LAN DESIGN

- Akshat Goyal (2018101075)

AIM

The aim is to design an efficient and reliable Lan Network for the Aakash Colony, Kurukshetra with the following main components.

1. Topology Design
2. Choice of cables at various levels
3. Choice of networking devices - types/category of devices, port speed, hub/switch, etc.
4. IP Addressing Schema

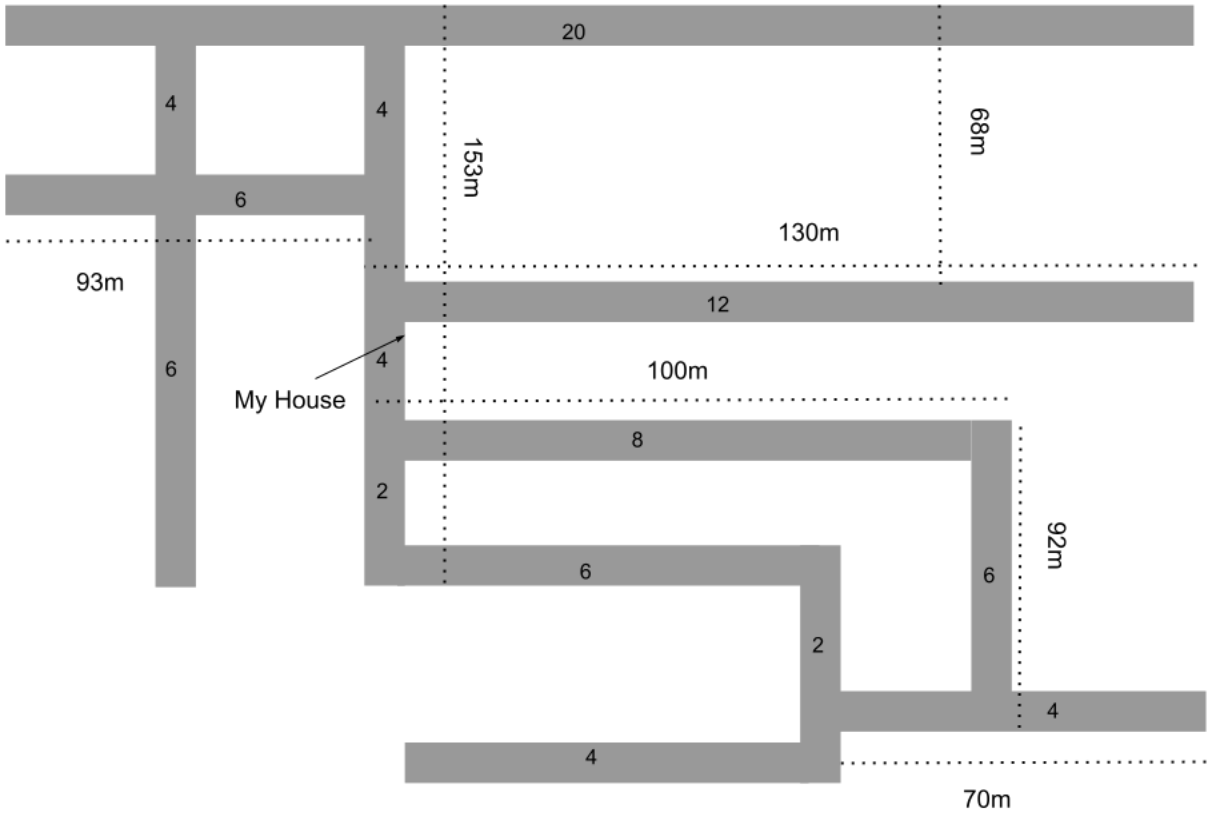
GOALS

The purpose of this design is to achieve following basic requirements.

1. Fair Availability: The topology of the Lan should be such that every household of the colony is easily connected to the Lan and has fair access to it.
2. Cost: Construction and maintenance of the design should be cost effective.
3. Bandwidth: The network should provide good bandwidth for different types of work like web surfing, gaming, video streaming, and allow people to work from home.
4. Security: The network should be secure from any cyber attacks and should ensure privacy to all the users.

5. Troubleshooting: It should be easy and cheap to troubleshoot failures.
6. Scalable: The design needs to be easily scalable to the future requirements and advancements.

COLONY STRUCTURE



1. This is the rough map of the colony taken from the google map. This map is not drawn to scale but measurements taken from the google map gives some idea of the size.

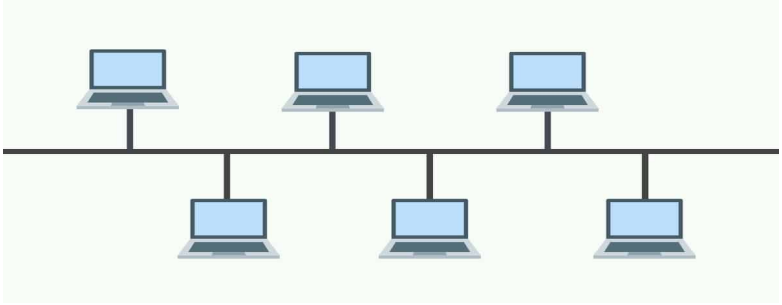
2. Gray blocks represent the streets and numbers written on them represent rough estimates of buildings. This colony is not very old and so there are less no. of buildings built here.

3. There are on average 4-5 members in each house and 7-8 devices per house. There are around 80 houses and 8 shops. On an average, 400 people and 640 devices in this colony.

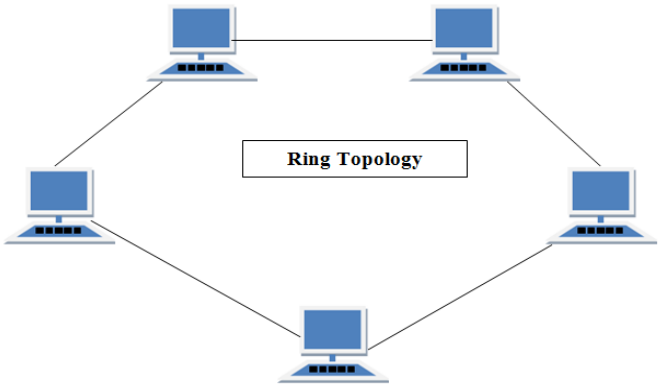
4. Many more buildings will be built here and so our LAN design should be scalable.

NETWORK TOPOLOGY

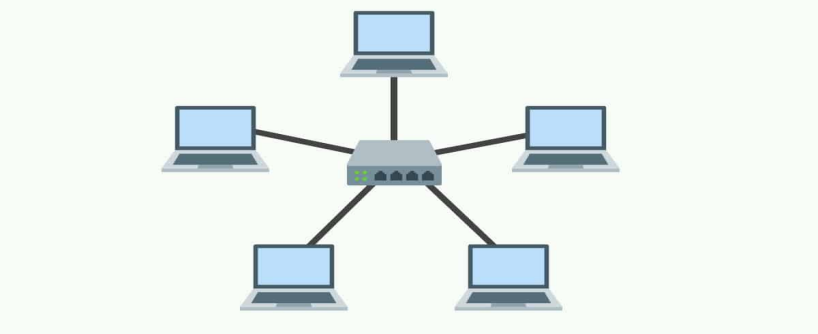
1. **Bus Topology:** Bus topology is a network in which all the nodes are connected to a single backbone cable by a drop cable or directly connected to it. It has a simple architecture but it is limited to a smaller network and has difficult troubleshooting.



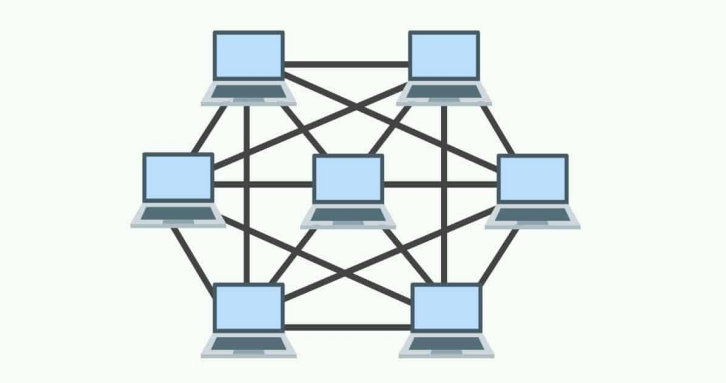
2. **Ring Topology:** In ring topology, each device is connected to two other devices in either side of it forming a ring like structure. It is easy to install and scale but a single link failure leads to failure of the whole network.



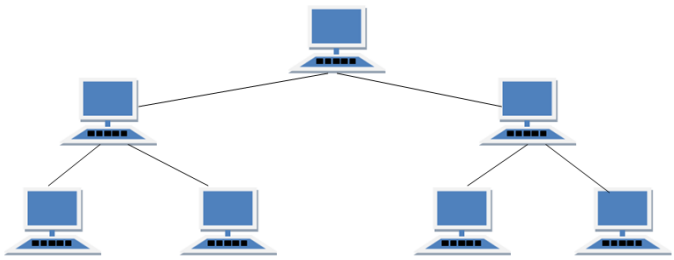
3. **Star Topology:** In star topology, each node is connected to the central device called hub/switch. It is scalable, easier to install but if the hub goes down, everything goes down.



4. **Mesh Topology:** In mesh topology, each node is connected to every other node on the network through point-to-point link. It is robust to failures but it uses a large amount of wires and therefore not scalable.



5. **Tree Topology:** Tree topology is a structure in which all the nodes are connected in a tree fashion with one node being root and others descendant. This topology is flexible and the amount of wires are less than mesh but failure of a single node disconnects its ascendant from its descendants.



6. **Hybrid Topology:** It is a topology with the mixture of two or more above topologies. We will use tree topology with partial mesh topology at top levels of the tree.

NETWORK DEVICES

Hubs and Switches are the LAN devices that connect various nodes to a single network to communicate with each other.

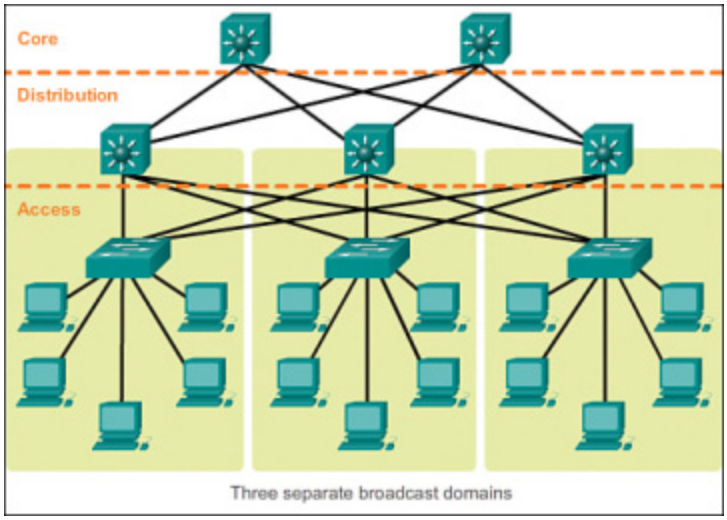
1. **Hub:** Hub operates on a physical layer. It is a half duplex transmission mode. It doesn't understand the MAC address and hence can't filter packets. In Hub, there is one collision domain and it is not efficient to use this device.

2. **Switch:** Switch operates on a data link layer. It supports full duplex transmission mode and can filter packets. In Switch, different ports have their own collision domain and it is a lot more efficient than Hub and hence we will use Switch.

HIGH-LEVEL ARCHITECTURE

Modern LAN designs use Switched Ethernet and a hybrid topology of tree with a partial mesh topology at top levels of the tree topology.

1. **Three-Tier Architecture**

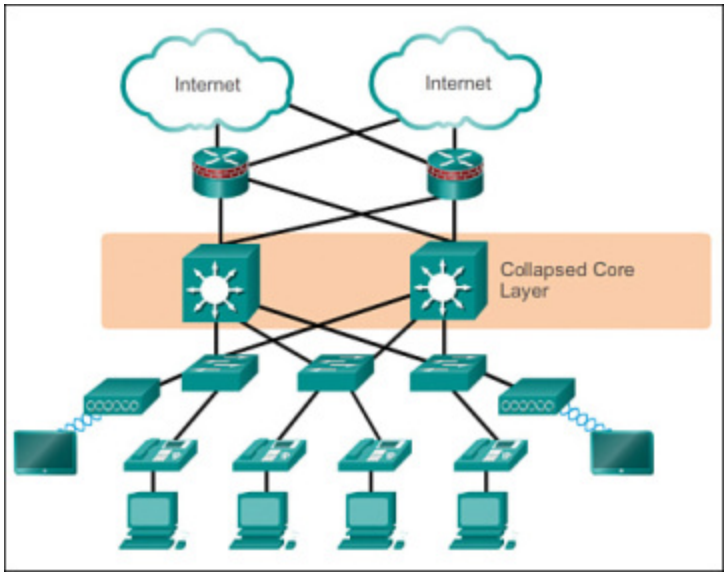


This architecture involves dividing the network into discrete layers where each layer has a specific function. At each layer, local traffic remains local and traffic that is destined for other networks is moved to a higher layer.

This network design includes the following three layers:

1. **Access Layer:** Provides user access to the network. All the hosts are connected here.
2. **Distribution Layer:** Provides policy-based connectivity and controls the boundary between the access and core layers.
3. **Core Layer:** Provides fast transport between distribution switches.

2. **Two-Tier Architecture or Collapsed Core Architecture**



In this, the core and distributed layer's functions are implemented by a single layer called Collapsed Core Layer. This is used when the network is small and will not grow over time. The motivation is reducing network cost while maintaining most of the benefits of the three-tier model.

Final Decision

The size of the colony is large with some streets quite large and apart from each other. So, we will group some streets to have lower two levels of architecture and will connect them using core switches to form three-tier architecture.

CABLING

Cabling has to be performed as per the Structured Cabling System (SCS). SCS is defined as building or campus telecommunications cabling infrastructure that consists of a number of standardized smaller elements (structured).

Need for Structured Cabling System:

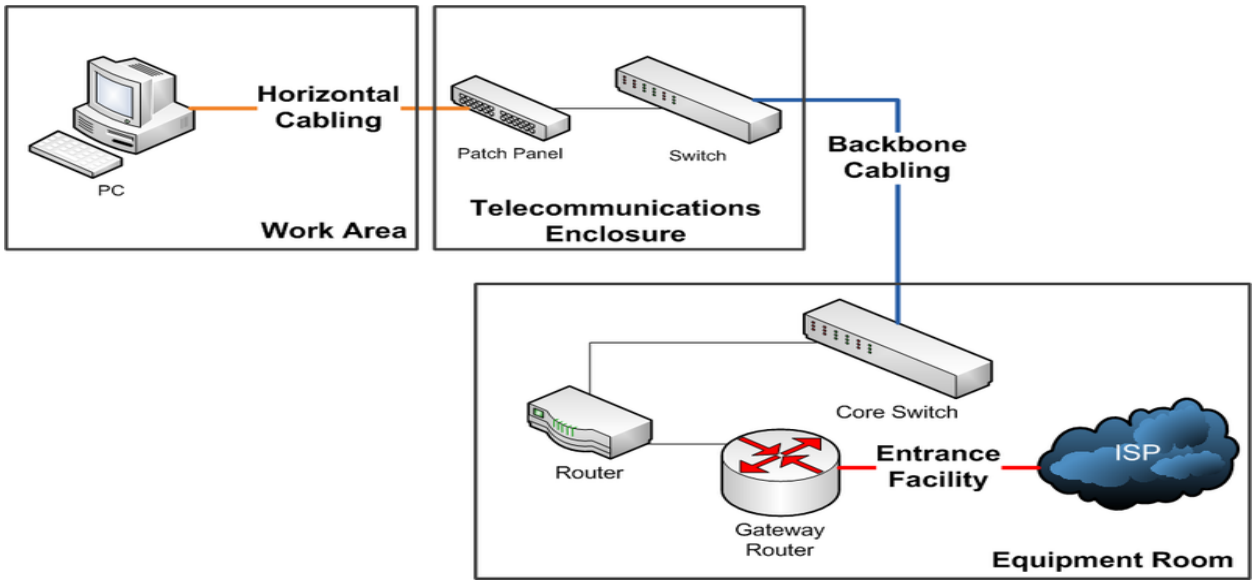
1. **Smaller Risk of Downtime:** With messy cabling, you run the risk of accidentally unplugging the wrong cable or any other kind of human error. Structured cabling is totally organized, minimizes the risk of human error.

2. **Time Saving:** This system offers a high level of simplicity and is far easier to identify the issue and solve it with structured network cabling. This means far less time and money lost in the long-term.

3. **Enhanced Flexibility:** It can quickly and easily accommodate moves, adds and changes which dramatically reduces installation time and ensures optimum adaptability to any network infrastructure changes. The flexibility also makes the system easy to take apart and move to a new office location.

4. **Future Proof:** Structured cabling system has the high bandwidth which makes it scalable and can respond quickly to industry changes.

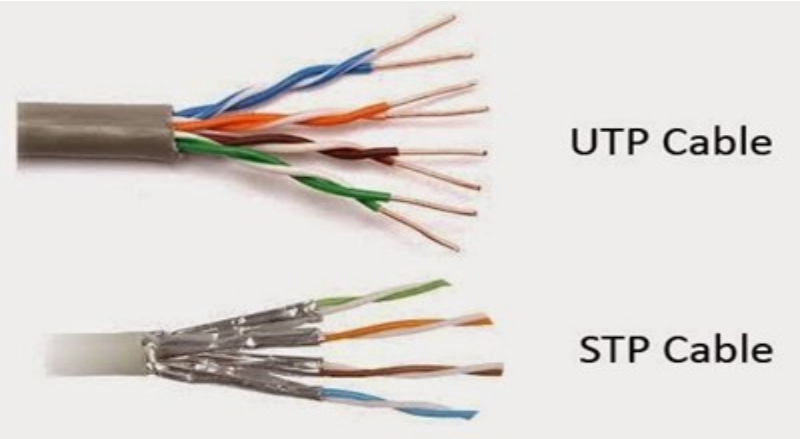
5. **Better Return of Investment:** Structured Cabling System reduces power and maintenance costs and eliminates the money spent on locating and rectifying any issues.



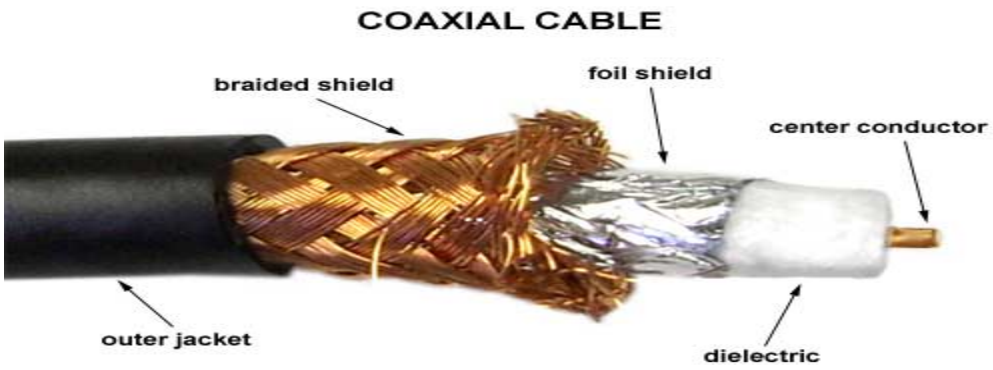
Types of Cables:

We will discuss two major type of cables:

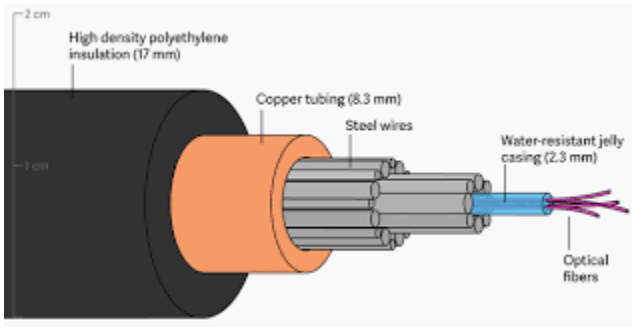
1. **Twisted-Pair Cables:** This cable consists of color-coded pairs of insulated copper wires. Every two wires are twisted around each other to form a pair in a regular spiral/helical form. Usually, there are four pairs. Each pair has one solid color and one striped color wire. Solid colors are blue, brown, green and orange. In striped color, the solid color is mixed with the white color.
   There are two types of twisted-pair cable; UTP and STP.
   1. **Unshielded Twisted-Pair:** All pairs are wrapped in a single plastic sheath.
   2. **Shielded Twisted-Pair:** Each pair is wrapped with an additional metal shield, then all pairs are wrapped in a single outer plastic sheath.



2. **Coaxial Cables:** Copper core, surrounded by an insulating material, encased by a cylindrical conductor (wire mesh), covered in a protective plastic sheath. They carry high-frequency electrical signals with low loss.



3. **Fibre Optic Cable:** Glass core, surrounded by a glass cladding of a lower index, covered by thin plastic jacket, protected by a sheath. Core carries the data signals in the form of light, cladding reflects light back to the core using internal reflection, the buffer protects the light from leaking, the jacket protects the cable from physical damage. There are two types of optical fibres:
    1. Multi-Mode Optical Fibres: Cheaper, suitable for shorter distance.
        a. Graded Index
        b. Step Index
    2. Single-Mode Optical Cables: Covers larger distance.



Final Decision:

1. Horizontal Cabling: UTP cables.
    a. We are not using STP as UTP cables are cheap and STP is used for noise reduction which is not a requirement in a colony.
    b. There are different types of UTP cables varying in bandwidth and carrying capacity. Cat5e cables support 100 Mbps which is

good enough for many households, but some may require more speed and so, unshielded Cat6 cable is the best option as it supports 10Gbps for upto 55 meters and 1Gpbs for long cables. So people can choose from Cat5e or Cat6 UTP cables.

2. Backbone Cabling: Fibre Optic Cables.
   We will use multimode optical fibre cable as they are cheaper than single mode optical fibre and suitable for shorter distances (1km).

COMPONENT SELECTION

1. **Access Switches:** We will use TP-Link TL-SG1008D Access Switch.

   a. It is 8 10/100/1000 Mbps Gigabit Ethernet Unmanaged Desktop Switch.

   b. Auto-negotiation, 80% power saving, cheap.

   c. It will support 4 houses, 2 ports per house. So we need 20 such switches.

2. **Distribution Switches:** We will use Cisco SG350-10MP Switch.

a. 8 x 10/100/1000 PoE Ports.

b. Supports Static routing, QoS, Voice/Guest VLAN, IPv6.

c. Advanced 802.1x, Web-based Authentication, IP Source Guard, IPv6 First Hop Security, Dynamic ARP Inspection.

d. We will use 4 switches of this type for better distribution though we require only 3 as more buildings will be built in coming time. So each switch supports 5 access switches for now.

3. **Core Switches:** We will use Cisco Catalyst 6509-E switch.

a. It has 9 ports of 10/100/1000, 1G, 10G, 40G ports.

b. Forwarding capacity up to 510 Mpps

c. 4 distribution switches will be connected to a single core switch.

4. **Wireless Access Point:** We will use TP-Link 300Mbps Wireless N Ceiling Mount Access Point.

a. Supports Passive PoE, Long Range Coverage, Secure Guest Network.

b. As each house has 7-8 devices and 2 ports of access switch, each house needs one WAP for wireless network which will connect to one port. Second port can be used by households to connect to devices directly by wire in case they need fast internet.

IP ADDRESSING SCHEMA

We will use an IPv4 address for the colony.

1. **Classful Addressing:** IPV4 address is divided into 5 classes from A to E.
    a. Class D is for multicasting and Class E is reserved.

    b. Class A with a mask of 255.0.0.0 supports 16,777,214 addresses, Class B with a mask of 255.255.0.0 supports 65,534 addresses which is quite large for our purpose and lead to wastage of many addresses.

    c. Class C provides 254 addresses which is not enough, so we may need many Class C addresses. Classful addressing is not efficient for LAN at our scale.

2. **Classless Addressing:** In Classless Inter-Domain Routing (CIDR), we can get variable length subnet masks leading to less wastage of IP addresses.
    a. **Static IP addressing:** It is provided by ISP. Each system is assigned a static IP address which can't be changed over time. It is less secure and costly.

    b. **Dynamic IP addressing:** It is provided by DHCP server and address changes over time. It is more secure, less costly and suitable for our purpose.

We are using Dynamic classless addressing. We need to support around 700 devices and they will increase over time. We can use a subnet mask of /21 which will support 2^11 - 2 = 2046 host addresses.

Let the network address be 127.0.0.0/21. We can use address space from 127.0.0.0/21 to 127.0.7.255/21.