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Bachelor of Science Cyber Security

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Details

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YEAR OF STUDY	: 3 rd
COURSE NAME	: Wireless Security
COURSE CODE	: CYS331
LECTURER	: Mr. Zilani Kaluba
TASK	: Assignment 1
DUE DATE	: 23 rd June, 2023

QUESTION

Design a simulation program for a 4-way handshake process (AP and Client) with the inputs

- a) SSID
- b) Password
- c) Client Mac Address [Validate the format of the physical address] Should be in the format (8C:04:BA:14:5B:A3)
- d) AP Physical Address (8C:04:BA:14:5B:A3) [Validate the format of the physical address] Should be in the format (8C:04:BA:14:5B:A3)

Clearly display the message keys exchanged and give sample Keys and show the keys which match for the handshake to be a success.

Table of Contents

Introduction.....	3
sokoFy.....	3
The 4-Way Handshake Phase	3
1. Authenticator Nonce	3
2. Supplicant Nonce	4
3. Temporal Key (GTK) + MIC.....	4
4. Acknowledgment	4
Simulated 4-way handshake (Allowing User Input).....	5
Network Adapters and Available Wi-Fi Networks.....	5
Simulated 4-way handshake	6
Actual 4-way handshake	6
1. New device with wrong password	6
2. New device with correct password	7
Conclusion	7

Table of Figures

Figure 1: sokoFy tool menu	3
Figure 2: 4-way handshake	4
Figure 3: Simulated 4-way handshake with user inputs	5
Figure 4: Validated format of a physical address	5
Figure 5: Scanned wireless networks.....	5
Figure 6: Simulated 4-way handshake with generated keys	6
Figure 7: Failed authentication	6
Figure 8: Successful authentication	7

Introduction

The 4-way handshake is the process of exchanging 4 messages between an access point (authenticator) and the client device (supplicant) to generate some encryption keys which can be used to encrypt actual data sent over Wireless medium.¹

To help us understand this process will utilize the tool called [sokoFy](#) developed by Soko James. It is written in C/C++ Programming and you can access all the files on the GitHub page including the source codes.

sokoFy

Is a lightweight educational simulator that visually demonstrates the WPA2 Wi-Fi 4-way handshake process. Designed for cybersecurity and networking students, it helps you understand how authentication and key exchange work between a client (STA) and an access point (AP) in a secure wireless network.

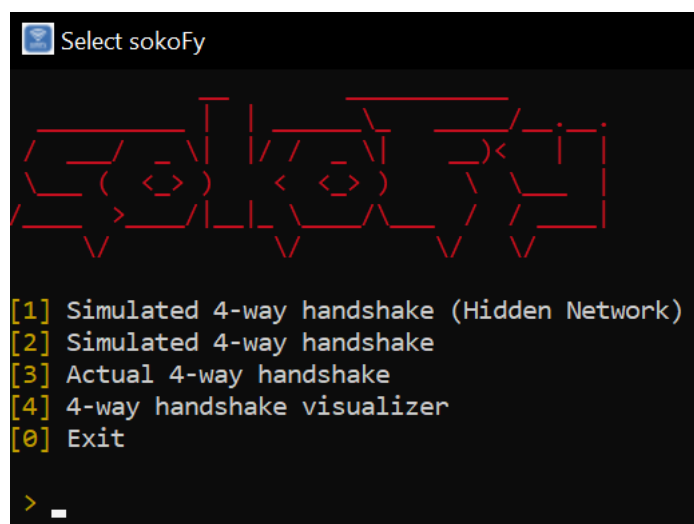


Figure 1: sokoFy tool menu

The 4-Way Handshake Phase

The 4-way handshake is essential in the IEEE 802.11 protocol, aiming to verify that the access point is legitimate to generate the PMK.²

1. Authenticator Nonce

The authenticator (Access Point) generates a fresh nonce, called the **ANonce**, and together with a replay counter (i.e., a counter used to protect the receiver against replay attacks) sends it to the supplicant (Client).³

¹ WiFi Professionals , 2019. 4-Way Handshake. [Online]
Available at: <https://www.wifi-professionals.com/2019/01/4-way-handshake>
[Accessed 21 June 2025].

² Alabdulatif, A., Ma, X. & Nolle, L., 2013. Analysing and Attacking the 4-Way Handshake of IEEE 802.11i Standard. s.l.:s.n.

³ Cremers, . C., Kiesl, B. & Medinger, . N., 2018. A Formal Analysis of IEEE 802.11's WPA2: Countering the Kracks Caused by Cracking the Counters. s.l.:s.n.

2. Supplicant Nonce

The supplicant generates its own fresh nonce, the **SNonce**, and uses a key derivation function to derive the Pairwise Transient Key (PTK) from the pre-shared secret (PMK) and the two nonces. Then, the supplicant sends the SNonce and the replay counter it received in message 1 to the authenticator. Additionally, to allow the authenticator to verify the integrity of the message, it appends a message integrity code (MIC) computed with the PTK.³

3. Temporal Key (GTK) + MIC

After receiving message 2, the authenticator also derives the PTK and checks its message integrity code. It then encrypts the **GTK** and together with an incremented replay counter and a MIC (also computed with the PTK) sends it to the supplicant.³

4. Acknowledgment

When the supplicant receives message 3, it checks the message integrity code. In case the check is successful, it installs the GTK and the PTK. To confirm to the authenticator that the installation was successful, the supplicant uses the PTK to compute a MIC for the replay counter of message 3 and sends both the replay counter and the MIC back to the authenticator. At this point, the authenticator also installs the pairwise transient key and the handshake is complete.³ We can visualize this using option 4 in sokoFy as shown below;

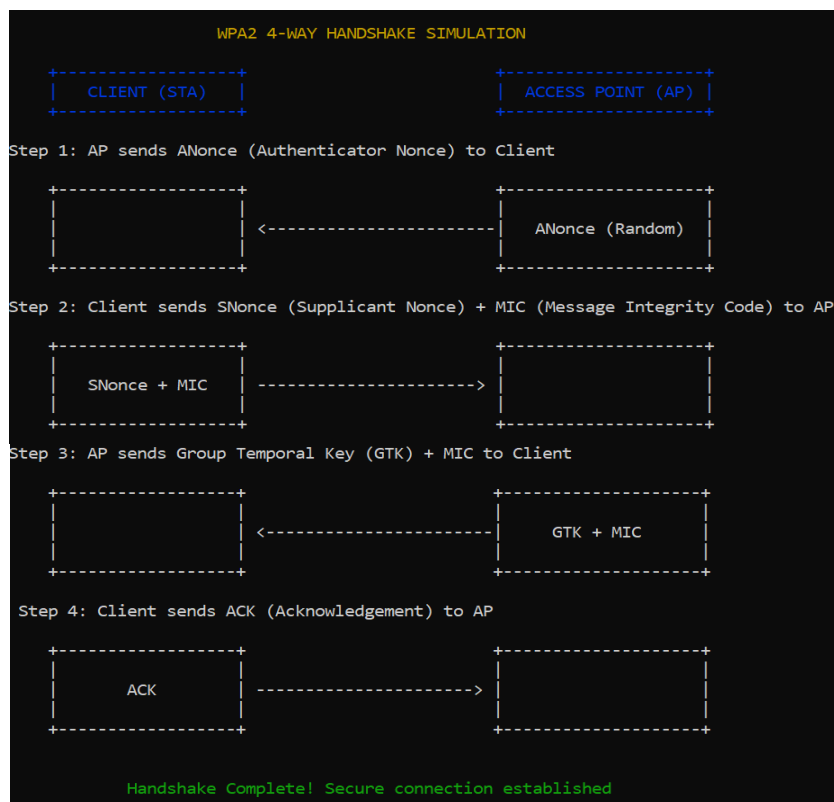


Figure 2: 4-way handshake

Simulated 4-way handshake (Allowing User Input)

```
> 1
[>] Enter SSID: sokojames
[>] Enter Password: 20231392
[>] Enter Client MAC Address (format XX:XX:XX:XX:XX:XX): 8C:04:BA:14:5B:A3
[>] Enter AP MAC Address (format XX:XX:XX:XX:XX:XX): CC:2F:71:D2:85:42

4-WAY HANDSHAKE SIMULATION

SSID          sokojames
Client MAC     8C:04:BA:14:5B:A3
AP MAC        CC:2F:71:D2:85:42
Step 1 AP sends ANonce D76D89A67A177A53AA2F533898181A44
Step 2 Client sends SNonce EB37CF694A3A4CA8E65BCA877139D5BE
Derived PMK     PMK_20231392_sokojames
Derived PTK     PTK_PMK_20231392_sokojames_D76D89A67A177A53AA2F533898181A44_EB37CF694A3A4CA8E65BCA877139D5BE
AP derived PTK  PTK_PMK_20231392_sokojames_D76D89A67A177A53AA2F533898181A44_EB37CF694A3A4CA8E65BCA877139D5BE
Handshake Success PTK Match!
```

Figure 3: Simulated 4-way handshake with user inputs

```
> 1
[>] Enter SSID: sokojames
[>] Enter Password: 20231392
[>] Enter Client MAC Address (format XX:XX:XX:XX:XX:XX): 8C:04:BA:14:5B:A3
[>] Enter AP MAC Address (format XX:XX:XX:XX:XX:XX): CC-2F-71-D2-85-42
[x] Invalid MAC address format.

0_0 Thank you for using sokoFy.

[?] Do you want to return to the main menu? (y/n): _
```

Figure 4: Validated format of a physical address

Network Adapters and Available Wi-Fi Networks

```
YOUR NETWORK ADAPTERS (MAC ADDRESSES)

Wireless LAN adapter Wi-Fi:

Media State . . . . . : Media disconnected
Connection-specific DNS Suffix . :
Description . . . . . : Intel(R) Dual Band Wireless-AC 8265
Physical Address. . . . . : CC-2F-71-D2-85-3E
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes

Wi-Fi

AVAILABLE WI-FI NETWORKS

1. KMU-WIFI (e4:7d:eb:a2:1a:e5) [Open]
2. TECNO POP 10C (b4:fb:e4:c7:a4:52) [Secured]
3. sokonalysis (c2:e7:41:fb:25:55) [Secured]
```

Figure 5: Scanned wireless networks

Simulated 4-way handshake

```
[>] Select the Wi-Fi network to connect to (number): 3
[>] Selected AP MAC: C2:E7:41:FB:25:55
[>] Enter your Client MAC address (format XX:XX:XX:XX:XX:XX): CC-2F-71-D2-85-3E
[>] Enter Wi-Fi key (8-63 chars): sokonalysiscryptotool

4-WAY HANDSHAKE
```

```
AP          Generated ANonce 5204f6abe0c598b6ede7f49c0000f1f8
Message 1   AP sends ANonce to Client
Client      Generated SNonce f337497e93b962458c52105788b58d09
Message 2   Client sends SNonce and MIC to AP
Derived PTK Results 81546f2f2f04bedf2577316464632543c5ba5c7e2bdf545b405198aa9746afae
Message 3   AP sends install PTK message to Client
Message 4   Client confirms install
```

Figure 6: Simulated 4-way handshake with generated keys

Actual 4-way handshake

1. New device with wrong password

```
WIFI

AVAILABLE WI-FI NETWORKS
1. KMU-WIFI (ba:fb:e4:c8:a4:52) [Open]
2. TECNO POP 10C (b4:fb:e4:c7:a4:52) [Secured]
3. sokonalysis (c2:e7:41:fb:25:55) [Secured]

[>] Select the Wi-Fi network to connect to (number): 2
[>] Selected AP MAC: B4:FB:E4:C7:A4:52
[>] Enter your Client MAC address (format XX:XX:XX:XX:XX:XX): CC-2F-71-D2-85-3E
[>] Enter Wi-Fi key (8-63 chars): 12345678
There is no profile "TECNO POP 10C" assigned to the specified interface.
[x] Failed to connect to TECNO POP 10C.

4-WAY HANDSHAKE
```

```
AP          Generated ANonce cbf63e98ab09694d8837bb7887ff8573
Message 1   AP sends ANonce to Client
Client      Generated SNonce 94419bbd58e15dc56d17794ca34b0c99
Message 2   Client sends SNonce and MIC to AP
Derived PTK Results 32afa5a74fd419624bf82c126a28433fc2fcad7d86393cdacf8f76130b72f8d8
Message 3   AP sends install PTK message to Client
Message 4   Client confirms install
```

Figure 7: Failed authentication

2. New device with correct password

Notice that the device is not connected to the internet but after a successful 4-way handshake the device is connect, this applies to a secured network with a correct password and open Wi-Fi network.

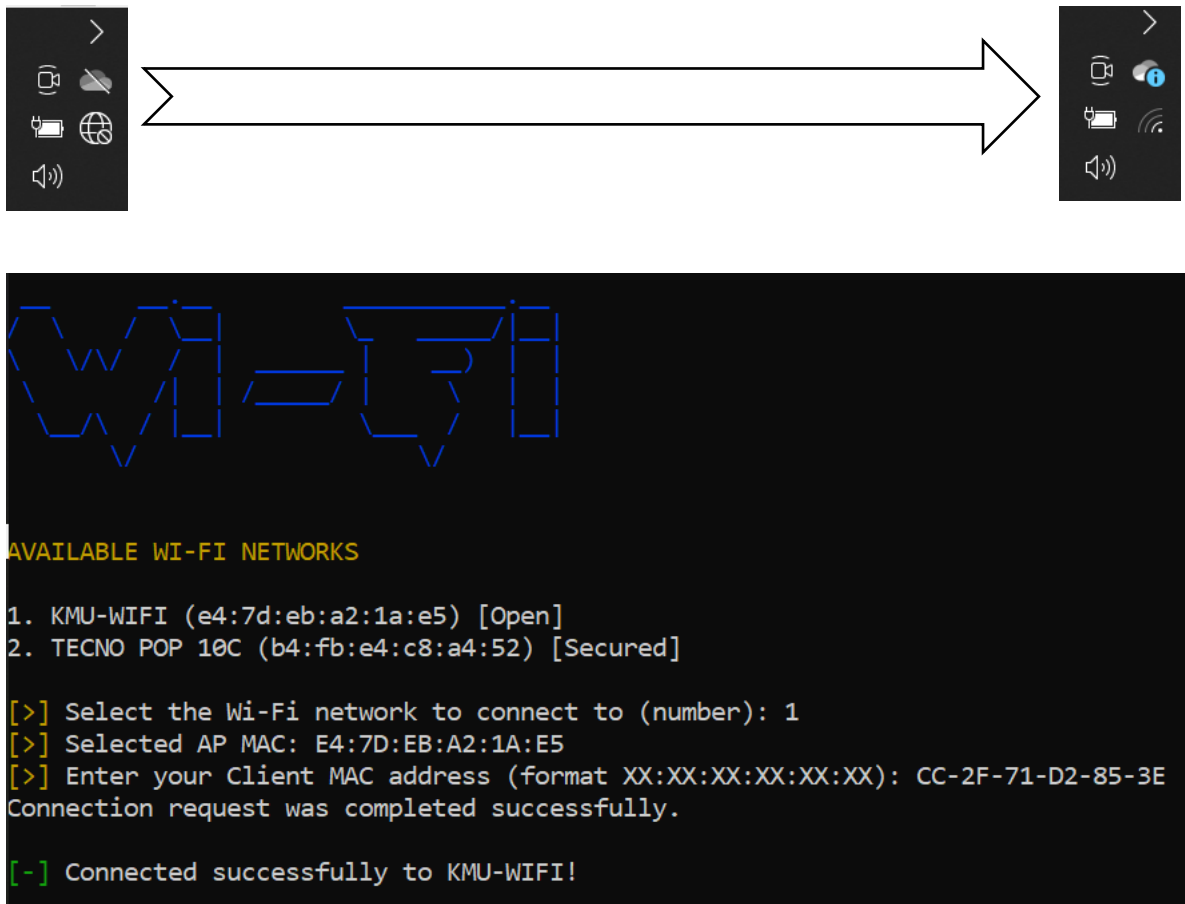


Figure 8: Successful authentication

NOTICE:

Was unable to provide the source codes in this documentation because it will consume a lot of pages, visit this [GitHub](#) repository for sokoFy to view the C (.h) and C++ (.cpp) files used to compile this program.

Conclusion

The 4-way handshake is a key part of securing Wi-Fi networks. Using the sokoFy simulator, we can better understand how the client and access point exchange keys to complete authentication. The simulation shows each step clearly and allows input validation for MAC addresses and credentials. This tool helps simplify a complex process and supports learning in wireless security.