802.11ac wireless throughput testing and validation guide

Contents

Introduction

This document will describe the way of testing the wireless throughput of an access point focusing on 802.11ac and what throughput to expect in given conditions.

Prerequisites

Requirements

This document assumes an already functioning setup with 802.11ac access points (APs) giving client connectivity already

Components Used

The information in this document is focused on 802.11ac technology and speeds.

Cisco APs with Wave1 technology:

3700 series

2700 series

1700 series

1570 series

Cisco APs with Wave2 technology:

4800 series

3800 series

2800 series

1850 series

1830 series

1560 series

1540 series

Understand

The 802.11ac can be subdivided into two standards: Wave1 and Wave2:

	802.11n	802.11n IEEE Specification	802.11ac Wave 1 Today	802.11ac Wave2 WFA Certification Process Continues	802.11ac IEEE Specification
Band	2.4 GHz & 5 GHz	2.4 GHz & 5 GHz	5 GHz	**5 GHz**	5 GHz
MIMO	Single User (SU)	Single User (SU)	Single User (SU)	**Multi User (MU)**	Multi User (MU)
PHY Rate	450 Mbps	600 Mbps	1.3 Gbps	**2.34 Gbps - 3.47 Gbps**	6.9 Gbps
Channel Width	20 or 40 MHz	20 or 40 MHz	20, 40, 80 MHz	20, 40, 80, **80-80, 160** MHz	20, 40, 80, 80-80, 160 MHz
Modulation	64 QAM	64 QAM	256 QAM	256 QAM	256 QAM
Spatial Streams	3	4	3	3-**4**	8
MAC Throughout*	293 Mbps	390 Mbps	845 Mbps	1.52 Gbps- 2.26 Gbps	4.49 Gbps

* Assuming a 65% MAC efficiency with highest MCS

802.11ac Wave1: supports up to 1.3 Gbps data rates on 3 spatial streams with 80 MHz channel bonding.

802.11ac Wave2: supports up to 3.47 Gbps data rates on 4 spatial streams with 160 MHz channel bonding. These numbers are only the theoretical numbers from the standard, differences will apply depending on the specific AP datasheet.

802.11ac is not directly defined in data rates speed, but is rather a combination of 10 modulation encoding scheme (MCS 0 to MCS 9), a channel width ranging from 20mhz (1 channel) to 160Mhz (8 channels), a number of spatial streams (typically 1 to 4). The short or long Guard Interval (GI) will also add around a 10% modification to this. Here is a table to evaluate a datarate in Mbps when knowing all those factors :

Spatial Streams	VHT MCS Index	Modulation	Coding Rate	20 MHz Data Rates (Mb/s)		40 MHz Data Rates (Mb/s)		80 MHz Data Rates (Mb/s)		160 MHz / 80+80 MHz Data Rates (Mb/s)	
				800ns GI	400ns GI	800ns GI	400ns GI	800ns GI	400ns GI	800ns GI	400

1	0	BPSK	1/2	6.5	7.2	13.5	15.0	29.3	32.5	58.5	65.
	1	QPSK	1/2	13.0	14.4	27.0	30.0	58.5	65.0	117.0	130
	2	QPSK	3/4	19.5	21.7	40.5	45.0	87.8	97.5	175.5	195
	3	16-QAM	1/2	26.0	28.9	54.0	60.0	117.0	130.0	234.0	260
	4	16-QAM	3/4	39.0	43.3	81.0	90.0	175.5	195.0	351.0	390
	5	64-QAM	2/3	52.0	57.8	108.0	120.0	234.0	260.0	468.0	520
	6	64-QAM	3/4	58.5	65.0	121.5	135.0	263.3	292.5	526.5	585
	7	64-QAM	5/6	65.0	72.2	135.0	150.0	292.5	325.0	585.0	650
	8	256-QAM	3/4	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780
	9	256-QAM	5/6	n/a	n/a	180.0	200.0	390.0	433.3	780.0	866
2	0	BPSK	1/2	13.0	14.4	27.0	30.0	58.5	65.0	117.0	130
	1	QPSK	1/2	26.0	28.9	54.0	60.0	117.0	130.0	234.0	260
	2	QPSK	3/4	39.0	43.3	81.0	90.0	175.5	195.0	351.0	390
	3	16-QAM	1/2	52.0	57.8	108.0	120.0	234.0	260.0	468.0	520
	4	16-QAM	3/4	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780
	5	64-QAM	2/3	104.0	115.6	216.0	240.0	468.0	520.0	936.0	104
	6	64-QAM	3/4	117.0	130.0	243.0	270.0	526.5	585.0	1053.0	117
	7	64-QAM	5/6	130.0	144.4	270.0	300.0	585.0	650.0	1170.0	130
	8	256-QAM	3/4	156.0	173.3	324.0	360.0	702.0	780.0	1404.0	156
	9	256-QAM	5/6	n/a	n/a	360.0	400.0	780.0	866.7	1560.0	173
3	0	BPSK	1/2	19.5	21.7	40.5	45.0	87.8	97.5	175.5	195
	1	QPSK	1/2	39.0	43.3	81.0	90.0	175.0	195.0	351.0	390
	2	QPSK	3/4	58.5	65.0	121.5	135.0	263.0	292.5	526.5	585
	3	16-QAM	1/2	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780
	4	16-QAM	3/4	117.0	130.0	243.0	270.0	526.5	585.0	1053.0	117
	5	64-QAM	2/3	156.0	173.3	324.0	360.0	702.0	780.0	1404.0	156
	6	64-QAM	3/4	175.5	195.0	364.5	405.0	n/a	n/a	1579.5	175
	7	64-QAM	5/6	195.0	216.7	405.0	450.0	877.5	975.0	1755.0	195
	8	256-QAM	3/4	234.0	260.0	486.0	540.0	1053.0	1170.0	2106.0	234
	9	256-QAM	5/6	260.0	288.9	540.0	600.0	1170.0	1300.0	n/a	n/a
4	0	BPSK	1/2	26.0	28.9	54.0	60.0	117.0	130.0	234.0	260
	1	QPSK	1/2	52.0	57.8	108.0	120.0	234.0	260.0	468.0	520
	2	QPSK	3/4	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780
	3	16-QAM	1/2	104.0	115.6	216.0	240.0	468.0	520.0	936.0	104
	4	16-QAM	3/4	156.0	173.3	324.0	360.0	702.0	780.0	1404.0	156
	5	64-QAM	2/3	208.0	231.1	432.0	480.0	936.0	1040.0	1872.0	208
	6	64-QAM	3/4	234.0	260.0	486.0	540.0	1053.0	1170.0	2106.0	234
	7	64-QAM	5/6	260.0	288.9	540.0	600.0	1170.0	1300.0	2340.0	260
	8	256-QAM	3/4	312.0	346.7	648.0	720.0	1404.0	1560.0	2808.0	312
	9	256-QAM	5/6	n/a	n/a	720.0	800.0	1560.0	1733.3	3120.0	346
	9	256-QAM	5/6	n/a	n/a	1440.0	1600.0	3120.0	3466.7	6240.0	693

Note: The data rate is NOT equal to the expected achievable throughput. This is related to the nature of 802.11 standard which has a lot of administrative overhead (management frames, contention, collision,acknowledgements,...) and it can depend on the link SNR, RSSI and other significant factors.

Note as well that wireless is shared environment, this means that the amount of clients connected to the AP will be sharing the effective throughput between each other. On top of that, more clients mean more contention and inevitably more collision. The effiency of the coverage cell will drastically decrease as the number of clients increase.

It is a rule of thumb:

Expected throughput = Data Rate x 0.65

In our case:

780 x 0.65 = 507

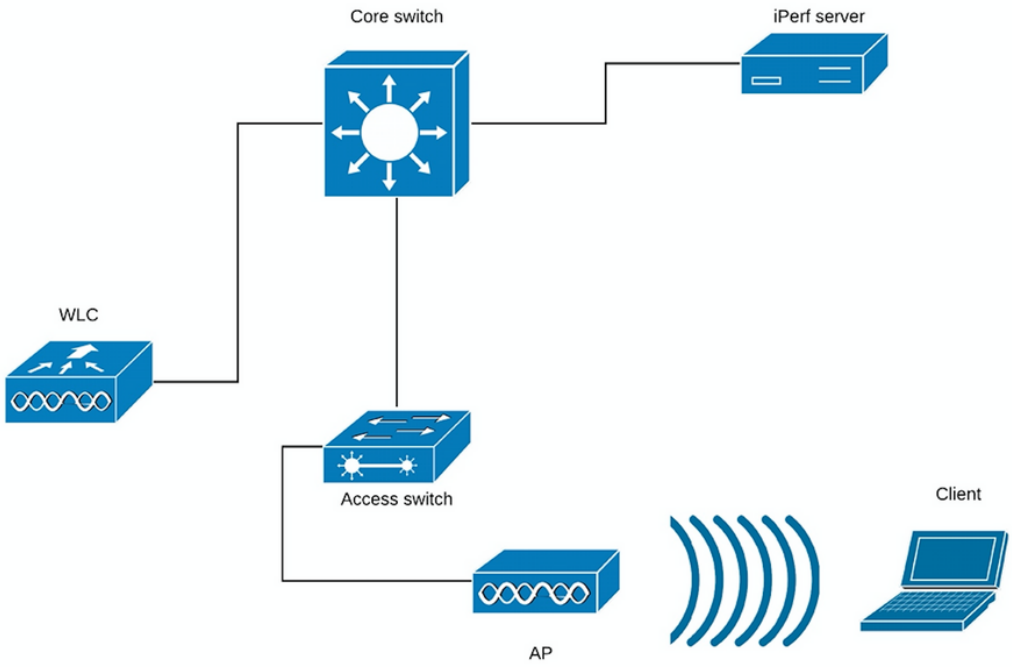
507 Mbps of throughput is what we may expect in good conditions in a lab with a single client.

Measure

Generally speaking, we can have two scenarios when we do a throughput test:

- APs are in Flexconnect local switching
- APs are in local mode or Flexconnect central switching

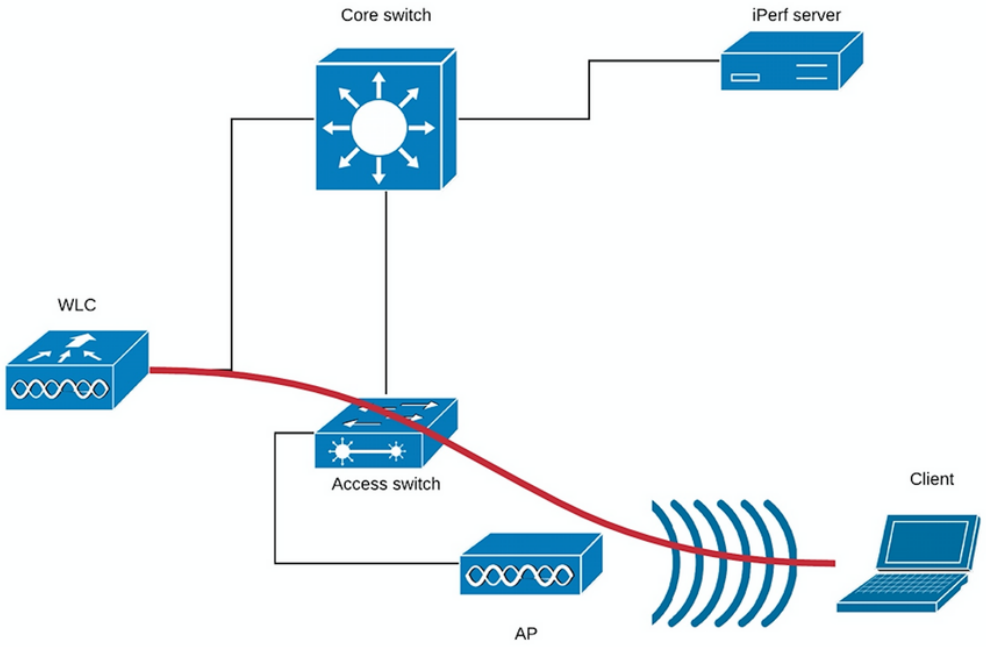
We will take those scenarios one by one:



(Diagram 1)

In case of Diagram 1 we suppose that the APs are in local mode of Flexconnect central switching.

This means that all client traffic is encapsulated into CAPWAP tunnel and terminated on the WLC.

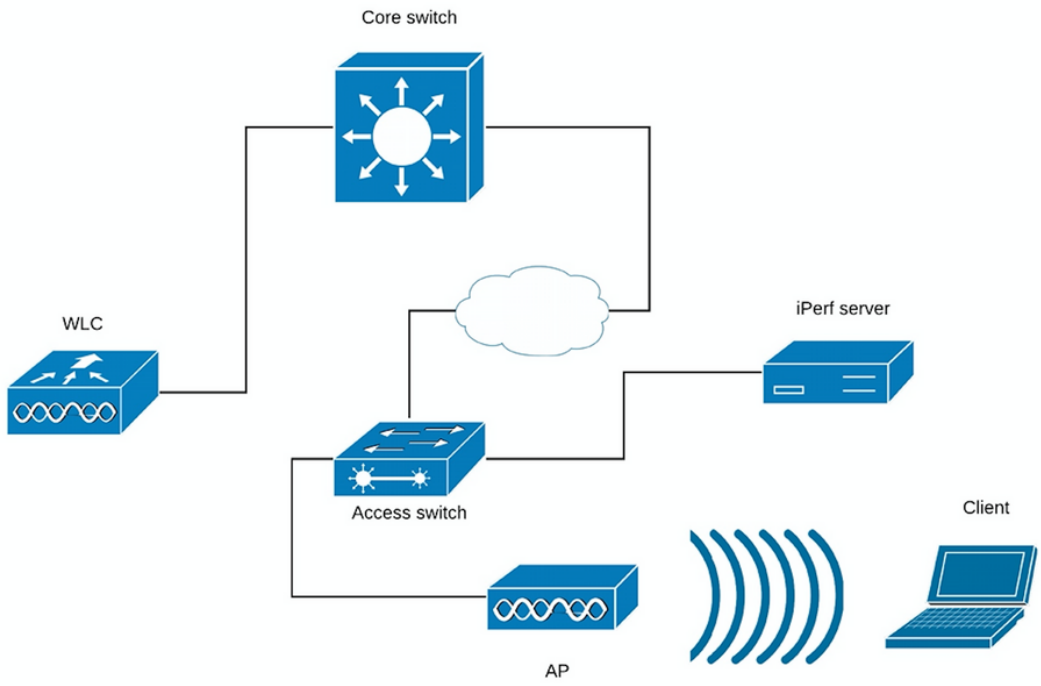


(Diagram 2)

The red line in the Diagram 2 shows the traffic flow from the wireless client.

The iPerf server should be as close as possible to the traffic termination point, ideally plugged in the same switch as the WLC itself and use the same VLAN.

In case of Flexconnect local switching, the client traffic is terminated on the AP itself, and considering that the iPerf server should be set up as close to the termination point of wireless client traffic, you should plug in the iPerf server to the same switch and same VLAN where AP is plugged. In our case this is access switch (Diagram 3).



(Diagram 3)

The iPerf tests can be subdivided into two categories: upstream and downstream.

Considering that the iPerf server is listening and iPerf client is generating the traffic, when the iPerf server is on the wired side, this is considered upstream test.

The wireless client will be using the iPerf application to push the traffic into the network.

The downstream test is vice-versa, meaning that the iPerf server is set on the wireless client itself and the iPerf client is on the wired side pushing the traffic to the wireless client, in this scenario this is considered downstream.

The test should be done using TCP and UDP. You can use the following commands to perform the tests:

```
iperf3 -s  <- this command starts iPerf server

iperf3 -c SERVER_ADDRESS -u -b700M <- this command initiates UDP iPerf test with bandwidth of
700 Mbps

iperf3 -c SERVER_ADDRESS <- this command initiates a simple TCP iPerf test

iperf3 -c SERVER_ADDRESS  -w WIDOW_SIZE  -P NUM_OF_PARALLEL_TCP_STREAMS <- this commands
initiates a more complex  TCP iPerf test where you can adjust the window size as well the number
of parallel TCP streams.
Please not that in this case you should consider the sum of all the streams as the result
```

Example of iPerf3 outputs:

TCP iPerf3:

```
iperf3 -s  <- this command starts iPerf server

iperf3 -c SERVER_ADDRESS -u -b700M <- this command initiates UDP iPerf test with bandwidth of
700 Mbps

iperf3 -c SERVER_ADDRESS <- this command initiates a simple TCP iPerf test

iperf3 -c SERVER_ADDRESS  -w WIDOW_SIZE  -P NUM_OF_PARALLEL_TCP_STREAMS <- this commands
initiates a more complex  TCP iPerf test where you can adjust the window size as well the number
of parallel TCP streams.
Please not that in this case you should consider the sum of all the streams as the result
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iperf3 -c SERVER_ADDRESS  -w WIDOW_SIZE  -P NUM_OF_PARALLEL_TCP_STREAMS <- this commands
initiates a more complex  TCP iPerf test where you can adjust the window size as well the number
of parallel TCP streams.
Please not that in this case you should consider the sum of all the streams as the result
```


UDP iPerf3:

Sometime iPerf does misbehave and does not give the average bandwidth in the end of the UDP test.

It is still possible to sum up the Bandwidth for each second and then devide it by number of seconds:


```
iperf3 -s  <- this command starts iPerf server

iperf3 -c SERVER_ADDRESS -u -b700M <- this command initiates UDP iPerf test with bandwidth of
700 Mbps

iperf3 -c SERVER_ADDRESS <- this command initiates a simple TCP iPerf test

iperf3 -c SERVER_ADDRESS  -w WIDOW_SIZE  -P NUM_OF_PARALLEL_TCP_STREAMS <- this commands
initiates a more complex  TCP iPerf test where you can adjust the window size as well the number
of parallel TCP streams.
Please not that in this case you should consider the sum of all the streams as the result
```


> **Note**: It is expected that the iPerf results will be slightly better on the Flexconnect local siwtching compared to the central switching scenario.
> This is caused by the fact that client traffic is encapsulated into CAPWAP, which adds more overhead to the traffic and in general the WLC acts as a bottleneck as it is the aggregation point for all wireless clients traffic.
> As well, it is expected that the UDP iPerf test will give better results in a clean environment as it is the most efficient transfer method when the connection is reliable. TCP however, might win in case of heavy fragmentation (when TCP Adjust MSS is used) or unreliable connection

.

Verify and validate

In order to check at which data rate the client is connected you need to issue following command in WLC CLI:

```
(Cisco Controller) >show client detail 94:65:2d:d4:8c:d6
Client MAC Address.............................. 94:65:2d:d4:8c:d6
Client Username ................................ N/A
AP MAC Address.................................. 00:81:c4:fb:a8:20
AP Name......................................... AIR-AP3802I-E-K9
AP radio slot Id................................ 1
Client State.................................... Associated
Client User Group..............................
Client NAC OOB State............................ Access
Wireless LAN Id................................. 2
Wireless LAN Network Name (SSID)................ speed-test-WLAN-avitosin
Wireless LAN Profile Name....................... speed-test
Hotspot (802.11u)............................... Not Supported
BSSID........................................... 00:81:c4:fb:a8:2e
Connected For .................................. 91 secs
Channel......................................... 52
IP Address...................................... 192.168.240.33
Gateway Address................................. 192.168.240.1
Netmask......................................... 255.255.255.0
Association Id.................................. 1
Authentication Algorithm........................ Open System
Reason Code..................................... 1
Status Code..................................... 0

--More-- or (q)uit
Session Timeout................................. 1800
Client CCX version.............................. No CCX support
QoS Level....................................... Silver
Avg data Rate................................... 0
Burst data Rate................................. 0
Avg Real time data Rate......................... 0
Burst Real Time data Rate....................... 0
802.1P Priority Tag............................. disabled
CTS Security Group Tag.......................... Not Applicable
KTS CAC Capability.............................. No
Qos Map Capability.............................. No
WMM Support..................................... Enabled
  APSD ACs.....................................  BK  BE  VI  VO
Current Rate.....................................  m9 ss2
Supported Rates................................. 12.0,18.0,24.0,36.0,48.0,
    ........................................... 54.0
Mobility State.................................. Local
Mobility Move Count............................. 0
Security Policy Completed....................... Yes
Policy Manager State............................ RUN
Audit Session ID................................ 0a3027a4000000105a9cd9ad
AAA Role Type................................... none
Local Policy Applied............................ none

--More-- or (q)uit
IPv4 ACL Name................................... none
FlexConnect ACL Applied Status.................. Unavailable
IPv4 ACL Applied Status......................... Unavailable
IPv6 ACL Name................................... none
IPv6 ACL Applied Status......................... Unavailable
Layer2 ACL Name................................. none
Layer2 ACL Applied Status....................... Unavailable
mDNS Status..................................... Disabled
mDNS Profile Name............................... none
```

```
No. of mDNS Services Advertised..... 0
Policy Type..... N/A
Encryption Cipher..... None
Protected Management Frame ..... No
Management Frame Protection..... No
EAP Type..... Unknown
Interface..... vlan240
VLAN..... 240
Quarantine VLAN..... 0
Access VLAN..... 240
Local Bridging VLAN..... 240
Client Capabilities:
      CF Pollable..... Not implemented
      CF Poll Request..... Not implemented

--More-- or (q)uit
      Short Preamble..... Not implemented
      PBCC..... Not implemented
      Channel Agility..... Not implemented
      Listen Interval..... 1
      Fast BSS Transition..... Not implemented
      11v BSS Transition..... Implemented
Client Wifi Direct Capabilities:
      WFD capable..... No
      Manged WFD capable..... No
      Cross Connection Capable..... No
      Support Concurrent Operation..... No
Fast BSS Transition Details:
Client Statistics:
      Number of Bytes Received..... 183844
      Number of Bytes Sent..... 119182
      Total Number of Bytes Sent..... 119182
      Total Number of Bytes Recv..... 183844
      Number of Bytes Sent (last 90s)..... 119182
      Number of Bytes Recv (last 90s)..... 183844
      Number of Packets Received..... 2536
      Number of Packets Sent..... 249
      Number of Interim-Update Sent..... 0
      Number of EAP Id Request Msg Timeouts..... 0

--More-- or (q)uit
      Number of EAP Id Request Msg Failures..... 0
      Number of EAP Request Msg Timeouts..... 0
      Number of EAP Request Msg Failures..... 0
      Number of EAP Key Msg Timeouts..... 0
      Number of EAP Key Msg Failures..... 0
      Number of Data Retries..... 0
      Number of RTS Retries..... 0
      Number of Duplicate Received Packets..... 0
      Number of Decrypt Failed Packets..... 0
      Number of Mic Failured Packets..... 0
      Number of Mic Missing Packets..... 0
      Number of RA Packets Dropped..... 0
      Number of Policy Errors..... 0
      Radio Signal Strength Indicator..... -25 dBm
      Signal to Noise Ratio..... 67 dB
Client Rate Limiting Statistics:
      Number of Data Packets Received..... 0
      Number of Data Rx Packets Dropped..... 0
      Number of Data Bytes Received..... 0
      Number of Data Rx Bytes Dropped..... 0
      Number of Realtime Packets Received..... 0
      Number of Realtime Rx Packets Dropped..... 0
      Number of Realtime Bytes Received..... 0
```

```
--More-- or (q)uit
      Number of Realtime Rx Bytes Dropped........ 0
      Number of Data Packets Sent................ 0
      Number of Data Tx Packets Dropped.......... 0
      Number of Data Bytes Sent.................. 0
      Number of Data Tx Bytes Dropped............ 0
      Number of Realtime Packets Sent............ 0
      Number of Realtime Tx Packets Dropped...... 0
      Number of Realtime Bytes Sent.............. 0
      Number of Realtime Tx Bytes Dropped........ 0
Nearby AP Statistics:
DNS Server details:
      DNS server IP ............................. 10.48.39.33
      DNS server IP ............................. 0.0.0.0
Assisted Roaming Prediction List details:


 Client Dhcp Required:     False
Allowed (URL)IP Addresses
-------------------------

AVC Profile Name: ............................... none
```

You can see the this particular client is connected on the following rate:

Current Rate..... m9 ss2

Which means that the client is using the MCS 9 (m9) index on 2 spatial streams (ss2)

From the "show client detail <MAC>" command, it is not possible to see if the client is connected on 20/40/80 MHz channel bonding.

This can be done directly on the AP:

Wave2 AP example:

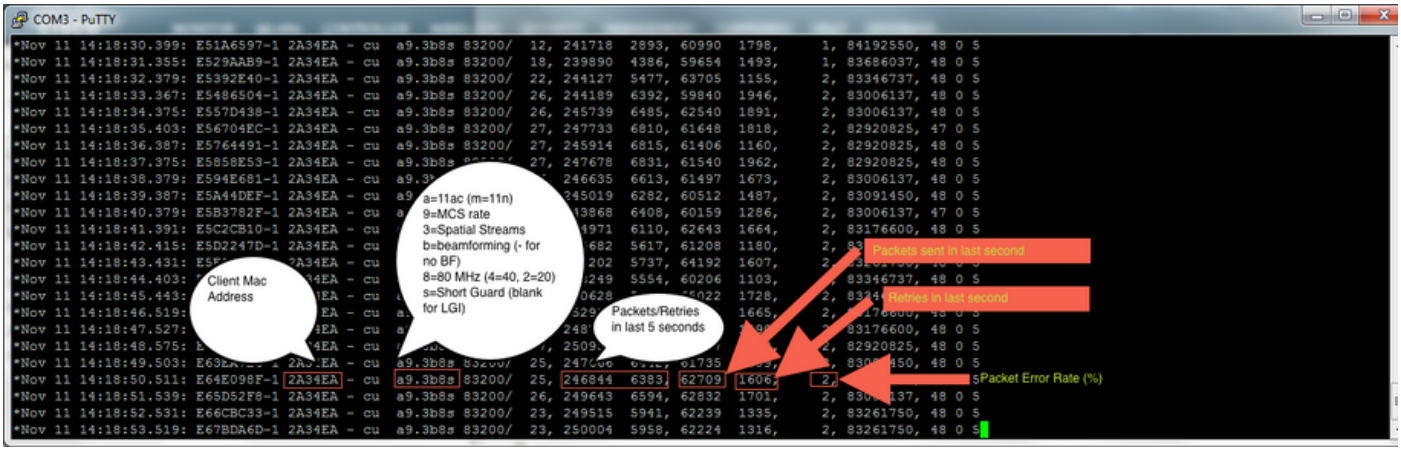
```
AIR-AP3802I-E-K9#show controllers dot11Radio 1 client 94:65:2D:D4:8C:D6
              mac radio vap aid state encr Maxrate is_wgb_wired      wgb_mac_addr
94:65:2D:D4:8C:D6     1   1   1   FWD OPEN MCS92SS        false 00:00:00:00:00:00

Configured rates for client 94:65:2D:D4:8C:D6
Legacy Rates(Mbps): 12 18 24 36 48 54
HT Rates(MCS):M0 M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15
VHT Rates: 1SS:M0-7 2SS:M0-9
HT:yes     VHT:yes     80MHz:yes     40MHz:yes     AMSDU:yes     AMSDU_long:yes
11w:no     MFP:no     11h:yes     encrypt_polocy: 1
_wmm_enabled:yes     qos_capable:yes     WME(11e):no     WMM_MIXED_MODE:no
short_preamble:no     short_slot_time:no     short_hdr:no     SM_dyn:yes
short_GI_20M:yes     short_GI_40M:yes     short_GI_80M:yes     LDPC:yes
is_wgb_wired:no     is_wgb:no

Additional info for client 94:65:2D:D4:8C:D6
RSSI: -25
PS  : Legacy (Awake)
Tx Rate: 0 Kbps
Rx Rate: 0 Kbps
VHT_TXMAP: 0
CCX Ver: 0

Statistics for client 94:65:2D:D4:8C:D6
```

```
              mac   intf TxData TxMgmt TxUC TxBytes TxFail TxDcrd RxData RxMgmt RxBytes RxErr
TxRt   RxRt idle_counter stats_ago expiration
94:65:2D:D4:8C:D6 apr1v1    254      0  254  121390      0      0   2568      0  185511     0
585000 866700          300  2.492000       1640

Per TID packet statistics for client 94:65:2D:D4:8C:D6
Priority Rx Pkts Tx Pkts Rx(last 5 s) Tx (last 5 s) QID Tx Drops Tx Cur Qlimit
       0    1424     146           17             3 136        0      0   4096
       1       0       0            0             0 137        0      0   4096
       2       0       0            0             0 138        0      0   4096
       3      34      26            0             0 139        0      0   4096
       4       0       0            0             0 140        0      0   4096
       5       0       0            0             0 141        0      0   4096
       6       0       0            0             0 142        0      0   4096
       7       0       0            0             0 143        0      0   4096
```

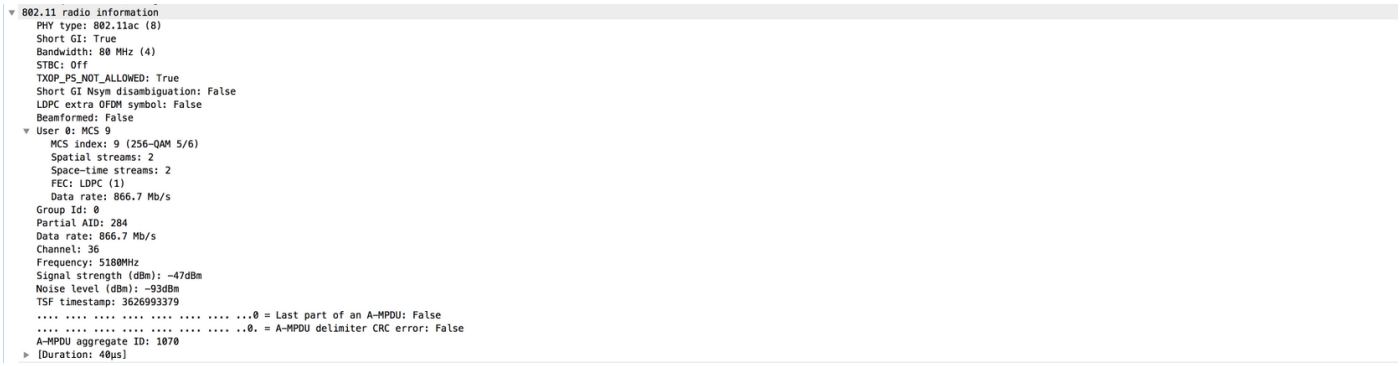
In case of Wave1 AP you need to run the debugs:

```
AIR-AP3802I-E-K9#show controllers dot11Radio 1 client 94:65:2D:D4:8C:D6
              mac radio vap aid state encr Maxrate is_wgb_wired      wgb_mac_addr
94:65:2D:D4:8C:D6     1   1   1   FWD OPEN MCS92SS        false 00:00:00:00:00:00

Configured rates for client 94:65:2D:D4:8C:D6
Legacy Rates(Mbps): 12 18 24 36 48 54
HT Rates(MCS):M0 M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15
VHT Rates: 1SS:M0-7 2SS:M0-9
HT:yes     VHT:yes     80MHz:yes     40MHz:yes     AMSDU:yes     AMSDU_long:yes
11w:no     MFP:no     11h:yes     encrypt_polocy: 1
_wmm_enabled:yes     qos_capable:yes     WME(11e):no     WMM_MIXED_MODE:no
short_preamble:no     short_slot_time:no     short_hdr:no     SM_dyn:yes
short_GI_20M:yes     short_GI_40M:yes     short_GI_80M:yes     LDPC:yes
is_wgb_wired:no     is_wgb:no

Additional info for client 94:65:2D:D4:8C:D6
RSSI: -25
PS  : Legacy (Awake)
Tx Rate: 0 Kbps
Rx Rate: 0 Kbps
VHT_TXMAP: 0
CCX Ver: 0

Statistics for client 94:65:2D:D4:8C:D6
              mac   intf TxData TxMgmt TxUC TxBytes TxFail TxDcrd RxData RxMgmt RxBytes RxErr
TxRt   RxRt idle_counter stats_ago expiration
94:65:2D:D4:8C:D6 apr1v1    254      0  254  121390      0      0   2568      0  185511     0
585000 866700          300  2.492000       1640

Per TID packet statistics for client 94:65:2D:D4:8C:D6
Priority Rx Pkts Tx Pkts Rx(last 5 s) Tx (last 5 s) QID Tx Drops Tx Cur Qlimit
       0    1424     146           17             3 136        0      0   4096
       1       0       0            0             0 137        0      0   4096
       2       0       0            0             0 138        0      0   4096
       3      34      26            0             0 139        0      0   4096
       4       0       0            0             0 140        0      0   4096
       5       0       0            0             0 141        0      0   4096
       6       0       0            0             0 142        0      0   4096
       7       0       0            0             0 143        0      0   4096
```

The meaning of the debug output can be found in the following picture:



The last option to check the connected rate is OTA captures. In the radio information of the data packet you can find the necessary information:



This OTA capture was taken with an 11ac macbook client.

Considering the information we get from the WLC and AP, the client is connected on m9 ss2 at 80 MHz channel bonding + long GI (800ns), which means that we can expect data rate of 780 Mbps.

> **Note**: APs in sniffer mode will not log 11ac data rates properly before version 8.5.130. Wireshark 2.4.6 or later will also be required to decide it properly.

Troubleshoot

In case you are not getting expected results during the test, there are several ways to troubleshoot the issue and collect necessary information before opening a TAC case.

The troughput issues can be caused by the following:

- Client

- AP

- Wired path (switching related issues)

- WLC

Client troubleshooting

- First step will be updating the drivers on the wireless client devices to the latest version
- Second step will be doing the iPerf test with clients that have a different wireless adapter to see if you get the same results

AP troubleshooting

There might be scenarios when the AP is dropping traffic, or certain frames or otherwise misbehaving.

In order to get more insight about this, there are needed Over The Air (OTA) captures + span session on the AP switchport (span should be done on the switch where the AP is connected)

The OTA captures and SPAN should be done during the test, using open SSID in order to be able to see the traffic passed to the AP and the traffic AP is passing towards the client and vice a versa.

There are several known bugs for this behavior:

CSCvg07438 : AP3800: Low throughput due to packet drops in AP in both fragmented and non-fragmented packets

CSCva58429 : Cisco 1532i AP: low throughput (FlexConnect Local switching + EoGRE)

Wired path troubleshooting

There might be some problems on the switch itself, you need to check the amount of drops on the interfaces and if those increase during the tests.

Try using another port on the switch to connect the AP or WLC.

Another option is to plug in a client to the same switch (where the client termination point [AP/WLC] is connected to) and put it to the same VLAN, then run the tests wired to wired on the same VLAN to see if there are any issues in the wired path.

WLC troubleshooting

It can be that the WLC is dropping the traffic (when APs are in local mode) from the client.

You can put the AP in Flexconnect mode and the WLAN into local switching, then run the tests.

If you see that there are significant differences in the throughput in local mode (central switching) compared to Flexconnect local switching and there is no problem on the switch connected to WLC, then most probably the WLC is dropping the traffic.

To troubleshoot this follow the action plan:

- SPAN captures on the WLC switchport (should be done on the switch)

- SPAN captures on the AP port

- OTA captures of the client

- Following debugs on WLC:

```
AIR-AP3802I-E-K9#show controllers dot11Radio 1 client 94:65:2D:D4:8C:D6
              mac radio vap aid state encr Maxrate is_wgb_wired      wgb_mac_addr
94:65:2D:D4:8C:D6     1   1   1   FWD OPEN MCS92SS        false 00:00:00:00:00:00

Configured rates for client 94:65:2D:D4:8C:D6
Legacy Rates(Mbps): 12 18 24 36 48 54
HT Rates(MCS):M0 M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15
VHT Rates: 1SS:M0-7 2SS:M0-9
HT:yes     VHT:yes     80MHz:yes     40MHz:yes     AMSDU:yes     AMSDU_long:yes
11w:no     MFP:no     11h:yes     encrypt_polocy: 1
_wmm_enabled:yes     qos_capable:yes     WME(11e):no     WMM_MIXED_MODE:no
short_preamble:no     short_slot_time:no     short_hdr:no     SM_dyn:yes
short_GI_20M:yes     short_GI_40M:yes     short_GI_80M:yes     LDPC:yes
is_wgb_wired:no     is_wgb:no

Additional info for client 94:65:2D:D4:8C:D6
RSSI: -25
PS  : Legacy (Awake)
Tx Rate: 0 Kbps
Rx Rate: 0 Kbps
VHT_TXMAP: 0
CCX Ver: 0

Statistics for client 94:65:2D:D4:8C:D6
              mac   intf TxData TxMgmt TxUC TxBytes TxFail TxDcrd RxData RxMgmt RxBytes RxErr
TxRt   RxRt idle_counter stats_ago expiration
94:65:2D:D4:8C:D6 apr1v1    254      0  254  121390      0      0   2568      0  185511     0
585000 866700          300  2.492000       1640

Per TID packet statistics for client 94:65:2D:D4:8C:D6
Priority Rx Pkts Tx Pkts Rx(last 5 s) Tx (last 5 s) QID Tx Drops Tx Cur Qlimit
       0    1424     146           17             3 136        0      0   4096
       1       0       0            0             0 137        0      0   4096
       2       0       0            0             0 138        0      0   4096
       3      34      26            0             0 139        0      0   4096
       4       0       0            0             0 140        0      0   4096
       5       0       0            0             0 141        0      0   4096
       6       0       0            0             0 142        0      0   4096
       7       0       0            0             0 143        0      0   4096
```

By performing the above mentioned troubleshooting and providing the results to TAC, this will sped up the troubleshooting process.