Research on the Application of Multiple LDPC Code Serial Decoding Algorithm in Optical Fiber Communication

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Abstract. Optical fiber communication technology is an important part of the information society, in the process of information transmission has a rapid, accurate, reliable and not limited by distance advantages. In this paper, the principle of optical fiber communication system and the basic concept of LDPC code are explained, and the application of multiple LDPC code serial decoding algorithm in optical fiber communication is studied, for readers' reference.

Keywords: Multiple LDPC Code, Fibre Optic Communication, The Dispersion

1. Introduction

To ensure the reliability and accuracy of information transmission is the key to information transmission. Due to the high complexity of decoding, the traditional Turbo code has been unable to meet the requirements of error-correcting coding in optical fiber communication technology. With the development of computer technology, multiple LDPC code serial decoding algorithm used in optical fiber communication, can get good performance, and in the field of communication information transmission has been widely used [1].

2. Principle of optical fiber communication system

2.1. Composition of optical fiber communication system

In terms of channel bandwidth alone, the coaxial cable channel is several quantitative grades smaller than the fiber channel. In the past, optical cables with low signal attenuation and reliable photonic devices for signal and signal detection have been developed over the past 20 years. These technologies have enabled the rapid development of fiber optic communication, which is not only used in domestic communication systems, but also used in trans-Atlantic and trans-Pacific communications. In principle, the carrier frequency of a fiber optic communication system is different from that of other communication systems [2]. The optical fiber communication system mainly consists of three parts:
optical transmitter, optical fiber link and optical receiver. The units of light emission and light receiving in the model can convert the photoelectric signals to each other. The processing unit of transmitting electrical signal is mainly responsible for matching the input information with the transmitting module; the processing unit of receiving electrical signal is mainly responsible for matching the optical receiving unit and processing the received information, so as to send the information out and realize the transmission of the signal (Figure 1. Optical fiber communication software).

![Optical fiber communication software](image)

**Figure 1.** Optical fiber communication software

### 2.2. Loss of optical fiber communication system

#### 2.2.1. dispersion

When the optical fiber transmits the optical signal of different components, the delay of time will be caused by the difference of group velocity [3]. This phenomenon is called dispersion. Dispersion in optical fiber communication system mainly refers to the optical pulse signal passing through the optical fiber.

After the channel transmission, resulting in the output terminal energy dispersion, so that the transmitted signal distortion. In the optical fiber digital communication system, the difference in the group transmission speed between the frequency component and the mode component of the signal leads to the widening of the pulse width of the signal, the problem of inter-code crosstalk, the increase of the bit error rate, the influence on the optical fiber bandwidth, the transmission capacity is limited. A dispersion compensating fiber with low dispersion slope and wide operating wavelength has been developed. Mode, polarization, and chromaticity are flat forms of optical fiber dispersion. The dispersion compensation method can reduce the influence of dispersion, but with the use of high-speed optical fiber transmission link, the polarization mode dispersion of optical fiber will have a great impact on the communication system at large capacity and high speed, which hinders the development of optical fiber communication. Therefore, the problem of optical fiber dispersion is gradually evolving into the fatal link of optical fiber transmission system (Fig. 2. Generation of optical fiber dispersion) [4].

![Generation of optical fiber dispersion](image)
2.2.2. Polarization mode dispersion. Polar Mode Dispersion (PMD) is attributed to the random birefringence of optical fibers.

Causing a characteristic of different group velocities for light in different phase states. This birefringence makes the optical signals of different polarization states cannot reach the receiving end at the same time, that is, there is a delay. The higher the signal transmission rate is, the higher the ratio of the delay value to the symbol period is, and its influence cannot be ignored [5]. The lower the transmission rate, the smaller the relative proportion, and the impact is negligible. Therefore, the polarization mode dispersion limits the transmission capacity and transmission distance of high-speed optical fiber communication system (Fig. 3 fiber polarization loss).

Nonlinear effect of optical fiber. In wavelength-division multiplexing optical communication systems, the use of high-power lasers or optical fibers with low attenuation will cause light.

Nonlinear effect of fiber. The nonlinear effects of optical fibers are mainly divided into two categories: stimulated scattering effect and refractive index perturbation.

When the light passes through the optical fiber, part of the energy will deviate from the original propagation direction, and its frequency will also change, this phenomenon is the stimulated scattering effect. Stimulated scattering effect mainly occurs in the modulation of light signals, resulting in light scattering problems or elongating the wavelength of light. Refractive index perturbation is a nonlinear phenomenon that the refractive index N of optical fiber varies with the intensity of light [6].
magnitude of the nonlinear effect in the fiber is related to the input optical power and the effective area of the fiber. For optical fiber communication, the nonlinear effect in optical fiber has both positive and negative effects. First, Brillouin, Raman and other fiber amplifiers, as well as light modulators are developed using nonlinear effects in the medium. Secondly, the nonlinear effect in WDM optical communication system will not only cause the additional loss of optical signal transmission, but also cause the crosstalk between the channels in the system.

3. Basic concepts of LDPC code

3.1. Binary graph representation of LDPC codes

Tanner proposed a simple representation for any kind of linear block code, which is called a dichotomous graph. The dichotomous graph of LDPC code is used to visually describe the relationship between check node and information bit node [7]. The encoded bits are represented by a set of vertices, the number of which is the code length, that is, the number of columns of the check matrix. Each bit corresponds to a node, which is called the variable node. The other set of vertices represents the check node and is equal to the number of rows in the check matrix. When the position in the check matrix is a line is connected between the two sets of vertices.

3.2. Loop length of LDPC code

When there are four ones in the check matrix to form a rectangle, it means there are two variable nodes in the two parity check equations, and the case is a circle 4. The same thing with six ones in a hexagon and eight ones in an octagonal is circle six and circle eight, and so on. The smaller the length of the loop, the greater the harm to the iterative decoding algorithm. For example, in loop 4, the variable nodes of 2 are all wrong, so the two check equations cannot be tested at the same time. Loop 6, loop 8 and so on.

3.3. LDPC code transformation method

3.3.1. LDPC code constructed by Gallagher. The LDPC code proposed by Gallagher is a regular, pseudo random block code 2. The method is as follows: the regular check matrix (such as the unit matrix) should be constructed in a definite way, and the matrix is formed into a series of regular matrices, which are randomly arranged and combined with all the columns, and then these regular submatrices are formed into the required check matrix [8].

A checksum matrix consists of a series of submatrices. Other submatrices can be obtained through the row and column transformation of HQ. As you can see, the check matrix is regular. But that doesn't avoid the circle four situation, because the row and column transformation of the submatrix is random.

3.3.2. LDPC codes constructed by Mackay. On the basis of Gallagher, MacKay proposed the following construction method:

Step 1: The column reweight is fixed, the row weight is fixed as uniformly as possible, and the intersection of any two columns is also made stack weight does not exceed 1.
Step 2: Set half of the columns and weight to 2, usually using two identity matrices stacked on top of each other. The rest of the columns of method 1 are still constructed in the same way.

Step 3: In the matrix constructed in the first two steps, eliminate the generation of smaller loop lengths in dichotomous graphs. Delete the bad inserts the randomly generated column.

3.3.3. Completely random construction method. This construction method can construct approximately regular non-positive F LDPC codes according to the given fixed column weight, and the matrix size. The construction method is called as follows:

(1) Select some positions at random in each column, and generate 1 in these positions.

(2) Spread the positions of the 1’s from the perspective of the column, so that the number of 1’s in each row is relatively balanced. Scattered. The method is to swap each row so that the row weight is all close to but not more than a fixed value.

(3) Eliminate the situation of circle 4. Search each row; Select a reference row, search for the remaining rows and compare them with the reference row; For the reference row and comparison row, search the column to see if there are 4 ones in a rectangle, and if there is a circle 4. If the circle 4 appears, the method of scattering columns is used to deal with. If every row is searched as a reference row and no circle 4 is found, it is considered that circle 4 is eliminated.

4. Research on the application of multiple LDPC code serial decoding algorithm in optical fiber communication

4.1. Super FEC error correction applied in optical fiber communication

Since the 1990s, when Internet technology and data communication began to enter a new stage of development, people have been puzzled by a problem for a long time, which is bandwidth problem. In order to solve the problem of insufficient bandwidth, WDM and dense form of WDM technology are produced accordingly [9]. After the application of this technology, optical signals with different wavelengths can be transmitted in the same optical fiber, which, in a sense, meets people's actual demand for bandwidth.

In current optical fiber communication system if you use the form of dense wavelength division multiplexing technology, far away or in larger data transmission capacity, such as noise, dispersion, attenuation of signal, inevitably, with different wavelength signal interference between each other will be on the system as a whole will impact on the communication effect [10]. It is precisely because of these defects that in the actual signal transmission work, it is basically necessary to carry out a corresponding optical relay activity at a stage of 80 kilometers, that is, to make corresponding compensation and amplification for the signal in transmission. In addition, the electrical signal needs to be regenerated every 400 kilometers, and the responsible signal will gradually disappear due to the long distance. However, the defects are also obvious. In addition to the greatly increased workload, each optical relay or the regeneration of electrical signals will cause the corresponding cost increase.

In order to effectively solve this problem, the use of super FECF in the current optical fiber communication system is called Forward error-correction technology, this technology is essentially
through the use of the corresponding Error Correction code to the corresponding Error control of a way. The main goal of its application is to achieve coding benefits beyond the estimated value.

4.2. Coding modulation of multivariate form LDPC codes

Compared with the traditional discrete methods, the BICM system has been gradually applied in the current optical fiber communication. This system can achieve a better total effective rate. In some systems, polarization multiplexing is also used to reduce the symbolic rate value. But it has also started to switch to BICM, because it can re-encode symbols in polarized states to improve the performance of the whole system, which is why it has been widely used.

5. Conclusion

To sum up, the application of LDPC code in optical fiber communication can effectively improve the coding error correction effect of optical fiber communication system. Therefore, the research on design optimization of LDPC code should be combined with optical fiber system to promote the development of optical fiber communication technology.

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