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WLC/AP FUNCTION ORCHESTRATOR

Jerome Henry

Robert Barton

Indermeet Gandhi

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Jerome Henry
Robert Barton
Indermeet Gandhi

ABSTRACT

Dynamically positioning orchestration functions, which operate at the scale of a few Access Points (APs), to a cluster of APs maintains efficiency of operations as the number of functions and clusters increases. Especially in contrast to a deployment model in which all functions either operate at an individual AP or operate on the Wireless Local Area Network (LAN) Controller (WLC), positioning functions in limited clusters of APs optimizes compute load/time and message travel time between participants. This distributed type of structure becomes more effective as a WLC is pushed toward a cloud network deployment, where travel delay and scale may interfere with centralizing function operation at the WLC.

DETAILED DESCRIPTION

Some network infrastructure vendors implement flexible containers on their networking devices. These containers allow the vendor to position functions (e.g., firewalls, virtual routers, etc.) on the networking devices. With increasing frequency, the network devices may use these containers to host specific functions related to neighboring hardware devices. For instance, some vendors may host IEEE 802.15.4 (e.g., (Bluetooth Low Energy (BLE), Zigbee, etc.) gateways, Global Positioning System (GPS) trackers, Ultra-wideband (UWB) dongles, on wireless network (e.g., Wi-Fi) APs for which the function is relevant.

Typically, this type of local function may require central coordination. For example, a single AP often does not have enough GPS information from its attached tracker to determine its own location determination, and it may coordinate with other APs to determine its location. Additionally, IEEE 802.15.4 technologies like Thread require a proxy function above the gateway function, which is shared among several APs. UWB functions require an election of a primary anchor and time coordination between anchors and the APs. Typically, these functions are delegated to a central entity (e.g., a WLC). However, this centralized approach suffers from limitations in scale, delay, and complexity.

A modern WLC may manage up to six thousand APs, which may result in thousands of virtual zones and function-specific queries per second. Although a WLC is typically designed to handle Wi-Fi-related management functions at scale, the processing capability of a WLC may not easily scale for an artificially high number of other functions, which may only be relevant for a few APs. While a centralized design makes sense from a basic engineering standpoint (e.g., put all of the additional functions above the AP in the WLC), a marketing standpoint (e.g., advertising support for any type of dongle on an AP, and expecting the WLC to manage the cross-AP case), but does not make sense from a scale standpoint.

A centralized deployment of additional functions also adds delay when performing those functions that affect a few APs next to each other (e.g., forming a UWB cluster). These functions are now delegated to a WLC that may be several hops, adding seconds of transit time to every message. Functions that are designed to operate in real time are no longer able to meet that requirement, which forces designers of those functions to hedge their promises to “near” real time functionality.

In a complex deployment, an AP may play several roles (e.g., as a primary anchor in one UWB cluster, a secondary anchor in two other clusters, a Thread gateway while also sharing its GPS data, all in near real time). In a centralized system, the WLC may be required to manage one AP, but with five different entities and functions. Troubleshooting one UWB issue may include comparing the WLC task load for all other functions for that same APs. Handling the processing of complex functions at one AP may lead to competition for processing resources with the management of functions of all of the other APs that the WLC has to handle at the same time.

As more of these functions are added to network devices, there is a growing need for an orchestration function to bring these upper functions closer to the APs. This proposal presents a method to optimize the count and distribution of virtual functions in a wireless network. Figure 1 illustrates the initial setup for locating an orchestration function on an appropriate AP.

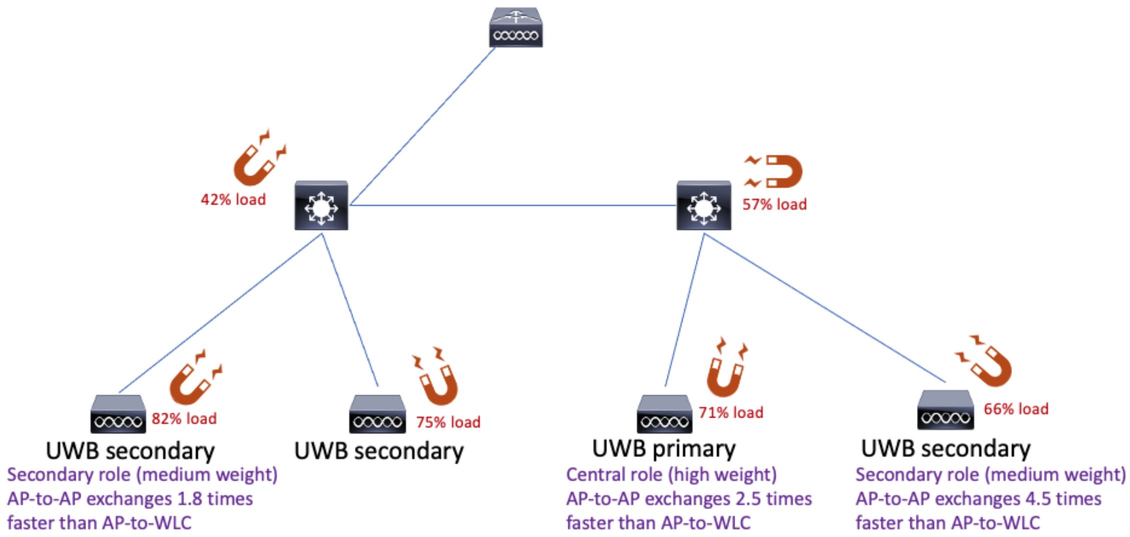

Figure 1 – Orchestration function pressure

Initially, all modules/functions are attached to APs. An upstream centralized management controller (e.g., a WLC) coordinates these functions. The controller establishes a traffic graph for each added function (e.g., GPS coordination, UWB, etc.) for each participating AP. Each branch of the graph is weighted with a time component, a traffic volume component and a compute component. The time component may be based on the ratio of the transit time between the AP and the WLC, and the transit time between the AP and the other participating APs for that function. The traffic volume component may be based on the amount of traffic exchanged between the AP and the other participating APs through the WLC. The compute component may be based on the amount of processing resources used by the WLC to support the function for the AP.

The weight associated with each AP acts as an attractor for an orchestration function. APs of higher weights have a more central role in the function (i.e., they have a higher volume/compute components), and are more likely to have the orchestration function near them. In contrast, the mean current traffic load, which may be related to the AP function and unrelated to the additional function, for each AP and node on the path acts as repulsor for the orchestration function. APs with higher loads (e.g., serving more clients and/or more traffic than other APs) push the orchestration function away.

The system reaches an equilibrium when the repulsive pressure of the traffic load balances the attraction weights, positioning the orchestration function as close to the APs as possible, but on the device where the function has least relative increase in function computation cost. The resulting location for the orchestration function minimizes the traffic flow outside the group of APs needing the function, and minimizes the time needed to exchange packets between participating APs. Figure 2 illustrates one example of the location selection for an orchestration function.

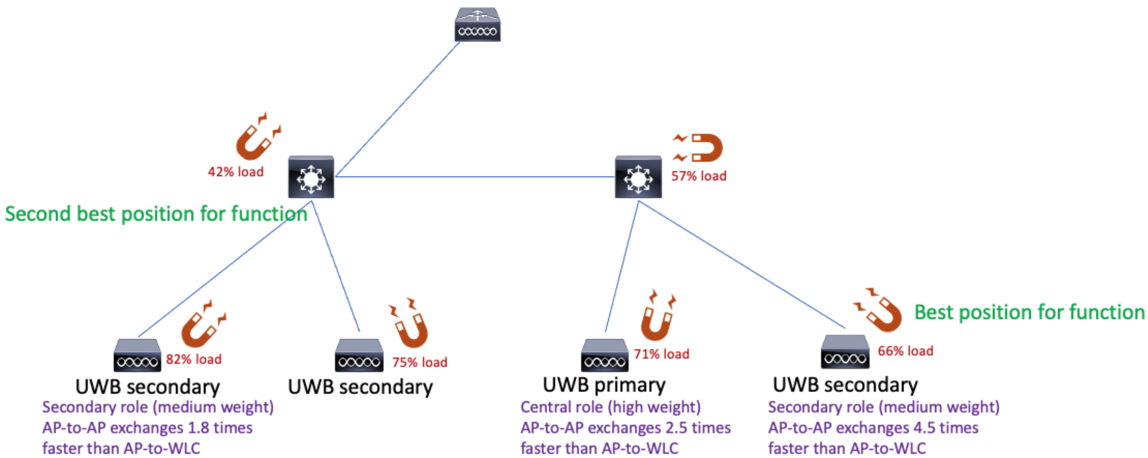

Figure 2 – Orchestration function location

Naturally, when more than one function needs to be deployed on a system of multiple APS, the method may simulate different scenarios to observe the conclusion of the multi-function deployment. The problem may in some cases be NP-hard, but convex optimization algorithms (e.g., artificial bee colony K-Means) can provide the convex solution.

In some cases, the repulsive pressure on all participating APs in a given cluster for a given function causes the WLC to conclude that no AP can host the orchestration function. The WLC then examines nodes on the path upstream from the APs with the same logic as above, to find the best location to host the orchestration function. In other cases, one AP surfaces as the best candidate, and the orchestration function is delegated to that AP. In some cases, no AP and no intermediate node can be found, and the orchestration function remains on the WLC. As conditions on the network change beyond a configurable threshold (e.g., AP mean loads, number and identity of participating APs to a given function, etc.), the position of the orchestration function may be recomputed to update the location of the orchestration function, while minimizing the effect on participating APs of moving the orchestration function.

One key characteristic of AP-related functions lies in the trend toward commoditization. Today, Wi-Fi is everywhere, and most vendors observe that, in any building on the planet, one can expect a Wi-Fi network providing adequate performance and coverage. The primary difficulty for all vendors is to differentiate their Wi-Fi network equipment from other vendors' equipment. Every vendor wants to claim the "best Wi-Fi 6 network." However, if the coverage and performance of the different network are good enough, then being "the best" is irrelevant.

Based on the commoditization of wireless networking equipment, vendors may begin to consider the network equipment for each Wi-Fi deployment as existing real estate, on which technical value can be built. Most large vendors start with the idea of adding modules that perform specific functions. As this art develops, new challenges emerge, because centralizing some of the AP Wi-Fi functions into a controller provides some advantages. However, centralizing added modules and services may or may not have advantages or disadvantages depending on the service, its scale, and the use case. Therefore, the industry is slowly inching toward this difficult question of organizing this overlay.

Accordingly, this proposal splits the management entity that typically resides at the WLC, by moving the orchestration function, but not the entire management entity, to a location that makes sense for each added module/service. Rather than adding virtual management entities at the centralized controller, this proposal distributes the orchestration function closer to the consumer of its services to improve efficiency without hurting the primary functions of the APs.