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## Station Authentication and Association

By Rowell Dionicio | July 25, 2018 | Network Troubleshooting, WiFi Monitoring

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WiFi connections happen in a matter of microseconds. Within that small time frame, there are many frame exchanges occurring between a station and access point. Beacon frames are transmitted at an interval to allow passive or active scanning stations to join a particular WiFi network.

For a station to successfully join a WiFi network, a series of frame exchanges must occur which make up the Authentication and Association process, the 802.11 State Machine. The frames part of this transaction are as follows:

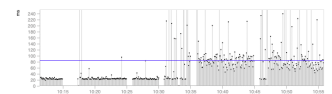
- Probe Request
- Probe Response
- Authentication Request
- Authentication Response
- Association Request
- Association Response

The sequence of frames exchanged are displayed in the

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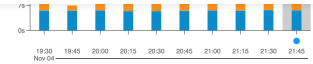
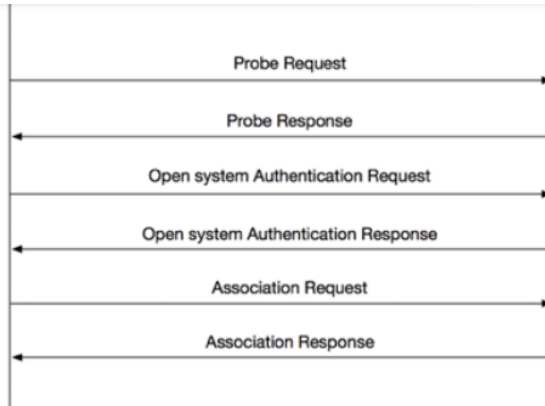
 

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## Authentication

In a station's WiFi network discovery process, a Probe Request will be sent from the station to the BSSID listed in a Beacon frame the station received. This is the beginning of the 802.11 State Machine.

No.	Time	Source	Destination	Protocol	Length	Channel	Signal Strength	Frame Type	Data Rate
1	21:20:00...	Apple_e0:30:c0	Broadcast	802.11	156	60	-44 dBm	Probe Request	6.0

▶ Frame 1: 156 bytes on wire (1248 bits), 156 bytes captured (1248 bits)

▶ Radiotap Header v0, Length 25

▶ 802.11 radio information

▶ IEEE 802.11 Probe Request, Flags: .....C

▼ IEEE 802.11 wireless LAN

▼ Tagged parameters (103 bytes)

▶ Tag: SSID parameter set: Wildcard SSID

▶ Tag: Supported Rates 6, 9, 12, 18, 24, 36, 48, 54, [Mbit/sec]

▶ Tag: HT Capabilities (802.11n D1.0)

▶ Tag: Extended Capabilities (4 octets)

▶ Tag: Interworking

▶ Tag: VHT Capabilities

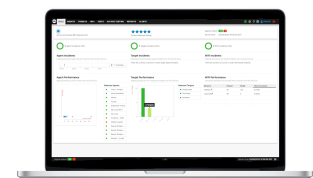
▶ Tag: Vendor Specific: Apple, Inc.

▶ Tag: Vendor Specific: Microsoft Corp.: Unknown 8

▶ Tag: Vendor Specific: Broadcom

*Sample Probe Request Frame*

## Remote Worker Monitoring



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Next, the station transmits an Authentication Request frame; this frame is also responded with an Acknowledgement Frame from the access point.

**NOTE:** This is not a security authentication process that you'd see with role PSK or 802.1X. This authentication frame starts the Open System authentication for joining the WiFi network. Any security methods, such as 802.1X, will occur after the 802.11 state machine.

No.	Time	Source	Destination	Protocol	Length	Channel	Signal Strength	Frame Type	Data Rate	SSID
1	21:19:58...	ea:55:2d:c0:75:e0	1e:84:f8:eb:4c:9d	802.11	419	60	-39 dBm	Probe Response	24.0	Packet6-Guest

```

> Frame 1: 419 bytes on wire (3352 bits), 419 bytes captured (3352 bits)
> Radiotap Header v0, Length 25
> 802.11 radio information
> IEEE 802.11 Probe Response, Flags: .....C
▼ IEEE 802.11 wireless LAN
  ▼ Fixed parameters (12 bytes)
    Timestamp: 0x000003fe3787500c
    Beacon Interval: 0.102400 [Seconds]
    Capabilities Information: 0x1511
  ▼ Tagged parameters (354 bytes)
    Tag: SSID parameter set: Packet6-Guest
    Tag: Supported Rates 24(0), 36, 48, 54, [Mbit/sec]
    Tag: DS Parameter set: Current Channel: 60
    Tag: Country Information: Country Code US, Environment Any
    Tag: Power Constraint: 3
    Tag: RSN Information
    Tag: QoS Load Element 802.11e CCA Version
    Tag: RM Enabled Capabilities (5 octets)
    Tag: AP Channel Report: Operating Class 5, Channel List : 36, 44, 48, 132, 153, 157, 161, 165,
    Tag: Mobility Domain
    Tag: HT Capabilities (802.11n D1.10)
    Tag: HT Information (802.11n D1.10)
    Tag: Extended Capabilities (8 octets)
    Tag: VHT Capabilities
    Tag: VHT Operation
    Tag: VHT Tx Power Envelope
    Tag: Vendor Specific: Microsoft Corp.: WMM/PM: Parameter Element
    Tag: Vendor Specific: Atheros Communications, Inc.: Advanced Capability
    Tag: Vendor Specific: Cisco Meraki
    Tag: Vendor Specific: Cisco Systems, Inc.: Aironet CCX version = 5
    Tag: Vendor Specific: Cisco Systems, Inc.: Aironet Client MFP Disabled
    Tag: Vendor Specific: Cisco Systems, Inc.: Aironet Unknown (11) (11)
    Tag: Cisco CCX1 CKIP + Device Name
  
```

*Sample Probe Response Frame*

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case.

Troubleshooting

There are only two messages that are part of the Authentication frame transaction. The access point responds with an Authentication Response frame. If the response frame is “successful” then the station has been authenticated.

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No.	Time	Source	Destination	Protocol	Length	Channel	Signal Strength	Frame Type	Data Rate
1	21:19:59...	Apple_e0:30:c0	ea:55:2d:c0:75:e0	802.11	89	60	-47 dBm	Authentication	24.0
2	21:19:59...	ea:55:2d:c0:75:e0	Apple_e0:30:c0	802.11	59	60	-41 dBm	Authentication	24.0

▶ Frame 1: 89 bytes on wire (712 bits), 89 bytes captured (712 bits)

▶ Radiotap Header v0, Length 25

▶ 802.11 radio information

▶ IEEE 802.11 Authentication, Flags: .....C

▼ IEEE 802.11 wireless LAN

▼ Fixed parameters (6 bytes)

Authentication Algorithm: Open System (0)

Authentication SEQ: 0x0001

Status code: Successful (0x0000)

▼ Tagged parameters (30 bytes)

▶ Tag: Extended Capabilities (4 octets)

▶ Tag: Vendor Specific: Apple, Inc.

▶ Tag: Vendor Specific: Broadcom

Sample Authentication Request Frame

No.	Time	Source	Destination	Protocol	Length	Channel	Signal Strength	Frame Type	Data Rate
1	21:19:59...	Apple_e0:30:c0	ea:55:2d:c0:75:e0	802.11	89	60	-47 dBm	Authentication	24.0
2	21:19:59...	ea:55:2d:c0:75:e0	Apple_e0:30:c0	802.11	59	60	-41 dBm	Authentication	24.0

▶ Frame 2: 59 bytes on wire (472 bits), 59 bytes captured (472 bits)

▶ Radiotap Header v0, Length 25

▶ 802.11 radio information

▶ IEEE 802.11 Authentication, Flags: .....C

▼ IEEE 802.11 wireless LAN

▼ Fixed parameters (6 bytes)

Authentication Algorithm: Open System (0)

Authentication SEQ: 0x0002

Status code: Successful (0x0000)





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exchanges, the station moves forward with associating. The station transmits an Association Request frame containing the station’s capabilities within fields and information elements of the frame.



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No.	Time	Source	Destination	Protocol	Length	Channel	Signal Strength	Frame Type	Data Rate
1	21:08:11...	OpenMesh_21:98:90	Broadcast	802.11	191	36	-52 dBm	Beacon	6.0
2	21:08:11...	Apple_1b:4f:05	Broadcast	802.11	152	36	-29 dBm	Probe Request	6.0
3	21:08:11...	OpenMesh_21:98:90	Apple_1b:4f:05	802.11	185	36	-52 dBm	Probe Response	6.0
4	21:08:11...	Apple_1b:4f:05	OpenMesh_21:98:90	802.11	78	36	-29 dBm	Authentication	6.0
5	21:08:11...		Apple_1b:4f:05 (d8:...	802.11	39	36	-52 dBm	Ack	6.0
6	21:08:11...	OpenMesh_21:98:90	Apple_1b:4f:05	802.11	59	36	-52 dBm	Authentication	6.0
7	21:08:11...	Apple_1b:4f:05	OpenMesh_21:98:90	802.11	160	36	-29 dBm	Association Reque...	6.0

► Frame 7: 160 bytes on wire (1280 bits), 160 bytes captured (1280 bits)

► Radiotap Header v0, Length 25

► 802.11 radio information

► IEEE 802.11 Association Request, Flags: .....C

▼ IEEE 802.11 wireless LAN

    ▼ Fixed parameters (4 bytes)

        ► Capabilities Information: 0x0011

        Listen Interval: 0x0014

    ▼ Tagged parameters (103 bytes)

        ► Tag: SSID parameter set: D-NET



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### *Sample Association Request Frame*

When the access point receives the Association Request frame, it responds with an Acknowledgement Frame and transmits an Association Response frame with the result of successful or unsuccessful. The station must support the required parameters defined by the WiFi network. If successful, the station will be assigned an Association ID which can be identified within the Association Response frame.

```

9 21:08:11... OpenMesh_21:98:90 Apple_1b:4f:05 802.11 147 36 -52 dBm Other Management Frame 6.0
> Frame 9: 147 bytes on wire (1176 bits), 147 bytes captured (1176 bits)
> Radiotap Header v0, Length 25
> 802.11 radio information
> IEEE 802.11 Association Response, Flags: .....C
▼ IEEE 802.11 wireless LAN
  ▼ Fixed parameters (6 bytes)
    ▶ Capabilities Information: 0x0011
    ▶ Status code: Successful (0x0000)
    ▶ ..00 0000 0000 0001 = Association ID: 0x0001
  ▼ Tagged parameters (88 bytes)
    ▶ Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    ▶ Tag: HT Capabilities (802.11n D1.10)
    ▶ Tag: HT Information (802.11n D1.10)
    ▶ Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Parameter Element

```

### *Sample Association Response Frame*

The station responds to the Association Response frame with an Acknowledgement Frame which completes the 802.11 State Machine.

At this point, if there is a PSK or 802.1X configured on the

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stations and access points communicate with each other can be beneficial to the process. The type of frames exchanged can assist in troubleshooting issues such as bad PSKs or failed 802.1X authentication. The frames tell the exact story happening within 802.11 wireless.

If you want to see this with your own eye, you can use [wireshark](#) packet capture and apply the following filters to your wifi network interface:

Probe Request: wlan.fc.type\_subtype == 0x0004

Probe Response: wlan.fc.type\_subtype == 0x0005

Authentication frame: wlan.fc.type\_subtype == 0x000b

Association Request: wlan.fc.type\_subtype == 0x0000

Association Response: wlan.fc.type\_subtype == 0x0001

### About the Author:


Rowell Dionicio is a network engineer for a west coast university specializing in Wi-Fi design, deployment, and troubleshooting. He supports a WLAN infrastructure with over 40k concurrent Wi-Fi devices in higher education. He is the co-host to a Wi-Fi focused podcast, <https://cleartosend.net> and is co-host on a YouTube show 'WiFi of Everything'. You can engage with him on Twitter @rowelldionicio where he encourages open

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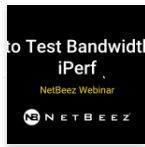
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