Analysis of Modeling Methods for Different Types of Channels

Ao Tang *

Department of communication engineering, Chongqing University of Post and Telecommunication, Chongqing, China

* Corresponding author: 2161102@brunel.ac.uk

Abstract. Contemporarily, channels are widely used in various fields. This study aimed at introducing different advanced modeling methods for different types of channels. It mainly introduces the method of modeling wireless channels, compositing channels and AWGN channels and the characteristics of each are summarized and compared. The development of channel modeling has gone through an evolutionary process from empirical models to statistical models, physical models, and evolutionary models. As communication technology continues to advance and application requirements continue to change, channel modeling will continue to develop, providing more accurate and practical model tools for the design and optimization of communication systems. This study analyzes the modeling methods for three different channels according to background introduction, theoretical research, result analysis, and performance comparison. For these three different channel modeling methods, this study obtained a very satisfactory fit, but there are still some errors, which proves more advanced algorithms for different channels are still waiting to be developed.

Keywords: Modeling, channels, noise.

1. Introduction

Channels can be classified according to different classification criteria: According to the transmission medium, it can be divided into wired channel and wireless channel; according to the nature of the signal, it can be divided into baseband channel and bandpass channel; according to the transmission mode, it can be divided into simplex channel, half-duplex channel, and full-duplex channel; and other classification, etc.

The development of any technology is not achieved overnight, and it must go through a certain development process. The history of channel modeling can be traced back to the early twentieth century: At the beginning of the 20th century, in the early days of radio communications, qualitative descriptions of channel behavior began to emerge. Early channel modeling mainly relied on experience and observation, and simply described and classified the characteristics of the propagation path. By 1920-1930, the development of ray propagation theory laid the foundation for channel modeling. This theory enables a deeper understanding of channel behavior in complex environments by tracking and simulating physical processes such as reflection, refraction, and scattering of signals along the propagation path. By 1950, Shannon's developments in information theory provided the mathematical and theoretical basis for channel modeling. The emergence of information theory makes it possible to quantitatively model parameters such as channel capacity and bit error rate. In the 1970s: the Rayleigh fading channel model was proposed, which described the multipath effect caused by the multipath propagation of the signal in the absence of a clear direct path. Since then, the Rayleigh fading model has become an important tool to measure the channel fading characteristics in wireless communication. In the 1980s, the Gaussian channel model was introduced to describe an ideal channel with Gaussian white noise added in wireless communication systems. This model is important for analyzing the performance of modulation and coding schemes. Finally, from the 1990s to the present, with the rapid development of wireless communication technology, research on large-scale multi-antenna systems, channel coding and modulation techniques, etc., has promoted the in-depth research and improvement of channel modeling. At the same time, advances in computer simulation technology have made complex channel modeling and performance evaluation possible.

In recent years, with the joint efforts of countless researchers, channel modeling has made great progress. Among them, the emerging modeling methods include OPNET wireless channel modeling [1]. For HF broadband channels there are: Vogler Shortwave Broadband Channel Model, Sub band Parallel-Wideband Narrowing Model and pseudo-deterministic channel model. Two Improved Models of Waterson (the model is followed by a group delay characteristic filter and a Gaussian random delay respectively) [2]; Wireless MIMO Channel Modeling [3]; composite fading channel [4]; AWGN channels [5] and so on. These different modeling methods are used to target the characteristics of various channels to achieve the highest degree of fitting, and more truly reflect the characteristics of channels in real life, to facilitate specific upgrades to signals, thereby improving the overall performance of the system. communication quality. Channel modeling is widely used in many fields, such as: system design and performance evaluation, including wireless communication systems, wired communication systems, and hybrid communication systems (such as optical fiber wireless communication systems). By establishing an appropriate channel model, the performance of different modulation, coding, and multiple access schemes can be evaluated and compared, thereby guiding system design and parameter selection. It can also be used for technology evaluation and comparison, i.e., to evaluate and compare the performance of different communication technologies or schemes. For example, by establishing multipath fading models and interference models, the performance differences of different cellular network technologies (such as 4G and 5G) or wireless local area network (WLAN) technologies can be compared, thereby guiding technology selection and network optimization. It can also be used for link budget and capacity estimation.

By establishing a suitable channel model, parameters such as attenuation, interference noise, and transmission rate during signal transmission can be calculated, thereby predicting link quality and system capacity, and performing system planning and resource planning. It can also be used for link adaptation and optimization. By understanding the characteristics of the channel, parameters such as modulation mode, coding scheme, and power allocation can be adjusted according to real-time channel status and quality indicators to optimize system performance and improve link quality. Finally, channel modeling can aid in rate adaptation and modulation selection. By establishing a channel model and estimating channel conditions, the system can select an appropriate modulation method and code rate according to the current channel quality to maximize the reliability and efficiency of data transmission. In conclusion, channel modeling plays an important role in communication system design, performance evaluation, capacity planning, technology comparison, adaptive adjustment etc. Through reasonable channel modeling, wireless communication systems can be better understood and optimized to achieve high-performance data transmission and wireless connections in different application scenarios.

This paper will introduce modeling method for different types of channels like wireless channel; composite fading channel; AWGN channel and so on. A wireless channel refers to a transmission medium or a transmission path for wireless communication. It is the medium of information transfer that allows wireless signals to travel between a sender and a receiver. Wireless channels usually consist of air or other media in which electromagnetic waves propagate in space in the form of wireless signals. These wireless signals can be radio waves, microwaves, infrared rays, or other forms of electromagnetic waves. In a wireless communication system, the transmitter converts information into a signal suitable for wireless transmission through modulation technology, and then sends it to the receiver through a wireless channel [1]. Composite fading channel is a channel model that describes the simultaneous existence of multiple fading effects in the signal propagation environment. In a wireless communication system, a signal may experience multiple fading effects such as multipath fading, shadow fading, and large-scale fading during propagation. These fading effects coexist and interact, resulting in intensity and phase changes in signal reception [4]. AWGN channel refers to Additive White Gaussian Noise (Additive White Gaussian Noise) channel, which is often used in communication systems to model ideal channels or noise components in actual communication systems. In the AWGN channel, signal transmission is interfered by additive white Gaussian noise. This channel model assumes that channel transmission is not affected by multipath fading, frequency selective fading or other interference sources, and only considers additive white Gaussian noise, which is often used for theoretical analysis and performance evaluation purposes [5].

2. Theoretical Analysis

2.1. Basic Principles

2.1.1. Wireless channel

The image shown in Fig. 1 depicts the interaction between the system level simulator and the wireless link level simulator chain. The system-level simulator receives the necessary input parameters from the road-level simulator, including the characteristics of the uplink and downlink's packet channel transmission delay and bit error rate. The entire wireless transmission technique may be employed for each transmit channel and receive channel pair. These transmission stages are a collection of parameter computations used in the modeling of wireless connections and are described by a combination of several single-function sub-transmission stages. Since there is a time sequence and reciprocal causation between numbers, the arrangement order of the transmission stage must also be decided in accordance with the actual transmission sequence. The entire wireless connection modeling method is explained in the following, along with the outcomes it produces.

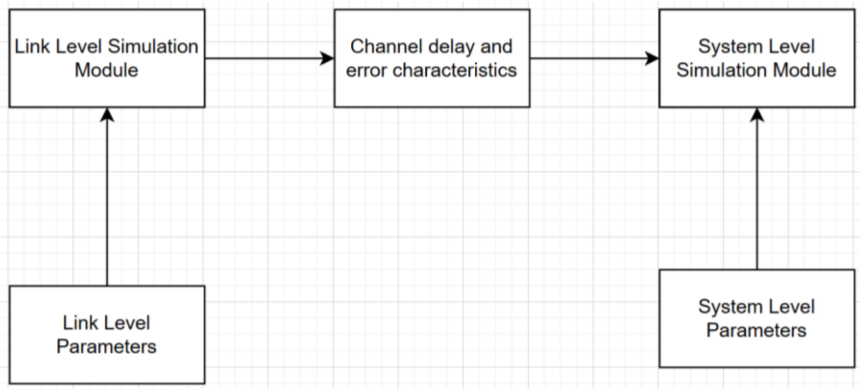

Figure 1. Interaction between the system level simulator and the wireless link level simulator chain.

The following introduces the entire process of wireless link modeling: first, the transmission delay is calculated, which is part of the delay experienced by the data packet in the wireless link. This time is the difference between the time when the first bit of the data packet starts to be sent and the time when the last bit is sent. It is also the simulation time used by the transmitting station to process the data packet. Next is the physical accessibility calculation, which reads the coordinates of the transmitting station and the receiving station on the geocentric coordinate system, and calculates the connection vector to determine whether it intersects with the earth's surface or obstacles. Then, there is the channel matching calculation: judging whether the channel matches based on five attributes such as frequency, bandwidth, data rate, transmission code and modulation method of the transmitting station and the receiving station. Then, one calculates the transmitter antenna gain and receive antenna gain. Propagation delay is another part of the delay experienced by the data packet in the wireless link, which can be calculated in Eq. (1) and (2).

$$V_{relative} = \frac{d_{end} - d_{start}}{D_{lx}} \tag{1}$$

$$F_{shifted} = \left(\frac{V_{relative} + V_{proporgation}}{V_{proporgation}}\right) * F_{unfinished} \tag{2}$$

Background noise and interfering noise also need to be considered. Finally, SNR and BER can be calculated respectively according to Eq. (3) and (4). After getting the results, perform error analysis.

$$SNR_{actural} = 10log_{10}\left[\frac{P_r}{P_b+P_i}\right] SNR_{effective} = SNR_{actural} + G_P \tag{3}$$

$$P_k = p^k(1-p)^{N-k}\binom{N}{k} \tag{4}$$

2.1.2. Composite fading channel

The graphic shown in Fig. 2 shows the block diagram for the composite fading channel simulation used in this work. The primary control PC and the high-speed signal processing module are the two components of the system, which uses the CPCI bus architecture. The high-speed signal processing module completes channel parameter estimation and monitoring, and the PC realizes user parameter interaction and status monitoring simulation.

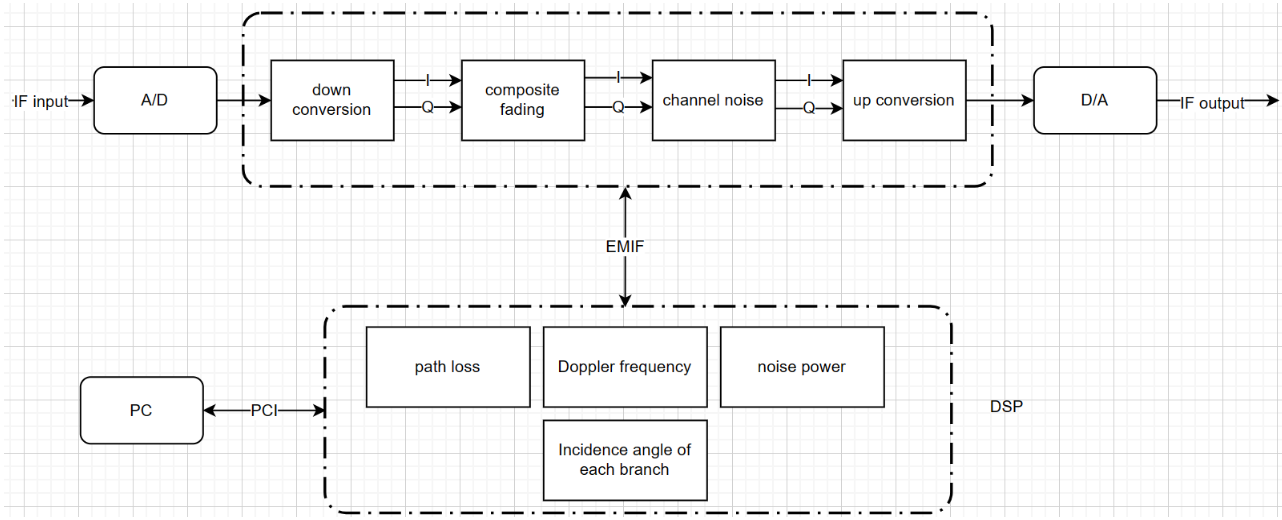

Figure 2. The block diagram for the composite fading channel simulation

The formula states that once the intermediate frequency input signal is A/D and down converted, it is transformed into two orthogonal baseband signals. After channel superimposition, the output signal may be represented as follows:

$$y_c(t) = \sum_{i=1}^{L}\{x_c(t-\tau_i) * r_{i,c}(t) - x_s(t-\tau_i) * r_{i,s}(t)\} + n_c(t) \tag{5}$$

$$y_s(t) = \sum_{i=1}^{L}\{x_c(t-\tau_i) * r_{i,s}(t) - x_s(t-\tau_i) * r_{i,c}(t)\} + n_s(t) \tag{6}$$

Assuming a complex baseband signal input signal as $\tilde{x}(t)$, the output signal can be expressed as:

$$\tilde{y}(t) = \sum_{i=1}^{L}\{r_i(t)e^{j\theta_i(t)} \cdot \tilde{x}(t-\tau_i)\} + \tilde{n}(t) \tag{7}$$

For the composite fading channel for Nakagami-Lognormal, the Nakagami distribution governs the amplitude at a given sampling period, the lognormal distribution governs the average power, and the path loss determines the regional mean value of the lognormal distribution.

$$f_{ri}(r) = \int_0^{+\infty} f_{\gamma i}(r/\beta) * f_{\beta i}(\beta/\alpha_{i)}\, d\beta \tag{8}$$

$$f_{\beta i}(x) = \frac{1}{\sqrt{2\pi}\sigma_i x} e^{-\frac{(lnx-\mu_i)^2}{2\sigma_i{}^2}} \tag{9}$$

$$f_{\gamma i}(x) = \frac{2}{\Gamma(m_i)}\left(\frac{m_i}{\omega_i}\right)^{m_i} x^{2m-1} e^{-\frac{m_i}{\omega_i}x^2} \tag{10}$$

This study employs the characteristics of lognormal and Nakagami random variables to recast the compound fading into the form of Gaussian random variable decomposition in order to conform to the features of the FPGA hardware structure. As can be seen, the complex fading simulation problem may be made simpler by using a variety of approaches, such as the filtering method, the finite-state Markov chain method, and the harmonic superposition method, which Clarke et al. The SoS approach that has been presented is the most popular. The goal is to construct a high stochastic process by superimposing a collection of harmonics at various frequencies.

$$u_i(t) = \sqrt{\frac{2}{N}}\sum_{n=1}^{N} cos\left(2\pi f_{i,d} t cos\alpha_{i,n} + \varphi_{i,n}\right) \tag{11}$$

When the model's parameters are chosen, they are all non-zero constants, and the variable t may be thought of as having a uniform distribution. The random variable has a mean and a variance of 0 and 1/N, respectively, and its amplitude distribution may be described by the transformability of random variables.

$$p_{u_{i,n}}(x) = \begin{cases} \frac{\sqrt{N}}{\pi\sqrt{2-Nx^2}} & |x| < \sqrt{\frac{2}{N}} \\ 0 & |x| < \sqrt{\frac{2}{N}} \end{cases} \tag{12}$$

The distribution of the output fading amplitude and the mean square error of the SoS module under varied branch numbers are simulated and compared in output accuracy of composite fading.

$$Er(x) = \left|f_{u,i}(x) - p_{u,i}(x)\right|^2 \tag{13}$$

2.1.3. AWGN channel

Establishment of channel model in deep space communication. A classic far space communication system is the MER system, which links Mars and Earth. The deep space communication channel may be modeled as a variable participatory white Gaussian noise signal (VPAWGN) with fading properties using the study of the MER system as well as the observation and analysis of numerous real signals. Although this type of channel has comparatively large frequency band resources, its power resources are severely constrained by the small size of detecting apparatus and the extraordinarily long transmission distance. As a result, it may be considered a channel with plentiful bandwidth and low power. dependable transmission path. Since the sun will have an impact on the route used for communication between Earth and Mars. The received signal on the earth will undergo amplitude fading and signal spectrum widening because of the action of charged particles. The severity of this phenomena increases with the separation between Earth and Mars, which also increases the channel's charge density. The received signal displays time-varying fading when the Doppler frequency shift is taken into account [6]. It is required to employ a variety of diversity receiving techniques (including space, frequency, time, and polarization diversity) to offset this impact brought on by the charged particles of the sun. They include the use of numerous ground antennas for space diversity and error-correcting coding and interleaving technology for time diversity. Due to atmospheric interference and solar particle interference, the signal travels across outer space. Multipath effects are caused by the scattering of radio waves, the reflection and refraction of radio waves by the ionosphere, and the reflection of radio waves by surface objects like mountains and buildings. In addition, the high-speed operation of the detector adds to the complexity of the communication channel in deep space. The Doppler frequency shift, path loss, and other effects are also caused by the movement, allowing the multipath transmission model to simulate the statistical properties of the received signal. The following VPAWGN channel model may be created to mimic the deep space communication using the theoretical analysis discussed above and study on the real Mars-Earth communication reception signal.

$$r(t) = Re\left\{\sum_{n=0}^{N(t)} a_n(t)m_n(t)X[t-\tau_n(t)]e^{j2\pi[f_c+f_{Dn}(t)][t-\tau_n(t)]}\right\} \tag{14}$$

Its complex baseband equivalent signal can be expressed as:

$$y(t) = \sum_{n=0}^{N(t)} \beta_n(t)e^{-j\varphi_n(t)}x(t-\tau_n(t)) \tag{15}$$

For the high-speed moving Earth and Mars communication system, its Doppler frequency shift can reach 200kHz. This study develops a simulation software platform for the deep space communication channel model using the Visual C++6.0 environment based on assessing the statistical properties of the deep space communication channel. The system block design for testing the VPAWGN channel is shown in Fig. 3. The signal is initially modulated by BPSK before entering the VPAWGN channel, after which it is attenuated, Doppler warped, and time delayed while being overlaid with white noise that follows the Gaussian distribution; The signal is processed at the receiving end using diversity reception, coherent demodulation, and equal-gain combination. The received sequence is then obtained using the minimum bit error rate criterion, and the bit error is then calculated by comparing the received sequence to the original signal rate. The information transmission rate, equivalent attenuation, noise mean and variance, and Doppler frequency shift are the channel optional parameters in the variable parameter Gaussian white noise channel.

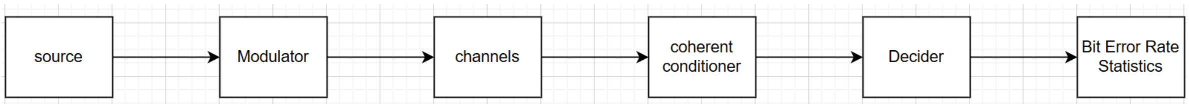

Figure 3. System block design

The library function rand makes it simple to implement white noise with a uniform distribution in the Vc++6.0 environment, but it is difficult to mimic white noise with a Gaussian distribution. The uniform is transformed in the article using the function transformation technique. Gaussian random noise is created from the dispersed noise. The following is the implementation procedure: The stone sequence is converted by mapping after being first created using the library function rand, whose joint distribution follows the uniform distribution on the range [0, 1] and possesses statistical properties of white noise signals.

$$y_1 = \sqrt{-2lnx_1}cos2\pi x_2 \tag{16}$$

$$y_2 = \sqrt{-2lnx_2}cos2\pi x_1 \tag{17}$$

The noise mean value, variance, channel equivalent fading, carrier frequency, Doppler frequency shift, and signaling rate are the system's input parameters. The bit error rate and signal noise ratio are the output parameters.

3. Result Analysis

3.1. Wireless Channels

People are paying more and more attention to the study of wireless networks as broadband wireless networks and multimedia technology evolve. Wireless local area networks (WLANs) are becoming more and more common because of how simple it is to connect, move around, expand, and use them [7]. Due to elements including noise, interference, multipath, and roaming of mobile terminals, channel states in a wireless environment fluctuate significantly over time [8]. Emulating a wireless link causes transmission packets to have delay and bit error characteristics. In the end, wireless link emulation enables several important performance metrics, such as immunity to interference, data success rate, data quality of service, and wireless channel bit error characteristics. But since a wireless link is a broadcast medium as opposed to a real thing, the whole network system's receiving terminals can be impacted by a single communication [9]. As a result, considering the combination of the transmit channel and all potential receive channels is necessary while modeling the transmission of a wireless data packet. The introduction of network simulation tools like OPNET has addressed several issues with wireless modeling. The whole process of the system OPNET is shown in the Fig. 4.

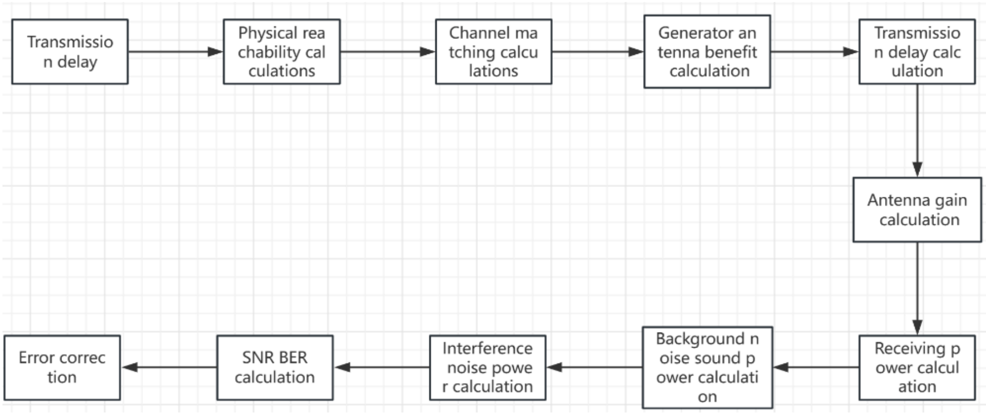

Figure 4. Process of the system OPNET

Different antenna gain levels are described by the antenna model. The phenomenon of the transmitted signal energy being amplified or dampened is referred to as antenna gain. The physical properties of the antenna construction and the azimuth at which it is broadcast determine the "shaping" of the transmitted power. The two angles (theta and phi) that are used to describe a direction vector on the geocentric three-dimensional coordinate system in antenna models are typically based on the geocentric coordinate system. The unique signal attenuation gain (dB) value selected by the user corresponds to this coordinate vector. The format of Table 1 can be used as the parameter input for the antenna model. The number of sample points for Phi and Theta may be used to compute the total number of antenna data. There are a total of 432 values based on the criteria set out in Table 1.

Table 1. Antenna Model Parameters

Number of sampling points for Phi (0~180.)		36 (angle interval 5.	
Theta (0-360.) The number of sampling points		l2 (angle interval 300)	
Theta/dB/Phi	0 (Phi)	30 (Ph i)	330 (Phi)
0 (theta)	-l8.0l668361154	-l8.00866803843	-17.44757792049
5 (theta)	-l0.6l83096278	-l0.6l830962780	-10.61830962780
10 (theta)	-7.528878733499	-7.532313979119	-7.772781172523
15 (theta)	-6.55326897740l	-6.546398486161	-6.65464099353
60 (theta)	-0.699610440816	-0.692739949576	-0.2l1805562767
90 (theta)	21.9833l6388452	21.983316388452	21.9833l6388452
175 (theta)	-l0.33375678227	-l0.33375678227	-l0.33756782279

Channel conditions change significantly over time in a wireless environment because of noise, interference, multipath, mobile terminal roaming, and other issues. The wireless connection is not a physical pair. Since the wireless connection is a broadcast medium and there is no isolated link entity, each transmission may have an impact on several receiving terminals across the whole network system. Even a moderate rate of speech has a relative decline of 12.8%, falling to 2.40%, a relative loss of 15.29% (seen from Table 2). The outcome is good, and the false recognition rate is decreased.

Table 2. Segment Length Correlation Applied to the Experimental Results of Digital String Recognition

Speech rate	system	insertion error	delete error	substitution error	total error rate
low	1	2.98%	0.40%	0.00%	3.38%
	2	2.38%	0.20%	0.00%	2.58%
medium	1	1.80%	0.20%	1.19%	3.20%
	2	1.60%	0.00%	1.19%	2.79%
high	1	0.00%	2.00%	0.83%	2.84%
	2	0.00%	1.69%	0.72%	2.40%

Additionally examined was continuous speech. extensive vocabulary lab for continuous speaking. The experiment makes use of male voice data that was given by the 863 Intelligent Computer Theme Office. There are a total of 83 speakers, and each speaker is associated with a file that has between 520 and 650 sentences. Nine of them—three for each category of slow, moderate, and fast—are utilized for recognition, while the remaining 74 files are used for training (Table 3.).

Table 3. Experimental results of paragraph length correlation applied to continuous speech recognition.

Speech rate	system	insertion error	delete error	substitution error	total error rate
low	1	4.64%	0.11%	19.44%	24.19%
	2	3.44%	0.10%	18.58%	22.12%
medium	1	0.30%	0.60%	22.21%	23.11%
	2	3.60%	0.59%	22.07%	23.02%
high	1	0.27%	1.66%	26.21%	28.15%
	2	0.32%	1.25%	25.96%	27.53%

The insertion error of the slow corpus fell for the continuous speech test with a big vocabulary from 4.64% to 3.44%, a relative decrease of 25.86%, and the overall error rate also decreased substantially by 8.56%. When compared to the slow corpus, the deletion error decreased from 1.66% to 1.25%. There was a small decrease in total error and a decline of 2470%. same for a medium speaking pace. Long-segment correlation is demonstrated to be useful for continuous speech as well, which obviously lowers the insertion and deletion mistakes brought on by the speech rate.

3.2. Composite Fading Channel

A hardware simulation method based on the principles of Gaussian variable decomposition and harmonic superposition is proposed, a composite fading channel model with path loss, shadow fading, and multipath fading is established, a relationship between the method's simulation parameters and the theoretical distribution of the output fading amplitude is deduced, and the output periodicity and bit-width selection issues of the fixed-point model of program are addressed. The whole process has been shown in Fig. 5.

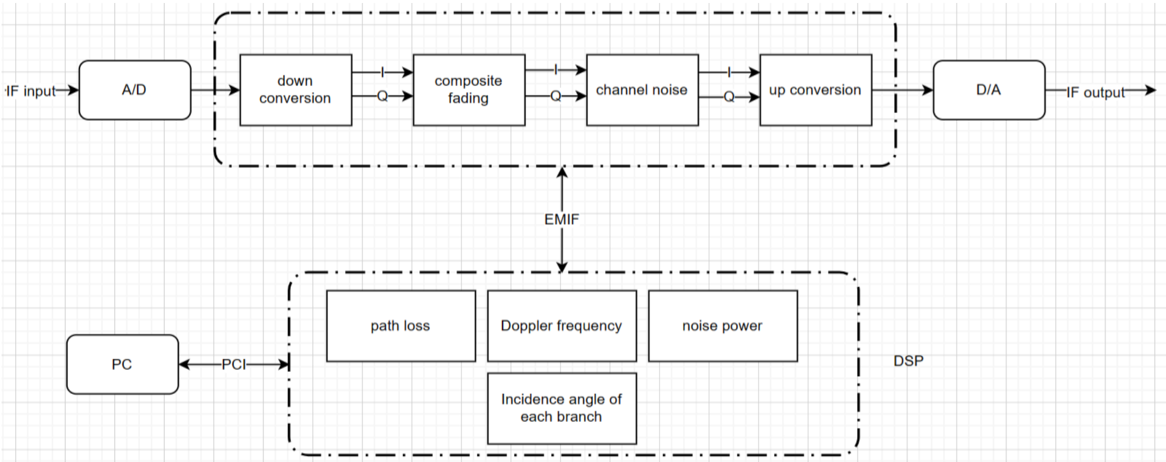

Figure 5. Process for composite fading channel.

Table 4. Statistical results of Nakagami multipath fading

theoretical value		measured value	
m	fading power Ω	$\hat{m}$	fading power $\hat{\Omega}$
0.5	$0.859*10^{10}$	0.4885	$0.85894*10^{10}$
1.0	$1.718*10^{10}$	1.0429	$1.6105*10^{10}$
1.5	$2.577*10^{10}$	1.4738	$2.4694*10^{10}$
2.0	$3.436*10^{10}$	1.9743	$3.3284*10^{10}$
2.5	$4.2950*10^{10}$	2.5037	$4.1873*10^{10}$
3.0	$5.1540*10^{10}$	3.0291	$5.0462*10^{10}$

Table 5. Statistical results of Lognormal shadow fading

theoretical value			measured value		
μ	σ	fading power	μ	σ	fading power
0.03	0.5	$1.5697*10^4$	0.0270	0.4921	$1.5603*10^4$
0.1	0.5	$1.6835*10^4$	0.0970	0.4921	$1.6734*10^4$
0.5	0.5	$2.5115*10^4$	0.4970	0.4921	$2.4965*10^4$
0.8	0.5	$3.3920*10^4$	0.7970	0.4921	$3.3699*10^4$
0.03	0.3	$1.4490*10^4$	0.0270	0.2857	$1.4388*10^4$
0.03	0.7	$1.7698*10^4$	0.0270	0.6984	$1.7708*10^4$
0.03	0.8	$1.9077*10^4$	0.0270	0.7937	$1.9089*10^4$

The statistical outcomes of multipath and shadow fading are shown in Table 4 and Table 5, respectively. The table shows that the greatest deviation is less than 10%, and that the deviation of the two statistical parameters is around 3%. The major application of the channel simulator is to perform repeatable bit error performance tests on communication equipment. The average error probability is one of the most significant performance indicators of wireless communication equipment. One employs R&S The spectrum analyzer serves as a receiver and provides symbol error rate statistics, while the company's vector signal source replicates the transmitter. The theoretical performance of BPSK in the Nakagami-Lognormal fading channel determined by the numerical integration approach in the literature reveals that the symbol error performance curves of the two are mostly compatible, according to the performance test findings. Distortion effects, suitable for performance evaluation of wireless communication system.

3.3. AWGN Channel

To simulate the deep space communication channel, a variadic AWGN (VPAWGN) model was established. The model mainly considers the influence of parameters such as path loss, Doppler shift, and noise power on channel characteristics [10]. One builds the VPWAGN model in the Visual C++ environment and verify the effect of each parameter on the channel. The whole process of WPAWGN testing system is shown in Fig. 6.

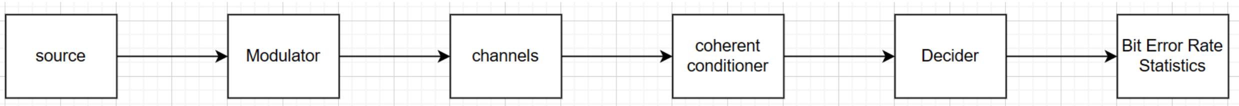

Figure 6. Process for AWGN channel.

Table 6. Variation of bit error rate with signal-to-noise ratio in VPAWGN channel

noise variance	SNR (dB)	carrier frequency (Hz)	information rate (bit/s)	channel attenuation (dB)	Doppler shift (Hz)	BER
0.64	3.876	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$<1.0*10^{-6}$
0.68	3.350	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$2.0*10^{-5}$
0.20	2.853	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$4.8*10^{-5}$
0.76	2.384	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$3.0*10^{-4}$
0.80	1.938	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$5.8*10^{-2}$
0.84	1.514	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$8.3*10^{-2}$
0.88	1.110	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$8.7*10^{-2}$
0.92	0.724	$8.439*10^9$	$1.28*10^5$	0.00	$2.0*10^5$	$9.1*10^{-2}$

Table 7. BER Statistics for Varying Schiller Shift

noise variance	SNR (dB)	carrier frequency (Hz)	information rate (bit/s)	channel attenuation (dB)	Doppler shift (Hz)	BER
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.20*10^5$	$2.0*10^{-4}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.32*10^5$	$<1.0*10^{-6}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.58*10^5$	$2.0*10^{-4}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.70*10^5$	$<1.0*10^{-6}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.76*10^5$	$4.0*10^{-4}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.82*10^5$	$<1.0*10^{-6}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.88*10^5$	$4.0*10^{-4}$
0.82	1.723	$8.439*10^9$	$1.28*10^5$	0.00	$1.94*10^5$	$<1.0*10^{-6}$

Table 6 shows that when the noise variance, or SNR, grows, the bit error rate of the system drops. However, when the SNR is less than 2 dB, the bit error rate of the system is quite high, as this indicates that the SNR is too low. The bit error rate is quite high when the signal amplitude is too little since it is essentially covered by noise. However, when the noise ratio hits 2.4dB, the bit error rate drops to less than 10, or almost nil. As a result, the variance of the noise shouldn't be bigger than 0.64, which means that the signal-to-noise ratio must be higher than 2.4dB, to guarantee that the bit error rate in the real system is on the order of 10". The attenuation has no impact on the system's bit error rate since the signal's judgment threshold is o. In this situation, the test cannot take the attenuation of the error rate into account. The impact of Doppler frequency shift on the bit error rate is seen in Table 7. According to the experimental results, there are decision points where the Doppler frequency shift has a bigger influence than others on the bit error rate at the corresponding frequency. The cause is because at specific decision time points, the phases of the frequency band signals at the relevant frequencies are near together. The signal's amplitude significantly decreases after being cosigned, which dramatically increases the effect of noise and raises the bit error rate. The signal's amplitude also significantly decreases after being cosigned. As a result of the Doppler frequency shift having little impact on the signal's amplitude, or because the change in the signal-to-noise ratio is very small, the bit error rate has little impact, the phase of the frequency band signal at some decision time points is, on the other hand, far from the center. The comparison results are given in Table 8.

Table 8. Comparison of the three types.

	Wireless channel	Composite fading channel	AWGN channel
performance	Outstanding	Excellent	Superior
work scene	Wireless environment	Real life	Deep space

4. Conclusion

To sum up, this study mainly introduces the modeling methods for three different channels, namely wireless channel, composite fading channel and AWSN channel. For the three different channels, different modeling methods can achieve a good effect of fitting the real situation, but there are still many errors. Then for more different channels, specific modeling methods are still waiting to be developed.

References

[1] Chen M, Zhang J, Wei G. OPNET Wireless Channel Modeling. Computer Engineering and Applications, 2003, 39 (25): 5.

[2] Tang W, Tu X, Li S. Broadband Channel Modeling Methods and Comparison in HF Communications. Journal of University of Electronic Science and Technology of China, 2003, 32 (005): 555 - 559.

[3] Zhao X. 4G and 5G Wireless MIMO Channel Modeling and Simulation Research Overview. Proceedings of the 2015 National Microwave and Millimeter Wave Conference. 2015.

[4] Zhu Q, Dai X, Liu X, et al. Research on modeling and simulation methods of composite fading channels. Signal Processing, 2015, 31(1): 7.

[5] Zhang Y. Characteristic Analysis and Simulation of Variable Parameter AWGN Deep Space Channel Model. Space Electronics Technology, 2010, (1): 22 - 25, 50.

[6] Jiang P. Modeling method and application of wireless propagation channel playback model. Journal of Communications, 2005, (4): 99 - 104.

[7] Lima M P, Takahashi R H C, Vieira M A M, et al. Multiobjective planning of indoor Wireless Local Area Networks using subpermutation-based hybrid algorithms. Knowledge-Based Systems, 2023, 263: 110293.

[8] Liao R, Bellalta B, Oliver M, et al. MU-MIMO MAC protocols for wireless local area networks: A survey. IEEE Communications Surveys & Tutorials, 2014, 18 (1): 162 - 183.

[9] Yoo S K, Cotton S L, Sofotasios P C, et al. Effective capacity analysis over generalized composite fading channels. IEEE Access, 2020, 8: 123756 - 123764.

[10] Bash B A, Goeckel D, Towsley D. Limits of reliable communication with low probability of detection on AWGN channels. IEEE journal on selected areas in communications, 2013, 31 (9): 1921 - 1930.