

## Wifi Roaming with Opportunistic Key Caching (OKC)

Goal: Show how LANforge can emulate an OKC VAP or OKC STA then observe the different results when OKC is enabled or not.

Opportunistic Key Caching (OKC) is a fast roaming solution that is one predecessor to **802.11r Fast BSS Transition**. OKC is also referred to as Proactive Key Caching (PKC). Here we will demonstrate the following four scenarios with OKC:

1. OKC on VAP and NOT on STA
2. OKC on both VAP and STA
3. OKC disabled on both VAP and STA
4. OKC disabled on VAP but enabled on STA

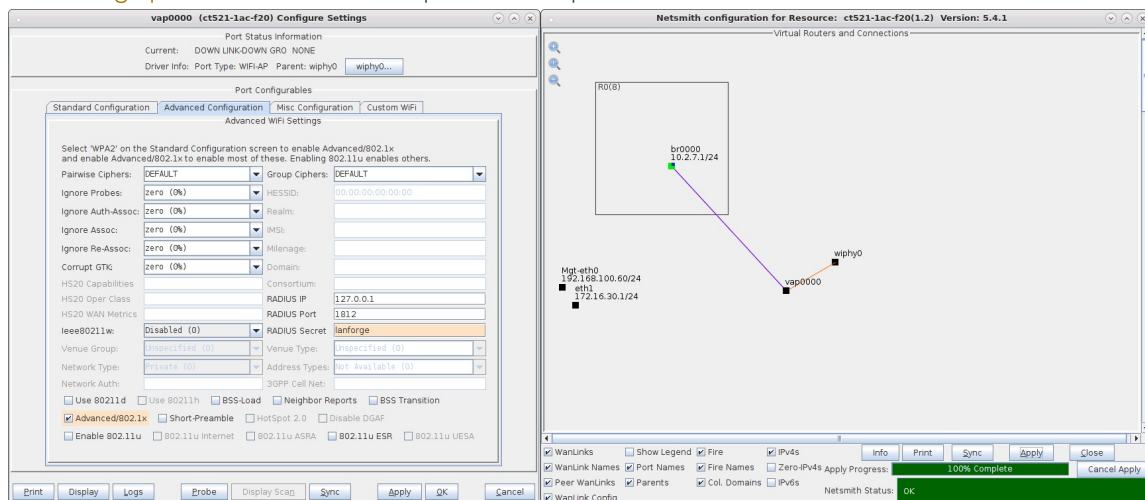
## OKC Scenarios

### OKC On VAP Only

**STA roam result: Full RADIUS authentication plus 4-way handshake.**

Using OKC on a VAP requires setting up a custom configuration file in LANforge to utilize the Multiple BSSID feature. In this scenario, the STA is not configured to use OKC and must do a full RADIUS authentication plus 4-way handshake when roaming to the next BSSID.

1. Setup a VAP using RADIUS and EAP-TTLS with a bridge in a virtual router.  
See [Setting up a RADIUS Server](#) for help with this step.



2. Add the following to the custom config section which will create two BSSIDs on the same hostapd process which is required for OKC to work on hostapd:

```
bss=vap0000_0
ssid=okctest1
bssid=04:f0:21:19:88:44
ieee8021x=1
own_ip_addr=127.0.0.1
auth_server_addr=127.0.0.1
auth_server_port=1812
auth_server_shared_secret=lanforge
wpa=2
wpa_pairwise=TKIP CCMP
rsn_pairwise=CCMP
```

```

wpa_key_mgmt=WPA-EAP WPA-EAP-SHA256
bss_load_update_period=100
chan_util_avg_period=600
rrm_neighbor_report=1
rrm_beacon_report=1
bss_transition=1
okc=1

bss=vap0000_1
ssid=okctest1
bssid=04:f0:21:19:89:44
ieee8021x=1
own_ip_addr=127.0.0.1
auth_server_addr=127.0.0.1
auth_server_port=1812
auth_server_shared_secret=lanforge
wpa=2
wpa_pairwise=TKIP CCMP
rsn_pairwise=CCMP
wpa_key_mgmt=WPA-EAP WPA-EAP-SHA256
bss_load_update_period=100
chan_util_avg_period=600
rrm_neighbor_report=1
rrm_beacon_report=1
bss_transition=1
okc=1

```

3. Reset the VAP to use the new configuration.
4. Modify the bridge to use the two new sub interfaces vap0000\_0 and vap0000\_1.

**br0000 (ct521-lac-f20) Configure Settings**

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

Port Configurables

Enable

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

Services

- HTTP
- FTP
- RADIUS
- IPSEC-Client
- IPsec-Upstream

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: 10.2.7.1 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: 04:f0:21:19:87:44 TX Q Len: 1000

Rpt Timer: 1100 (1.1 s) WiFi Bridge: NONE

IPSec GW: 0.0.0.0 IPSec Password:

IPSec Local ID.: IPSec Remote ID.:

Spanning-Tree

Spanning-Tree

Aging Time: 300

Bridge Priority: 32768

Max Age: 20

Hello Time: 2

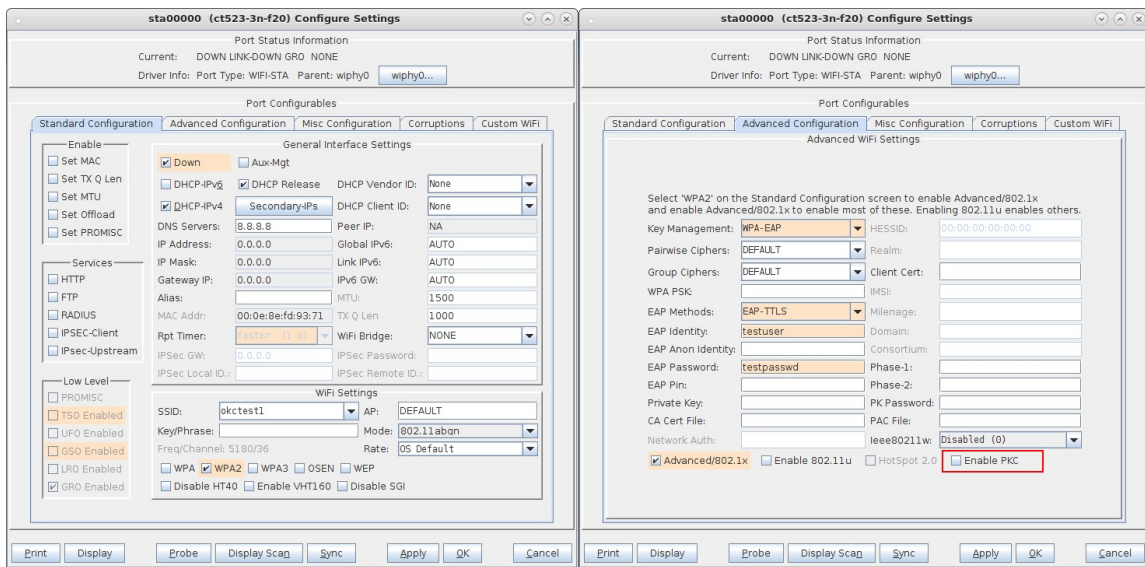
Forwarding Delay: 15

Bridge Information

Configured Ports	Current Ports
vap0000	vap0000
vap0000_0	vap0000_0
vap0000_1	vap0000_1

vap0000\_0  
vap0000\_1

5. Modify a STA so that it is configured to connect to the SSID with 802.1X authentication for EAP-TTLS and with PKC disabled.

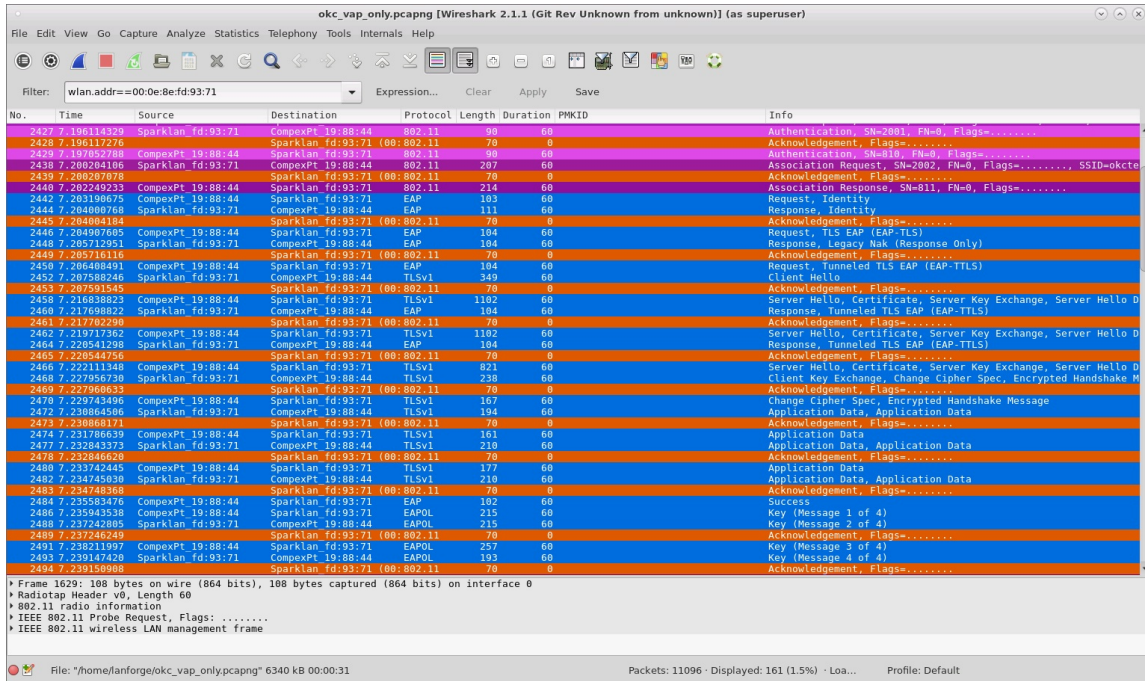


6. Start a packet capture then admin the STA up.

7. Use `wpa_cli` to force the STA to roam with the following terminal commands:

```
# cd /home/lanforge
# .lanforge.profile
# wpa_cli -i sta00000 scan
# wpa_cli -i sta00000 roam <next BSSID>
```

8. In the packet capture, the initial RADIUS authentication and 4-way handshake are shown:



9. Then the STA sends a Reassociation Request which is missing the PMKID and another full RADIUS authentication and 4-way handshake take place to associate to the new BSSID.

okc\_vap\_only.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)] (as superuser)

Filter: wlan.addr==00:0e:8e:fd:93:71 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Duration	PKMID	Info
7782	22.442317866	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7783	22.442335316	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	106	60		Authentication, SN=801, FN=0, Flags=.....
7786	22.443229230	Sparklan fd:93:71	Broadcast	802.11	106	0		Data, Src=0, Prio, Flags=.....
7787	22.443679548	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	98	60		Authentication, SN=885, FN=0, Flags=.....
7790	22.448169193	Sparklan fd:93:71	ComplexPT 19:89:44	802.11	213	60		Reassociation Request, SN=2007, FN=0, Flags=....., SSID=okc
7791	22.448172400	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7792	22.449154014	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	114	60		Reassociation Response, SN=886, FN=0, Flags=.....
7794	22.450299508	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	103	60		Request, Identity
7796	22.451168477	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	111	60		Response, Identity
7797	22.451172401	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7798	22.452154787	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, TLS EAP (EAP-TLS)
7800	22.453045244	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Legacy Nak (Response Only)
7801	22.453234893	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7803	22.453924608	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
7807	22.455230935	Sparklan fd:93:71	ComplexPT 19:89:44	TLV1	287	60		Client Hello
7809	22.455234893	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7810	22.463080100	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
7814	22.464758157	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
7815	22.464761370	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7817	22.467604000	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
7820	22.468462206	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
7821	22.468465518	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7822	22.470149300	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	821	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
7828	22.476224958	Sparklan fd:93:71	ComplexPT 19:89:44	TLV1	238	60		Client Key Exchange, Change Cipher Spec, Encrypted Handshake M
7829	22.476228216	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7830	22.476892500	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	167	60		Change Cipher Spec, Encrypted Handshake Message
7832	22.479458238	Sparklan fd:93:71	ComplexPT 19:89:44	TLV1	194	60		Application Data, Application Data
7833	22.479454014	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7834	22.480411283	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	161	60		Application Data
7836	22.481108100	Sparklan fd:93:71	ComplexPT 19:89:44	TLV1	210	60		Application Data, Application Data
7837	22.481501487	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7842	22.482613018	ComplexPT 19:89:44	Sparklan fd:93:71	TLV1	177	60		Application Data
7844	22.483540964	Sparklan fd:93:71	ComplexPT 19:89:44	TLV1	210	60		Application Data, Application Data
7845	22.483650214	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7846	22.484618507	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	102	60		Success
7848	22.484942407	ComplexPT 19:89:44	Sparklan fd:93:71	EAPOL	215	60		Key (Message 1 of 4)
7850	22.486455579	Sparklan fd:93:71	ComplexPT 19:89:44	EAPOL	215	60		Key (Message 2 of 4)
7851	22.486459100	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	EAP	70	0		Acknowledgement, Flags=.....
7853	22.487063855	ComplexPT 19:89:44	Sparklan fd:93:71	EAPOL	257	60		Key (Message 3 of 4)
7855	22.488793750	Sparklan fd:93:71	ComplexPT 19:89:44	EAPOL	193	60		Key (Message 4 of 4)

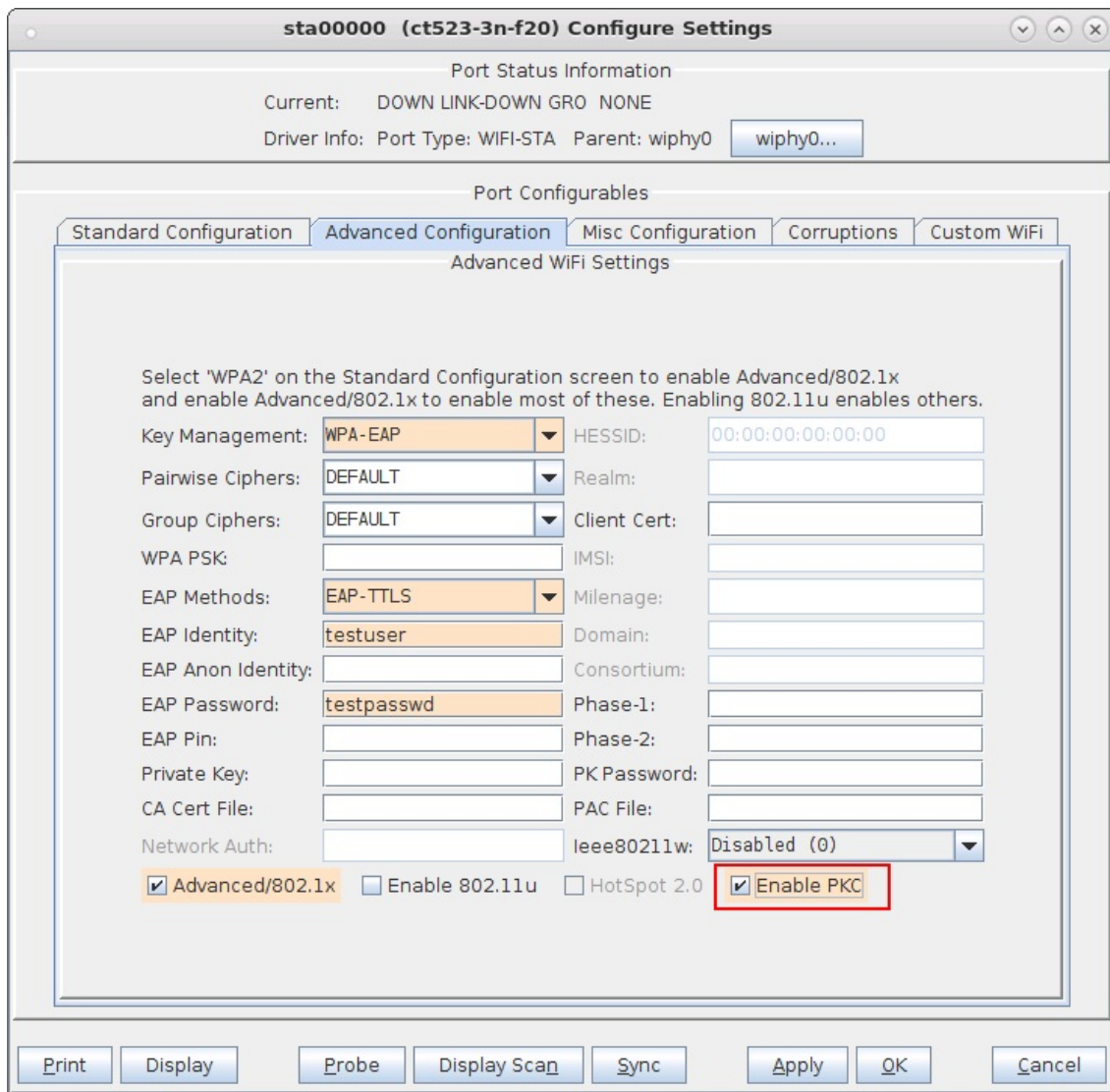
File: "/home/anforge/okc\_vap\_only.pcapng" 6340 kb 00:00:31 Packets: 11096 · Displayed: 161 (1.5%) · Loa... Profile: Default

## OKC On Both VAP and STA

**STA roam result: PMKID is sent, then only 4-way handshake is required.**

When both VAP and STA are using OKC, the STA sends its calculated PMKID in the Reassociation Request to the target AP which means the full RADIUS is not needed and only a 4-way handshake is sufficient to connect to the new VAP.

1. Admin the STA down , then modify the STA to enable PKC



2. Start a packet capture then admin the STA up.
3. Use `wpa_cli` to force the STA to roam with the following terminal commands:

```
# wpa_cli -i sta00000 scan
# wpa_cli -i sta00000 roam <next BSSID>
```

4. In the packet capture, the initial RADIUS authentication and 4-way handshake are shown:

okc\_both.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)] (as superuser)

Filter: wlan.addr==00:0e:8e:fd:93:71

No.	Time	Source	Destination	Protocol	Length	Duration	PKMID	Info
2561	7.547330714	2c:33:11:d8:1b:ad	Sparklan fd:93:71	802.11	371	60		Probe Response, SN=474, FN=0, Flags=.....R....., BI=100, SSID=cis
3363	8.897948189	Sparklan fd:93:71	Sparklan fd:93:71	802.11	98	60		Authentication, SN=1972, FN=0, Flags=.....
3364	8.897948189	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3365	8.898999802	ComexPPT 19:89:44	Sparklan fd:93:71	802.11	98	60		Authentication, SN=538, FN=0, Flags=.....
3367	9.898414681	Sparklan fd:93:71	ComexPPT 19:89:44	802.11	207	60		Association Request, SN=1973, FN=0, Flags=....., SSID=okcte
3368	9.898414681	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3372	9.894065644	ComexPPT 19:89:44	Sparklan fd:93:71	EAP	103	60		Request, Identity
3374	9.894801819	Sparklan fd:93:71	ComexPPT 19:89:44	EAP	111	60		Response, Identity
3375	9.894801819	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3376	9.895828840	ComexPPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, TLS EAP (EAP-TLS)
3378	9.896635222	Sparklan fd:93:71	ComexPPT 19:89:44	EAP	104	60		Response, Legacy Nak (Response Only)
3379	9.896635222	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3381	9.897415539	ComexPPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
3383	9.898185328	Sparklan fd:93:71	ComexPPT 19:89:44	TLV1	349	60		Client Hello
3386	9.898185328	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3389	9.898433088	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3394	9.891191843	Sparklan fd:93:71	ComexPPT 19:89:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
3395	9.891191843	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3396	9.891483308	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3399	9.891474541	Sparklan fd:93:71	Sparklan fd:93:71	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
3400	9.891483308	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3401	9.891645939	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	821	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3404	9.892189455	Sparklan fd:93:71	Sparklan fd:93:71	TLV1	230	60		Response, Tunnelled TLS EAP (EAP-TTLS)
3405	9.892189455	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3406	9.892371137	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	167	60		Change Cipher Spec, Encrypted Handshake Message
3408	9.892480145	Sparklan fd:93:71	ComexPPT 19:89:44	TLV1	230	60		Application Data, Application Data
3409	9.892480344	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3411	9.892579957	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	161	60		Application Data
3413	9.892671213	Sparklan fd:93:71	ComexPPT 19:89:44	TLV1	210	60		Application Data, Application Data
3414	9.892671213	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3415	9.892751355	ComexPPT 19:89:44	Sparklan fd:93:71	TLV1	177	60		Application Data
3417	9.892845696	Sparklan fd:93:71	ComexPPT 19:89:44	TLV1	210	60		Application Data, Application Data
3418	9.892845696	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3419	9.892934523	ComexPPT 19:89:44	Sparklan fd:93:71	EAP	102	60		Success
3421	9.892976705	ComexPPT 19:89:44	Sparklan fd:93:71	EAPOL	215	60		Key (Message 1 of 4)
3423	9.893180845	Sparklan fd:93:71	ComexPPT 19:89:44	EAPOL	215	60		Key (Message 2 of 4)
3424	9.893181196	ComexPPT 19:89:44	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
3425	9.893171388	ComexPPT 19:89:44	Sparklan fd:93:71	EAPOL	257	60		Key (Message 3 of 4)
3427	9.892671213	ComexPPT 19:89:44	Sparklan fd:93:71	EAPOL	193	60		Key (Message 4 of 4)
3428	9.892640450	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....

File: "/home/lanforge/okc\_both.pcapng" 6802 KB 00:00:33 Packets: 11792 · Displayed: 129 (1.1%) · Load... Profile: Default

5. Then the STA sends a Reassociation Request which includes its PMKID and only the 4-way handshake is required to associate to the new BSSID.

okc\_both.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)] (as superuser)

Filter: wlan.addr==00:0e:8e:fd:93:71

No.	Time	Source	Destination	Protocol	Length	Duration	PKMID	Info
7241	20.716147686	ComexPPT f2:ea:bd	Sparklan fd:93:71	802.11	254	60		Probe Response, SN=447, FN=0, Flags=....., BI=240, SSID=jw
7242	20.716443811	Sparklan c1:fb:01	Sparklan fd:93:71	802.11	255	60		Probe Response, SN=2322, FN=0, Flags=....., BI=240, SSID=f
7243	20.716748791	Sparklan 4b:c7:2f	Sparklan fd:93:71	802.11	213	60		Probe Response, SN=2734, FN=0, Flags=....., BI=240, SSID=br
7246	20.717262058	ComexPPT 19:88:44	Sparklan fd:93:71	802.11	292	0		Probe Response, SN=585, FN=0, Flags=....., BI=240, SSID=okc
7248	20.718074511	ComexPPT 19:89:44	Sparklan fd:93:71	802.11	292	0		Probe Response, SN=598, FN=0, Flags=....., BI=240, SSID=okc
7249	20.71835847	ComexPPT f2:ea:bd	Sparklan fd:93:71	802.11	254	60		Probe Response, SN=447, FN=0, Flags=....., BI=240, SSID=jw
7251	20.718823352	ComexPPT c2:fd:b0	Sparklan fd:93:71	802.11	240	60		Probe Response, SN=1648, FN=0, Flags=....., BI=240, SSID=be
7252	20.719284338	ComexPPT c2:fd:b0	Sparklan fd:93:71	802.11	240	60		Probe Response, SN=1648, FN=0, Flags=....., BI=240, SSID=be
7254	20.71974144	2c:33:11:d8:1b:ad	Sparklan fd:93:71	802.11	371	60		Probe Response, SN=474, FN=0, Flags=....., BI=100, SSID=cis
7259	20.746228843	Sparklan fd:93:71	ComexPPT 19:89:44	802.11	90	44		QoS Null function (No data), SN=0, FN=0, Flags=.....T
7270	20.746245723	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
7271	20.746457372	Sparklan fd:93:71	ComexPPT 19:89:44	802.11	86	60		QoS Null function (No data), SN=0, FN=0, Flags=.....T
7272	20.746440833	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8173	23.580597968	Sparklan fd:93:71	ComexPPT 19:88:44	802.11	98	60		Authentication, SN=1977, FN=0, Flags=.....
8174	23.580608810	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8175	23.581131211	ComexPPT 19:89:44	Broadcast	802.11	106	0		Disauthentication, SN=0, FN=0, Flags=.....
8176	23.582134319	ComexPPT 19:88:44	Sparklan fd:93:71	802.11	98	60		Authentication, SN=597, FN=0, Flags=.....
8181	23.585334727	Sparklan fd:93:71	ComexPPT 19:88:44	802.11	231	60	424934013b5891d6096dd4db69e14ddd	Reassociation Request, SN=1978, FN=0, Flags=....., SSID=okc
8182	23.585337617	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8184	23.586403046	ComexPPT 19:88:44	Sparklan fd:93:71	EAPOL	214	60		Reassociation Response, SN=598, FN=0, Flags=.....
8186	23.588083435	ComexPPT 19:88:44	Sparklan fd:93:71	EAPOL	215	60		Key (Message 1 of 4)
8188	23.589349096	Sparklan fd:93:71	ComexPPT 19:88:44	EAPOL	233	60	424934013b5891d6096dd4db69e14ddd	Key (Message 2 of 4)
8189	23.589288289	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8190	23.589988233	ComexPPT 19:88:44	Sparklan fd:93:71	EAPOL	257	60		Key (Message 3 of 4)
8192	23.511867247	Sparklan fd:93:71	ComexPPT 19:88:44	EAPOL	193	60		Key (Message 4 of 4)
8193	23.510965550	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8195	23.511628823	ComexPPT 19:88:44	Sparklan fd:93:71	802.11	87	60		Action, SN=599, FN=0, Flags=.....
8200	23.521066722	Sparklan fd:93:71	ComexPPT 19:88:44	802.11	93	60		Action, SN=1979, FN=0, Flags=.....
8201	23.521066722	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8202	23.521166601	ComexPPT 19:88:44	Sparklan fd:93:71	802.11	93	60		Action, SN=0, FN=0, Flags=.....
8204	23.521899262	Sparklan fd:93:71	IPv6cast:16	802.11	190	44		QoS Data, SN=0, FN=0, Flags=.....T
8205	23.521899262	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8206	23.522338099	Sparklan fd:93:71	IPv6cast:16	802.11	184	0		Data, SN=0, FN=0, Flags=.....F
8464	24.221222478	Sparklan fd:93:71	IPv6cast:16	802.11	190	60		QoS Data, SN=1, FN=0, Flags=.....T
8465	24.221222478	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
8466	24.221696231	Sparklan fd:93:71	IPv6cast:16	802.11	184	0		Data, SN=1, FN=0, Flags=.....F
9784	28.062035477	Sparklan fd:93:71	IPv6cast:02	802.11	170	44		QoS Data, SN=2, FN=0, Flags=.....T
9785	28.062035477	Sparklan fd:93:71	Sparklan fd:93:71	000:802.11	70	0		Acknowledgement, Flags=.....
9786	28.062035477	Sparklan fd:93:71	IPv6cast:02	802.11	164	0		Data, SN=3, FN=0, Flags=.....F

File: "/home/lanforge/okc\_both.pcapng" 6802 KB 00:00:33 Packets: 11792 · Displayed: 129 (1.1%) · Load... Profile: Default

## OKC Disabled On VAP and STA

STA roam result: Full RADIUS authentication plus 4-way handshake.

Because neither is using OKC, a full RADIUS authentication plus 4-way handshake is required when the STA roams to the new VAP.

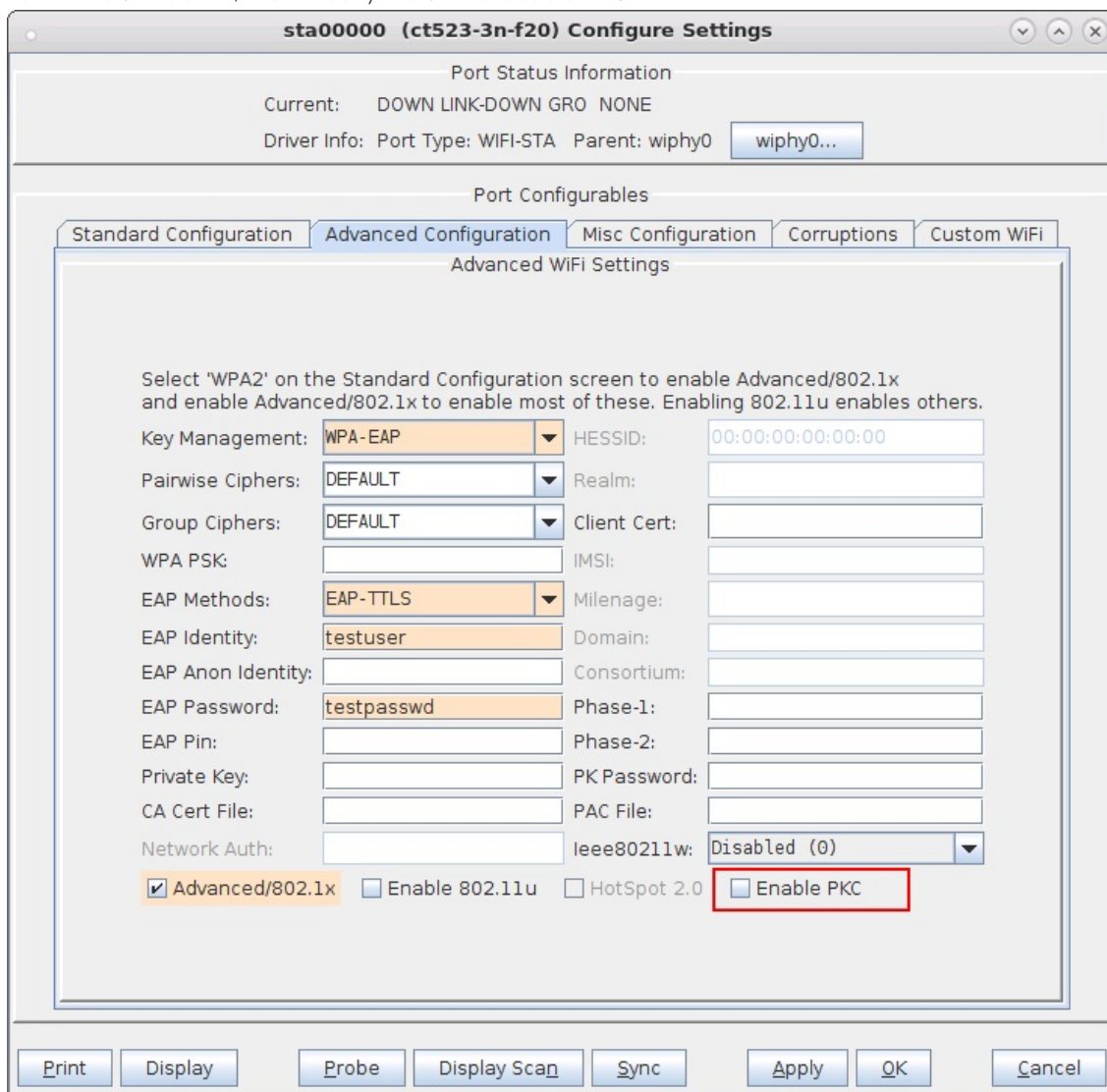
1. To disable OKC on the VAP, comment out the okc=1 lines in the VAP custom configuration, then reset the VAP.

```
bss=vap0000_0
ssid=okctest1
bssid=04:f0:21:19:88:44
ieee8021x=1
own_ip_addr=127.0.0.1
auth_server_addr=127.0.0.1
auth_server_port=1812
auth_server_shared_secret=lanforge
```

```
wpa=2
wpa_pairwise=TKIP CCMP
rsn_pairwise=CCMP
wpa_key_mgmt=WPA-EAP WPA-EAP-SHA256
bss_load_update_period=100
chan_util_avg_period=600
rrm_neighbor_report=1
rrm_beacon_report=1
bss_transition=1
#okc=1
```

```
bss=vap0000_1
ssid=okctest1
bssid=04:f0:21:19:89:44
ieee8021x=1
own_ip_addr=127.0.0.1
auth_server_addr=127.0.0.1
auth_server_port=1812
auth_server_shared_secret=lanforge
wpa=2
wpa_pairwise=TKIP CCMP
rsn_pairwise=CCMP
wpa_key_mgmt=WPA-EAP WPA-EAP-SHA256
bss_load_update_period=100
chan_util_avg_period=600
rrm_neighbor_report=1
rrm_beacon_report=1
bss_transition=1
#okc=1
```

2. Admin the STA down , then modify the STA to disable PKC

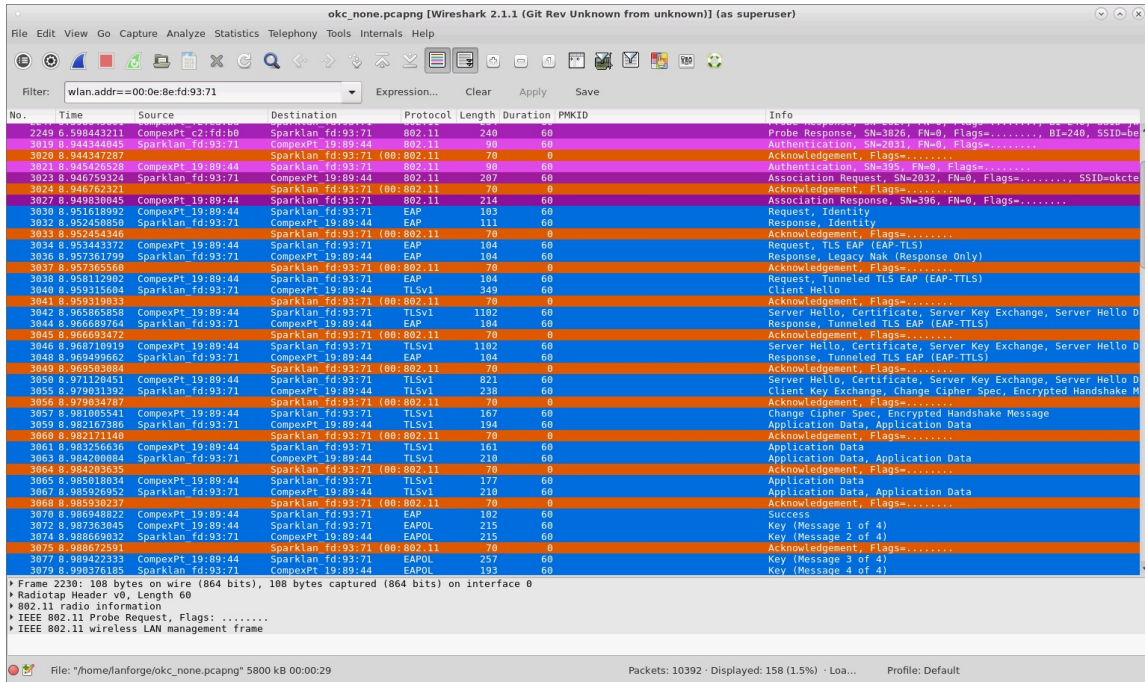


3. Start a packet capture then admin the STA up.

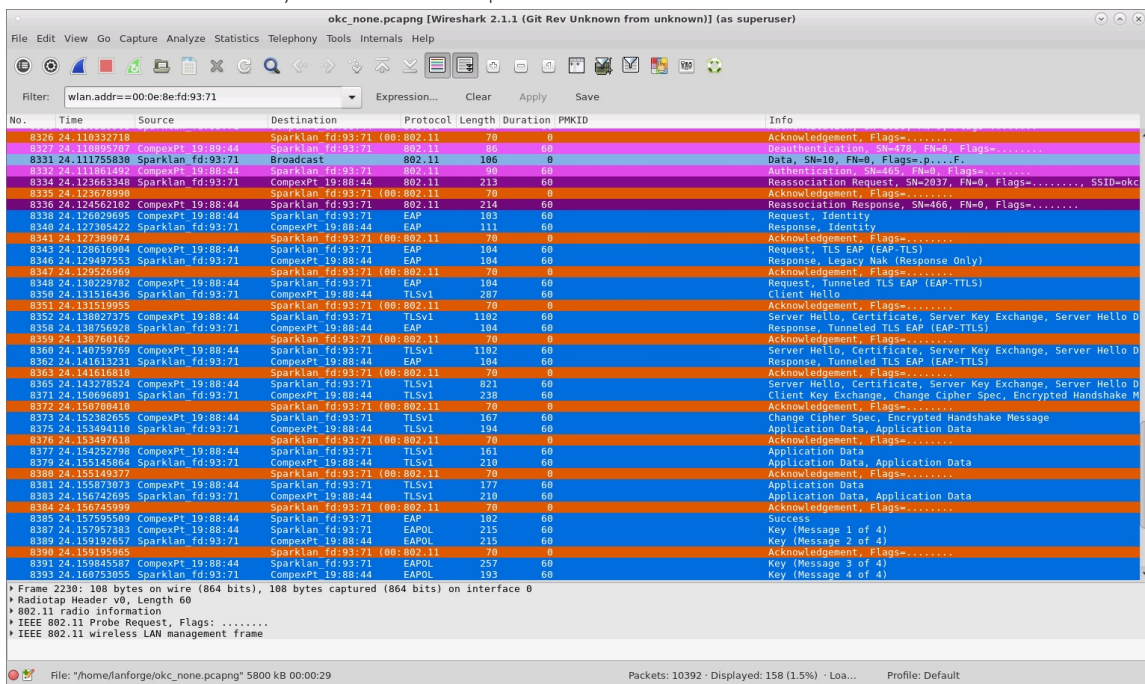
4. Use `wpa_cli` to force the STA to roam with the following terminal commands:

```
# wpa_cli -i sta00000 scan  
# wpa_cli -i sta00000 roam <next BSSID>
```

5. In the packet capture, the initial RADIUS authentication and 4-way handshake are shown:



6. Then the STA sends a Reassociation Request which is missing the PMKID and another full RADIUS authentication and 4-way handshake take place to associate to the new BSSID.



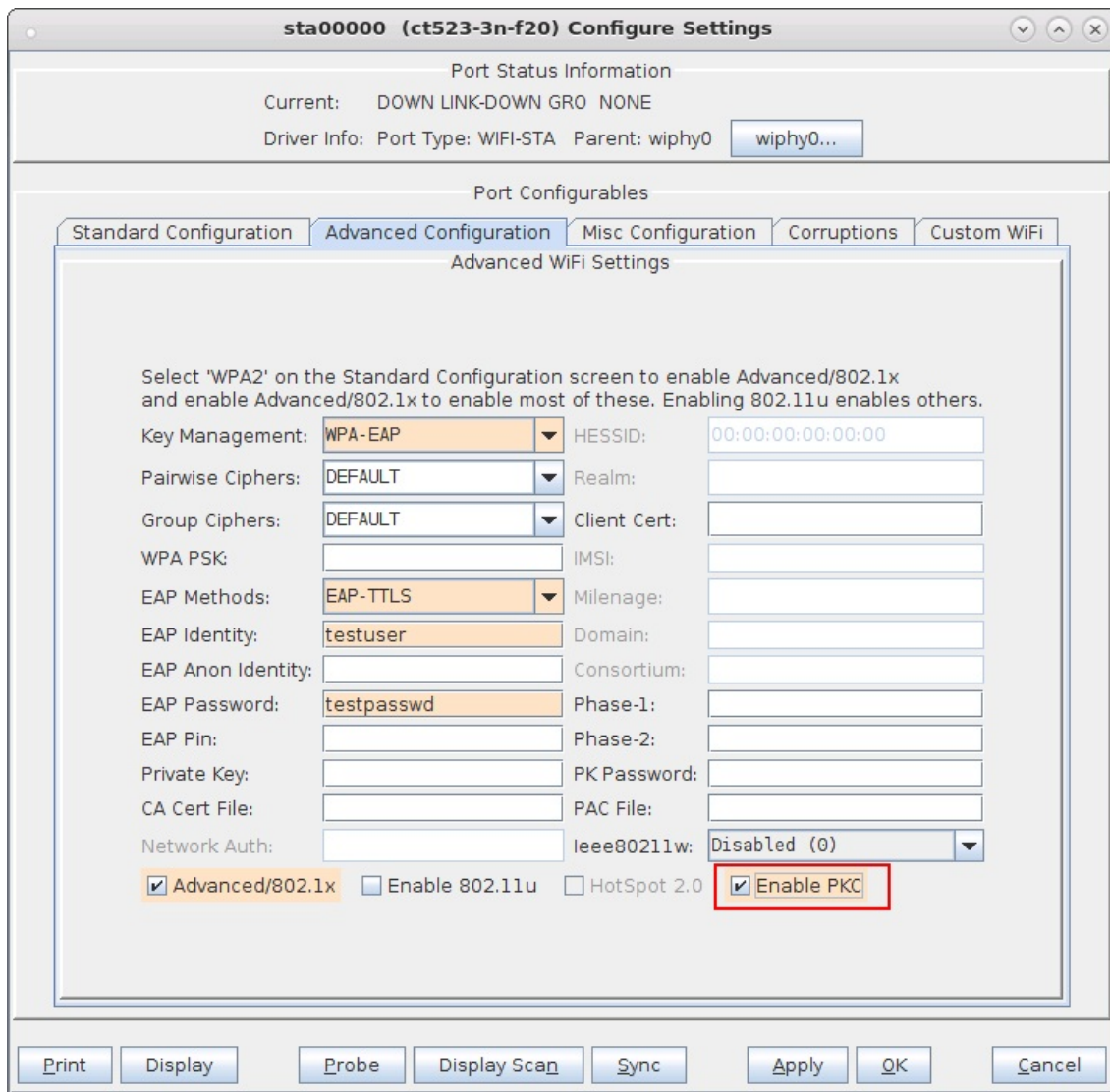
## OKC Disabled On VAP and Enabled On STA

STA roam result: PMKID is sent, then full RADIUS authentication plus 4-way handshake.

If just the STA is using OKC, it will send its calculated PMKID in a Reassociation Request to the target AP, but the AP ignores it and the STA must perform a full RADIUS authentication plus 4-way handshake.

1. Admin the STA down , then modify the STA to enable PKC





2. Start a packet capture then admin the STA up.
3. Use `wpa_cli` to force the STA to roam with the following terminal commands:

```
# wpa_cli -i sta00000 scan
# wpa_cli -i sta00000 roam <next BSSID>
```

4. In the packet capture, the initial RADIUS authentication and 4-way handshake are shown:

okc\_sta\_only.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)] (as superuser)

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: wlan.addr==00:0e:bf:fd:93:71 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Duration	PKMID	Info
2585	9.362903125	2c:33:11:d8:1b:ad	Sparklan fd:93:71	802.11	371	60		Probe Response, SN=417, FN=0, Flags=....., BI=100, SSID=c18
3411	9.708844182	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	98	60		Authentication, SN=1943, FN=0, Flags=.....
3412	9.708847018	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3413	9.708891375	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	98	60		Authentication, SN=890, FN=0, Flags=.....
3415	9.710458178	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	207	60		Association Request, SN=1944, FN=0, Flags=....., SSID=okc
3416	9.710458193	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3417	9.712226675	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	214	60		Association Response, SN=481, FN=0, Flags=.....
3419	9.713546576	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	103	60		Request, Identity
3422	9.714612174	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	111	60		Response, Identity
3423	9.714713187	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3424	9.715549601	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, TLS EAP (EAP-TLS)
3427	9.719377205	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Legacy Nak (Response Only)
3428	9.719380593	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3429	9.720956928	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
3431	9.721234891	Sparklan fd:93:71	ComplexPT 19:89:44	TLVsv1	349	60		Client Hello
3432	9.721238223	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	70	0		Acknowledgement, Flags=.....
3433	9.727602430	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3439	9.728597461	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
3439	9.728510931	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
3442	9.730448629	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3439	9.731281018	Sparklan fd:93:71	ComplexPT 19:89:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
3440	9.731284448	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
3441	9.732260691	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	821	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
3445	9.740689972	Sparklan fd:93:71	ComplexPT 19:89:44	TLVsv1	238	60		Client Key Exchange, Change Cipher Spec, Encrypted Handshake M
3446	9.740692992	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3447	9.742578219	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	167	60		Change Cipher Spec, Encrypted Handshake Message
3449	9.743789749	Sparklan fd:93:71	ComplexPT 19:89:44	TLVsv1	194	60		Application Data, Application Data
3450	9.743783766	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
3451	9.744752445	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	161	60		Application Data
3453	9.745609071	Sparklan fd:93:71	ComplexPT 19:89:44	TLVsv1	210	60		Application Data, Application Data
3454	9.745609218	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	70	0		Acknowledgement, Flags=.....
3455	9.746612062	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	177	60		Application Data
3459	9.747510729	Sparklan fd:93:71	ComplexPT 19:89:44	TLVsv1	210	60		Application Data, Application Data
3458	9.747552126	ComplexPT 19:89:44	Sparklan fd:93:71	TLVsv1	70	0		Acknowledgement, Flags=.....
3461	9.7486808317	ComplexPT 19:89:44	Sparklan fd:93:71	EAP	102	60		Success
3462	9.749071678	ComplexPT 19:89:44	Sparklan fd:93:71	EAPOL	215	60		Key (Message 1 of 4)
3465	9.750322571	Sparklan fd:93:71	ComplexPT 19:89:44	EAPOL	215	60		Key (Message 2 of 4)
3466	9.750326176	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
3467	9.751019106	ComplexPT 19:89:44	Sparklan fd:93:71	EAPOL	257	60		Key (Message 3 of 4)
3469	9.75232109	Sparklan fd:93:71	ComplexPT 19:89:44	EAPOL	193	60		Key (Message 4 of 4)

File: "/home/anforge/okc\_sta\_only.pcapng" 7481 KB 00:00:37 Packets: 13185 · Displayed: 160 (1.2%) · Load... Profile: Default

5. Then the STA sends a Reassociation Request which includes its PMKID but the VAP ignores it and a full RADIUS authentication plus 4-way handshake are required.

okc\_sta\_only.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)] (as superuser)

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: wlan.addr==00:0e:bf:fd:93:71 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Duration	PKMID	Info
8680	24.82969678	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8701	24.830352248	ComplexPT 19:89:44	Sparklan fd:93:71	802.11	106	60		Authentication, SN=539, FN=0, Flags=.....
8684	24.830393958	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	98	60		Authentication, SN=540, FN=0, Flags=.....
8686	24.834493647	Sparklan fd:93:71	ComplexPT 19:89:44	802.11	231	60	dc660e86bde24f862297e94fa2b39b4	Reassociation Request, SN=1949, FN=0, Flags=....., SSID=okc
8687	24.834496322	Sparklan fd:93:71	ComplexPT 19:89:44	802.11	70	0		Acknowledgement, Flags=.....
8688	24.835456431	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	214	60		Reassociation Response, SN=547, FN=0, Flags=.....
8690	24.837139293	ComplexPT 19:88:44	Sparklan fd:93:71	EAP	103	60		Request, Identity
8692	24.838297278	Sparklan fd:93:71	ComplexPT 19:88:44	EAP	111	60		Response, Identity
8693	24.838309752	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
8694	24.839225546	ComplexPT 19:88:44	Sparklan fd:93:71	EAP	104	60		Request, TLS EAP (EAP-TLS)
8696	24.84063305	Sparklan fd:93:71	ComplexPT 19:88:44	EAP	104	60		Response, Legacy Nak (Response Only)
8697	24.840637005	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
8698	24.840764926	ComplexPT 19:88:44	Sparklan fd:93:71	EAP	104	60		Request, Tunnelled TLS EAP (EAP-TTLS)
8700	24.842407557	Sparklan fd:93:71	ComplexPT 19:88:44	TLVsv1	287	60		Client Hello
8701	24.842411011	Sparklan fd:93:71	Sparklan fd:93:71 (00:802:11)	802.11	70	0		Acknowledgement, Flags=.....
8703	24.84059037	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
8705	24.849756212	Sparklan fd:93:71	ComplexPT 19:88:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
8706	24.849768405	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8707	24.851091053	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	1102	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
8709	24.852080129	Sparklan fd:93:71	ComplexPT 19:88:44	EAP	104	60		Response, Tunnelled TLS EAP (EAP-TTLS)
8710	24.852811503	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8711	24.854466327	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	821	60		Server Hello, Certificate, Server Key Exchange, Server Hello D
8714	24.859616192	Sparklan fd:93:71	ComplexPT 19:88:44	TLVsv1	238	60		Client Key Exchange, Change Cipher Spec, Encrypted Handshake M
8715	24.859641877	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8716	24.861510220	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	167	60		Change Cipher Spec, Encrypted Handshake Message
8718	24.862539899	Sparklan fd:93:71	ComplexPT 19:88:44	TLVsv1	194	60		Application Data, Application Data
8719	24.862568787	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8720	24.864889838	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	161	60		Application Data
8723	24.865918078	Sparklan fd:93:71	ComplexPT 19:88:44	TLVsv1	210	60		Application Data, Application Data
8724	24.865823366	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8725	24.866660154	ComplexPT 19:88:44	Sparklan fd:93:71	TLVsv1	177	60		Application Data
8727	24.867571520	Sparklan fd:93:71	ComplexPT 19:88:44	TLVsv1	210	60		Application Data, Application Data
8728	24.867575042	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8729	24.868578312	ComplexPT 19:88:44	Sparklan fd:93:71	EAP	102	60		Success
8731	24.868903422	ComplexPT 19:88:44	Sparklan fd:93:71	EAPOL	215	60		Key (Message 1 of 4)
8733	24.870254506	Sparklan fd:93:71	ComplexPT 19:88:44	EAPOL	233	60	dc660e86bde24f862297e94fa2b39b4	Key (Message 2 of 4)
8734	24.870257998	ComplexPT 19:88:44	Sparklan fd:93:71	802.11	70	0		Acknowledgement, Flags=.....
8735	24.870977518	ComplexPT 19:88:44	Sparklan fd:93:71	EAPOL	257	60		Key (Message 3 of 4)
8737	24.871829355	Sparklan fd:93:71	ComplexPT 19:88:44	EAPOL	193	60		Key (Message 4 of 4)

File: "/home/anforge/okc\_sta\_only.pcapng" 7481 KB 00:00:37 Packets: 13185 · Displayed: 160 (1.2%) · Load... Profile: Default