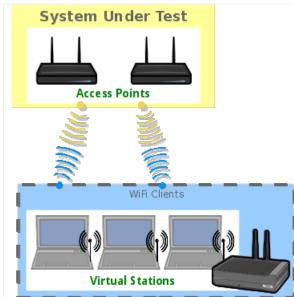


## LANforge WiFi Testing Fast Roaming Stations with 802.11r

**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:

	Current: I	Port Status Inform LINK-UP GRO Autho Port Type: WIFI-STA	orized	)	
		Port Configurabl	es		
Standard Configura	ation Advance	ed Configuration	erface Settings		
Set IP Info	DHCP-IPv6	DHCP Release	Down	Aux-Mgt	
🗹 Set IP6 Info	DHCP-IPv4	Secondary-IPs	DHCP Client ID:		
🗌 Set IF Down	_	192.168.2.1	Peer IP:	NA	
Set MAC	IP Address:	0.0.0.0	Global IPv6:	DELETED	i
🔲 Set TX Q Len	IP Mask:	0.0.0.0	Link IPv6:	DELETED	
Set MTU	Gateway IP:	0.0.0.0	IPv6 GW:	DELETED	
Set Offload	Alias:		MTU:	1500	
Set PROMISC	MAC Addr:	00:aa:aa:aa:aa:01	TX Q Len	1000	
	Rpt Timer:	medium (8 s) 🖵	WiFi Bridge:	NONE	
🔲 НТТР		WiFi	Settings		
FTP	SSID:	aironetl-5 💌 /	AP:	DEFAULT	]
	Key/Phrase:	lanforge	Mode:	802.11abqn 🛛 🔻	
Low Level	Freq/Channel:	5180/36	Rate:	OS Default 🛛 🔻	
PROMISC TSO Enabled	RTS:	-1	Tx-Power:	17 dBm	
	AMPDU-Factor	: OS Default 🔽 🗸	AMPDU-Density:	OS Default 🗸 👻	
	Max-AMSDU:	OS Default 🔻 I	Bridge-IP:	0.0.0.0	1
	🗌 Use WPA 🕨	Use WPA2 🗌 Use	WEP 🔲 Disable	HT40 🔲 Disable SGI	
GRO Enabled	🗌 Scan Hidde	n 🔲 Allow Migratio	on		
1					

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:

	Port Status In			
	Current: LINK-UP GRO			
	Driver Info: Port Type: WIF	I-STA Parent: v	vipnyo	
	Port Config	urables		
Standard Configurat				
	Advanced WiF	i Settings		1
	e Standard Configuration s o enable most of these. En			
Key Management:	FT-EAP (llr)	HESSID:		
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 📃 P	C/SC & SIM/USIM 📃 Enabl	e 802.11u 🗌 H	otSpot 2.0 🗹 Enable PKC	
🗌 Custom WPA Cfg	WPA Cfg:	/home/lanforge/	/wifi/stal_wpa.conf	
Restart DHCP on	Connect			

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:

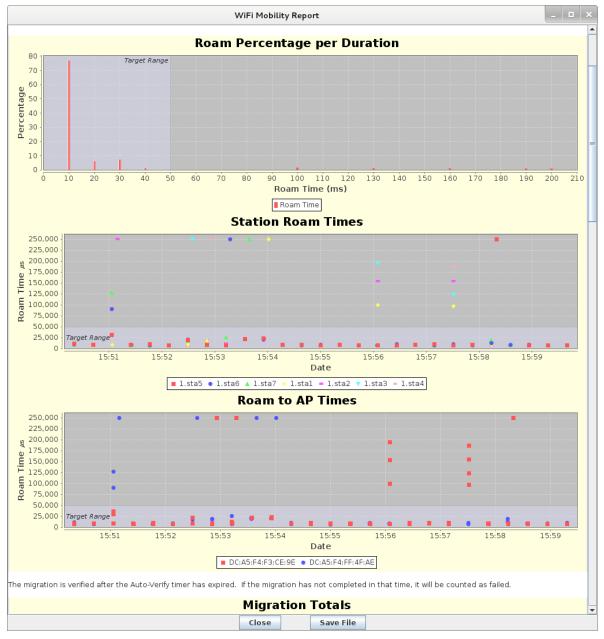
					Create/Mod	lify Cro	ss Connect						_ 🗆 ×
					Cros	ss Conn	ect Information						
сх	Name:	voip-001	Rp	pt Timer:	fast (1 :	s)	<ul> <li>Test Manager</li> </ul>	de	fault_tm 👻	сх т	ype: Voice	e - SIP 🔻	
۲	Multi-Call	Directe	ed Mi	lin Call Du	ration (s) F	ile	➡ Max Ring Time (s):	20	-	Cod	ec: G.71	lu 🔻	
0	Continuous Call	🔾 Use Ga	ateway M	lax Call Du	ration (s) F	ile	▼ Min Inter-Call Gap	(s): 3	-	Star	rt Delay: 3	-	
		Don't S	Send RTP Nu	umber Of	Calls II	NFINITE	Max Inter-Call Gap	o (s): 3	-	Quie	esce: 45 (4	5) 🔻	
										1.			
TX Endpoint (endpoint A)													
Endp Name:	voip-001-A		UnMana	ged 🛛	Bind SIP		JDP Port	AUTO			Tx File	media/female_	voice_8khz.wav
Shelf:	1	<b>•</b>	🗌 Don't An	nswer	Record		SIP Port	5060			Destination:	AUTO	
Resource: Port:	1 (ct521-5359-F1 2 (stal)	7x64) 🔻	Rcv Call	Г	Enable PE	50	P ToS:	VO (WiF	i) (19)	2) 🗸	Speaker	/dev/audio	•
IP Addr:	AUTO	<b>•</b>	No Tunn				Socket Priority:	0				anonymous@:	0
Phone #	AUTO		No Fast				· · · · · ·	250			Record File	/dev/null	
Display Name:	6670135			-	VAD		/AD Delay(ms)						
Auth User Name:	AUTO		Single Co	odec	Override 9	SDP	/AD Force Send	3000			PESQ Server:		8
Reg Expire:	300	-				1	itter Buffer:	8			Quiesce:	45 (45)	<b>*</b>
					RX	Endpoi	nt (endpoint B)						
Endp Name:	voip-001-B							AUTO			Tx File	media/female	uning Oldhauunu
Shelf:	1	-	UnMana	5	Bind SIP		JDP Port						voice_aknz.wav
Resource:	1 (ct521-5359-F1	7x64) 🔻	🗌 Don't An	iswer	Record	1	SIP Port	5060			Destination:	AUTO	
Port:	1 (eth1)	-	Rcv Call		Enable PE	SQ	P ToS:	VO (WiF	i) (192	2) 🔻	Speaker	/dev/audio	•
IP Addr:	AUTO	-	No Tunn	eling [	Play to sp	eaker	Socket Priority:	0			Call Gateway	r: anonymous@:	
Phone #	AUTO		No Fast !	Start	VAD	,	/AD Delay(ms)				Record File		
Display Name:	4974595		Single Co	odec	Override S	SDP	/AD Force Send	3000			PESQ Server:	127.0.0.1:399	8
Auth User Name:							itter Buffer:	8			Quiesce:	45 (45)	
Reg Expire:	300	•					itter barren				quicacer	12 ( 13)	
			Apply	OK		Refresh	Batch-Crea	ate	Cano	el			
	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 Mobilit	у		_ 0	×	
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 S	tations				
Ports in Use			Free Ports 1.1.10 sta8			
1.1.4 sta2			1.1.11 sta9			
1.1.5 sta3			1.1.12 sta10			
1.1.5 sta5	bbA →	Station	1.1.13 sta11			
1.1.7 sta5			1.1.14 sta12			
1.1.7 sta5			1.1.15 sta13			
1.1.0 stab	Remove S	Station $\rightarrow$	1.1.16 sta14			
1.1.9 Sta7			1.1.16 sta14 1.1.17 sta15			
			1.1.18 sta16	•		
Before roaming, you should first scan the proper fre		ida ali asan 1	l 1 sta1 NA 'trigger	frog 5190 5200		
Otherwise, the supplicant process may do an intern which may significantly affect the connection time: do_cli scan 1 Resource STA NA 'trigger frac To roam to a new Access Point, add a line in the tex the following format: roam Resource STA BSSID Resource: Station's resource ID number, often ': STA: name of the station to roam: 'stal1' BSSID: the BSSID address of the AP: 00:01:02:0 F1: the first frequency to scan: 5180 F2: Optional second frequency to scan: 5300 After issuing ROAM commands, a pause should be an the stations adjust (in seconds, floating-point allows sleep 20 To issue a generic LANforge CLI command, begin co do_cli Example: do_cli scan 1 1 stal NA 'trigger freq 5180 sleep 1 roam 1 stal dc:a5:f4:ff:4f:ae sleep 20 do_cli scan 1 1 stal NA 'trigger freq 5180 sleep 20 do_cli scan 1 1 stal NA 'trigger freq 5180 sleep 1 roam 1 stal dc:a5:f4:f3:ce:9e sleep 20	eq F1 F2' tt area with 1' )3:04:05 dded to let ed): mmand with: 0 5300'	roam 1 sta2 roam 1 sta3 roam 1 sta4 roam 1 sta5 roam 1 sta6 roam 1 sta7 sleep 20 do_cli scan 1 sleep 1 roam 1 sta7 roam 1 sta6 roam 1 sta5 roam 1 sta3 roam 1 sta3 roam 1 sta2	dc:a5:f4:ff:4f:ae dc:a5:f4:ff:4f:ae dc:a5:f4:ff:4f:ae dc:a5:f4:ff:4f:ae dc:a5:f4:f3:ce:9e dc:a5:f4:f3:ce:9e dc:a5:f4:f3:ce:9e l 1 sta1 NA 'trigger dc:a5:f4:ff:4f:ae dc:a5:f4:ff:4f:ae dc:a5:f4:ff:4f:ae dc:a5:f4:f3:ce:9e dc:a5:f4:f3:ce:9e dc:a5:f4:f3:ce:9e dc:a5:f4:f3:ce:9e	freq 5180 5300'		
Clear Counters on Start	<mark>⊮</mark> Run Sc	ript in Loop	Start	<u>C</u> lose		

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 that about once every 10-20 seconds. If reporting is less important, then the stations can roam more often.

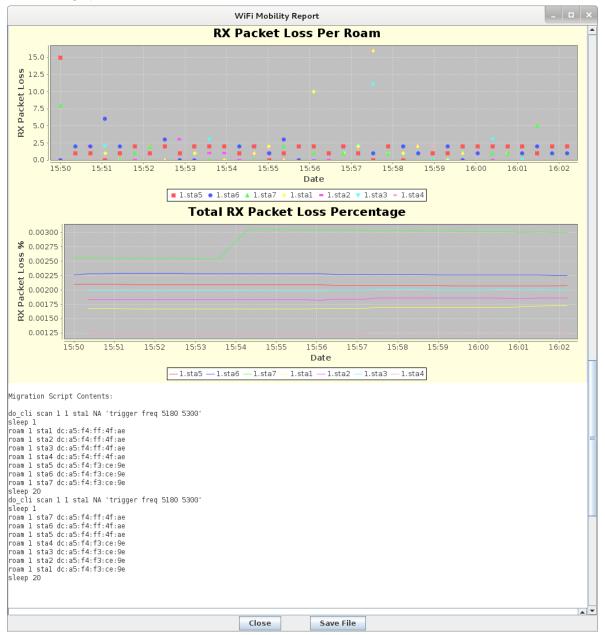
C. Once the script is properly configured, click Start to start the roaming. A window will pop up that has liveupdating graphs of various reports. A text log is at the bottom for more detailed analysis, and the whole thing can be saved as HTML. The graphs can be scaled and configured through right-click 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 coorelated with wpa\_supplicant logs and other log files to debug specific roam attempts.

WiFi Mobility Report	
—1.sta5 —1.sta6 —1.sta7 —1.sta1 —1.sta2 —1.sta3 —1.sta4	
ligration Script Contents:	
lo_cli scan l l stal NA 'trigger freq 5180 5300'	
leep l voam 1 stal dc:a5:f4:ff:4f:ae	
oam 1 sta2 dc:a5:f4:ff:4f:ae	
oam l sta3 dc:a5:f4:ff:4f:ae oam l sta4 dc:a5:f4:ff:4f:ae	
oam l sta5 dc:a5:f4:f3:ce:9e	
oam l sta6 dc:a5:f4:f3:ce:9e oam l sta7 dc:a5:f4:f3:ce:9e	
sleep 20 do cli scan l 1 stal 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 l sta4 dc:a5;f4;f3;ce:9e roam l sta3 dc:a5;f4;f3;ce:9e	
roam l sta2 dc:a5:f4:f3:ce:9e	
roam 1 stal dc:a5:f4:f3:ce:9e sleep 20	
.384905051.623 sta7: connected to: DC:A5:F4:F3:CE:9E in: 9,024 us	
384905062.111 CLI: scan 1 1 stal NA 'trigger freq 5180 5300'	
384905063.212 CLI: wifi_cli_cmd 1 1 sta7 'roam DC:A5:F4:FF:4F:AE' 384905063.263 CLI: wifi_cli_cmd 1 1 sta6 'roam DC:A5:F4:FF:4F:AE'	
L384905063.314 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 (nx) packets during roam attempt, station: 1.1.6(sta4), BSSID: DC:A5:F4:F3:CE:9E	
L384905064.417 Detected: 2 dropped (nx) packets during roam attempt, station: 1.1.5(sta3), BSSID: DC:A5:F4:F3:CE:9E L384905064.468 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	
L384905069.629 stal: connected to: DC:A5:F4:F3:CE:9E in: 8,067 us L384905069.631 sta3: connected to: DC:A5:F4:F3:CE:9E in: 29,865 us	
L384905069.632 sta4: connected to: DC:A5:F4:F3:CE:9E in: 35,853 us	
.384905069.634 sta5: connected to: DC:A5:F4:FF:4F:AE in: 30,478 us .384905069.635 sta6: connected to: DC:A5:F4:FF:4F:AE in: 90,238 us	
.384905069.636 sta7: connected to: DC:A5:F4:FF:4F:AE in: 127,157 us	
.384905075.639  sta2:  connected to: DC:A5:F4:FF:4F:AE in: 718,170 us .384905083.619   CLI: scan 1 1 sta1 NA 'trigger freq 5180 5300'	
.384905084.720 CLI: wifi_cli_cmd 1 1 sta1 roam DC:A5:F4:FF:4F:AE	
384905084.771 Skipping roam request for port: 1.sta2 because it is already associated with AP: DC:A5:F4:FF:4F:AE 384905084.822 CLI: wifi_cli_cmd 1 1 sta3 'roam DC:A5:F4:FF:4F:AE'	
.384905084.873 CLI: wifi_cli_cmd 1 1 sta4 'roam DC:A5:F4:FF:4F:AE'	
.384905084.924  CLI: wifi_cli_cmd 1 1 sta5 'roam DC:A5:F4:F3:CE:9E' .384905084.975  CLI: wifi_cli_cmd 1 1 sta6 'roam DC:A5:F4:F3:CE:9E'	
.384905085.103 CLI: wifi_cli_cmd 1 1 sta7 'roam DC:A5:F4:F3:CE:9E' .384905085.723 Detected: 0 dropped (nx) packets during roam attempt, station: 1.1.2(sta1), BSSID: DC:A5:F4:FF:4F:AE	
.384905085.823 Detected: 2 dropped (rx) packets during roam attempt, station: 1.1.5(sta3), BSSID: DC:A5:F4:FF:4F:AE	
L384905085.874 Detected: 1 dropped (rx) packets during roam attempt, station: 1.1.6(sta4), BSSID: DC:A5:F4:FF:4F:AE L384905085.924 Detected: 1 dropped (rx) packets during roam attempt, station: 1.1.7(sta5), BSSID: DC:A5:F4:F3:CE:9E	
L384905085.976 Detected: 2 dropped (nx) packets during roam attempt, station: 1.1.8(sta6), BSSID: DC:A5:F4:F3:CE:9E	
L384905086.105 Detected: 0 dropped (rx) packets during roam attempt, station: 1.1.9(sta7), BSSID: DC:A5:F4:F3:CE:9E	

Candela Technologies, Inc., 2417 Main Street, Suite 201, Ferndale, WA 98248, USA www.candelatech.com | sales@candelatech.com | +1.360.380.1618