WLAN Airtime Scheduling Technology White Paper

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About This Document

Keywords

Airtime, WMM, fair scheduling, throughput, user experience

Abstract

Airtime is a fair scheduling technology to ensure that downlink users with different access rates can obtain the same accumulative scheduling time. This document describes the implementation and major applications of Airtime scheduling.

Abbreviations

Abbreviation	Full Name
AP	Access Point
AC	Access Control
WMM	Wi-Fi MultiMedia
EDCA	Enhanced distributed channel access

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1 Background

On a wireless local area network (LAN), it takes longer time for a low-rate STA to transmit the same packet on an air interface than a high-rate STA because the STA capabilities and the wireless environment are different. This situation affects experience of STAs especially high-rate STAs connected to an AP, and the overall throughput of the AP.

When determining that the signal strength of a low-rate STA is not strong enough, an AP can reject the access request from the STA. This method is not proper because low-rate STA access is directly rejected. Besides, it is difficult to control accesses from low-rate STAs and a large number of continuous access requests may cause extra load of the air interface.

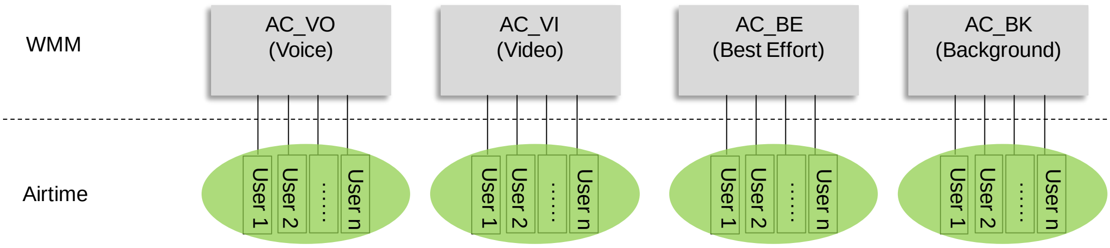
On the live network where the downlink traffic is the mainstream traffic, time-based fair scheduling for the downlink traffic of each STA ensures that packets of each STA can be processed, improves user experience and the downlink throughput of the AP. This method also prevents extra load on the air interface caused by a large number of access requests.

Huawei Airtime fair scheduling (Airtime scheduling) is such a time-based fair scheduling technology for downlink traffic.

2 Technology Implementation

In terms of Airtime scheduling technology, Wi-Fi Multimedia (WMM), a basic scheduling framework, is described here. Airtime scheduling fairly schedules services of the same access category (AC) based on time. The scheduled STA obtains enhanced distributed channel access (EDCA) parameters for the AC queue where the STA belongs to, and then competes for the air interface.

Figure 2-1 Relationship between Airtime and WMM

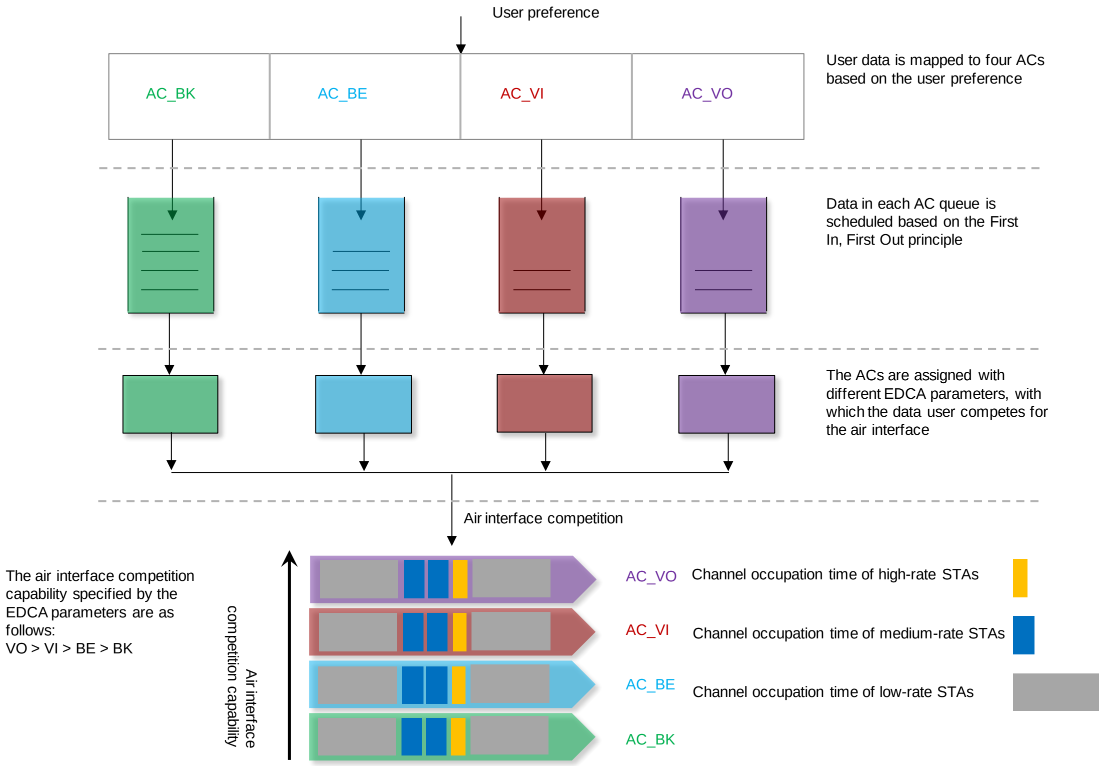


WMM introduces EDCA at the MAC layer. EDCA is an extension to Distributed Coordination Function (DCF), and supports quality of service (QoS) based on packet priorities. The EDCA mechanism defines four types of ACs and each AC defines a set of access parameters. The parameters determine the capability of each AC queue to preempt channels. The following table lists the mapping between access priority, user preference, and AC.

Priority	User Preference	Access Category
Lowest	1	AC_BK (Background)
	2	AC_BK (Background)
	0	AC_BE (Best Effort)
	3	AC_BE (Best Effort)
	4	AC_VI (Video)
	5	AC_VI (Video)
Highest	6	AC_VO (Voice)
	7	AC_VO (Voice)

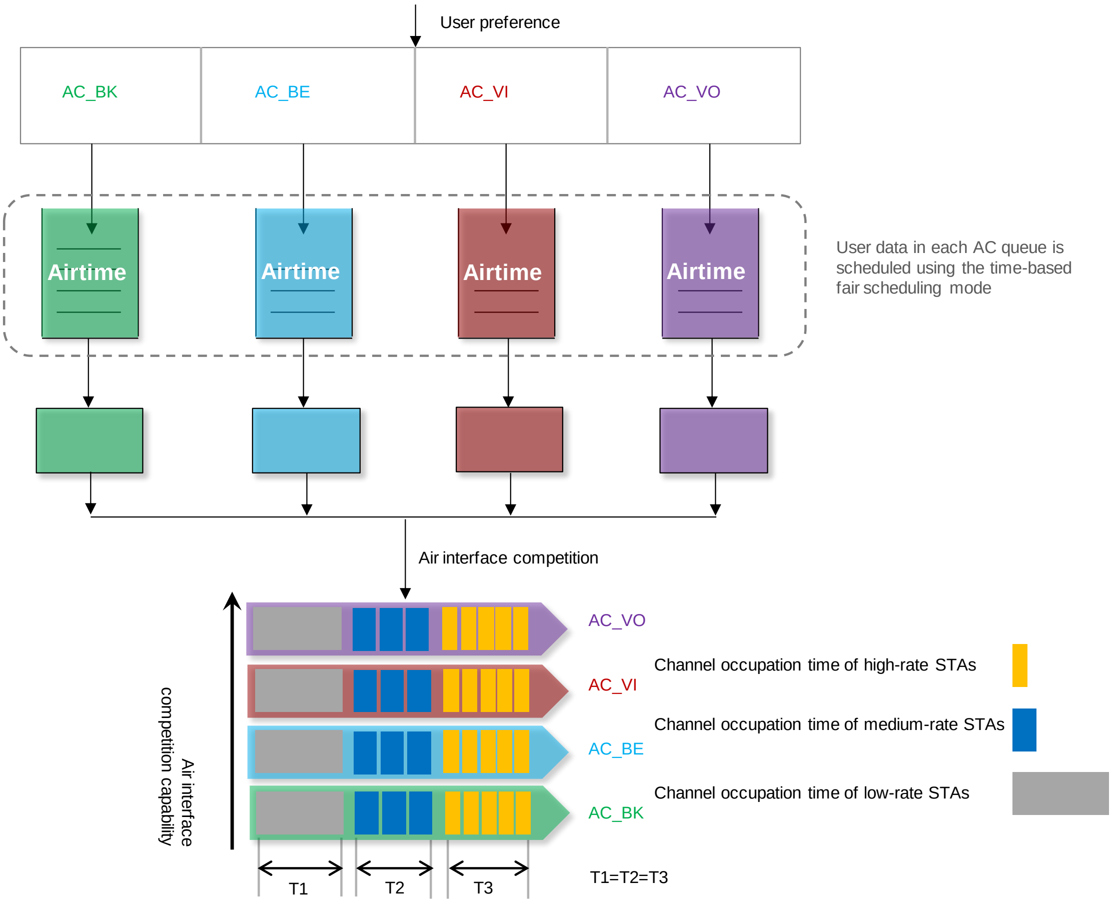
In the EDCA, services are sorted into four queues, and each queue corresponds to one AC, as shown in the following figure. The AP maps user data to the ACs based on the user preference. User data in each queue is processed according to the First In First Out (FIFO) principle. The AP assigns different EDCA parameters to outgoing data in each AC queue, and the data uses these parameters to compete for the air interface. Generally, EDCA parameters allow the voice service to easily occupy the air interface compared with other services. That is, the voice service will be scheduled preferentially. The preceding table describes the priorities of different services.

Figure 2-2 WMM scheduling



Airtime technology changes the scheduling mode for user data in each AC queue used by WMM. Different from the FIFO principle, Airtime uses the time-based fair scheduling to ensure that users with different access rates can obtain the same accumulative scheduling time. Packets that have occupied the minimum cumulative duration are sent preferentially. In this manner, users in one queue are assigned with almost the same duration for occupying the air interface. As shown in the following figure, users with different access rates in one AC queue can obtain the same scheduling time after Airtime technology is used. Then, low-rate users no longer occupy the air interface for a long time, and high-rate users have more chances to send packets.

Figure 2-3 WMM+Airtime scheduling

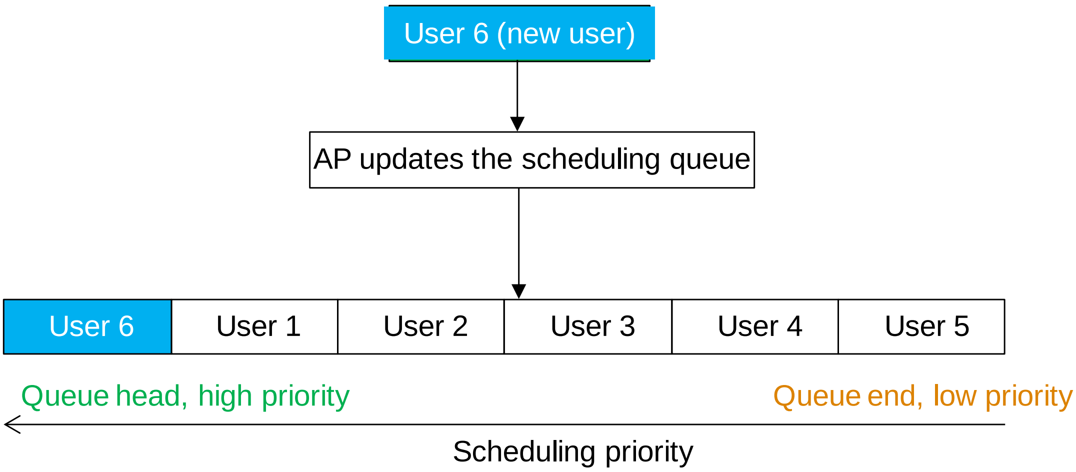


The preceding part describes the differences between WMM and WMM+Airtime scheduling. The following part will describe how Airtime scheduling is implemented.

1. New users

   A user added to a queue will be added to the head of the queue and scheduled first because there is no scheduling history about the user and the corresponding accumulative scheduling time is 0.

Figure 2-4 Scheduling of new users

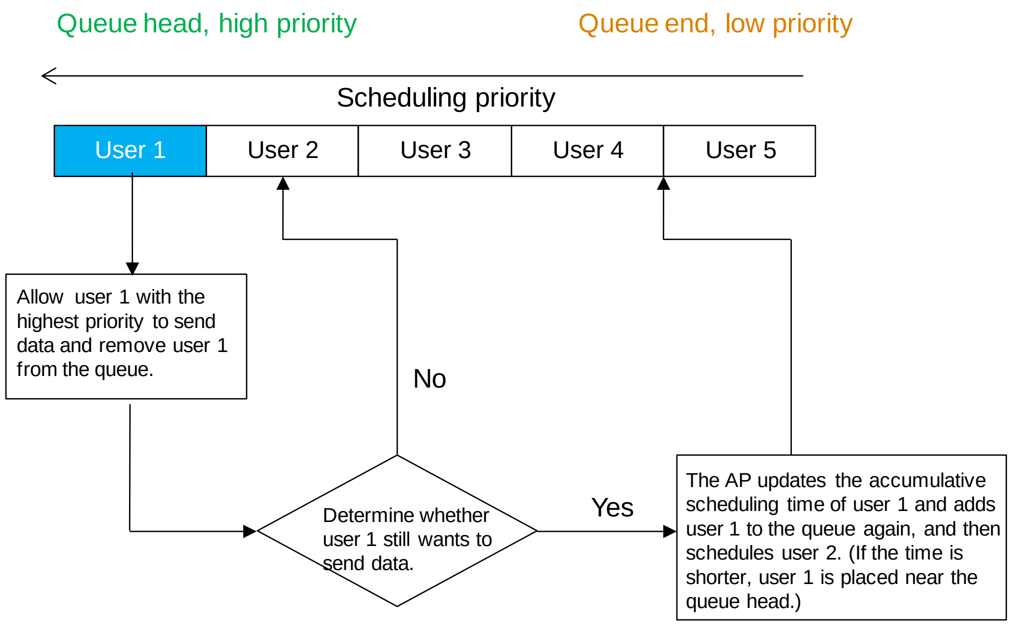


As shown in the preceding figure, there are five users in an AC queue of the AP. When user 6 joins the AC queue, the AP updates the scheduling queue to add user 6 to the head of the queue because there is no scheduling history about user 6 and the corresponding accumulative scheduling time is 0. Then user 6 is scheduled first.

2. User already in the queue

   If a user already in a queue still needs to send data after sending a packet, the AP updates the location for the user according to the accumulative scheduling time. If no data needs to be transmitted, the user is removed from the queue.

Figure 2-5 Scheduling of users already in the queue

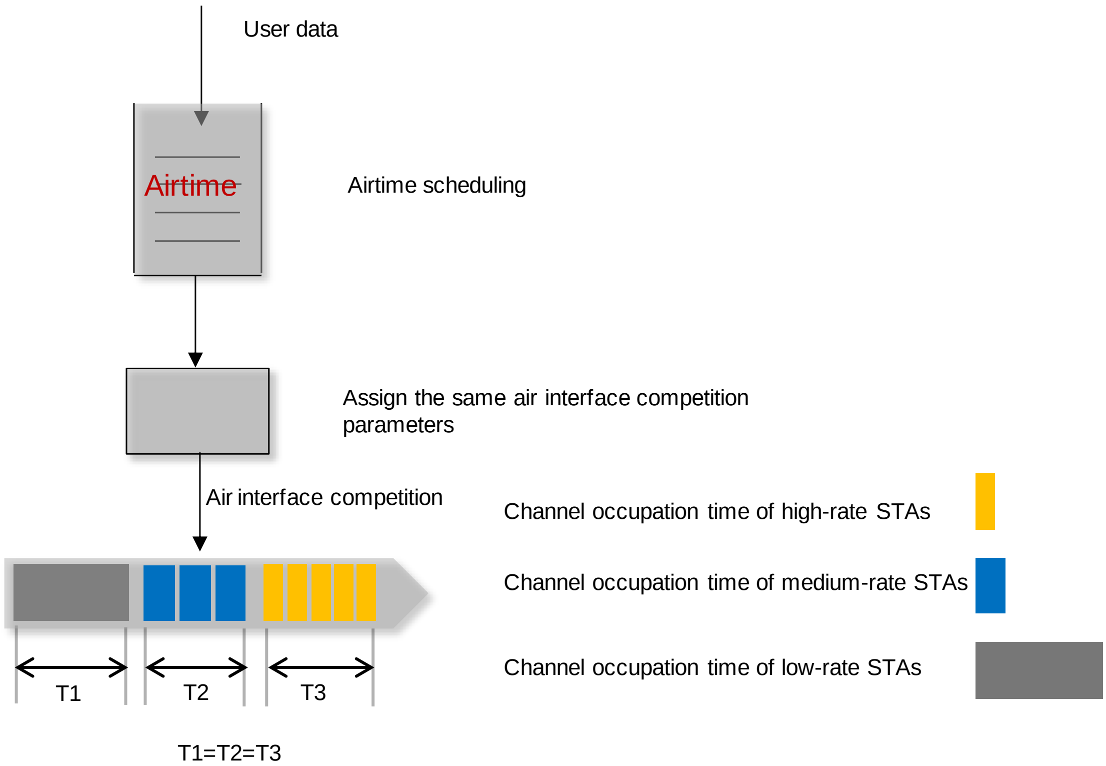


As shown in the preceding figure, users 1 to 5 are sequenced in a queue according to their priorities. After user 1 sends a data packet, it is removed from the queue. If user 1 has no data to transmit, the AP schedules user 2 with the second highest priority. If user 1 still has data to transmit, the AP updates the accumulative scheduling time of user 1 and adds user 1 to the queue again based on the accumulative time. If the time is shorter, user 1 is placed near the queue head. For example, user 1 can be inserted between user 4 and user 5. After that, the AP schedules user 2 with the second highest priority.

Packets of some users such as a new user will be scheduled for several times, but packets from some other users may be starved. To prevent this problem, the accumulative scheduling time of users needs to be cleared periodically and the recommended period is 5 seconds.

Although WMM is widely used on WLANs, some networks may not have WMM deployed. Airtime can still take effect when WMM is disabled. After WMM is disabled, users join the same queue but not different AC queues according to the user preference. In this case, Airtime still takes effect on the common queue.

Figure 2-6 Airtime scheduling in a non-WMM scenario



3 Benefits to Customers

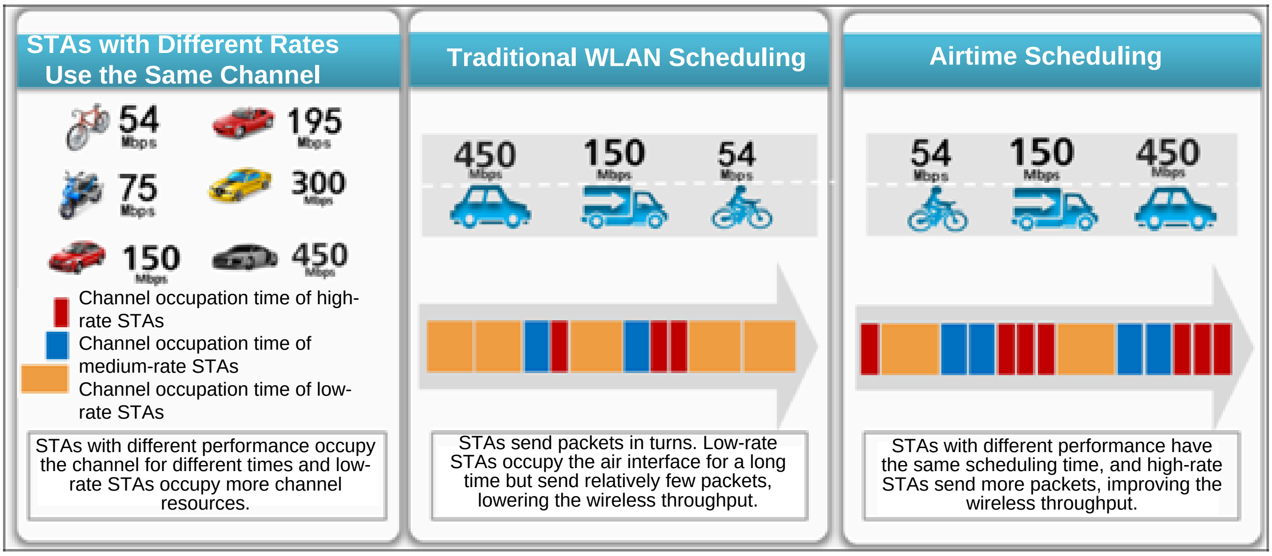
1. Improving user experience

   When Airtime scheduling is disabled, low-rate STAs may occupy an air interface for a long time, while high-rate STAs needs to wait until the low-rate STAs complete packet transmission. In this case, high-rate STAs must wait a long period after sending a packet. User experience of the high-rate STAs is affected. Airtime scheduling ensures that high-rate STAs and low-rate STAs have the same transmission time, improving user experience of high-rate STAs.

2. Improving AP system throughput

   The same packet transmitted by STAs at different rates requires different time. A high-rate STA has strong transmission capability and high spectrum efficiency, so less time is taken to send packets on the air interface. A low-rate STA has low transmission capability and low spectrum efficiency, so more time is taken to send packets on the air interface. This reduces the throughput of each AP and lowers the system efficiency. Airtime scheduling evenly allocates the downlink transmission time and helps high-rate STAs transmit more data, improving the AP system throughput.

Figure 3-1 Comparison between Airtime and traditional scheduling methods



3. Improving the fairness

If a STA receives weak signal strength, the AP can reject the access request from the STA if it determines that the signal strength is not strong enough. This method, however, deprives access rights of the low-rate STAs; therefore, it is not fair. Airtime scheduling does not reject the access request from STAs, but assigns the same scheduling time for all the STAs. This scheduling method allows all STAs to be scheduled and high-rate STAs to send more packets, ensuring fairness and improving efficiency.

4. Avoiding extra loads over the air interface

   When access requests from low-rate STAs are rejected, they may send access requests repeatedly. This may result in a large number of access requests on the network, increasing the loads over the air interface. Airtime scheduling ensures the fairness because it does not reject user access requests. In addition, it also avoids extra loads over the air interface caused by a large number of access requests.

4 Typical Application Scenarios

Airtime scheduling effectively improves user experience, increases the system throughput, ensures the fairness, and prevents loads over the air interface caused by a large number of access requests. The advantages of Airtime scheduling are obvious when low-rate and high-rate STAs coexist on a network, which is a common phenomenon in WLAN applications. Two common scenarios are described as follows:
Scenario 1: A large number of old low-rate terminals (such as, the 802.11b/g terminals) are still active on the network, while high-rate terminals (for example, 802.11n terminals) coexist with the old terminals for a period of time. Scenario 2: Users are not distributed in a centralized manner. Some users are near to the AP while some others are far away from the AP. Users near to the AP receive strong signals and obtain higher throughput. Users far away from the AP receive weak signals and have lower access rate. This commonly occurs in an outdoor scenario.

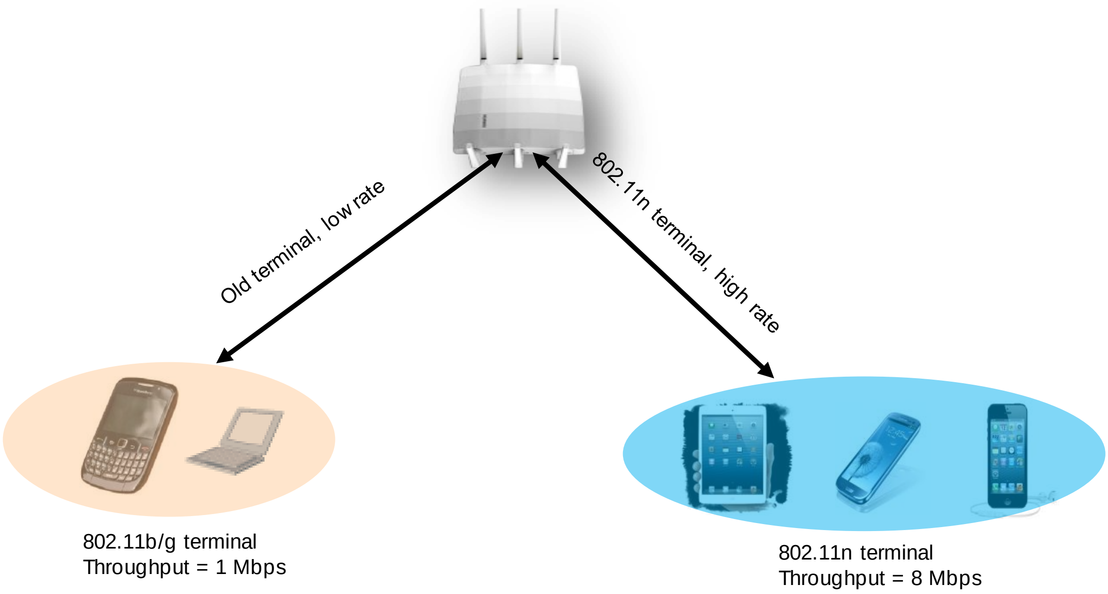
Airtime scheduling is easy to configure. You only need to run the **airtime-schedule enable** command in a radio profile.

[AC6605-wlan-view]radio-profile id 0

[AC6605-wlan-radio-prof-2.4g]airtime-schedule enable

4.1 Access of Both Old and New Users

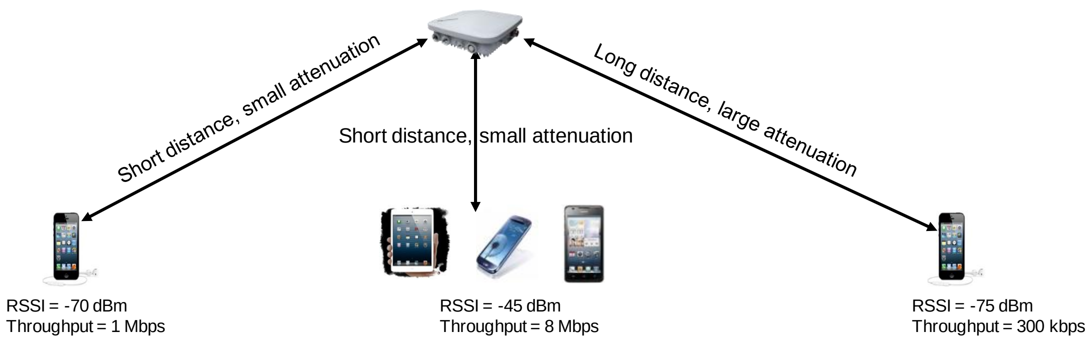
Figure 4-1 Access of both old and new users



The terminal capabilities are continuously improving. A large number of old low-rate terminals (such as, the 802.11b/g terminals) are still active on the network, while high-rate terminals (for example, 802.11n terminals) coexist with the old terminals for a period of time, as shown in the preceding figure. In this scenario, low-rate old terminals occupy the air interface a longer time than the high-rate 802.11n terminals. Airtime scheduling can reduce the air interface occupation time of low-rate terminals to improve user experience of high-rate terminals and the AP system throughput.

4.2 Access of Users from Different Distances

Figure 4-2 Access of users from different distances



In some scenarios, such as outdoor, some terminals are near to the AP; therefore, the signal attenuation is small and the received signal strength is strong. Some terminals are far away from the AP; therefore, the signal attenuation is large and the received signal strength is weak. As shown in the preceding figure, short-distance terminals receive stronger signals than long-distance terminals and have higher throughput. In this scenario, Airtime scheduling can reduce the air interface occupation time of low-rate terminals to improve user experience of high-rate terminals and the AP system throughput.