An Efficient e-Learning System for TCP/IP Protocols Suite

Hyungoo Han Department of Computer Science & Engineering Hankuk University of Foreign Studies 89 Wangsan-ri Mohyeon Cheoin-gu Yongin-si, Gyeonggi-do 449-791 South Korea

ABSTRACT

An efficient e-learning system for TCP/IP protocols suite is studied. In this learning method, the concept of TCP/IP protocols suite is described by a top-down approach to overcome the shortcoming of the bottom-up approach. In addition, the system describes the problems of each layer in terms of security. The system is implemented in a Java-based script language to simulate security problems with animation effects. These features provide an efficient and effective study method. This learning system can be used to easily and quickly learn about network systems, especially TCP/IP protocols suite, through simulation and animation. Since the e-learning system will be used by government personnel in Korea, a prototype of the system is implemented in Korean. Beginners to network systems like government workers, who have limited study time and lack basic knowledge on network systems like TCP/IP protocols suite, can use this e-learning system.

Keywords: TCP/IP protocols suit, Denial of Service, open system interface, top-down approach, e-learning systems.

1. INTRODUCTION

Understanding the concept of a TCP/IP protocols suite is the first step to understanding the basic concepts of a network system. In this paper, a top down approach for studying the concept of a TCP/IP protocols suite is proposed to provide an efficient e-learning system. The TCP/IP protocols suite has been taught as a major curriculum subject in fields such as data communications or computer networks in the computer science, electrical engineering, and information engineering. It has also been taught to personnel in governmental organizations or business companies. However, many people have had difficulty in understanding or applying the knowledge learned to an advanced field due to their limited education time or basic knowledge.

In this paper, an efficient TCP/IP protocols suite e-learning system is developed, which can be used to easily and quickly learn about network systems, especially the TCP/IP protocols suite, through simulations and animations. This e-learning system is specially designed for learners who have limited study time and lack basic knowledge on TCP/IP protocols suite. The proposed e-learning system may require only five days, seven hours per day, to successfully finish the study on the TCP/IP protocols suite. Because of the similarities between the internet transmission system and the postal transmission system, the concepts of network services were presented in terms of the postal transmission system. The proposed e-learning system provides the following advantages:

- (1) Although most of the traditional textbooks use the bottom-up approach to teach the TCP/IP protocols suite, the proposed e-learning system adopts the top-down approach[1][2]. With the bottom-up about knowledge various approach. data transmission theories would be a prerequisite, and the data receive process would have to be explained beforehand [3]. However, with the top-down approach, the data transmission flow can be explained together with data sending, thereby allowing the learners to learn about transmission flow without studying data processing mechanisms.
- (2) This e-learning system addresses the possible security issues, which can be raised in each layer, and it explains each layer of the TCP/IP protocols suite in the top-down approach. This feature can maximize the efficiency of study while minimizing the learning time.
- (3) This e-learning system provides animation effects, which can help the learners to intuitively understand complicated concepts about the TCP/IP protocols suite [4].
- (4) This e-learning system also provides assessment tools, which the learners can use to test themselves. The test results are provided with various statistics data, which can be referenced by the instructor to evaluate a learner's progress and to improve the e-learning system for further lectures.

3. SYSTEM DESIGN

2. STRUCTURE OF TCP/IP PROTOCOLS SUITE

The structure of TCP/IP protocols suite and its functionality in each layer are introduced. All possible scenarios that can occur in each layer are not addressed. The TCP/IP protocols suite consists of five layers: application, transport, network, data link, and physical, from top to bottom [5].

The application layer is used by most applications for network communications. A message for network communication is generated in this layer. Once the message is generated, the encoded data are encapsulated into the transport layer. Example protocols of an application layer are Hypter Text Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP).

The transport layer is responsible for end-to-end message transfer by addressing port numbers. A transport layer can be divided into two representative protocols: Transmission Control Protocol (TCP), which is connection-oriented, and User Datagram Protocol (UDP), which is connectionless. TCP provides reliable data transmission by using connection-setup, end-to-end retransmission and feedbacks such as ACK and NAK, flow control, and congestion control. UDP provides unreliable but fast transmission with its connectionless property, which is appropriate for loss-tolerant but time-sensitive multimedia applications.

The network layer is responsible for sending datagrams across one or more networks. The network layer defines an IP datagram with an IP address. The Internet Control Message Protocol (ICMP) is also defined to generate an error message for an unexpected situation such as an unreachable host. The major role of the network layer is path determination by using a routing algorithm that determines a path from a source to a destination. Routing algorithms can be categorized into global and decentralized algorithms. Each of the different routing algorithms have a common goal, which is to find the path of least cost.

In the link layer, a data packet is encapsulated into a frame. The frame is locally delivered to an adjacent network node. The data link layer protocol is broadly divided into broadcast protocols and point-to-point protocols. In order to find a way to provide fair resource sharing among multiple nodes in a random access channel, many protocols such as Ethernet, Taking-Turn protocol, and IEEE 802.11a/b/g have been proposed in wired/wireless network systems. Finally, the physical layer is the basic hardware in a network structure that transmits electrical signals through cables.

Since the e-learning system will be used by government personnel in Korea, the prototype of the e-learning system is implemented in Korean. Therefore, the figures in this paper, which were captured from the running screens of the prototype, have Korean texts. However, I need to mention that this e-learning system can be used anywhere in the world by changing the texts into appropriate languages for intended users.

This e-learning system was designed with the following considerations. First, this system is specialized for businessmen, government employees, or learners with no basic knowledge of TCP/IP protocols suite. Second, this system is based on the guidebook of 2010 Ministry of Public Administration and Security of Korea and is reorganized into the top-down approach; that is, the learner will be able to understand the nature of transmission flow from the sending side to the receiving side like as the postal transmission system. With this approach, the learner can learn about the TCP/IP protocols suite without any prior knowledge of low level transmission techniques. Third, the characteristics and possible problems of each level are explained simultaneously [6]. With this organization, the learner can learn about both transmission flow and its associated security. Also, instructors can maximize their teaching efficiency quickly. Finally, in order to provide security training, the system was designed with a virtual Denial of Service (DoS) in a Java script-based program, so that it would not disturb the normal operations of the actual system. Table 1 compares the bottom-up approach with the top-down approach.

Table 1.Comparison of Bottom-up and Top-down	1
Approaches	

	Bottom-up	Top-down
Direction	From low level to high level	From high level to low level
Flow	From data process to data sending	From data sending to data process
Pros/cons	Communication theory is required as prerequisite	No prerequisite

3.1 System structures

The overall structure of the proposed system is shown in Figure 1. The e-learning system consists of three parts: study module, training module, and evaluation module. The study module is connected to the training module, but the evaluation module is located on the web with limited access to learners. The learners will first study the transmission theory and TCP/IP protocols suite

security in the study module and then simulate DoS operations in the training module. After completing these two modules, the learners can conduct a self-evaluation in the evaluation module.



Figure 1. System structure.

3.1.1 Study module

The number of colors on the screen was limited to help the learners concentrate on their studies. Animation effects were employed for visualization of transmission flow. Such animations will help learners to understand the TCP/IP protocols suite from concrete information. The detail of the study module is depicted in Figure 2.As shown in Figure 2, the study module is categorized into introduction three sections: of information communications, introduction of Open System Interface (OSI) methods, and structure of the TCP/IP protocols suite. In the section on the introduction of information communication, the basic concepts of network communication is introduced. It offers an introductory study of OSI methods and TCP/IP protocols suite for learners without basic knowledge of network communications. Flash is adopted to describe the operation and equipment of the each layer of the TCP/IP protocols suite, from message generation in the application layer to bit operation in the physical layer.



Figure 2. Study module

The structure of the TCP/IP protocols suite is the main contribution of this paper. Therefore, each layer of the TCP/IP protocols suite and the possible network issues of each layer are explained to efficiently cover both transmission theory and TCP/IP protocols suite security. The composition of the top-down approach of the structure of the TCP/IP protocols suite is shown in Figure 3.



Figure 3. Top-down approach of TCP/IP protocols suite

In addition to the existing learning system [7], in my newly developed system, I consider the following advanced features

- (1) In the transport layer, Stream Control Transmission Protocol (SCTP) is discussed. The SCTP supports the mobility of terminal equipment, which has multi-homing functions [8]. The SCTP combines advantage of TCP and UDP. That is, it takes the advantage of reliability of the TCP as well as high speed transmission of the UDP.
- (2) In the network layer, in addition to the traditional path determination algorithms, the switching and call setup procedure is explained in detail. For path determination switching, the link stage algorithm and the distance vector algorithm are described with appropriate examples. In addition to 32-bit IPv4 addressing, the new e-learning system also covers the 128-bit IPv6 with address translator, which links the existing IPv4-based network with the new IPv6-based network environment [9].
- (3) In data link layer, various Medium Access Control (MAC) protocols, which have been developed for wireless mobile networks such as IEEE 802.11 a/b/g/e/n, are discussed [10].
- (4) In the physical layer, fiber optics and radio-spectrum as well as twisted pair lines, cooper wires, and coaxial cables are added. The target-application based bandwidth allocation algorithm, which can be applied to those network resources as last mile transmission, is also included [11].

Owing to these extensions, I believe that the new e-learning system can be used as a guideline for users who want their further studies as well as beginners to the network systems. I plan to extend my current system to include more cutting-edge network technologies such as multicasting services [12], and wireless sensor networks [13, 14].

3.1.2 Training module

The Java script-based DoS program is described in Figure 4. The right part of the screen is activated by selecting the forth menu (iv) in the left part of the screen, and then, the users will enter necessary information such as the IP addresses and port numbers of source and destination networks. In the training module, the system trains the learners about DoS attacks by simulating them in a Java script-based program. Graphical methods are used to visualize a DoS attack. In the e-learning system, there are six DoS attack simulations which are very helpful for the learners to understand the DoS attacks in virtual environment.

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Figure 4. Java script-based DoS program

3.1.3 Evaluation module

The evaluation module was run in a server (http://firstblood.ite-station.com). The evaluation results will be saved in Microsoft Words or Excels. A certification process was added in the evaluation module, and three tables were created in the database, as shown in Figure 5.



Figure 5. Evaluation module

4. IMPLEMENTATION

4.1 Study screen

As shown in Figure 6, the screen was divided into two parts. The left screen shows the outline of the study. The OSI study section is connected to the section on the theory of the TCP/IP protocols suite. Learners can link associated concepts of the study. In this study screen, the TCP/IP protocols suite is categorized into 4 layers instead of 5 layers for more efficient learning. The data link and the physical layers are too closely connected with the lower levels of network systems, so they are combined into the network access layer. The 4 layers are application layer, transport layer, internet layer, and network access layer.



Figure 6. Study screen

4.2 DoS simulation screen

The Dos simulation screen includes the fundamentals of a SYN Flooding attack and the multiple figures of DoS attacks. A Java script-based DoS program was implemented as mentioned in section III-1.2 to simulate the DoS attacks.

4.3 Evaluation screen

The evaluation screen is connected to the study module. When the learner clicks a picture on the right part of the evaluation screen, which is activated by selecting the fifth menu (v) of the study screen, the page moves to the evaluation module (http://firstblood.ite-station.com). The web page requires the users to provide the necessary information such as the learner's name, as shown in Figure 7.



Figure 7. Evaluation module start-up page

5. CONCLUSION

An e-learning system for the TCP/IP protocols suite was designed with the top-down approach. This e-learning system can be used by anyone to easily and quickly learn about network systems, especially the TCP/IP protocols suite through simulations and animations. Most of the TCP/IP protocols suite guide books use the bottom-up approach to teach. In this paper, the top-down approach has been adopted as a promising alternative for overcoming the shortcomings of the bottom-up approach. Animation effects were used to deliver TCP/IP information more efficiently. A Java script-based DoS program was implemented to train the learners about DoS attacks by simulating them in virtual environment. The results of the evaluation module can be used by the instructors to evaluate the learners in various ways. In future research, the system will be modified to reflect the dynamical changes in communication theory and to accommodate various simulations.

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