Practice on Improving the "Computer Network" Teaching with Knowledge Visualization Representation

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***Abstract*—Knowledge visualization promotes the knowledge creation and knowledge transfer with various graphic visual representation means. According to the problems of universities in "Computer Network" teaching including abstract expounded theory and shortage of experimental equipment, and the updating can't keep up with the technical development, this thesis has presented the knowledge visualization solution, selected the knowledge map, mind mapping, Sniffer, OPNET and Packet Tracer as the tools for knowledge representation, to visual representation of " computer network" knowledge points, and introduced corresponding teaching samples. After tireless explorations and practices, it has obtained good teaching effect to adopt corresponding visualization representation tools according the "Computer Network" knowledge type.**

Keywords—Knowledge Visualization;Visual Representation; Network Analog; Network Simulation

I. POSING OF PROBLEM

The difficulty of "Computer Network" course teaching technologically mainly include[1][2]: ① The course has diversified concepts which are mostly established on abstract theoretical model, and are impalpable or intangible in the real network application, and only depend on imagination; ② The network experimental equipments are expensive, and it requires millions to construct a network to simulate the Internet real working environment, with restraint in capital, the Computer Network experiment is short of software and hardware; ③ Computer Network is the technology with rapid development with diversified theories, new technologies and new equipments, it requires timely updating the experimental facilities to obtain good teaching effect, which has caused great pressure on cost for the university.

The knowledge visualization technology represents the abstract knowledge with visual means such as visual graphics to greatly improve the identification of knowledge, and make the knowledge easy for remembering, understanding, processing and using; with visual tools including network analog and simulation technique, it is capable of simulating the network of any scale, simulating the working principle and process of new protocols and new equipments, which can save the investment with convenient upgrading, therefore, the students may keep pace with the updating of network equipments and master the latest technologies.

In the first part of this paper, the connotation of knowledge visualization is described. The second part of this paper is to classify the knowledge points of the course of "computer network", and select the appropriate visualization tools. In the third part of the paper, the visualization of the course of "computer network" is introduced

II. VISUAL REPRESENTATION CONNOTATION OF KNOWLEDGE VISUALIZATION

Knowledge visualization is a new research field developed basing on scientific computing visualization, data visualization and information visualization. It means a kind of mode to represent knowledge with visual representation means, and is to represent the individual knowledge with graphic, form the external representation of knowledge with direct action on the senses of human, thus promoting the spreading and innovation of knowledge [3][4].

The theoretical basis of knowledge visualization is dual coding theory which is presented by the psychologist Pavio[5].

It is presumed in dual coding theory that there exist two cognitive subsystems: one is for representing and processing nonverbal things and events (mapping), and the other is for processing language. Pavio also assumed there're two different representation units: "image unit" which is suitable for psychological mapping and "language unit" which is suitable for language entity. The "image unit" is organized according to the relation of whole and its parts, however, the "language unit" is organized according to the association and hierarchy. Dual coding theory has also identified three processing types: ① Representative: directly activate the phraseological or nonverbal representation; ② Callable: activate the phraseology system with nonverbal system; ③ Associational: activate the representation in the same phraseology or nonverbal system. The most important principle of dual coding theory is: enhance the information memory and identification through the combination form of vision and language for representing the information.

Therefore, knowledge visualization technology can greatly improve the identification of knowledge by representing the abstract knowledge with visual means including visual graphics, and making knowledge easy for memorizing, understanding, processing and using.

III. Classification of "Computer Network" Knowledge and Selection of Visual Tools

A. Knowledge Classification

When visualizing knowledge with visual representation, the type and property of knowledge must be taken into considerate, reasonably classify the knowledge, and provide specific visualization form for knowledge of different types. Currently, in the knowledge visualization field, there isn't knowledge classification which correspond the visualization form and knowledge type [6][7].

In the practice, knowledge classification which was presented in the report of Organization for Economic Co-operation and Development (OECD) "Economy Based on Knowledge" [8] is adopted for classifying the knowledge into four types from the angle of knowledge economy application: Know-what knowledge (Know-what) to know what it is; principle knowledge (Know-why) to know why; How-to knowledge (Know-how) to know how to do and Expert knowledge (Know-who) to know who have the knowledge.

B. Selection of Visual tools

48 kinds of diagrams (it is named as the visual method of organizing information)forms are summarized in the book of Doctor Peirce "Visual Tools for Knowledge Workers: Aids for Critical Thinking", including concept map, Vean diagram, generalizing tower, organization chart, time line, flow chart, pyramid drawing, ray diagram, object map, cyclic graph and comparison matrix. In accordance with the features of "Computer Network" knowledge and rich experience in teaching, visual tools including knowledge map, mind mapping, Sniffer, OPNET, Packet Tracer are mainly adopted during teaching.

1) Knowledge Map

Knowledge map has a universal use in the knowledge management field: ① As the knowledge guide, it displays which resources are available; ② As the knowledge management tool, it helps user know where to find the knowledge; ③ As the navigation of knowledge catalogue and field expert, it allows to process, browse and visualize the described knowledge resources; ④ The knowledge resources total distribution map include the general catalogue of resources and the relation of the knowledge points, it is also an expert network for describing the expert of knowledge skill and relevant fields; ⑤ It is capable of visually display the acquired information and interrelation, it promotes the effective exchange and learning knowledge in the specific layers of users under different backgrounds.

2) Mind Mapping

Mind mapping means to grasp the key of the thing and draw the process with image and color after finding the relation with the thing through association and imagination, and changes a long line of boring information into colorized easily remembered and highly organized graphics, it matches the natural mode of transaction processing of our brain.

The mind mapping made with NovaMind software can be played as PPT to solve the problems that the PPT has low implicative contents and can't highlight the logical structure.

Adopt mind mapping which can help thinking and remembering to represent the knowledge, which features clear consecution and is easy to be understood and remembered; and won't apart from the context, and can freely see the ambient contents, perfectly express the relation between a whole and its parts; and is interactive with audiences, convenient for modification during demonstration.

3) Sniffer

Sniffer is the software to acquire, analyze and produce the network package, and is capable of decoding in 7-layer protocol. Sniffer differentiate different layers with different colors from the lowest layer to the 7th layer as peeling onion.

In the Computer Network course, hierarchies and protocol stack are two important terms and are very abstract; the traditional method is to aid the students to understand the contents with actual case for analogy and multimedia flash demonstration, for example: analyzing the process of posting package, but the actual effect is not good. We have utilized the function of Sniffer in analyzing and decoding the data package to aid the students during teaching.

4) OPNET

OPNET is a kind of communication protocol modeling and simulation tool with advanced modeling system, complete modelbase and sufficient external interfaces.

OPNET integrates different stages of communication network simulation, including model design, simulation, data collection and analysis. It adopts the simulation system basing on discrete event driven, the information of the event is transmitted through event interruption mode between different modulus during simulation; basing on the system of package communication, it simulates the flow of data package and internal process in node equipments during the actual physical network through simulating the transfer of package in the simulation model. It adopts 3-layer modeling system, the lowest layer is the process layer model to describe the protocol with limited state machine, the second layer is the node model which composes of corresponding protocol models to show the properties of the equipments, and the up layer is the network topology model, three layer of models are completely corresponding to the actual network, equipments and protocol hierarchy with excellent heritage and reusability.

5) Packet Tracer

Packet Tracer is the network simulation software developed by Cisco with the main properties shown as below:

① Providing diversified components for network design --- switches, routers, host computers and wireless AP of different models, basically configuring the network equipments through graphic user interface or text interface;

② Providing two design modes of logical space and physical space. The logical space mode is used for actualizing the logical topological structure; the physical space mode supports to construct the virtual settings such as city, building, office and wiring room;

③ Packet Tracer provides the design mode (Topology) and simulation mode (Simulation). User may design and conFig. the network topology structure in the design mode; switch to the simulation mode for observing the process of transmitting protocol data unit (PDU) in the network, checking the swap table of switch and router table of router, tracking the real time detailed process of PDU in different nodes of the network, and observing the real-time working state of the network;

④ Supporting performance analysis. During the simulation process, the user is allowed to modify the network topology, entity parameter and network protocols, flexibly set the parameter of every entity in the network simulation environment, and only acquire the data of the interested network running details.

C. "Computer Network" [9] Knowledge Type and Visual Representation Tools

"Computer Network" Knowledge Type and Visual Representation Tools are, shown in Table 1.

TABLE I. "COMPUTER NETWORK" KNOWLEDGE TYPE AND VISUAL REPRESENTATION TOOLS

Knowledge Type	***Knowledge Unit***	***Knowledge Point***	***Representation Tool***
Know-Who Knowledge	Basic Concept of Computer Network	Definition, application site, development history and classification of network	Knowledge map
	OSI, TCP/IP Model	Model structure, major functions of different layers, protocol stack	
	Ethernet	Types of transmission medium, Ethernet standard, types of networking equipments	
	Wireless LAN	Networking standard, networking mode and networking equipments	
	Network Interconnection Plan	connection-oriented and non connection-oriented plan	
	IP Address Structure	IP address hiberarchy, classification, representation method, special IP address	
	IP datagram Format	IP datagram masthead area, content of data area	
	Router Selection	Router table type and structure, router protocol type	
	transmission layer	Transmission layer protocol, port	
	Network Application	Client / server model, DNS server structure, WEB server structure, ADSL equipments	
Principle Knowledge	OSI, TCP/IP Hierarchies	Functions of different layers, data encapsulation and transfer	Sniffer
	Medium Access Control	CSMA/CD, CSMA/CA	OPNET
	Working Principle of Switch	Working process, data forwarding mode, address learning, communication filtering, spanning tree protocol	OPNET
	IP Protocol and IP Layer Service	IP Internet working principle, property of IP layer service	OPNET
	ARP Protocol	Working process of ARP protocol	OPNET
	IP Message	MTU and fragmentation, reassembly, control; ICMP control message, request /respond message	Sniffer
	Router Algorithm	RIP protocol and vector -distance algorithm, OSPF protocol and link -state algorithm	OPNET
	Data Transmission and Control	End-to-End communication, TCP service, reliability, buffering, flow control	OPNET
	Process of Network Application Service	Client / server working process, DNS working process, E-mail working process, WEB service working process	OPNET
How-to Knowledge	LAN Establishing	Equipments and devices installation , network connectivity test , VLAN division	Packet Tracer
	Wireless Network Establishing	Equipments and devices installation, software configuration, connectivity test	
	Subnetwork Division	Subnetwork planning, subnetwork division in LAN	
	Router Configuration	static router configuration, RIP router configuration, OSPF router configuration, router test	
	Port Application	Network address switching	
	Data Stream Test during the Process of Application System Service	Client / server working process data stream, DNS working process data stream, E-mail working process data stream, WEB service working process data stream	
Expert Knowledge	Materials for Teaching and Disabusing	Teacher organizes the expert class knowledge and skill on "Computer Network" through key words, online, image and color, and change the knowledge into the colorized, easily remembered and highly organized graphics, and passes on to the students.	mind mapping

IV. "COMPUTER NETWORK" VISUAL TEACHING CASES

A. *Construction of "Computer Network" Knowledge Map*

The process of establishing knowledge map includes knowledge identification and organization, knowledge classification, building connection and showing knowledge map[10][11]. Please see Fig. 1 for the Overall Structure of "Computer Network" Knowledge Map.

The knowledge points in the knowledge modulus can be layered and build connection according to the development and evolution relation of knowledge, and represent according to the cognitive sequence of mot people. The hierarchy and connection relation between the knowledge points show the sequence and dependence of learning, the connection of knowledge points of same hierarchy is relatively weak, and user may freely control the time sequence of learning.

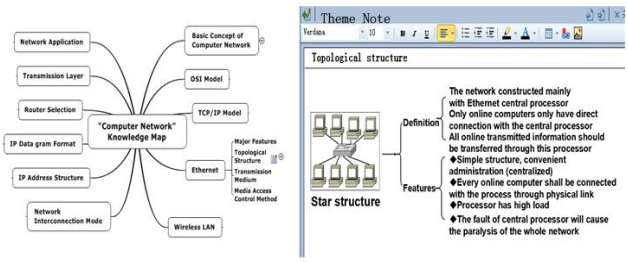

Fig. 1. "Computer Network" Knowledge Map

B. *Making Courseware with Mind Mapping*

Making the courseware with NovaMind, through intuitive, visual and essential knowledge representation, it promotes the teacher to possess the expert class knowledge spreading and innovation, besides the fact, also teaching the opinion, experience, attitude, value viewpoint and expectation of the teacher to students.

Fig.2. is the OSPF router protocol mind mapping courseware. When demonstrating, the teacher may freely specify the node displayed in the slide, specify the visual range displayed in the slide, and switch the slide with flash seamlessly, the slide is integrated in the general drawing for avoiding loss of contents.

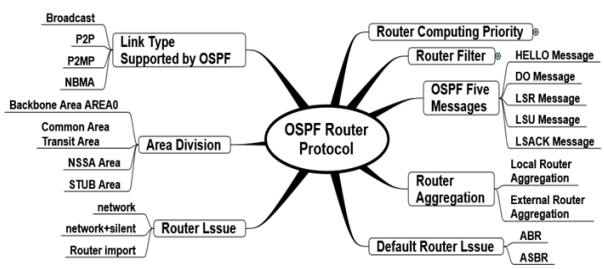

Fig. 2. OSPF Router Protocol Mind Mapping Courseware

C. *TCP/IP Hierarchical Structure Demonstration*

Table 2 shows the 4-layer protocol in the network structure, different hierarchies for different functions, and every hierarchy composes of diversified protocols.

TABLE II. 4-LAYER PROTOCOL IN THE NETWORK STRUCTURE

Application layer -----Telnet, Ftp and Email
Transmission layer --TCP and UDP
Network layer ---------IP, ICMP and IGMP
Link layer ----------equipments drivers and interface card

Decoding analysis of protocol of different layers in the Sniffer decoding table, DLC is corresponding the link layer, IP is corresponding the network layer, UDP is corresponding the transmission layer, RTP is corresponding the application layer and high layer protocol. Sniffer is capable of implementing detailed structural decoding analysis for diversified protocols, and displays with hierarchical structure, shown in Fig. 3.

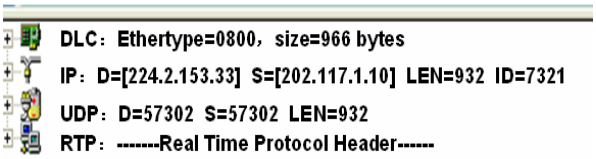

Fig. 3. TCP/IP Hierarchical Structure

D. *Training on Network Establishing and Configuration with Packet Tracer*

Construct the network topology shown in Fig. 4 with Packet Tracer for static router configuration and test experiment.

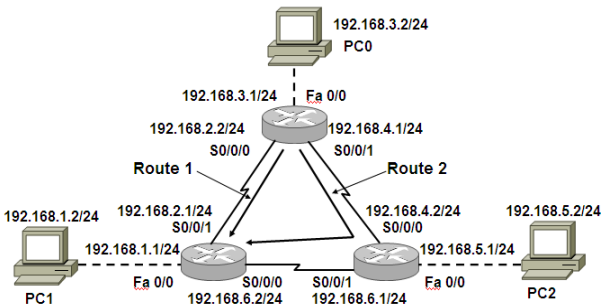

Fig. 4. Static Router Configuration and Test

ConFig. the static router in RT0:

```
ip route 192.168.1.0 255.255.255.0 192.168.2.1
ip route 192.168.1.0 255.255.255.0 192.168.4.2 10
ip route 192.168.5.0 255.255.255.0 192.168.4.2
ip route 192.168.5.0 255.255.255.0 192.168.2.1 10
```

ConFig. the static router in RT1 and RT2.

It is shown in Fig. 5 to check the RT0 router table, and Fig. 6. to test the result with Tracert.

```
S    192.168.1.0/24 [1/0] via 192.168.2.1
C    192.168.2.0/24 is directly connected, Serial0/0/0
C    192.168.3.0/24 is directly connected, FastEthernet0/0
C    192.168.4.0/24 is directly connected, Serial0/0/1
S    192.168.5.0/24 [1/0] via 192.168.4.2
RT0#
```

Fig. 5. RT0 Router Table

```
PC>tracert 192.168.1.2
Tracing route to 192.168.1.2 over a maximum of 30 hops:
  1   109 ms    47 ms    47 ms    192.168.3.1
  2    94 ms    94 ms    94 ms    192.168.2.1
  3    *       110 ms   1 40 ms   192.168.3.1
Trace complete.
```

Fig. 6. Test Result with Tracert

E. PVC Speed Selection Design Simulation of Frame Relay in WAN Environment

It is very expensive to construct a large-scale network in the laboratory, and is even impossible. But it is very necessary for the operation of big company, and the company administrator must master the maintenance technology.

For example, Standard Chartered Bank has 70 branches, one headquarter building and one Richmond Processing Center. Currently, it requires testing how the change of PVC speed of frame relay influences the performance of application programs.

It is shown in Fig. 7 to construct the WAN environment with OPNET, set the frame relay PVC protocol parameters, enable simulation (run simulation), select the test parameters (Global Statistics->DB Query->Response Time(sec)), display the result (Fig. 8), the average file share response time is about 20s.

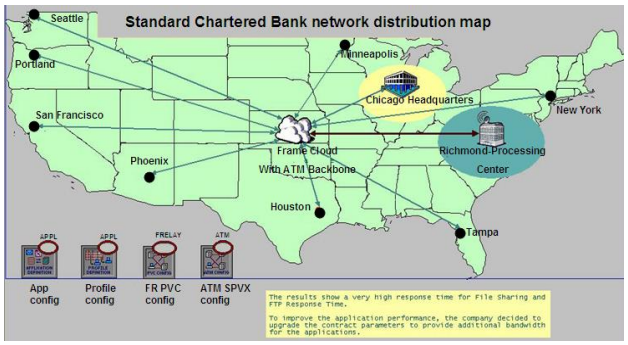

Fig. 7. Standard Chartered Bank Network Topology

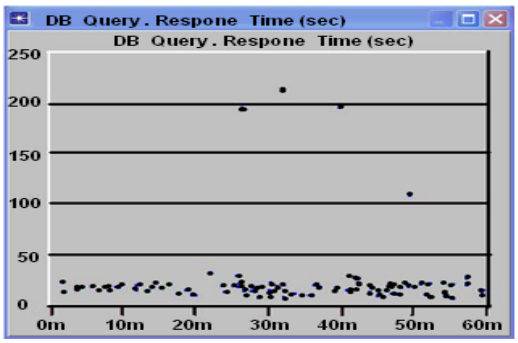

Fig. 8. The Influence of Speed Change of PVC to the File Share Response Time

V. CONCLUSIONS

The adoption of knowledge visualization technology is capable of transferring the abstract theoretical learning and complicated practice into simple, visual and regular knowledge for teaching and practice.

The use of knowledge map and mind mapping helps improve the initiative and innovation of students in learning, and promotes the students to easily master the knowledge, form a good habit of studying and improve the non-specialty quality.

It can completely expand the connotation and denotation of the network laboratory to adopt Snifer, OPNET and Packet Tracer as the visualization representation tool for network system working principle, establishing process and performance test. Additionally, the adoption of Sniffer, OPNET and Packet Tracer software for teaching and experiment in different stages of Computer Network course teaching is capable of promoting the students to deepen the comprehension on theoretical knowledge and skillfully use the equipments, cultivate the abilities of students in comprehensive analysis, development, innovation and project design, and promote the students of master the major network application tools and set a good foundation for the actual work.

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