

@WJComms

Tuning Cisco WLC for High Density Deployments

-

William Jones

Assumptions made in this document:

- Cisco WLCs (2504/5508/8510/WiSM2).
- APs in Local Mode.
- 7.6 MR3 Code or higher.
- No requirement to support legacy (802.11b) devices at 2.4GHz.
- RF Design techniques for High-Density networks have been followed.
- RF-Profiles can be used to assign specific settings to groups of AP's.
- Familiarity with Cisco WLCs and their configuration.

Revision 3.2 - November 25, 2014

Preface:

This document started life as an internal document for engineers I was working with to serve as a quick guide to deploying and configuring a Cisco WLC for a high-density deployment, it covers at a high level the basics required to bring a Cisco WLC from its factory default configuration to a state where it would operate more or less successfully in a high-density deployment with some further minimal tuning.

It is by no means the be all and end all a guide of wireless design or tuning and certainly does not cover the subject in any great detail – least not where high-density design and deployment are concerned!

This guide is also under constant review, it seems that we are always writing and rewriting the book on how to do this HD thing, and over the last ten years or so I have been working in this industry have certainly found plenty of ways how *not* to do this, hopefully people following this guide will be able to avoid some of the early mistakes I made.

The configuration guidelines here are based on what we are generally using in the real world to deliver events, large and small they all more or less get the same initial configuration and we have found that these values and settings have proved to be an excellent starting point that allow us to deliver a consistent and predictable level of performance from our networks.

As with most of my work this document is also taken from a view of someone who works predominantly in deploying networks for large temporary events and into large public venues. All environments and networks are different and what works for me may be a complete disaster for you, but then nobody ever learned anything by not trying to do something new did they?

At a high level this document loosely covers the following areas:

- *Configuring and selecting data rates.*
- *Tuning and configuring RRM (DCA / TPC).*
- *Tuning and configuring band-select and other advanced features.*
- *Basic checklist for creating WLAN profiles from the point of view of a large public network.*
- *Working with 802.11k and some of the newer assisted roaming features.*
- *CLI Cheat Sheet – a few useful commands.*

Data Rates:

Given that the vast majority of WiFi devices released in the last 3+ years are 802.11n capable it is generally considered safe to disable support for legacy devices on high-density networks.

This has the advantage of improving airtime efficiency of the network and forces management and control frames to a higher data rate. A frame transmitted at 6Mbps with OFDM encoding is actually more efficient than a frame transmitted at 11Mbps with DSSS encoding. Removing legacy devices from the network also removes the need to rely on protection mechanisms and can greatly improve performance.

Some client devices may not be able to "see" the network as they require support for legacy data rates to be enabled, these devices are few and far between. Whilst not enabling legacy data rates can cause connectivity issues for a small number of clients the overall performance gains for the network made by removing this support far outweighs the detrimental effects of leaving support for legacy devices in place.

The following are considered current best practices, and a starting point for high-density tuning.

802.11b/g Global Parameters

<p>General</p> <p>802.11b/g Network Status <input checked="" type="checkbox"/> Enabled</p> <p>802.11g Support <input checked="" type="checkbox"/> Enabled</p> <p>Beacon Period (milliseconds) <input type="text" value="100"/></p> <p>Short Preamble <input checked="" type="checkbox"/> Enabled</p> <p>Fragmentation Threshold (bytes) <input type="text" value="2346"/></p> <p>DTPC Support. <input checked="" type="checkbox"/> Enabled</p> <p>Maximum Allowed Clients <input type="text" value="200"/></p> <p>RSSI Low Check <input type="checkbox"/> Enabled</p> <p>RSSI Threshold (-60 to -90 dBm) <input type="text" value="-80"/></p> <p>CCX Location Measurement</p> <p>Mode <input type="checkbox"/> Enabled</p>	<p>Data Rates**</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>1 Mbps</td><td>Disabled</td></tr> <tr><td>2 Mbps</td><td>Disabled</td></tr> <tr><td>5.5 Mbps</td><td>Disabled</td></tr> <tr><td>6 Mbps</td><td>Disabled</td></tr> <tr><td>9 Mbps</td><td>Disabled</td></tr> <tr><td>11 Mbps</td><td>Disabled</td></tr> <tr><td>12 Mbps</td><td>Mandatory</td></tr> <tr><td>18 Mbps</td><td>Supported</td></tr> <tr><td>24 Mbps</td><td>Mandatory</td></tr> <tr><td>36 Mbps</td><td>Supported</td></tr> <tr><td>48 Mbps</td><td>Supported</td></tr> <tr><td>54 Mbps</td><td>Supported</td></tr> </table>	1 Mbps	Disabled	2 Mbps	Disabled	5.5 Mbps	Disabled	6 Mbps	Disabled	9 Mbps	Disabled	11 Mbps	Disabled	12 Mbps	Mandatory	18 Mbps	Supported	24 Mbps	Mandatory	36 Mbps	Supported	48 Mbps	Supported	54 Mbps	Supported
1 Mbps	Disabled																								
2 Mbps	Disabled																								
5.5 Mbps	Disabled																								
6 Mbps	Disabled																								
9 Mbps	Disabled																								
11 Mbps	Disabled																								
12 Mbps	Mandatory																								
18 Mbps	Supported																								
24 Mbps	Mandatory																								
36 Mbps	Supported																								
48 Mbps	Supported																								
54 Mbps	Supported																								

802.11a Global Parameters

<p>General</p> <p>802.11a Network Status <input checked="" type="checkbox"/> Enabled</p> <p>Beacon Period (milliseconds) <input type="text" value="100"/></p> <p>Fragmentation Threshold (bytes) <input type="text" value="2346"/></p> <p>DTPC Support. <input checked="" type="checkbox"/> Enabled</p> <p>Maximum Allowed Clients <input type="text" value="200"/></p> <p>RSSI Low Check <input type="checkbox"/> Enabled</p> <p>RSSI Threshold (-60 to -90 dBm) <input type="text" value="-80"/></p> <p>802.11a Band Status</p> <p>Low Band Enabled</p> <p>Mid Band Enabled</p> <p>High Band Enabled</p>	<p>Data Rates**</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>6 Mbps</td><td>Disabled</td></tr> <tr><td>9 Mbps</td><td>Disabled</td></tr> <tr><td>12 Mbps</td><td>Mandatory</td></tr> <tr><td>18 Mbps</td><td>Supported</td></tr> <tr><td>24 Mbps</td><td>Mandatory</td></tr> <tr><td>36 Mbps</td><td>Supported</td></tr> <tr><td>48 Mbps</td><td>Supported</td></tr> <tr><td>54 Mbps</td><td>Supported</td></tr> </table> <p>CCX Location Measurement</p> <p>Mode <input type="checkbox"/> Enabled</p>	6 Mbps	Disabled	9 Mbps	Disabled	12 Mbps	Mandatory	18 Mbps	Supported	24 Mbps	Mandatory	36 Mbps	Supported	48 Mbps	Supported	54 Mbps	Supported
6 Mbps	Disabled																
9 Mbps	Disabled																
12 Mbps	Mandatory																
18 Mbps	Supported																
24 Mbps	Mandatory																
36 Mbps	Supported																
48 Mbps	Supported																
54 Mbps	Supported																

DCA – 2.4GHz Recommended Settings:

- Set DCA interval to 1 hour.
- Avoid Foreign APs – this works well in an environment with a lot of neighbor APs helping you avoid the interference they present, however if you are deploying a large, dense network or if you control the airspace it may be best to disable this feature and have the WLC compute a channel plan that works best for your network without placing APs on the same channel to avoid a single rouge.
- EDRRM Enabled set to low threshold (ensure CleanAir is enabled globally for 2.4GHz).

802.11b > RRM > Dynamic Channel Assignment (DCA)

Dynamic Channel Assignment Algorithm

Channel Assignment Method: Automatic Freeze OFF

Interval: 1 hour AnchorTime: 0

Invoke Channel Update Once

Avoid Foreign AP interference: Enabled

Avoid Cisco AP load: Enabled

Avoid non-802.11b noise: Enabled

Avoid Persistent Non-WiFi Interference: Enabled

Channel Assignment Leader: MW-2504-03 (10.1.18.3)

Last Auto Channel Assignment: 1342 secs ago

DCA Channel Sensitivity: Medium (10 dB)

DCA Channel List

DCA Channels: 1, 6, 11

Select	Channel
<input checked="" type="checkbox"/>	1
<input type="checkbox"/>	2
<input type="checkbox"/>	3
<input type="checkbox"/>	4
<input type="checkbox"/>	5
<input type="checkbox"/>	6

Event Driven RRM

EDRRM: Enabled

Sensitivity Threshold: Low

DCA – 5GHz Recommended Settings:

- Set DCA interval to 1 hour.
- Set sensitivity to low to discourage channel hopping by AP's.
- Use 20MHz channel width only for high-density deployments, RF-Profiles can be used to set wider channels if desired on groups of APs as of version 8.
- EDRRM Enabled set to low threshold (ensure CleanAir is enabled globally for 5GHz).
- Avoid foreign AP's enabled for 5GHz band – we have enough channels to move around with.
- Enable all DFS channels (FCC Region has 149-165 available too) most devices support them, worth the tradeoff for added capacity in dense areas.
- Watch for DFS events and consider restricting use of UNII2/2e channels based on devices on the network. Version 8 now allows a DCA channel list per RF-Profile for advanced planning.

802.11a > RRM > Dynamic Channel Assignment (DCA)

Dynamic Channel Assignment Algorithm

Channel Assignment Method Automatic Freeze OFF

Interval: 1 hour AnchorTime: 0

Avoid Foreign AP interference Enabled

Avoid Cisco AP load Enabled

Avoid non-802.11a noise Enabled

Avoid Persistent Non-WiFi Interference Enabled

Channel Assignment Leader MW-2504-03 (10.1.18.3)

Last Auto Channel Assignment 2299 secs ago

DCA Channel Sensitivity Low (15 dB)

Channel Width 20 MHz 40 MHz

Avoid check for non-DFS channel Enabled

DCA Channel List

DCA Channels

36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140

Select	Channel
<input checked="" type="checkbox"/>	36
<input checked="" type="checkbox"/>	40
<input checked="" type="checkbox"/>	44
<input checked="" type="checkbox"/>	48
<input checked="" type="checkbox"/>	52
<input checked="" type="checkbox"/>	56
<input checked="" type="checkbox"/>	60
<input checked="" type="checkbox"/>	64
<input checked="" type="checkbox"/>	100
<input checked="" type="checkbox"/>	104
<input checked="" type="checkbox"/>	108
<input checked="" type="checkbox"/>	112
<input checked="" type="checkbox"/>	116
<input checked="" type="checkbox"/>	120
<input checked="" type="checkbox"/>	124
<input checked="" type="checkbox"/>	128
<input checked="" type="checkbox"/>	132
<input checked="" type="checkbox"/>	136
<input checked="" type="checkbox"/>	140

Extended UNII-2 channels Enabled

Event Driven RRM

EDRRM Enabled

Sensitivity Threshold Low

TPCv1 – 2.4GHz & 5GHz Recommended Settings:

TPCv2 is deprecated in my opinion; it struggles to converge to a steady state and is seemingly no longer maintained by Cisco, as of version 7.6 we are reverting to TPCv1.

- Use RF-Profiles to fine-tune for different AP/Antenna combinations and densities of deployments.
- 2.4GHz Global Max/Min set at 16/9 and power threshold at -70dBm.
- 5GHz Global Max/Min set at 18/12 and power threshold at -70dBm.
- Exact values in the global config should be tuned according to APs deployed and granularity can be achieved via the use of RF-Profiles.
- Be careful to not allow your TX power to drop *too* low, as the noise floor rises in a busy venue you need to maintain a sufficiently high TX power in order to keep the SNR/SNIR to the clients at a healthy level.
- Minimum TX power we expect to see in a *normal* network would be held at around 9dBm in 2.4GHz and 12dBm in 5GHz.
- Consider your client devices too, try and balance the RF link between the typical device you expect to serve and your infrastructure – there is no point in shouting if they can't talk back!

802.11a > RRM > Tx Power Control(TPC)

TPC Version

Interference Optimal Mode (TPCv2)
 Coverage Optimal Mode (TPCv1)

Tx Power Level Assignment Algorithm

Power Level Assignment Method Automatic Every 600 secs
 On Demand
 Fixed 1

Maximum Power Level Assignment (-10 to 30 dBm) 30
 Minimum Power Level Assignment (-10 to 30 dBm) 10

Power Assignment Leader WJC-WLC-01 (212.13.198.38)
 Last Power Level Assignment 332 secs ago
 Power Threshold (-80 to -50 dBm) -67
 Power Neighbor Count 3

802.11b > RRM > Tx Power Control(TPC)

TPC Version

Interference Optimal Mode (TPCv2)
 Coverage Optimal Mode (TPCv1)

Tx Power Level Assignment Algorithm

Power Level Assignment Method Automatic Every 600 secs
 On Demand
 Fixed 1

Maximum Power Level Assignment (-10 to 30 dBm) 18
 Minimum Power Level Assignment (-10 to 30 dBm) 9

Power Assignment Leader WJC-WLC-01 (212.13.198.38)
 Last Power Level Assignment 239 secs ago
 Power Threshold (-80 to -50 dBm) -71
 Power Neighbor Count 3

Tuning Band Select, Aggressive Load Balancing & 802.11h:

Band Select:

We modify the following settings from their default values:

- Probe cycle count should be set to 3, 4 is also viable though can delay the connection too much for some devices.
- Age Out Dual Band should be set to 300 seconds – this command controls how long the WLC will ignore a device at 2.4GHz after it has been determined to be capable of using 5GHz.

Modifying the age out value has the following advantages and disadvantages:

- Can help keep devices at 5GHz during roaming, especially if moving between coverage areas.
- Can create problems where devices with no DFS support move into an area with a high proportion of AP's on DFS channels.
- Can cause the client table on the AP to fill up faster than expected and not have enough space to clear expired clients.

Band Select	
Probe Cycle Count	3
Scan Cycle Period Threshold (milliseconds)	200
Age Out Suppression (seconds)	20
Age Out Dual Band (seconds)	300
Acceptable Client RSSI (dBm)	-80
<i>* Band Select is configurable per WLAN.</i>	

Aggressive Load Balancing:

The default settings can be a bit too aggressive for dense environments where you often have surges of devices associating to the network and can often result in connectivity issues.

We are generally not using aggressive load balancing anymore, instead use 802.11k and assisted roaming with much greater success.

- Client windows size set to 10
- Denial count set to 1 or 2 if you want to be more forceful.

Load Balancing	
Client Window Size	10
Maximum Denial Count	1
Load Balancing Statistics	
Total Denied Client Count	0
Total Denial Message Sent	0
Exceeded Denial Max Limit Count	0
None 5G Candidate Count	0
None 2.4G Candidate Count	0
<i>* Load Balancing is configurable per WLAN.</i>	

802.11h CSA:

Enable 802.11h CSA (channel switch announcements) basically allowing the WLC to inform clients what channel they will change to ahead of the move.

Not all clients support the 802.11h CSA however in recent years the quantity of devices with full support for 802.11h has greatly risen and in general enabling these features does not impact other devices on the network.

802.11h Global Parameters

Power Constraint

Local Power Constraint(0-30) dB

Channel Switch Announcement

Channel Announcement

Channel Quiet Mode

WLAN Profile Advanced Configuration:

The following should be set when configuring the WLAN profile for a high-density public network and assume centrally switched traffic with APs in local mode.

- If L2 security is used ensure that only WPA2 & AES are enabled.
- Set peer to peer blocking action to “drop” if inter-device communication is not required.
Note: P2P Block is only within a single WLC, if using multiple WLCs with APs spread across them you must use interface ACLs to isolate clients between the WLCs.
- Implement ACLs to filter unnecessary traffic (Bonjour, mDNS, SSDP etc.) from being able to travel over the air, also isolate clients if required between multiple WLCs and filter where the traffic meets the wire.
- Set session timeouts to 28800 seconds, this helps avoid unnecessary disconnects but prevents “stale sessions” adding up on the WLC.
- For a public network multicast should not normally need to be enabled.
- Disable mDNS Snooping on the WLAN profile if not required.
- Enable band select if dual-band SSID, however also consider using discrete SSIDs for 2.4GHz and 5GHz if appropriate.
- Disable client exclusion.
- Disable management frame protection, many devices unfortunately do not support 802.11w yet and this has been seen to cause some clients connectivity issues.
- Disable coverage hole detection (this prevents the network winding up TX power unnecessarily when people say move between big plenary sessions and corridors for example).
- Configure 802.11k / assisted-roaming on CLI, this cannot be enabled at the same time as aggressive load balancing.
- Configure and enable an appropriate AVC profile for the network.

Misc. useful WLC CLI Commands:

RRM Restart:

```
#config 802.11a/b channel global restart
```

This command puts the WLC into DCA startup state (high sensitivity) for 10 DCA runs, typically it is recommend to execute this command after you have made significant changes to the RRM configuration of a controller or deployed large quantities of new AP's. If AP's are spread across multiple WLC's in a given area you should restart DCA on each controller. We generally run this command 2 hours before doors open on event days and after we have finished deploying all our APs.

A-MPDU Support:

```
#config 802.11a/b 11nSupport a-mpdu tx priority all enable  
#config 802.11a/b 11nSupport a-mpdu tx scheduler timeout rt 1000
```

The above commands enable MPDU priority for all traffic classes and set the retry timeout to 1000ms. You need to have the 11a/b networks disabled on the WLC before sending these commands.

A-MPDU is a mechanism where multiple Ethernet frames can be aggregated and transmitted in a single 802.11n MAC.

Normally this is less efficient than MSDU aggregation, but it *may* be more efficient in environments with high error rates, because of a mechanism called block acknowledgement. This mechanism allows each of the aggregated data frames to be individually acknowledged or retransmitted if affected by an error.

RX-SOP Threshold:

```
#config 802.11a/b rx-sop threshold X
```

RX-SOP Threshold commands should be used with caution; it is not recommended to change these settings unless you thoroughly understand the implications. 8.0 Code introduced high/med/low/auto dropdowns for these to the GUI (Wireless>Advanced>RX-SOP and Under RF-Profile), see Cisco docs for what values they apply. It is also possible to configure this on per AP and a per RF-Profile basis for granular configuration.

Small changes can make a big difference to performance of a network, but also can have catastrophic effects if used inappropriately! If you do not understand how 802.11 CSMA/CA works without resorting to Google you should not be using these commands.

802.11k / Assisted Roaming:

```
#config wlan assisted-roaming neighbor-list enable [WLAN ID]  
#config wlan assisted-roaming prediction enable [WLAN ID]
```

The above commands enable 802.11k (neighbor-list) roaming and also Cisco assisted roaming. The WLAN profile needs to be disabled to enter these commands; these features cannot be used at the same time as aggressive load balancing. The assisted roaming only functions within a single WLC, ensure that APs are grouped logically across multiple WLCs if required.

Recommended Reading:

The following are various white papers and books that cover different design strategies for high-density deployments.

Whilst not all are from Cisco the general concepts they cover are transferable and provide a great insight into the considerations that should be undertaken for any high-density network.

In my opinion the Aruba guide is one of the best out there and has formed the basis of many of my approaches for high-density network designs in recent years.

Aerohive High Density Principals White Paper:

<http://www.aerohive.com/pdfs/Aerohive-Whitepaper-Hi-Density%20Principles.pdf>

Apple iOS 8 Device Roaming for Enterprise Customers:

<http://support.apple.com/en-us/HT203068>

Aruba High Density Validated Reference Design:

http://www.arubanetworks.com/wp-content/uploads/DG_HighDensity_VRD.pdf

Cisco High Density WLAN Design:

http://www.cisco.com/web/strategy/docs/education/cisco_wlan_design_guide.pdf

Cisco Radio Resource Management / RF Grouping Algorithm (7.4):

http://www.cisco.com/en/US/docs/wireless/controller/technotes/7.4/RRM_DG_74.pdf

CWNA & CWDP Study Guides:

<http://www.cwnp.com/study-guides/>

No Strings Attached Show – RX Sop Whitepaper:

<http://nostringsattachedshow.com/RXSOP/>

Xirrus High Density Application Guide:

http://www.xirrus.com/cdn/pdf/Xirrus_Application_Note_High-density_Wi-Fi.aspx