**Client sends a BSS Transition Management Query**

*apfMsConnTask_1: Nov 14 05:40:32.857: c4:7d:4f:3a:0f:5c Got action frame from this client.  
*apfMsConnTask_1: Nov 14 05:40:32.858: c4:7d:4f:3a:0f:5c Received a 11v Action Frame with code [6] from mobile station  
*apfMsConnTask_1: Nov 14 05:40:32.858: Received 80211v_BSS_TRANS_QUERY Action Frame  
*apfMsConnTask_1: Nov 14 05:40:32.859: WLAN-id : 1 | vap_ip : 1  
*apfMsConnTask_1: Nov 14 05:40:32.859: c4:7d:4f:3a:0f:5c Posting msg of type: APF_80211v_MSG_BSS_TRANS_QUERY for STA and LRAD:00:c8:8b:26:2c:d0,slot:0, len:1  
*apfMsConnTask_1: Nov 14 05:40:32.859: Session URL is not NULL  
*apfMsConnTask_1: Nov 14 05:40:32.859: Disassociation Imminent is 1  
*apfMsConnTask_1: Nov 14 05:40:32.859: Disassociation Timer is 200  
*apfMsConnTask_1: Nov 14 05:40:32.860: Building BSS Transition Request Frame  
*apfMsConnTask_1: Nov 14 05:40:32.860: Adding Neighbor List Subelement  
*apfMsConnTask_1: Nov 14 05:40:32.861: 11v g_msgQueue = 0x2b415828, osapiMessageSend rc = 0
AP sends BSS Transition Management Frame due to load balancing

AP sends BSS Transition Management Frame due to optimized roaming
rc = 0
*apfMsConnTask_0: Nov 04 04:58:55.320: **11v BSS Transition Request is posted to 11v queue.**
*apf80211vTask: Nov 04 04:58:55.321: Session URL is not NULL
*apf80211vTask: Nov 04 04:58:55.321: Disassociation Imminent is 1
*apf80211vTask: Nov 04 04:58:55.321: Disassociation Timer is 40
*apf80211vTask: Nov 04 04:58:55.321: Building BSS Transition Request Frame
*apf80211vTask: Nov 04 04:58:55.321: Adding Neighbor List Subelement
*apf80211vTask: Nov 04 04:58:55.321: No Neighbor Candidate found :Resetting Candidate Included List
*apf80211vTask: Nov 04 04:58:55.321: Data Length of BSS Transition Request Frame: 4
*apf80211vTask: Nov 04 04:58:55.321: apf80211vHandleBSSTransQuery: lradMacAddr: 7c:0e:ce:7d:d9:10 rscb parent MAC ADDR: 7c:0e:ce:7d:d9:10 rscb mac address: 00:00:00:00:00
*apf80211vTask: Nov 04 04:58:55.322: 11v Action Frame sent:
*apf80211vTask: Nov 04 04:58:55.322: a4:f1:e8:58:95:0a apf80211vSendPacketToMs: 802.11v Action Frame sent successfully to wlc
*apf80211vTask: Nov 04 04:58:55.322: Successfully sent BSS Transition Request Action Frame to STA: a4:f1:e8:58:95:0a
*apf80211vTask: Nov 04 04:58:55.322: a4:f1:e8:58:95:0a Setting Session Timeout to 4 sec – starting session timer for the mobile
*apf80211vTask: Nov 04 04:58:55.322: a4:f1:e8:58:95:0a Disassociate client in 4 seconds

References

Chapter: 802.11r, 802.11k, 802.11v, 802.11w Fast Transition Roaming

IEEE Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications