SEAMLESS WIRELESS ROAMING

INTRODUCTION

Over the last several years, providing customers with a seamless roaming experience within a home or business has become an important topic. More wireless devices are providing performance-sensitive video and streaming applications to users who wish to consume this content anywhere in the home. Additionally, with the proliferation of wireless technologies, homes have become hostile wireless environments as the variety of devices broadcasting and connecting wirelessly creates layers of radio interference.

In this white paper, we are going to explore the process of roaming and how it works; factors that affect roaming; how the industry, client vendors, and network manufacturers are addressing it; and how all of these approaches—including properly designing the network—can deliver the best roaming experience.

ROAMING OVERVIEW

Roaming, often referred to as client handoff, is the process whereby a wireless device (client) moves from one access point (AP) to another while maintaining a connection to the network within the home. The goal of wireless roaming is to identify an alternate AP that can provide a stronger signal to the client than the existing AP. In a well-designed network, this handoff happens quickly and seamlessly, so a user does not notice an interruption of network services.

The 802.11 wireless specification requires that the client device make the roaming decision. Client devices use proprietary algorithms to assess the signal strength of its client-AP connection using a handful of factors, including signal strength and throughput, to make the decision to connect to a new AP if the current connection is deemed unusable. Because these client device algorithms are proprietary, there is a wide range of variability in the reliability and efficiency of the ability for these client devices to seamlessly roam.

In an effort to provide a more seamless roaming experience, several methods have been developed to compensate for this variability. One method is the development of industry standards—supported by both the network manufacturers and client device vendors—that streamline the authentication process for connecting to an AP, as well as provide easy identification of nearby APs. Additionally, in an attempt to compensate for client device variability in roaming algorithms, some networking equipment manufacturers have developed proprietary technology to assist devices in making the decision to roam. Building a seamless roaming experience often requires utilizing a mix of both methods—standards support and assistive roaming technology built into networking equipment.

Even the most sophisticated roaming technology and networking hardware cannot compensate for a poorly designed and installed wireless network. A network professional plays a vital role in creating a seamless roaming experience. AP placement, signal strength, and channel selection work together to create the best environment for seamless roaming. Professionals who select the right equipment and thoughtfully plan a network, paying attention to coverage overlap and channel interference, can deliver a reliable and robust wireless network.

COMMON CAUSES OF POOR ROAMING

STICKY CLIENTS

In the last few years, leading client device manufacturers such as Apple and Microsoft have successfully deployed support for industry roaming standards and more sophisticated proprietary roaming features within their devices. Some of these advanced features include active scanning that continuously searches for APs with a stronger signal.

However, these advancements have not been made universally across all client device manufacturers. Some popular devices either run outdated software or lack effective algorithms that inform the decision to roam efficiently. These Devices—often called "sticky clients"—leave the user frustrated and often blaming the network rather than the device itself. To assist sticky clients to roam more efficiently, some network manufacturers, including Pakedge, have developed technology that forces a client to disconnect from an AP when the connection quality degrades below a usable threshold.

IMPROPER WIRELESS DESIGN AND AP PLACEMENT

While roaming is the responsibility of the client device, AP placement and configuration plays an important role in providing a client device with the right environment determine the best AP to connect to. When APs are placed too close together or too far apart, the client device can struggle to determine which AP to connect to, delaying or even failing to establish a usable connection. Creating the right wireless design often requires planning and measuring signal quality and strength throughout the home. Pakedge Certified Network Administrator (PCNA) training has an entire chapter dedicated to wireless design and AP placement.

CHANNEL INTERFERENCE

Only one device may transmit on a given channel at the same time. When a radio hears another radio transmitting on the same frequency, it must not transmit, but will instead defer transmission until it has regained control of the channel.

A poorly designed network may place multiple APs on the same (or nearby) channel. When there is not a clear separation between these channels, clients and APs are forced to wait their turn to transmit, introducing latency and delays.

WIRELESS DESIGN TOPOLOGY

As wireless networking has evolved, so has wireless infrastructure design. There are two primary approaches to wireless infrastructure design: single-channel architecture (SCA) and multi-channel architecture (MCA). SCA was the answer for roaming and other issues in the early days of WiFi, but MCA has evolved to provide a superior connection experience when used in conjunction with expanding industry standards and increasingly intelligent client devices.

SINGLE-CHANNEL ARCHITECTURE

In the early days of WiFi, single-channel architecture (SCA) was leveraged to simplify wireless deployment. SCA was devised to assist in the roaming process by tricking the client device into believing the entire wireless network is comprised of a single AP, obfuscating the existence of the individual APs on the network. Roaming was then managed by the wireless controller, which would transition a client device from one AP to another as it moved around the home. While this experience appears seamless to the client, the decision to roam may experience delays, depending on the performance of the wireless controller. Also, by pushing all wireless traffic onto a single channel, additional latency and throughput limitations are introduced.

The IEEE 802.11 wireless standard introduces a technology called Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA). In plain English, CSMA/CA allows only a single device (AP or client) to transmit on a channel at a given time. To avoid collisions or interference on the channel, all wireless devices must take turns transmitting on that channel. In a single-channel architecture, large bottlenecks can occur when there are multiple devices within a given area, even if they are connected to different APs. With it becoming commonplace in a modern smart home to have several wireless devices used simultaneously, SCA may cause these homes to experience delays in performance, as each device must wait its turn for the ability to transmit.

SCA was a superior approach when multi-AP systems were first deployed and the demand for high-throughput on a wireless network was still low. However, advancements in AP technology, development of industry standards, and more intelligent client devices have rendered this approach inferior for performance in a modern smart home that includes many wireless devices.

MULTI-CHANNEL ARCHITECTURE

Multi-channel architecture (MCA) is a more robust wireless architecture that enables the client to see multiple access points throughout a home, as opposed to the “virtual AP” approach of SCA. This approach provides the client with the ability to connect to the best AP, rather than leaving the management of the AP connection to a wireless controller. MCA relies on non-overlapping wireless channels to minimize channel interference, reduce channel congestion, and ensure every connected device experiences optimal throughput.

MCA is the most commonly used wireless architecture deployed today, and enhancements to networking software have simplified the complexity related to channel planning and avoiding co-channel interference. One such software enhancement is auto-channel selection. With this feature, once the AP is powered on, it scans the environment to determine the best channel for its location. Auto-channel will typically run each time the AP is powered on, so it is best to disable this feature once you have completed a final site survey and validated network performance.

All Pakedge APs include auto-channel selection and come out of the box with power settings that balance the need for coverage while reducing the chance for co-channel interference. These default power settings also include granular 1 dBm steps to provide for the ability to fine-tune the transmit power, expanding or shrinking the coverage area.

UNDERSTANDING ROAMING TECHNOLOGY

Achieving a seamless roaming experience requires a multi-layered approach, beginning with the selection of the right networking equipment, and followed by good network design.

Quality networking hardware can provide the right foundation for a seamless roaming experience with the combination of support for industry standards and innovative technology to assist client devices.

STANDARDIZED ROAMING TECHNOLOGIES

Two key industry standards, IEEE 802.11r and IEEE 802.11k, have been developed to help a client device make a faster and more seamless transition between two APs. To be effective, these standards must be supported on both the client device and the AP. Many—but not all—of the most popular clients today support one or both of these standards. All Pakedge APs and the NK-1 support both of these standards.

IEEE 802.11r (also called *Fast Transition*):

> In a nutshell, 802.11r eliminates the traffic required to re-authenticate a client device when it connects to a new AP on the same network by storing the wireless encryption keys on all APs on the network. This mechanism dramatically reduces the time it takes to establish a strong connection to the network.

IEEE 802.11k (also called Radio *Resources Management*):

> With 802.11k, the AP provides client devices with a report of neighboring APs and the channels they are using. When the signal strength of the current AP weakens, the client device will scan the APs on this list, reducing the time it takes to find a good roaming candidate.

PROPRIETARY ROAMING TECHNOLOGIES

In addition to industry standards, some networking manufacturers, including Pakedge, have developed technologies unique to their hardware to assist in the roaming process. Where standards are helpful for client devices that support them, additional roaming technologies are typically designed to enhance the roaming experience for devices that don't roam well (the "sticky clients" noted above).

With Pakedge roaming technology, the AP monitors the receive signal strength indication (RSSI) for every client device. If the RSSI falls below the specified threshold, the client device is de-authenticated from the AP so that it can transition to a stronger AP. This feature is disabled by default, as it is useful only for devices that do not reliably disconnect on their own when the signal degrades.

PROPER WIRELESS DESIGN FOR OPTIMAL PERFORMANCE

As discussed earlier, proper wireless design is a critical component of achieving good roaming and overall solid network performance. AP placement and WiFi band overlap enable a client device to more clearly see all APs and communicate on channels that are not congested.

AP placement is the crucial first step in wireless deployment. Examples of a poorly designed wireless network may include APs that have been placed too close together or the AP transmit power levels have been set too high—both scenarios create too much overlap between APs, and a client device will struggle to connect to an AP with a stronger signal.

Another cause is the opposite problem, where the APs have been placed too far apart, and the client device is forced to disconnect entirely from the network and reconnect once in range of the new AP.

RESOURCES TO ASSIST IN WIRELESS DESIGN

Site survey

Pakedge APs and the NK-1 Wireless Controller deliver a built-in site survey tool that scans the RF environment, including WiFi and non-WiFi channels, from the vantage point of each AP. Site survey can be used to validate the channel selection, identify sources of interference, and determine if any modifications to the placement of the APs or to channel and power settings are needed.

RF Planner

The Pakedge NK-1 Wireless Controller offers a built-in wireless AP deployment tool that simulates wireless coverage on a given floorplan. Use this tool to model power settings and AP placement for any home.

Wireless Design Guide

The *Pakedge Wireless Design Guide* gives you step-by-step instructions for planning and deploying a wireless network. You can download it here.

Pakedge Certified Network Administrator (PCNA)

PCNA is a hands-on instructional course that covers all networking topics, with an entire chapter dedicated to wireless networking. Wireless topics include AP placement, site survey, channel planning, and more. Register for PCNA on the Dealer Portal.

pakedge®