Designing a LAN for Campus Layout
ECE 453 | Project 2

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Abstract

The objective of this project is to design a LAN connecting four departments in a campus layout. Two designs meeting specific requirements are discussed in this report, one using thin coax and the other using UTP. Arguments justifying the design and correctness, together with the total implementation costs are presented for each implementation. Fiber optic cable is used in the network backbone because it offers high data rate capacity, no electrical interference, ability to withstand severe weather conditions and larger maximum segment length.

1 Introduction

Computer networks are essential for day-to-day communication, e-commerce transactions, information sharing and the like. Networks can be broadly categorized according to their size, which helps determine their scope and intended application. Different networks are implemented in different ways.

Local Area Network (LAN) is a high speed computer network used for connecting computers and sharing resources over a relatively small area (few kilometers). Typically, LAN can be implemented in an area as small as a dorm room to one that is as large as a university campus [1]. In this project, we will design a wired LAN for one such campus layout.

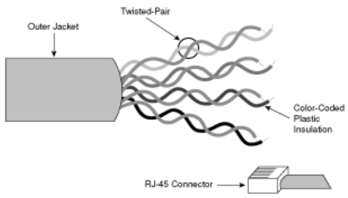
We will use two different cabling technologies and topologies for our wired LAN. The first Ethernet design will be implemented using *thin coax* cable on a *bus topology* in which all devices will be connected to the central bus. The second design featuring the *UTP* cable will be implemented using *star topology* in which all devices will communicate on the network by passing data through a hub.

1.1 Ethernet Cables

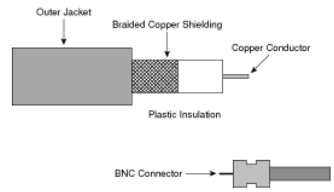
Unshielded Twisted Pair (UTP) cable consists of eight insulated copper wires grouped together to form four pairs. The wires in each pair are twisted around each other to reduce signal degradation from interference. The number of twists per meter for each pair can be varied to further reduce crosstalk noise. The Category 5 UTP (also 100BaseT) used for fast Ethernet, supports data rates of 100 Mbps or higher and has a maximum segment length of 100-meters. The standard connector for UTP is an RJ-45 connector. By far, UTP is the most popular and generally the best option for wired LANs. **Thin Coax** cable consists of an insulated copper wire surrounded by a woven copper braid to reduce the amount of outside interference. An outer jacket covers the two conducting elements. Coax cable supports data rates from 10 to 100 Mbps and can be laid over greater distances than UTP with fewer repeaters. The *thinnet* cable used for Ethernet has a maximum segment length of 185-meters. Network interface cards (NIC) with the standard connector for coax cables, the British Naval Connector (BNC), are a rare find nowadays.

Fiber Optic cable consists of a center glass core surrounded by layers of protective plastic shield, followed by a very strong plastic Kevlar (used in making armor) and an outer jacket. The electrical interference is absent in fiber optics since it transmits light and not electrical signals. 100BaseF is the fiber optic specification used for carrying Ethernet signals. It supports data rates up to 10 Gbps and has a maximum segment length of 2000-meters. The most common connector for 100BaseF is the SC connector, which has two optical connections, one each for connecting to transmit and receive.

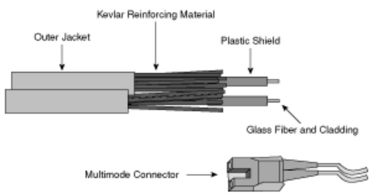
The exceptional qualities of 100BaseF such as high data rate capacity, no electrical



(a) UTP Cable and RJ-45 Connector



(b) Coax Cable and BNC Connector



(c) Fiber Optic Cable and SC Connector

Figure 1.1: Ethernet Cables [2]

interference, ability to withstand severe weather conditions and larger maximum segment length, makes it an ideal choice for connecting networks between buildings. Figure 1.1 illustrates all the three types of Ethernet cables discussed in this section.

1.2 Repeater

A *repeater* is a Physical Layer (layer 1) analog device that connects two cable segments. It operates on bits on the cable segments, amplifying their signal strength before sending it to the other segments. Classic Ethernet allowed four repeaters to join five segments together. The concept is still in use, mainly for reliable data transfer.

1.3 Hub

A *hub* is also a Physical Layer (layer 1) device and somewhat similar to the repeater; it operates on bits and the number of hubs is limited to four for a joining segments together. It is mainly used for UTP networks to provide connection between nodes. A hub does not isolate traffic because two signals arriving at the same time on a hub will collide and will have to be retransmitted. Hubs form a single collision domain.

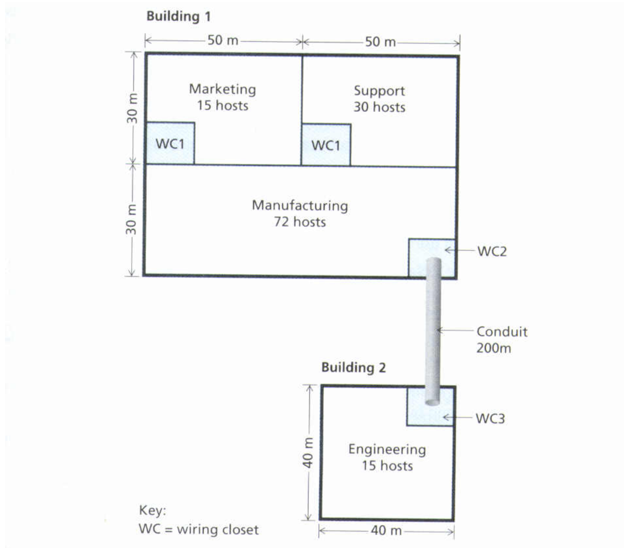


Figure 2.2: Campus Layout

1.4 Bridge

A *bridge* is a Data Link Layer (layer 2) device and unlike repeaters and hubs, it operates on frames of data. Bridges use look-up tables to route the data frames to the destination address after reading it from the frame header. Unlike hubs, bridges manage traffic to avoid collisions.

2 Design

In this section, we will discuss the thinnet and UTP LAN implementations for the campus layout shown in Figure 2.2. The cost listing of the available equipment for our design is depicted in Table 2. The backbone consists of a 6-port fiber repeater with four 2-port bridges. We will be using the same network backbone for both designs. The only change would be using Fiber/Coax 2-port bridges for thin coax implementation as opposed to using Fiber/UTP 2-port bridges for UTP implementation.

It should be noted that all repeaters and bridges are placed in wiring closets (WC). WC1 of Marketing and WC3 of Engineering departments house their file server and 2-port bridge, WC1 of Support contains their file server, 2-port bridge and 8-port repeater. Similarly WC2 of manufacturing is home to their three file servers, two 8-port repeaters, a 2-port bridge and the 6-port fiber optic backbone repeater.

Equipment	Cost
Thin Coax	\$1/m
UTP	\$1/m
Fiber-optic Cable Pair	\$2/m
NIC Thin Coax Ports	\$70
NIC UTP Port	\$70
2-port Repeater	\$800
Multiport Repeater (8 Thin Coax Ports)	\$1500
Multiport Fiber Repeater (6 fiber ports)	\$2000
2-Port Bridge (any combo of Thin Coax, UTP, Fiber)	\$2200
Hub-36 UTP ports	\$4000
Hub-6 Fiber Ports, 24 UTP Ports	\$6000
Pentium File Server-w/NOS (30 users)	\$9000

Table 2.1: Equipment Cost

2.1 Thin Coax Implementation & Justification

Our implementation for the campus layout using thin coax is shown in Figure 2.3. The hosts are connected on a bus topology with the thin coax connected via the T-connector in a daisy-chain fashion. All hosts numbered 15, 30, 24, 48 and 72 in Figure 2.3 are terminated with a 50 Ω BNC terminator. We have already discussed the benefits of fiber optic cable in Section 1.1. A fiber optic cable repeater is used as a backbone for the thin coax network. The backbone is used to provide network reliability and to make it robust. Four 2-port Fiber/Coax bridges are used to connect each department to the network. The total length of required fiber cable is 200 + 80 + 130 + 40 (probable roouting overhead) = 450 meters.

Each file server supports a maximum of 30 users and they are not be shared through departments. Therefore, one each is given to Engineering, Marketing and Support for their 15, 15 and 30 users respectively while Manufacturing gets three file servers for their 72 users.

One segment of coaxial cable is needed for Marketing and Engineering departments, two are needed for Support while three are in use for Manufacturing. This is because it is not advisable to have more than 30 connections on a single coax length. The total length of required coax cable is 185 + 185 + 370 + 555 + 55 (overhead) = 1350 meters.

In order to connect all the hosts and the file server on the network, the number of required NIC/coax ports is # Hosts (15 + 15 + 30 + 72) + #Servers (6) = 138.

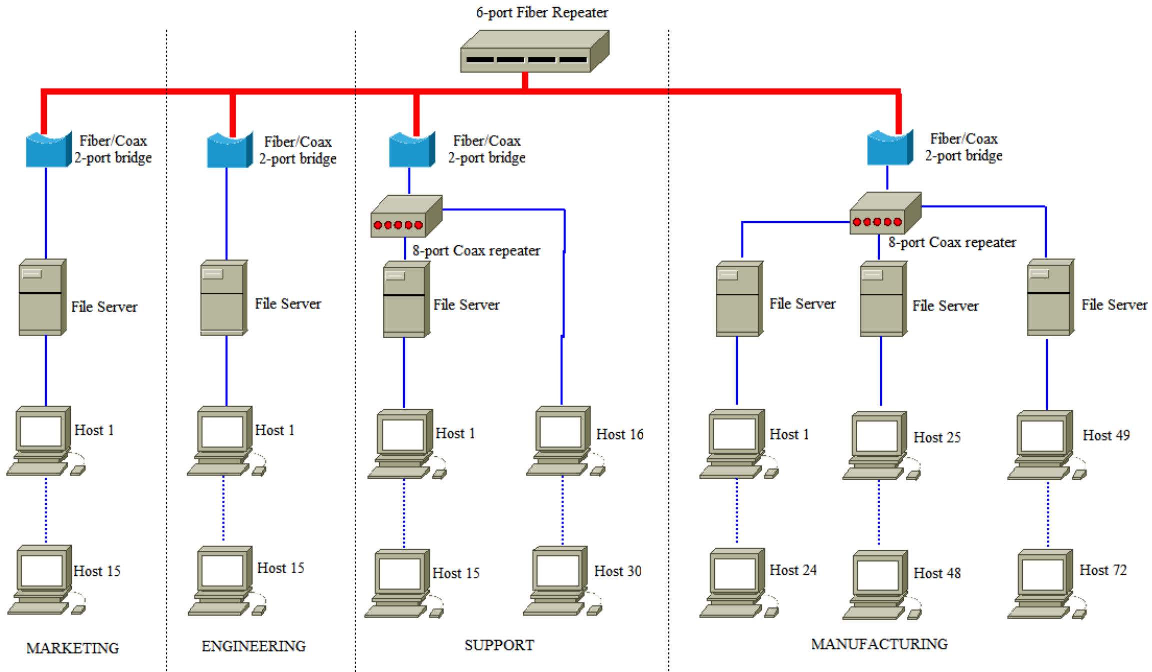


Figure 2.3: Thin Coax LAN Implementation

2.1.1 Thin Coax Implementation Cost

Equipment	**Units**	**Cost ($)**
Thin Coax	1350	1350
Fiber-optic Cable Pair	450	900
NIC/Thin Coax Ports	138	9660
Multiport Coax Repeater	2	3000
Multiport Fiber Repeater	1	2000
2-port Fiber/Coax Bridge	4	8800
Pentium File Server	6	54000
Total		79710

2.2 UTP Implementation & Justification

A fiber optic cable repeater is again used here as a backbone for the UTP network. Four 2-port Fiber/UTP bridges are used to connect each department to the network. The total length of required fiber cable is 200 + 80 + 130 + 40 (probable roouting overhead) = 450 meters.

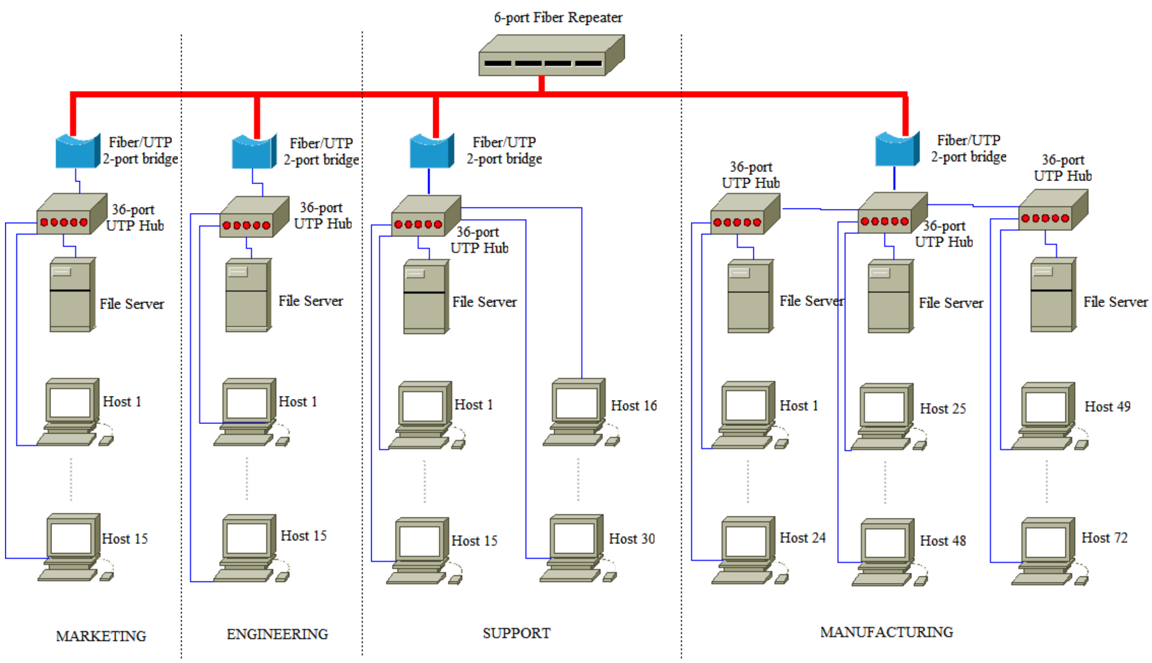


Figure 2.4: UTP LAN Implementation

Each file server supports a maximum of 30 users and they are not be shared through departments. Therefore, one each is given to Engineering, Marketing and Support for their 15, 15 and 30 users respectively while Manufacturing gets three file servers for their 72 users.

Since UTP uses star topology (all hosts and servers connected to their respective hubs) we need one 36-port hub each for Engineering, Support and Marketing departments. For Manufacturing department however, we will need three 36-port hubs (72 hosts + 1 server. The there hubs in manufacturing will be connected in daisy chain fashion (similar to the thin coax network connection).

The estimate of the total length of UTP cable required for cabling is rather tricky. From the department floorplan we can see that Marketing and Support departments are 50-m wide. Assume that $\frac{1}{5}$ of the hosts of both lie within 10-m the next $\frac{1}{5}$ at 20-m and so on. The floorplan of Manufacturing department shows that it is 100-m wide. Assume that $\frac{1}{18}$ of hosts lie at 4-m intervals. Similarly for Engineering, assume that $\frac{1}{5}$ of hosts are placed at 8-m intervals. Then the total UTP cable length comes to $450 + 900 + 3240 + 300 = 4890$.

In order to connect all the hosts and the file server to the hubs on the network, the number of required NIC/UTP ports 138.

2.2.1 UTP Implementation Cost

Equipment	**Units**	**Cost ($)**
UTP Cable	4890	4890
Fiber-optic Cable Pair	450	900
NIC/UTP Ports	138	9660
36-port UTP Hub	6	24000
Multiport Fiber Repeater	1	2000
2-port Fiber/UTP Bridge	4	8800
Pentium File Server	6	54000
Total		104250

3 Summary and Conclusions

We implemented a LAN for campus layout using two different cabling techniques and compared the cost of one to the other. Turns out that UTP network is more expensive to implement than thin coax (by about $25000). This however is a smal price to pay for stable more reliable network. In case of thin coax, if a cable segment of any daisy chain connected host is damaged then the entire department's network will be lost. This problem does not arise in UTP because each host has a dedicated connection with the hub. In addition to that users on UTP-based LAN will also get more bandwidth and thus higher preformance than thin coax.

We used fiber optic in the network backbone due to its ability to transmit Ethernet signals to farther distances than either UTP or coax, without the use of signal boosters and repeaters. Furthermore, we are guaranteed zero interference because of fiber.

4 References

[1] Andrew S. Tanenbaum, *Computer Networks, Fourth Edition*, Prentice Hall PTR.

[2] Stephen McQuerry, *CCNA Self-Study: Introduction to Cisco Networking Technologies*, Cisco Press.