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Research on Teaching Methodology for MPLS VPN Advanced Routing Protocol Course for Students with Weak Foundations

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Abstract: With the rapid development of information technology, MPLS VPN (Multi-Protocol Label Switching Virtual Private Network), as an important component of modern network architecture, has raised higher requirements for students' learning due to its complexity and technicality. Especially for students with weak foundations, learning MPLS VPN and its advanced routing protocols has become a major challenge. This article aims to explore teaching methods for the MPLS VPN high-level routing protocol course for students with weak foundations, by optimizing teaching content, innovating teaching methods, and constructing an effective learning environment to enhance students' comprehension ability and practical skills. This article will discuss the introduction of MPLS VPN, analysis of teaching status quo, and design of teaching strategies, providing theoretical support and practical guidance for the teaching of related courses.

1. Introduction

MPLS VPN, also known as Multi-Protocol Label Switching Virtual Private Network, is a shining pearl of modern network technology. With its outstanding performance advantages, it has demonstrated extraordinary potential in building efficient, flexible and secure network architectures [1]. This technology achieves fast and accurate forwarding in complex network environments by attaching short tags to data packets, greatly improving the efficiency of data transmission. It also provides a powerful isolation and protection mechanism for enterprise networks and carrier networks, ensuring security and privacy during data transmission [2]. Therefore, MPLS VPN technology has been widely used worldwide and become the preferred solution for many industries to build an efficient information circulation system.

However, despite the many advantages of MPLS VPN technology, its learning curve is particularly steep for students with relatively weak network foundations. This is mainly due to the profound and complex theoretical knowledge involved in MPLS VPN and its supporting high-level

routing protocols (such as Label Distribution Protocol LDP, Multi-Protocol Border Gateway Protocol MP-BGP, etc.), with abstract concepts that are intertwined. In addition, the configuration process is cumbersome and requires a high degree of accuracy, making it difficult for beginners to quickly get started [3]. This learning challenge not only affects students' understanding and mastery of MPLS VPN technology, but also may dampen their enthusiasm and confidence in learning to some extent.

Faced with this situation, how to design and implement an effective teaching method that can help students overcome learning obstacles and successfully master the knowledge and skills of MPLS VPN and its advanced routing protocols has become a topic of common concern for educators and industry experts. This requires teaching methods that not only focus on the in-depth explanation of theoretical knowledge, but also combine practical operations. By simulating real network environments, designing interesting learning cases, and introducing interactive learning tools, we can stimulate students' interest and desire to explore through learning. At the same time, we provide personalized guidance and answer questions about common difficulties and doubts for students to ensure that each student can keep up with their learning progress and gradually build a solid knowledge system. Through such efforts, I believe that it can open a door to the world of MPLS VPN technology for students and help them go further and more steadily in their future careers.

2. Introduction to MPLS VPN

In today's complex and ever-changing network environment, MPLS VPN (Multi Protocol Label Switching Virtual Private Network), as an innovative network technology, has become the preferred solution for enterprises to build a cross-regional, high reliability network architecture with its excellent performance, flexibility and security. MPLS VPN is not only a single technology, but also an integrated solution that combines MPLS (Multi-Protocol Label Switching) [4], IS-IS protocol [3], BGP (Border Gateway Protocol) and its extended BGP-MP (Multi-Protocol BGP) [5] and other advanced routing protocols and technologies. MPLS VPN greatly simplifies the transmission process of data packets in the network by introducing a label switching mechanism at the network layer, enabling efficient forwarding of data. At the same time, the application of protocols such as BGP-MP enables MPLS VPN to exchange and synchronize routing information across multiple autonomous systems (AS), providing users with a seamless virtual private network experience. The progressiveness of this technology is not only reflected in its technical complexity, but also in its ability to flexibly respond to various network requirements and meet the high requirements of enterprises for data transmission speed, security, and reliability.

MPLS VPN (Multi-Protocol Label Switching Virtual Private Network) involves multiple protocols and technologies to ensure its efficient and secure operation. The following are some of the core technologies involved in MPLS VPN:

1) MPLS (Multi-Protocol Label Switching): MPLS is the basic technology of MPLS VPN, which uses labels for forwarding and simplifies the routing process in the network.

2) BGP (Border Gateway Protocol): In MPLS VPN, BGP is mainly used to transfer VPN routing information between PE (Provider Edge) devices.

3) IGP (Interior Gateway Protocol): IGPs, such as OSPF and ISIS, are used in MPLS VPN to distribute internal routing information within the operator's network. Although IGP itself does not directly participate in the transmission of VPN routes, it provides a foundation for routing selection in MPLS networks.

4) Tunnelling technology of MPLS VPN: In the MPLS VPN, tunnelling technology is used to establish a secure communication channel between devices.

It should be noted that MPLS VPN is not a single VPN technology, but rather an integrated solution combining multiple technologies. These protocols and technologies work together to ensure that MPLS VPNs can efficiently transport data while providing the necessary security and isolation.

3. Analysis of the current situation of MPLS VPN high-level routing protocol learning for students with weak foundation

3.1. Theoretical cognitive barriers

When facing the high-level routing protocol MPLS VPN, students with weak foundation often face great challenges in theoretical cognition. As a key technology in modern network architecture, MPLS VPN technology deeply integrates the efficient forwarding mechanism of MPLS (Multi-Protocol Label Switching) and the flexible isolation characteristics of VPN (Virtual Private Network), forming a complex yet powerful network solution. However, the theoretical framework of this technology is so vast and abstract that it undoubtedly poses a formidable challenge for students who haven't yet firmly grasped basic network knowledge.

Specifically, students first need to understand the core concepts of MPLS, namely how label switching enables fast forwarding in a network and how these labels are generated, distributed, and effectively managed between network nodes. This process involves complex network protocol interactions and data processing flows, such as the working principle of LDP (Label Distribution Protocol) and the establishment and maintenance of LSP (Label Switch Path). These concepts are abstract and difficult for beginners to grasp intuitively.

Next, students need to deeply understand how MPLS VPN achieves isolation and interoperability between different VPNs through mechanisms such as VRF (Virtual Routing Forwarding) tables, route distinguisher (RD), and route target (RT).These concepts not only require students to have solid knowledge of network layer protocols, but also require them to possess high abstract thinking and logical reasoning abilities in order to accurately grasp the flow direction and control strategies of information in complex network environments.

In addition, MPLS VPN also involves deep integration with IP routing protocols such as BGP (Border Gateway Protocol) to achieve interconnection and routing information transfer across domain VPNs. These advanced features further increase the difficulty of learning, requiring students not only to master the technical details of MPLS VPN itself but also to integrate it with existing network architectures and protocol systems to form a complete network solution.

In summary, for students lacking a solid network foundation, the theoretical cognitive barriers presented by MPLS VPN technology are enormous. They need to overcome cognitive bottlenecks in the learning process and deepen their understanding of relevant concepts through repeated study and practice. At the same time, teachers should also adopt various teaching methods and approaches such as case analysis and experimental simulation to help students better grasp the essence and key points of MPLS VPN technology.

3.2. Insufficient practical operation ability

Insufficient practical operation ability. In the current teaching situation of computer networks in Chinese universities, the importance of combining theory with practice is self-evident. This principle is particularly crucial when dealing with high-level routing protocols such as MPLS VPNs. However, in reality, weak foundation students generally show significant deficiencies in practical operational abilities.

On the one hand, although students may have mastered basic configuration commands and steps

of MPLS VPN through classroom learning or self-study, some students also grasp the details of these commands. However, in the process of translating theoretical knowledge into practical operations, they often feel inadequate. This is because they do not have a deep understanding of the logic and principles behind these commands, and lack the ability to combine abstract concepts with specific scenarios. Therefore, in the actual configuration process, once they encounter complex or changing situations, they are prone to configuration errors and it is difficult for them to achieve the expected network effect.

On the other hand, when facing network failures and anomalies, these students' practical experience and problem-solving abilities are even more inadequate. Due to their lack of sufficient practical opportunities and real-world experience, they often lack systematic approaches and methods for diagnosing and troubleshooting network failures. When confronted with problems, they may feel lost and anxious, unsure of where to start in order to identify and solve the issue. This sense of helplessness not only affects their learning enthusiasm and self-confidence, but also further exacerbates their deficiencies in practical operation.

3.3. Lack of motivation and interest in learning

In the current teaching situation of computer networks in Chinese universities, learning MPLS VPN high-level routing protocols faces two challenges: on one hand, its learning content itself is diverse and difficult. For students with weak network foundation, mastering this knowledge is undoubtedly a time-consuming and laborious task; On the other hand, due to the relatively limited application scenarios of MPLS VPN technology in real life, especially in the network environment that students are exposed to daily, it is difficult for them to intuitively feel the urgency and importance of their studies. This leads to a lack of motivation and interest in learning.

For students with weak foundations, facing complex and seemingly "distant" technologies like MPLS VPN often makes it difficult for them to find the intrinsic motivation to learn. They may think that these profound knowledge is not related to their future career development or daily life, so they lack the enthusiasm for active exploration and learning. In addition, due to the high level of concentration and patience required for the learning process of MPLS VPN, students with weak foundations may gradually lose interest and confidence in this technology as they frequently encounter setbacks and difficulties during their learning.

What is more worrying is that some teachers may not fully consider the learning psychology and needs of students during the teaching process, and adopt traditional and cramming teaching methods. This approach often focuses on the impartation of knowledge and ignores students' initiative and creativity, making the classroom dull and uninteresting, which makes it difficult to stimulate students' interest and motivation. In such a teaching environment, students are more likely to develop a dislike for learning and even have a psychological resistance towards learning.

Therefore, how to stimulate the interest and motivation of weak foundation students in learning MPLS VPN high-level routing protocols has become an urgent problem that needs to be solved to improve teaching effectiveness.

4. Teaching Strategy Design

In response to the problems faced by students with weak foundations in learning MPLS VPN advanced routing protocols, this article proposes the following teaching strategy design, aiming to improve students' learning effectiveness and application abilities through innovative teaching methods.

4.1. Layered teaching, tailored to individual needs

When delving into the teaching field of MPLS VPN, an advanced network routing protocol, I keenly noticed significant differences in students' basic level. MPLS VPN, with its complex architecture, rich features, and wide range of application scenarios, places extremely high demands on students' learning abilities. In the face of this challenge, we firmly believe that adopting a layered teaching strategy is a necessary and efficient solution. Firstly, in order to accurately grasp the starting point of each student, a detailed survey and questionnaire are designed to comprehensively understand their mastery of network basic knowledge, especially their understanding of MPLS VPN related concepts, as well as their learning interests in this field. This process not only provides valuable reference for subsequent teaching design, but also allows students to have a clearer understanding of their own learning situation.

Based on a deep understanding of students' basic level, a carefully planned implementation plan for layered teaching has been developed. Divide students into different levels or groups, with each level corresponding to a specific MPLS VPN learning stage and goal. For students with weak foundations, they are well aware of their confusion and struggle when facing MPLS VPN advanced routing protocols, so they pay special attention to strengthening and consolidating their basic knowledge. Using intuitive and vivid teaching methods such as animated demonstrations and experimental operations, complex network concepts are transformed into easily understandable forms to help students gradually build a knowledge framework for MPLS VPN. For students who already have a certain foundation, they are encouraged to move towards higher levels and guided to explore the details and advanced applications of MPLS VPN, such as complex routing policy configuration, security performance optimization, etc., with the aim of cultivating their innovative thinking and ability to solve practical problems.

By implementing a layered teaching strategy, we are delighted to see significant progress in students' learning of MPLS VPN. Students with weak foundations gradually overcome learning barriers and have a deeper understanding of MPLS VPN after strengthening their basic knowledge learning; Students with a certain foundation, on the other hand, continuously broaden their knowledge boundaries through in-depth learning and exploration, demonstrating outstanding innovation and problem-solving abilities. This achievement not only validates the effectiveness of the layered teaching strategy, but also provides valuable experience for future teaching. Looking ahead to the future, we will continue to deepen research and practice on MPLS VPN teaching, constantly explore more efficient and personalized teaching methods and strategies, in order to better meet the learning needs of students and promote them to achieve more brilliant achievements in the field of advanced network routing protocols such as MPLS VPN.

4.2. Combining theory with practice, iteratively strengthening

MPLS VPN is not a single VPN technology, but a comprehensive solution that combines multiple technologies. Its learning requires not only solid theoretical knowledge, but also rich practical experience. Therefore, in the teaching process, full attention should be paid to the combination of theory and practice. On the one hand, through classroom lectures and case studies, students can understand and master the basic concepts, working principles, and configuration methods of MPLS VPN; On the other hand, through eNSP simulation operation, students can personally configure and debug, deepening their understanding and memory of theoretical knowledge. At the same time, students are encouraged to participate in the development and maintenance of practical routing configuration projects, apply their learned knowledge to practical work, and improve their practical operation and problem-solving abilities.

1) Deepen theoretical understanding: In the theoretical teaching process, it is not only sufficient

to introduce the basic knowledge of MPLS VPN, but also to guide students to deeply understand the technical principles and protocol interaction process behind it. By analysing how MPLS achieves fast forwarding of data through label stacks, and how LDP is responsible for label distribution and management, students can form an intuitive understanding of the internal operation mechanism of MPLS networks. At the same time, we will also delve into how the BGP-MP protocol plays a role in MPLS VPN, enabling the exchange and synchronization of VPN routing information across autonomous domains. In order to enhance the interactivity of learning, group discussions and debates are adopted to encourage students to express their own opinions and questions, and solve problems together through collective wisdom.

2) Deep application of eNSP simulation practice: eNSP, as a powerful network simulation software, provides almost unlimited simulation practice opportunities. In the teaching of MPLS VPN, we fully utilize the virtual environment of eNSP to construct complex network topology and simulate real network environments. Students can freely perform device configuration, routing planning, troubleshooting, and other operations in this environment without worrying about affecting the actual network. In addition, eNSP also supports simulation of multiple protocols and interfaces, enabling students to comprehensively master the configuration and debugging skills of MPLS VPN. In order to increase the challenge of learning, complex network scenarios and fault cases will also be designed, allowing students to continuously improve their practical abilities and innovative thinking in the process of solving these problems.

3) Integration and expansion of actual projects: In addition to classroom learning and simulated practice, actual projects are also integrated into the teaching process. By collaborating with enterprises or participating in open-source projects, we provide students with real network configuration and maintenance tasks. These projects not only require students to have a solid theoretical foundation and practical abilities, but also require them to possess teamwork spirit and good communication skills. During the project execution process, students will personally experience various aspects such as requirement analysis, scheme design, equipment selection, configuration implementation, testing and verification, and post maintenance, in order to comprehensively enhance their overall quality. At the same time, enterprise experts or industry leaders will be invited to give lectures and exchange ideas at the school, providing students with more industry perspectives and career development suggestions.

4.3. Diversified teaching to stimulate interest

4.3.1. Problem guided teaching method

When using problem oriented teaching method, teachers can construct a series of progressive problem chains, gradually guiding students to delve into the core of MPLS VPN from understanding basic concepts to exploring advanced applications. For example, starting from basic questions such as "What is MPLS? How does it work?", gradually delving into more complex questions such as "How are routing encapsulated and transmitted in MPLS VPN?" and "How does BGP-MP help exchange VPN routing information between PE devices. These questions not only stimulate students' curiosity, but also encourage them to actively explore and consult information, and gradually build their own knowledge system in the process of solving problems.

4.3.2. Project based teaching method

The project-based learning approach is a more in-depth and comprehensive teaching method. In MPLS VPN projects, teachers can set clear project goals and requirements, such as designing an MPLS VPN network that supports multi tenant isolation, optimizing the performance of existing

MPLS VPN networks, etc. [6]. Students need to collaborate in groups to complete the entire process from requirement analysis, solution design, equipment selection, configuration implementation, to performance tuning and troubleshooting. In this process, students can not only apply their learned knowledge to practice, but also learn essential skills in the workplace such as project management, teamwork, communication and coordination. At the same time, teachers can also invite industry experts or corporate mentors to participate in project evaluation and guidance, providing students with more professional and practical feedback and suggestions.

4.3.3. Task based incremental teaching method

Due to the numerous protocols involved in MPLS VPN and its high difficulty, in the teaching process of practical courses, if different tasks are assigned for each class, students will spend a lot of time from understanding the tasks to configuring the MPLS VPN protocol, resulting in limited effective configuration time and weak mastery of configuration commands and principles in the 2-hour course. The task incremental teaching method refers to setting up a large background task in the practical teaching process of MPLS VPN courses. Students complete some of the tasks in the configuration of each class, and the subsequent courses are the continuation of the previously completed tasks. This method enables students to quickly understand the tasks of each class during the configuration process, and to configure them based on the previous class, reducing the difficulty of configuration. At the same time, it also enables students to have a clearer understanding of the connections and differences between each class, and to comprehend the technical principles of MPLS VPN from a global perspective.

In summary, diversified and practical teaching methods play an important role in the teaching of MPLS VPN. Through the comprehensive application of problem oriented, case analysis, project-based learning, and task-based incremental teaching methods, students' learning interest and motivation can be stimulated, helping them better understand and master the knowledge and skills of MPLS VPN and its related protocols.

4.4. Pay attention to feedback and evaluation, and adjust teaching strategies in a timely manner

In the teaching process, in-depth explanations of MPLS VPN and its core protocols (such as MPLS, LDP, RSVP-TE, BGP-MP, etc.) were given, and Huawei eNSP (Enterprise Network Simulation Platform), a powerful network simulation software, was fully utilized to enhance students' learning experience and effectiveness in a practical way.

Firstly, through classroom questioning, students' understanding of the basic theory of MPLS VPN is immediately tested, such as the working principle of MPLS, how LDP establishes label distribution paths, and how RSVP-TE provides QoS guarantees for MPLS traffic. These questions not only promote classroom interaction, but also help teachers effectively grasp students' understanding of knowledge points.

Subsequently, in the homework inspection phase, students are required to use eNSP software to build an MPLS VPN network, configure relevant protocols, and solve specific network problems. By checking students' homework, we can visually see their mastery of MPLS VPN configuration commands, their ability to design routing strategies, and their proficiency in troubleshooting.

In terms of experimental reports, students are encouraged to record the experimental process in detail, analyze the experimental results, and reflect on the problems and solutions encountered during the experimental process. By reviewing the experimental report, we can gain a deeper understanding of students' learning ideas, problem-solving strategies, and innovative points, thereby providing them with more personalized learning advice.

Based on the collected learning data and information, teaching strategies and methods are adjusted in a timely manner. We organize specialized lectures, group discussions, or one-on-one tutoring to address students' weak areas in MPLS VPN configuration, routing optimization, and troubleshooting, ensuring that each student receives targeted assistance.

At the same time, a scientific evaluation system has been established, taking into account multiple dimensions such as eNSP simulation experiment scores, classroom performance, homework completion, and experimental report quality, to comprehensively, objectively, and fairly evaluate students' learning outcomes. This diversified evaluation method not only motivates students to continuously learn and improve, but also provides a basis for teachers to further optimize teaching content.

5. Conclusion and Prospect

This article conducts in-depth research on the teaching methods of MPLS VPN advanced routing protocol courses for students with weak foundations. By adjusting teaching content, innovating teaching methods, and optimizing the learning environment, measures aim to improve students' learning effectiveness and interest. Practice has proven that these teaching methods have achieved good results to a certain extent, but further improvement and optimization are still needed. In the future, we will continue to pay attention to the learning characteristics and needs of students with weak foundations, and constantly explore more effective teaching methods. At the same time, we will strengthen cooperation and communication with enterprises and industries, introduce more practical cases and project practice opportunities, and enable students to learn and master the knowledge and skills of MPLS VPN and its advanced routing protocols in real work environments. I believe that with continuous efforts and exploration, we will be able to cultivate more network technology talents with innovative spirit and practical ability.

References

[1] F. Bensalah, N. E. Kamoun, and Y. Baddi, "A novel approach for improving MPLS VPN security by adopting the software defined network paradigm," Procedia Computer Science, vol. 160, pp. 831-836, 2019/01/01/, 2019.

[2] A. Perez, "4 - Transport Network MPLS-VPN Technology," Implementing IP and Ethernet on the 4G Mobile Network, A. Perez, ed., pp. 65-86: Elsevier, 2017.

[3] W. Da, Huawei MPLS VPN Learning Guide, Beijing: Posts and Telecommunications Press, 2023.

[4] L. Aimaretto, and D. Dujovne, "Enhancing end-to-end determinism and reliability in 6TiSCH networks with disjoint leaf-based MPLS-like tunnels," Internet of Things, vol. 24, pp. 100988, 2023/12/01/, 2023.

[5] M. Saad, A. Anwar, A. Ahmad, H. Alasmary, M. Yuksel, and D. Mohaisen, "RouteChain: Towards Blockchain-based secure and efficient BGP routing," Computer Networks, vol. 217, pp. 109362, 2022/11/09/, 2022.

[6] H. a. Xu, Y. Wu, and Y. Luo, "Exploration of MPLS VPN Teaching Practice Based on Case Teaching." National Conference on Collaborative Teaching of Electronic Information Science and Engineering Majors in Higher Education Institutions, pp. 134-138, 2018.