Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
September-October 2022 Page No. 92-101
Article History: Received: 05 April 2022, Revised: 27 April 2022, Accepted: 03 May 2022, Publication: 14 May 2022

Optical Fiber Network Path Optimization Design for Data Classification Cloud Computing

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Abstract:

Improving the efficiency of network communication without changing the original optical fiber network hardware equipment is an important topic of network optimization technology, and it is also a research hotspot of existing network optimization in recent years. In order to reduce the probability of network congestion and improve the utilization of network resources, the data priority level and transmission path are analyzed from two aspects, and the optical fiber network path optimization model based on data classification cloud computing is designed. The optimization function mainly uses the least time cost classification and the least weighted routing scheme to filter the communication data level and type, and finally achieve the goal of optimal network communication indicators. The experiment conducted a simulation analysis of data communication between domains in four typical communication situations. The results showed that the optimized priority index increased from 0.0207 to 0.0992, the blocking probability decreased by about 1/2, and the average resource utilization increased by 5.96%. . The path optimization of this classified cloud computing model can improve the transmission efficiency of the inter-domain optical fiber network.

Keywords: *Optical fiber communication, Path optimization, Priority classification, Cloud computing, Data type.*

I. INTRODUCTION

The maturity of optical fiber communication technology has greatly increased the number of network terminals. According to incomplete statistics, the total global IP traffic still maintains a compound annual growth rate of more than 20% every year [1-3]. The massive growth of user groups and data flows makes the traditional single domain fiber optic network (SDON [4]) unable to withstand all data transmission, so the multi-domain fiber optic network (MDON [5]) is gradually replacing its status as the control method for the data flow of optical fiber networks in the future. MDON is composed of many SDONs, which are interconnected by inter-domain links, gateways, border nodes, etc. [6]. The internal topology details of each domain are hidden from other domains because the management policies of the domains require the network to have security and privacy-preserving properties. In the process of optical fiber communication, the uncertainty of communication resource allocation due to the unknown data flow types and flows in two different domains, when the allocated bandwidth cannot support a certain data flow type, network delays and other phenomena will occur [7]. Therefore, research on the rational optimization of data flow resource

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allocation on the basis of ensuring data privacy has become an important means to ensure efficient communication in optical fiber networks [8].

At present, a common countermeasure is to ensure the smoothness of the backbone network through time-sharing and current limiting. When the network traffic surges, restricting the traffic of each sub-client has achieved the goal of normalizing the backbone network. However, this method cannot essentially improve network communication performance, and using the same resource current limiting method for different clients neither achieves optimization nor affects user experience. Therefore, network communication can be optimized only by rationally allocating data flow resources. Therefore, researching data flow classification and optimization algorithm has become one of the important means to improve the communication efficiency of optical fiber network. L.M. Contreras et al. [9] designed a cloud architecture to provide cloud services for data centers, which is characterized by providing suitable virtualization models for different problems to improve the problem of uneven distribution of data resources. M.A. Klinkowski [10] proposed a low-cost and high-efficiency mathematical model for calculating the flow of optical networks. S. Peng [11] discussed the application of cloud computing in optical network virtualization, which can use optical network virtualization to provide data services for cloud computing. J. Lim [12] proposed a communication protocol error-tolerant algorithm, which provides error correction for the type conflict of communication data streams in different domains and improves the data matching effect. Wang Xiao et al. [13] proposed an architecture that ensures the lowest resource usage and avoids the infinite loop problem in the data flow. In a word, the current research focuses on the statistical analysis of data flow and its incidental information, and realizes the optimization of data flow allocation, but lacks comprehensive analysis of data flow type, structure and communication period characteristics. Therefore, this paper proposes a priority-based method. And data type classification of optical fiber communication network optimization algorithms.

II. SYSTEM CONFIGURATION

2.1 Optical Fiber Network System

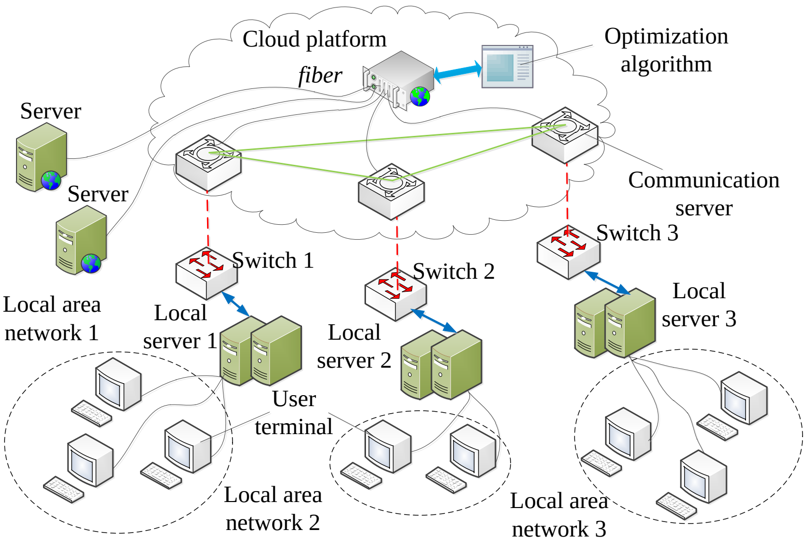

Fig 1: optical fiber communication network based on cloud platform

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The optical fiber communication network based on the cloud platform is shown in Fig 1. The end users converge into an independent local area network. In the absence of a local area network, the authority and resource allocation relationship in the corresponding network are set. The local area network is connected to the local server [14] (Local server) and is connected to the backbone network through the switch [15] (Switch), and the data transmission between each communication server in the main network becomes the main data flow channel of the network. On this basis, a cloud computing-based network traffic classification optimization algorithm is designed to integrate data flow types and resource occupancy in the communication process, so as to achieve the purpose of resource allocation optimization.

As shown in Fig 1, the communication between two user terminals is determined by the domain to which they belong. When the data communication resources of the backbone network are fixed, it is mainly affected by the communication period and the communication path, and the communication period is often determined by the user. Therefore, communication path optimization is the key to improve communication efficiency. This paper proposes an optimization algorithm based on priority setting and data type classification.

2.2 Path Optimization Ideas

Set up in a multi-domain optical fiber communication network [16-18], the three main parameters that can characterize the network state are the range D_r of the topology network domain, the inter-domain connection L_i, and the number of wavelengths available in the optical fiber communication network fiber link N_{wdm}, Therefore, the multi-domain topology fiber network function is $F\{ D_r, L_i, N_{wdm}\}$. In the multi-domain topology, let the function of a single domain be expressed as $D_r\{ GN_r, IN_r, L_r\}$, where GN_r is the set of gateway nodes, L_r is the set of core nodes, and Lr is the intra-domain link set of the rth domain. In order to realize the optimization of the communication path, it is improved from three levels: setting the priority level of the data flow, constructing the time parameter based on the data level and the scheduling strategy based on the optimization function. First, give higher priority to communication requests with high communication quality and short transmission distance in the network; secondly, set the transmission time-consuming comparison function $f(t)$ to compare the time-consuming of data communication; finally, according to the data type and Communication characteristics complete data path planning.

III. OPTIMIZING MODEL DESIGN

3.1 Optimization Function Construction

The essence of the optimization function is the path planning with the least communication time, that is, the traffic scheduling based on the data characteristics. Therefore, it is necessary to analyze the connection cost of each communication channel, and then complete the classification according to the descending order of communication time cost, and select the lowest cost. The weighted routing scheme completes the communication, and the judgment is based on

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$$f(t)_i = \frac{L_i}{L_{\max}} + \frac{T_i}{T_{\max}} \tag{1}$$

Among them, L_i represents *Level i*, which refers to the service level of the ith connection request, L_{max} represents the maximum value in the Level; T_i represents *Time i*, which refers to the holding time of the ith connection request, and T_{max} represents the maximum holding time of the connection request.

After estimating all types of transmission data through Equation (1), they are arranged in increasing order of path length. The weight coefficient of the route is composed of the path length (hop count) and the number of passing domains. In this process, the path can be obtained. The weight coefficient $W_{i,k}$ function of routing has

$$W_{i,k} = \frac{Pl_{i,k}}{Pl_{\max}} + \frac{D_{i,k}}{D_{\max}} \tag{2}$$

Among them, $Pl_{i,k}$ represents *Path length i,k*, which refers to the length of the kth path of the ith connection request, Pl_{max} represents the maximum value among all paths; $D_{i,k}$ represents *Domain I,k*, which refers to the length of the ith connection request. The number of domains passed on the kth path, D_{max} represents the maximum number of domains passed in network communication. Therefore, the optimization of the communication path can be completed by using the equations (1) and (2) in the network communication.

3.2 Algorithm Program Implementation

Based on the design idea of the above optimization path, the implementation steps of the optimization algorithm are completed, and the program flow chart is given according to the steps, as shown in Fig 2. The algorithm steps are as follows:

(1) Input the initial dataD_r, L_i, N_{wdm} of the optical fiber network, calculate the possible k communication paths, and include the parameters $Pl_{i,k}$, Pl_{max}, $D_{i,k}$ and D_{max} information in the *k* communication paths;

(2) The main analysis indicators in the initialization network channel: priority satisfaction [19] (PI, Priority Index), blocking probability [20] (BP, Blocking Probability), resource utilization [21] (RU, Resource Utilization);

(3) Data flow classification, complete the classification of data flow by priority level and data type, and mark the data flow level level;

(4) According to the calculation principle of formula (1), the network time consumption of all data is sorted in descending order. In this step, i is firstly incremented from 1 to $i_{\max}$, and then cyclically

substituted into formula (1) for comparison, and the final output is in descending order. The $f(t)_i$ computed value sequence of;

(5) Use formula (2) to complete the routing and wavelength assignment (RWA, Routing and Wavelength Assignment) in the optical fiber network. In this step, firstly, i is incremented from 1 to i_{max}, and at the same time, k is performed from 1 to k_{max}. Increase, and then use formula (2) to calculate the weight coefficient of routing communication, compare, and finally output the $f(t)_I$ calculation value sequence in descending order;

(6) Feedback the optimized communication path to the system, and then calculate the current values of PI, BP and RU again, and finally complete the path optimization.

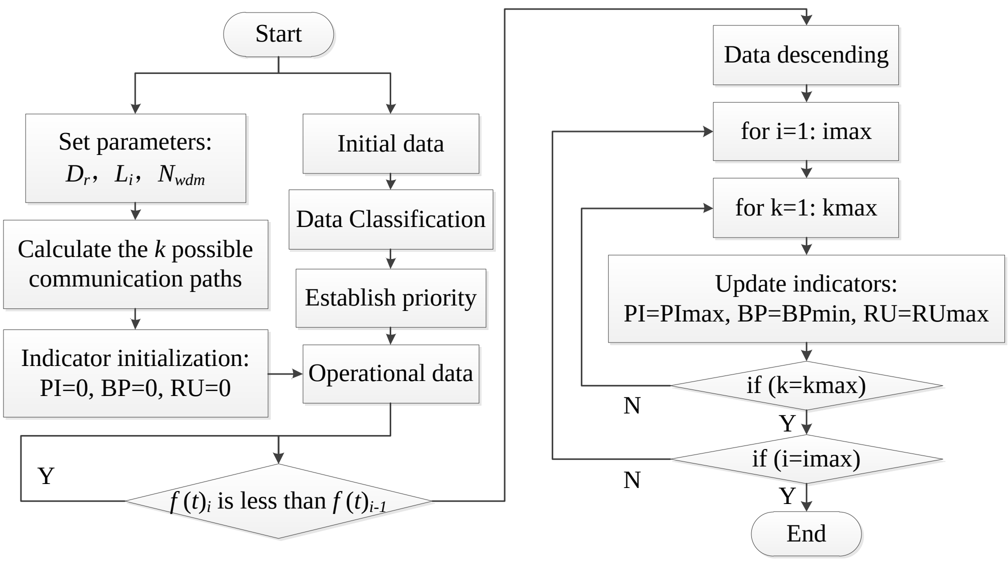

Fig 2: algorithm flow chart

IV. TEST EXPERIMENTS

During the experiment, multiple local area networks were established to simulate inter-domain data communication. A single local area network was composed of multiple computers to simulate different types of user groups. The multi-domain networks were all connected to the cloud platform and server, so as to realize the optimization of data computing through the cloud platform. The purpose of a fiber optic network communication path. Several typical situations are used to analyze the communication status of the optical fiber network: first, different types of data are continuously exchanged between different domains (A); second, all computers upload or download different types of data resources in the cloud platform at the same time (B); third , the same type of data is continuously exchanged between different domains (C); fourth, all computers upload or download the same type of data resources in the cloud platform at the same time (D). On this basis, the main technical indicators of the network channel are analyzed and compared.

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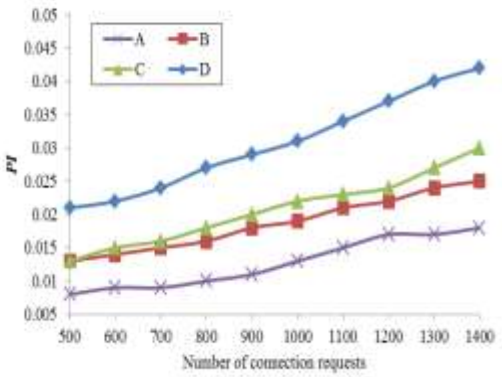
4.1 Priority Index Test

The purpose of prioritizing communication data is to ensure the fluency and stability of important data, so the priority index is first evaluated and analyzed. This indicator is expressed by the ratio of the priority level and the number of wavelength links used to the total number of links, there are

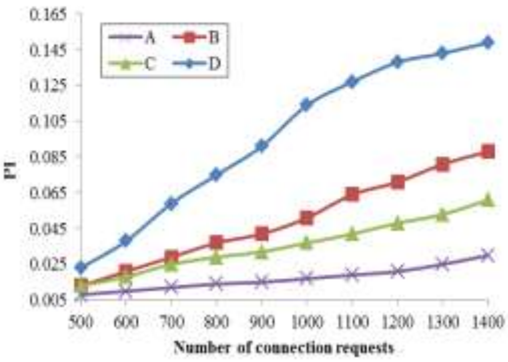
$$PI = \sum_{i=1}^{Z} f(t)_i \left(\sum_{i=1}^{Z} WL \right)^{-1} \tag{3}$$

Among them, Z represents the total demand for creating links, and WL is the wavelength link volume.

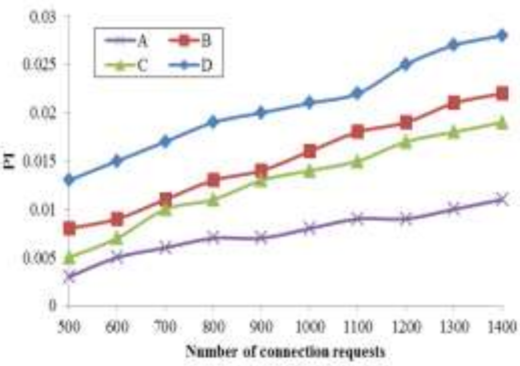
Comparing the two different data flow states, we use the intra-domain and inter-domain request ratio p as the division basis. Since the classification of communication data has a very obvious impact on the data communication process, in other words, the completion of different data types of communication under the same network communication conditions will lead to completely different communication performance and network resource utilization. As the division basis, the analysis of the network state can be completed from the perspective of data types. The test results for the four test conditions are shown in Figure 3(a), (b) and Figure 3(c), (d).



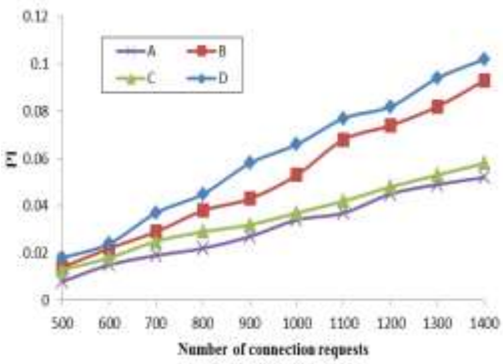
(a) p = 1:1 (Before optimization)



(b) p = 1:1 (After optimization)



(c) p = 1:4 (before optimization)



(d) p = 1:4 (after optimization)

Fig.3 pi results of four test conditions under different p values

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Comparing Fig 3(a) and Fig 3(b) in the test results, it can be seen that when the intra-domain request ratio is 1:1, the PI index can be improved after optimization. The mean PI values corresponding to the four cases are 0.0307 and 0.0187 respectively. , 0.0208 and 0.0127, the overall mean is 0.0207; while the PI mean using the optimized algorithm is 0.0957, 0.0497, 0.0358 and 0.0171, respectively, and the overall mean is 0.0992. Among them, the improvement effect corresponding to case A is the best. The analysis believes that the optimization method of priority and data type can redistribute the occupancy of resources during data communication, so as to achieve the purpose of improving resource utilization, and then the priority index can be significantly improved. Improve. In contrast, although the D situation is improved, the effect is not very obvious. The analysis believes that because this situation is a special transmission situation set in the experiment, all data streams are transmitted at the same time and of the same type, so their transmission The main factor of the bottleneck is the bandwidth of the main communication network, and the optimization effect of only using the method of classifying and planning communication paths is relatively weak. Comparing Figures 3(a) and (c) and Figures 3(b) and (d), it can be seen that when the total proportion of inter-domain data flows increases, it will have a certain impact on the total network transmission speed, resulting in a decrease in the PI index. However, when the overall trend can still reflect the data increment, the communication path optimization has a greater impact on the priority data transmission rate and stability. Comparing Figures 3(c) and (d), it can be seen that when the intra-domain and inter-domain request ratio is 1:4, the PI index can be improved after optimization, but as the amount of inter-domain data increases, the incremental effect of PI is different. The increments of cases A and B are higher than those of cases C and D with the same amount of data traffic. The analysis believes that the main reason is that cases A and B are both for different data types, and all communication path optimizations completed under this condition will be better. The effect of this optimization will be weakened if the data types are consistent.

4.2 Blocking Probability Test

In order to describe the smoothness of the optical fiber network, the blocking probability BP is used for analysis, and the test results when the intra-domain and inter-domain request ratios are 1:1 and 1:4 are also used, as shown in TABLE I.

TABLE I. Comparison of blocking probabilities before and after optimization

Total	*p* =1:1		*p* =1:4		Total	*p* =1:1		*p* =1:4	
	BP_i	BP_o	BP_i	BP_o		BP_i	BP_o	BP_i	BP_o
500	0.002	0	0.008	0.002	1000	0.214	0.104	0.249	0.129
600	0.012	0.003	0.054	0.011	1100	0.256	0.121	0.314	0.143
700	0.016	0.009	0.103	0.052	1200	0.317	0.154	0.369	0.187
800	0.038	0.018	0.155	0.075	1300	0.366	0.182	0.431	0.204
900	0.127	0.067	0.198	0.112	1400	0.425	0.215	0.527	0.237

It can be seen from Table 1, where BP_i and BP_o sum represent the unoptimized blocking probability and the optimized blocking probability, respectively. It can be optimized to analyze the congestion situation in the communication network. Quantitative analysis of network smoothness using blocking

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probability can characterize the state of the network before and after optimization. Under the condition of $p = 1:1$, with the increase of the total amount of data, the maximum blocking probability of the original communication path reaches 0.425, while the maximum blocking probability after using classification cloud computing optimization reaches 0.215; under the condition of $p = 1:4$ With the increase of the total amount of data, the maximum blocking probability of the original communication path reaches 0.527, and the maximum blocking probability after using classification cloud computing optimization reaches 0.237. As the total amount of data increases significantly, the blocking probability continues to increase. When the total amount of data reaches 1,400, the blocking probability is around 0.5 regardless of the proportion of inter-domains when it is not optimized, indicating that the overall data transmission is not smooth. In contrast, the blocking probability after path optimization is reduced to about half of the original value on average, and the optimization effect is better when the amount of inter-domain data is large.

4.3 Resource Utilization Test

In the process of data communication, in addition to ensuring the effect of high-priority data communication and reducing the overall network congestion, it is also necessary to consider the optimization of resource utilization, so that the maximum communication efficiency can be maximized in the limited bandwidth. Therefore, starting from the time dimension, the fluctuation range of resource utilization under the condition of total data transmission change is discussed, as shown in Fig 4.

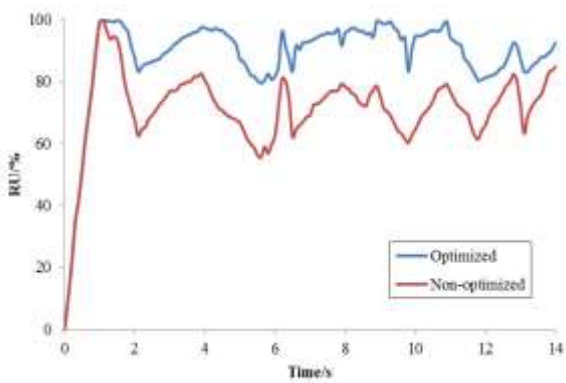

Fig 4: comparison of resource utilization before and after optimization

It can be seen from Figure 4 that the resource utilization rate reaches the maximum value from 0 in the initial state after the operation starts, indicating that the data is effectively transmitted. However, although the further increase in the amount of data and the increase in inter-domain paths gradually reduces the resource utilization rate, for For the unoptimized network communication data, the first lowest value is around 2.3s, and the RU is 62.4%. In the whole test period, there are 6 times of valley positions, all of which are generated during the period of data communication, and the minimum value of RU is 56.2%. In contrast, after the optimization is adopted, the fluctuation curve of resource utilization is similar to the previous one, but the average amplitude is significantly better than that of the unoptimized one, and it exhibits certain data characteristics. The positions of the valleys are basically the same, but the average

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value of the valleys is improved about 20.0%. The mean value analysis of the resource utilization in all periods shows that the resource utilization is increased by 5.96% after optimization, indicating that the data has been greatly improved in the process of network communication. The improvement of RU at the peak position is significantly smaller than that at the valley position, indicating that the results of algorithm optimization are more obvious when there are many data types and large amounts of data.

V. CONCLUSION

This paper designs a path planning model that balances the minimum time of communication and the minimum weight of routing, and improves the communication capability of optical fiber network by researching data priority and data type. The experiment tests four typical communication modes under different intra-domain and inter-domain request ratios. The results show that the overall mean value of the priority index is improved from 0.0207 to 0.0992 after optimization, which is significantly improved; as the amount of data increases, it can be seen that The optimization results reduce the blocking probability by about 1/2, and at the same time, the resource utilization rate has also been improved to a certain extent. Especially in the process of inter-domain communication with various data types, the test effect of this algorithm can be significant. It can be seen that the optimization based on this algorithm can improve the communication performance of the optical fiber network from the perspective of data flow classification.

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