Design and Implementation of a Network Management Course for Undergraduate Information Systems Students

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Abstract

This paper describes the author's experience in setting up a network management course suitable for an undergraduate Information Systems (IS) program. Network management is a multi-disciplinary field dealing with the planning, provisioning, operation, monitoring, maintenance, and administration of the communication networks in a secure and accountable way. Networks have become mission critical in many firms, and the graduates of IS programs are expected to be involved in management of these networks. The IS curriculum in many universities covers the topic of network management, typically in a lecture or two in a networking course. Therefore, a new additional course in network management for IS students has become necessary. This new course for IS students should focus on the application of network management technologies rather than the development of these technologies. This paper discusses in detail the objectives, outlines, and logistics of such a course. It also provides a detailed account of the implementation and delivery of the course. After two offerings of the course, results were promising. Graduating students were able to find jobs because of the network management exposure they had in this class.

Keywords: Networks, Network Management, SNMP, Information Systems

1. INTRODUCTION

Network management is a multi-disciplinary field borrowing from computer science, electrical engineering, management science and operations research and others extensively. The primary purpose of this collaboration of various fields is to make sure that the communication networks that have become part of our daily life are managed properly; engineered, provisioned, operated, monitored, maintained, and administered in a secure and accountable way. The Network management framework, principles, and following standards are based on the overall goal of efficient management of traditional telecommunication and emerging data networks and services. Regardless of being wired or wireless, these networks and services are managed based on the principles that reliability and availability are maximized, and delays are minimized (Aidarous and Plevyak 1992, Subramanian 2000, Burke 2004, Hegering et.al. 1999).

Ubiquitous availability of the Internet and wireless communications and their impact in our daily life in business, personal, and otherwise, management of these and other networks have gained significant importance recently. An increasing portion of the IT professionals are being involved in managing

some type of networks (Robert 2005, Computerworld 2006).

While many academic institutions have been offering courses on networking for many years now, only a few of them offer *network management* specific courses with varying and limited scope and schedule. Furthermore, almost all of these offerings are part of either electrical engineering or computer science programs which are more concerned about the development of network management technologies; architectures, protocols, etc.

Information Systems (IS), generally associated with Business Schools and MBA programs, is an inter-disciplinary field that incorporates many principles from the areas of computer science, decision science, information science, information management, and more. The IS graduates enter a work force that is involved in information technology and network architecture and support, electronic commerce operation and management, human computer interaction and design, or other significant pillars of the scientific and business community. Graduates of IS programs are expected to be employed in IT departments and to be involved in system level tasks including applications and management of networks which have become mission critical in many small to large firms. Like electrical engineering and computer science departments, IS departments also have been offering data communications and networking related course. The topic of network management has been covered typically in a lecture or two in these networking courses.

IS graduates will find themselves more and more involved in managing the networks (Robert 2005). Therefore, it is desirable that IS students be armed with the necessary knowledge, skills and tools to better position themselves as network manager in the face of ever increasing competition not only from other disciplines but also from overseas. Yet, a quick survey of about 50 institutions indicates that only a couple of business schools offer courses in the network management field (Waldman, et.al., 2005).

This article describes the author's experience in setting up an undergraduate course in network management within an IS department in a Business School.

This paper is organized as follows: After this introduction section, the paper focuses on the syllabus aspects of the course. This is discussed in terms of the objectives and fundamentals. The next chapter discusses the implementation of the course and experiences gained so far. The final section provides a brief summary and some conclusions.

2. SYLLABUS DESIGN

Having worked in the field and taught a course in network management in many years (although in another discipline), the author has accumulated a considerable amount of experience and materials on the topic. However, in this case, the intended audience is the senior students in the IS program. Therefore, a new approach with a different objective and content is necessary to address the needs of the IS students.

Although the curriculum for IS majors includes computer related courses such as programming, hardware, software, database, networking, system analysis and design, and e-business technologies, the emphasis is typically on the application and system aspects rather than the underlying technologies. Therefore, a course in network management for IS students should focus on the application of the management technologies rather than the development aspects of these technologies. For example, we need to keep in mind that the IS graduates are most likely to be involved in the usage of Simple Network Management Protocol (SNMP), the prevailing protocol used by network management systems, rather than the development of the next generation, or the successors, of SNMP.

Additionally, any application focused course must be accompanied with hands-on lab experiments so that students can "digest" the lecture topics easily, and also get a "taste" of the type of work that they would be engaged in after graduation. A network management course, especially for IS students, needs to be augmented with sufficient hands on lab experiments, projects, and site visits, if possible.

Objectives of the course

With the above points in mind, we set the course objectives as follow:

"The objective of this course is to provide a basic understanding of how the information and telecommunications networks are planned, managed, administered, and operated. It is an introduction to a broad spectrum of network, system and applications management. Students will gain theoretical and practical knowledge of network and system management concepts to prepare them for their professional or academic careers. Topics include: management architectures such as Telecommunications Management Network (TMN), protocols such as Simple Network Management Protocol (SNMP), modeling, information databases, and network management applications such as configuration, fault, and performance management. Students will be able to understand the SNMP and associated systems, technologies, and applications. Students will be able to evaluate cost benefit relationships of alternative systems and strategies.

This course builds on the knowledge and skills that have been acquired in prior IS courses. Students taking this course are assumed to have a general understanding of information networks and telecommunications networks as covered in CIS 326 (Telecommunications and Networking) or similar courses."

Course outline

To be able to achieve the objectives established above, the following topics have been identified as the content for this new course:
- Overview
- A Framework for Network Management: TMN
- Simple Network Management Protocol Version 1 (SNMPv1)
- SNMPv2 and v3
- Remote Network Monitoring (RMON)
- Management Functional Areas (MFAs)
- Web Based Management
- NM Tools

The following paragraphs provide a more detailed descriptions of these topics:

Overview - to provide overall aspects of the network management functional areas, architectures, protocols, standards, and systems and tools used in managing the networks. This part should also include a brief refresher on the basics of networking topics and types of popular networks that the graduates will be dealing with in the business world.

A Framework for Network Management: TMN - to cover traditional aspects of network management within an outline defined by the Telecommunications Management Network (TMN) framework (Udupa 1999). This part should also cover functional, logical, information, and physical architectures complete with layers and management areas. The TMN layers include business management, service management, network management, element management, and network element components. And the management areas include configuration management, fault management, performance management, security management, and accounting management.

Simple Network Management Protocol Version 1 (SNMPv1) – to cover SNMPv1 Organization and Information Models including an overview of concepts, history, standards, Structured of Management Information (SMI), and Management Information Base (MIB). (Although there are a number of competing network management protocols, SNMP has become the mainstream protocol used by a significant majority of network management software and systems (Stallings 1999, Miller 1997).) This part should also include a discussion of the "communication model" that includes SNMP architecture, SNMP Protocol Specifications, and SNMP Operations.

SNMPv2 and v3 – to cover major changes that SMNP v2 introduces over SNMP v1 However this part should begin with a discussion of a critical evaluation SNMPv1; its strengths and weaknesses. This part should also cover SNMPv3 specific architectural and protocol specific changes focusing on the modularization of architecture, the SNMP engine, and security in SNMPv3.

Remote Network Monitoring (RMON) – to cover RMON architecture, its managed objects and two versions: RMON 1 and RMON 2. RMON provides a set of capabilities to manage a Local Area Network (LAN) as a whole (while SNMP is interested in network element specific management issues) (Perkins 1998).

Management Functional Areas (MFAs) - to cover five basic areas of network management, also called FCAPS: Fault

management, Configuration management, Accounting management, Performance management, and Security management (Subramanian 2000). Configuration Management includes activities involved in network planning and network design, resource provisioning in response to procurement and deployment of hardware and software resources and service provisioning in response to customer orders. Fault Management includes the topics of alarm surveillance, fault localization, test management, restoration and repair, and trouble administration. Performance Management covers the topics of performance monitoring and performance control. Accounting Management includes the activities in usage data collection, tariff (if applicable) and pricing,, billing, and collections. Finally Security Management covers the security risks and threats, prevention, detection, containment and recovery, as well as the security administration topics.

Web Based Management – to introduce one of the new approaches that are becoming popular due to the ubiquitous availability of the Internet and WWW. This part should cover the Web-Based Enterprise Management (WBEM) and its components. WBEM provides an-integrated set of standardized tools developed by Distributed Management Task Force (DMTF). The tools include Common Information Model (CIM), CIM-XML, Service Location Protocol (SLP), Universal Resource Identifier (URI), and CIM Queries (www.dmtf.org/standards/wbem).

NM Tools - to address the tools and systems used in managing the networks today. Hardware tools such as Bit Error Rate Testers (BERTs) and analyzers; software tools such as status monitoring tools, traffic monitoring tools, and route monitoring tools; network management tools such as SNMP command tools and MIB Browsers; and Network Management Systems (NMSs) such as Enterprise NMS, Low End and High End NMSs should be covered in this part of the course.

Textbook

Section 5 (References) provides a list of books published on the subject of network management. However most of them seem to be not suitable as a textbook for this course. Some of the books [Burke 2003, Feit 1995, Hegering et.al. 1999, Leinwand

et.al. 1996, Stallings 1999, Subramanian 2000, Terplan 1999, Udupa 1999, and Wang 1999] come close but they are mostly written with the Computer Science and Electrical Engineering students in mind. Many of these books cover more topics than the course content and furthermore the matching topics are treated at a different level than IS students appreciate. Therefore, the textbook selected needs to be carefully used and augmented with lecture notes and other handouts.

Assignments, Projects, and Labs

In addition to the reading and homework assignments, the course is designed to have a number of projects assignments. Some of these projects should be individually assigned, while at least one of the projects should be a group project including in-class presentations. The projects are intended to allow the students to further explore some of the topics they learn in the class. Group projects may include an in-depth study of a specific commercial network management system, or involve in investigating an existing network and its network management systems, procedures, and functions.

The course is intended to include a number of lab sessions as well. The lab exercises allow the students to apply what they learn in the class. Students should learn how to use some of the basic networking related commands available by the Operating Systems as well as some of the popular utilities such as Wireshark (www.wireshark.org). One of the focal points of lab exercises should be to allow students to become familiar with SNMP tools and MIB browsers. The lab assignments should be made available prior to the lab session. Students should be expected to come to the lab prepared. Students should bring their notes for reference purposes when working on the problem given in the lab. The work done at these sessions and the reports should be saved and submitted to the instructor at the end of the lab session.

3. IMPLEMENTATION OF THE COURSE

This section discusses the implementation of the objectives detailed in Section 2.

After going through the procedures required by the School's Curriculum Committee for incorporating this new course into the IS curriculum, the following text was adopted as the course description to be listed in *Undergraduate Catalog*:

> **CIS 426. Network Management**. *An introduction to a broad spectrum of network, system and applications management. Students will gain theoretical and* practical *knowledge of network and system architectures such as TMN, protocols such as SNMP, modeling, information databases, and NM applications such as Configuration, Fault, and Performance management. Prerequisite: CIS 326. (Cr.3)*

The course has been offered twice so far. The course outline (week-by-week) in Table 1 has been used in the two offerings of the network management courses.

Table 1. Outline of the NM Course offered

	Topic
Week 1	Overview
Week 2	Standards, Models, and Functions
Week 3	A Framework for Network Management: TMN
Week 4	SNMP v1 Network Management: Organization Models
Week 5	SNMP v1 Network Management: Information Models
Week 6	SNMP v1 Network Management: Information Models
Week 7	SNMP v1 Network Management: Communication and Functional Models
Week 8	SNMPv2
Week 9	SNMPv3
Week 10	RMON
Week 11	NM Applications – Configuration Management
Week 12	NM Applications – Fault and Performance Management
Week 13	NM Applications – Security and Accounting Management
Week 14	Web Based Management
Week 15	NM Tools

The SNMP related topics occupied a big portion of the semester. This was necessary to make sure that the students understand not only the underlying concepts in information modeling and protocol specification, but also practical aspects of the SNMP approach. Students were asked to become familiar with the Internet Engineering Task Force (IETF) site (www.ietf.org) especially in retrieving some of the basic Request for Comments (RFCs) and basic Management Information Bases (MIBs). (IETF is the industry organization responsible for producing many Internet related standard protocols including SNMP, RFC is the initial name given to its standard documents.) A number of in-class demonstrations about the managed objects, their use, SNMP operations, agent discovery, etc., were provided during these "SNMP weeks." Also, three, one-hour labs (to be discussed later), were conducted during the SNMP related period.

As for the textbook, as discussed before, none of the books available in the market was an exact match for the outlines set for the course. At the end, the book entitled Network Management: Principles and Practice by Mani Subramanian [Subramanian 2000] was used as the textbook for the course. The book has 14 chapters and 2 appendixes. Chapter 1 is an overview of networking and network management. Chapter 2 is a review of networking technologies. We used only a small portion of these chapters. Chapter 3 is about the basic foundations of standards on network management. We skipped the ASN.1 and encoding aspects in this chapter. Chapters 4 and 5 cover SNMPv1. We used most of these two chapters. Chapter 6 and 7 present SNMv2 and SNMv3, respectively. We used a condensed version of these two chapters. Chapter 7 is about RMON. We used most of this chapter. We skipped Chapter 9 and Chapter 10, which cover network management of broadband technologies. Chapter 11 is on TMN. We used some of this chapter early on in the course. Chapter 12 presents network

management tools and systems. We used most of this chapter. Chapter 13 is about the MFAs. And Chapter 14 is about the web based management. Again, we used most of these two chapters.

The text book, which was written for the Computer Science and Electrical Engineering students, was used in the course carefully by skipping many theoretical details and by focusing on the practical and application aspects. The students were provided the lecture notes and materials and readings from other books as well.

Students were given weekly reading, and sometimes written, assignments covering lecture topics. In addition, two projects were given: one individual and one group project. The individual project in the first offering of the course consisted of a MIB design for a rather simple router. Students were asked to identify the managed objects representing the logical and physical entities of the simple router. They were also required to write the formal specifications of the objects by using the simple syntax defined in the SMI. The first project in the second offering consisted of a set of relatively complex problems including simple MIB constructs and table manipulations using SNMP operations. Group projects in both offerings of the course consisted of an in-depth study of a commercial network management product (e.g., HP Openview). Each group was given a product and asked to do a research on it, and then write a comprehensive report about the product's capabilities, strengths, weaknesses, market share, price, and primary applications. Each group was also required to make a PowerPoint presentation for the class. These projects were graded based on the content, the report (writing), and the presentation of the project.

As shown in Table 2, a total of four lab experiments were designed.

Table 2. Lab Experiments

	Experiment Subject
Lab 1	SNMP Browser and Agent Discovery
Lab 2	Browsing singular and tabular objects
Lab 3	SNMP operations
Lab 4	OS tools; MRTG tool

Three SNMP related lab exercises were designed. The first one included some trivial activities for students to download and install a MIB browser. For this purpose we used the trial version of the VisualMIB browser by NuDesign (www.ndt-inc.com/walker.html). After installing it, during this lab hour and following two other lab hours, the students were asked to become familiar with some of the important features of the tool, to be able load/unload MIBs, to be able to discover the SNMP agents in the lab networks, and browse through the Managed Objects in one of the agents that they found. By using the SNMP operations such as GET, GET-NEXT, the students were able to inquire about a specific object or walk through a tabular managed object. At the end of each lab session, students provided a report demonstrating their lab activities.

Another lab exercise, the fourth one, was designed to allow students to have hands on experience with some of the network management tools. This lab included exercises with several Operating Systems commands such as ping, nslookup, nbtstat, netstat, arp, and tracert, route. Use of various options available with each command was also part of the exercise. Also included in this lab, was experimentation with the MRTG tool (www.ee.ethz.ch/stats/mrtg). With this tool, students were able to go to a predetermined destination and examine daily, weekly, monthly, and yearly views of traffic on this site. Students were asked to make appropriate conclusions about the usage of this site and report back in their lab report.

One midterm exam and a cumulative final exam were given in both offerings. The exams included traditional essay and problem type questions.

Since this is a senior level elective course, the class sizes were relatively small (about 10 students). Classes were also conducted in an informal and seminar atmosphere. Students were attentive, interacting and enthusiastic. Students had difficulty in putting together a comprehensive report and presentation for their second projects about a commercial network management product. This is partially due to their reliance on Internet search and their use of unfiltered results. It is partially due to the larger scope of the project.

The feedback from the students has been positive. They liked the labs, but as usual, they wanted more. They also liked the site trip to the network control center of the college. They complained about the textbook being not too readable. A couple of recent graduates have sent me email and indicated that the SNMP knowledge they acquired in this course was instrumental in their employment in the IT industry.

4. CONCLUSIONS

This paper discussed the author's experience in setting up a senior level IS course in network management. The course was set up to familiarize students with the basics of planning, monitoring, administering, and managing the networks that have become mission critical in the business world.

After two offerings of the course, we received positive results. Small class sizes, enthusiastic graduating seniors, and an informal seminar like atmosphere made class more useful to the students. Graduating students found jobs because of SNMP and network management exposure.

As indicated above, so far we have two semesters of experience with this course. Based on the positive feedback we plan to continue with the course. We plan to include a few more lab exercises, more hands on and more practical assignments. As part of this effort, we are in the process of putting together a networking lab with an emphasis in the management aspects.

Finally, like any other field in networking, the network management field is also changing rapidly. Therefore, we plan to monitor this field and if any technology makes significant impact in the field, we plan to update the course content accordingly.

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