

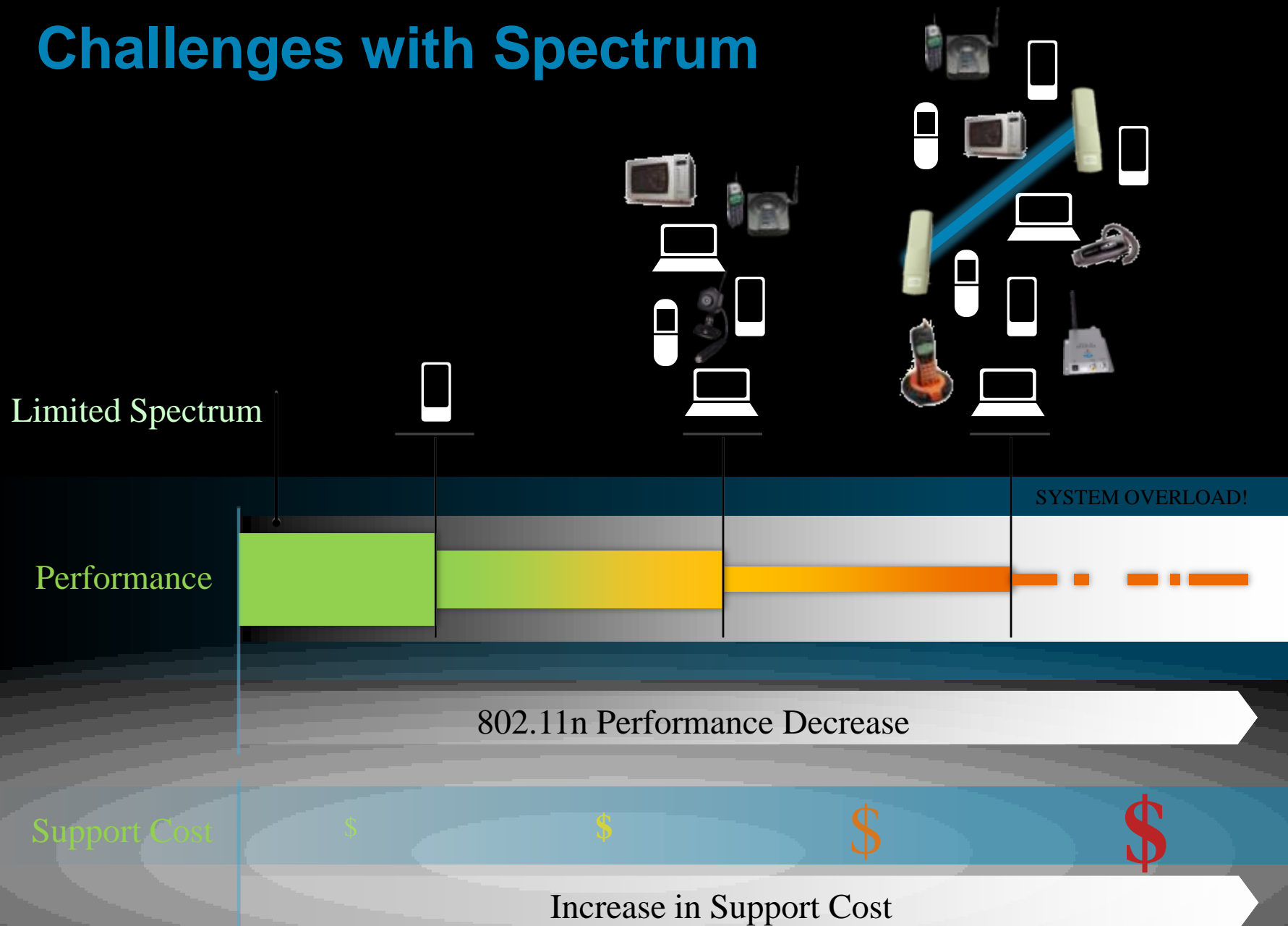
Clean
Air

TechWiseTV WorkShops

Jimmy Ray Purser
Chief Geek
www.techwisetv.com



Challenges with Spectrum



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

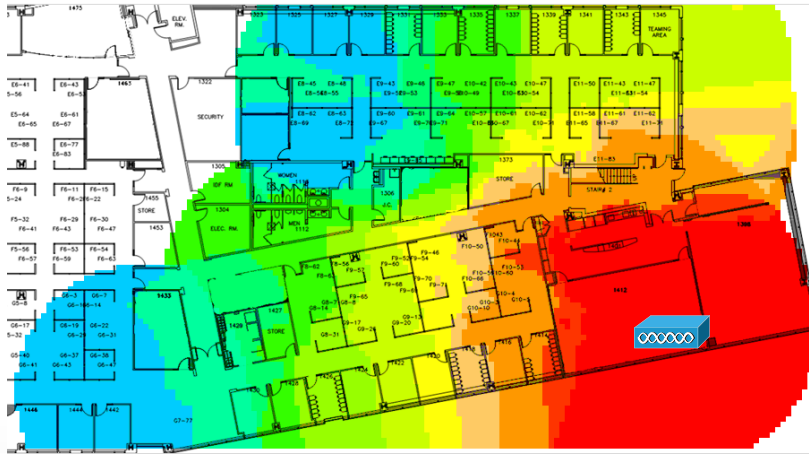
- Potential security breaches
- Support calls
- Increased cost of operation

| | | Throughput Reduction | |
|------------------------------|---|----------------------|-------------|
| Interference Type | | Near (25 ft) | 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% |

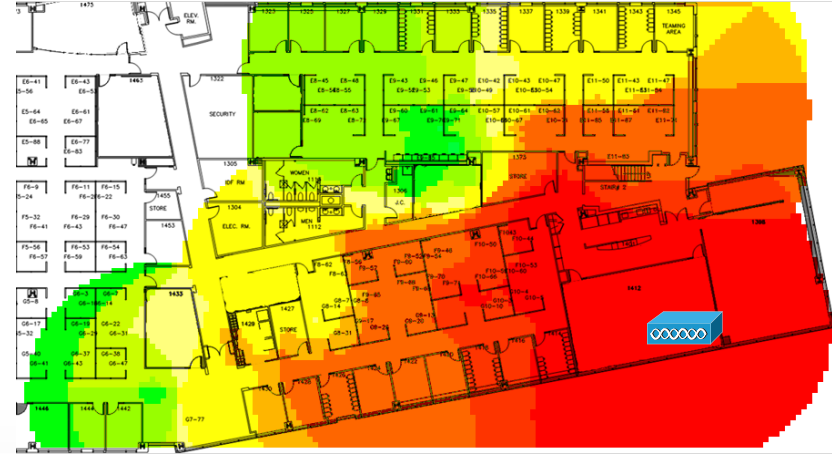
Source: FarPoint Group

Coverage Comparison – 5GHz

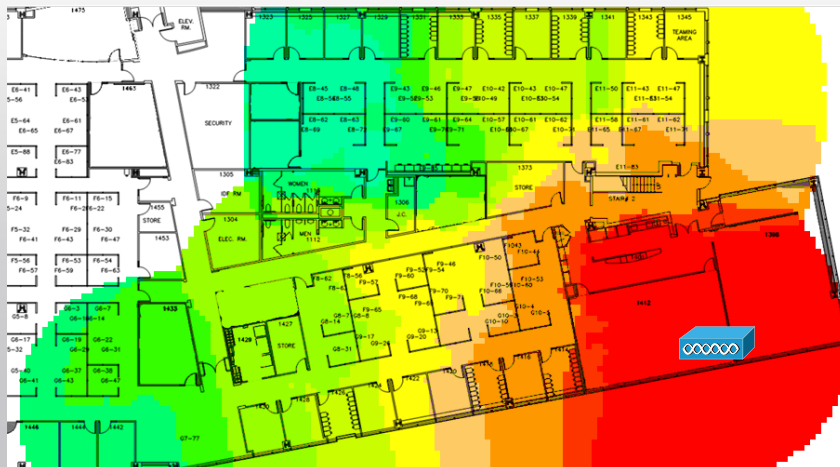
AP1140



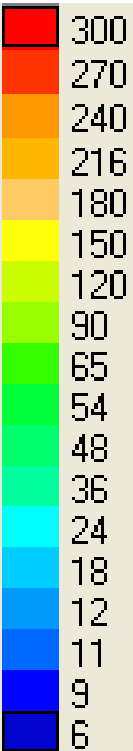
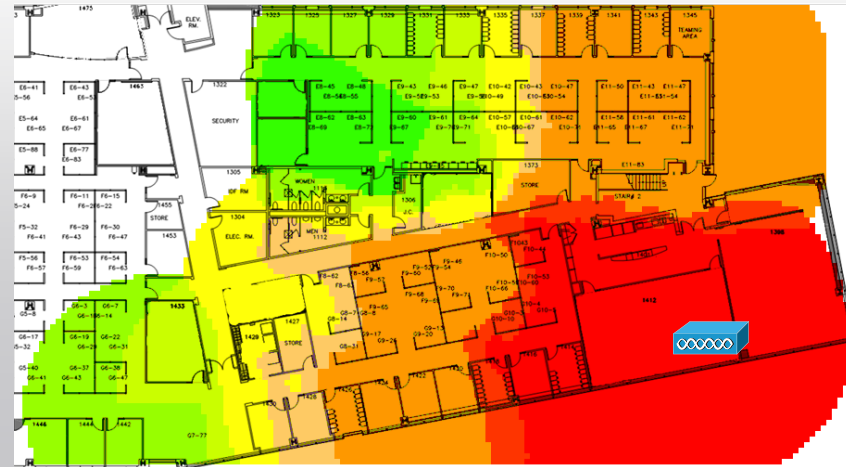
AP1250



AP3500i

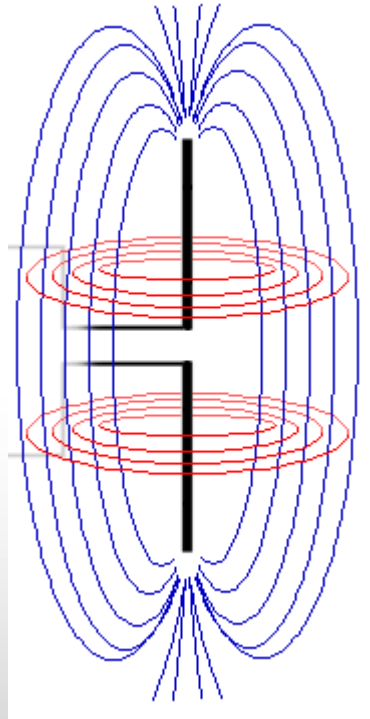


AP3500e

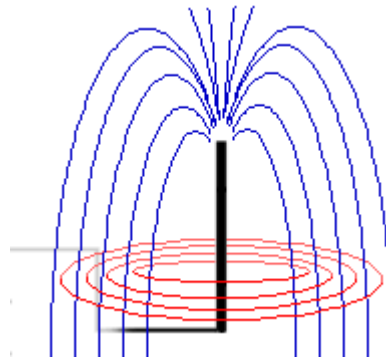


Antenna theory (Dipole & Monopole)

Dipole



Monopole



A Monopole requires a ground plane – (conductive surface)

Dipole does not require a ground plane as the bottom half is the ground (counterpoise).



Monopole (left) is significantly smaller

How does Interference impact Wi-Fi?

Separating the FUD from the Fact's

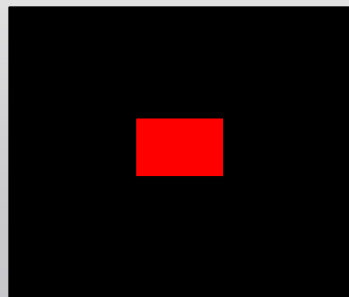
- 802.11a/b/g/n - CSMA/CA or LBT (listen Before Talk)
- Collision Avoidance – 802.11 very very polite – by design
 - CCA
 - Collisions
 - SNR
- CCA – Clear Channel Assessment
 - ED – quick – low power - prone to false positives
 - Preamble – takes time – power – less prone to false
- CCA threshold for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

How does Interference impact Wi-Fi?

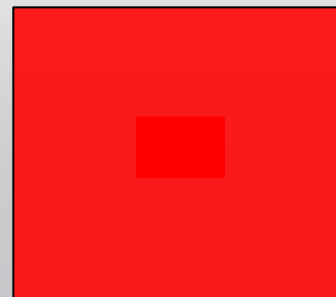
Separating the FUD from the Fact's

- 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



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

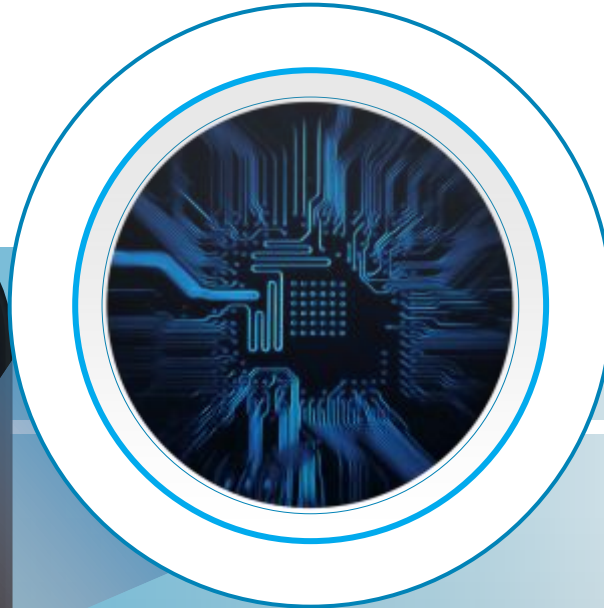
802.11B/G/A and Duty Cycle

| DSSS | | Beacon Size | | | | |
|------|--|-------------|------|------|------|------|
| | | 100 | 200 | 250 | 300 | 350 |
| 1 | | 896 | 1696 | 2096 | 2496 | 2896 |
| 2 | | 496 | 896 | 1096 | 1296 | 1496 |
| 5.5 | | 241 | 387 | 460 | 532 | 605 |
| 11 | | 169 | 241 | 278 | 314 | 351 |
| OFDM | | | | | | |
| 6 | | 153 | 287 | 353 | 420 | 487 |
| 12 | | 87 | 153 | 187 | 220 | 253 |
| 24 | | 53 | 87 | 103 | 120 | 137 |
| 54 | | 35 | 50 | 57 | 64 | 72 |
| 130 | | 26 | 32 | 35 | 38 | 42 |
| 300 | | 23 | 25 | 27 | 28 | 29 |

Time μ S

Introducing CleanAir

New!



Mitigate

Cisco CleanAir

A system-wide feature that uses silicon-level intelligence to automatically mitigate the impact of wireless interference, optimize network performance and reduce troubleshooting costs

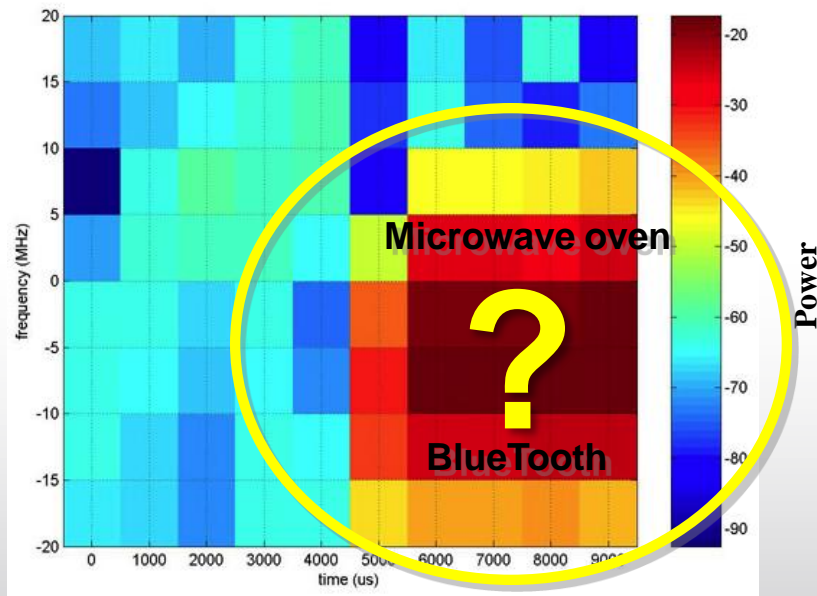
Wi-Fi and Spectrum Knowledge – Why is silicon important?

- 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

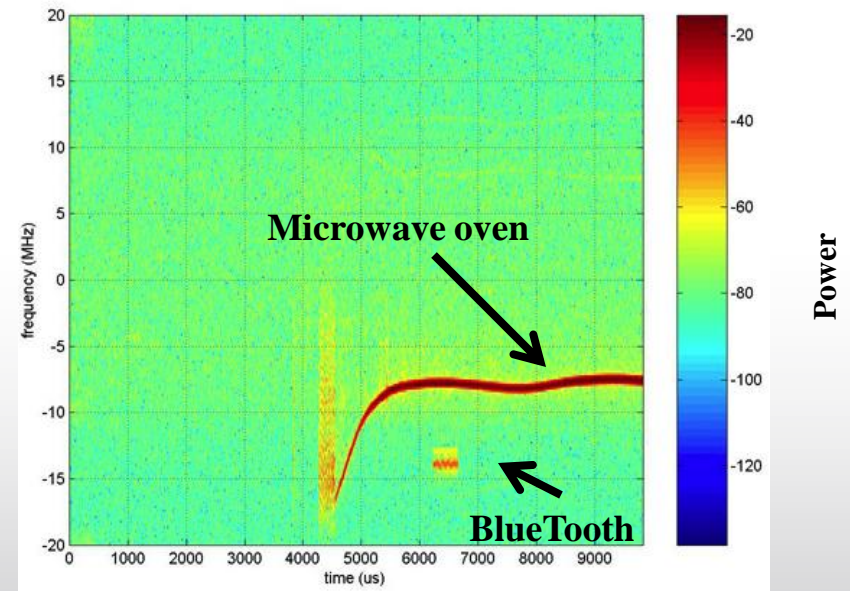
High Resolution Spectral Advantage

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

CleanAir Technology in Cisco Unified Wireless Networks

Cisco Aironet 3500 Series and Wireless LAN Controller

- Radio Troubleshooting and Automatic Interference Mitigation
- Air Quality by Access Point
- Air Quality Alarm Threshold
- SNMP Interference Traps
- 3rd Party MIB
- Spectrum Expert Connect Mode



Cisco Wireless Control System (WCS)

- Historical Trending of AQ and Policy enforcement
- Visibility into the performance and security of the wireless network
- Locate Physical DOS Attacks and Hidden Rogues
- Monitor and Alarm when Unwanted Devices are present



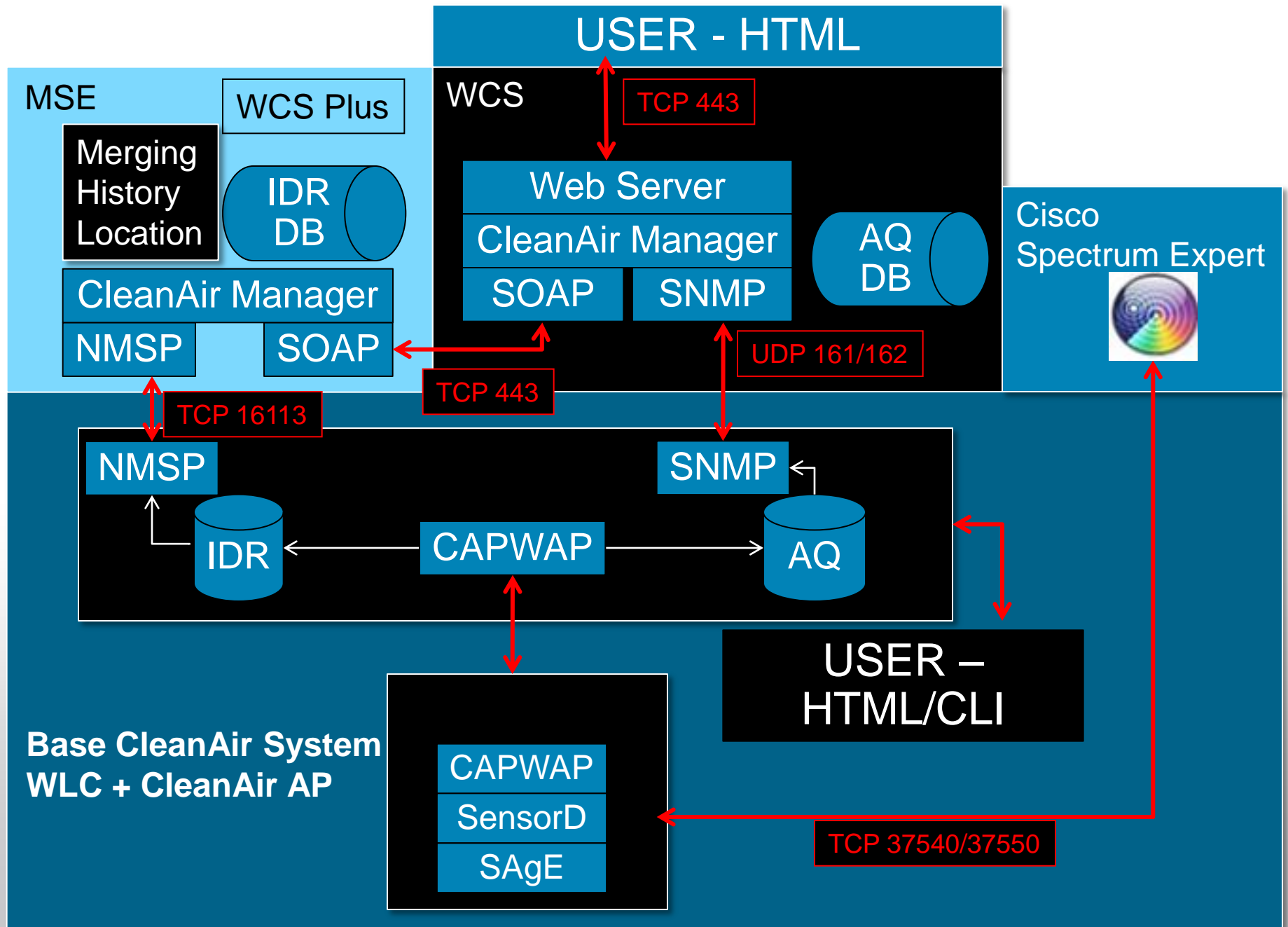
Mobility Services Engine (MSE)

- Location tracking for Zone of Impact
- Merging Correlates Interference Data at a System Level
- Historical Reporting and Trending allows Proactive Interference Management



CleanAir Specific Acronyms

- AQI – Air Quality Index – also seen as AQ
- IDR – Interference Device Report
- PMAC – Pusudo 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
- AOCI – Adjacent Overlapping Channel Interference



Key Components Interaction

- Information is driven in two ways
 - AQI – Air Quality index reporting
 - IDR – Interference device report
- Air Quality – Is driven 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

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

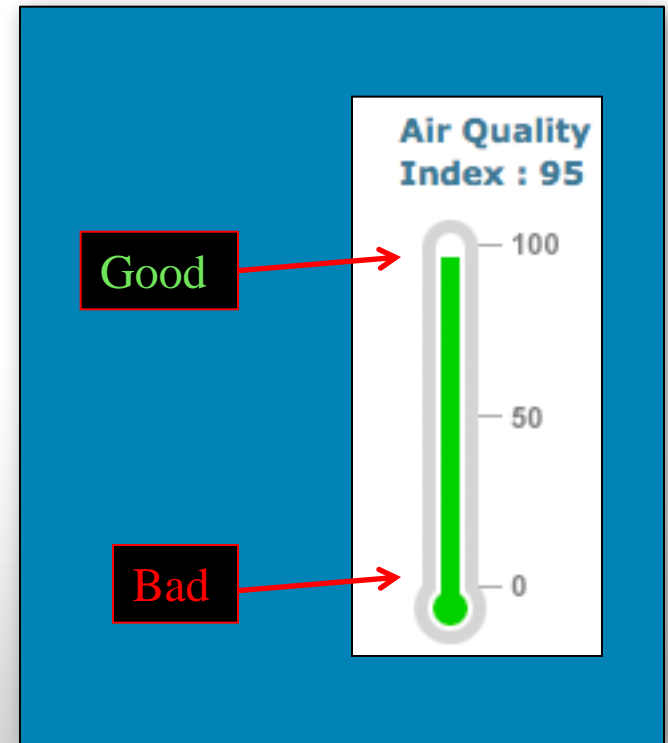
The CleanAir AP

- Built into the silicon of the Wi-Fi chip is an additional 250K logic gates that house the SAgE logic.
- SAgE is the spectrum analyzer
- Controlling the SAgE hardware is software known as SensorD
- 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

Air Quality Index - AQI

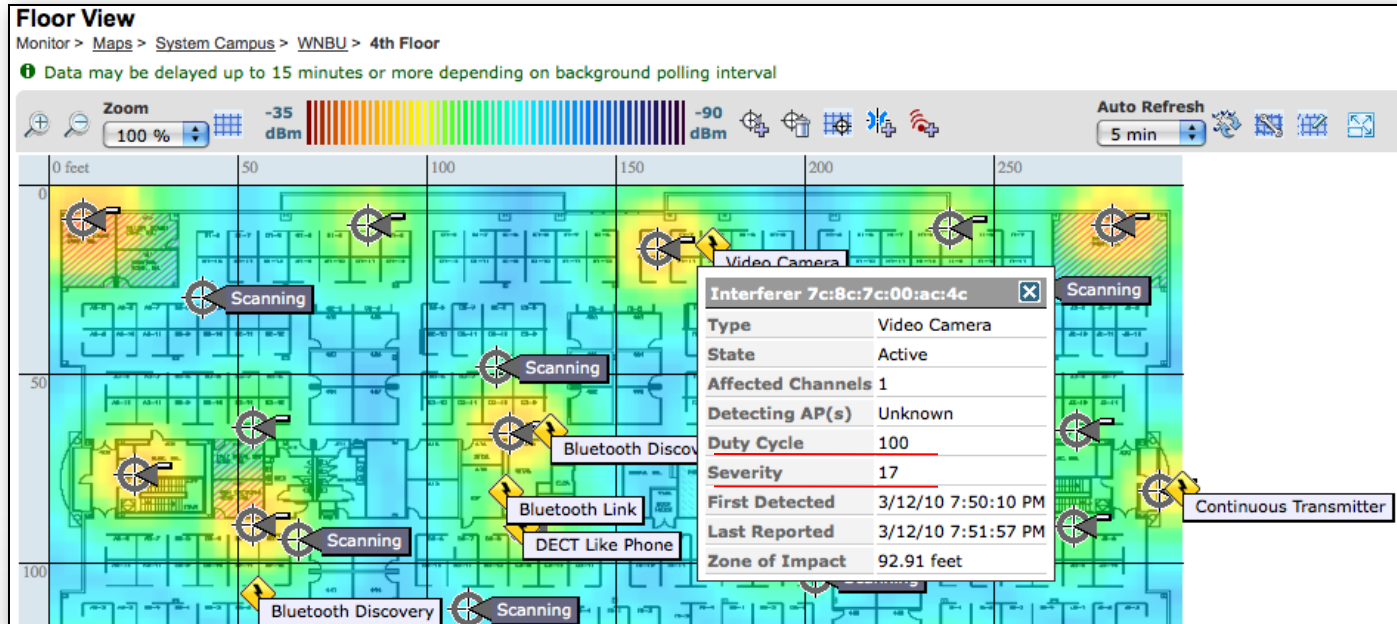
- Air Quality is a measurement of non-wifi and adjacent channel interference
- All Individual devices when Classified are assigned a Severity Value
- Air Quality is a measure of all Devices/Severities within a Radio, Floor, Building, or Campus



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.

Air Quality and Severity



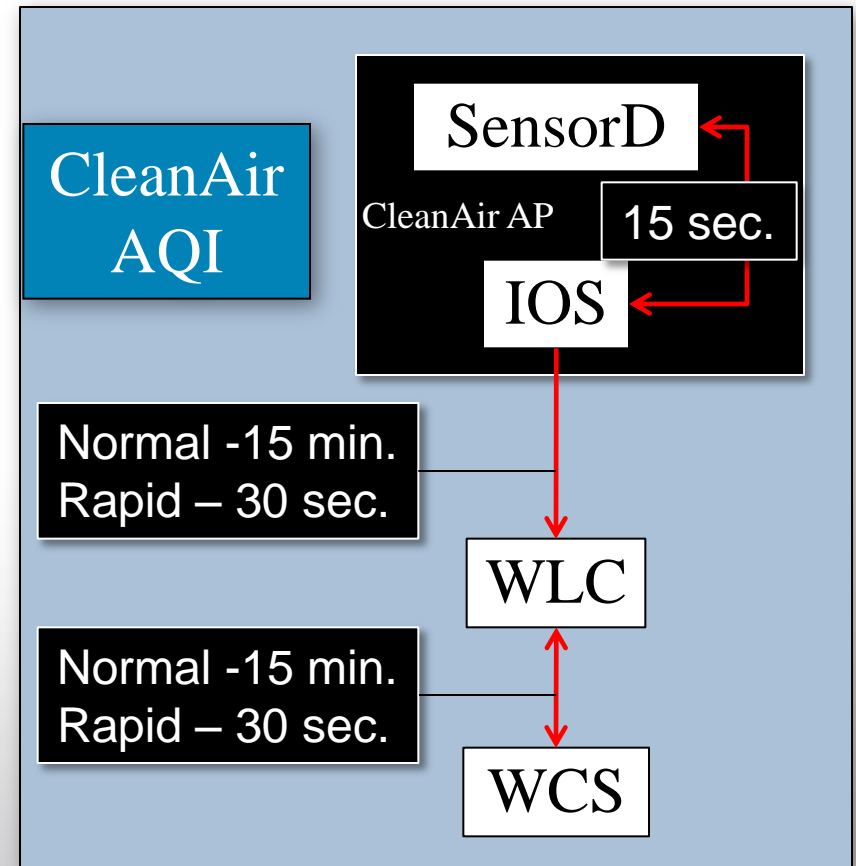
- Severity is used to understand the potential impact to a Wi-Fi network
- The RSSI at the AP for this interferer (-78) is well below CCA threshold
- Even with duty cycle of 100% - the severity here is 17 – if it were closer to us severity would be much higher

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.

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



AQI In-Depth

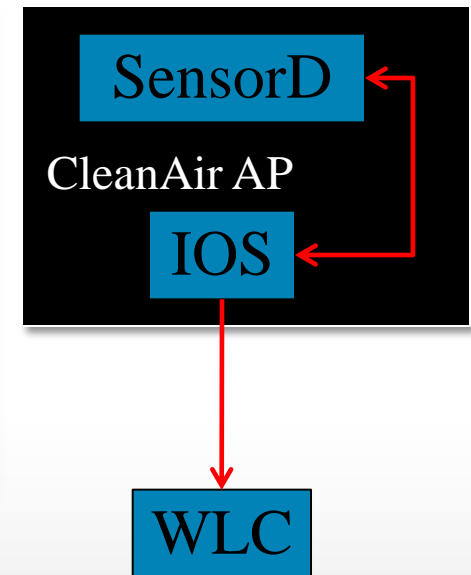
- Each AQ report contains the average, and the minimum observed AQ during the period
- Each CleanAir Radio sends AQ reports independently to the WLC for the channel it is serving (15 Minutes by default) or all channels if in Monitor Mode (MMAAP)
- WLC Maintains last normal AQ report for each radio until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

Design Decision Moment: Rapid Update mode for a given radio interface, pollutes overall average as normal averaging is suspended while active

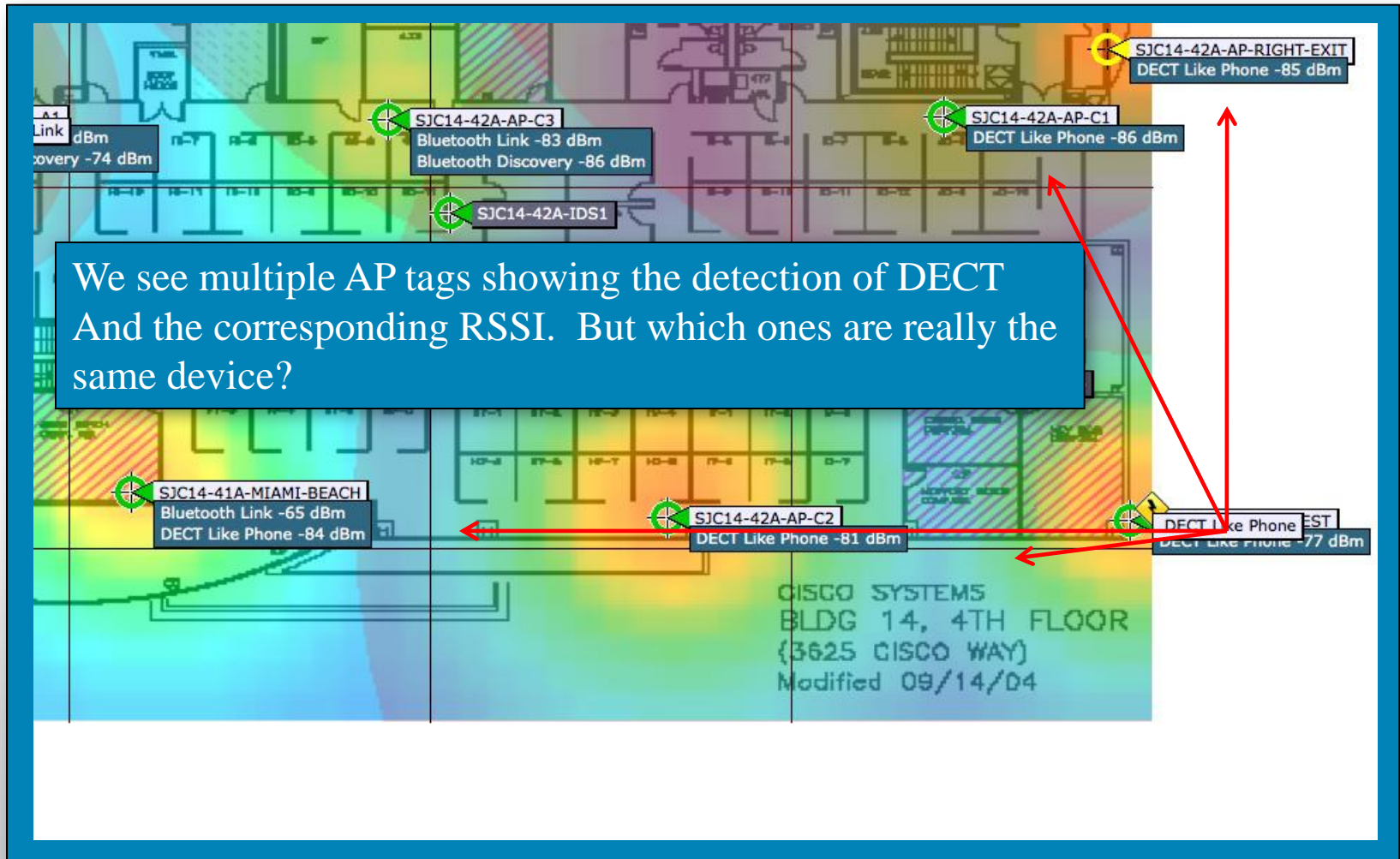
Interference Device Report IDR and The AP

- 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 | |



Multiple AP's = Multiple Sensors



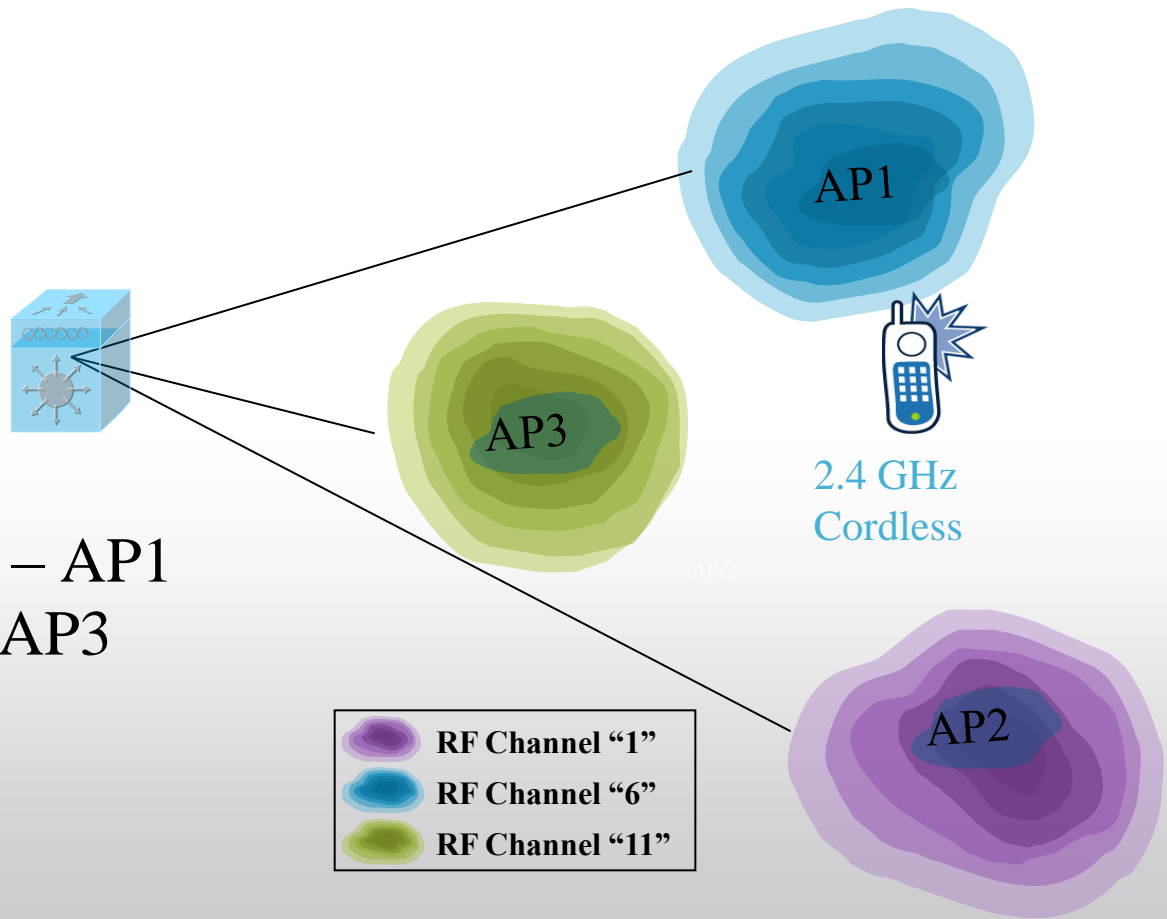
IDR In-Depth – The AP - PMAC

- 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 droop – temp variations
 - Measurement accuracy – or inaccuracy

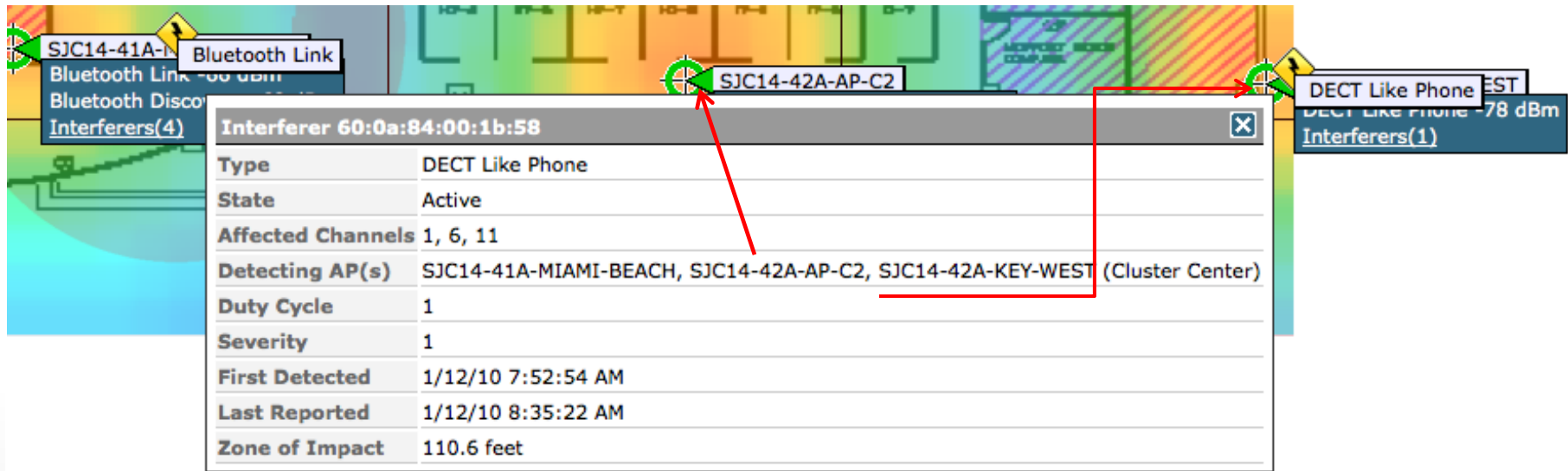
An example would be TDD Phone and Basestation that an AP can distinguish based on relative timing and a PLL loop, which cannot be exported to the Controller without fine grain clock locking

WLC Merging – and PMAC “The Cluster”

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



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

WLC and PMAC Merging

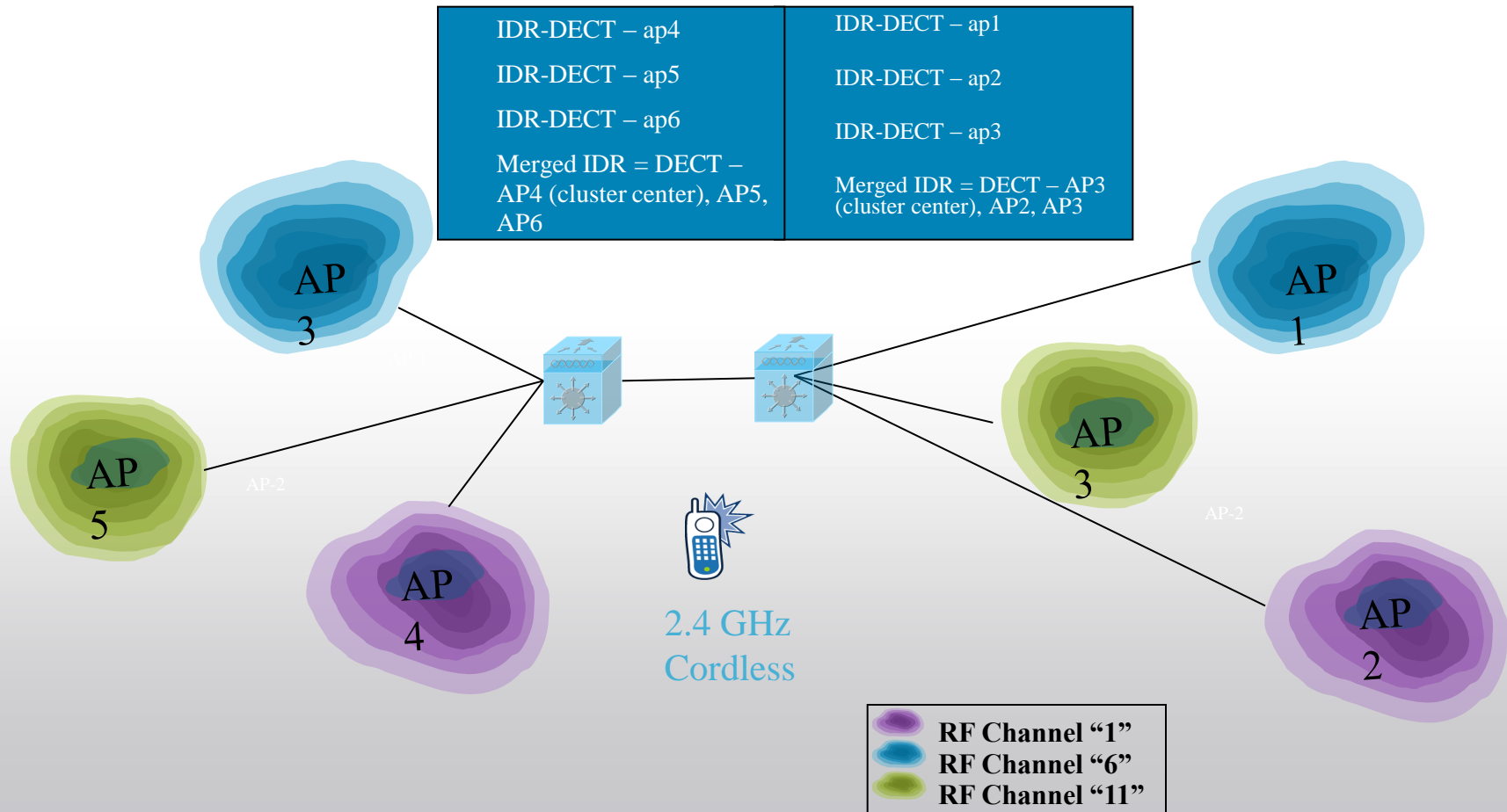
- WLC performs comparison function on received IDR's PMAC
- WLC can merge devices for AP's physically connected to it
- WLC merge results are only viewable in IDR traps sent to trap receiver (WCS)
- No Location is performed on WLC merged interferers
- The result of a WLC merge is forwarded to the MSE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

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 1 client for CAS license purpose – each active merged interferer will consume 1 seat

MSE Merging – LMAP X-WLC

MSE Merge



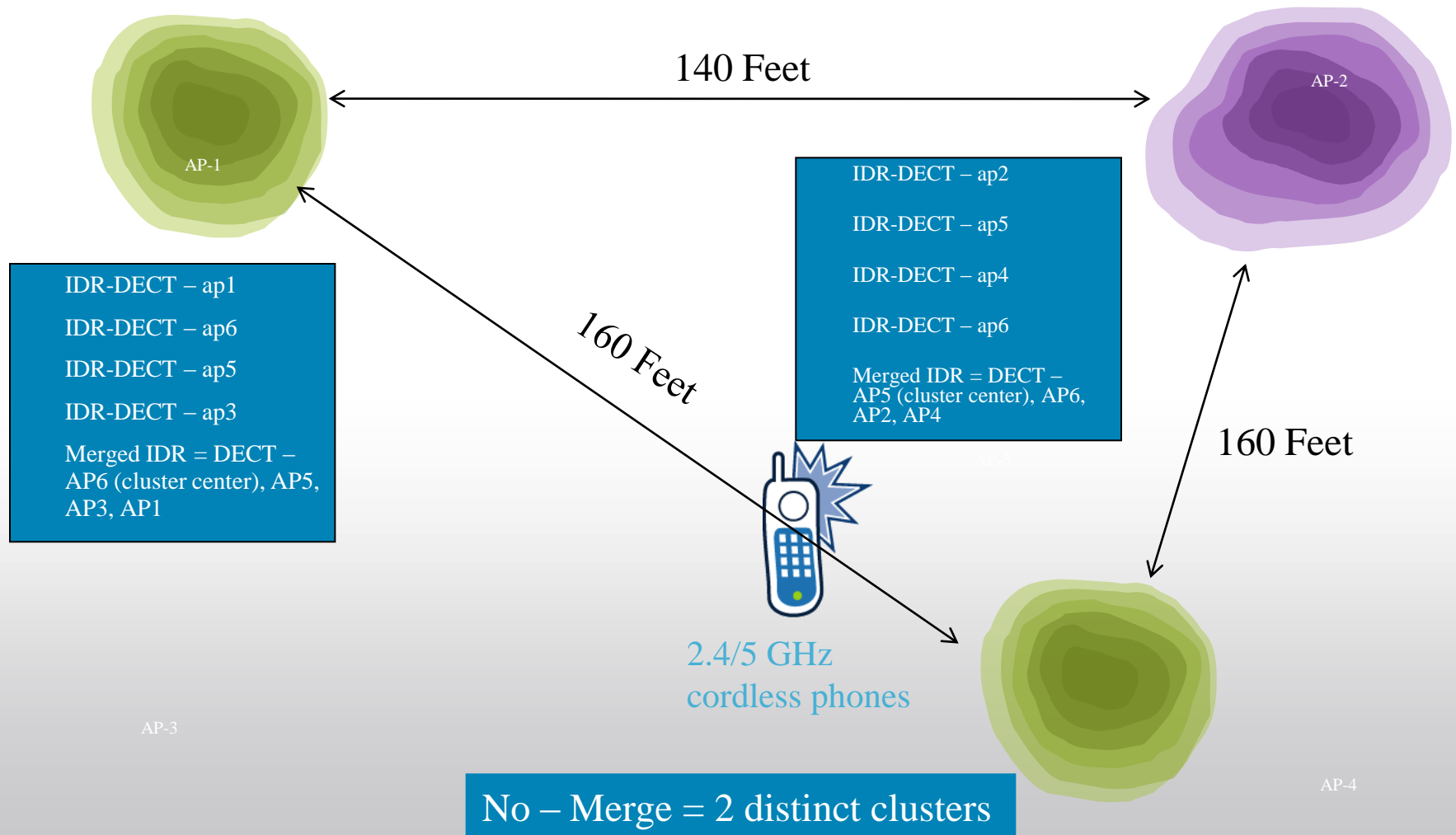
MSE – WLC Merging and Location

- 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

MMAP overlay CleanAir operation

- MSE does all clustering and merging – even if only one controller
- No MSE – No Merging
- MSE will use X/Y position of AP's located on the map to establish RF Proximity
- AP's must be within 150 feet of each other
- Over 150 feet, possibly will get two merged clusters

MMAP Relations



MMAP-MSE controls

- Properties file allows setting of the 150' limitation
- RSSI cutoff in location services controls how many records will be used to establish location

The screenshot displays the Cisco MMAP-MSE configuration interface. At the top, there is an 'Alarm Summary' bar with three status indicators: a red triangle with '17', an orange triangle with '0', and a yellow circle with '20'. Below this is a navigation menu with options: Monitor, Reports, Configure, Services, Administration, Tools, and Help. The left sidebar shows a tree view with categories: System, Context Aware Service (selected), Administration, Tracking Parameters, Filtering Parameters, History Parameters, Presence Parameters, Import Asset Information, Export Asset Information, Wired, Advanced, Location Parameters, Notification Parameters, Partner Engine, and Status. The main content area is titled 'Location Parameters: mse' and shows the breadcrumb path: Services > Mobility Services > Context Aware Service > Advanced > Location Parameters. The 'Location Parameters' section contains several settings: 'Enable calculation time' (checkbox, Enable), 'Enable OW Location' (checkbox, Enable), 'Relative discard RSSI time (1 - 99999 min)' (text input, 3), 'Absolute discard RSSI time (1 - 99999 min)' (text input, 60), 'RSSI Cutoff (-90 to -50 dBm)' (text input, -75, highlighted with a red underline), 'Enable Location Filtering' (checkbox, checked, Enable), 'Chokepoint Usage' (checkbox, checked, Enable), 'Use Chokepoints for Interfloor conflicts' (dropdown menu, Never), 'Chokepoint Out of Range Timeout (1-99999 secs)' (text input, 60), and 'Interferer Merge Algorithm Aggressiveness' (dropdown menu, High). At the bottom, there are 'Save' and 'Cancel' buttons.

CleanAir supported Deployment Options

| | Feature | Partial Overlay Monitor | Full Pervasive In-line |
|--------------|--|----------------------------|---------------------------|
| Detect | Detect and Analyze RF signals | ✓ | ✓ |
| Classify | Classify Interference source and impact severity | ✓ | ✓ |
| Locate | Locate on map with zone of impact | ✓ | ✓ |
| Troubleshoot | Cisco Spectrum Expert Connect | ✓ | ✓ |
| | WCS Integration | ✓ | ✓ |
| AP Service | CleanAir | ✓ | ✓ |
| | Monitoring (RRM, Rogue, WIPS, Location, etc) | ✓ | ✓ |
| | Client Traffic | | ✓ |
| Mitigate | Event Driven channel changes | | ✓ |
| | Persistent Device avoidance | | ✓ |

Overlay Monitor deployments are recommended for a 1:5 ratio

* - monitor mode accuracy dependant on AP density

Interference Device Location

- Location is measured by Triangulating receive measurements
- With Clients – we have a standard, sort of
- Not so with Interference devices, consumer class transmitters

Battery operated – voltage sags

Directional antenna?

Different assumed TX power?




There is no Guarantee of Location Accuracy with Interference devices.
In Practice – this works fairly well, certainly better than the competitions

CleanAir Deployment Recommendations

Pervasive

Pervasive 3500
(local mode)

Adding to existing AP deployment

-  Self Healing
-  Troubleshooting
-  Location





Recommended for:

- New or Upgrading to 802.11n
- New areas for ongoing 802.11n deployments
- Networks severely impacted by non-WiFi interference

Overlay

Pervasive 1140, 1250, 1260
(local mode or non-Cisco)

Overlay 3500
(monitor mode 5:1 ratio)

-  Self Healing 
-  Troubleshooting
-  Location

- CleanAir Technology required in AP for Self Healing (local mode)






Recommended for:

- Existing 802.11n deployments
- Competitive Installed 802.11n deployments

Mixed

~~**Pervasive 1140, 1250, 1260**
(local mode or non-Cisco)~~

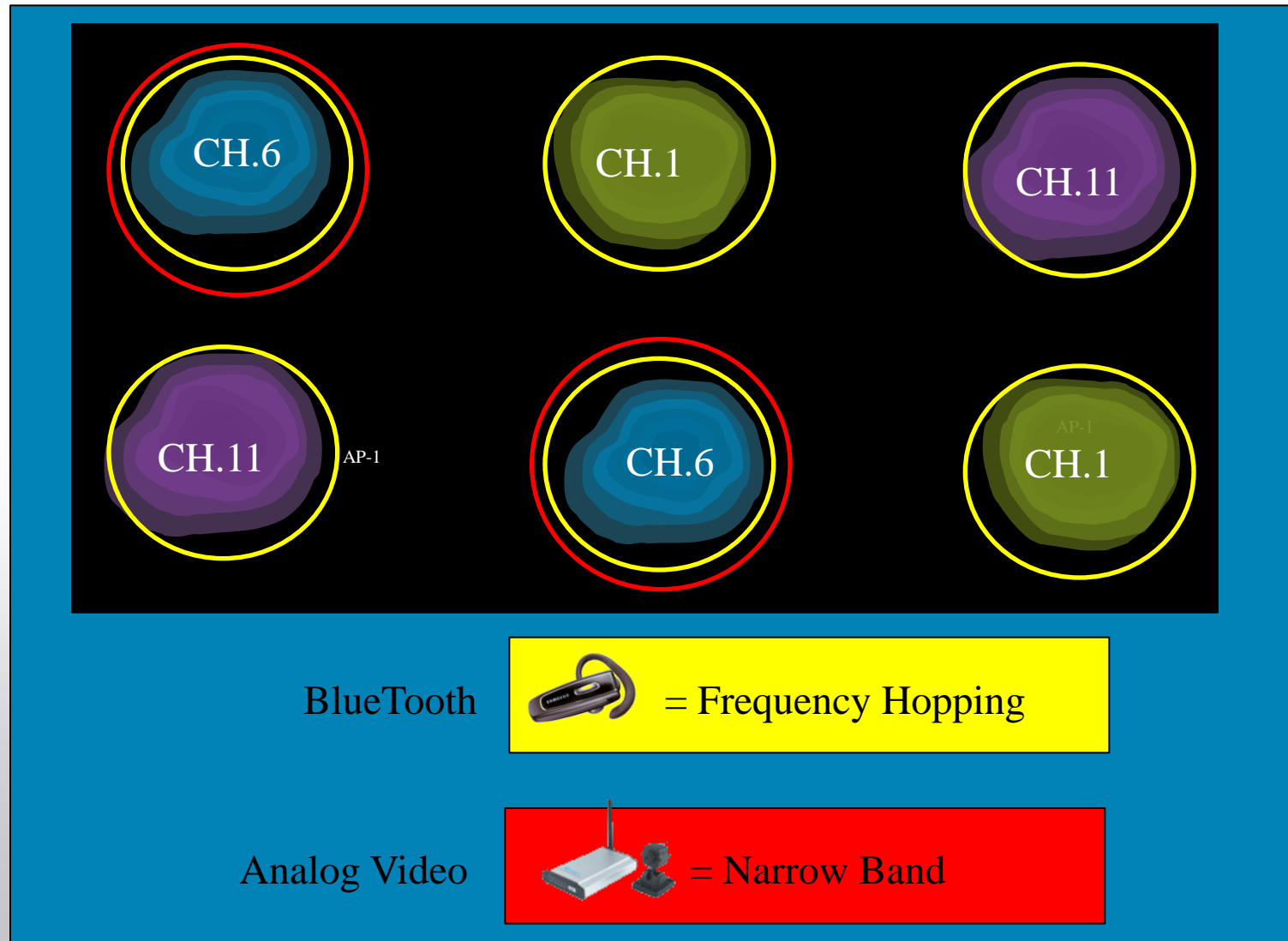
~~**Inlay 3500**
(local mode 5:1 ratio)~~

-  Self Healing 
-  Troubleshooting 
-  Location

- CleanAir Technology required in AP for Self Healing (local mode)
- Limited spectrum visibility and location capabilities because local mode 3500 spectrum scans only data serving channel.

Not Recommended

Local Mode AP CleanAir Deployment – LMAP and Detection






CleanAir Deployment Recommendations

Pervasive

Pervasive 3500
(local mode)

Adding to existing AP deployment

-  Self Healing
-  Troubleshooting
-  Location





Recommended for:

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- New areas for ongoing 802.11n deployments
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Overlay

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



Recommended for:

- Existing 802.11n deployments
- Competitive Installed 802.11n deployments

Mixed

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(local mode or non-Cisco)~~








~~**Inlay 3500**
(local mode 5:1 ratio)~~

- ~~ Self Healing ~~
- ~~ Troubleshooting ~~
- ~~ Location~~

- CleanAir Technology required in AP for Self Healing (local mode)
- Limited spectrum visibility and location capabilities because local mode 3500 spectrum scans only data serving channel.

Not Recommended

Aironet Indoor Access Point Comparison

| | AP 1130  | AP 1140  | AP 3500i  “Zest” | AP 1240  | AP 1250  | 1260  | 3500e  “Larch” |
|----------------------------|---|---|---|---|---|--|--|
| Integrated CleanAir | No | No | Yes | No | No | No | Yes |
| Data Uplink (Mbps) | 10/100 | 10/100/1000 | 10/100/1000 | 10/100 | 10/100/1000 | 10/100/1000 | 10/100/1000 |
| Power Requirement | 802.3af | 802.3af | 802.3af | 802.3af | E-PoE 802.3af* | 802.3af | 802.3af |
| Installation | Carpeted | Carpeted | Carpeted | Rugged | Rugged | Rugged | Rugged |
| Temp Range | 0 to +40° C | 0 to +40° C | 0 to +40° C | -20 to +55° C | -20 to +55° C | -20 to +55° C | -20 to +55° C |
| Antennas | Internal | Internal | Internal | External | External | External | External |
| Wi-Fi standards | a/b/g | a/b/g/n | a/b/g/n | a/b/g | a/b/g/n | a/b/g/n | a/b/g/n |
| DRAM | 32 MB | 128 MB | 128 MB | 32 MB | 64 MB | 128 MB | 128 MB |
| Flash | 16 MB | 32 MB | 32 MB | 16 MB | 32 MB | 32 MB | 32 MB |

•802.3af fully powers single radio AP1250 or provides 1x3 performance on a dual radio 1250

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Aironet Indoor Access Point Comparison



| | AP 1130 | AP 1140 | AP 3500i "Zest" | AP 1240 | AP 1250 | AP 1260 | AP 3500e "Larch" |
|------------------|---------|---------|--------------------|---------|---------|---------|---------------------|
| ClientLink | No | Yes | Yes | No | Yes | Yes | Yes |
| Bandselect | No | Yes | Yes | No | Yes | Yes | Yes |
| Videostream | No | Yes | Yes | No | Yes | Yes | Yes |
| Office-extend | Yes | Yes | Yes ? | No | No | No | No |
| DFS | 0.8μs | 0.8μs | 0.5μs | 0.8μs | 0.8μs | 0.5μs | 0.5μs |
| Standalone | Yes | Yes | No | Yes | Yes | Yes | No |
| Controller-based | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Monitor Mode | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| WIPS | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| HREAP | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Identifying different Access Point models

AP-3500i Series...

Similar in Physical Design as 1140



More sensitive receiver – integrated Spectrum Intelligence

AP-3500e and AP-1260 Series...

Similar in Physical Design as AP-1140 with RF connectors



AP-3500E (Debossed logo) has Spectrum Intelligence AP-1260 (pad printing) does not.

AP-3500e and AP-1260 Series...

Similar in Physical Design as 1140



AP-3500E (Debossed) “color-less” logo has Spectrum Intelligence the AP-1260 (pad printing) does not.

Access Point differences

Aironet 3500i Series AP

Designed for enterprise carpeted areas

- The Aironet AP-3500i is designed for carpeted areas.
 - Support for 5 GHz 802.11a/n and 2.4 GHz 802.11b/g/n radios
 - Cognio Spectrum Intelligence (SAgE)
- Designed to run full 802.11n features using 802.3af power.
- Faster 0.5 μ s DFS detection
- Temperature range 0 to +40° C



Aironet 3500e Series AP

Higher temperature range (MFG verticals)

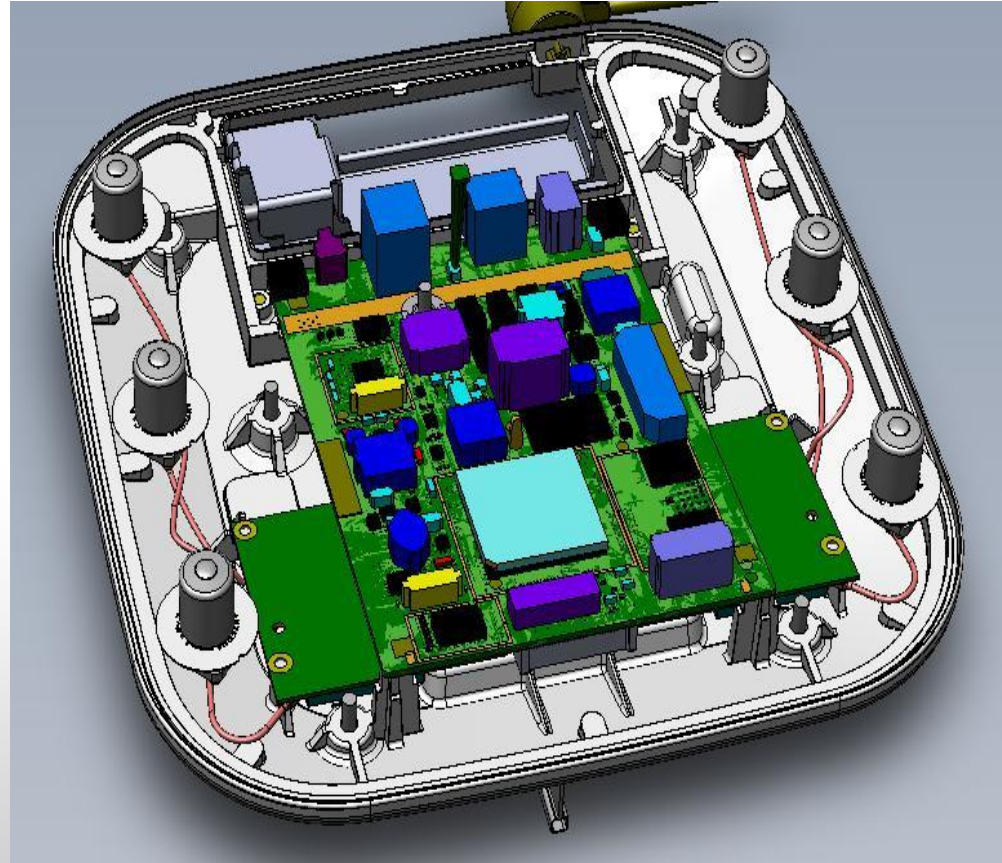
- The Aironet AP-3500e is designed for retail and manufacturing verticals or where there is a requirement for external antennas.
 - Support for 5 GHz 802.11a/n and 2.4 GHz 802.11b/g/n radios
 - Cognio Spectrum Intelligence (SAgE)
- Designed to run full 802.11n features using 802.3af power.
- Faster 0.5 μ s DFS detection
- **Higher Temperature range** -20 to +55 C



Differences AP-1140 ver. AP3500

The following components are different from the Cascade design and will cause changes in the software:

- Newer Microprocessor
- This processor draws less power (allowing us to stay within 802.3af) and has an improved processor packet rate.
- AP-3500 can do 360 MB per second due to increased L1 & L2 Cache – The older AP-1140 used an earlier processor which lacked L2 Cache and topped out at approx 300 MB per second.
- Broadcom BCM54610 Gigabit PHY
- Marvell 88W8364C 802.11n MAC/PHY (SC1)
- Integrated Spectrum Intelligence (SAGE)
- Marvell 88W8063RF (Raven)



Connectorized AP-3500e

Support for dipole and monopole antennas



AP-3500e with monopole antennas (also supports dipoles)
Use swivel dipoles when wall mounting this device.