

# Wifi-Protocol-2

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# Plan

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

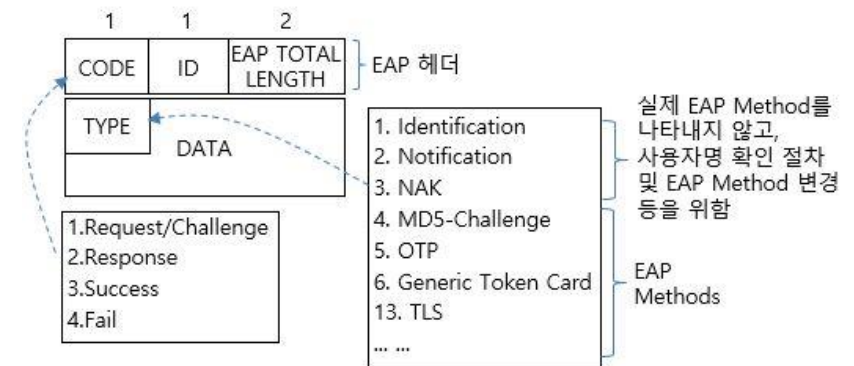
# Review

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

# EAP / EAPOL

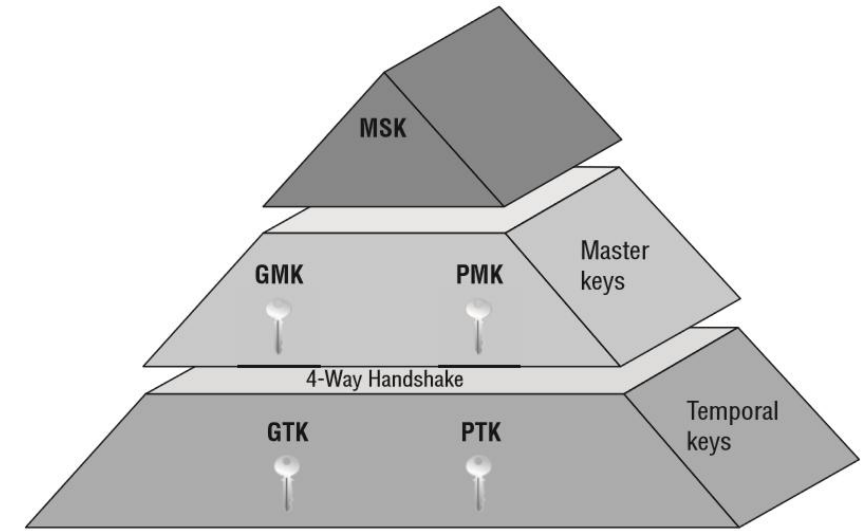


- 802.1x: 포트 기반 접근 제어
  - Supplicant, Authenticator, Authentacation Server 간의 프레임워크
  - 인증 이후에 제어된 포트를 이용하도록 하는 형태
  - 무선 랜 환경에서 인증에 사용 되는 것이 EAP이다
- EAP: 인증 프로토콜을 위한 프레임워크
  - EAPOL: EAP Encapsulation over LAN
  - RADIUS 패킷: Authenticator - 인증 서버



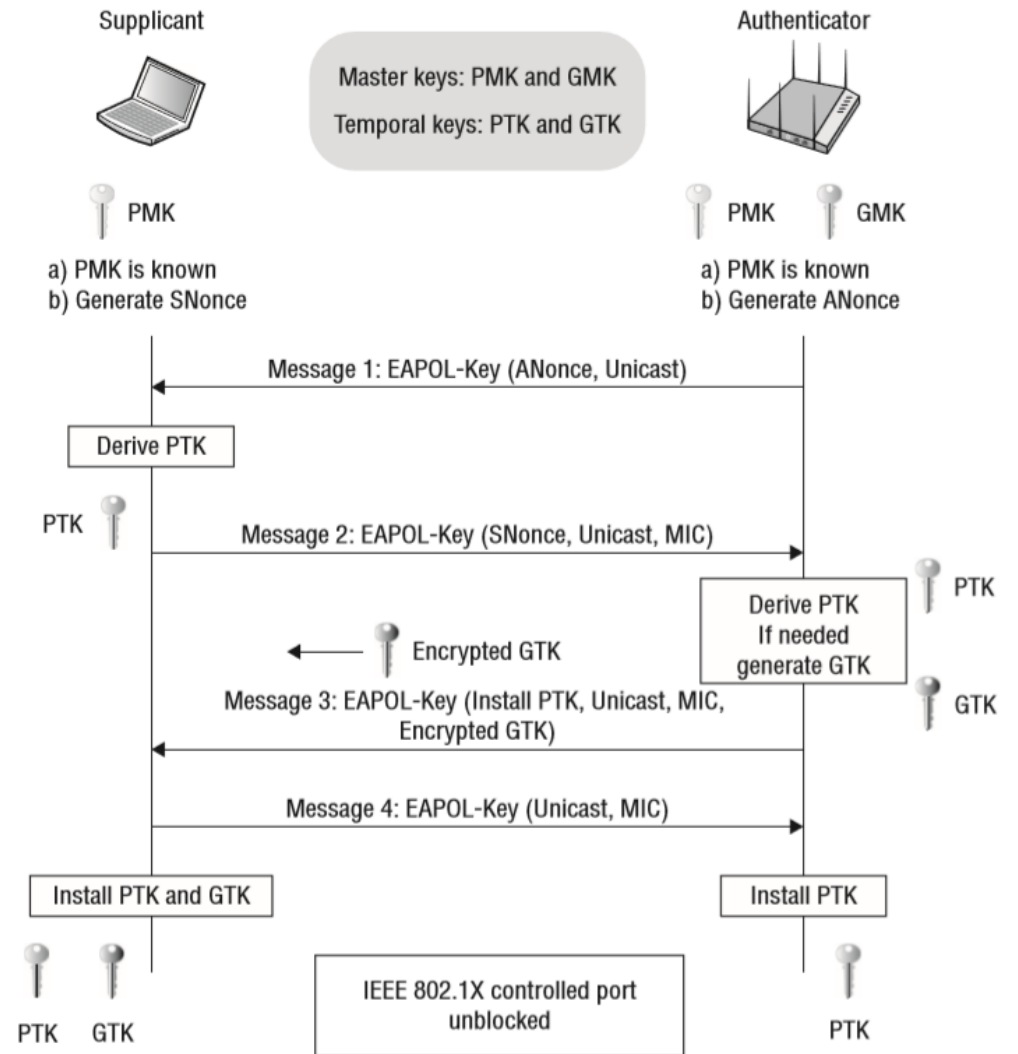
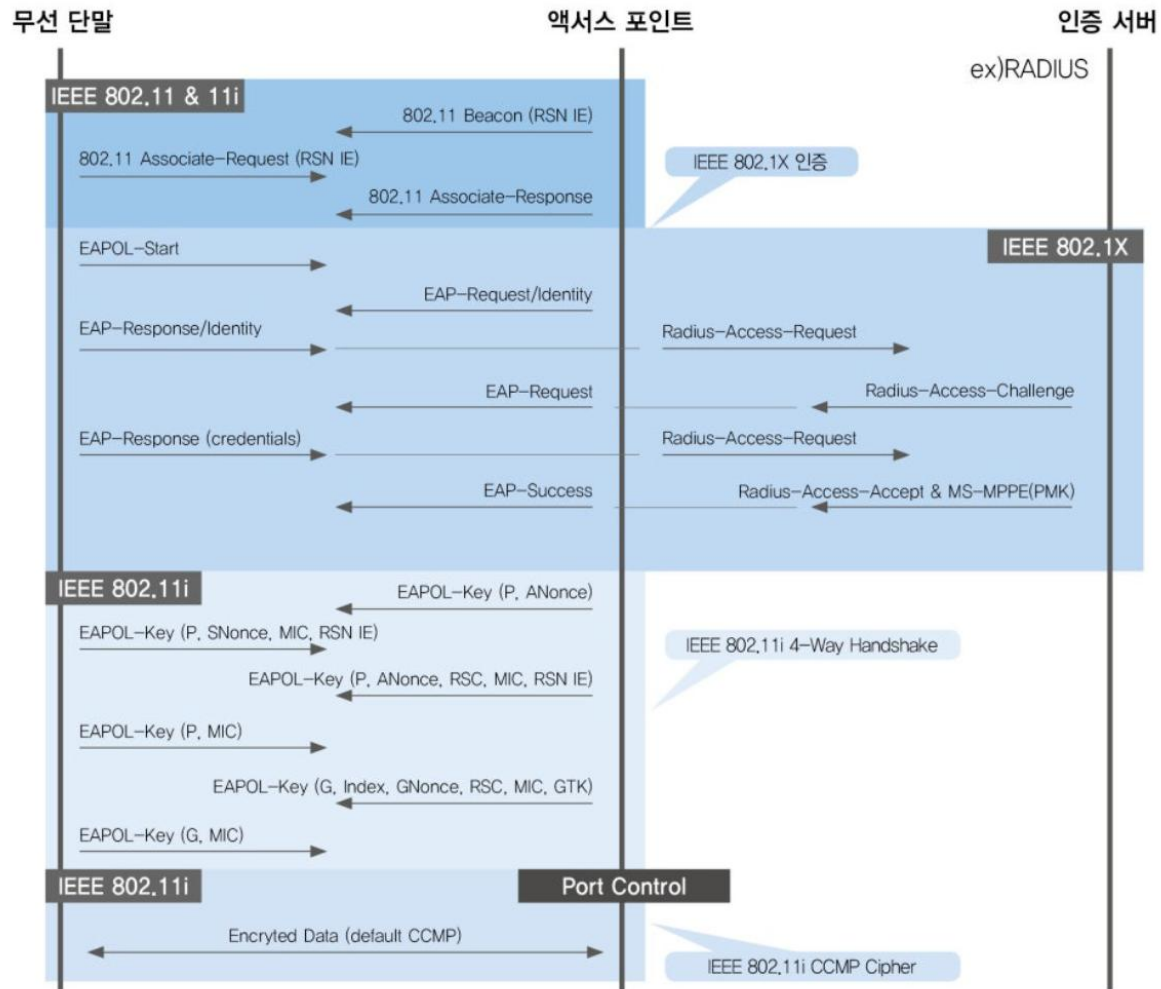
# 4-way handshake: key level

- 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 사용 되는 동적 암호 키



# 4-way handshake: overall

- Authentication, Association → 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





# Dragonblood Attack

- Dragonfly handshake
  - convert password into group element (point on elliptic 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

```
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,  $\sqrt{x^3 + ax + b}$ )
```



# Wireshark

- Wireshark 공식 홈페이지의 샘플을 이용
  - wpa2linkupphraseiswireshark.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)

```
▶ Frame 1: Packet, 298 bytes on wire (2384 bits), 298 bytes captured (2384 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Beacon frame, Flags: .....
  Type/Subtype: Beacon frame (0x0008)
  ▼ Frame Control Field: 0x8000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    1000 .... = Subtype: 8
    ▼ 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 0000 0000 = Duration: 0 microseconds
  ▶ Receiver address: Broadcast (ff:ff:ff:ff:ff:ff)
  ▶ Destination address: Broadcast (ff:ff:ff:ff:ff:ff)
  ▶ Transmitter address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▶ Source address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
  ▶ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    .... .... 0000 = Fragment number: 0
    1011 1101 1111 .... = Sequence number: 3039
  [WLAN Flags: .....]
```

```
▼ IEEE 802.11 Wireless Management
  ▶ Fixed parameters (12 bytes)
  ▼ Tagged parameters (238 bytes)
    ▶ Tag: SSID parameter set: "ikeriri-5g"
    ▶ Tag: Supported Rates 6(B), 9(B), 12(B), 18(B), 24(B), 36(B), 48(B), 54(B), [Mbit/sec]
    ▶ Tag: Traffic Indication Map (TIM): DTIM 0 of 2 bitmap
    ▶ Tag: HT Capabilities
    ▼ 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) PSK
      ▶ RSN Capabilities: 0x003c
```

# Wireshark(Probe Request)

```
▶ Frame 2: Packet, 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Probe Request, Flags: .....
  Type/Subtype: Probe Request (0x0004)
  ▼ Frame Control Field: 0x4000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    0100 .... = Subtype: 4
    ▶ Flags: 0x00
    .000 0000 0000 0000 = Duration: 0 microseconds
    ▶ Receiver address: Broadcast (ff:ff:ff:ff:ff:ff)
    ▶ Destination address: Broadcast (ff:ff:ff:ff:ff:ff)
    ▶ 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: Broadcast (ff:ff:ff:ff:ff:ff)
    .... .... .... 0000 = Fragment number: 0
    0001 0111 1011 .... = Sequence number: 379
    [WLAN Flags: .....]
  ▼ IEEE 802.11 Wireless Management
    ▼ Tagged parameters (82 bytes)
      ▼ Tag: SSID parameter set: Wildcard SSID
        Tag Number: SSID parameter set (0)
        Tag length: 0
        SSID: <MISSING>
```

# Wireshark(Probe Response)

```
▶ Frame 3: Packet, 292 bytes on wire (2336 bits), 292 bytes captured (2336 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Probe Response, Flags: ....R...
  Type/Subtype: Probe Response (0x0005)
  ▼ Frame Control Field: 0x5008
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    0101 .... = Subtype: 5
    ▼ Flags: 0x08
      .... ..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
      ▶ .... 1... = Retry: Frame is 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)
    ▶ Destination address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Transmitter address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ Source address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
      .... .... 0000 = Fragment number: 0
      0110 1101 0100 .... = Sequence number: 1748
    [WLAN Flags: ....R...]
```

# Wireshark(Authentication)

```
▶ Frame 4: Packet, 54 bytes on wire (432 bits), 54 bytes captured (432 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Authentication, Flags: .....
  Type/Subtype: Authentication (0x000b)
  ▼ Frame Control Field: 0xb000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    1011 .... = Subtype: 11
    ▼ 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 0010 .... = Sequence number: 482
    [WLAN Flags: .....]
```

# Wireshark(Authentication)

```
▶ Frame 5: Packet, 54 bytes on wire (432 bits), 54 bytes captured (432 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Authentication, Flags: .....
  Type/Subtype: Authentication (0x000b)
  ▼ Frame Control Field: 0xb000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    1011 .... = Subtype: 11
    ▶ Flags: 0x00
    .000 0000 0011 1100 = Duration: 60 microseconds
    ▶ Receiver address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Destination address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Transmitter address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ Source address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    .... .... 0000 = Fragment number: 0
    1110 1101 1010 .... = Sequence number: 3802
    [WLAN Flags: .....]
  ▼ IEEE 802.11 Wireless Management
    ▼ Fixed parameters (6 bytes)
      Authentication Algorithm: Open System (0)
      Authentication SEQ: 0x0002
      Status code: Successful (0x0000)
```

# 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)

```
▼ IEEE 802.11 Wireless Management
  ▶ Fixed parameters (4 bytes)
  ▼ Tagged parameters (191 bytes)
    ▶ Tag: SSID parameter set: "ikeriri-5g"
    ▶ Tag: Supported Rates 6(B), 9(B), 12(B), 18(B), 24(B), 36(B), 48(B), 54(B), [Mbit/sec]
    ▶ Tag: Power Capability Min: 13, Max: 23
    ▶ Tag: Supported Channels
    ▼ 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
```

# Wireshark(Association Response)

```
▶ Frame 7: Packet, 173 bytes on wire (1384 bits), 173 bytes captured (1384 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Association Response, Flags: .....
  Type/Subtype: Association Response (0x0001)
  ▼ Frame Control Field: 0x1000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    0001 .... = Subtype: 1
    ▶ Flags: 0x00
    .000 0000 0011 1100 = Duration: 60 microseconds
    ▶ Receiver address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Destination address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Transmitter address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ Source address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ BSS Id: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    .... .... 0000 = Fragment number: 0
    1110 1101 1011 .... = Sequence number: 3803
    [WLAN Flags: .....]
  ▼ IEEE 802.11 Wireless Management
    ▼ Fixed parameters (6 bytes)
      ▶ Capabilities Information: 0x8531
        Status code: Successful (0x0000)
        ..00 0000 0000 0110 = Association ID: 0x0006
      ▶ Tagged parameters (119 bytes)
```

# 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)

```
▶ Frame 9: 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: .....T
  Type/Subtype: QoS Data (0x0028)
  ▼ Frame Control Field: 0x8801
    .... ..00 = Version: 0
    .... 10.. = Type: Data frame (2)
    1000 .... = Subtype: 8
    ▼ Flags: 0x01
      .... ..01 = DS status: Frame from STA to DS via an AP (To DS: 1 From DS: 0) (0x1)
      .... .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)
    ▶ Transmitter address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ Destination address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
    ▶ Source address: Sony_50:73:db (40:40:a7:50:73:db)
    ▶ 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: .....T]
    ▶ Qos Control: 0x0006
  ▶ Logical-Link Control
  ▶ 802.1X Authentication
```

```
▼ 802.1X Authentication
  Version: 802.1X-2001 (1)
  Type: Key (3)
  Length: 117
  Key Descriptor Type: EAPOL RSN Key (2)
  [Message number: 2]
  ▼ Key Information: 0x010a
    .... .... .010 = Key Descriptor Version: AES Cipher, HMAC-SHA1 MIC (2)
    .... .... 1... = Key Type: Pairwise Key
    .... .... .000 = Key Index: 0
    .... .... .0.. = Install: Not set
    .... .... 0... = Key ACK: Not set
    .... ...1 .... = Key MIC: Set
    .... ..0. .... = Secure: Not set
    .... .0.. .... = Error: Not set
    .... 0... .... = Request: Not set
    .... 0000 .... = Encrypted Key Data: Not set
    ..0. .... .... = SMK Message: Not set
  Key Length: 0
  Replay Counter: 1
  WPA Key Nonce: 1b9717293f9d9d6979d94b36dbc9d83418bbce09f72edc1e1ae4fd79821ffda4
  Key IV: 00000000000000000000000000000000
  WPA Key RSC: 0000000000000000
  WPA Key ID: 0000000000000000
  WPA Key MIC: 2f8e7921e572afd75a7c898e625ffb43
  WPA Key Data Length: 22
  ▼ WPA Key Data: 30140100000fac040100000fac040100000fac023c00
    ▶ Tag: RSN Information
```

# Wireshark(4-way handshake, M3)

```
▶ Frame 10: Packet, 213 bytes on wire (1704 bits), 213 bytes captured (1704 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 0001 .... = Sequence number: 1
      [WLAN Flags: .....F.]
    ▶ Qos Control: 0x0007
  ▶ Logical-Link Control
  ▶ 802.1X Authentication
```

```
▼ 802.1X Authentication
  Version: 802.1X-2004 (2)
  Type: Key (3)
  Length: 151
  Key Descriptor Type: EAPOL RSN Key (2)
  [Message number: 3]
  ▼ Key Information: 0x13ca
    .... .... .010 = Key Descriptor Version: AES Cipher, HMAC-SHA1 MIC (2)
    .... .... 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: 15adf473164f43a34f211ebc34495b588af5b915c0dd4478f5fbc89d2f7bd0fa
  Key IV: 00000000000000000000000000000000
  WPA Key RSC: 0000000000000000
  WPA Key ID: 0000000000000000
  WPA Key MIC: e481fe9d4a2e0a53dd1119fb36104330
  WPA Key Data Length: 56
  WPA Key Data: b43c7737faedbf17306b5ea1d5059fd5379d0145fa6ddac1e08d460de93cd72c103a7fb2c21445d2b740139c80ac569ae1e865a198c79a21
```

# 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: 22fffbcadfbdb96816884599c16d65dd]
```

# Wireshark(4-way handshake, M4)

```

> Frame 11: Packet, 157 bytes on wire (1256 bits), 157 bytes captured (1256 bits)
> Radiotap Header v0, Length 24
> 802.11 radio information
> IEEE 802.11 QoS Data, Flags: .....T
    Type/Subtype: QoS Data (0x0028)
    > Frame Control Field: 0x8801
        .... ..00 = Version: 0
        .... 10.. = Type: Data frame (2)
        1000 .... = Subtype: 8
        > Flags: 0x01
            .... ..01 = DS status: Frame from STA to DS via an AP (To DS: 1 From DS: 0) (0x1)
            .... .0.. = More Fragments: This is the last fragment
            .... 00.. = 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)
        > Transmitter address: Sony_50:73:db (40:40:a7:50:73:db)
        > Destination address: Cisco_70:18:d0 (50:0f:80:70:18:d0)
        > Source address: Sony_50:73:db (40:40:a7:50:73:db)
        > 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 0001 .... = Sequence number: 1
            [WLAN Flags: .....T]
        > Qos Control: 0x0006
> Logical-Link Control
> 802.1X Authentication

```

```

▼ 802.1X Authentication
    Version: 802.1X-2001 (1)
    Type: Key (3)
    Length: 95
    Key Descriptor Type: EAPOL RSN Key (2)
    [Message number: 4]
    ▼ Key Information: 0x030a
        .... .010 = Key Descriptor Version: AES Cipher, HMAC-SHA1 MIC (2)
        .... 1... = Key Type: Pairwise Key
        .... ..00 .... = Key Index: 0
        .... .0.. .... = Install: Not set
        .... 0... .... = Key ACK: Not set
        .... ...1 .... = Key MIC: Set
        .... ..1. .... = Secure: Set
        .... .0.. .... = Error: Not set
        .... 0... .... = Request: Not set
        ...0 .... .... = Encrypted Key Data: Not set
        ..0. .... .... = SMK Message: Not set

    Key Length: 0
    Replay Counter: 2
    WPA Key Nonce: 0000000000000000000000000000000000000000000000000000000000000000
    Key IV: 00000000000000000000000000000000
    WPA Key RSC: 0000000000000000
    WPA Key ID: 0000000000000000
    WPA Key MIC: 14ac2c3067058ee2c6fc3f5a7d5a5839
    WPA Key Data Length: 0

```

# Encrypted data

```
▶ Frame 12: Packet, 132 bytes on wire (1056 bits), 132 bytes captured (1056 bits)
▶ Radiotap Header v0, Length 36
▶ 802.11 radio information
▼ IEEE 802.11 QoS Data, Flags: .p....F.
  Type/Subtype: QoS Data (0x0028)
  ▼ Frame Control Field: 0x8842
    .... ..00 = Version: 0
    .... 10.. = Type: Data frame (2)
    1000 .... = Subtype: 8
    ▼ Flags: 0x42
      .... ..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
      .1.. .... = Protected flag: Data is protected
      0... .... = +HTC/Order flag: Not strictly ordered
      .000 0000 0010 1000 = Duration: 40 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_9c:6a:e4 (18:80:90:9c:6a:e4)
    ▶ 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: .p....F.]
    ▶ Qos Control: 0x0000
    ▶ CCMP parameters
  ▼ Data (62 bytes)
    Data: 425140326b1d4fd39c6d3a9247d3c82ec709c89a58457d06fb7062e892a08daaceb3023a3e71dd811fe08a3d82d6e03045942cdc55a218bc3e0680faf030
    [Length: 62]
```



# 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

```
▶ Frame 16: Packet, 50 bytes on wire (400 bits), 50 bytes captured (400 bits)
▶ Radiotap Header v0, Length 24
▶ 802.11 radio information
▼ IEEE 802.11 Disassociate, Flags: .....
  Type/Subtype: Disassociate (0x000a)
  ▼ Frame Control Field: 0xa000
    .... ..00 = Version: 0
    .... 00.. = Type: Management frame (0)
    1010 .... = Subtype: 10
    ▼ 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
      0011 1100 0110 .... = Sequence number: 966
      [WLAN Flags: .....]
  ▼ IEEE 802.11 Wireless Management
    ▼ Fixed parameters (2 bytes)
      Reason code: Unspecified reason (0x0001)
```

# 3주차 취약점 공격 실습

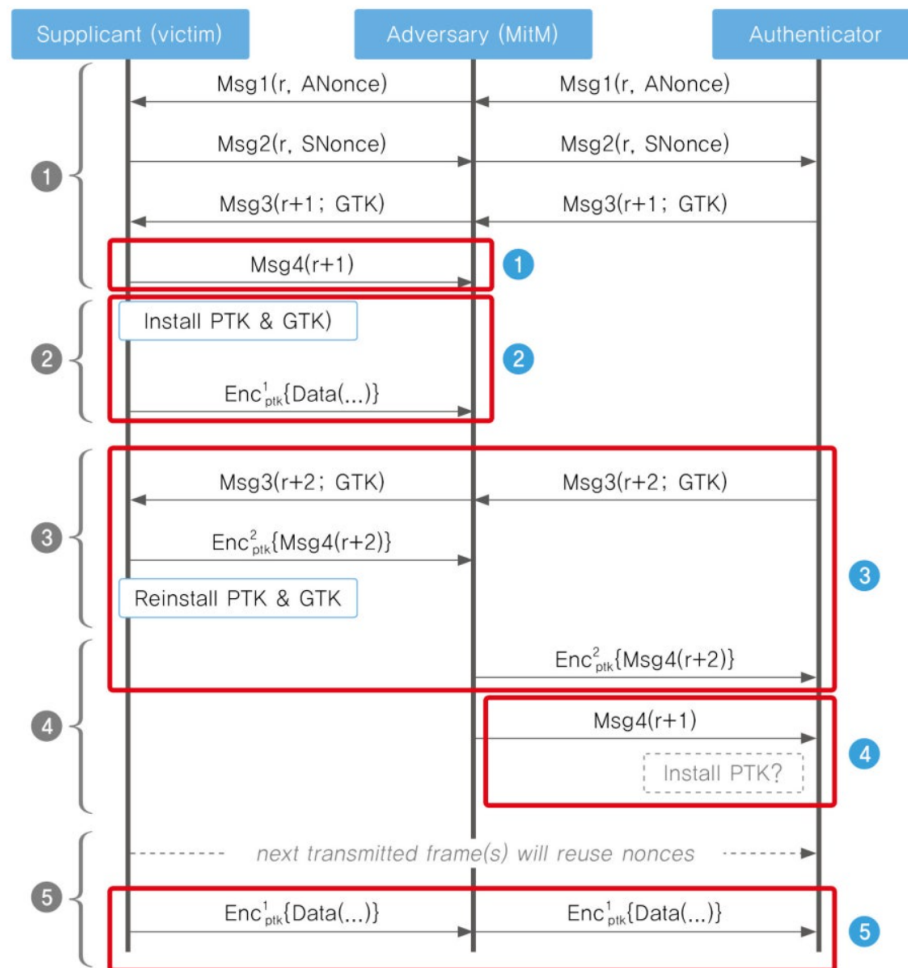
- Fragattack, Dragonblood Attack : 개념 이해 (1주차 완료)
- KRACK, PMKID offline dictionary match: 실습 (3주차 예정)
  - 무선 랜카드를 이용하여 kali linux 환경에서 직접 테스트 가능
  - 기제공된 pcap 파일 등을 활용하여 PMKID attack 해보기

# Fragattack/KRACK

[vanhoefm/fragattacks](https://github.com/vanhoefm/fragattacks)

[vanhoefm/krackattacks-scripts](https://github.com/vanhoefm/krackattacks-scripts)

kali linux 환경에서 테스트



# PMKID Offline dictionary match

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

[New attack on WPA/WPA2 using PMKID](#)