HAPS Wireless Communication Network Channel Modeling and Simulation

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Abstract-**High altitude platform station (HAPS) is a new means of wireless communication method, which operate in stratosphere whose altitude is about 20km. In order to improve the channel quality of wireless communication transmission and signal-to-noise ratio.The wirless communication network of HAPS are studied in this paper. The performance of the wireless communication channel and channel model are analyzed and the characteristics of near space wireless channel are considered.The simulation results shows that signal level is different when the spacing distance is different.There is always a direct path between users and HAPS.**

Keywords-high altitude platform station; near space; channel model; communication performance

I. INTRODUCTION

HAPS (High Altitude Platform Station) is an airship equipping radio transponders which stays in the stratosphere (the altitude of about 20km) whose weather conditions is comparatively stable for a long period of time. HAPS is a seamlessly connected information acquisition and distribution network formed by interconnected the near space vehicles, such as airship and unmanned aircraft. Present research is mainly focus on the near space vehicle development and design at home and abroad in order to offer the right bearing to near space network platform. The study of HAPS wireless communication network efficient network and transmission is relatively lagging. It mainly concentrated in the study of the multi-beam antenna design and cover scheme, and the capacity research of a single platform for the communication system, and so on [1-10].

The transmission rate, delivery reliability, and network lifetime are three fundamental but conflicting design objectives in HAPS networks. The references [11-17] propose a cross-layer analytical model for the study of network coding (NC)-based Automatic Repeat reQuest (ARQ) medium access control (MAC) protocols in correlated slow-faded (shadowed) environments, where two end nodes are assisted by a cluster of relays to exchange data packets.

The rest of this paper is organized as follows. In Section II, the HAPS wireless communication system model is set up. In Section III, the channel mathematical model is built up for the HAPS communication system. In Section IV, simulation analytical results are presented. Finally, conclusions are drawn in Section V.

II. HAPS WIRELESS COMMUNICATION NETWORK

The HAPS wireless communication network is drawn in Fig.1. 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 [18-20].

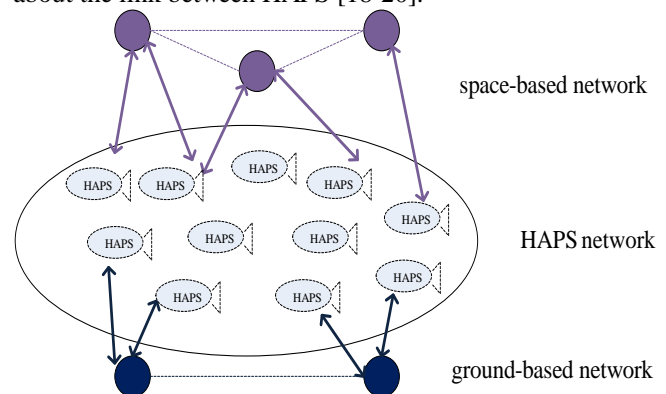space-based network

HAPS network

ground-based network

Figure 1.   HAPS wireless communication network

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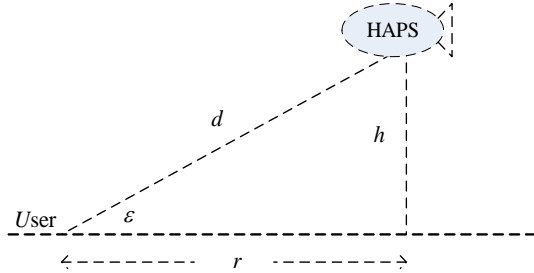

Figure 2.   The geometric relationships of a communications system

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 Fig.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 [21-30].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.
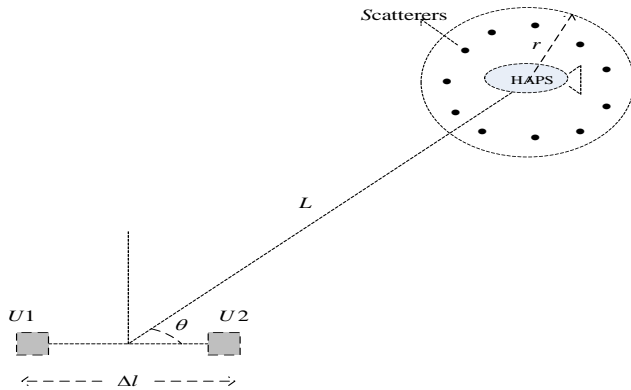

Figure 3.   The scatterers of HAPS

III. CHANNEL MODELING

The model of channel tap delay in HAPS wireless communication network can be expressed as:

$$h(t,\tau) = c_0 \cdot \delta(t - t_0) + \sum_{n=1}^{N} c_n(t)\delta(t - \tau_n) \tag{1}$$

Where, c_0 is the part of LOS (Line of Sight), $c_n(t)$ shows the variable coefficient, which follow the Gaussian distribution. τ_n is the delay time of n tap.

The envelope of the signal is plural, which can be shown in:

$$S(t)e^{j\theta(t)} = u(t)e^{j\alpha(t)} + v(t)e^{j\beta(t)} \tag{2}$$

In the above formula, $u(t)$ is a random variables which obey Rayleigh distribution.

$\alpha(t)$ obey $(0, 2\pi)$ Uniform distribution. $v(t)$ and $\beta(t)$ are the deterministic signals.

The PDF (Probability Density Function) of $S(t)$ be expressed as:

$$f(s) = \frac{s}{\sigma^2}e^{(-\frac{s^2+v^2}{2\sigma^2})}I_0(\frac{sv}{\sigma^2}) \tag{3}$$

In the above formula, $s > 0$, I_0 is the Besell function. The root mean square can be calculated by using this formula:

$$E[s^2] = v^2 + 2\sigma^2 \tag{4}$$

Where, v is the signal envelope which can receive the direct signal. $2\sigma^2$ is the average power of the HAPS space path.The properties of the Rice distribution is related to the k factor.

$$k = \frac{v^2}{2\sigma^2} \tag{5}$$

k is the average power. Besell function can be approximated by:

$$I_0(x) = \frac{e^x}{\sqrt{2\pi x}}, x \to \infty \tag{6}$$

Then, $f(s)$ can be expressed as:

$$f(s) = \sqrt{\frac{s}{2\pi x}}e^{(-\frac{(s-v)^2}{2\sigma^2})} \tag{7}$$

IV. SIMULATION ANALYSIS

The PDF (Probability Density Function) under different v is shown in Fig.4.
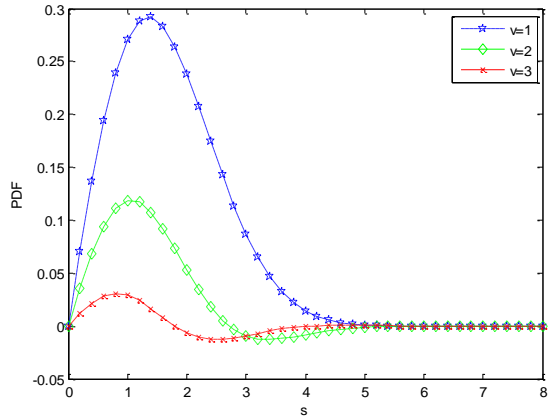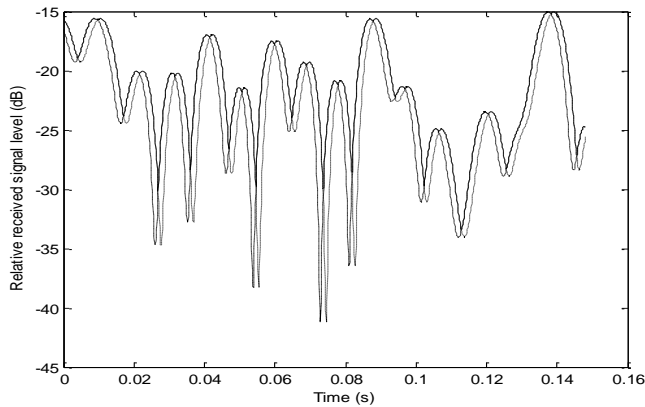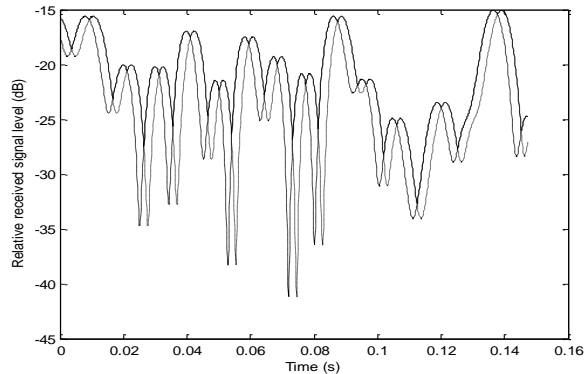
Figure 4.   PDF of different v

As can be seen from Fig.4.With the increase of v, the Rice factor k also increases. Different k values represent different LOS (line-of-sight) transmission conditions. There is always a direct path between users and HAPS.
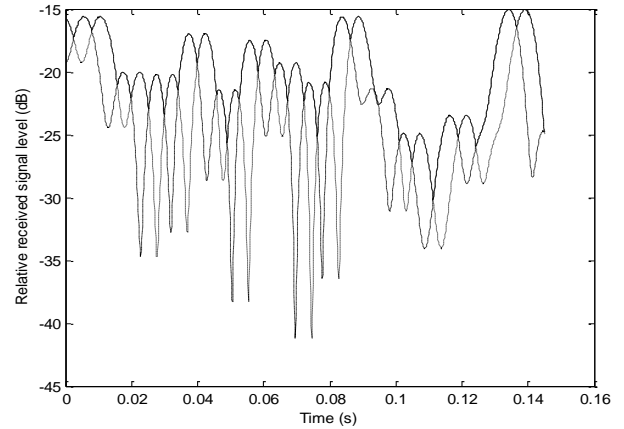
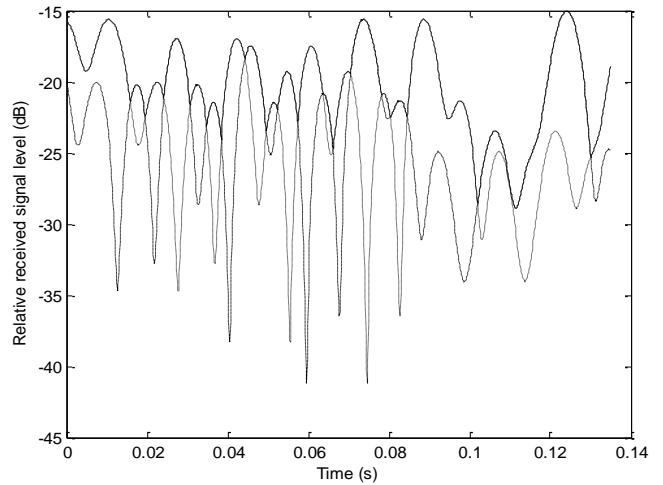The distance is set up with 15km.Relative received signal level under different spacing λ is shown in Fig.5.

(a)   Spacing 1/9 λ

(b) Spacing 1/6 λ

(c) Spacing 1/3 λ

(d) Spacing λ

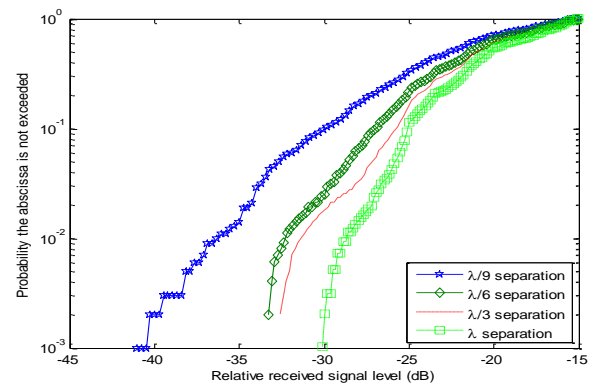Figure 5.   Relative received signal level under different spacing λ

Figure 6.   Signal level(dB)

As can be seen from Fig.6,Signal level is different when the spacing distance is different. The smaller the interval, the better of the signal level.

V. CONCLUSIONS

Through the analysis of the wireless communication network of near space HAPS, we can get some conclusions. First of all, relative received signal level is related to the spacing distance. Second, the authentication process for HAPS mobile communication is to confirm the identity of Mobile Station, which is by exchanging information between Mobile Station and Base Station. The next step in our research is to focus on the performance and characteristics of HAPS wireless communication network system which will be measured with an extensive system of sensors, in order to optimize it further.

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