Content

Chapter 1 WMM QoS

1.1 Introduction to WMM QoS

802.11 network provides wireless access service based on competition. The requirements of different application for network are different. The original network cannot provide the access service with different quality for different application, so it cannot satisfy the actual application demand.

For distinguishing services, we provide ability to support peer-to-peer QoS. The QoS policy application of peer-to-peer application layer and IP layer requires providing the policy which supports QoS service in link layer and MAC layer. IEEE 802.11e corrects the definition of coordination function and leads into the new access coordination function of HCF (Hybrid Coordination Function). HCF includes the distinguishing service function based on competition of EDCA (Enhanced Distributed Channel Access) and HCCA based on no competition (HCF Controlled Channel Access). It adds QoS property for WLAN based on 802.11 protocol and the standardization time of this protocol is very long. In this process, Wi-Fi organization defines WMM (Wi-Fi Multimedia) standard for making sure the devices interoperability provided by different WLAN companies.

Through WMM protocol, 802.11 can provide wireless network access service which supports QoS in link layer and MAC layer. With the QoS policy of application layer and IP layer which wired network has had, it can provide the ability to support wireless device peer-to-peer QoS.

1. QoS controlling fields

For adding QoS property, 802.11e adds the QoS controlling fields in 802.11MAC frame (WMM adopts the same frame format), it is shown in the following picture:

MAC frame format (QoS Data):

octets: 2	2	6	6	6	2	6	2	n	4
Frame Control	Duration / ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	QoS Control	Frame Body	FCS
				MAC Header					

QoS Control Field:

Applicable Frame (sub) Types	Bits 0-3	Bit 4	Bit 5-6	Bit 7	Bits 8-15
QoS (+)CF-Poll frames sent by HC	TID	EOSP	Ack Policy	Reserved	TXOP limit
QoS Data, QoS Null, and QoS Data+CF-Ack frames sent by HC	TID	EOSP	Ack Policy	Reserved	QAP PS Buffer State
QoS data type frames sent by non-AP QSTAs	TID	0	Ack Policy	Reserved	TXOP duration requested
	TID	1	Ack Policy	Reserved	Queue size

In the picture, non-access point site is called QSTA (QoS Supporting Station); access point is called HC (Hybrid Coorinator), sometimes, it is also called QAP (QoS Supporting AP). In EDCA mode, there is only QoS Data in frame types, others such as Qos CF-Poll and Qos NULL frames are applied under HCCA mode.

TID: Traffic Identifier, it is applied as User Priority under EDCA mode.

EOSP: End of Service Period, EOSP=1, it means this frame is the last one in service time and it is used as APSD.

2. Access category

Access Category: WMM is divided according to the priority of high to low into AC-VO (voice flow), AC-VI (video flow), AC-BE (best effort flow) and AC-BK (background flow). Make sure that the packet priority is higher; the ability of seizing channel is higher when configuring EDCA parameters.

AC-BK: the queue with lowest priority and high throughput capacity. The volume packets which need high throughput capacity and are not sensitive to the time requirement will be sent to this queue.

AC-BE: with medium throughput and delaying, it is the queue with medium priority. Most ordinary IP data will be sent to this queue.

AC-VI: the delaying queue with smallest priority. The video flow which is sensitive to time will be sent to this queue.

AC-VO: the delaying queue with smallest priority. The data which is sensitive to time, such as network voice and medium flow will be sent to this queue.

3. User priority

Corresponding to wired 802.1d priority rule, WMM stipulates eight user priorities. Their meanings are the same as wired 802.1d priority and they can be mapped

one-to-one.

The TID parameter of QoS controlling fields in 802.11 MAC frame means the user priority of packets (please read the section of **QoS controlling fields**)

The device which supports WMM put packets into different access classes according to user priority. The corresponding relationship is as below:

Priority	802.1d priority	802.1d description	AC (access classes)	WMM description
Lowest	1	background	AC-BK	Background flow
	2	-		
	0	best effort	AC-BE	Best effort flow
	3	exceptional effort		
	4	controlled load	AC-VI	Video flow
	5	video		
	6	voice	AC-VO	Voice flow
Highest	7	network control		

4. EDCA parameters

EDCA defines an EDCAF (Enhanced Distributed Channel Access Function) for every AC. It uses EDCA parameters set to compete for the channels. EDCA function is bodiless from DCF function in 802.11, but the differences are that DCF parameters are fixed or determined by physical layer, EDCA distributes parameters through management entity or AP. These basic parameters include AIFSN (Arbitration Inter Frame Space Number) which is used in process of backoff, ECWmin, ECWmax and TXOP Limit.

AIFSN (Arbitration Inter Frame Spacing Number): EDCA adopts CSMA/CA function as DCF in 802.11 standard. The differences are that DCF adopts DIFS of same frame interval, but different AC in EDCA adopts AIFS (Arbitration InterFrame Space) of different frame interval. The formula of AIFS is as below:

AIFS[i]=AIFSN×aSlotTime+SIFS

Contradistinction: DIFS= 2×aSlotTime+SIFS

The higher priority of AC is, the smaller AIFS is. The site can start backoff process earlier, it will increase the opportunity of AC with high priority accessing channel.

ECWmin (Exponent form of CWmin) and ECWmax (Exponent form of CWmax) determined the average backoff time value. EDCA continue to follow DCF contention windows to reduce channel conflict. In order to make sure that the AC with higher priority can send message before the AC with lower priority sending it, the AC with higher priority will be distributed a shorter CW, it is achieved through configuring different CWmin and CWmax for different AC. As shown in the table above, by default, the AC, AC-BE and AC-BK with low priority use the CWmin which is same as the one in 802.11DCF and the

CWmin of the AC, AC-VI and AC-VO with high priority is quarter or half of the one of low priority.

When the free time of site monitoring channel is larger than AIFS, random backoff process will be conducted. When conducting random backoff process, site will produce a random integer of uniform distribution to put it into the retreated counter of the site. Site will select a time slot in contention window of [0，CW[AC]] to conduct retreated waiting. For the corresponding contention window of an AC, CW[AC] will select in[CWmin, CWmax]. High priority has smaller AIFS and CW[AC], so the time slot selected in random is also smaller, the opportunity to achieve TXOP is bigger.

TXOPLimit (Transmission Opportunity Limit) is the time that wireless channel can be accessed in a row and it will not be disturbed after user achieved TXOP through once successful competition. This value is bigger; the time of user occupying the channel once is bigger. If the value is 0, only one packet can be sent after occupying the channel.

EDCA allows the AC achieved TXOP to send more than one frame in a row. If the AC of the same site which achieved TXOP has other frame to need to be sent and the time of this frame plusing confirming frame and frame interval does not exceed TXOPLimit time remaining, after the channel vacating SIFS time, the site can send the remaining data frame directly and needs not to compete for channel again after waiting for AIFS. Different AC has different TXOP Limit value. If the transmission time of remaining frame exceeds TXOP Limit time, TXOP is over and the site enters backoff process to compete for channel again. If TXOP Limit value is 0, it means site can send only one data frame when it achieved TXOP. The TXOP of AC-BK data and AC-BE data is 0; and the TXOP Limit of video data and voice data is larger than 0 generally. Notice: the opportunity of sending in a row is given to AC but not site. Site has controlling right in the whole TXOP Limit time, but other ACs of site cannot use the TXOP achieved by this AC even if there is data needing to be sent, they should compete for accessing channel again. If EDCA adopts RTS/CTS method, send RTS and CTS frames once before the first frame only when the data frames are sent in a row. There is no need to send every frame. When TXOP Limit time expires or there is not frame in AC needing to be sent, site will quit channel and other sites will compete for channel again.

5. APSD mode

Battery capability of mobile terminal is very important; battery standby time and talking time affect the availability of wireless voice network directly. If the maintenance time is too short, the voice network is not available almost.

802.11 standard power-saving mode allows station to enter into hibernation and regular to awake later (listening interval is an integer multiple of beacon cycle) to monitor beacon frame of AP. When station is in hibernation, AP will cache the station which would be sent to frame. At the same time, AP produces TIM to represent which stations cached

frame and send TIM through beacon frame. After station awaked, extract TIM from monitoring beacon frames to check if the access point cached frame for itself. If access point does not cache frame, station will enter into hibernation again; if access point cached frame, station will keep to work and send PS-POLL frame to receive the cached packets. It will enter hibernation again after the sign of “more data” in received frame is cleared.

In the situation of standby, voice terminal can use this mode. But terminal cannot stay in this mode in case the talking is started. It is for power-saving. The listening time of terminal is very long (one beacon interval is at least), it will cause data delay too long and users cannot receive it.

In 802.11e, the new power-saving mode of APSD (Automatic Power-Save Delivery) is stipulated. It is divided into U-APSD (Unscheduled APSD) and S-UPSD (scheduled APSD). APSD defines a kind of more effective way that station extracts packets cached by itself from AP. In S-APSD, all cached packets are sent to station according to the predefined time. Station must awake before AP sending and prepare for receiving these packets. In U-APSD, AP only saves frames of AC which has sending property, station must send a trigger frame to AP and then AP will send out the cached frames of AC which has sending property. Any packets which are waiting for handling can be used as trigger frame. If there is no packets like this, a free packet is also can be used. Station will keep receiving these packets until it receives a frame with EOSP sign. Wi-Fi WMM-PS authentication includes U-APSD. Voice terminal can use APSD mode when talking to decrease voice data delay.

6. SVP service

SVP (SpectraLink Voice Priority) is the voice priority protocol designed by Spectralink Company for providing QoS indemnification for voice talking. Protocol ID in IP header is 119.

When AP identities SVP packets through protocol ID fields in IP header, it will put it in high priority queue to transmit it. There are two situations as below:

When WMM function of AP is not enabled, there is no concept of access class (AC) and all packets (non-SVP packets) share the same queue. But SVP packets will enjoy the high priority queue itself and use the parameters of AIFSN=1, cwMIN=0, cwMAX=0 and Max Burst=1.5 to transmit packets.

When WMM function of AP is enabled, SVP packets will be put into AC-VO queue and the WMM priority is 6.

7. Priority mapping

1) Priority mapping of uplink data: After the AP which supports WMM received client data, it will configure 802.1p field value according to client packet type and relevant field

parameters; the AP which does not support WMM will configure the 802.1p field value according to the relevant field parameters of SVP or DSCP to complete the priority mapping from wireless to wired network.

Frame Type	802.1p ValueAssignment
If AP WMM enabled and WMM frame	Use WMM UP directly
Else if ipv4 SVP(protocol 119)	6
Else if any other ipv4	MAP IP DSCP CS0-CS7'0-7(all others 0)
All other frames	0

2) Priority mapping of downlink data: After the AP which supports WMM received packets from wired network, it will configure 802.11 QoS value according to wired packets type and relevant field parameters and put it into relevant AC queue to complete the priority mapping from wired to wireless network. Firstly, map the 802.1p priority according to downlink wired packets content. For the packets with VLAN tag, value directly from VLAN tag field; for the packets without tag, map 802.1p according to the packets content and DSCP content. Then, map WMM priority and AC queue according to 802.1p value.

Frame Type	802.1p ValueAssignment
If VLAN tagged frame	0-7(use value in VLAN tag)
Else if ipv4 SVP(protocol 119)	6
Else if any other ipv4	MAP IP DSCP CS0-CS7'0-7(all others 0)
All other frames	0

1.2 WMM QoS Configuration

1) Enable/disable APSD mode

Command	Explanation
Radio Configuration Mode	
apsd **no apsd**	Enable APSD, the no command will disable APSD. Use command **show wireless ap profile <1-16> radio <1-2>** to check whether APSD is enabled.

2) Configure EDCA parameters of AP

Command	Explanation
Radio Configuration Mode	

qos ap-edca {background | best-effort | video | voice} {aifs <1-255> | cwmin <cwmin-time> | cwmax <cwmax-time> | max-burst <0-999900>} **no qos ap-edca {background | best-effort | video | voice} {aifs | cwmin | cwmax | max-burst }**	Set the EDCA parameters' value of AC (access class) on AP to provide different ability of channels competition. Use **show wireless ap profile *<1-16>* radio *<1-2>* qos ap-edca** command to check the configured values of the parameters.

3) Configure EDCA parameters of Client

Command	Explanation
Radio Configuration Mode	
qos station-edca {background | best-effort | video | voice} {aifs <1-255> | cwmin <cwmin-time> | cwmax <cwmax-time> | txop-limit <0-65535>} **no qos station-edca {background | best-effort | video | voice} { aifs | cwmin| cwmax | txop-limit}**	Set the EDCA parameters' value of AC (access class) on Client to provide different ability of channels competition. Use the command: **show wireless ap profile *<1-16>* radio *<1-2>* qos ap-edca** to examine the set parameter values.

4) Enable/disable WMM function

Command	Explanation
Radio Configuration Mode	
wmm **no wmm**	When enabled WMM Function, AP will support WMM protocol. The no command will disable WMM Function.

1.3 WMM QoS Configuration Examples

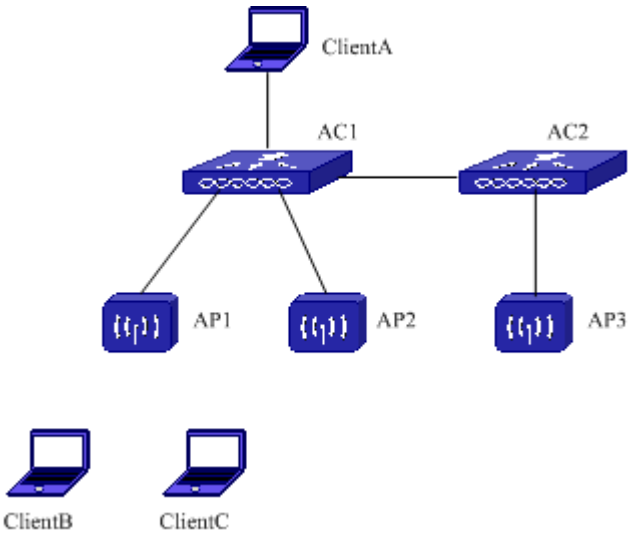

Fig 1-1 WMM QoS configuration topology

AC1 and AC2 make up cluster. AP1 and AP2 are associated with AC1, AP3 is associated with AC2. The basic configuration including network profile is already configured.

The content as below is needed to be configured (the configurations of 2 ACs are the same and AC1 is as the example):

1. Global enable WMM
2. Configure EDCA parameters of AP
3. Configure EDCA parameters of Client
4. Enable APSD mode

Configuration process:

1. Global enable WMM

AC1#config
AC1(config)#wireless
AC1(config-wireless)#ap profile 1
AC1(config-ap-profile)#radio 1
AC1(config-ap-profile-radio)#wmm

2. Configure EDCA parameters of AP

AC1(config-ap-profile-radio)#qos ap-edca voice aifs 3
AC1(config-ap-profile-radio)#qos ap-edca voice cwmax 15
AC1(config-ap-profile-radio)#qos ap-edca voice cwmin 7
AC1(config-ap-profile-radio)#qos ap-edca voice max-burst 3000
AC1(config-ap-profile-radio)#qos ap-edca video aifs 5

AC1(config-ap-profile-radio)#qos ap-edca video cwmax 31
AC1(config-ap-profile-radio)#qos ap-edca video cwmin 15
AC1(config-ap-profile-radio)#qos ap-edca video max-burst 4000
AC1(config-ap-profile-radio)#qos ap-edca best-effort aifs 7
AC1(config-ap-profile-radio)#qos ap-edca best-effort cwmax 511
AC1(config-ap-profile-radio)#qos ap-edca best-effort cwmin 63
AC1(config-ap-profile-radio)#qos ap-edca best-effort max-burst 1000
AC1(config-ap-profile-radio)#qos ap-edca background aifs 15
AC1(config-ap-profile-radio)#qos ap-edca background cwmax 511
AC1(config-ap-profile-radio)#qos ap-edca background cwmin 127
AC1(config-ap-profile-radio)#qos ap-edca background max-burst 2000

3. Configure EDCA parameters of Client
AC1(config-ap-profile-radio)#qos station-edca voice aifs 3
AC1(config-ap-profile-radio)#qos station-edca voice cwmax 15
AC1(config-ap-profile-radio)#qos station-edca voice cwmin 7
AC1(config-ap-profile-radio)#qos station-edca voice txop-limit 100
AC1(config-ap-profile-radio)#qos station-edca video aifs 4
AC1(config-ap-profile-radio)#qos station-edca video cwmax 31
AC1(config-ap-profile-radio)#qos station-edca video cwmin 15
AC1(config-ap-profile-radio)#qos station-edca video txop-limit 200
AC1(config-ap-profile-radio)#qos station-edca best-effort aifs 5
AC1(config-ap-profile-radio)#qos station-edca best-effort cwmax 127
AC1(config-ap-profile-radio)#qos station-edca best-effort cwmin 63
AC1(config-ap-profile-radio)#qos station-edca best-effort txop-limit 300
AC1(config-ap-profile-radio)#qos station-edca background aifs 6
AC1(config-ap-profile-radio)#qos station-edca background cwmax 511
AC1(config-ap-profile-radio)#qos station-edca background cwmin 255
AC1(config-ap-profile-radio)#qos station-edca background txop-limit 400

4. Enable APSD mode
AC1(config-ap-profile-radio)#apsd

After the configuration above, profile needs to be issued.
AC1#wireless ap profile apply 1
All configurations will be send to the aps associated to this profile . Are you sure you want to apply the profile configuration? [Y/N] y

Examine EDCA parameters of AP:

AC1#show wireless ap profile 1 radio 1 qos ap-edca

AP Profile ID..... 1
Profile Name..... Profile1
Radio..... 1 - 802.11b/g/n
Mode..... 802.11b/g/n
WMM Mode..... Enable

AP EDCA Configuration

QoS Queues	AIFS	Minimum Contention Window	Maximum Contention Window	Maximum Burst
Voice (0)	3	7	15	3000
Video (1)	5	15	31	4000
Best-Effort (2)	7	63	511	1000
Background (3)	15	127	511	2000

Examine EDCA parameters of client:
AC1#show wireless ap profile 1 radio 1 qos station-edca

AP Profile ID..... 1
Profile Name..... Profile1
Radio..... 1 - 802.11b/g/n
Mode..... 802.11b/g/n
WMM Mode..... Enable

Station EDCA Configuration

QoS Queues	AIFS	Minimum Contention Window	Maximum Contention Window	Tx Op Limit
Voice (0)	3	7	15	100
Video (1)	4	15	31	200
Best-Effort (2)	5	63	127	300
Background (3)	6	255	511	400

1.4 WMM QoS Troubleshooting

- ☞ Make sure the physical connection of network is correctly.
- ☞ Make sure WMM has been global enabled.
- ☞ Confirm if the configuration has been issued correctly.
- ☞ Confirm if AC is created correctly.

Chapter 2 Client QoS

2.1 Introduction to Client QoS

Because of the rise of audio and video in WLAN, client QoS is more and more important. Our WS mainly supports visiting controlling list, DiffServ and classification queue. ACLs mainly deals with flow, it is generally used in some physical ports, LAGs or VLAN. DiffServ is mainly used in physical ports and LAGs. DiffServ has classifiers, if the packet sent to physical port or LAG is matching with a policy successfully, this packet will be sent to the corresponding queue to wait for handling. Class-of-Service queuing provides different treatment for different types of data, for some application data, such as VoIP, it can be dealt with firstly.

WS supports the QOS white list rate-limit function. In some applications, configure the MAC address white list of the same SSID accessing service, the rate-limit value in the white list is different to the one which is not in the white list. Clients can access in the wireless network through SSID and AP can provide different qualities of service.

2.2 Client QoS Configuration

Client QoS task list is as below:

(1) Enable/stop Client QoS function

(2) Enable/stop Network QoS function

(3) Configure Client QoS relevant property in Network

1) Configure/delete the maximum bandwidth rate restriction of this network
2) Configure/delete the maximum arp rate limit of this network
3) Configure/delete controlling list of this network
4) Configure policy supervision rule
5) Configure/delete DiffSer policy of this network
6) Configure/delete the flow restriction parameter based on SSID in uplink and downlink
7) Configure the parameters of the white list rate-limit
   a. Enable of disable the white list rate-limit function
   b. Configure or delete the client of the rate-limit white list which added the network
   c. Configure the bandwidth of uplink and downlink of the rate-limit white list or recover it to be the default value

1. Enable/stop Client QoS function

Command	Explanation

Wireless Global Mode	
ap client-qos **no ap client-qos**	Enable the AC global Client QoS function. The no command will disable this function.

2. Enable/stop Network QoS function

Command	Explanation
Network Configuration Mode	
client-qos enable **no client-qos enable**	Enable the AP Client QoS of current network. The no command will disable this function.

3. Configure Client QoS relevant property in Network

Command	Explanation
Network Configuration Mode	
client-qos bandwidth-limit {down | up} <*1-4194303*> **no client-qos bandwidth-limit**	Set Client QoS default maximum bandwidth rate (in bits per second) associated with this Network. No command will set the Client QoS default maximum bandwidth rate value as 0 which does not limit the bandwidth rate.
client-qos bandwidth-limit arp {down | up} <1-128> **no client-qos bandwidth-limit arp {down | up}**	Configure/delete the maximum arp rate limit of this network.
client-qos access-control {down | up} {ip {<*1-199*> | <*acl-name*>} | ipv6 <*acl-name*> | mac <*acl-name*>} **no client-qos access-control {down | up}**	Configure the Client default control list in the network. No command will delete the control list information.
policy {<*1-10000000*> <*1-1000000*> conform-action {drop | set-prec-transit <*0-7*> | set-dscp-transit <*0-63*> | set-cos-transit <*0-7*>} {exceed-action {drop}}	Configure policy supervision rules.

client-qos diffserv-policy {down | up} *<policy-name>* **no client-qos diffserv-policy {down | up}**	Configure the Client default DiffSer policy associated with the network. No command will delete the configured default DiffSer policy.
qos max-bandwidth {down|up} *<1-4194303>* **no qos max-bandwidth {down|up}**	Configure/delete the flow restriction parameter based on SSID in uplink and downlink.
ratelimit-whitelist enable **no ratelimit-whitelist enable**	Enable of disable the white list rate-limit function.
ratelimit-whitelist bandwidth-limit {down|up} *<1-4194303>* **no ratelimit-whitelist bandwidth-limit {down|up}**	Configure the bandwidth of uplink and downlink of the rate-limit white list or recover it to be the default value.
ratelimit-whitelist client-mac <macAddr> **no ratelimit-whitelist client-mac <macAddr>**	Configure or delete the client of the rate-limit white list which added the network.

2.3 Client QoS Configuration Examples

Case 1：

Associate and manage an AP on an AC, the profile ID of AP is 1 and this value is default. QoS is configured on network1 (vap 0).

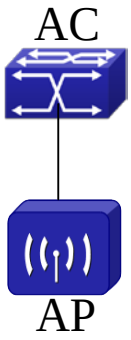

Fig 2-1 QoS configuration

Configuration steps:

Configure AC

AC(config)#access-list 100 permit tcp any-source any-destination

AC(config)#wireless

AC(config-wireless)#ap client-qos

AC(config-wireless)#ap profile 1

AC(config-ap-profile)#radio 1
AC(config-ap-profile-radio)#vap 0
AC(config-ap-profile-vap)#network 20
AC(config-wireless)#network 20
AC(config-network)#cient-qos enable
AC(config-network)#client-qos bandwidth-limit down 1000000
AC(config-network)#client-qos access-control down ip 100
AC(config-network)#end
AC#config
AC(config)#class-map c
AC(config-classmap-c)#match vlan 1
AC(config-classmap-c)#exit
AC(config)#policy-map p
AC(config-policymap-p)#class c
AC(config-policymap-p-class-c)#exit
AC(config-policymap-p)#exit
AC(config)#wireless
AC(config-wireless)#network 20
AC(config-network)# client diffserv-policy up p
AC(config-network)#end
AC#wireless ap profile apply 1

Case 2：

Manage an AP on an AC, the profile ID of AP is 1 and this value is default. The QoS white list rate-limit configuration is on network1 (vap 0), and there are two users are connected to AP. Configure the uplink rate-limit of one user whose MAC address is 34-59-9f-21-03-9e as 1M, and another user is not be limited the rate.

Associate and manage an AP on an AC, the profile ID of AP is 1 and this value is default. QoS is configured on network1 (vap 0).

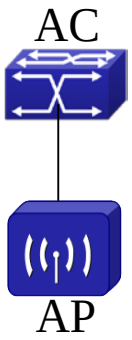

Fig 2-2 QoS Configuration

Configuration steps:

Configure AC

AC (config)#wireless

AC (config-wireless)#ap client-qos

AC (config-wireless)#network 1

AC (config-network)#client-qos enable

AC (config-network)#ratelimit-whitelist enable

AC (config-network)#ratelimit-whitelist client-mac 34-59-9f-21-03-9e

AC(config-network)#ratelimit-whitelist bandwidth-limit up 1024

AC#wireless ap profile apply 1

2.4 Client QoS Troubleshooting

If there are problems when using Client QoS, please check if it is wrong with the reasons as below:

- ☞ If enabling wireless global and network QoS on-off. When the two on-offs are enabled, client QoS function will be effective.
- ☞ If issuing profile configuration file. Configuring or deleting client QoS relevant property in network need to issue profile to affect it.
- ☞ If updating Client QoS configuration. Updating Client QoS configuration does not need to issue configuration to be effective in time.

If there are problems when using QoS white list, please check if it is wrong with the reasons as below:

- ☞ If enabling the wireless global and network QoS on-off. When the two on-offs are enabled, QoS white list function will be effective.
- ☞ if enabling or disabling the white list rate-limit function.
- ☞ If adding the MAC of the user which needs to be limited in the white list.