



# CVU Wireless

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# Fra sidste CVU:

# Udfordringer med de nye APer

# Cisco Aironet 802.11ac Wave 2 Access Point Portfolio

## Industry's most comprehensive and innovative

### Enterprise Class

### Mission Critical

### Best in Class

DNA Ready | RF Excellence | CMX

Dual 5 GHz | Flexible Radio | HDX

Future Proof



#### 1810 Wall Plate

- 2x2:2SS 80 MHz; 867 Mbps
- Tx Beam Forming
- 1 GE Port uplink
- 3 GE Local Ports, including 1 PoE out
- Local ports 802.1x ready
- Integrated BLE Gateway\*

#### 1810 Teleworker

- 2x2:2SS 80 MHz; 867 Mbps
- 3 GE Local Ports downlink, including 1 PoE out
- One or Two Local Ports can be tunneled back to corporate



#### 1830

- 3x3:2SS 80MHz
- 867 Mbps Performance
- Tx Beam Forming
- 1 GE Port Uplink
- USB 2.0
- Mobility Express



#### 1850

- 4x4:3SS 80MHz
- 1.7 Gbps Performance
- Internal or External Antenna
- Tx Beam Forming
- 2 GE Ports Uplink
- USB 2.0
- Mobility Express



#### 2800

- 4x4:3SS 160 MHz
- 5 Gbps Performance
- 2.4 and 5GHz or Dual 5GHz
- 2 GE Ports Uplink
- CleanAir and ClientLink
- Internal or External Antenna
- Smart Antenna Connector
- Enhanced Location<sup>1</sup> (External Antenna)
- USB 2.0
- Mobility Express



#### 3800

- 4x4:3SS 160 MHz
- 5 Gbps Performance
- 2.4 and 5GHz or Dual 5GHz
- 2 GE Ports Uplink or 1 GE + 1 mGig (5G)
- CleanAir and ClientLink
- StadiumVision
- Internal or External Antenna
- Smart Antenna Connector
- Enhanced Location<sup>1</sup> (External Antenna)
- USB 2.0
- Mobility Express
- Investment Proof Modularity

# Det var hardwaren, hvad med Softwaren ?

- Ny hardware kræver ny software !!!!
- Do and Don'ts
  - Læs release note
  - Brug almindelige features
  - 8.2.130 eller 8.2.140 (Slut november) ikke 8.3 !!!!!

# Læs release notes:

## Features Not Supported on Cisco Aironet 1810 OEAP, 1810W, 1830, 1850, 2800, and 3800 Series APs

**Table 12 Features Not Supported on Cisco Aironet 1810 OEAP, 1810W, 1830, 1850, 2800 and 3800 Series APs**

|                      |                                                                                                                                                                                                                                                                                                          |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operational Modes    | <ul style="list-style-type: none"><li>• Spectrum Expert Connect</li><li>• Workgroup Bridge (WGB) mode as a part of Cisco Mobility Express</li><li>• Mesh mode</li><li>• Flex plus Mesh</li><li>• 802.1x supplicant for AP authentication on the wired port</li></ul>                                     |
| Protocols            | <ul style="list-style-type: none"><li>• 802.11u</li><li>• Full Cisco Compatible Extensions (CCX) support</li><li>• Rogue Location Discovery Protocol (RLDP)</li><li>• Native IPv6</li><li>• Telnet</li></ul>                                                                                             |
| Security             | <ul style="list-style-type: none"><li>• Encryption<ul style="list-style-type: none"><li>– Temporal Key Integrity Protocol (TKIP)</li></ul></li><li>• Locally Significant Certificate (LSC)</li><li>• TrustSec SXP</li><li>• Dynamic WEP</li><li>• Static WEP key for TKIP or CKIP <sup>6</sup></li></ul> |
| Quality of Service   | <ul style="list-style-type: none"><li>• Cisco Air Time Fairness (ATF)</li></ul>                                                                                                                                                                                                                          |
| Spectrum Utilization | <ul style="list-style-type: none"><li>• Wi-Fi Tag</li><li>• Aggressive Load Balancing</li></ul>                                                                                                                                                                                                          |

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Packet Forwarding    | <ul style="list-style-type: none"><li>• Split tunnels</li><li>• PPPoE</li><li>• NAT</li></ul>                                                                                                                                                                                                                                                                                                                                                                                            |
| Location Services    | <ul style="list-style-type: none"><li>• Data RSSI (Fast Locate)</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                |
| FlexConnect Features | <ul style="list-style-type: none"><li>• Per Client AAA (QoS Override)</li><li>• Bidirectional rate-limiting</li><li>• Split Tunneling</li><li>• EoGRE</li><li>• Multicast to Unicast (MC2UC)</li><li>• Traffic Specification (TSpec)<ul style="list-style-type: none"><li>– Cisco Compatible Extensions (CCX)</li><li>– Call Admission Control (CAC)</li></ul></li><li>• DHCP Option 60</li><li>• NAT/PAT support</li><li>• VSA/Realm Match Authentication</li><li>• Proxy ARP</li></ul> |

 <http://www.cisco.com/c/en/us/td/docs/wireless/controller/release/notes/crn82mr1.html#pgfld-1469357>

# Læs release notes:

## What's **New** in this Release

- Changes in Images and Installation Procedure for Cisco 2504 WLC, Cisco 5508 WLC, and Cisco WiSM2
- Access Point Provisioning Using Plug-n-Play
- Optimized Wi-Fi Connectivity and Prioritized Business Applications in Cisco and Apple Environments
- Cisco CMX Cloud Connector
- Client Troubleshooting Tool
- URL Filtering for Domains
- Default FlexConnect Group
- IPv6 Support for EoGRE Tunnels
- Mesh Off-Channel Background Scanning
- Support for NBAR2 Protocol Pack 19.1.0
- OfficeExtend Support for Wave 2 802.11ac Access Points
- Enabling RADIUS NAC on a WPA and WPA2-PSK WLAN
- Link Layer Discovery Protocol in Recovery Image
- EoGRE Enhancements
- Workgroup Bridge (WGB) Downstream Broadcast On Multiple VLANs
- Support for –M Regulatory Domain on Cisco Industrial Wireless 3700 Series APs
- Security Enhancements
- Cisco Hyperlocation Enhancements
- Cisco TrustSec Capabilities with FlexConnect
- Cisco WLC GUI Enhancements
- Important Note on Interoperability Issue Between Release 8.3 and SpectraLink Phones



<http://www.cisco.com/c/en/us/td/docs/wireless/controller/release/notes/crn82mr1.html#pgfld-1469357>

# TAC Sager kørt for danske kunder:

- Manglende TKIP Support
- AP virker ikke på 802.1x enabled port på switch
- Spectrum Expert virker ikke
- Alle disse er nævnte som manglede features i release note

# Status Januar 2017



# Status Januar 2017

- 8.2.141 har løst mange problemer
- 8.2.141 blev releaset 6 December 2016
- 8.2.150 forventes 8-9 uger efter 8.2.141 dvs. omkring midten af Feb.
- Nuværende esclation image 8.2.141.7
  - Hvis I ser fejl få oprettet TAC sager

# Udeståender

- De nye APer har ikke en 802.1x supplicant.
  - Så kan ikke anvendes på en switch port, der har 802.1x enablet.
  - Denne feature var lovet til 8.3mr1 men er rykket til en senere release
- Manglende TKIP
  - Denne feature har ikke været implementeret på anbefaling fra WiFi Alliance
    - The WIFI Alliance deprecated TKIP last year
    - [https://www.wi-fi.org/download..php?file=/sites/default/files/private/WiFi\\_Alliance\\_Technical\\_Note\\_TKIP\\_v1.0.pdf](https://www.wi-fi.org/download..php?file=/sites/default/files/private/WiFi_Alliance_Technical_Note_TKIP_v1.0.pdf)
  - 8.2.141.7 og den kommende 8.2.150 får TKIP support igen.

# Udeståender

Se release note !!!!!

<http://www.cisco.com/c/en/us/td/docs/wireless/controller/release/notes/crn82mr4.html>

# Nuværende software anbefaling (oct. 2016)

|                                           |                                                                       |                                                                                                                                                                 |
|-------------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Release 8.0<br/>(MD release train)</b> | 8.0.140.0 is latest release, next release Q1CY17 <sup>1</sup>         | <ul style="list-style-type: none"><li>• 8.0.140.0</li></ul>                                                                                                     |
| <b>Release 8.1</b>                        | No more MRs                                                           | <ul style="list-style-type: none"><li>• 8.2 release train</li></ul>                                                                                             |
| <b>Release 8.2</b>                        | 8.2.130.0 is latest release, next release planned Q4CY16 <sup>1</sup> | <ul style="list-style-type: none"><li>• Recommended for customers using 5520 or 8540 controllers or 1800, 1800-ME, 2800, or 3800 series access points</li></ul> |
| <b>Release 8.3</b>                        | 8.3.102.0 is latest release, next release planned Q4CY16 <sup>1</sup> | <ul style="list-style-type: none"><li>• For customers needing the latest feature set</li></ul>                                                                  |

# 8.3 Update

# Software anbefaling

- Brug ikke 8.3.102 sammen med 2800 / 3800 !!!!
- 8.3.110 forventes Februar 2017
- 8.3.120 forventes April 2017
  - (Dette bliver den første release TAC anbefaler)
- 8.3 forventes, at blive et langt levende MD release train

# Product Roadmap

## AireOS 8.3/8.3 MR

|                                                                                                                                 |                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <b>Insights &amp; Cloud Services</b>           | <ul style="list-style-type: none"><li>• APIC-EM PnP</li><li>• CMX Cloud Connector</li></ul>                                       |
| <b>Automation &amp; Analytics</b>              | <ul style="list-style-type: none"><li>• Flexible Radio Assignment</li><li>• <b>Apple Optimized Roaming and FastLane</b></li></ul> |
| <b>Security &amp; Compliance</b>               | <ul style="list-style-type: none"><li>• Geofence with CMX</li><li>• URL Filtering: <a href="#">http</a></li></ul>                 |
| <b>DNA Opt Platforms &amp; Virtualization</b>  | <ul style="list-style-type: none"><li>• AP1560</li><li>• ME Enhancements</li></ul>                                                |

De nævnte AireOS features er gennemgået på sidste CVU og sidste Tech Update:

[http://www.cisco.com/c/dam/global/da\\_dk/assets/training/seminaria-materials/Cisco\\_Virtual\\_Update\\_-\\_Wireless.pdf](http://www.cisco.com/c/dam/global/da_dk/assets/training/seminaria-materials/Cisco_Virtual_Update_-_Wireless.pdf)

[http://www.cisco.com/c/dam/global/da\\_dk/training-events/seminaria-materials/Cisco\\_Tech\\_Update-Wireless-30-august\\_og\\_1-september\\_2016.pdf](http://www.cisco.com/c/dam/global/da_dk/training-events/seminaria-materials/Cisco_Tech_Update-Wireless-30-august_og_1-september_2016.pdf)







## Optimizing Wi-Fi Connectivity



## Prioritizing Business Apps



## Integrating Voice and Collaboration

# Hvad er omfattet af dette samarbejde ?

- Optimized Wi-Fi connectivity
  - Always-on 802.11k og v
  - Adaptive 802.11r (Apple only)
- Fastlane
  - AutoQOS
  - QoS profiling (Apple Only)
  - Voice Upstream Trust (Apple Only)
- Collaboration
  - iPhone UC integration with Jabber



# Optimized Wi-Fi Connectivity

# *IOS Roaming*

# Associated to one AP, and not moving

- As long as you are associated, signal from the AP is good, and you are not moving, the IOS8 client will not scan.

Scan upon associating to SSID

| Time           | Info                                                     |
|----------------|----------------------------------------------------------|
| 135.050995000  | Probe Request, SN=276, FN=0, Flags=.....C, SSID=Testwifi |
| 135.072986000  | Probe Request, SN=278, FN=0, Flags=.....C, SSID=Testwifi |
| 135.095734000  | Probe Request, SN=279, FN=0, Flags=.....C, SSID=Testwifi |
| 135.117612000  | Probe Request, SN=280, FN=0, Flags=.....C, SSID=Testwifi |
| 356.792520000  | Probe Request, SN=420, FN=0, Flags=.....C, SSID=Testwifi |
| 356.814009000  | Probe Request, SN=422, FN=0, Flags=.....C, SSID=Testwifi |
| 356.837398000  | Probe Request, SN=423, FN=0, Flags=.....C, SSID=Testwifi |
| 356.858761000  | Probe Request, SN=424, FN=0, Flags=.....C, SSID=Testwifi |
| 457.928791000  | Probe Request, SN=1, FN=0, Flags=.....C, SSID=Broadcast  |
| 457.984414000  | Probe Request, SN=2, FN=0, Flags=.....C, SSID=Broadcast  |
| 458.105541000  | Probe Request, SN=3, FN=0, Flags=.....C, SSID=Testwifi   |
| 2728.872815000 | Probe Request, SN=1810, FN=0, Flags=op.P.MFT.            |

Then no scan until you move far

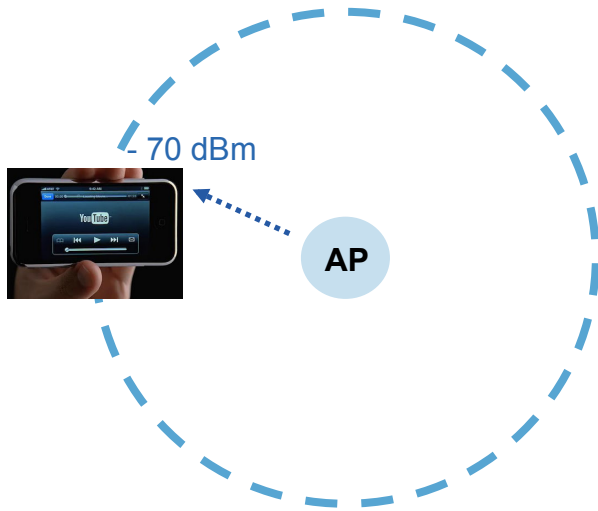


AP

# Associated to one AP, and moving

- IOS8 does not scan even if you move (no accelerometer trigger), until the AP signal falls below -70 dBm RSSI\*. At that point phone scans and tries to roam.

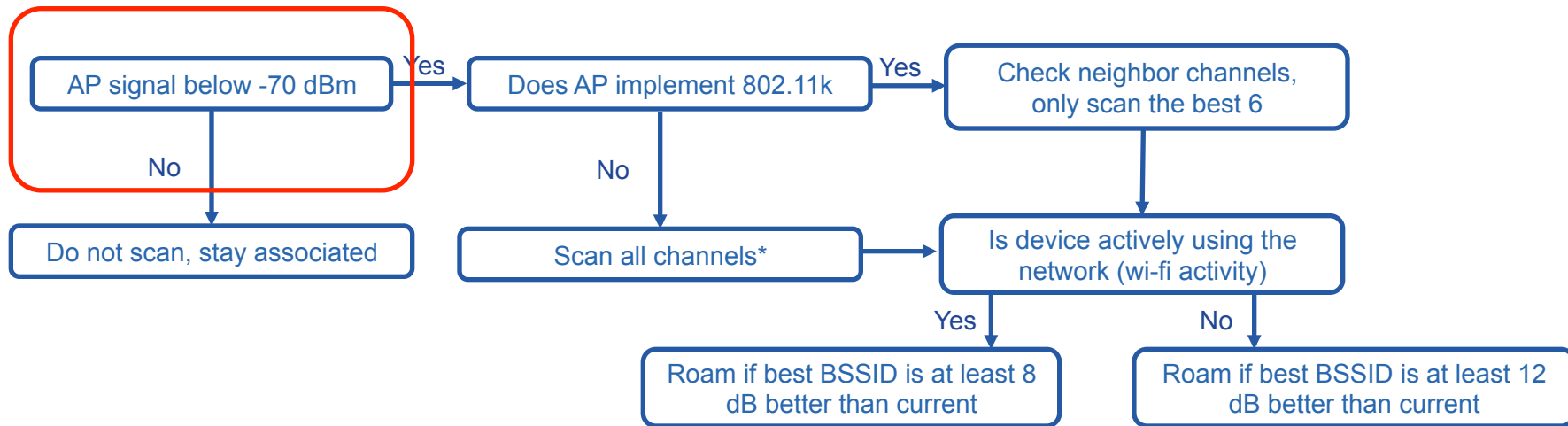
AP signal is below -70 dBm,  
I need to roam to a better AP  
-> I start scanning



\* (any packet from the AP, beacon or data is used; signal has to be received at less than -70 dBm for more than one second to trigger behavior)

# Probing and Roaming Decisions

- IOS8 scanning and roaming behavior decision tree is as follows:



\* All IOS8 tested devices scan 2.4 GHz, UNII1, UNII2, UNII3, and only scan passively once every 6 scan cycles UNII2e

# Hvad checker vi først:

| Network Name      | BSSID             | Security          | Protocol    | RSSI | Noise | Channel | Band   | Width  |
|-------------------|-------------------|-------------------|-------------|------|-------|---------|--------|--------|
| AirCard-51B6      | 84:db:2f:46:51:b6 | WPA/WPA2 Personal | 802.11b/g/n | -73  | 0     | 3       | 2.4GHz | 20 MHz |
| EnviiButik        | 54:64:d9:81:67:1a | WPA2 Personal     | 802.11ac    | -85  | 0     | 108     | 5 GHz  | 80 MHz |
| FreeWifi Fields   | 98:4b:e1:22:36:e2 | Open              | 802.11a/n   | -90  | 0     | 36      | 5 GHz  | 40 MHz |
| FreeWifi Fields   | 98:4b:e1:22:46:32 | Open              | 802.11b/g/n | -70  | -99   | 13      | 2.4GHz | 20 MHz |
| FreeWifi Fields   | 98:4b:e1:22:46:61 | Open              | 802.11a/n   | -75  | 0     | 36      | 5 GHz  | 40 MHz |
| Halas iPhone      | 2a:a0:2b:02:e7:66 | WPA2 Personal     | 802.11b/g/n | -59  | 0     | 11      | 2.4GHz | 20 MHz |
| HomeBox-14E0_2.4G | 6c:2e:85:c3:14:e6 | WPA2 Personal     | 802.11n     | -72  | -99   | 1       | 2.4GHz | 20 MHz |
| HomeBox-14E0_5G   | 6c:2e:85:c3:14:ea | WPA2 Personal     | 802.11a/n   | -79  | 0     | 132     | 5 GHz  | 40 MHz |
| HomeBox-2070_5G   | 54:64:d9:81:20:7a | WPA2 Personal     | 802.11ac    | -78  | 0     | 44      | 5 GHz  | 80 MHz |
| HomeBox-2830_5G   | 40:f2:01:a2:28:3a | WPA2 Personal     | 802.11a/n   | -86  | 0     | 112     | 5 GHz  | 40 MHz |
| HomeBox-318F      | 7c:03:4c:cb:31:95 | WPA2 Personal     | 802.11b/g/n | -59  | 0     | 6       | 2.4GHz | 20 MHz |
| HomeBox-6E80_5G   | 54:64:d9:7f:6e:8a | WPA2 Personal     | 802.11ac    | -67  | 0     | 36      | 5 GHz  | 80 MHz |
| HomeBox-A934      | 7c:03:d8:ca:a9:3a | WPA2 Personal     | 802.11b/g/n | -69  | 0     | 6       | 2.4GHz | 20 MHz |
| NETGEAR05-5G      | 80:37:73:fe:27:9c | WPA2 Personal     | 802.11ac    | -81  | 0     | 44      | 5 GHz  | 80 MHz |
| Normal Staff      | e2:55:6d:1e:9d:d1 | WPA/WPA2 Personal | 802.11ac    | -88  | 0     | 104     | 5 GHz  | 80 MHz |
| WLAN1-D195A2      | 5c:7d:5e:74:53:04 | WPA/WPA2 Personal | 802.11n     | -68  | 0     | 11      | 2.4GHz | 20 MHz |



# Hvad checker vi først:

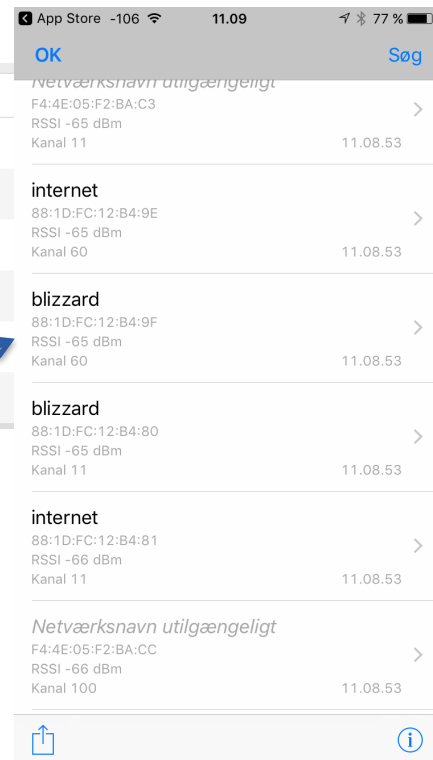
| Network Name      | BSSID             | Security          | Protocol    | RSSI | Noise | Channel | Band   | Width  |
|-------------------|-------------------|-------------------|-------------|------|-------|---------|--------|--------|
| AirCard-51B6      | 84:db:2f:46:51:b6 | WPA/WPA2 Personal | 802.11b/g/n | -73  | 0     | 3       | 2.4GHz | 20 MHz |
| EnviiButik        | 54:64:d9:81:67:1a | WPA2 Personal     | 802.11ac    | -85  | 0     | 108     | 5 GHz  | 80 MHz |
| FreeWifi Fields   | 98:4b:e1:22:36:e2 | Open              | 802.11a/n   | -90  | 0     | 36      | 5 GHz  | 40 MHz |
| FreeWifi Fields   | 98:4b:e1:22:46:32 | Open              | 802.11b/g/n | -70  | -99   | 13      | 2.4GHz | 20 MHz |
| FreeWifi Fields   | 98:4b:e1:22:46:61 | Open              | 802.11a/n   | -75  | 0     | 36      | 5 GHz  | 40 MHz |
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| HomeBox-14E0_2.4G | 6c:2e:85:c3:14:e6 | WPA2 Personal     | 802.11n     | -72  | -99   | 1       | 2.4GHz | 20 MHz |
| HomeBox-14E0_5G   | 6c:2e:85:c3:14:ea | WPA2 Personal     | 802.11a/n   | -79  | 0     | 132     | 5 GHz  | 40 MHz |
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| HomeBox-318F      | 7c:03:4c:cb:31:95 | WPA2 Personal     | 802.11b/g/n | -59  | 0     | 6       | 2.4GHz | 20 MHz |
| HomeBox-6E80_5G   | 54:64:d9:7f:6e:8a | WPA2 Personal     | 802.11ac    | -67  | 0     | 36      | 5 GHz  | 80 MHz |
| HomeBox-A934      | 7c:03:d8:ca:a9:3a | WPA2 Personal     | 802.11b/g/n | -69  | 0     | 6       | 2.4GHz | 20 MHz |
| NETGEAR05-5G      | 80:37:73:fe:27:9c | WPA2 Personal     | 802.11ac    | -81  | 0     | 44      | 5 GHz  | 80 MHz |
| Normal Staff      | e2:55:6d:1e:9d:d1 | WPA/WPA2 Personal | 802.11ac    | -88  | 0     | 104     | 5 GHz  | 80 MHz |
| WLAN1-D195A2      | 5c:7d:5e:74:53:04 | WPA/WPA2 Personal | 802.11n     | -68  | 0     | 11      | 2.4GHz | 20 MHz |



RSSI -70dBm set med MBP. Hvilket AP skal den roame til ?

# Hvad checker vi først:

| Network Name    | BSSID                    | Security               | Protocol        | RSSI       |
|-----------------|--------------------------|------------------------|-----------------|------------|
| AerohiveTEST    | 40:18:b1:cb:25:e8        | WPA2 Personal          | 802.11a/n       | -80        |
| blizzard        | 88:1d:fc:12:b4:80        | WPA2 Enterprise        | 802.11b/g/n     | -66        |
| <b>blizzard</b> | <b>88:1d:fc:12:b4:8f</b> | <b>WPA2 Enterprise</b> | <b>802.11ac</b> | <b>-62</b> |
| blizzard        | 88:1d:fc:12:b4:9f        | WPA2 Enterprise        | 802.11ac        | -59        |
| blizzard        | 88:1d:fc:12:c2:4f        | WPA2 Enterprise        | 802.11ac        | -69        |
| blizzard        | f4:4e:05:f2:ba:cf        | WPA2 Enterprise        | 802.11ac        | -72        |



MBP ser Blizzard SSIDet med -59dBm  
iPhone 7 ser Blizzard SSIDet med -65dBm



Check med det device, hvor roamingen er vigtigt

# Sticky Clients:

- En IOS Client som ser APet med et RSSI over -70dBm roamer Ikke.
- Derfor kan devicet blive “hængende” på et AP som ikke er det nærmeste.
- Typisk hvis APet kører med høj transmit Power og der er “line of sight”
- Brug RF-Profiles til at begrænse Transmit Poweren og få en mere forudsigelig roaming

# Sticky Clients:

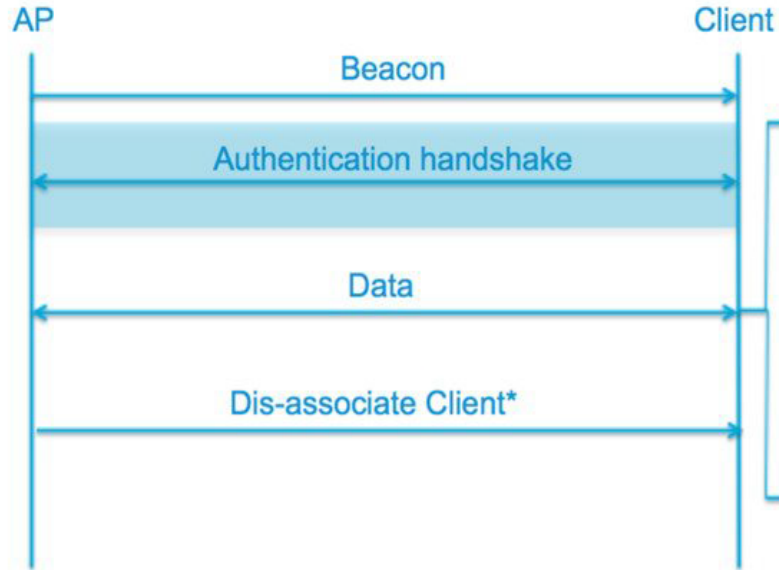
- Hvis et IOS device prøver at roame, men ikke finder et AP med et bedre signal vil det blive hængende på det AP som det er connected til.
- Måske bedre at skifte til 3G / 4G
- Features:
  - Optimized Roaming
  - Eller
  - Low RSSI Check
- **Brug kun disse features hvis I forstår hvad de gør !!!!!!!!!!!!!!!**
- **Og ikke begge på samme tid.**

# Optimized Roaming

## Optimized Roaming:

- Løser problemet med Sticky Clients ved at De-authenticate Clienter, hvis følgende kriterier er opfyldt:
- RSSI på de fra klienten modtagne pakker kommer under en given threshold og klientens datarate kommer under en given hastighed.
- Man kan disable datarate så der kun kigges på RSSI
- [http://www.cisco.com/c/en/us/td/docs/wireless/controller/8-0/configuration-guide/b\\_cg80/b\\_cg80\\_chapter\\_0101000.html](http://www.cisco.com/c/en/us/td/docs/wireless/controller/8-0/configuration-guide/b_cg80/b_cg80_chapter_0101000.html)

# Optimized Roaming



If more than X% of at least Y packets in a 5 sec period is less than Z RSSI, the AP will disassociate the client once the reporting interval expires

```
Frame 85: 40 bytes on wire (320 bits), 40 bytes captured (320
  Radiotap Header v0, Length 26
    Header revision: 0
    Header pad: 0
    Header length: 26
  Present flags
    MAC timestamp: 4738705159
  Flags: 0x10
    Data Rate: 6.0 Mb/s
    Channel frequency: 5580 (A 116)
  Channel type: 802.11a (0x0140)
  SSI Signal: -84 dBm
  SSI Noise: -94 dBm
```

Key:

X – Coverage Exception Level Percentage

Y – Number of packets

Z – Data RSSI threshold value

353196

# Optimized Roaming

The screenshot shows the Cisco Wireless configuration page. The left sidebar has a menu with 'Wireless' expanded, showing 'Access Points' and 'Advanced'. Under 'Advanced', 'Optimized Roaming' is selected. The main content area is titled 'Optimized Roaming' and has two sections: '802.11a' and '802.11b'. In the '802.11a' section, 'Optimized Roaming Mode' is checked (Enable), 'Optimized Roaming Interval' is set to 90 seconds, and 'Optimized Roaming Data Rate Threshold' is set to 18 mbps. In the '802.11b' section, 'Optimized Roaming Mode' is unchecked (Disable). A blue arrow points from the 'Optimized Roaming Mode' checkbox in the 802.11b section to the 'Optimized Roaming Data Rate Threshold' field in the 802.11a section.

**Wireless**

- Access Points
  - All APs
  - Radios
    - 802.11a/n/ac
    - 802.11b/g/n
    - Dual-Band Radios
    - Global Configuration
- Advanced
  - RF Management
  - Flexible Radio Assignment
  - Load Balancing
  - Band Select
  - Rx Sop Threshold
  - Optimized Roaming

## Optimized Roaming

### 802.11a

Optimized Roaming Mode ☒ Enable

Optimized Roaming Interval  sec

Optimized Roaming Data Rate Threshold  mbps

### 802.11b

Optimized Roaming Mode ☐ Enable

*1. CHDM configuration can be done in Wireless---> RF Profile ---> Edit 'f*

# Optimized Roaming

The screenshot shows the Cisco WLC configuration interface. The top navigation bar includes 'MONITOR', 'WLANs', 'CONTROLLER', 'WIRELESS', and 'SECURITY'. The 'WIRELESS' tab is selected. On the left, the 'Wireless' menu is expanded, showing 'Access Points' (All APs, Radios) and 'Advanced' (RF Management). The 'Radios' section is further expanded, showing '802.11a/n/ac', '802.11b/g/n', 'Dual-Band Radios', and 'Global Configuration'. The main content area is titled '802.11a > RRM > Coverage'. Under the 'General' section, 'Enable Coverage Hole Detection' is checked. Under the 'Coverage Threshold' section, 'Data RSSI (-60 to -90 dBm)' is set to '-80'.

**CISCO** MONITOR WLANs CONTROLLER **WIRELESS** SECURITY

**Wireless**

- ▼ **Access Points**
  - All APs
  - ▼ Radios
    - 802.11a/n/ac
    - 802.11b/g/n
    - Dual-Band Radios
    - Global Configuration
- ▼ **Advanced**
  - ▼ RF Management

**802.11a > RRM > Coverage**

**General**

Enable Coverage Hole Detection ☒

**Coverage Threshold**

Data RSSI (-60 to -90 dBm)

RSSI Værdi der checkes imod



# Optimized Roaming

- Optimized roaming checker også indkommend ass- requests mod Data RSSI. Hvis det indkommende signal ikke er min 6db bedre end det konfigurerede RSSI kommer klienten ikke på !!!!!

| Filter: <b>!:(11:ac)    (wlan.bssid==c0:25:5c:23:37:7f)</b> Expression... Clear Apply Save |      |                  |                |          |        |                                                                          |
|--------------------------------------------------------------------------------------------|------|------------------|----------------|----------|--------|--------------------------------------------------------------------------|
| No.                                                                                        | Time | Source           | Destination    | Protocol | Length | Info                                                                     |
| 38 22.595635                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3966, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 39 23.622710                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3967, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 40 24.419281                                                                               |      | Cisco_23:37:7f   | Apple_a4:11:ac | 802.11   | 296    | Probe Response, SN=454, FN=0, Flags=...R...C, BI=1003, SSID=sb-wifi-test |
| 41 24.434882                                                                               |      | Apple_a4:11:ac   | Cisco_23:37:7f | 802.11   | 107    | Authentication, SN=370, FN=0, Flags=.....C                               |
| 42 24.435161                                                                               |      | Cisco_23:37:7f   | Apple_a4:11:ac | 802.11   | 96     | Authentication, SN=3968, FN=0, Flags=.....C                              |
| 43 24.435523                                                                               |      | Apple_a4:11:ac   | Cisco_23:37:7f | 802.11   | 206    | Association Request, SN=371, FN=0, Flags=.....C, SSID=sb-wifi-test       |
| 44 24.436931                                                                               |      | Cisco_23:37:7f   | Apple_a4:11:ac | 802.11   | 102    | Association Response, SN=3969, FN=0, Flags=.....C                        |
| 45 24.649791                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3970, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 46 25.676895                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3971, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 47 26.703909                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3972, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 48 26.713513                                                                               |      | Cisco_23:37:7f   | Cisco_58:75:d9 | 802.11   | 296    | Probe Response, SN=455, FN=0, Flags=...R...C, BI=1003, SSID=sb-wifi-test |
| 49 26.714107                                                                               |      | Cisco_23:37:7f   | Cisco_58:75:d9 | 802.11   | 296    | Probe Response, SN=455, FN=0, Flags=...R...C, BI=1003, SSID=sb-wifi-test |
| 50 26.714458                                                                               |      | Cisco_23:37:7f   | Cisco_58:75:d9 | 802.11   | 296    | Probe Response, SN=455, FN=0, Flags=...R...C, BI=1003, SSID=sb-wifi-test |
| 51 27.731039                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3973, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 52 28.673648                                                                               |      | Buffalo_f2:aa:13 | Cisco_23:37:7f | 802.11   | 100    | Null function (No data), SN=103, FN=0, Flags=.....TC                     |
| 53 28.758100                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3974, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |
| 54 29.785187                                                                               |      | Cisco_23:37:7f   | Broadcast      | 802.11   | 302    | Beacon frame, SN=3975, FN=0, Flags=.....C, BI=1003, SSID=sb-wifi-test    |

▶ Frame 44: 102 bytes on wire (816 bits), 102 bytes captured (816 bits)

▶ Ethernet II, Src: Cisco\_00:37:41 (00:1b:54:00:37:41), Dst: Vmware\_Ba:69:df (00:50:56:8a:69:df)

▶ Internet Protocol Version 4, Src: 172.16.110.251 (172.16.110.251), Dst: 172.16.100.176 (172.16.100.176)

▶ User Datagram Protocol, Src Port: personal-agent (5555), Dst Port: complex-main (5000)

▶ AlroPeek/OmniPeek encapsulated IEEE 802.11

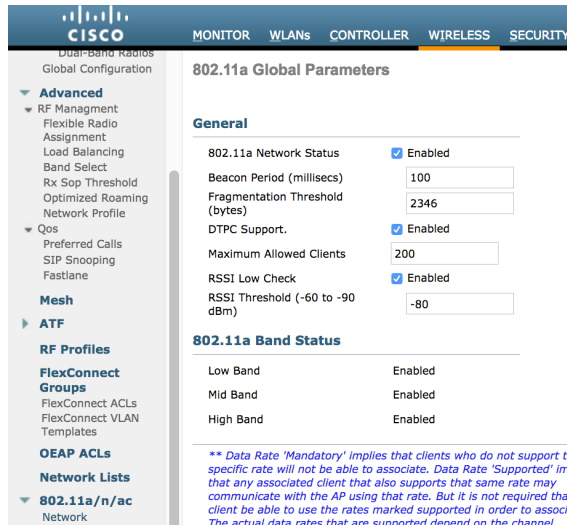
▶ IEEE 802.11 Association Response, Flags: .....C

▼ IEEE 802.11 wireless LAN management frame

- Fixed parameters (6 bytes)
  - Capabilities Information: 0x0001
    - Status code: Association denied due to excessive frame loss rates and/or poor conditions on current operating channel (0x0022)
    - ..00 0000 0000 0000 = Association ID: 0x0000
- Tagged parameters (6 bytes)

# Low RSSI Check

- With RSSI Low check enabled, a clients association requests will be ignored, unless the AP hears them stronger than -80 (configurable)Måske bedre at skifte til 3G / 4G



The screenshot shows the Cisco Wireless Configuration interface. The left sidebar contains a navigation menu with categories like Advanced, Qos, Mesh, ATF, RF Profiles, FlexConnect Groups, OEAP ACLs, Network Lists, and 802.11a/n/ac. The main content area is titled '802.11a Global Parameters' and is divided into two sections: 'General' and '802.11a Band Status'.

**802.11a Global Parameters**

**General**

|                                 |                                             |
|---------------------------------|---------------------------------------------|
| 802.11a Network Status          | <input checked="" type="checkbox"/> Enabled |
| Beacon Period (milliseconds)    | 100                                         |
| Fragmentation Threshold (bytes) | 2346                                        |
| DTPC Support                    | <input checked="" type="checkbox"/> Enabled |
| Maximum Allowed Clients         | 200                                         |
| RSSI Low Check                  | <input checked="" type="checkbox"/> Enabled |
| RSSI Threshold (-60 to -90 dBm) | -80                                         |

**802.11a Band Status**

|           |         |
|-----------|---------|
| Low Band  | Enabled |
| Mid Band  | Enabled |
| High Band | Enabled |

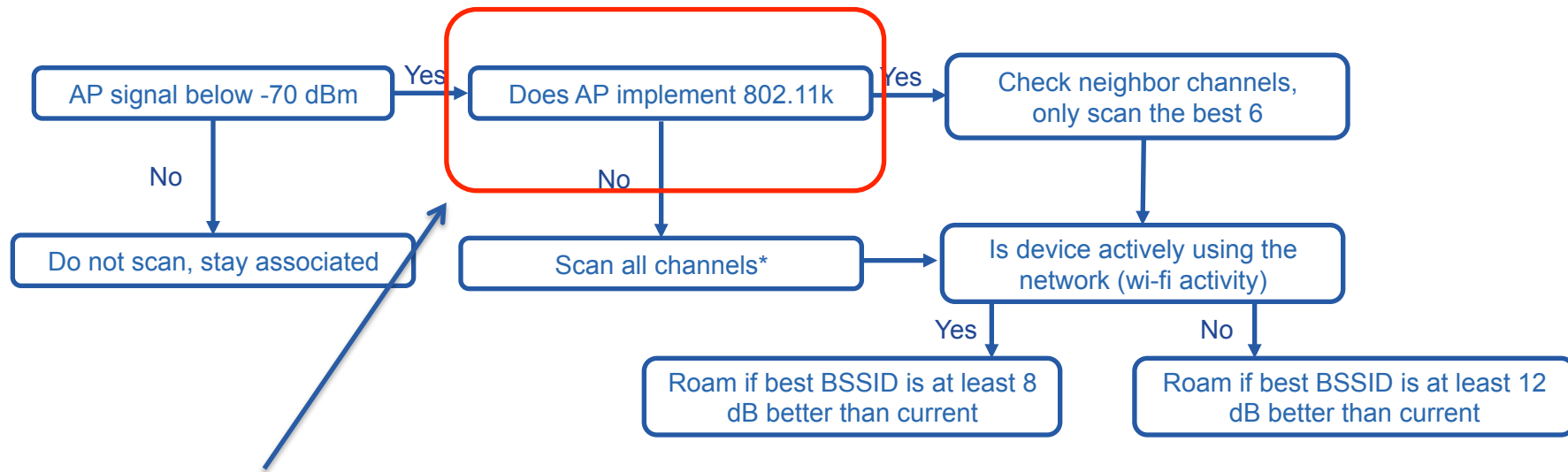
\*\* Data Rate 'Mandatory' implies that clients who do not support that specific rate will not be able to associate. Data Rate 'Supported' implies that any associated client that also supports that same rate may communicate with the AP using that rate. But it is not required that client be able to use the rates marked supported in order to associate. The actual data rates that are supported depend on the channel

# Test og forstå inden I konfigurerer disse

- Endten Optimized Roaming eller Low RSSI Check ikke begge

# Probing and Roaming Decisions

- IOS8 scanning and roaming behavior decision tree is as follows:



I AireOS 8.3 er 802.11K enablet som default

# 802.11K



<http://blogs.cisco.com/wireless/why-the-802-11k-and-neighbor-report-are-important>

# 802.11K

WLANs > Edit 'test'

| General                                         | Security | QoS                                 | Policy-Mapping | Advanced |
|-------------------------------------------------|----------|-------------------------------------|----------------|----------|
| <b>General</b>                                  |          |                                     |                |          |
| FlexConnect Local Switching <a href="#">2</a>   |          | <input type="checkbox"/>            | Enabled        |          |
| FlexConnect Local Auth <a href="#">12</a>       |          | <input type="checkbox"/>            | Enabled        |          |
| Learn Client IP Address <a href="#">5</a>       |          | <input checked="" type="checkbox"/> | Enabled        |          |
| Vlan based Central Switching <a href="#">13</a> |          | <input type="checkbox"/>            | Enabled        |          |
| Central DHCP Processing                         |          | <input type="checkbox"/>            | Enabled        |          |
| Override DNS                                    |          | <input type="checkbox"/>            | Enabled        |          |
| NAT-PAT                                         |          | <input type="checkbox"/>            | Enabled        |          |
| Central Assoc                                   |          | <input type="checkbox"/>            | Enabled        |          |
| <b>11k</b>                                      |          |                                     |                |          |
| Assisted Roaming Prediction Optimization        |          | <input type="checkbox"/>            | Enabled        |          |
| Neighbor List                                   |          | <input checked="" type="checkbox"/> | Enabled        |          |
| Neighbor List Dual Band                         |          | <input type="checkbox"/>            | Enabled        |          |
| Denial Maximum Count                            |          | <input type="text"/>                | 2              |          |
| Prediction Minimum Count                        |          | <input type="text"/>                | 2              |          |

Enablet

Bør ikke enables.  
Tillader roaming  
mellem 2.4 / 5Ghz  
På samme AP

# 802.11K

```
+ Frame 45: 58 bytes on wire (464 bits), 58 bytes captured (464 bits) on interface 0
+ Radiotap Header v0, Length 18
- IEEE 802.11 Action, Flags: .....C
  Type/Subtype: Action (0x000d)
  + Frame Control Field: 0xd000
    .000 0000 0011 1100 = Duration: 60 microseconds
  Receiver address: 00:24:97:88:48:ee (00:24:97:88:48:ee)
  Destination address: 00:24:97:88:48:ee (00:24:97:88:48:ee)
  Transmitter address: 04:f7:e4:ea:5b:66 (04:f7:e4:ea:5b:66)
  Source address: 04:f7:e4:ea:5b:66 (04:f7:e4:ea:5b:66)
  BSS Id: 00:24:97:88:48:ee (00:24:97:88:48:ee)
  Fragment number: 0
  Sequence number: 2740
  + Frame check sequence: 0xc7eea10c [correct]
- IEEE 802.11 wireless LAN management frame
  - Fixed parameters
    Category code: Radio Measurement (5)
    Action code: Neighbor Report Request (4)
    Dialog token: 182
  - Tagged parameters (9 bytes)
    + Tag: SSID parameter set: MRN-EAP
```



Se denne blog for detaljer:

<https://mrncciew.com/2014/09/11/cwsp-802-11k-ap-assisted-roaming/>

# 802.11K

```
Frame 47: 79 bytes on wire (632 bits), 79 bytes captured (632 bits) on interface
Radiotap Header v0, Length 18
IEEE 802.11 Action Class: .....C
Type/Subtype: Action (0x000d)
Frame Control Field: 0xd000
000 0000 0011 1100 = Duration: 60 microseconds
Receiver address: 04:f7:e4:ea:5b:66 (04:f7:e4:ea:5b:66)
Destination address: 04:f7:e4:ea:5b:66 (04:f7:e4:ea:5b:66)
Transmitter address: 00:24:97:88:48:ee (00:24:97:88:48:ee)
Source address: 00:24:97:88:48:ee (00:24:97:88:48:ee)
BSS Id: 00:24:97:88:48:ee (00:24:97:88:48:ee)
Fragment number: 0
Sequence number: 3245
Frame check sequence: 0x587a281c [correct]
IEEE 802.11 Wireless LAN management frame
Fixed parameters
Category code: Radio Measurement (5)
Action code: Neighbor Report Response (5)
Dialog token: 182
Tagged parameters (30 bytes)
Tag: Neighbor Report
Tag Number: Neighbor Report (52)
Tag length: 13
BSSID: 2c:3f:38:2a:b1:2e (2c:3f:38:2a:b1:2e)
BSSID Information: 0x000002b7
.....11 = AP Reachability: Reachable (0x
.....1.. = Security: True
.....0... = Key Scope: False
.....10 1011 = Capability: 0x0000002b
.....1.... = Spectrum Management: True
.....1.... = QoS: True
.....0... = APSD: False
.....1.... = Radio Measurement: True
.....0.... = Delayed Block Ack: False
.....1.... = Immediate Block Ack: True
.....0... = Mobility Domain: False
.....0... = High Throughput Control (+HTC)
0000 0000 0000 0000 0000 = Reserved: 0x00000000
Operating Class: 1
Channel Number: 40 (iterative measurements on that Channel Number)
PHY Type: 0x07
Tag: Neighbor Report
Tag Number: Neighbor Report (52)
Tag length: 13
BSSID: 64:a0:e7:af:47:4e (64:a0:e7:af:47:4e)
BSSID Information: 0x000002b7
.....11 = AP Reachability: Reachable (0x
.....1.. = Security: True
.....0... = Key Scope: False
.....10 1011 = Capability: 0x0000002b
.....1.... = Spectrum Management: True
.....1.... = QoS: True
.....0... = APSD: False
.....1.... = Radio Measurement: True
.....0.... = Delayed Block Ack: False
.....1.... = Immediate Block Ack: True
.....0... = Mobility Domain: False
.....0... = High Throughput Control (+HTC)
0000 0000 0000 0000 0000 = Reserved: 0x00000000
Operating Class: 1
Channel Number: 36 (iterative measurements on that Channel Number)
PHY Type: 0x07
```

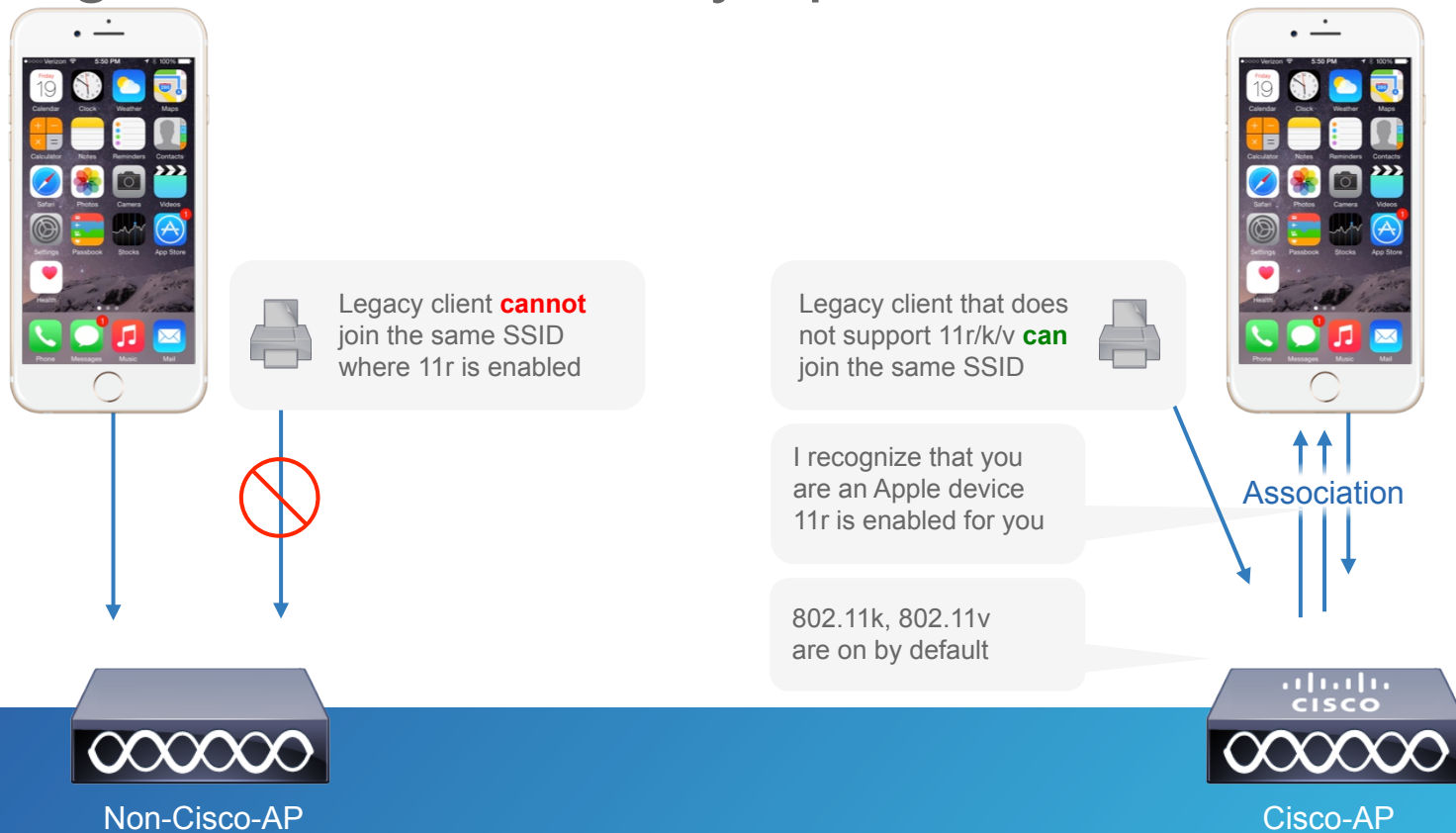


Se denne blog for detaljer:

<https://mrnciew.com/2014/09/11/cwsp-802-11k-ap-assisted-roaming/>



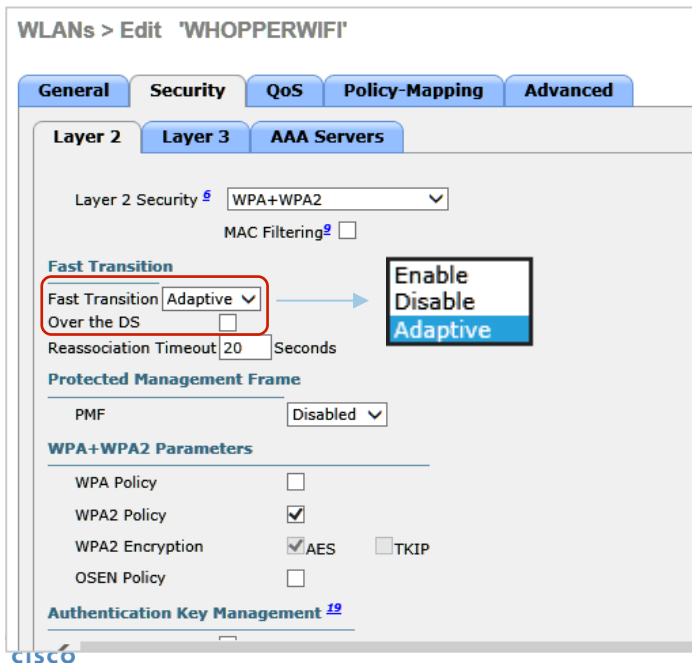
# Cisco-Apple Optimized Roaming reduces management overhead by up to 50%



# Adaptive 11r

## Feature enabled by default on a newly created SSID

- Even if 802.11r is not enabled on the WLAN, it is enabled for the WLAN for the Apple iOS 10 devices (adaptive 11r) by default:



```
Show wlan 3
```

```
.../...
```

```
Security
```

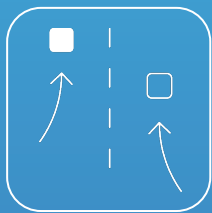
```
802.11 Authentication:..... Open System
```

```
FT Support..... Adaptive
```

# 802.11r

| Authentication method                     | Average Roaming time (ms) | Average Packet loss % | Maximum consecutive lost datagrams (Average) |
|-------------------------------------------|---------------------------|-----------------------|----------------------------------------------|
| Baseline – Full 802.1X EAP authentication | 525                       | 1.8                   | 53                                           |
| Fast Transition using 802.11r             | 42                        | 0.2                   | 6                                            |

<http://blogs.cisco.com/wireless/what-is-802-11r-why-is-this-important>



# Prioritizing Business Apps

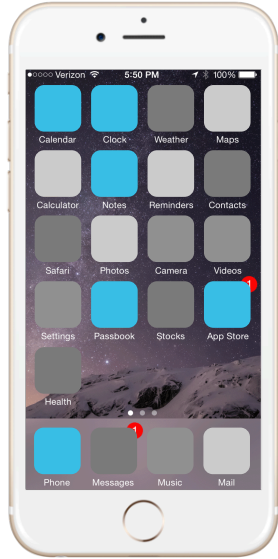
# What Happens Today?

Inability to prioritize business-critical real-time traffic all the way from clients to the destination

- Today IT Administrators can classify traffic **ONLY** at the access point. this implies:
  - Inability to prioritize between the client and the AP
  - Burden on IT administrator to manage the applications across the enterprise



# Prioritizing Business Apps



Prioritize business critical apps and real time data

Simplify configuration

IT has control over which Apps get priority

# Fast Lane Configuration Profiles

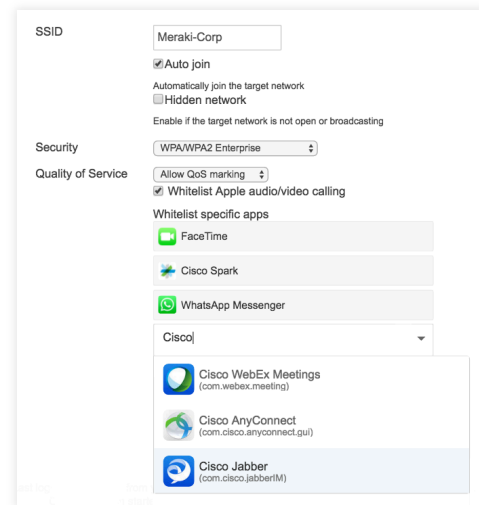
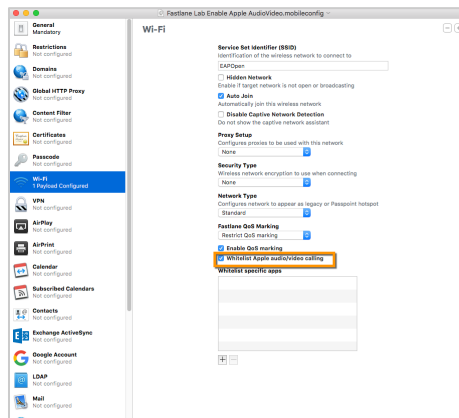
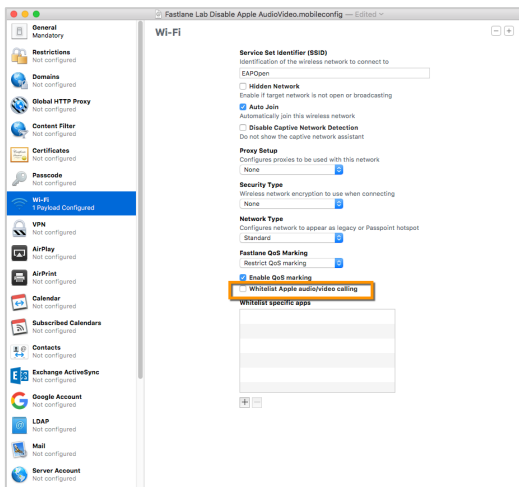
A QoS configuration profile will ONLY be acted upon on an iOS 10 client

Uses standard Apple iOS Profiling techniques (MDM, email, Web-based)

- Profile lists “whitelisted” applications in a dictionary file
- Whitelisted applications are allowed to mark QoS (DSCP/UP) upstream
- ‘Non-Whitelisted’ applications receive only BE/BK marking upstream

Used in Combination with Cisco and Apple mutual detection

# Creating Fast Lane Profiles

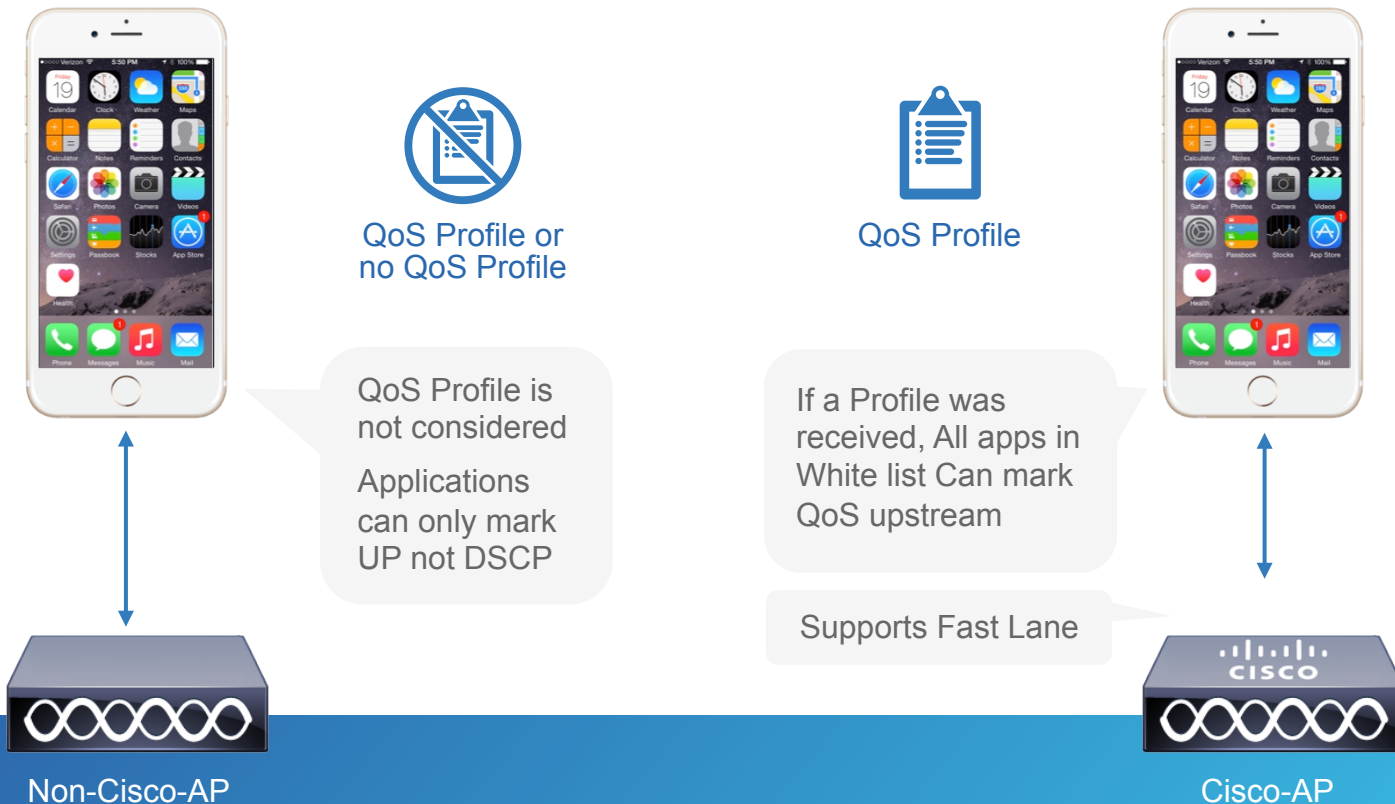


Apple Configurator

Meraki Systems  
Manager MDM



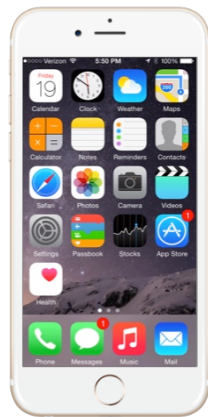
# Fast Lane only applies to Cisco-Apple Deployments



\* DSCP can be marked with IP\_TOS/IPv6\_TCLASS when SO\_NET\_SERVICE\_TYPE is best effort

# Fast Lane enables network administrator to prioritize applications per your environment

Supports Fast lane

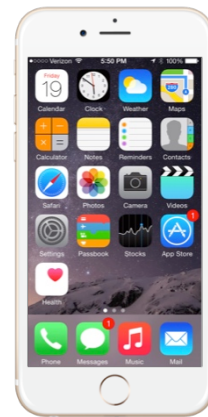


Admin can provision Apple IOS device with a QoS profile\*  
Applications in whitelist get QoS marking\*\*  
Other applications get BE/BK

My profile for  
this environment:  
Minecraft = Realtime-interactive  
Viber = BE

My profile for  
this environment:  
Minecraft = BE  
Viber = Voice

Supports Fast lane



Supports Fast Lane



Cisco-AP

Supports Fast Lane

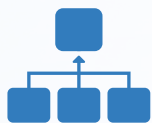


Cisco-AP

\*Without a profile, all applications are whitelisted by default in a FastLane cell

\*\*FastLane does NOT override apps QoS, it either allow the app QoS or apply BE

# App prioritization elements



## QoS Profile

Helps determine which applications should receive QoS upstream



## Voice QoS Trust

Trust upstream voice traffic, with ACM and without TSPEC



## AutoQoS

Benefits IT Administrator

Configure optimal WLC QoS in one click

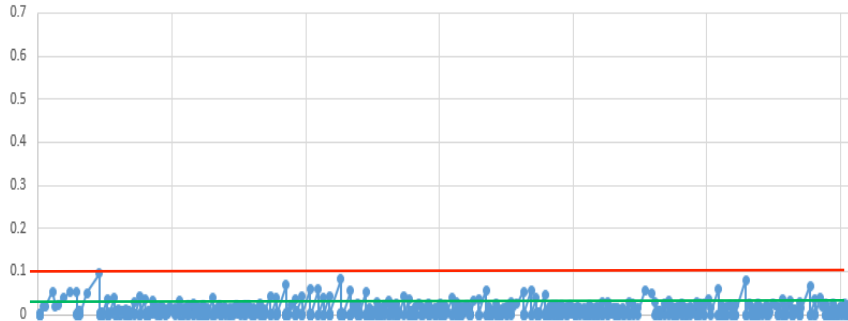
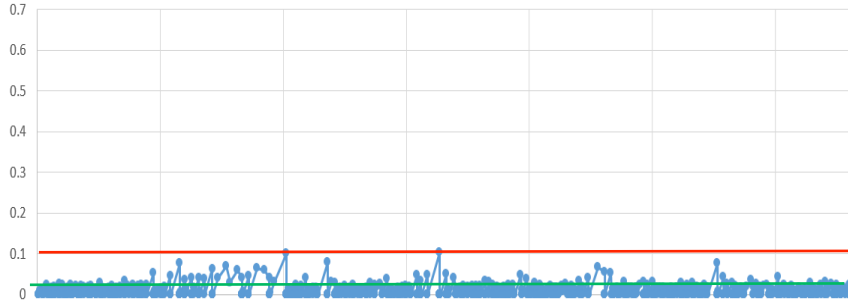


## Better EDCA

Ease of Use

IEEE 802.11-2016 EDCA

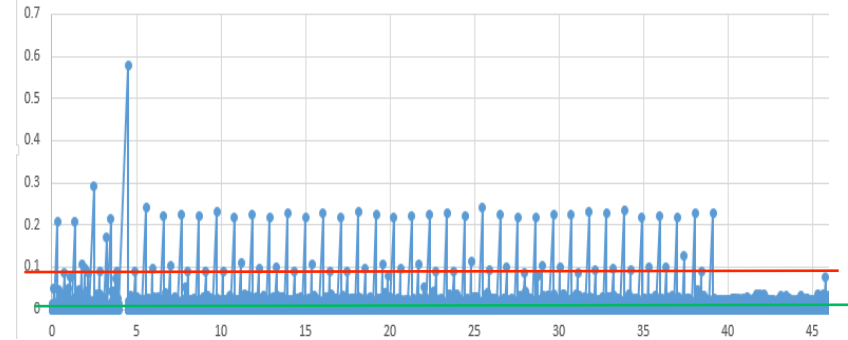
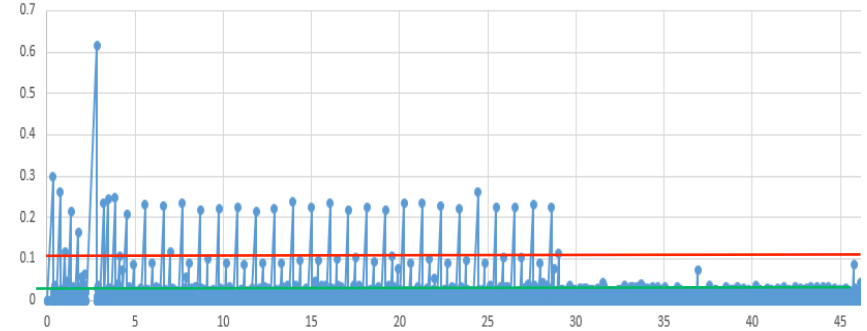
# Fast Lane Results : Upstream Frame Interval, Against Competing Traffic



Interval between upstream frames (voice and video), for each station.



“table 1” (L3, L2 QoS enabled)

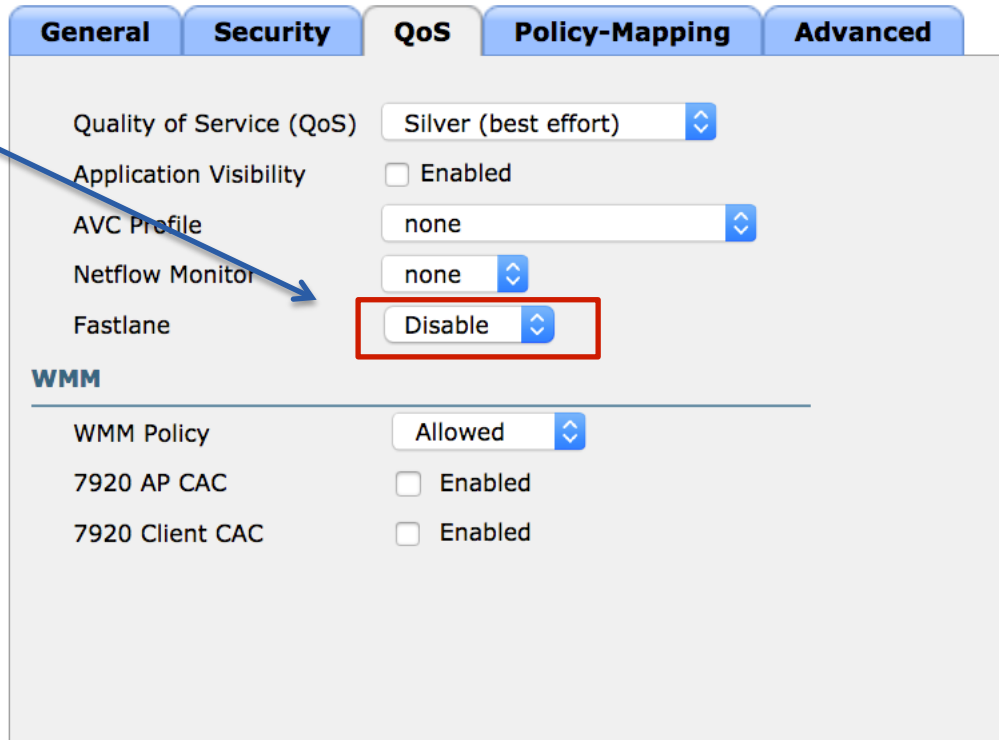


“table 2” (L3, L2 QoS disabled)

# Fast Lane på WLC

- Enables fra QoS tab på WLAN configuration

WLANs > Edit 'fastlane'



The screenshot shows the 'fastlane' configuration page with the following settings:

| General                         | Security | QoS                              | Policy-Mapping | Advanced |
|---------------------------------|----------|----------------------------------|----------------|----------|
| <b>Quality of Service (QoS)</b> |          |                                  |                |          |
| Quality of Service (QoS)        |          | Silver (best effort) ▾           |                |          |
| Application Visibility          |          | <input type="checkbox"/> Enabled |                |          |
| AVC Profile                     |          | none ▾                           |                |          |
| Netflow Monitor                 |          | none ▾                           |                |          |
| Fastlane                        |          | Disable ▾                        |                |          |
| <b>WMM</b>                      |          |                                  |                |          |
| WMM Policy                      |          | Allowed ▾                        |                |          |
| 7920 AP CAC                     |          | <input type="checkbox"/> Enabled |                |          |
| 7920 Client CAC                 |          | <input type="checkbox"/> Enabled |                |          |

# Fast Lane

- Enabling Fastlane:
- Configures best QoS globally
- Sets the WLAN for Platinum →
- Sets WMM to Required
- (Notice AV is still disabled)

**WLANs > Edit 'fastlane'**

**General** **Security** **QoS** **Policy-Mapping** **Advanced**

Quality of Service (QoS) Platinum (voice) ▾

Application Visibility ☐ Enabled

AVC Profile none ▾

Netflow Monitor none ▾

Fastlane Enable ▾

**WMM**

---

WMM Policy Required ▾

7920 AP CAC ☐ Enabled

7920 Client CAC ☐ Enabled

# Fast Lane

- When Fastlane is enabled on a WLAN, enabling AV automatically applies the AUTOQOS-AVC-PROFILE

WLANs > Edit 'WHOPPERWIFI'

General Security QoS Policy-Mapping Advanced

Quality of Service (QoS) Platinum (voice) ▾

Application Visibility ☐ Enabled

AVC Profile none ▾

Flex AVC Profile none ▾

Netflow Monitor none ▾

Fastlane Enable ▾

**Override Per-User Bandwidth Contracts (kbps)**

|                        | DownStream                     | UpStream                       |
|------------------------|--------------------------------|--------------------------------|
| Average Data Rate      | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Burst Data Rate        | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Average Real-Time Rate | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Burst Real-Time Rate   | <input type="text" value="0"/> | <input type="text" value="0"/> |

**Override Per-SSID Bandwidth Contracts (kbps)**

WLANs > Edit 'WHOPPERWIFI'

General Security QoS Policy-Mapping Advanced

Quality of Service (QoS) Platinum (voice) ▾

Application Visibility ☒ Enabled

AVC Profile AUTOQOS-AVC-PROFILE ▾

Flex AVC Profile none ▾

Netflow Monitor none ▾

Fastlane Enable ▾

**Override Per-User Bandwidth Contracts (kbps) <sup>16</sup>**

|                        | DownStream                     | UpStream                       |
|------------------------|--------------------------------|--------------------------------|
| Average Data Rate      | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Burst Data Rate        | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Average Real-Time Rate | <input type="text" value="0"/> | <input type="text" value="0"/> |
| Burst Real-Time Rate   | <input type="text" value="0"/> | <input type="text" value="0"/> |

**Override Per-SSID Bandwidth Contracts (kbps) <sup>16</sup>**

# Fast Lane

- Ændrer også EDCA

The screenshot shows the Cisco Wireless configuration page. The left sidebar contains a navigation tree with the following items: Access Points, Radios (802.11a/n/ac, 802.11b/g/n, Dual-Band Radios, Global Configuration), Advanced, Mesh, ATF, RF Profiles, FlexConnect Groups (FlexConnect ACLs, FlexConnect VLAN, Templates), OEAP ACLs, Network Lists, and 802.11a/n/ac (Network, RRM, RF Grouping, TPC, DCA, Coverage, General, Client Roaming, Media, EDCA Parameters). The main content area is titled 'General' and shows the 'EDCA Profile' dropdown set to 'Fastlane' and the 'Enable Low Latency MAC' checkbox unchecked. A blue note at the bottom states: 'Turn this ON only if DSCP marking is correct for media (RTP) and signaling packets. Low latency Mac feature is not supported for 1140/1250/3500 platforms if more than'.

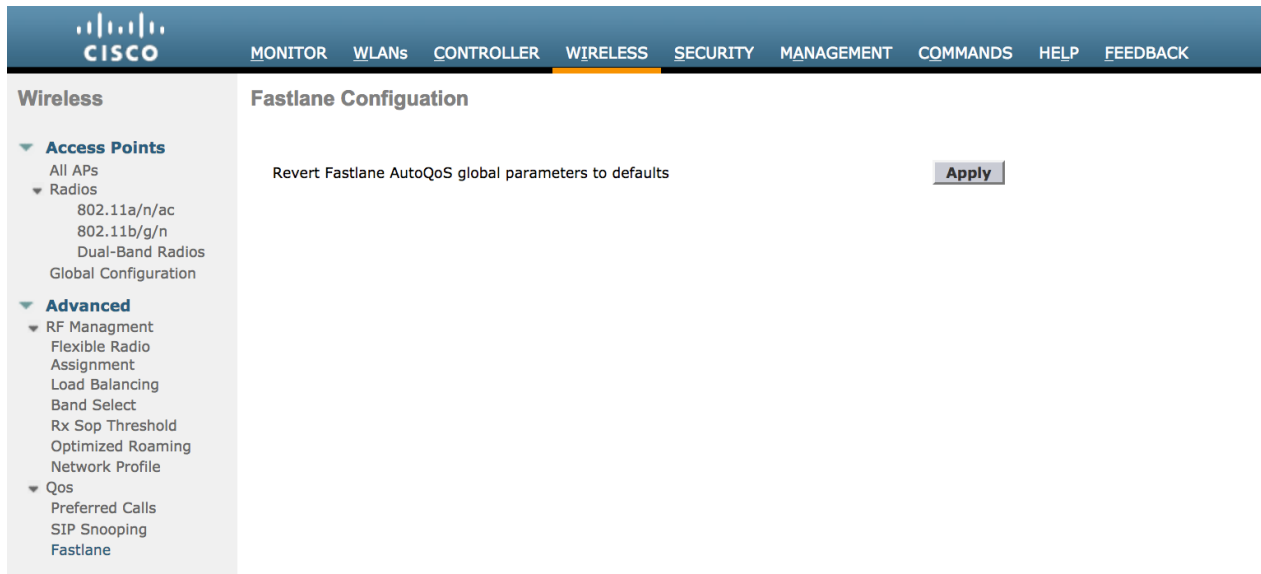


# Cisco live Wireless QOS Session:

- By combining these timers, the theoretical probability of higher priority frames is greatly improved, but is not guaranteed



# Revert Defaults



The image shows a screenshot of the Cisco Wireless configuration interface. The top navigation bar includes links for MONITOR, WLANs, CONTROLLER, WIRELESS (which is highlighted), SECURITY, MANAGEMENT, COMMANDS, HELP, and FEEDBACK. On the left, the 'Wireless' menu is expanded, showing 'Access Points' (with sub-items: All APs, Radios, 802.11a/n/ac, 802.11b/g/n, Dual-Band Radios, Global Configuration) and 'Advanced' (with sub-items: RF Management, Flexible Radio Assignment, Load Balancing, Band Select, Rx Snp Threshold, Optimized Roaming, Network Profile, Qos, Preferred Calls, SIP Snooping, Fastlane). The main content area is titled 'Fastlane Configuration' and contains the text 'Revert Fastlane AutoQoS global parameters to defaults' with an 'Apply' button to its right.

**Wireless**

- ▼ **Access Points**
  - All APs
  - ▼ Radios
    - 802.11a/n/ac
    - 802.11b/g/n
    - Dual-Band Radios
    - Global Configuration
- ▼ **Advanced**
  - ▼ RF Managment
    - Flexible Radio Assignment
    - Load Balancing
    - Band Select
    - Rx Snp Threshold
    - Optimized Roaming
    - Network Profile
  - ▼ Qos
    - Preferred Calls
    - SIP Snooping
    - Fastlane

**Fastlane Configuration**

Revert Fastlane AutoQoS global parameters to defaults **Apply**

# Recommended Platforms



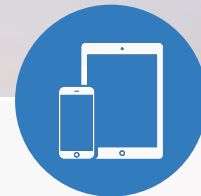
## Network Infrastructure

- Wireless controller: Running AireOS 8.3, 8.3MR or connected to Meraki cloud
- 802.11ac Aironet and Meraki MR Access points
- Catalyst and Meraki MS Multigigabit-capable switches
- Meraki Systems Manager EMM
- Software licenses, maintenance & support



## Caching

- ISR 4000 Series
- WAAS – Wide Area Application Services
- Akamai Connect license
- Software licenses, maintenance & support



## iOS devices

### Optimized Efficient Roaming

- iPhone 6s and later
- iPhone 6s Plus and later
- iPad Air 2 and later
- iPad mini 4 and later
- iPad Pro and later
- iPhoneSE

### Fast Lane

- iPhone 5 and later
- iPad mini 2 and later
- iPad Air and later
- iPad Pro
- iPod touch (6th generation)

Thank you.

