Computer Life (CPL) ISSN: 1819-4818
DELIVERING QUALITY SCIENCE TO THE WORLD

Working Principle and Reference Architecture of 802.11 WLAN

Qi Li [a,*], Chunyan Fen

Beijing University of Posts and Telecommunications, China

[a]liqi1996@aol.com

Abstract: To complement and expand the limited local area network (LAN) communication technology, the working principle of 802.11 wireless local area network (WLAN) and the WLAN reference architecture is studied, especially discussing the MAC layer of the IEEE 802.11b protocol in detail. It also discusses how to build a practical WLAN implementation plan and optimize the network through access point AP devices. It is found that the scheme uses the characteristics of high mobility, long transmission distance, low development and operation cost, easy expansion, flexible networking, and convenient management. It builds a wide, scalable and manageable wireless network in the areas difficult in expansion of wired network, and fills the shortcomings of the traditional wired LAN.
Keywords: Wireless local area network (WLAN), 802.11, network optimization, reference system.

---

1. INTRODUCTION

Since 1980s, the wired LAN, represented by Ethernet (IEEE 802.3) and token ring network (IEEE 802.5), has made considerable progress. Especially in the 1990s, the rapid development of Internet in the world has further promoted the development of computer network communication technology. One of the development directions of communication is to realize the so-called personal communication, that is, "any one, any time, any place" can achieve interoperability and sharing of information. Like the development of voice communications from cable phones to mobile phones, wireless computer network communications, represented by wireless local area network (WLAN), are showing more and more strong momentum. The 802.11 standard is the first wireless LAN standard set by the IEEE 802.11 working group. The maximum rate can only reach 2Mbps, and it mainly stipulates the physical (PHY) layer of the network and medium access control (MAC) layer, in which the regulation of the MAC layer is the key. The products of each vendor based on this protocol can be interoperable on the same physical layer, requiring the logical link control (LLC) layer to be consistent. In other words, the network application is transparent under the MAC layer. This makes the two main uses of wireless network -- "multi-point access in the same network segment" and "multi network interconnection" easy to implement with high quality and low cost.

With the rapid increase of social dependence on computers, the number of computers interconnected required by users is more and the types are more complex. However, due to the constraints of design

or environmental conditions, the traditional wired network has a series of problems in physics, logic and capital, especially when it involves the network movement and re-layout, so it is a need to develop a feasible wireless communication network technology as an extension of existing data connection (Baek and Choi, 2017)). Compared with the wired LAN, WLAN has the characteristics of high mobility, long transmission distance, good network secrecy, low development and operation cost, easy expansion, small impact on natural environment, flexible networking and convenient management, which makes up the shortage of traditional wired LAN (Ekpenyong et al., 2018). Under the above background, this topic carries on the analysis of the wireless local area network's related communication protocol.

2. LITERATURE REVIEW

At present, WLAN is still in the coexistence of many standards. Behind each standard is the support of large companies or large groups (Goodall, 2017). In the United States and Europe, a number of mutually exclusive high-speed wireless standards are formed: 802.11b is supported by companies such as 3Com, Lucent, Apple, Cisco, and so on. This standard is now very popular in North America. Its competition standards are HomeRF standards supported by Intel, Proxim, Motorola and Compaq. The United States IEEE creates another high-speed wireless standard 802.11a, which is nearly 5 times faster than the current 802.11b technology (Ismail, 2017). The European Telecommunications Standards Board creates a competitive high-speed standard HyperLAN2, Ericsson is a major supporter, and the HyperLAN2 standard is widely used in Europe. As a big country in mobile communication applications, China also releases the national standard of wireless LAN (Kim, 2016).

Since the 802.11 standard related products are introduced earlier, the implementation of wireless LAN in the market is dominated by this series of standards, which makes the EEE802.11 standard continuously replenished and upgraded, and the latest standard published by IEEE is 802.11g (Kim and Park, 2017). At present, the system supporting user transmission rate above 11Mbps is quite mature. The system with implementation rate of 40Mbps or 80Mbps has been developed in specialized laboratories in Canada, the United States, Europe, Japan and other countries. The scope of the research is from radio design, physical layer implementation, and media access control (MAC) technology to network support for wireless multimedia (Lakshmi et al., 2016). According to the trend of technology development and research status, it is possible to provide users with up to 1Gbps rate system in the next 10 years or so. It is this development speed that stimulates the rapid development and application of wireless networks today (Morales et al., 2016).

3. ANALYSIS OF THE WORKING PRINCIPLE OF WLAN

3.1 Transmission mode

The transmission mode involves the transmission media, the selected frequency bands and the modulation modes adopted by the wireless network. At present, there are mainly two kinds of transmission media, namely radio and infrared. The wireless network which uses radio wave as transmission medium can be divided into extended spectrum mode and narrowband modulation mode according to different modulation modes.

Mode 1: extended spectrum mode

In the extended spectrum mode, the spectrum of the baseband signal is expanded to several times to tens of times before being transferred to radio frequency. Although this method sacrifices the bandwidth of the band, it improves the anti-jamming capability and security of the communication system. As the power in the unit band decreases, the interference to other electronic devices is also reduced.

In the wireless LAN that uses the extended spectrum mode, the so-called ISM band is generally chosen, where ISM is taken from the first letter of Industrial, Scientific and Medical, respectively. The energy of much industrial, scientific and medical equipment is concentrated on the frequency band. For example, the ISM band in the United States consists of three bands of 902MHz-928MHz, 2.4GHz-2.48GHz, and 5.725GHz-5.850GHz. If the transmit power and bandwidth radiation meet the requirements of the Federal Communications Commission (FCC), there is no need to apply specifically to FCC for the ISM band.

Mode 2: narrowband modulation mode

In narrowband modulation mode, the spectrum of data baseband signal is directly transferred to radio frequency without any expansion.

Compared with the extended spectrum mode, the narrowband modulation mode occupies less frequency band and has higher frequency band utilization. WLAN that uses narrowband modulation in general chooses special band, and it needs to be licensed by the state radio management department. Of course, the ISM band can also be selected, so that the application to the radio management committee can be neglected. But the problem is that when the adjacent instruments or communications equipment are also using this band, the quality of communication will be seriously affected and the reliability of communication cannot be guaranteed.

Mode 3: infrared mode

Infrared-based transmission technology has made great progress in recent years. At present, the widespread used home appliances remote control almost all use infrared transmission technology. As a transmission mode of WLAN, the greatest advantage of infrared is that this transmission is not subject to radio interference, and the use of infrared is not restricted by the National Radio Management Committee. However, the transmittance of infrared to non-transparent objects is very poor, which leads to limited transmission distance.

3.2 Network topology

At present, the network mode of WLAN mainly includes point to point mode, infrastructure mode, multi AP mode, wireless network bridge mode and wireless repeater mode five networking modes.

Mode 1: point to point mode

The point to point mode is also called Ad hoc mode, which requires that any two wireless clients in the network can communicate directly, all wireless clients in the network are equal, and no central control nodes are required to be set. Each wireless client is equipped with wireless network card, but not connected to access point and wired network but through wireless network card to communicate with each other. A wireless client in the point to point must be able to "see" other wireless clients in the network at the same time; otherwise, the network will be interrupted. It is

mainly used to build wireless LAN quickly and easily without infrastructure. The networking pattern of point to point mode is shown in Figure 1.

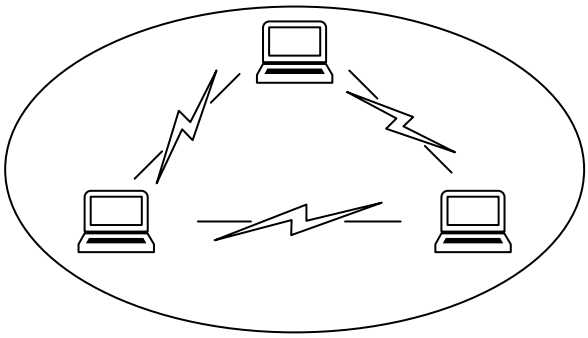

Figure 1. Point to point mode

Mode 2: infrastructure pattern

It is one of the most common architecture at present, which includes an access point and multiple wireless terminals. On the one hand, access point can be connected to cable networks through cable connections. On the one hand, it can be connected to wireless terminals through radio waves, and the communication between wireless terminals as well as communication between wireless terminals and wired network can be realized. The networking mode of the infrastructure network is shown in Figure 2. The map is composed of wireless access point (AP), wireless work station (STA) and distributed system (DSS) and the area covered is called the basic service set (BSS).

Wireless access point, also known as wireless hub, is used to receive, cache and forward data between wireless STA and wired network. All wireless communications are completed through AP. Wireless access points usually cover dozens to hundreds of users, covering a radius of up to 100 meters. AP can be connected to the wired network to realize interconnection between wireless network and wired network.

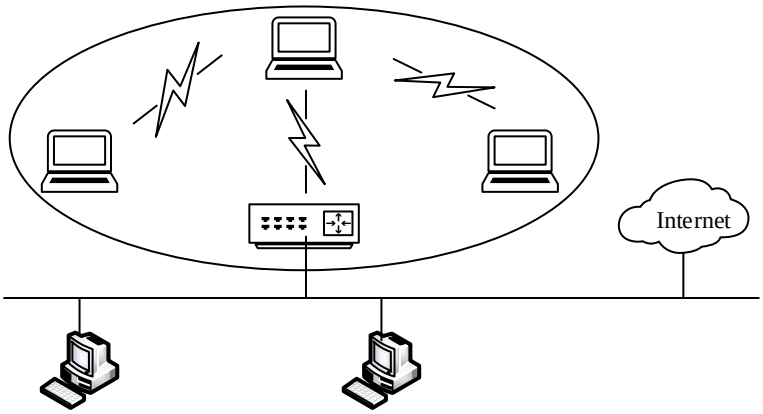

Figure 2. Infrastructure mode

Mode 3: multi AP mode

It refers to the infrastructure mode network composed of multiple AP and distributed systems connected to them, also known as extended service area. Each AP in the extended service area is an independent wireless network basic service area. All AP share the same extension service set

identifier (ESSID). Although no distributed system is defined in the 802.11 standard, most of them now refer to Ethernet. Wireless networks with the same ESSID can roam, and different ESSID wireless networks form logical subnets. The network pattern of this mode is shown in Figure 3.

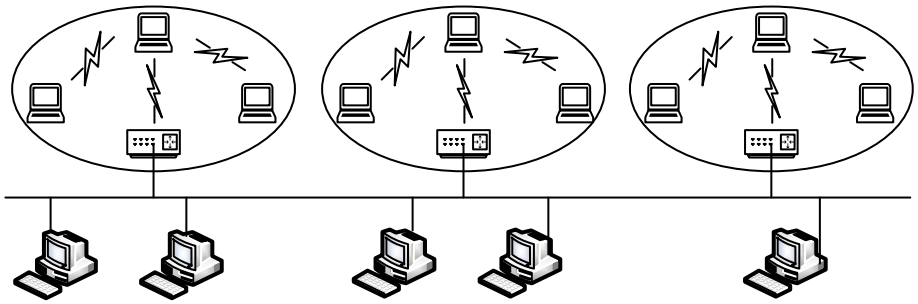

Figure 3. Multi AP mode

3.3 Features of extended spectrum technology

Feature 1: strong anti-interference ability

From the published signals to a wide frequency band, the extended spectrum signal is processed at the receiver end, that is, bandwidth compression, and the narrowband signal is restored. For the interference signal, because it is not related to the pseudorandom code used in the extended spectrum, it is extended to a very wide band, so that the interference power in the signal pass-band is greatly reduced, and the output signal / interference ratio of the correlator is increased correspondingly, so it has strong anti-interference ability. The anti-jamming ability is directly proportional to the expansion multiplier of the frequency band. The wider the spectrum is, the stronger the anti-jamming capability is.

Feature 2: multiple access communication

The extended spectrum communication itself is a kind of multiple access communication. It is called SSMA-Spread Spectrum Multiple Access, which is actually a kind of code division multiple access (CDMA), which consists of different networks with different spread spectrum codes. Although the extended spectrum system takes up a wide band, the utilization rate of the frequency band is even higher than that of single road single carrier system because of the sharing of a frequency band at the same time. CDMA is a main multiple access communication mode for future global personal communications.

Feature 3: security and secrecy

As the extended spectrum system extends the transmitted information to a wide frequency band, the power density of the system decreases with the broadening of the spectrum, and even the communication signal can be submerged in the noise. Therefore, its secrecy is very strong, and it is very difficult for interception or eavesdropping, reconnaissance of such signals. Except for the use of the spread spectrum code with the transmitter and the related detection after it is synchronized with it; otherwise, it is incapable of spreading the extended spectrum signal. As the power spectrum density of the extended spectrum signal is very low, in many countries, such as the United States, Japan and

Europe, for special band like the ISM band, as long as the power spectral density satisfies certain requirements, the frequency band can be used without approval.

Feature 4: anti-multipath interference

In the communication environment, such as mobile communication and indoor communication, multipath interference is very serious, and the system must have strong anti-interference ability to ensure the smooth communication. The extended spectrum technology has strong anti-multipath ability. It uses the correlation characteristic of extended spectrum code used in spread spectrum to resist multipath interference, and even can use multipath energy to improve the performance of the system.

4. DISCUSSION ON THE REFERENCE ARCHITECTURE OF WLAN

4.1 Layer protocol architecture

Figure 4 shows the protocol entity of the IEEE 802.11 standard. The traditional and simple MAC layer and physical layer defined in some sub standards of IEEE 802 are subdivided into more sub-layers, which make it easier to standardize the process. The MAC layer is divided into the MAC sub-layer and the MAC management sub-layer. The MAC sub-layer is mainly responsible for the implementation of the access mechanism and the splitting and regrouping of the packets. The management sub-layer of the MAC layer is mainly responsible for ESS roaming management and power management, as well as the management of processes such as association, de-association, and re-association in the registration process. The physical layer of 802.11 is divided into three sub layers: PLCP (physical layer convergence protocol), PMD (physical media disagreement) and physical layer management sub-layer. The PLCP sub-layer mainly carries out the analysis of carrier interception and the grouping of corresponding formats for different physical layers. The PMD sub-layer is used to identify modulation and coding techniques for signals transmitted by related medium. The physical layer management sub-layer performs channel selection and tuning for different physical layers. In addition, IEEE 802.11 also defines a station management sub-layer, whose main task is to coordinate the interaction between the physical layer and the MAC layer.

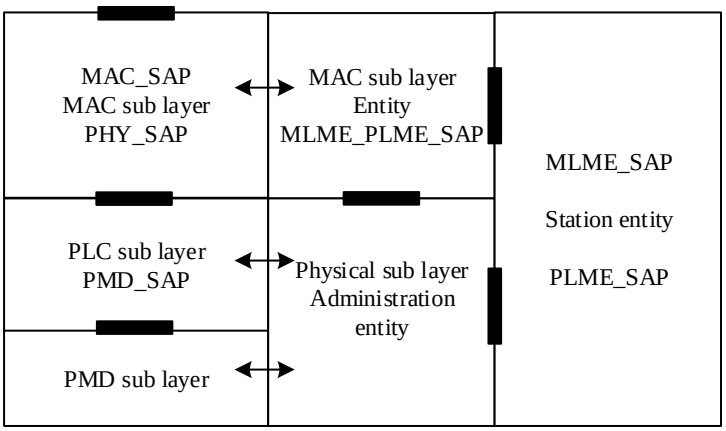

Figure 4. IEEE 802.11 agreement entity

4.2 Frequency hopping expansion

Figure 5 is a detailed format of the PLCP packet header, which is added to the whitened MAC protocol data unit, and the formed packets can be transmitted by the FHSS physical layer specified by the IEEE 802.11. The data rates used for transmission are two kinds of 1Mbps and 2Mbps. The modulation technologies adopted are two-level and four-level GFSK (Gauss frequency shift keying), respectively. The lower transmission rate usually provides a simpler synchronization environment for different adaptive parts of the receiver. In addition, all groups start with the same format, so the receiver can easily start the conversation process with the transmitter. The result is that the PLCP header always uses a two-bit GFSK modulation technology to send the data with the rate lower than 1Mbps, which is popular saying that the receiver can start the initialization of the communication negotiation process at a slower speed. However, in the near future, maybe MPDU can implement the transmission not only at the rate of 1Mbps or 2Mbps, but also realize information transmission at any rate.

Figure 5. PLCP frame format

There are the following equations:

$$SYNC = 0 \ \ or \ \ 1 \tag{1}$$

$$SFD = 0000110010111101 \tag{2}$$

$$PLW = the \ \ length \ \ of \ \ group \tag{3}$$

$$PSF = 500kbps \tag{4}$$

$$CRC = the \ \ code \ \ of \ \ frame \ \ header \tag{5}$$

4.3 MAC layer

The term "MAC service" generally refers to the service provided by the MAC layer to other layers in the protocol stack, or the function provided by the MAC layer to maintain network operation. The MAC protocol is designed to provide several basic services that can be distinguished by using MAC data services and MAC management services. For IEEE 802.11 wireless local area network, MAC data service mainly provides effective data communication for stations (synchronous or asynchronous mode). The role of asynchronous data communication also includes distributing channels for different users according to pre-determined protocols when channel competition occurs in wireless networks. In contrast, synchronous data communication is often used in uncompetitive environments.

The MAC layer protocol also provides management functions such as session management, power management and synchronization control to achieve mutual communication between terminals. Session management refers specifically to such contents as registration activities, address filtering, and message security protection when a network terminal attempts to access the network. The power management can make the mobile station dormant as long as possible so as to save the battery energy,

and will not miss the data transmitted during the dormancy process. Finally, the synchronization management of MAC clock between multiple stations is also very important. This is consistent with the principle that the transmitter and receiver must be synchronized in the network layer.

4.4 Case design and analysis

In this plan, we propose to adopt an enhanced device based on the 802.11 g protocol, that is, 108Mbps wireless devices. This type of device adopts 802.11g protocol and supports 802.11b protocol, and provides a supercharging mode. It can double the channel bandwidth and increase the number of concurrent users in the area network under the premise of unchangeable investment. The number of concurrent users in each area can be raised to about 80 people, and it can fully satisfy with the high bandwidth requirements at present and in the future. Moreover, it provides the foundation for future campus wireless voice, wireless video and other high bandwidth network applications.

The indoor wireless access point AP device is a TL-641G/642G 108M wireless broadband router, which uses 802.11g protocol enhancement mode to provide a 108Mbps channel bandwidth. In the meanwhile, it can support the 802.11b and 802.11g protocol user adapters, and support advanced WDS (wireless distributed set) technology to support AP coverage and network bridge function. Outdoor equipment adopts RG-P-780 high performance dual frequency base station type AP of the third mock exam, the device with dual 802.11g can support 108Mbps channel bandwidth, and can provide 802.1a/b/g three frequencies technology. In addition, it provides the partition based on 802.1Q VLAN, and can adapt to the high temperature range of -40 DEG + 65 DEG and completely provide smooth network and access for a large number of concurrent users.

5. CONCLUSION

As a new network communication technology, wireless local area network (WLAN) has been widely applied in many mobile communication fields. WLAN uses an effective method of wireless multiple access channels to support communication between computers, and provides a possibility for the mobile, personalized and multimedia applications of communication. This paper studies the working principle of 802.11 WLAN, and introduces the characteristics and technology of WLAN. At the same time, the reference architecture of WLAN is studied, the communication protocol of 802.11 WLAN is analyzed, and the MAC layer of IEEE 802.11 B protocol is analyzed and studied in detail.

REFERENCES

[1] Baek, S., & Choi, B. D. (2017). Performance analysis of power save mode in ieee 802.11 infrastructure wireless local area network. Journal of Industrial & Management Optimization, 5(3), 481-492.

[2] Ekpenyong, M. E., Inyang, U. G., Asuquo, D. E., Ekong, U. O., Usip, P. U., & Umoh, U. A., et al. (2018). Intelligent test bed tuning for improved wireless local area network service quality in academic environments. International Journal of Artificial Intelligence, 16(1), 60-87.

[3] Goodall, N. J. (2017). Fundamental characteristics of wi‐fi and wireless local area network re-identification for transportation. Iet Intelligent Transport Systems, 11(1), 37-43.

[4] Ismail, M. N. (2017). Best approach for video codec selection over voip conversation using wireless local area network. International Journal of Interdisciplinary Telecommunications & Networking, 3(1), 36-49.

[5] Kim, E. (2016). Method and apparatus for dynamic station enablement procedure in a wireless local area network system. Annalen Der Physik, 264(6), 230–244.
[6] Kim, I., & Park, S. (2017). Delay model of multicast protocols co-existing with legacy unicast in ieee 802.11 wireless local area network. Iet Communications, 11(9), 1438-1445.
[7] Lakshmi, N. V. S. S. R., Bhalaji, N., & Sivakumar, B. (2016). On the construction of qos based overlay architecture for wireless local area network. Wireless Personal Communications, 90(2), 1-13.
[8] Morales, J., Akopian, D., & Agaian, S. (2016). Mitigating anomalous measurements for indoor wireless local area network positioning. Iet Radar Sonar & Navigation, 10(7), 1220-1227.