802.11n 속도 문제 해결

목차

소개

이 문서에서는 무선 처리량 문제를 해결할 때 고려해야 할 일반적인 문제를 다룹니다.이 문서에서는 유사한 테스트 환경에서 Cisco 1252 AP와 비교하여 다양한 벤더 802.11n 액세스 포인트(AP)를 포함하는 무선 네트워크의 성능 및 처리량을 측정하는 툴을 사용합니다.

사전 요구 사항

요구 사항

Cisco에서는 다음과 같은 요구 사항을 충족하는 것이 좋습니다.

- iPerf와 같은 툴 및 OmniPeek 및 Cisco Spectrum Analysis와 같은 네트워크 분석
- 802.11n 지원 1140, 1250, 3500 및 1260 Series AP

사용되는 구성 요소

이 문서의 정보는 다음 소프트웨어 및 하드웨어 버전을 기반으로 합니다.

- 소프트웨어 버전 6.0.182을 실행하는 WS-SVC-WiSM 컨트롤러
- AIR-LAP1142-A-K9 AP

표기 규칙

문서 규칙에 대한 자세한 내용은 [Cisco 기술 팁 표기 규칙을 참고하십시오.](#)

배경 정보

802.11n은 AP의 프레임 어그리게이션에 대한 여러 변경 사항으로 인해 탄생했습니다.A-MPDU 및 A-MSDU.

- 블록 ACK 크기
- MCS 및 채널 본딩
- MIMO
- 5GHz를 2.4GHz 이상 사용:5GHz에서 채널 본딩을 인증하는 Wi-Fi도 언급함

11n 속도에 대한 컨트롤러 트러블슈팅

다음 단계를 완료하십시오.

1. 컨트롤러에서 802.11n 지원이 활성화되었는지 확인합니다.
   ```
   (WiSM-slot3-2) >show 802.11a
   802.11a Network.................................. Enabled
   11nSupport....................................... Enabled
   802.11a Low Band........................... Enabled
   802.11a Mid Band........................... Enabled
   802.11a High Band.......................... Enabled
   802.11a Operational Rates
   802.11a 6M Rate............................. Mandatory
   802.11a 9M Rate............................. Supported
   802.11a 12M Rate............................ Disabled
   802.11a 18M Rate............................ Supported
   802.11a 24M Rate............................ Mandatory
   802.11a 36M Rate............................ Supported
   802.11a 48M Rate............................ Supported
   802.11a 54M Rate............................ Supported
   802.11n MCS Settings:
   MCS 0....................................... Supported
   MCS 1....................................... Supported
   MCS 2....................................... Supported
   MCS 3....................................... Supported
   MCS 4....................................... Supported
   MCS 5....................................... Supported
   ```

2. N율은 두 가지 방법으로 달성됩니다.채널 본딩을 사용하지 않고도 MCS(Modulation Coding Scheme) 7까지 속도를 높일 수 있습니다.MCS 속도가 7보다 크고 최대 15인 경우 채널 결합을 활성화해야 합니다.컨트롤러에서 다음 show 명령을 사용하여 채널 본딩이 활성화되었는지 확인할 수 있습니다.
   ```
   (WiSM-slot3-2) >show advanced 802.11a channel
   Automatic Channel Assignment
   Channel Assignment Mode....................... AUTO
   Channel Update Interval....................... 600 seconds [startup]
   Anchor time (Hour of the day)................. 0
   Channel Update Contribution................... SNI.
   Channel Assignment Leader..................... 00:1d:45:f0:d2:c0
   Last Run...................................... 371 seconds ago
   DCA Sensitivity Level......................... STARTUP (5 dB)
   DCA 802.11n Channel Width..................... 40 MHz
   Channel Energy Levels
   Minimum....................................... unknown
   Average....................................... unknown
   Maximum....................................... unknown
   Channel Dwell Times
   Minimum....................................... unknown
   Average....................................... unknown
   Maximum....................................... unknown
   802.11a 5 GHz Auto-RF Channel List
   ```

```
    Allowed Channel List..........................
    36,40,44,48,52,56,60,64,149,
    153,157,161
    Unused Channel List..........................
    100,104,108,112,116,132,136,
```

3. 다음 명령을 사용하여 AP당 채널 너비를 구성할 수도 있습니다.

```
(WiSM-slot2-2) >config 802.11a disable AP0022.9090.8e97
(WiSM-slot2-2) >config 802.11a chan_width AP0022.9090.8e97 40
Set 802.11a channel width to 40 on AP AP0022.9090.8e97
```

4. 가드 간격 및 해당 MCS 속도는 802.11n 클라이언트에 표시되는 데이터 속도를 결정하는 데 도움이 됩니다.다음은 이 컨피그레이션을 확인하는 명령입니다.

```
(WiSM-slot3-2) >show 802.11a
802.11a Network.................................. Enabled
11nSupport....................................... Enabled
802.11a Low Band........................... Enabled
802.11a Mid Band........................... Enabled
802.11a High Band.......................... Enabled
802.11a Operational Rates
802.11a 6M Rate............................. Mandatory
802.11a 9M Rate............................. Supported
802.11a 12M Rate............................ Disabled
802.11a 18M Rate............................ Supported
802.11a 24M Rate............................ Mandatory
802.11a 36M Rate............................ Supported
802.11a 48M Rate............................ Supported
802.11a 54M Rate............................ Supported
802.11n MCS Settings:
MCS 0....................................... Supported
MCS 1....................................... Supported
MCS 2....................................... Supported
MCS 3....................................... Supported
MCS 4....................................... Supported
MCS 5....................................... Supported
MCS 6....................................... Supported
MCS 7....................................... Supported
MCS 8....................................... Supported
MCS 9....................................... Supported
MCS 10...................................... Supported
MCS 11...................................... Supported
MCS 12...................................... Supported
MCS 13...................................... Supported
MCS 14...................................... Supported
MCS 15...................................... Supported
802.11n Status:
A-MPDU Tx:
Priority 0............................. Enabled
Priority 1............................. Disabled
Priority 2............................. Disabled
Priority 3............................. Disabled
Priority 4............................. Disabled
Priority 5............................. Disabled
Priority 6............................. Disabled
Priority 7............................. Disabled
Beacon Interval................................ 100
CF Pollable mandatory.......................... Disabled
CF Poll Request mandatory...................... Disabled
--More-- or (q)uit
CFP Period..................................... 4
CFP Maximum Duration........................... 60
Default Channel................................ 36
Default Tx Power Level......................... 1
DTPC Status.................................... Enabled
Fragmentation Threshold........................ 2346
```

```
Pico-Cell Status.................................. Disabled
Pico-Cell-V2 Status............................... Disabled
TI Threshold...................................... -50
Traffic Stream Metrics Status..................... Disabled
Expedited BW Request Status....................... Disabled
World Mode........................................ Enabled
EDCA profile type................................. default-wmm
Voice MAC optimization status..................... Disabled
Call Admission Control (CAC) configuration
Voice AC - Admission control (ACM)............ Enabled
Voice max RF bandwidth........................ 75
Voice reserved roaming bandwidth.............. 6
Voice load-based CAC mode..................... Enabled
Voice tspec inactivity timeout................ Disabled
Video AC - Admission control (ACM)............ Disabled
Voice Stream-Size............................. 84000
Voice Max-Streams............................. 2
Video max RF bandwidth........................ Infinite
Video reserved roaming bandwidth.............. 0
```

A-MPDU 패킷 집계를 확인합니다.최선의 노력을 위해 다음 명령을 통해 QoS 레벨을 활성화 합니다.**config 802.11a 11n지원 a-mpdu tx priority 0 enableconfig 802.11b 11n지원 a-mpdu tx priority 0 enable**

5. A 라디오의 안테나 세 개를 모두 사용해야 합니다.안테나가 동일한 모델인지 확인합니다.

6. 클라이언트 연결을 위해 구성된 WLAN에서 WMM을 허용하거나 요구해야 하며, AES 또는 개 방형 암호화만 사용해야 합니다.이 명령은 다음 명령 출력을 사용하여 확인할 수 있습니다.

```
(WiSM-slot2-2) >show wlan 1
WLAN Identifier................................... 1
Profile Name...................................... wlab5WISMip22
Network Name (SSID)............................... wlab5WISMip22
Status............................................ Enabled
MAC Filtering..................................... Disabled
Broadcast SSID.................................... Enabled
AAA Policy Override............................... Disabled
Network Admission Control
NAC-State......................................... Disabled
Quarantine VLAN................................... 0
Number of Active Clients.......................... 0
Exclusionlist Timeout............................. 60 seconds
Session Timeout................................... 1800 seconds
CHD per WLAN...................................... Enabled
Webauth DHCP exclusion............................ Disabled
Interface......................................... management
WLAN ACL.......................................... unconfigured
DHCP Server....................................... Default
DHCP Address Assignment Required.................. Disabled
Quality of Service................................ Silver (best effort)
WMM............................................... Allowed
CCX - AironetIe Support........................... Enabled
CCX - Gratuitous ProbeResponse (GPR).............. Disabled
CCX - Diagnostics Channel Capability.............. Disabled
Dot11-Phone Mode (7920)........................... Disabled
Wired Protocol.................................... None
IPv6 Support...................................... Disabled
Peer-to-Peer Blocking Action...................... Disabled
Radio Policy...................................... All
DTIM period for 802.11a radio..................... 1
DTIM period for 802.11b radio..................... 1
Radius Servers
Authentication.................................... Global Servers
Accounting........................................ Disabled
Local EAP Authentication.......................... Disabled
Security
```

```
802.11 Authentication:...................... Open System
Static WEP Keys............................. Disabled
802.1X...................................... Disabled
Wi-Fi Protected Access (WPA/WPA2)............. Enabled
WPA (SSN IE)................................ Disabled
WPA2 (RSN IE).............................. Enabled
TKIP Cipher................................ Disabled
AES Cipher................................. Enabled
Auth Key Management
802.1x..................................... Enabled
PSK........................................ Disabled
CCKM....................................... Disabled
FT(802.11r)................................ Disabled
FT-PSK(802.11r)............................ Disabled
FT Reassociation Timeout...................... 20
FT Over-The-Air mode........................ Enabled
FT Over-The-Ds mode......................... Enabled
CKIP ...................................... Disabled
IP Security................................ Disabled
IP Security Passthru........................ Disabled
Web Based Authentication.................... Disabled
Web-Passthrough............................ Disabled
Conditional Web Redirect.................... Disabled
Splash-Page Web Redirect.................... Disabled
Auto Anchor................................ Disabled
H-REAP Local Switching...................... Enabled
H-REAP Learn IP Address..................... Enabled
Infrastructure MFP protection................ Enabled (Global
Infrastructure
MFP Disabled)
Client MFP................................. Optional
Tkip MIC Countermeasure Hold-down Timer....... 60
Call Snooping.............................. Disabled
Band Select................................ Enabled
Load Balancing............................. Enabled
```

7. 안테나 다양성:어떤 이유로든 안테나 2개만 사용하는 경우 송신기/수신기 포트에 안테나 A와 B를 사용해야 합니다.

클라이언트 측:

1. 무선 카드를 제어하는 데 사용되는 서 플리 컨 트가 무선 카드에 서 플리 컨 트의 판매자와 일치시키는 것이 좋습니다.
2. 클라이언트 드라이버:무선 카드에서 최신 클라이언트 드라이버가 실행 중인지 확인해야 합니다.
3. 무선 어댑터 공급업체에 문의하십시오.
4. 11n 인증 어댑터를 사용하여 11n 데이터 속도를 달성해야 합니다.

Wi-Fi 인증 제품:

http://www.wi-fi.org/certified_products.php

성능 향상 방법:

1. Channel utilization(채널 사용률) - 네트워크 분석기는 프레임을 송수신하는 데 소요되는 시간의 백분율로 채널 사용률을 보고합니다.이렇게 하면 액세스 포인트와 거리가 떨어져 있는 잠재적인 속도 차이를 측정할 수 있습니다.이는 예를 들어, 1Mbps의 속도로 전송이 완전히 사용되고 있는 채널이 100% 활용률에서 0.94Mbps로 작동하는 경우를 모니터링하고 확인하는 데 도움이 됩니다.
2. 무선에 사용되는 물리적 매체도 성능을 좌우합니다.802.11b를 통해 802.11g 또는 802.11a를

사용하면 802.11b보다 처리량이 훨씬 높고, 802.11b보다 30Mbps까지 높은 처리량을 얻을 수 있습니다. 이 경우 6mpbs 무선 용량이 모든 연결된 스테이션으로 나누어집니다.

3. Cell Sizes(셀 크기) - 클라이언트가 가능한 한 AP에 가깝게 있도록 셀 크기를 축소하는 것이 좋습니다.이렇게 하면 클라이언트가 AP에 연결할 수 있는 데이터 속도가 향상됩니다.이를 위해서는 AP의 전력 수준을 가장 낮은 수준으로 낮추어야 합니다.

4. 셀 크기를 줄이면 공동 채널 간섭도 감소합니다.RRM을 사용하는 경우 AP는 구축별로 동적으로 채널을 선택해야 합니다.그러나 동적 채널 할당을 구현하는 경우, 동일한 채널 바로 옆에 고전력 레벨의 AP가 2개 없는지 확인합니다.

5. 또한 보호는 처리량 적중을 유발합니다.

iPerf를 통한 처리량 계산 방법

Iperf 설치 팁

Chariot를 소유하지 않은 고객이나 테스터에게는 Iperf를 대신 사용할 수 있습니다
.http://www.macalester.edu/crash/software/pc/iperf/kperf_setup.exe에서 확인할 수 있습니다.

TCP 처리량 측정

서버 측에서 이 명령을 실행합니다.

```
Iperf –s -w 256k
```
클라이언트 측에서 이 명령을 실행합니다.

```
Iperf –c -P 6 –w 256k -r –t 60
```

```
------------------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  256 KByte
------------------------------------------------------------------------

------------------------------------------------------------------------
Client connecting to 10.10.10.10, TCP port 5001
TCP window size:  256 KByte
------------------------------------------------------------------------
[1788] local 10.10.10.20 port 1155 connected with 10.10.10.10 port 5001
[1820] local 10.10.10.20 port 1153 connected with 10.10.10.10 port 5001
[1868] local 10.10.10.20 port 1150 connected with 10.10.10.10 port 5001
[1836] local 10.10.10.20 port 1152 connected with 10.10.10.10 port 5001
[1804] local 10.10.10.20 port 1154 connected with 10.10.10.10 port 5001
[1852] local 10.10.10.20 port 1151 connected with 10.10.10.10 port 5001
[ ID] Interval       Transfer     Bandwidth
[1788]  0.0-60.1 sec   124 MBytes  17.3 Mbits/sec
[1868]  0.0-60.1 sec   123 MBytes  17.1 Mbits/sec
[1820]  0.0-60.2 sec   110 MBytes  15.4 Mbits/sec
[1804]  0.0-60.1 sec  84.6 MBytes  11.8 Mbits/sec
[1852]  0.0-60.1 sec  89.2 MBytes  12.4 Mbits/sec
[1836]  0.0-60.2 sec  86.3 MBytes  12.0 Mbits/sec
[SUM]   0.0-60.2 sec   617 MBytes  86.0 Mbits/sec
[1952] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2663
[1832] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2664
[1748] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2665
[1732] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2666
[1800] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2667
[1812] local 10.10.10.20 port 5001 connected with 10.10.10.10 port 2668
[ ID] Interval       Transfer     Bandwidth
[1800]  0.0-60.0 sec   114 MBytes  15.9 Mbits/sec
[1812]  0.0-60.0 sec   117 MBytes  16.3 Mbits/sec
[1952]  0.0-60.1 sec  89.6 MBytes  12.5 Mbits/sec
[1748]  0.0-60.1 sec   129 MBytes  18.1 Mbits/sec
[1732]  0.0-60.1 sec   111 MBytes  15.5 Mbits/sec
[1832]  0.0-60.1 sec   112 MBytes  15.6 Mbits/sec
[SUM]   0.0-60.1 sec   672 MBytes  93.8 Mbits/sec
```

이 이미지의 첫 번째 원 안의 숫자는 업스트림 처리량을 나타내며, 두 번째 원 안의 숫자는 다운스트림(AP-클라이언트) 처리량을 나타냅니다.

UDP 처리량 측정

서버와 클라이언트 측 모두에서 이전 Iperf 애플리케이션을 닫습니다.둘 다 다시 설정해야 하지만 이번에는 UDP 성능 테스트를 위해 설정해야 합니다.
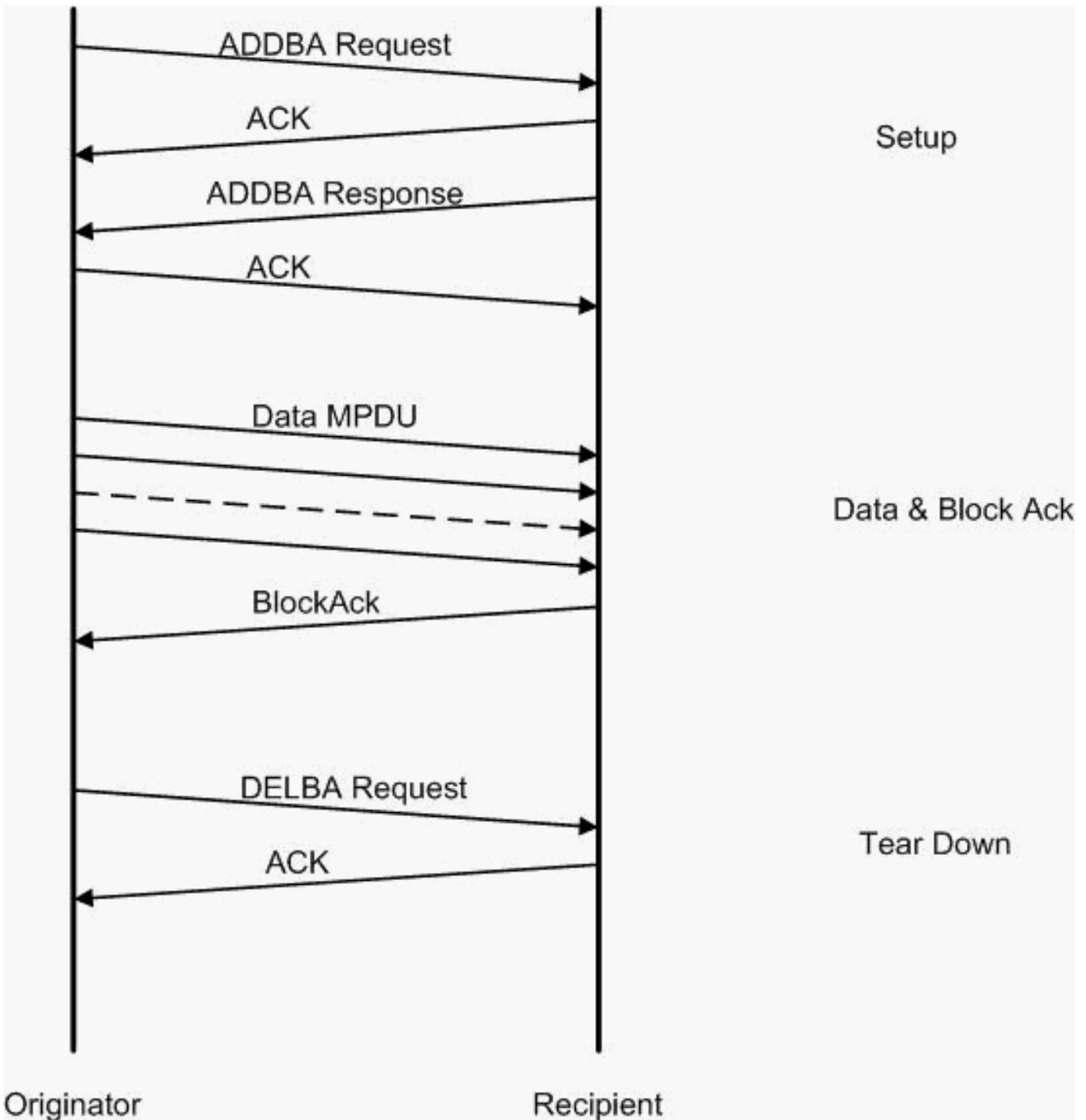
서버 측에서 이 명령을 실행합니다.

```
Iperf -s -u -l 56k
```
클라이언트 측에서 이 명령을 실행합니다.

```
Iperf -c -u -b 50M -l 56k -P
```
다음은 집계 **MAC 서비스 데이터 유닛**을 분석하기 위한 Omnunipeek **캡처의 예입니다.**

A-MSDU 추적은 하나의 패킷을 보여줍니다.

- 첫 번째 하위 프레임만 표시됩니다.
- 추가 하위 프레임을 보려면 16진수 덤프를 검사해야 합니다.

추가된 A-MSDU 다음 하위 프레임 표시

- A-MPDU는 PHY에서 단일 PSDU로 전송되는 여러 MPDU를 포함하는 구조입니다.
- 패킷이 PLCP(Physical layer convergence procedure)의 Data A-MPDU임을 나타냅니다.

다음은 집계 **MAC 프로토콜 데이터 유닛**을 분석하기 위한 Omnunipeek **캡처의 예입니다**.

A-MPDU 설정

- ADDBA - 블록 승인 추가
- ADDBA Request(ADDBA 요청) - 식별자, 블록 ACK 정책, 버퍼 크기 등을 포함합니다.
- ADDBA Response(ADDBA 응답) - 정책 및 버퍼 크기를 변경할 수 있습니다.

A-MPDU 설정

- ADDBA 요청
- AP1250은 시간 초과가 없음을 나타내기 위해 0을 사용합니다.

A-MPDU 설정

- ADDBA 응답

- 수신자는 블록 ACK 계약이 성공적으로 설정되었음을 표시해야 합니다.

```
OmniPeek - [AMPDUSetup.apc - Packet #3]

File  Edit  View  Capture  Send  Monitor  Tools  Window  Help

Packet:           3   [x]

📡 802.11 MAC Header
  🔷 Version:                 0
  🔷 Type:                    %00     Management
  🔷 Subtype:                 %1101   Management Action
  📡 Frame Control Flags:     %00000000
    🔷                                 0... .... Non-strict order
    🔷                                 .0.. .... Non-Protected Frame
    🔷                                 ..0. .... No More Data
    🔷                                 ...0 .... Power Management - active mode
    🔷                                 .... 0... This is not a Re-Transmission
    🔷                                 .... .0.. Last or Unfragmented Frame
    🔷                                 .... ..0. Not an Exit from the Distribution System
    🔷                                 .... ...0 Not to the Distribution System
  🔷 Duration:                40      Microseconds
  📑 Destination:             00:17:DF:A6:4C:90
  📑 Source:                  00:13:E8:1D:F0:55
  📑 BSSID:                   00:17:DF:A6:4C:90
  🔷 Seq Number:              876
  🔷 Frag Number:             0
📡 802.11 Management - Action
  🔷 Category Code:           3       Block Ack
  🔷 Action Code:             1       ADDBA Response
  🔷 Dialog Token:            1
  🔷 Status Code:             0       Successful
  📡 BlockAck Param Set:      %0001000000000010
    🔷                                 -------- --...... Buffer Size:64
    🔷                                 ........ ..0000.. TID: 0
    🔷                                 ........ ......1. BlockAck Policy: Immediate Block Ack
    🔷                                 ........ .......0 A-MSDU: Not Permitted
  🔷 BlockAck Timeout Value:5000      TUs
📡 FCS - Frame Check Sequence
  🔷 FCS:                     0x3DD891AF

0000: D0 00 28 00 00 17 DF A6 4C 90 00 13 E8 1D F0 55 00 17 DF A6 4C   ..(.....L......U....L
0021: 90 C0 36 03 01 01 00 00 02 10 88 13 3D D8 91 AF                  ..6.........=...

For Help, press F1                                                      📑 None
```

A-MPDU 데이터 전송

- Block Ack에는 수신된 MPDU를 나타내는 압축된 비트맵이 포함되어 있습니다.
- 블록 ACK 전송에 대한 자세한 내용은 IEEE 802.11n 섹션 9.10.7 "HT-immediate Block Ack Extensions"를 참조하십시오.

신호에서 광고되는 기능

HT Capability Info
  Element ID: 45   HT Capability Info
  Length: 26
  HT Capability Info: %0001100001101110
                 0....... .... L-SIG TXOP Protection Support: Not Supported
                 .0...... .... AP allows use of 40MHz Transmissions In Neighboring BSSs
                 ..0..... .... Device/BSS does Not Support use of PSMP
                 ...1.... .... BSS does Allow use of DSSS/CCK Rates @40MHz
                 ....1... .... Maximal A-MSDU size: 7935 bytes
                 ......0.. .... Does Not Support HT-Delayed BlockAck Operation
                 ......00 .... No Rx STBC Support
                 .... 0....... Transmitter does Not Support Tx STBC
                 .... .1...... Short GI for 40 MHz: Supported
                 ....1..... Short GI for 20 MHz: Supported
                 ....0.... Device is Not Able to Receive PPDUs with GF Preamble
                 ....11.. Spatial Multiplexing Enabled
                 ....1. Both 20MHz and 40MHz Operation is Supported
                 ....0 LDPC coding capability: Not Supported
  A-MPDU Parameters: %00011011
                 xxx..... Reserved
                 ...110.. Minimum MPDU Start Spacing: 8 usec
                 ......11 Maximum Rx A-MPDU Size: 64K
  Supported MCS Set
    One Spatial Stream: %11111111
      MCS Index 0 Supported - BPSK. Coding Rate: 1/2
      MCS Index 1 Supported - QPSK. Coding Rate: 1/2
      MCS Index 2 Supported - QPSK. Coding Rate: 3/4
      MCS Index 3 Supported - 16 QAM. Coding Rate: 1/2
      MCS Index 4 Supported - 16 QAM. Coding Rate: 3/4
      MCS Index 5 Supported - 64 QAM. Coding Rate: 2/3
      MCS Index 6 Supported - 64 QAM. Coding Rate: 3/4
      MCS Index 7 Supported - 64 QAM. Coding Rate: 5/6
    Two Spatial Streams: %01111111
      MCS Index 8 Supported - BPSK. Coding Rate: 1/2
      MCS Index 9 Supported - QPSK. Coding Rate: 1/2
      MCS Index 10 Supported - QPSK. Coding Rate: 3/4
      MCS Index 11 Supported - 16 QAM. Coding Rate: 1/2
      MCS Index 12 Supported - 16 QAM. Coding Rate: 3/4
      MCS Index 13 Supported - 64 QAM. Coding Rate: 2/3
      MCS Index 14 Supported - 64 QAM. Coding Rate: 3/4
      MCS Index 15 Not Supported - 64 QAM. Coding Rate: 5/6
  Rx Bitmask b16-b23:   %00000000
  Rx Bitmask b24-b31:   %00000000
  Rx Bitmask b32-b39:   %00000000
  Rx Bitmask b40-b47:   %00000000
  Rx Bitmask b48-b55:   %00000000

비컨에서 광고되는 기능:

```
--- ⬤ Rx Bitmask b64-b76:    %0000000000000
--- ⬤ Reserved:              %000
--- ⬤ Highest Supported Rate:0  Mbps
--- ⬤ Reserved:              %000000
--- ⬤ Tx Supported MCS Set:  %0   Not Defined
--- ⬤ Tx and Rx MCS Set:     %0   Equal
--- ⬤ Tx Maximum Number Spatial Streams Supported:%00   1 Spatial Stream
--- ⬤ Tx Unequal Modulation:%0   Not Supported
--- ⬤ Reserved:              %00000000000000000000000000000   b101-b127
```
HT Extended Capabilities Info:%0000000000000000
```
--- ⬤              XXXX .... .... ....   Reserved
--- ⬤              .... 0... .... ....   Reverse Direction Responder: Supported
--- ⬤              .... .0.. .... ....   +HTC Support: Supported
--- ⬤              .... ..00 .... ....   MCS Feedback: STA Does Not Provide MCS Feedback
--- ⬤              .... .... XXXX X...   Reserved
--- ⬤              .... .... .... .00.   Transition Time: No Transition
--- ⬤              .... .... .... ...0   Transmitter Supports PCO: Supported
```
Tx Beam Forming Capability (TxBF):%00000000000000000000000000000000
```
--- ⬤    XXX. .... .... .... .... .... .... ....   Reserved
--- ⬤    ...0 0... .... .... .... .... .... ....   Channel Estimation Capability: 1 Space Time Stream
--- ⬤    .... .00. .... .... .... .... .... ....   CSI Max Number of Rows: 1 Row of CSI
--- ⬤    .... ...0 0... .... .... .... .... ....   Compressed BF Feedback Matrix: 1 TX Antenna Sounding
--- ⬤    .... .... .00. .... .... .... .... ....   Uncompressed BF Feedback Matrix: 1 TX Antenna Sounding
--- ⬤    .... .... ...0 0... .... .... .... ....   CSI Number of BF Antennas: 1 TX Antenna Sounding
--- ⬤    .... .... .... .00. .... .... .... ....   Minimal Grouping: STA Supports Groups of 1 (No Grouping)
--- ⬤    .... .... .... ...0 0... .... .... ....   Compressed BF Feedback Matrix: Not Supported
--- ⬤    .... .... .... .... .00. .... .... ....   Uncompressed BF Feedback Matrix: Not Supported
--- ⬤    .... .... .... .... ...0 0... .... ....   TxBF CSI Feedback: Not Supported
--- ⬤    .... .... .... .... .... .0.. .... ....   Compressed BF Feedback Matrix Capable: Not Supported
--- ⬤    .... .... .... .... .... ..0. .... ....   Uncompressed BF Feedback Matrix: Not Supported
--- ⬤    .... .... .... .... .... ...0 .... ....   Explicit CSI TxBF Capable: Not Supported
--- ⬤    .... .... .... .... .... .... 00.. ....   Calibration: Not Supported
--- ⬤    .... .... .... .... .... .... ..0. ....   Implicit TxBF Capable: Not Supported
--- ⬤    .... .... .... .... .... .... ...0 ....   Tx NDP Capable: Not Supported
--- ⬤    .... .... .... .... .... .... .... 0...   Rx NDP Capable: Not Supported
--- ⬤    .... .... .... .... .... .... .... .0..   Tx Staggered Sounding Capable: Not Supported
--- ⬤    .... .... .... .... .... .... .... ..0.   Rx Staggered Sounding Capable: Not Supported
--- ⬤    .... .... .... .... .... .... .... ...0   Implicit TxBF Receiving Capable: Not Supported
```
Antenna Selection Capability (ASEL):%00000000
```
--- ⬤         X... ....   Reserved
--- ⬤         .0.. ....   Tx Sounding PPDUs Capable: Not Supported
--- ⬤         ..0. ....   Rx ASEL Capable: Not Supported
--- ⬤         ...0 ....   Antenna Indices Feedback Capable: Not Supported
--- ⬤         .... 0...   Explicit CSI Feedback: Tx AS Capable: Not Supported
--- ⬤         .... .0..   Antenna Indices Feedback Based Tx ASEL Capable: Not Supported
--- ⬤         .... ..0.   Re-Explicit CSI Feedback Tx ASEL Capable: Not Supported
               .... ...0   Antenna Selection Capable: Not Supported
```

비컨에서 광고되는 기능:

```
Element ID:             61    Additional HT Information
Length:                 22
Primary Channel:        6
Srvc Int Granularity:   %000   6ms
PSMP STAs Only:         %0    Association Requests are Accepted Regardless of PSMP Capability
RIFS Mode:              %1    Use of RIFS Permitted
STA Channel Width:      %1    Use Any Channel Width Enabled Under Supported Channel Width Set
2nd Channel Offset:     %01   Above the Primary Channel
HT Info Element 2:      %0000000000000100
                           xxxxxxxx xxx..... Reserved
                           ........ ...0.... OBSS Non-HT STAs: Use of Protection for Non-HT STAs Not Needed
                           ........ ....0... Transmit Burst Limit: No Limit
                           ........ .....1.. Non-Greenfield STAs: One or more HT STAs are Not Greenfield Capable
                           ........ ......00 Operating Mode: Pure HT (No Protection) – All STAs in the BSS are 20/40 MHz HT
HT Info Element 3:      %0000000000000000
                           xxxx.... ........ Reserved
                           ....0... ........ PCO Phase: Switch To/Continue Use 20MHz Phase
                           .....0.. ........ PCO Active: Not Active in the BSS
                           ......0. ........ L-SIG TXOP Protection: Not Full Support
                           .......0 ........ Secondary Beacon: Primary Beacon
                           ........ 0....... Dual CTS Protection: Not Required
                           ........ .0...... Dual Beacon: No Secondary Beacon Transmitted
                           ........ ..xxxxxx Reserved
Basic MCS Set
    One Spatial Stream:    %00000000
        MCS Index 0 Not Supported – BPSK. Coding Rate: 1/2
        MCS Index 1 Not Supported – QPSK. Coding Rate: 1/2
        MCS Index 2 Not Supported – QPSK. Coding Rate: 3/4
        MCS Index 3 Not Supported – 16 QAM. Coding Rate: 1/2
        MCS Index 4 Not Supported – 16 QAM. Coding Rate: 3/4
        MCS Index 5 Not Supported – 64 QAM. Coding Rate: 2/3
        MCS Index 6 Not Supported – 64 QAM. Coding Rate: 3/4
        MCS Index 7 Not Supported – 64 QAM. Coding Rate: 5/6
    Two Spatial Streams:   %00000000
        MCS Index 8 Not Supported – BPSK. Coding Rate: 1/2
        MCS Index 9 Not Supported – QPSK. Coding Rate: 1/2
        MCS Index 10 Not Supported – QPSK. Coding Rate: 3/4
        MCS Index 11 Not Supported – 16 QAM. Coding Rate: 1/2
        MCS Index 12 Not Supported – 16 QAM. Coding Rate: 3/4
        MCS Index 13 Not Supported – 64 QAM. Coding Rate: 2/3
        MCS Index 14 Not Supported – 64 QAM. Coding Rate: 3/4
        MCS Index 15 Not Supported – 64 QAM. Coding Rate: 5/6
    Rx Bitmask b16-b23:    %00000000
    Rx Bitmask b24-b31:    %00000000
    Rx Bitmask b32-b39:    %00000000
    Rx Bitmask b40-b47:    %00000000
```

A-MPDU에 대한 블록 ACK 설정 추가와 유사한 연결:

194	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	6.0	14
195	00:17:DF:A6:4C:90	Ethernet Broadcast	802.11 Beacon	00:17:DF:A6:4C:90	*	100%	6.0	204
196	00:13:E8:1D:F0:55	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	81
197	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Probe Rsp	00:17:DF:A6:4C:90	*+	100%	6.0	204
198	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	6.0	14
199	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	87
200	00:13:E8:36:19:77	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	81
201	00:17:DF:A6:4C:90	00:13:E8:36:19:77	802.11 Probe Rsp	00:17:DF:A6:4C:90	*+	100%	6.0	204
202	00:13:E8:36:19:77	00:17:DF:A6:4C:90	802.11 Ack		#	100%	6.0	14
203	00:13:E8:36:19:77	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	74
204	00:13:E8:36:19:77	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	81
205	00:17:DF:A6:4C:90	00:13:E8:36:19:77	802.11 Probe Rsp	00:17:DF:A6:4C:90	*+	100%	6.0	204
206	00:13:E8:36:19:77	00:17:DF:A6:4C:90	802.11 Ack		#	100%	6.0	14
207	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	52%	1.0	55
208	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	97%	1.0	55
209	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	87
210	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	55
211	00:17:DF:A6:4C:90	Ethernet Broadcast	802.11 Beacon	00:17:DF:A6:4C:90	*	100%	6.0	204
212	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	95%	1.0	55
213	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	87
214	00:13:CE:89:DC:A2	Ethernet Broadcast	802.11 Probe Req	Ethernet Broadcast	*	100%	1.0	55
215	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Auth	00:17:DF:A6:4C:90	*	100%	36.0	34
216	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Ack		#	100%	36.0	14
217	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Auth	00:17:DF:A6:4C:90	*	100%	36.0	34
218	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
219	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Assoc Req	00:17:DF:A6:4C:90	*	100%	36.0	134
220	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Ack		#	100%	36.0	14
221	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Assoc Rsp	00:17:DF:A6:4C:90	*	100%	130.0	180
222	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
223	192.168.170.89	224.0.0.1	IGMP	00:17:DF:A6:4C:90		100%	130.0	84
224	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
225	192.168.170.89	224.0.0.1	IGMP	00:17:DF:A6:4C:90	+	100%	130.0	84
226	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
227	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	WLCCP	00:17:DF:A6:4C:90		100%	130.0	92
228	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
229	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Action	00:17:DF:A6:4C:90	*	100%	130.0	37
230	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Ack		#	100%	36.0	14
231	00:13:E8:1D:F0:55	00:17:DF:A6:4C:90	802.11 Action	00:17:DF:A6:4C:90	*	100%	36.0	37
232	00:17:DF:A6:4C:90	00:13:E8:1D:F0:55	802.11 Ack		#	100%	36.0	14

Verifying A-MPDU is enabled on the controller

Above is a beacon frame from an SSID enabled for n rates

- *************** **Showing the channel Width to be 40MHz** **

- interface Dot11Radio1
- Radio AIR-RM1252A, Base Address 001f.9ea6.8520, BBlock version 0.00, Software version 2.10.20
- Serial number: FOC1212405A
- Number of supported simultaneous BSSID on Dot11Radio1: 16
- Carrier Set: Americas (OFDM) (US) (-A)
- Uniform Spreading Required: Yes
- **Configured Frequency: 5180 MHz Channel 36 40MHz, extended above**
- Allowed Frequencies: 5180(36) 5200(40) 5220(44) 5240(48) *5260(52) *5280(56) *5300(60) *5320(64) *5500(100) *5520(104) *5540(108) *5560(112) *5580(116) *5660(132) *5680(136) *5700(140) 5745(149) 5765(153) 5785(157) 5805(161) 5825(165)
- * = May only be selected by Dynamic Frequency Selection (DFS)
- Listen Frequencies: 5180(36) 5200(40) 5220(44) 5240(48) 5260(52) 5280(56) 5300(60) 5320(64) 5500(100) 5520(104) 5540(108) 5560(112) 5580(116) 5660(132) 5680(136) 5700(140) 5745(149) 5765(153) 5785(157) 5805(161) 5825(165)
- Beacon Flags: 0, Interface Flags 20105; Beacons are enabled; Probes are enabled
- Configured Power: 14 dBm (level 1)
- Active power levels by rate
-    6.0 to 54.0 , 14 dBm
-   6.0-bf to 54.0-b, 8   dBm, changed due to regulatory maximum
-     m0. to m15.-4, 11 dBm, changed due to regulatory maximum
-   OffChnl Power: 14, Rate 6.0
-   --More--   Allowed Power Levels: -1 2 5 8 11 14
-   --More--   Allowed Client Power Levels: 2 5 8 11 14
- Receive Antennas : right-a left-b middle-c
- Transmit Antennas : right-a left-b, ofdm single
- Antenna: external, Gain: Allowed 11, Reported 0, Configured 0, In Use 11
- Active Rates: basic-6.0 9.0 basic-12.0 18.0 basic-24.0 36.0 48.0 54.0
- Current Rates: basic-6.0 9.0 basic-12.0 18.0 basic-24.0 36.0 48.0 54.0
- Allowed Rates: 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0
- All Rates: 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 m0. m1. m2. m3. m4. m5. m6. m7. m8. m9. m10. m11. m12. m13. m14. m15.
- **Default Rates: basic-6.0 9.0 basic-12.0 18.0 basic-24.0 36.0 48.0 54.0 m0. m1. m2. m3. m4. m5. m6. m7. m8. m9. m10. m11. m12. m13. m14. m15.**
- **Best Range Rates: basic-6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 m0. m1. m2. m3. m4. m5. m6. m7. m8. m9. m10. m11. m12. m13. m14. m15.**
- **Best Throughput Rates: basic-6.0 basic-9.0 basic-12.0 basic-18.0 basic-24.0 basic-36.0 basic-48.0 basic-54.0 m0. m1. m2. m3. m4. m5. m6. m7. m8. m9. m10. m11. m12. m13. m14. m15.**

MCS Rates on 802.11n beacon

Supported MCS rates

802.11a with N rates Enabled

802.11A Beacon frame

관련 정보

- 기술 지원 및 문서 – Cisco Systems