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IMPROVING DETERMINISM OF WIRELESS/WI-FI USING CRITICAL NETWORK PARAMETERS

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ABSTRACT

Techniques are described herein for improving wireless determinism by enhancing the Access Point (AP) join and client association processes. The AP join process may be enhanced by considering several factors to improve the determinism of wireless service. These factors include reliability, controller availability, network availability, and value-added services. Similarly, the client association process may also be enhanced by considering these factors to select a better AP / Service Set Identifier (SSID).

DETAILED DESCRIPTION

With each passing day, Wi-Fi adoption is ever increasing in various deployment areas including time critical and lifesaving applications. Hence it is essential for wireless/Wi-Fi® service to be more reliable and deterministic. The techniques described herein increase the reliability and performance of the Wi-Fi service and make it more deterministic. This may be achieved by ensuring the nodes involved in an end-to-end Wi-Fi network service abide by certain performance factors (PFs) while joining the upper nodes which provide Wi-Fi service.

In the context of Wi-Fi, currently Access Point (APs) join a Wireless Local Area Network (LAN) Controller (WLC) to get the managed service and clients (STAs) associate to APs for Wi-Fi service using only the basic criteria of “Load” and “Platform”. This results in a scenario of giving the same preference, irrespective of where they are deployed and what they are used for.

Described herein is a mechanism to consider certain critical parameters, PFs, and value-added services for APs to select and join to a WLC, and also for a STA to select and associate to a particular AP. These factors are designed and computed considering the reliability, controller availability, network availability, and value-added services which are essential for certain functionality. These criteria play a major role in enhancing the stability and performance of the system, and hence may increase determinism.

Wireless determinism may be improved by enhancing the AP join and client association processes.

As per the mechanism described herein, the AP may get the parameters from the WLCs as part of the joining process. In particular, with the Control and Provisioning of Wireless APs (CAPWAP) AP join mechanism, APs may broadcast discovery requests. WLCs may compute the PF from the critical parameters and send it along with the discovery response to the AP. Once the AP has the information from all the available WLCs, based on its "Usage Profile" it selects the controller of its choice.

Similarly, the critical Wi-Fi network preference factors deduced by the AP may be sent to STA/client before association using Access Network Query Protocol (ANQP), which is part of the 802.11u standard.

Figure 1 below illustrates the AP join mechanism.

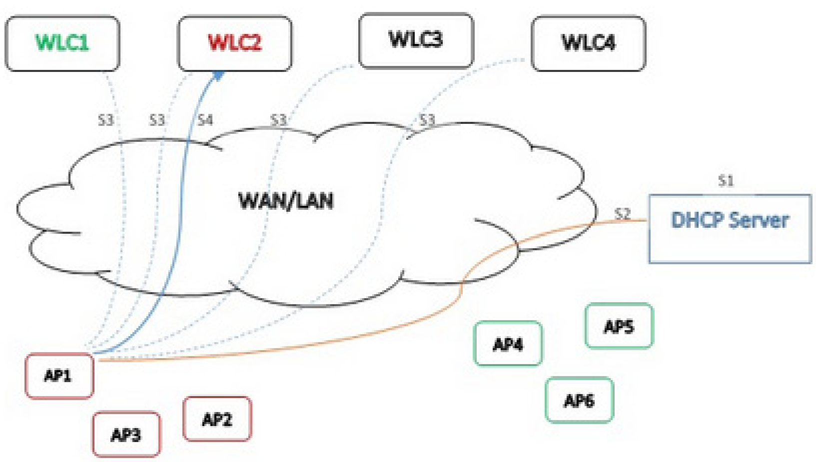

Figure 1

At the first step (S1), the administrator provisions an "AP usage profile" for AP1 on a Dynamic Host Configuration Protocol (DHCP) server based on the location where it is deployed (e.g., For a hospital "Lobby" area, Operation "theatre" area, etc.).

At the second step (S2), the AP gets an Internet Protocol (IP) address from the DHCP server. Along with the IP address, it also gets the "AP usage profile" as part of DHCP option 43, as provisioned by the administrator for that AP.

At the third step (S3), the AP sends a discovery request in its network. All the WLCs reply back with a discovery response. This response also contains critical PFs for the WLC.

At the fourth step (S4), by now the AP has PFs of all the WLCs and it computes its PF for each WLC based on its usage profile. The AP decides to join a WLC which has the maximum PF.

Figure 2 below illustrates a flow chart explaining the AP join considering the PFs.

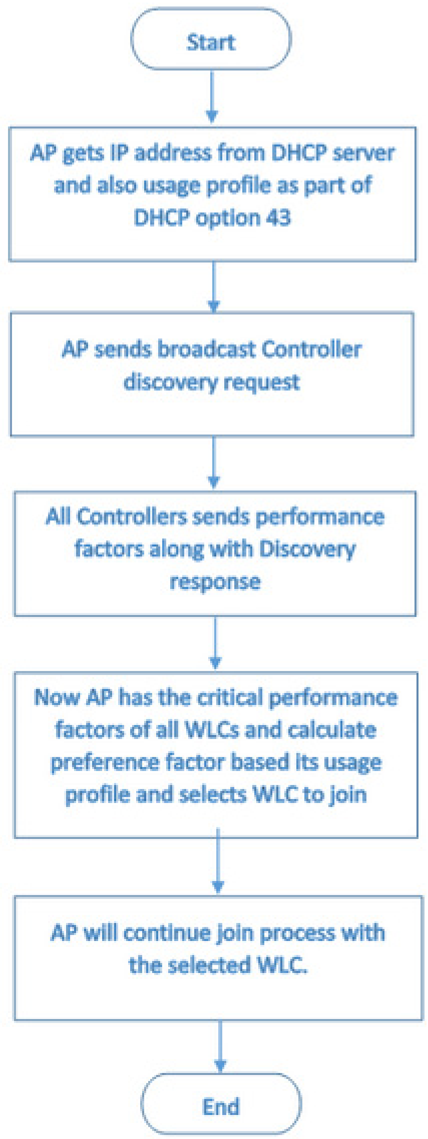

Figure 2

The AP Usage profile can be configured on the DHCP server as part of option 43 and sent to the AP in hex string format in the DHCP offer.

The AP usage profile characterizes the deployment and location of the AP. It represents the nature of applications that run on the client devices. Based on the type of the profile, priority for different parameters may vary.

The AP usage profiles may be of the general, critical, dense deployment, or media types. The general profile is the default profile for normal usage. The critical profile is used in critical applications where high availability is desired. The dense deployment profile is used for dense deployments. The media profile is used for media focused applications where strict Quality of Service (QoS) is desired.

An example syntax may be option 43 American Standard Code for Information Interchange (ASCII) "<type><length><Usage profile ID> <Value-Added services Bitmap>."

For "AP usage profile," the type may be 0xfb, the length may be four bytes, and the value may be specific to the usage profile and the required value-added services.

Figure 3 below illustrates example usage profiles and corresponding option 43 values.

Sno	Profile name	Option43 value
1	General (Default)	fb040104
2	Critical	fb040206
3	Dense	fb040308
4	Media	fb0404A0

Figure 3

PFs may be computed by the WLC and sent to the AP. These may be broadly divided into four categories: reliability, controller availability, network availability, and value-added services.

The following procedure explains the mechanism for calculating the factors on every controller when they share with the AP.

Reliability

Figure 4 below illustrates how this describes sub-features indicating the reliability of the controller.

Feature	Feature ID	Inversely Proportional	Min value of Feature (min_fx)	Max value of Feature (max_fx)	Weight of Feature (weight_fx)
Redundancy Support	1	No	1	7	0.4
Image Quality	2	No	1	5	0.1
Uptime	3	No	1	365	0.3
Crashes (In last 180 days)	4	Yes	0	5	0.2

Figure 4

As shown, the minimum-maximum range is provided. The weight of the feature in calculating the redundancy factor is also specified. "Inversely Proportional" may indicate whether the values of the factor are inversely proportional.

Figure 5 below illustrates the values for each of the features within redundancy support and image quality.

Redundancy Support	Value
No HA	1
Port Failover / LAG Enabled	2
N+1 HA	3
N+1 Port Failover / LAG Enabled	4
SSO	5
SSO + Gw Failover	6
SSO + Gw Failover + Port Failover / LAG	7
Image Quality	

Image Quality	Value
Development Image	1
Escalation Image	2
CCO Image	3
MR CCO Image	4
MD CCO Image	5
Uptime	

Figure 5

Uptime may indicate how long the WLC is up and running, and crashes may indicate whether any crashes have occurred within a period of time (e.g., the last 180 days), and if yes how many.

To get the redundancy factor, the weighted summation of these features may be required, as illustrated in Figure 6 below.

$$R = \sum_{f=1}^{n}[\text{Round}((((fx - min\_fx) / (max\_fx - min\_fx)) * weight\_fx)] + \sum_{f=1}^{m}[\text{Round}(\frac{c}{(((fy - min\_fy) / (max\_fy - min\_fy)) * weight\_fy)})]$$

Figure 6

Here, "f" is the feature set, "n" is the number of features which are not inversely proportional, "m" is the number of features which are inversely proportional, "c" is a constant (e.g., 1), and "R" is the redundancy factor.

Controller Availability

Figure 7 below illustrates controller availability in terms of resources.

Feature	Feature ID	Inversely Proportional	Min value of Feature (min_fx)	Max value of Feature (max_fx)	Weight of Feature (weight_fx)
Present AP Load	1	Yes	1	Max AP Supported	0.4
Present Client Load	2	Yes	1	Max Client Supported	0.3
Hardware Resources	3	No	1	4	0.2
AP Drops	4	Yes	1	100	0.1

Figure 7

The present AP load indicates the APs that are presently connected to the WLC. Its inverse provides the availability. The present client load indicates the present clients connected to the WLC. Its inverse also provides the availability. Hardware resources may be ranked 1-4 based on the type of hardware capability. AP drops indicates the number of AP drops that have occurred since the WLC went up.

To obtain the "Controller Availability" factor, the weighted summation of these features may be required, as illustrated in Figure 8 below.

$$C = \sum_{f=1}^{n}[\text{Round}((((fx - min\_fx) / (max\_fx - min\_fx)) * weight\_fx)] + \sum_{f=1}^{m}[\text{Round}(\frac{c}{(((fy - min\_fy) / (max\_fy - min\_fy)) * weight\_fy)})]$$

Figure 8

Here, "f" is the feature set, "n" is the number of features which are not inversely proportional, "m" is the number of features which are inversely proportional, "c" is a constant (e.g., 1), and "C" is the controller availability factor.

Network Availability

Figure 9 below illustrates network availability in terms of resources.

Feature	Feature ID	Inversely Proportional	Min value of Feature (min_fx)	Max value of Feature (max_fx)	Weight of Feature (weight_fx)
AP - WLC Network Type	1	No	1	2	0.2
WLC - DS Bandwidth Availability	2	No	1	100	0.5
RTT between AP to WLC	3	Yes	1	3000	0.3

Figure 9

AP to WLC network type indicates whether it is a Wide Area Network (WAN) link. WLC to Digital Signal (DS) bandwidth availability indicates the average availability of WLC bandwidth in terms of percentage. Round Trip Time (RTT) may be expressed as a number of milliseconds.

To obtain the "Network Availability" factor, the weighted summation of these features may be required as illustrated in Figure 10 below.

$$N = \sum_{f=1}^{n}[\text{Round}(\ (((fx - min\_fx)\ /\ (max\_fx - min\_fx))\ *\ weight\_fx)] + \sum_{f=1}^{m}[\text{Round}(\frac{c}{(((fy - min\_fy)\ /\ (max\_fy - min\_fy)) * weight\_fy)})]$$

Figure 10

Here, "f" is the feature set, "n" is the number of features which are not inversely proportional, "m" is the number of features which e inversely proportional, "c" is a constant (e.g., 1), and "N" is the network availability factor.

A decision may be made based on these factors. The WLC may send factors "R," "C," and "N." The AP may obtain the usage profile from the DHCP server during IP address allocation. The AP may obtain these values and calculate the Preference Factor (PF) for a given WLC. Here, PF = (R * x) + (C * y) + (N * z), where "x," "y," and "z" are the values based on the usage profile at the AP.

Figure 11 below illustrates different usage profiles and weights for each profile.

Usage Profile	Reliability	Network Availability	Controller Availability
Default	0.2	0.4	0.4
Critical	0.5	0.2	0.3
Media	0.2	0.5	0.3
Dense	0.1	0.4	0.5

Figure 11

The AP may calculate the PF for each controller. The AP may join the WLC having the higher PF value.

The critical Wi-Fi network PFs deduced by the AP may be sent to the STA/client before association using ANQP. Clients may send ANQP request packets over Layer 2 (L2) wireless transport to all the neighboring APs before association. APs may send the ANQP response packet to the client with the capability and PFs as part of vender specific IE in the ANQP response. Client logic in the firmware may select the best AP / Basic Service Set Identifier (BSSID) and associate with the same.

Figure 12 below illustrates the client join mechanism considering the PFs.

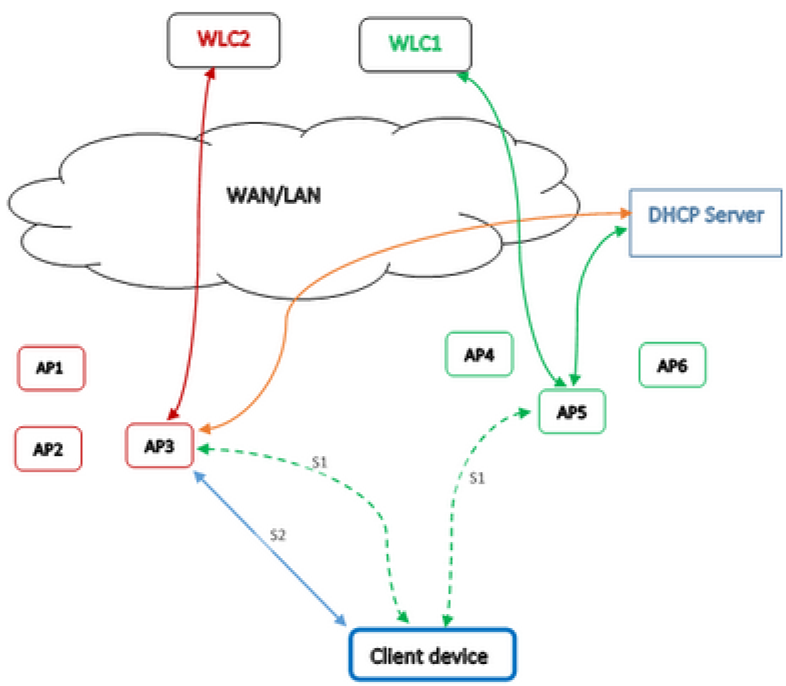

Figure 12

At the first step (S1), the Wi-Fi client device communicates with the APs in its vicinity and queries for the critical parameters and preference factor.

At the second step (S2), the client may select the AP based on either the PF or individual critical parameters based on its implementation.

Figure 13 below illustrates a flow chart explaining the client join sequence.

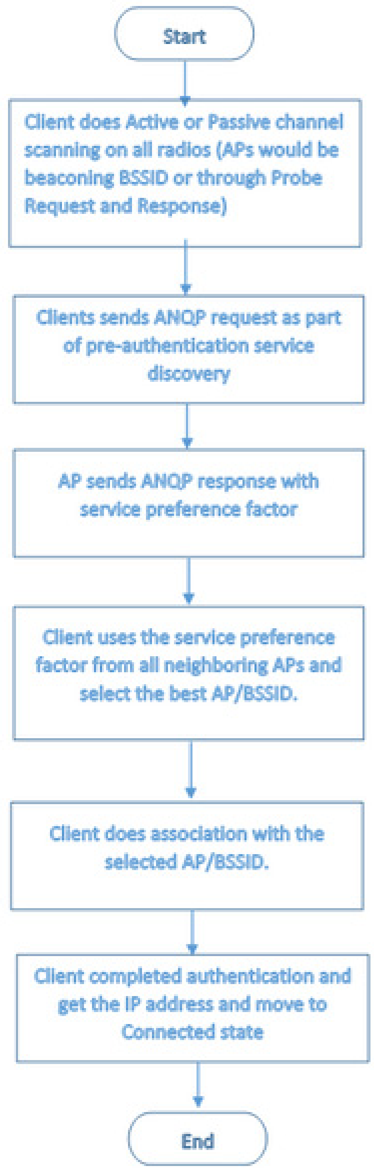

Figure 13

The mechanism described herein may become significant especially with large deployments. For example, in a deployment such as a hospital, APs installed in the Operation theatre may require a more reliable service than APs deployed in Lobby area. This mechanism helps APs to select a suitable WLC to get the required service. For deployments such as Mining and Warehouses, reliability is more important for the continuous functioning of the system. This mechanism helps in these scenarios as well.

Moreover, in Internet of Things (IoT) based devices and deployments, network availability is essential. This mechanism helps in these scenarios to configure and prioritize network availability parameters. Locations such as Malls and Airports have the presence of more than one service provider. Client devices in these locations may make use of these PFs to select a better service provider and hence service.

In summary, techniques are described herein for improving wireless determinism by enhancing the AP join and client association processes. The AP join process may be enhanced by considering several factors to improve the determinism of wireless service. These factors include reliability, controller availability, network availability, and value-added services. Similarly, the client association process may also be enhanced by considering these factors to select a better AP / Service Set Identifier (SSID).