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University of New Hampshire
**InterOperability
Laboratory**

Wireless Group
802.11 Interoperability
Version 1.1

TECHNICAL DOCUMENT

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REVISION HISTORY

REVISION	DATE	AUTHOR	EXPLANATION
1.0	August 2022	Sara Overhulser Sriyam Rimal	Initial Version
1.1	December 2022	Craig Chabot Sriyam Rimal	Formatting changes Multiple Station Test added

ACKNOWLEDGEMENTS

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Sriyam Rimal	University of New Hampshire InterOperability Laboratory
Craig Chabot	University of New Hampshire InterOperability Laboratory

INTRODUCTION

Overview

The University of New Hampshire's InterOperability Laboratory (UNH-IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard.

Note that successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other compliant devices. However, combined with satisfactory operation in the UNH-IOL's interoperability test bed, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function well in most environments.

Organization of Tests

The tests contained in this document are organized to simplify the identification of information related to a test and to facilitate the actual testing process. Each test contains an identification that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Tests are grouped in order to reduce setup time in the lab environment.

Each test contains the following information:

- **Test Number**

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

- **Purpose**

The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level. The section may also cover the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here.

- **References**

The references section lists cross-references to the IEEE 802.1x and 802.11 standards and other documentation that might be helpful in understanding and evaluating the test results.

- **Resource Requirements**
The requirements section specifies the test hardware and/or software needed to perform the test. This is generally expressed in terms of minimum requirements, however in some cases specific equipment manufacturer/model information may be provided.
- **Discussion**
The discussion covers the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here.
- **Test Configuration & Setup**
The setup section describes the initial configuration of the test environment. Small changes in the configuration may be included in the test procedure.
- **Procedure**
The procedure section of the test description contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing and may be interspersed with observable results.
- **Observable Results**
This section lists the specific observables that can be examined by the tester in order to verify that the DUT is operating properly. When multiple values for an observable are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is often based on the successful (or unsuccessful) detection of a certain observable.
- **Possible Problems**
This section contains a description of known issues with the test procedure, which may affect test results in certain situations. It may also refer the reader to test suite appendices and/or whitepapers that may provide more detail regarding these issues.

Definitions

The following terms are used throughout this document:

AP	Access Point
STA	Station, a device that connects to a wireless network
DUT	Device Under Test
Downlink	Traffic from the AP to the STA
Uplink	Traffic from the STA to the AP

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TEST SETUP & CONFIGURATION

This section provides general information about test setups, configurations, and other information that may be common across the test plan. Individual test cases may include additional information, changes, or diagrams, as required for the specific test case.

Physical Test Setup

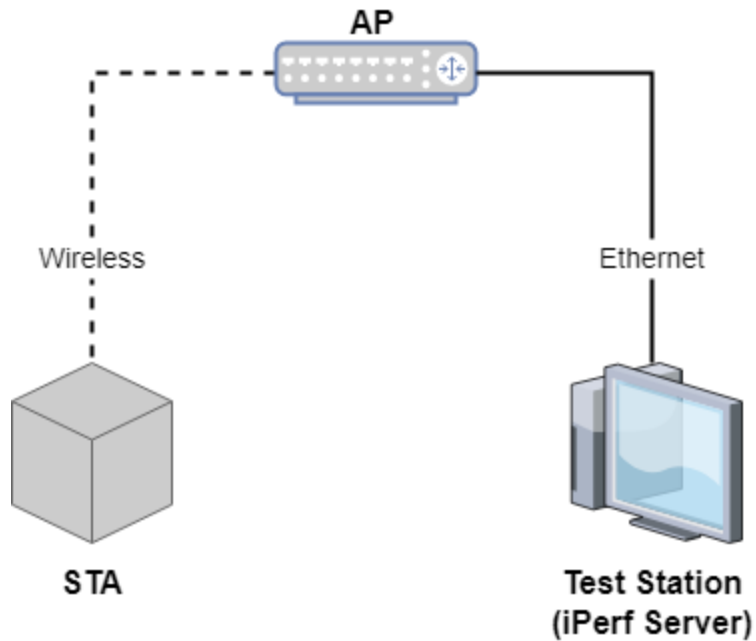


Figure 1: Physical Test Setup

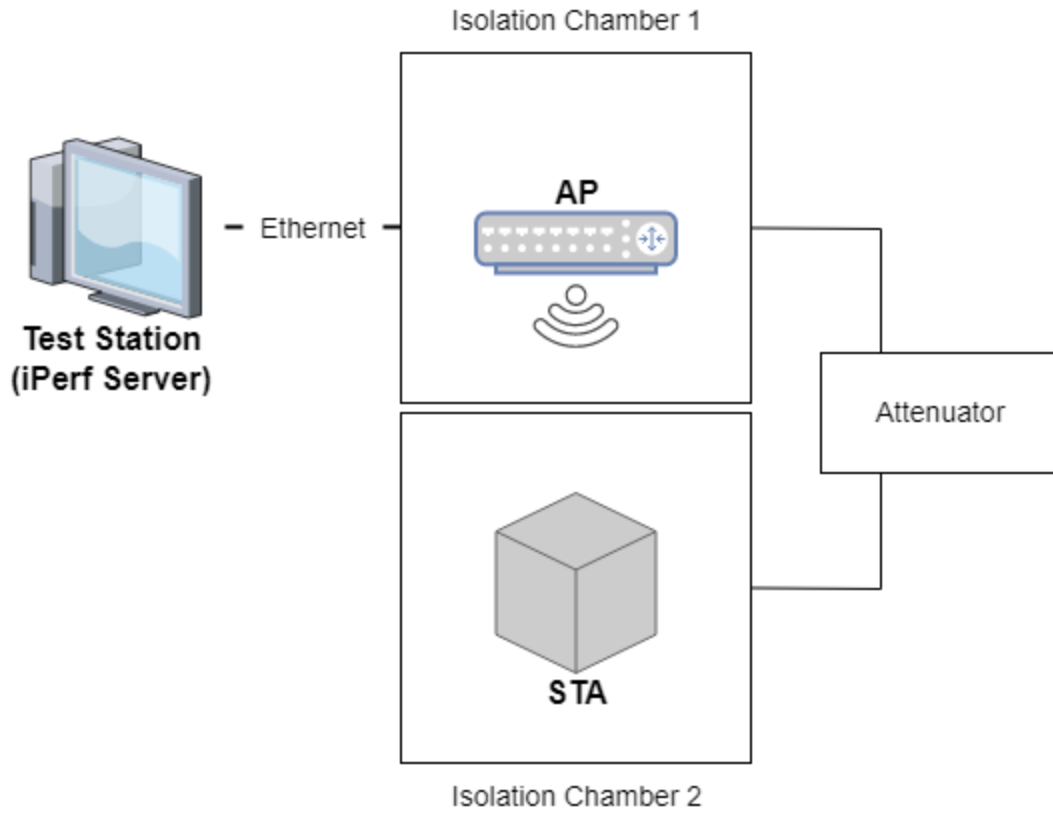


Figure 2: OctoBox Physical Test Setup

Baseline Access Point Configuration

All tests are run with the AP in its default “out of box” 802.11 mode, spatial streams, and bandwidth settings, and the network configurations shown below.

Table A: Baseline Access Point Configuration for 2.4GHz Band

2.4 GHz			
SSID	Channel	Security Type	PSK
UNH-IOL_Interop_2.4G	6	WPA2/WPA3	wireless

Table B: Baseline Access Point Configuration for 5GHz Band

5 GHz			
SSID	Channel	Security Type	PSK
UNH-IOL_Interop_5G	36	WPA2/WPA3	wireless

Baseline Station Configuration

All tests are run with the STA in its default “out of box” configuration.

Interop Partners

This test plan can be performed from the perspective of either the AP or STA acting as the DUT. Multiple Interop Partners will be chosen to test against the DUT. Ideally, they will be chosen in order to reflect a diverse set of 802.11 standards support including “legacy” 802.11abgn standards and varying Spatial Stream configurations. The selection of a diverse set of Interop partners will provide a more exhaustive set of 802.11 Interoperability Scenarios to be tested without the need to artificially configure Interop Partners and the DUT itself below its highest capabilities. Additional configurations of Interop Partners may be tested at request.

1. Interoperability Tests in 2.4GHz

1.1 Channel Test in 2.4GHz

Purpose:

The Channel Test verifies the DUT's ability to authenticate and pass traffic across different operational channels in the 2.4GHz band.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table A.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can successfully pass traffic across a variety of operating channels. The DUT is required to pass traffic for channels 1, 6, and 11, an additional channel chosen randomly between 2 - 5 and 7 - 10 as well as channels 12 and 13 if supported by the device and Interop Partners. Channel 14 will only be tested at the request of the vendor. Additional channels may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 1.1.1: Test Configurations for Channel Test

Configuration	Channel
a	1
b	6
c	11
d	2-5, 7-10 *
e	12
f	13
<i>g</i>	<i>14</i>
<i>Italicized configurations are optional * A random channel within these ranges will be selected</i>	

Procedure:

1. Set the AP's channel as indicated in configuration A of Table 1.1.1.
2. Instruct the STA to authenticate and associate with the AP.
3. Send ICMP Echo requests from the Ethernet Test Station to the STA and confirm that ICMP Echo replies are received.
4. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
5. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
6. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
7. Repeat steps 2-6 using all remaining configurations in Table 1.1.1.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully across all tested channels.

1.2 Security Type Test in 2.4GHz

Purpose:

The Security Type Test verifies the DUT's ability to authenticate and pass traffic through various security types. It is assumed that if the DUT can pass traffic then it can successfully authenticate on the configured security type.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table A.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can authenticate and pass traffic through multiple security types. The DUT is required to pass traffic for all tested security types. WPA3 will only be tested at the request of the vendor. Additional security types may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 1.2.1: Test Configurations for Security Test

Configuration	Security Type
a	Open
b	WPA2-PSK
c	<i>WPA3-PSK</i>
<i>Italicized configurations are optional</i>	

Procedure:

1. Modify the AP network settings with Open Security per configuration A in Table 1.2.1.
2. Instruct the STA to authenticate and associate with the AP.
3. Send ICMP Echo requests from the Ethernet Test Station to the STA and confirm that

ICMP Echo replies are received.

4. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
5. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
6. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
7. Repeat steps 2-6 using configuration B and C in Table 1.2.1.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully across all tested security types.

1.3 Multiple Station Test in 2.4GHz

Purpose:

This test verifies the DUT's ability to authenticate, associate and pass traffic with multiple Stations present on the wireless network.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table A.
- Two STAs that are capable of running iPerf.

Discussion:

This test verifies that the DUT can authenticate and pass traffic with multiple wireless Stations present on the Network. In the case that the DUT is an AP, two of the STA Interop Partners are chosen as STA1 and STA2. In the case that the DUT is a STA, it is treated as STA1 and an additional STA is chosen as STA2.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on STA1, STA2, and the Ethernet Test Station.

Procedure:

1. Instruct STA1 to authenticate and associate with the AP.
2. Send ICMP Echo requests from the Ethernet Test Station to STA1 and confirm that ICMP Echo replies are received.
3. Run 60 seconds of downlink TCP traffic through the AP to STA1 and record the throughput.
4. Run 60 seconds of uplink TCP traffic from STA1 to the Ethernet Test Station and record the throughput.
5. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA1 and record the throughput.
6. Instruct STA2 to authenticate and associate with the AP.
7. Send ICMP Echo requests from the Ethernet Test Station to STA1 and STA2 and confirm that ICMP Echo replies are received.
8. Run 60 seconds of downlink TCP traffic through the AP to STA1 and STA2 simultaneously and record the throughput.

9. Run 60 seconds of uplink TCP traffic from STA1 and STA2 to the Ethernet Test Station and record the throughput.
10. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA1 and STA2 and record the throughput.
11. Instruct STA1 to deauthenticate and disassociate with the AP.
12. Send ICMP Echo requests from the Ethernet Test Station to STA2 and confirm that ICMP Echo replies are received.
13. Run 60 seconds of downlink TCP traffic through the AP to STA2 and record the throughput.
14. Run 60 seconds of uplink TCP traffic from STA2 to the Ethernet Test Station and record the throughput.
15. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA2 and record the throughput.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully with and without multiple STAs present throughout the entire procedure.

1.4 Range Versus Rate Test in 2.4GHz

Purpose:

The Range Versus Rate Test verifies the DUT's ability to authenticate and pass traffic using the AP and the DUT's factory default state. The range will be achieved through attenuation to approximate distance between the AP and the DUT. Note, this total attenuation includes both the "air-gap" between the STA and the test setup antennas, as well as the additional attenuation inserted by the programmable attenuator.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default "out of box" state with network configuration shown in Table A.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can achieve throughput traffic after resetting the AP & STA, and preserving those settings for the duration of the test section. Additional attenuations may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 2
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 1.4.1: Test Configurations for Range Test

Configuration	Attenuation (dB)
a	0
b	10
c	20
d	30
e	40
f	50

Procedure:

1. Modify the attenuation as indicated in configuration A of Table 1.4.1.
2. Instruct the STA to authenticate and associate with the AP.
3. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
4. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
5. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
6. Repeat steps 2-5 using attenuation configurations B-F.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully unless the attenuation level prevents traffic from passing successfully.

2. Interoperability Tests in 5GHz

2.1 Channel Test in 5GHz

Purpose:

The Channel Test verifies the DUT's ability to authenticate and pass traffic across different operational channels in the 5GHz band.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table B.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can successfully pass traffic across a variety of operating channels. The DUT is required to pass traffic for channels 36, 149, and 165 if supported by the device. Channels 52 and 188 will only be tested on vendor request. Additional channels may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 2.1.1: Test Configurations for Channel Test

Configuration	Channel
a	36
<i>b</i>	<i>52</i>
c	149
d	165
<i>e</i>	<i>188</i>
<i>Italicized configurations are optional</i>	

Procedure:

1. Set the AP's channel as indicated in configuration A of Table 2.1.1.
2. Instruct the STA to authenticate and associate with the AP.
3. Send ICMP Echo requests from the Ethernet Test Station to the STA and confirm that ICMP Echo replies are received.
4. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
5. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
6. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
7. Repeat steps 2-6 using all remaining configurations in Table 2.1.1.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully across all tested channels.

2.2 Security Type Test in 5GHz

Purpose:

The Security Type Test verifies the DUT's ability to authenticate and pass reasonable traffic through various security types. It is assumed that if the DUT can pass traffic then it can successfully authenticate on the current security type.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table B.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can authenticate and pass traffic through multiple security types. The DUT is required to pass traffic for all tested security types. WPA3 will only be tested at the request of the vendor. Additional security types may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 3.1.1: Test Configurations for Security Test

Configuration	Security Type
a	Open
b	WPA2
c	<i>WPA3</i>
<i>Italicized configurations are optional</i>	

Procedure:

1. Modify the attenuation as indicated in configuration A.
2. Instruct the STA to authenticate and associate with the AP.
3. Send ICMP Echo requests from the Ethernet Test Station to the STA and confirm that

ICMP Echo replies are received.

4. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
5. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
6. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
7. Record throughput from the DUT to ensure successfully passed traffic to the STA.
8. Repeat steps 1-7 using configuration B.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully.

2.3 Multiple Station Test in 5GHz

Purpose:

This test verifies the DUT's ability to authenticate, associate and pass traffic with multiple Stations present on the wireless network.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default “out of box” state with network configuration shown in Table B.
- Two STAs that are capable of running iPerf.

Discussion:

This test verifies that the DUT can authenticate and pass traffic with multiple wireless Stations present on the Network. In the case that the DUT is an AP, two of the STA Interop Partners are chosen as STA1 and STA2. In the case that the DUT is a STA, it is treated as STA1 and an additional STA is chosen as STA2.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 1.
2. Prepare iPerf on STA1, STA2, and the Ethernet Test Station.

Procedure:

1. Instruct STA1 to authenticate and associate with the AP.
2. Send ICMP Echo requests from the Ethernet Test Station to STA1 and confirm that ICMP Echo replies are received.
3. Run 60 seconds of downlink TCP traffic through the AP to STA1 and record the throughput.
4. Run 60 seconds of uplink TCP traffic from STA1 to the Ethernet Test Station and record the throughput.
5. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA1 and record the throughput.
6. Instruct STA2 to authenticate and associate with the AP.
7. Send ICMP Echo requests from the Ethernet Test Station to STA1 and STA2 and confirm that ICMP Echo replies are received.

8. Run 60 seconds of downlink TCP traffic through the AP to STA1 and STA2 and record the throughput.
9. Run 60 seconds of uplink TCP traffic from STA1 and STA2 to the Ethernet Test Station and record the throughput.
10. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA1 and STA2 and record the throughput.
11. Instruct STA1 to deauthenticate and disassociate with the AP.
12. Send ICMP Echo requests from the Ethernet Test Station to STA2 and confirm that ICMP Echo replies are received.
13. Run 60 seconds of downlink TCP traffic through the AP to STA2 and record the throughput.
14. Run 60 seconds of uplink TCP traffic from STA2 to the Ethernet Test Station and record the throughput.
15. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic with STA2 and record the throughput.

Observable Results:

2. The DUT shall authenticate, associate, and pass traffic successfully with and without multiple STAs present throughout the entire procedure.

2.4 Range Versus Rate Test in 5GHz

Purpose:

The Range versus Rate Test verifies the DUT's ability to authenticate and pass traffic using the AP and the DUT's factory default state. The range will be achieved through attenuation to approximate distance between the AP and the DUT. Note, this total attenuation includes both the "air-gap" between the STA and the test setup antennas, as well as the additional attenuation inserted by the programmable attenuator.

References:

[1] IEEE Std 802.11™-2016 Edition

Resource Requirements:

- An AP that is in its default "out of box" state with network configuration shown in Table B.
- A STA that is capable of running iPerf.

Discussion:

This test verifies that the DUT can achieve throughput traffic after resetting the AP & STA, and preserving those settings for the duration of the test section. Additional attenuations may also be tested upon request.

Test Configuration & Setup:

1. Configure the test setup as shown in Figure 2
2. Prepare iPerf on the STA and Ethernet Test Station.

Table 1.4.1: Test Configurations for Range Test

Configuration	Attenuation (dB)
a	0
b	10
c	20
d	30
e	40
f	50

Procedure:

1. Modify the attenuation as indicated in configuration A of Table 1.4.1.
2. Instruct the STA to authenticate and associate with the AP.
3. Run 60 seconds of downlink TCP traffic through the AP to the STA and record the throughput.
4. Run 60 seconds of uplink TCP traffic through the AP to the Ethernet Test Station and record the throughput.
5. Run 60 seconds of bidirectional (uplink and downlink) TCP traffic and record the throughput.
6. Repeat steps 2-5 using attenuation configurations B-F.

Observable Results:

1. The DUT shall authenticate, associate, and pass traffic successfully unless the attenuation level prevents traffic from passing successfully.