High Density Experience (HDX) Deployment Guide

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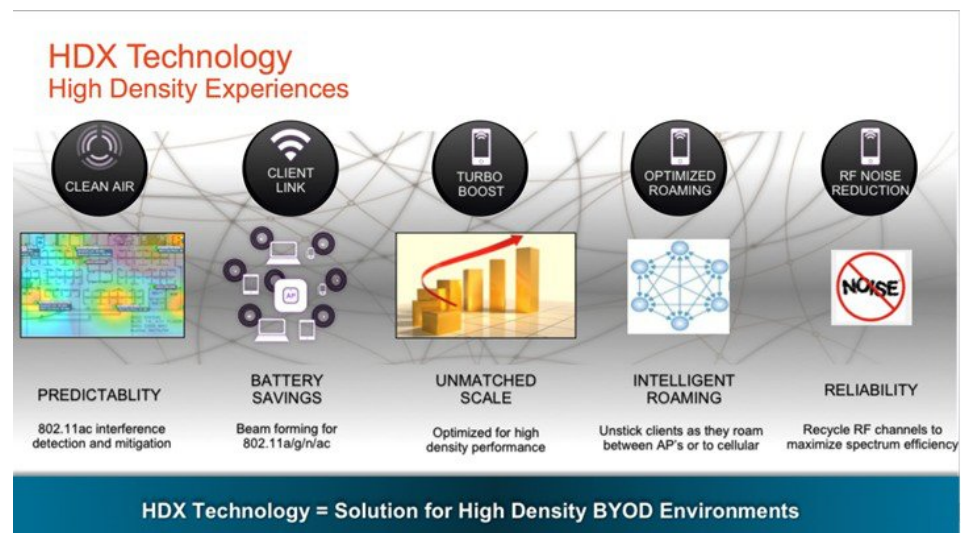# C O N T E N T S

C H A P T E R **1**

Introduction

Introduction

As more wireless clients are connecting to your wireless network, every network is quickly becoming a high density network. Some of the key trends that are leading to high density are growing number of:

- Clients per Access Point (AP)

- APs per WLAN

- Independent but neighboring WLANs

Cisco APs have many built-in features that provide an optimal performing network, even when these trends continue to grow.

High Density Experience (HDX) is a broad and comprehensive suite of solutions that are built-in to Cisco Access Points, consisting of custom hardware, application-specific integrated circuits (ASICs), and software to provide optimal performance in high density WLAN environments.

These features are discussed in depth as part of the Cisco High Density Experience Whitepaper: http://www.cisco.com/c/en/us/products/collateral/wireless/aironet-3700-series/white-paper-c11-731923.html

This document will focus on the HDX software features that are included as part of the 8.0 software release.

High Density Experience Features in Release 8.0

This section covers the following topics in depth:

Receiver Start of Packet Detection Threshold

Receiver Start of Packet Detection Threshold (RX-SOP) determines the Wi-Fi signal level in dBm at which an AP radio will demodulate and decode a packet. The higher the RX-SOP level, the less sensitive the radio is and the smaller the receiver cell size will be. By reducing the cell size, we ensure that the clients are connected to the nearest access point using the highest possible data rates. This is ideal for high density environments such as stadiums and large auditoriums where there are a large number of client devices connected per AP. In a high density environment, the smaller the cell size, the better.
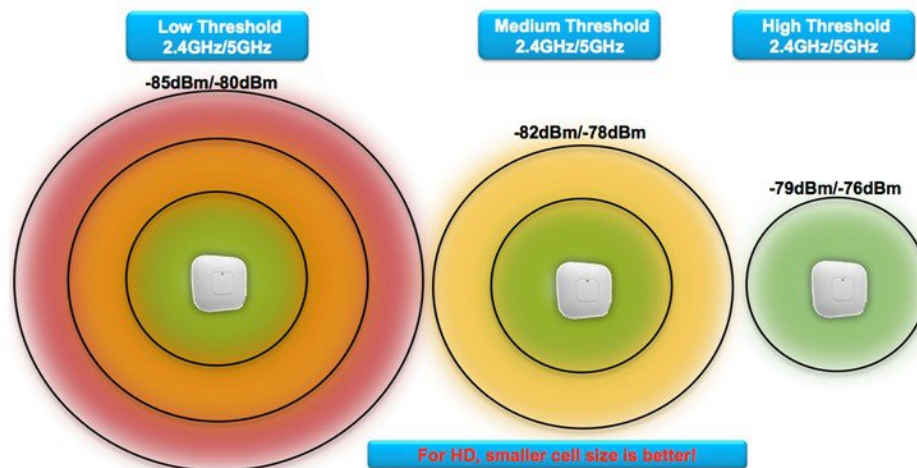

As the RX-SOP value increase, only packets of a higher RSSI value are decoded by the AP's radio. This decreases the cell size as shown in the figure above, but ensures that all clients are connected with a good RSSI value.

The following is an example of an AP receiving 802.11 packets. All frames received with weaker RSSI than configured RS-SOP will be classified as non-WiFi frames and will not get decoded by the radio, only packets

with acceptable RSSI values are decoded. Packets that are not decoded are treated as non-WiFi interference and detected at the AP as noise.
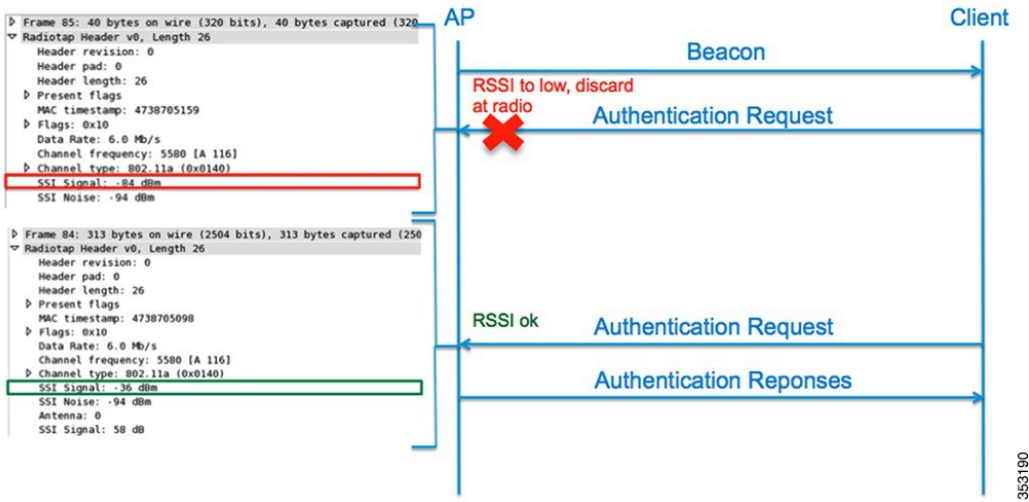
In this example, the RX-SOP threshold is set to low, so authentication requests sent at -84 dBm are not decoded, but when the same message is sent at -36 dBm, it is decoded.

Table 1: RX-SOP Template Thresholds

802.11 Band	High Threshold	Medium Threshold	Low Threshold	Auto
5 GHz	-76 dBm	-78 dBm	-80 dBm	Use radio default
2.4 GHz	-79 dBm	-82 dBm	-85 dBm	Use radio default

The RX-SOP default threshold value is **Auto**, which means that the RX-SOP threshold is set to the radio's default value.
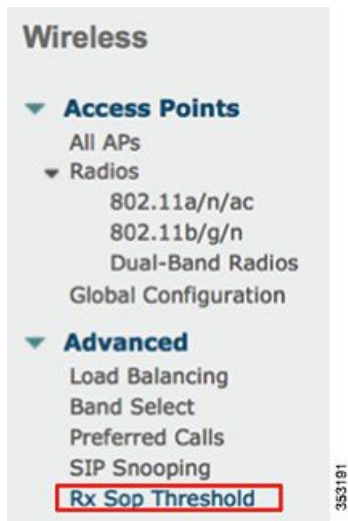
Note RX-SOP is supported on the following APs:

- 1552

- 1570

- 1600

- 1700

- 2600, 2700

- 3500, 3600, 3700

Configuring RX-SOP via the WLC GUI

1. To configure the RX-SOP threshold on a global level, go to **Wireless > Advanced > Rx Sop Threshold**.

2. A different value can be selected for the 2.4 GHz and the 5 GHz band. This value will be set globally for all APs. Only an RF Profile can override these settings.

Configuring RX-SOP via a RF Profile

1. To create a new RF Profile, from the WLC GUI, go to **Wireless > RF Profile**, and then click **New**.

2. Enter a RF Profile name and select a band. A separate profile must be applied to the 2.4 GHz band and 5 GHz band.

3. Select the **High Density** tab and choose the desired RX-SOP threshold.

> **Note** Existing RF profiles can be modified to include an RX-SOP Threshold. You need not create a new profile solely for RX-SOP.

4. The RF Profile must now be applied to an AP Group. Go to **WLANs > Advanced > AP Groups**, then either add a new group or modify an existing group.

5. Under the **RF Profile** tab, select the pre-band RF Profiles with the desired RX-SOP thresholds.

To complete the AP Group configuration, additional steps such as adding WLANs and selecting APs are required. These steps are not listed as part of this guide.

Configuring RX-SOP via the WLC CLI

```
config 802.11<a/b> rx-sop threshold <level>

auto          Revert 802.11a radio receiver SOP to auto
high          Set 802.11a radio receiver SOP to high
low           Set 802.11a radio receiver SOP to low
medium        Set 802.11a radio receiver SOP to medium
```

Optimized Roaming
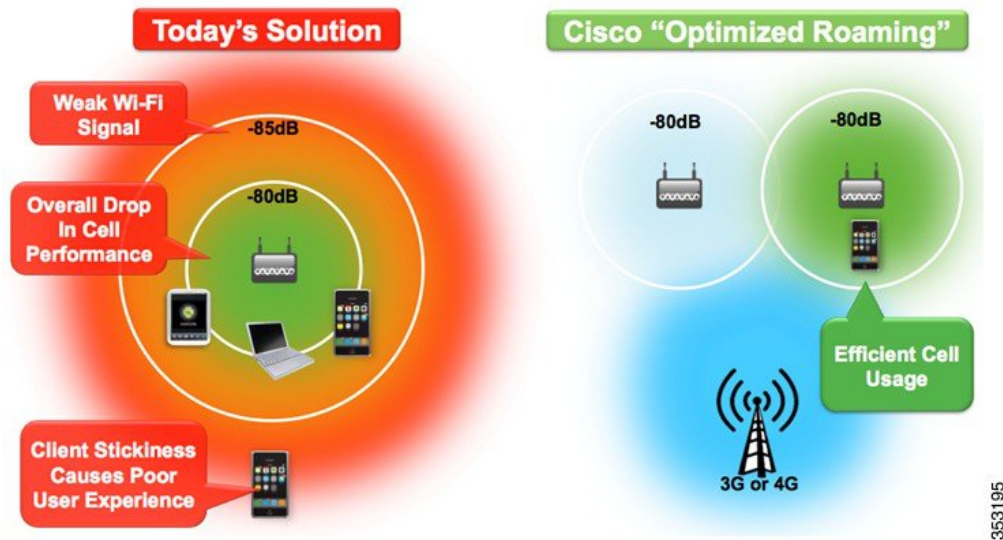
The Sticky Client Problem:

A client is referred as "Sticky" when it does not roam or move to a nearby AP connection that has stronger signal strength. As illustrated in the above figure, when Optimized Roaming is disabled, the client will continue to stay with the AP at very weak signal strength, for example—lower than -86 dB. Lower signal strength will lead to increase in Airtime interference, thus reducing the overall performance.

Solution—Cisco Optimized Roaming:

Cisco Optimized Roaming addresses the sticky client challenge by pro-actively disconnecting clients, thus enabling the clients to move to a nearby AP that offers stronger connectivity. It achieves this functionality by actively monitoring Data RSSI packets, and enforcing client disassociation when the RSSI is lower than the set threshold. As illustrated in the above figure, when Optimized Roaming is enabled, the clients with signal strength lower than -80 dB will receive disassociation and achieves the following:

- Client receives best connectivity and maintains the quality of experience.
- Improves overall performance of each AP cell by reducing Airtime interference.

Key:
X – Coverage Exception Level Percentage
Y – Number of packets
Z – Data RSSI threshold value
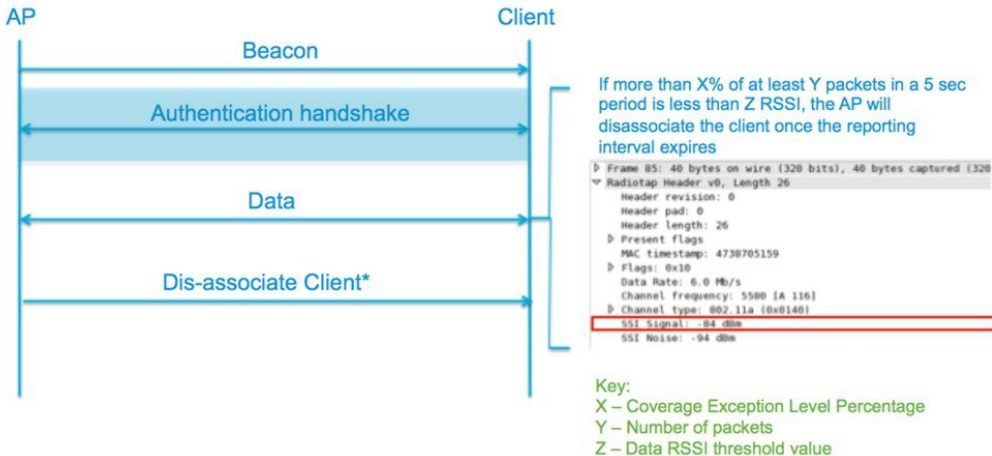
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Note The client will be allowed to rejoin the AP when the client RSSI value has increased to 6 dBm above the disassociation threshold. For example, if the Data RSSI threshold is -80 dBm, the client will be allowed to re-associate once the RSSI values is increased to -74 dBm.

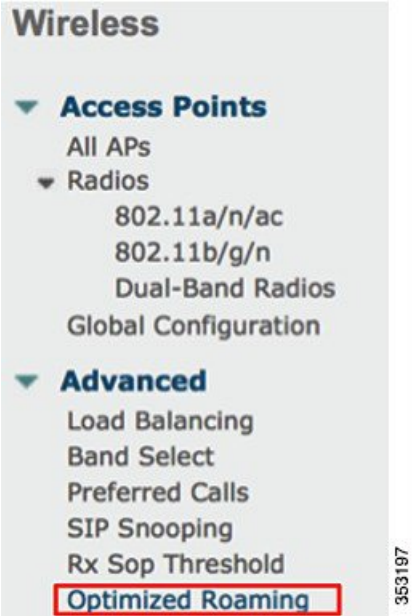*Table 2: Description of the Optimized Roam Feature*

Feature	Description	Default
Enabling Optimized Roaming	Optimized Roaming is disabled by default. It can be enabled per band, meaning it can be enabled on b/g/n, a/ac/n, or both.	Disable

| Feature	Description	Default
Setting the Optimized Roaming threshold parameters	The Optimized Roaming thresholds are shared with the coverage hold detection thresholds. Here is a description of the three fields used for Optimized Roaming: 1. Data RSSI value - This is the threshold value to determine if a data packets RSSI value is too low. Packets received at or below this value are considered below the optimized roaming threshold. 2. Coverage Exception Level Percentage - This marks the percentage of data packets that can be received below the Data RSSI value. If this percentage exceeds, the client will be disassociated. 3. Number of Data Packets Received - This is the minimum number of packets that must be received to trigger a client disassociation. By default, the data RSSI value is set to -80 dBm, the coverage exception level is 25%, and the default number of packets is 50. So by default, if Optimized Roaming is enabled and more than 25% of at least 50 packets in a 5 second period is less than -80 Data RSSI, the AP will disassociate the client once the reporting interval of 90 seconds expires.	-80 dBm / 25% / 50 Packets
Optimized Roaming Interval	The time interval at which the AP reports the client statistics. This value is defaulted to 90 seconds	90

Feature	Description	Default
Optimized Roaming Data Rate Threshold	The goal of the Optimized Roaming feature is only to affect clients that are connected on legacy data rates. These are the clients that are using a majority of the Airtime. This value applies the Optimized Roaming feature to clients connected at this data rate or lower. By default this is disabled, meaning Optimized Roaming is applied to all clients.	Disabled

Configuring Optimized Roaming from the WLC GUI

1. To configure Optimized Roaming on a global level, go to **Wireless > Advanced > Optimized Roaming**.

Wireless

▼ **Access Points**
 All APs
 ▼ Radios
 802.11a/n/ac
 802.11b/g/n
 Dual-Band Radios
 Global Configuration

▼ **Advanced**
 Load Balancing
 Band Select
 Preferred Calls
 SIP Snooping
 Rx Sop Threshold
 Optimized Roaming

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2. On selecting the page, Optimized Roaming Mode, Optimized Roaming Interval, and Data Rate Threshold appear. Different values can be selected for the 802.11a/n/ac and 802.11b/g/n radios.
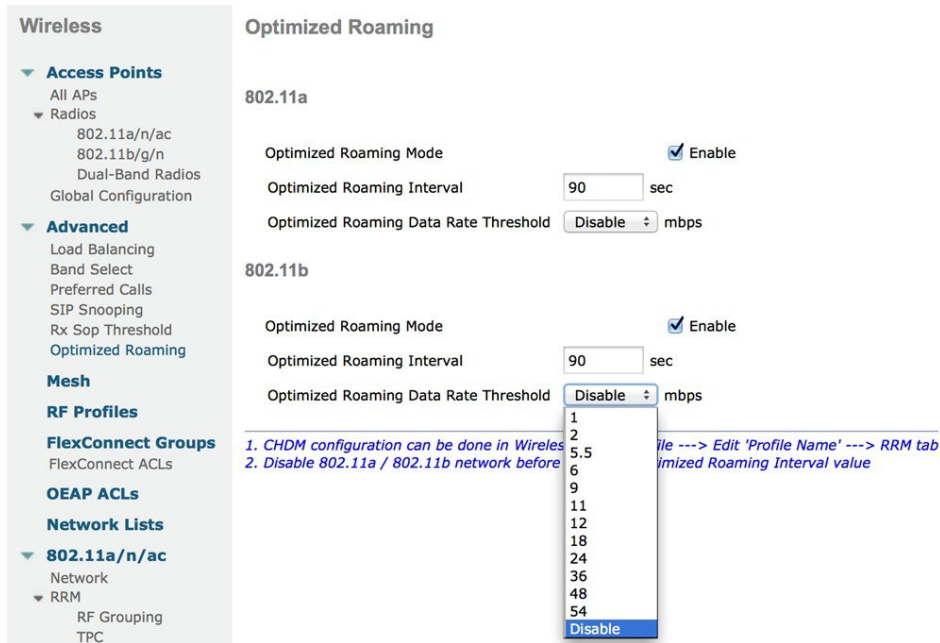
3. To change the Optimized Roaming RSSI thresholds, go to **Wireless > *802.11a/n/ac or 802.11b/g/n* > RRM > Coverage**.
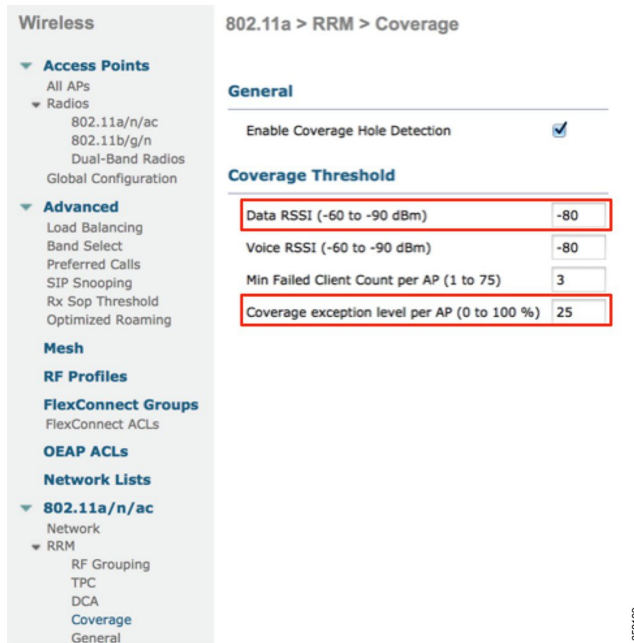
The Data RSSI value and the Coverage Exception level percentage can be configured using the WLC GUI or WLC CLI (See the WLC CLI command in the next section). The received data packet count can only be configured via the WLC CLI.

These values can also be set via an RF profile. If an RF Profile is applied, the RF Profile values will override the globally set values.

To view the Optimized Roaming statistics, go to **Monitor > Statistics > Optimized Roaming**.

Configuring Optimized Roaming from the WLC CLI

Enabling Optimized Roaming:

```
config advanced 802.11<a/b> optimized-roaming <enable/disable>

enable        Enable 802.11a OptimizedRoaming
disable       Disable 802.11a OptimizedRoaming
```

Setting the Data RSSI Threshold:

```
config advanced 802.11<a/b> coverage data rssi-threshold <dBm>
-60 to -90
```

Setting the Coverage Exception Level Percentage:

```
config advanced 802.11<a/b> coverage data fail-percentage <percent>

<percent>     1 to 100
```

Setting the Number of Data Packets Received:

```
config advanced 802.11<a/b> coverage packet-count <num-packets>

<num-packets>    1 to 255
```

Optimized Roam Interval:

```
config advanced 802.11<a/b> optimized-roaming interval <seconds>

Configure the reporting interval of 802.11a/b Optimized-Roaming
```

Optimized Roaming Data Rate Threshold:

```
config advanced 802.11<a/b> optimized-roaming datarate <mbps>
Enter a rate of either 6, 9, 12, 18, 24, 36, 48 or 54, or 0 for disable
```

Sample Configuration:

```
(WLC-IPv6) >config advanced 802.11a optimized-roaming enable

(WLC-IPv6) >show advanced 802.11a optimized-roaming

OptimizedRoaming
  802.11a OptimizedRoaming Mode.................. Enabled
  802.11a OptimizedRoaming Reporting Interval.... 90 seconds
  802.11a OptimizedRoaming Rate Threshold........ disabled
```

Note   Per WLAN Coverage Hold Detection must be enabled on all WLANs that participate in Optimized Roaming.

# Dynamic Channel Assignment in RF Profiles

The 8.0 release now supports the ability to configure Dynamic Channel Assignment in an RF Profile. This is very powerful because of the following:

- Assign the channels that are supported per country to a specific group of APs in a multiple country supported WLC.
- Manage mixed channel (802.11n/ac 40/80 MHz) environment.
- Channel assignment by physical area – different channels can be assigned to different group of APs depending on their physical location.

RF Profiles allow Network Administrators to apply different RF characteristics to an AP Group. This allows for a completely customized RF environment for access points that are connected to the same physical WLC.

In the following example, the APs covering a large meeting room with many clients are assigned a High Density RF Profile. The High Density RF Profile uses 40 MHz channels to minimize channels from being reused, lower the TX power to shrink the cell size, and disable lower data rates to remove low performing clients.

The APs in RF Profile 2 are deployed in a less density enterprise office space. Their cell sizes are larger, 80 MHz channel widths are used, and the Tx power is greater.
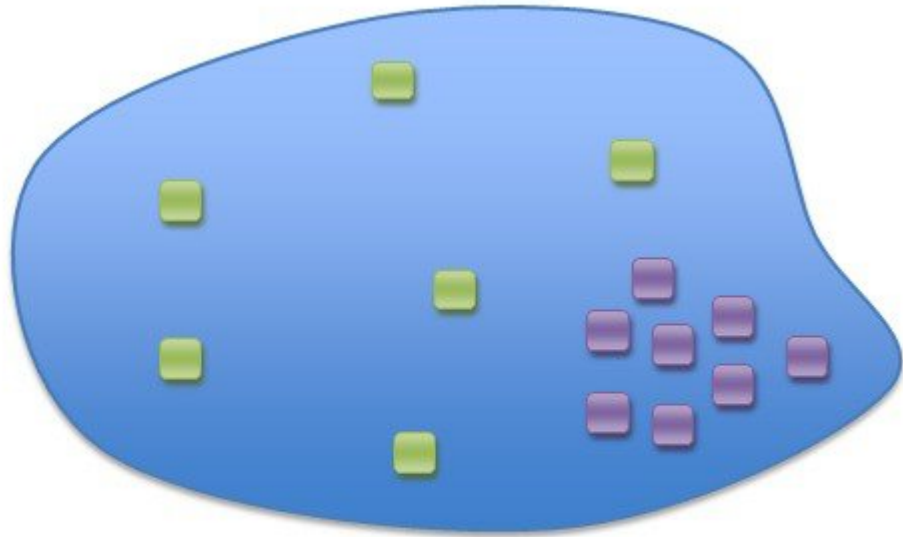
High density RF Profile 1 AP: Bandwidth 40 MHz

RF Profile 2 AP: Bandwidth 80 MHz

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In previous releases, the following features were supported in RF Profiles:

- Data Rates
- Tx Power Control Threshold
- Tx Power Max/Min
- High Density Configurations

    - Start Of Packet Threshold
    - Clear Channel Assessment Threshold
    - Client Limitation per WLAN/Radio(s)

- Stadium Vision Configurations

    - Multicast Data Rate

- Out-Of-Box AP Configurations
- Band Select Configurations
- Load Balancing Configurations
- Coverage Hole Mitigation Configurations

In the 8.0 release, the following DCA and Trap Threshold configurations are supported:

- DCA Configurations:

    - Avoid Foreign AP Interference
    - Channel Width
    - DCA Channel List

- Trap Thresholds:

    - Clients

- Interference
- Noise
- Utilization

Assigning Channels to a RF Group

We can now assign channels to an RF Group. This gives the network administrator the ability to select the channels that DCA can select by group of APs. The administrator can configure the first floor of a building to use only UNII-1 channels, the second floor to use UNII-2, and the third floor to use UNII-3.

You can either edit an existing RF profile or create a new RF profile. Go to **Wireless > RF Profile > Edit**
RF Profile Name **> RRM** tab.

Select the channels that you would like configured for this RF Profile.

Note

- The country code with the desired channels must be enabled on the WLC globally. Channels that are not part of the selected country codes cannot be selected here.
- WLCs with Bridge Mode APs will not allow multiple country codes to be selected.
- Channels must be selected under Global DCA on the controller to be available in profiles.
- You must disable 802.11a/b networks to change DCA channels or Bandwidth (20/40/80).
- RF Profiles and AP groups must be present on every controller in the RF Group.
- DCA Channel Sensitivity and Channel Assignment Interval are only configurable on a global WLC level.

Assigning Channel Width to an RF Group

Different channel widths can be assigned to different RF groups. This allows network administrators to select 20/40/80 MHz channel widths per group of APs.

You can either edit an existing RF profile or create a new RF profile. Go to **Wireless > RF Profile > Edit** *RF Profile Name* **> RRM** tab.

C H A P T E R 3

High Density Experience Features in Release 8.1

This section covers the following topics in depth:

Dynamic Bandwidth Selection

Dynamic Bandwidth Selection (DBS) algorithm addresses smart switching between channel bandwidths in current and future 802.11ac radios and new coexistence scenarios. DBS will be a differentiating factor for enterprise WLAN networks that have 11ac APs along with legacy APs. DBS also signifies the flexibility of RRM in managing coexistence between 11ac and legacy APs and devices.

To provide much anticipated significant increase in data rates, 11ac introduces several new wide bandwidth modes, such as operation at 80 MHz and 160 MHz. Additionally, 11ac also allows an AP to switch from these modes to one of the existing narrower bandwidths, such as 20 MHz or 40 MHz. This is particularly useful for networks that have 11ac APs along with legacy APs and/or clients, which only have the narrower bandwidths. While it is obvious that the AP should do so to improve the performance, the exact conditions for when to do so are not specified in the standard and are open for innovations.

The DBS algorithm provides a smooth transition for various configurations as customers upgrade from 11n to 11ac. The core Dynamic Channel Assignment (DCA) algorithm deals with assignment of channels based on steady-state conditions, such as neighboring AP distances, rogue channel configurations, and AP types. But, to achieve the highest performance, it would be necessary to fine-tune the channel allocations based on relatively more transient parameters, namely to select between 40 MHz and 80 MHz bandwidths. The main objectives of the DBS and Core DCA are not to compete with different channel and bandwidth choices. DBS applies an additional layer of bias values on top of those applied in Core DCA, such that the net result of the final channel assignment will steer towards DBS's recommendations. To optimize the channel bandwidth along with the channel selection, DCA classifies overall channel metrics for all modes of channel widths. Along with the previously mentioned Wi-Fi metrics, it also takes into consideration adjacent channel penalties due to 40/80 MHz OBSS along with primary channel misalignment penalties. In certain cases, selecting 40 MHz can be more efficient depending on the number of 40 MHz 11n clients in a BSS. It may not be efficient to allocate 80 MHz to all 11ac BSSs from a frequency reuse point of view. Similarly, certain traffic flows may not benefit from having wider bandwidths.

To steer the deployment as described above, when a BSS or deployment is detected with a significant number of 11n clients or is completely made up of 11n clients, then DBS should steer the channel allocations as such:

- When client stations are all 11n (or above a certain preset threshold hysteresis) or there are traffic flow types that favor narrower bandwidth: Change the 80 MHz 11ac BSS to use 40 MHz channel widths (that is, DBS with BW constraint).

- When there is a mix of 11n and 11ac client stations (or above a preset certain threshold hysteresis): Allow sharing secondary40 between 80 MHz BSS (that is, DBS with misaligned primary40).

Both these can be accomplished by use of appropriate biases. Traffic based bias can be added as a function of the number of clients of each type and fractions of different types of traffic on a particular AP.

Enabling Dynamic Bandwidth Selection (DBS)

1. Disable 802.11a network.

2. Go to **Wireless > 802.11a > RRM > DCA**.

3. In the **Channel Width** field, click the **Best** radio button.

4. Enable 802.11a network.

Enabling Dynamic Bandwidth Selection (DBS) in RF Profile

1. Create an RF Profile on 802.11a radio.

2. Edit the RF Profile you just created. On the **RRM** tab, in the **DCA** area, in the **Channel Width** field, click the **Best** radio button to enable DBS.

3. Apply the RF Profile to AP groups.

Dynamic Bandwidth Selection (DBS) Best Practices

Following are some of the best practices for dynamic bandwidth selection:

- Allow DCA with DBS to run every 10 minutes.

- DBS should be set globally.

- **Channel Width** should be set to **Best** on all deployments.

- A global restart should be initiated when DBS is enabled.

  - **config 802.11a channel globabl restart**.

Dynamic Frequency Selection

Dynamic Frequency Selection (DFS) is created to increase the availability and usability of channels in the 5 GHz spectrum. Depending on regulatory domain, this can be from 4 to 12 additional channels. More channels imply more capacity. The DFS function detects radar signals and moves AP channel on valid detection, thus ensuring primary spectrum users (weather radar, military radar, and so on) that there will not be interference from the access point. DFS avoidance of radar also helps to prevent the AP from suffering from interference The DFS requirements also designates a primary AP as a monitor for the group that will steer clients away as well. Traditionally, there are some misgivings in North America about using DFS channels, but, there are only eight non DFS channels (each channel is 20 MHz wide). In the ETSI regulatory domain (Europe), there are only four non DFS channels and have been using DFS channels successfully for many years.

Although the 5 GHz band offers more channels, care should be given to the overall design as the 5 GHz channels have varying power and indoor/outdoor deployment restrictions. For example, in North America, the U-NII-1 can only be used indoors and it has power restriction of 50 mW maximum power (soon to be changed to much higher power). Both U-NII-2 and U-NII-2e are subject to Dynamic Frequency Selection.

The following figure shows current 5 GHz channels allocation in North America, Europe, and Japan.
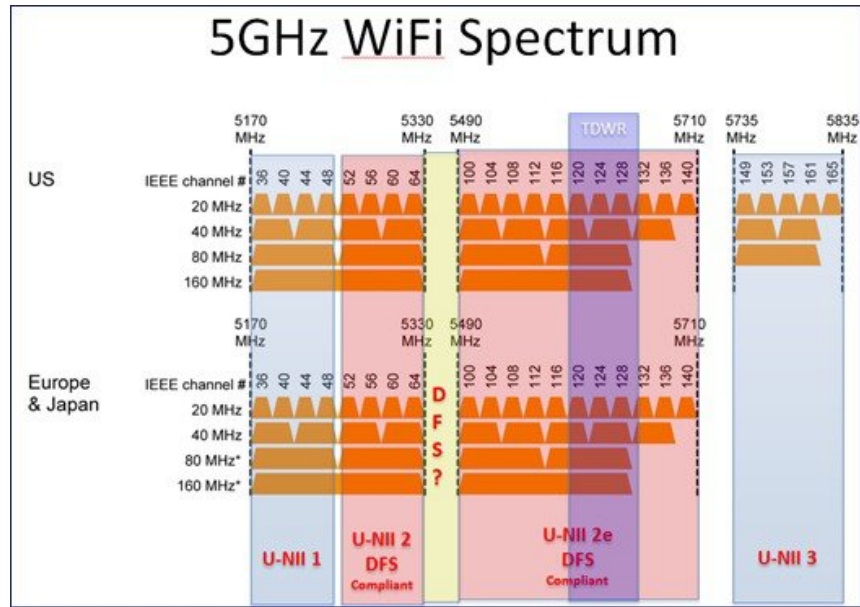
In the US, there are currently **22/10/5/1** channels with bandwidth 20/40/80/160 MHz channels respectively. With the proposed opening up of 5.35 – 5.47 GHz and 5.85 – 5.925 GHz spectrum, the number of channels increases to **34/16/8/3**. If the industry manages to take back the TDWR channels, the number of channels increases to **37/18/9/4**.
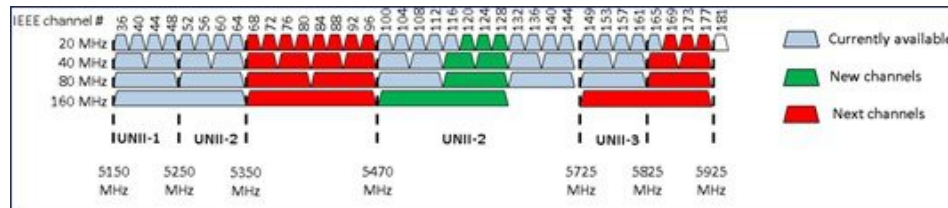
The following table displays the number of DFS channels supported.

Reg. Domain	Total 20 MHz Channels	DFS Channels
-A	22	11
-E	15	11

There is a huge demand for spectrum in US and all over the world. The more spectrum we have the more channels we will have to operate in and hence we get better solution and system performance. In the current implementation, if the DFS channel is chosen for operation in 20/40/80/160 MHz bandwidth, the following process occurs continuously.

DFS-enabled radios monitor the operating frequency for radar signals on DFS channels only. If radar signals are detected on the channel, the AP performs the following actions:

- Blocks new transmissions on the channel.

- Flushes the power-save client queues.

- Broadcasts an 802.11h channel-switch announcement to all one hop neighbors.

- Disassociates remaining client devices.

- Blocks DFS channel for 30 minutes.

- Starts Channel Availability Check (CAC) process and randomly selects a different channel.

- If the AP does not select a DFS-required channel, it enables beacons and accepts client associations on the new channel.

- If the AP selects a DFS-required channel, it scans the new channel for radar signals for 60 seconds.

- If there are no radar signals on the new channel, the AP enables beacons and accepts client associations.

- If a radar signal is detected, the AP selects a different new channel.

- If a preferred channel is configurable and available, it is selected first.

- DFS channels is continuously monitored for the radar interference when receiving data packets.

This existing behavior has a huge negative impact for wide band channel deployments that experience either real radar detection or DFS falsing. As shown in the following figure, an 80 or 160 MHz channel (4 to 820 MHz channels) can be completely disabled, off the air (for at least 30 minutes) if a narrowband radar is detected. This loss of spectrum can have a negative ripple effect throughout the rest of the wireless network.
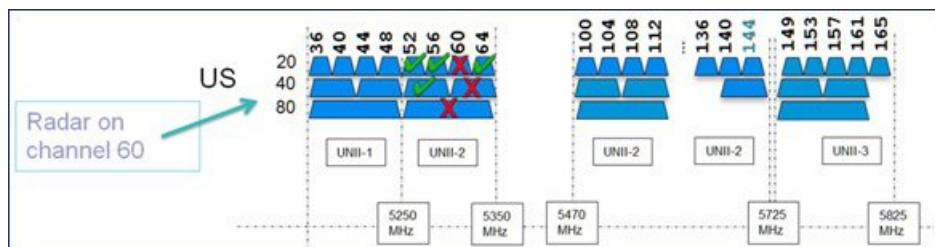
The solution to this collision scenario is the Cisco's patent pending Flex-DFS technology. This feature leverages the advanced signal processing capabilities within SAgE (Spectrum Analysis Engine ASIC) to accurately identify Wi-Fi channel location of a DFS radar signal. This information can be used by the access point and wireless controller to optimally select a new channel allocation. Thus, both access point and the wireless controller avoid the detected channel and then changes to a new channel and/or channel width that is least disruptive and widest.

The foundational technology to this feature is the accurate radar signal frequency estimation that SAgE provides. This accuracy is beyond what Cisco's competitors can support. With accurate knowledge of the radar signal frequency, the access point can turn off just that sub channel, and not the entire larger channel. The following steps, for an 160 MHz channel, illustrate this:

1. Identify radar frequency to 1 MHz accuracy.

2. Isolate radar event only to one 20 MHz channel and mark it as unavailable.

3. Continue using rest of the spectrum, that is, 40/80 MHz intelligently.

4. If possible, avoid rolling back to lower bandwidth, that is, 20/40 MHz if possible.

5. Avoid running the CAC process and impacting system and clients performance.

You can envision a 5 GHz band wireless network, composed of a large number of access points and managed by a wireless controller. You can also imagine this network that serves a large number of clients (for example, a wireless-only corporate network) requiring reliable use of DFS channels set for wideband operation.

Additionally, if there is weather radar, military radar or any RF signal that could cause a DFS detection in the vicinity, and that detection exceeds the DFS threshold in access points, then that wireless network is susceptible to significant client disruptions and traffic throughput degradation.

With FlexDFS feature incorporated on the access point, the wireless network has precise information regarding the frequency location of the interfering radar frequencies, and can steer the network channel allocation in a more optimal and efficient manner than before. So, this feature works integrally with wireless controller as it configures channel allocation and bandwidth optimally to serve the clients. RRM-DCA utilizes this new information to achieve better channel utilization and reuse across the network.

As mentioned previously, Cisco is the only wireless networking vendor with this capability.

Although FlexDFS has the most applicability for 11ac networks, it will become available on all SAgE based APs previously used for Clean Air capabilities: 3500, 3600, 3700, 2600, 2700, 1550, and 1570 Mesh APs. APs that support CA Express or other legacy AP are not currently planned to support FlexDFS. However, when a SAgE based AP detects radar interference on the DFS operated channels, it can inform all 802.11ac capable neighbor APs about the radar interference.

Summary

Both DBS and FlexDFS provide better utilization of wideband .11ac rates in the enterprise network. Combined, they provide confidence to customers in operating their WLANs with wide channel widths and help give Cisco an advantage over the competition in real world wireless network performance.

Summary