Teaching Tip

LAN Configuration and Analysis: Projects for the Data Communications and Networking Course

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ABSTRACT

We implemented two local area network (LAN) projects in our introductory data communications and networking course. The first project required students to develop a LAN from scratch for a small imaginary organization. The second project required student groups to analyze a LAN for a real world small organization. By allowing students to apply what they learn in class to real world situations, the projects bridge the gap between technical concepts and business applications.

Keywords: Networking, Team projects, Project-based learning, Server configuration, Network administration & management

1.INTRODUCTION

The importance of computer networks in organizations cannot be over emphasized. However, the typical networking course involves many technical concepts and terms; as a result, lectures and textbooks are often perceived to be too technical, too abstract, or a bit "dry". To make the class more interesting and to engage students in active experiential learning, many instructors add hands-on exercises and activities. For example, Sanders (2003) utilized simple hacking techniques to teach system security and hacker identification; Cavaiani reported using the Ipconfig command to teach network troubleshooting techniques (2005) and using Wireshark to conduct data packet analysis (2007). OPNet network simulation software (OPNet University Program) is gaining popularity in network classes for hands-on exercises; one indicator of its popularity is that several data communication textbooks integrate lab manuals

for using OPNet, such as textbooks by Stallings (2004 and 2009), Fitzgerald and Dennis (2008), and Panko (2008).

In addition to using hands-on exercises to make the abstract and "dry" concepts concrete and interesting, instructors also need to create opportunities for students to understand how a network can be configured to support business in a real world organization. This teaching tip describes two such projects for the introductory data communications and networking course for MIS majors at the undergraduate level in a business school. The purpose of the projects is to strengthen the connection between technical concepts and business applications so that students gain not only a deeper understanding of how a network works, but also how a network can be managed and configured to support operations in an organization.

One project focuses on LAN configuration; student groups are required to set up a small LAN for a small imaginary organization. The other project focuses on LAN analysis; student groups are required to analyze a LAN in a

small real world organization and recommend improvements to the organization's LAN. These two projects are independent of each other and can be implemented one without the other; however, we believe the two projects complement each other in terms of content.

2. LAN CONFIGURATION AND LAN ANALYSIS PROJECTS

Students form groups of three or four by themselves at the beginning of the term. They are in the same group for both projects because of its convenience for both students and instructors. This means that students have fewer team meetings, and their schedules are easier to coordinate; for instructors, it is easier to track the teams' progress and to contact individual teams. Whether students are in the same group or not should not affect their learning in either project. To prepare students for both projects, we cover the OSI and TCP/IP network layer models, explain the layers of the TCP/IP model, and then explain LANs, wireless LANs, and network operating systems in detail during the first half of the term. In the second half of the term, we cover wide area networks (including the Internet), network design, network management, and network security.

Students start to work on the LAN analysis project several weeks before the midterm examination, and they start to work on the LAN configuration project after the midterm examination. It takes more time to do the LAN analysis project than the LAN configuration project. Since these two projects are independent of each other, the order for starting the project does not effect learning. In this paper, we will explain the LAN configuration project before we explain the LAN analysis project because the configuration project is smaller in scale.

For the LAN configuration project, we provide a small computer laboratory with all the needed hardware: two computers, a network printer, network cables, and a switch. Students are required to install Windows Server 2003 on one computer as the server and Windows XP on another computer as the client. The computers that we use for the project are older machines that cannot handle the RAM requirements of the newer versions of Windows Server and Windows. It would be better to use newer versions of the software (see Section 3 for our plans in this area).

Students also need to perform the following tasks for the configuration project.

- Configure the server as a domain controller
- Join the workstation to the domain
- Partition and format the data disk
- Create needed folders on the data disk
- Share files on the data disk and configure security
- Create user accounts
- Create appropriate groups with appropriate permissions/rights
- Configure a shared network printer
- Configure the Group Policy.

We provide details about the user accounts. We also provide the needed software: trial versions of Windows Server 2003 and Windows XP. Students need to find the printer driver by themselves online. Since this is an introductory networking class, we also provide a LAN configuration tutorial in class to illustrate the step-by-step configuration process. We do not use a written tutorial; we expect students to take detailed notes during the tutorial and to use Internet searches for troubleshooting. If they encounter serious difficulty, students can contact their instructor.

The final deliverables of the project are the functional LAN they have configured and a formal written report about four pages long. In the report, students

- Explain their reasoning for the groups they created.
- Explain their reasoning for the file system rights they granted.
- Explain their reasoning for the file shares they created.
- Explain their reasoning for the shared printer permissions they configured.
- Discuss the advantages of assigning permissions to groups rather than users.
- Discuss what they have learned from this activity.
- Discuss which problem-solving method they used when they encountered problems or were not sure how to complete a task.
- Explain how each member of the group contributed to the project.

Each group has four days to complete the LAN configuration project; since the lab is small, only one group can conduct the project at a time. Once the group completes the project, the instructor marks the project and wipes the hard drives clean on both computers for the next group. The purpose of the LAN configuration project is for students to gain hands-on experience about how to set up a small LAN. The configuration project allows students to apply several concepts that they have learned from lectures to a hands-on, active experiential learning exercise that includes the following concepts: LANs, network connecting devices (switch, cables), IP addressing, DNS servers, network operating systems, and network security. Please see Appendix A for the configuration project assignment.

For the LAN analysis project, the students must first identify a real world organization meeting the criteria stated in the LAN analysis assignment and obtain the organization's permission to interview several staff members in the IT/networking area. The analysis project requires students to analyze the network of a real world organization. The network must have at least 10 users and 13 nodes. The final deliverables are a 20-minute class presentation describing the project and a formal report (see appendix B for the analysis project assignment) that includes:

- An introduction to the organization
- The organization's current networking status (including a network diagram)
- An analysis of the strengths and weaknesses of the existing network
- Recommendations for network improvements, including technical descriptions of the improvements, benefits, cost, and cost justification
- A timetable for implementing recommendations
- What was learned from the project
- Conclusion

The LAN analysis project allows students to gain a big picture view of networks in a working environment: applications needed for a specific organization, hardware needed to support these applications, services needed to support the hardware and software, and policies for using the network. By providing detailed information about network improvement costs and justification, students also gain an understanding of the costs of supporting and upgrading a network. The project is due at the end of the term.

The two projects complement each other. The configuration project focuses on technical skills while the analysis project includes both technical and managerial aspects.

3. OBSERVATIONS AND STUDENT FEEDBACK

Students usually complete the configuration project within the four days that are allocated; sometimes, they cannot correctly perform a step and cannot figure out the problem by simply following their tutorial notes. As expected, they frequently search the Internet to troubleshoot any problems they encounter. Only occasionally do students resort to asking the professor. Students' written reports and our casual conversations with students indicate that students like both projects and learn a lot from them. We often hear students say, "Now I understand how a network administrator sets up a network." Students frequently report orally to us that they "had fun" with the assignment, that the assignment was "cool", and that they learned a lot from the assignment.

Before we implemented the LAN analysis project, we were concerned that organizations may not want to reveal to outsiders (i.e., our students) how their networks are configured for security reasons. Surprisingly, more than four years after implementing this project, there was only one group (out of about 20 groups) that indicated that their network administrator was reluctant to reveal the network configuration for their organization.

Another concern that we had before implementing the analysis project was that students might not learn enough to make recommendations for network improvements; therefore, we tell students that the purpose of the project is to give them an opportunity to see how a computer network is configured and supported in a real world organization; the focus is on understanding the current network's configuration, not the potential for improvements. If the current network is sufficient for the organization, we ask that the students simply imagine that the business will expand dramatically in two years and then determine how the network could be updated to support the expanded business. Students appear relieved after our explanation. Most groups do in fact work with organizations that need to upgrade their existing networks; students make recommendations that the organizations consider seriously; however, we have not kept track of which organizations actually implemented the students' recommendations.

It was interesting to see students chose a variety of organizations for their projects, for example, an elementary school, a store selling agricultural equipment, a hotel, a campus computer lab, a campus library, a restaurant, the city transit organization's IT department, a video rental store, a construction company, a landscaping company, and a consulting company. Most of the networks that students have worked with are wired LANs; several groups have worked with organizations that had a wired LAN but needed to add a new wireless LAN. Due to the diversity of the organizations that the groups chose, students learn not only from the experience of conducting their own projects but also from the presentations of the projects that are done by the other student groups.

In the analysis report, students document what they learn from the project. The learning occurred in four major areas. First, students learned how important a computer network is for organizations, for example, in students' words:

> *The biggest lesson we learned in this project was how important an IT infrastructure can be to a simple organization such as a hotel. Our group thought that the operation of the hotel was mostly manual work, but we discovered that most of the work of the hotel is done through its network.*
> *Traditionally, we felt that a good marketing plan was the best way to go about increasing business, but we now know that information and technology can play a large role in increasing the sales of a business.*

Second, the project enriched the content that students learned in class. For example,

> *We were able to propose a successful implementation of the necessary technologies that were required for our LAN project. These technologies included a VLAN, firewall, intrusion detection system (IDS), and wireless technology...Having the opportunity to discuss our plans with a real-world representative for a real-world entity was very satisfying as it heightened our skills in dealing with the requirements and needs of the client.*

> *We acquired some valuable first-hand knowledge in LAN configuration including server and client structure, network topologies, switches, wired and wireless connections, NOS [network operating system], network security, and other aspects.*

Third, they learned the content in its business context; students could see how the concepts were applied in real business.

> *More so than a paper or a test, this project gave us a chance to utilize the information we've been taught rather than just spew it out on a piece of paper. It let us put everything we were taught into action, and we were thrilled with the results.*

> *Through this project, we have had the ability to take our theory based knowledge and apply it to a real business application. It has broadened our understanding of the materials and really helped us see how it can be used to benefit business.*

> *We do not get the opportunity to do projects with real business very often, and so this was a memorable experience... In this project, we were able to extract*

much of the knowledge we have learned from the textbook and bring it to a real business situation.

We have been able to identify the different parts from the course content and how the parts fit together to support organizations' needs.

Fourth, in addition to the technical aspects of networking, students also gained insights into the managerial aspects of networking.

We learned a lot of specific details about actually designing a LAN, ... but more importantly, we gained valuable knowledge about the business side of this project.

One thing that surprised us was the high costs of equipment and hardware to make a simple network upgrade.

The students have also learned other things, for example,

...be aware of changing needs and how this will impact your systems and overall IT structure. Since resources are limited, it is important to weigh all your options.

We also learned that a lot of emphasis must also be placed on constraints. While one solution may theoretically be optional for a network problem, it may not be practically feasible given certain physical or financial constraints of a company or institution.

We expected that the analysis project would allow students to make the connection between technical concepts and business applications and to understand networks in a real world environment. It turned out that students learned more than we expected. After several years of using the LAN analysis project, we are convinced that it is worthwhile to share our experiences with instructors who teach a similar course.

In the future, we hope to make two changes for the LAN configuration project: first, we hope to acquire newer computers so that students can install the newer versions of the Windows software, second, we will require students to configure two PCs as clients instead of just one PC. For the LAN analysis project, we feel it is important to teach the network management chapter earlier so that when students write about network improvement, management, and related costs, they are well prepared.

4. CONCLUSION

The networking course involves many technical concepts and terms, and the lectures and textbooks may be viewed by students as a bit "dry", particularly when presented without context. One way to make the course more interesting and relevant to students and to achieve expected learning outcomes is to design experiential learning assignments that allow students to actually configure a network and to see how a network is managed to support daily business operations in a real world organization. We have designed

and implemented a LAN configuration project and a LAN analysis project. Student feedback indicates that they have learned a lot from these two projects.

5. REFERENCES

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Appendix A
LAN Configuration Project

The purpose of this team assignment is to familiarize you with the fundamentals of network configuration. For this assignment, you will be configuring one Windows XP workstation and one computer running Windows Server 2003. You need to install the operating system before configuration.

Each team will get a 4-day block of time to complete the activity in room 150. The paper is due after your block of time is complete.

Scenario

Swift Accounting is a small office with 6 staff. Until now, Swift accounting has been using a peer-to-peer network. However, they have had problems with security and with document organization. After listening to your brilliant sales presentation about using Windows Server 2003 as a dedicated server, they want to buy it.

You have ordered the server from Dell and it came with Windows Server 2003 CD-ROM, you have to install the operating system and configure it. All of the company data has been copied onto a CD-ROM but has not yet been placed on the new server. You need to complete the installation and configuration including:

- Configure the server as a domain controller.
- Join the workstation to the domain.
- Partition and format the data disk on the server.
- Create needed folders on the data disk on the folder.
- Share files on the data disk and configure security.
- Create appropriate groups with their permissions/rights.
- Create user accounts with their associated groups, permissions, and rights.
- Configure a shared network printer.
- Configure the Group Policy.

Windows XP Configuration

Most of the configuration for this assignment is accomplished on the Windows server. However, the users created in the Active Directory must be able to log on to the Windows XP computer, access their files over the network, and print to the network printer. Verify that this is possible by logging in as each user and testing file access and printing.

To accomplish these tasks you must:

- Configure the Windows XP computer to use the Windows server to resolve DNS names.
- Join the Windows XP computer to the Active Directory domain.

All domain users should be configured as standard users on the workstation except for the user named Consultant. The Consultant user should be a local administrator on the Windows XP workstation. This user account will be used to perform maintenance on the Windows XP workstation.

Active Directory Configuration

Before the Windows XP computer can join the domain, you must configure the Active Directory on your server. After the Active Directory is installed you can create the appropriate user account.

Use the following information to install the Active Directory:

- Domain name: swift.local
- Configure the local server as a DNS server.

Users

There are six staff members at Swift Accounting. A user account needs to be created in the Active Directory for each user. The user names and job roles are listed in the following table. Each user should be able to log on by using their first name, followed by a period, followed by their last name, e.g., first.last. . When the user account has been created, each user should be assigned a temporary password of Pa$$w0rd. When users log in, they should be prompted to change their passwords so that the administrator does not know their passwords.

User	Job Role
Ted Nugent	Owner
Sebastian Bach	Accountant
Scott Ian	Accountant
Evan Seinfeld	Accountant Assistant
Jason Bonham	Accountant Assistant
Doc McGhee	Executive Assistant to the owner
Consultant	Used to perform maintenance

Create the appropriate groups for assigning file system permissions/rights. Document your reasoning.

Disks and Data
The data disk should be configured as three partitions, one partition for the operating system and two equal sized partitions for data: one for internal data and the other for client data. You will need to make up some files and folders for internal data and client data.
Some data types to consider:
- Internal firm data such as internal financial data
- Client data files
- Home folders for private storage space
- Technical files such as software updates

Configure security for the folders that you create for the users and share the data in an appropriate way. Document your reasoning.

Shared Printer
Install the printer on the Windows XP workstation. Configure the appropriate share permissions and document your reasoning.

Configure Group Policy
The Group Policy is used to configure user and computer settings.
- Create a logon script for your users that maps at least one driver letter to a data share used by all users.

Paper to hand-in
Include the following information:
- Explain your reasoning for the groups you created.
- Explain your reasoning for the file system rights you granted.
- Explain your reasoning for the file shares you created.
- Explain your reasoning for the shared printer permissions you configured.
- Discuss the advantages of assigning permissions to groups rather than users.
- Discuss what you have learned from this activity.
- The problem solving method you used when you encountered problems or were not sure how to complete a task.
- Explain how each member of your group contributed to the project.

When the paper is complete, hand in the hard copy to the instructor by the end of the fourth day your group has been in the computer network lab. .

Appendix B
LAN Analysis Project

Student teams are to analyze the network of a real organization. The network must have at least ten (10) users and 13 nodes. Please talk to your instructor to make sure the network that you select is appropriate for the assignment.

This project is the "capstone" of the course. As such, it should include most technical and managerial issues that have been covered during the semester. Your team is to prepare, for senior management of a real organization, an analysis of the network in their organization. Your analysis is a formal business document that explains the current network environment, analyzes the existing configuration, and makes recommendations for improvements.

It is very rare that a network analysis will not uncover some potential improvements. For your recommended improvements, your should include technical specifications and specifics regarding each stage of implementation, costs, a proposed timetable, and managerial issues, such as organizational change, human resources and training, security, and financing. If no improvements are suggested, then you must justify why the existing configuration is sufficient.

Your network analysis paper should include:

- A table of contents
- An executive summary, summarizing the contents of your report
- An introduction, describing the organization's current networking status
    - Include a network diagram (you can draw this using MS PPT or Visio)
- An analysis of the strengths and weaknesses of the existing network
- Recommendations for network improvements, including:
    - A lay persons description of the improvements
    - A technical description of the improvements
    - Justification for each improvement
        - Benefits in general
        - Benefits compared to other options
        - Value vs. cost
    - Budget for the improvements
- A cost justification and budget for all improvements
- A detailed description of the network improvement project, from planning to installation and maintenance stages of the systems development life cycle. You may incorporate a proposed timetable in this section or include it elsewhere in your proposal. You may do the same with a description of project responsibilities/assignments and vendor selection. You should also include, probably in this section, a discussion of the managerial issues mentioned above as well as any additional managerial issues affecting the network project or its outcome.
- A proposed timetable, project/job descriptions, and vendor selection criteria, including potential vendors (unless included above)
- A brief report of what you learned from this project and from working with the real business you selected
- Conclusion

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