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:

	Vapi (CO2	Port Status Inform	ation		00		
	Current:	LINK-DOWN GRO	IONE				
	Driver Info	Port Type: WIEI-AP	Parent: wiphy0				
		Port Configurab	les				
Standard Configura	tion Advanced Co	nfiguration Misc C	onfiguration Cu	stom WiFi	_		
Enable		General In	terface Settings				
Set IF Down	Down	🗌 Aux-Mgt					
Set MAC	DHCP-IPv6	DHCP Release	DHCP Vendor ID:	None			
Set TX Q Len	DHCP-IPv4	Secondary-IPs	DHCP Client ID:	None			
Set Offload	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			
Services —	Alias:		MTU:	1500			
HTTP	MAC Addr:	00:0e:8e:6c:38:71	TX Q Len	1000			
FTP	Rpt Timer:	medium (8 s) 🔻	WiFi Bridge:	NONE			
		WiF	i Settings				
	SSID: 80211	.r-ssid	- AP: [DEFAULT			
	Key/Phrase:		Mode:	(802.11abqn-AC) 🔹			
TS0 Enabled	Freq/Channel: 522	Freq/Channel: 5220/44 Rate: OS Default					
UFO Enabled	DTIM-Period: 2 Max-STA: 2007						
GSO Enabled Beacon: 240							
LR0 Enabled	WPA WPA2	OSEN WEP	Disable HT40 🔲 🛛	Disable HT80 🔲 Disable SGI			
GRO Enabled	🗌 Verbose Debug						
,							
View Details	Logs Pro	Display Sca	n Sync	Apply OK	Canc		

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.

•	vap1 (ct523-3n-	f20)	Configure Set	tings	\odot \otimes \times			
	Port Status Information							
	Current: LINK	(-DO)	WN GRO NONE					
	Driver Info: Port	: Тур	e: WIFI-AP Parer	nt: wiphy0				
	Po	ort C	onfigurables					
Standard Configuration	Advanced Configura	ation	Misc Configura	ation Custom WiFi				
	Adva	nce	d WiFi Settings		1			
Select 'WPA2' on th and enable Advance	e Standard Configuration ed/802.1x to enable mos	n scr st of	een to enable Ad these. Enabling 8	lvanced/802.1x 802.11u enables others.				
Ignore Probes:	zero (0%)	-	HESSID:					
Ignore Auth-Assoc:	zero (0%)	-	Realm:					
Ignore Assoc:	zero (0%)	•	IMSI:					
Ignore Re-Assoc:	zero (O%)	-	Milenage:					
Corrupt GTK:	zero (0%)	•	Domain:					
HS20 Capabilities			Consortium:					
HS20 Oper Class			RADIUS IP	127.0.0.1				
HS20 WAN Metrics			RADIUS Port	1812				
leee80211w:	Disabled (0)	-	RADIUS Secret	lanforge				
Venue Group:	Unspecified (0)	-	Venue Type:	Unspecified (0) 🗸				
Network Type:	Private (O)	-	Address Types:	Not Available (0) 🗸				
Network Auth:			3GPP Cell Net:					
Use 80211d [Use 80211d Use 80211h Short-Preamble							
Advanced/802.1	Advanced/802.1x HotSpot 2.0 Disable DGAF							
Enable 802.11u	Enable 802.11u 802.11u Internet 802.11u ASRA 802.11u ESR 802.11u UESA							
Print View Details L	ogs Probe	Di	splay Scan	Sync Apply OK	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 (ct523-3n-f20) Configure Settings	\mathbf{x}
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	
Custom WiFi User-Specified supplicant/hostapd configuration text: Wpa_key_mgmt=FT-EAP ft_over_ds=1 nas_identifier=000e8e7ee271 mobility_domain=a1a r0_key_lifetime=10000 r1_key_holder=0000887ee271 reassociation_deadline=1000 pmk_r1_push=1 r0kh=00:0e:8e:cb:fc:48 0000e8ecbfc48 000102030405060708090a0b0c0d0e0f r1kh=00:0e:8e:cb:fc:48 00:0e:8e:cb:fc:48 0f0e0d0c0b0a09080706050403020100	
Print View Details Logs Probe Display Scan Sync Apply OK Ca	ancel

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=ala1
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
```

rlkh=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 delimeters, yours will differ. mobility_domain=a1a1 r0_key_lifetime=10000 r1_key_holder=000e8ecbfc48 #vap2 MAC without colon delimeters, 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:

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/cgit/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.

0			Create VLANs o	n Port: 1.1.00		\odot \otimes \bigotimes
1	○ MAC-VLAN○ WiFi STA	○ 802.1Q-VLAN ○ Red) WiFi VAP ○ WiFi Monit	irect 💿 Bridge or 🔾 WiFi Virtu	○ GRE Tunnel al Radio		
2	Shelf:	1	Resource:	1 (ct523-3n-f20) 🔻	Port: 0 (e	eth0)(MGT)
â	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:			r
	WiFi AP:		Key/Phrase:			
	WPA	WPA2	WEP			
A	Down					
	Apply	<u>C</u> ancel		Re	ady	

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						
		Current: Driver Info:	Port Status Inform LINK-DOWN TSO U Port Type: Bridge	ation FO GSO GRO Cannot Detect		
			Port Configurab	les		
Enable		General In	terface Settings			
Set IF Down	Down	Aux-Mgt	<u> </u>		Aging Time:	300
Set MAC	DHCP-IPv6	DHCP Release	DHCP Vendor ID:	None 💌	Bridge Priority:	32768
Set TX Q Len	DHCP-IPv4	Secondary-IPs	DHCP Client ID:	None	Max Age:	20 👻
Set MIU	DNS Servers:	BLANK	Peer IP:	NA	Hello Time:	2 💌
Set Bridge Info	IP Address:	192.168.0.1	Global IPv6:	AUTO	Forwarding Delay:	15 💌
	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		
Services	Configured P	dge Information — orts Current Port	s Rem Add	Ports		
	Print View	Details Pr	robe Sync	Apply OK	Cancel	

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

br0 (ct523-3n-f20) Configure Settings						\odot \times \times	
		Current: Driver Info:	Port Status Inform LINK-UP TSO UFO Port Type: Bridge	ation GSO GRO Cannot Detect			
			Port Configurab	les			
Enable		General In	terface Settings				
Set IF Down	Down	🗌 Aux-Mgt				300	
Set MAC	DHCP-IPv6	☑ DHCP Release	DHCP Vendor ID:	None 💌	Bridge Priority:	32768	
Set TX Q Len	DHCP-IPv4	Secondary-IPs	DHCP Client ID:	None	Max Age:	20	-
Set MTU	DNS Servers:	BLANK	Peer IP:	NA	Hello Time:	2	-
Set Officiad	IP Address:	192.168.0.1	Global IPv6:	AUTO	Forwarding Delay:	15	-
	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			
Services	Brid Configured P vap1	dge Information	s Rem	ove Ports Ports			
	Print View	Details	robe 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.

•	Create/I	Мос	lify Connection	×
			Interface-Cost:	1
Port 1-A:	8 (br0)	-	RIP-Metric:	1
			OSPF Area:	0.0.0.0
Port 1-B: 🗹 Skip	<auto create="" new="" port=""></auto>		VRRP IP:	0.0.0/24
WanLink: 🕑 Skip	<auto create="" new="" wanlink=""></auto>	-	VRRP ID:	1
Port 2-B	<auto create="" new="" port=""></auto>		VRRP Priority:	100
			VRRP Interval:	1
Port 2-A: 🗹 Skip	<auto create="" new="" port=""></auto>	-	Next-Hop:	0.0.0.0
DHCP Lease Time:	43200		Subnets (a.b.c.d/xx):	
DHCP DNS:	192.168.0.1			
DHCP Range Min:	192.168.0.10			
DHCP Range Max:	192.168.0.254			
DHCP Domain:				
DHCPv6 DNS:			Next-Hop-IPv6:	
DHCPv6 Range Min:			IPv6 Subnets (aaa::0/xx):	r
DHCPv6 Range Max:				
DHCPd Config File:				
NAT DHCP	🗌 DHCPv6 🛛 🗌 Custom D	HCF	P 🗌 VRRP 📄 Cand-RP	
	ОК		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.

Port Status Information Current: LINK-UP TSO UFO GSO GR0 Driver Info: Port Type: Bridge Cannot Detect Port Configurables Port Configurables Port Configurables Port Configurables Set MAC Set MAC Set MAC DHCP-IPv6 Ø DHCP Release DHCP Vendor ID: None DHCP-IPv6 Ø DHCP Release DHCP Vendor ID: None DHCP-IPv4 Secondary-IPs DHCP Client ID: None Set MTU DNS Servers: BLANK Peer IP: NA IP Address: 192.168.0.1 Global IPv6: AUTO DNS Servers: BLANK Peer IP: NA IP Address: 192.168.0.1 Global IPv6: AUTO IP Mask: 255.255.255.0 Link IPv6: AUTO Alias: MTU: 1500 MIA: 255.255.255.0 Link IPv6: AUTO Alias: MTU: 1500 Bridge Information Bridge Information Bridge Information Bridge Information Bridge Information Bridge Information Bridge Information Bridge Information Remove Ports Add Ports Vap1 V		br0 (ct523-3n-f20) Configure Settings	\odot
Enable General Interface Settings Set IF Down Aux-Mgt Set MAC DHCP-IPv6 Set TX Q Len DHCP-IPv4 Set MTU DNS Servers: BLANK Peer IP: NA IP Address: IP Address: 192.168.0.1 Gateway IP: 0.0.0.0 Alias: MTU: MAC Addr: 00:0e:8e:7e:e2:71 TMC Bridge Information Bridge Information Remove Ports Add Ports Add Ports		Port Status Information Current: LINK-UP TSO UFO GSO GRO Driver Info: Port Type: Bridge Cannot Detect	
Enable General Interface Settings Set IF Down Aux-Mgt Set MAC DWCP-IPv6 Set TX Q Len DHCP-IPv4 Set MTU DHCP-IPv4 Set Offload IP Address: IP Address: 192168.0.1 Gateway IP: 0.0.0 IP Mask: 255.255.255.0 Link IPv6: AUTO Alias: MTU: Set Timer: medium Mac Addr: 00:0e:8e:7e:e2:71 TX Q Len TX Q Len Bridge Information Remove Ports Add Ports Add Ports		Port Configurables	
Set IF Down Down Aux-Mgt Set MAC DHCP-IPV6 DHCP Release DHCP Vendor ID: None Aging Time: 300 Set TX Q Len DHCP-IPV6 DHCP Release DHCP Client ID: None Max Age: 20 Set Offload DHCP-IPV4 Secondary-IPS DHCP Client ID: None Max Age: 20 Set Offload IP Address: 192.168.0.1 Global IPv6: AUTO Hello Time: 2 IP Mask: 255.255.255.0 Link IPv6 GW: AUTO Forwarding Delay: 15 IP Mask: 255.255.255.0 Link IPv6 GW: AUTO Alias: MTU: 1500 MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len 0 Pristinge Information Pristinge Information <t< td=""><td></td><td>General Interface Settings</td><td></td></t<>		General Interface Settings	
Set MAC □ DHCP-IPV6 ≥ DHCP Release DHCP Vendor ID: None Pring Title: Bridge Priority: 32768 Set MTU DNS Servers: BLANK Peer IP: NA Pille: 2 Set Offload IP Address: 192.168.0.1 Global IPV6: AUTO Period Peer IP: NA Peilo Time: 2 IP Address: 192.168.0.1 Global IPV6: AUTO Auto Period Peilo Time: 2 Gateway IP: 0.0.0.0 IPV6 GW: AUTO Auto Auto Auto Period <	Set IF Down	Down Aux-Mgt Ading Time: 300	
Set TX Q Len DHCP-IPv4 Secondary-IPs DHCP Client ID: None ✓ Set MTU DNS Servers: BLANK Peer IP: NA Hello Time: 2 IP Address: 192.168.0.1 Global IPv6: AUTO Hello Time: 2 IP Mask: 255.255.255.0 Link IPv6: AUTO Forwarding Delay: 15 IP Mask: 255.255.255.0 Link IPv6 GW: AUTO Auto Addro Gateway IP: 0.0.0.0 IPv6 GW: AUTO Addro Addro: 00:0e:8e:7e:e2:71 TX Q Len 0 Rpt Timer: medium (8 s) WiFi Bridge: NONE ✓ ✓ Services Configured Ports Current Ports Add Ports ✓ ✓ HTTP FTP RADIUS Add Ports Idd Ports Idd Ports Idd Ports	Set MAC	DHCP-IPv6 DHCP Release DHCP Vendor ID: None Ridge Priority 32768	
Set MTU DNS Servers: BLANK Peer IP: NA Hello Time: 2 IP Address: 192.168.0.1 Global IPv6: AUTO Forwarding Delay: 15 IP Mask: 255.255.255.0 Link IPv6: AUTO Auto Is Forwarding Delay: 15 Gateway IP: 0.0.0 IPv6 GW: AUTO Auto Is Is Is Is Is MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len 0 Pride Ports Image: Toology in the index ind	🗌 Set TX Q Len	DHCPJPv4 SecondarvJPs DHCP Client ID: None Max Are: 20	
Set Offload Dros servers. Deaver. reer n. ree	Set MTU	DNS Servers: PLANK Peer IP. NA Hello Time: 2	
Set Bridge Info IP Mask: 255.255.25.0 Link IPv6: AUTO Gateway IP: 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 Bridge Information Configured Ports Current Ports Add Ports FTP RADIUS Prove Ports Prove	Set Offload	IP Address: 192168.0.1 Global IPV6: AUTO Forwarding Delay: 15	
Services Services Configured Ports Confi	Set Bridge Info	IP Mask: 255.255.25.0 Link IPv6: AUTO	
Alias: MTU: 1500 MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len 0 Rpt Timer: medium (8 s) ♥ WiFi Bridge: NONE ♥ Bridge Information Remove Ports Configured Ports Current Ports Add Ports FTP FTP RADIUS		Gateway IP: 0.0.0.0 IPv6 GW: AUTO	
MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len 0 Rpt Timer: medium (8 s) ♥ WiFi Bridge: NONE ♥ Bridge Information Remove Ports Configured Ports Current Ports Add Ports FTP RADIUS		Alias: MTU: 1500	
Services Configured Ports Current Ports Add Ports FTP RADIUS Rpt Timer: medium (8 s) WiFi Bridge: NONE Remove Ports Add Ports Add Ports		MAC Addr: 00:0e:8e:7e:e2:71 TX Q Len 0	
Services Configured Ports Current Ports HTTP FTP RADIUS		Rot Timer: medium (8 s) ViFi Bridge: NONE	
	- Services	Bridge Information Configured Ports Current Ports Add Ports Add Ports	

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 If_kinstall 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

root@ct523-3n-f20:~ File Edit View Search Terminal Help Hie Edit View search leminal Heip (root@ct523:3n-f20-l# ps auxww |grep hostapd oot 2996 0.1 0.0 55796 4436 ? -B -P /home/lanforge/wifi/hostapd_vap1.pid wi oot 3026 0.1 0.0 55796 4352 ? -B -P /home/lanforge/wifi/hostapd_vap2.pid wi oot 6784 0.0 0.0 112672 2196 pts/0 oot 10878 0.0 0.0 55928 5248 ? -2 /bome/lanforge/wifi/hostapd_pt0.pid wifi/ho Start S S<s Mar29 1:53 ./local/bin/hostapd -t -d -d -f /home/lanforge//wifi/hostapd_log_vap1.txt</pre> vap1.pid wifi/ home/lanforge/wifi/ho t@ct523-3n-f20 ~]# br0

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.

0			Create VLAN	ls on Port:		\sim \sim
1	○ MAC-VLAN○ WiFi STA	○ 802.1Q-VLAN ○ Red) WiFi VAP ○ WiFi Moni	direct 💿 Bridge tor 🔾 WiFi Virtu	○ GRE Tunnel al Radio		
2	Shelf:	1	Resource:	1 (ct523-3n-f20) 🔻	Port: 1 (e	ethl) 👻
a	VLAN ID:		DHCP-IPv4			
e	Parent MAC:	00:90:0b:2d:6a:83	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:	brl	#2 Redir Name:			
	STA ID:		SSID:			r
	WiFi AP:		Key/Phrase:			
	WPA	WPA2	WEP			
4	Down					
	Apply	<u>C</u> ancel		R	eady	

which should show something similar to the following:

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

0	br1 (ct523-3n-f20) Configure Settings		\odot \land \times
	Port Status Information Current: LINK-UP PROBE-ERROR TSO UFO GSO GRO Driver Info: Port Type: Bridge Driver: bridge(2.3) Bus: N/	Ą	
	Port Configurables		
Enable	General Interface Settings		
Set IF Down	Down Aux-Mgt	Aging Time:	_
Set MAC	DHCP-IPv6 DHCP Release DHCP Vendor ID: None	Rridge Priority 32768	
🔲 Set TX Q Len		Max Area	
Set MTU	DNS Sanvers: PLANK Page IP: NA	Hello Time: 2	
Set Offload		Forwarding Delay: 15	· ·
📄 Set Bridge Info	IP Mask: 0.0.0 Link IPv6: AUTO		
	Gateway IP: 0.0.0.0 IPv6 GW: AUTO		
	Alias: MTU: 1500		
	MAC Addr: 00:0e:8e:cb:fc:48 TX Q Len 0		
	Rpt Timer: medium (8 s) 🔻 WiFi Bridge: NONE 💌		
Services — HTTP FTP RADIUS	Bridge Information Configured Ports Current Ports Vap2 Vap2 Add Ports Add Ports		
	Print View Details Probe Sync Apply 0	K Cancel	

- 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.

•	Create/M	oc	lify Connection	×
			Interface-Cost:	1
Port 1-A:	<auto create="" new="" port=""></auto>	•	RIP-Metric:	1
Port 1 P. V Skip	-Auto Create New Ports		OSPF Area:	000.000.000.000
гон т-в: 💌 экір	Addo create New Forts	4	VRRP IP:	0.0.0/24
WanLink: 🗹 Skip	<auto create="" new="" wanlink=""></auto>	•	VRRP ID:	1
Port 2-B: 🔽 Skip	<auto create="" new="" port=""></auto>	-	VRRP Priority:	100
Port 2-A: Skin	<auto create="" new="" port=""></auto>	-	VRRP Interval:	1
		-	Next-Hop:	
DHCP Lease Time:	43200		Subnets (a.b.c.d/xx):	
DHCP DNS:	0.0.0.0			
DHCP Range Min:				
DHCP Range Max:				
DHCP Domain:	example.com			
DHCPv6 DNS:			Next-Hop-IPv6:	
DHCPv6 Range Min:			IPv6 Subnets (aaa::0/xx):	
DHCPv6 Range Max:				
DHCPd Config File:				
	DHCPv6 Custom DH	ICP	VRRP Cand-RP	
]	Cancel	
DHCPv6 Range Min: DHCPv6 Range Max: DHCPd Config File:	0::0 0::0 DHCPv6 Custom DH		IPv6 Subnets (aaa::0/xx):	

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.

o 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	Enable ——— General Interface Settings								
Set IF Down	Down	Aux-Mgt			Spanning-Tree	200			
Set MAC	DHCP-IPv6	DHCP Release	DHCP Vendor ID:	None	Aging Time: Bridge Priority:	32768			
Set TX Q Len	DHCP-IPv4	Secondary-IPs	DHCP Client ID:	None 💌	Max Age:	20 🗸			
Set MTU	DNS Servers:	BLANK	Peer IP:	NA	Hello Time:	2 🗸			
Set Officiad	IP Address:	192.168.0.1	Global IPv6:	AUTO	Forwarding Delay:	15 👻			
	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					
	Brid	ge Information	Rem	ove Ports					
Services —	Configured P	orts Current Port	s						
НТТР -	vap⊥ rdd∨R0	rddVR0	Add	Ports					
FTP									
RADIUS									
,									
P	Print View Details Probe Sync Apply OK Cancel								

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							
Enable Set IF Down Set MAC Set TX Q Len Set MTU Set Offload Set Bridge Info	Down DHCP-IPv6 DHCP-IPv4 DNS Servers: IP Address: IP Mask: Gateway IP: Alias: MAC Addr: Rpt Timer: Bric Configured P vap2 rddVR1	General In General In Aux-Mgt ✓ DHCP Release Secondary-IPs BLANK 0.0.0 0.	ype: Bridge Drive Port Configurab terface Settings DHCP Vendor ID: DHCP Client ID: Peer IP: Global IPv6: Link IPv6: IPv6 GW: MTU: TX Q Len WiFi Bridge: Rem Add	None None None None NA AUTO AUTO ISOO NONE V Ove Ports Ports	☐ Spanning-Tree Aging Time: Bridge Priority: Max Age: Hello Time: Forwarding Delay:	300 32768 20 2 15		
Print View Details Probe Sync Apply OK Cancel								

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.

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 VolP/RTP VolP/RTP Endps Armageddon WanLinks Attenuators File-IO								
Disp: 127.0.0.1:1.0 Sn	iff Packets	Clear Co	unters	Reset Port Del	ete			
Rpt Timer: faster (1 s) 🔻	Apply	′ <u>V</u> iew D	etails	Cr <u>e</u> ate <u>M</u> o	dify <u>B</u>	atch Modify	-	
		aces (Ports) f	for all Resou	irces.				
bps TX LL Bytes TX LL bps RX LL Bytes RX	Reset TX-Rate	RX-Rate	Status	AP	Activity	Signal	Noise	
0 365,192 3,314,901 31,060 281,938	Complete 1 Gbps	1 Gbps			0			
0 0 0 159 1,480	Complete				0			
0 0 0 0	Complete 6 Mbps	26 Mbps A	uthorized	00:0E:8E:7E:E2:71	0.956	-44 dBm	-95 dBm	
0 7 72 16,323 152,334	Complete	0 bps			0.958			
	Complete	0 bps			0			
	Complete 0 Mbps	Obps N	ONE	Not-Associated	0	0 dBm	-1 dBm	
	Complete 0 Mbps	O bps N	ONE	Not-Associated	0	0 dBm	-1 dBm	
Logged in to: localhost:4002 as: Admin								

A. Client connected to vap1.

B. Client roams to vap2.



0	LANforge Manager Version(5.3.4)									\odot \otimes \otimes		
<u>C</u> ontrol	<u>C</u> ontrol <u>Reporting</u> <u>Tear-Off</u> Info <u>P</u> lugins											
	Stop All Restart Manager Refresh HELP											
Layer-	Layer-4 Generic Test Mgr Test Group Resource Mgr Event Log Alerts Port Mgr VAP Stations Messages											
Jocaci	Status Lager-s LS chups VOIP/KIP VOIP/KIP chups Annageuon waitunks Attenuators Pile-IO											
	Disp: 127.0.0.1:1.0 Sniff Packets A Clear Counters Reset Port Delete											
	Rpt	Timer: fas	ster (1 s) 🔻	Apply	•	View	Details	Cr <u>e</u> ate <u>M</u> o	dify <u>E</u>	atch Modify	/
						ernet Interf	aces (Ports) for all Reso	urces.			
bps	TX LL	Bytes TX LL	bps RX LL	Bytes RX	Reset	TX-Rate	RX-Rate	Status	AP	Activity	Signal	Noise
0 19	0,631	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
Logge	ogged in to: localhost:4002 as: Admin											

C. Client roams back to vap1.



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 VolP/RTP VolP/RTP Endps Armageddon WanLinks Attenuators Fi	le-I0							
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 N	oise							
12,636, 2,417,8 154,186 26,860, Complete 1 Gbps 1 Gbps 0 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 dE	≩m							
0 0 0 0 Complete 0 Mbps 0 bps NONE Not-Associated 0 0 dBm -1 dE	3m							
681 7,337 851 19,599 Complete 175.5 M 26 Mbps Authorized 00:0E:8E:7E:E2:71 1.199 -44 dBm -95 c	lBm 🔤							
	•							
.ogged in to: localhost:4002 as: Admin								

D. FT messaging in hostapd logs.

root@ct523-3n-f20:/home/lanforge/wifi \bigtriangledown \land \propto File Edit View Search Terminal Help [root@ct523-3n-f20 wifi]# tail -f hostapd_log_vap2.txt |grep FT 1459376710.817415: FT: Received authentication frame: STA=00:0e:8e:56:0b:b5 BSSID=00:0e:8e:cb:fc:48 transaction=1 1459376710.817422: FT: Received authentication frame IEs - hexdump(len=143): 30 26 01 00 00 0f ac 02 01 00 00 0f ac 04 01 00 00 0f ac 03 00 00 01 00 c9 73 8a 1c fd 4a 81 dc fa 6c 2c 8f c6 f4 c9 4f 36 37 31 1459376710.817479: FT: STA R0KH-ID - hexdump(len=12): 30 30 30 65 38 65 37 65 65 32 37 31 1459376710.817491: FT: Requested PMKR0Name - hexdump(len=16): c9 73 8a 1c fd 4a 81 dc fa 6c 2c 8f c6 f4 c9 4f 1459376710.817512: FT: Derived requested PMKR1Name - hexdump(len=16): e6 60 05 31 e8 97 7c 2f 31 41 0d 26 22 9e 2d 4b 1459376710.817531: FT: Selected PMK-R1 - hexdump(len=32): [REMOVED] 1459376710.818014: FT: Received SNonce - hexdump(len=32): 38 48 85 67 b5 da 1c ef 57 55 d4 07 9c d6 5a bf e2 7a ee c6 e3 45 02 19 61 dc 75 be 63 ae 24 47 1459376710.818031: FT: Generated ANonce - hexdump(len=32): 37 55 bb eb 18 84 33 c3 da 0c 86 5e 54 97 1459376710.818031: FT: Generated ANonce - hexdump(len=32): 37 55 bb eb 18 84 33 c3 da 0c 86 5e 54 97 48 a4 a6 c4 88 82 e8 0c a1 89 44 51 bb bf 1 c2 d1 f1 1459376710.818063: FT: KCK - hexdump(len=16): [REMOVED] 1459376710.818067: FT: KEK - hexdump(len=16): [REMOVED] 1459376710.818067: FT: TK - hexdump(len=16): [REMOVED] 1459376710.818071: FT: PTKName - hexdump(len=16): f4 a8 6c fb ad 05 ee 40 d9 0a 45 0c 2d ad d3 da 1459376710.818241: FT: FT authentication response: dst=00:0e:8e:56:0b:b5 auth_transaction=2 status=0 1459376710.818254: FT: Response IES - hexdump(len=15): 30 2a 01 00 00 of ac 02 00 00 of ac 04 00 ef ac 02 01 00 00 fac 03 0.00 01 ac 04 00 00 fac 02 02 00 00 of ac 04 00 of ac 02 01 00 00 0f ac 03 0c 00 01 00 c9 73 8a 1c fd 4a 81 dc fa 6c 2c 8f c6 f4 c9 4f 36 03 a1 a1 65 37 65 65 32 37 31 1459376710.818396: 1459376710.818397: vap2: STA 00:0e:8e:56:0b:b5 IEEE 802.11: authentication OK (F 1459376710.818413: 1459376710.818414: vap2: STA 00:0e:8e:56:0b:b5 MLME: MLME-AUTHENTICATE.indication (00:0e:8e:56:0b:b5, FT) 1459376710.821931: FT: Reassoc Req IEs - hexdump(len=211): 00 0b 38 30 32 31 31 72 2d 73 73 69 64 01 00 00 0f ac 03 00 00 01 00 145976710.821951: P1: Reassoc Req 1Es - hexdump(leh=211): 00 00 38 30 32 31 31 72 20 73 73 69 64 01 08 0c 12 18 24 30 48 60 6c 30 26 01 00 00 0f ac 02 01 00 00 0f ac 04 01 00 00 of ac 03 00 00 01 00 e6 60 05 31 e8 97 7c 2f 31 41 0d 26 22 9e 2d 4b 36 03 a1 a1 01 37 68 00 03 d2 97 88 40 93 b0 90 21 3 b 53 ce 19 2c fa b3 7c 37 55 bb eb 18 84 33 c3 da 0c 86 5e 54 97 48 a4 a6 c4 88 82 e8 0c a1 89 44 51 1b 1b f1 c2 d1 f1 38 48 85 67 b5 da 1c ef 57 55 d4 07 9c d6 5a bf e2 7a ee c6 e3 45 02 19 61 dc 75 be 63 ae 24 47 01 06 00 0e 8e cb fc 48 03 0c 30 30 30 65 38 65 37 65 65 32 37 31 2d 1a ef 11 1b ff f ee c6 e3 45 02 19 61 dc 75 be 63 ae 24 47 01 06 00 0e 8e cb fc 48 03 0c 30 30 30 65 38 65 37 65 65 32 37 31 32 37 31 1459376710.822506: FT: MIC data - hexdump(len=6): 00 0e 8e 56 0b b5 1459376710.822524: FT: MIC data - hexdump(len=6): 00 0e 8e cb fc 48 1459376710.822534: FT: MIC data - hexdump(len=1): 06 1459376710.822541: FT: MIC data - hexdump(len=44): 30 2a 01 00 00 0f ac 02 02 00 00 0f ac 04 00 0f a c 02 01 00 00 of ac 03 0c 00 01 00 e6 60 05 31 e8 97 7c 2f 31 41 0d 26 22 9e 2d 4b 1459376710.822593: FT: MIC data - hexdump(len=5): 36 03 a1 a1 01 1459376710.822602: FT: MIC data - hexdump(len=4): 37 9d 00 03

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

0	. 11r-trial-07.pcap [Wireshark 1.10.14 (Git Rev Unknown from unknown)] (as superuser) 📀 🔊 🛞									
File B	File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help									
	● ● ∡ ■ ⋨ ┺ T X G Q < > % ⊼ ⊻ 🗐 🖬 ㅎ = ¤ 🖬 👹 🛛 💀 🙄									
Filter:	ilter: Wlan.addr.contains 00:0e:8e:56:0b:b5 🗧 🛟 Expression Clear Apply Save									
	Channel: 🗍 Channel Offse	t: 🔺 FCS Filter: All Fran	nes 🗍 None 🛓							
No.	Time	Source	Destination	Protocol	Info					
6	20 1459376706.625741000	Sparklan_56:0b:b5	Broadcast	802.11	Probe Request, SN=254, FN=0, Flags=, SSID=Broadcast					
e	21 1459376706.626220000	Netgear_01:b7:56	Sparklan_56:0b:b5	802.11	Probe Response, SN=2649, FN=0, Flags=, BI=100, SSID=NETGEAR30-					
e	23 1459376706.626977000	Sparklan_7e:e2:71	Sparklan_56:0b:b5	802.11	Probe Response, SN=3498, FN=0, Flags=, BI=240, SSID=80211r-ssid					
e	25 1459376706.627479000	Sparklan_cb:fc:48	Sparklan_56:0b:b5	802.11	Probe Response, SN=197, FN=0, Flags=, BI=240, SSID=80211r-ssid					
6	26 1459376706.628047000	Netgear 01:b7:56	Sparklan 56:0b:b5	802.11	Probe Response, SN=2649, FN=0, Flags=R, BI=100, SSID=NETGEAR30-					
e	31 1459376706.655079000	Sparklan_56:0b:b5	Sparklan_7e:e2:71	802.11	Null function (No data), SN=255, FN=0, Flags=T					
e	32 1459376706.655110000	Sparklan_56:0b:b5	Sparklan_7e:e2:71	802.11	Null function (No data), SN=255, FN=0, Flags=T					
6	33 1459376706.655119000		Sparklan 56:0b:b5 (RA)	802.11	Acknowledgement, Flags=					
e	34 1459376706.655160000	Sparklan 56:0b:b5	Sparklan 7e:e2:71	802.11	Null function (No data), SN=256, FN=0, Flags=T					
e	35 1459376706.655194000	Sparklan 56:0b:b5	Sparklan 7e:e2:71	802.11	Null function (No data), SN=256, FN=0, Flags=T					
e	36 1459376706.655228000		Sparklan 56:0b:b5 (RA)	802.11	Acknowledgement, Flags=					
8	356 1459376710.812741000	Sparklan 56:0b:b5	Sparklan cb:fc:48	802.11	Authentication. SN=257. FN=0. Flags=					
8	357 1459376710.812802000		Sparklan 56:0b:b5 (RA)	802.11	Acknowledgement, Flags=					
8	358 1459376710.814799000	Sparklan cb:fc:48	Sparklan 56:0b:b5	802.11	Authentication, SN=218, FN=0, Flags=					
8	360 1459376710 817303000	Sparklan 56:0b:b5	Sparklan ch:fc:48	802.11	Reassociation Request SN=258 EN=0 Elags= SSID=80211r-ssid					
8	361 1459376710 817354000		Sparklan 56:00:05 (BA)	802.11	Acknowledgement, Elags=					
8	862 1459376710 818671000	Sparklan 56:0b:b5	Broadcast	802 11	Data SN=1315 EN=0 Flags= n E					
8	363 1459376710.819479000	Sparklan cb:fc:48	Sparklan 56:0b:b5	802.11	Reassociation Response, SN=219, FN=0, Flags=					
	CE 14E0276710 010004000	Concellon chifer40	Coocklon EGIObibE	002 11	Action CN 220 EN 0 Floor					
-					4					
	0000 0011 = E	lement Count: 3								
	MTC: d297884093b090213b	53ce192cfab37c								
	ANonce: 3755bbeb188433c	3da0c865e549748a4a6c4	8882e80ca189							
	SNonce: 38488567b5da1ce	f5755d4079cd65abfe27a	eec6e3450219							
	Subelement TD: PMK-R1 k	ev holder identifier	(B1KH-TD) (1)							
	Length: 6	-,								
	PMK-R1 key holder_ident	ifier (R1KH-ID): 000e	8ecbfc48							
	Subelement TD: PMK-R0 k	ev holder identifier	(B0KH-TD) (3)							
	Length: 12	c, notaci identifici								
	PMK-R0 key holder ident	ifier (ROKH-TD): OOOe	8e7ee271							
▼ T:	ag: HT Capabilities (80)	2.11n D1.10)								
	Tag Number: HT Capabili	ties (802.11n D1.10)	(45)							
	Tag length: 26	(002.1111 01.10)	(,							
v	HT Capabilities Info: 0	x11ef								
	in capabilities into: o	UT I DDC	1:4 +		I DBC solid solution					
00c0	e3 45 02 19 61 dc 75 b	e 63 ae 24 47 01 06	00 0e .Ea.u. c.\$G							
00d0	8e cb fc 48 03 0c 30 3	0 30 65 38 65 37 65	65 32H00 0e8e7ee2							
00e0	37 31 2d 1a ef 11 1b f	f ff ff 00 00 00 00	00 00 71							
0010	00 00 00 01 00 00 00 0	0 00 00 00 00 00 00	dd 07							

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



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