University of New Hampshire
InterOperability Laboratory

WLAN Consortium

Wi-Fi IoT Test Suite Summary

Version 1.0

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REVISION HISTORY

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1.0	10/08/2024	Stella La Vallee	Initial Version.

INTRODUCTION

Overview

This test plan is intended to test internet of things (IOT) and medical devices in a large range of situations and environments. This test suite will give reassurance that a device can operate as intended and recover from situations including common network failures and environmental interference.

Definitions

The following terms are used throughout this document:

AP	Access Point
DUT	Device Under Test
LTS	Long Term Stability
PTL	Packet Throughput Loss
RSSI	Received Signal Strength Indicator
STA	Station

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1. Baseline Performance

1.1 Maximum Throughput Test (iPerf)

Establishes the throughput of the DUT over an ideal channel (i.e. a short distance). This evaluates the DUT's throughput in an optimal environment.
Results from this test are informational only. The results of this test will be used as a baseline measurement for later test sections.
Requirements:
The DUT must be able to run iPerf.

1.2 Impaired Signal Throughput Test (iPerf)

Measures the maximum throughput performance of the DUT over a suboptimal channel (i.e. a low received signal strength or further distance). This evaluates the DUT's throughput in a suboptimal environment. Results from this test are informational only.
Requirements:
The DUT must be able to run iPerf.

1.3 Bidirectional Throughput Test (iPerf)

Measures the uplink and downlink throughput achieved simultaneously through the DUT and an AP. Results from this test are informational only.
Requirements:
The DUT must be able to run iPerf.
Test section 1.1 (Maximum Throughput Test) must be run prior to this test section.

2. Coverage

2.1 Range Test

Simulates an increasing distance as the DUT moves away from an AP, while observing data packets sent, retransmissions, and the RSSI at the wireless link transmitted by the DUT. The data packets will be recorded in the wireless capture. The test is designed to provide information of how the DUT performs sending data at increasing attenuations. Results from this test are informational only.
Application:
For any scenario where the DUT is not stationary, such as a handheld, cable-less device, the Range Test will give insights into how far away the DUT can be from an AP before losing connection and the ability to receive and send data.

2.2 Range Versus Rate Test (iPerf)

Measure the baseband and RF chain performance of a Wi-Fi device. The attenuation of signals due to range increase is achieved by using an attenuator between the DUT and the AP. The increase of attenuation can approximate the distance between the DUT and AP, according to

the freespace loss for the given band (i.e. 2.4GHz or 5GHz). This assumes a line-of-sight channel between the DUT and AP. Results from this test are informational only.
Requirements:
The DUT must be able to run iPerf.

2.3 Range Versus Round Trip Time Test
Measure performance of a Wi-Fi device as attenuation increases in regards to the Round Trip Time (RTT). The attenuation of signals due to range increase is achieved by using an attenuator between the DUT and the AP. The increase of attenuation can approximate the distance between the DUT and AP, according to the freespace loss for the given band (i.e. 2.4GHz or 5GHz). This assumes a line-of-sight channel between the DUT and AP. Results from this test are informational only.

2.4 Spatial Consistency for Throughput Test (iPerf)
Intends to verify that the throughput pattern of the DUT is consistent (omnidirectional). This is achieved across a single plane, using directional antennas within the test setup, while rotating the DUT relative to the antenna. Results from this test are informational only.
Requirements:
The DUT must be able to run iPerf.
Application:
For any device without directional antennas, it is important to determine how well the DUT is able to receive signal from all sides of the DUT. For some devices, perfect omni-directionality may not be necessary, but for many devices (for example, a mobile device), consistent directional signal reception may be intended (or expected). This test helps determine how well the DUT can receive signals from all directions.

2.5 Spatial Consistency for RSSI Test
Intends to verify that the RSSI pattern of the DUT is consistent (omnidirectional). This is achieved across a single plane, using directional antennas within the test setup, while rotating the DUT relative to the antenna. Results from this test are informational only.
Application:
See Section 2.4 (Spatial Consistency for Throughput).

3. Congested Network

3.1 Saturated Network Test
Simulates a case where the DUT is introduced to a continuously more saturated wireless environment by adding additional STAs over time. This test is designed to identify how the DUT can perform when placed in a saturated wireless environment. Up to 32 additional wireless stations will be placed in the same wireless environment as the DUT. This test can help identify problems a DUT may have in a congested wireless network. Results from this test are informational only.
Application:

The results of this test are applicable in any scenario where the network environment would be congested to any degree. For example, a hospital is an environment with a large number of devices, from medical devices to visitor devices, all which require network connection. This test helps ensure that the DUT would be able to maintain connectivity in any sort of busy environment, such as a hospital.

3.2.1 Baseline Initial AP Selection Test

Evaluates how the DUT is associating with an AP at initial startup when more than one AP is available. Results from this test are informational only.

3.2.2 802.11k Initial AP Selection Test

802.11k helps optimize the wireless network by providing a client device with network usage information that the client uses when deciding which AP to roam to. This improves the overall efficiency of the network, encourages a better balance in the utilization of the APs, and reduces interference. This test evaluates if the DUT is able to make an informed decision on which AP to roam to using the features of 802.11k. We provide the DUT with one AP (AP-1) that has 32 STAs associated with it (highly saturated), and one AP (AP-2) that has no traffic.

This test evaluates if the DUT is able to utilize the improvements of 802.11k and choose to associate with an AP that is underutilized instead of one that is overutilized, even if the underutilized AP has a somewhat weaker signal strength. In order to be successful, the DUT shall associate with the AP that has no traffic in each iteration of the test.

Requirements:

Test Section 3.2.1 (Baseline Initial AP Selection) must be run prior to this test section.

4. Power Usage

4.1.1 Baseline Power Usage Test (For further study)

This test is conducted to provide a baseline for how a device's power usage performs when 802.11v is not enabled. Results from this test are informational only.

4.1.2 802.11v Power Usage Test(For further study)

Determines how a device's power usage performs when 802.11v is enabled. The time between messages will increase due to less use of the radio. This will cause less power used to power the radio, resulting in power savings. Results from this test are informational only.

Requirements:

Test section 4.1.1 (Baseline Power Usage Test) must be conducted prior to this test section.

5. Roaming

5.1 Basic Roaming Test (iPerf optional)

Simulates a roaming case where the DUT physically moves from one AP towards another AP on the same network, while observing data packets, retransmissions and RSSI at the wireless link transmitted by the DUT. The data packets will be recorded from the wireless capture.This test is designed to identify when the DUT roams from one AP to the other AP.

Requirements:

Baseline roaming must be run with 802.11v/k/r protocol disabled.

Application:

The results of this test are applicable in any scenario where the DUT is moving physical locations in and out of the range of an AP. For example, physically walking from one room to another while holding the DUT.

5.1.1 802.11v Roaming Test (iPerf optional)

This test, once compared to the baseline Basic Roaming Test (Test Section 5.1), will show if the DUT is able to utilize the improvements to roaming time implemented by the 802.11v protocol.

Requirements:

Test section 5.1 (Basic Roaming Test) must be conducted prior to this test section.

5.1.2 802.11k Roaming Test (iPerf optional)

This test, once compared to the baseline Basic Roaming Test (Test Section 5.1), will show if the DUT is able to utilize the improvements to roaming time implemented by the 802.11k protocol.

Requirements:

Test section 5.1 (Basic Roaming Test) must be conducted prior to this test section.

5.1.3 802.11r Roaming Test (iPerf optional)

This test, once compared to the baseline Basic Roaming Test (Test Section 5.1), will show if the DUT is able to utilize the improvements to roaming time implemented by the 802.11r protocol. In order to be successful, the duration the DUT requires to roam in the 802.11r Roaming Test shall be less than the baseline result reported by the Baseline Roaming Test.

Requirements:

Test section 5.1 (Basic Roaming Test) must be conducted prior to this test section.

5.2 Long Term Roaming Test (iPerf optional)

Simulates a roaming case where the DUT physically moves from one AP towards another AP on the same network, repeatedly, over a long period of time, while observing data packets, retransmissions and RSSI at the wireless link transmitted by the DUT. The data packets will be recorded from the wireless capture.

This test is designed to identify if the DUT can roam from one AP to the other AP and back multiple times. In order to be successful, the DUT shall roam from one AP to the other AP during each iteration.

Requirements:

If the device supports iPerf, Test section 1.1 (Maximum Throughput Test) must be run prior to this test section.

5.3 Roaming Between Protocols Test (iPerf optional)

Simulates a roaming case where the DUT physically moves from one AP towards another AP on the same network but the APs support different standards (e.g. 802.11ax and 802.11ac). It is expected that the DUT will be capable of roaming across protocols. In order to be successful, the DUT shall roam from one AP to the other AP in each iteration.

5.4 Roaming Event Duration Test (iPerf)

Simulates a roaming case where the DUT moves continuously from one AP towards another AP on the same network. The duration the DUT takes to roam from AP to another is measured.

This test is designed to identify the amount of time that the DUT takes for a roaming event from one AP to the other AP. Results from this test are informational only.

6. Failure/Change Tolerance

6.1 Failover Roaming Test

Measures the DUT's ability to establish reliable connectivity with a secondary AP after the primary AP experiences a failure. In order to be successful, the DUT shall establish connectivity with AP2 after the failure of AP1.

6.2 DUT Configuration Change Test (iPerf optional)

This test observes the behavior of the DUT in the event that a configuration setting on the DUT was changed while the DUT was in use. This test will determine how quickly the DUT is able to recover from and apply the configuration change, and how that change affects the DUT's ability to send/receive packets. In order to be successful, the DUT shall either reassociate to the AP after the configuration change, or never lose connectivity to the AP.

Requirements:

This test requires the ability to change DUT configuration settings remotely (not on the physical DUT).

If the device supports iPerf, Test Section 1.1 (Maximum Throughput Test) must be conducted prior to this test section.

Application:

The results of this test are applicable in a scenario where a technician or other person with access to the DUT changes a configuration such as the bandwidth on the DUT.

6.3 AP Configuration Change Test (iPerf optional)

This test observes the behavior of the DUT in the event that a configuration setting on the AP was changed while the DUT was in use. This test will determine how quickly the DUT is able to recover from the AP's configuration change, and how that change affects the DUT's ability to send/receive packets. In order to be successful, the DUT shall either reassociate to the AP after the configuration change, or never lose connectivity to the AP.

Requirements:

This test requires the ability to change AP configuration settings remotely (not on the physical AP)

If the device supports iPerf, Test Section 1.1 (Maximum Throughput Test) must be conducted prior to this test section.

Application:

The results of this test are applicable in a scenario where a technician or other person with access to the AP changes a configuration such as the channel on the AP. Regardless of if this was intentional or unintentional, this test will show the DUT's behavior in this circumstance.

6.4 DUT Power Loss Test

This test observes the behavior of the DUT in the event that the power cable to the DUT would be unplugged, and then plugged back in. This test will determine how quickly the DUT is able to recover from its power failure and begin sending/receiving packets again. In order to be successful, the DUT shall reassociate to the AP after the DUT loses and regains power. Other measurements gathered during this test are informational only.

Application:

The results of this test are applicable in a scenario where the DUT is unintentionally unplugged, there is a partial power outage, or the DUT loses power for any other reason. This test will show the DUT's behavior in this circumstance.

6.5 AP Power Loss Test

Measures the DUT's ability to reestablish reliable connectivity with the AP after the AP experiences a power failure. In order to be successful, the DUT shall successfully reestablish connectivity with the AP after it experiences a power failure. Other measurements gathered during this test are informational only.

Application:

The results of this test are applicable in a scenario where the AP is unintentionally unplugged, there is a partial power outage, or the AP loses power for any other reason. This test will show the DUT's behavior in this circumstance.

6.6 AP Connection Loss Roam Test

This test observes the behavior of the DUT in the event that the ethernet cable to the AP is unplugged (and plugged back in). This test evaluates the length of time that the DUT does not send data for, as well as the percent of packets that are lost during the iteration.

Application:

The results of this test are applicable in a scenario where the AP the DUT was initially associated with loses connection to the network. This could be because the AP was unintentionally unplugged. This test shows the behavior of the DUT in this circumstance.

7. Stability

7.1 Long Term Stability Test (iPerf)

Measures the DUT's ability to handle heavy user loads over long periods of time. The DUT must maintain a stable connection for the duration of the test without significant drops in throughput. In order to be successful, the PTL shall not exceed 1E-2 in any iteration, and the DUT must maintain connectivity for the duration of the test.

Requirements:

The DUT must be able to run iPerf.

Test section 1.1 (Maximum Throughput Test) must be conducted prior to this test section.

Application:

For any DUT that will be expected to transmit/function over a long period of time, the Long Term Stability Test will help ensure that the DUT is able to maintain a stable connection. For example, a monitoring device may need to be running for many hours at a time in order to monitor a patient, and this test will help show the DUT's behavior in this circumstance.

7.2 Impaired Signal Long Term Stability Test (iPerf)

Measures the DUT's ability to handle user loads over long periods of time with a significantly impaired signal. The DUT must maintain a stable connection for the duration of the test without significant drops in throughput. In order to be successful, the PTL shall not exceed 1E-2 in any iteration, and the DUT must maintain connectivity for the duration of the test.

Requirements:

The DUT must be able to run iPerf.

Test section 7.1 (Long Term Stability Test) (and therefore section 1.1: Maximum Throughput Test) must be run prior to this test section.

Application:

For any DUT that will be expected to transmit/function over a long period of time, it is important to ensure that the DUT will be able to maintain connectivity even in a suboptimal environment. Many real-world environments are less than ideal, so understanding how the DUT performs in these environments is essential.

7.3 Variable Signal Long Term Stability Test (iPerf)

Measures the DUT's ability to handle user loads over long periods of time with significant changes in signal strength. The DUT must maintain a stable connection for the duration of the test without significant drops in throughput. In order to be successful, the PTL shall not exceed 1E-2 in any iteration (if the DUT supports iPerf), and the DUT must maintain connectivity for the duration of the test.

Requirements:

If the device supports iPerf, Test section 7.2 (Impaired Stability Test) (and therefore section 7.1: Long Term Stability Test and test section 1.1: Maximum Throughput Test) must be run prior to this test section.

Applications:

For any DUT that will be expected to transmit/function over a long period of time, it is important to understand how the DUT will perform over ideal and suboptimal conditions, but also how it will perform in variable conditions. With this test, we simulate a wireless environment where the signal strength is constantly changing, in order to observe how the DUT responds to a changing environment.