WLAN Indoor Channel Modeling

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***Abstract*—This experiment introduces the method of WLAN indoor channel modeling. Based on the literature of path loss and shadow fading, the basic principle of receiving signal varying with distance is introduced. In the experimental process, we simplify the model and use MATLAB to simulate, and obtain the fitting curve and fitting function of signal strength.**

Keywords-WLAN; channel modeling; propagation modeling

I. INTRODUCTION

The parameters of any given wireless communications system are to a large extent determined by the propagation characteristics of the environment in which it is deployed. Numerous wireless channel models have been developed, primarily for propagation out-doors, in an effort to predict the effect of the channel without the expense of directly measuring it[1]. Most of these models describe the temporal properties of the channel, but recent interest in the use of multiple antennas on both ends of the communication link have led to the development of models that also account for spatial spreading of the signal.

In this paper, the average of multiple measurements at a given distance and multiple measurements at different points in the same distance are used for data collection, and the existing model is simplified, fitting out a WLAN propagation function.

II. PROPAGATION MODELING

A. Propagation path loss model

Free space is defined as an infinite space with zero electrical conductivity and isotropy of radio wave propagation[1]. In this ideal space, radio waves travel at the speed of light in a vacuum, and there are no phenomena such as reflection, refraction, diffraction, dispersion and absorption of radio waves.

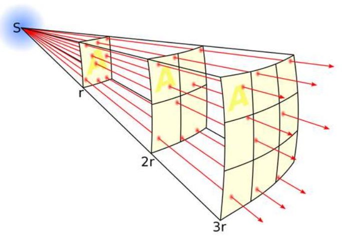

Fig 1. Example of a figure caption.

The free-space model can be used to predict the intensity of the received signal when there is no obstacle between the transmitter and the receiver, i.e. there is a direct path that is shown in Fig 1.

It is assumed that the signal travels through free space to the receiver at distance d, that there are no obstacles between the transmitter and the receiver, and that the signal travels in a straight line. Such a channel is called a channel(line-of-sight, LOS[6]), and the corresponding received signal is called an LOS signal. Free space path loss causes the received signal to introduce a complex factor relative to the sent signal, producing the received signal:

$$r(t) = \mathrm{Re}\{\frac{\lambda\sqrt{G_l}e^{-j2\pi d/\lambda}}{4\pi d} \cdot u(t)e^{j2\pi f_c t}\} \tag{1}$$

Where $\sqrt{G_l}$ is the product of the gain of transmitting antenna and receiving antenna in the line-of-sight direction, $e^{-j2\pi d/\lambda}$ is the phase shift caused by the propagation distance d. Let the power of transmitted signal $s(t)$ be P_t [3], and the ratio of received power to transmitted power can be obtained from the expression of received signal $r(t)$:

$$\frac{P_r}{P_t} = (\frac{\sqrt{G_l}\lambda}{4\pi d})^2 \tag{2}$$

It can be seen that the received power is inversely proportional to the square of the distance d between the transceiver antenna and is directly proportional to the square of the signal wavelength λ^2[5]. Therefore, the higher the carrier frequency and the shorter the signal wavelength, the lower the received power. The received power is related to wavelength λ because the effective area of the receiving antenna is related to wavelength.

The corresponding path loss can be expressed as:

$$P_L \text{ dB} = 10\log_{10}\frac{P_t}{P_r} = -10\log_{10}\frac{G_l\lambda^2}{(4\pi d)^2} \tag{3}$$

A large number of experimental statistics and theoretical analysis show that the average power of received signals decreases exponentially with the increase of distance. In practical application, according to theoretical analysis and experience, the average path loss of wireless channel can be expressed as a function of the distance between transmitter and receiver:

$$\overline{PL}(dB) = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right) \tag{4}$$

B. Shadow fading model

The shadow fading model mainly discusses the shadow fading phenomenon. When electromagnetic wave is blocked, a shadow area will be formed behind these obstacles[2]. When mobile users pass through different shadow areas, the value in the received field strength will change, thus forming fading. The characteristics of shadow fading are usually described by the logarithmic normal distribution of random variables, which means that the probability density of a random variable is normally distributed when it is expressed in dB.

In the log-distance path loss model, the average path loss only considers the influence caused by distance, and does not consider the difference of signal strength caused by the different surrounding environment of different paths at the same distance. A large number of measurement statistics show that path loss $PL(d)$ is a lognormal random variable at distance d from the transmitter.

$$PL(d)[\mathrm{dB}] = \overline{PL}(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) + X_\sigma \tag{5}$$

X_σ is the shielding factor.In other words, lognormal distribution describes the random shadow effect that occurs at a large number of measured locations with the same transmitter-receiver distance, which is called lognormal shadow. A lognormal shadow means that the signal level measured at a particular transmitting range has a Gaussian distribution[4], the mean of which is the average path loss.

III. EXPERIMENT RESULT

Intensity is the mean value of six measured values after three measurements at a fixed point and two measurements at different points at the same distance.

TABLE I. EXPERIMENTAL DATA

Distance/m	*Mean*	*Num 1*	*Num 2*	*Num 3*	*Num 4*	*Num 5*	*Num 6*
1	-39.8	-44	-32	-45	-40	-37	-41
2	-42.7	-43	-39	-39	-46	-42	-47
3	-45.5	-48	-45	-52	-46	-38	-44
4	-50	-52	-54	-50	-56	-50	-38
5	-49.3	-49	-45	-50	-53	-46	-53
6	-50.5	-44	-50	-55	-52	-48	-54
7	-49.3	-47	-51	-53	-52	-46	-47
8	-51.7	-48	-49	-51	-51	-52	-59
9	-51	-55	-49	-49	-46	-47	-60
10	-48	-51	-45	-49	-44	-50	-49

a. Intensity is measured in dB.

In the experiment, Huawei router was used to test and a simplified indoor channel model was adopted. We make X_σ equals 0 and d_0 equals 1. So the signal strength function is:

$$R(d) = R(d_0) - 10n\lg(d) \tag{6}$$

n is the path loss factor.

Using MATLAB fitting to draw scatter diagram and fitting curve as follows:

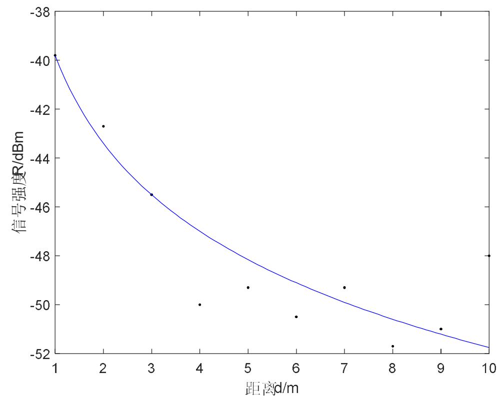

Fig 2. Simulation curve

The signal strength function is:

$$R(d) = -39.8 - 5.193\lg(d)$$

IV. SIGNAL IMPROVEMENT METHOD

Wireless signals are susceptible to obstacles, walls, weather, electromagnetic interference and other factors, which will lead to consumption and signal attenuation in the transmission process.

- Select an appropriate placement point for the wireless AP. The position of the placement point is higher, which can reduce the obstruction of obstacles and reduce the signal blind area; The location is as visible as possible between the wireless client in the room and the wireless AP.
- Reduce interference from household appliances to ensure unimpeded signal, and place the AP far away from microwave ovens, wireless mice, and wireless keyboards.
- The wireless signal can be enhanced by replacing the high gain antenna.
- Ban on weak signal the client access function, through configuration allows access to the wireless client minimum signal strength threshold method, can be directly refused to signal strength is lower than the specified threshold wireless client access to the WLAN network, reduce the weak signals of clients to other wireless clients, so as to increase the application effect of WLAN network.

V. CONCLUSION

In this paper, the principle of transmission model is introduced, a simplified model is proposed based on this principle, and the signal propagation function is calculated on the basis of experiments.

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