

Optimization Strategy for Experimental Teaching Based on eNSP Network Simulation Platform

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Abstract. To address outdated content, limited methods, and low engagement in computer network experimental teaching, this paper proposes an optimized strategy using Huawei's eNSP simulation platform. Leveraging eNSP's robust simulation and interactive capabilities, a multi-level teaching system is designed around core network concepts. Through two-layer and three-layer topologies and packet capture analysis, the plan strengthens understanding of data link and network layers. An integrated online exam environment further enhances the teaching process. Practical application shows improved student skills, better integration of theory and practice, and increased learning motivation. This strategy provides valuable insights for reforming network teaching in applied universities.

Keywords: eNSP; Network simulation platform; Online course system

1. Introduction

With the rapid advancement of information technology, computer networks have become increasingly diverse, complex, and virtualized. In response to the growing national demand for skilled network professionals, university students must not only master foundational theoretical knowledge but also cultivate practical skills in areas such as network deployment, management, troubleshooting, fault diagnosis, and data analysis.

Computer networking courses, by nature, rely heavily on hands-on practice. However, traditional teaching methods often struggle to support large-scale [1], repeatable experiments due to the high cost and operational complexity of real network hardware. To address these challenges, many universities have turned to virtual simulation platforms, which provide students with realistic network experiences while significantly enhancing the interactivity and effectiveness of instruction.

This paper introduces and implements a teaching model supported by the Huawei eNSP network simulation platform. Through configuring Layer 2 network topologies, students gain a deeper understanding of the data link layer; Layer 3 configurations help clarify core principles of the network layer; and data packet capture and analysis exercises further bridge the gap between theory and practice [2]. Practical application has demonstrated that the eNSP platform effectively simulates real-world network scenarios and substantially improves students' engagement and hands-on abilities.

Moreover, the virtualization capabilities of eNSP remove the traditional dependency on physical hardware and classroom space. The platform not only enables remote instruction but also allows students to perform experiments on their own schedules, aligning well with the growing trend toward online education and digital transformation. Through this system, students can efficiently complete network configuration tasks [3], become proficient in mainstream device command interfaces, and build a strong foundation for future career development.

2. Theoretical Basis and Development of the OBE Model

The content of computer network courses is inherently complex, encompassing a wide range of protocols and technologies that span from the physical layer to the application layer, as illustrated in Figure 1. In traditional experimental teaching, tools such as packet capture software and data analysis programs are typically employed to help students visualize data units and understand the transmission mechanisms of various protocol layers. While these methods can deepen students' comprehension of protocol principles to some extent, the overall instruction remains theory-oriented and lacks systematic training in areas such as network configuration, end-to-end architecture design, and comprehensive network analysis.

This issue is particularly evident in applied undergraduate institutions, where the emphasis should be placed on developing students' practical skills and vocational competencies. However, the experimental design of many computer network courses still falls short of meeting the actual demands of the industry for skilled professionals in applied network technologies [4]. As a result, students often struggle to bridge the gap between theoretical knowledge and real-world engineering applications, limiting the development of their hands-on capabilities and comprehensive problem-solving skills.

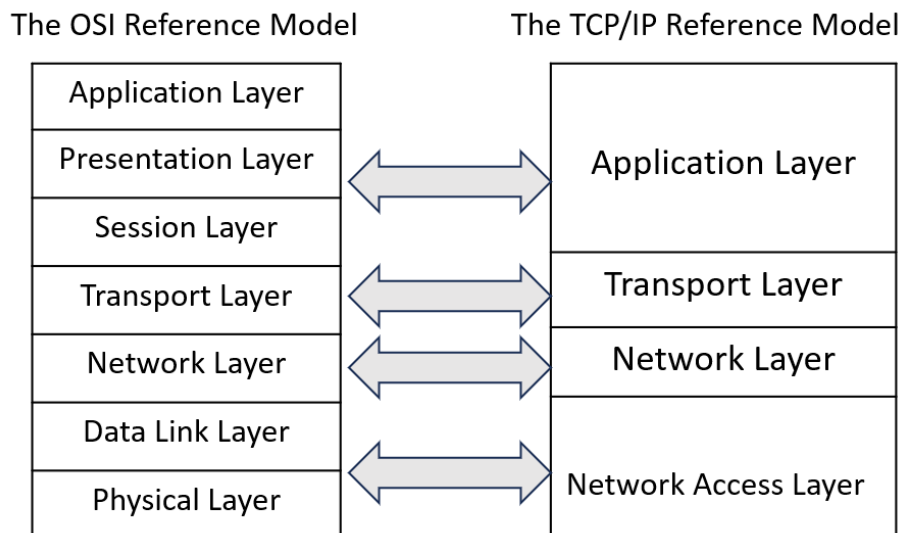


Figure 1. Computer network structure

In recent years, many universities have established physical hardware environments such as campus network laboratories, specialized rooms for network technologies, and practice-oriented network operation labs. These efforts have significantly improved the infrastructure for teaching computer network courses and expanded the available teaching resources. Within such environments, students have the opportunity to interact with various types of real network equipment—such as switches, routers, and firewalls—across different brands and models, and can perform basic configuration tasks and operations. However, simply upgrading hardware facilities is not sufficient to fundamentally enhance the quality of teaching in computer networking [5]. In actual classroom practice, several persistent challenges remain:

2.1 Restricted Teaching Content. Computer networking courses often accommodate large student cohorts. Relying entirely on physical equipment for experimental teaching leads to difficulties in resource allocation and constrains the scope of instruction. Due to limitations in device quantity and space, instructors frequently can only schedule basic operations such as powering up devices and conducting initial configurations. As a result, advanced tasks—like building complex topologies, debugging protocols, and simulating faults—are seldom implemented.

This greatly hinders students from gaining a deeper understanding of networking concepts or applying them meaningfully in practice.

Additionally, constructing physical network topologies involves complicated wiring [6], physical device connections, and layout planning. These operational complexities often divert students' attention from core learning objectives, causing them to focus excessively on procedural details rather than the underlying design logic or communication principles. This leads to rote, surface-level learning that undermines the goals of experimental instruction and weakens students' abilities in critical thinking and network analysis.

2.2 Low Configuration Efficiency. Network experiments typically require configuring devices such as switches, routers, and firewalls through either command-line interfaces (CLI) or graphical user interfaces (GUI). In a physical lab setting, limited equipment forces students to work in groups, reducing opportunities for individual hands-on practice. Often, only a few students can actively operate the devices, while the rest merely observe, resulting in a passive learning experience. This widespread “look but don't touch” phenomenon severely limits student engagement and practical skill development.

Although this group-based operation may superficially fulfill instructional goals, it undermines students' active involvement and weakens the cultivation of practical competencies. Without direct interaction, students struggle to internalize key operational processes and face difficulties independently configuring and deploying network systems later in their studies or careers.

2.3 High Construction and Maintenance Costs. Supporting experimental teaching in computer networks typically requires the purchase of substantial hardware resources—including routers, switches, and firewalls—along with auxiliary facilities like racks and power supplies, representing a significant financial investment. In practice, schools often implement group-based, rotational use of the equipment, but it remains challenging to achieve the ideal scenario of one device per student.

Moreover, the setup, testing, and daily maintenance of these devices require dedicated technical personnel, leading to high labor costs and frequent maintenance issues. Students' misoperations can damage equipment, increasing repair expenses and complicating management. Additionally, with rapid advances in network technologies, the lifecycle of hardware devices has shortened, making existing equipment quickly outdated for teaching new protocols or technologies. This not only hampers the continuous updating of course content but also forces institutions into ongoing spending cycles, intensifying financial and logistical pressures.

3. The Significance of Virtual Simulation Experiment Teaching

Virtual simulation platforms play an increasingly vital role in modernizing the teaching of computer network experiments. They offer practical solutions to long-standing problems such as limited hardware resources, insufficient hands-on time, and low teaching efficiency. As information technology continues to reshape higher education, these platforms support more flexible, adaptive, and student-centered learning environments.

A key advantage of virtual platforms is their ability to overcome hardware constraints. Traditional network labs require expensive investments in switches, routers, servers, and designated lab spaces. These infrastructures are not only costly to upgrade but often lag behind curriculum development. In contrast, platforms such as Huawei eNSP can operate on standard Windows-based systems without demanding high-performance computers. They are easy to install, replicate, and maintain, reducing the threshold for building network lab environments and supporting long-term, scalable development of experimental teaching.

The platform enables a “one machine per student” model, removing the bottleneck of shared devices in physical labs. Students can independently complete experiments on their own computers, promoting autonomy, engagement, and motivation. Since the platform supports offline use, students can practice anytime, anywhere—an ideal complement to hybrid teaching models that combine in-class learning with self-paced practice.

Virtual simulation also greatly enhances troubleshooting skills. In physical labs, even minor mistakes—such as incorrect cabling or misconfigured parameters—can lead to experiment failures and waste valuable teaching time. Virtual platforms provide clear visual interfaces and parameter displays, allowing students to quickly identify and correct errors. They can explore different configuration scenarios without the risk of damaging physical devices, boosting their technical confidence and problem-solving capabilities.

Moreover, virtual simulation breaks the time and space constraints of traditional lab environments. Physical labs are limited to specific locations and schedules, making it hard to accommodate flexible learning. With virtual tools, students can access lab environments from dorms, libraries, or remote locations. This supports remote learning and facilitates synchronous collaboration between students and teachers across regions. Such flexibility is particularly beneficial during public health emergencies or when engaging in cross-institutional educational projects [7].

In terms of teaching efficiency, virtual platforms support features such as auto-saving and quick scene restoration. Students can seamlessly resume previous sessions, enabling iterative improvements to their configurations and reducing repetitive work. For courses that require rotating use of lab resources, this function minimizes setup time and ensures continuity in teaching.

Finally, enterprise-grade platforms like Huawei eNSP provide highly accurate simulations of real-world network environments. These tools replicate the interfaces, behaviors, and protocol logic of actual hardware devices, allowing students to observe realistic data flows and protocol interactions. This tightens the link between theoretical study and industry practice, enhances engineering literacy, and equips students with the skills and mindset needed in professional environments. Teachers, in turn, can build representative network architectures and use the platform to clearly demonstrate protocol mechanisms, improving teaching clarity and relevance.

4. eNSP Simulator Assists in Teaching Computer Network Applications

In the theoretical component of computer networking courses, topics such as subnetting and network address planning are always core areas of focus. By systematically covering subnet masks, IP address partitioning rules, and subnet design strategies for networks of varying scales, students can acquire foundational skills in planning network layer structures [8]. However, classroom instruction alone is often insufficient for students to fully grasp the complexities of network topology construction. Hands-on methods are essential to reinforce and deepen this understanding.

In practical instruction, the introduction of high-fidelity network simulation platforms such as Huawei’s eNSP can significantly aid students in configuring commonly used network devices like routers and switches within virtual environments. By simulating enterprise-level network scenarios, students not only gain a more intuitive grasp of theoretical knowledge but also develop practical network engineering skills through repeated practice—enhancing their abilities in design, implementation, and maintenance.

4.1 Teaching at the Data Link Layer. The data link layer, the second layer of the TCP/IP model, plays a foundational role in enabling direct communication between hosts. Theoretical lessons at this level typically cover channel access protocols, collision detection and avoidance in broadcast

domains, the evolution of Ethernet standards, and the mechanisms of data frame forwarding. Instructors also introduce MAC addressing, frame structures, and the logic behind switch forwarding to build a solid understanding of link-layer communication.

However, theoretical instruction alone cannot fully convey how the data link layer operates in real-world networks. Practical training must therefore focus on how this layer functions in local area network (LAN) environments. Since Ethernet—particularly switched Ethernet—remains the dominant standard due to its high bandwidth and minimal collisions, students need hands-on experience configuring and troubleshooting such systems.

Huawei's eNSP simulator enables the construction of typical VLAN-based network topologies (see Figure 2), including multiple switches and end devices, to simulate real-world segmentation scenarios common in enterprise and campus settings. Students learn to configure VLANs, trunk links, PVIDs, and other parameters. They also assign IP addresses and default gateways to terminals to test inter-VLAN communication. This hands-on approach reinforces abstract concepts by applying them in concrete, realistic configurations—strengthening both technical skills and conceptual comprehension.

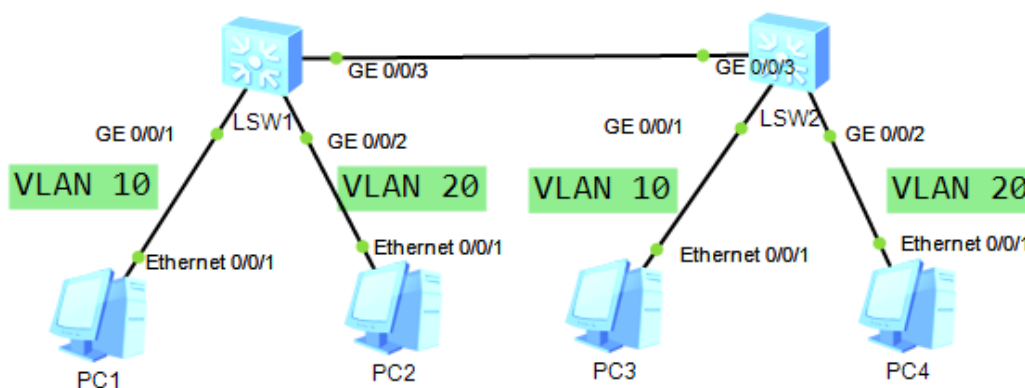


Figure 2. VLAN Cross switch communication network topology

4.2 Network Layer Teaching. The network layer, situated above the data link layer, plays a critical role in data forwarding and path selection across multiple networks. Within the TCP/IP architecture, its core responsibility lies in routing and delivering packets, thereby enabling end-to-end communication across heterogeneous network environments. Devices operating at this layer handle protocol data units such as IP datagrams, extract destination IP addresses and subnet information, and rely on the data link layer for point-to-point transmission.

Key theoretical topics covered in network layer instruction include IP addressing, subnetting and network planning, the Address Resolution Protocol (ARP), packet forwarding, routing protocols (such as RIP and OSPF), Virtual Private Networks (VPNs), and Network Address Translation (NAT) [10]. These topics are not only logically intricate but also essential for real-world network implementation.

In the practical component of teaching, emphasis is placed on applying these concepts through exercises involving subnetting, inter-subnet communication, performance tuning, and fault troubleshooting. Unlike purely theoretical learning, these hands-on activities foster students' abilities to configure devices and resolve real networking issues. As the network layer serves as a bridge between theory and practice, it plays a pivotal role in achieving the goal of "learning by doing." Theoretical study helps students grasp the underlying logic of network operations, while practical training translates that understanding into applicable skills.

To reinforce this integration, Huawei’s eNSP simulation platform is employed to replicate real-world networking environments. Students engage in configuring IP addresses, implementing routing protocols, and ensuring connectivity across a three-layer subnet topology (see Figure 3). This process not only deepens their understanding of network-layer protocols but also enhances their proficiency in equipment configuration and network planning—skills essential for future networking professionals.

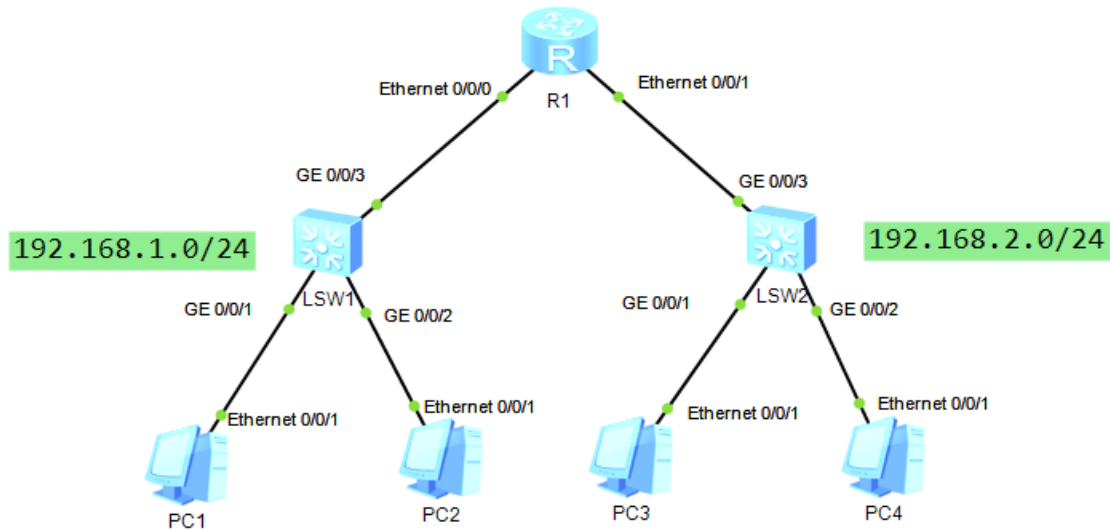


Figure 3. Topology structure of three-layer cross subnet communication network

4.3 Teaching on the Connection between Data Link Layer and Network Layer. In network design, deployment, and maintenance, core competencies involve configuring and troubleshooting devices—a process rooted in a thorough understanding of both the data link and network layers. Though distinct in function, these two layers work in tandem to ensure reliable end-to-end communication through coordinated protocol encapsulation and decapsulation. While the network layer uses IP addresses for logical routing, the data link layer handles MAC addressing and physical link control. This interplay is fundamental to networking and represents a key concept in computer network education.

Importantly, IP and MAC addresses are not interchangeable; they function in a complementary manner. The close coordination between these layers underpins the stable operation of network architecture, yet it also poses instructional challenges due to the abstract and complex nature of protocol interactions. Traditional lectures relying solely on textual explanations or static diagrams often fall short in conveying the full scope of inter-layer collaboration.

In real-world networks, protocol analysis through packet capture is complicated by high traffic volume and system complexity, making it difficult for students to isolate relevant protocol behaviors. To address this, a simplified three-layer topology is constructed within the eNSP environment (Figure 4), allowing packet capture at each device interface. This controlled setup significantly reduces traffic complexity, enabling students to more easily observe and analyze protocol functions. Focused exercises on ARP [11] help students understand its operational mechanics. By examining routing tables, MAC address tables, and ARP caches at different nodes, students gain clear insight into how the network layer leverages the data link layer to achieve reliable communication at both point-to-point and end-to-end levels.

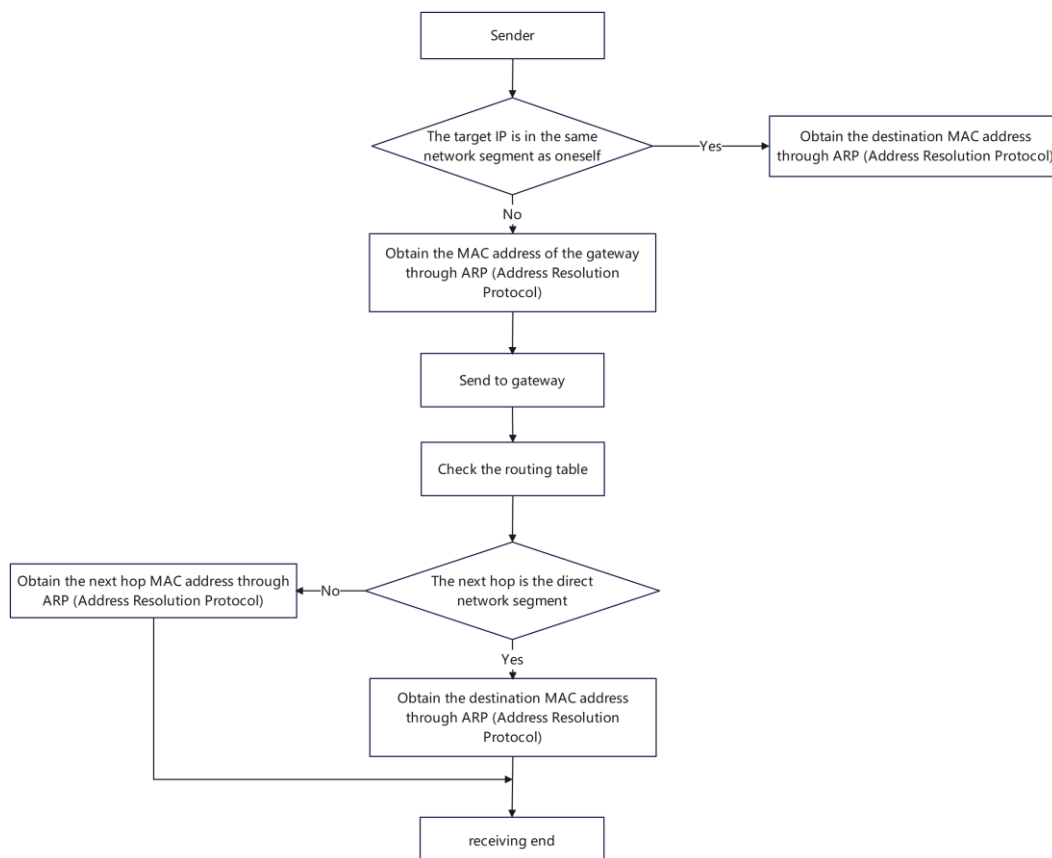


Figure 4. End to end data communication process

5. Build a Course Examination Platform

Assessment is a vital component of computer network courses, serving as a key indicator of teaching effectiveness and student learning outcomes. However, current assessment mechanisms still face several challenges that require urgent improvement.

First, the assessment methods are relatively limited in scope. With the widespread adoption of platforms such as Chaoxing Learning Platform [12], many institutions have successfully transitioned from traditional paper-based exams to online testing. These platforms enable instructors to distribute exam content and manage grades efficiently. However, given the hands-on nature of computer network courses, which emphasize both theoretical understanding and practical skills, online exams alone cannot fully capture students' competence—especially in areas such as network configuration and protocol implementation. These practical components still require either actual network equipment or simulators, often involving manual grading by instructors. This not only increases the instructional workload but may also reduce the objectivity and timeliness of evaluations.

Second, assessment frequency tends to be inadequate, making it difficult to monitor students' progress and knowledge retention over time. Most current assessment practices focus heavily on midterm and final exams, while lacking formative assessments and continuous feedback mechanisms. As a result, educators are unable to capture students' learning trajectory or provide timely interventions during the learning process.

To address the challenges mentioned above, this article leverages the "Exam Engineering" feature of Huawei's eNSP simulator to construct an intelligent assessment platform tailored for online network courses. This function allows instructors to flexibly design tests, automatically

evaluate student configurations, and enhance grading efficiency and objectivity. In practice, assessment content can be aligned with course progress and learning objectives, covering key topics such as IP addressing, VLAN configuration, STP, static routing, OSPF, and DHCP.

By selecting “New Test Paper Project” from the toolbar, instructors can name the project, set the save path, and enter the exam editor to configure the test environment. The platform’s intuitive interface enables seamless network topology design, precise definition of assessment points, and clear configuration of scoring rules, thus creating a realistic and operable hands-on assessment environment (see Figure 5).



Figure 5. Exam paper editing interface

In the process of designing exam engineering, the creation of network topology and writing exam instructions are crucial to ensuring the assessment's effectiveness. Teachers can either draw a new network topology or use standard templates based on the assessment goals and experimental content. Careful consideration should be given to the required network elements and protocol configurations for each assessment point, ensuring the topology is both functional and practical. Additionally, detailed exam instructions must be written, covering the task background, operational requirements, configuration goals, and grading criteria. These instructions help students understand the task and complete it accurately.

Figure 6 illustrates the network topology and exam description interface on the eNSP platform. Combining graphical topology with clear task descriptions enhances students' guidance and accuracy in completing the tasks, supporting the practical assessment of online courses.

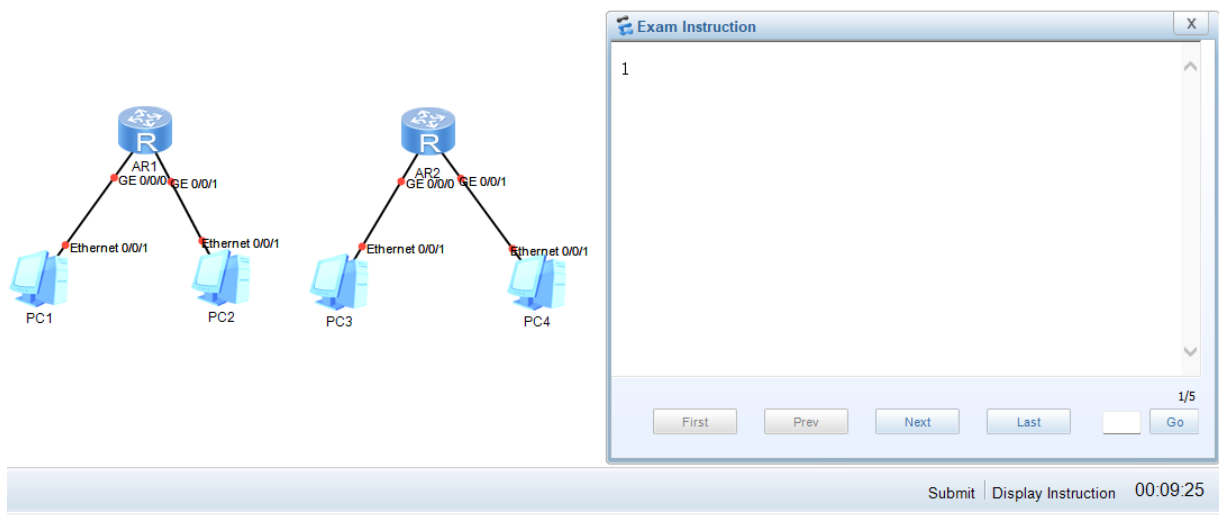


Figure 6. Exam topology

After creating the exam papers and standard answers, the eNSP-based exam process involves several stages, including configuration implementation, paper generation, student responses, result submission, and grading, forming a complete and closed-loop assessment system.

First, the teacher returns to the topology interface, activates the network devices, and completes the required configuration tasks on each device according to the exam instructions. To ensure that the configuration is saved for grading, the teacher must use the "save" command after completing all tasks.

Next, the teacher switches to the "Generate Test Paper and Answer" tab, selects the assessment items, sets scoring criteria, matching conditions, and filtering rules. The system automatically calculates the scores for each item and generates the necessary files. Parameters like exam timing, duration, and paper locking can also be adjusted. Once complete, the system outputs two key files: a paper exam file and a model answer file.

Before the test, teachers should verify the exam configuration and scoring logic. After confirming accuracy, the test paper is sent to the student terminal. During the exam, students complete the configuration tasks in eNSP and save their work. Once saved, they submit their answers, and the system generates a ".ans" answer file for grading.

After the exam, the teacher collects the student answer files, opens the "Marking" module in eNSP, and compares them to the standard answers. The system automatically evaluates the configurations and generates grading reports for teachers to review and export.

This automated exam process improves the efficiency and management of practical assessments, enhancing the accuracy, transparency, and scientific approach to teaching evaluations, supporting the development of high-quality online course systems.

6. Summary

As network technologies continue to evolve, computer network laboratory courses are playing an increasingly important role in the cultivation of technical talent at the university level. However, traditional experimental teaching approaches still face limitations due to resource constraints, outdated methodologies, and incomplete evaluation systems.

This study explores the integration of Huawei's eNSP network simulation platform into experimental teaching, demonstrating its potential to overcome existing limitations. With its high degree of simulation accuracy, flexible operations, and support for a wide range of protocols, eNSP offers students an authentic virtual lab environment that closely mirrors real-world networks.

By incorporating eNSP into instruction, educators can provide students with extensive practice opportunities, reduce dependence on physical equipment, and foster deeper understanding of network principles and configurations. Furthermore, the platform's built-in Exam Engineering feature enables the construction of automated, scenario-based assessments that align with instructional content and practical competencies.

The implementation of this teaching model significantly enhances interactivity, engagement, and students' comprehensive skills in network planning, configuration, and troubleshooting. Empirical findings suggest that adopting eNSP can optimize the teaching process, improve instructional quality, and better prepare students for future careers in the networking field.

Therefore, it is strongly recommended that universities actively adopt the eNSP platform in their computer network curricula, leveraging its advanced capabilities to support teaching reform and promote the development of a more practical, efficient, and high-quality network engineering education system.

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