Constructing a computer networking ability based on existing curricula in technical colleges

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ABSTRACT: A set of ability indicators on computer networking was constructed as an aid to teaching computer networking at technology universities. Outlined in this article is a set of commonly taught topics, derived using an induction method and grounded theory, from 34 syllabuses of computer networking courses at computer-related departments of Taiwan universities. These topics were subsequently discussed with 29 specialists from industry and education. The set of computer networking skill indicators was produced using the Delphi method. Also, an on-line survey system was designed to speed the collecting of opinions. This methodology resulted in five indicators: 1) Basic Network and Communication Theory; 2) Network Planning and Building; 3) Network Communication Protocols; 4) World Wide Web and Related Applications; and 5) Network Security and Management. These indicators are composed of 33 computer networking issues, which provide teachers with guidelines for developing a computer networking curriculum. An on-line questionnaire system was also developed to collect survey data with higher reliability.

INTRODUCTION

Computer networking technology has become an essential knowledge for computer and information science majors. Many textbooks on networking, including those of Tanenbaum et al [1] and Kurose et al [2], have been published. The rapid growth of technologies used in the Internet has created a large number of potential topics for classroom coverage. With only a semester or two for instruction, computer networking topics must be carefully organised.

First, it is necessary to summarise the computer networking topics as an essential base for developing a computer networking curriculum of a few semesters in length. Second, a set of ability indicators for computer networking courses must be constructed. The authors surveyed the current contents of computer networking curricula in local technology universities to outline a set of topics taught in computer networking courses using the induction method and grounded theory. The authors then consulted computer networking specialists in education and industry to develop ability indicators using the Delphi method. To collect opinions from the specialists, an on-line survey system was developed and a e-mail system was used.

METHODOLOGY

A set of general course issues for computer networking was constructed from the existing curricula of computer-related departments of technology universities in Taiwan. The issues were discussed, using a Delphi procedure, with 29 specialists from education and industry. To collect survey data, an on-line questionnaire system was developed. Finally, a set of ability indicators for a computer networking course was constructed for further development of a complete curriculum of computer networking. This work and its conclusions are described below.

INDUCTION OF A SET OF GENERAL COURSE ISSUES

The rapid spread of computer networking has led to an equally rapid expansion of knowledge, technologies, and facilities and infrastructure. Teachers must select topics for instruction from among a constantly growing list of computer networking issues and shoehorn them into one or two semesters.

To construct a basis for an ability indicator for computer networking curricula, computer networking courses were collected from 34 computer-related departments, and selected based on the 2005, 2006 and 2007 evaluations of Taiwan universities and colleges by the Taiwan Assessment and Evaluation Association (TWAEA) [3]. This process was based on induction, a kind of reasoning that generalises conclusions from a finite collection of observations and facts [4]. The list of general issues constructed is shown in Table 1.

Table 1: Category and sub-category of general issues of computer networking courses.

Category	Sub-Category
Basic network and communication principles	Signal Processing, Network Operation System, Network Topology and Structure, Proper Nouns of Computer Network, Network Model, Coding and Physical Layer Technology
Network planning and setting	Connecting LAN and WAN, Common Network Commands and Solving Problems, Sub-netting and Integration, NAT, Eliminating the Failure of Network, Making and Testing Network Cables
Setting network protocols	TCP/IP Protocols, Packet Analysis, LAN Protocols, Physical Layer Protocols, Router Protocols
Network applications	Network Information Centre, Electronic and Mobile Business, Basic Internet Program Design, Network Video, Application Protocols and Services
Network security and management	Intrusion Detection System, Proxy Server and Fire Wall, Antivirus, QoS, Data Encryption and Decryption, Information Network Administration
Transmission medium and facilities	Wired Network, Wireless Network, WAN and Broadband Network

GATHERING OPINIONS FROM SPECIALISTS WITH THE DELPHI METHOD

Twenty-four networking specialists from education and industry were invited to participate in summarising the structure of, and abilities for, a computer networking curriculum. They were asked a series of open questions and summarised their opinions and suggestions using grounded theory. Their opinions converged on the final indicators of the course after multiple rounds of inquiry process.

The purposive sampling method was applied in this research following Neuman, who suggested it as a sampling method suitable for exploratory research [5]. Neuman also argued that respondents must answer questions carefully using an open question method, especially when they face complex questions. Further, respondents may discover new ideas before they have filled out the open questions. It is worth noting that all specialists responded to the inquiries within a few days using our on-line survey system, described below.

The aggregated results of the two foregoing procedures formed the basis for construction of the ability indicators of computer networking using the Delphi method. Twenty-nine specialists were invited to participate in several rounds of the questionnaire process. They adapted their opinions after considering other specialists' responses. Hence, the specialists' opinions converged after several rounds. Eventually, this convergence enabled the construction of a set of ability indicators for computer networking.

The key to the Delphi method is to determine a termination threshold for the number of rounds. Several principles are suggested in the literature. Green stated that a termination can be decided upon when: 1) 70% or more of opinions fall between points 3 and 4; and 2) the median is higher than 3.25 on a four-point Likert scale [6]. Similarly, Ulschak argued that a termination is reached when 80% or more of opinions fall between any two points within a Likert seven-point scale [7]. Miller argued that termination can be determined when a designated proportion of opinion falls in a designated interval on a Likert scale [8]. Based on these suggestions, the authors terminated when 80% or more of opinions fell between adjacent points on the Likert scale. Further, a sign test was used to determine the variance of the opinions. In this study, if the opinions converged and the sign test is not significant, the Delphi method process is terminated.

ON-LINE QUESTIONNAIRE

The questionnaire used in the Delphi process is long, complex and disordered because of the large amount of information and great number of blank cells. Good questionnaire clarity requires careful question construction. Implementing a questionnaire in electronic form avoids postal costs and the problems of transferring data from paper to electronic format, and enables delivery and return of the questionnaire within seconds. The data can then be directly fed to analytical tools. Hence, the authors constructed an on-line questionnaire to speed the process of the Delphi method.

Figure 1 shows images of the on-line questionnaire system. It has several Web pages representing the sections of the questionnaire. The system highlights important words, to give good readability. It is implemented using the Microsoft .NET framework [9], and a third party tool, Visual WebGui [10]. The design of the system provides high

orderliness and clarity. The on-line questionnaire system also monitored the process of the survey, sending status messages to the administrator of the questionnaire. Hence, it significantly improved the response rate and quality of the questionnaire.

Figure 1: On-line Delphi survey system.

Two rounds of the Delphi questionnaire were carried out. In the first round, paper questionnaires were mailed in May of 2009 and all responses were received by the end of that same month. The response rate was 100%. The opinions and modifications of the questionnaire content for the second round were summarised. The second round questionnaire was put into the on-line questionnaire system. The system sent requests to the specialists in August of 2009, and received all responses within 15 days. The second round response rate was also 100%.

Table 2: Computer networking categories and sub-categories.

Ability Indicators	Contents
Understanding principles of networking and communication methods	Network Models, Network Operation System, Network Topology, Network Types, Signal Processing, Transmission Medium, Network Facilities
Planning and managing networks	Eliminating the Failure of Network, Common Network Commands, Connecting LAN, Constructing LAN, Connecting Internet
Understanding network protocols	TCP/IP Protocols, Packet Analysis, Ethernet, Router Protocols, OSI, NetBEUI, Wireless Network Protocols
Using network applications	E-mail, Data Transport and Downloading, Remote Desktop Connection, Peer to Peer, Electronic and Mobile Business, Instant Message, IDC
Understanding network security and management	Network Security Protocols, Proxy Server and Fire Wall, VPN, QoS, Intrusion Detection System, Data Security and Identify, Flow Monitor

RESULTS AND DISCUSSION

Outlined in this article is a set of ability indicators that were constructed for computer networking, taught in technology and vocational universities. It provides teachers with guidance to help them determine which issues are useful in a computer networking curriculum. It was constructed in three main steps: 1) surveying the general subjects of computer networking curricula in selected computer-related departments in universities in Taiwan based on the TWAEA 2005-2007 reports; 2) collecting from specialists skilled in computer networking and working in education and industry, the opinions on computer networking issues needed for computer majors; and 3) constructing the ability indicators, with the specialists invited into a virtual discussion group, using the Delphi method implemented in the pre-developed on-line questionnaire system.

All the specialists' opinions were statistically similar after the second Delphi questionnaire was completed, with agreement between 80% or more of the specialists on each item. Based on the rule that surveyed data are highly identical if the quartile deviation is less than 0.6, the opinions of the specialists were identical when the quartile deviation of each question fell between 0 and 0.5 [11]. Further, the sign test was not significant for all the questions. The indicators, as well as their contents, are shown in Table 2. They form the basis for further development of the complete curriculum of computer networking in a forthcoming project entitled: *Developing a new instruction model of computer networks with virtual machines and cooperative web-based learning*.

The results of this investigation were determined in consultation with skilled computer networking specialists. After completion, it was sent to the specialists for use as a reference for creating a teaching outline for their students/employees, if needed. The on-line questionnaire system provided a powerful way to collect survey data effectively from correspondents distributed across a wide area. The on-line questionnaire system is also used as material for teaching the students engaged in learning programming, including object-oriented technology, as well as Windows and Web applications.

The authors currently have planned for the students at their institutions to be research assistants for programming customised on-line questionnaire systems for further research work. As well, this on-line questionnaire system may help other researchers who want to do surveys electronically. In summary, the result provides a foundation for development of computer networking curricula for universities, as well as construction of an on-line questionnaire system.

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