# LAN Design for an Apartment Complex

Abhinav Gupta
IIIT, Hyderabad
abhinav.g@students.iiit.ac.in

## Abstract

*In this work, we present an efficient local area network(LAN) design for an apartment complex. We consider the topological design, the choice of cables, the choice of switching devices and the IP addressing schema while designing the LAN for a society. We present a detailed and meticulous design of our network, discussing the specifics for each of our design choices and supporting it logical and rational reasons.*

## 1. Introduction

### 1.1. Local Area Network

A local area network, known commonly as LAN, is a computer network that interconnects computers within a limited area such as a residence, schools, university campuses, office buildings and apartment complexes. LANs typically connect nearby devices, like those devices in the same room, in the same building, or in a campus of buildings. On the contrary, wide area networks (WAN) connect devices that are relatively at farther distances from one another and cover larger geographical distances. LAN's can beither wired (ethernet) or wireless(wi-fi) and help in the efficient communication of data packets, delivering information from one system to another. Ethernet or wired LANs, as the name suggests, use cables for connecting nodes whereas wireless LANs or wi-fi do not use any cables. Instead, they use radio waves for linking one node to another.

Our objective is to design an efficient and reliable LAN for an apartment complex. We assume that the apartment complex under consideration is a huge building with nine floors, each floor accommodating 14 flats. Each apartment is either a two or three bedroom flat, and there are a total of 14*9 = 126 apartments in the complex. In addition, the complex also houses a gym, a cafeteria and a TV room, all of which have free internet connectivity for the residents of the building with wi-fi access points. We wish to design a LAN that connects the devices in all the apartments for efficient and quick transfer of data. We also assume that each apartment would have a 'mini' LAN network within itself, after all, we live in the 21st century where every member of the household owns atleast one network device, in addition to common devices such as the printer and the television.

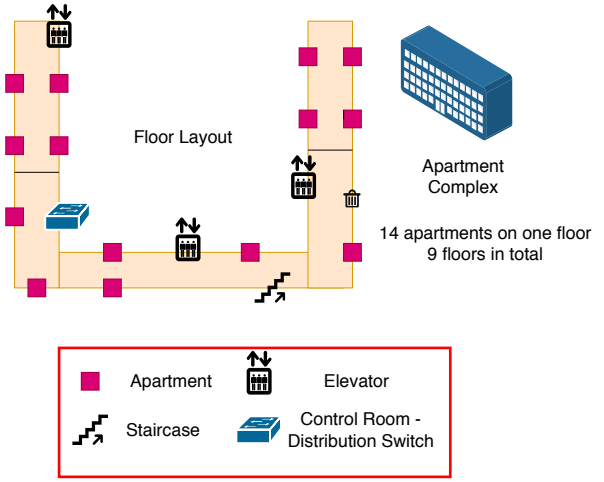


Figure 1. Floor Layout

## 2. Network Design

We shall be using the hierarchical inter-networking model defined by Cisco, which is also known as the 3-tier architecture.

### 2.1. Network Devices

Let us first consider the design of our apartment complex. There are 9 floors, and the layout of each floor is as shown in Fig. 1. We create a grouping based on each floor, and create 9 groups corresponding to the 9 floors, where each group consists of 9 apartments each. We install two distribution switches on each floor (to account for redundancy), which is placed in the control room as shown in Fig. 1. An access switch is then connected from the distribution switches, into each apartment. Hence, for each floor, we have

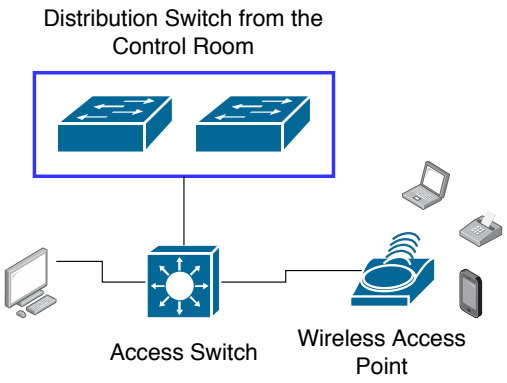


Figure 2. Network Design for each apartment

- 2 distribution switches, which are placed in the control room. These are further connected to the core switches, which is explained later.

- 14 access switches, which are placed in each of the 14 apartments. These are connected to the distribution switches.

The wiring of the building ensures that the distribution switches are connected to the access switches, which are placed in each apartment. However, in today's age of technology, there are atleast 9-10 network devices that are used by an average family. Let's consider a family of three - a father, mother and a 15 year old child. Each of them would own their own smart phone. The parents would share one computer and their child would have another laptop, for his studies. A printer would be attached to the computer system as well. So we have 6 devices in total, but that's not it! We also need to consider the family devices, such as the family iPad, the television and the music speakers. All these devices come today with internet connectivity, so that families can listen to music from the internet, print documents from their smartphones and stream netflix on the television. Hence, it's not feasible to connect so many devices physically to the access switch in an apartment. We require a wireless connection, which enables a large number of devices to be connected to the network.

We propose the use of a wireless access point, popularly known as AP, that should be installed in each home and connected to the access switch. A wireless access point is a networking device which allows other wi-fi devices to connect to a wired network. This way, each device in the home can be connected through wi-fi, with the help of the access point. At the same time, if anyone wishes to physically connect using the ethernet LAN, they can do so by connecting their device directly to the access switch itself. The design for each apartment is shown in Fig. 2.

Figure 3. Cisco SG300-28P 28-Port Gigabit PoE Managed Switch, an access switch which we place in the control room on each floor.

## 2.2. Choice of Devices

### 2.2.1 Access Switches

At the lowermost layer, our access switches are placed in the control room on each floor, and all the WAP's in the apartments are connected to this access switch. We wish to have two outlets in the apartment - one for the WAP and one extra port, in case someone wishes to connect their device directly to the switch without the WAP. Hence, each apartment requires two ports, and all a4 aprtments on the floor would require 28 ports. We can use something like the Cisco SG300-28P 28-Port Gigabit PoE Managed Switch, an ideal choice and a little expensive, but worth spending for the 9 floors of the building. Depending on the requirement, we can choose to have 1000 Mbps or 100 Mbps port speed. Also, it is essential we choose a layer-2 switch for security purposes. This is because the access switches are placed at the user's end and is crucial for network security.

### 2.2.2 Wireless Access Point

Each home has a WAP, which is connected to the access switch from the control room. Since we estimate around 10 devices per home and since all of them would be connected wirelessly, it is advantageous to have a strong WAP in every home. We can use the Cisco Catalyst 9100 Access Points, which is a popular choice for wi-fi's in homes. These access points have higher capacity and better power efficiency. They're also resilient and intelligent and provide integrated security for mobile and IoT devices with rapid threat containment. This is very useful since this is the closest to the end-users, and would play a vital role in keeping the network secure. Also, since this is the time of the coronavirus, we require strong networks at home for video calls and office work. This WAP from Cisco is ideal for work-from-home users who need the enterprise network extended to them.

### 2.2.3 Distribution Switches

Our distribution switch is what connects the access switches on each floor to the router. Our access switches were layer-2, but we must ensure that our distribution switches are layer-3 switches, so as to provide inter-VLAN routing pro-

Figure 4. Cisco Catalyst 9100 Access Points, a good choice for WAP in each apartment.

Figure 5. Cisco Catalyst 8500 Series Edge Platform Model, for the main router.

vision. Since there are total of 18 switches, we are using two distribution switches, each connected to 9 access switches. Hence, a 12 port layer 3 switch, like the x-stack 12-Port SFP Layer 3+ Gigabit Switch would be a nice choice for our design.

#### 2.2.4 Router

And finally, a router is present in the building, which provides the connectivity between our LAN and the WAN, connecting the distribution switches to the internet. We would need a high speed LAN, as there are around 1260 devices which rely on the internet. Since we are using cables to connect the distribution switch to the router, there is no need to have wireless router and we require 2 ports, since there are two distribution switches. We should also use a router that can provide connectivity for landline phones, since some homes may want to use landline. We can choose the Cisco Catalyst 8500 Series Edge Platforms, a new cisco model with upto 120-Gbps Cisco Express Forwarding aggregate throughput.

### 2.3. The Two-Tier Architecture

Network topology refers to the layout of interconnections between

#### 2.3.1 The Two Switch Layers

Let us now provide the overall design for the entire building, to support the devices in every household. We shall

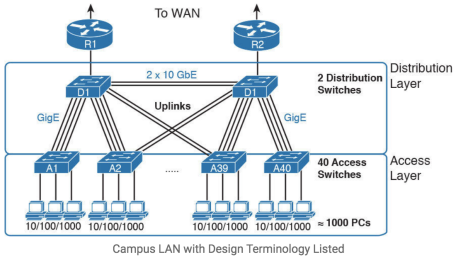


Figure 6. An example of a two-tier architecture, which we are following in our network design, except that we use one router instead of two.

use Cisco's terminology of the three switch layers - access, distribution and core layers, to propose a LAN design for our building. The access layer is basically the end users, and these 'access' switches forward traffic from user devices. The switches in the distribution and core layers forward traffic between other LAN switches. The core layer is the 'upmost', that is, closest to the router and farthest from end user, followed by the distribution layer.

- Access Switch: Switches present in the lowermost layer which connect directly to end users, providing user device access to the LAN. They send traffic to and from the end-user devices and sit at the edge of the LAN.
- Distribution Switch: These switches provide a path through which the access switches can forward traffic to each other. By design, each of the access switches will connect to the distribution switch, which will forward traffic to other parts of the LAN.

#### 2.3.2 Network Topology

Our three tier architecture design highly inspired by Cisco LAN designs has a hybrid topological design. It uses the 'star' topology at the access layer, and a partial 'mesh' topology at the distribution layer. This is because at the access layer, each user device is connected to the access switch. This resembles a star design where all the devices are forming a 'star' around the sun, which in this case, is the access switch. In our design, there is just one additional device - the WAP - which connects all the user devices to the access switch. The distribution layer creates a partial mesh. We have seen earlier in the previous section that we create 2 'groups' of access switches and connect them to the distribution switch. In our building, we have two access switches on each floor, and 18 in total. All of these are connected to two distribution switches (for redundancy), which are further connected to the router.

We can see that this distribution layer is creating a 'partial mesh', that is, a mesh which is not complete. Some

nodes have a link between them and some do not, since an access switch can be connected to only one distribution switch. Our design does not need to use a full mesh topology, as it would results in the creation of a huge network with lots of links and ports, which is not needed in our case. Hence, our two-tier architecture comprising of the distribution and access layer switches is a hybrid topology of star and a partial mesh design.

#### 2.3.3 Why not the 3-tier LAN architecture?

Cisco inspired 3-tier architectures are very popular for designing local area networks. As the name suggests, these include an additional third layer over the two layers proposed in the two-tier architecture: the core layer. A 'core' switch is added to the design, which is used to connect the distribution switches. This is particularly helpful when there are multiple buildings in the campus, whose distribution switches can be connected to one another using a core switch. However for our apartment complex, we only have one building, with 18 access switches and 2 distribution switches! Hence, we don't require this additional layer and it would not be of much use to add a core switch.

## 3. Cabling

Since we have access switches in the control rooms spanning 9 floors, and only two distribution switches, the cables connecting access switch to distribution switch would have to cover longer distances. Using fiber optic cables for this would be expensive, so we must choose something cheaper, but reliable. Also, the distances are not too much that using fiber optic is absolutely essential, since we have access switches on every floor. We can opt for unshielded twisted pair cables or the UTP cables. They are very cheap and not difficult for installing. We can use the category-5 UTP cables, specifically the CAT5e - which provides upto 1Gbps data rate and a maximum length of 100m. CAT5e is the most widely used cabling specification world-wide which replaced the old coaxial cables that were not able to keep up with the constant growing need for faster and more reliable networks.

For the remaining connections, such as distribution switch to router and the WAPs in every home to the access switch, we decide to spend a little more and use Fiber Optic cables. This is the backbone cabling, which connects every home to the switch, and hence must have the best bandwidths. These are the best cables with the greatest life spans, and to ensure the longevity of our building and its network, it's useful to have fiber optic cables. We can use the multi-mode fiber optic cables, specifically the OM3 cables which are capable of running 10 Gigabit Ethernet at lengths up to 300 meters. 10 Gigabit Ethernet is its most common use. Multi-mode is cost effective for installations where the lengths don't exceed a few hundred meters, which is the case in our building where access switches are placed in every control room.

## 4. IP Addressing Schema

IP address is a distinctive numerical symbol allotted to every device on a network to spot each affiliation without any ambiguity. For our LAN design of the apartment complex, we consider all devices in the network to run on IPv4 addressing. We use the classless addressing in our LAN, because this removes any constraints on the length of the addresses. We can specifically choose the number of bits that represent the network and host addresses. This way, we can fine tune the adresses for our building, thereby reducing the wastage in excess host addresses.

#### 4.0.1 Why not classful addressing?

As explained above, we can spcify the number of bits we require for the addresses, which is not possible in case of classful addressing. We have seen in Sec. 1 that there are, on an average, 10 devices per household. Since there are 126 apartments in this building, we have a total of 1260 devices connected to the LAN. We know that IPv4 addresses are divided into 5 classes. The first two classes would allow a huge number of addresses, which are greater than 60k, leading to a massive wastage of addresses as we only require around 1300. The later classes are ¡500, which aren't sufficient. Hence, it is best for us to use classless addressing IPv4 schema.

#### 4.0.2 Static vs Dynamic IP Addressing

Static IP addresses don't keep changing, that is, it can't be modified once it's provided. Each system would be assigned a fixed IP address for a protracted amount of time, and this address is provided by the ISP. On the contrary, dynamic addresses changes often whenever the system is booted. These addresses are mechanically allotted and provided by the DHCP (Dynamic Host Configuration Protocol). In general, static IP addresses are less secure and the cost to maintain these is more. Whereas in dynamic IP address, there is lower amount of risks and is easier to designate. Moreover, the device designed by static IP address can be traced, which is not the case for dyanamic IP.

Static IP addresses are highly useful for business offices and hosting servers, whereas dynamic is better suited for residential areas and homes. Hence, we'll be using an IP addressing schema which is dynamic and classless. There are around 1260 devices connected in the building, we can use a 11-bit host address, since 2 multipled 11 times is 2048, which is greater than 1260. Hecne, 32-11 = 21, and we can use 21 bit network address. We can assume 10.0.0.0/21

be our first IP address, then we will have 2048 subsequent addresses. And we can dynamiccaly allocate these classless addresses to all users in the building!

### 4.1. References


- https://www.internold.com/lesson/analyzing-ethernet-lan-designs/tab-con-10
- https://www.geeksforgeeks.org/difference-between-static-and-dynamic-ip-address/
- https://www.internold.com/lesson/fundamentals-of-ethernet-lans/