

Corrupting EAPOL-Key 3/4 Handshake Message RSNXE WPA-Key Information Elements

Goal: Manually override RSN-Extension-Element (RSNXE) of 3 of 4-way EAPOL authentication handshake messages sent by a LANforge system in AP Mode for testing purposes.

The `rsnxe_override_eapo1` field in LANforge **Custom WiFi Parameters** provides capability to corrupt specific information elements of **EAPOL-Key Message 3 of 4** of WPA3 authentication sequence using SAE with encrypted management frames (802.11w). The Robust Security Network Extension Element (RSNXE), used to communicate and confirm certain aspects of security negotiation such as "SAE-hash-to-element", must be consistent between Beacon frames and EAPOL-Key messages; this method corrupts this RSNXE IE, provoking authentication failure with a distinctive response message: **WPA: RSNXE mismatch between Beacon/ProbeResp and EAPOL-Key msg 3/4.**

1. Initial Setup for WPA3-Authentication Testing with Simultaneous Authentication of Equals (SAE).

The setup requires AP and station NIC drivers capable of enabling SAE encryption (this example uses MediaTek radios with ath10k(988x) driver), enabling encrypted management frames (802.11w), enabling WPA3 and disabling WPA2-PSK authentication in both station and AP.

- A. Set up a virtual AP for testing.
In this test, it is named `vap0000` on parent device `wi.phy0`.
For more information see [Create VAP in Bridge Mode](#)
- B. On a separate radio, create a station to authenticate with `vap0000`:
In the **Port Manager** tab, select `wi.phy1` and click **Create**; select **WiFi STA**, then click **Apply**.
In this test, the station is named `wlan1` on parent device `wi.phy1`.
For more information see [Generating Traffic for WLAN Testing](#)
- C. Configure `vap0000` and `wlan1` to use **WPA3-SAE** encrypted authentication.
Ensure that `802.11w` is enabled, since it is required for WPA3.
For more information see [Setting up WPA3](#)
- D. Configure `vap0000` and `wlan1` with **SSID** `test-wpa2-psk` and **Keyphrase** `qwertyuiop`.
- E. Create a Monitor Port on its own radio to sniff wireless packets.
In this test, the monitor port is named `moni3a`.
For more information see [Using Wireshark to Sniff WiFi Monitors](#)

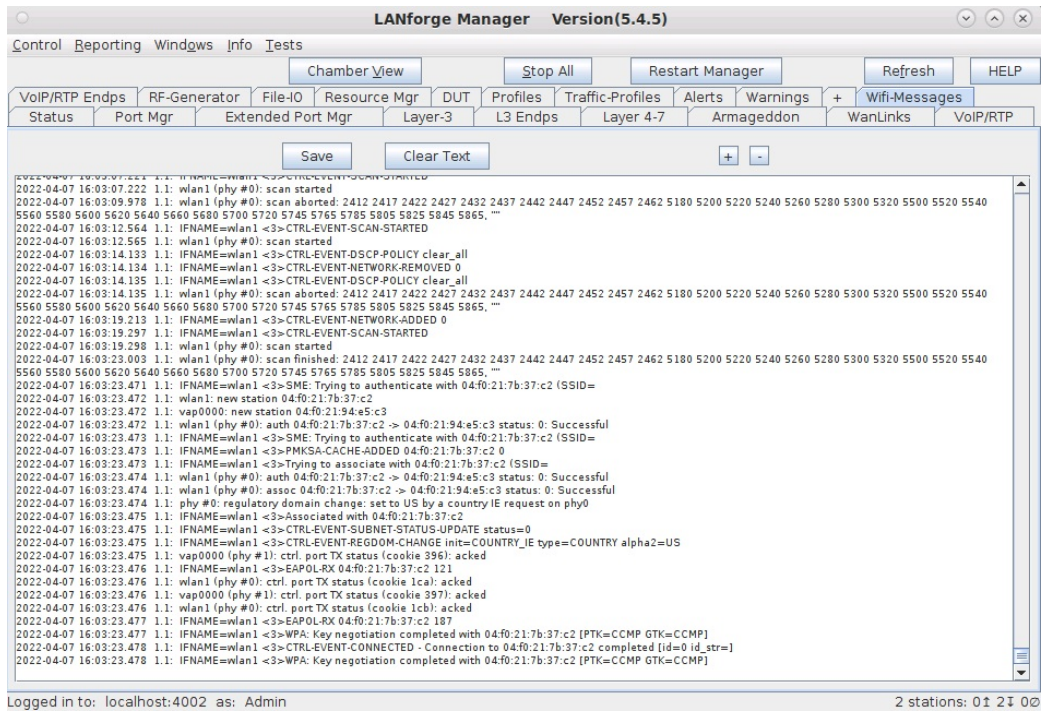
2. Control (No Change):

- A. Configure **Custom WiFi** in `vap0000`:
Select `vap0000` and click **Modify**.
Navigate to the **Custom WiFi** tab.
Ensure that no `sae_commit_override` parameter is set in **User-Specified supplicant/hostapd configuration text**.
Click **Apply** then **OK**.
- B. Set the vAP down and back up to allow changes to take effect:
In the **Port Manager** tab, select `vap0000`.
Admin all selected interfaces **DOWN** (CTRL-PLUS).
Admin all selected interfaces **UP** (CTRL-MINUS).
- C. Sniff packets to observe the authentication behavior:
On the observation system in the **Port Manager** tab, select only `moni3a`:
Click **Sniff Packets**.

- D. Observe the results, which should be similar to the following:
- The station wlan1 succeeds in authenticating with vap0000.
 - LANforge **WiFi Messages** shows WPA: Key negotiation completed.

E. Example results:

A. Behavior in LANforge **WiFi Messages**: Control Test



3. **RSNXE Mismatch in EAPOL-Key Message 3/4:**

- A. Configure **Custom WiFi** in vap0000:
 Select vap0000 and click **Modify**.
 Navigate to the **Custom WiFi** tab.
 In the **User-Specified supplicant/hostapd configuration text** field, write:
`rsnx_override_eapol=F40100.`
 Click **Apply** then **OK**.
- B. Reset ports and sniff packets:
 Repeat steps B through D of **Step 2**.
- C. Observe the results, which should be similar to the following:
- Message 2/4 shows only encrypted in Wireshark due to having enabled **802.11w**.
 - The station wlan1 fails to authenticate with vap0000.
 - LANforge **WiFi-Messages** recognizes WPA:RSNXE mismatch between Beacon/ProbeResp and EAPOL-Key msg 3/4 and gives CTRL-EVENT-DISCONNECTED for reason 17: Information element in 4-way handshake different from (Re-)associate request/Probe response/Beacon.
 - Deauthentication management frame is sent by the station with Reason code: Information element in 4-way Handshake different from (Re)Association Request/Probe Response/Beacon frame (0x0011).
 - Compare **EAPOL-Key Message 3 of 4** and **BEACON** RSNXE information for mismatch.
- D. Example results:

A. Behavior in LANforge **Wifi Messages: RSNXE Override Test**

LANforge Manager Version(5.4.5)

Control Reporting Windows Info Tests

Chamber View Stop All Restart Manager Refresh HELP

VoIP/RTP Endps RF-Generator File-I/O Resource Mgr DUT Profiles Traffic-Profiles Alerts Warnings + Wifi-Messages

Status Port Mgr Extended Port Mgr Layer-3 Layer 4-7 WanLinks VoIP/RTP

Save Clear Text + -

```

2022-04-04 16:09:24.846 1.1: IFNAME=wlan1 <3>Trying to associate with 04:f0:21:7b:37:c2 (SSID=
2022-04-04 16:09:24.846 1.1: wlan1 (phy #0): assoc 04:f0:21:7b:37:c2 -> 04:f0:21:94:e5:c3 status: 0: Successful
2022-04-04 16:09:24.846 1.1: IFNAME=wlan1 <3>Associated with 04:f0:21:7b:37:c2
2022-04-04 16:09:24.847 1.1: IFNAME=wlan1 <3>CTRL-EVENT-SUBNET-STATUS-UPDATE status=0
2022-04-04 16:09:24.847 1.1: IFNAME=wlan1 <3>CTRL-EVENT-REGDOM-CHANGE init=COUNTRY_IE type=COUNTRY alpha2=US
2022-04-04 16:09:24.850 1.1: phy #0: regulatory domain change: set to US by a country IE request on phy0
2022-04-04 16:09:24.851 1.1: IFNAME=wlan1 <3>EAPOL-RX 04:f0:21:7b:37:c2 121
2022-04-04 16:09:24.853 1.1: vap0000 (phy #1): ctrl. port TX status (cookie 384): acked
2022-04-04 16:09:24.854 1.1: wlan1 (phy #0): ctrl. port TX status (cookie 1c8): acked
2022-04-04 16:09:24.854 1.1: vap0000 (phy #1): ctrl. port TX status (cookie 385): acked
2022-04-04 16:09:24.855 1.1: IFNAME=wlan1 <3>EAPOL-RX 04:f0:21:7b:37:c2 187
2022-04-04 16:09:24.855 1.1: IFNAME=wlan1 <3>WPA: RSNXE mismatch between Beacon/ProbeResp and EAPOL-Key msg 3/4
2022-04-04 16:09:24.856 1.1: vap0000 (phy #1): unprotected deauth 04:f0:21:94:e5:c3 -> 04:f0:21:7b:37:c2 reason: 17: Information element in 4-way handshake different from (Re-)Associate request/Probe response/Beacon
2022-04-04 16:09:24.856 1.1: wlan1: del station 04:f0:21:7b:37:c2
2022-04-04 16:09:24.857 1.1: IFNAME=wlan1 <3>CTRL-EVENT-DISCONNECTED bssid=04:f0:21:7b:37:c2 reason=17 locally_generated=1
2022-04-04 16:09:24.857 1.1: wlan1 (phy #0): deauth 04:f0:21:94:e5:c3 -> 04:f0:21:7b:37:c2 reason: 17: Information element in 4-way handshake different from (Re-)Associate request/Probe response/Beacon
2022-04-04 16:09:24.859 1.1: wlan1 (phy #0): disconnected (local request) reason: 17: Information element in 4-way handshake different from (Re-)Associate request/Probe response/Beacon
2022-04-04 16:09:24.860 1.1: IFNAME=wlan1 <3>CTRL-EVENT-DSCP-POLICY clear_all
2022-04-04 16:09:24.860 1.1: IFNAME=wlan1 <3>CTRL-EVENT-DSCP-POLICY clear_all
2022-04-04 16:09:24.861 1.1: IFNAME=wlan1 <3>WPA: PTK not available, cannot decrypt EAPOL-Key Key Data
2022-04-04 16:09:24.861 1.1: IFNAME=wlan1 <3>CTRL-EVENT-DSCP-POLICY clear_all
2022-04-04 16:09:25.130 1.1: vap0000 (phy #1): ctrl. port TX status (cookie 386): no ack
2022-04-04 16:09:27.131 1.1: vap0000 (phy #1): ctrl. port TX status (cookie 387): no ack
2022-04-04 16:09:29.133 1.1: vap0000 (phy #1): ctrl. port TX status (cookie 388): no ack
2022-04-04 16:09:29.175 1.1: IFNAME=wlan1 <3>CTRL-EVENT-SCAN-STARTED
2022-04-04 16:09:29.175 1.1: wlan1 (phy #0): scan started
2022-04-04 16:09:31.130 1.1: vap0000 (phy #1): mgmt TX status (cookie 389): no ack
2022-04-04 16:09:31.173 1.1: vap0000: del station 04:f0:21:94:e5:c3
2022-04-04 16:09:32.858 1.1: wlan1 (phy #0): scan finished: 2412 2417 2422 2427 2432 2437 2442 2447 2452 2457 2462 5180 5200 5220 5240 5260 5280 5300 5320 5500 5520 5540
5560 5580 5600 5620 5640 5660 5680 5700 5720 5745 5765 5785 5805 5825 5845 5865, ...
2022-04-04 16:09:32.943 1.1: IFNAME=wlan1 <3>SME: Trying to authenticate with 04:f0:21:7b:37:c2 (SSID=
2022-04-04 16:09:32.944 1.1: wlan1: new station 04:f0:21:7b:37:c2
2022-04-04 16:09:32.944 1.1: IFNAME=wlan1 <3>Trying to associate with 04:f0:21:7b:37:c2 (SSID=
2022-04-04 16:09:33.127 1.1: vap0000: new station 04:f0:21:94:e5:c3
2022-04-04 16:09:33.128 1.1: IFNAME=wlan1 <3>Associated with 04:f0:21:7b:37:c2
    
```

Logged in to: localhost:4002 as: Admin 2 stations: 1 1 1 0 0

B. Deauthentication: RSNXE Override Test

```

Type/Subtype: Deauthentication (0x000c)
- Frame Control Field: 0xc000
  ... ..00 = Version: 0
  ... ..00.. = Type: Management frame (0)
  1100 ... = Subtype: 12
  - Flags: 0x00
    ... ..00 = DS status: Not leaving DS or network is operating in AD-HOC mode (To DS: 0 From DS: 0) (0x0)
    ... ..0.. = More Fragments: This is the last fragment
    ... ..0... = Retry: Frame is not being retransmitted
    ... ..0 .... = PWR MGT: STA will stay up
    ... ..0 .... = More Data: No data buffered
    ... ..0... = Protected flag: Data is not protected
    ... ..0... = Order flag: Not strictly ordered
  .000 0000 0011 1100 = Duration: 60 microseconds
  Receiver address: 04:f0:21:7b:37:c2
  Destination address: 04:f0:21:7b:37:c2
  Transmitter address: 04:f0:21:94:e5:c3
  Source address: 04:f0:21:94:e5:c3
  BSS Id: 04:f0:21:7b:37:c2
  ... ..0000 = Fragment number: 0
  0001 0000 1000 ... = Sequence number: 264
- IEEE 802.11 Wireless Management
  - Fixed parameters (2 bytes)
    Reason code: Information element in 4-Way Handshake different from (Re)Association Request/Probe Response/Beacon frame (0x0011)
0000 00 00 44 00 2f 40 40 a0 20 08 00 a0 20 08 00 a0 ..D./00. ....
0010 20 08 00 a0 20 08 00 00 0b 3a 77 fb 00 00 00 00 ... ..:w.....
0020 00 0c 3c 14 40 01 ee 00 00 00 00 00 00 00 00 ...<@.....
0030 0b 3a 77 fb 00 00 00 00 00 00 01 03 ee 00 e3 01 :W.....
0040 e3 02 e4 03 c0 00 3c 00 04 f0 21 7b 37 c2 04 f0 .....<...!{7...
0050 21 94 e5 c3 04 f0 21 7b 37 c2 80 10 01 00 !.....!{ 7...
    
```

C. EAPOL-Key Message 3 of 4: RSNXE Override Test

```
▶ Frame 263: 289 bytes on wire (2312 bits), 289 bytes captured (2312 bits) on interface moni3a, id 0
▶ Radiotap Header v0, Length 68
▶ 802.11 radio information
▶ IEEE 802.11 QoS Data, Flags: .....F.
▶ Logical-Link Control
▼ 802.1X Authentication
  Version: 802.1X-2004 (2)
  Type: Key (3)
  Length: 183
  Key Descriptor Type: EAPOL RSN Key (2)
  [Message number: 3]
  ▼ Key Information: 0x13c8
    .... = Key Descriptor Version: Unknown (0)
    ....1... = Key Type: Pairwise Key
    ....00.... = Key Index: 0
    ....1.... = Install: Set
    ....1.... = Key ACK: Set
    ....1.... = Key MIC: Set
    ....1.... = Secure: Set
    ....0.... = Error: Not set
    ....0.... = Request: Not set
    ...1.... = Encrypted Key Data: Set
    ..0.... = SMK Message: Not set
  Key Length: 16
  Replay Counter: 2
  WPA Key Nonce: 6502b4fda34d00be8fba0cb671f6034263d9c8a92c21a73c...
  Key IV: 00000000000000000000000000000000
  WPA Key RSC: 0000000000000000
  WPA Key ID: 0000000000000000
  WPA Key MIC: 31e19714b1e9446765b97589060f326e
  WPA Key Data Length: 88
  WPA Key Data: 33dbdd5179a576dbc3f7d2b58baf36b897159e50d4f4ead7...
```

0000	00 00 44 00 2f 40 40 a0	20 08 00 a0 20 08 00 a0	--D-/00
0010	20 08 00 a0 20 08 00 00	9e 01 77 fb 00 00 00 00	...w
0020	00 0c 3c 14 40 01 e7 00	00 00 00 00 00 00 00 00	<@
0030	9e 01 77 fb 00 00 00 00	00 00 01 01 e6 00 e2 01	w
0040	df 02 dc 03 88 02 24 00	04 f0 21 94 e5 c3 04 f0	\$.!
0050	21 7b 37 c2 04 f0 21 7b	37 c2 10 00 07 00 aa aa	!{7...!{ 7
0060	03 00 00 00 88 8e 02 03	00 b7 02 13 c8 00 10 00	
0070	00 00 00 00 00 00 02 65	02 b4 fd a3 4d 00 be 8f	...e...M
0080	ba 0c b6 71 f6 03 42 63	d9 c8 a9 2c 21 a7 3c 0d	...q...Bc...!<
0090	4e 1c a1 59 af 0c 0f 00	00 00 00 00 00 00 00 00	N...Y
00a0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	
00b0	00 00 00 00 00 00 00 31	e1 97 14 b1 e9 44 67 65	...1...Dge
00c0	b9 75 89 06 0f 32 6e 00	58 33 db dd 51 79 a5 76	...u...2n...X3...Qy...v
00d0	db c3 f7 d2 b5 8b af 36	b8 97 15 9e 50 d4 f4 ea	...6...P
00e0	d7 58 47 72 85 ea 2f 00	25 f4 d9 e0 3e 72 d5 f3	XGr.../...%...>r
00f0	57 3c 6f 2d fa 34 42 22	fd c7 53 ef 12 7a 2d ad	w<0...4B...S...z
0100	4f 08 a8 51 68 5e 0d 78	5a a7 d2 2b 31 35 ba ea	0...Qh^x Z...+15
0110	66 ee 01 42 6a 6e d2 69	88 fd e0 55 92 2e ef 05	F...Bjn...i...U
0120	91		

D. BEACON: RSNXE Override Test

```
▼ Tagged parameters (248 bytes)
  ▶ Tag: SSID parameter set: juicer-wifi
  ▶ Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
  ▶ Tag: DS Parameter set: Current Channel: 36
  ▶ Tag: Traffic Indication Map (TIM): DTIM 0 of 0 bitmap
  ▶ Tag: Country Information: Country Code US, Environment Any
  ▼ Tag: RSN Information
    Tag Number: RSN Information (48)
    Tag length: 20
    RSN Version: 1
    ▶ Group Cipher Suite: 00:0f:ac (Ieee 802.11) AES (CCM)
    ▶ Pairwise Cipher Suite Count: 1
    ▶ Pairwise Cipher Suite List 00:0f:ac (Ieee 802.11) AES (CCM)
    ▶ Auth Key Management (AKM) Suite Count: 1
    ▶ Auth Key Management (AKM) List 00:0f:ac (Ieee 802.11) SAE (SHA256)
    ▼ RSN Capabilities: 0x00cc
      .... = RSN Pre-Auth capabilities: Transmitter does not support pre-authentication
      ....0. = RSN No Pairwise capabilities: Transmitter can support WEP default key 0 simultaneously with Pairwise key
      ....11.. = RSN GTKSA Replay Counter capabilities: 16 replay counters per GTKSA/GTKSA/STakeySA (0x3)
      ....00.... = RSN GTKSA Replay Counter capabilities: 1 replay counter per GTKSA/GTKSA/STakeySA (0x0)
      ....1.... = Management Frame Protection Required: True
      ....1.... = Management Frame Protection Capable: True
      ....0.... = Joint Multi-band RSNA: False
      ....0.... = PeerKey Enabled: False
      ..0.... = Extended Key ID for Individually Addressed Frames: Not supported
    ▶ Tag: Supported Operating Classes
    ▶ Tag: HT Capabilities (802.11n D1.10)
    ▶ Tag: HT Information (802.11n D1.10)
    ▶ Tag: Extended Capabilities (10 octets)
    ▶ Tag: VHT Capabilities
    ▶ Tag: VHT Operation
    ▶ Tag: VHT Tx Power Envelope
    ▶ Ext Tag: HE Capabilities (IEEE Std 802.11ax/D3.0)
    ▶ Ext Tag: HE Operation (IEEE Std 802.11ax/D3.0)
    ▶ Ext Tag: MU EDCA Parameter Set
    ▶ Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Parameter Element
```

0000	00 00 44 00 2f 40 40 a0	20 08 00 a0 20 08 00 a0	--D-/00
0010	20 08 00 a0 20 08 00 00	9e df 5d fb 00 00 00 00	...]
0020	00 0c 3c 14 40 01 f2 00	00 00 00 00 00 00 00 00	<@
0030	9c df 5d fb 00 00 00 00	00 00 01 01 f1 00 ea 01]
0040	e6 02 eb 03 80 00 00 00	ff ff ff ff ff 04 f0	
0050	21 7b 37 c2 04 f0 21 7b	37 c2 00 04 47 40 93 2f	!{7...!{ 7...0-/
0060	66 00 00 00 f0 00 11 00	00 0b 6a 75 69 63 65 72	f...juicer
0070	2d 77 69 66 69 01 08 8c	12 98 24 b0 48 00 6c 03	-wifi...\$ H L
0080	01 24 05 04 00 02 00 00	07 0c 55 53 20 24 00 17	\$...US \$
0090	64 0c 17 95 05 1e 30 14	01 00 00 0f ac 04 01 00	d...0
00a0	00 0f ac 04 01 00 00 0f	ac 08 cc 00 3b 02 00 00	
00b0	2d 1a 6e 00 03 ff ff ff	ff 00 00 00 00 00 00 00	-n
00c0	00 01 00 00 00 00 00 00	00 00 00 00 3d 16 24 05	= \$
00d0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	
00e0	00 00 00 00 7f 0a 04 00	00 02 00 00 00 40 00 40	0 0
00f0	bf 0c b1 59 8a 31 aa ff	00 00 aa ff 00 00 c0 05	...Y 1