Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(3):366-372**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Research on High Dynamic Transmission Model of HAPS Based on Markov Chain

Xiaoyang LIU, Hengyang LIU*, Chao LIU, Ya Luo

School of Computer Science and Engineering, Chongqing University of Technology, Chongqing, 400054, China

Abstract Aiming at the high dynamic and low throughput of HAPS wireless communication system in network space, a channel transmission model of HAPS wireless communication system is proposed. Firstly, the antenna model is established based on the 3dB beamwidth characteristics of the antenna. Secondly, the throughput of the communication system is analyzed with the Shannon formula. The bit error rate of the communication system is studied by using Markov chain attributes. Simulation results show that the proposed model is better than the traditional HSDPA transmission model in terms of performance such as throughput and bit error rate, and the proposed model is reasonable and effective.

Keywords high altitude platform station; transmission model; high dynamic; bit error

1. Introduction

High Altitude Platform Stations (HAPS) is a platform that stays in the adjoining space at a height of 20km to 50km and is stationary relative to a specific location on the earth. It can be seen as a communication system between a land-based communication system and a satellite communication system, aiming to develop the potential for a high degree of space between land and space benefits, increase communication capacity and spectrum utilization, reduce system equipment cost and complexity. HAPS has a smaller path fading than terrestrial communication systems and has a smaller delay than satellite communication systems [1-3].

Research on the HAPS communication system began in the 1960s. The U.S. Echo satellite project facilitated the passive reflection of broadcast signals with large balloons in orbit [9-10]. With the development of airship technology, countries have successively launched airship-based communication system research projects or carried experiments, mainly including: North American SHARP, Sky Station, HALO, European HALE, HeliNet, CAPANINA, HAPCOS, Japan's SkyNet, etc. [4-5].

The technology involved in the near-space platform communication system is very complex and a new set of industry standards needs to be developed. The main research results at home and abroad include: 1) Research on platform mobility. Literature [6-7] studies the potential problems that platform mobility brings to communication performance. 2) Research on multi-beam cell partitioning. In [8-9], three multi-beam coverage schemes have been studied and proposed. 3) Platform antenna design. To achieve multi-beam coverage, multiple beam antennas are used in the near-space HAPS. Because HAPS communication has many advantages that traditional wireless communication facilities (such as terrestrial and satellite communication systems) do not have, the use of high-altitude platform wireless communication systems has become the focus of attention in the world. Using multiple high-altitude communication platforms with the same bandwidth to serve a common area can greatly increase user capacity and improve spectrum utilization [10-11]. Several kinds of HAPS spot beam structure channel assignment algorithms have been tested in [12-13], and ground algorithms, especially beam overlap, have been further studied. In this paper, the channel allocation algorithm is discussed and the performance of the algorithm is analyzed. However, this algorithm does not consider Dynamic Channel Allocation (DCA). At the same time, HAPS CDMA system is proposed under the condition of high load on the network to ensure the fairness of the call. A dynamic channel allocation algorithm is proposed to effectively reduce the congestion of the system. Probability guarantees the fairness of the system; however, it does not consider the call interruption rate and GoS (Grade of Service) comprehensive index. The literature [14] proposes a randomized channel allocation algorithm for HAPS communication. The algorithm has a simple allocation but does not consider the service quality of each service and the fairness of allocation is lacking. The study of HAPS in China started late. Currently, HAPS key technologies such as airships have achieved some breakthroughs, mainly focusing on HAPS. Key technologies such as networking, emergency mobile communications, and emergency data broadcasting [14-15]. In addition, there are many scientific researches in China. The organization is engaged in the research work of HAPS networking communication technology and has achieved certain key technological breakthroughs in different fields. Literature [15-16] proposed the worst acceptable channel allocation algorithm for HAPS communication. The algorithm can effectively improve system call blocking performance, but it also reduces the quality of each call connection. The literature [17-18] addresses the near-space communication channel model of cell coverage. Literature [19-20] focuses on multipath modeling. In this project, wireless communication channels will be modeled on the premise of near-space low-velocity aircraft communication. At the same time, the comprehensive effects of multi-path fading and rain attenuation on low-velocity spacecraft in the near space are taken into consideration. The factors affecting the channel in the wireless channel are considered more comprehensively in order to establish a more realistic channel model. The literature [21-22] considers the wireless network made up of HAPS, and study the influence of horizontal mobility of the platform from the system level characteristics. In [23-24], it is proposed that for a near-space HAPS, a multi-beam scanning antenna array using an annular cell is better than a conventional honeycomb. The ring honeycomb can reduce the influence of the vertical axis rotation of the platform. The disadvantage of this model is that it only deals with platform motion from the perspective of antenna design and cell coverage. It does not consider HAPS link characteristics and does not verify the correctness of the model from the link. An adaptive soft-switching algorithm for HAPS is proposed in [24-25]. This algorithm adjusts the mobile terminal based on the downlink output power of the platform and the downlink output power of each base station considering only the platform mobility. It is clear that there is no inherent solution to the impact of platform instability on HAPS performance from the link.

2. Traditional HSDPA transmission model

In the HAPS wireless communication system, HAPS is deployed in a space of 20km to 50km.There will be various forms of interference and noise. Figure 1 is the HAPS downlink geometry [22-23].

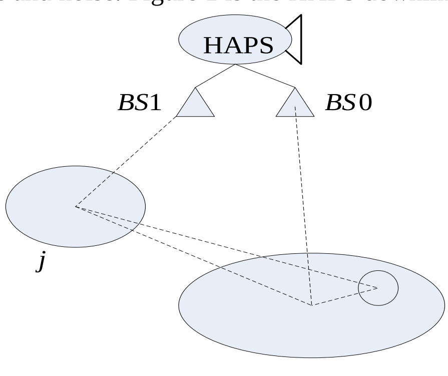

Figure 1: Geometrical diagram of HAPS downlink spatial interference

The carrier-to-noise and interference ratio (CNIR) can be expressed as:

$$CNIR = \frac{G_p P_{ru}}{P_{intra} + P_{inter} + P_N} \tag{1}$$

In the above equation, G_p is the HAPS wireless communication link gain, P_{ru} is the received signal power, $P_{\text{int}ra}$ is the interference within the wireless unit, $P_{\text{int}er}$ is the interference between the units, and e P_N is the received thermal noise power.

According to the Shannon formula, the theoretical upper limit of spectrum efficiency can be obtained:

$$\eta = \log_2(1 + CNIR) \tag{2}$$

The path loss L of the HAPS communication system can be expressed as: $L(dB) = 20\log_{10}\left(\frac{4\pi d}{\lambda}\right) + L_{BPL} + L_{shd} - G_{ant-HAP}(dB)$.

In the above equation, d is the distance between the HAP and the user, λ is the wavelength, L_{BPL} is the extra penetration loss, L_{shd} is the shadow masking loss, and e $G_{ant-HAP}$ is the antenna gain of the HAP.

3. HAPS High Dynamic Transmission Model

In the HAPS wireless communication system, it is also crucial to obtain high-performance communication performance of its antenna. The aperture of the antenna main lobe can be approximated as:

$$D = D_{\max}(\cos\theta)^n \tag{3}$$

In the above formula, θ is the pitch angle of the transmitting antenna. If the low side-lobe situation its peak can be expressed as:

$$D = D_{\max} = \frac{32\ln 2}{{\theta_{3\text{dB}}}^2 + {\phi_{3\text{dB}}}^2} \tag{4}$$

The antenna 3dB beamwidth can be expressed as:

$$\theta_{3\text{dB}} = \arccos(\sqrt[n]{1/2}) \tag{5}$$

Combined with (3) ~ (5), D can be expressed as:

$$D = (\cos\theta)^n \frac{32\ln 2}{2[\arccos(\sqrt[n]{1/2})]^2} \tag{6}$$

The transmission model of the HAPS wireless communication system is shown below.

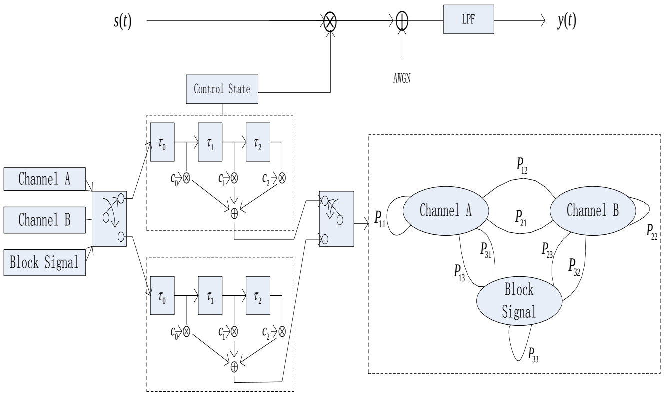

Figure 3: HAPS system model

The direct channel model in Figure 3 is also a line of light (LOS) signal, which is a low-pass filter. The state transition diagram in Figure 3 is a finite state machine with Markov chain attributes.

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1M} \\ p_{21} & p_{22} & \cdots & p_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ p_{M1} & p_{M2} & \cdots & p_{MM} \end{bmatrix} \tag{7}$$

In the HAPS wireless communication system, the average bit error ratio (BER) of the receiving node can be expressed as:

$$P_d = \sum_{j=0}^{i} P(E \mid j \& i) P(j \& i) \tag{8}$$

$P(j \& i)$ can be expressed as:

$$P(j \& i) = \binom{i}{j} P_{er}^{j} (1 - P_{er})^{i-j} \tag{9}$$

$$P_{er} = \int_{\gamma_\tau}^{\infty} \mathrm{P}_R(\gamma) \rho_R^{\gamma_\tau}(\gamma) d\gamma \tag{10}$$

$$\mathrm{P}_R(\gamma) = \frac{1}{\pi} \int_0^{\pi/2} \exp\left(-\frac{\gamma}{\sin^2\theta}\right) d\theta \tag{11}$$

The transmission model of the wireless communication system plays a key role in the influence of throughput. that in a wireless HAPS wireless communication system, it is necessary to achieve reasonable allocation of M subcarriers by Q users. For each sub-user system, due to the different propagation paths, subcarriers that are severely fading for a user may have higher channel response gains for other users. The throughput of the m-th subcarrier can be expressed as:

$$C_m = B_0 \log_2 (1 + \frac{\alpha_m^2 P_m}{N_0 B_0 \Gamma}) \tag{12}$$

The total throughput of M subcarriers is:

$$C_m = B_0 \sum_{m=1}^{M} \log_2 (1 + \frac{\alpha_m^2 P_m}{N_0 B_0 \Gamma}) \tag{13}$$

4. Simulation and Analysis

We assume that the HAPS is located 20km above the earth's surface, the system bandwidth B is 12MHz, and the noise power W. The beam emission power is 35mW. The path loss is free space loss with a loss factor of 1.Obey the logarithm is too faint distribution, the standard deviation is 2dB. The system throughput under different carrier counts is shown in Figure 4.

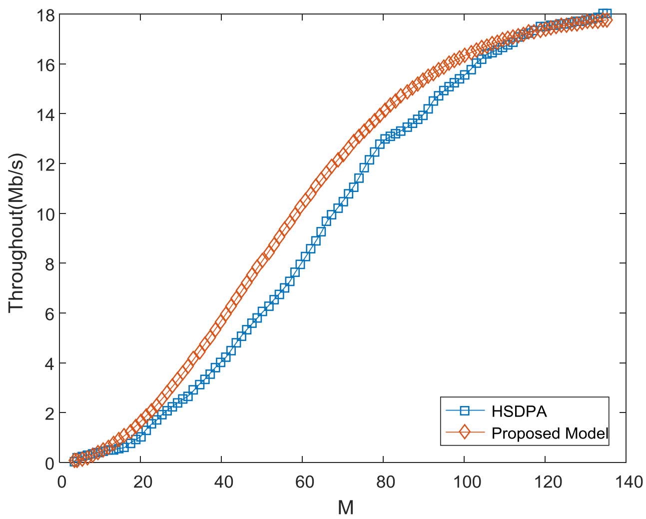

Figure 4: Throughput with different carrier counts

In Figure 4, the number of carriers in the system is assumed to change from 2 to 138. As the number of carriers increases, their respective system throughputs show an upward trend. However, the model constructed in this paper is superior to the traditional HSDPA transmission model.

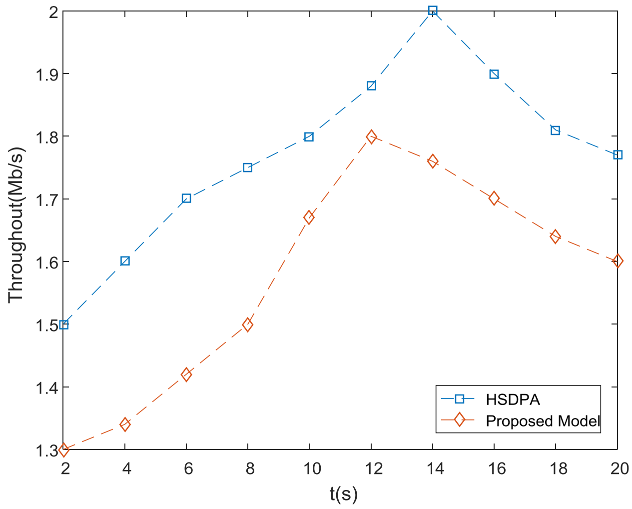

Figure 5: Throughput of different times

In Figure 4, the system time changes from 2 to 20. With the increase of the loading time, the respective system throughput is presented. The upward trend, but after the peak, it will show a downward trend. However, the system throughput of the model constructed in this paper is better than that of the traditional HSDPA transmission model.

The BER change rate of HAPS wireless communication system is shown in Figure 6.

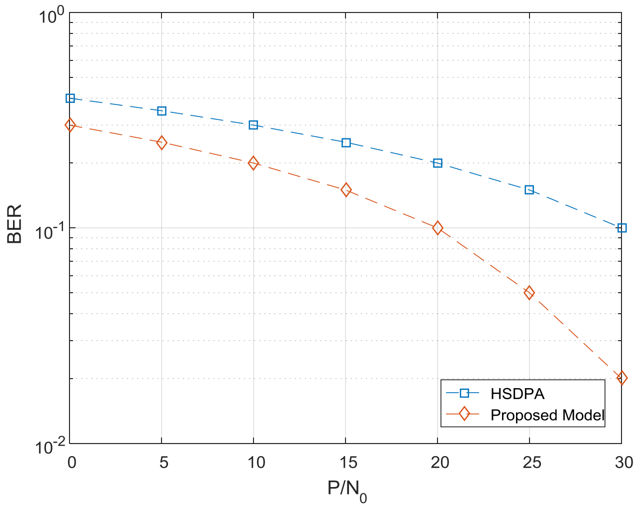

Figure 6: Bit Error Rate at Different Powers

From Figure 6, it can be seen that as the ratio of the transmitted power to the noise power increases, the bit error rate of its communication system gradually decreases. But at the same ratio of transmit power to noise power, the system model proposed in this paper is superior to the traditional model.

5. Conclusion

This article starts with the HAPS characteristics, analyzes in detail its communication performance and the research status at home and abroad and the current. The main key scientific and technical issues based on the analysis of the traditional HAPS system model, the channel transmission model was constructed.The superiority of the proposed model is demonstrated from the two main aspects of throughput and bit error rate. The next step is to start with the characteristics of the rain attenuation of the HAPS system. Study the three-dimensional characteristics of its scattering system and build a MIMO communication mechanism.

Acknowledgments

The paper was supported by National Social Science Fund of China West Project(17XXW004),Young Fund Project of Humanities and Social Sciences Research of Ministry of Education of China(16YJC860010), Social Science of Humanity of Chongqing Municipal Education Commission(17SKG144),Science and Technology Research Program of Chongqing Municipal Education Commission(KJ1600923,KJ17092060), Natural Science Foundation of China (61571069,61501065,61502064,61503052).Open Fund Project of Chongqing Technology and Business University, Research Center of Chongqing University Network Public Opinion and Ideological Dynamic (KFJJ2017024).The author Xiaoyang Liu thanks for the financial support from CSC(China Scholarship Council)(No.201608505142).

References

[1]. Xian Li, Qiuling Tang, Changyin Sun. The impact of node position on outage performance of RF energy powered wireless sensor communication links in overlaid deployment scenario [J]. Journal of Network and Computer Applications, 2016, 73(9):1-11.

[2]. Rui Yuan Wu; Yun Bo Li; et al. High-Gain Dual-Band Transmit array [J]. IEEE Transactions on Antennas and Propagation, 2017, 65(7):3481-3488.

[3]. YANG Gui-de, ZHOU Yuan-ping, XIA Wen-long. Coordinated channel space optimization of MIMO wireless transmission system [J]. Journal of Electronics Information Technology, 2017, 39(9):23-30.

[4]. ZHANG Ping, TAO Yun-zheng, ZHANG Zhi.5G critical technical review [J]. Journal on Communication, 2016, 26(7):43-51.

[5]. Mustafa A. Kishk, Harpreet S. Dhillon. Effect of Cell-Selection on the Effective Fading Distribution in a Downlink K -Tier HetNet [J]. IEEE Wireless Communications Letters, 2017, 6(4):526-529.

[6]. Diego V. Queiroz, Marcelo S. Alencar, et al. Survey and systematic mapping of industrial Wireless Sensor Networks [J]. Journal of Network and Computer Applications, 2017, 97(1): 96-125.

[7]. Soham Chatterjee, Archana Iyer, et al. Design Optimisation for an Efficient Wireless Power Transfer System for Electric Vehicles [J]. Energy Procedia, 2017, 117(6):1015-1023.

[8]. Ruijiao Zhang, Jianxin Ma. Full-duplex hybrid PON/RoF link with 10-Gbit/s 4-QAM signal for alternative wired and 40-GHz band wireless access based on optical frequency multiplication[J]. Optik - International Journal for Light and Electron Optics, 2017, 138:55-63.

[9]. Omer Korçak, Fatih Alagoz. Efficient integration of HAPs and mobile satellites via free-space optical links [J]. Computer Networks, 2011, 55(13):2942-2953.

[10]. Yasser Albagory, Omar Said. Performance enhancement of high-altitude platforms wireless sensor networks using concentric circular arrays [J]. AEU - International Journal of Electronics and Communications, 2015, 69(1)382-388.

[11]. Marga Lopez, Xavier Martinez-Farre,et al. Intelligent composting assisted by a wireless sensing network[J].Waste Management, 2014, 34(4):738-746.

[12]. Manish Sharma; D. Chadha; Vinod Chandra. High-altitude platform for free-space optical communication: Performance evaluation and reliability analysis [J]. IEEE/OSA Journal of Optical Communications and Networking, 2016, 8(8):600-609.

[13]. Jianwei Niu, Yuhang Gao, Meikang Qiu, Zhong Ming. Selecting proper wireless network interfaces for user experience enhancement with guaranteed probability [J]. Journal of Parallel and Distributed Computing, 2012, 72(12):1565-1575.

[14]. Nadeem Javaid, Sheraz Hussain, et al. Region based cooperative routing in underwater wireless sensor networks [J]. Journal of Network and Computer Applications, 2017, 92(8):31-41.

[15]. Kuttathati Srinivasan Vishvaksenan, Kaliyappa Mithra, et al. Mutual Coupling Reduction in Microstrip Patch Antenna Arrays Using Parallel Coupled-Line Resonators [J]. IEEE Antennas and Wireless Propagation Letters 2017, 16:2146-2149.

[16]. Muddassar Hussain, Syed Ali Hassan. Impact of Intra-Flow Interference on the Performance of 2-D Multi-Hop Cooperative Network [J]. IEEE Communications Letters, 2017, 21(4):869-872.
[17]. Hieu Duy Nguyen, Sumei Sun. Closed-Form Performance Bounds for Stochastic Geometry-Based Cellular Networks [J]. IEEE Transactions on Wireless Communications, 2017, 16(2):683-693.
[18]. Parisa A. Eliasi, Sundeep Rangan, Theodore S. Rappaport. Low-Rank Spatial Channel Estimation for Millimeter Wave Cellular Systems [J]. IEEE Transactions on Wireless Communications, 2017, 16(5): 2748-2759.
[19]. Xuehua Zhang, Hamid Jafarkhani. Asynchronous Network Coding for Multiuser Cooperative Communications [J]. IEEE Transactions on Wireless Communications, 2017, 99:1-11.
[20]. Bogdan S. Chlebus, Vicent Cholvi, Paweł Garncarek, et al. Routing in Wireless Networks With Interferences[J].IEEE Communications Letters,2017, 21(9):105-2108.
[21]. Jianfeng Zhu, Shufang Li, Shaowei Liao, Bin-Long Bu. High-Gain Series-Fed Planar Aperture Antenna Array [J]. IEEE Antennas and Wireless Propagation Letters, 2017, 16:2750-2754.
[22]. Thang X. Vu, Hieu Duy Nguyen, Tony Q. S. Quek, Sumei Sun. Adaptive Cloud Radio Access Networks: Compression and Optimization [J]. IEEE Transactions on Signal Processing, 2017, 65(1):228-241.
[23]. Chang-Yong Kim, Hyeong-Dong Kim. Comparison between the Ki-hap technique and verbal encouragement on activation of abdominal muscles in healthy participants [J]. Journal of Bodywork and Movement Therapies, 2017,9:12-20.
[24]. Minh Q. Vu, Nga T.T. Nguyen, Hien T.T. Pham, Ngoc T. Dang. All-optical two-way relaying free-space optical communications for HAP-based broadband backhaul networks [J]. Optics Communications, 2018, 410(3):277-286.
[25]. Minh Q. Vu, Nga T.T. Nguyen, et al. All-optical two-way relaying free-space optical communications for HAP-based broadband backhaul networks [J]. Optics Communications, 2018, 410(3):277-286.