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RF TROUBLESHOOTING



Back to Basics



What Affects Signal Strength?

- **AP Characteristics**

- Number and type of Radios (a/b/g/n)
- Max Tx Power
- Receive Sensitivity
- Number of Spatial Streams
- Antenna – Internal/External
- Antenna Pattern
- Number of clients supported

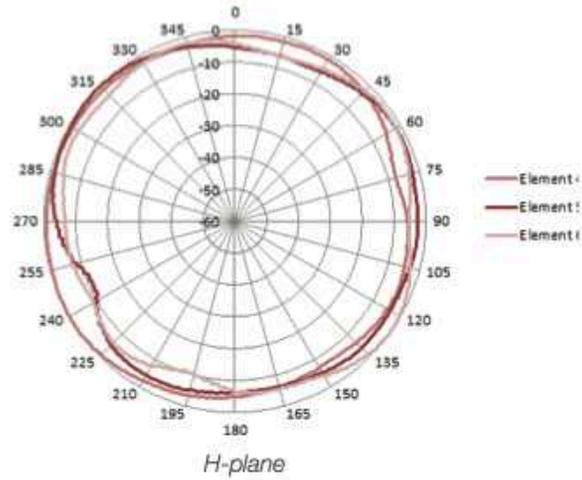
**APs are not created equal
Choose the right AP for the occasion**



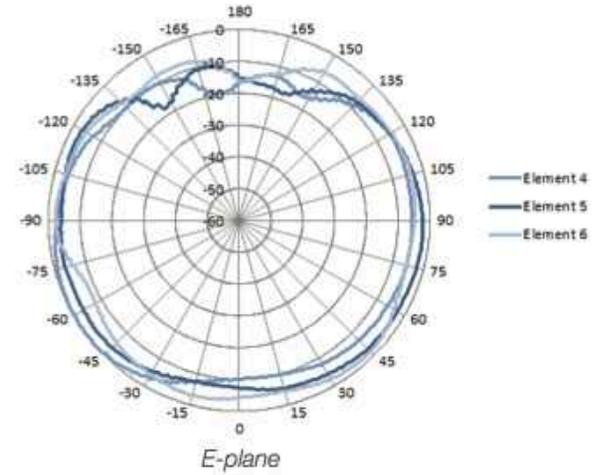
AP-135 Antenna Pattern

AP-135 ANTENNA PATTERN PLOTS

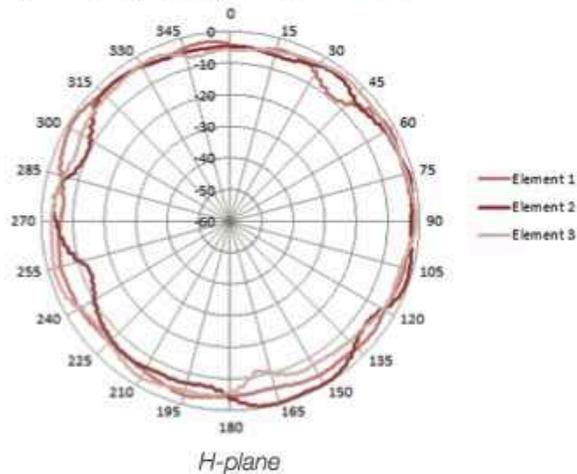
2.450 GHz, H-Plane, 20 degrees down-tilt



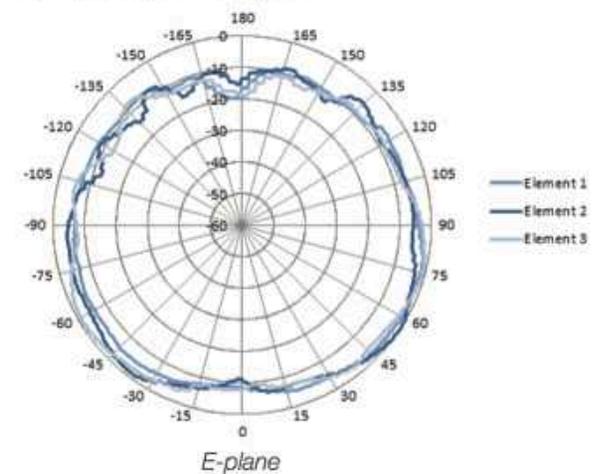
2.450 GHz, E-plane, AP facing down



5.500 GHz, H-Plane, 20 degrees down-tilt

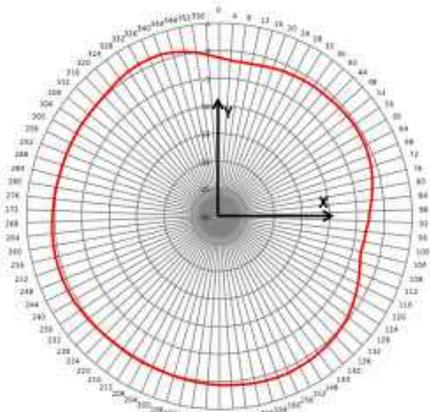
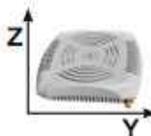
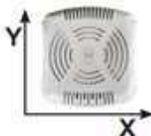


5.500 GHz, E-plane, AP facing down

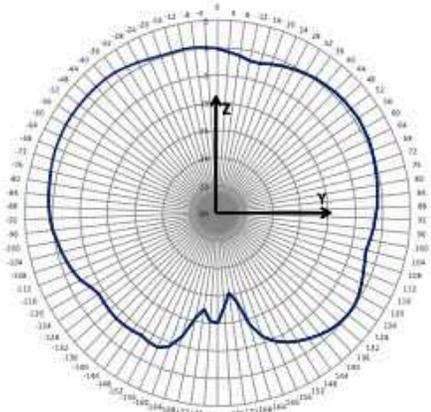


AP-93 Antenna Pattern

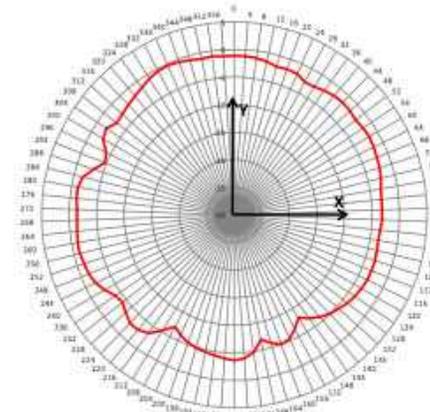
ANTENNA PLOTS



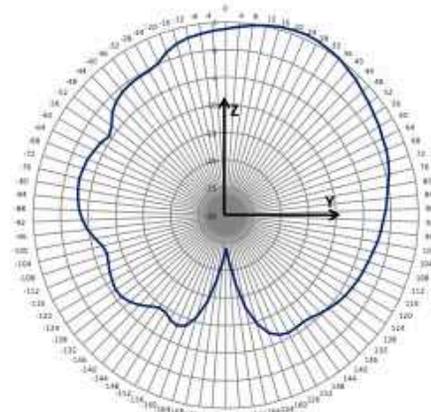
H-plane - 2.45 GHz



E-plane - 2.45 GHz



H-plane - 5.5 GHz



E-plane - 5.5 GHz



What Affects Signal Strength?

AP Radiated Power (EIRP)

= Radio Transmit Power (dBm)

+ Transmit Antenna Gain (dBi)

Antenna is **PASSIVE** – Does Not **ADD** energy
Higher Gain just means energy more focused
Not always a good thing

- AP Regulatory Domain
- Country Code - allowed channels
- Radio Band (2.4GHz/5GHz)
- Channel (different channel has different allowed Max EIRP)

What Affects Signal Strength?

- **Attenuation (Path Loss)**
 - Line-of-sight
 - Building materials (walls, windows, partitions)
 - Furniture
 - People

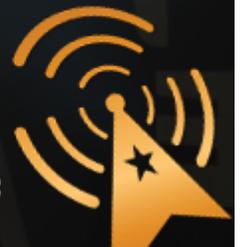
Client Received Power (dBm)

= Radiated Power/EIRP from AP (dBm)
+ Receiver Antenna Gain (dBi)
- free space path loss

Attenuation of Common Building Material

	2.4GHz	5.0GHz
Fabric, blinds, ceiling tiles	~1dB	~1.5dB
Interior drywall	3-4 dB	3-5 dB
Cubicle wall	2-5 dB	4-9 dB
Wood door (Hollow – Solid)	3-4 dB	6-7 dB
Brick/Concrete wall	6-18 dB	10-30 dB
Glass/Window (not tinted)	2-3 dB	6-8 dB
Double-pane coated glass	13 dB	20 dB
Steel/Fire exit door	13-19 dB	25-32 dB

Noise, Interference, and SNR



Noise & Interference

.... Signals are **corrupted** so they don't make sense to the receiver ...

- **Noise**

- **Random** 'background' that has got mixed up with your signal. Usually doesn't vary too much over time.

- **Interference**

- **Additional** signals are added to the one you want. Can be intermittent or persistent.

Source of Interference

802.11 Source

- Your own APs (over-designed)
- Somebody else's APs (neighbor)
- Municipal Wi-Fi Network
- iPhone Personal Hotspots
- Clients connected to other's APs
- Faulty Clients

Non 802.11 Source

- Blue-tooth (headset, keyboards, mouse, modem)
- Microwave Oven
- Cordless phones, mouse
- Very strong out-of-band source (GSM tower)
- Baby monitor
- WiMax (2.5GHz)
- ZigBee (802.15.4)
- Video or security cameras
- Faulty anything



Signal to Noise Ratio (SNR)

SNR is not actually a ratio

SNR = Signal (Received Power) – Noise floor

Assume:

Signal received is -65 dB; Noise floor is -85 dB

SNR = -65 – (-85) = 20 dB

Why SNR is Important

SNR determines the ability of wireless devices to demodulate data rates

Legacy SNR Table

Rate (Mbit/s)	1	2	5.5	11	6	9	12	18	24	36	48	54
Noise (dBm)	-85	-85	-85	-85	-85	-85	-85	-85	-85	-85	-85	-85
SNR (RSSI) (dB)	4	6	8	10	4	5	7	9	12	16	20	21
Signal Level (dBm)	-81	-79	-77	-75	-81	-80	-78	-76	-73	-69	-65	-64

SNR and 11n

802.11n data rates are dependent not only on SNR, but on error rates and the ability to support multiple spatial streams in the environment

There isn't one table to display 11n data rates like there is for legacy data rates

A rough guideline is that a minimum SNR of 30 dB or higher is necessary to demodulate higher 802.11n data rates



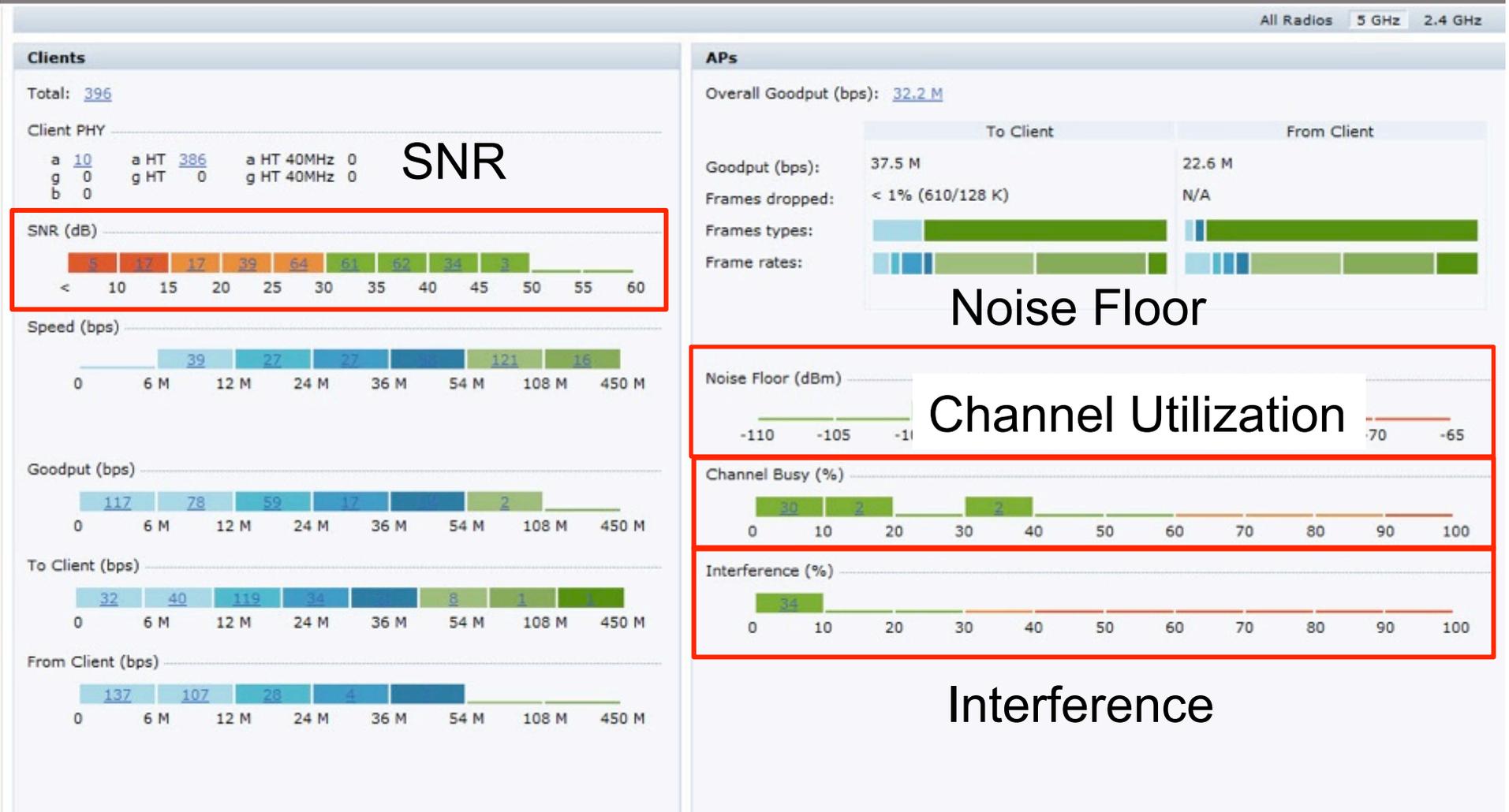
Tools of the Trade



WLAN Engineer Toolkit

- **Network Management/Monitoring Platform**
- **Spectrum Analysis**
- **Site-Survey**
- **Understanding Client NIC**
- **Performance Testing**
- **Packet Capture**
- **Command Line Interface (CLI)**

ArubaOS Dashboard - Performance



AOS RF Dashboard – Potential Issues



- Performance
- Usage
- Security
- > **Potential Issues**
- WLANs
- Access Points
- Clients

Potential Issues

Clients with potential issues: [11 out of 21](#)

Radios with potential issues: [25 out of 198](#)

	2.4 GHz	5 GHz
Low SNR	0	1
Low speed	0	1
Low goodput	5	6

	2.4 GHz	5 GHz
High noise floor	0	0
Busy channel	0	0
High interference	12	0
Low goodput	8	6
High client association	0	0



RF Health report

ARUBA networks

New Devices: 35 Up: 563 Wired: 34 Down: 191 Wired: 5

Rogue: 1 Clients: 221 Alerts: 22

Log out peter

Search

Home Groups APs/Devices Clients **Reports** System Device Setup AMP Setup RAPIDS VisualRF

Generated Definitions **Detail**

1344 RF health report for Group Ethersphere-lms3

2/26/2012 5:00 AM to 2/27/2012 5:00 AM
Generated on 2/27/2012 5:01 AM

XML (XHTML) export
CSV export
Email this report
Print report

Most Noise (5 GHz)

Rank ▲	Device	Average Noise (dBm)	Channel Changes	Average Channel Busy (%)	Number of Clients	Usage (bps)	Location
1	ITC	-87.00	14	7.87	0	0.00	-
2	72C	-87.50	11	7.87	0	0.00	-
3	140C	-88.00	15	6.69	0	0.00	-
4	24C	-89.50	18	6.69	0	0.00	-
5	167C	-89.50	12	3.54	0	0.00	-
6	1341-AP35	-89.50	0	2.36	1	0.00	-
7	41C	-90.00	181	6.30	0	0.00	-
8	AL21 (1344-1-al21.arubanetworks.com)	-90.00	37	1.18	0	0.00	-
9	175C	-90.00	20	4.33	0	0.00	-
10	1344-2-184C	-90.00	0	3.94	0	0.00	-
11	196C	-90.00	0	3.94	0	0.00	-
12	78C	-90.00	17	4.72	0	0.00	-
13	1263	-90.00	0	32.68	0	0.00	-
14	03C	-91.00	29	6.69	0	0.00	-
15	1344-2-12C	-91.50	55	5.12	1	0.00	-

Most Noise (2.4 GHz)

Rank ▲	Device	Average Noise (dBm)	Channel Changes	Average Channel Busy (%)	Number of Clients	Usage (bps)	Location
1	175C	-86.00	5	15.75	0	0.00	-
2	ITC	-87.00	7	41.73	0	0.00	-
3	196C	-89.00	0	33.46	0	0.00	-
4	140C	-90.50	1	55.91	0	0.00	-
5	1344-2-92C	-91.50	2	50.39	0	0.00	TAC
6	78C	-92.00	1	38.98	0	0.00	-
7	1344-2-12C	-91.50	55	5.12	1	0.00	-



Channel utilization trigger

Channel Utilization Trigger

Type: Channel Utilization
Severity: Normal
Duration: 5 minutes
e.g. '15 minutes', '75 seconds', '1 hr 15 mins'

Conditions

Matching conditions: All Any
Available Conditions: Interference (%), Radio Type, Time Busy (%), Time Receiving (%), Time Transmitting (%)

New Trigger Condition

Option	Condition	Value	
Time Busy (%)	>=	75	<input type="button" value="X"/>
Interference (%)	>=	30	<input type="button" value="X"/>

Trigger Restrictions

Folder: Sunnyvale HQ
Include Subfolders: Yes No
Group: - All Groups -

Alert Notifications

Additional Notification Options: Email NMS
Add NMS servers on the [AMP Setup NMS page](#)
Logged Alert Visibility: By Role
Suppress Until Acknowledged: Yes No

Client Diagnostics

ARUBA networks

New Devices: 35 | Up: 560 | Wired: 34 | Down: 194 | Wired: 5 | Rogue: 1 | Clients: 210 | Alerts: 23

Log out peter

205c

Home Groups APs/Devices **Clients** Reports System Device Setup AMP Setup RAPIDS VisualRF

Connected All Rogue Clients Guest Users Client Detail **Diagnostics** VPN Sessions VPN Users Tags

Client: ARUBANETWORKS\jturner | Network: ethersphere-wpa2 | AP: 1344-2-92C | Controller: ethersphere-lms3

Radio Info

- AP: 1344-2-92C
- AP Type: Aruba AP 135
- Last Contacted: 2/27/12 10:09 PM
- Radio: 802.11an
- Band: 5 GHz
- Channel: 165
- TX Power: 16 dBm
- Antenna:
- MAC Address: D8:C7:C8:83:A3:70
- Notes:
- Floor Plan: [Sunnyvale -> 1344 Crossman -> HQ Floor2](#)

Performance

- Clients: 1
- Noise: -93 dBm
- Total Usage: 1.59 Kbps
- Usage To Clients: 616 bps
- Usage From Clients: 976 bps
- Uptime: 100%

Trends

Clients

Channel Utilization

Usage

Noise (dBm)

Quality

Overall rating: good

Possible Issues (Network)

Indicator	Value	Ideal
Too Many Down Neighbor APs	21	0

Additional Indicators (Network)

Indicator	Value	Ideal
Channel Utilization	5.51%	≤ 60%
Noise floor	-93 dBm	≤ -90 dBm
Avg. SNR	40.02 dB	≥ 35 dB
Avg Frame errors/sec	7 frames/s	≤ 250 frames/s

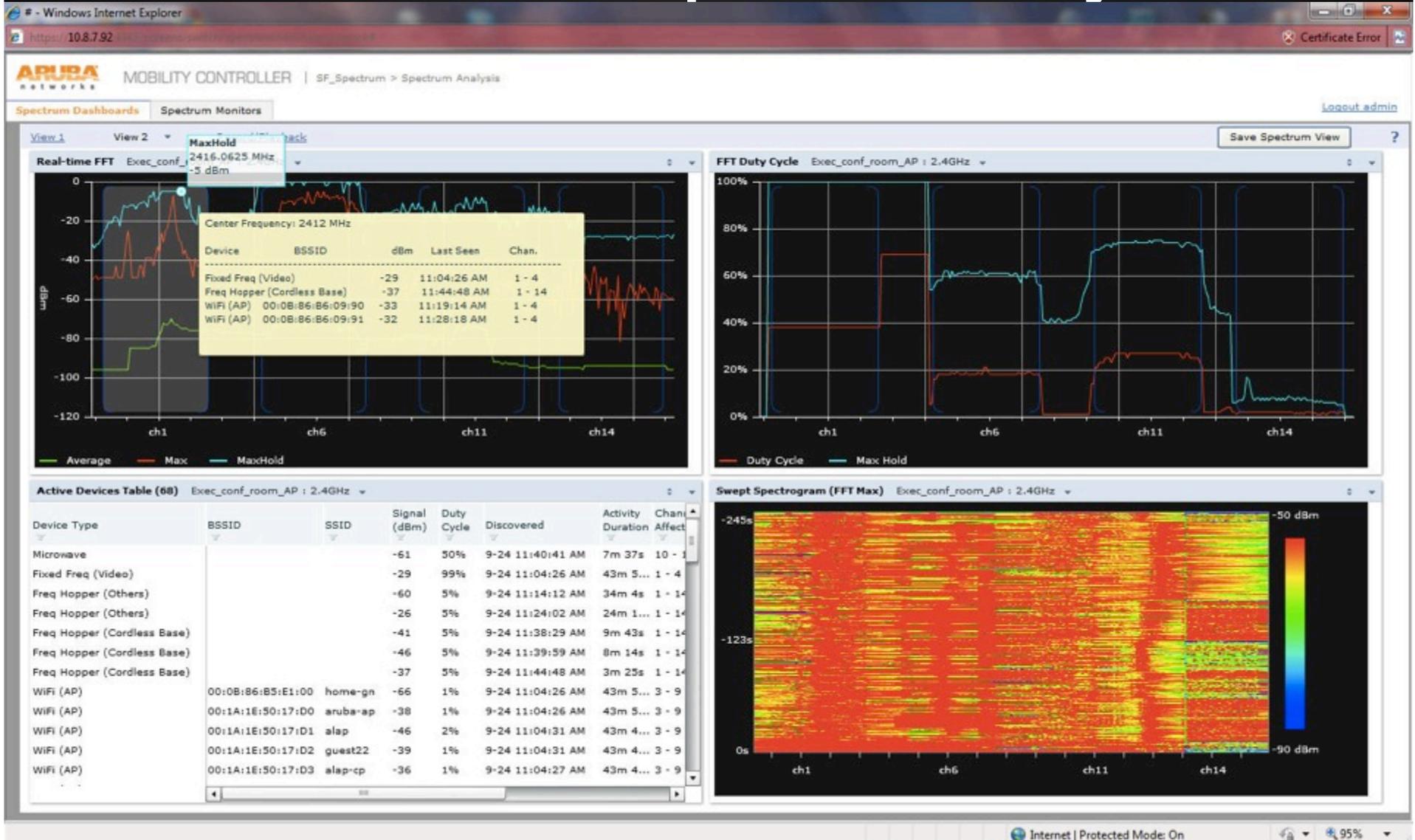
Spectrum Analysis



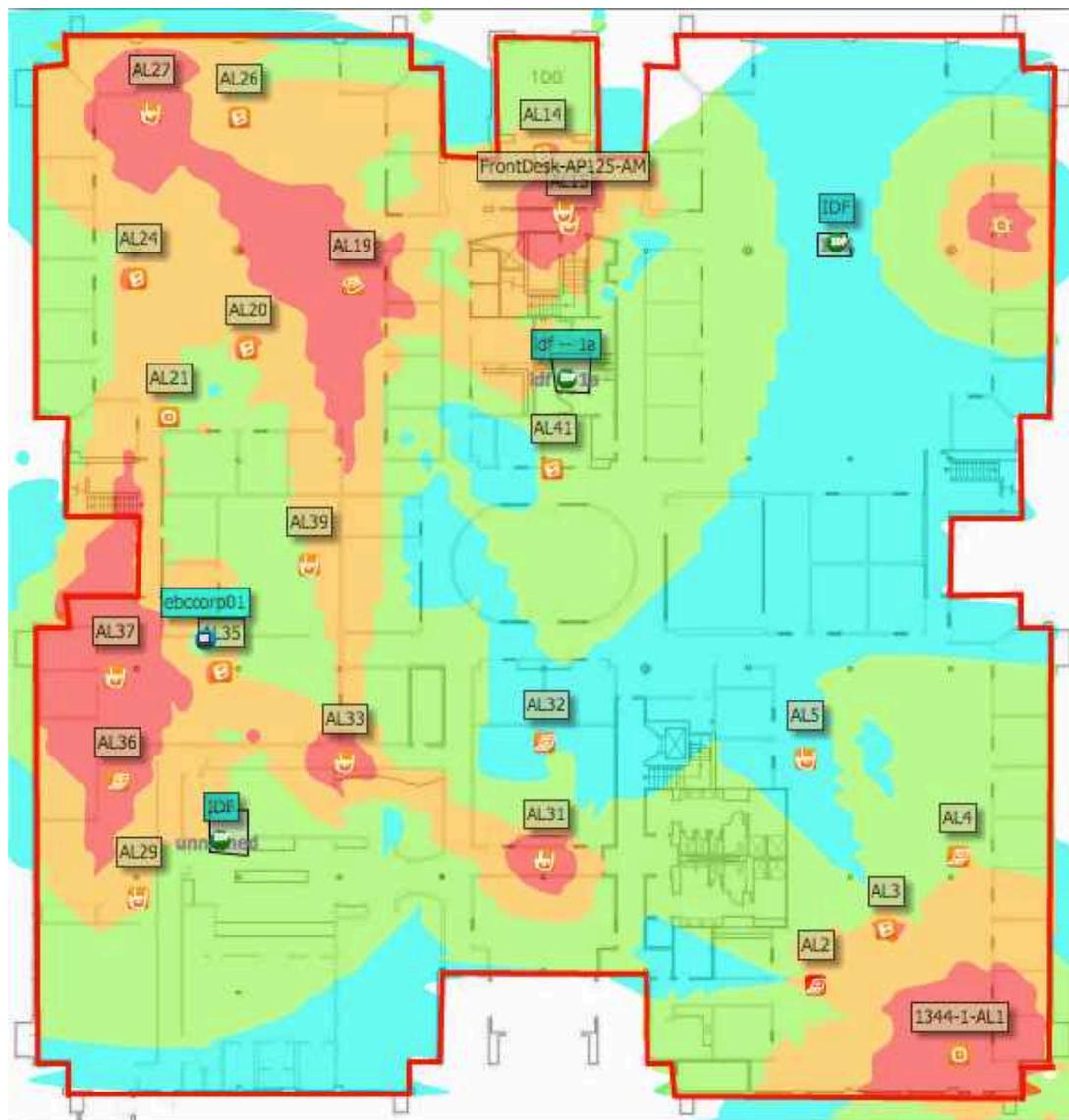
Spectrum Analysis

- **Aruba AP in Spectrum Mode**
- **Aruba AP in Hybrid Spectrum Mode**
 - AP-9x/10x/13x
 - Software configurable
- **Dedicated Spectrum Analysers**
 - Fluke Networks – AirMagnet Spectrum XT
 - Metageek – Wi-Spy
 - Others
- **Airwave VisualRF**

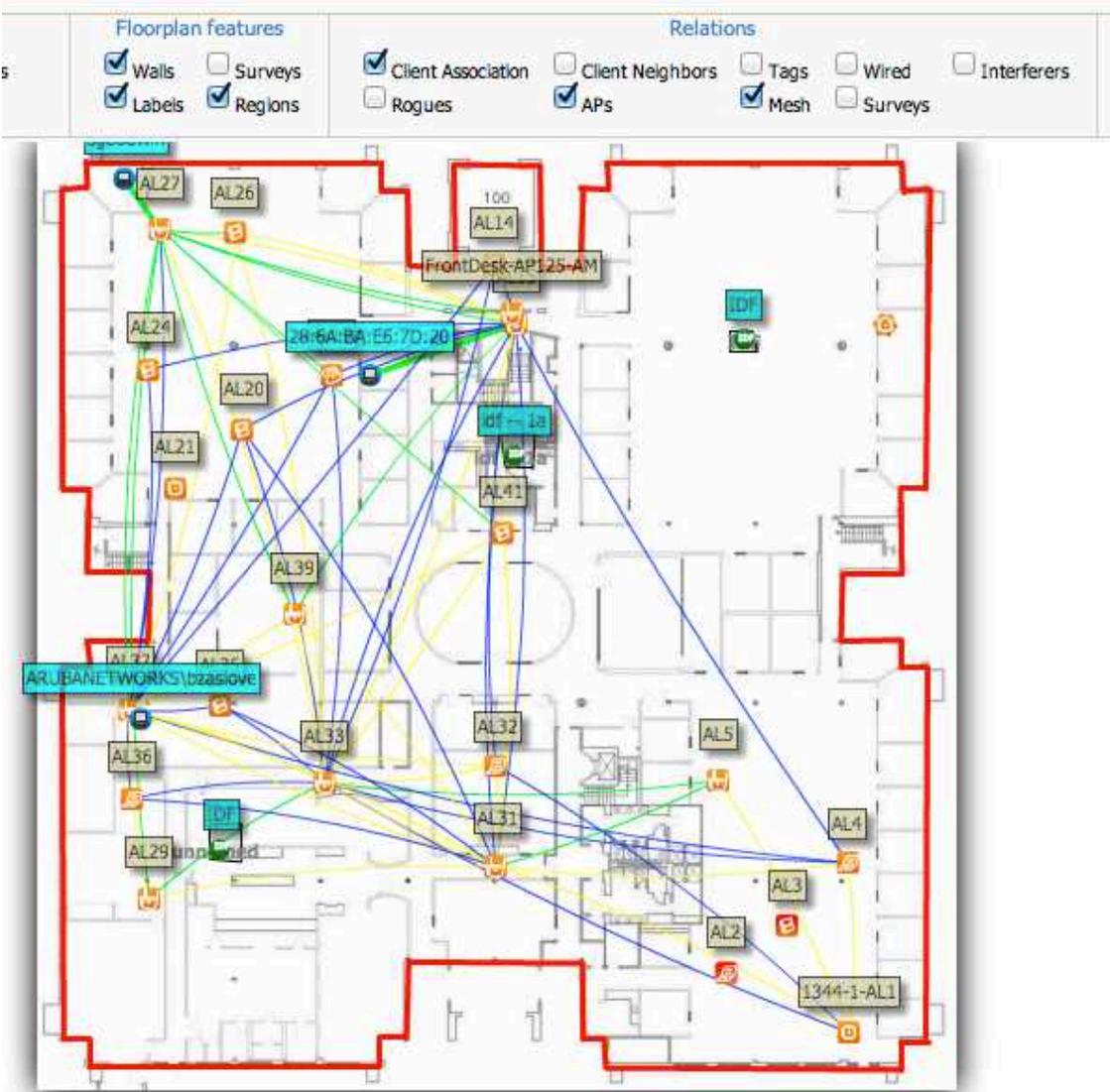
Wireless Tools – Spectrum Analysis



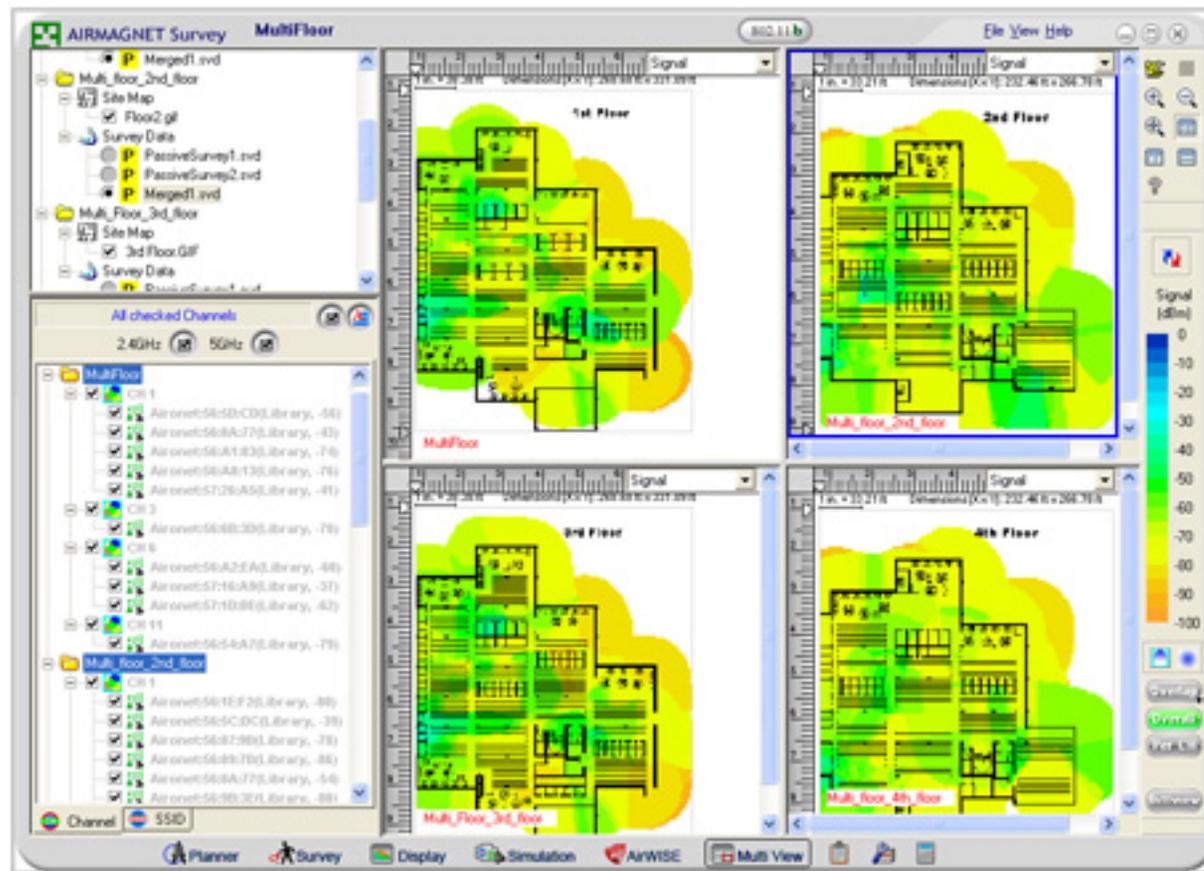
Heatmap (AirWave VisualRF)



Airwave (Client Association)

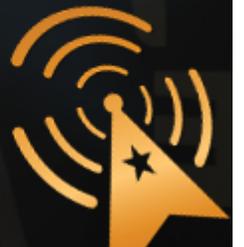


Site-Survey (AirMagnet Survey Pro)



Takes two to Tango

Understanding the client NIC



Understanding the Client NIC

- **Client devices have different characteristics and capabilities**
 - Is it 802.11a, 802.11g, b/g/n, a/b/g/n?
 - If the client supports 11n, is it one spatial stream, 2 spatial streams, or 3 spatial streams?
 - Is the wireless NIC using the latest driver?
 - Smartphones often use lower transmit power to save battery
 - SNR works in both directions—the client needs sufficient SNR to demodulate 802.11 data rates—noise close to the client can hurt performance
 - Sometimes, the client can hear the AP, but the AP cannot hear the client

Wireless NIC Connectivity

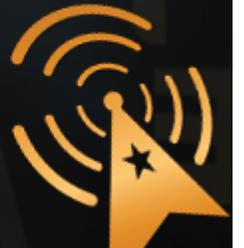
```
C:\Users\ckrispin>netsh wlan show interface
```

```
There is 1 interface on the system:
```

```
Name                : Wireless Network Connection
Description          : Intel(R) Centrino(R) Ultimate-N 6300 AGN
GUID                 : f079b84f-1fdf-47a9-8baa-6e8ab9b10b8c
Physical address     : 00:24:d7:7c:44:28
State                : connected
SSID                 : DCMI@Hilton CLublounge
BSSID                : 00:04:e2:ff:d8:78
Network type         : Infrastructure
Radio type           : 802.11g
Authentication       : Open
Cipher               : None
Connection mode      : Auto Connect
Channel              : 11
Receive rate (Mbps) : 54
Transmit rate (Mbps) : 54
Signal               : 99%
Profile              : DCMI@Hilton CLublounge

Hosted network status : Not available
```

Performance Testing



Performance Testing

When testing, it is best to do wired server (connected to LAN) to wireless client testing.

This allows testing the performance of the wireless LAN, and not depending on Internet access and limited bandwidth.

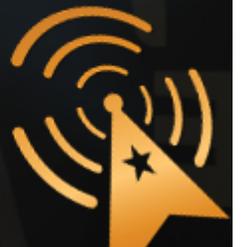
Pure performance can be measured.

Performance Testing

- **iperf/jperf**
- **ixChariot**
- **Veriwave – WaveDeploy**

- **iperf (Traffic flow is from client to server)**
 - Server (receiver)
 - `iperf -s -w 512k -i 1`
 - Client (sender)
 - `iperf -c <Server IP> -w 512k -i 1 -t 60 -P 4`

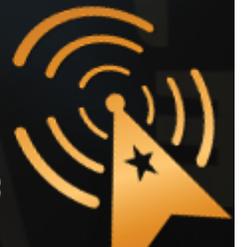
Packet Capture Tools



Packet Capture

- **Local Packet Capture**
 - Tools running on laptop (Omnipeek/Wireshark)
 - You have to be where the problem is
- **Remote Packet Capture**
 - Use Aruba AP as remote agent
 - Anywhere with network access to AP
- **Session Mirroring**
 - Sends unencrypted traffic to remote agent – good for application layer troubleshooting
 - Anywhere with network access to AP
- **Port Mirroring**

Advanced CLI Examples



Verify All Known APs are UP

- show ap active

```
(Aruba-Demo-Master3200) #  
(Aruba-Demo-Master3200) #show ap active
```

Active AP Table

Name	Group	IP Address	11g Clients	11g Ch/EIRP/MaxEIRP	11a Clients	11a Ch/EIRP/MaxEIRP	AP Type	Flags	Uptime	Outer IP
AP-28	demo	172.30.0.242	0	AP:HT:6/9/20.5	2	AP:HT:44+/20/21	125	E	29m:7s	N/A
AP-B6	demo	172.30.0.244	1	AP:HT:1/9/20.5	0	AP:HT:36+/18/21	125abg	E	23m:11s	N/A
AP-2A	demo	172.30.0.246	0	AP:HT:1/9/20.5	1	AP:HT:157+/21/21	125	E	30m:34s	N/A
Ap105A-MPP-00:24:6c:c0:01:00	AP-Group1	172.30.0.247	8	AP:HT:6/6/20.5	4	MPP:149+/6/20.5	105	M	1h:42m:4s	N/A
AP65C-MPT-00:1a:1e:c7:68:e0	AP-Group1	172.30.0.249	1	AP:11/22/22	0	MP:149/15/23	65	EM	1h:40m:15s	N/A
AP65A-MPT-00:1a:1e:c7:67:c8	AP-Group1	172.30.0.251	12	AP:6/9/22	2	MP:149/15/23	65	EM	1h:43m:42s	N/A
AP65B-MPT-00:1a:1e:c7:67:d6	AP-Group1	172.30.0.253	16	AP:1/9/22	9	MP:149/15/23	65	EM	1h:43m:42s	N/A

Flags: R = Remote AP; P = PPPoE; E = Wired AP enabled; A = Enet1 in active/standby mode;
L = Client Balancing Enabled; D = Disconn. Extra Calls On; B = Battery Boost On;
X = Maintenance Mode; d = Drop Mcast/Bcast On; N = 802.11b protection disabled;
a = Reduce ARP packets in the air; S = RFprotect Sensor; d = Disconnected Sensor
M = Mesh; U = USB modem; K = 802.11K Enabled;

Channel followed by "*" indicates channel selected due to unsupported configured channel.

Num APs:7

```
(Aruba-Demo-Master3200) #
```

Verify All Known SSIDs are Broadcasting

- **show ap bss-table ap-name <ap name>**

```
(ArubaThailand) #show ap bss-table
```

```
Aruba AP BSS Table
```

bss	ess	s/p	ip	phy	type	ch/EIRP/max-EIRP	cur-cl	ap name	in-t(s)	tot-t	mtu	acl-state
00:1a:1e:80:02:f0	Bangkok_Corp	1/1	192.168.101.253	a-HT	ap	153-/19/36	2	Bangkok_ICH_AP1	0	2h:41m:15s	1578	-
00:1a:1e:80:02:f1	Bangkok_Voice	1/1	192.168.101.253	a-HT	ap	153-/19/36	0	Bangkok_ICH_AP1	0	2h:41m:15s	1578	-
00:1a:1e:80:02:e0	Bangkok_Corp	1/1	192.168.101.253	g-HT	ap	1/19/33	0	Bangkok_ICH_AP1	0	2h:41m:15s	1578	-
00:1a:1e:80:02:e1	Bangkok_Voice	1/1	192.168.101.253	g-HT	ap	1/19/33	0	Bangkok_ICH_AP1	0	2h:41m:15s	1578	-
00:1a:1e:c0:00:2f	N/A	1/1	192.168.101.253	e	N/A	N/A	N/A	Bangkok_ICH_AP1	0	2h:41m:15s	1578	N/A

Channel followed by "*" indicates channel selected due to unsupported configured channel.

```
Num APs:5
```

```
Num Associations:2
```

```
(ArubaThailand) #
```

Check Device's 802.11 capabilities

```
(Aruba-Demo-Master3200) #show ap association client-mac 00:21:6a:51:71:ea
```

```
Flags: W: WMM client, A: Active, K: 802.11K client, B: Band Steerable
```

```
PHY Details: HT: High throughput; 20: 20MHz; 40: 40MHz  
<n>ss: <n> spatial streams
```

Association Table

Name	bssid	mac	auth	assoc	aid	l-int	ssid	vlan-id	tunnel-id	phy	assoc. time	num assoc	Flags
AP-B6	00:1a:1e:89:4b:70	00:21:6a:51:71:ea	y	y	2	10	demo	1	0x1090	a-HT-40sgi-2ss	18m:48s	1	UAB

00:21:6a:51:71:ea-00:1a:1e:89:4b:70 Stats

Parameter	Value
Channel	36
Channel Frame Retry Rate(%)	0
Channel Frame Low Speed Rate(%)	0
Channel Frame Non Unicast Rate(%)	0
Channel Frame Fragmentation Rate(%)	0
Channel Frame Error Rate(%)	0
Channel Bandwidth Rate(kbps)	1
Channel Noise	96
Client Frame Retry Rate(%)	0
Client Frame Low Speed Rate(%)	0
Client Frame Non Unicast Rate(%)	0
Client Frame Fragmentation Rate(%)	0
Client Frame Receive Error Rate(%)	0
Client Bandwidth Rate(kbps)	1
Client Tx Packets	12030
Client Rx Packets	3884
Client Tx Bytes	996873
Client Rx Bytes	4318530
Client SNR	56
Client Tx Rate	18 mbps
Client Rx Rate	6 mbps

```
(Aruba-Demo-Master3200) #
```



View Device's 802.11 Performance

- show ap debug client-table ap-name <ap name>

```
(ArubaThailand) #show ap debug client-table ap-name Bangkok_ICH_AP1
```

```
Client Table
```

MAC	ESSID	BSSID	Assoc_State	HT_State	AID	PS_State	UAPSD	Tx_Pkts	Rx_Pkts	PS_Pkts	Tx_Retries	Tx_Rate	Rx_Rate
Last_ACK_SNR	Last_RX_SNR	Tx_Chains	Tx_Timestamp	RX_Timestamp									
00:1e:c2:b4:86:90 -128	Bangkok_Corp 11	00:1a:1e:80:02:f0 3[0x7]	Associated	WM	0x1	Power-save	(0,0,0,0)	6415	19684	4	1422	13	13
00:18:de:66:09:5c 54	Bangkok_Corp 54	00:1a:1e:80:02:f0 2[0x3]	Associated	None	0x3	Power-save	(0,0,0,0)	59	5103	0	0	54	6
00:16:ea:5f:d6:d4 61	Bangkok_CorpLegacy 57	00:1a:1e:80:02:f2 2[0x3]	Associated	None	0x1	Awake	(0,0,0,0)	52	1600	0	0	54	12
00:1e:4c:c9:db:72 65	Bangkok_Corp 66	00:1a:1e:80:02:e0 2[0x5]	Associated	M	0x1	Awake	(0,0,0,0)	1292	3011	0	0	130	130
00:11:24:92:64:70 52	Bangkok_CorpLegacy 53	00:1a:1e:80:02:e2 2[0x5]	Associated	None	0x1	Awake	(0,0,0,0)	256991	82863	0	390	54	36

```
UAPSD:(VO,VI,BK,BE)
```

```
HT Flags: A - LDPC Coding; W - 40Mhz; S - Short GI; M - Max A-MSDU  
D - Delayed BA; G - Greenfield; R - Dynamic SM PS  
Q - Static SM PS; N - A-MPDU disabled
```

```
(ArubaThailand) #
```

Check 802.11 and non-802.11 Interference

```
(ArubaThailand) #show ap arm rf-summary ap-name Bangkok_ICH_API
```

Channel Summary

channel	retry	low-speed	non-unicast	frag	bwidth	phy-err	mac-err	noise	cov-idx	intf_idx
161	0	0	0	0	0	0	4	106	8/0	9/106//0/0
1	57	53	3	0	7	0	7	91	10/0	853/126//0/0
48	0	0	0	0	0	0	0	0	0/0	173/123//0/0
165	0	0	0	0	0	0	0	0	0/0	198/11//0/0
5	0	0	0	0	0	0	0	0	0/0	40/849//0/0
6	0	0	0	0	0	0	0	0	0/0	537/496//0/0
7	0	0	0	0	0	0	0	0	0/0	62/929//0/0
11	0	0	0	0	0	0	0	0	0/0	736/341//0/0
149	0	0	0	0	0	0	0	0	0/0	118/70//0/0
36	0	0	0	0	0	0	0	0	0/0	286/20//0/0
153	0	0	0	0	0	0	0	0	0/0	189/83//0/0
40	0	0	0	0	0	0	0	0	0/0	57/144//0/0
157	0	0	0	0	0	0	0	0	0/0	121/63//0/0
44	0	0	0	0	0	0	0	0	0/0	343/80//0/0

HT Channel Summary

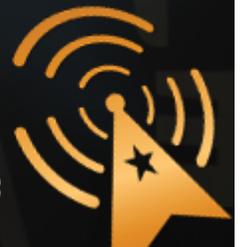
channel_pair	Pairwise_intf_index
1-5	1868
7-11	2068
149-153	460
36-40	507
157-161	299
44-48	719

```
Interface Name           :wifi0
Current ARM Assignment   :161-/21
Target Coverage Index    :10
Covered channels a/g     :0/0
Free channels a/g        :9/0
ARM Edge State           :disable
Last check channel/pwr   :21s/3m:16s
Last change channel/pwr  :1h:5m:52s/54m:57s
Next Check channel/pwr   :3m:49s/3m:3s
```

```
Interface Name           :wifi1
Current ARM Assignment   :1/30
Target Coverage Index    :10
Covered channels a/g     :0/0
Free channels a/g        :0/3
ARM Edge State           :disable
Last check channel/pwr   :2m:21s/1m:1s
Last change channel/pwr  :2m:21s/15m:14s
Next Check channel/pwr   :1m:43s/4m:15s
```



List of Advanced CLI Commands



Advanced RF Troubleshooting

- **General AP/Client**

- show ap active [ap-name] <AP name>
- show ap bss-table [ap-name] <AP name>
- show ap association [ap-name] <AP name>
- show ap association client-mac <client MAC>
- show ap debug client-table ap-name <AP name>
- show ap debug client-table ap-name <AP name> | include <client MAC>
- show ap debug client-stats <client MAC> advanced
- show ap remote debug mgmt-frames client-mac <client MAC>
- show ap remote debug mgmt-frames ap-name <AP name>

Advanced RF Troubleshooting Cont.

- **ARM**

- show ap monitor ap-list ap-name <AP name>
- show ap arm rf-summary ap-name <AP name>
- show ap arm history ap-name <AP name>
- show ap arm scan-times ap-name <AP name>
- show ap arm state ap-name <AP name>

- **RF**

- show ap debug radio-stats ap-name <AP name> radio [0 or 1] advanced

Advanced RF Troubleshooting Cont.

- **User**

- show user [IP address or client MAC]
- show user-table verbose
- show auth-tracebuf [client MAC or count]
- show datapath session table <user IP address>

- **System**

- show ap debug system-status ap-name <AP name>
- show ap tech-support ap-name <AP name>
- show ap spectrum tech-support ap-name <AP name>
- show tech-support
- tar logs tech-support



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