Multi-Campus Adult Education Resources Network Model Based on MPLS VPN

Hongzhuo Qi

School of Computer Science and Technology, Harbin University of Science and Technology, Harbin 150080, China

Abstract

Most universities and colleges which have experienced 'college and university combination' have the problems of scattered campus, difficult convergence of original adult education resources networks, inconvenient use of teaching resources by students, etc. In the paper, it is proposed that MPLS VPN technology can be used for integrating multi-campus adult education resources networks aiming at the above-mentioned problems. Safe transmission of data is ensured by MPLS VPN through establishing a safe tunnel among adult education subnets, thereby reaching the purposes of resource convergence, optimization and sharing, realizing the objective of applying private network for special purpose aiming at adult education business. The method has stronger superiority than traditional VPN networking mode.

Keywords: MPLS VPN, remote access, construction of private network, multi-campus, adult education.

1. INTRODUCTION

Adult education in colleges and universities is characterized by high student quantity, wide range of dispersion and diversified education resources. How to ensure the smooth progress of adult education in college and university is the most important problem that should be considered for integrating existing multi-campus adult education networks. Various broadband access modes appear constantly with further development of network technology. VPN technology also arises at the historic moment. The so-called VPN (virtual private network) is a network of realizing safe special-purpose communication on the public network through encryption, authentication, tunnel protocol and similar technologies (Luo et al., 2011). The VPN technology is applied to construction and convergence of adult education networks in colleges and universities. It can ensure data safety on one hand, and it can save visit cost of students on the other hand. Remote teaching in different forms also can be implemented on VPN at the same time (Jiang, 2008). However, traditional VPN network has the problems of complicated networking, tedious management and maintenance, difficult expansion, etc. Advanced MPLS (multi-protocol label switching) technology is used in the current VPN network for solving these problems. Convergence of multi-campus adult education resources networks is realized better. It will play an important role in adult education.

2. ANALYSIS ON EXISTING MULTI-CAMPUS ADULT EDUCATION RESOURCES NETWORK MODEL

Isolation' is critical for constructing multi-campus adult education private network. Convergence' is the goal. It is determined that all branches have own independent teaching resource networks since multi-campus adult education departments have different geographical positions, thereby their network interconnection must be trans-campus. However, connection routes among different campuses of campus network mostly belong to shared channel of teaching, office and other similar business among different departments in the campus. It is impossible to realize construction of adult education private network if special channel cannot be opened in the public channel, and the purpose of multi-network convergence cannot be achieved (Fang, 2011; Luo, 2016). The author finds that two networking modes are mainly adopted in all colleges and universities after investigation on current multi-
campus adult education network interconnection mode. However, the operation condition of the two modes is not optimistic:

Firstly, realization of multi-campus adult education resources network interconnection by IPSec VPN technology is shown in figure 1. When network interconnection in the mode is adopted, data encryption, tunnel and identity authentication as well as other modes must be adopted to prevent transmitted data from being changed, lost and counterfeited in order to pass cross the untrustworthy internet network. Therefore, the following shortcomings can be produced, such as high networking cost, poor expandability, etc. (Luo et al., 2011; Dong, 2016) Multi-campus adult education network constructed with IPSec VPN can establish private network through tunnel technology, thereby realizing network isolation, but it is difficult to guarantee such network privacy, security, and reliability since adult education private network does not have its own network equipment. Meanwhile, problems of difficult maintenance and management, etc. can be produced (Xu, 2012). In addition, all branches' teaching departments not only should be provided with private network equipment and certification software, but also should be responsible for tedious maintenance work of IPSec VPN. Transmission rate of adult education business must be decelerated inevitably, and it is impossible to provide high-quality network teaching service (Chen, 2011).

![Figure 1. IPSec VPN tunnel network mode.](image)

Secondly, subnets of multi-campus departments are mixed with campus backbone network as shown in figure 2. In the pattern, interconnection among adult education departments in all campuses is realized through original backbone network of campus network. Business of adult teaching departments in all campuses is mostly exchanged through routing equipment of own campus due to limitation in the aspects of original network equipment, transmission media, etc., thereby gathering together many business flows in non-adult education types, such as full-time undergraduate teaching business, campus one-card business, student apartment data transmission and other unified hybrid transmission (Dong, 2011). Obviously, multi-campus adult education resources always suffer from network attack, virus outbreak, poor QoS effect, P2P software bandwidth occupation and other faults like an undefended city due to the simple networking mode. These faults may produce deadly blows to operation of adult education resources network (Feng, 2010).

In the above mode, the former is 'inharmonious by fusion'. Adult education business in such network is usually submerged by other business of the school. The latter is 'not fused by harmony', and such private network can lead to poor service quality (Sun and Zhao, 2012). Therefore, the two networking modes cannot meet the demands of 'safe isolation' and 'multi-network fusion' required by multi-campus adult education resources networks. However, it is gradually characterized by many students, dispersed distribution locations, excessive teaching locations, remote isolation distance, shared teaching resources requirements, etc. with further development of adult education. Multi-campus adult education resources network should not be networked for networking under the circumstances. Better utilization of existing campus network infrastructure also should be studied, and interconnection mode of traditional adult education network should be transformed, thereby reaching the purposes of isolating non-adult education business, and integrating adult education sub-nets of all campuses.
3. APPLICATION AND REALIZATION OF MPLS VPN IN MULTI-CAMPUS ADULT NETWORK EDUCATION RESOURCES NETWORK

3.1 Application of MPLS VPN in multi-campus adult network education resources network

Convergence of multi-campus adult network education resources lies the core in realizing sound isolation between adult education and non-adult education business data flows as well as perfect convergence of local area network (LAN) of all branch adult education points. Construction of adult education private network is the only choice to realize the core aspect. It is found that two existing modes for constructing adult education resources have problems through analyzing existing multi-campus adult education resources network mode. However, it is possible to realize this aim by using MPLS VPN technology accompany with constant development of IPSec VPN and MPLS technology (Vandana et al., 2014).

Network structure principle of MPLS VPN is shown in figure 3. It refers to the second layer and the third layer switching technology, which is combined with MPLS. Own virtual private network of users can be constructed in the public network through labels appointed in IP data packet. There are mainly three kinds of routers in MPLS VPN network: P core router, PE edge router and CE user edge router. Router P is mainly responsible for data exchange of VPN grouping outer labels. The router PE is mainly responsible for binding or removing marks in VPN user data packets; router CE is mainly responsible for forwarding received data packets to clients, and sending the data on the clients to the router PE.
How to realize the convergence of multi-campus adult education resources network subnets based on MPLS VPN technology and isolation from non-adult education business is the key problem which is mainly considered in the paper. For figure 3, the author plans as following: router P is used as the core equipment of campus backbone network, the equipment does not provide VPN routing functions, which is responsible for routing of backbone network business and rapid forwarding of data. The router PE is regarded as middle network convergence routing switching equipment connected with campus backbone network router P. It is mainly responsible for connecting with subnet CE router, and maintaining VPN subnet user information on all adult education points. Router CE is regarded as the network equipment for connecting adult education networks of all campuses with middle network router PE of campus networks. The network equipment is scattered in all adult education networks. CE is transparent, completely aiming at VPN network. The author has established a structure model for constructing multi-campus adult education resources network convergence through the above plans.

Router P completes switching of data labels on the outermost layer of adult education resources network in the structure model. Router PE is responsible for storing VRF routing table of adult education resource networks and global routing table of backbone network. Router CE is responsible for connecting adult education subnets of all campuses which should be added into MPLS VPN private networks. Operation of the model depends on two key technologies of VRF and MPLS of MPLS VPN, wherein the establishment of virtual private networks is ensured by VRF technology. However, label forwarding MPLS technology ensures routing delivery of data in each virtual private network. Transmission of data isolated from other business systems on router PE can be realized by setting different VRFs of adult education departments according to multi-campus adult education network. In addition, campus backbone network router P can realize connection among CE equipment of all branch campus adult education subnets under MPLS label guidance and exchange with arrival of adult education business data, thereby forming private network routing and completing mutual delivery of data. Therefore, the networking model not only can realize data isolation between adult education business and non-adult education business, but also can realize the convergence of all campus adult education subnets.

In addition, the MPLS VPN networking model not only keeps all the functions of original VPN network, but also provides better QoS service. Therefore, the model has advantages of high reliability, high security, flexible control strategy, etc. It is also unnecessary to modify configuration of all original nodes by the model on new increased nodes (Luo et al., 2016; Mhdawi, 2016). Therefore, network has better maintainability and extensibility, therefore adult education college of the schools has real initiative of mastering adult education resource private networks.

In a word, MPLS VPN is more suitable for convergence of multi-campus university adult education resources networks with its flexible network expansibility, powerful dynamic routing isolation characteristics and high guaranteed data security. Meanwhile, better solution is also provided for designing and constructing such similar large-scale network convergence.

3.2 Realization of multi-campus adult education resources MPLS VPN network

Adult Education College of the author's university not only has much electronic teaching documents and courseware’s, but also a lot of teaching video resources. All teaching departments are respectively located in four teaching points, namely main campus west zone, Nangang campus south zone, Xiangfeng campus east zone and Jiangbei campus north zone, which are 9 km to 20 km away from each other. Currently, adult education network of the school has its independent information resources service system. The database is mainly composed of self-built database, local database and remote database. Digital automatic processing is realized in the aspects of teaching resources formulation, sorting, storage, communication, public inquiry, student downloading, other adult teaching management and other business. However, the following phenomena are produced frequently after the adult education subnets of four campuses are connected into campus backbone network, including unstable network operation, low data transmission efficiency, difficult screening of network faults, etc. Student management system of adult education resources network suffers from the most severe influence due to the excessive access of users. School adult education resource network structure is shown in figure 4 before transformation:
Study shows that adult education resources network shown in figure 4 is a campus network which is characterized by multi-campus distribution and mixed data business. Various data of the network are interfered easily. In addition, failure of any one network device can lead to collapse of the whole network. Therefore, construction of virtual private network is the best approach to solve the problems (Bian et al., 2015). In recent years, west campus, east campus and south campus of the school have formed a private network through redundant optical fiber of original network. However, the north campus cannot form physical private network because it is connected with main campus through one optical fiber, thereby leading to isolation between data flow of adult education department in the north campus from other teaching data flow. Data conflict of the whole adult education resource network can be produced; data congestion is still produced frequently, etc.

Adult education resources network of the school is modified and constructed by MPLS VPN after investigation and study in many aspects. Adult education resources network structure of the school after transformation is shown in figure 5:

The main transformation process is shown as follows:

Network isolation is realized through using MPLS VPN technology on the basis of not changing the network connection mode between north campus and main campus. Meanwhile, respective VRF of adult education departments can be established in router PE and CE, thereby adult education subnets of north campus and adult education network of other campuses can be integrated into a private network VPN. Adult education business is isolated from other teaching business through MPLS forwarding. In addition, since the main network 10 gigabit core router ZXR10 T240G and north campus 10 gigabit convergence router ZXR10 T40G have the functions of MPLS VPN and Multi VRF, therefore it can be transformed into PE router as long as a 10G MPLS multi-business
block is added for them respectively. Original convergence router of adult education college can be transformed into CE equipment directly, and information exchange with router PE can be realized.

Target attributes of the same adult education college are used in router PE VRF, thereby realizing mutual access among all adult education departments in north campus, east campus, west campus and south campus; the router PE is connected with routers CE of all adult education departments, thereby guaranteeing that the router PE contains VPN VRF corresponding to all adult education departments. In addition, separate routing identifier RD is set for VRF of all adult education departments, thereby ensuring that router PE can forward the received data packets correctly. Sub-nets of adult education departments in all campuses can be combined together.

MPLS and MBGP protocols are installed on the backbone network router PE so as to realize VPN establishment of dynamic tunnel and routing. In addition, BGP is used; access strategy is configured in order to realize the access control of each subnet. The same routing target RT is used in all branch teaching departments of the adult education college. The routing tables are installed for realizing mutual access among all adult education subnets.

IP address is planed rationally. Router PE and CE routing table are configured. Internal IP addresses of adult education resource network are reserved well. Static routing is used among routers PE and CE by school adult education college in the network convergence. OSPF dynamic routing is used in MPLS.

Progressive mode of MPLS VPN network is adopted in arrangement. Firstly, all branch departments of adult education college are transformed into top layer VRF private networks isolated from other data of campus backbone network uniformly. Then, corresponding bottom layer VRF subnets are established according to concrete demands of all adult education departments, such as teaching data sharing VRF, student information management VRF, recruitment information management VRF, data backup VRF, etc., and various demands of adult education resources network are realized comprehensively.

3.3 Performance test of MPLS VPN network

The research group tests the integrated network as follows after the completion of network convergence among all campuses.

MPLS VPN network connection number test: software test tool Loadrunner is selected by the research group. 10 test times in one second is regarded as one cycle for concluding the maximum connection number rule of MPLS VPN network model as shown in figure 6.

![Figure 6. Test of connection number.](image)

Analysis shows that the maximum connection number of integrated MPLS VPN network is about 600, which can meet the application requirements.

MPLS VPN network throughput test: the research group selects PC machine of Windows XP operation system. Ordinary network card with communication rate of 10MB/S is selected. The size of tested data block is 110088018 Byte. The throughput of multi-campus adult education resources network under traditional IPSec VPN and SSL
VPN modes before transformation as well as MPLS VPN after transformation are tested. The test results are shown in figure 7.

![Figure 7. Comparison of throughput between traditional VPN and MPLS VPN.](image)

Experimental results in figure 7 shows that. It is obvious that the average time for transmitting test data is 270.8 seconds for traditional SSL VPN, 174.8 seconds for traditional IPSec VPN, and 144 seconds for MPLS VPN after transformation. Therefore, the throughput of traditional SSL VPN is 397KB/s. The throughput of traditional IPSec VPN is 615.03KB/s. The throughput of MPLS VPN after transformation is 746.58KB/s, and the demand of multi-campus adult education resources network communication can be satisfied.

4. CONCLUSION

MPLS VPN technology is particularly suitable for integrating multi-campus teaching resources network with its unique advantages, especially for the convergence of adult education resources networks in colleges and universities. Adult education subnets of the four campuses are integrated well through exerting performance of existing network equipment sufficiently under the precondition of not increasing additional VPN equipment. The access of non-adult teaching college is isolated successfully. Meanwhile, the network has better scalability. It is predictable that MPLS VPN technology will be used in multi-network convergence widely with broader space in its development.

ACKNOWLEDGMENTS

This work was supported by Education and Teaching Research Project of Harbin University of Science and Technology No. 220150019, University Nursing Program for Young Scholars with Creative Talents in Heilongjiang Province No. UNPYSCT-2016034.

REFERENCES


Jiang Q. (2008). Application of MPLS VPN in Modern Distance Education, Software Tribune (education technology), 25 (7), 62-64.