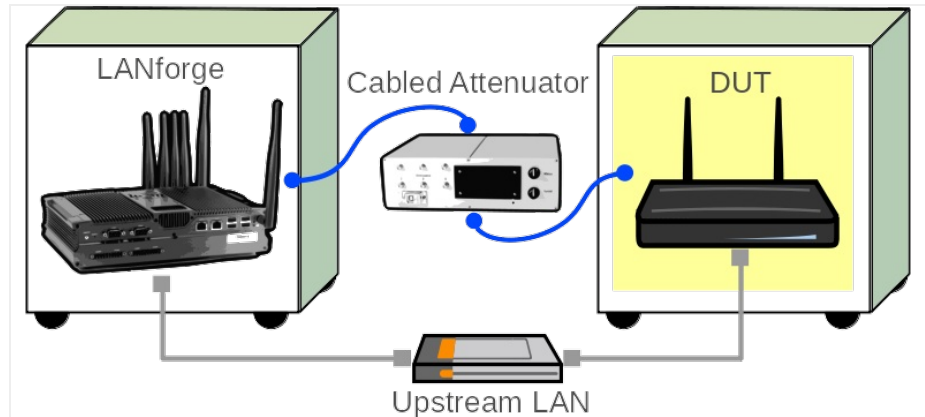


Calibrating TR-398 Issue-2 and Mesh on a 4-Chamber Setup

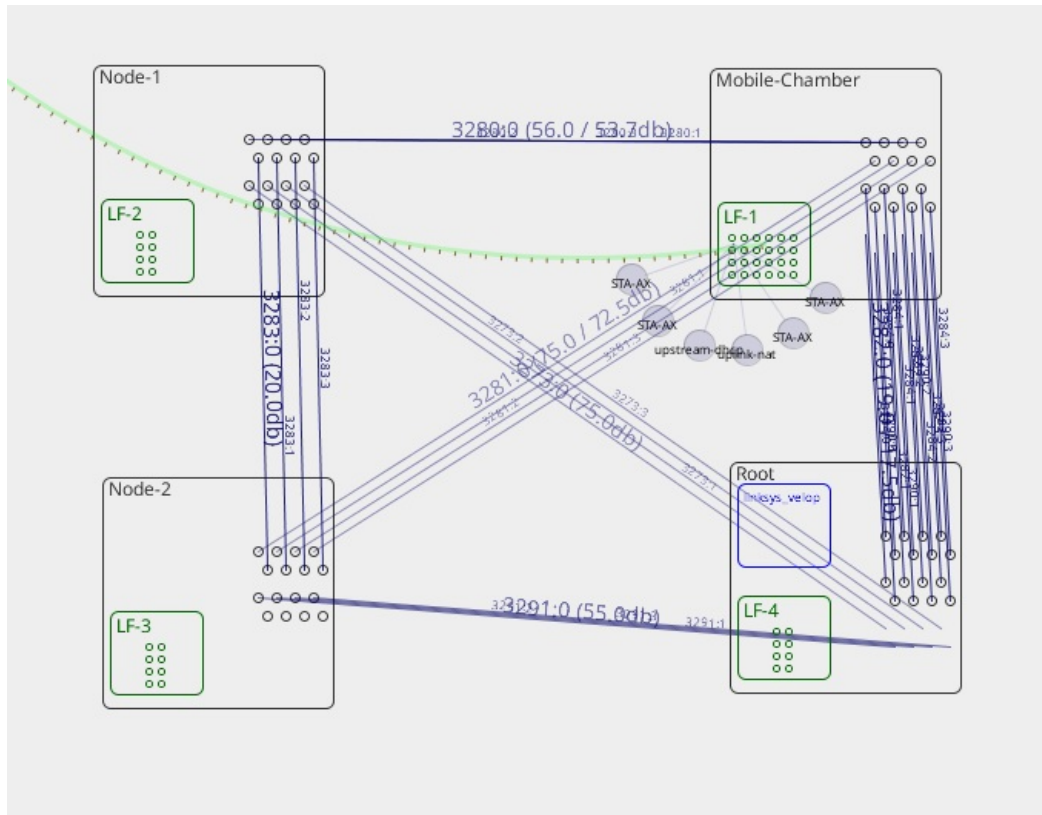
Goal: Setup and run a TR-398 Issue 2 test for an AP using a 6-radio version of the LANforge CT523c or similar system in order to test how well the AP can handle the various test cases specified in the TR-398 Issue 2 test document.

In this test scenario, a LANforge cluster (of a 1 523c and 3 521as) is used to emulate different station and AP scenarios and generate and receive traffic with an AP. This example assumes user has some experience with Chamber View, and has an appropriate LANforge system (fit for TR-398 Issue 2), programmable attenuators like the CT714 and some isolation chambers like the CT820a and CT840a. Please contact support@candelatech.com for assistance in setting up the TR-398 testbed.



1. Configure Chamber View for TR-398 and Similar Tests.

- A. Open Chamber View by clicking on the 'Chamber View' button in the LANforge-GUI. If you have an appropriate scenario already created, please skip to the next section, otherwise you will need to build a scenario that matches your system. Right-click in Chamber View to create various objects. This cookbook will use the Chamber View scenario seen below.

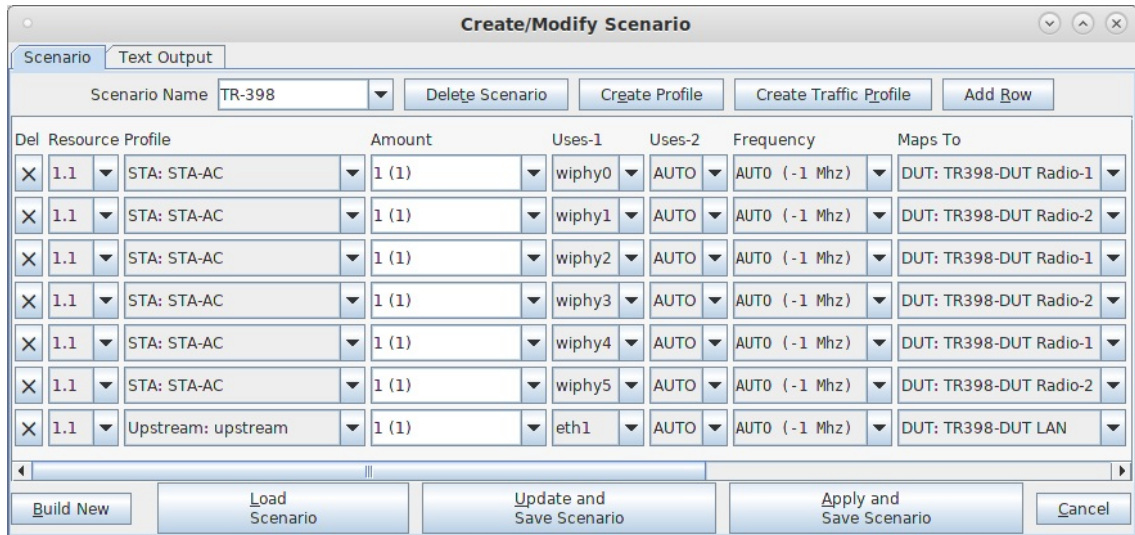


- B. Create a Device Under Test (DUT) Profile that matches your AP. The BSSID is important to configure so that LANforge knows when it is connected to the correct AP. In a mesh scenario, 3 DUT objects may be created, one for each of the mesh AP chambers.

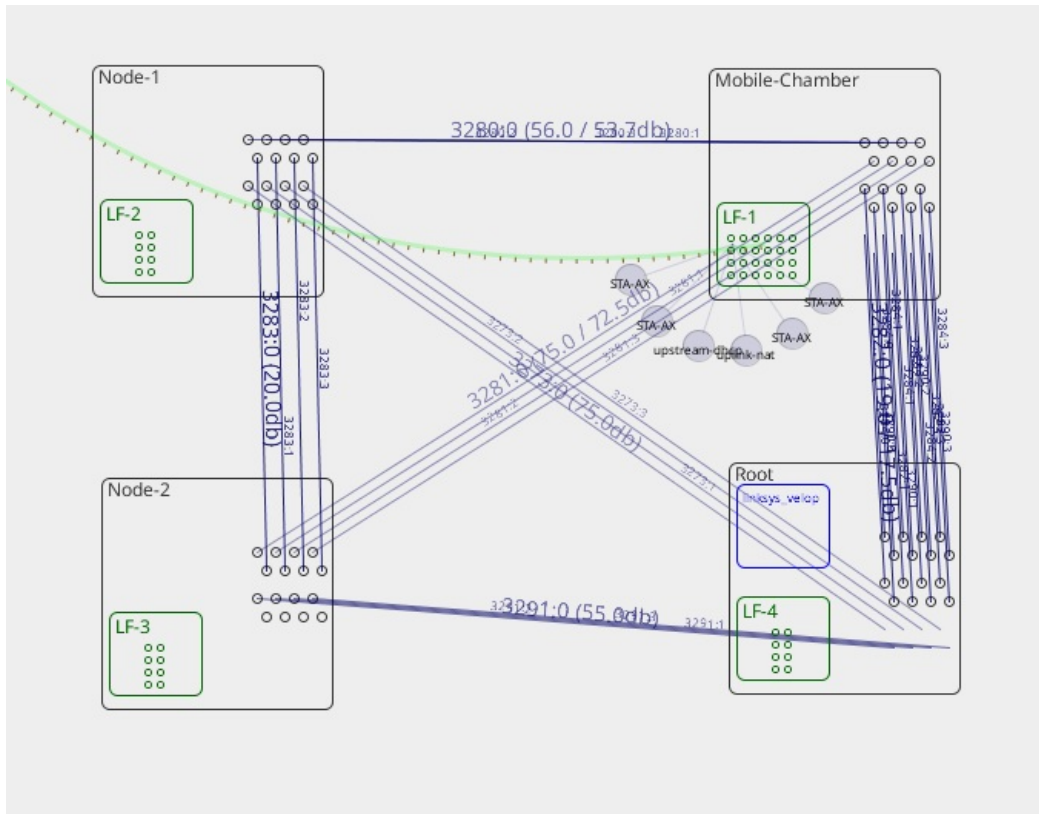
Create/Modify DUT

| | | | | | |
|--|----------------|-----------------|----------|-----------------|---|
| Name | linksys_velop | Image file | NONE | Choose Image | x |
| SW Info | | HW Info | | Model Number | |
| Serial Number | | Serial port | | API version | 0 |
| WAN | | LAN | | | |
| SSID-1 | velop_lanforge | Password-1 | lanforge | BSSID-1 | d8:ec:5e:7a:21:e8 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input checked="" type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-2 | velop_lanforge | Password-2 | lanforge | BSSID-2 | d8:ec:5e:7a:21:e9 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input checked="" type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-3 | | Password-3 | | BSSID-3 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-4 | | Password-4 | | BSSID-4 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-5 | | Password-5 | | BSSID-5 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-6 | | Password-6 | | BSSID-6 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-7 | | Password-7 | | BSSID-7 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| SSID-8 | | Password-8 | | BSSID-8 | 00:00:00:00:00:00 <input type="checkbox"/> WEP <input type="checkbox"/> WPA <input type="checkbox"/> WPA2 <input type="checkbox"/> WPA3 <input type="checkbox"/> 802.11r <input type="checkbox"/> EAP-TTLS <input type="checkbox"/> EAP-PEAP |
| EAP-ID | | Mgt IP | 0.0.0.0 | | |
| Num Ant Radio 1 | 0 | Num Ant Radio 2 | 0 | Num Ant Radio 3 | 0 |
| <input type="checkbox"/> Active <input checked="" type="checkbox"/> Provides DHCP on LAN <input type="checkbox"/> DHCP Client <input type="checkbox"/> Provides DHCP on WAN <input checked="" type="checkbox"/> AP DUT | | | | | |
| Notes | | | | | |
| <input type="text"/> | | | | | |
| <input type="button" value="Apply"/> <input type="button" value="OK"/> <input type="button" value="Cancel"/> | | | | | |

- E. Configure a Chamber View Scenario and add the STA profile (mapped to desired wiphyX radio and DUT). Add an upstream profile mapped to DUT LAN side (or possibly WAN side if that is more appropriate for your DUT).



2. For TR398 tests, the DUT AP's front should face the antennas for the Group-1 stations. Or, optionally, one can use the Advanced configuration tab to specify the default turntable angle for non rotational tests.
3. Open Chamber View by clicking on the 'Chamber View' button in the LANforge-GUI. Load appropriate scenario. Apply the Scenario, then Build the scenario.



4. Select the **TR-398-Issue-2** test from Tests dropdown in the right panel. Then click Run Test. The following window below should pop up. In the Settings tab, set slots 'Selected DUT 5G', 'Selected DUT 2G', and 'Selected DUT 6G' the according BSSIDs found in the 'Root' Chamber. Also set the upstream port. In this example, the upstream port is the eth2 port on the LANforge in Mobile Stations chamber.

TR-398 Issue 2 Automated Test (cv-inst-1)

Per-Test Config 1 | Per-Test Config 2 | Per-Test Config 3 | **Advanced Configuration** | Report Configuration | TR398-Issue3

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | Mesh Settings | Mesh Settings 2

Selected DUT 5G: linksys_velop_velop_lanforge d8:ec:5e:7a:21:e9 (2) | Upstream Port: 1.1.2 eth2

Selected DUT 2G: linksys_velop ve **Select 5Ghz DUT to be used in this test.** | Turn-Table-Chamber:

Selected DUT 6G: linksys_velop_velop_lanforge d8:ec:5e:7a:21:e9 (2) | Extra Download Path-loss: 0 (0)

2.4Ghz 2m RSSI: -26 | 5Ghz 2m RSSI: -30

Skip 2.4Ghz Tests
 Skip 5Ghz Tests
 Skip 6Ghz Tests
 Skip N/AC Tests
 Skip AX Tests
 Use Issue-3 Behaviour
 Allow-11w (MFP/PMF)

TR-398 Tests to Run: Estimated Test Duration: 3 m

Calibrate 802.11AX Radios Calibrate 802.11AC Radios Calibrate Group Throughput
 Calibrate 802.11AX Attenuators Calibrate 802.11AC Attenuators
 Calibrate Mesh Root Attenuators Calibrate Mesh Node-1 Attenuators Calibrate Mesh Root to Node-1 Attenuators
 Calibrate Mesh Node-2 Attenuators Calibrate Mesh Node-1 to Node-2 Attenuators Calibrate Mesh Root to Node-2 Attenuators
 6.1.1 Receiver Sensitivity 6.2.6 Latency 6.4.2 Multiple Assoc Stability
 6.2.1 Maximum Connection 6.2.7 Quality of Service 6.4.3 Downlink MU-MIMO
 6.2.2 Maximum Throughput 6.3.1 Range Versus Rate 6.4.4 Multicast
 6.2.3 Airtime Fairness 6.3.2 Spatial Consistency 6.5.1 Long Term Stability
 6.2.4 Dual-Band Throughput 6.3.3 AX Peak Performance 6.5.2 AP Coexistence
 6.2.5 Bi-Directional Throughput 6.4.1 Multiple STAs Performance 6.5.3 Automatic Channel Selection
 8.1.1 Mesh Backhaul RvR 8.1.2 Mesh Backhaul Node-2 RvR 8.2.1 Mesh Roam Time

 Another Iteration
 Pause

5. Configure the Virtual Sta Radio Settings tab.

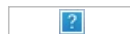
- A. Select the Virtual Sta Radio Settings tab. This tab is for radios that can have virtual stations on them (either AC, N, some AX). Notice that there are 3 groups here, this will be the 3 slots of radios (Slots 2, 3, 4) in the Mobile Clients Chamber. Visit the pictures in the next 2 steps to see close ups of the attenuator diagram that has the slots. Slot 2 (Group 0) has W0 and W1 (wiphy0 and wiphy1). Slot 3 (Group 1) has W2 and W3 (wiphy2 and wiphy3). Slot 4 (Group 2) has W4 and W5 (wiphy4 and wiphy5). Leave the '2.4Ghz RSSI 0 Atten' and '5Ghz RSSI 0 Atten' blank, those will be auto calculated when we calibrate the attenuators. Lastly, fill out the attenuator modules column (with the correct serial numbers that relate to each group). All these attenuators will be the TR-398 section of the attenuator stack. In this case, those are attenuators T1, T2 and T3. These attenuators are also all connecting the **Node 3/Root** chamber to the **Mobile Clients** chamber. Match the according attenuator to each group on the attenuator diagram. Fill out all the dropdowns under 'Attenuator Modules' for ports 0-3 on the matching attenuator. Select the 'Use Virtual AX Stations' checkbox.

| Group | Radio | 2.4Ghz RSSI 0 Atten | 5Ghz RSSI 0 Atten | Attenuator Modules | |
|----------|--------|---------------------|-------------------|--------------------|------------|
| Group: 0 | 5Ghz | 1.1.4 wiphy0 | -23 | -44 | 1.1.3282.0 |
| | 2.4Ghz | 1.1.5 wiphy1 | -23 | -44 | 1.1.3282.1 |
| | 6Ghz | | -23 | -44 | 1.1.3282.2 |
| Group: 1 | 5Ghz | 1.1.6 wiphy2 | -23 | -43 | 1.1.3290.0 |
| | 2.4Ghz | 1.1.7 wiphy3 | -23 | -43 | 1.1.3290.1 |
| | 6Ghz | | -23 | -43 | 1.1.3290.2 |
| Group: 2 | 5Ghz | 1.1.8 wiphy4 | -30 | -47 | 1.1.3284.0 |
| | 2.4Ghz | 1.1.9 wiphy5 | -30 | -47 | 1.1.3284.1 |
| | 6Ghz | | -30 | -47 | 1.1.3284.2 |

Use Virtual AX Stations
 Use AX Radios for AC tests

 Another Iteration
 Pause

- B. Below is the attenuator diagram of the 4-chamber setup in the example. Another name for the Node-3 Chamber is the Root chamber.



- C. Below is a closer look at the bottom right box of the attenuator diagram in the step above.



- D. Below are the serial numbers of the attenuator stack. They are stacked in the same order as the attenuator diagram.



6. Configure the 802.11 AX Settings (1 & 2) tabs. Please contact support@candelatech.com for assistance in filling out these tabs. These settings only apply to AX capable radios that do not support virtual stations.
7. Configure the Mesh Settings and Mesh Settings 2 tabs. If the test bed being setup has no need for Mesh, please skip this step.

- A. Select the Mesh Settings tab. The picture below is a final version of the calibrated mesh setup. In an uncalibrated version (yours), all the rows in the 'RSSI 0 Atten' columns will be empty. Fill out select the 2.4Ghz and 5Ghz BSSIDs for both Node 1 and Node 2 Chambers in the top section. Fill out the 'Atten Modules' column for each group (using ports 0-3 for each attenuator). To find out the correct attenuator, trace the attenuator diagram to find out which attenuator connects which 2 Chambers. In Group 1 (in this section), use the attenuator and radios used in 'Group 2' of the Virtual Sta Radio Settings tab. This attenuator is both TR398 and Access (A3/T1), so it belongs in both Virtual Sta Radio Settings and Mesh Settings

TR-398 Issue 2 Automated Test (cv-inst-1)

Per-Test Config 1 | Per-Test Config 2 | Per-Test Config 3 | **Advanced Configuration** | Report Configuration | TR398-Issue3

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | **Mesh Settings** | Mesh Settings 2

Node-1 DUT 5G:

Node-1 DUT 2G:

Node-2 DUT 5G:

Node-2 DUT 2G:

Use 2-band pass/fail

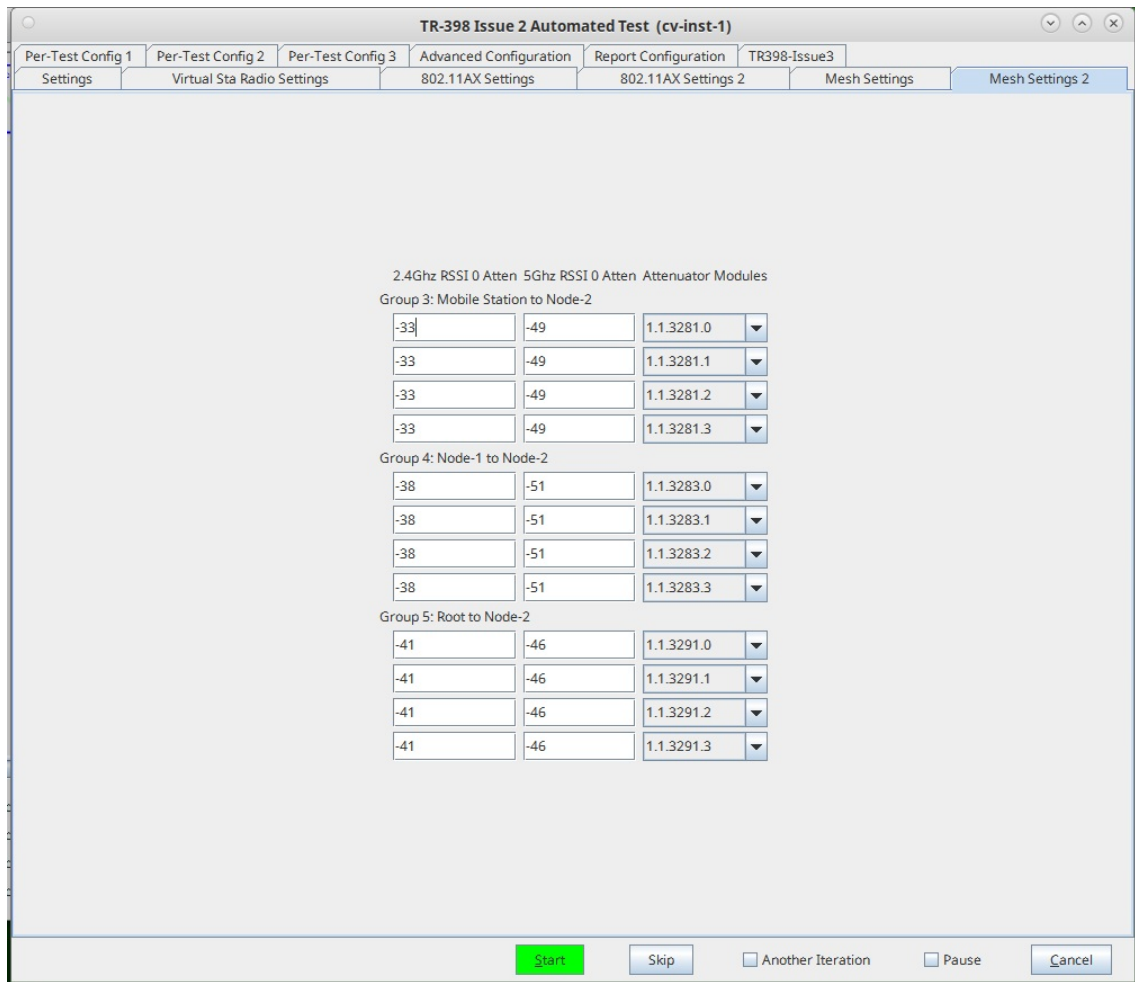
Background Scan Module: RSSI Threshold:

Short Interval: Long Interval:

| Radio | 2.4Ghz RSSI 0 Atten | 5Ghz RSSI 0 Atten | Attenuator Modules |
|--|---|----------------------------------|---|
| Group 0: Root to Node-1 | | | |
| | <input type="text" value="-49"/> | <input type="text" value="-63"/> | <input type="text" value="1.1.3273.0"/> |
| | <input type="text" value="-49"/> | <input type="text" value="-63"/> | <input type="text" value="1.1.3273.1"/> |
| | <input type="text" value="-49"/> | <input type="text" value="-63"/> | <input type="text" value="1.1.3273.2"/> |
| | <input type="text" value="-49"/> | <input type="text" value="-63"/> | <input type="text" value="1.1.3273.3"/> |
| Group 1: Mobile Station to Root | | | |
| 5Ghz | <input type="text" value="1.1.9 wiphy5"/> | <input type="text" value="-30"/> | <input type="text" value="-47"/> |
| 2.4Ghz | <input type="text" value="1.1.8 wiphy4"/> | <input type="text" value="-30"/> | <input type="text" value="-47"/> |
| | <input type="text" value="-30"/> | <input type="text" value="-47"/> | <input type="text" value="1.1.3284.0"/> |
| | <input type="text" value="-30"/> | <input type="text" value="-47"/> | <input type="text" value="1.1.3284.1"/> |
| | <input type="text" value="-30"/> | <input type="text" value="-47"/> | <input type="text" value="1.1.3284.2"/> |
| | <input type="text" value="-30"/> | <input type="text" value="-47"/> | <input type="text" value="1.1.3284.3"/> |
| Group 2: Mobile Station to Node-1 | | | |
| | <input type="text" value="-45"/> | <input type="text" value="-38"/> | <input type="text" value="1.1.3280.0"/> |
| | <input type="text" value="-45"/> | <input type="text" value="-38"/> | <input type="text" value="1.1.3280.1"/> |
| | <input type="text" value="-45"/> | <input type="text" value="-38"/> | <input type="text" value="1.1.3280.2"/> |
| | <input type="text" value="-45"/> | <input type="text" value="-38"/> | <input type="text" value="1.1.3280.3"/> |

Another Iteration
 Pause

B. Fill out the Mesh Settings 2 tab similarly to Mesh Settings 1



8. Click on the Advanced Configuration tab. Set 2.4GHz channel and 5GHz channel to '-1' / AUTO. AUTO won't work for all cases (like the ap-coex test), but will work for most of them.

TR-398 Issue 2 Automated Test (cv-inst-1)

Per-Test Config 1 | Per-Test Config 2 | Per-Test Config 3 | **Advanced Configuration** | Report Configuration | TR398-Issue3

Settings | Virtual Sta Radio Settings | **802.11AX Settings** | 802.11AX Settings 2 | Mesh Settings | Mesh Settings 2

Show Config

Import Config

Save

Load

Delete

DEFAULT

DEFAULT

DEFAULT

Auto-Helper

| | | | |
|--------------------------------|-----------------|------------------------------|-----------------|
| IP ToS: | Best Effort (0) | Multi-Conn: | Ten (10) |
| 2.4Ghz Channel | AUTO (-1 Mhz) | 5Ghz Channel | AUTO (-1 Mhz) |
| Duration-60: | Default (1 min) | Duration-120: | Default (2 min) |
| Attenuation Adjustment | 0 | Test Retries: | 0 |
| STA TX Power: | 20 dBm (20) | | |
| DUT AP Expected TX Power-2.4G: | 20 dBm (20) | DUT AP Expected TX Power-5G: | 23 dBm (23) |
| Opposite-Speed: | None (0 bps) | | |

Start | Skip | Another Iteration | Pause | Cancel

9. Calibrate Zero Attenuation RSSI for all chamber to chamber connections and attenuators. This also verifies attenuators are connected and functioning as expected. We are calculating 0 atten against the LANforge.
 - A. Start by setting the LANforge in the center of all the chambers to be calibrated, with the LANforge wiphy0 antenna pointing straight up, while the other antennas lay flat. Then point all the chamber antennas to the LANforge wiphy0 antenna sticking straight up.
 - B. Calibrate the attenuators first. In this example, we calibrated the 802.11AC attenuators first. Similarly in other testbed setups, if there are AX radios or single-sta radios, calibrate the attenuators for those first (**one checkbox at a time**). Do 3 trials of each attenuator calibration and take the average as your final value to put as the box values. Make sure to rotate 'AP' and 'station' LANforge (if able to and the LANforge is not cabled into the wall) with the LANforge W0 antennas still pointed in the middle of all the chamber antennas on every trial.

Calibrate 802.11AC Attenuators

- C. In the image below, similarly as above, run each of the checkboxes **one** at a time, until all are run. Do 3 trials of path calibration and take the average as your final value. Make sure to rotate 'AP' and 'station' LANforge (if able to and the LANforge is not cabled into the wall) with the LANforge W0 antennas still pointed in the middle of all the chamber antennas on every trial.

The screenshot shows the 'TR-398 Issue 2 Automated Test (cv-inst-1)' configuration window. The window has several tabs: 'Per-Test Config 1', 'Per-Test Config 2', 'Per-Test Config 3', 'Advanced Configuration', 'Report Configuration', and 'TR398-Issue3'. The 'Advanced Configuration' tab is active, showing settings for '802.11AX Settings' and '802.11AX Settings 2'. The 'Settings' sub-tab is selected, displaying various configuration options.

Selected DUT 5G: linksys_velop_velop_Janforge d8:ec:5e:7a:21:e9 (2)
 Selected DUT 2G: linksys_velop_velop_Janforge d8:ec:5e:7a:21:e8 (1)
 Selected DUT 6G: linksys_velop_velop_Janforge d8:ec:5e:7a:21:e9 (2)
 2.4Ghz 2m RSSI: -26
 Upstream Port: 1.1.2 eth2
 Turn-Table-Chamber: (empty)
 Extra Download Path-loss: 0 (0)
 5Ghz 2m RSSI: -30

Options to skip tests:
 Skip 2.4Ghz Tests
 Skip 5Ghz Tests
 Skip 6Ghz Tests
 Skip N/AC Tests
 Skip AX Tests
 Use Issue-3 Behaviour
 Allow-11w (MFP/PMF)

TR-398 Tests to Run: Estimated Test Duration: 30 m

Calibration options:
 Calibrate 802.11AX Radios
 Calibrate 802.11AC Radios
 Calibrate 802.11AX Attenuators
 Calibrate 802.11AC Attenuators
 Calibrate Mesh Root Attenuators
 Calibrate Mesh Node-1 Attenuators
 Calibrate Mesh Node-2 Attenuators
 Calibrate Mesh Node-1 to Node-2 Attenuators
 Calibrate Mesh Root to Node-1 Attenuators
 Calibrate Mesh Root to Node-2 Attenuators

Performance and stability tests:
 6.1.1 Receiver Sensitivity
 6.2.1 Maximum Connection
 6.2.2 Maximum Throughput
 6.2.3 Airtime Fairness
 6.2.4 Dual-Band Throughput
 6.2.5 Bi-Directional Throughput
 8.1.1 Mesh Backhaul RvR
 6.2.6 Latency
 6.2.7 Quality of Service
 6.3.1 Range Versus Rate
 6.3.2 Spatial Consistency
 6.3.3 AX Peak Performance
 6.4.1 Multiple STAs Performance
 8.1.2 Mesh Backhaul Node-2 RvR
 6.4.2 Multiple Assoc Stability
 6.4.3 Downlink MU-MIMO
 6.4.4 Multicast
 6.5.1 Long Term Stability
 6.5.2 AP Coexistence
 6.5.3 Automatic Channel Selection
 8.2.1 Mesh Roam Time

Buttons at the bottom: Start (green), Skip, Another Iteration, Pause, Cancel.

10. At this point, all the 0 Atten values should be filled out (for Virtual Sta Radio Settings and Mesh Settings 1 & 2 tabs in this example). **Save these values as a database in both the TR398 window database and the LANforge 'Status' tab database sections. May also be good to take screenshots of all the final values and save it off-LANforge.**
11. Run a TR-398 Issue 2 throughput test. Select the 6.2.2 Maximum Throughput checkbox to run the test. After verifying the throughput test is working as expected, select and run other tests as desired.

TR-398 Issue 2 Automated Test (cv-inst-1)

Per-Test Config 1 | Per-Test Config 2 | Per-Test Config 3 | **Advanced Configuration** | Report Configuration | TR398-Issue3

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | Mesh Settings | Mesh Settings 2

Selected DUT 5G: linksys_velop_velop_lanforge d8:ec:5e:7a:21:e9 (2) | Upstream Port: 1.1.2 eth2

Selected DUT 2G: Select 5Ghz DUT to be used in this test. 21:e8 (1) | Turn-Table-Chamber:

Selected DUT 6G: linksys_velop_velop_lanforge d8:ec:5e:7a:21:e9 (2) | Extra Download Path-loss: 0 (0)

2.4Ghz 2m RSSI: -26 | 5Ghz 2m RSSI: -30

Skip 2.4Ghz Tests Skip 5Ghz Tests Skip 6Ghz Tests Skip N/AC Tests Skip AX Tests

Use Issue-3 Behaviour Allow-11w (MFP/PMF)

TR-398 Tests to Run: Estimated Test Duration: 6 m

Calibrate 802.11AX Radios Calibrate 802.11AC Radios Calibrate Group Throughput

Calibrate 802.11AX Attenuators Calibrate 802.11AC Attenuators

Calibrate Mesh Root Attenuators Calibrate Mesh Node-1 Attenuators Calibrate Mesh Root to Node-1 Attenuators

Calibrate Mesh Node-2 Attenuators Calibrate Mesh Node-1 to Node-2 Attenuators Calibrate Mesh Root to Node-2 Attenuators

6.1.1 Receiver Sensitivity 6.2.6 Latency 6.4.2 Multiple Assoc Stability

6.2.1 Maximum Connection 6.2.7 Quality of Service 6.4.3 Downlink MU-MIMO

6.2.2 Maximum Throughput 6.3.1 Range Versus Rate 6.4.4 Multicast

6.2.3 Airtime Fairness 6.3.2 Spatial Consistency 6.5.1 Long Term Stability

6.2.4 Dual-Band Throughput 6.3.3 AX Peak Performance 6.5.2 AP Coexistence

6.2.5 Bi-Directional Throughput 6.4.1 Multiple STAs Performance 6.5.3 Automatic Channel Selection

8.1.1 Mesh Backhaul RvR 8.1.2 Mesh Backhaul Node-2 RvR 8.2.1 Mesh Roam Time

 Another Iteration
 Pause

12. When the test is complete, click the **Save HTML** button to save an HTML report and generate the PDF. The PDF file will be linked from the HTML page. Another option is to click 'Save PDF' and the browser will be directed to open the pdf file directly. Please see this [passing example TR-398 Issue 2 Maximum Throughput Test Report](#) .