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Review on Performance Simulation of using Non Binary Low Density Parity Check (LDPC) Codes to Against Rain Fade in K_a Band

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Abstract: **In satellite communication a Rain fade degrades the performance of the system especially effect on Ka band. To avoid rain fade in communication system channel coding is efficient way and achieves better performance. The different types of error correcting coding techniques are used like Non binary Low Density Parity Check (LDPC), Binary Low Density Parity Check (LDPC,) Turbo codes. Non-binary LDPC codes, as an advanced error correcting code, having strong ability to correct errors, can be used to against rain fade. This paper presents an analysis on influence of rainfalls in Ka-band Satellite communication and establishes the channel model of rain fade. Non binary LDPC codes based on sparse graph means it has infinite field. Here we compare simulation results between Binary un coded LDPC and non binary LDPC. Result shows, LDPC codes can obtain over 20dB gains over un coded situation, and non-binary LDPC codes have 1dB performance advantage over binary LDPC codes.**

I. INTRODUCTION

In satellite communication a Rain fade degrades the performance of the system especially effect on Ka band. To avoid rain fade in communication system channel coding is efficient way and achieves better performance [1]. The different types of error correcting coding techniques are used like Non binary Low Density Parity Check (LDPC), Binary Low Density Parity Check (LDPC,) Turbo codes. Non-binary LDPC codes, as an advanced error correcting code, having strong ability to correct errors, can be used to against rain fade. Non binary LDPC codes based on sparse graph means it has infinite field [1]. Research showed that non-binary LDPC codes can correct more burst errors than binary codes. In Ka-band satellite communication channel, it may occur a lot of burst errors, non-binary LDPC codes is very useful in such channel.

These non-binary LDPC codes have shown significant improvement in performance over their binary counterparts from small to moderate code lengths. Since then research on non-binary LDPC codes is highlight in channel code research. Research showed that non-binary LDPC codes can correct more burst errors than binary codes. In Ka-band satellite communication channel, it may occur a lot of burst errors, non-binary LDPC codes is very useful in such channel. A simulation of using non-binary LDPC codes to against rain fade in Ka band is placed; results show that non-binary LDPC codes can obtain great advantages over condition using binary LDPC codes and un coded situation [2].

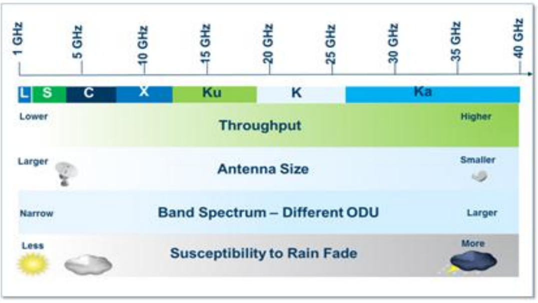

Figure 1 Electromagnetic wave spectrum

Rain fade refers primarily to the absorption of a microwave radio frequency (RF) signal by atmospheric rain, snow or ice, and losses which are especially prevalent at frequencies above 11 GHz [3]. It also refers to the degradation of a signal caused by the electromagnetic interference of the leading edge of a storm. Ka band has high frequency (27GHz-40GHz), its wavelength is closed to the raindrop diameter, so electromagnetic wave in Ka band suffers from the worst rain fade [4].

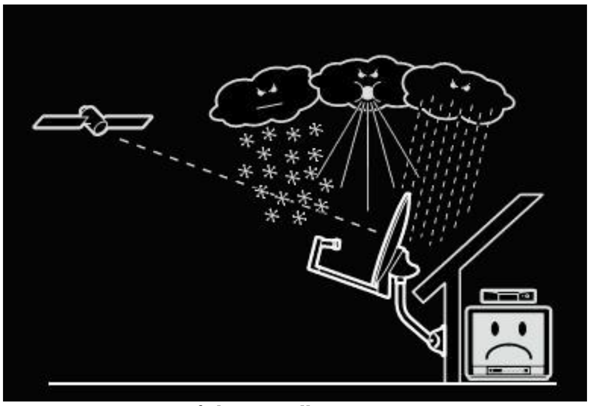

Figure 2 Rain fades in satellite communication.

II. LOW DENSITY PARITY CHECK (LDPC)

It belongs to class of linear error correcting codes, a method of transmitting a message over a noisy transmission channel .The term 'low density 'means characteristics of the Parity check matrix which contains only few 1's in comparison to 0's. An LDPC is constructed using a sparse bipartite graph. LDPC codes are finding increasing use in applications requiring reliable and highly efficient information transfer over bandwidth or return channel constrained links in the presence of corrupting noise [5].

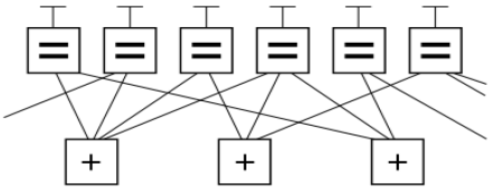

Figure 3 representation of the LDPC codes

III. NON BINARY LOW DENSITY PARITY CHECK (NB-LDPC)

In LDPC codes we have two types like Binary LDPC codes and Non-binary LDPC codes. A non binary LDPC code is the form of LDPC code on finite field. It is similar to binary LDPC codes; both can be represented in the form of parity check matrix H or a factor graph. The main difference is that the non-zero elements in parity check matrix of Non-binary LDPC codes belongs to finite field, GF (q) but (q>2) but non-zero elements of binary LDPC codes is 1.A non binary LDPC is constructed by sparse graph.

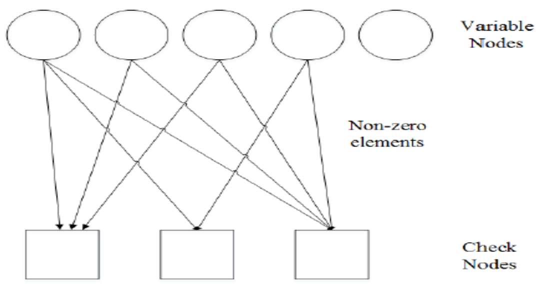

Figure 4 Factor graph of non-binary LDPC codes

It is same as binary LDPC codes; the decoding is successful when check equation is satisfied. If *X* is a code word, then

$$\sum_{h_{ij} \neq 0} h_{ij} x_j = 0$$

h_{ij} represents the non-zero elements in check matrix of non-binary LDPC codes, and x_j represents a symbol in code word.

IV. SIMULATION MODEL

To analyze performance of non-binary LDPC codes against rain fade in satellite communication, we need to built satellite communication channel and rain fade channel.

1. Channel model of satellite communication: Let *S* (*t*) be the digital modulated signal transmitted in the channel, the equivalent baseband signal of it in the time domain is $S_l(t)$ [7]. Since the Ka band is not frequency selective channel, the received signal can be expressed as:

$$r_l(t)=a(t)\exp(j\phi(t))S_l(t)$$

It is considered that the received signal is obtained after the transmitted signal pass through a multiplicative fading. a(t) represents the equivalent envelope of low pass channel ϕ(t) represents the equivalent phase of low pass channel, both of them are the real random process. Because channel fading changes very slowly with time, the multiplicative fading of channel can be seen as a constant in at least one symbol time, so the multiplicative fading can be further simplified into:

$$r_l(t)=a\exp(j\phi)S_l(t)$$

2. Rain fade model of Ka band: To find the distribution of a and ϕ in Ka band rain fade, we have consider the lot of propagation measurement experiment and got a large number of data. Loo had proved that the characteristics of Ka band immovable satellite Communication channel is mainly determined by the weather Condition, the probability distribution of the signal envelope and phase are the Gauss distribution, and their probability density functions can be expressed as follow[8].

$$P(a)=\frac{1}{\sqrt{2\pi\delta'}}\exp\left\{-\frac{(a-m')^2}{2\delta'^2}\right\}$$

$$p(\varphi)=\frac{1}{\sqrt{2\pi\delta''}}\exp\left\{-\frac{(\varphi-m'')^2}{2\delta''^2}\right\}$$

P (a) is the PDF of the signal envelope, P(ϕ) is the PDF of the signal phase.δ'^2 and δ''^2 is variance of the signal envelope and phase, m' and m'' is the mean value of them. We select Loo's model to build rain fade channel response. Probability distribution parameters of the signal envelope and phase in Ka band immovable satellite communication channel under different weather conditions like sunny, light rain, moderate rain, and thunderstorm. As showed in Table 1 and Table 2.

Table1 Envelop of immovable satellite communication channel

parameter	m'	δ'2
sunny	0.455	0.00056
Light rain	0.483	0.00003
Moderate rain	0.662	0.02
Thunderstorm	0.436	0.01386

Table2 Phase of immovable satellite communication channel

parameter	m''	δ''2
sunny	0.0079	0.00381
Light rain	0.0088	0.00546
Moderate rain	-0.0089	0.03077
Thunderstorm	0.0068	0.00414

Thus, statistical channel model of Ka band immovable satellite communication can be established like figure 2, in this model, *C*(*t*) represent the channel multiplicative interference vector, *Z*(*t*) is the additive white Gauss noise.

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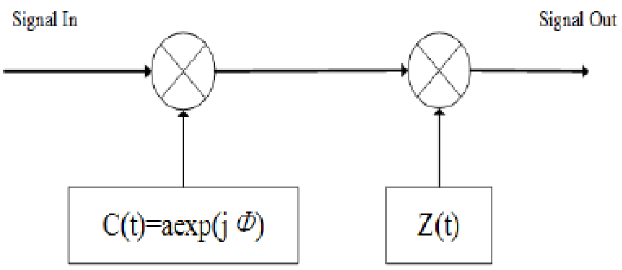

Figure 5 Statistics channel model of Ka band

3. Simulation model of rain fade channel: We know from the above analysis, the Ka band satellite communication channel can be modeled by a multiplicative noise vector and additive white Gauss noise. The thing we need do is set C(t) and Z(t) according to different condition of rainfall [9]. As shown in the figure 3, Gauss process 1 and Gauss process 2 are two independent band limited and zero mean stochastic process, their variance are δ'^2 and δ''^2 . Gauss process 1 together with real constant number generator 1, produce Gauss stochastic process a. Similarly we can obtain Gauss random process ϕ. Passing though the index generator turn to be the exp(jϕ) , after multiplying with multiplicative interference vector, we have C(t)=a exp(jϕ) . All parameters are set in accordance with the weather conditions from table 1 and 2.

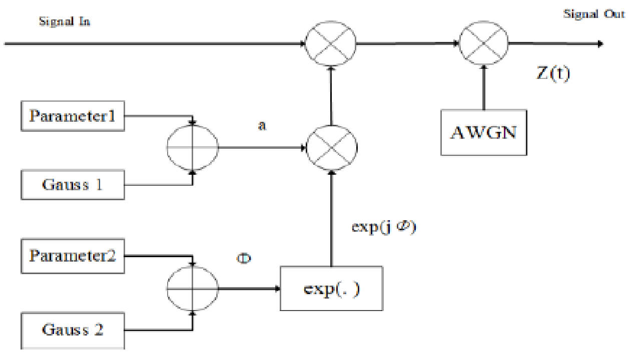

Figure 6 Simulation model of Ka band channel

Use Mat lab to simulate rain fade in satellite communication system, the simulation process is shown in fig 7[10]. The binary sequences are randomly generated, and the generated data symbols are independent, two kind of symbol appear at equal possibility. Non binary LDPC code is used in encoder, the code length is 700, and code rate is 3/7. The modulation is BPSK.

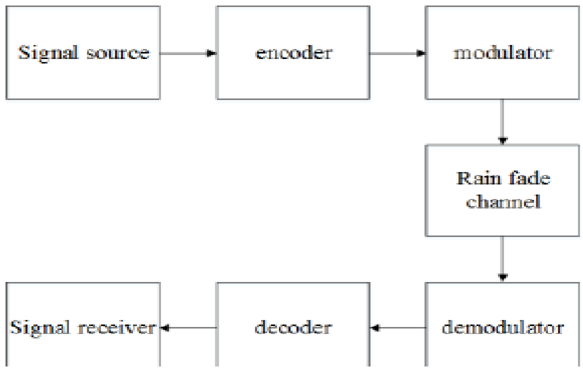

Figure 7 Simulation model of Ka band satellite communication system

V. SIMULATION RESULTS

The simulation was performed using Mat lab software. The non-binary LDPC code we choose is (300,700) code. To make a contrast, we also consider simulation on binary LDPC code and un code. The length of binary LDPC code is 2800, the rate keeps unchanged, and all LDPC codes belong to regular codes. In order to ensure the reliability of simulation, the simulation stop criterion is error number equals to 100 or BER is smaller than $10e^{-7}$. Change SNR, we obtain performance under different channel SNR. At the same time, rain fade effect is considered in transmitted symbols [11].

A) BER under different weathers when un coded :

The simulation results are shown in fig without coding appeared transmission errors cannot be effectively corrected [12].With the increase of the SNR, the influence of white noise reduces, but fading caused by rainfall is still causing numerous bit errors. Generally speaking, BER decreases very slowly with the increasing of SNR, all need more than 30dB to make the bit error rate reduced to below $10e^{-3}$.

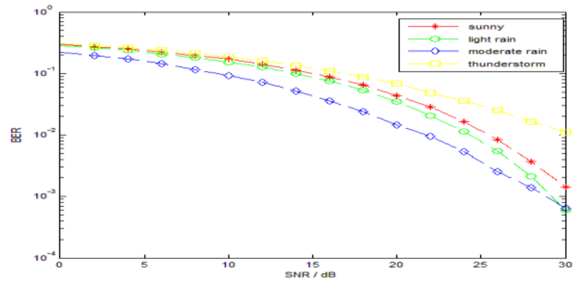

Figure 8 BER under different weathers when un coded

B. BER under different weathers when non-binary LDPC encoding [13].

The performance of non-binary LDPC codes is much better than the un coded condition, as fig 6 shows. When BER is at level of $10e^{-3}$, non-binary LDPC codes can obtain coding gain over 20dB, proves that the non-binary LDPC code is an efficient way to resist rain fade.

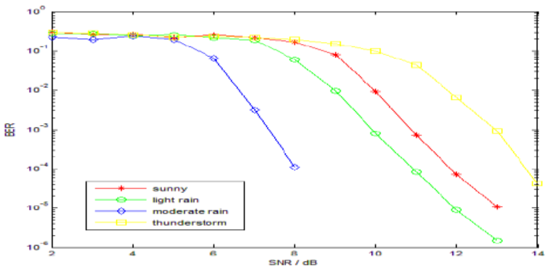

Figure 9 BER under different weather when non-binary LDPC encoding

C. BER under different weather and coding schemes

The non-binary LDPC code, binary LDPC code and un coded condition are taken into comparison, as shown in figure 7. As can be seen, both non-binary LDPC code and binary LDPC code can resist rainfall attenuation well. In addition, compared with binary LDPC coding, non-binary LDPC codes have better performance, when BER is at level of $10e^{-5}$. 16-LDPC codes can obtain 1dB coding gain [14].

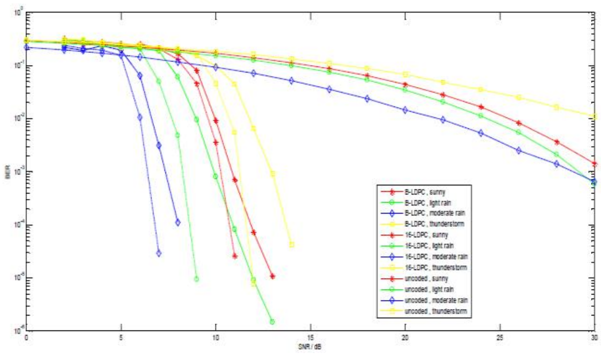

Figure 10 BER under different weather and coding schemes

VI. CONCLUSION

The main objective of this paper is studies the way to resist rain fade, mainly focus on using non-binary LDPC code [15]. when compare to other error correcting codes like turbo codes ,binary LDPC codes over non binary LDPC is better and gives a good performance to protect against rain fade in satellite communication especially in ka band.

In LDPC codes, loops in parity check matrix will degrade the performance of code word, so reduce the ringlet as much as possible will make a great improvement. Here multiple symbols are en coded so this leads to ability of avoiding small loop in parity check matrix. Eventually make the code error correction ability improved. In wireless communication channel, because of the influence of channel noise and interference, there will be a lot of burst errors in information transmission. Non-binary LDPC codes can convert continuous burst bit errors into less symbol errors, increasing the potential possibility of correcting decoding

Beginning with the rain attenuation theory, after establishing rain fade model and satellite channel model, performance comparison simulation under different coding schemes is completed, simulation results indicate that the non-binary LDPC coding scheme have great advantage of resisting rain fade.

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