Wifi-Protocol-2

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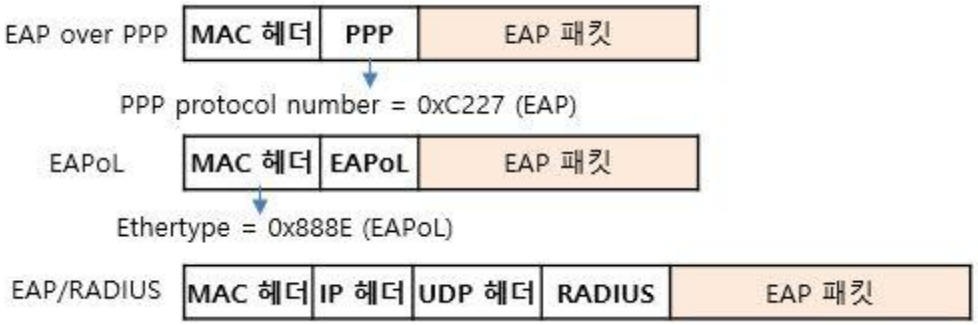
Plan

- Week 1: Wifi Protocol + 취약점 알아보기
- Week 2: 복습 + Wireshark
- Week 3: 실제 환경에서의 테스트

Review

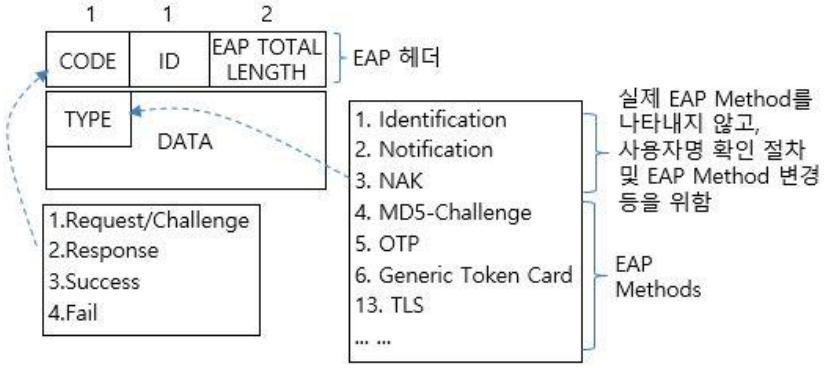
- EAP/EAPOL
- PSK, PMK, PTK?
- 4-way handhsake
- Dragonblood attack (Timing + DoS)

EAP / EAPOL

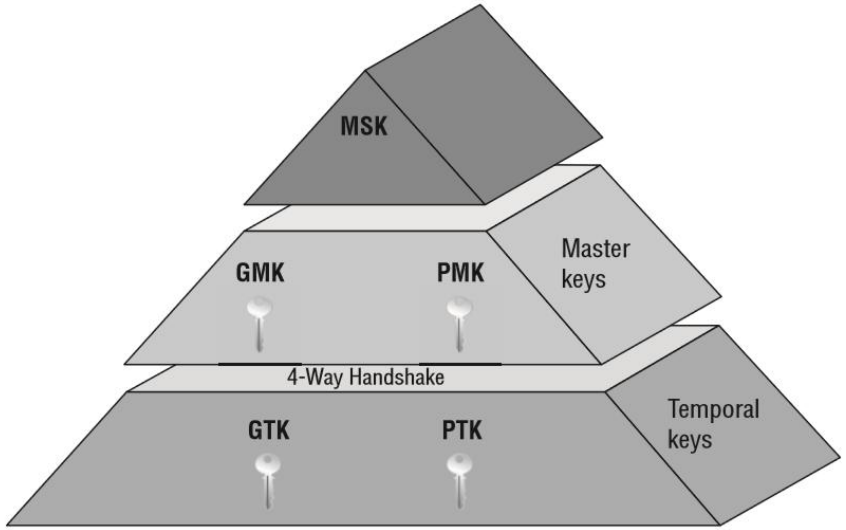


- 802.1x: 포트 기반 접근 제어
  - Supplicant, Authenticator, Authentacation Server 간의 프레임워크
  - 인증 이후에 제어된 포트를 이용하도록 하는 형태
  - 무선 랜 환경에서 인증에 사용 되는 것이 EAP이다

- EAP: 인증 프로토콜을 위한 프레임워크
  - EAPOL: EAP Encapsulation over LAN
  - RADIUS 패킷: Authenticator - 인증 서버



4-way handshake: key level



- MSK/MK (Master Session Key)
  - 802.1X/EAP 혹은 PSK authentication로 생성
- PMK (Pairwise Master Key)/GMK (Group Master Key)
  - MSK 이용
- PTK (Pairwise Transient Key)/GTK (Group Temporal Key)
  - AP와 STA 간 통신(unicast/multicast or broadcast)에서 암호화에 사용되는 동적 암호 키

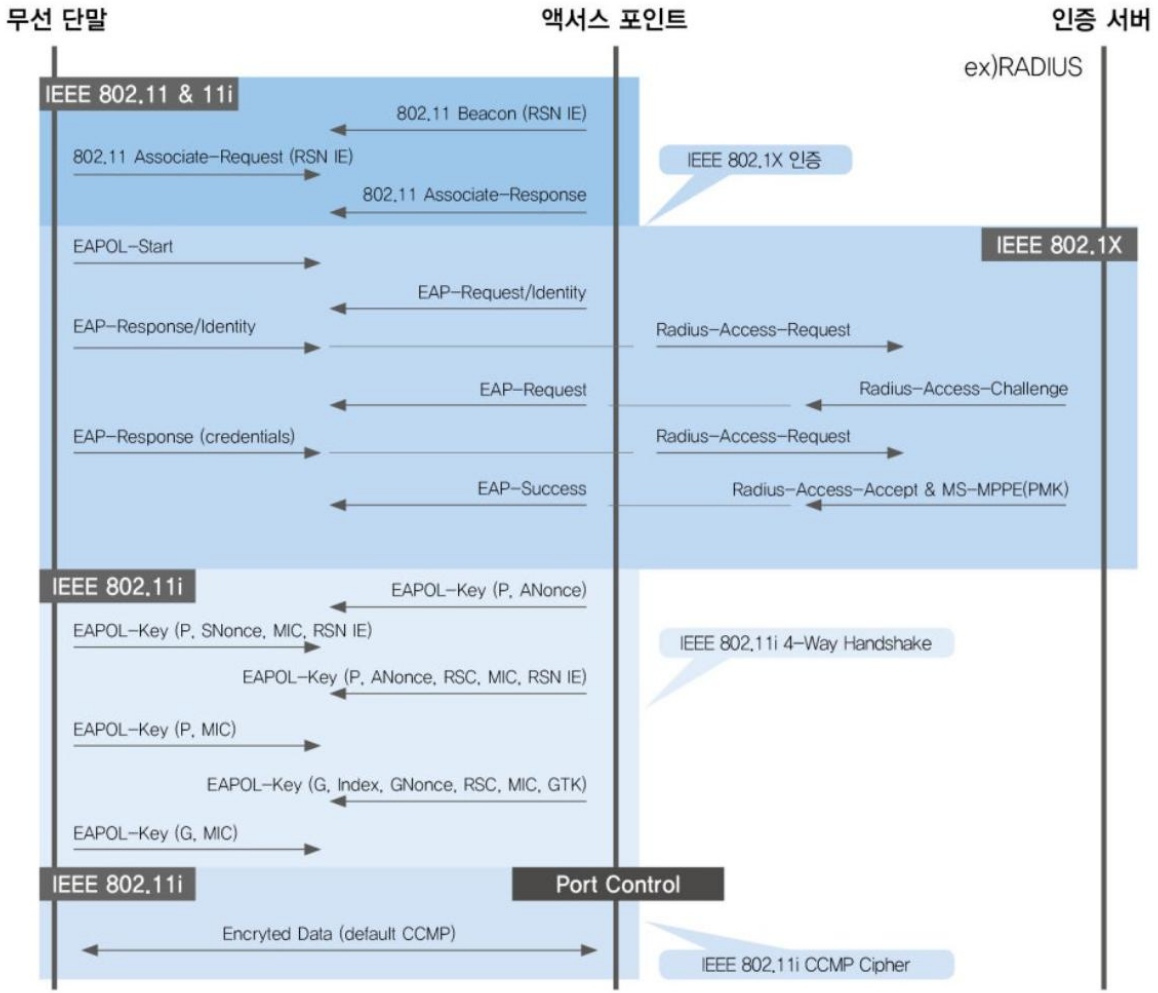
4-way handshake: overall

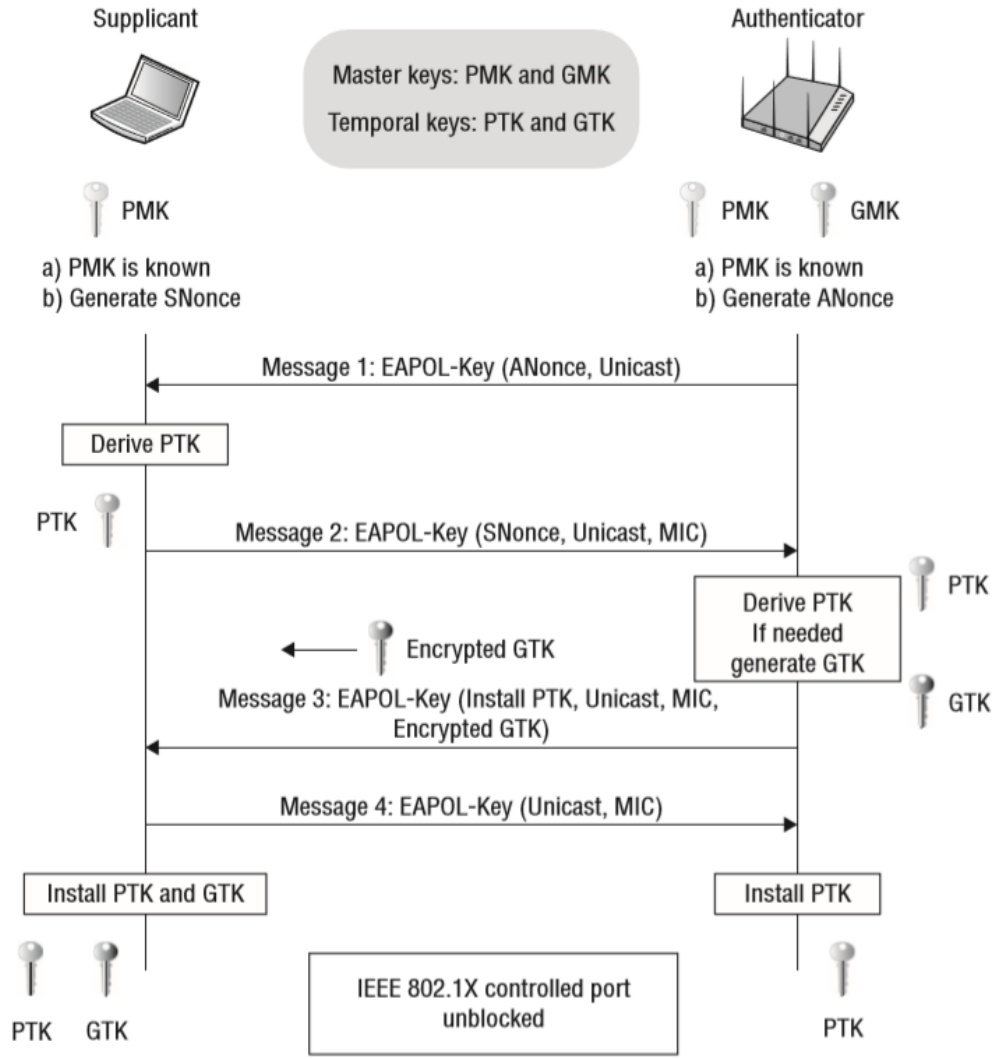
- Authentication, Assosiation → 4-way handshake → Encrypted data flow with PTK/GTK
  - 802.11 인증 및 연결: beacon frame, management frame
  - 802.1X 인증: EAP 이용 (data frame)

- PMK 유도 방식
  - WPA-개인: PSK(사전 공유키) 모드 (PSK=MSK로 사용됨)
  - WPA-엔터프라이즈: 802.1x 인증 모드 (Radius 서버가 생성한 MSK의 일부)

- PTK = PRF (PMK + Anonce + SNonce + Mac (AA)+ Mac (SA))
  - Anonce/Snonce: Authenticator/Supplicant의 난수

- MIC: Message Integrity Check


무선 단말
액서스 포인트
인증 서버
ex)RADIUS
IEEE 802.11 & 11i
802.11 Beacon (RSN IE)
802.11 Associate-Request (RSN IE)
802.11 Associate-Response
IEEE 802.1X 인증
IEEE 802.1X
EAPOL-Start
EAP-Request/Identity
EAP-Response/Identity
Radius-Access-Request
EAP-Request
Radius-Access-Challenge
EAP-Response (credentials)
Radius-Access-Request
EAP-Success
Radius-Access-Accept & MS-MPPE(PMK)
IEEE 802.11i
EAPOL-Key (P, ANonce)
EAPOL-Key (P, SNonce, MIC, RSN IE)
IEEE 802.11i 4-Way Handshake
EAPOL-Key (P, ANonce, RSC, MIC, RSN IE)
EAPOL-Key (P, MIC)
EAPOL-Key (G, Index, GNonce, RSC, MIC, GTK)
EAPOL-Key (G, MIC)
IEEE 802.11i
Port Control
Encryted Data (default CCMP)
IEEE 802.11i CCMP Cipher


Supplicant
Authenticator
Master keys: PMK and GMK
Temporal keys: PTK and GTK
PMK
PMK
GMK
a) PMK is known
b) Generate SNonce
a) PMK is known
b) Generate ANonce
Message 1: EAPOL-Key (ANonce, Unicast)
Derive PTK
PTK
Message 2: EAPOL-Key (SNonce, Unicast, MIC)
PTK
Derive PTK
If needed
generate GTK
Encrypted GTK
GTK
Message 3: EAPOL-Key (Install PTK, Unicast, MIC,
Encrypted GTK)
Message 4: EAPOL-Key (Unicast, MIC)
Install PTK and GTK
Install PTK
IEEE 802.1X controlled port
unblocked
PTK
GTK
PTK

Dragonblood Attack

Hash-to-curve: EAP-pwd

```
for (counter = 1; counter < 40; counter++)
    x = hash(pw, addr1, addr2, counter)
    if x >= p: continue
    if square_root_exists(x) and not P:
        return (x, √(x³ + ax + b))
```

- Dragonfly handshake
  - convert password into group element (point on eliptic curve)
  - Iteration is affected by pw and mac address
- Timing (side-channel) attack
  - By spoofing mac addresses, we can filter out password with iteration (average time)
  - Offline dictionary attack possible
- DoS attack
  - Hash-to-curve algorithm iterates 40 times to prevent side-channel attack

Wireshark

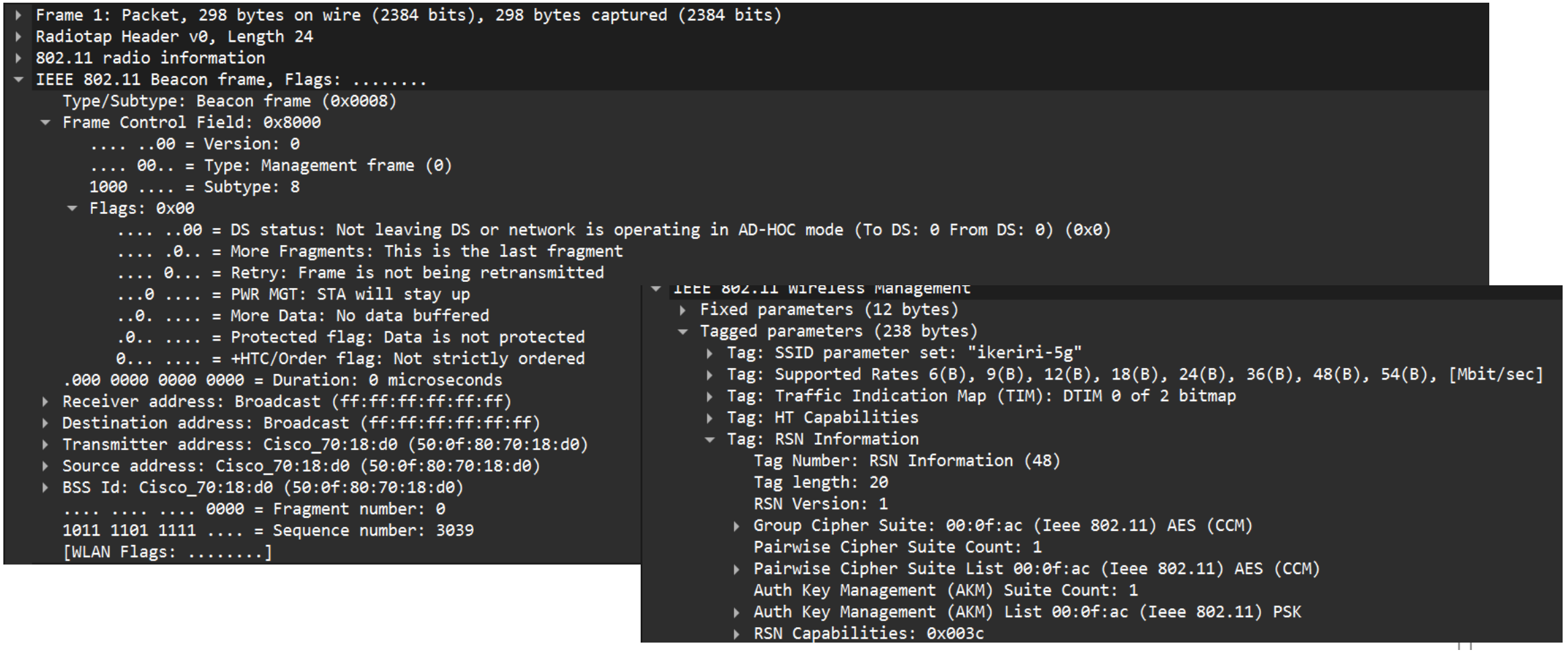
- Wireshark 공식 홈페이지의 샘플을 이용
  - wpa2linkuppassphraseiswireshark.pcap

- 앞서 설명한 과정 직접 살펴보기
  - Connection to Wifi (Beacon frame, probe, authentication, association)
  - 4-way handshake (EAPoL)
  - CCMP Cipher (WPA-2)
    - DHCP
  - Disassociation

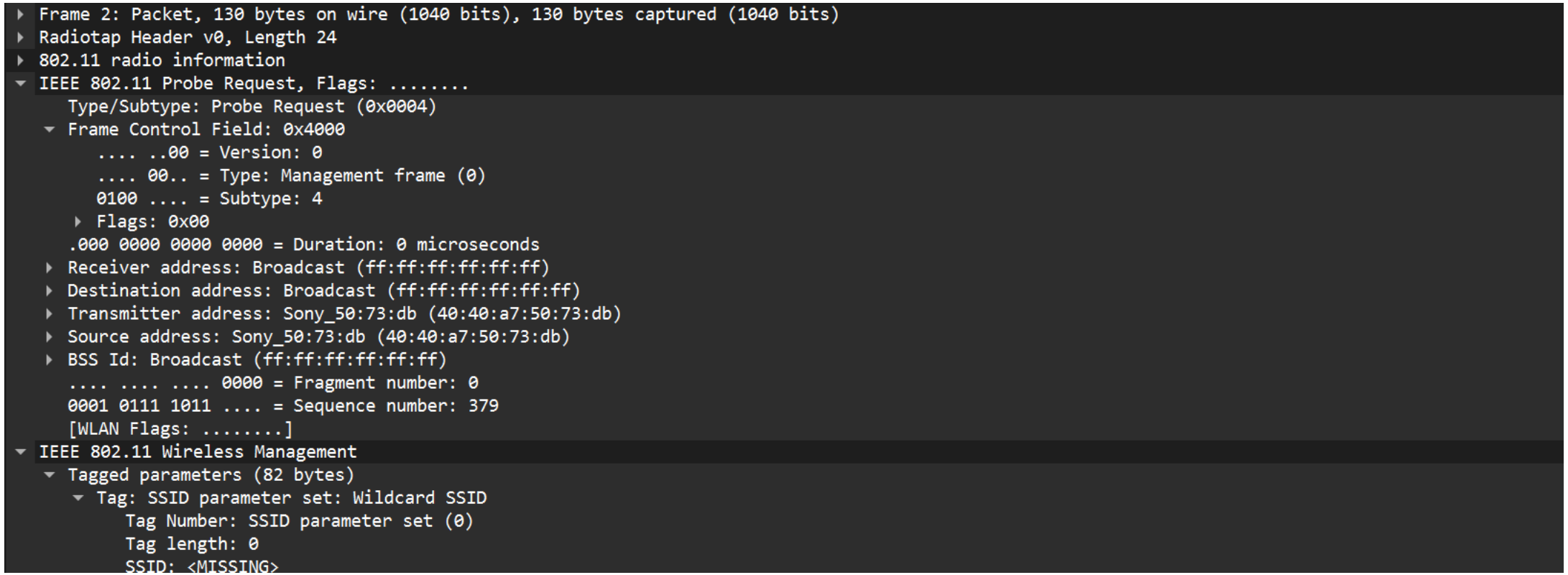
Wireshark

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	Cisco_70:18:d0	Broadcast	802.11	298	Beacon frame, SN=3039, FN=0, Flags=........, BI=102, SSID="ikeriri-5g"
2	37.245000	Sony_50:73:db	Broadcast	802.11	130	Probe Request, SN=379, FN=0, Flags=........, SSID=Wildcard (Broadcast)
3	37.247000	Cisco_70:18:d0	Sony_50:73:db	802.11	292	Probe Response, SN=1748, FN=0, Flags=....R..., BI=102, SSID="ikeriri-5g"
4	50.744000	Sony_50:73:db	Cisco_70:18:d0	802.11	54	Authentication, SN=482, FN=0, Flags=........
5	50.744000	Cisco_70:18:d0	Sony_50:73:db	802.11	54	Authentication, SN=3802, FN=0, Flags=........
6	50.744000	Sony_50:73:db	Cisco_70:18:d0	802.11	243	Association Request, SN=483, FN=0, Flags=........, SSID="ikeriri-5g"
7	50.746000	Cisco_70:18:d0	Sony_50:73:db	802.11	173	Association Response, SN=3803, FN=0, Flags=........
8	50.746000	Cisco_70:18:d0	Sony_50:73:db	EAPOL	179	Key (Message 1 of 4)
9	50.789000	Sony_50:73:db	Cisco_70:18:d0	EAPOL	179	Key (Message 2 of 4)
10	50.798000	Cisco_70:18:d0	Sony_50:73:db	EAPOL	213	Key (Message 3 of 4)
11	50.798000	Sony_50:73:db	Cisco_70:18:d0	EAPOL	157	Key (Message 4 of 4)
12	50.799000	Cisco_9c:6a:e4	Sony_50:73:db	802.11	132	QoS Data, SN=0, FN=0, Flags=.p....F.
13	50.990000	Sony_50:73:db	Broadcast	802.11	408	QoS Data, SN=0, FN=0, Flags=.p.....T
14	50.990000	Modacom_94:ea:bc	Sony_50:73:db	802.11	662	QoS Data, SN=1, FN=0, Flags=.p....F.
15	51.126000	Sony_50:73:db	Broadcast	802.11	102	QoS Data, SN=1, FN=0, Flags=.p.....T
16	92.162000	Sony_50:73:db	Cisco_70:18:d0	802.11	50	Disassociate, SN=966, FN=0, Flags=........

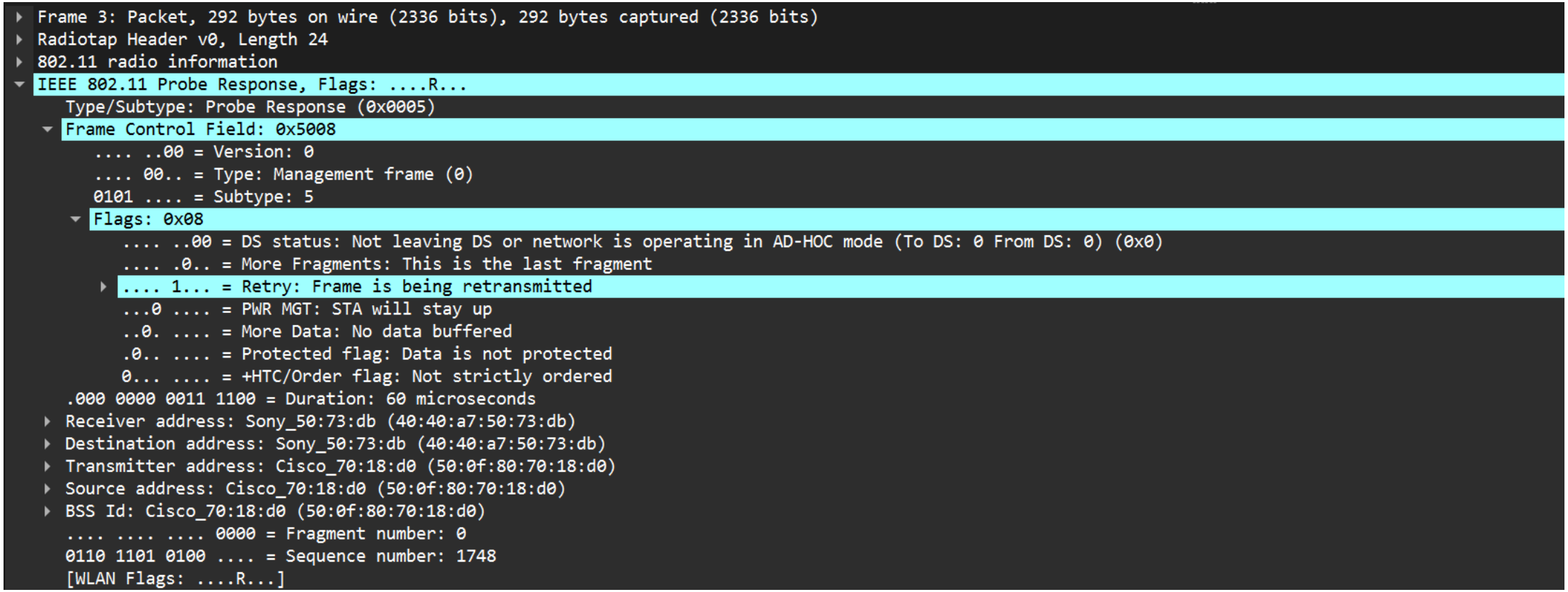
Wireshark(Beacon frame)



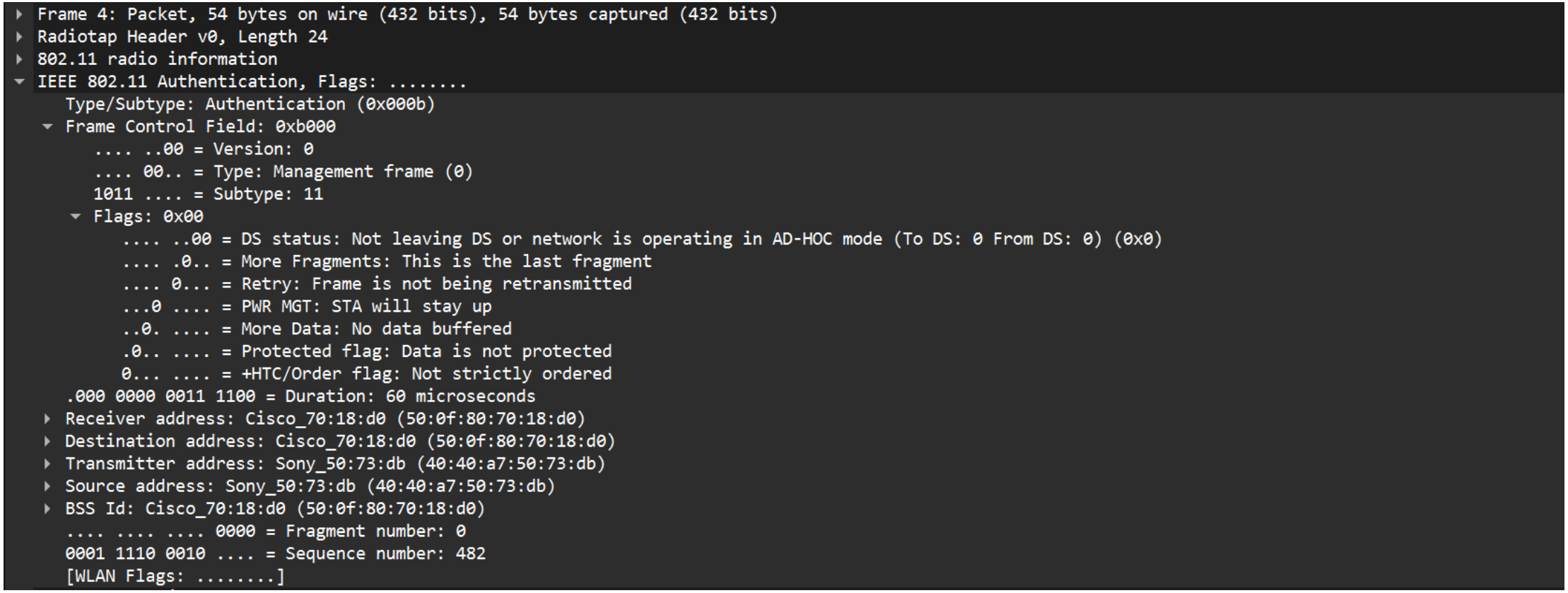
Wireshark(Probe Request)



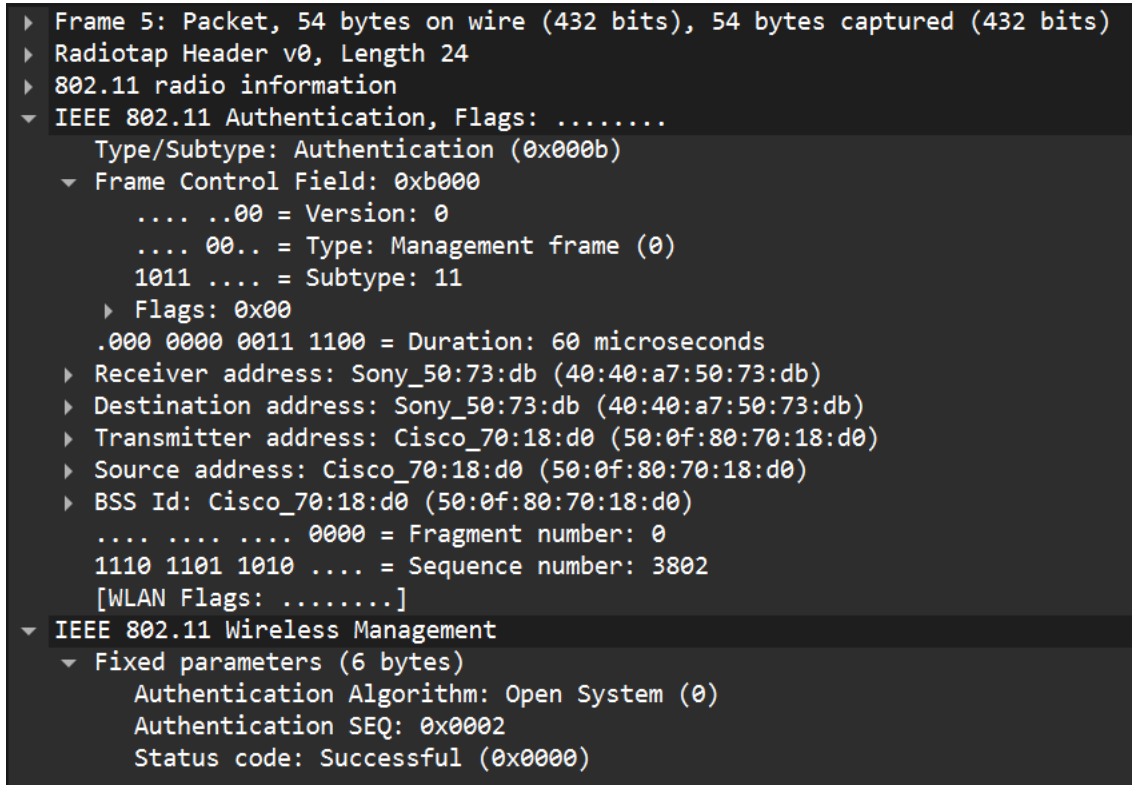
Wireshark(Probe Response)



Wireshark(Authentication)



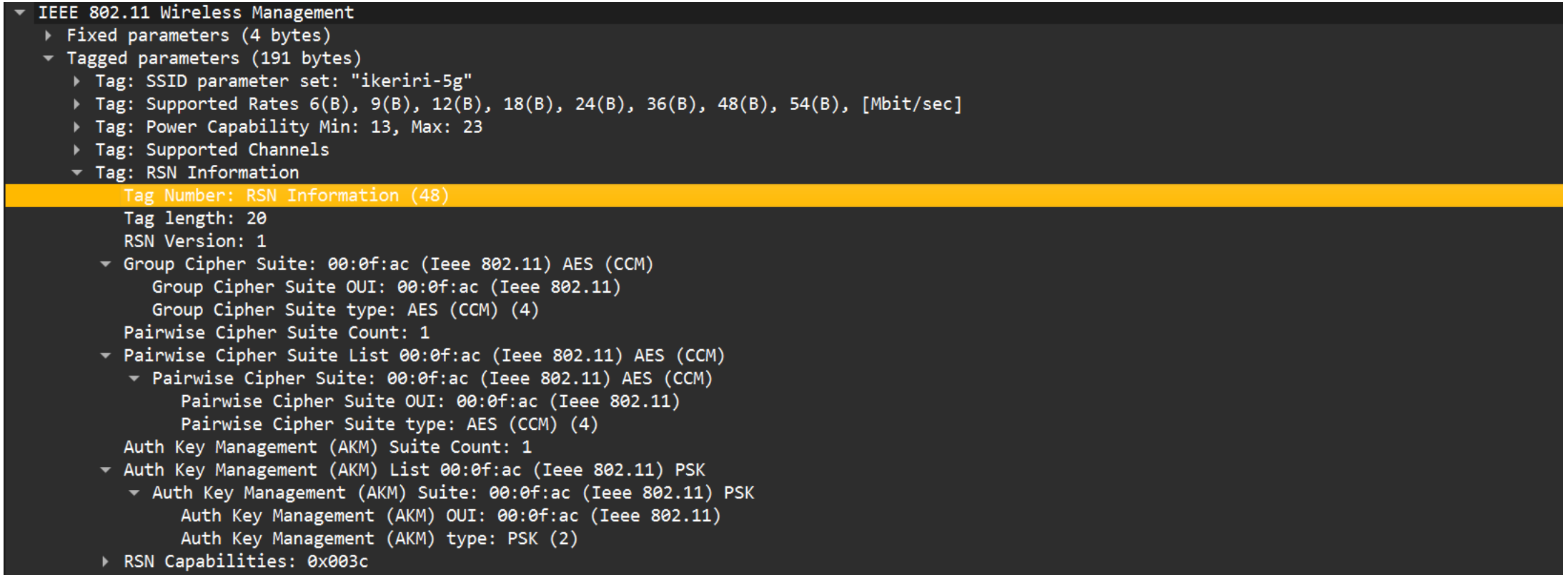
Wireshark(Authentication)



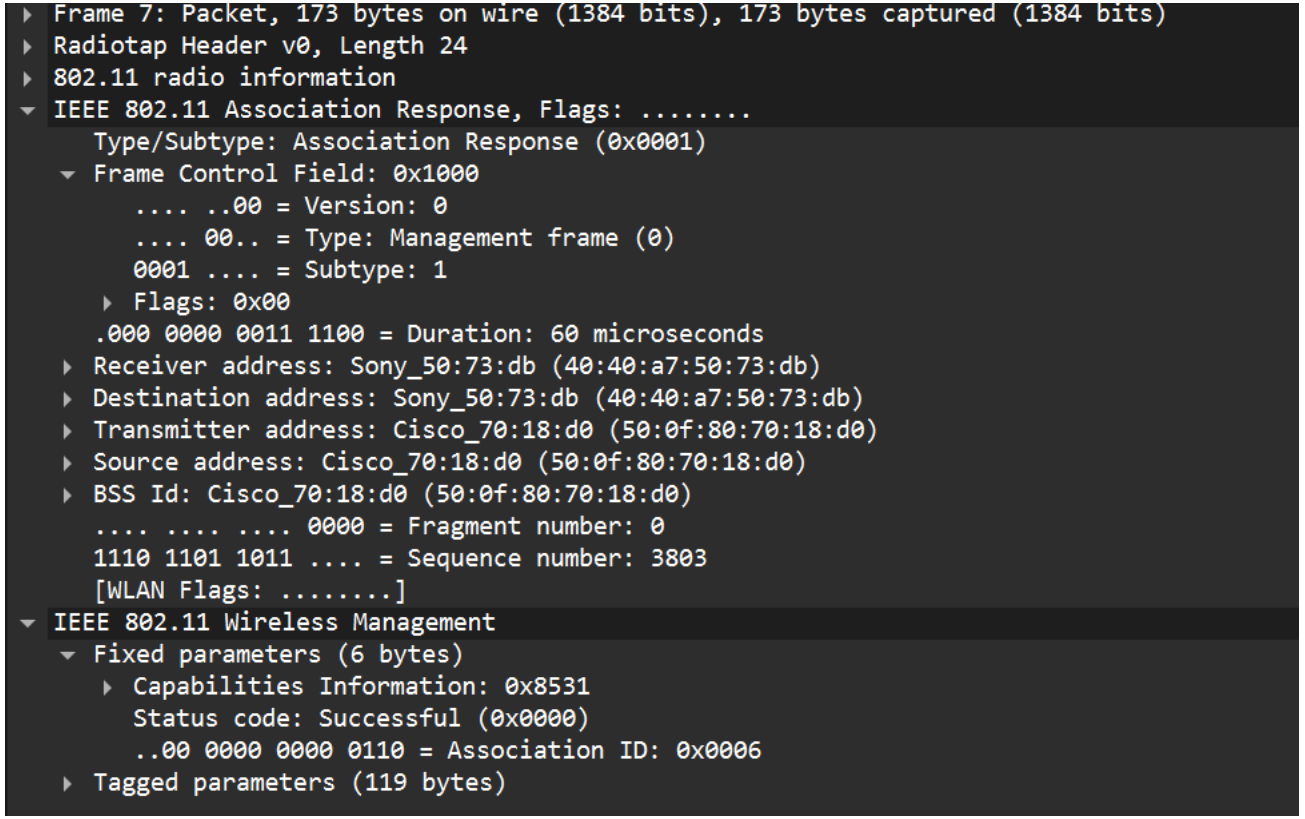
Wireshark(Association Request)

```
▸ Frame 6: Packet, 243 bytes on wire (1944 bits), 243 bytes captured (1944 bits)
▸ Radiotap Header v0, Length 24
▸ 802.11 radio information
▾ IEEE 802.11 Association Request, Flags: ........
    Type/Subtype: Association Request (0x0000)
  ▾ Frame Control Field: 0x0000
      .... ..00 = Version: 0
      .... 00.. = Type: Management frame (0)
      0000 .... = Subtype: 0
    ▾ 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... .... = +HTC/Order flag: Not strictly ordered
    .000 0000 0011 1100 = Duration: 60 microseconds
  ▸ Receiver address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▸ Destination address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▸ Transmitter address: Sony_50:73:db (40:40:a7:50:73:db)
  ▸ Source address: Sony_50:73:db (40:40:a7:50:73:db)
  ▸ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    .... .... .... 0000 = Fragment number: 0
    0001 1110 0011 .... = Sequence number: 483
    [WLAN Flags: ........]
```

Wireshark(Association Request)



Wireshark(Association Response)

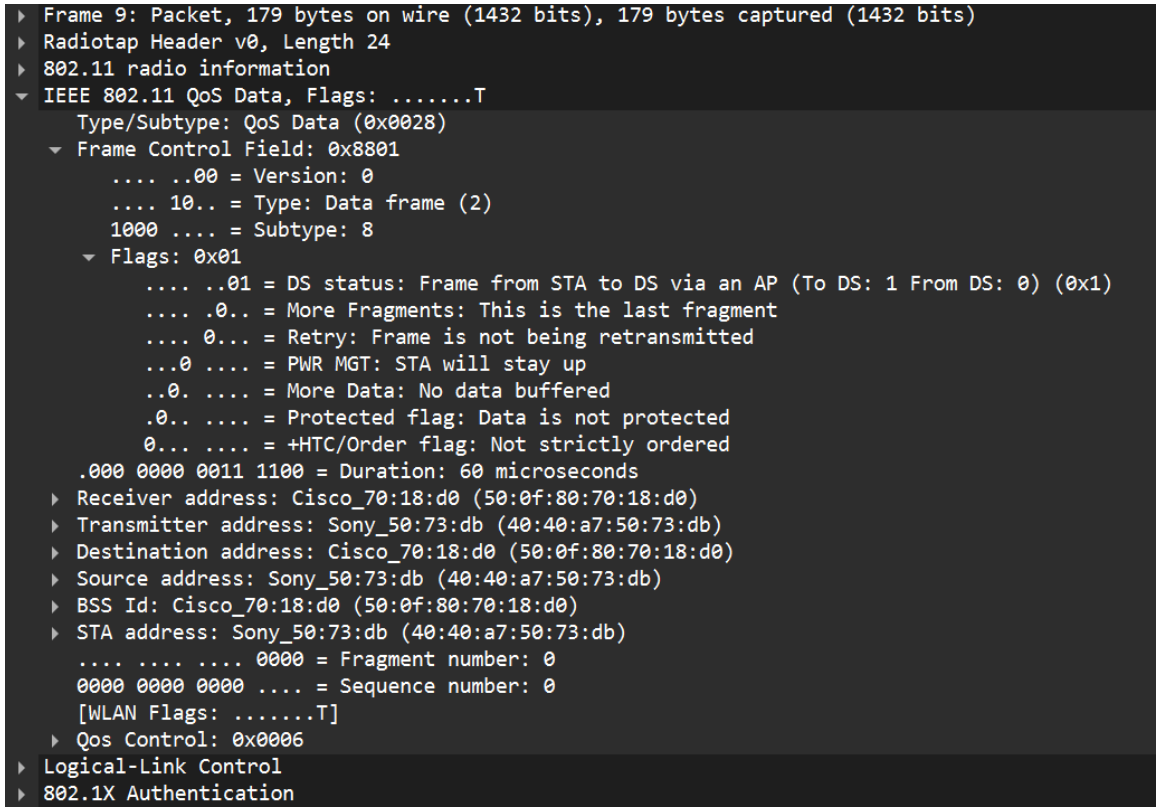


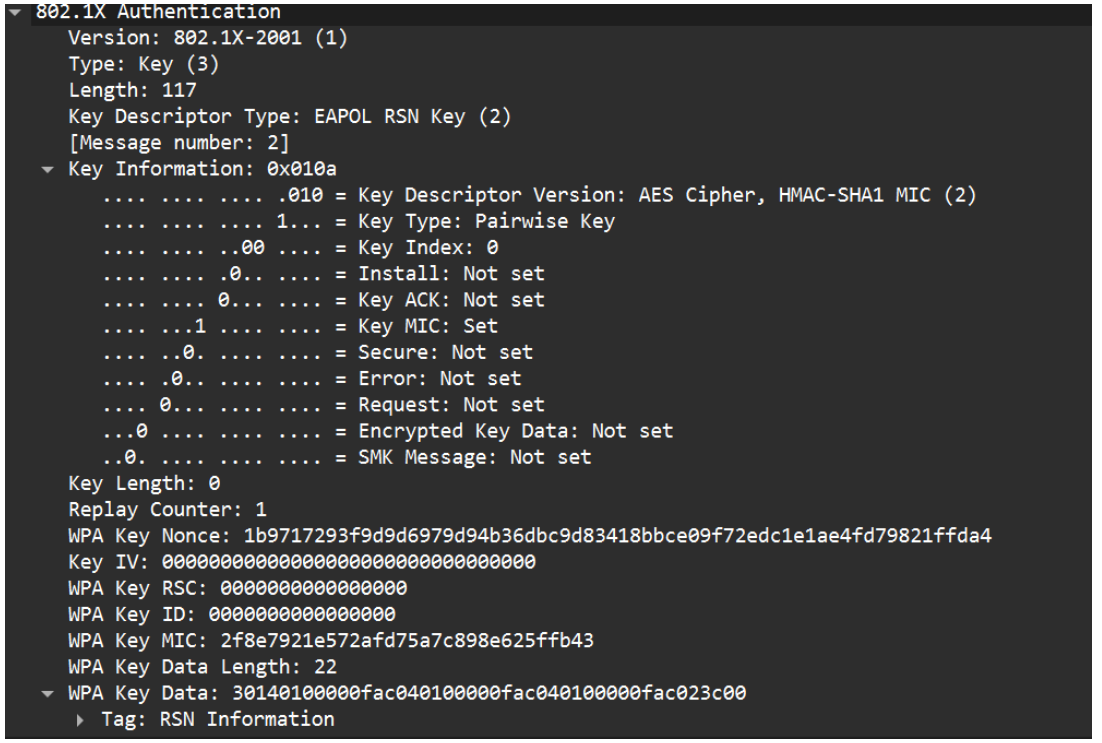
Wireshark(4-way handshake, M1)

```
▸ Frame 8: Packet, 179 bytes on wire (1432 bits), 179 bytes captured (1432 bits)
▸ Radiotap Header v0, Length 24
▸ 802.11 radio information
▾ IEEE 802.11 QoS Data, Flags: ......F.
    Type/Subtype: QoS Data (0x0028)
  ▾ Frame Control Field: 0x8802
      .... ..00 = Version: 0
      .... 10.. = Type: Data frame (2)
      1000 .... = Subtype: 8
    ▾ Flags: 0x02
        .... ..10 = DS status: Frame from DS to a STA via AP(To DS: 0 From DS: 1) (0x2)
        .... .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... .... = +HTC/Order flag: Not strictly ordered
    .000 0000 0011 1100 = Duration: 60 microseconds
  ▸ Receiver address: Sony_50:73:db (40:40:a7:50:73:db)
  ▸ Transmitter address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▸ Destination address: Sony_50:73:db (40:40:a7:50:73:db)
  ▸ Source address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▸ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▸ STA address: Sony_50:73:db (40:40:a7:50:73:db)
    .... .... .... 0000 = Fragment number: 0
    0000 0000 0000 .... = Sequence number: 0
    [WLAN Flags: ......F.]
  ▸ Qos Control: 0x0007
▸ Logical-Link Control
▸ 802.1X Authentication
```

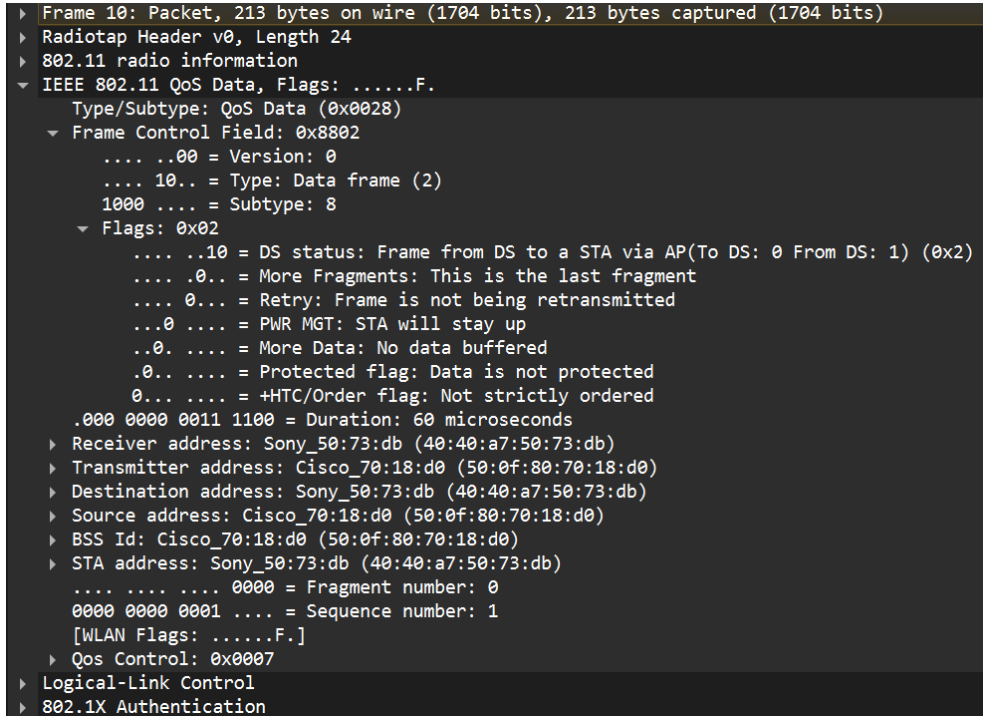
```
▾ 802.1X Authentication
    Version: 802.1X-2004 (2)
    Type: Key (3)
    Length: 117
    Key Descriptor Type: EAPOL RSN Key (2)
    [Message number: 1]
  ▾ Key Information: 0x008a
      .... .... .... .010 = Key Descriptor Version: AES Cipher, HMAC-SHA1 MIC (2)
      .... .... .... 1... = Key Type: Pairwise Key
      .... .... ..00 .... = Key Index: 0
      .... .... .0.. .... = Install: Not set
      .... .... 1... .... = Key ACK: Set
      .... ...0 .... .... = Key MIC: Not set
      .... ..0. .... .... = Secure: Not set
      .... .0.. .... .... = Error: Not set
      .... 0... .... .... = Request: Not set
      ...0 .... .... .... = Encrypted Key Data: Not set
      ..0. .... .... .... = SMK Message: Not set
    Key Length: 16
    Replay Counter: 1
    WPA Key Nonce: 15adf473164f43a34f211ebc34495b588af5b915c0dd4478f5fbc89d2f7bd0fa
    Key IV: 00000000000000000000000000000000
    WPA Key RSC: 0000000000000000
    WPA Key ID: 0000000000000000
    WPA Key MIC: 00000000000000000000000000000000
    WPA Key Data Length: 22
  ▾ WPA Key Data: dd14000fac04b9c9f71f0c96f62b6c11f545d2dff41b
    ▾ Tag: Vendor Specific: Ieee 802.11: RSN PMKID
        Tag Number: Vendor Specific (221)
        Tag length: 20
        OUI: 00:0f:ac (Ieee 802.11)
        Vendor Specific OUI Type: 4
        Data Type: PMKID KDE (4)
        PMKID: b9c9f71f0c96f62b6c11f545d2dff41b
```

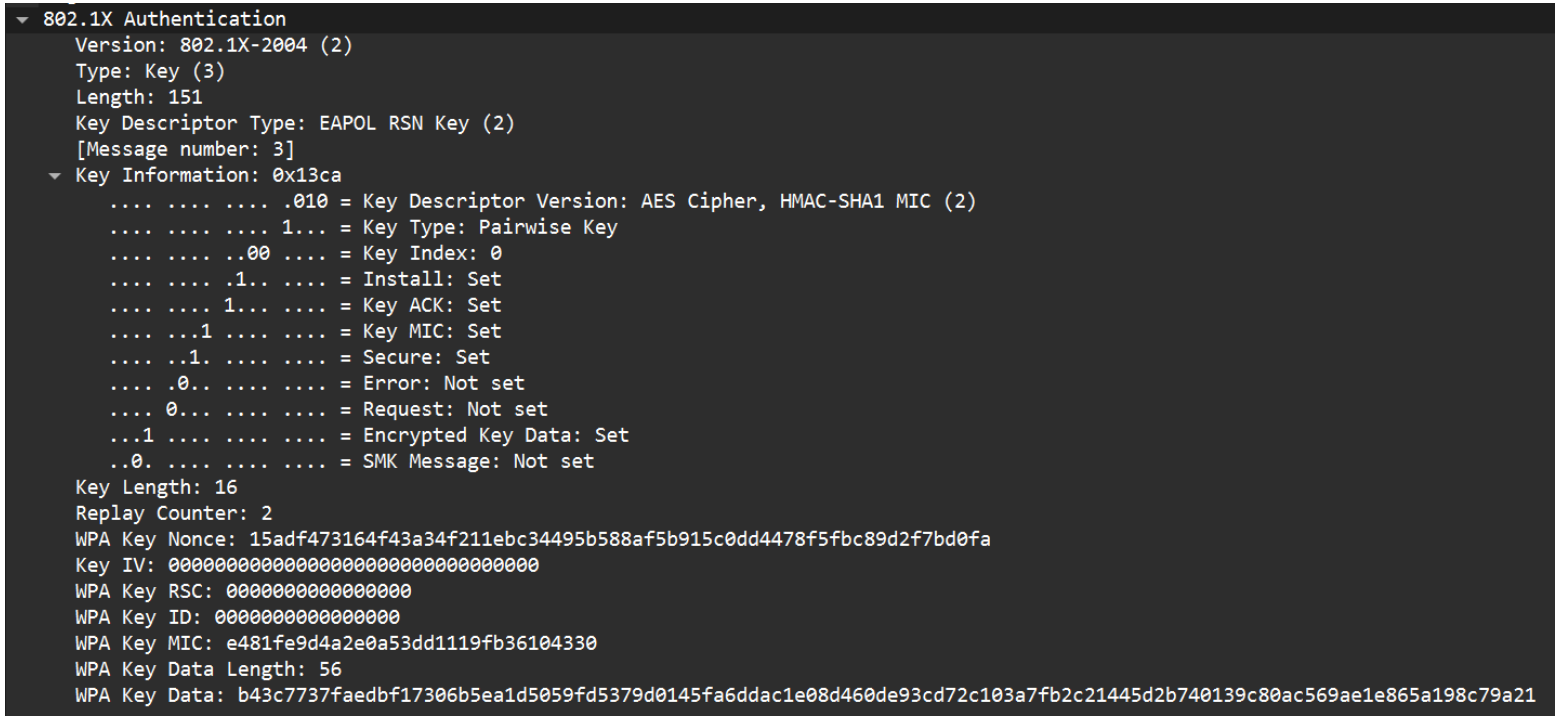
Wireshark(4-way handshake, M2)





Wireshark(4-way handshake, M3)

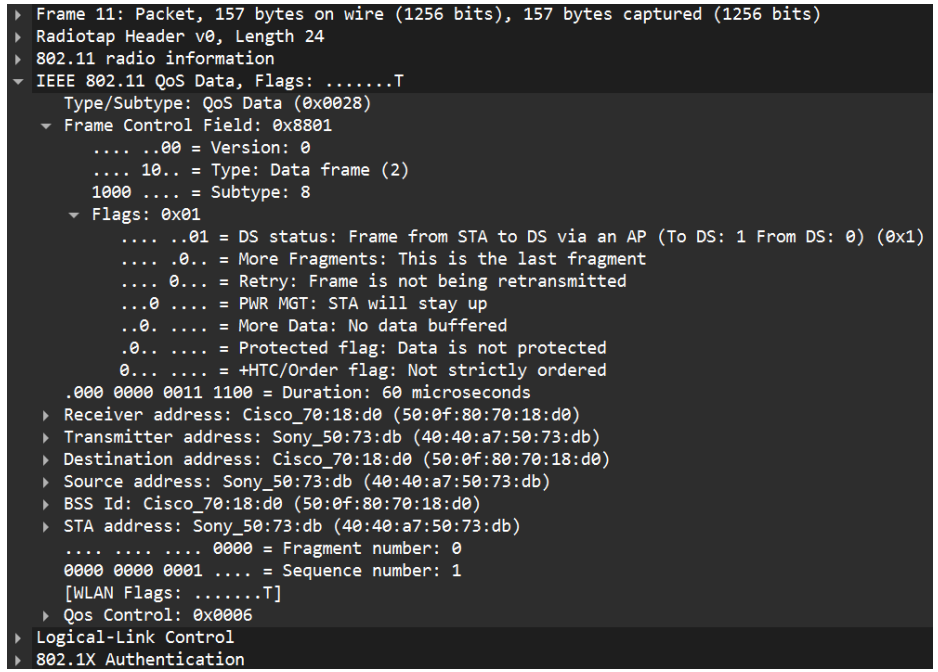


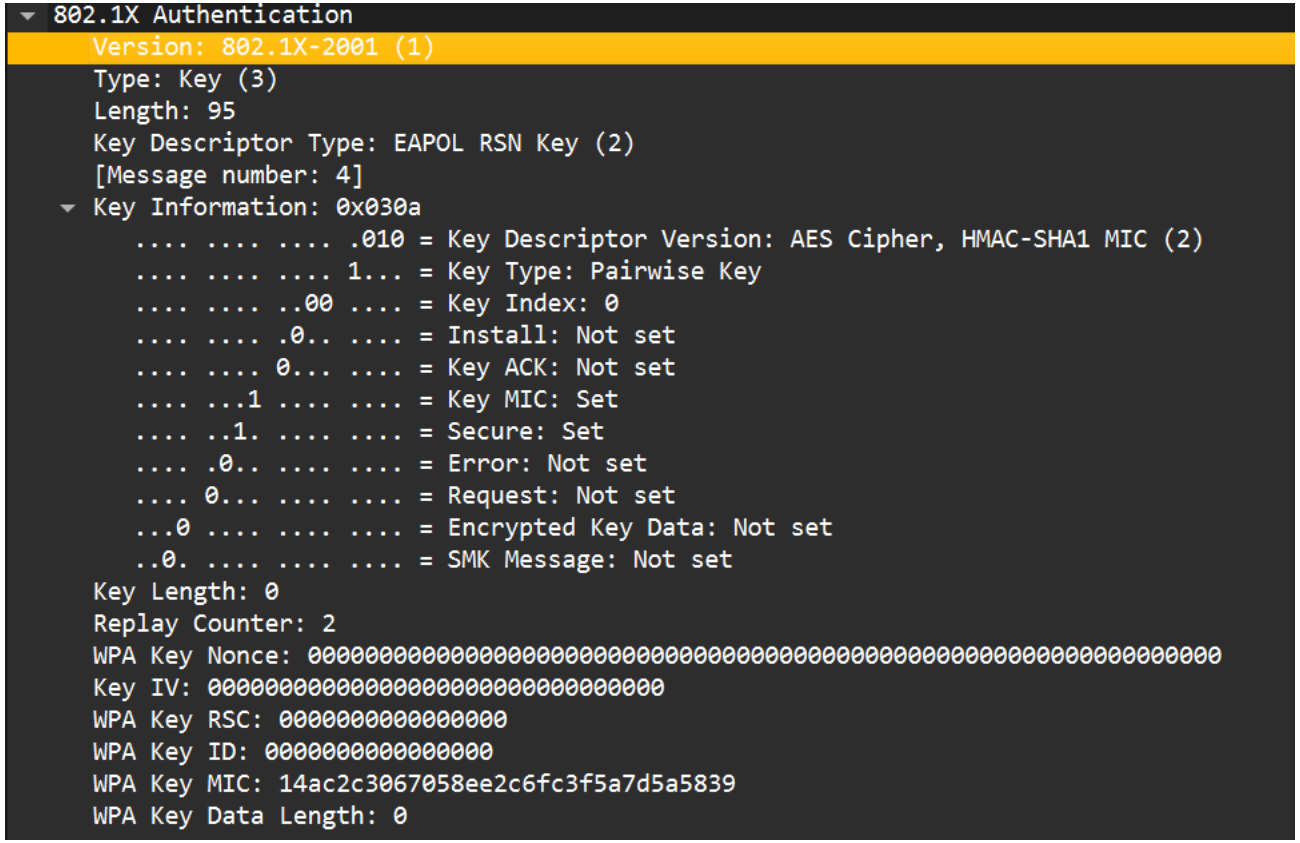


Wireshark(4-way handshake, M3)

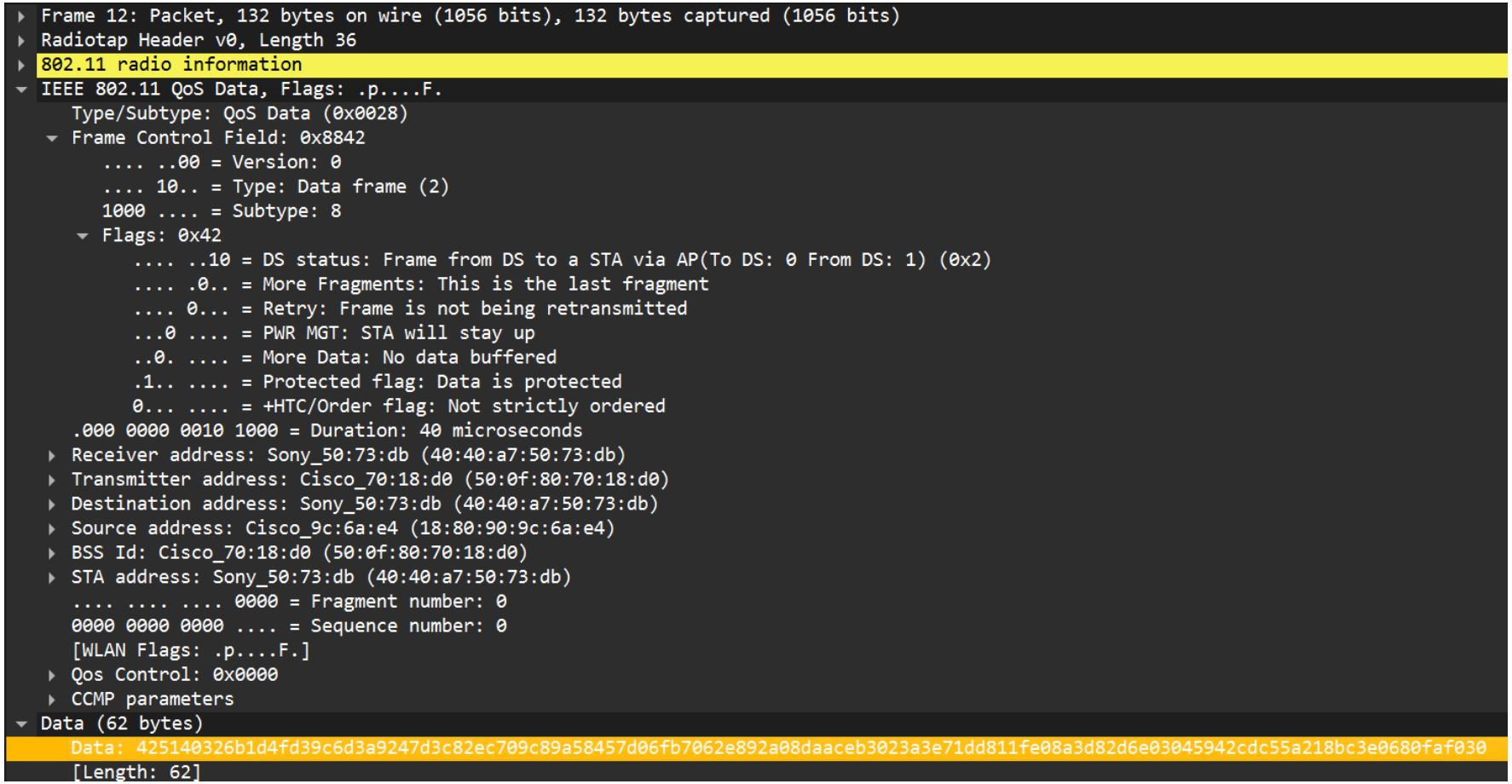
```
▾ WPA Key Data: b43c7737faedbf17306b5ea1d5059fd5379d0145fa6ddac1e08d460de93cd72c103a7fb2c21445d2b740139c80ac569ae1e865a198c79a21
  ▾ Tag: RSN Information
      Tag Number: RSN Information (48)
      Tag length: 20
      RSN Version: 1
    ▾ Group Cipher Suite: 00:0f:ac (Ieee 802.11) AES (CCM)
        Group Cipher Suite OUI: 00:0f:ac (Ieee 802.11)
        Group Cipher Suite type: AES (CCM) (4)
      Pairwise Cipher Suite Count: 1
    ▾ Pairwise Cipher Suite List 00:0f:ac (Ieee 802.11) AES (CCM)
      ▾ Pairwise Cipher Suite: 00:0f:ac (Ieee 802.11) AES (CCM)
          Pairwise Cipher Suite OUI: 00:0f:ac (Ieee 802.11)
          Pairwise Cipher Suite type: AES (CCM) (4)
      Auth Key Management (AKM) Suite Count: 1
    ▾ Auth Key Management (AKM) List 00:0f:ac (Ieee 802.11) PSK
      ▾ Auth Key Management (AKM) Suite: 00:0f:ac (Ieee 802.11) PSK
          Auth Key Management (AKM) OUI: 00:0f:ac (Ieee 802.11)
          Auth Key Management (AKM) type: PSK (2)
    ▸ RSN Capabilities: 0x003c
  ▾ Tag: Vendor Specific: Ieee 802.11: RSN GTK
      Tag Number: Vendor Specific (221)
      Tag length: 22
      OUI: 00:0f:ac (Ieee 802.11)
      Vendor Specific OUI Type: 1
      Data Type: GTK KDE (1)
      .... ..01 = Key ID: 0x1
      .... .0.. = Tx: Temporal key used only for reception
      0000 0... = Reserved: 0x00
      Reserved: 0x00
      GTK: eab4e5b93588db11d1ecfda6eac5606b
    WPA Key Data Padding: dd00
    [KCK: d9eb99b06ea78764cf358998050f017f]
    [KEK: 22fffbcadfbbd96816884599c16d65dd]
```

Wireshark(4-way handshake, M4)





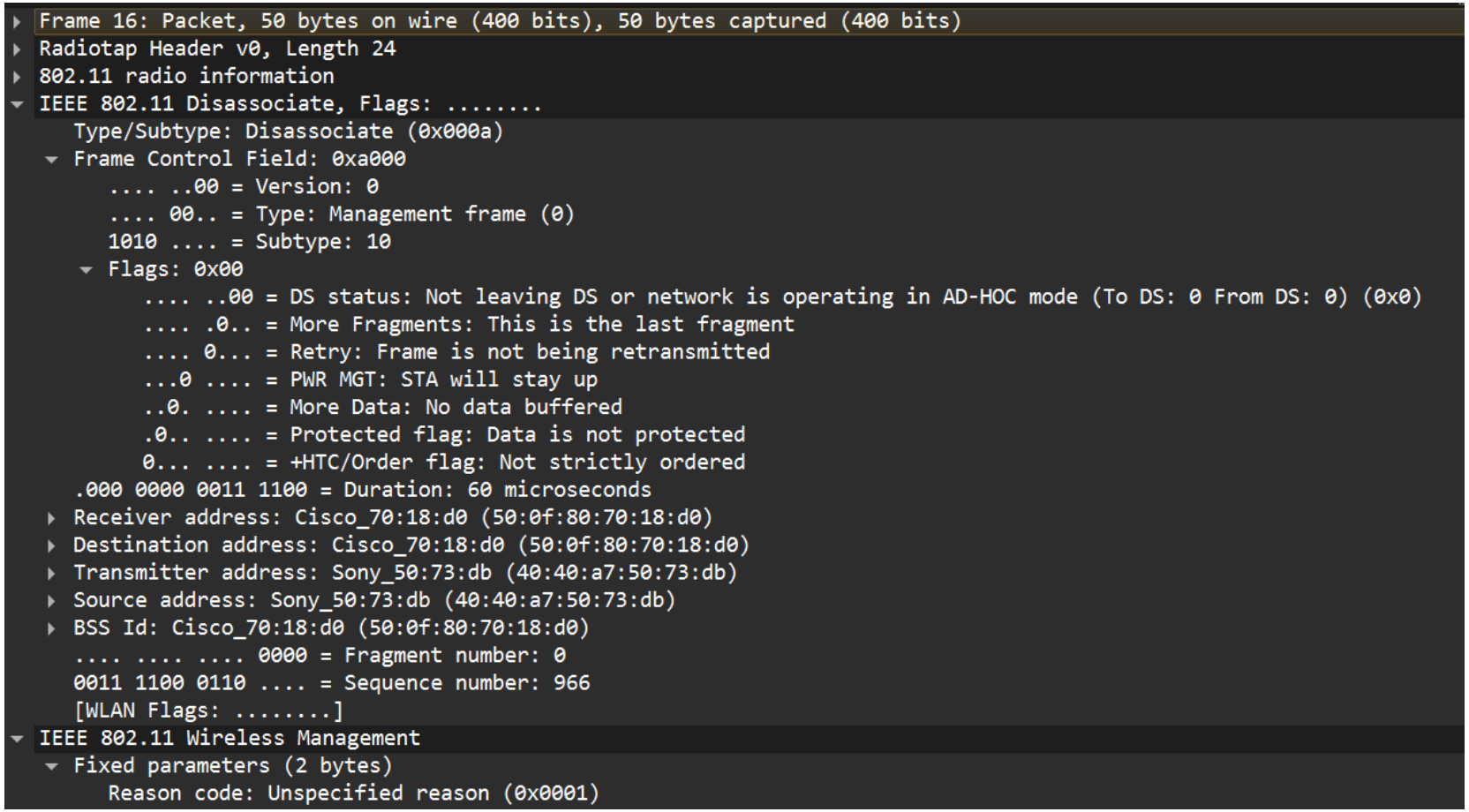
Encrypted data



Decrypted data with wpa-pwd

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	Cisco_70:18:d0	Broadcast	802.11	298	Beacon frame, SN=3039, FN=0, Flags=........, BI=102, SSID="ikeriri-5g"
2	37.245000	Sony_50:73:db	Broadcast	802.11	130	Probe Request, SN=379, FN=0, Flags=........, SSID=Wildcard (Broadcast)
3	37.247000	Cisco_70:18:d0	Sony_50:73:db	802.11	292	Probe Response, SN=1748, FN=0, Flags=....R..., BI=102, SSID="ikeriri-5g"
4	50.744000	Sony_50:73:db	Cisco_70:18:d0	802.11	54	Authentication, SN=482, FN=0, Flags=........
5	50.744000	Cisco_70:18:d0	Sony_50:73:db	802.11	54	Authentication, SN=3802, FN=0, Flags=........
6	50.744000	Sony_50:73:db	Cisco_70:18:d0	802.11	243	Association Request, SN=483, FN=0, Flags=........, SSID="ikeriri-5g"
7	50.746000	Cisco_70:18:d0	Sony_50:73:db	802.11	173	Association Response, SN=3803, FN=0, Flags=........
8	50.746000	Cisco_70:18:d0	Sony_50:73:db	EAPOL	179	Key (Message 1 of 4)
9	50.789000	Sony_50:73:db	Cisco_70:18:d0	EAPOL	179	Key (Message 2 of 4)
10	50.798000	Cisco_70:18:d0	Sony_50:73:db	EAPOL	213	Key (Message 3 of 4)
11	50.798000	Sony_50:73:db	Cisco_70:18:d0	EAPOL	157	Key (Message 4 of 4)
12	50.799000	192.168.100.3	224.0.0.1	IGMPv2	132	Membership Query, general
13	50.990000	0.0.0.0	255.255.255.255	DHCP	408	DHCP Request - Transaction ID 0x5e51762c
14	50.990000	192.168.100.254	192.168.100.121	DHCP	662	DHCP ACK - Transaction ID 0x5e51762c
15	51.126000	Sony_50:73:db	Broadcast	ARP	102	ARP Announcement for 192.168.100.121
16	92.162000	Sony_50:73:db	Cisco_70:18:d0	802.11	50	Disassociate, SN=966, FN=0, Flags=........

Disassociate



3주차 취약점 공격 실습

- Fragattack, Dragonblood Attack : 개념 이해 (1주차 완료)

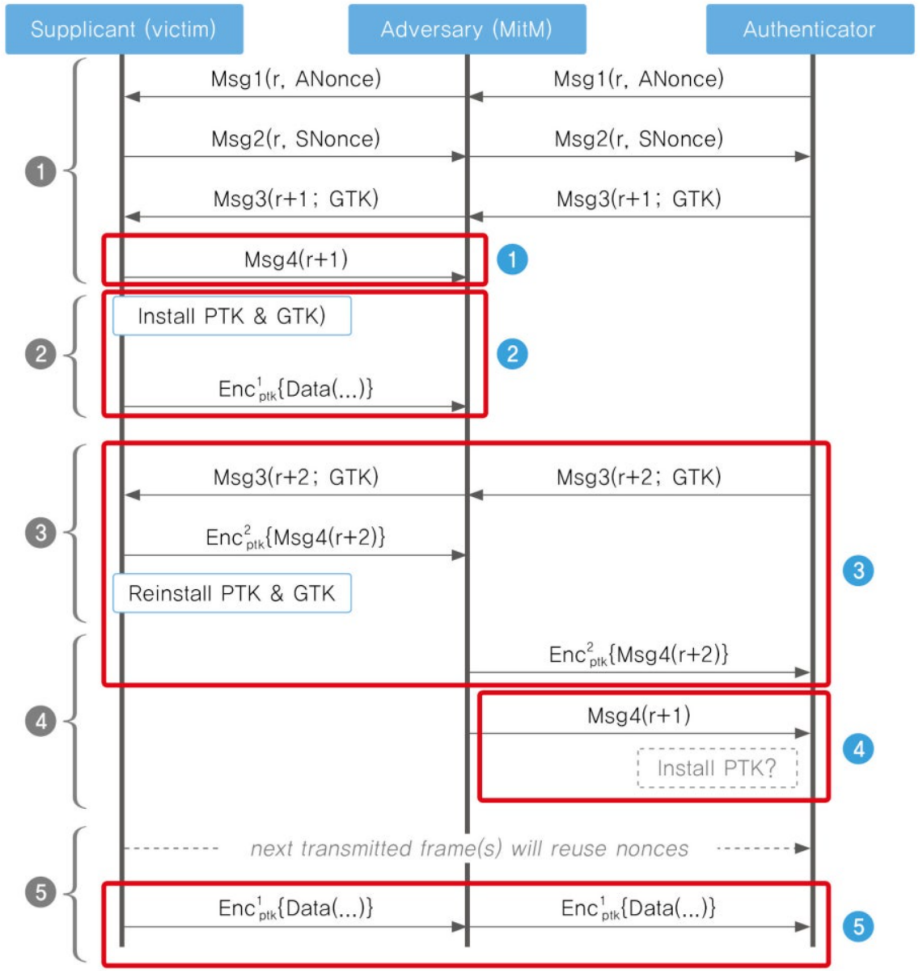
- KRACK, PMKID offline dictionary match: 실습 (3주차 예정)
  - 무선 랜카드를 이용하여 kali linux 환경에서 직접 테스트 가능
  - 기제공된 pcap 파일 등을 활용하여 PMKID attack 해보기

Fragattack/KRACK

[vanhoefm/fragattacks]

[vanhoefm/krackattacks-scripts]

kali linux 환경에서 테스트



PMKID Offline dictionary match

- Full handshake 없이 첫 번째 메시지만으로도 알아낼 수 있음
- Hcxdumptool을 이용하여 패킷을 캡쳐
- Hashcat을 이용하여 Pre shared key 추출

New attack on WPA/WPA2 using PMKID