Mathematics and Computer Science
2016; 1(1): 10-16
http://www.sciencepublishinggroup.com/j/mcs
doi: 10.11648/j.mcs.20160101.13

High Altitude Platform Station Network and Channel Modeling Performance Analysis

Xiaoyang Liu[1, 2], Chao Liu[1], Wanping Liu[1], Xiaoping Zeng[2]

[1]School of Computer Science and Engineering, Chongqing University of Technology, Chongqing, China

[2]Postdoctoral Research Station of Information and Communication Engineering, Chongqing University, Chongqing, China

Email address:

lxy3103@163.com (Xiaoyang Liu)

To cite this article:

Xiaoyang Liu, Chao Liu, Wanping Liu, Xiaoping Zeng. High Altitude Platform Station Network and Channel Modeling Performance Analysis. *Mathematics and Computer Science.* Vol. 1, No. 1, 2016, pp. 10-16. doi: 10.11648/j.mcs.20160101.13

Received: April 16, 2016; **Accepted**: April 28, 2016; **Published**: May 13, 2016

Abstract: High altitude platform station (HAPS) is a wireless repeater in the air. It can play a dominant role in observations, remote sensing and communication. The structure and composition of formation of HAPS are studied in this paper. The performance of the wireless communication link are researched. The simulation results shows that the power of receiver is proportional to the received power and thermal noise power ratio.

Keywords: High Altitude Platform Station, Nearspace, Linkbudget, Communication Performance

1. Introduction

High altitude platform station (HAPS) is a stranded in 20 km ~ 50 km height of near space, a particular location relative to the earth the stillness of the platform. It can be seen as between terrestrial communication system and satellite communication system between a communications system. Aimed at the height of the development of land and space between space of potential interest [1-2]. It can improve the communication capacity and spectrum efficiency, also can reduce the equipment cost and complexity. The path decline of HAPS is smaller than terrestrial communication system, and they have smaller delay than the satellite communication system. In recent years, in order to improve the observation and coverage. In near space platform construction of monitoring and communication system was further attention. The development of HAPS is similar with satellite communication in the 1960s [3-4]. HAPS can be described as "a kind of has a broad application prospect, can overturn the development of telecom industry new technology". It is the foundation of the next generation of wireless communication. And have to make full use of radio spectrum resources, large capacity of the system user, communication of good quality, low operational risk, etc. And you can upgrade communication load operation at any time.

ITU (International Telecommunication Union) described HAPS as "a kind of has a broad application prospect, can overturn telecom industry development of new technology. It is the foundation of the next generation of wireless communication, and the ability to make full use of radio spectrum resources, users of the system, large capacity, good quality of communication, low operational risk, etc, and can upgrade at any time communication load operation [5-6].

The papers are [7-8] studied the near space HAPS forward pilot frequency, band pass filter is adopted to establish the HAPS forward model, and the quantitative analysis of space communication link SNR of signal quality. HAPS IMT-2000 system are analyzed [9-10], and the ultra high frequency (47/49GHZ) link features of mathematical modeling and simulation analysis. Nouha Baccour [11-13] analyzed the uplink TDD capacity limit and the expansion has capacity of near space method. Juan J. Gálvez, Pedro M. Ruiz [14-18] in the time domain analysis such as the AMC (the Adaptive Modulation and Coding, Adaptive Modulation) and ARQ (Automatic Repeat Request, Automatic retransmission Request) and QoS (Quality of Service, Quality of Service), the relationship between. According to channel state dynamic adjustment ways of modulation, encoding, time domain parameter. Gu Wenzhe, Sun Qibo, Zhang Hai, Yang Fangchun, etc [19-22] combines the spatial channel transmission characteristics, spatial information based on link adaptive cross layer optimization design is studied combined the physical AMC/channel coding and data link layer ARQ techniques.

2. HAPS Communication Network

Figure 1 shows the integration of space aviation telecommunication network architecture based on HAPS. HAPS network includes a set of forward can perform routing, and traffic management HAPS communication node. It can be implemented with a laser or microwave communication between them. It is a challenging problem about the link between HAPS [23-25].

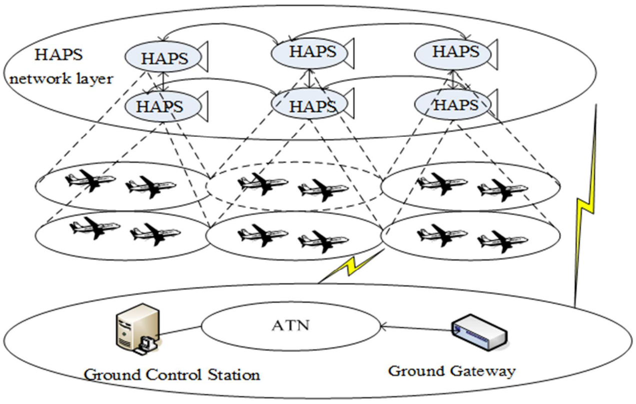


Figure 1. *System architecture diagram of HAPS.*

The geometric relationships of a communications system of HAPS is shown in figure 2.

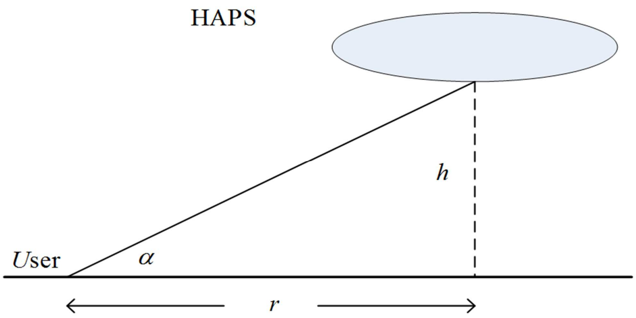
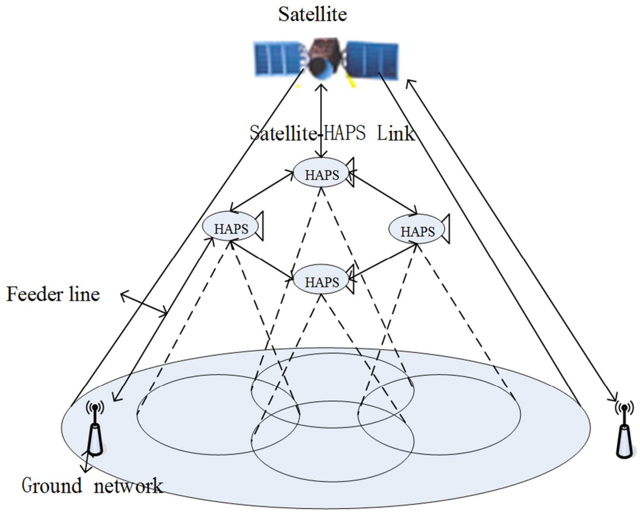
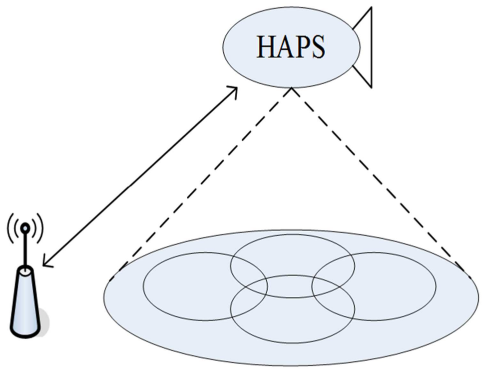


Figure 2. *The geometric relationshipsof a communications system.*

Within the scope of the near-earth space using stable communications platform as a microwave relay station. With the ground control equipment, entrance equipment and a variety of wireless communication system in the composition of the user. High altitude platform can comprehensive network and satellite ground, also can separate and ground network, as can be seen in Figure 3. The communication platform to keep in sync with the earth's rotation, can reside the air for a long time. High altitude platform communication of good waves transmission characteristics [26-30]. Through the platform to realize the ground between the user, platform or platform and satellite communication between the connection. With flexible layout, wide application, the advantages of low cost, safe and reliable. Platform of mobile will affect the communication quality, the greater the speed of mobile, the more unstable. The longer the elevation Angle, the smaller the path, with the decrease of the elevation Angle and channel quality becomes poor.



(a) The network Satellites, ground and HAPS



(b) The comprehensive network of Ground and HAPS

Figure 3. *The communication network structure of HAPS.*

3. System Model

Based on the space integration of the HAPS aviation telecommunication network architecture is shown in Figure 1. HAPS network includes a set of can perform routing and forwarding HAPS communication nodes, and traffic management can be implemented with a laser or microwave communication between them. The link problem are introduced to HAPS.

In near-earth space within the scope of use the stable communications platform for microwave relay station, with the ground control equipment, entrance equipment and a variety of wireless communication system in the composition of the user, high altitude platform can be integrated network and satellite ground, also can separate and ground network. The communication platform to keep in sync with the earth's rotation, can reside the air for a long time [31-34]. High altitude platform communication of good waves transmission characteristics, Through the platform to realize the ground between the user, platform or platform and satellite communication between the connection, with a flexible layout, widely used, the advantages of low cost, safe and reliable. HAPS space communication network diagram is shown in Figure 4 [35-40].

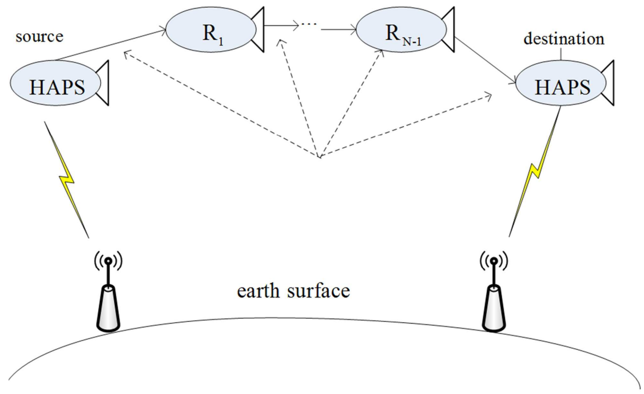


Figure 4. *HAPS space communication network diagram.*

As can be seen from the Figure 4. HAPS is a highly dynamic space platform. During the communication is relate to atmospheric environment, multipath fading, space, flash and other factors. Near space vehicle can stay a long time in the space, usually can stay for several years. The higher the altitude, the better of its field of view. Space-airs safety is the important pillar of national security.

4. Technical Analysis

The main goal of link budget is to ensure the availability of HAPS communication link. Given the cost of space and ground station equipments. Need to elaborate design of HAPS link. To fully optimize and save the use of all available resources. The HAPS link budget can be seen in Figure 5, and the uplink and downlink of HAPS is shown in Figure 6.

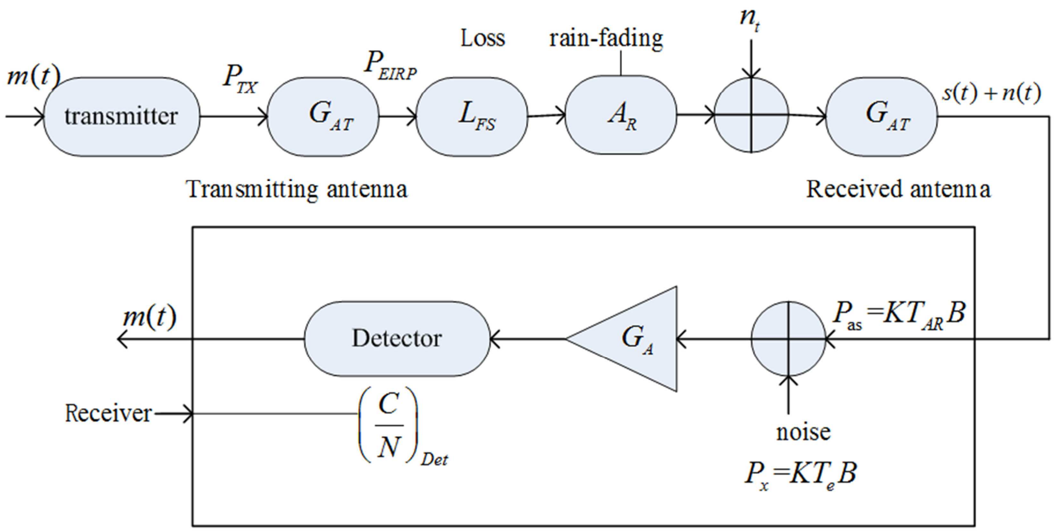


Figure 5. *HAPS link budget.*

As can be seen in Figure 5, the performance of the HAPS mainly determined by the decline of the rain. $m(t)$ is the input signal. P_{TX} is the transmit power. In order to accurate analysis of the High altitude platform station (HAPS) link budget. It is very important for the cognition to some of the factors. These factors mainly include: The power amplifier gain, Equipment noise factor, Transmission antenna gain, angle of slope and atmospheric l path loss, Receiving antenna and amplifier gain, noise characteristics and climate factor.

HAPS (High altitude platform station)'s link budgethas been widely used in the satellite communication system on the basis of the program and algorithm. Some parameters needed adjustments on the advice of the ITU-R. The main aim of HAPS (High altitude platform station)'s link budget is to ensure that the link budget communication link availability. The cost of the ground segment and the space station are considered in HAPS. Need to elaborate design the HAPS link precisely. HAPS of TDD communication system has directly related to the following factors: The transmit power of ground station, User transmission power, HAPS transmit power, HAPS antenna gain, the receive dearth station antenna gain, Uplink path loss, Downlink path loss and multipath interference, and so on.

In the spectrum (27/31GHz and 47/48GHz), in order to ensure to provide customers with quality service in all circumstances. In the process of system design, according to different application, all link parameters should be able to guarantee QOS.

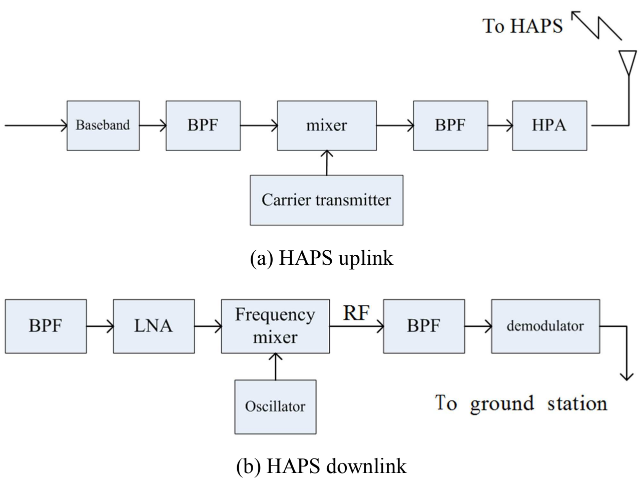


Figure 6. *High altitude platform station (HAPS) link.*

Under the condition of a given a set of resource constraints, the optimal strategy of adaptive transmission need to be in one of the layers of communication protocol for joint optimization.

Combined with the spatial channel transmission characteristics, Spatial information based on link adaptive cross layer optimization is proposed to consider joint first of AMC/HARQ/channel coding the physical and data link layer ARQ techniques, just as shown in Figure 7.

This paper intends to combine the space collaboration node orbit, periodicity and regularity of the movement, research collaboration node selection algorithm based on node movement probability, just as shown in Figure 8.

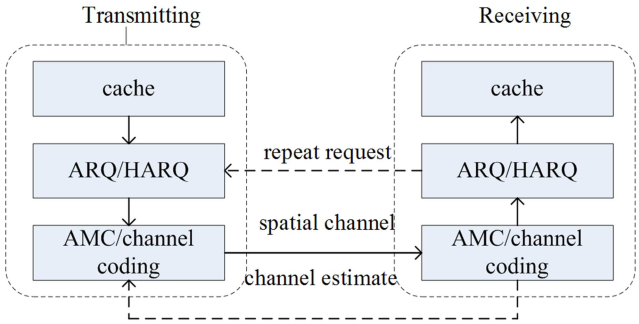


Figure 7. *Adaptive cross layer optimization design.*

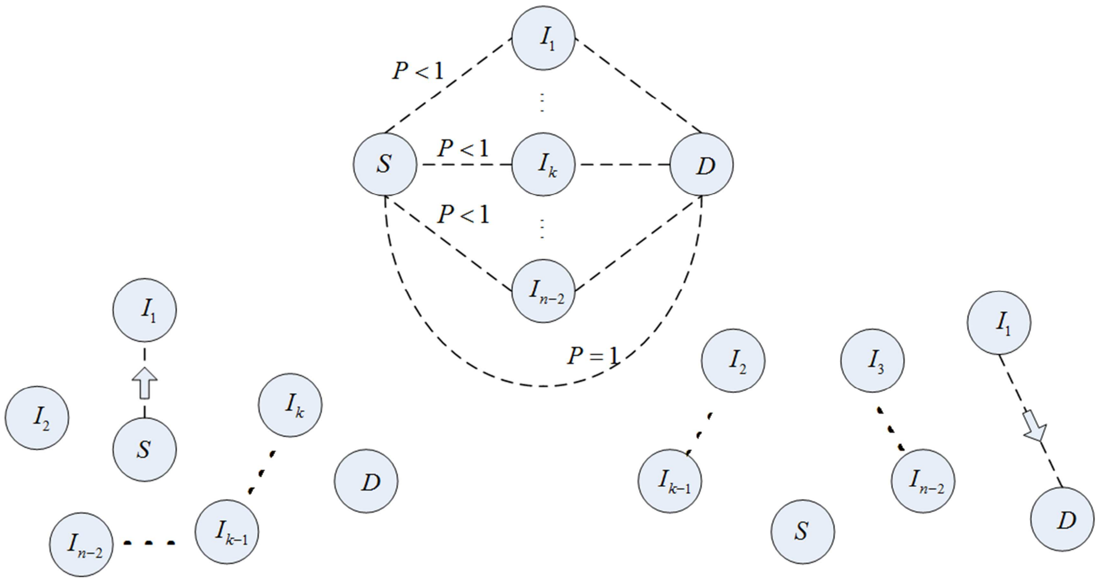


Figure 8. *Collaboration node selection strategy.*

5. Mathematical Modeling

The antenna diameter D can be expressed as

$$D \quad 10\lg \frac{32\ln 2}{{}_{2} \quad {}_{2}} \tag{1}$$

ison behalf of the azimuth, is angle of pitch.

The antenna gain G_H can be expressed

$$G_H \quad 10\lg(\ ) \quad D \tag{2}$$

Where, is the power efficiency of the antenna.

The beamwidth of 3dB is:

$$_{3dB} \quad 2\arccos \sqrt[n]{1/2} \tag{3}$$

Where, n is coefficient of refraction. The performance of HAPS is associated with the signal to noise ratio of receiver. The power of receiver P can be expressed as.

$$P \quad \frac{P_1 g_1}{l_1} \tag{4}$$

Where, P_1 is effective isotropic radiated power of receiver. g_1 shows the antenna gain. l_1 is the loss of the free space.

The received power and thermal noise power ratio is:

$$\frac{C}{N} \quad \frac{P_1 g_1}{k T_s B l_1} \tag{5}$$

Where, k is the boltzmann constant. T_s the temperature of the Accept receiver noise. B is the equivalent bandwidth of intermediate frequency.

6. Simulation Analysis

The antenna gain (dBi) is 29. The Boltzmann constant is -228. The path loss of free space is set with 10m. The noise accept factor is 20dB. The thermal noise level of receiver is 174dBm/Hz.

The relationship of C/N and P_t is shown in Figure 9.

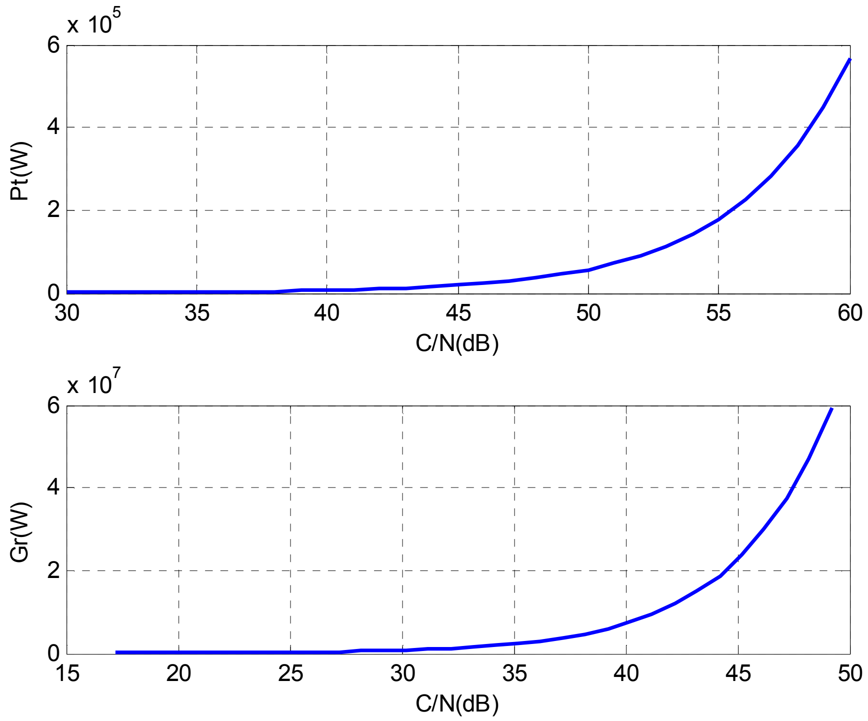


Figure 9. *The link budget analysis of uplink and downlink.*

As can be seen from Figure 8, transmission power P_t match with C/N.

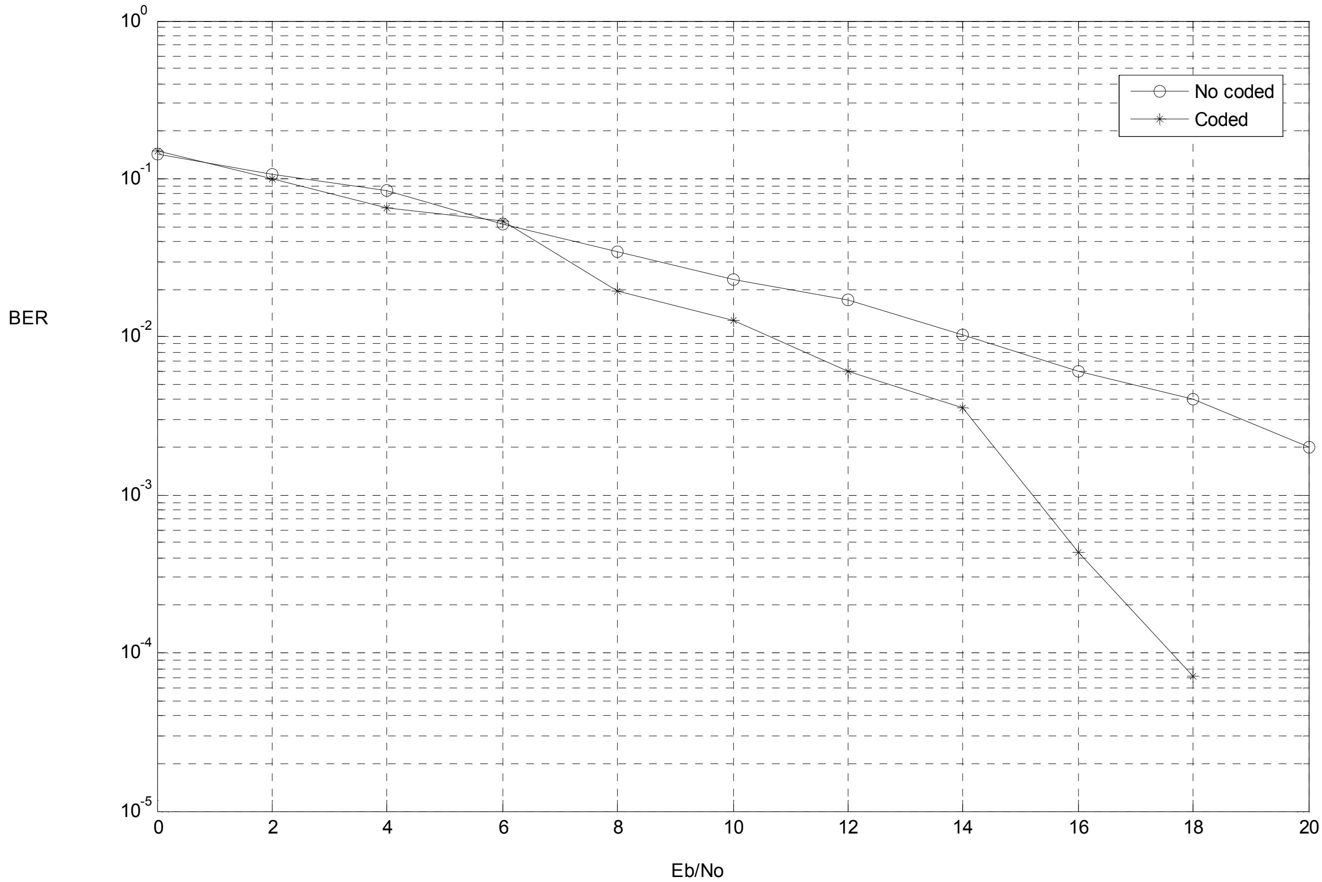


Figure 10. *The relationship betweenamount of noise ratio and frequency.*

As can be seen from Figure 10. With the increase of E_b / N_o, the BER (Bit Error Rate) is decrease. The channel performance of coded is better than the uncoded of wireless communication channel.

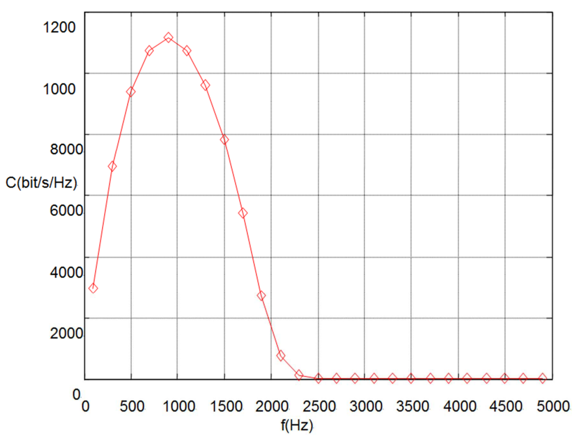


Figure 11. *The relationship between capacity and frequency.*

As can be seen from Figure 11. When the frequency f is set up with almost 1000, the capacity C can reach the maximum. With the increasing of the signal frequency, the capacity of HAPS channelis decreasing.

7. Summary

Through the analysis of the link budget of three HAPS work frequency band, we can get some conclusions. First of all, free space path loss, rain is closely related to failure and working frequency, the higher the frequency, the higher the loss. The failure is the key factor in the process of HAPS link design. Much affected by seasonal change and geographical location. Link budget calculation parameters are determined. And did not describe the statistical characteristics of the rain. This could lead to a prediction error in the process. Second, the elevation also has a great influence on the link performance. Due to the tilt paths, elevation Angle decreases. To increase the free space loss and rain failure. In addition, the shadow is also influenced by the elevation, so elevation changes cannot be ignored. Especially when working in low frequency band, so the lognormal distribution statistics fading margin should be considered the slow change.

The HAPS have become the focus in the wireless communication in recent years. Next we will mainly study the following key technologies: The capacity of HAPS three-dimensional modeling and target characteristics of electromagnetic scattering in near space of HAPS, Space platform of network technology, Research and development of channel model with low latency in HAPS and so on.

Acknowledgment

The paper are supported by Chongqing Postdoctoral Researchers Research Project Special Funded (Grant No. Xm2015029), Scientific and Technological Research Program of Chongqing Municipal Education Commission (Grant No. KJ1500926), Chongqing Science and Technology Committee Fund of Foundation and Cutting-edge Research Plan (Grant No. cstc2014jcyjA40007), Natural Science Foundation of China (Grant No. 61502064, 61503052, 91438104, 11547148).

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