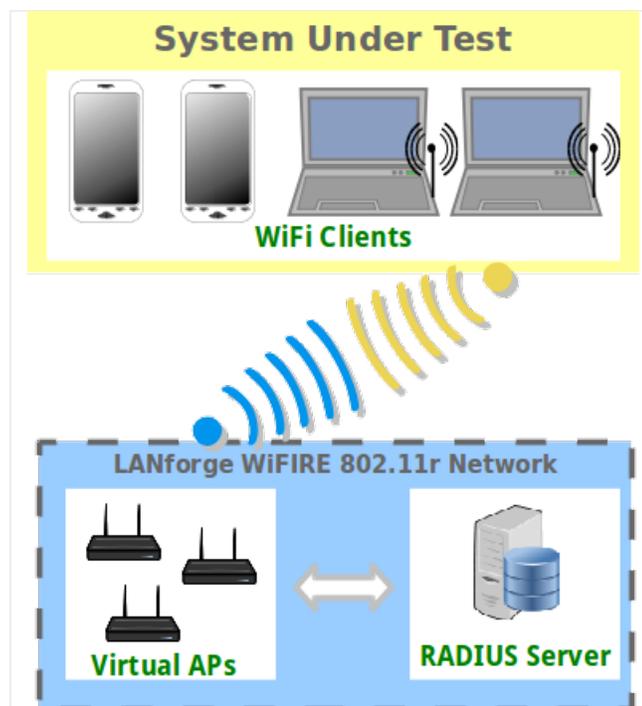


## LANforge WiFi Access Point Network with 802.11r

**Goal:** Configure a virtual AP network with 802.11r to allow testing fast transition (FT) clients. Configure virtual Access Points to use 802.11r with FT-EAP. This example uses a LANforge CT523 system but the procedure will work on all CT522, CT523 and CT525 multi-radio systems.

The wifi clients under test are also 802.11r enabled so that they can initiate FT Requests and roam. Here we are using another LANforge WiFire as the system under test to emulate 802.11r stations and force them to roam.

In LANforge, each virtual access point will be running its own hostapd process configured to enable 802.11r and bridged to other virtual access points. The bridged VAP network will emulate the Distributed System (DS) for FT over-the-DS roaming.



1. Setup a single virtual access point on each wifi NIC for at least two NICs and configure them for the same channel and SSID.
  - A. Go to the Port Manager tab, select the parent device such as wiphy0, click Modify, set a specific channel/frequency. Repeat for wiphy1.
  - B. Select wiphy0, click Create, fill out appropriate information and create a virtual access point. Repeat for wiphy1.

- C. The new vap should appear in the Port-Mgr table. Double-click to modify. Configure SSID and select WPA2 but do not fill in the Key/Phrase:

**vap1 (ct523-3n-f20) Configure Settings**

Port Status Information  
Current: LINK-DOWN GRO NONE  
Driver Info: Port Type: WIFI-AP Parent: wiphy0

Port Configurables

Standard Configuration | Advanced Configuration | Misc Configuration | Custom WiFi

**Enable**

- 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**

- Down  Aux-Mgt
- DHCP-IPv6  DHCP Release DHCP Vendor ID: None
- DHCP-IPv4  DHCP Client ID: None
- DNS Servers: BLANK Peer IP: NA
- IP Address: 0.0.0.0 Global IPv6: AUTO
- IP Mask: 0.0.0.0 Link IPv6: AUTO
- Gateway IP: 0.0.0.0 IPv6 GW: AUTO
- Alias: MTU: 1500
- MAC Addr: 00:0e:8e:6c:38:71 TX Q Len: 1000
- Rpt Timer: medium (8 s) WiFi Bridge: NONE

**WiFi Settings**

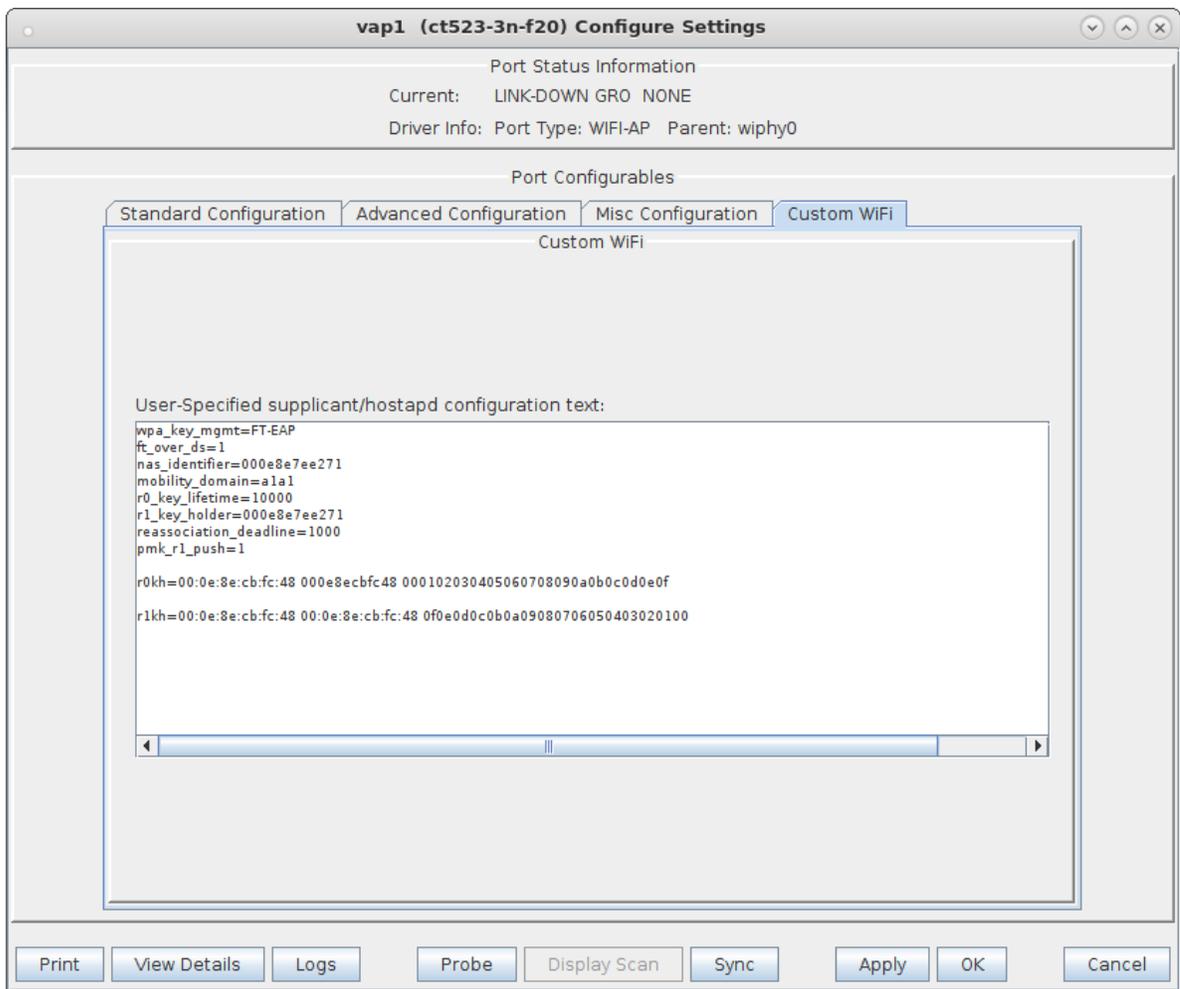
- SSID: 80211r-ssid AP: DEFAULT
- Key/Phrase: Mode: (802.11abgn-AC)
- Freq/Channel: 5220/44 Rate: OS Default
- DTIM-Period: 2 Max-STA: 2007
- Beacon: 240
- WPA  WPA2  OSEN  WEP  Disable HT40  Disable HT80  Disable SGI
- Verbose Debug

Print View Details Logs Probe Display Scan Sync Apply OK Cancel

- D. Select the **Advanced Configuration** tab in the Port-Modify window and check the box Advanced/802.1x and fill in the RADIUS IP/Port/Secret. Here the RADIUS server will be another instance of hostapd configured on a bridge interface and accessible via localhost.

The screenshot shows the 'vap1 (ct523-3n-f20) Configure Settings' window. At the top, it displays 'Port Status Information' with 'Current: LINK-DOWN GRO NONE' and 'Driver Info: Port Type: WIFI-AP Parent: wiphy0'. Below this is the 'Port Configurables' section, which includes tabs for 'Standard Configuration', 'Advanced Configuration', 'Misc Configuration', and 'Custom WiFi'. The 'Advanced Configuration' tab is selected, and the 'Advanced WiFi Settings' sub-tab is active. A text box at the top of this sub-tab reads: 'Select 'WPA2' on the Standard Configuration screen to enable Advanced/802.1x and enable Advanced/802.1x to enable most of these. Enabling 802.11u enables others.' The settings are organized into two columns. The left column contains dropdown menus for 'Ignore Probes', 'Ignore Auth-Assoc', 'Ignore Assoc', 'Ignore Re-Assoc', 'Corrupt GTK', 'HS20 Capabilities', 'HS20 Oper Class', 'HS20 WAN Metrics', 'leee80211w', 'Venue Group', 'Network Type', and 'Network Auth'. The right column contains text input fields for 'HESSID', 'Realm', 'IMSI', 'Milenage', 'Domain', 'Consortium', 'RADIUS IP', 'RADIUS Port', 'RADIUS Secret', 'Venue Type', and 'Address Types'. At the bottom of the sub-tab, there are several checkboxes: 'Use 80211d', 'Use 80211h', 'Short-Preamble', 'Advanced/802.1x' (checked), 'HotSpot 2.0', 'Disable DGAF', 'Enable 802.11u', '802.11u Internet', '802.11u ASRA', '802.11u ESR', and '802.11u UESA'. The 'RADIUS IP' field is set to '127.0.0.1', 'RADIUS Port' to '1812', and 'RADIUS Secret' to 'lanforge'. The 'Advanced/802.1x' checkbox is highlighted with an orange background. At the bottom of the main window, there are buttons for 'Print', 'View Details', 'Logs', 'Probe', 'Display Scan', 'Sync', 'Apply', 'OK', and 'Cancel'.

- E. Select the **Custom WiFi** tab in the Port-Modify window to fill in the additional hostapd options to enable and configure 802.11r. These lines will be appended to the end of the LANforge generated hostapd configuration file located in /home/lanforge/wifi of the resource in use.



**vap1 00:0e:8e:7e:e2:71 - Your MAC will be different.**

```
wpa_key_mgmt=FT-EAP
ft_over_ds=1
nas_identifier=000e8e7ee271 #vap1 MAC without colon delimiters, yours will differ.
mobility_domain=alal
r0_key_lifetime=10000
r1_key_holder=000e8e7ee271 #vap1 MAC without colon delimiters, yours will differ.
reassociation_deadline=1000
pmk_r1_push=1

#r0kh is vap2 MAC address, vap2 nas identifier, AES key
r0kh=00:0e:8e:cb:fc:48 000e8ecbfc48 000102030405060708090a0b0c0d0e0f

#r1kh is vap2 MAC address, vap2 r1 key holder MAC, AES key
r1kh=00:0e:8e:cb:fc:48 00:0e:8e:cb:fc:48 0f0e0d0c0b0a09080706050403020100
```

full configuration file: [hostapd\\_vap1.conf](#)

**vap2 00:0e:8e:cb:fc:48 - Your MAC will be different.**

```
wpa_key_mgmt=FT-EAP
ft_over_ds=1
nas_identifier=000e8ecbfc48 #vap2 MAC without colon delimiters, yours will differ.
mobility_domain=alal
r0_key_lifetime=10000
r1_key_holder=000e8ecbfc48 #vap2 MAC without colon delimiters, yours will differ.
reassociation_deadline=1000
pmk_r1_push=1

#r0kh is vap1 MAC address, vap1 nas identifier, AES key
r0kh=00:0e:8e:7e:e2:71 000e8e7ee271 0f0e0d0c0b0a09080706050403020100

#r1kh is vap1 MAC address, vap1 r1 key holder MAC, AES key
r1kh=00:0e:8e:7e:e2:71 00:0e:8e:7e:e2:71 000102030405060708090a0b0c0d0e0f
```

full configuration file: [hostapd\\_vap2.conf](#)

If you wanted to add FT-PSK capability, add the following to the hostapd configuration file:

```
wpa_key_mgmt=FT-EAP FT-PSK
wpa_passphrase=1234567890
```

In this example, we are configuring push mode key distribution where the master key holder, R0KH, derives the R1 key for all secondary key holders, R1KH, listed in the configuration file and sends it to them over the DS via bridge interfaces. The R0KH and R1KH entries must be configured for all virtual access points in the 802.11r network.

For more information on hostapd 802.11r configuration, see:

**general hostapd configuration**

<https://www.w1.fi/cgiit/hostap/plain/hostapd/hostapd.conf>

**how to enable wifi roaming**

<https://blog.fem.tu-ilmenau.de/archives/1002-HowTo-enable-WiFi-roaming-with-hostapd-and-VLANs.html>

**802.11r hostapd example**

<ftp://ftp.raspberry-pi-geek.com/pub/listings/rasp-pi-geek.com/04/AccessPoint/Listing04.txt>

F. Repeat above steps A-E for vap2 on wiphy1.

2. Create a bridge device for the first virtual access point, vap1. This bridge will be placed inside a virtual router so that it can serve DHCP requests and act as a RADIUS authentication server.

A. Go to the port manager tab, select Create, then select Bridge and enter Quantity 1 and a Bridge Name, then Apply to create the bridge.

**Create VLANs on Port: 1.1.00**

1  MAC-VLAN  802.1Q-VLAN  Redirect  Bridge  GRE Tunnel  
 WiFi STA  WiFi VAP  WiFi Monitor  WiFi Virtual Radio

2 Shelf: 1 Resource: 1 (ct523-3n-f20) Port: 0 (eth0)(MGT)

3 VLAN ID:   DHCP-IPv4  
Parent MAC: 00:90:0b:2d:6a:82 DHCP Client ID: None  
MAC Addr:  IP Address:  Global IPv6: AUTO  
Quantity: 1 IP Mask or Bits:  Link IPv6: AUTO  
Gateway IP:  IPv6 GW: AUTO  
Bridge Name: br0 #2 Redir Name:   
STA ID:  SSID:   
WiFi AP:  Key/Phrase:   
 WPA  WPA2  WEP

4  Down  
Apply Cancel Ready

- B. Modify the new bridge device to add vap1. Type vap1 in the text entry box, then select Add Ports, then select Apply.

**br0 (ct523-3n-f20) Configure Settings**

Port Status Information  
Current: LINK-DOWN TSO UFO GSO GRO  
Driver Info: Port Type: Bridge Cannot Detect

Port Configurables

Enable

- Set IF Down
- Set MAC
- Set TX Q Len
- Set MTU
- Set Offload
- Set Bridge Info

General Interface Settings

- Down  Aux-Mgt
- DHCP-IPv6  DHCP Release DHCP Vendor ID: None
- DHCP-IPv4 Secondary-IPs DHCP Client ID: None
- DNS Servers: BLANK Peer IP: NA
- IP Address: 192.168.0.1 Global IPv6: AUTO
- IP Mask: 255.255.255.0 Link IPv6: AUTO
- Gateway IP: 0.0.0.0 IPv6 GW: AUTO
- Alias: MTU: 1500
- MAC Addr: 00:00:00:00:00:00 TX Q Len: 0
- Rpt Timer: medium (8 s) WiFi Bridge: NONE

Spanning-Tree

- Aging Time: 300
- Bridge Priority: 32768
- Max Age: 20
- Hello Time: 2
- Forwarding Delay: 15

Services

- HTTP
- FTP
- RADIUS

Bridge Information

Configured Ports | Current Ports

Remove Ports

Add Ports

vap1

Print View Details Probe Sync Apply OK Cancel

- C. Select Sync to verify vap1 is a configured and current bridge member.

**br0 (ct523-3n-f20) Configure Settings**

Port Status Information  
Current: LINK-UP TSO UFO GSO GRO  
Driver Info: Port Type: Bridge Cannot Detect

Port Configurables

Enable

- Set IF Down
- Set MAC
- Set TX Q Len
- Set MTU
- Set Offload
- Set Bridge Info

General Interface Settings

- Down  Aux-Mgt
- DHCP-IPv6  DHCP Release DHCP Vendor ID: None
- DHCP-IPv4 Secondary-IPs DHCP Client ID: None
- DNS Servers: BLANK Peer IP: NA
- IP Address: 192.168.0.1 Global IPv6: AUTO
- IP Mask: 255.255.255.0 Link IPv6: AUTO
- Gateway IP: 0.0.0.0 IPv6 GW: AUTO
- Alias: MTU: 1500
- MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len: 0
- Rpt Timer: medium (8 s) WiFi Bridge: NONE

Spanning-Tree

- Aging Time: 300
- Bridge Priority: 32768
- Max Age: 20
- Hello Time: 2
- Forwarding Delay: 15

Services

- HTTP
- FTP
- RADIUS

Bridge Information

Configured Ports | Current Ports

vap1 | vap1

Remove Ports

Add Ports

Print View Details Probe Sync Apply OK Cancel

- D. Go to NetSmith, right-click the bridge and select Modify to add DHCP service. Select the DHCP checkbox at the bottom, then fill in the DHCP Lease Time, DHCP DNS, DHCP Range Min, DHCP Range Max and DHCP Domain if needed, then select OK.

Port 1-A: 8 (br0)

Port 1-B:  Skip <Auto Create New Port>

WanLink:  Skip <Auto Create New WanLink>

Port 2-B:  Skip <Auto Create New Port>

Port 2-A:  Skip <Auto Create New Port>

DHCP Lease Time: 43200

DHCP DNS: 192.168.0.1

DHCP Range Min: 192.168.0.10

DHCP Range Max: 192.168.0.254

DHCP Domain:

DHCPv6 DNS:

DHCPv6 Range Min:

DHCPv6 Range Max:

DHCPd Config File:

Interface-Cost: 1

RIP-Metric: 1

OSPF Area: 0.0.0.0

VRRP IP: 0.0.0.0/24

VRRP ID: 1

VRRP Priority: 100

VRRP Interval: 1

Next-Hop: 0.0.0.0

Subnets (a.b.c.d/xx):

Next-Hop-IPv6:

IPv6 Subnets (aaa::0/xx):

NAT  DHCP  DHCPv6  Custom DHCP  VRRP  Cand-RP

OK Cancel

- E. Go to NetSmith, right-click in a free area and select New Router and select OK. Then drag the bridge br0 into the virtual router and select NetSmith Apply.

For more information see [Virtual Router with DHCP Cookbook \(skip the wanlink portion\)](#)

3. Add a RADIUS server to the bridge device.

- A. Go to NetSmith, right-click the bridge and select Modify Port to add RADIUS service.

- B. Select the RADIUS checkbox, then select OK.

- C. Setup the following configuration files to start the RADIUS service. You will need to create these files, but the certificate files can be created by running the `lf_install` script with the `--do_radius` option.

**/etc/hostapd.radius\_clients**

```
0.0.0.0/0 lanforge
```

**/etc/hostapd.eap\_user**

```
"dot11r.user" PEAP
"dot11r.user" MSCHAPV2 "!!dot11r123" [2]
```

**/home/lanforge/wifi/hostapd\_br0.conf**

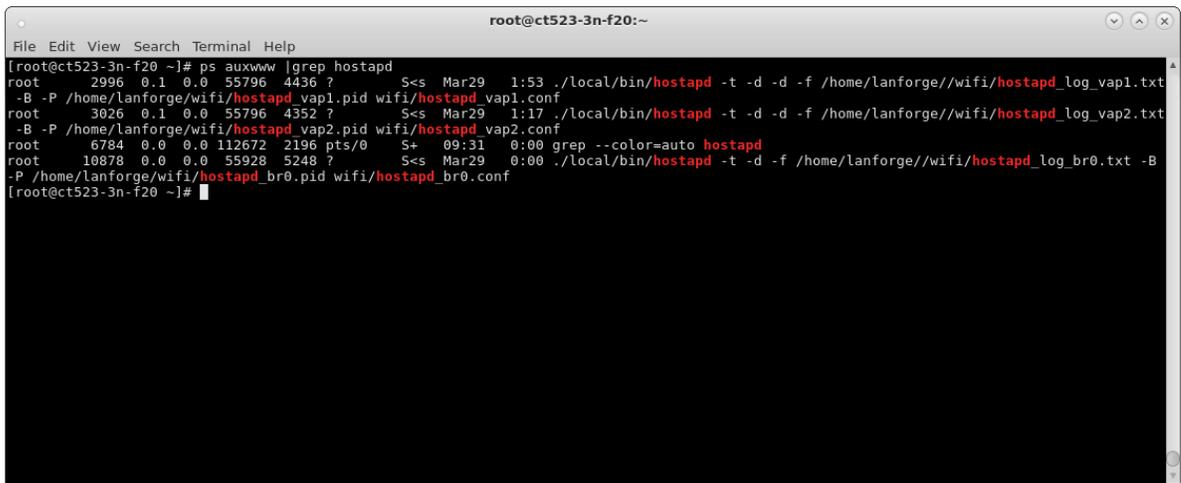
```
interface=br0
driver=wired
logger_syslog=-1
logger_syslog_level=2
logger_stdout=-1
logger_stdout_level=2
ctrl_interface=/var/run/hostapd
ctrl_interface_group=0
eapol_key_index_workaround=0
eap_server=1
eap_user_file=/etc/hostapd.eap_user
server_id=ct523-3n-f20 #Your server_id will be different.
radius_server_auth_port=1812
radius_server_clients=/etc/hostapd.radius_clients

ca_cert=/etc/raddb/certs/ca.pem
server_cert=/etc/raddb/certs/server.pem
private_key=/etc/raddb/certs/server.key
private_key_passwd=lanforge
```

D. Verify that there are three hostapd processes running with the command:

```
ps auxwww |grep hostapd
```

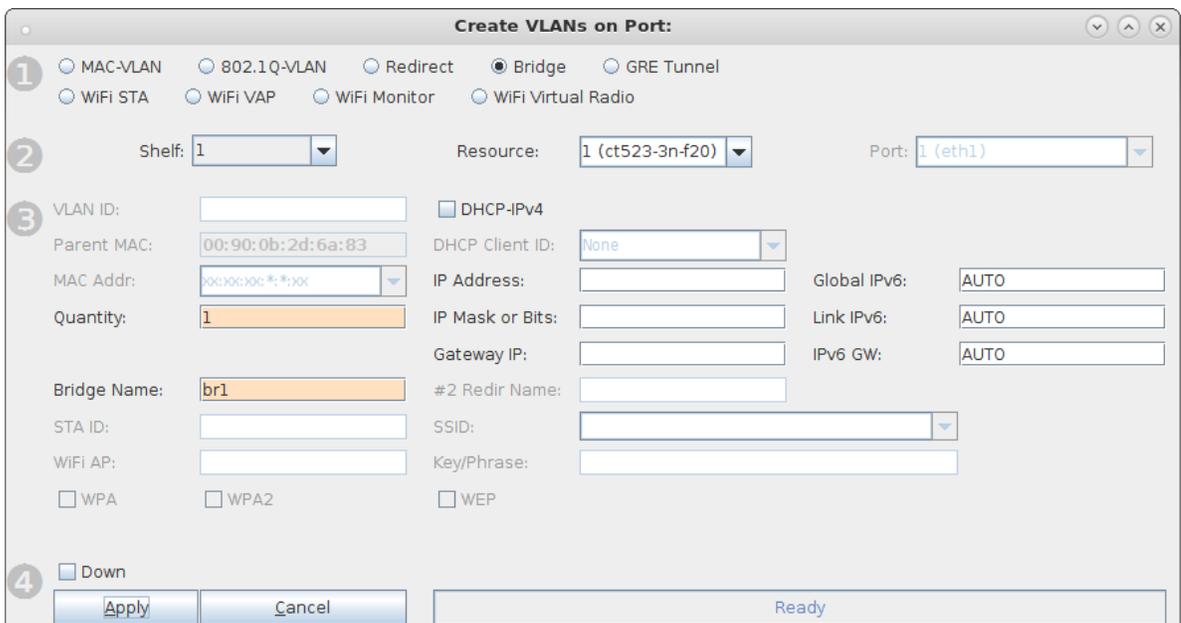
which should show something similar to the following:



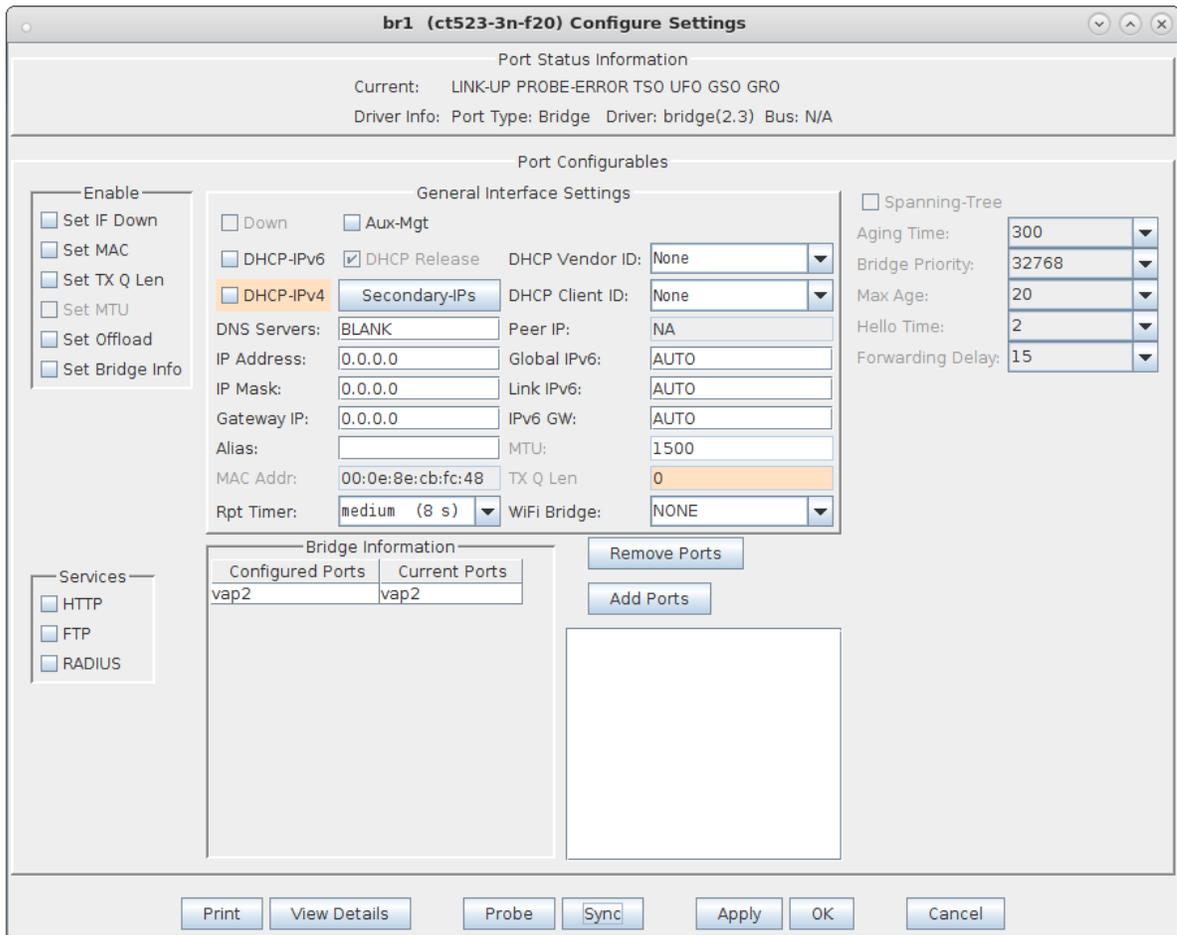
4. Create a second bridge device for the second virtual access point, vap2.

Each vap in the 802.11r network requires its own bridge so that the bridge device receive logic can correctly process packets from each vap during fast-transition client roaming.

A. Go to Netsmith, right-click in a free area, select New Bridge, enter Quantity 1 and a Bridge Name, then select Apply. Sync Netsmith to view the new bridge.

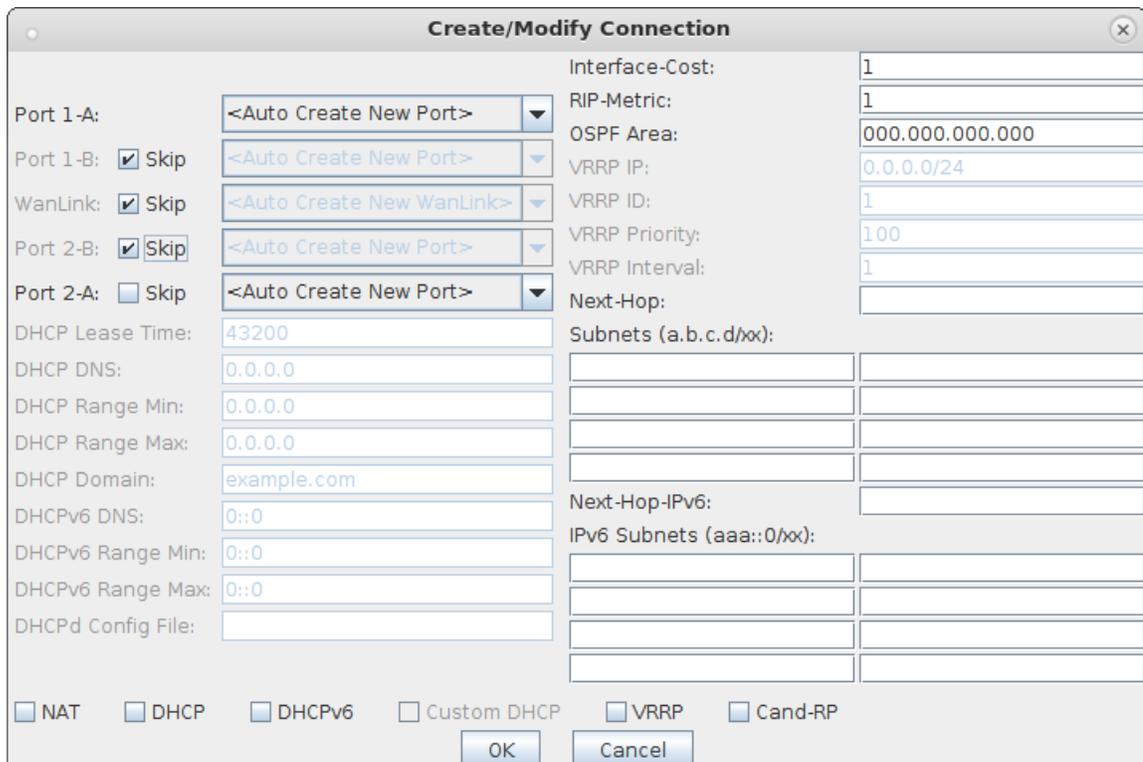


- B. Right-click the new bridge and select Modify Port to add vap2 as a bridge member.



5. Each bridge will share a connection to a redirect device (rdd) pair so that FT messages can be sent and received.

- A. In Netsmith, right-click in a free area and select New Connection to create an rdd pair. Select **Skip** for Port 1-B, WanLink and Port 2-B then select OK. Select Netsmith Apply after creating the new connection.



- B. Right-click and select Modify Port br0, then add rddVR0 to br0, select Add Ports then select Apply. Your rddVRX numbering may differ depending on what other Netsmith objects are created.

**br0 (ct523-3n-f20) Configure Settings**

Port Status Information  
 Current: LINK-UP TSO UFO GSO GRO  
 Driver Info: Port Type: Bridge Cannot Detect

Port Configurables

Enable

- Set IF Down
- Set MAC
- Set TX Q Len
- Set MTU
- Set Offload
- Set Bridge Info

General Interface Settings

Down     Aux-Mgt

DHCP-IPv6     DHCP Release    DHCP Vendor ID:

DHCP-IPv4        DHCP Client ID:

DNS Servers:     Peer IP:

IP Address:     Global IPv6:

IP Mask:     Link IPv6:

Gateway IP:     IPv6 GW:

Alias:     MTU:

MAC Addr:     TX Q Len:

Rpt Timer:     WiFi Bridge:

Spanning-Tree

Aging Time:

Bridge Priority:

Max Age:

Hello Time:

Forwarding Delay:

Services

- HTTP
- FTP
- RADIUS

Bridge Information

Configured Ports	Current Ports
vap1	vap1
rddVR0	rddVR0

- C. Right-click and select Modify Port br1, then add rddVR1 to br1, select Add Ports then select Apply. Your rddVRX numbering may differ depending on what other Netsmith objects are created.

**br1 (ct523-3n-f20) Configure Settings**

Port Status Information  
 Current: LINK-UP PROBE-ERROR TSO UFO GSO GRO  
 Driver Info: Port Type: Bridge Driver: bridge(2.3) Bus: N/A

Port Configurables

**Enable**

Set IF Down

Set MAC

Set TX Q Len

Set MTU

Set Offload

Set Bridge Info

**General Interface Settings**

Down     Aux-Mgt

DHCP-IPv6     DHCP Release    DHCP Vendor ID:

DHCP-IPv4        DHCP Client ID:

DNS Servers:     Peer IP:

IP Address:     Global IPv6:

IP Mask:     Link IPv6:

Gateway IP:     IPv6 GW:

Alias:

MAC Addr:     TX Q Len:

Rpt Timer:     WiFi Bridge:

Spanning-Tree

Aging Time:

Bridge Priority:

Max Age:

Hello Time:

Forwarding Delay:

**Services**

HTTP

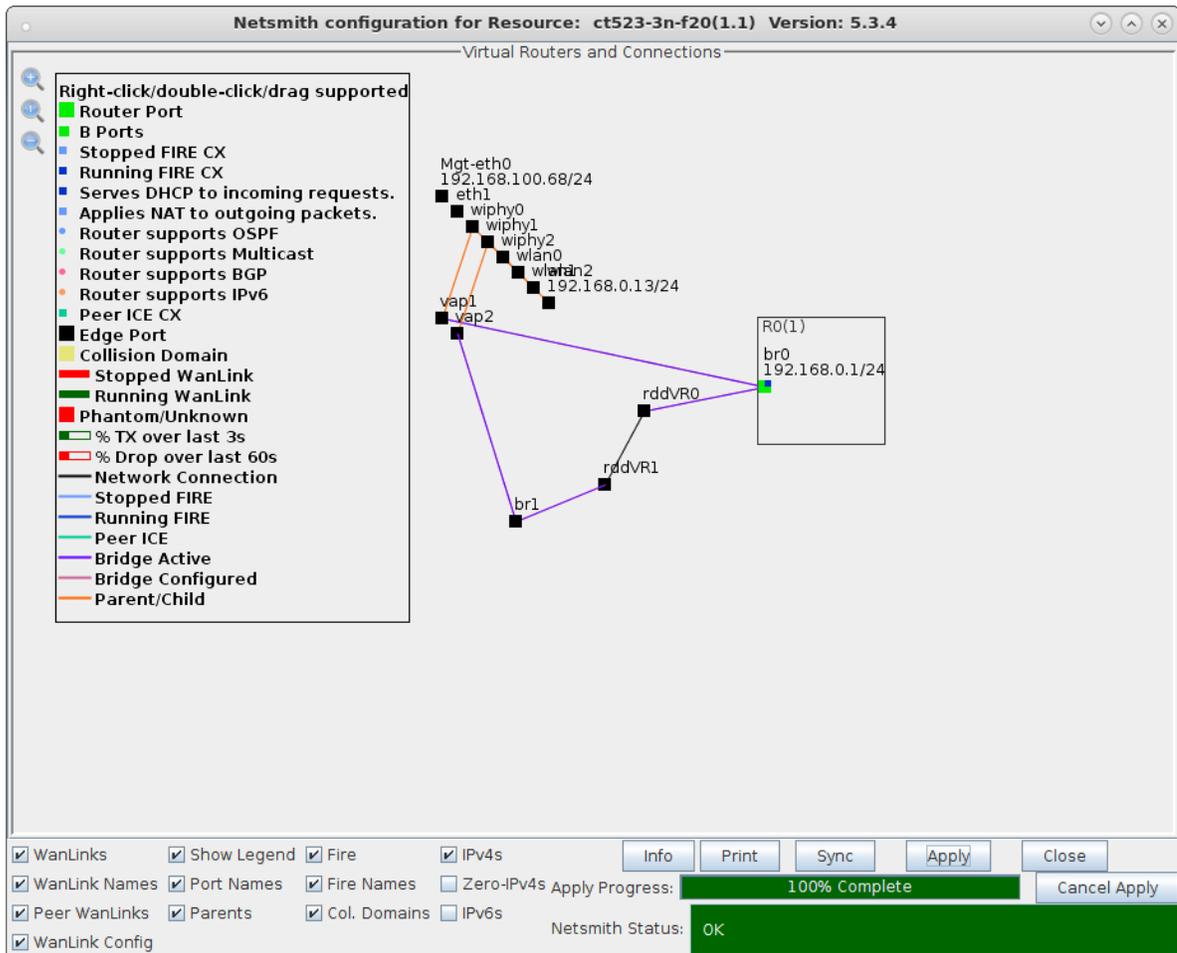
FTP

RADIUS

**Bridge Information**

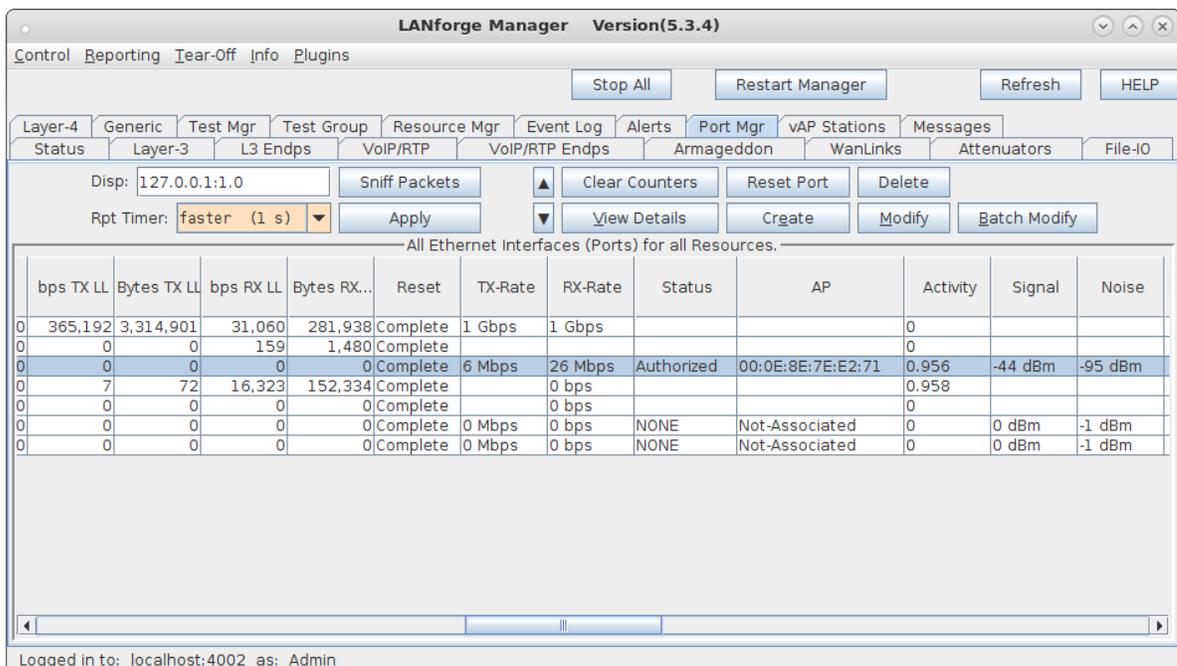
Configured Ports	Current Ports
vap2	vap2
rddVR1	rddVR1

D. The final Netsmith display should show the two bridged virtual access points connected by a rdd pair



6. Connect clients and force them to roam from vap to vap. This can be accomplished with a wpa\_cli command for one or two clients or the Mobility Plugin Script for many clients. If the system under test is not able to force a roam, a variable attenuator on each vap radio may help induce a client to roam as the signal strength from vap to vap is varied.

A. Client connected to vap1.



B. Client roams to vap2.

```

root@ct521-lac-f20:/home/lanforge
File Edit View Search Terminal Help
[root@ct521-lac-f20 lanforge]# wpa_cli -i sta1 scan
OK
[root@ct521-lac-f20 lanforge]# wpa_cli -i sta1 roam 00:0e:8e:cb:fc:48 DS
OK
[root@ct521-lac-f20 lanforge]# █

```

LANforge Manager Version(5.3.4)

Control Reporting Tear-Off Info Plugins

Stop All Restart Manager Refresh HELP

Layer-4 Generic Test Mgr Test Group Resource Mgr Event Log Alerts Port Mgr vAP Stations Messages

Status Layer-3 L3 Endps VoIP/RTP VoIP/RTP Endps Armageddon WanLinks Attenuators File-IO

Disp: 127.0.0.1:1.0 Sniff Packets Clear Counters Reset Port Delete

Rpt Timer: faster (1 s) Apply View Details Create Modify Batch Modify

All Ethernet Interfaces (Ports) for all Resources.

	bps TX LL	Bytes TX LL	bps RX LL	Bytes RX...	Reset	TX-Rate	RX-Rate	Status	AP	Activity	Signal	Noise
0	190,631	6,996,062	17,399	583,995	Complete	1 Gbps	1 Gbps			0		
0	0	0	197	4,440	Complete					0		
0	11	133	14	161	Complete	6 Mbps	6 Mbps	Authorized	00:0E:8E:CB:FC:48	1.024	-42 dBm	-95 dBm
0	62	811	6,521	263,346	Complete		0 bps			1.025		
0	0	0	0	0	Complete		0 bps			0		
0	0	0	0	0	Complete	0 Mbps	0 bps	NONE	Not-Associated	0	0 dBm	-1 dBm
0	0	0	0	0	Complete	0 Mbps	0 bps	NONE	Not-Associated	0	0 dBm	-1 dBm

Logged in to: localhost:4002 as: Admin

C. Client roams back to vap1.

```
root@ct521-lac-f20:/home/lanforge
File Edit View Search Terminal Help
[root@ct521-lac-f20 lanforge]# wpa_cli -i sta1 scan
OK
[root@ct521-lac-f20 lanforge]# wpa_cli -i sta1 roam 00:0e:8e:7e:e2:71 DS
OK
[root@ct521-lac-f20 lanforge]#
```

LANforge Manager Version(5.3.4)

Control Reporting Tear-Off Info Plugins

Stop All Restart Manager Refresh HELP

Layer-4 Generic Test Mgr Test Group Resource Mgr Event Log Alerts Port Mgr vAP Stations Messages

Status Layer-3 L3 Endps VoIP/RTP VoIP/RTP Endps Armageddon WanLinks Attenuators File-IO

Disp: 127.0.0.1:1.0 Sniff Packets Clear Counters Reset Port Delete

Rpt Timer: medium (8 s) Apply View Details Create Modify Batch Modify

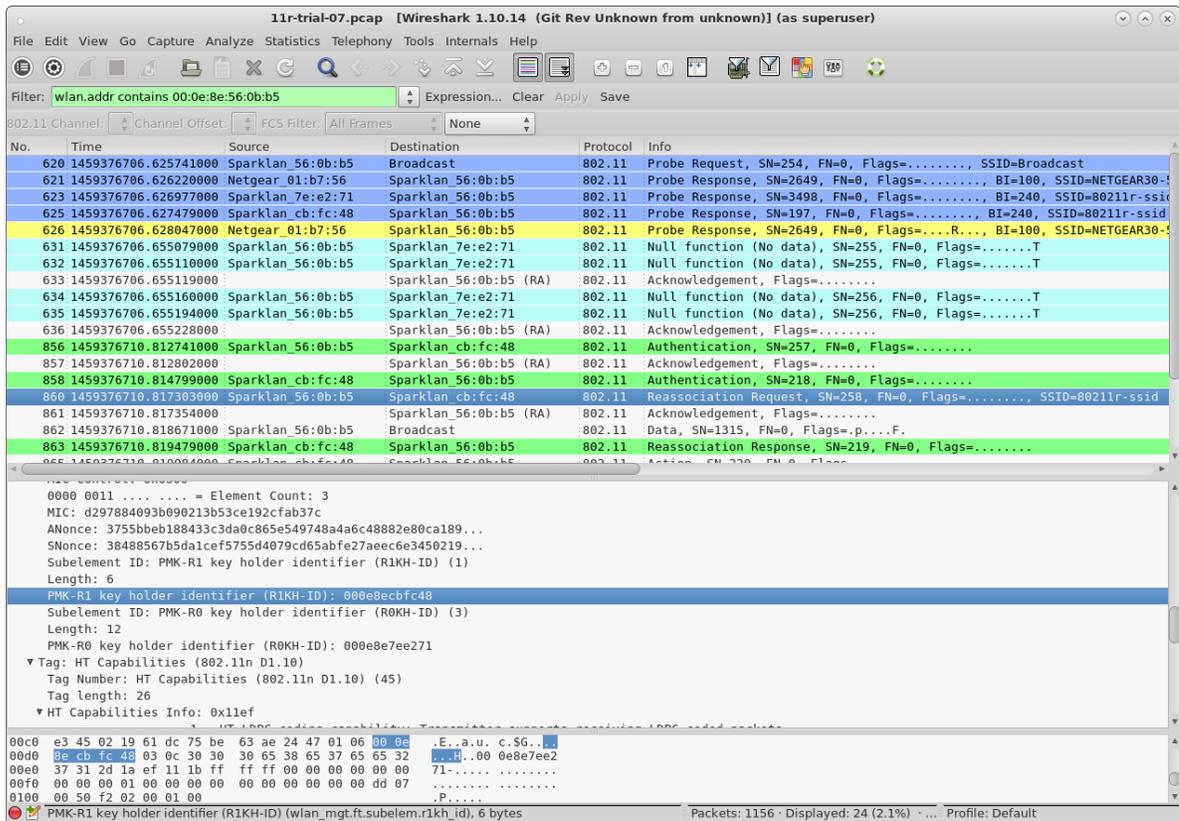
All Ethernet Interfaces (Ports) for all Resources.

bps TX LL	Bytes TX LL	bps RX LL	Bytes RX...	Reset	TX-Rate	RX-Rate	Status	AP	Activity	Signal	Noise
12,636,...	2,417,8...	154,186	26,860,...	Complete	1 Gbps	1 Gbps			0		
0	1,548	225	79,550	Complete	1 Gbps	1 Gbps			0		
0	0	0	245	Complete		0 bps			0		
899	812,653	6,937	11,203,...	Complete		0 bps			0		
0	0	0	0	Complete	0 Mbps	0 bps	NONE	Not-Associated	0	0 dBm	-1 dBm
0	0	0	0	Complete	0 Mbps	0 bps	NONE	Not-Associated	0	0 dBm	-1 dBm
681	7,337	851	19,599	Complete	175.5 M...	26 Mbps	Authorized	00:0E:8E:7E:E2:71	1.199	-44 dBm	-95 dBm

Logged in to: localhost:4002 as: Admin



E. A wireless capture of over-the-air packets shows the transition.



F. Output graph of the Mobility Plugin script of several roaming stations.

