



Research on Security Enhancement Algorithm of Data Dynamic Migration in Optical Fiber Network

Yan-song Hu^(✉)

Liaoning Petrochemical Vocational and Technology, Jinzhou, China
hys961@126.com

Abstract. Aiming at the problem that the transmission error of the traditional algorithm is too large, a dynamic data migration security enhancement algorithm for optical fiber network communication is proposed. Firstly, the migration data in the optical fiber network is collected. According to the data transmission process, the electric domain compensation, optical domain compensation and optical domain electric domain hybrid compensation in the PMD compensation unit design scheme are used to calculate the path of data safe migration. The dynamic migration data is collected by the variable electric delay algorithm, and then the amplitude of migration data is preprocessed according to the transmission characteristics of optical pulse in the optical fiber, to the preprocessing formula, use the PSO search mechanism to calculate the migration security feature data, and calculate the dynamic migration amount of n input layers, and finally get the dynamic migration security enhancement algorithm. The experimental results show that compared with the traditional methods, the error of dynamic data migration security enhancement algorithm is smaller when transmitting enhanced data.

Keywords: Optical network · Communication data · Dynamic migration · Security enhancement algorithm

1 Introduction

With the development of new network applications such as cloud computing and large-scale distributed scientific computing, the optical data center network has attracted the attention of academia [1]. The data center network has a high peak throughput and a great deal of burst, and the data center network has a large demand for bandwidth. The data center network urgently needs a physical layer technology to enhance the transmission security of this kind of data. Recent research in elastic optical network shows that it has very good performance of spectrum resource management and control, and it has dynamic migration on the optical path layer. At the same time, elastic optical network can provide huge bandwidth and strong stability. Therefore, elastic optical network is the inevitable choice of data center network interconnection. In order to better study the anycast routing and spectrum allocation of optical data center, the security enhancement algorithm of data dynamic migration in optical network is studied [2].

Single path and multi-path are used to solve the problem of unicast routing and spectrum allocation. For single path routing, some dynamic routing and spectrum allocation algorithms are proposed to achieve high throughput when the network is in dynamic service. In the calculation of dynamic data migration security enhancement algorithm, two types of algorithms in network dynamics are mainly calculated, namely, dynamic path migration data and spectrum allocation algorithm. In the pre-processing stage, the single path routing algorithm is extended to multi-path routing algorithm, including two types of multi-path algorithm, hybrid single path/ multi-path real-time computing path algorithm and hybrid single path/ multi-path algorithm using fixed path set. The simulation results show that, compared with the two traditional enhancement algorithms, the dynamic data migration security enhancement algorithm in optical fiber network has smaller transmission error in the transmission of enhanced communication data. It has a very low bandwidth blocking rate and is more suitable for enhancing the security of data dynamic migration in optical fiber network.

1.1 Security Enhancement Algorithm of Dynamic Data Migration in Optical Fiber Network

The security enhancement algorithm of communication data migration firstly collects the migration data in the optical fiber network. Aiming at the PMD problem in the high-speed optical fiber communication system in the process of data transmission, analyzes the law of dynamic migration, compares various PMD online monitoring and compensation methods, and collects the dynamic migration data in the optical fiber network.

By using the basic equation of optical transmission in single-mode fiber and the nonlinear schrodinger equation of pre-processing PMD effect, the vector models of first-order, second-order and high-order PMD are established in Stokes space to deal with the enhanced security relationship between DGD and DOP in optical fiber network. The PC of optical domain compensation scheme is combined with the variable (or fixed) delay line to make the network communication data in the optical fiber be placed in two dynamic migration processes of polarization disturbance and orthogonal polarization to complete the dynamic data preprocessing.

Then using the search algorithm of PMD compensation system, on the basis of the standard PSO algorithm, the security feature data is selected, the migration security inertia weight is adjusted, the immune clone principle in the immune mechanism is introduced, and the migration security feature data feature is calculated [3].

Using the improved SM as the tracking algorithm, using the fast and fine search ability of the tracking algorithm, through the reflection and expansion operation of the feature migration data, the tracking algorithm can quickly approach the extreme point in the iterative process, and estimate the dynamic migration security. Finally, the search algorithm and tracking algorithm are used to calculate the speed and position of ions in the optical fiber network, calculate the optimal fitness, get the compensation response time of the enhancement algorithm and the amount of particle data, and form the security enhancement algorithm.

1.2 Collect Dynamic Migration Data

When collecting the dynamic migration data in the optical fiber network, three kinds of PMD compensation unit are used: electric compensation, optical compensation and optical electric hybrid compensation. The optical domain compensation adopts the method of adjusting the PC in the optical path, changing the polarization direction of the light by adjusting the angle of three wave plates in the PC, making the fast and slow axis of the optical fiber at the end correspond to the fast and slow axis of the back polarization maintaining optical fiber, then dividing the two polarization states of the optical signal into two channels through the polarization beam splitter, using the polarization maintaining optical fiber as the delay line to introduce the appropriate delay for compensation, and finally using the polarization combiner combine the two optical signals. Introduce the fast axis into the delay of $\Delta t/2$ and the slow axis into the delay of $-\Delta t/2$, so that the delay difference between the two polarization modes is zero, so as to achieve the function of eliminating PMD and obtain a safe migration data path, as shown in Fig. 1 below:

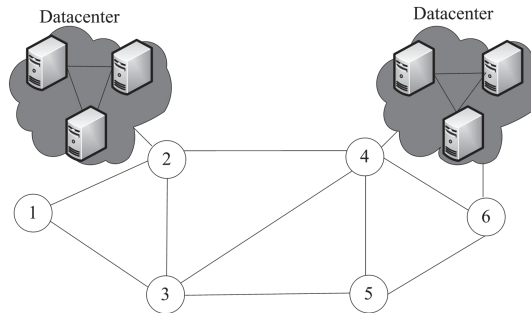


Fig. 1. Secure migration data path

The resulting security path is transmitted according to the sequence numbers 1–6 in Fig. 1 above. The dynamic compensation of data in the transmission process is to compensate the electric signal in the receiver by using the electric equalization compensator. However, in the process of data security migration, the hybrid compensation of optical domain and electric domain separates the two main polarization states of the optical signal, using the PC and polarization beam splitter contained in itself, and separates the optical data and electric data [4]. Let each optical signal change into electrical signal through photodiode, and collect the dynamic migration number of this part, as shown in the figure below, the rectangle of d changes into the ellipse of D , which is the dynamic migration data of the optical signal and electrical signal collected. In order to prevent the collected data from not dynamically changing data, the variable electric delay line is used to screen out the electric signal data mixed in the transmission of optical signal, and finally the acquisition process as shown in Fig. 2 is obtained:

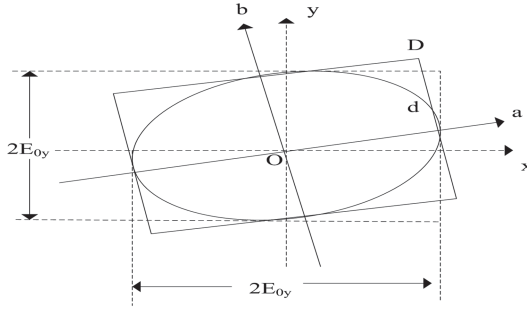


Fig. 2. Dynamic data collection process

After the acquisition, the dynamic data error needs to be calculated, and the electric field compensation calculation method is used to balance and reshape the electric signal. For the dynamic data collected by optical compensation, due to the limitation of electronic bottleneck, real-time extraction of line PMD change information is very easy to cause dynamic error value change. However, the sensitivity of PMD change information extraction is high, that is, it has the ability to reflect small PMD changes [5]. The sensitivity of the enhanced control signal is calculated, and the correlation between the enhanced precision of the acquisition PMD and the dynamic BER is obtained. According to the acquisition principle that the stronger the correlation is, the better the acquisition precision is, the response time of the acquisition is calculated. The response time of PMD and the time required by the control algorithm to process information are far lower than the time required by the PMD change rate, otherwise the optical fiber network will not work effectively.

In the optical fiber network communication, the electric Q value or eye pattern opening and migration process affect the transmission error, but a high-speed decision gate needs to be added, which has low sensitivity to PMD. Using SHB effect, the spectrum monitoring method of baseband radio frequency (RF) signal can accurately measure the DGD value which is larger than one bit period. It has high sensitivity to the smaller DGD value and short response time, but it needs the expensive narrow-band filter. DOP monitoring method has nothing to do with transmission rate, dispersion and modulator. Therefore, DOP value is used as PMD on-line monitoring signal for optimal control. By changing the control voltage to adjust the angle of wave plate in PC, an optimal angle is found to minimize the error of collected data.

1.3 Preprocessing Dynamic Migration Data

Preprocessing the dynamic migration data, using the electromagnetic theory of light, according to the transmission characteristics of optical pulse in the optical fiber, using the max equation group to calculate the vertical component, we get:

$$B_m = \frac{|\beta_x - \beta_y|}{k_0} = n_x - n_y \tag{1}$$

In the formula, B_m is the vertical component, k_0 is the fiber coefficient β_x, β_y is the component of X and Y axis n_x, n_y is the mapping component of X and Y axis. The

component is not a constant, but fluctuates. When transmitting, the two vertical components will produce delay, which will widen the signal pulse. When the spread caused by PMD is too large, the performance of the system will be seriously degraded, and the error rate of the receiving system will rise. Mathematically, the propagation constant is slightly different for the two polarization modes in the X and Y directions, which is called mode birefringence. The mode birefringence level P_k is defined as:

$$P_k = \frac{H_k + |H_k|}{2} \tag{2}$$

Where H_k is the refractivity. The pretreatment PMD is random, and the PMD of any section of optical fiber is a random variable subject to the Maxwell distribution function, which is different from the chromatic dispersion with certainty, and its value is closely related to factors such as fiber manufacturing process, material, transmission line length and application environment [6].

In the optical fiber link, the delay difference generated by two orthogonal polarization modes follows a certain probability density distribution. PMD and chromatic dispersion have the same effect on the performance of the system, that is to say, they cause pulse broadening and limit the transmission rate. However, for the low-speed optical fiber transmission system, the PMD effect is much smaller than the chromatic dispersion, which can be ignored, even not included in the earlier fiber performance index. However, with the increase of system transmission rate, the influence of PMD gradually appears, which becomes the key factor to limit transmission speed and distance after attenuation and chromatic dispersion. PMD cannot be avoided, it can only be minimized. Control PMD value to achieve the effect of preprocessing transmission distance, and calculate the maximum transmission distance to get:

$$L_{\max} = \frac{10000}{(D_{PMD} \times BR)^2} \tag{3}$$

Where BR is the bit rate, and the unit is GB/s. D_{PMD} is the transmission polarization coefficient in PMD, and the influence of PMD value and transmission rate on transmission distance is calculated. As shown in Table 1 below:

Table 1. PMD value and transmission rate

PMD (ps/ \sqrt{km})	Maximum transmission capacity		
	2.5 Gbit/s	10 Gbit/s	40 Gbit/s
3.0	180	11	<1
1.0	1600	100	6
0.5	6400	400	25
0.1	160000	10000	625

Since the amplitude of the pre-processing migration data is between zero and the maximum residual amplitude $\max|D_k|$, the main calculation methods of the migration

data are as follows: in the first case, if the amplitude of meaning is greater than the maximum residual amplitude $\max|D_k|$, then we will keep the transmission speed of the transmission optical path unchanged, because this is generally caused by the communication signal of data dynamic migration.

In the second case, if the amplitude of \hat{S}_k is equal to the maximum migration data amplitude $\max|D_k|$, then we will take the smaller value, that is, we will keep the migration data unchanged. Although it is caused by the communication signal of dynamic migration, such processing can retain the transmission signal of small transmission rate for the amplitude of migration data.

The third case: if the amplitude of the migration data is less than the maximum migration residual amplitude $\max|D_k|$, then we generally take the minimum value of the adjacent frames as the enhanced communication signal value, because this case is generally caused by network communication.

To sum up, according to the idea of migration data attenuation method, we can get the specific preprocessing formula as follows:

$$|\hat{S}_k(k)| = \begin{cases} |\hat{S}_k(k)| & |\hat{S}_k(k)| \geq \max|D_k| \\ \min[|\hat{S}_k(k)|], j = i - 1, i, i + 1 & |\hat{S}_k(k)| < \max|D_k| \end{cases} \quad (4)$$

Among them, \hat{S}_k is the electric field compensation coefficient, K is the control coefficient and D_k is the equilibrium coefficient. The final preprocessing results are used to calculate the data migration characteristic data.

1.4 Calculate Migration Security Feature Data

Use the search mechanism of PSO to get the transmission characteristics of characteristic data first. The search mechanism of PSO is shown in the following Fig. 3:

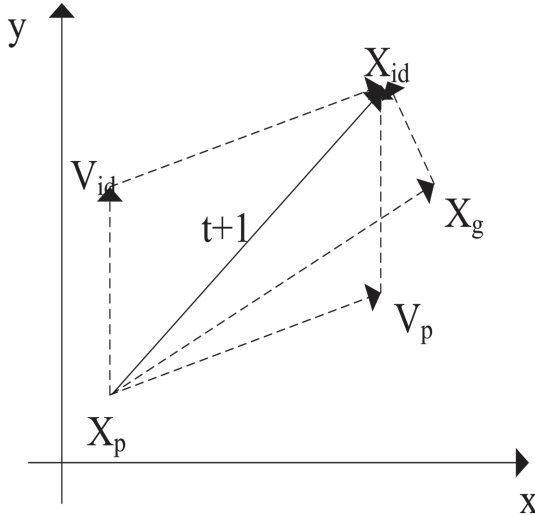


Fig. 3. PSO search mechanism

For each communication data, each feature data will have a fixed transmission feature. The transmission path in the figure above corresponds to a window sampling mechanism. Using dynamic consistency, the binary function of feature data is defined.

$$\partial(i, \hat{S}_k, D_k) = \begin{cases} 1 : \omega(i, \hat{S}_k, D_k) \leq T \\ 0 : \omega(i, \hat{S}_k, D_k) > T \end{cases} \quad (5)$$

In the formula, T is the possibility of parameter t in the consistency stage, and ω is the mechanism coefficient. The calculated point-to-point delay of data package is shown in Table 2 below:

Table 2. Point to point delay feature

Network type	Point to point delay	
	Normal value	Maximum value
10 M-CE	0.427	0.534
10 M-TE	0.238	0.350
100 M-CE	0.0728	0.0736
100 M-TE	0.0534	0.0543

The algorithm of real-time path calculation needs to establish a virtual topology every time, which has high computational complexity. The dynamic RMSA problem can also be realized by using the fixed path set method. In the topology $G(V, E, B, D)$, K shortest paths are calculated for each s-d node pair in advance, so the complexity of dynamic service is greatly reduced.

Formula (5) describes the detailed steps of this fixed path set HSMR algorithm [7].

Then in the service of an optical path request LR (s, d, c), the path set of s-d is sorted based on the path selection strategy mentioned later. When allocating spectrum c, we use a single path best effort service model, that is, we use the largest available spectrum block to allocate spectrum c. only when the largest spectrum block resources can not meet c, we can enable multi-path routing.

When using multi-path routing, calculate the migration security characteristic data according to the following algorithm. The detailed algorithm is shown in Table 3 below:

Table 3. The algorithm of using migration data in multipath computing

Reference algorithm	EPS-RMSA	Exhaustive path search RMSA
	Split-spectrum	Split-spectrum RMSA
Online algorithms	HSMR-OPC	HSMR with online path computation
Fixed path sets algorithms	HSMR-FPS-SPF	HSMR with the shortest path first
	HSMR-FPS-MSF	HSMR with the most slots path first
	HSMR-FPS-MLSF	HSMR with the most left slots path first
	HSMR-FPS-LSoHF	HSMR with the path has the 1 of slots-over- hops weight
	HSMR-FPS-LSoSHF	HSMR with the path has the largest weight of slots-over-square-of-hops

1.5 Estimating Dynamic Migration Security

The following steps are required to estimate and implement the whole dynamic migration security algorithm:

First, the initial data dynamic migration population size is n populations, including their location and speed data.

Second, calculate the fitness value of each particle according to updating the speed and position of the transmission particles in the optical fiber network.

Finally, for each particle, the fitness value is calculated and compared with the experienced safe position P . When the calculated result is 1, it is taken as the current best position P , and the distance between the two particles is calculated [8].

For each particle, its fitness value is compared with the best position P experienced by the whole, and the data amount of projection position of these two particles is calculated. The calculation process is as follows (Fig. 4):

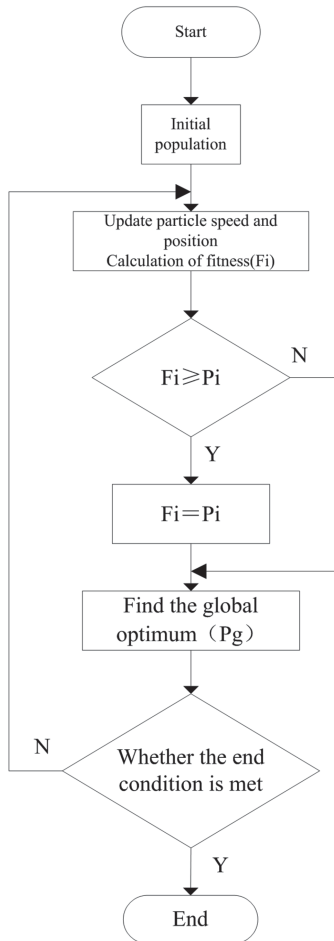


Fig. 4. Estimation process

The deviation method is used to estimate the deviation. The deviation method is to add a small deviation to the input of the input layer of the deep neural network structure, and then transfer the deviation in the network to calculate the change of the output of each hidden layer, that is, compared with the change of the output value of each hidden layer of the optical network when there is no deviation in the input layer [9]. The output value of the optical network layer changes as shown in the following Fig. 5:

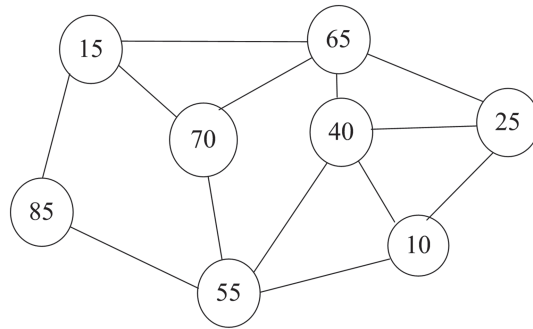


Fig. 5. Deviation

It is assumed that the input deviation value of input layer produces a small deviation value on the basis of the original input layer. Therefore, in the n-th layer, the dynamic migration amount of N input layers can be calculated cumulatively. The process of cumulative calculation is the process of data dynamic migration security enhancement algorithm [10].

2 Simulation Experiment

2.1 Experimental Preparation

Prepare two computers with the same parameters of high computing power, as shown in the following Fig. 6:



Fig. 6. Computer laboratory environment

The computer parameters in the laboratory are shown in Table 4 below:

Table 4. Computer parameters

Serial number	Name	Parameter
1	Memory capacity	8 GB
2	Mechanical hard disk capacity	DDR4-2666 MHz
3	Video card capacity	1 TB
4	Solid state disk	6G
5	CPU	i7-9750H
6	Resolving power	1920*1080

Prepare the data migration of optical fiber network communication in the experiment, as shown in the following Table 5:

Table 5. Experimental preparation data

Transmission efficiency(%)	Communication node	Data volume (MB)
15	1	10
20	2	20
25	3	30
30	4	40
35	5	50
40	6	60

Using data prepared in the above table, each data node represents the amount of data of 10 MB, and simultaneously interpreting the transmission error of data transmission under the same transmission efficiency.

2.2 Experimental Results

Simultaneous interpreting data transmission error under the same transmission rate is achieved by using the traditional security enhancement algorithm and the dynamic migration security enhancement algorithm of optical network communication data. The results of the following Fig. 7 are as follows:

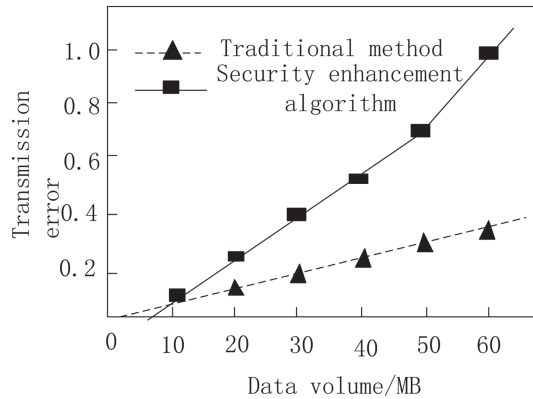


Fig. 7. Error comparison results

As can be seen from the above figure, when the two algorithms transmit 0–10 mb of data, there is no error in transmission, while when the amount of data is more than 10 MB, up to 60 MB, the transmission error of the traditional algorithm is far greater than the dynamic migration security enhancement algorithm of optical network communication data, which is beneficial to the transmission of security data in dynamic migration.

3 Concluding Remarks

In order to effectively reduce the space occupied by communication data resources and enhance the security of communication data dynamic migration, this paper studies the integrity and security protection of data communication security issues, optimizes the method of data encryption of communication data privacy information, so as to improve the security of data dynamic migration. The simulation results show that the dynamic data migration security enhancement method can effectively improve the network communication effect and ensure the quality of optical fiber communication.

References

1. He, Y., Xie, L.: Selection of the optimal laser sensor node after the optical fiber communication network is invaded. *Laser J.* **39**(4), 129–133 (2018)
2. Shi, Y., Zhang, H., Zhao, B., et al.: Selection of the optimal laser sensor node after the optical fiber communication network is invaded. *Laser J.* **39**(4), 65–75 (2018)
3. Ma, S., Wang, B., Wang, B., et al.: Research on real-time monitoring algorithm for tunnel safety status based on fiber Bragg grating strain sensors. *Chin. J. Sci. Instrum.* **38**(2), 304–311 (2017)
4. Mao, L., Cheng, G.: Dynamic OpenFlow switch migration algorithm based on the attractor selection. *Inf. Control* **46**(5), 525–530 (2017)
5. Wang, F.: Dynamic controllable flexible resource scheduling algorithm under cloud computing. *Sci. Technol. Eng.* **18**(3), 291–296 (2018)

6. Ma, S., Nie, G., Ye, T., et al.: Dynamic distribution selection algorithm for post mobile relay nodes after optical fiber network intrusion. **42**(5), 44–47 (2018)
7. Zhao, S., Ji, X., Mao, Y., et al.: Research on dynamic migration of virtual machine based on security level. **38**(7), 165–174 (2017)
8. Liu, H., Wang, T.: Research on breakpoint fault detection method of optical fiber communication LAN. *Modern Electron. Tech.* **40**(16), 81–85 (2017)
9. Ren, H., Shi, X.: Research on data management for smart grid based on dynamic migration. *Chin. J. Power Sour.* **42**(2), 291–293 (2018)
10. Zhao, C., Yan, L., Cui, Y., et al.: Dynamic adjusting threshold algorithm for virtual machine migration. *J. Comput. Appl.* **37**(9), 2547–2550 (2017)