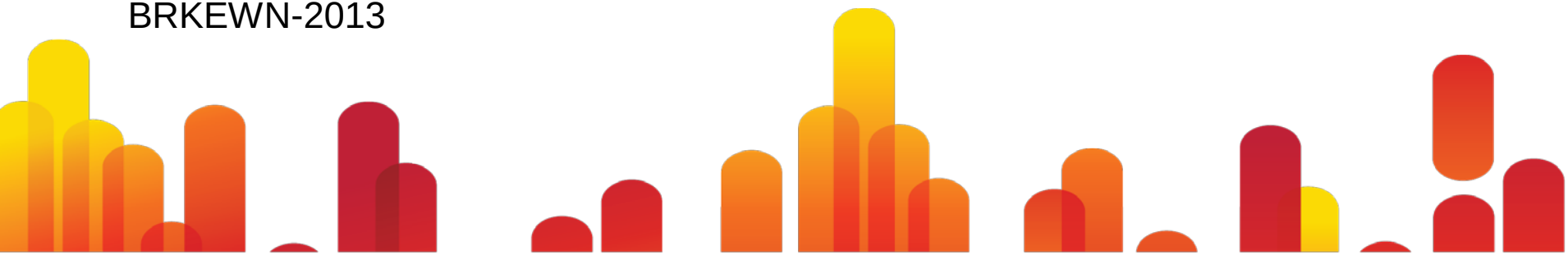
Understanding CleanAir Technology to Improve Wlan Spectrum Management

BRKEWN-2013



Housekeeping

- We value your feedback- don't forget to complete your online session evaluations after each session & complete the Overall Conference Evaluation which will be available online from Thursday
- Visit the World of Solutions
- Please remember this is a 'non-smoking' venue!
- Please switch off your mobile phones
- Please make use of the recycling bins provided
- Please remember to wear your badge at all times

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Agenda

- Why does interference matter?
- CSMA-CA and Duty Cycle?
- AP modes of Operation
- Technical Details
  - Interference Detection
  - Interference Mitigation
  - CleanAir Monitoring
  - Spectrum Expert Mode
- Configuration Essentials

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RF terms and Wi-Fi behavior basics

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The Impact of a Crowded Spectrum

Performance At Risk in Unprotected Networks

End User Impact

- Reduced network capacity and coverage
- Poor quality voice and video
- Potential complete link failure

IT Manager Impact

- Potential security breaches
- Support calls
- Increased cost of operation

Interference Type		Throughput Reduction: Near (25 ft)	Throughput Reduction: Far (75 ft)
2.4 or 5 GHz Cordless Phones		100%	100%
Video Camera		100%	57%
Wi-Fi (busy neighbor)		90%	75%
Microwave Oven		63%	53%
Bluetooth Headset		20%	17%
DECT Phone		18%	10%

Source: FarPoint Group

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How does Interference impact Wi-Fi?
Separating the FUD from the Fact's

- 802.11a/b/g/n - CSMA/CA or LBT (listen Before Talk)
- Collision Avoidance – 802.11 very very polite – by design
  - CCA
  - Collisions
  - SNR
- CCA – Clear Channel Assessment
  - ED – quick – low power - prone to false positives
  - Preamble – takes time – power – less prone to false
- CCA threshold for 802.11b/g is -65 dBm
- CCA for 802.11a is different -65 dBm ED, if true then 20 dB lower for Preamble interrogation needs to be processed -85 dBm

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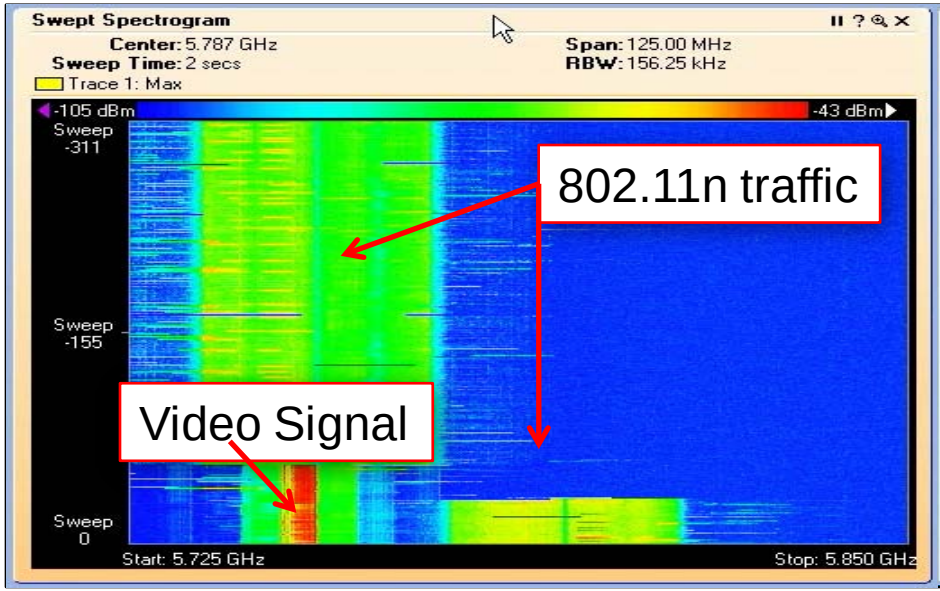
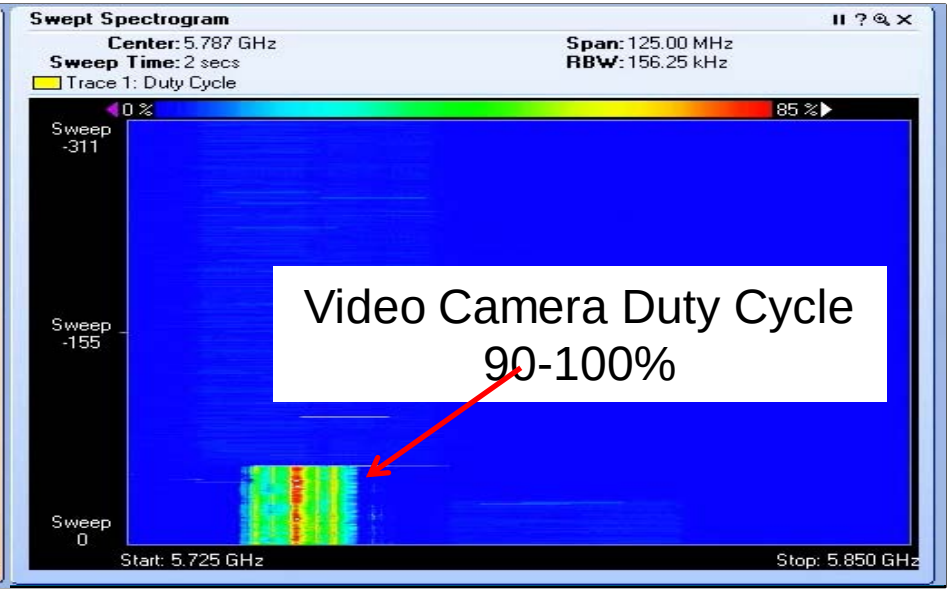
CCA Blocked or High





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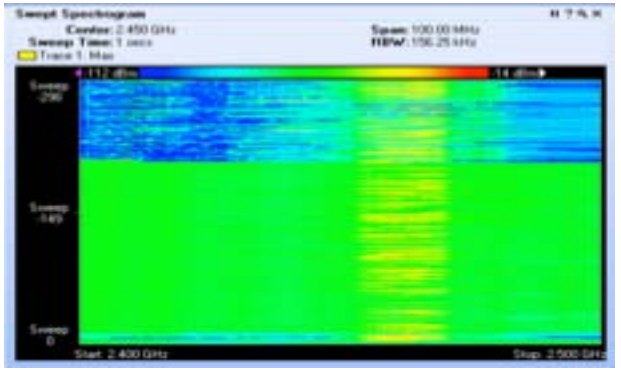
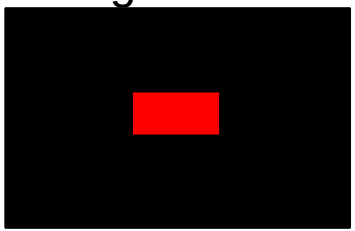
How does Interference impact Wi-Fi?
Separating the FUD from the Fact's

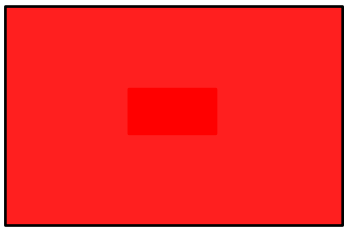
- Collisions - Non Wi-Fi devices do not participate in our CA mechanism – they have their own
- No respect for Wi-Fi – results in:
  - Corrupted packets
  - Increased retransmissions
  - Increased Duty Cycle
  - Less available bandwidth
- SNR – Signal to Noise ratio



High SNR



Low SNR



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802.11 and Duty Cycle – Channel Utilization

- Retransmit a packet
- Duty Cycle of interference is directly proportionate to channel time available
- Busy network – less interference tolerance
- Less busy – might not even notice low levels of interference
- Bandwidth is like Money – the more you get the more you spend

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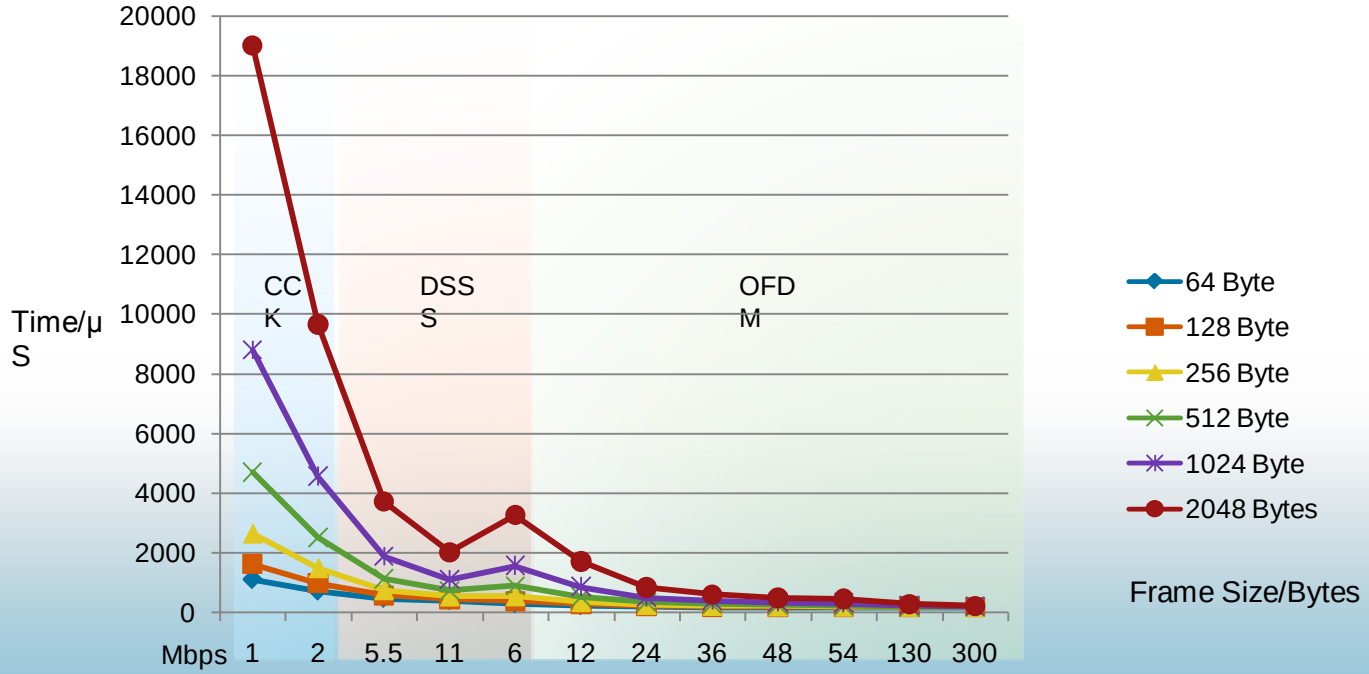
Understand Protocol Selection 802.11 b/g/a/n and Duty Cycle—Important? Why?



Spectrum is a Shared Finite Resource

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Cisco Access Points – Modes of Operation

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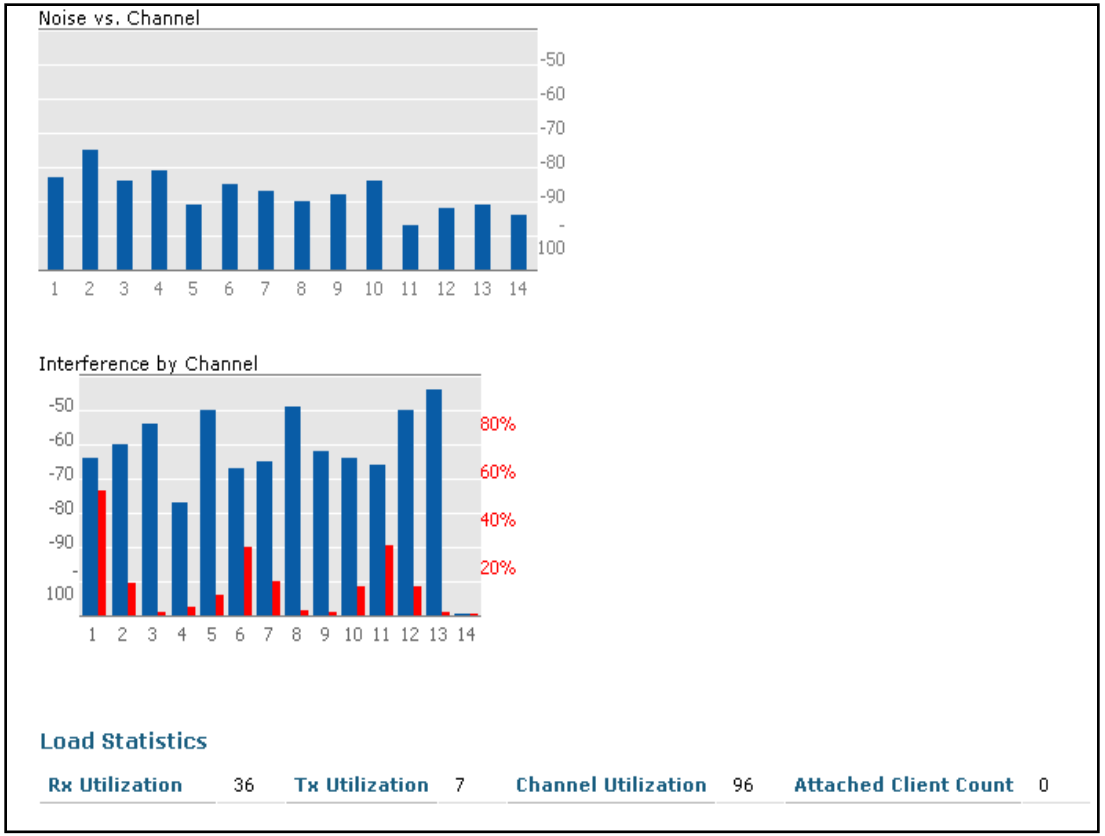
Any Cisco Access point already sees and reports noise and interférence per Channel



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Wi-Fi and Spectrum Knowledge – Why is silicon important?

- A Wi-Fi chip is a communications processor – a MODEM
- It only knows
  - Energy that can be demodulated = Wi-Fi
  - Energy that can not be demodulated = Noise
- Noise is complicated –
  - Collisions, fragments, corruption
  - Wi-Fi that is below sensitivity threshold of the receiver
- Peaks in Wi-Fi activity can cause all of the above to occur

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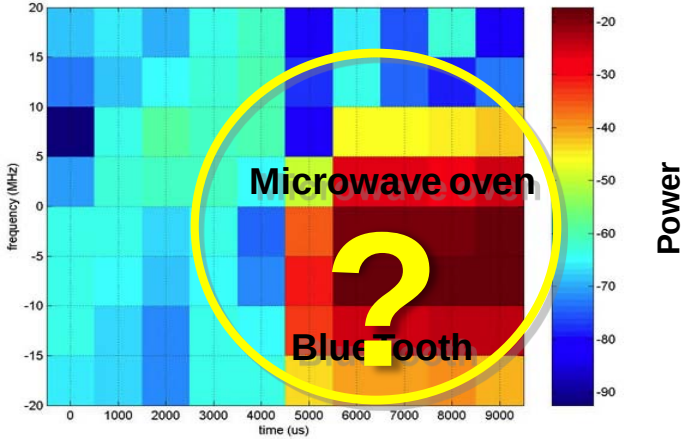
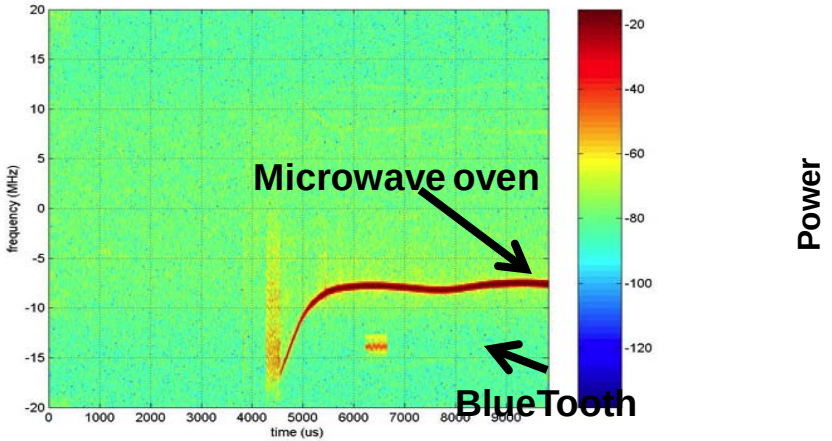
High Resolution Spectral Advantage

The Industry's ONLY in-line high-resolution spectrum analyzer

Typical Wi-Fi chipset
Spectral Resolution at 5 MHz



Cisco CleanAir Wi-Fi chipset
Spectral Resolution at 78 to 156 KHz



'Chip View Visualization' of Microwave oven and BlueTooth Interference

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The Value of ASIC Based Intelligence

Troubleshooting Workflow	Response A: CleanAir Technology	Response B: Software-only Solution
Event: SpyCam and Microwave causing strong interference		
Detect presence of interference	Two unique sources detected by all APs	Energy detected by all APs
Classify source of interference	Spycam and microwave uniquely identified	Inability to differentiate between multiple sources of interference
Correlate interference events across APs	Interference correlated across all APs as two events	None – seen as unique event by each AP
Assess impact to AP and network	Severity and impact of each interferer measured	Total Interference measured only
Alert to IT	Intelligent alert on sources and impact	One alert per AP on “interference detect”
Physically locate SpyCam and Microwave	Interferers precisely located on floor map	Unable to locate automatically, manual search for both
Mitigate impact of interference	Intelligent and automatic channel change	Manual changes based on limited data
Air Quality Report	Network-wide view of Wi-Fi health by AP	None

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Enterprise Wireless Evolution

From Best Effort to Mission Critical

2005

2011

Hotspot

System Management

Scalable Performance

Self Healing & Optimizing – Spectrum Policy

Legacy RRM

4.1.185 – DCA Enhancements
Coverage hole fixes
Spectrum Intelligence (SE Based)

5.0 RRM Dashboard
Complete re-vamp of CH
802.11n

6.0 NG-DCA
6.0 Client Link
6.0 BandSelect
6.0 MR-1 TPC changes
6.0 MR-1 MC-UC

7.0 CleanAir
7.0 MR1 Static Grouping

Market Transitions

Mobility

1.3 Billion new Networked Mobile Devices in the Next Three Years

Workplace Experience

Blurring the Borders:

Consumer ↔ Workforce
Employee ↔ Partner

Video

50% of all Cisco Network Traffic Today Is Video

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"When the students returned this year, if you asked me what percentage of students are using the Wi-Fi network – I would have told you 40%. I was shocked to see 85% of them using the Wi-Fi network"

Scott Ksander – September 2009 – Cisco Education TAB
Purdue University

Influx of Mobile Devices Creates IT Challenge

IT Consumerization: Now a Reality

Smartphone adoption is growing at 50%+ annually

A Smartphone can use as much bandwidth as 200 legacy phones

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CleanAir Technical Details

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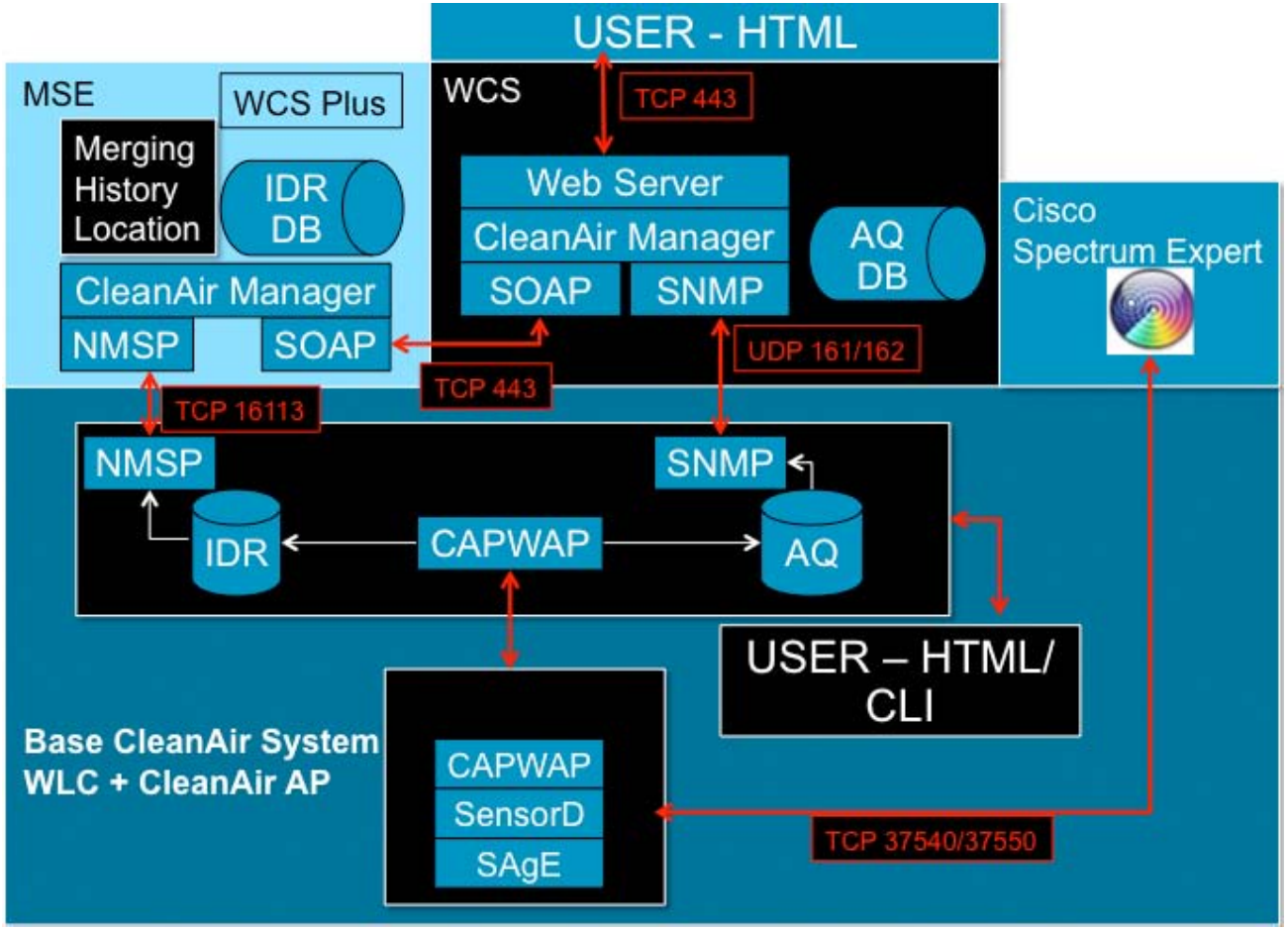

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CleanAir Specific Acronyms

- AQI – Air Quality Index – also seen as AQ
- IDR – Interference Device Report
- PMAC – Pseudo MAC
- Merge – Correlation of IDR's based on PMAC
- ZOI – Zone of Impact
- LMAP – Local Mode AP – AP serving clients
- MMAP – Monitor Mode AP – AP scanning all bands

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Key Components Interaction

- Information is driven in two ways
  - AQI – Air Quality index reporting
  - IDR – Interference device report
- Air Quality – Is derived by the AP's, Stored on WLC, and polled by WCS
- Interference Device Reports – are reported to WLC
  - WLC will merge multiple IDR's
  - Keep a limited Database (single reporting period)
  - Forward NMSP notification message with IDR payload to MSE

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Non Wi-Fi Interference Detection

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The CleanAir AP

- Built into the silicon of the Wi-Fi chip is an additional 500K logic gates that house the SAgE logic.
- SAgE is the spectrum analyzer that was used on the Spectrum Expert Cards (Spectrum Analysis Engine)
- Controlling the SAgE hardware is a software known as SensorD – where all measurements are gathered and reported to and from the AP
- SensorD does all classification of devices and calculations required to populate upstream information stores and handles interfacing to CAPWAP

Information passed from the AP to controllers is minimal. No off platform calculations are performed: it all happens on the AP

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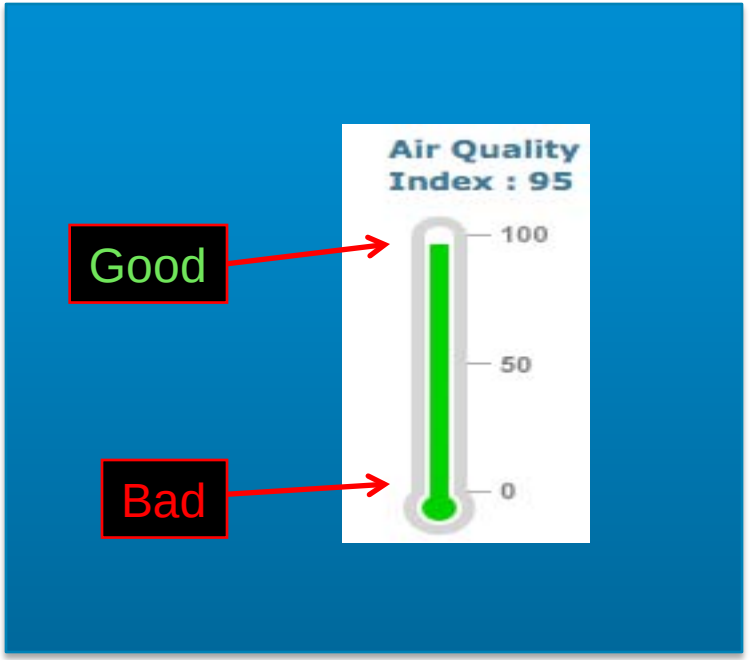
Air Quality Index - AQI

- Air Quality is a measurement of non-wifi and adjacent channel interference
- All Individual devices when Classified are assigned a Severity Value
- Air Quality is a measure of all Devices/Severities within a Radio, Floor, Building, or Campus



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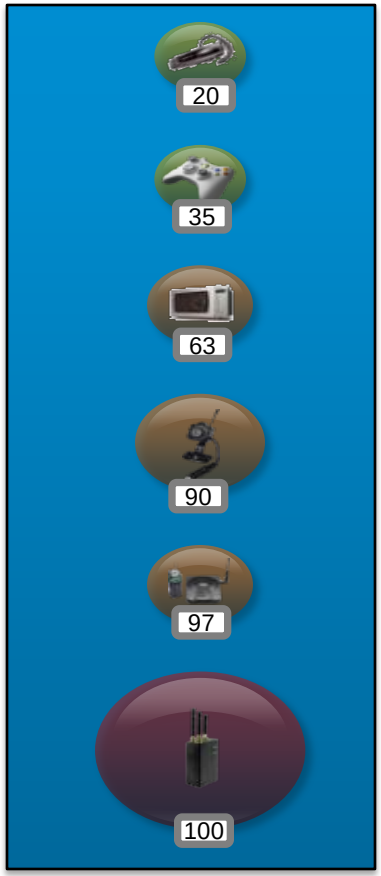
Air Quality and Severity

- For each Classified Device – a Severity Value is calculated
- Severity of 0 is not Severe – a Severity of 100 is very severe.
- Severity is a local opinion of the reporting AP and takes into account the type of device, Duty Cycle (persistence) and Power as measured by the AP.
- For the same device – severity will differ on each reporting AP because of the AP's RF relationship to that device.



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Supported Interferers
Cisco Unified Wireless Network 7.0 Release

- 2.4 GHz only
  - Bluetooth Link
  - Bluetooth Discovery
  - 802.11FH
  - Microwave Oven
  - Industrial wireless/802.15.4
  - Xbox
- 5 GHz only
  - Radar
  - WiMAX Mobile
  - WiMAX Fixed
- 2.4 or 5 GHz
  - Jammer
  - WiFi Inverted
  - WiFi Invalid Channel
  - Continuous Transmitter
  - Video Camera
  - SuperAG
  - Canopy
  - Other (i.e. unclassified devices)
  - TDD Transmitter
  - DECT-like Phone

1. Classifiers are expandable over time with software upgrade.
2. All third party trademarks are the property of their respective

Definite Security Threat Devices
Potential Security Threat Devices
Performance Impacting Devices

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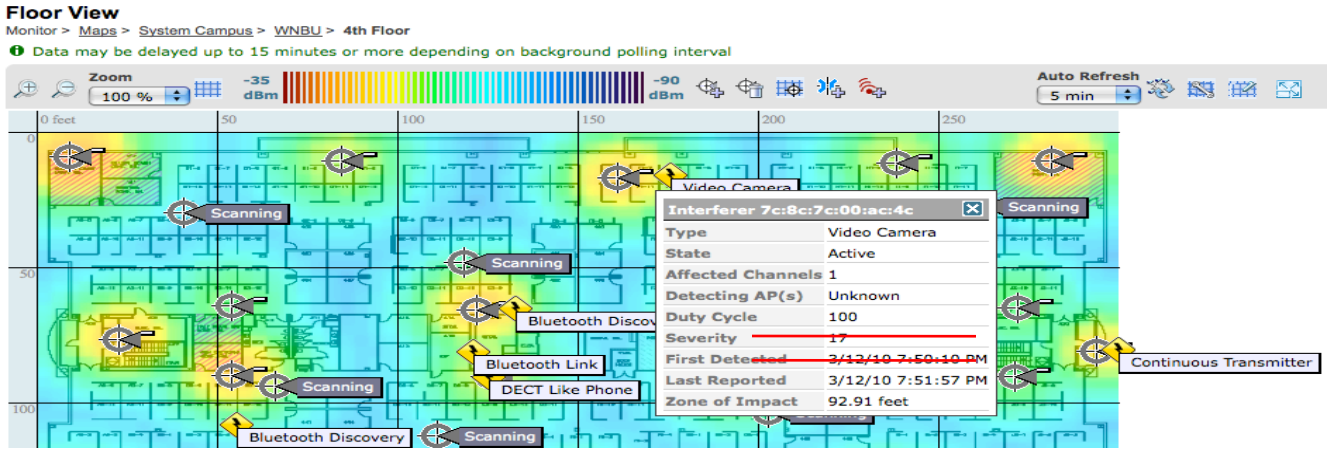
Air Quality and Severity



- Severity is used to understand the potential impact to a Wi-Fi network
- The RSSI at the AP for this interferer (-78) is well below CCA threshold (Clear Channel Assessment)
- Even with duty cycle of 100% - the severity here is 17 – if it was closer to us, the severity would be much higher

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Air Quality and Severity

- Severity is calculated for a single device
- All devices affecting a radio/channel are added together and subtracted from Air Quality for that for that radio/ served channel
- Separate AQ metrics exist per band
- Air Quality is observable at the Radio/channel level, or averaged together for a Floor, Building, Campus in a hierarchical fashion.

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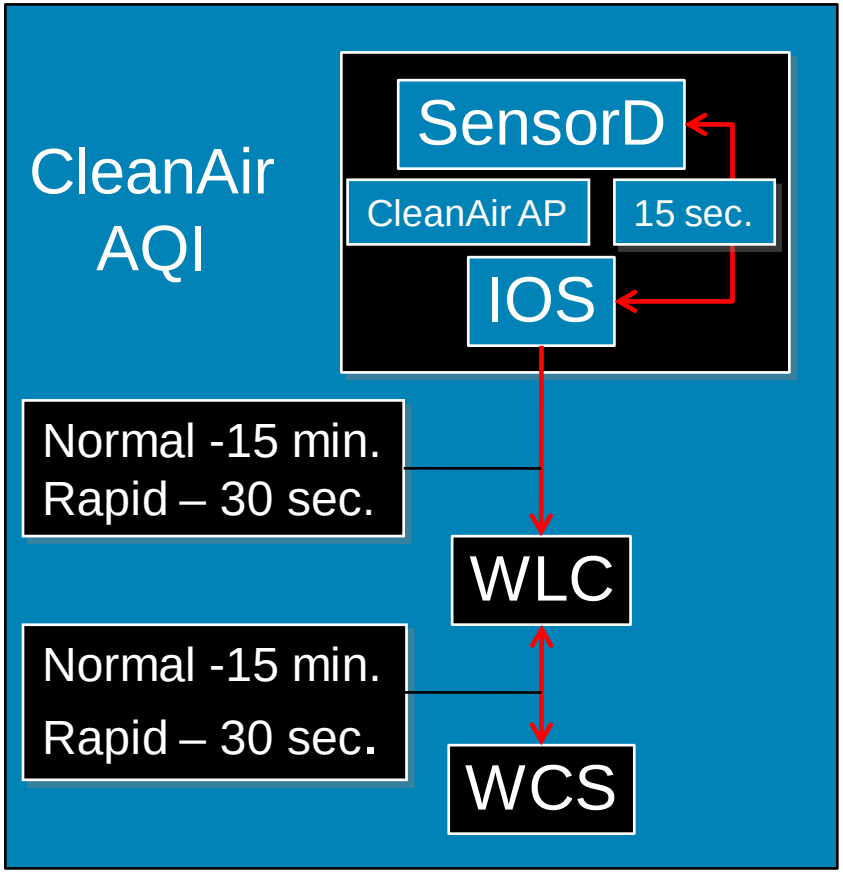
AQ Detail

- AP manages AQI data – averaging period is decided by WCS/WLC, and configured on AP by WLC
- Default AQ Averaging periods are
  - 15 min. default (up to 1 hour)
  - Rapid Update Mode – 30 seconds
- AP-SensorD reports AQ information every 15 seconds to IOS



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AQI In-Depth

- Each AQ report contains the average, and the minimum observed AQ during the period
- Each CleanAir Radio sends AQ reports independently to the WLC for the channel it is serving (15 Minutes by default) or all channels if in Monitor Mode (MMAP)
- WLC Maintains last normal AQ report for each radio until update is received
- WCS polls each WLC at predetermined (normal or rapid) intervals (Normal 15 minutes, Rapid 30 second)

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AQI Summary

- AQ reports drive the AQI
- AQ is good at 100 and bad at 0
- ED-RRM feature is driven by AQ directly from the AP – independent of the controller or RRM
- Air Quality is a measure of NON Wi-Fi interference and Adjacent Channel Wi-Fi only
- All on channel Wi-Fi is monitored by the Wi-Fi chip, CleanAir is locked out.

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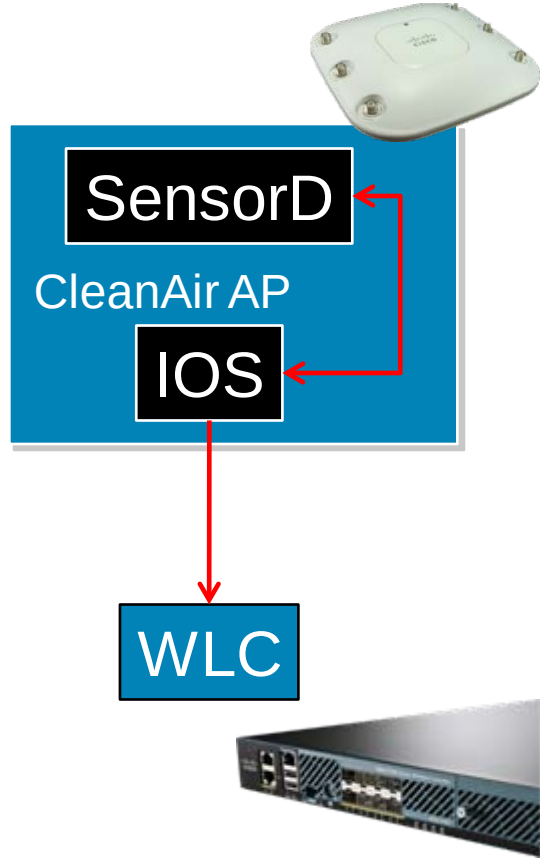
Interference Device Report IDR and The AP

- IDR's are reports of devices classified by SensorD
- Top 10, by severity are reported to WLC
- A Security IDR will always be reported regardless of severity
- IDR up/down reporting is near real time
- AP tracks all IDR's not reported to WLC

TYPE	SEV	WLC
SEC	1	*
INT	20	*
INT	9	*
INT	2	*
INT	2	*
INT	1	*
INT	1	*
INT	1	*
INT	1	*
INT	1	*
INT	1	
INT	1	
INT	1	



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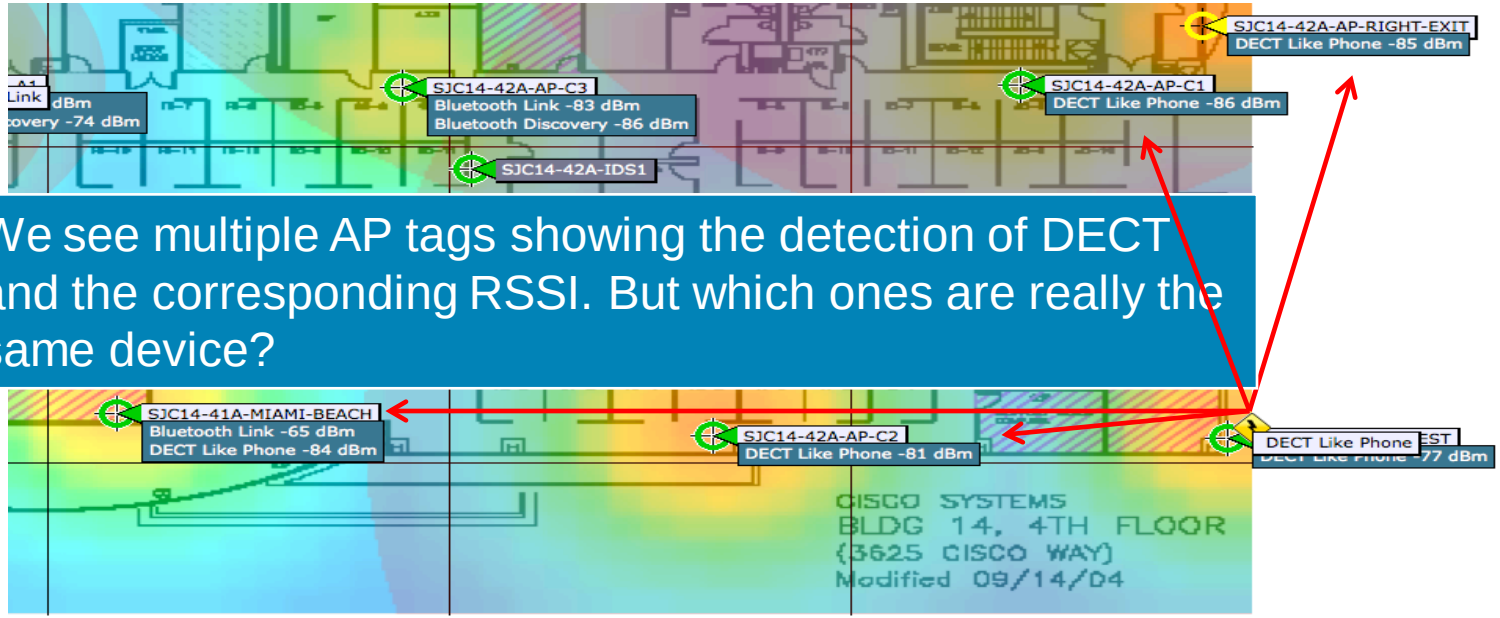
Multiple AP's = Multiple Sensors



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IDR In-Depth – The AP - PMAC

- Pseudo – MAC applied to analog device signatures
- PMAC will never calculate exactly the same on all AP's detecting the same device – but rather similar
- PMAC will change overtime for a given device
  - Battery operated devices – voltage drop – temp variations
  - Measurement accuracy – or inaccuracy
- The AP will combine devices that can not reliably be merged with devices seen by another AP

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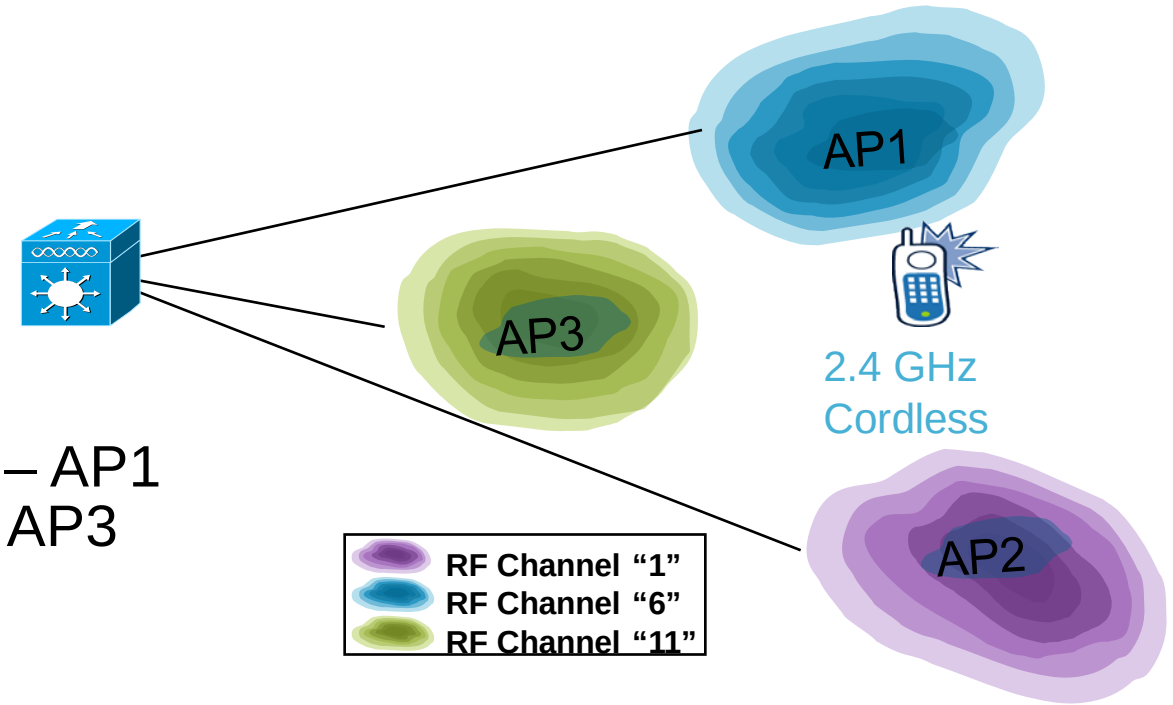
WLC Merging – and PMAC "The Cluster"

- IDR-DECT – ap1
- IDR-DECT – ap2
- IDR-DECT – ap3
- Merged IDR = DECT – AP1 (cluster center), AP2, AP3



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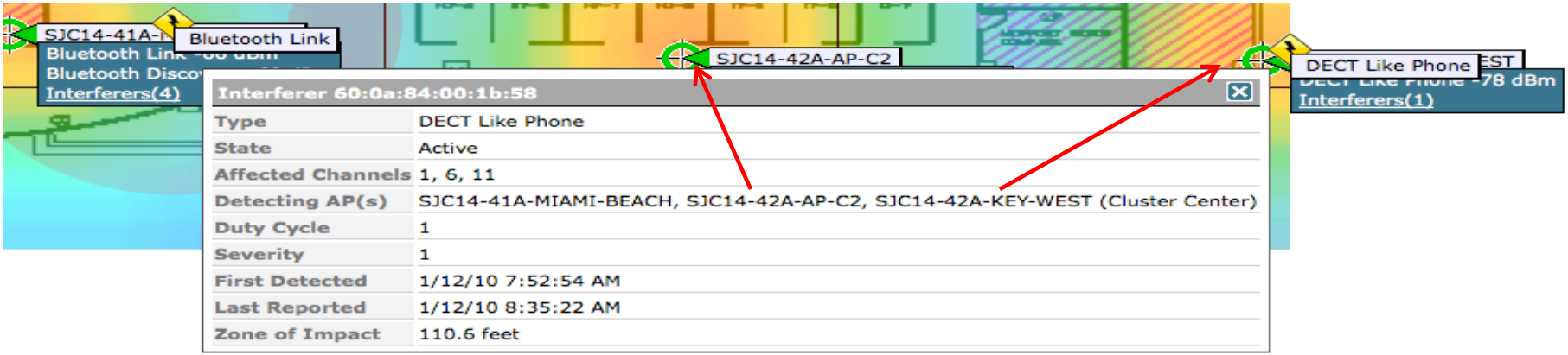
PMAC Merge



- Once the PMAC Signatures are merged – we can identify which AP's are hearing the same device
- Notice the Cluster Center – this is the closest AP to the device

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WLC and PMAC Merging

- WLC performs comparison function on received IDR's PMAC
- WLC can merge devices for AP's physically connected to it
- WLC merge results are only viewable in IDR traps sent to trap receiver (WCS)
- No Location is performed on WLC merged interferers
- The result of a WLC merge is forwarded to the MSE (If present) along with all of the supporting IDR's

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The MSE

- All IDR's received by a WLC are sent to MSE via NMSP notify with IDR payload
- NMSP message includes the merged IDR and the individual IDR's used for that conclusion
- IDR's are re-merged at the MSE, this accommodates multiple WLC systems
- A tracked Interferer is equal to a client for CAS license purpose – each active merged interferer will consume 1 seat

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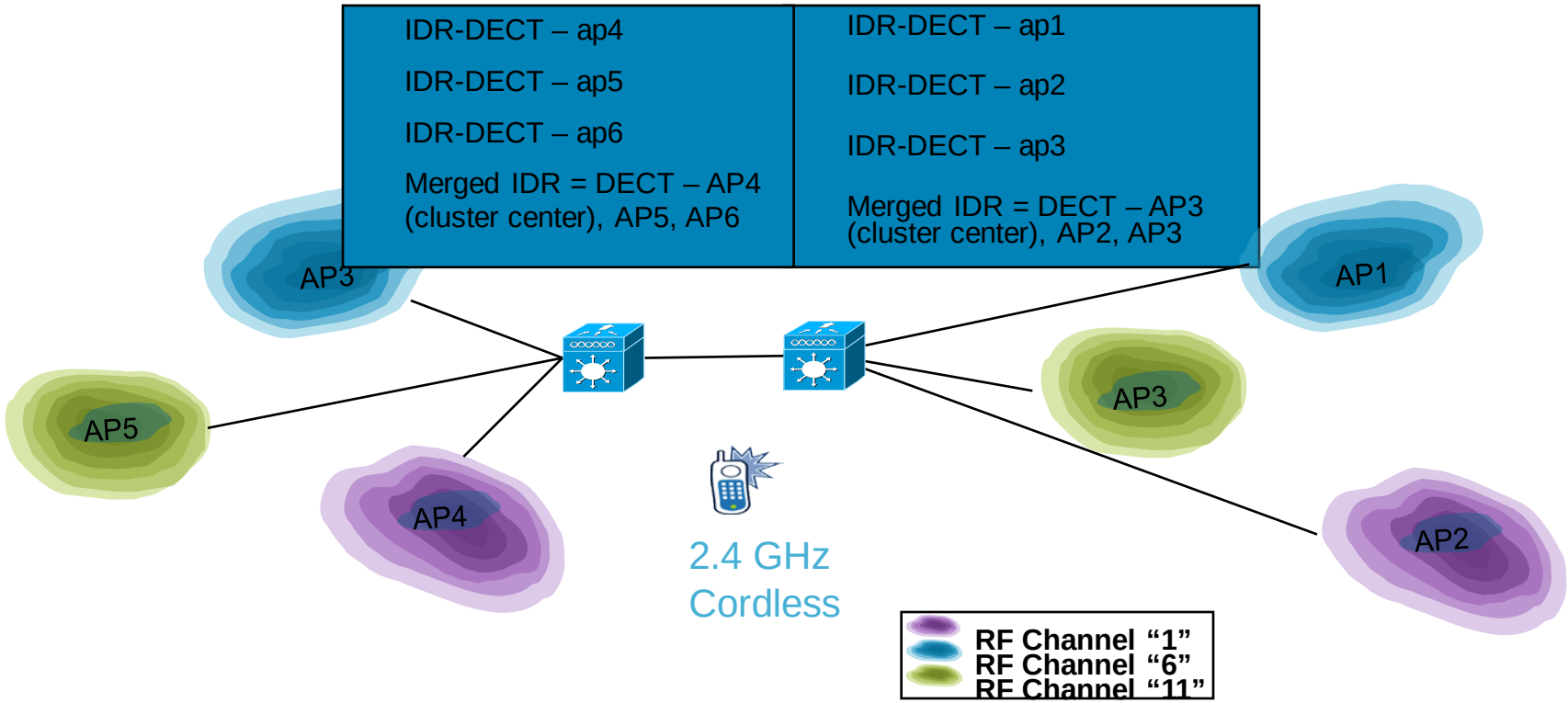
MSE Merging – LMAP X-WLC



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MSE – WLC Merging and Location

- MSE and the WLC rely 1st on RF Neighbor lists to establish spatial probability in a merge
- LMAP AP's are active and send neighbor messages as part of normal RRM operation
- Changing Neighbor message defaults will affect merging
- MMAP AP's are passive devices and do not send neighbor messages

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CleanAir Mitigation Modes

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Interference Mitigation Features

- Persistent Device Avoidance – PDA
  - Operates on Classification – IDR on a per AP basis
  - Once set – biases DCA against the PDA channel for the detecting AP only
  - Remembers interference and avoids placing the AP back on the same channel
- Energy Detect – RRM or ED-RRM
  - Fast acting (=< 30 seconds)
  - Works on AQI on a per AP basis
  - Designed to prevent catastrophic interference from disrupting channel/clients

NOTE: Only Available with full CleanAir enabled installation – not overlay

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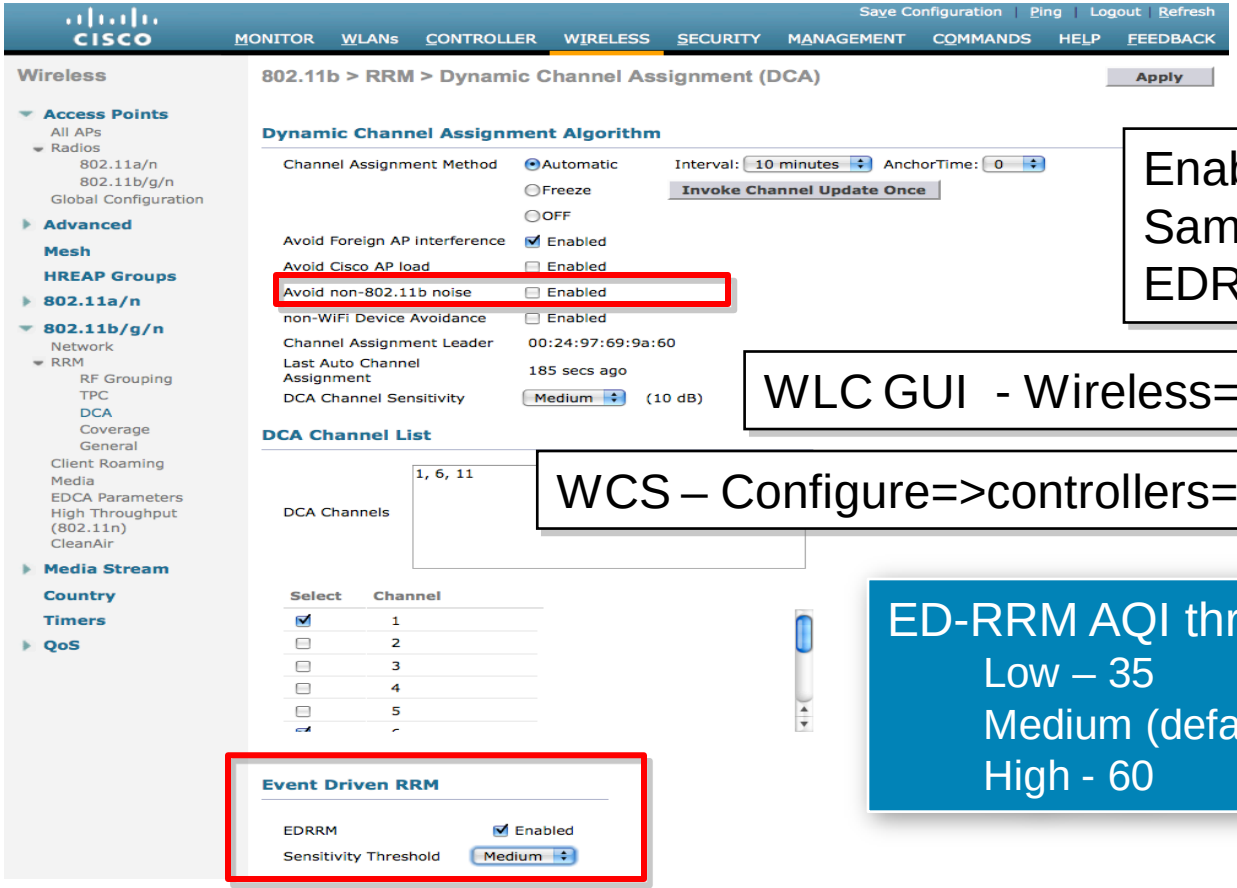
PDA - configuration



Enabled Per Band
Same on WCS or WLC
EDRRM has threshold variable

WLC GUI - Wireless=>802.11a/b=>RRM=>DCA

WCS – Configure=>controllers=>802.11a/b=>RRM=>DCA

ED-RRM AQI thresholds:
- Low – 35
- Medium (default) – 50
- High - 60

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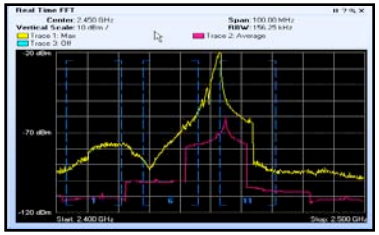
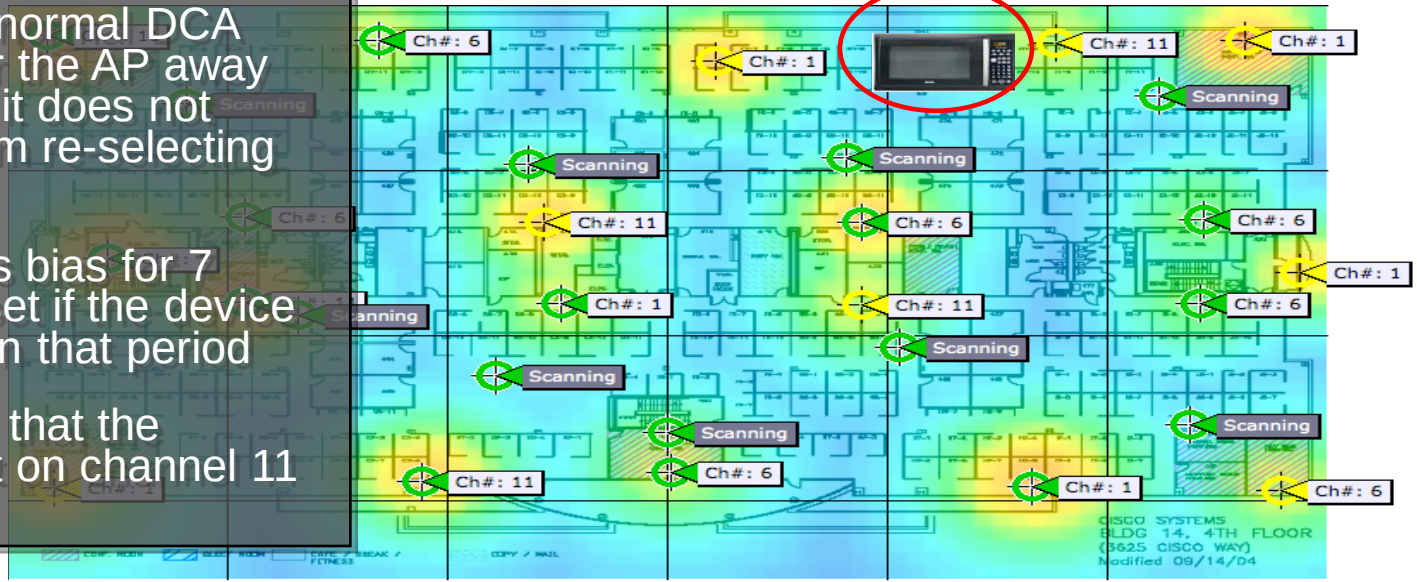
PDA – Use case

- PDA logs the device for this AP.
- A CM bias is added to this AP's channel 11 only
- The bias works in normal DCA operations to steer the AP away from channel 11 – it does not prevent the AP from re-selecting this channel
- AP remembers this bias for 7 days, which is re-set if the device is seen again within that period
- If DCA determines that the affected AP is best on channel 11 it will be assigned



Microwave Oven detected Channel 11 – highest Impact.



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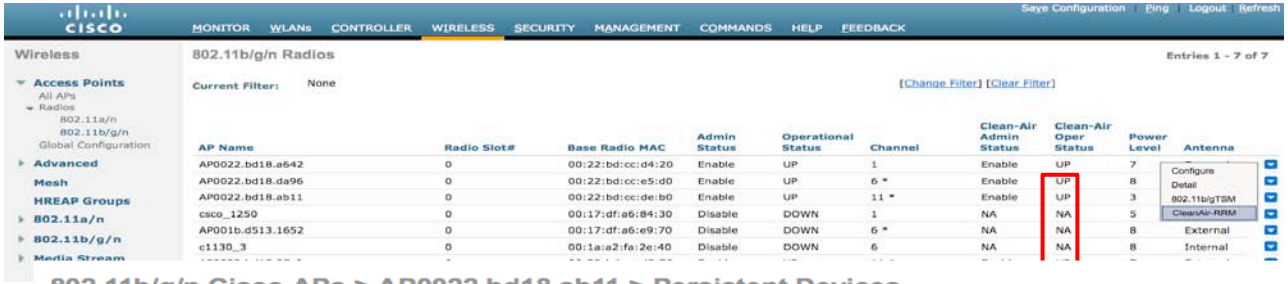
PDA Operation

- If channel change is caused by PDA event – it will be logged in WCS – Monitor=>RRM
- PDA event is viewable on WLC=>wireless=>Access Points=>Radios=>802.11a/b=>CleanAir RRM
- Only available with full LMAP deployment
- Microwave Oven, Video Camera, Canopy, Fixed Wi-Fi are all persistent devices



802.11b/g/n Cisco APs > AP0022.bd18.ab11 > Persistent Devices

Class Type	Channel	DC(%)	RSSI(dBm)	Last Seen Time
Video Camera	11	100	-64	Tue Mar 16 15:28:10 2010

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ED-RRM Operation

- ED-RRM operates based on Air Quality (AQ)
- Each AP measures AQ over a 15 second period and reports it to the controller in as little as 30 second increments (rapid update mode)
- ED-RRM is designed to instantly sense a catastrophic interference source defined as a high duty cycle interferer – and if the AQI drops perilously – immediately change the AP's channel independent of RRM.
- ED-RRM prevents the AP from returning to the original channel for 3 hours after the event.
- Channel Change reason is logged in Monitor RRM as catastrophic AQI event

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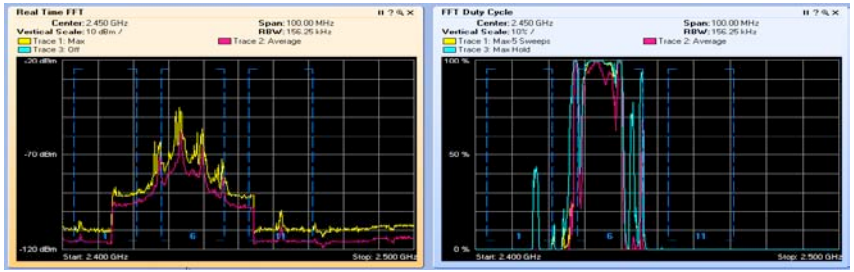
ED-RRM Use Case

Video camera produces 100% DC
If seen at an AP above CCA threshold the AP will stop beaconing, clients will not attempt to associate



- The AP reacts almost instantly (within 30 seconds)
- Clients that have decent roaming capabilities will reconnect
- ED-RRM AQI thresholds are:

  Low – 35

  Medium (default) – 50

  High - 60

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Spectrum Monitoring

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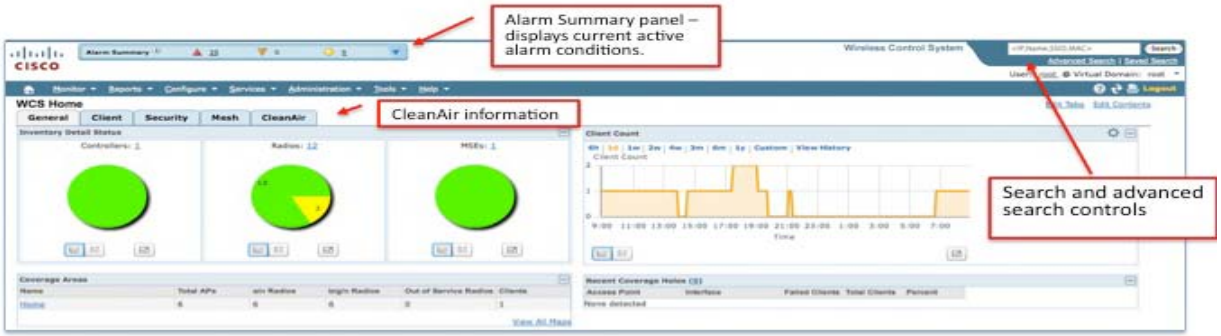
WCS - Home



- WCS version 7.0.x includes the CleanAir information Tab
- The Alarm Summary Panel will display both AQ alerts under Performance and Security Alerts under Security
- Advanced Search function includes Interference – rich interface for searches

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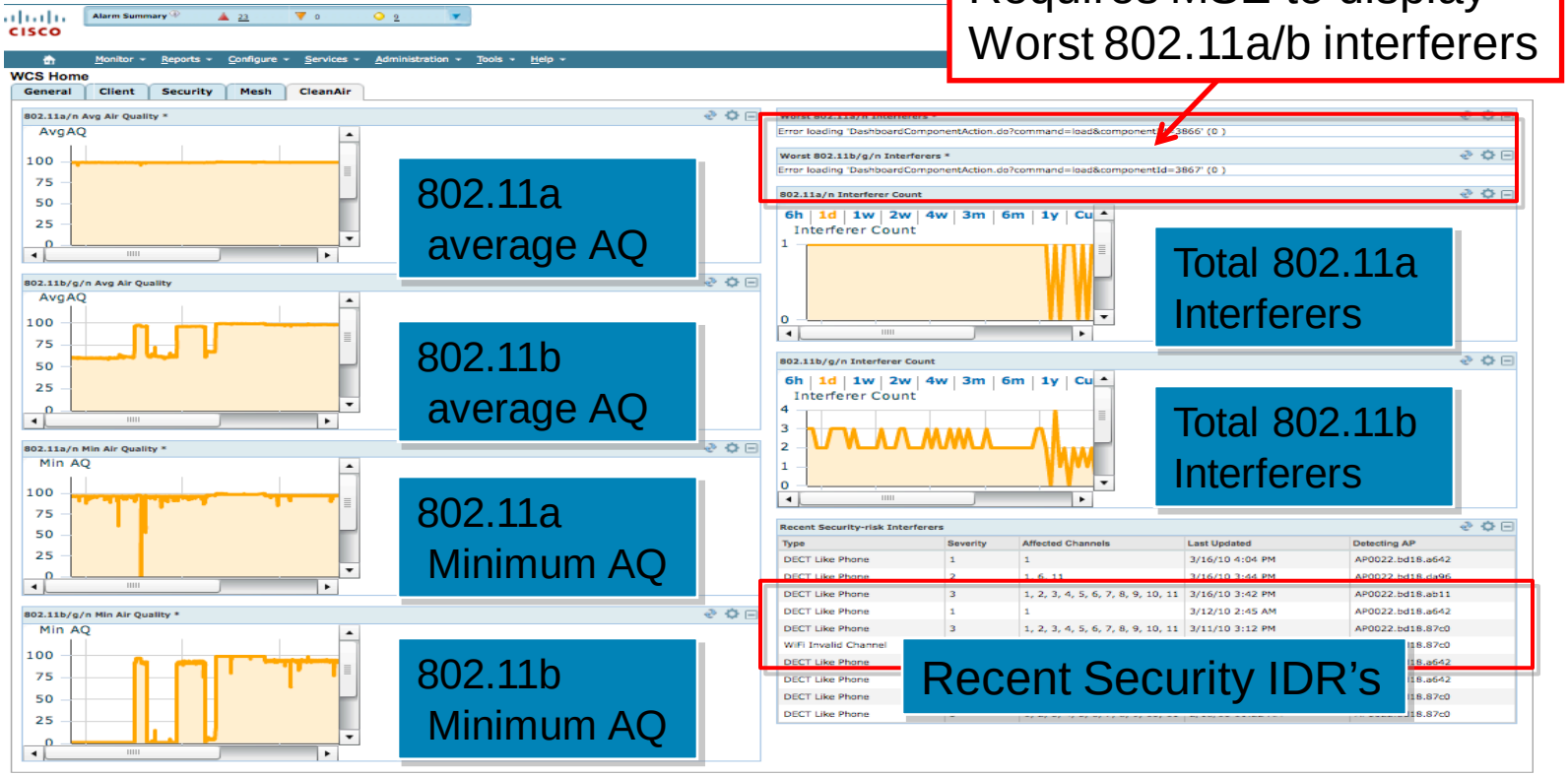
WCS – CleanAir TAB



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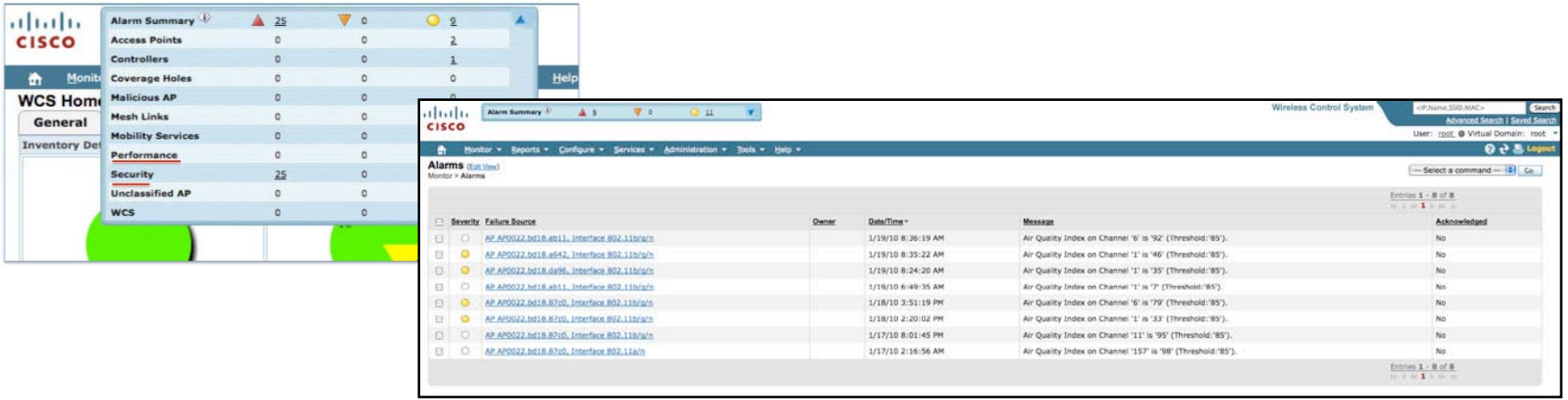
WCS – Alarm Summary



- Performance alarms report AQ threshold violations
- Security Alarms Report security IDR instances
- CleanAir Alarms and Traps configured from Configure=>Controllers=>802.11a/b=>CleanAir

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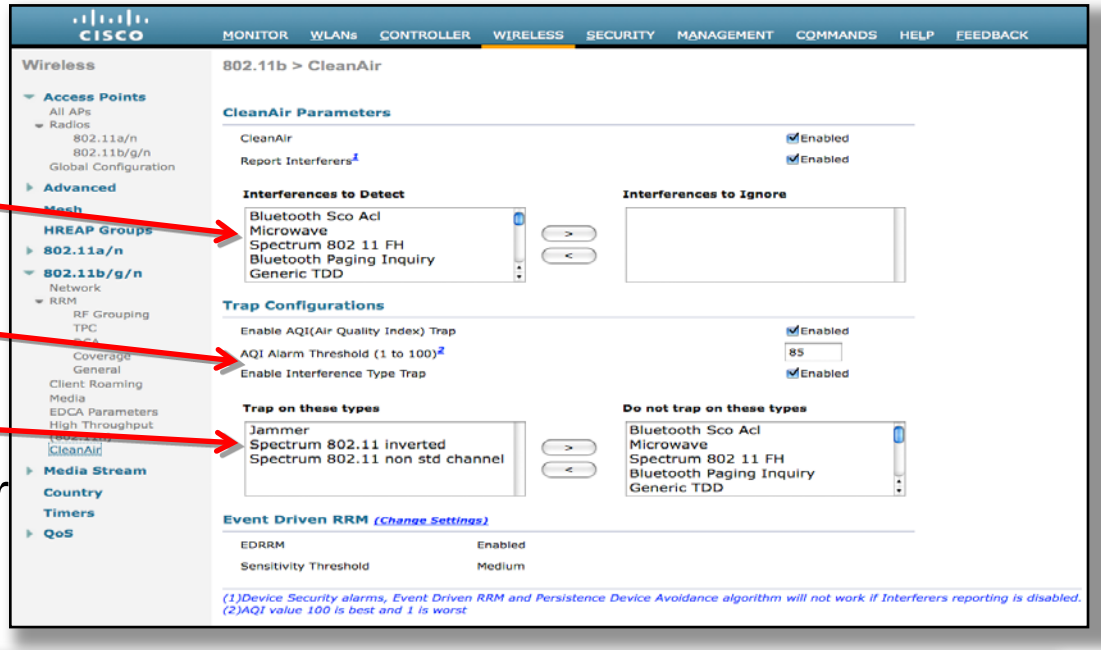
CleanAir
SNMP Trap Settings/controls

- Select trap configurations per band
- Select which interference
- Enable/Disable AQ threshold alert
- Select Interference types for Security alert trap



Granular control over trap messages for performance thresholds as well as security concerns

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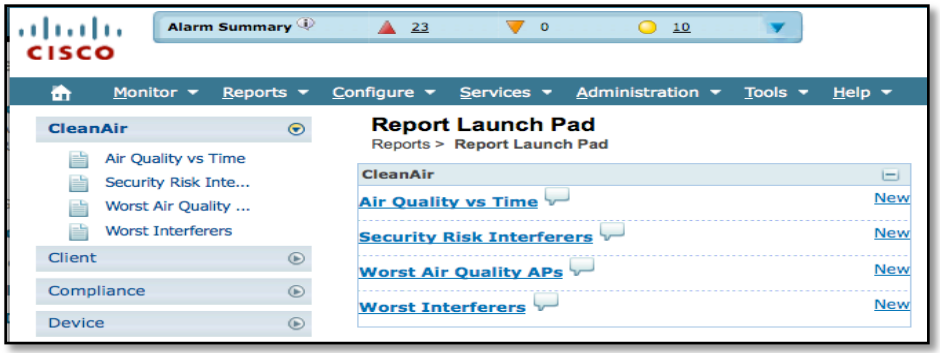
WCS CleanAir reports

- CleanAir reports allow configuration by floor-controller-AP and radio
- Air Quality and Security Risk Reports are all functional without MSE
- Worst Interference report requires MSE



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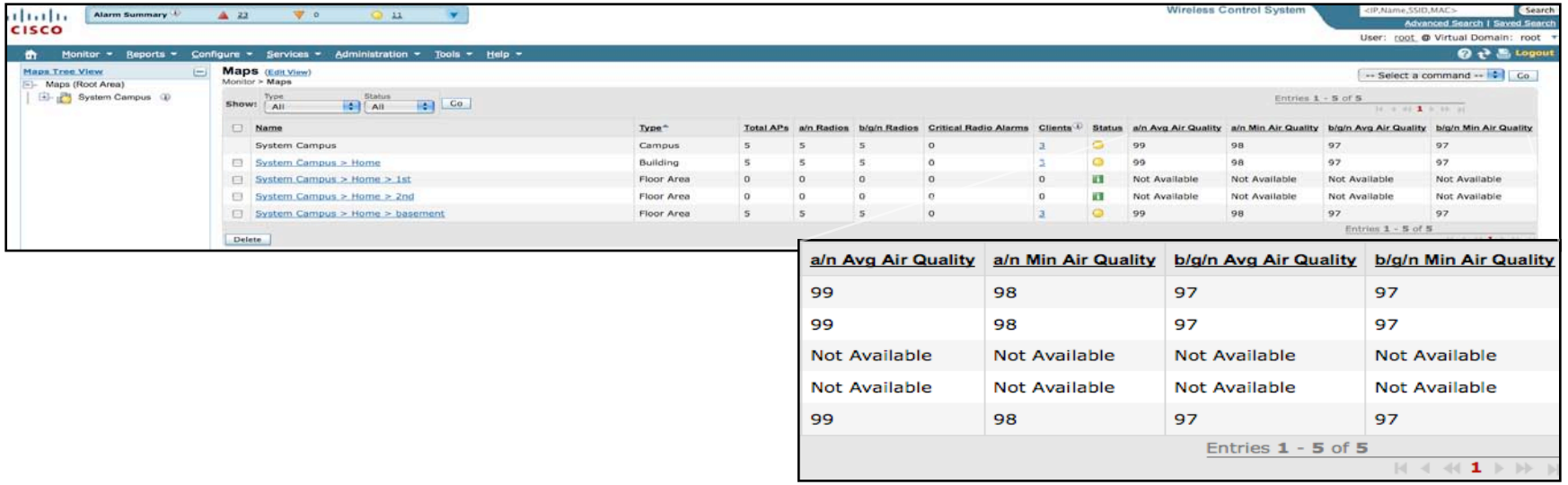
WCS CleanAir Maps



a/n Avg Air Quality	a/n Min Air Quality	b/g/n Avg Air Quality	b/g/n Min Air Quality
99	98	97	97
99	98	97	97
Not Available	Not Available	Not Available	Not Available
Not Available	Not Available	Not Available	Not Available
99	98	97	97

Entries 1 - 5 of 5

1

CleanAir Air Quality reports per radio and is averaged up:
By AP, By Floor, By Building, and by Campus

Select Edit View to add CleanAir Average and Minimum readings to the Maps View

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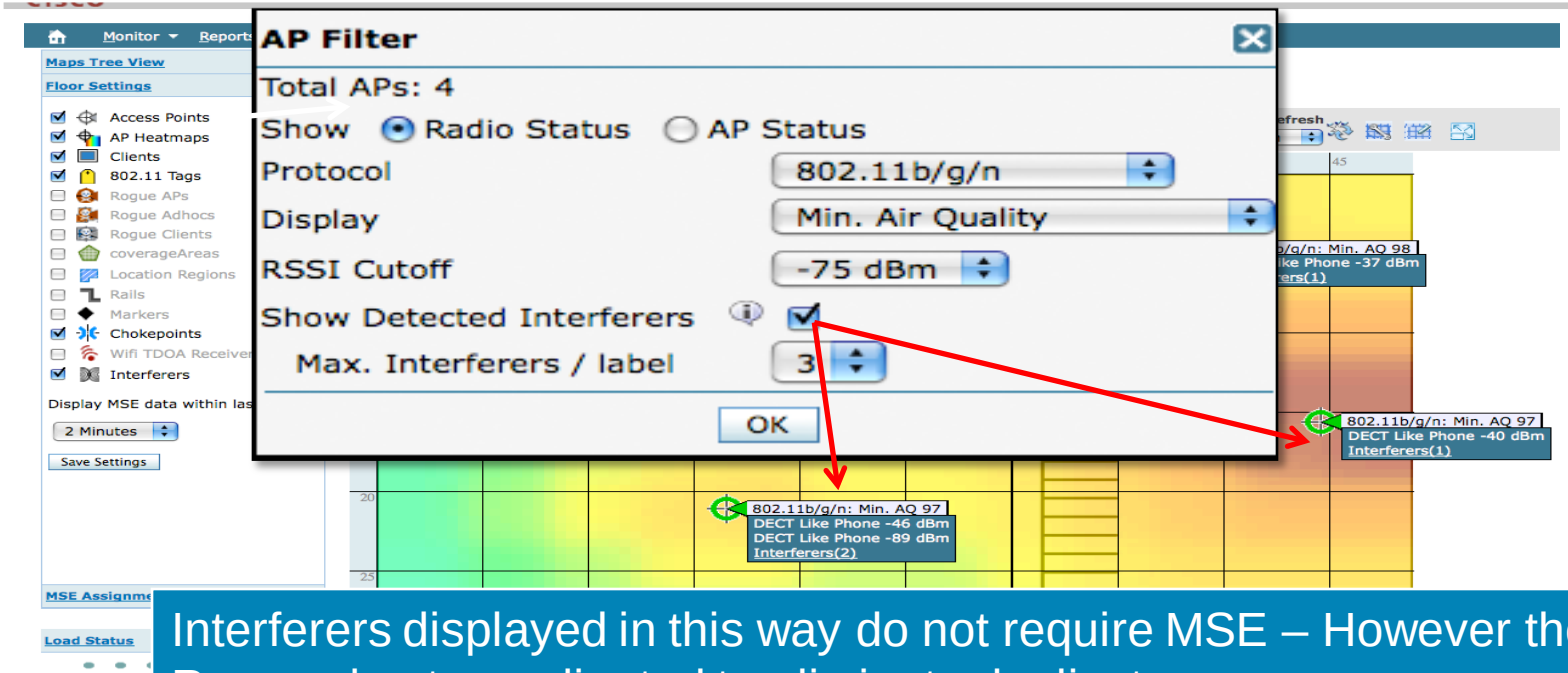
WCS CleanAir Maps

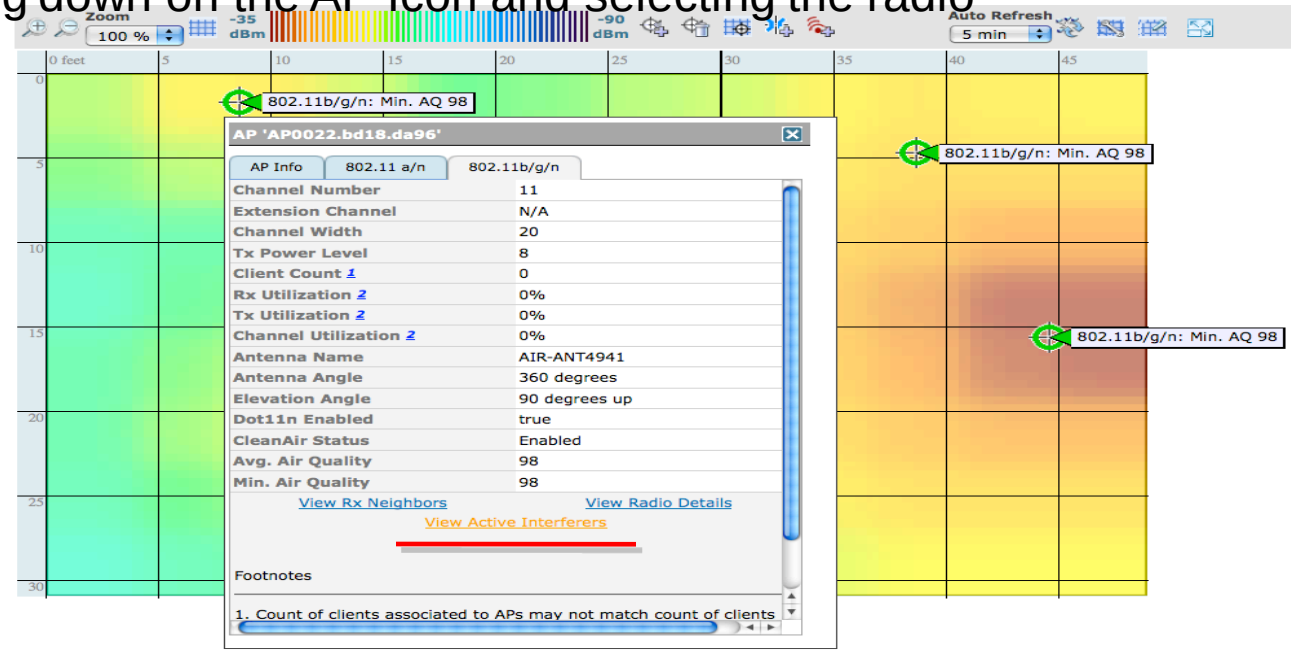
Selecting a map for a given floor provides detail relevant to the selected floor. You can change the AP tags to display CleanAir information such as CleanAir Status (shows which AP's are capable), Min or average AQ values, or Average and Minimum values. The values are relevant to the band selected.



Interferers displayed in this way do not require MSE – However they are Raw and not coordinated to eliminate duplicates

WCS CleanAir Maps

You can also view interference information being seen on any radio interface by drilling down on the AP Icon and selecting the radio



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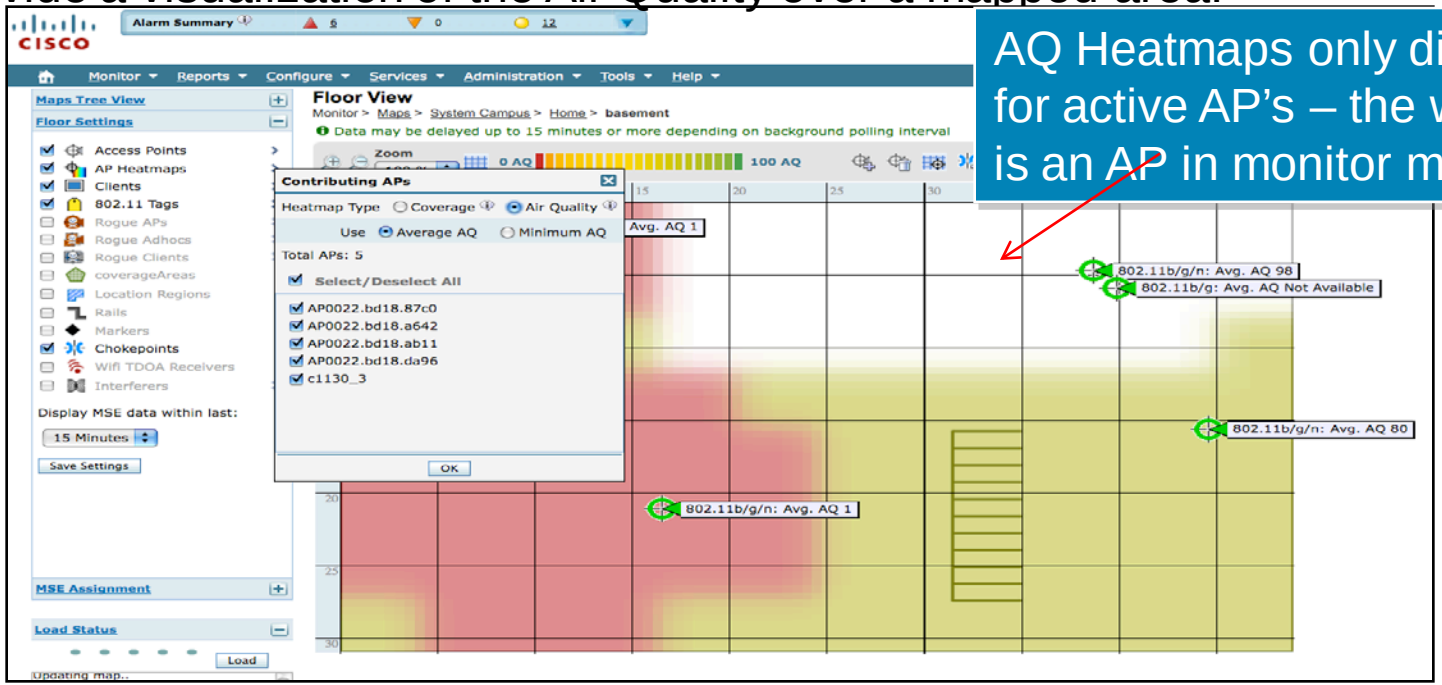
WCS CleanAir Maps

Air Quality heatmaps can be selected to represent average or minimum AQ and Provide a visualization of the Air Quality over a mapped area.



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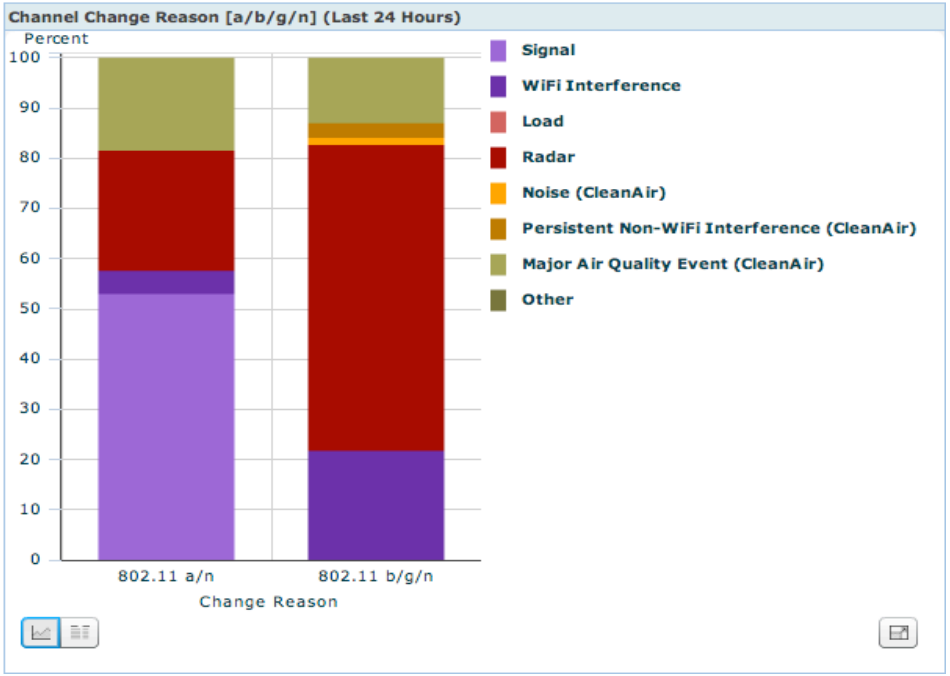
WCS – RRM Dashboard

- RRM Dashboard has been modified to capture CleanAir metrics
- Persistent device (PDA)
- Major Air Quality (ED-RRM)
- Noise



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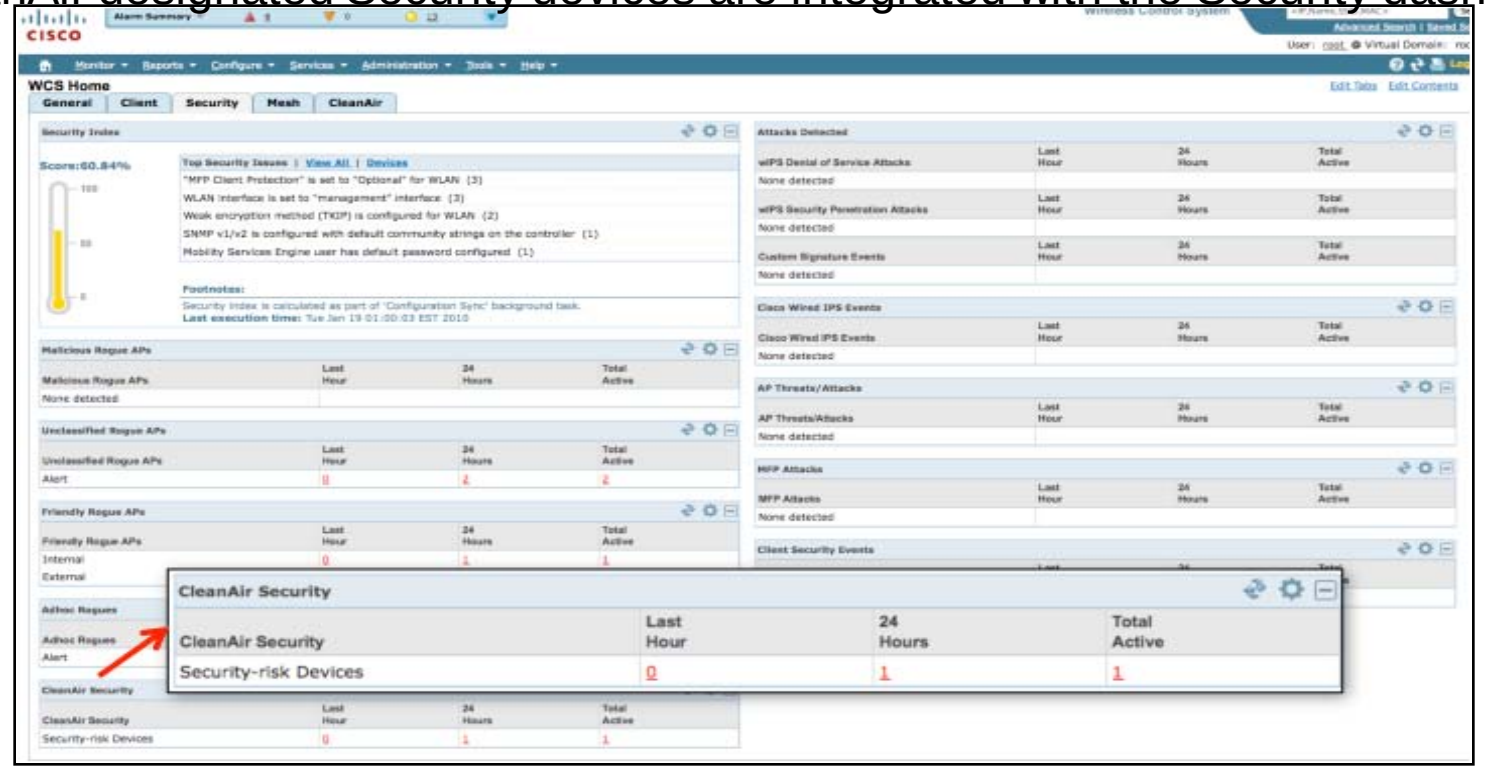
WCS CleanAir enabled Security Dashboard

CleanAir designated Security devices are integrated with the Security dashboard



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WCS CleanAir Security

- There are three devices enabled by Default for security – And not a single WIDs/WIPs solution on the market can see them
- The customer can also add any other device that they deem appropriate
  - Jammer
  - Wi-Fi Inverted
  - Wi-Fi Invalid channel
- Jammers – are self explanatory – and readily available online
- Wi-Fi inverted is simply inverting the I and the Q of the RF signal – very effective
- Off Channel is a fairly easy hack with DD-WRT – simply moving the center frequency by a few KHz will render it invisible.

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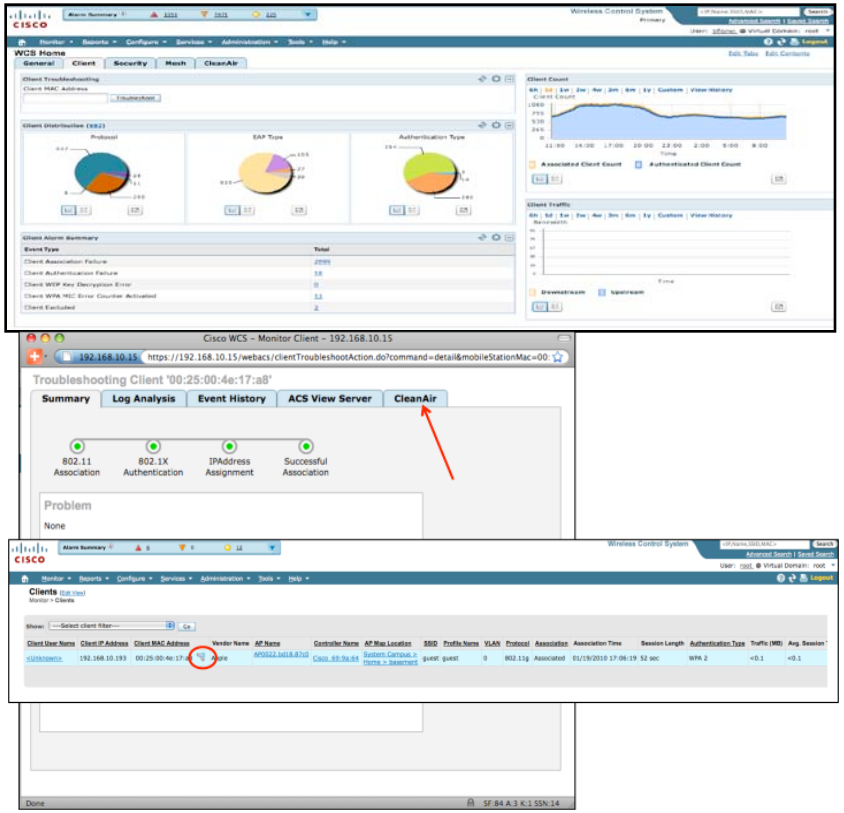
WCS CleanAir Client Troubleshooting integration

- CleanAir information is also coordinated into the client troubleshooting dashboard
- Selecting a client – and launching the client TS dashboard now adds a CleanAir tab
- The TAB displays any interference source that is currently being detected by the AP the client is attached to



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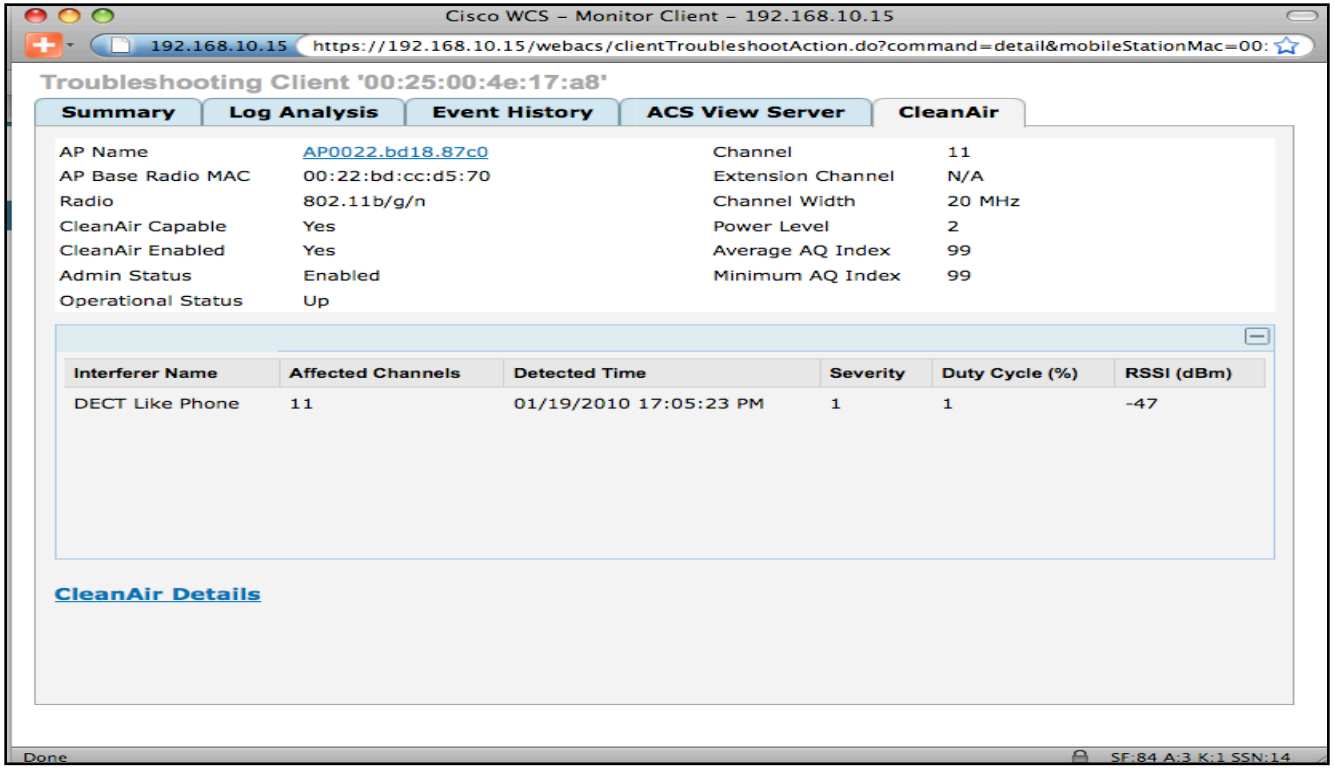
WCS CleanAir Client TS integration



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CleanAir Configuration

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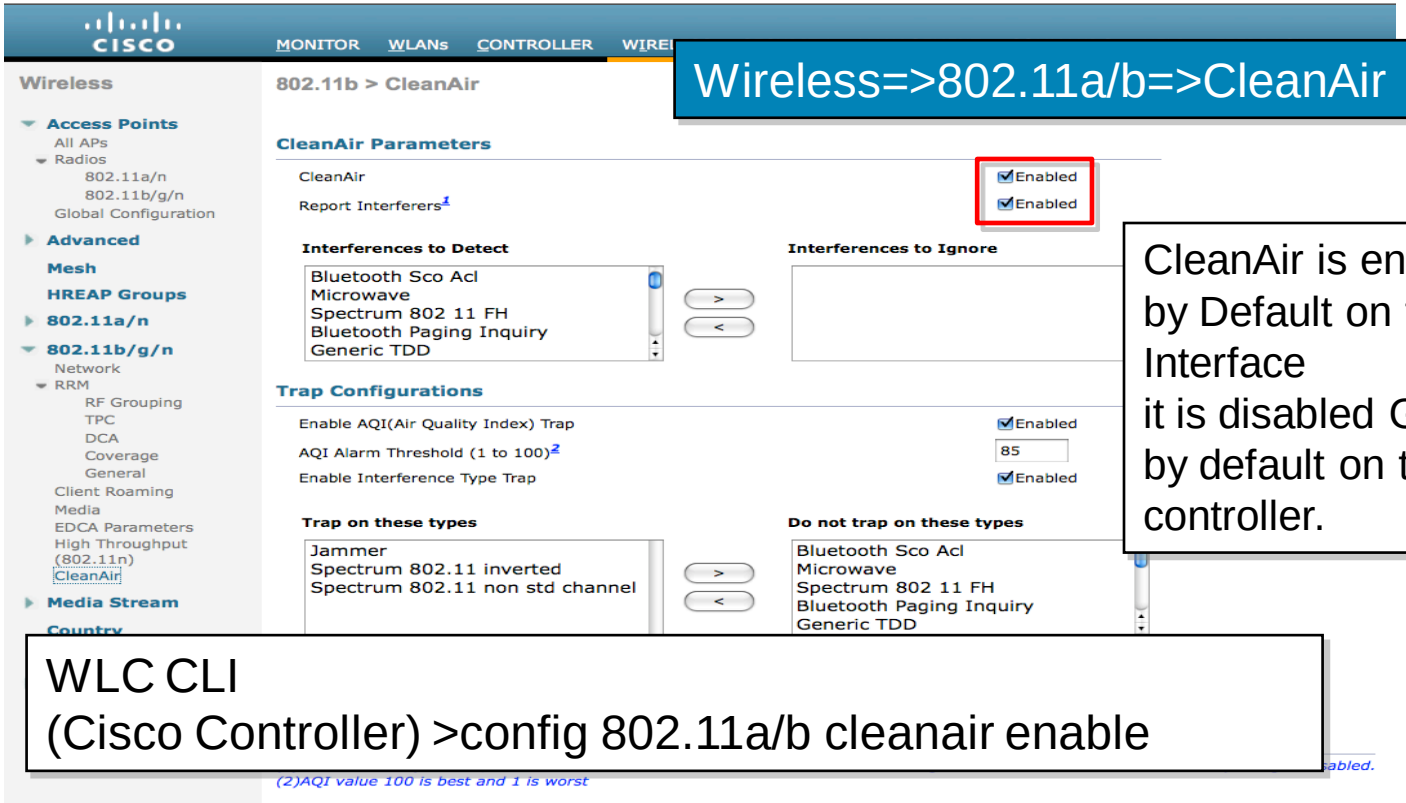
CleanAir WLC enable (WCS identical under Configure=>Controllers)



CleanAir is enabled by Default on the AP Interface
it is disabled Globally by default on the controller.

WLC CLI
(Cisco Controller) >config 802.11a/b cleanair enable

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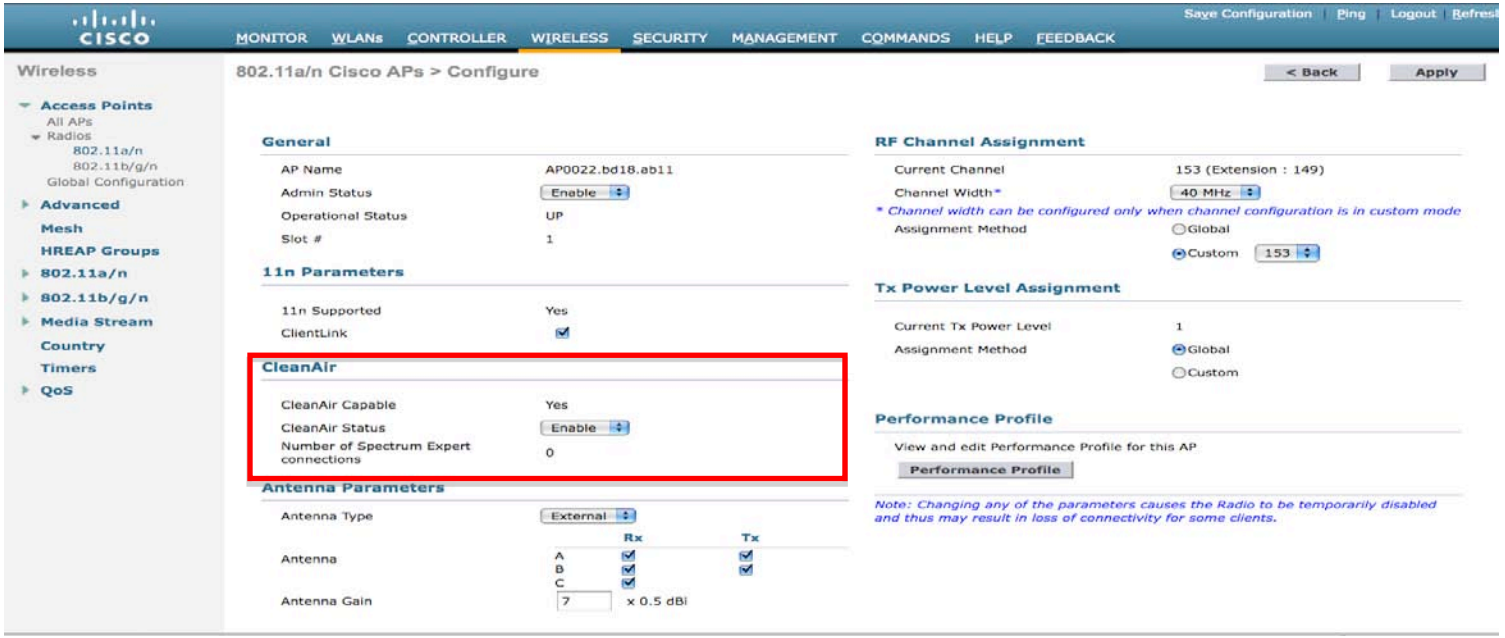
Per AP radio CleanAir Feature Enable

- Enabled by default – but the first place to check -



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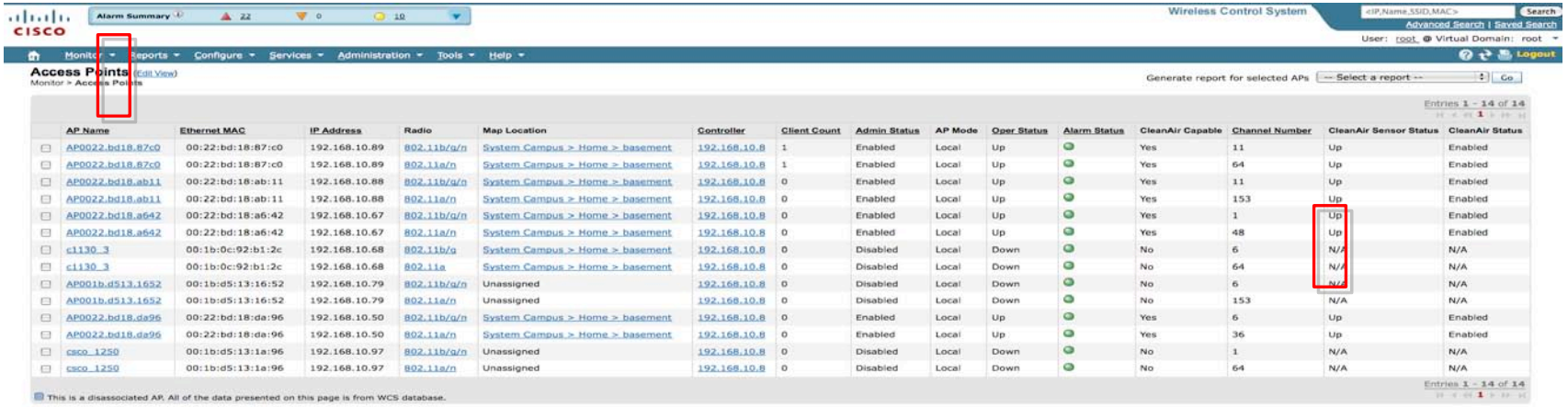
WCS CleanAir Status



- Monitor=>Access Points
- Edit View – add CleanAir Status and CleanAir Capable
- CleanAir sensor status –

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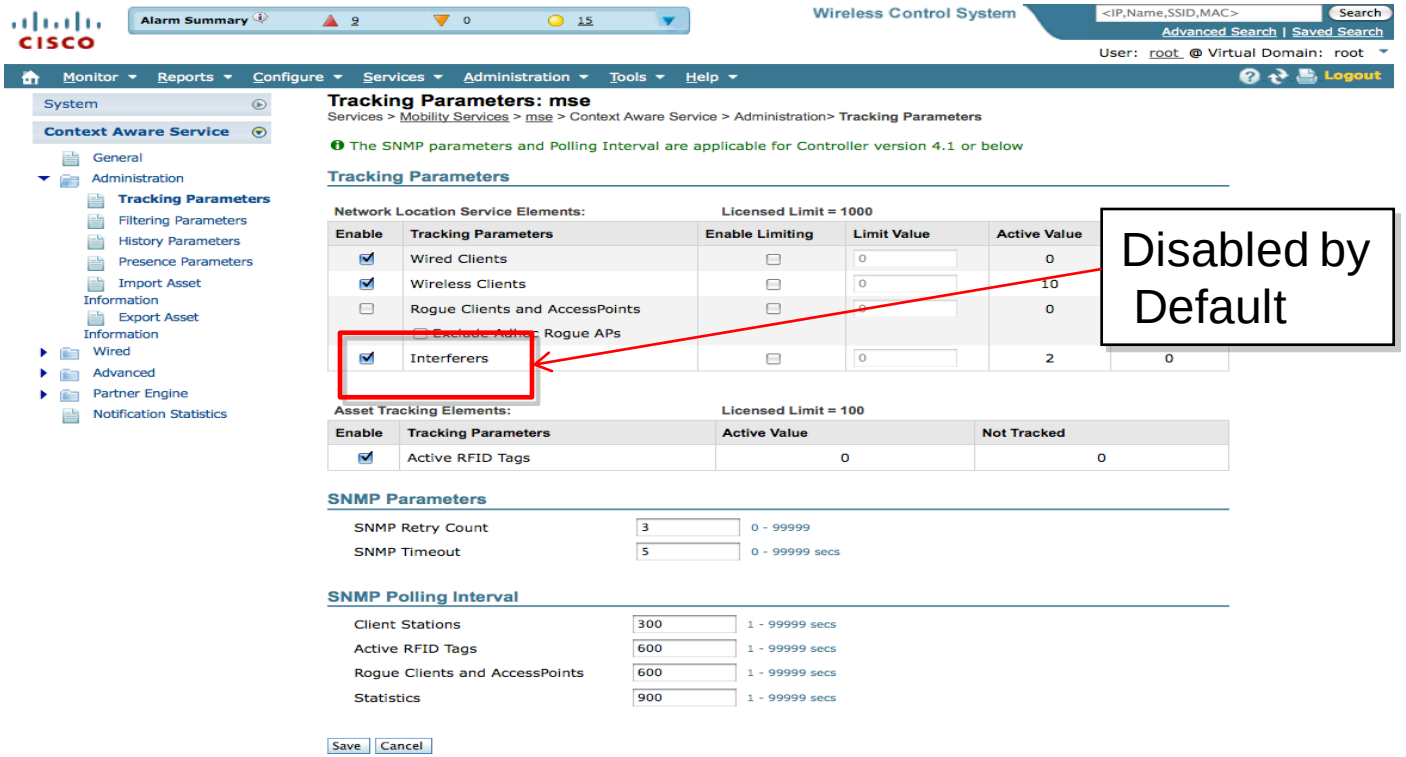
MSE – Context Aware

WCS=>Services=>MSE=>Context Aware Service=>Administration=>tracking parameters



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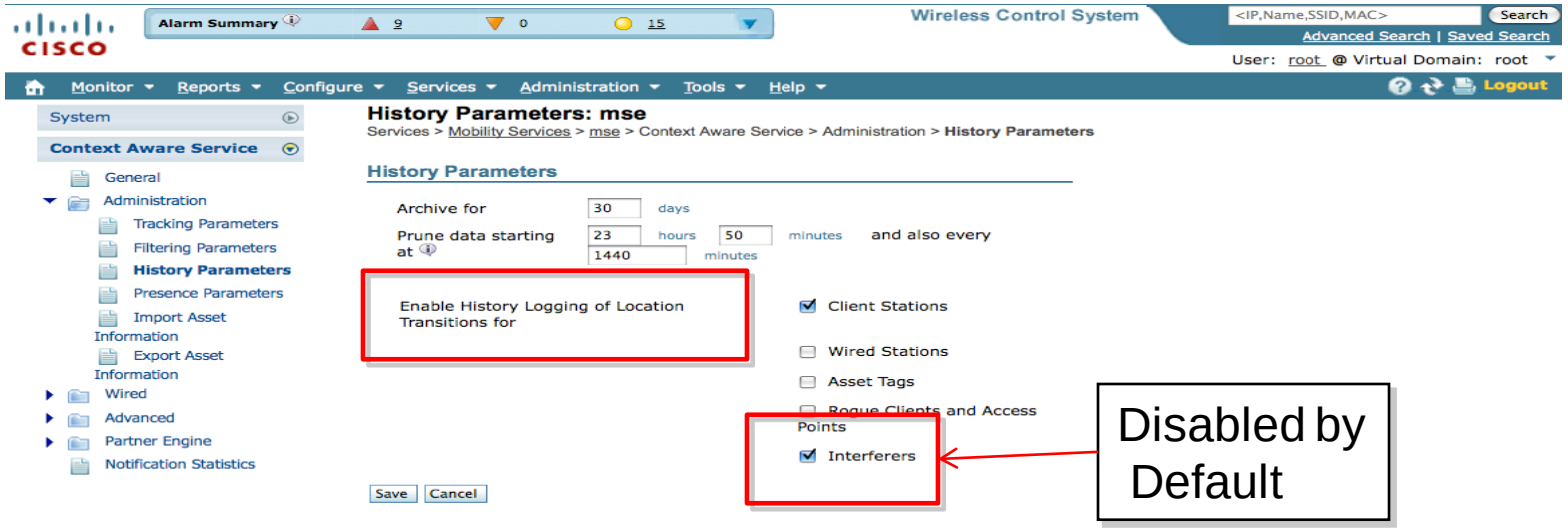
MSE – Context Aware - History

WCS=>Services=>MSE=>Context Aware Service=>Administration=>History Parameters



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Online Resources

- Cisco CleanAir design Guide
  - http://www.cisco.com/en/US/products/ps10315/products_tech_note09186a0080b4bdc1.shtml
- Cisco CleanAir – White Papers
  - http://www.cisco.com/en/US/netsol/ns1070/networking_solutions_white_papers_list.html
- CleanAir TechWise TV Broadcast
  - http://www.cisco.com/en/US/solutions/ns340/ns339/ns638/ns914/html_TWTV/twtv_episode_67.html
- Cisco AP3500 – CleanAir
  - http://www.cisco.com/en/US/products/ps10981/index.html

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