

A Case Study of the Network Installation Process

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Abstract:

An analysis of the process of designing a new computer network is outlined as planning, installing and supporting the future network. The planning process includes a business needs analysis which is determined in part by interviews. According to the requirements of the new network, the choice of hardware and the installation process gives the readers the logical flow of the process. On-going network support is an important issue as the network changes with time; it should be analyzed for speed and efficient operation. The case study provides a sample outline of possible questions to ask during the interview process. The interviewer must be prepared for the interview and should be able to create new questions based on responses received. The case study includes a sample scenario and a new network design. All of the practices described are put to use in order to create a viable network solution for a company described in the scenario. The case analysis is intended for business school students exposed to basic telecommunication concepts to provide an overview of network design.

Key Words: design, network, sample scenario, case

1. INTRODUCTION

Today, businesses collect and manage a large variety of data to extract information to increase profitability and facilitate smoother operation. Technology allows companies to collect substantial data on

their current clients as well as potential customers. Since their inception, Amazon.com collects all types of customer data, which is used for marketing purposes and improving customer service. Computers help collect, store and sort the detailed information available. Networks connect workstations to

servers to enable each business unit access to the vast amounts of data for analysis facilitating the sharing of data.

Computer networks have advanced quickly over the years. The transmission speeds have jumped from 2 to 10, ending in 1,000 megabits per second, using copper wire as a transmission medium. In addition, the use of fiber optics has facilitated faster transmission rates; however, useless if the network is poorly planned and implemented. Today's high speed local area networks must be properly planned, have the optimum hardware base, meticulously implemented and occasionally adjusted in order to maintain maximum performance.

Dramatic changes in the business climate in the 1990s increased electronic commerce altering business operation by enhancing the importance of computer systems. "Connectivity has never been as important as it is today," (Murhammer, 1999). The process of designing a new computer network should be outlined for future expansion to guarantee smooth operation and development.

The case study analyzes the process of designing a new computer network. The planning process includes a business needs analysis which is determined in part by interviews (Microsoft, 2006). The requirements of the new network are based on current and forecasted needs. After identifying the requirements, the network planner can define the scope of the project to prevent scope creep, establish tasks and delegate responsible parties. Prior to installation, selection of hardware should be reviewed. The installation process is smoothly initiated due to a thoroughly planned design. All hardware should be carefully tested before it is run in a production environment. On-going network support is critical as the network changes with time; it should be analyzed for speed and efficient operation. A sample outline of possible questions to ask during the interview process is shown in Appendix A. The interviewer must be able to create new questions based on responses received. In order to create a viable network solution, planning, installing and supporting processes must be implemented.

2. PLANNING

The first step in planning a new network is to understand the network client or user and what their requirements will be, known as a business needs analysis (Microsoft, 2006). Departmental interviews are one way of acquiring data, but looking at Help Desk history is also useful. Analyzing the Help Desk history will give the network planner useful insight and information on what questions to ask during the interview and how to ask them. A sample outline of possible questions to ask during the interview process is shown in Appendix A. If the interviewees feel uncomfortable, they may not provide the interviewer with any useful information.

Prior to user interviews, the planner must inform the department managers why they are conducting interviews. Interviews with those managers will provide a departmental functionality overview, a number of network users and different security or access restrictions for users. This interview should be used to pull future plans and ideas from the manager. The manager would know if there were plans to implement new technology, for example, a document imaging system. Asking how new and future technology could make their department run more efficient would help when forecasting future requirements. User interviews will give the network planner a list of current software programs used, how the programs and users access information over the network, any time of day demand differences and a look at how network efficiency can be turned into user efficiency.

A consultant who is contracted to build a new network needs to interview the in-house tech support and network personnel. A sample outline of possible questions to ask during the interview process is shown in Appendix A. Learning about the organization's current network topology, hardware base and trouble areas would be helpful in highlighting the areas need improvements (Acosta, 2006). Any hardware preferences should be obtained so that they can be worked into the new network plan. In addition, the consultant should obtain a preference for the future network's architecture (Acosta, 2006). Even though the consultant will provide a recommendation for the best possible configuration, it will give him/her insight into the experience of the network support personnel. Sometimes advanced training might need to be included in the

recommendation, and other times just a brief overview of the system is needed before it is turned over to in-house support.

Network Requirements

When a network design is considered, the main points to pay attention to are bandwidth needs, resource needs, performance and quality of service requirements, network scalability and network security. Once the interviews are complete and the information is analyzed, the planner should start a list of network requirements, first being bandwidth needs. If the department manager does not foresee any large changes, current bandwidth requirements can be used to calculate future requirements. However, usage growth should be planned due to personnel additions and a general increase in network resource utilization.

Resource needs is a network requirement regarding email accounts to network printing of the shared network folders. Supported applications and protocol requirements ensure correct functionality and efficient communication. Older software might require the installation of non standard protocols as a means of communication. If in use, this information needs to be known up front so the network hardware and software can be set up to facilitate that specific protocol.

Performance and quality of service requirements must be taken into account to evaluate response time between client and server. The network design must be configured for optimum speed levels; however, different protocols can be prioritized so that they receive the highest placement in the network queue.

Network scalability is a requirement to enable expansion and accommodation for future requirements. New network segments should not create bottleneck issues on the existing network (Mueller, 2003). Networks are easier to manage when they are modular in nature. For this reason, modularity is an essential requirement. Having a modular network helps when bringing new departments on line or divesting an entire business unit. Modularity isolates a network problem to one segment ensuring the entire network is not affected.

Another important requirement is network security. Security encompasses electronic

access to the network through wired or wireless connections and physical access to network hardware. All non-used hardware connections should not stay patched into the network. Even with tight network security, a hacker could still gain access by plugging in a laptop or other portable device; viruses or spyware could be spread almost instantly. As a minimum, MAC address restrictions should be set in place so that no outside device can use the firm's wireless connection. There are also security considerations when connecting a network to the internet. A network address translation (NAT) router with a built in firewall is a common internet security device (Murhammer, 1999). The use of network address translation enables many computers to be connected to the internet while hiding their true identity.

Define the Project

After the list of network requirements has been created, the planning team should discuss the findings. To ensure that no steps get overlooked, the team should create a simple work breakdown schedule (WBS) by brainstorming all required tasks. Once the WBS is complete, they can estimate resource requirements and costs associated with each task. With this data, the team can make a recommendation on technical and economic feasibility. Some IT departments lack the knowledge or man power in house that is required to perform the network project; as a result, an outside vendor must be contracted. A number of cost estimates will require quotes from vendors, causing the team to produce a request for proposal documents. Few network teams are given the authority to proceed on the project no matter the cost; subsequently, the network team must create a close cost estimate to distribute to senior management.

A computer based project management program, like Microsoft Project, tracks tasks, responsibilities, financials and formulates a proposal to court the management staff. One advantage of using Microsoft Project is the ability to create PERT/CPM charts to graphically show how certain tasks can be completed in unison. Milestones can be created to give the team motivation and the ability to track their progress to know what tasks each individual is responsible for completing.

Hardware Selection

Before the planning team can send their proposal and estimate to management, hardware decisions need to be completed. Standardizing on one manufacturer for the same type of equipment is an ideal design; although, security concerns would be addressed better if equipment from a couple of different vendors were used. In order to simplify this case, we will limit selection to one manufacturer. If a company installed ten 24 port switches, purchasing the same switch enables unity due to researching and understanding only one switch interface and management program. Cisco is known for their quality routers, while Nortel and 3Com produce excellent network switches. Other companies, like Netgear, cater to small and home businesses. Manufacturer support is an essential factor when deciding what products to purchase as well.

Open standards, networks typically comprised of components from different manufacturers, are another consideration for hardware selection. Communication between products is crucial. Purchasing network components from Brand X, a company without credentials accepted in the market, exclusively creates high risk; the company would have little support or product replacement if Brand X goes out of business. "In considering supplier options, one size usually does not fit all," (Sliman, 2002).

After hardware selections, prices researched, request for proposal (RFP) returned and bids submitted, the planning team launches the proposal to management. The proposal should include an executive summary, a problem description, a resolution outline, a benefits assessment and a cost evaluation (Products and Services, 2006).

3. INSTALLATION

Once management approves the project, the process of implementing the network must be started. Installing a new network is easier than upgrading an old one due to after normal business hours work to ensure the flow of company data is not interrupted (Mueller, 2003). An empty building is an easier place to install a new network. Through the use of Microsoft Project, the project manager can oversee each activity or task. Some of the tasks can be performed

simultaneously, while others are dependant on a predecessor.

Most of the hardware installation can occur simultaneously; for instance, the network wiring can be run while the network racks are mounted. The end of each run can be punched down and labeled while the switches are put in place and configured. The project manager should post print outs of the PERT/CPM and WBS charts to guarantee each person involved understands the tasks he/she is responsible for completing, what has been accomplished and what still needs to be done. Marking completed items on the diagrams increases efficiency by encouraging the team and renews interest in a large project.

After hardware installation, the network is ready to test. All network drops should be tested for continuity and at least one network drop in every room must be checked with a computer to ensure that it connects properly. Virtual local area networks (VLAN) will be used in large networks, to ensure that the PC receives the proper internet protocol (IP) address for the building's VLAN scheme. Large and small files should be transferred from PC to server to confirm that speed and error rates are acceptable. Once the internal tests are complete, the network should be connected to the Internet for more connectivity tests. Data must be sent out and received. The firewall should be checked for configuration errors and test packets verify the firewall is actually blocking what it says it is.

At this time, disaster plans should be in progress. If there is a backup firewall, the primary should be forced to fail to confirm proper backup initialization. Power should be cut to all network equipment to test the battery backup devices. The switches should be powered down completely and when brought back up, the current configuration should be double checked against their original configuration. Once the network is stable, move-in can occur and departments can be brought on line.

4. FINE TUNING

Once a strain has been put on the network and all departments have come on line, adjustments to the original network configuration may be necessary. Some departments

may not receive the data transmission rate that is required and others may need access to cross-department shared data restricted by the enhanced VLAN security. After the irregularities are resolved, the network should be analyzed for optimum performance. Unused protocols show up, must be traced back to the source and turned off. Certain broadcasts tie up network resources and could bring down a segment of the network due to a broadcast storm, a broadcasted message across a network resulting in more responses and each response results in another set of responses creating a snowball effect possibly ending in a block on all network traffic. For security reasons, when a computer is moved, the unused network drop should be disconnected from the switch. New computers and printers have an effect on network performance; therefore, the network is constantly evolving and routine analysis should be executed to ensure optimum performance.

5. ANALYSIS

In this case study, a scenario of designing a new network for an insurance company has been analyzed. The appendices provide sample interview questions (Appendix A) and sample interview responses (Appendix B). The scenario for design and implementation considerations is as follows:

A 200 person insurance company has outgrown its current office space. The company has secured the top four floors in an office building but the area must be retrofitted. As a network engineer, you have been contracted to work with the architect and contractors to design and install their new computer network. The CEO envisions an open office layout of cubicle style furniture for the majority of the employees, some enclosed offices, 8 enclosed meeting rooms, and a reception area. The first three floors will accommodate 60 to 70 employees each and have 2 meeting rooms each. The top floor will consist mostly of offices for 35 to 45 employees and will also have a meeting room. If the company outgrows the current space, the building manager has promised the use of additional floors in the building, but they might not be adjacent floors. Your job is to research the com-

pany's needs, recommend hardware, and install the entire network.

The insurance company needs a faster network, specifically dealing with large amounts of digital audio, photography and video. Gigabit Ethernet to the desktop is a necessity, not just a desire (Microsoft, 2006). Category 6 network cables need to be installed to handle the bandwidth requirements of gigabit speeds. The three network servers should be connected directly to the backbone at gigabit speeds; however, these servers should be connected via fiber.

Since the new office layout spans 4 floors if a building, fiber should be used to connect the departmental switches to the core switch. The architects need to design a network closet into each floor that can house at least one floor mounted rack system for the network components. Since this company secured the top four floors in the building, the Network Control Center will be designed in the company's lowest floor to allow future expansion.

The bottom three floors support a maximum of 70 employees each. There should be at least one network drop in each conference room. Analyzing the network printers, network locations, employee count and employee locations, two 48 port switches should be installed on each of the lower three floors. The installation of networked printers can support approximately 8 users without proximity issues allowing more than enough open ports on the switch. The top floor requires one 48 port switch due to the maximum number of employees, 45. Mandating the use of another switch due to network printers, a 16 or 24 port switch could be added later. Since multiple VLANs and switches will be used, the new network architecture can be described as a *multi-switch VLAN rack based collapsed backbone network*.

Sending data electronically to the major credit reporting agencies creates a need for higher bandwidth; therefore, the internet connection speed should be upgraded. Road Runner, one of the regional ISPs, has the ability to provide higher speeds than what the company is currently receiving. At first, increase the bandwidth to 10 Mbps, if it is sufficient, negotiations can be started with Road Runner or even another ISP.

Hardware Proposal

Design is viewed differently by multiple network professionals; therefore, there is a variety of successful solutions. The equipment selection and design architecture are determined by the network needs and requirements of the organization. In this section, the approach to the scenario may offer alternative solutions or a more effective blueprint due to the subjective nature of network design.

Netgear, the primary network hardware vendor, offers extensive customer support options including an on-line knowledgebase (FAQ), a telephone warranty service, email support options and multiple plans for pay based support. Most of their products offer a limited lifetime warranty which is exceptional in the computer/electronics field. Netgear established a great reputation for manufacturing quality products at an affordable price. Their products are easy to configure, designed to be modular and enables network expansion.

Seven Netgear GSM7352S 48 Port Gigabit switches will be installed in the network closets across the four floors. Faster than the original switches or hubs, Netgear GSM7352S can handle large audio and video files with ease. The bottom three floors will contain two Netgear switches stacked together to form one logical unit switch requiring one IP address to manage and make changes. They are Layer 3 switches, so VLAN and Port routing are available. Different departments will be set up on different VLANs to cut down on broadcast traffic over the entire network, although, access to shared resources like files and printers is available. The Netgear switches will be connected to desktop computers via gigabit category 6 copper cables and to the core switch via gigabit multimode fiber. Each switch has room for expansion using four high speed module bays and eight 10/100/1000 Mbps combo ports. In order to stack the switches together and connect them to the core switch with fiber, both types of expansion ports will be used. Two high speed module bays and two Netgear 24 Gigabit Stacking Kits, Model #AX742 will be used for stacking purposes. Only one of the combo ports, Netgear Gigabit Interface Converter (GBIC) Module 1000Base-SX Fiber SFP, Model # AGM731F, will be used to con-

nect the stack to the core switch. The core switch needs one GBIC Module for each fiber connection, totaling eleven GBIC Modules: one for each of the four network stacks, four in the core switch to connect the stacks, and three in the core switch for server connections.

The core switch is a Netgear 12 port Gigabit Layer 3 managed switch, Model #7312 with 12 shared RJ-45 Gigabit Ethernet ports built in. Each RJ-45 port is shared with a GBIC port for Gigabit fiber connectivity. The core switch will be able to handle the network demands of the company. The speed and expansion options for this backbone are impressive. The stacking options with the two switches per floor communicate with each other at 24 Gbps, as does the backplane of the core switch. The core switch communicates with the other switches at a speed of 1 Gbps over fiber cables which are extremely accurate and dependable.

If network expansion initiates an upgrade to the core switch, the speed it communicates with all of the other switches can be upgraded as well. A high speed module bay on each switch in the stack will be upgraded with a Netgear 10 Gigabit Ethernet XFP Adapter Module, Model #AX741 allowing the switches to communicate at 10 Gbps, instead of 1 Gbps. If the company expands to an additional floor in the building, the core switch, Netgear 12 port Gigabit Layer 3 managed switch Model #7312, can handle the added strain; in addition, there are four available ports on the switch.

A firewall and router are needed to connect the internal network to the internet. Again, a Netgear product was chosen – the Netgear Gigabit VPN Firewall 25 with 4 Gigabit LAN and Dual WAN Port Switch, Model # FVS124G. The firewall and router combo was chosen for its high speed connection to the LAN and the two ports for connecting the internet. A second ISP can be added performing load balancing between the two ISPs and provide fail-over redundancy. It allows the use of Virtual Private Networks (VPN) to allow the company to let users work from home. The WAN port can connect 100 Mbps accommodating every speed Road Runner, or any other ISP offers. It has an easy management interface and can be configured with the same software that is used to configure all Netgear switches. It com-

municates with the LAN at Gigabit speeds, to prevent bottlenecks between the router and LAN.

The high speed components of this network were chosen with bandwidth usage in mind. All of the components can handle VLANs, which help cut down on traffic and use Quality of Service to prioritize packet transmission. The insurance company has a call center may upgrade to a phone system that uses Voice over IP; all components of the network design can handle the stringent requirements and bandwidth needs for VoIP. The network is modular in nature and has the ability to be upgraded with ease. It provides many years of trouble free networking and smooth network management.

6. CONCLUSION

Computer networks are the new backbone of many companies. When the network fails, productivity and customers are lost resulting in a decrease in millions of dollars. Building a reliable network is time consuming and requires many resources; however, with proper planning installing the appropriate equipment is relatively smooth (Mueller, 2003). A network design and installation team with clear objectives will ensure that the business needs are met, while meeting the desires for future expansion.

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Appendices

Appendix A: Sample Interview Questions for the Designer

Sample questions for Department Manager:
Do you have any current needs that the IT Department is not handling? <i>(If so, they must be listed in order of importance and addressed immediately.)</i>
Please give me a general overview of what your department does. <i>(Gives the interviewer a department summary and allows them to formulate additional questions based on the manager's response.)</i>
How many of your employees require network access? Do some of them have access to files that others do not? <i>(Useful for network wiring needs and provides needed info for a hierarchical security diagram.)</i>
Have you received complaints of network slowness or has slow network response time hampered productivity? <i>(If so, find out what programs were being used, what time of day, and what days the slowness was experienced. Create a log sheet for users to document slowness, so it can be examined by network personnel.)</i>
Do you see your division expanding rapidly any time soon? <i>(If so, then it might be wise to install a 48 port switch instead of a 24 port switch.)</i>
Is there any possibility that your department will be relocated in the near future? <i>(If so, the backbone and/or core switch needs extra scalability.)</i>
Are there any new laws that might affect the way you operate in the digital age? <i>(If so, those laws must be addressed. For example, privacy concerns are forcing companies to audit their security policies for improvement.)</i>
Is there new technology out there that will improve employee efficiency in your department? <i>(If so, do you plan on implementing it in the future, and what network requirements does it have?)</i>
Do you plan on upgrading or adding any new software in the near future? <i>(If so, how does it tie into the network? Does it require extra bandwidth?)</i>
Sample questions for Department Employees:
What software are you currently using? <i>(List all software titles for analysis.)</i>
Do any of the programs perform slow or just seem to hang up briefly? Is it intermittent or always slow? Do you notice it at certain times of the day? <i>(If always slow, report to Help Desk or network personnel. If intermittent, give user the log sheet so they can document it.)</i>
Do you have any programs that require a certain response time? <i>(If so, list the titles and the response time, if known.)</i>
What type of information do you access over the network? How often do you access the internet, shared files, and email? <i>(List all for later analysis.)</i>
Do you know of any other programs available that would make your job easier or more efficient? <i>(If so, list the titles and time saving benefits.)</i>
If it was possible, would network speed improvements make your job easier or more efficient? <i>(If yes, note their response.)</i>
Do you have any other suggestions? <i>(Be prepared for criticism, don't get defensive, and note their response.)</i>
Consultant Sample questions for in-house support:
What is your current network architecture/backbone architecture? <i>(speed analysis.)</i>
Are you using switches or hubs and what speed are they? <i>(speed analysis.)</i>
What types of wiring are you using? Twisted pair? What speed rating? Any fiber? <i>(speed analysis.)</i>
Are you using wireless? 802.11g? <i>(planning the new network.)</i>
Who is your preferred Internet Service Provider vendor? <i>(connectivity)</i>

Do you have any networking hardware vendor preferences? (*Support personnel might be familiar with configuring switches from a certain manufacturer.*)

What network backbone architecture would you recommend for the new network and how would you lay it out? (*support personnel's network knowledge.*)

Appendix B: Interviews

Interview with in-house tech support:	
Q.	What is your current network architecture?
A.	We have a star topology using 100Base-T category 5 twisted pair throughout the offices. Everything has been patched together as we have grown using 100Base-T hubs and switches. Only a couple of offices still have hubs. We have been able to phase in switch technology over the last few years. We are using a collapsed backbone network and the core switch is simply a 100Base-T switch. In places, switches are cascaded off of each other in order to span distances longer than 300 feet. We don't have any fiber or wireless technologies. We have the basic Business Class service which offers 6 Mbps download and 2 Mbps upload speed provided by Road Runner.
Q.	Is that sufficient?
A.	Actually it is not. We have been looking at upgrading to a fiber connection for greater bandwidth, but knew this office move was approaching. We want to explore our options with Road Runner further and upgrade service when the new building comes on-line.
Q.	Do you have any networking hardware vendor preferences?
A.	No. Over the years, the head IT support person has been replaced several times. Our hubs and switches are a mix of brands, which probably reflects the preferences of the different personnel. As long as the new system is easy to configure, has excellent support, and works as advertised, I have no loyalties to any manufacturers.
Q.	Having seen the preliminary plans for the new office space, do you have any recommendations on backbone architecture and system layout?
A.	Our network is currently pretty maxed out bandwidth wise. The use of digital video and photography in the insurance industry is putting a strain on network resources. I would recommend gigabit speeds to the desktop. Some of our current computers can only connect at 100 Mbps, but all of our new computers are coming equipped with gigabit network cards. I would like to implement VLANs into the new network configuration, so Layer 3 switches would need to be purchased. We have also started to use all rack mounted equipment, so a rack based collapsed backbone would make sense to me.
Interview with Department Manager:	
Q.	Please give a general overview of what your department does.
A.	We are responsible for handling motorcycle, automobile, and boat claims. We investigate all claims, interview clients and witnesses, document the findings. We are moving into a paperless filing system, so all of our information is digital. We also record interviews, so digital audio files are also used. We have 55 employees accessing the same information so that when a client calls requesting information on a current claim, any one of my employees must be able to access their files. On occasion I have heard complaints that the computers and I guess network is slow when accessing digital video files. Our division expands maybe one to two new employees per year. We need to comply with privacy laws. Because we are in the insurance business, we send information back and forth to the big three credit reporting companies. We also have to comply with FEMA standards to ensure fraud is kept at bay.
Q.	Do you send any personal information over the internet or is it transferred to the credit reporting companies in hard copy or other digital format?
A.	I believe we send the information on DVD.
Q.	Do you know if they have the ability to receive that information over the internet?

A.	I think that might be a new service they are just starting to offer.
Q.	Do you know of any new technology or software out there that will improve employee efficiency in your department?
A.	No.
Q.	Do you plan on upgrading or adding any new software in near future?
A.	No.
Interview with Department Employee:	
Q.	What software do you currently use to perform your job?
A.	We have a custom application called Safeguard that allows us to enter all necessary information. I also use Microsoft Word and Excel to draft different documents. Other than email, that is just about it.
Q.	How do digital audio, pictures, and video get on the system?
A.	Safeguard is a pretty robust program. To conduct a phone interview, I click a button in the program to start recording. It automatically creates an audio file for it somewhere, and links it to the claim. Anyone can listen to it later by clicking on another button. Transferring pictures and video into a claim is easy also. Safeguard opens a browser window, and I just drag and drop the files in. Our digital cameras record video as well as pictures, and plug into the computer through this cable.
Q.	Do any of the programs perform slow or just seem to hang up briefly?
A.	When transferring files from the camera it seems a little slow. It also has problems playing back some of the audio and video.
Q.	What do you mean by problems?
A.	Occasionally it pauses during playback and takes few seconds to restart.
Q.	Is it intermittent or always slow? Does it happen at certain times?
A.	Honestly, I think it is always slow.
Q.	Do you have any programs that require a certain response time?
A.	Yes. When we first got Safeguard, it had problems recording audio. I was told that it was trying to record straight to the network server, and the slow network response time hampered that feature. An update to safeguard was later released that temporarily recorded the audio file to our computer, and then transferred it to the network server later.
Q.	Other than Safeguard, how often do you access email, files on the network, or the internet?
A.	Pretty regularly throughout the day. I don't correspond with clients over email that often - we use email more as a means of inside communication. I do have to send a lot of letters. Safeguard has a plug-in that interfaces with MS Word to pull the client's information like a form letter, and that gets saved in the client's file. I do have to use the internet pretty regularly to access information from government sites and other insurance agencies.
Q.	If it was possible, would network speed improvements make your job easier or more efficient?
A.	From what they tell me, a faster network would help out with digital audio, pictures, and video.

Appendix C: Hardware Costs as of May 2006

Model #	Description	# Needed	Price Each	Extended Price
GSM7352S	48 Port Gigabit Switch	7	\$3,800.00	\$26,600.00
GSM7312	12 Port Gigabit Switch	1	\$1,100.00	\$1,100.00
AGM731F	GBIC Fiber Module	11	\$300.00	\$3,300.00
FVS124G	Gigabit Firewall	1	\$200.00	\$200.00
	Floor Mount Rack	4	\$700.00	\$2,800.00
	Rack Mounted UPS	4	\$1,000.00	\$4,000.00
	Backbone Wiring	1	\$2,500.00	\$2,500.00
	Computer Wiring per Floor	4	\$2,000.00	\$8,000.00
				\$48,500.00

Appendix D: Network Diagram

Network Diagram

