

How Access Point Power, Placement, Wireless Planning & Tuning Affects Client Roaming Behavior

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Agenda

- 802.11 Concepts That Impact Client Roaming and Performance
- How a Client Roams
- Controlling Co-Channel and Adjacent Channel Interference
- Other Things That Can Impact Client Roaming



802.11 Concepts That Impact Client Roaming and Performance



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802.11 Concepts That Impact Client Roaming and Performance

Wireless Networks allow one device to communicate at a time per channel

Each Wi-Fi channel is in effect a hub that is in the air

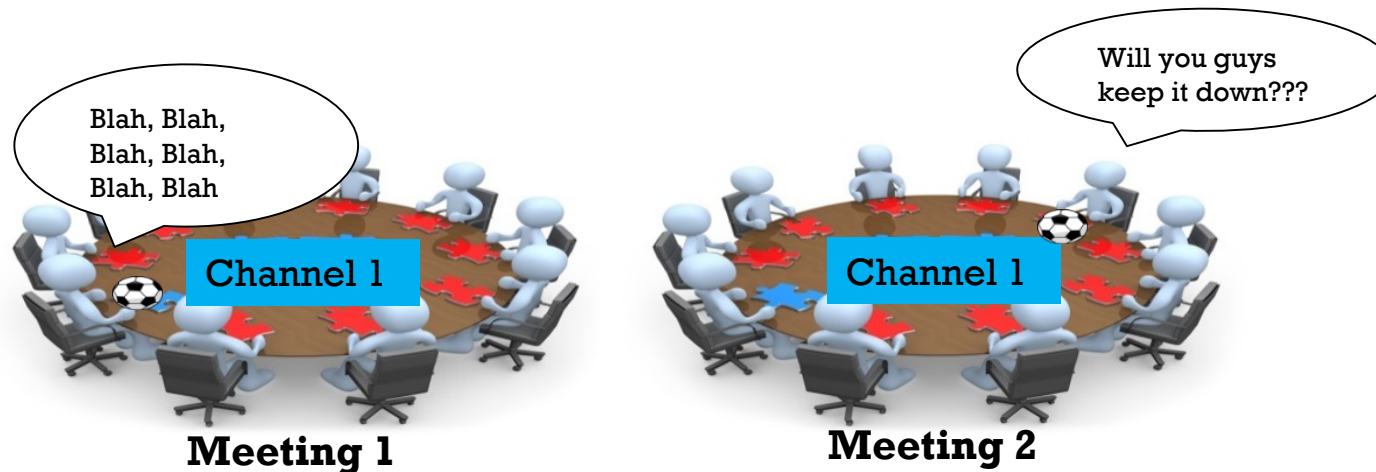
- In the analogy below, only the person with the ball can talk.
- All the others within earshot can hear him speak, **including potentially others outside of the meeting area** depending on how loud the person is speaking
- The volume that the speaker speaks with is equivalent to the wireless transmit power
- Access points can transmit at a much higher power than clients can
- A significant imbalance between the power that the access point communicates at and a client transmits at is the equivalent to having a conversation where one person shouts while the other person whispers



802.11 Concepts That Impact Client Roaming and Performance

The same channel being re-used in close proximity negates the benefit of the additional access point (same contention domain/co-channel interference)

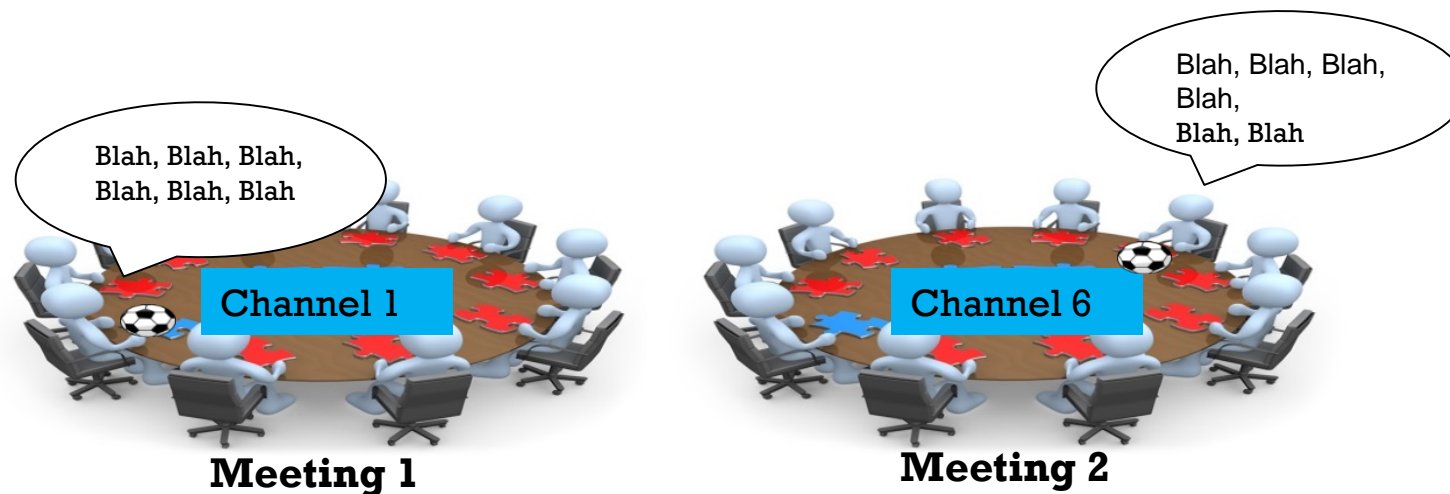
- In the analogy below, the two tables/meetings are clients associated to two different access points on the same channel and can hear each other
- This causes things to be repeated, or in the wireless world re-transmitted
- Another bad thing is that meeting 2 can't hear what exactly is being said in meeting 1 so it can't pick a good time to interrupt
- The louder the speaker's voice (transmit power) the worse this problem can be
- In other words, too many wireless access points can be as bad as too few access points



802.11 Concepts That Impact Client Roaming and Performance

The solution is to use another channel so that the communications don't overlap each other

- In the analogy below, the two tables/meetings are clients associated to two different access points but now are on different channels
- Now each can communicate within each meeting without having to worry about hearing things from the other meeting and being interrupted with noise
- Once again, only one speaker can speak at a time in each meeting but you only have to worry about competing with others in your respective meeting for “talk time”, or in the wireless world, “Airtime”

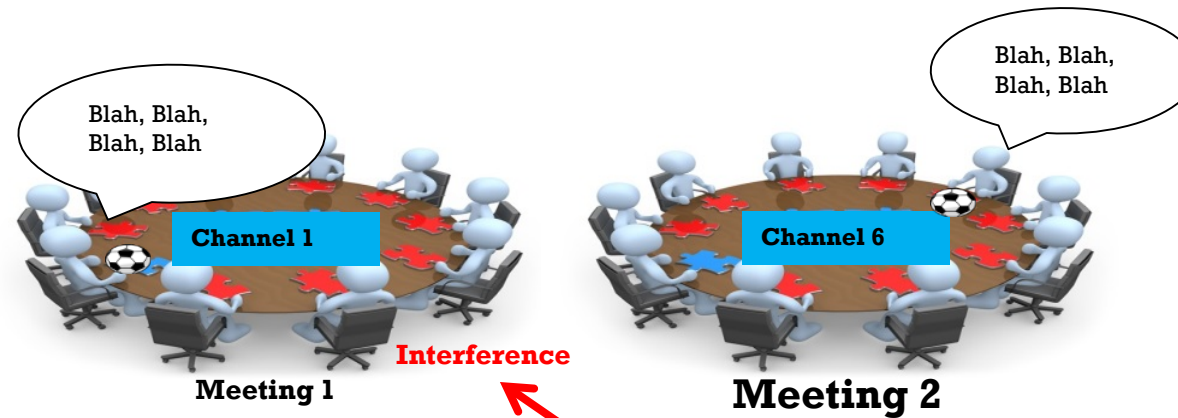


802.11 Concepts That Impact Client Roaming and Performance

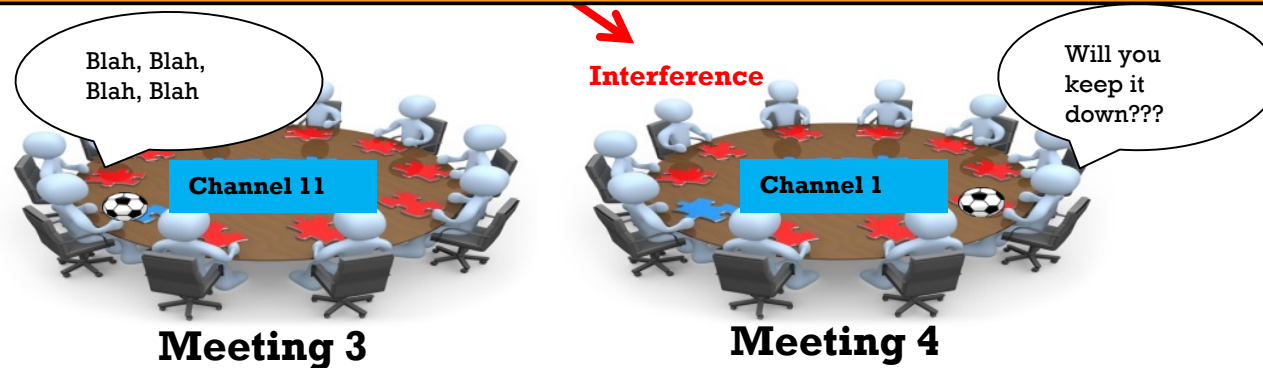
RF is 3 Dimensional

- Common sense but easy to forget
- The louder the meetings are (transmit power), the worse this gets

2nd Floor



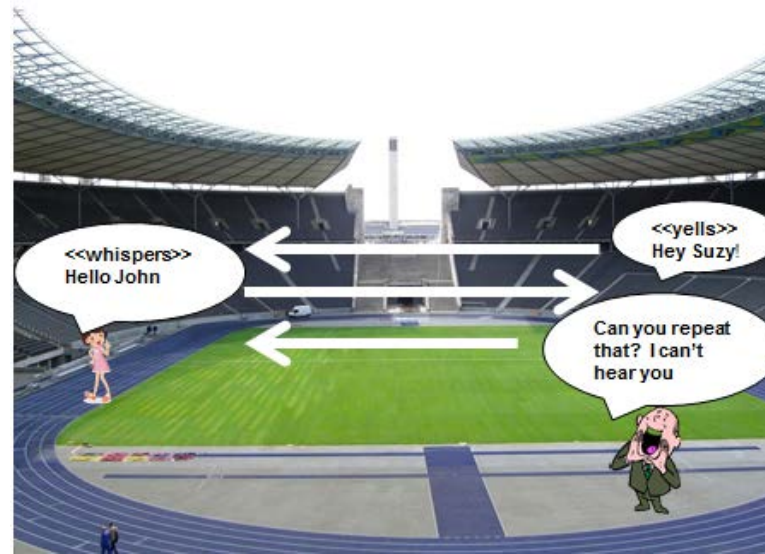
1st Floor



802.11 Concepts That Impact Client Roaming and Performance

Transmit Power

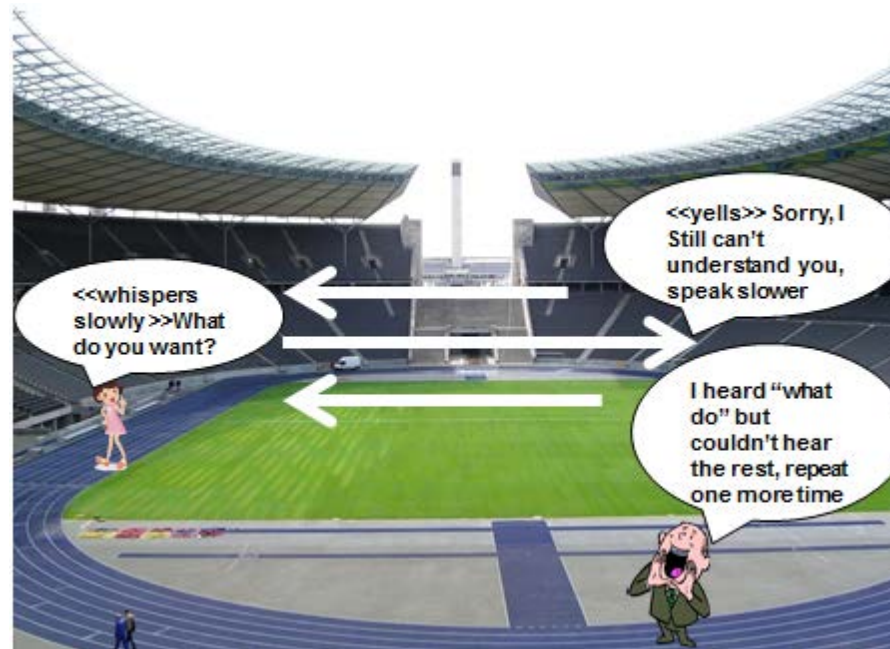
- Using high transmit power on access points doesn't create significantly increased usable coverage because of the two way nature of communications
 - Laptop Clients can only typically transmit at 30 milliwatts versus access points that can transmit at up to 200 milliwatts
 - You typically want to keep the AP to user power at no more than a 2 to 1 ratio to your highest powered client
 - Most laptops transmit around 30 milliwatts so you typically don't want your AP power higher than 60 milliwatts
 - Yes access points have better receive sensitivity but the CCI/ACI introduced by higher power negate the benefit of it



802.11 Concepts That Impact Client Roaming and Performance

- Down-rating

- If the client or access point can't successfully transmit to the other party they "down rate" and try using a slower mbps data rate. This can go down as low as 1, 2 or 5mbps which really means that the signal is all but unusable and will cause major customer satisfaction issues with the network
- Once again, bringing the power levels more in balance with each other will sustain higher data rates and make happier users



802.11 Concepts That Impact Client Roaming and Performance

Down Rating Affects Faster Users on that Channel

Each channel is hub

- Also, remember that each channel is in effect, a hub, and thus a very finite resource so having clients connected at lower data rates slows everyone down on that AP since they have to wait for those slow clients to get on and off the channel
- So the further away a client is from an AP, the lower his signal to noise ratio and thus the client's data rate
- Walls/Floors exacerbate this issue if AP's are not put in correct positions



802.11 Concepts That Impact Client Roaming and Performance

Client Transmit Power

- The smaller the device, typically the lower the transmit power and the weaker the signal is to the AP
 - Laptop – 30 milliwatts
 - Old iPad – 12 milliwatts
 - Newer iPad – 50 milliwatts
 - Android device 10-13 milliwatts
 - Vocera B3000 – 39 milliwatts
 - Motorola Handhelds – 12 to 30 milliwatts
- AP's can transmit at very high power relative to the clients
 - Over 200 milliwatts for indoor



802.11 Concepts That Impact Client Roaming and Performance

Signal to Noise Ratio Determines Downstream and Upstream Data Rates

- There are two SNR's and two data rates!!!
 - From the AP to the client
 - From the client to the AP ←Hint, this is the one that ALMOST EVERYONE forgets about!
- Remember the two way nature of communications
 - AP's usually transmit at a higher power level than the client(s)
 - The client may be transmitting at 30 milliwatts and the AP at 60 milliwatts so the signal to noise ratios will be different downstream versus upstream
 - The worse this power imbalance the worse the upstream signal to noise ratio, the lower the upstream data rate and the more susceptible the upstream is to interference
 - Therefore, the client signal to noise ratio (from client to AP) that the access point sees is almost always the limiting factor as it relates to performance
 - Signal to noise ratios below 20 are practically un-useable because of client performance expectations and this is about the point you want your devices to roam to a better AP



802.11 Concepts That Impact Client Roaming and Performance

Control Down Rating and Roaming by Trimming Data Rates

- Why Trim the Lower Rates?
 - If the client can't down rate any further, it must roam
 - Has a similar effect to lowering the power in that it effectively shrinks the cell size of each AP
 - Get the slower users off the AP to let the faster users better utilize the channel/AP
- Once the user down rates to a value lower 11 or so the connection is almost unusable so it makes sense, especially in typical office environments
- The denser the AP deployment, the more trimming the rates helps
- There are certain older devices that must see the lower data rates in order to connect
- If the customer is using newer devices then it makes sense
 - What devices need to see the low data rates for connectivity?
 - Older gaming systems
 - Older handheld scanners but this is fine since low data rates really don't affect these devices negatively since they mostly use terminal applications.
 - Old VoIP Phones
 - Certain medical devices/monitors



How a Client Roams



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Client Roaming

Clients are the ultimate decision maker of the best access point to initially connect to, as well as move to, when in motion

- Clients make connection decisions primarily based on power
and/or 802.11k channel and neighbor reports (if supported)
- They don't always make the right decision especially if the access points are not placed properly and/or access point power is too high (with the latter typically being a symptom of the former)
- When moving, a client bases its roaming decisions on probe responses
or beacons if they don't support probe requests on DFS channels



Client Roaming – Properly Designed and Tuned Network

Signal Strength

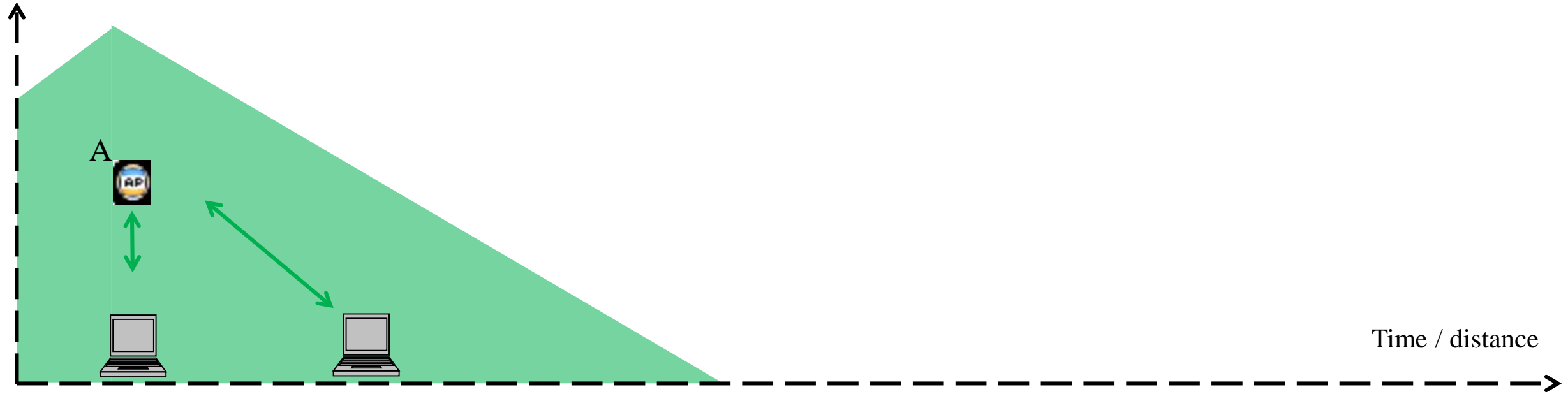


Good signal!



Client Roaming – Properly Designed and Tuned Network

Signal Strength



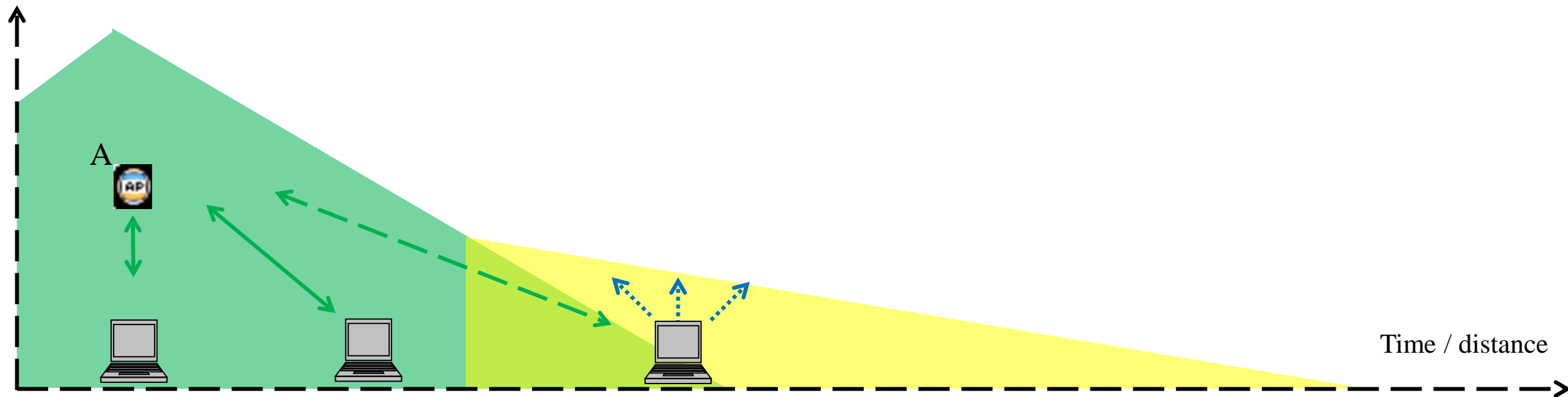
Good signal!

Device starts to move



Client Roaming – Properly Designed and Tuned Network

Signal Strength



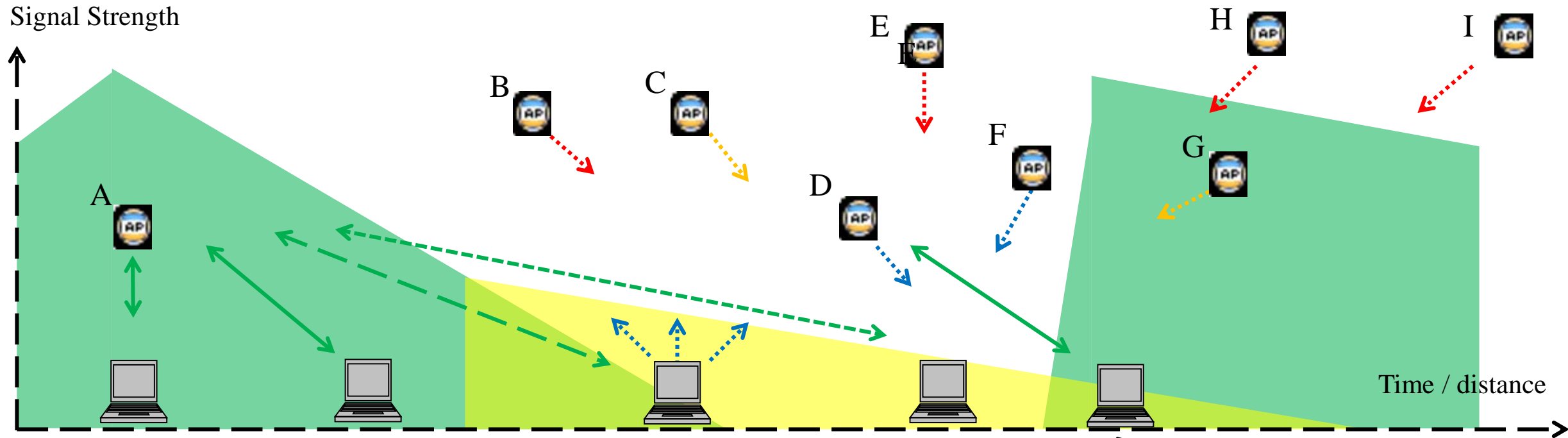
Good signal!

Probe Threshold Reached
Device Sends out Probe Requests

Device starts to move



Client Roaming – Properly Designed and Tuned Network



Good signal!

Device starts to move

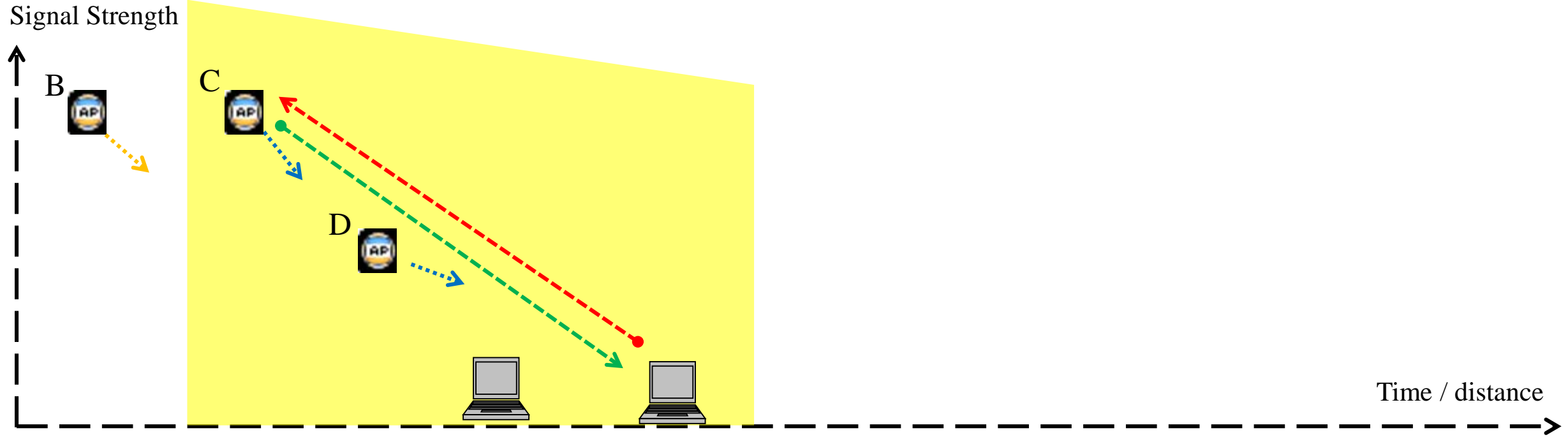
Probe Threshold Reached
Device Sends out Probe Requests

All AP's that hear >-85dBm
respond

Roaming threshold reached and device picks an AP in the table built from the probe responses based on signal strength received and/or 802.1k information (if supported)



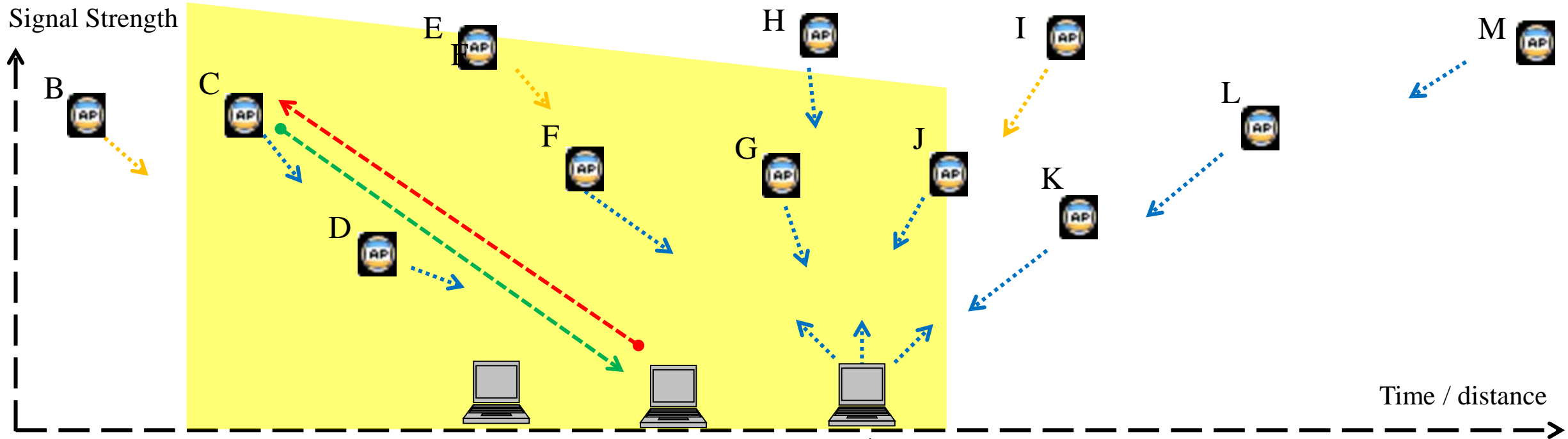
Client Roaming – AP Power Too High



Client picks far away AP versus the proper one since the received signal strengths of the probe response were within -10dB of each other. The down stream connection (green line) is okay but the up stream from the client (red line) is garbage leading to down-rating, retransmissions, errors and slowing other users down on that channel for any AP on the same channel within earshot.



Client Roaming – AP Power Too High

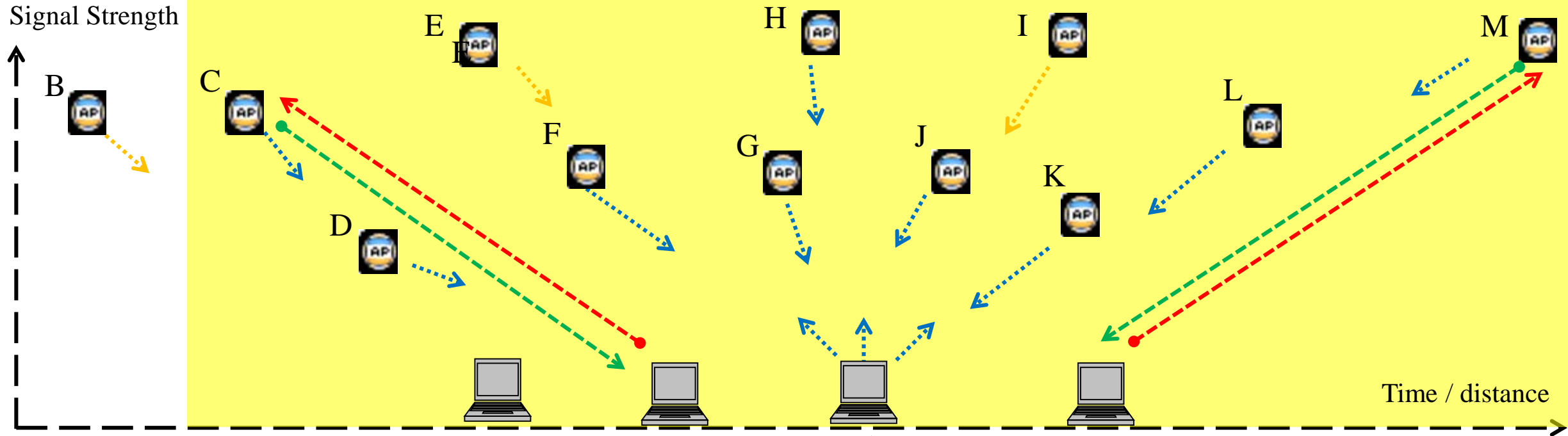


Client picks far away AP versus the proper one since the received signal strengths of the probe response were within -10dB of each other. The down stream connection (green line) is okay but the upstream from the client (red line) is garbage leading to down-rating, retransmissions, errors and slowing other users down on that channel for any AP on the same channel within earshot.

Device reaches an error threshold and starts looks for another AP to go to by probing and once again may go to a far away AP



Client Roaming – AP Power Too High



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Device reaches an **error threshold** and starts looks for another AP to go to by probing and once again may go to a far away AP



Controlling Co-Channel and Adjacent Channel Interference



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Controlling CCI and ACI

Access Point Planning and Placement

AP Placement is the single most important predictor of user satisfaction

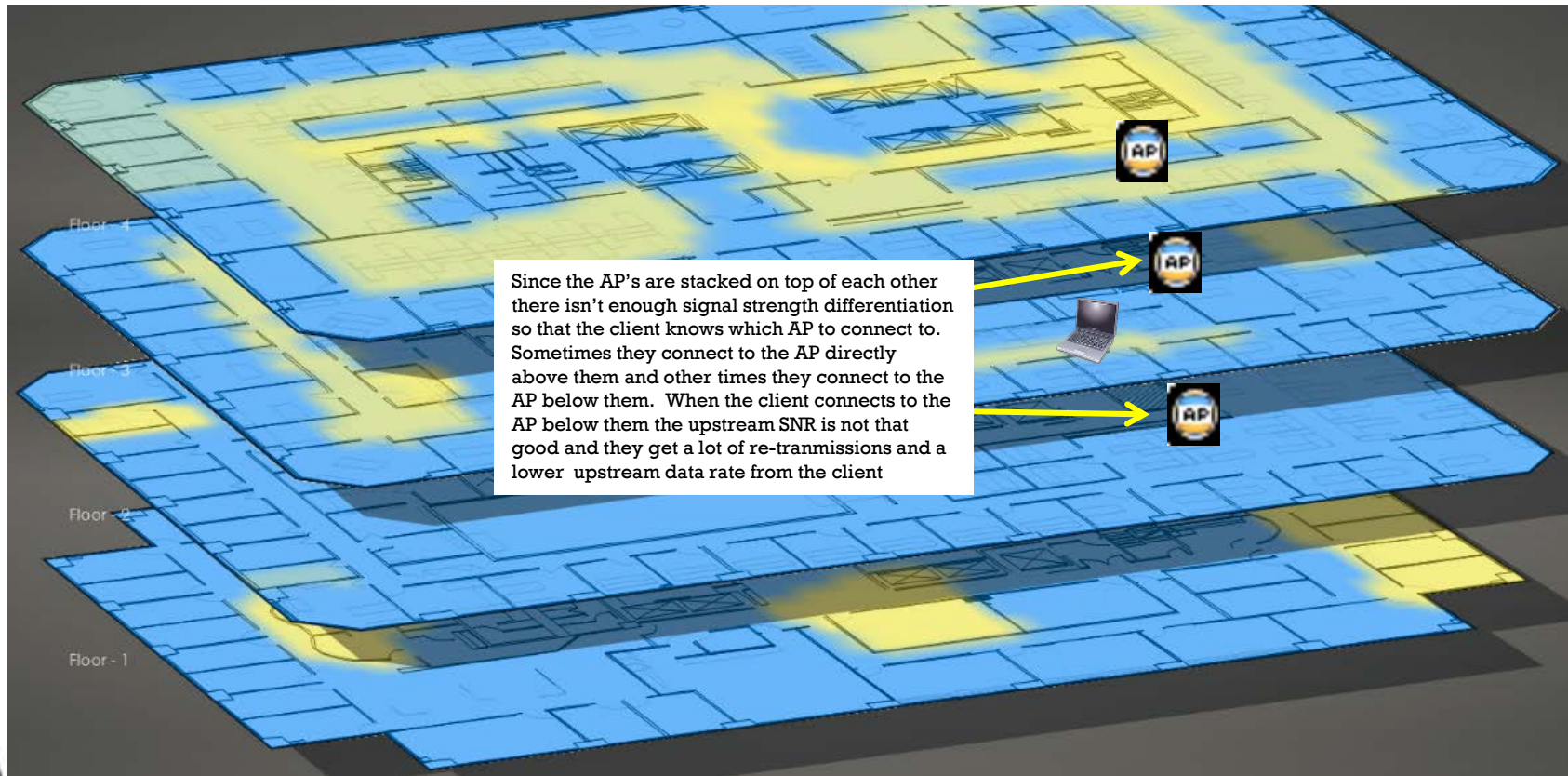
- Automatic channel and power vendor technologies are effective in most circumstances but it can't defy the laws of physics and make up for poor AP placements
- Cabling is a very large expense when deploying network devices.
- Make poor AP placement decisions and you are going to live with them for a long time.
- Too many AP's for the building/users and you are going to be locked into 20 MHz channels if you can't use the DFS channels
- Too Few AP's and you are going to create bad coverage areas
 - Automatic channel/power technologies are going to want to put the AP power too high creating roaming issues
- Badly placed AP's are almost as bad as putting too many AP's and too few AP's
 - Avoid AP's having Line of Sight to each other if you can avoid it
 - In dense deployments you can't avoid this most of the time but the fewer AP's that have LOS to each other, the better.
 - Think about the number of channels in each band and how much overlap you have in dense areas
- A few feet can make a big difference in signal quality and co-channel interference
- Don't stack AP's on top of each other floor to floor



Controlling CCI and ACI

Access Point Planning and Placement

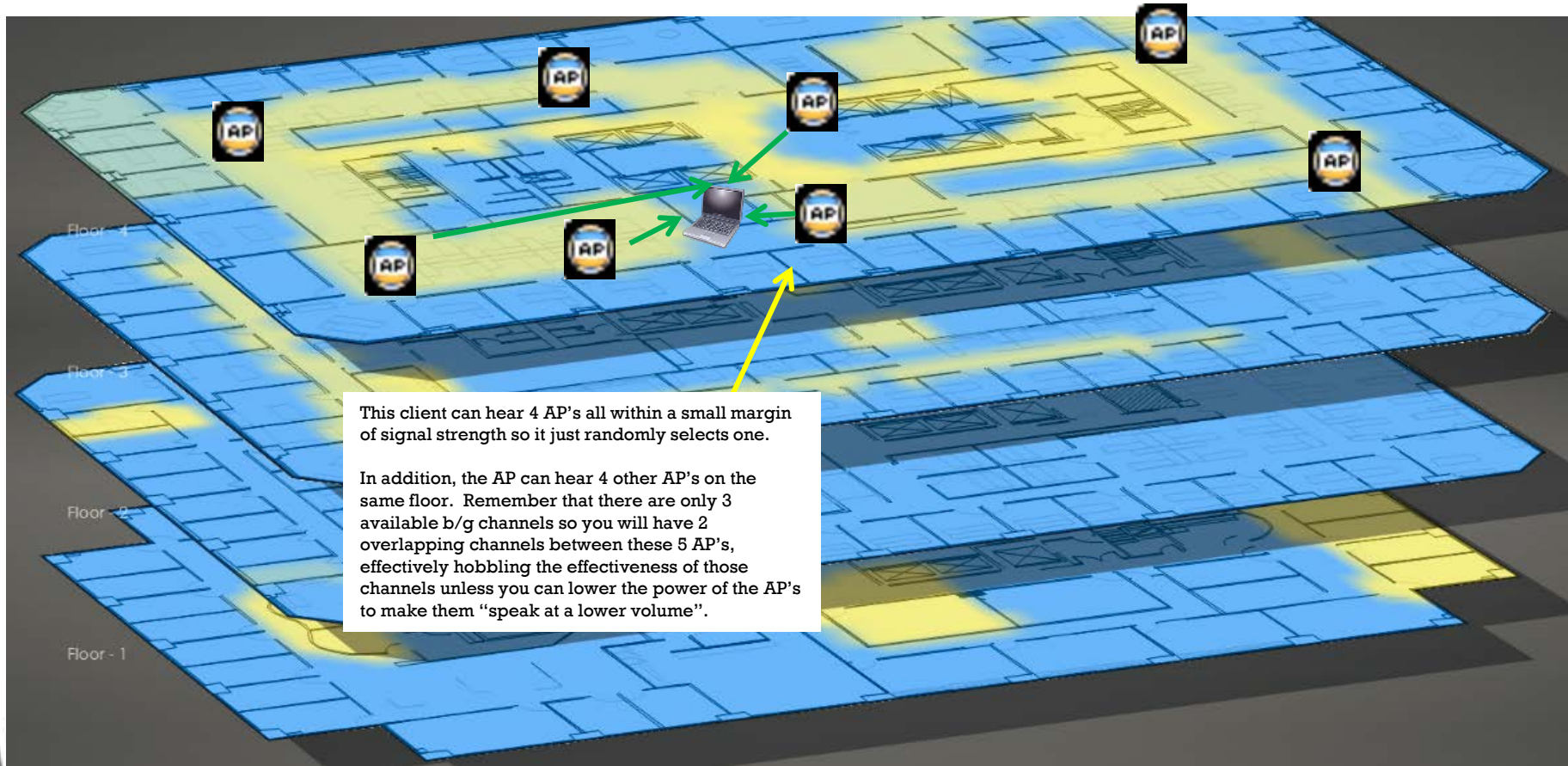
- Stacking AP's Floor to Floor Usually Causes Major Issues
 - Remember if the client sees AP power within 10-12dB of each other it will randomly select an AP to connect to and it might be the AP on the floor above or below



Controlling CCI and ACI

Access Point Planning and Placement

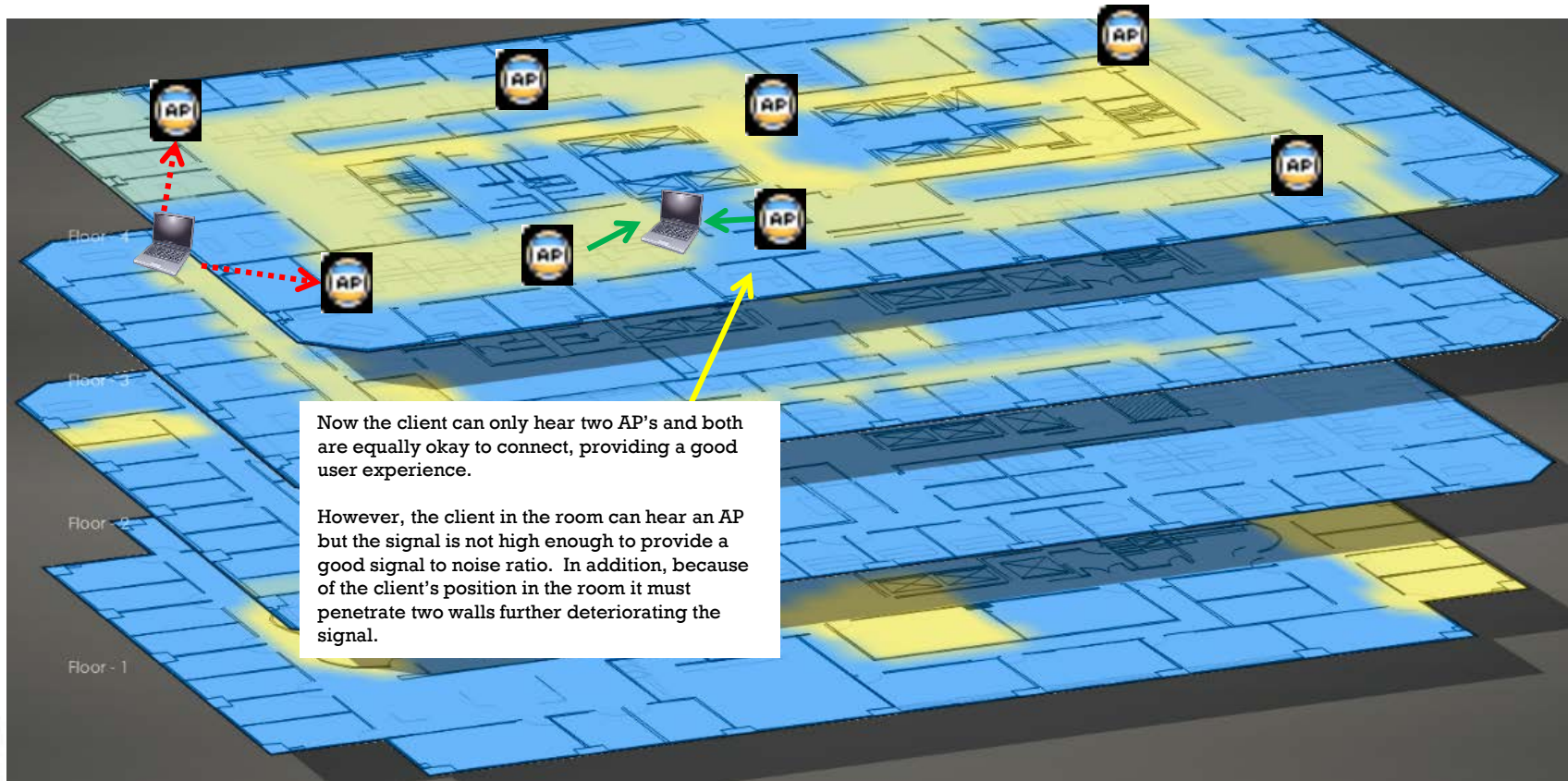
- Having a too many AP's with line of sight to each may cause issues as well
 - Remember if the client sees AP power within 10-12dB of each other is will randomly select an AP to connect to



Controlling CCI and ACI

Access Point Planning and Placement

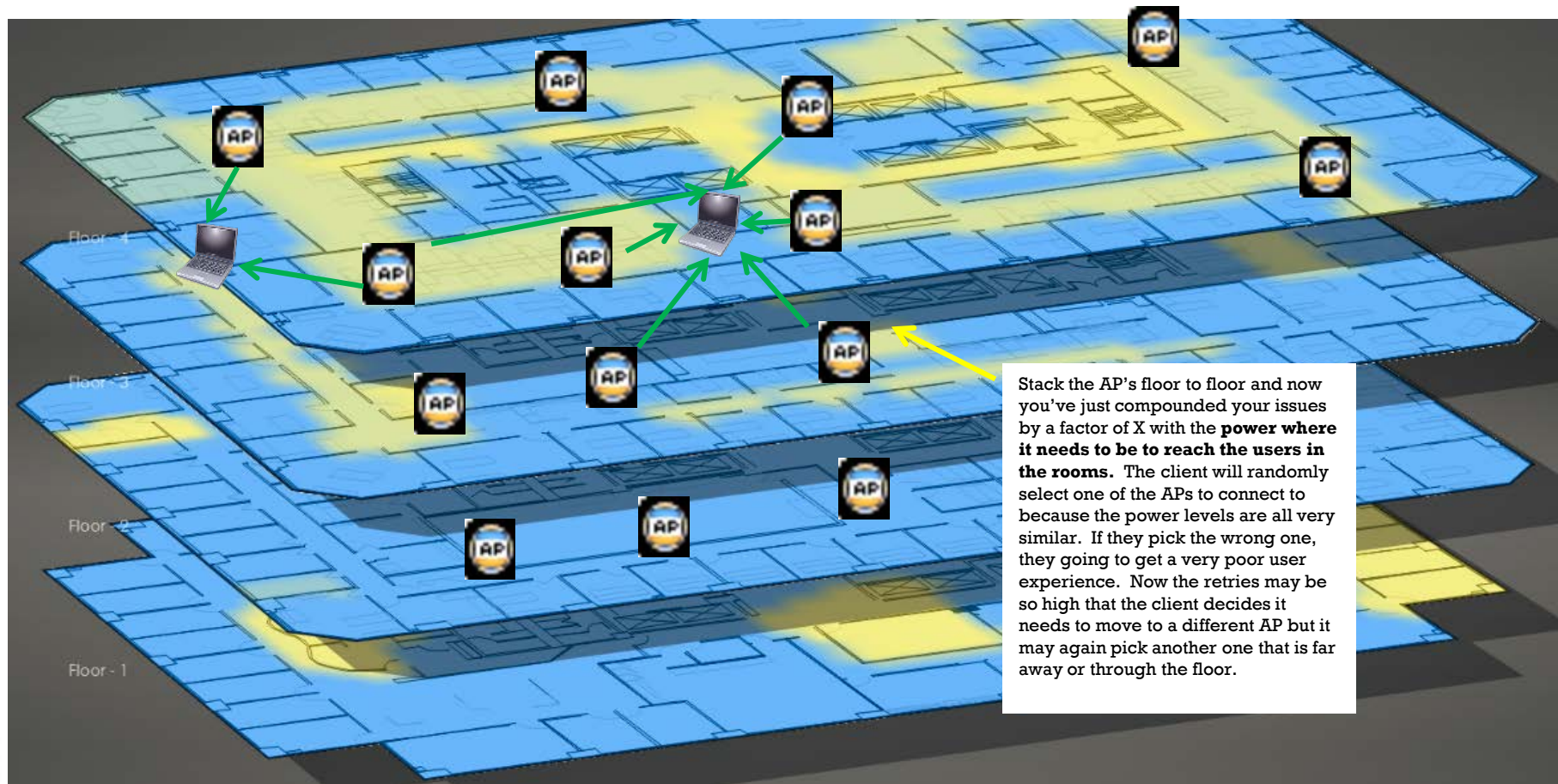
- You can't lower power too much if you only have AP's in hallways
 - Lower the power too much and it will not be enough to reach users in rooms where the signal has to go through walls
 - Raise the power enough to penetrate the walls and you have out of control co-channel interference



Controlling CCI and ACI

Access Point Planning and Placement

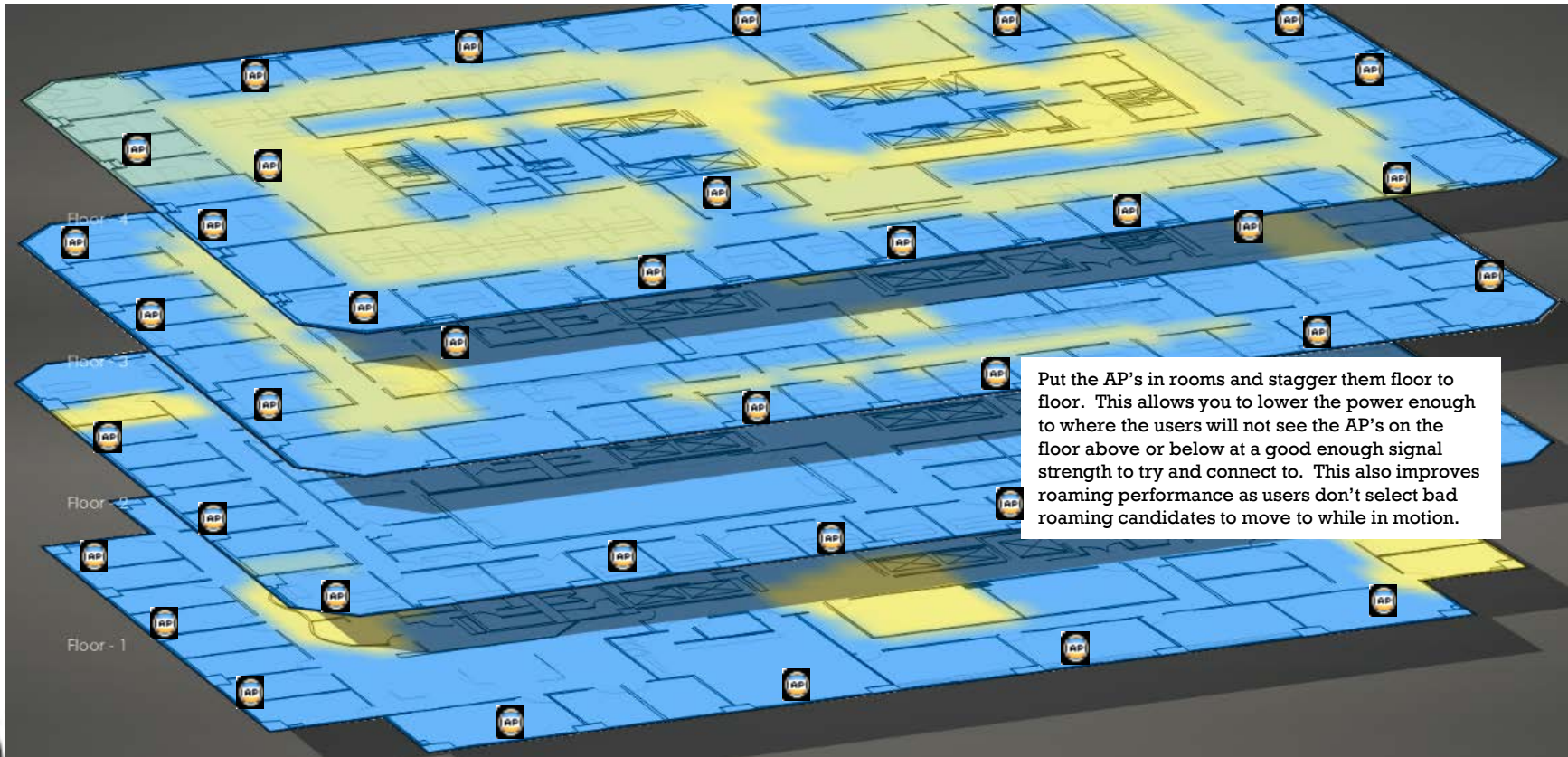
- AP's with line of sight and stacked on top of each other leads to an extremely poor
- client experience (aka, the perfect storm)



Controlling CCI and ACI

Access Point Planning and Placement

- With a proper design you can lower the AP power to a point where the clients are encouraged to connect to the correct AP
- Now the client only will see AP's that it should connect to at strong signal levels



Controlling CCI and ACI

AP Density

- How many AP's does it take to cover typical areas without taking user density into account ?
 - The higher the downtilt AP is mounted (105, 135, 225) the larger the cone of coverage
 - If mounting a true omni (no downtilt) don't mount too high
 - Warehouse (terminal applications and no VoIP)**
 - 1 AP every 7500 to 10,000 sq feet with 50% overlap so an AP every 85 to 100 feet
 - Retail (open floors, eg. Grocery Store)**
 - 1 AP every 5000 to 7500 sq feet with 50% overlap so an AP every 70-85 feet
 - Open Office Space (open floor/cubes with offices around periphery)**
 - 1 AP every 2500 to 3600 sq feet with 50% overlap so an AP 50-60 feet
 - Closed Office Space**
 - Needs to be walked, depends on construction materials
- Why is more AP density needed
 - User Density
 - Device Density/Devices per use
 - All Wireless Offices



Controlling CCI and ACI

AP Density

- What is a dense deployment?
 - The most dense deployments are an AP every 1500-1600 sq feet so the AP's are anywhere between 35-40 feet apart
 - This is extreme and you must use 20 MHz channels 5GHz channels to avoid too much CCI if you can't use the DFS channels
 - If you are deploying 802.11ac and you want to use 40 MHz or 80MHz channels you **MUST** use the DFS channels in dense deployments



Controlling CCI and ACI

Channel Width

- If you are **NOT** using DFS channels
 - 80 MHz
 - 2 channels
 - In a 2 AP deployment which really means never
 - Too much CCI if there are more than 2 APs
 - 40 MHz
 - 4 channels
 - Close office space or cubicles with outer offices ringing
 - No more than 4 AP's with line of sight between each other
 - 20 MHz
 - 9 channels (some older devices don't see channel 165)
 - Wide open office space with dense AP deployment
 - More than 4 AP's that have line of sight to each other
 - Dense cubicles
 - Device density with each user having at least 2 devices (laptop, smartphone, tablet, VoIP phone)



Controlling CCI and ACI

Channel Width

- If you **ARE** using DFS channels
 - 80 MHz
 - 5 channels but some of your devices may not support 3 of them
 - Less than 25-30 users per channel
 - High AP density to support SNR's higher than 35 (support the highest 802.11ac data rates)
 - Requires close monitoring of your user community for the first month to identify potential issues
 - Be prepared to drop back to 40 MHz channels
 - 40 MHz
 - 10 channels
 - Any deployment where 80MHz channels are problematic because of more than 4 AP's with line of sight to each other or because of client side support issues
 - 20 MHz
 - 22 channels
 - Large Public Venues



Other Things That Can Impact Client Roaming



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Other Things That Can Impact Client Roaming

- 802.1X Authentication
 - 802.1X used as part of WPA2/AES is the source of most authentication issues in wireless networks, especially with client roaming
 - Remember that there are a LOT of radius transactions that occur during initial connectivity and/or roaming between access points unless PMK caching or OKC is utilized by the client and AP.
 - **Server issues**
 - Where is the radius authentication server? What is the latency to that server?
 - Does this radius server have to do a backend authentication request to another AA repository like Active Directory? What is the latency between the radius front end and backend AA database?
 - Are there any timeouts occurring
 - **Client driver/supplicant issues**
 - Key exchanges not happening properly?
 - Other client transactions not happening properly?
 - EAP Type Mismatch?
 - Client not trusting root when using 802.1X



Other Things That Can Impact Client Roaming

- 802.1X Authentication
 - 802.1X authentication happens when
 - The user initially connects
 - **The user roams between access points**
 - Pairwise Master Key (PMK) Caching
 - Enables 4 way key exchange versus going through a full authentication
 - Is done when a user roams back to an access point that the user has been to in the last X hours
 - Doesn't always work, the key can be invalidated and often is forcing a normal full 802.1X authentication to take place!

From IEEE 802.11i section 8.4.1.2.1 - A STA (AP) can retain PMKs for APs (STAs) in the ESS to which it has previously performed a full IEEE 802.1X authentication. If a STA wishes to roam to an AP for which it has cached one or more PMKsAs, it can include one or more PMKIDs in the RSN information element of its (Re)Association Request frame. An AP whose Authenticator has retained the PMK for one or more of the PMKIDs can skip the 802.1X authentication and proceed with the 4-Way Handshake. The AP shall include the PMKID of the selected PMK in Message 1 of the 4-Way Handshake. If none of the PMKIDs of the cached PMKsAs matches any of the supplied PMKIDs, then the Authenticator shall perform another IEEE 802.1X authentication. Similarly, if the STA fails to send a PMKID, the STA and AP must perform a full IEEE 802.1X authentication."

- Opportunistic Key Caching (OKC)
 - Enabled by default in most vendors products
 - Enables 4 way key exchange versus going through a full authentication
 - Not all clients support
- Based on all this the radius server **MUST** be local or available over a very low latency link
 - Remember that there are 20+ radius transactions per user authentication if no PMK caching or OKC



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Server Issues

- Common issue when radius servers are not local (or even when they are because of overutilization)
- DO NOT forget about the backend server as well like Active Directory, where it is and how utilized it is
- Look and see if you have radius server timeouts on your wireless controller and what your average response times are

```
( [REDACTED] ) #show aaa authentication-server radius statistics
```

RADIUS Server Statistics

Server	Acct Rq	Raw Rq	PAP Rq	CHAP Rq	MSCHAP Rq	MSCHAPv2 Rq	Mismatch Rsp	Bad Auth	Acc	Rej	Acct Rsp	Chal	Ukn Rsp	Tmout	AvgRspTm	Tot Rq	Tot Rsp	Rd Err	Uptime	SEQ
[REDACTED]	0	0	119	0	0	0	0	0	0	0	0	0	0	476	0	119	0	0	1:5:58	255/255
[REDACTED]	607	10470	660	0	0	0	1353	77	1156	26	330	8688	0	6124	2129	11737	11630	0	2:17:10	255/255
[REDACTED]	125578	4424599	172924	0	0	0	10423	36	721957	11656	125405	3862539	0	35816	486	4723101	4732016	0	0:16:37	255/250

*AvgRspTm is in msec, Uptime is in d:h:m, SEQ is in Total/Free

Orphaned requests = 0

Average response times should be below 100ms and the timeouts should not be incrementing



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Almost Normal Full 802.1X Authentication

```
(XYZ Company) #show auth-tracebuf | include 38:aa:3c:12:dd:32
May 29 20:16:47 station-down * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - -
May 29 20:16:50 station-up * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - - wpa2 aes
May 29 20:16:50 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 1 5
May 29 20:16:50 eap-id-resp → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 1 26 northamericaluser-X
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 65517 214
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65517 90
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 6
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 240
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65526 466
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65526 1188
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 3 1096
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 3 6
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65535 232
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65535 1188
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 4 1096
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 4 6
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 3 232
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 3 781
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 5 693
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 5 220
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65486 446
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65486 153
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 6 69
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 6 6
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 4 232
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 4 127
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 7 43
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 7 96
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65475 322
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65475 143
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 8 59
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 8 96
May 29 20:16:50 rad-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 5 322
May 29 20:16:50 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 5 159
May 29 20:16:50 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 9 75
May 29 20:16:50 eap-req → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 9 160
```

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Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Almost Normal Full 802.1X Authentication

```
May 29 20:16:50 rad-req      → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65512 386
May 29 20:16:50 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 65512 175
May 29 20:16:50 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          10  91
May 29 20:16:53 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          10  91 ←user supplicant timed out here and server had to make another EAP-ID request
May 29 20:16:53 eap-resp     → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          10  80
May 29 20:16:53 rad-req      → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 6   306
May 29 20:16:53 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 6   191
May 29 20:16:53 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          12  107
May 29 20:16:53 eap-resp     → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          12  144
May 29 20:16:53 rad-req      → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 8   370
May 29 20:16:53 rad-accept   <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/RADIUS-2 8   356
May 29 20:16:53 eap-success  <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          12   4
May 29 20:16:53 station-data-ready * 38:aa:3c:12:dd:32 00:00:00:00:00:00          851  -
May 29 20:16:53 wpa2-key1     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          -  117
May 29 20:16:53 wpa2-key2     → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          -  135
May 29 20:16:53 wpa2-key3     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          -  151
May 29 20:16:53 wpa2-key4     → 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc          -   95
```



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Normal Full 802.1X Authentication After Roam

```
May 29 20:17:27 station-down      * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - - ← User roams here 40 seconds later
May 29 20:17:27 station-up        * 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 - - wpa2 aes
May 29 20:17:27 eap-id-req       <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 1 5
May 29 20:17:27 eap-id-req       -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 1 26 northamerica\User-X
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 17 214
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 17 90
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 2 6
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 2 240
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 19 466
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 19 1188
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 3 1096
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 3 6
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 18 232
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 18 1188
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 4 1096
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 4 6
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 23 232
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 23 1188
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 5 1096
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 5 6
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 27 232
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 27 1188
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 6 1096
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 6 6
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 28 232
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 28 132
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 7 48
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 7 220
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 26 446
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 26 153
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 8 69
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 8 6
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 1 232
May 29 20:17:27 rad-req          <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 1 127
May 29 20:17:27 eap-req         <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 9 43
May 29 20:17:27 eap-req         -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 9 96
May 29 20:17:27 rad-req          -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 31 322
```

Continued on next page



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Normal Full 802.1X Authentication After Roam

```
May 29 20:17:27 rad-req      -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 31 322
May 29 20:17:27 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 31 143
May 29 20:17:27 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      10 59
May 29 20:17:28 eap-resp     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      10 96
May 29 20:17:28 rad-req      -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 65528 322
May 29 20:17:28 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 65528 159
May 29 20:17:28 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      11 75
May 29 20:17:28 eap-resp     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      11 160
May 29 20:17:28 rad-req      -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 25 386
May 29 20:17:28 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 25 175
May 29 20:17:28 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      12 91
May 29 20:17:28 eap-resp     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      12 80
May 29 20:17:28 rad-req      -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 33 306
May 29 20:17:28 rad-resp     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 33 191
May 29 20:17:28 eap-req      <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      14 107
May 29 20:17:28 eap-resp     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      14 144
May 29 20:17:28 rad-req      -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 30 370
May 29 20:17:28 rad-accept   <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8/Radius-2 30 356
May 29 20:17:28 eap-success  <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      14 4
May 29 20:17:28 station-data-ready * 38:aa:3c:12:dd:32 00:00:00:00:00:00 851 -
May 29 20:17:28 wpa2-key1     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      - 117
May 29 20:17:28 wpa2-key2     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      - 117
May 29 20:17:28 wpa2-key3     <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      - 151
May 29 20:17:28 wpa2-key4     -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8      - 95
```

All good with this exchange and user roam



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – PMK Caching After Roaming Back to Original BSSID

```
May 29 20:18:04 station-down      * 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 - - - ← User roams here 36 seconds later
May 29 20:18:04 station-up        * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - - - wpa2 aes
May 29 20:18:04 station-data-ready * 38:aa:3c:12:dd:32 00:00:00:00:00:00 851 -
May 29 20:18:04 wpa2-key1       <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - 117
May 29 20:18:04 wpa2-key2       -> 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - 135
May 29 20:18:04 wpa2-key3       <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - 151
May 29 20:18:04 wpa2-key4       -> 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - 95
```

Note the abbreviated authentication since PMK caching has kicked in here



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

 - Viewing the 802.1X Transactions – User Supplicant Not Responding to EAP-ID Request

- May 29 20:21:17 station-down * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - - ← User roams here
- May 29 20:21:17 station-up * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - - wpa2 aes
- May 29 20:21:17 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 1 5 ← Appears that the AP no longer has the PMK cached so a full re-auth is started
- May 29 20:21:17 eap-id-req -> 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 1 26 northamerica\User-X
- May 29 20:21:17 rad-req -> 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 65425 214
- May 29 20:21:17 rad-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc/Radius-2 65425 90
- May 29 20:21:17 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 6
- May 29 20:21:21 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 6 ← Houston we have a problem...the client is not responding to the eap requests, see the next 3 requests and the timestamps.
- May 29 20:21:24 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 6
- May 29 20:21:27 eap-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 6
- May 29 20:21:30 eap-failure <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 2 4 server timeout ← Remember that these EAP messages are between the client and the server so the server decides to timeout and force the client to try again.
- May 29 20:21:30 eap-failure <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 3 4 station timeout ← The station didn't respond to the last message so it's timed out and the process starts over
- May 29 20:21:30 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 3 5
- May 29 20:21:33 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 3 5
- May 29 20:21:36 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc 4 5
- May 29 20:21:36 station-down * 38:aa:3c:12:dd:32 d8:c7:c8:96:70:bc - -
- May 29 20:21:36 station-up * 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 - - wpa2 aes
- May 29 20:21:36 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 1 5
- May 29 20:21:39 eap-id-req <- 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 1 5
- May 29 20:21:39 eap-id-req -> 38:aa:3c:12:dd:32 d8:c7:c8:96:4b:b8 1 26 northamerica\User-X ← On the next try the user responds to the second EAP ID request and then things proceed normally.

Note that this ended up to be a client driver/supplicant issue that was reported to the appropriate manufacturer



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Bad Client Driver

```
Jan 29 07:15:00 rad-resp <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 65522 140
Jan 29 07:15:00 eap-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 52 69
Jan 29 07:15:00 eap-resp -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 52 6
Jan 29 07:15:00 rad-req -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 65523 237
Jan 29 07:15:00 rad-accept <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 65523 204
Jan 29 07:15:00 eap-success <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 52 4
Jan 29 07:15:00 wpa2-key1 <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - 117
Jan 29 07:15:00 wpa2-key2 -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - 117
Jan 29 07:15:00 wpa2-key3 <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - 151
Jan 29 07:15:00 wpa2-key4 -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - 95
Jan 29 07:15:28 station-down * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - -
Jan 29 07:15:30 station-up * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - - wpa2 aes
Jan 29 07:15:30 wpa2-key1 <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - 117
Jan 29 07:15:30 wpa2-key2 -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - 135
Jan 29 07:15:30 wpa2-key3 <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - 151
Jan 29 07:15:30 wpa2-key4 -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - 95
Jan 29 07:23:53 station-down * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - -
Jan 29 07:23:53 station-up * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - - wpa2 aes
Jan 29 07:23:53 eap-id-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 1 5
Jan 29 07:23:54 eap-start -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - -
Jan 29 07:23:54 eap-id-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 1 5
Jan 29 07:23:57 eap-id-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 1 5
Jan 29 07:23:57 eap-id-resp -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 1 11 nmdq87
Jan 29 07:23:57 rad-req -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 3 211
Jan 29 07:23:57 rad-resp <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 3 77
Jan 29 07:23:57 eap-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 81 6
Jan 29 07:23:57 eap-resp -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 81 227
Jan 29 07:23:57 rad-req -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 4 458
Jan 29 07:23:57 rad-resp <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 4 1089
Jan 29 07:23:57 eap-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 82 1012
Jan 29 07:23:57 eap-resp -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 82 6
Jan 29 07:23:57 rad-req -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 5 237
Jan 29 07:23:57 rad-resp <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 5 1085
Jan 29 07:23:57 eap-req <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 83 1008
Jan 29 07:23:57 eap-resp -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 83 6
Jan 29 07:23:57 rad-req -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 6 237
Jan 29 07:23:57 rad-resp <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 6 1085
```

Continued on next page



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Bad Client Driver

```
Jan 29 07:23:57 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      84 1008
Jan 29 07:23:57 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      84 6
Jan 29 07:23:57 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 7 237
Jan 29 07:23:57 rad-resp     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 7 1085
Jan 29 07:23:57 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      85 1008
Jan 29 07:23:57 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      85 6
Jan 29 07:23:57 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 8 237
Jan 29 07:23:57 rad-resp     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 8 266
Jan 29 07:23:57 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      86 195
Jan 29 07:23:57 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      86 1310
Jan 29 07:23:57 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 9 1551
Jan 29 07:23:57 rad-resp     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 9 77
Jan 29 07:23:57 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      87 6
Jan 29 07:23:57 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      87 895
Jan 29 07:23:57 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 10 1132
Jan 29 07:23:57 rad-resp     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 10 140
Jan 29 07:23:57 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      88 69
Jan 29 07:23:57 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      88 6
Jan 29 07:23:57 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 11 237
Jan 29 07:23:57 rad-accept   <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0/Radius-2 11 204
Jan 29 07:23:57 eap-success   <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      88 4
Jan 29 07:23:57 wpa2-key1     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      - 117
Jan 29 07:23:57 wpa2-key2     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      - 117
Jan 29 07:23:57 wpa2-key3     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      - 151
Jan 29 07:23:57 wpa2-key4     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0      - 95
Jan 29 07:24:25 station-down * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:c0 - - -
Jan 29 07:24:27 station-up  * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - - - wpa2 aes
Jan 29 07:24:27 wpa2-key1     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 117
Jan 29 07:24:28 wpa2-key1     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 117
Jan 29 07:24:29 wpa2-key2     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 135
Jan 29 07:24:29 wpa2-key3     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 151
Jan 29 07:24:29 wpa2-key4     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 95
Jan 29 07:25:36 station-up  * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0 - - - wpa2 aes
Jan 29 07:25:36 eap-id-req   <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      2 5
Jan 29 07:25:37 eap-start    -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - -
Jan 29 07:25:37 eap-id-req   <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      2 5
Jan 29 07:25:37 eap-id-resp  -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      2 11 nmdq87
```

Continued on next page



Other Things That Can Impact Client Roaming

- 802.1X Authentication – Client Issues

Viewing the 802.1X Transactions – Bad Client Driver

```
Jan 29 07:25:37 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      96  6
Jan 29 07:25:38 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      96 895
Jan 29 07:25:38 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0/Radius-2 28 1132
Jan 29 07:25:38 rad-resp     <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0/Radius-2 28 140
Jan 29 07:25:38 eap-req      <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      97  69
Jan 29 07:25:38 eap-resp     -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      97  6
Jan 29 07:25:38 rad-req      -> 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0/Radius-2 29 237
Jan 29 07:25:38 rad-accept   <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0/Radius-2 29 204
Jan 29 07:25:38 eap-success  <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      97  4
Jan 29 07:25:38 wpa2-key1    <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 117
Jan 29 07:25:39 wpa2-key1    <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 117
Jan 29 07:25:41 wpa2-key1    <- 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0      - 117
Jan 29 07:25:44 station-down * 3c:a9:f4:32:da:bc 9c:1c:12:8a:75:d0
```

Ubuntu Linux Driver Issue with Intel 6300

Resolution was to disable 40 MHz channels on the client (Old Issue)



Other Things That Can Impact Client Roaming

- Client Drivers

- So you just went out and spent \$\$\$ upgrading the wireless network and you are still getting user complaints and you've checked everything!oh wait a minute, these are walkie talkies right?
- YOU MUST upgrade your wireless drivers at least every 6-12 months!!!
 - All device manufacturers have bugs and issues they fix but with device drivers you have no idea (for the most part) what gets fixed in each new driver (most release notes are very vague)
 - Without naming any names, I will bet a paycheck that all of the 802.11ac NICs that have been on the market for at least 2 years have had **at the very least** 100 bug fixes since their releaseand a lot around DFS support and roaming to DFS channels

```
C:\Users\m836784\Desktop>netsh wlan show driver
Interface name: Wireless Network Connection

Driver               : Intel(R) Centrino(R) Advanced-N 6235
Vendor               : Intel Corporation
Provider              :
Date                 : 6/3/2012
Version              : 15.2.0.19
INF File              : C:\WINDOWS\INF\Netw309.inf
Files                : C:\WINDOWS\system32\DRIVERS\Netwcn88.sys
                    C:\WINDOWS\system32\Netwcn88.dll
                    C:\WINDOWS\system32\Netwcn88.dll
                    C:\WINDOWS\system32\drivers\wvifibus.sys

Type                 : Native Wi-Fi Driver
Radio types supported : 802.11a 802.11b 802.11g 802.11n
IEEE 802.11n mode supported : Yes
Hosted network supported : Yes
Authentication and cipher supported in infrastructure mode:
Open                 None
Open                 WEP-40bit
Open                 WEP-104bit
Open                 WEP
```

Come'On MAN!!!



Other Things That Can Impact Client Roaming

- Directional Antennas!
 - Directional antennas are good in the right application but in most cases not for client roaming
 - The signal edge usually drops off very quickly which means the signal does not gradually drop off so the client hits it probe threshold
 - It usually drops off rather abruptly which means the client loses the signal and does not roam gracefully
 - In addition, you have to be cognizant of where the beam of RF energy is going
 - The signal is going to travel farther because of the focus of the pattern
 - The signal is going to bounce a lot more than it would with an Omni
 - Examples-
 - At a large airport they were using directional antennas on the jet bridges on parallel terminals and handheld devices were roaming to the other terminal 100 yards away
 - At a large theme park a design was done with 60 degree antennas at 45 degree angles on each side of large walkway and the signal bounce and the cell edges made the RF signal vary incredibly walking just a few feet
- For the most part, Omni-directional AP's are fantastic these days and there are very few deployments where directional antennas are appropriate



Key Takeaways

- AP power is everything when it comes to roaming
- Proper AP placement makes any issue fixable
- Improper AP placement puts you in a situation of “hey, that’s as good as it gets”
- Think about channel width and how that impacts airtime per channel based on the AP density you are using
- Don’t forget about the number of radius transactions that can potentially occur with each client connection/roam
- Work with your desktop group to come up with a plan to regularly update your client drivers



Thank You! Questions?

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IT Professional Wi-Fi Trek 2016

