Indian Institute of Technology Kanpur

Department of Computer Science and Engineering

Computer Networks- CS425A

Design of Network

Lecture Hall Complex

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1 Introduction

This assignment deals with network design for Lecture Hall Complex of IIT Kanpur. This project report is aimed to provide fully functional solution for designing the network for the building and also provide the solution for enabling its communication with the other buildings on IITk network and outside world.

2 Network Requirements and Design Goals

This section explains network requirements and design goals, keeping in mind, our expectations from LHC network. Network size, load, capacity, LAN ports requirement, number of users, devices per users, etc. will be discussed in this section.
This section also discusses the various other requirements related to network like reliability, security, robustness, scalability, adaptability to technological challenges etc.

2.1 LHC building description

LHC comprises of 20 lecture halls with different student capacities, and LHC office and a student lounge. These rooms are spread in a non-uniform pattern on two floors across 3-4 separate buildings.

2.2 Analysis of size of network and other aspects

Network Size and other requirements are roughly estimated in the **Table 1**. Devices mostly include computers, printers, projectors, and mobiles(a large part). We can also use IP cameras and Wireless monitor if installed in future.

Room	**Devices(during peak load)**	**Active Devices**	**LAN ports**	**Wireless AP**
L1	150	75	8	2
L2	200	100	10	2
L3	200	100	10	2
L4	200	100	10	2
L5	200	100	10	2
L6	200	100	8	2
L7	500	250	12	4
L8	150	75	8	2
L9	150	75	8	2
L10	150	75	8	2
L11	150	75	8	2
L12	150	75	8	2
L13	150	75	8	2
L14	150	75	8	2
L15	150	75	8	2
L16	300	150	12	3
L17	300	150	12	3
L18	450	225	13	4
L19	450	225	13	4
L20	700	350	15	6
LHC Office	20	20	6	1
Student Lounge	50	50	10	4
Total	**4420**	**2245**	**213**	**57**

Table 1: Please Note the number of active clients are assumed to be half of number of clients during peak load in Lecture Halls because they will not be active all the time.

2.3 Fundamental Design Goals

1. **Scalability -** Designed network should have capability of expansion for supporting new users, groups and applications without affecting existing users, groups and application.

2. **Reliability -** The network should be available for 24*7 and should deliver consistent and reliable performance. The whole network should not fail in case of any single point failure or any equipment failure.

3. **Security -** Security is most important necessity in a Modern day Network.

We need the firewall, security devices, protocols, etc, so that network and its resources are properly safeguarded.

4. **Manageability -** A good network is one that takes minimal efforts to manage after it is functional. It is required that network is not complex and is easy to manage.

5. **Efficiency -** Network should be efficient with maximum bandwidth and throughput for high performance and speed.

2.4 Bandwidth Requirements

Each user have current requirement of 2-3 MB/s which we expect to rise to 5 MB/s, since students or faculty will not require high bandwidth application in lecture hall complex.

2.5 Growth of users

Number of users are expected to be fairly stable in future. We will be designing our network to handle maximum number of users(limited by LHC size constraint). We can have a steep growth of users in case a new lecture hall is constructed. We will be keeping mind that our network is scalable.

3 Network Topology and Architecture

3.1 Topology

Our network topology is hybrid which has capabilities of bus and star. Our topology consists of 7 star network connected as nodes of a tree. Tree is a hierarchical topology. This allows to extend the extending the capabilities of bus and star-configured systems. Our is 4-level hierarchical tree.
The below topology figure is made in Tetcos NetSim software(`https://github.com/shivankgarg98/CS425A`) describing the how the switches are connected. The root node(Switch A) is connected to CC and other switches are connected to switch A. Our Switches have 28 ports each Wired Nodes and Wireless Access Points can be connected to these ports. So total number of available ports are-
Number of Available ports $= 28 * 7 + (28 - 7) = 217$
Since we need only 213 ports, the number of switches and their arrangement fit our purpose. Expansion of our network is possible with adding more number of switch at $II^{nd} or III^{rd}$ level.

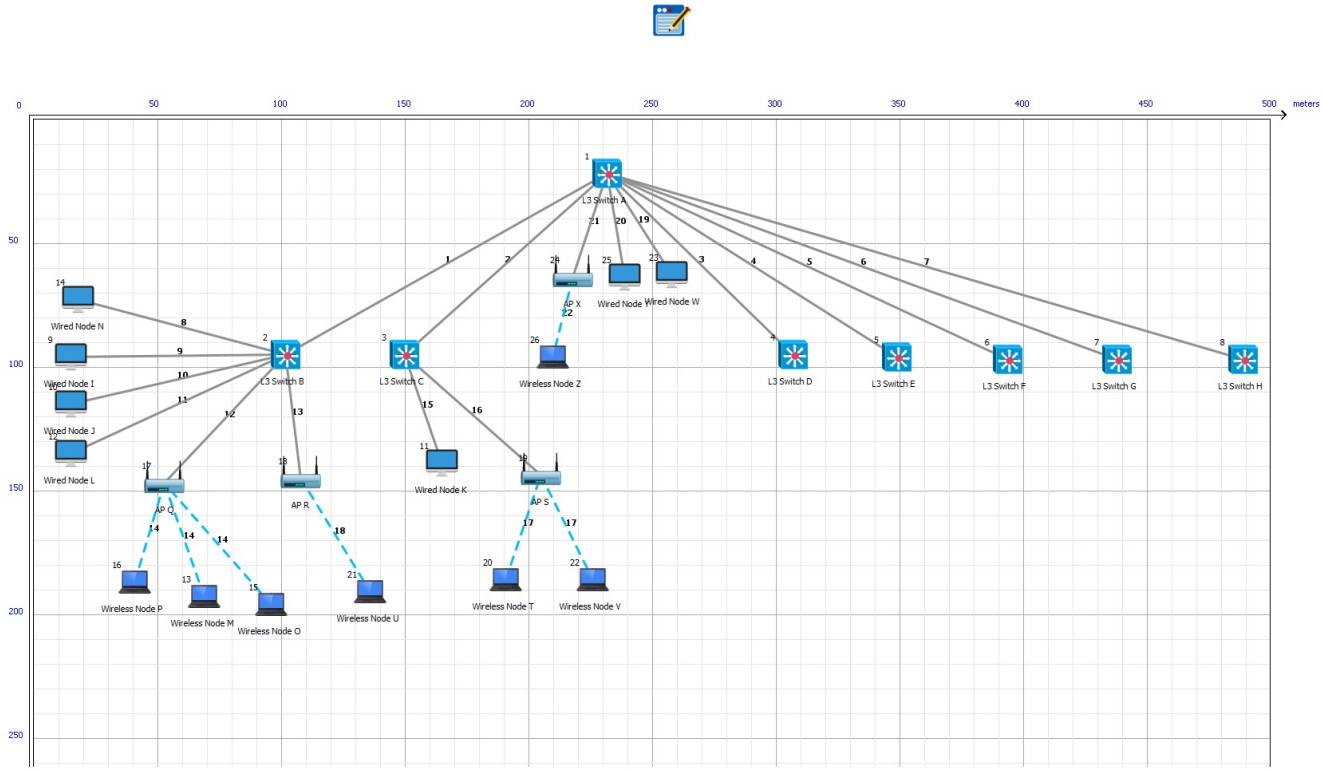

Figure 1: Topology Design for LHC made in Tetcos NetSim

We have adopted this hierarchical topology due to following reasons-

1. The designed topology will ease the burden of error detection and troubleshooting.
2. It allows our network to scaled in sizes quickly by adding more switches.
3. It is ideal for us as it allows to form groups.
4. Since, our tree is small, we will not face difficulties in expansion and maintenance.

3.2 Architecture

Our network should support Client/Server architecture. This is necessary to run various type of applications like mail, etc. Also capable of supporting Peer-to-Peer(P2P)

to support services like FTP. We can run one or more application servers and database servers for the client to connect.

4 Cabling and Connectors

Cabling is one of the most challenging task in network design. This involves choosing right type of cable among different types available in market. The cabling should support our high-speed data network and must have capability to sustain the technological advancements in near future.

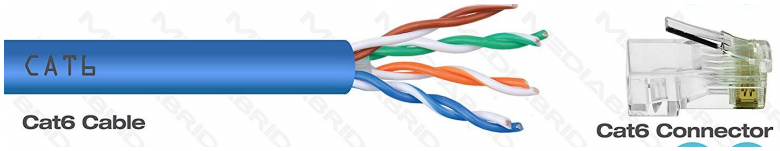

Figure 2: Source: `https://www.amazon.com/Mediabridge-Cat7-Connector-Gold-Shielded/dp/B0711716RK`

Figure 3: Source: `https://www.amazon.com/Mediabridge-Cat7-Connector-Gold-Shielded/dp/B0711716RK`

We will be using **CAT7** for Ethernet cabling to connect with Computer Centre. CAT7 is one of the newest version cable available in market which is about 34% expensive than its predecessor CAT6A.
Since, cabling is done once in a building for a long time. We have to be prepared for potential future evolution in technology and it will be wise to spend little more on cabling in present rather than making whole network obsolete a few years later.
For connectors, we'll be using **RJ45 connectors for CAT7**. These connectors are gold-plated and fully-shielded to reduce external noise and interference.

And we will be using CAT 6 cables to connect wireless AP and LAN ports to the switches since the switches that we will be using transmits at 10 GBps and also most

of the devices are still running on Gigabit Ethernet ports. We can have a maximum of 100 users on single WiFi AP, so each node requiring 5Mbps simultaneously needs only 500Mbps throughput from the router and CAT 6a is capable of delivering this speed. The maximum distance from a switch to a LAN port cannot be more that 100 meters which again is within the limits of CAT 6a. So there is no need of CAT 7 and at the same time we cannot use CAT 6 since it can be used for 37 meters without attenuation.

4.1 CAT-6A Pros and Cons

Pros of using CAT-6a cabling

1. It is capable of supporting data transfer rates of up to 10Gbps at a maximum bandwidth of 500MHz.
2. It has additional and tighter twists, with additional insulation to reduce cross talk.
3. It is also backwards compatible with CAT6 and CAT5E, however, speeds are always limited and will perform to the lowest category cable or connector that is installed in the link.
4. It is fast becoming the lowest cost effective solution as it is seen as a future proof cable system.

Cons of using CAT-6A cabling

1. One of the perceived disadvantages of CAT6A is the actual size and weight of the cable.
2. CAT6A requires additional testing, however, network testers are all pre-configured and automated with PASS / FAIL requirements for the link and can quickly and effectively test the performance of the network.
3. Alien cross talk begins at 350MHz so compared to CAT6 and CAT5E, CAT6A requires additional testing.

4.2 CAT7 cable pros and cons

Pros of using CAT7 cabling-

1. It has an estimated lifespan of around 15 years which is very good compared to 10 year lifespan of CAT6 which compensate for its pricing.

Cable	Max Transmission speed	Max bandwidth
CAT 5e	1 Gbps upto 100m	250MHz
CAT 6	10 Gbps upto 37m	250MHz
CAT 6a	10 Gbps upto 100m	500MHz
CAT 7	10 Gbps upto 100m	600MHz

Table 2: Comparison between available network cables

2. It has better insulation than its predecessor which helps reduce cross-talks and noise significantly.

3. It is backwards compatible, that is, it can work well with CAT6/CAT6A/CAT5.

4. It has higher bandwidth and is well-versed for future high-data rate application.

Cons of CAT7 cabling-

1. It is expensive and may come under budget-constraints. Also, It is costly and difficult to install.

2. CAT7 is not yet TIA/EIA recognized.

4.3 Power over Ethernet

We will chose PoE(Power of Ethernet) in our network. PoE enables network cable carry electrical power means less cable. PoE provide significant advantage in case of time and cost. It is flexible and allows installation of devices at remote location of building. It is safe and reliable.

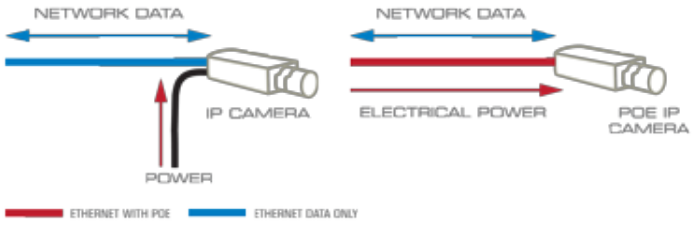

Figure 4: Source: http://www.veracityglobal.com/media/78161/poe-explained-one-diagram-two.png

Devices that can be used with PoE are IP cameras, VoIP phones, Wireless(Wifi AP), etc. We will chose the **CISCO SG350-28-K9 28-Port Gigabit Managed Switch** that is PoE enabled. Working of that switch can be seen in below figure.

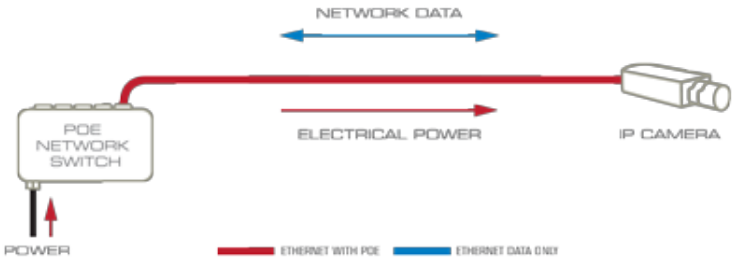

Figure 5: Source : http://www.veracityglobal.com/media/78161/poe-explained-one-diagram-two.png

4.4 Specifications & Standards

CAT7 is defined under ISO/IEC 11801, 2002. and has specifications as described in `http://www.ieee802.org/3/10GBT/public/jan03/hess_1_0103.pdf`. It is not yet recognized by TIA but it is backwards compatible with CAT6/CAT6A which are recognized by latter.

4.5 Network Connectivity Devices

1. **Routers -** Routing is the most important part of a network. We want all the devices in our network to be able to communicate with the rest of the campus and also be able to access internet. Some of the requirements to be satisfied :

   - There will be approximately 2000 active devices in this network and it increases upto 4400 in peak times. So our router should be able to manage this amount of traffic.
   - Since this network is open to a lot of members, potential attacks on it are bound to happen. So our router should allow us to configure firewall, gateway and important features and it also should provide an easy interface for the same.
   - Other feature like power consumption, cooling facilities, robustness, strong firmware level encryption system should be there.

   We have a router in Computer Centre which support all these requirements so we will be using the same.

2. **Switches -** We need a lot of LAN Ports and also all the devices in the network should be interconnected. But using many routers for this task will increase the cost and complexity substantially. So we are going to use switches for this task. Factors considered :

   - It should be a manged one. Since this will be a large network with different persons working with different devices security and traffic control should be maintained. It should give network administrators control over devices like printers etc.
   - We need one with 24-30 ports, Since increase of lecture halls will demand more LAN ports and with each class we will need at least 10 ports, so having 28 port switch stack, we can easily increase them in future.
   - Buffer size, Speed, Cost are other factors to be kept in mind.

   Considering all these we are going to use this switch **Cisco SG350-28-28-port-gigabit** from cisco available at `http://amzn.in/d/7bfnsKB`. We need **8** such switches for LHC complex.

4.6 Unbounded Media(Wireless)

Since devices density will be very high and not all devices used by students have LAN ports, we need to have WiFi Access Points in each and every classroom and corridor. These factors are kept in mind while selecting a router.

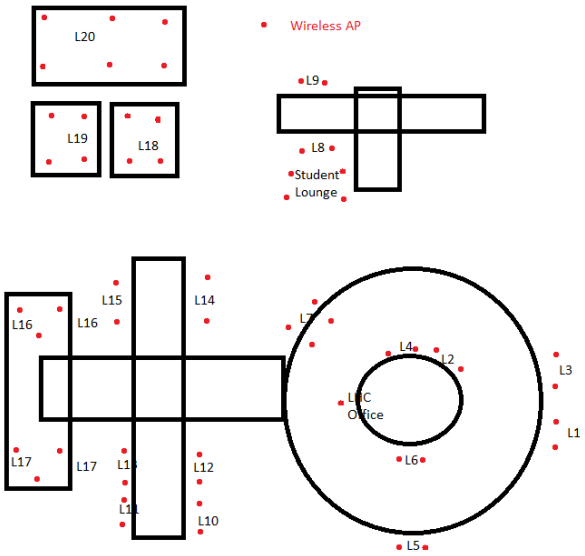

Figure 6: Placement of Wireless AP around LHC

- It should be dual-band(one 2.4GHz and the other 5GHz) because some devices support only 2.4GHz and some only 5GHz. The other reason is that range of 5GHz is very less which will create no WiFi zones in places like corridors. So in such places we can have 2.4GHz by sacrificing speed.
- Support for latest 802.11ac Wave 2 WiFi standard.
- It should contain a feature like Smart Quality of Service which adapt and change its QoS in real time.
- Other more common features like smart connect, Beamforming are a certain advantage. It should also be easily configurable.
- It should be able to serve a large number of users(>100) simultaneously.

Taking account of all these factors we are going to use this WiFi router **Cisco WAP150 Wireless-AC/N Dual Radio Access Point** with PoE available at `http://amzn.in/d/aXhJQuz`. It can serve upto 120 connections per AP.
We need **41** such Wireless AP for our design of LHC.

5 Addressing

An Internet Protocol (IP) address is a unique address assigned to every device on the network so that the packets can be delivered to the intended destination. The Internet uses DNS (Domain Name System) to enable the use words instead of numbers for Internet addresses. The CC will take care of the DNS Servers. The router placed in CC which is connected to the global network will take care of the Subnets and the LHC network will be one of the many subnets present in the campus.

5.1 Static

When a device is assigned a static IP address, the address does not change. Static IP addresses will be used to the Ethernet ports in the LHC to which a wireless AP is connected and some private static IP addresses will be reserved for the future uses such as installation of Wireless CC-TV Cameras, Wireless Printers etc.

5.2 Dynamic

A dynamic Internet Protocol address (dynamic IP address) is a temporary IP address that is assigned to a node when it is connected to a network. The dynamic IP addresses is managed by a Dynamic Host Configuration Protocol (DHCP) server.The main reason behind using dynamic IP addresses is the shortage of static IP address under IPv4. Dynamic IP addresses allow a single IP address to be assigned to different nodes, at different times to solve this problem. We will be using dynamic private IP addresses for the wireless devices that will be connected to the wireless AP in the LHC.

6 Connecting with the outside world

The network of the LHC will be connected to a router in Computer Center via a Layer 3 switch. This router will be connected to the global network. We will be using CAT-7 cables to connect LHC with CC because CAT-7 has a very strong shielding and hence less attenuation even for large distances, which is not in the case of CAT-6 cables. CAT-6a cables can transmit at 10 GBPS just like the CAT-7 cables but only until 100 metres and the distance from CC to LHC is more than 100 metres and hence to prevent anymore attenuation, we will be using CAT 7 cables between LHC and CC.

6.1 Network Address Translation (NAT)

According to Wikipedia, Network address translation (NAT) is a method of remapping one IP address space into another by modifying network address information in the IP header of packets while they are in transit across a traffic routing device. We need NAT because we are using a set of private IP address for the campus. This translation of address will be taken care at the CC, where the main router is connected to the Global Network.

6.2 Proxy Server

There is no need for a separate proxy server for the LHC network. There should be a proxy server administered by the Computer Centre so that people can use them.

7 Summary

Our report covers an overview of setting up the network architecture of the lecture hall complex if it had to be built right from scratch today. We have estimated the number of devices at the time of peak load, and have decided on the structure of the network and the number of switches, wireless access points and LAN ports according to it. We have tried to build a scalable, reliable, manageable and efficient network. We have tried to accommodate the latest and the best technologies keeping in mind the future need, growth and the cost..We proposed to use CAT-7 cabling for connecting our network with the Computer Centre because of its shielding and CAT-6a for connections inside the LHC network because of its cost-effectiveness and future reliability. We will be using a layer3 switch to connect our network w ith the Computer Centre's router, which will be further connected to other switches for providing the LAN ports and wireless AP to all the lecture halls. The firewall, proxy and authentication servers have been assumed to be provided by the Computer Centre.

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