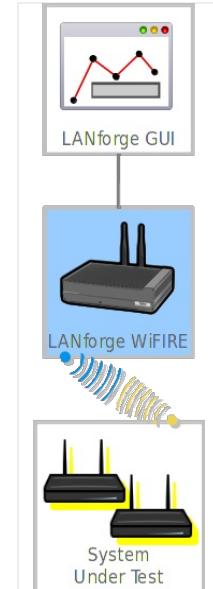
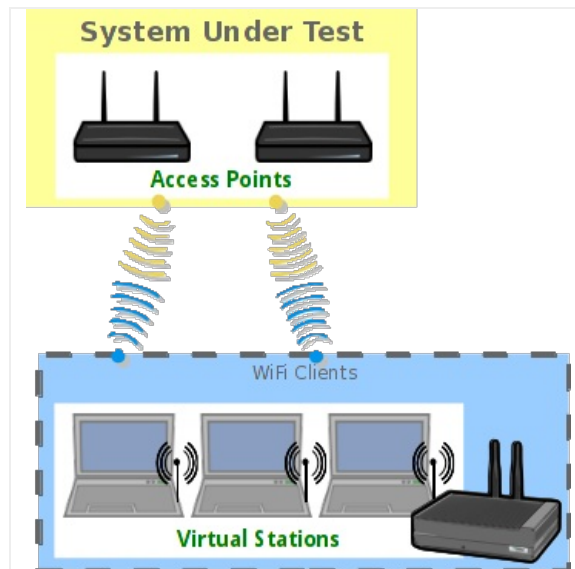


LANforge WiFi Testing Fast Roaming Stations with 802.11r

Goal: Use automated script to migrate stations between APs and report results.

Requires LANforge 5.2.11 or later. Configure Stations to use FT-EAP (802.11r) and associate them with an 802.11r AP network. Use the 'WiFi Mobility' LANforge-GUI Plugin to automate roaming the stations between the APs. The plugin will create graphs and other reports that can be saved to HTML. This example uses a LANforge CT523 system but the procedure should work on all CT520, CT523 and similar systems.

The two APs under test are on the same channel, so a single radio/NIC on LANforge can roam virtual stations between the APs. But, if the APs were on different channels, only a single station per radio would be supported. Multiple CT523 or other high-density systems can be used to migrate stations between APs on different channels.



1. Configure stations to connect to APs configured for 802.11r. This requires special AP software support and usually an AP Controller (APC).
 - A. Go to the Port Manager tab, select wiphy0 on proper resource, click Create, fill out appropriate information and create desired number of Station interfaces.

- B. The new stations should appear in the Port-Mgr table. Double-click to modify one of them. Configure IP Address information, SSID and select WPA2:

sta1 (ct521-5359-F17x64) Configure Settings

Port Status Information
Current: LINK-UP GRO Authorized
Driver Info: Port Type: WIFI-STA Parent: wiphy0

Port Configurables

Standard Configuration **Advanced Configuration**

Enable

- ☒ Set IP Info
- ☒ Set IP6 Info
- ☐ Set IF Down
- ☐ Set MAC
- ☐ Set TX Q Len
- ☐ Set MTU
- ☐ Set Offload
- ☐ Set PROMISC

Services

- ☐ HTTP
- ☐ FTP

Low Level

- ☐ PROMISC
- ☐ TSO Enabled
- ☐ UFO Enabled
- ☐ GSO Enabled
- ☐ LRO Enabled
- ☒ GRO Enabled

General Interface Settings

- ☐ DHCP-IPv6 ☒ DHCP Release ☐ Down ☐ Aux-Mgt
- ☒ DHCP-IPv4 **Secondary-IPs** DHCP Client ID: None
- DNS Servers: 192.168.2.1 Peer IP: NA
- IP Address: 0.0.0.0 Global IPv6: DELETED
- IP Mask: 0.0.0.0 Link IPv6: DELETED
- Gateway IP: 0.0.0.0 IPv6 GW: DELETED
- Alias: MTU: 1500
- MAC Addr: 00:aa:aa:aa:aa:01 TX Q Len: 1000
- Rpt Timer: medium (8 s) WiFi Bridge: NONE

WiFi Settings

- SSID: aironet1-5 AP: DEFAULT
- Key/Phrase: lanforge Mode: 802.11abgn
- Freq/Channel: 5180/36 Rate: OS Default
- RTS: -1 Tx-Power: 17 dBm
- AMPDU-Factor: OS Default AMPDU-Density: OS Default
- Max-AMSDU: OS Default Bridge-IP: 0.0.0.0
- ☐ Use WPA ☒ Use WPA2 ☐ Use WEP ☐ Disable HT40 ☐ Disable SGI
- ☐ Scan Hidden ☐ Allow Migration

Print **View Details** **Probe** **Display Scan** **Sync** **Apply** **OK** **Cancel**

- C. Select the **Advanced Configuration** tab in the Port-Modify window and configure the Key Management, Private Key and other values needed to connect to the APs. Be sure to un-select the **Restart DHCP on Connect** checkbox so that DHCP is not refreshed each time a station roams:

sta1 (ct521-5359-F17x64) Configure Settings

Port Status Information
Current: LINK-UP GRO Authorized
Driver Info: Port Type: WIFI-STA Parent: wiphy0

Port Configurables

Standard Configuration **Advanced Configuration**

Advanced WiFi Settings

Select 'WPA2' on the Standard Configuration screen to enable 802.1x and enable 802.1x to enable most of these. Enabling 802.11u enables others.

Key Management: FT-EAP (11r) HESSID: 00:00:00:00:00:00
Pairwise Ciphers: DEFAULT Realm:
Group Ciphers: DEFAULT Client Cert:
WPA PSK: IMSI:
EAP Methods: EAP-TLS Milenage:
EAP Identity: client Domain:
EAP Anon Identity: Consortium:
EAP Password: lanforge Phase-1:
EAP Pin: Phase-2:
Private Key: /home/lanforge/wifi/client.p12 PK Password: lanforge
CA Cert File: /home/lanforge/wifi/ca.pem PAC File:
Network Auth:
☒ Use 802.1x ☐ PC/SC & SIM/USIM ☐ Enable 802.11u ☐ HotSpot 2.0 ☒ Enable PKC
☐ Custom WPA Cfg WPA Cfg: /home/lanforge/wifi/sta1_wpa.conf
☐ Restart DHCP on Connect

Print View Details Probe Display Scan Sync Apply OK Cancel

- D. Once the single station is connecting properly, use Batch-Modify to configure the rest of the stations to match the first.

For more information see [LANforge User's Guide: Ports \(Interfaces\)](#) , [WiFi Station Cookbook](#)

2. Create VOIP connections between the wired Ethernet eth1 interface and the stations. This will add realistic traffic load to the network under test and allow LANforge to report packet-loss statistics during roaming. The VOIP feature costs extra, so you may wish to use a normal Layer-3 UDP connection which should also provide good reports and a realistic traffic load. The steps below are for VOIP, but Layer-3 would be very similar.

- A. Go to the VOIP/RTP tab, click Create, and configure a VOIP connection on eth1 and the first station:

Create/Modify Cross Connect

Cross Connect Information

CX Name: voip-001 Rpt Timer: fast (1 s) Test Manager: default_tm CX Type: Voice - SIP

☒ Multi-Call ☒ Directed Min Call Duration (s): File Max Ring Time (s): 20 Codec: G.711u

☐ Continuous Call ☐ Use Gateway Max Call Duration (s): File Min Inter-Call Gap (s): 3 Start Delay: 3

☐ Don't Send RTP Number Of Calls: INFINITE Max Inter-Call Gap (s): 3 Quiesce: 45 (45)

TX Endpoint (endpoint A)

Endp Name: voip-001-A Shelf: 1 Resource: 1 (t521-5359-F17x64) Port: 2 (sta1) IP Addr: AUTO Phone #: 6670135 Display Name: 6670135 Auth User Name: AUTO Reg Expire: 300

☐ UnManaged ☒ Bind SIP ☐ Don't Answer ☐ Record ☐ Rcv Call ☐ Enable PESQ ☐ No Tunneling ☐ Play to speaker ☐ No Fast Start ☐ VAD ☐ Single Codec ☐ Override SDP

UDP Port: AUTO SIP Port: 5060 IP ToS: VO (WiFi) (192) Socket Priority: 0 VAD Delay(ms): 250 VAD Force Send: 3000 Jitter Buffer: 8

Tx File: media/female_voice_8khz.wav Destination: AUTO Speaker: /dev/audio Call Gateway: anonymous@:0 Record File: /dev/null PESQ Server: 127.0.0.1:3998 Quiesce: 45 (45)

RX Endpoint (endpoint B)

Endp Name: voip-001-B Shelf: 1 Resource: 1 (t521-5359-F17x64) Port: 1 (eth1) IP Addr: AUTO Phone #: 4974595 Display Name: 4974595 Auth User Name: AUTO Reg Expire: 300

☐ UnManaged ☒ Bind SIP ☐ Don't Answer ☐ Record ☒ Rcv Call ☐ Enable PESQ ☐ No Tunneling ☐ Play to speaker ☐ No Fast Start ☐ VAD ☐ Single Codec ☐ Override SDP

UDP Port: AUTO SIP Port: 5060 IP ToS: VO (WiFi) (192) Socket Priority: 0 VAD Delay(ms): 250 VAD Force Send: 3000 Jitter Buffer: 8

Tx File: media/female_voice_8khz.wav Destination: AUTO Speaker: /dev/audio Call Gateway: anonymous@:0 Record File: /dev/null PESQ Server: 127.0.0.1:3998 Quiesce: 45 (45)

Apply OK Refresh Batch-Create Cancel

- B. Apply the configuration and make sure the call can complete. Then click Modify on the VOIP connection and use Batch-Create to create one connection for each of the WiFi stations.
- C. Select the VOIP and/or Layer-3 connections and start traffic flow. For this example, the connections should remain running while the roaming takes place. It would also be valid to do roaming without any traffic if that is the desired test case.

3. Start the WiFi Migration script.

- A. Go to the Port Manager tab, select the stations you wish to roam, right-click and choose the **WiFi Mobility** menu option.

WiFi Mobility

Refresh Interval (ms):

5000

Pause Between Commands (ms):

50

Pause after Show-Port (ms):

1000

Auto-Verify timer (ms):

1000

Maximum roam-time in graphs (ms):

250

WiFi Stations

Ports in Use

1.1.2 sta1
1.1.4 sta2
1.1.5 sta3
1.1.6 sta4
1.1.7 sta5
1.1.8 sta6
1.1.9 sta7

← Add Station

Remove Station →

Free Ports

1.1.10 sta8
1.1.11 sta9
1.1.12 sta10
1.1.13 sta11
1.1.14 sta12
1.1.15 sta13
1.1.16 sta14
1.1.17 sta15
1.1.18 sta16
1.1.19 sta17

Before roaming, you should first scan the proper frequencies. Otherwise, the supplicant process may do an internal scan which may significantly affect the connection time:

do_cli scan 1 Resource STA NA 'trigger freq F1 F2'

To roam to a new Access Point, add a line in the text area with the following format:

roam Resource STA BSSID

- Resource: Station's resource ID number, often '1'
- STA: name of the station to roam: 'sta11'
- BSSID: the BSSID address of the AP: 00:01:02:03:04:05
- F1: the first frequency to scan: 5180
- F2: Optional second frequency to scan: 5300

After issuing ROAM commands, a pause should be added to let the stations adjust (in seconds, floating-point allowed):

sleep 20

To issue a generic LANforge CLI command, begin command with:

do_cli

Example:

```
do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta1 dc:a5:f4:ff:4f:ae
sleep 20
do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta1 dc:a5:f4:f3:ce:9e
sleep 20
```

```
do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta1 dc:a5:f4:ff:4f:ae
roam 1 sta2 dc:a5:f4:ff:4f:ae
roam 1 sta3 dc:a5:f4:ff:4f:ae
roam 1 sta4 dc:a5:f4:ff:4f:ae
roam 1 sta5 dc:a5:f4:f3:ce:9e
roam 1 sta6 dc:a5:f4:f3:ce:9e
roam 1 sta7 dc:a5:f4:f3:ce:9e
sleep 20
do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta7 dc:a5:f4:ff:4f:ae
roam 1 sta6 dc:a5:f4:ff:4f:ae
roam 1 sta5 dc:a5:f4:ff:4f:ae
roam 1 sta4 dc:a5:f4:f3:ce:9e
roam 1 sta3 dc:a5:f4:f3:ce:9e
roam 1 sta2 dc:a5:f4:f3:ce:9e
roam 1 sta1 dc:a5:f4:f3:ce:9e
sleep 20
```

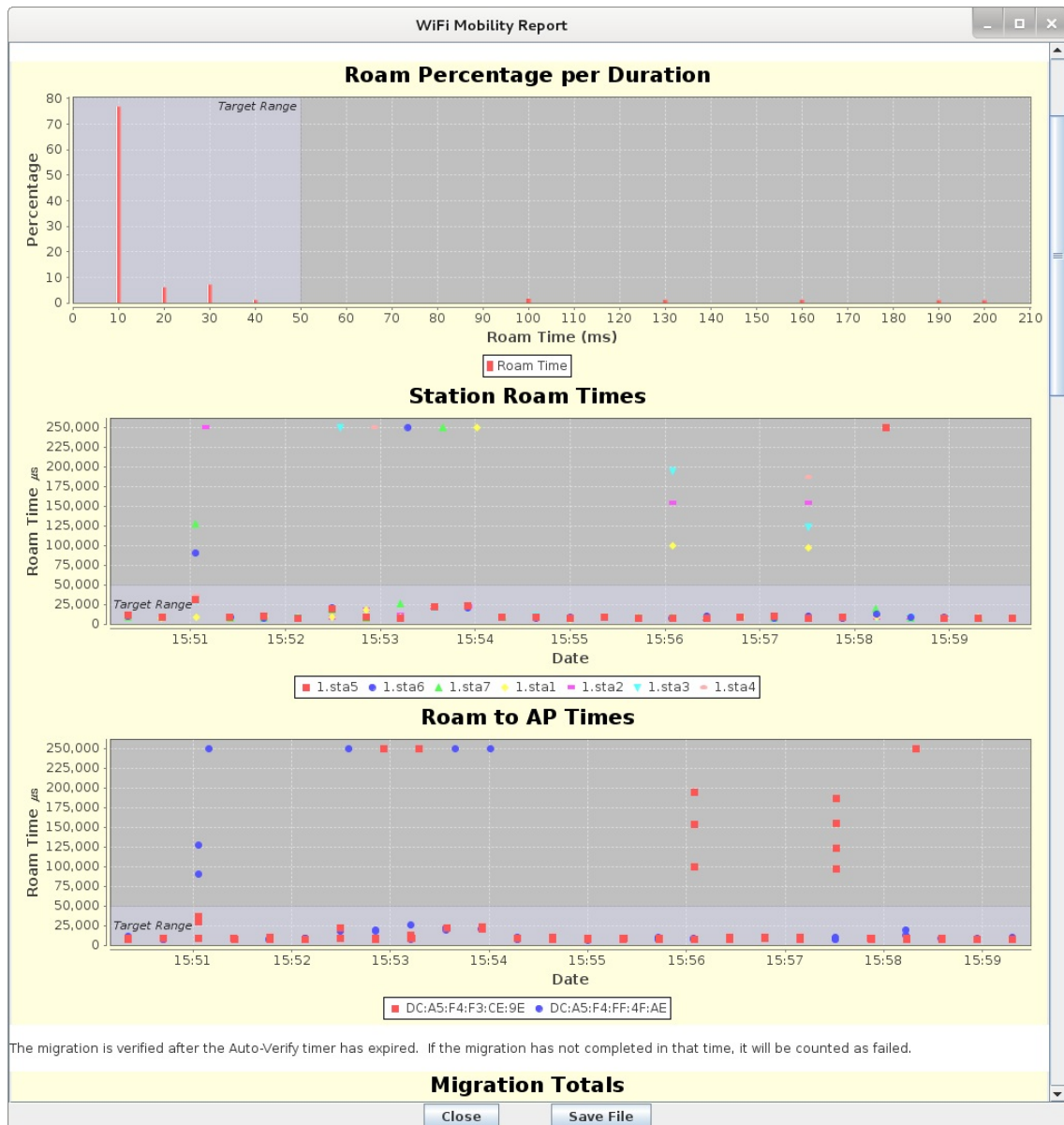
☒ Clear Counters on Start
☒ Run Script in Loop

Start

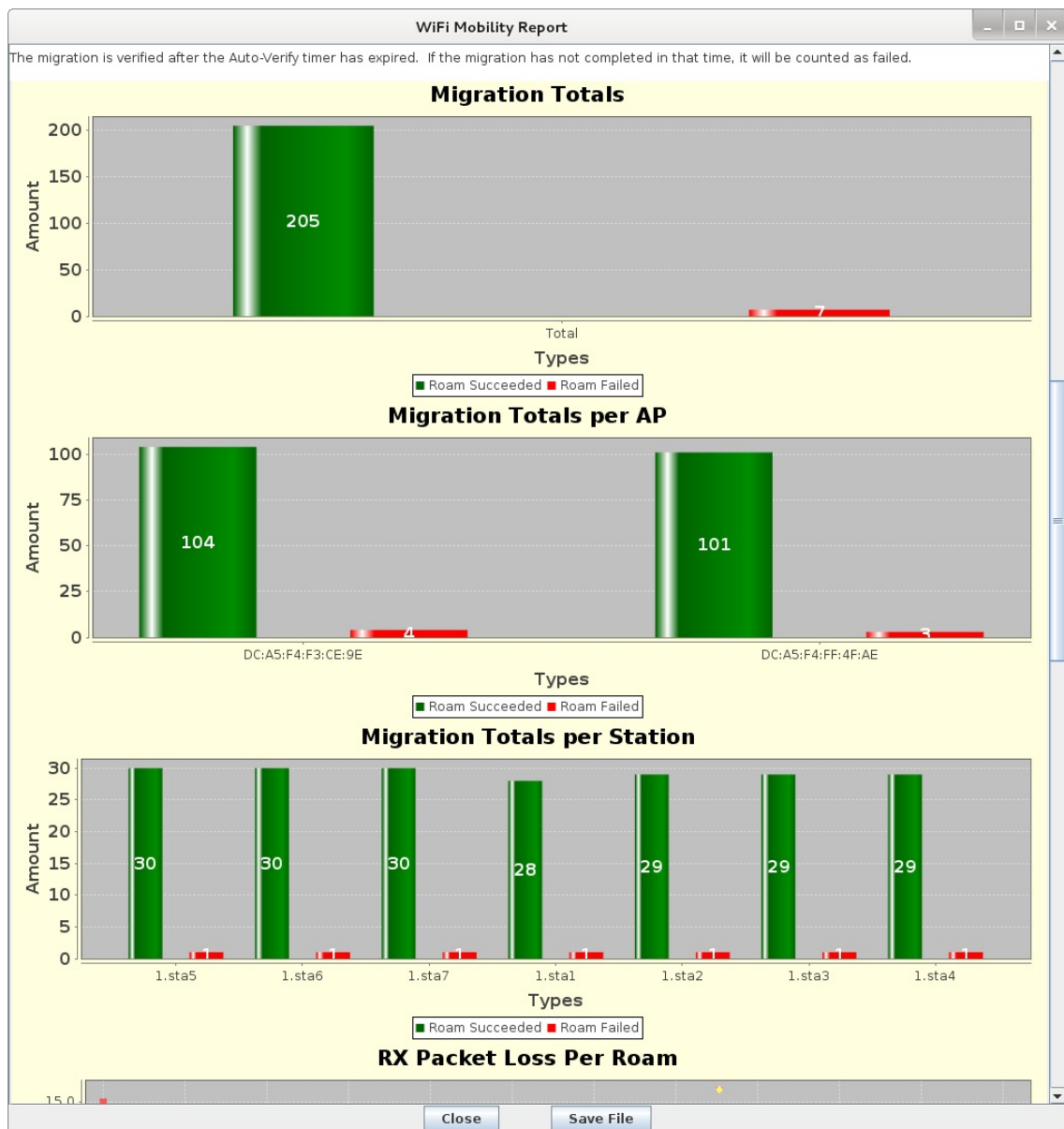
Close

- B. The options at the top default to common values and may not need to be changed. The ports will be automatically configured based on the selection on the Port Manager tab, and can be adjusted before starting the script. The Ports in Use should normally include all stations used in the script. The configuration requiring the most work from the user is the roaming script itself. There is a help section on the left, and a script-entry field on the right. Once the script is written, it should be saved in a text file on the user's PC so that it can easily be pasted into future WiFi Mobility scripts. Some key points are that you must scan about 1 second before roaming or the roam logic in the supplicant process will either fail or do it's own roaming. Either way, the results may be worse than if you do the roam properly in the script. It can take a bit of time for LANforge to get all of the data it needs to report on the roam attempt, so it is suggested that stations not roam more often than about once every 10-20 seconds. If reporting is less important, then the stations can roam more often.

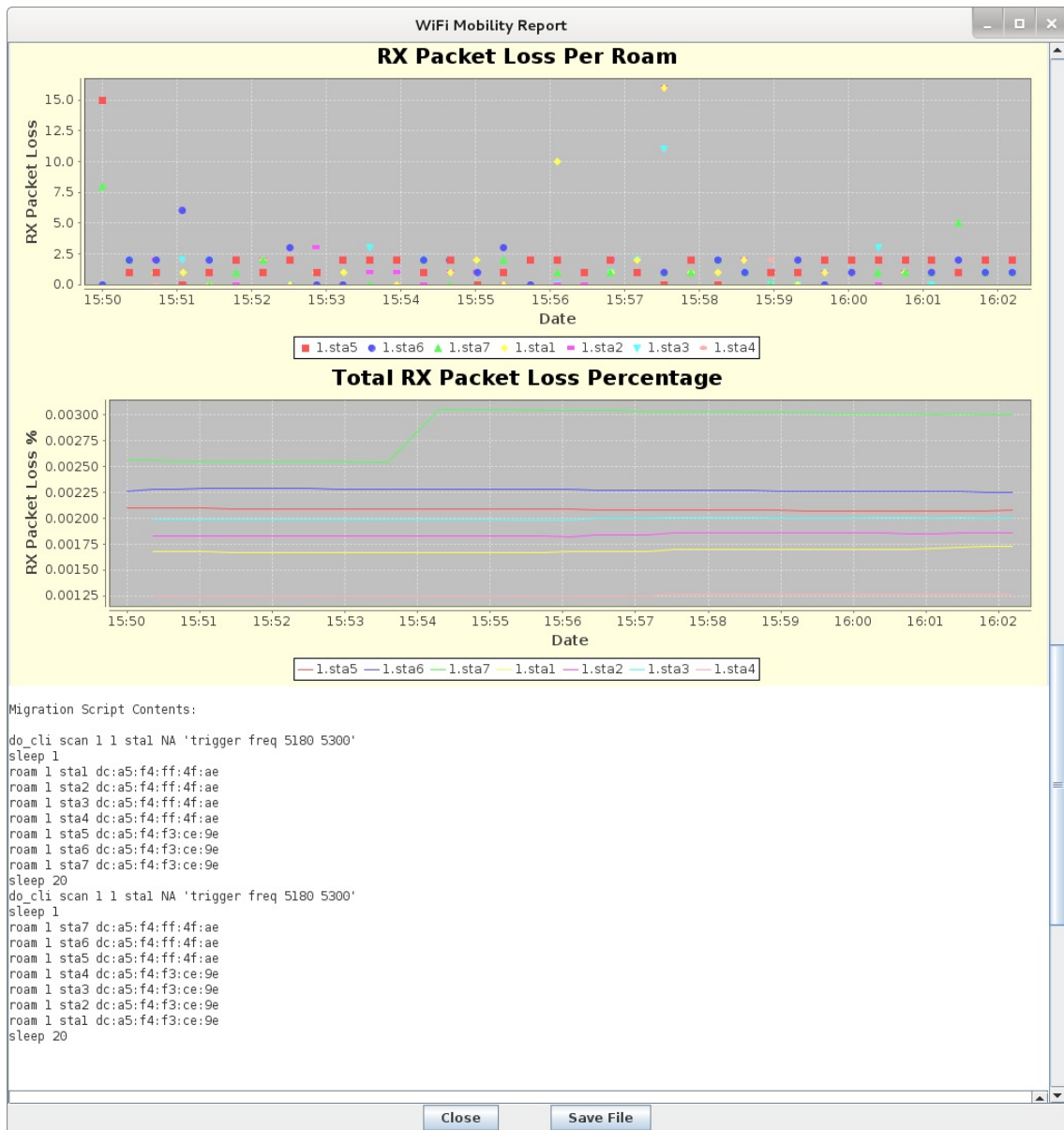
- C. Once the script is properly configured, click Start to start the roaming. A window will pop up that has live-updating graphs of various reports. A text log is at the bottom for more detailed analysis, and the whole thing can be saved as HTML. The graphs can be scaled and configured through right-click menus if desired. It will take 1-2 complete roam attempts before the graphs are able to show any useful information.



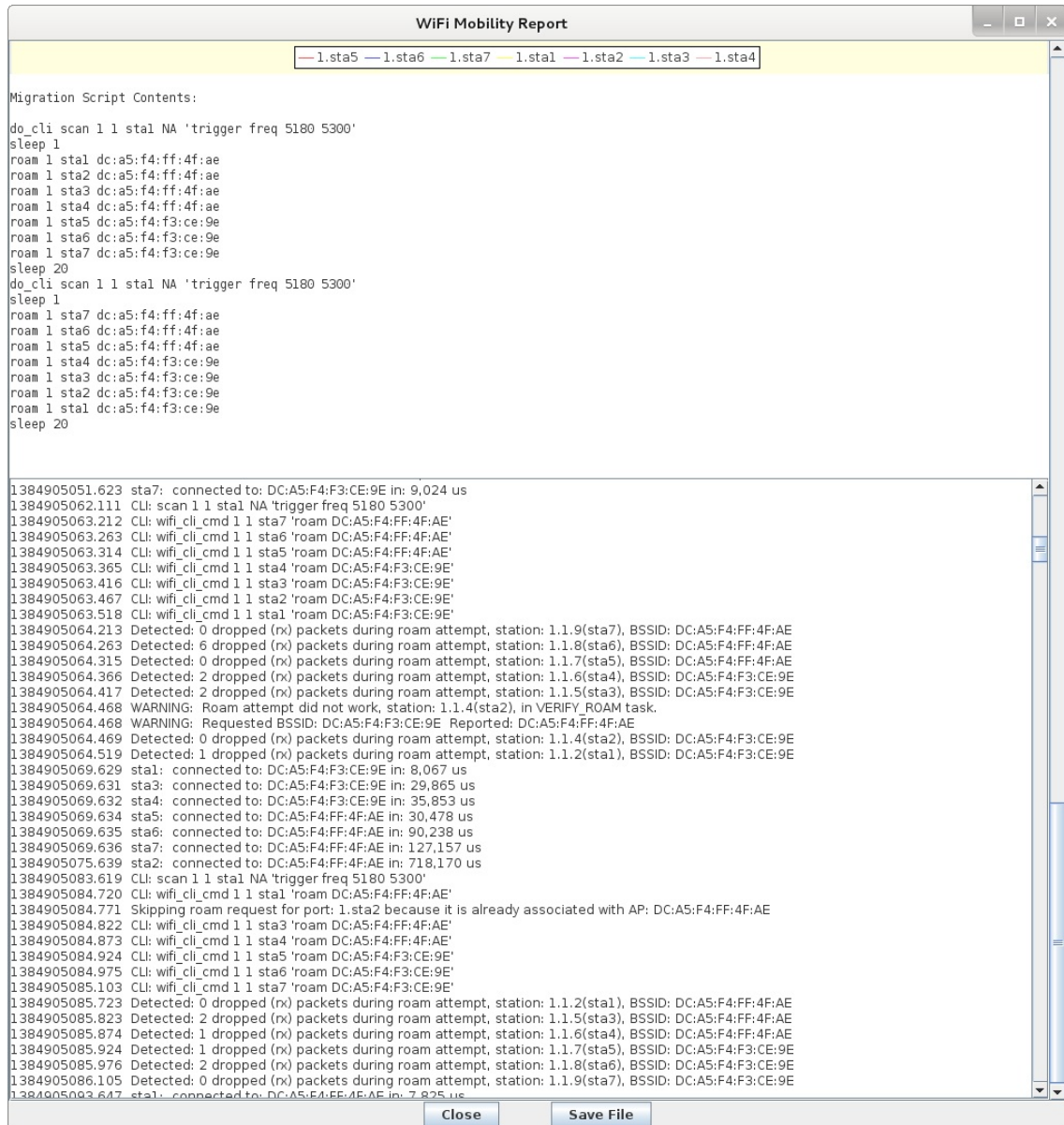
D. Migration totals graphs.



E. Packet Loss graphs.



- F. Text log with timestamps. Can be correlated with wpa_supplicant logs and other log files to debug specific roam attempts.



The screenshot shows a window titled "WiFi Mobility Report" with a yellow header bar containing a legend for stations 1.sta5 through 1.sta4. The main content area is divided into two sections. The top section, "Migration Script Contents:", displays a script with commands like `do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'` and `sleep 1`, followed by a list of roam commands for various stations. The bottom section displays a log of events, each starting with a timestamp and a station ID, followed by a description of the event, such as "connected to" or "Detected: 0 dropped (rx) packets during roam attempt". The log includes details like BSSIDs and station IDs. At the bottom of the window, there are "Close" and "Save File" buttons.

```
Migration Script Contents:

do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta1 dc:a5:f4:ff:4f:ae
roam 1 sta2 dc:a5:f4:ff:4f:ae
roam 1 sta3 dc:a5:f4:ff:4f:ae
roam 1 sta4 dc:a5:f4:ff:4f:ae
roam 1 sta5 dc:a5:f4:f3:ce:9e
roam 1 sta6 dc:a5:f4:f3:ce:9e
roam 1 sta7 dc:a5:f4:f3:ce:9e
sleep 20
do_cli scan 1 1 sta1 NA 'trigger freq 5180 5300'
sleep 1
roam 1 sta7 dc:a5:f4:ff:4f:ae
roam 1 sta6 dc:a5:f4:ff:4f:ae
roam 1 sta5 dc:a5:f4:ff:4f:ae
roam 1 sta4 dc:a5:f4:f3:ce:9e
roam 1 sta3 dc:a5:f4:f3:ce:9e
roam 1 sta2 dc:a5:f4:f3:ce:9e
roam 1 sta1 dc:a5:f4:f3:ce:9e
sleep 20

1384905051.623 sta7: connected to: DC:A5:F4:F3:CE:9E in: 9,024 us
1384905062.111 CLI: scan 1 1 sta1 NA 'trigger freq 5180 5300'
1384905063.212 CLI: wifi_cli_cmd 1 1 sta7 'roam DC:A5:F4:FF:4F:AE'
1384905063.263 CLI: wifi_cli_cmd 1 1 sta6 'roam DC:A5:F4:FF:4F:AE'
1384905063.314 CLI: wifi_cli_cmd 1 1 sta5 'roam DC:A5:F4:FF:4F:AE'
1384905063.365 CLI: wifi_cli_cmd 1 1 sta4 'roam DC:A5:F4:F3:CE:9E'
1384905063.416 CLI: wifi_cli_cmd 1 1 sta3 'roam DC:A5:F4:F3:CE:9E'
1384905063.467 CLI: wifi_cli_cmd 1 1 sta2 'roam DC:A5:F4:F3:CE:9E'
1384905063.518 CLI: wifi_cli_cmd 1 1 sta1 'roam DC:A5:F4:F3:CE:9E'
1384905064.213 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.9(sta7), BSSID: DC:A5:F4:FF:4F:AE
1384905064.263 Detected: 6 dropped (rx) packets during roam attempt, station: 1.1.8(sta6), BSSID: DC:A5:F4:FF:4F:AE
1384905064.315 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.7(sta5), BSSID: DC:A5:F4:FF:4F:AE
1384905064.366 Detected: 2 dropped (rx) packets during roam attempt, station: 1.1.6(sta4), BSSID: DC:A5:F4:F3:CE:9E
1384905064.417 Detected: 2 dropped (rx) packets during roam attempt, station: 1.1.5(sta3), BSSID: DC:A5:F4:F3:CE:9E
1384905064.468 WARNING: Roam attempt did not work, station: 1.1.4(sta2), in VERIFY_ROAM task.
1384905064.468 WARNING: Requested BSSID: DC:A5:F4:F3:CE:9E Reported: DC:A5:F4:FF:4F:AE
1384905064.469 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.4(sta2), BSSID: DC:A5:F4:F3:CE:9E
1384905064.519 Detected: 1 dropped (rx) packets during roam attempt, station: 1.1.2(sta1), BSSID: DC:A5:F4:F3:CE:9E
1384905069.629 sta1: connected to: DC:A5:F4:F3:CE:9E in: 8,067 us
1384905069.631 sta3: connected to: DC:A5:F4:F3:CE:9E in: 29,865 us
1384905069.632 sta4: connected to: DC:A5:F4:F3:CE:9E in: 35,853 us
1384905069.634 sta5: connected to: DC:A5:F4:FF:4F:AE in: 30,478 us
1384905069.635 sta6: connected to: DC:A5:F4:FF:4F:AE in: 90,238 us
1384905069.636 sta7: connected to: DC:A5:F4:FF:4F:AE in: 127,157 us
1384905075.639 sta2: connected to: DC:A5:F4:FF:4F:AE in: 718,170 us
1384905083.619 CLI: scan 1 1 sta1 NA 'trigger freq 5180 5300'
1384905084.720 CLI: wifi_cli_cmd 1 1 sta1 'roam DC:A5:F4:FF:4F:AE'
1384905084.771 Skipping roam request for port: 1.sta2 because it is already associated with AP: DC:A5:F4:FF:4F:AE
1384905084.822 CLI: wifi_cli_cmd 1 1 sta3 'roam DC:A5:F4:FF:4F:AE'
1384905084.873 CLI: wifi_cli_cmd 1 1 sta4 'roam DC:A5:F4:FF:4F:AE'
1384905084.924 CLI: wifi_cli_cmd 1 1 sta5 'roam DC:A5:F4:F3:CE:9E'
1384905084.975 CLI: wifi_cli_cmd 1 1 sta6 'roam DC:A5:F4:F3:CE:9E'
1384905085.103 CLI: wifi_cli_cmd 1 1 sta7 'roam DC:A5:F4:F3:CE:9E'
1384905085.723 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.2(sta1), BSSID: DC:A5:F4:FF:4F:AE
1384905085.823 Detected: 2 dropped (rx) packets during roam attempt, station: 1.1.5(sta3), BSSID: DC:A5:F4:FF:4F:AE
1384905085.874 Detected: 1 dropped (rx) packets during roam attempt, station: 1.1.6(sta4), BSSID: DC:A5:F4:FF:4F:AE
1384905085.924 Detected: 1 dropped (rx) packets during roam attempt, station: 1.1.7(sta5), BSSID: DC:A5:F4:F3:CE:9E
1384905085.976 Detected: 2 dropped (rx) packets during roam attempt, station: 1.1.8(sta6), BSSID: DC:A5:F4:F3:CE:9E
1384905086.105 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.9(sta7), BSSID: DC:A5:F4:F3:CE:9E
1384905093.647 sta1: connected to: DC:A5:F4:FF:4F:AE in: 7,825 us
```