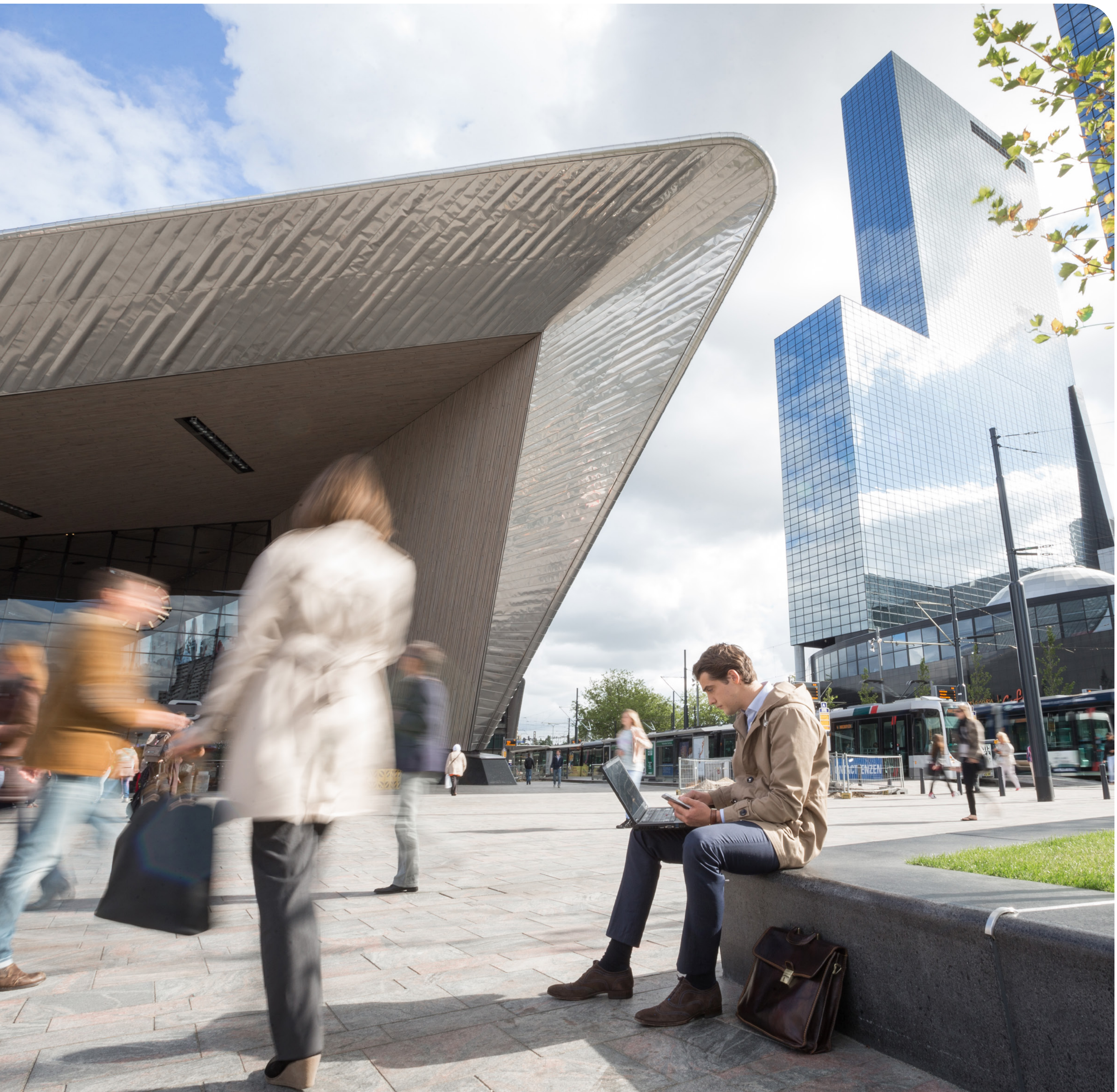
White paper

# Optimizing iOS and macOS Devices on Cisco Wireless Networks



# 1. Executive Summary

The advent of digitization has ushered in a new era of wireless technology wherein an increasing number of critical applications are being supported on mobile devices such as tablets, smartphones, and laptops. Employees collaborating in open-space offices or students working together on group projects create an increase in devices roaming across the wireless network, which during peak hours leads to packet loss, dropped calls, and other performance issues. Therefore, the primary challenges faced by IT administrators and end users across sectors such as education, healthcare, retail, and enterprise pertain to mobility, scalability, and prioritization. This white paper describes the Apple and Cisco collaboration for creating a superior wireless solution by providing optimal roaming (802.11 r/k/v amendments), analytics, and prioritization for business apps. It explains the benefits of the Apple and Cisco wireless solution that end users and IT administrators will be able to take advantage of on iOS and macOS devices. It uses the results of tests conducted jointly by Apple and Cisco to showcase enhanced end-user experience and reduced network load.

Following are the salient benefits of the Apple and Cisco partnership, based on interoperability tests:

- Greater reliability for real-time apps – up to a 20 percent increase in audio quality
- Improved end-user experience – up to a 90 percent reduction in web browsing failures
- Enhanced network performance – up to an 86 percent reduction in network message load from the device during roaming

# 2. Device mobility in wireless networks

## 2.1 Standard roaming in 802.11

When a mobile device joins a wireless network, it tries to associate itself to the access point from which it has the strongest signal. The 802.11 standard expects devices roaming between access points to run the entire association or authentication mechanism with the new access point. Reauthentication and reassociation are time-critical processes that affect network connectivity during client roaming. This results in suboptimal end-user experience and network performance for devices roaming in 802.11.

## 2.2 Roaming amendments (802.11 r/k/v)

802.11r, which is the IEEE standard for fast roaming, defines a mechanism by which clients can transition faster between access points. Using 802.11r, clients on a secure WLAN can perform an initial handshake with the new access points even before roaming to the target access point. The handshake allows access points in a network to preload the encryption keys, thereby eliminating the overhead associated with roaming. This decreases the latency associated with network connectivity during device roaming without compromising on security and quality of service (QoS). In the standard 802.11, the number of messages being sent from the WLAN to the back-end server during device roaming would vary depending on the type of authentication protocol used, and would increase with higher levels of security. Enabling 802.11r can dramatically decrease the number of messages sent from the devices to the back-end RADIUS server, thereby dramatically decreasing network load. This reduction is especially significant in a strongly secure WLAN (using 802.1X and Extensible Authentication Protocol [EAP] methods for authentication).

Wireless LAN radio measurements (802.11k) can enable a device, access point, or client to better understand the environment in which it is operating. Neighbor report is a very useful type of 802.11k request sent from client to access point. The access point communicates the list of target access points that the client can associate with, and the client uses this list to scan for the next access point to roam to, thereby reducing roam latency.

Wireless network management (802.11v) strives to improve the quality of the end-user experience by enabling information exchange. Basic Service Set (BSS) transition management is a vital aspect of 802.11v by which devices can solicit advice from the WLAN as well as receive unsolicited advice from the WLAN about which access point they should next associate to. The decision to associate or not would ultimately depend on the device. Additionally, 802.11v includes multiple extensions that enable the client to sleep for a longer duration and thereby save battery life.

### 2.3 Adoption challenges in 802.11 roaming amendments (802.11r/k/v)

Despite the profound advantage of 802.11r, network administrators are reluctant to enable it for a WLAN. The two-way dilemma for enabling 802.11r pertains to a mixed network comprising both 802.11r-compliant and noncompliant devices. Turning on 802.11r could prevent some devices that don't support 802.11r (the ones that do not recognize the fast transition Authenticated Key Management [AKM] types in Robust Security Network Information Exchange [RSN IE]) from joining the network. Consequently, network administrators often configure two service set identifiers (SSIDs) per network per authentication type, one with 802.11r enabled and the other with 802.11r disabled, which increases management overhead. Customers also often do not turn on 802.11k/v functionality, since it entails manual configuration and increased operational overhead.

### 2.4 Visibility issues in 802.11

Phones and tablets are highly mobile. Although access points and wireless clients use 802.11-capable radios, their environment is very different. Access points are often placed at ceiling level or at locations with fewer interfering objects. By contrast, phones and tablets are at ground level, where obstacles alter or block the Wi-Fi signal. When a wireless client needs to roam, the access point can leverage 802.11k/v to provide information about the best next access points. However, without visibility into how the client sees the Wi-Fi signals, the indication from the access points is imperfect and partial, as they rely on the "view from the ceiling" instead of the "view from the ground."

### 2.5 Prioritization issues in 802.11

In today's deployments, administrators don't have the ability to control the priorities of the apps that end users are using on their devices. There is no way for administrators to control the 802.11e priorities in the upstream direction, from the client to the access point. This could lead to unreliable quality of service for real-time applications such as video and voice, resulting in a poor end-user experience. Additionally, network administrators encounter scalability issues while managing application priorities.

## 3. Apple and Cisco enterprise mobility innovations

### 3.1 Cisco Wi-Fi oOptimization for iOS

Apple and Cisco interoperability in wireless allows a handshake between Cisco Aironet™ WLANs running AireOS software version 8.3 or later, as well as Cisco® Meraki® WLANs, and iOS devices running iOS 10 or later. As part of this handshake, the Cisco WLAN identifies iOS devices joining the wireless network and selectively enables 802.11r for the identified devices without affecting the functionality and operation of devices not running iOS 10 or later. iOS devices joining a Cisco WLAN can thereby automatically enjoy the benefits of fast transition roaming. The Cisco and Apple handshake enables turning 802.11r on selectively on a single SSID for iOS 10 devices, thereby reducing the management overhead resulting from multiple SSIDs. The above Cisco and Apple environments also enable 802.11k/v by default. This allows iPhones and iPads to reduce their roaming latency and improve their power consumption without adversely affecting nonsupporting devices.

### 3.2 Cisco Wi-Fi Analytics for iOS

Apple and Cisco interoperability allows Apple devices running iOS 11 or later to recognize Cisco Aironet WLANs running AireOS software version 8.5 or later. When iOS devices join the wireless network, they report to the access point their "view from the ground." This report includes the iOS device view of access points and their channel and signal levels that the client detected before joining the current access point. The report also mentions the iPhone or iPad hardware and software release details, to allow the WLAN network to make a better prediction as to which access point to recommend to the next iOS device of the same type needing support in the same area. Also, upon client deassociation, the iOS device provides a reason code. This additional element of analytics information allows the network to understand whether disconnections are due to user actions (such as disabling Wi-Fi on an iPhone), network issues, or RF challenges. Cisco Wi-Fi Analytics for iOS allows the Cisco WLANs and iOS devices to interact more efficiently by enabling the access points to tailor their responses to each iOS device type and location.

### 3.3 Cisco Fast lane

Administrators can prioritize iOS and macOS apps and data, similar to a fast lane on the highway. This is possible through the installation of a profile on iPhone, iPad, or macOS devices. When these devices identify a Cisco WLAN running AireOS software version 8.3 or later, or a Meraki WLAN, the device activates the profile. The profile determines which apps are on the "whitelist" and are allowed to receive priority treatment for their flows. All other apps will be limited to best effort or background. With this granular control, administrators can be sure that only the iOS and macOS apps that are critical to their business receive preferential treatment. This is especially important when deploying business-grade collaboration solutions or other apps that use real-time data.

## 4. Benefits of the Apple and Cisco innovations

The Apple and Cisco collaboration enhances the experience for both end users of iOS and macOS devices and IT administrators managing the wireless network:

- **End users of iOS and macOS devices:** iPhone and iPad users running iOS 10 or later on Cisco WLAN networks can get a much better end-user experience in terms of audio and video quality and reliability due to the efficient roaming features enabled. In our tests, audio clients can roam with up to a 20 percent increase in average quality, based on the Perceptive Objective Listening Quality Assessment (POLQA). Web browsing clients can experience up to a 90 percent reduction in web browsing failures, based on web stall probability tests. The probability of a good audio experience improved by 66x, based on the percentage of samples with a POLQA score of less than 2.5. Prioritizing business apps for iPhone and iPad users running iOS 10 or later and Mac users running macOS 10.13 or later helps ensure that high-efficiency queues are kept for business-relevant apps, thereby providing highly reliable QoS.
- **IT administrators managing wireless networks:** IT administrators get the dual benefits of improved network performance and ease of network management due to the efficient roaming features. Reduced load from the WLAN controller to back-end servers improves network performance. Selective enablement of 802.11r (adaptive 802.11r) helps in deploying and managing mixed networks by having just one SSID per network per authentication type, thereby reducing network SSID overhead. The reduction in management traffic overhead could be as high as 50 percent in network deployments with iOS devices and legacy mobile devices that don't support 802.11r. Automatic configuration of 802.11r/k/v helps reduce configuration complexity and improves ease of management. App prioritization helps network administrators easily prioritize business-critical apps and tailor the upstream QoS policies to the IT-defined business-critical apps. This is a first in the history of Wi-Fi.

## 5. Apple and Cisco interoperability test summary

### 5.1 Lab topology

Apple and Cisco engineers conducted joint audio and web browsing tests in their labs.

For audio tests, fast transition roaming was tested using two iPhone devices while performing Wi-Fi Calling. The Wi-Fi network in the lab was made up of Cisco Aironet 3700 Series Access Points with Cisco 2504 Wireless Controllers. Hostapd running software version 2.4 served as the RADIUS server. The Transport Layer Security (TLS) protocol was used for EAP authentication. The RADIUS load was an average delay of 30 ms with 20 percent standard deviation. Controller traffic load was emulated using an external simulator.

Wireless controller and access point configurations were done as per the best practices guide. Refer to https://www.cisco.com/c/en/us/td/docs/wireless/controller/7-0MR1/configuration/guide/wlc_cg70MR1.html.

Roaming was tested by simulating an RF environment that mimics a user walking in an office environment with roughly two roams per minute.

For web browsing tests, we used the lab topology outlined here. Safari was used for the browsing test, and a constant web page content was used.

## 5.2 Lab results

### 5.2.1 Audio quality

Audio quality was measured using POLQA, which is an ITU-T standard that provides a model to predict speech quality by means of digital speech signal analysis. More than 10 hours of audio were assessed using Wi-Fi Calling as the application in the topology described in section 5.1. Audio quality and network load were measured for two scenarios – one with over-the-air fast transition enabled and the other with fast transition disabled. Table 1 captures the POLQA metrics from samples taken during roaming with and without 802.11r enabled. The results were captured for a network with and without simulated traffic load. With 802.11r enabled, the average POLQA metric improved from 3.14 to 3.84. Enabling 802.11r reduced the probability of deteriorated voice quality (POLQA < 2.5) from approximately 29.67 percent to approximately 0.48 percent in a network with simulated traffic load.

Table 1 Audio quality test results

| | 802.11r enabled | | 802.11r disabled | |
|---|---|---|---|---|
| **Roaming samples only** | **POLQA No load** | **POLQA Simulated load** | **POLQA No load** | **POLQA Simulated load** |
| **Average** | 3.83 | 3.84 | 3.17 | 3.14 |
| **Standard deviation** | 0.27 | 0.26 | 1.03 | 0.96 |
| **% of samples with POLQA < 3.5** | 8.33 | 8.10 | 39.94 | 42.07 |
| **% of samples with POLQA < 3** | 1.92 | 1.32 | 35.92 | 35.16 |
| **% of samples with POLQA < 2.5** | 0.661375661 | 0.484764543 | 31.89655172 | 29.67479675 |

### 5.2.2 Web browsing

The web browsing tests measured two metrics: (1) web page load times and (2) web page stall probability. A web page is considered stalled if it does not successfully load (either TCP connection or TCP graceful termination failure) within 15 seconds. For successful attempts, the time taken was measured as web page load time. For both cases, 1000 samples of web page tests were performed. As seen in Table 2, 802.11r shows a reduced time to load (by 37 percent) as well as a decrease (by approximately 10x) in probability of web page stall.

Table 2 Web browsing test results

| Roaming Samples Only | | |
|---|---|---|
| **Roaming samples only** | **802.11r disabled** | **802.11r enabled** |
| **Average web load times (sec)** | 5.38 | 3.33 |
| **Web page stall probability (%)** | 8.30 | 0.86 |

### 5.2.3 Network load

Without adaptive 802.11r, during every roam an average of approximately 30 messages were measured from the device to the access points, of which 21 messages were between the client and the RADIUS server. With adaptive 802.11r, the average number of messages measured from the client to the access points was approximately 4, with 0 messages between the WLAN controller and the RADIUS server.

As an example, in a typical large educational institution deployment with around 30,000 iOS devices, 50 percent of the devices could be roaming during specific time periods (burst hours). The number of messages sent from the wireless controller to the back-end RADIUS server could be reduced by about 300,000, which would greatly reduce network congestion and vastly improve network performance.

### 5.2.4 App prioritization

In our tests we compared apps on devices running iOS 10 and macOS 10.13, with prioritization enabled and a high-priority queue to the same devices on another network without prioritization enabled. We then created a congestion scenario in which 70 percent of the cell airtime was occupied by competing (best effort) traffic. We used an application that sent a smooth flow of real-time frames (voice and video). We then measured the interval between upstream frames in both scenarios.

With application prioritization enabled, the interval between frames was 50 percent shorter than that without application prioritization. This means that with prioritization the application has access to the medium twice as often, and can send twice as much traffic, compared to the nonprioritized network. As a consequence, the user experience is likely to be twice as good with application prioritization than it is without (more packets at regular intervals means less loss, fewer retries, less compression due to congestion, and therefore better video and audio quality).

This performance gain was also apparent for roaming. Our tests show that the delay between the last data frame on the old access point and the first data frame on the next access point was up to eight times shorter with application prioritization than in the nonprioritized network. In an application-prioritized network, real-time roaming is likely to be seamless, while it may lead to losses, clicks, and compression issues in a nonprioritized network.

# 6. Conclusion

Apple and Cisco are helping enterprise customers everywhere take advantage of their wireless networks to run mobile business apps with simplicity, performance, and reliability. With new features in iOS and macOS devices, combined with the most advanced networking technology and new features from Cisco, we're delivering the very best mobile user experiences for the modern enterprise.