Advanced Computer Networks

INDRANIL PRADHAN
Roll - 2019202008
M.Tech, CSIS

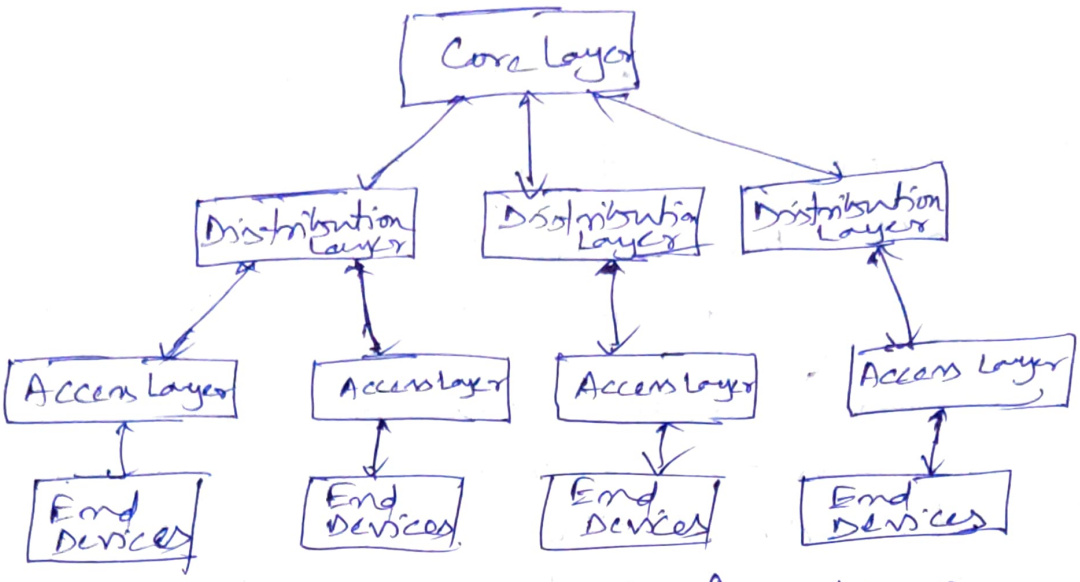
Design LAN for your Locality.

(1) Topological Design :-

Area Description :-

I live in Colony area. There approximately are 250 houses. And all the houses are not uniformly distributed in the area. There are some areas with dense areas where several houses are densed. And there are ~~areas~~ areas where the number of houses are less. Because of lockdown many of professionals are doing work from home. There are IPTVs in several houses. And there are houses ~~who~~ who need internet connection for normal use. Considering all these scenarios I have designed LAN connection for our gated community and the design has been considered on the ~~need~~ priorities of need of internet connection.

Hierarchical Design ⇒



The design I have used to design LAN Connection in my area is Hierarchical design.

Hierarchical design consists of three Layers Access Layer, Distribution Layer and core Layer.

Each Layer does its part to efficiently deliver frames to intended LAN destination in the model.

The access layer is mainly responsible to enable users to access the network. The access layer includes user's work area.

The distribution Layer serves as the merging point for access layer switches. The uplinks from access Layer switches terminates at distribution Layer switch. The distribution Layer is responsible for policy enforcement and inter VLAN routing.

The core layer is merging point for distribution Layer devices and high speed Network redundant network backbone. The benefits of the hierarchical design:—

1) Manageability :- Switches at diffent layers make the network more manageable.

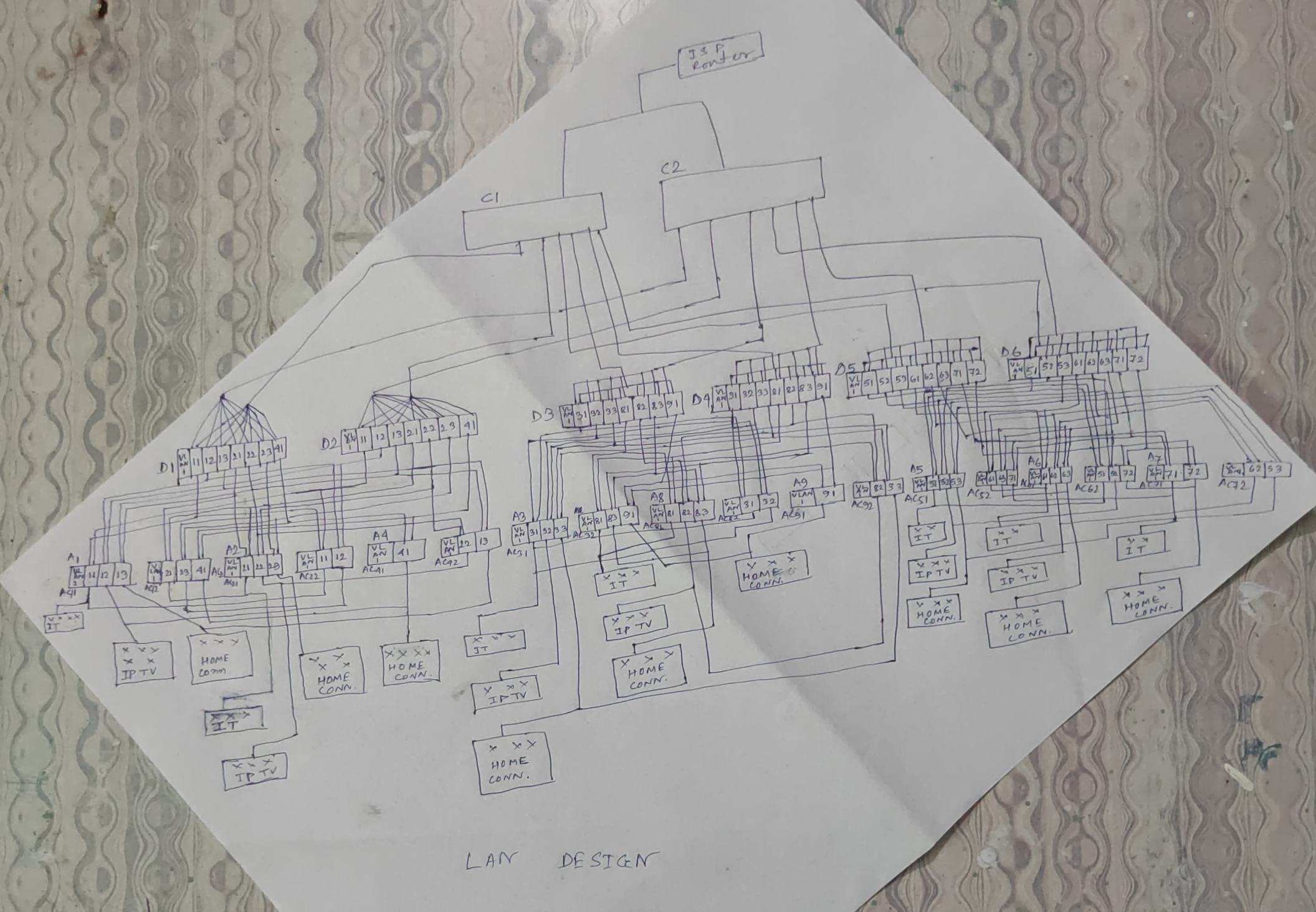
2) Redundancy :— Redundency at the core layer and distribution layers ensure path availability.

3) Security :- Port security and policy enforcement at distribution layer makes network more secure.

4) Maintainance :- Modularity at design makes the maintainance easy.

5) Scalability :- It is expand to the network.

6) Performance :— Link aggregation high performing core and distribution Layer enhances the performance.


ISP Router
C1
C2
D1
D2
D3
D4
D5
D6
A1
A2
A3
A4
A5
A6
A7
A8
A9
IT
IP TV
HOME CONN.
LAN DESIGN

Design Explaination ⇒ Based on the geographical density of the area I have divided the whole area into multiple sub areas. These are A1, A2, A3, A4, A5, A6, A7, A8, A9.

Area A1, A3, A5 has 40 houses on average out of which 10 houses with IT professionals in diagram it is mentioned as "IT". 10 houses with IPTVs in diagram it is mentioned as "IP TV" and 20 houses with normal internet connection in diagram it is mentioned as "HOME Conn." on average.

Area A2, A6, A8 has 7 houses with IT professionals, 5 houses with IPTVs, and 18 houses with normal interconnection on average.

Area A7 has 2 houses with IT professionals and 18 houses normal internet connection.

Area A4 and A9 has 10 houses with normal home internet connection.

For each area there acces level switches.

For Area A1, A3, A5 there is acces level switch AC11, AC31, AC51.

Based on the network usage I have logically grouped "IT", "IPTV" and "HOME Conn" into VLANs. In Acces Layer switches. These are static VLAN.

Like for Access Layer switch AC11, the "IT"s have been grouped into VLAN 11. The "IPTV"s' been grouped into VLAN 12 and Normal home connections have been grouped into VLAN 13.

Similarly for Access Layer switches AC31 and AC51 as :-

AC31
- VLAN 31 - "IT"s
- VLAN 32 - "IPTV"s
- VLAN 33 - "HOME Conn"s.

AC51
- VLAN 51 - "IT"s
- VLAN 52 - "IT"s
- VLAN 53 - "HOME Conn"s.

For area A2, A6, A8 the access Layer switches are AC21, AC61, AC81.

Similarly based on the need of the internet usage & have logically grouped the "IT"s, "IPTV"s. and "HOME Conn."s in VLANs. as.

AC21
- VLAN 21 - "IT"s
- VLAN 22 - "IPTV"s
- VLAN 23 - "HOME Conn"s

AC61
- VLAN 61 - "IT"s
- VLAN 62 - "IPTV"s
- VLAN 63 - "HOME Conn"s

AC81
- VLAN 81 - "IT"s
- VLAN 82 - "IPTV"s
- VLAN 83 - "HOME Conn"s.

For Area A7, similarly 9 have also logically grouped "IT" and "HOME conn". in Access Layer switch AC71

AC71 VLAN 71 → "IT's
VLAN 72 → "HOME conn"s

For Area A4 and A9, as there are only houses with normal home connections., so 9 have single VLAN for "HOME conn"s. in Access Layer switches AC41 and AC91.

AC41 VLAN 41 - "HOME conn"s

AC91 VLAN 91 - "HOME conn"s.

There other Access Layer switches. AC12, AC22, A32, AC42, AC52, AC62, AC72, AC82, AC92. These switches are used for redundancy such as when one line/switch gets down this redundant VLANs with switches does not allow the network to get hamper.

AC12 VLAN 21 → Redundant for VLAN 21 in AC21.
VLAN 23 → Redundant for VLAN 23 in AC21.
VLAN 41 → Redundant for VLAN 41 in AC41

AC22
VLAN 11 → Redundant for VLAN 11 in AC11.
VLAN 12 → Redundant for VLAN 12 in AC11.

AC32
VLAN 81 → Redundant for VLAN 81 in AC81
VLAN 83 → Redundant for VLAN 83 in AC81
VLAN 91 → Redundant for VLAN 91 in AC91

AC_{42}
VLAN 22 → Redundant for VLAN 22 in AC 21
VLAN 13 → Redundant for VLAN 13 in AC 11.

AC_{52}
VLAN 61 → Redundant for VLAN 61 in AC_{61}
VLAN 63 → Redundant for VLAN 63 in AC_{61}
VLAN 71 → Redundant for VLAN 71 in AC 71

AC_{62}
VLAN 51 → Redundant for VLAN 51 in AC_{51}
VLAN 52 → Redundant for VLAN 52 in AC_{51}.
VLAN 72 → Redundant for VLAN 72 in AC 71.

AC_{72}
VLAN 62 → Redundant for VLAN 62 in AC_{61}
VLAN 53 → Redundant for VLAN 53 in AC_{51}

AC_{82}
VLAN 31 → Redundant for VLAN 31 in AC_{31}
VLAN 32 → Redundant for VLAN 32 in AC_{31}

AC_{92}
VLAN 82 → Redundant for VLAN 82 in AC_{81}
VLAN 33 → Redundant for VLAN 33 in AC_{31}.

In the distribution layer also I have used switches with redundancy. The distribution switches D1 & D2 will collect VLANs from Access layer switches redundantly, the access layer switches are AC_{11}, AC_{12}, AC_{21}, AC_{22}, AC_{41} and AC_{42}, and the VLANs are VLAN 11, 12, 13, 21, 22, 23, 41.

Similarly the distribution Layer switches D3 & D4 will collect VLANs from Access Layer switches redundantly. The access layer switches are AC31, AC32, AC81, AC82, AC91, AC92 and the connected VLANs are VLAN 31, 32, 33, 81, 82, 83, 91.

Similarly the distribution Layer switches D5 & D6 will collect VLANs from Access Layer switches. The access layer switches are AC51, AC52, AC61, AC62, AC71, AC72. and the collected VLANs are VLAN 51, 52, 53, 61, 62, 63, 71, 72.

Finally the distribution Layer switches are connected to the two core layer switches. Here two core layer switches C1 and C2, have been used for Redundancy. such that if one switch gets down or any link from C1 gets down C2 can serve the same purpose.

VLAN 1 in switches is used to manage the VLANs.

Redundancy :-

From the diagram it can be observed, every VLANs from access layer switches are connected to two different distribution layer switches.

And every VLAN has been used redundantly in two different access layer switches. Every VLAN has two copies in two different access layer switches.

Consider Access layer switch AC_{11} gets down, the VLANs in AC_{11}, 11 and 12 has copies in AC_{22} and 13 has copy in AC_{42}. So the houses in area A1 will not face any disconnectivity.

Again suppose, the connection between VLAN 11 in AC_{11} and Distribution layer switch D1 gets down, then the redundant line between VLAN 11 in AC_{11} and D_2 can serve the purpose.

For every distribution Layer switch also there is one redundant switch. For D1 it is D2. For D3, it is D_4. And for D5 it is D_6.

If one the switch gets down in distribution Layer, the other redundant switch can take its place and serve the same purpose as before.
In core layer also, redundant switch have been used to keep the connection up all the time.

Spanning Tree Protocol :- Because of redundancy path in each layer, it is highly likely to form loop in the network i.e. the packet does not get transferred to the desired destination.
To tackle this, the spanning tree protocols will be using. This protocol enables one single path for the frame to reach to the destination this prevent from looping.
Let, D1 switch gets down, then, spanning Tree protocols will now calculate the path using D2 switch to reach VLAN 11 in AC11.

Trunking :-

Between Access Layer switches and Distribution Layer switches and between Distribution Layer switches and Core Layer switches IEEE standard Trunking protocol, 802.1q has been used. This trunking has been done in

redundant way such that if one trunk gets down other can serve the purpose.

While using VLAN, the VLAN adds few extra field with normal ethernet framing. The fields are Tag type, Priority, CFI, VLAN Identifiers. Trunking can handle multiple VLANs packets simultaneously. And VLAN's priority field can be useful to set the VLAN priority as we have grouped "IT", "IPTV" and "HOME Conn" in different VLANs. And this priority field classifies one VLAN's precedence over the another VLAN's precedence.

This concept is also used in Trunk to handle congestion. The lower priority VLAN gets dropped in order to avoid congestion, so the higher priority VLAN gets transfered.

The spanning Tree protocol will run on whole Trunks rather than on individual VLAN within a trunk.

2. Choice of Cable at various Levels:

Cable Types Used :-

10 Base FL :-

1) Fibre optic cable.
2) Range of upto 2 km.
3) Single mode, Full duplex.
4) Transmission mode Baseband.
5) Connector SC, ST.
6) Speed - 10 Mbps

100 Base FX :-

1) IEEE standard for running Fast Ethernet over fiber-optic cable.
2) Single mode, Full duplex.
3) Range of upto 10 Km.
4) Transmission mode Baseband.
5) Connector SC, ST.
6) Speed 100 Mbps.

1000 Base LX

1) Transmission mode Baseband
2) Long wave length.
3) Single mode fiber.
4) Rang upto 5 Km.
5) Two 10-micron single mode optical Fibers.
6) Fiber Connectors
7) Speed 1000 Mbps.

10 G Base LR

1) Long wave length
2) Single mode Fiber
3) Full duplex
4) Speed 10 Gbps
5) Range upto 10 kms.

Access Layer Switch to End devices:

There three types connection is provided to end devices, as - "IT", "IPTV" and "HOME Conn.". "IT" and "IPTV" has ~~been provid~~ subscribed for 25 Mbps as they need high speed internet connectivity And normal "HOME Conn" is provided with 2 Mbps as it does not high speed internet connectivity.

For houses with "IT" and "IPTV" it is full duplex connection. so, at any time there will be transmission of total bandwidth is 2*25 = 50 Mbps.

So, 100 BaseFX cable is used for it. For 100 BaseFX almost 40-50% bandwidth is used efficiently rest of bandwidth is used because of congestion.

For houses with normal "HOME Conn", it is full duplex connection and so, at any given time total bandwidth is 2*2 = 4 Mbps.. Here 10 BaseFL cable is used. As of 10 Bas FL cable 40-50% is used only for transmission and rest bandwidth is wasted because of congestion.

Access Layer to Distribution Layer

Uplinks bandwidth needed for different access layer switches -

AC_{11} → 540 Mbps
For Full duplex → 2×540 = 1080 Mbps

AC_{12} → 231 Mbps
For Full duplex → 2×231 = 462 Mbps

AC_{21} → 436 Mbps
For Full duplex → 2×436 = 872 Mbps

AC_{22} → 500 Mbps
For Full duplex → 2×500 = 1000 Mbps

AC_{41} → 20 Mbps
For Full duplex → 2×20 = 40 Mbps

AC_{42} → 265 Mbps
For Full duplex → 2×265 = 530 Mbps

AC_{31} → 540 Mbps
For Full duplex → 2×540 = 1080 Mbps

AC_{32} → 231 Mbps
For Full duplex → 2×231 = 462 Mbps

AC_{81} → 436 Mbps
For Full duplex → 2×436 = 872 Mbps

AC_{82} → 500 Mbps
For Full duplex → 2×500 = 1000 Mbps

AC_{91} → 20 Mbps
For Full duplex → 2×20 = 40 Mbps

AC_{92} → 265 Mbps
For Full duplex → 2×265 = 530 Mbps

AC_{51} → 540 Mbps
For Full duplex → 2×540 = 1080 Mbps

AC_{52} → 231 Mbps
For Full duplex → 2×231 = 462 Mbps

AC_{61} → 436 Mbps
For Full duplex → 2×436 = 872 Mbps

AC_{62} → 536 Mbps
For full duplex → 2×536 = 1172 Mbps
AC_{71} → 86 Mbps
For full duplex → 2×86 = 172 Mbps
AC_{72} → 265 Mbps
For full duplex → 2×265 = 530 Mbps.

For uplinks of access layer switches AC_{12}, AC_{42}, AC_{32}, AC_{92}, AC_{52}, AC_{72}, AC_{71}, the 1000 Base LX cable is used considering that it is full duplex transmission and only 40-50% of total bandwidth will be used and rest of bandwidth is wasted due to congestion.

For uplinks of AC_{41}, AC_{91}, the 100 Base FX cable is used considering it is full duplex transmission and only 40-50% of total bandwidth is used and rest of the bandwidth is wasted due to congestion.

For uplinks of access layer switches AC_{11}, AC_{21}, A_{22}, AC_{31}, AC_{81}, AC_{82}, AC_{51}, AC_{61}, AC_{62}, the 10G Base LR is used considering it is a full duplex transmission and only 40-50% of total bandwidth is used and rest of the bandwidth is wasted due to congestion.

Distribution Layer to Core Layer :-

Uplinks bandwidth needed for distribution Layer switches as follows

For, D_1 ; D_2 → 1992 Mbps

For full duplex → 2 × 1992 = 3984 Mbps

For D_3, D_4 → 1992 Mbps

For full duplex → 2 × 1992 = 3984 Mbps

For D_5, D_6 → 2094 Mbps

For full duplex → 2 × 2094 = 4188 Mbps.

For uplinks of distribution Layer switches D_1, D_2, D_3, D_4, D_5, D_6 → the 10 GBase LR cable is used considering it is full duplex transmission and 40-50 % of total bandwidth only used for transmission and rest of the bandwidth is wasted due to congestion.

3. Choice of switching devices:-

Access Layer Switches:-

Access Layer switches should have VLAN capability. Sufficient port density in access layer is necessary.

The switch I have chosen for access layer switch is -

Cisco SF 220 48P

The reason behind choosing the switch for access layer :-

1) Ports → 48 Fast Ethernet Port, and 2 Gigabit Ethernet.
2) Forwarding Rate - 10.12 mpps.
3) Switching Capacity - 13.6 Gigabits per second
4) there may be upto 8192 MAC Addresses in MAC Table.
5) Support Spanning Tree Protocol.
6) Support Link aggregation upto 8 groups.
7) Support upto 256 VLANs simultaneously
8) Voice traffic is automatically assigned for QoS.
9) Support Jumbo Frame upto 9216.
10) Loopback detection against loops on which loop protection is enabled.
11) If crossover happens in cable it automatically adjusts transmit and receive pairs.

12) DROP or rate limit based on source and destination MAC, VLAN ID, IP address, port, TCP/UDP source and destination port, ICMP.

13) Lock the MAC addresses to Ports.

14) MAC address Filtering.

15) Support Broad cast, Multicast and unknown unicast.

16) DOS attack prevention.

17) Provides protection against Layer 2 forwarding Loops.

18) SSH for secure Telnet traffic.

19) Encrypts all HTTPS traffic.

20) Maintain priorities queues, There are 8 queues per port.

21) Provides class of service based on Port, VLAN priority, IPV4/IPV6 precedence, ToS, DSCP-service.

22) Controls rate for per VLAN, per port and flow-based.

23) IGMP packets limits bandwidth intensive multicast traffic to only the requester, 256 There are 256 multicast groups.

24) IGMP querier is used to support a Layer 2 multicast domain in case of mulicast router is absent.

25) Supports IPV6 addresses, IPV4/IPV6 dual stack, ICMP version 6, MTU discovery.

26) D Limit IPV6 packets flow and Prioritizes IPV6 packets.

27) Deliver IPV6 Multicast packets to requester only.

28) Built on switch configuration utility for browser. based device configuration.

29) Config files can be edited with text editor.

30) Support SNMP version 1, 2c and 3 and SMP version 3 user based security Model..

31) Supports 4 Remote Monitoring group (history, statistics, alarms and events) for traffic management.

32) Supports Port Mirroring.

33) DHCP options gives tighter option to obtain IP address from DHCP server.

34) Does time synchronization using SNTP.

35) The switch has capability to advertise it self.

36) Supports Energy Efficiency Ethernet on all ports.

37) Automatically turns off power on gigabit Ethernet when Link down is detected.

38) All ports support POE.

39) Packet Buffer of 12 Mb.

40) Supported SFP Modules are single Mode fider, Multimode fiber, UTP cat 5.

41) Operating Temparature 0-50°C

42) Operating Humidity 10%-90%.

43) Power Consumption is EEE + Energy detect green power mode. The system consumes 39.5W on 110 V. and power consumption with (POE) is 413 W for 110 V. and Heat dissipation is 1409.2 BTU/hr.

44) Fan of 4 pcs/9500, The noise level is 39 dB when temperature < 39°C, 50.3 dB when temperature is 32°C - 40°C and 52 dB when temperature is >40°C.

45) MTBF at 50°C is 210,753 hours.

* Distribution Layer Switches :-

Distribution Layer switches must have fast-forwarding Rates. as these switches aggregate traffic from multiple access layer switches. Here Port density is not as important as access layer switches. Layer 3 switching should be considered And As VLAN and trunking is done access layer switches, then VLAN and should configured on Distribution Layer switch.

Keeping all this mind I have chosen switch for distribution Layer -

CISCO Catalyst 2960 XR - 24PS - I

The reason behind choosing the switch :-

1) the number of 10/100/1000 Ethernet ports i'm 24.
2) 4 Fixed 10 gigabit Ethernet SFP uplinks.
3) IP Lite Cisco IOS Image is loaded with the switch.
4) The available POE power is 370W.
5) The power supply is 640 WAC.
6) The Flex Stack plus and Flex Stack Extended capabilities are present.
7) Web UI is present for easy on boarding with dashboard configuration
8) Bluetooth is present for over the air access.
9) SSH for telnet is provided.
10) Cisco DNA centre is provided for day-zero plug and play, switch discovery and management, topology visualization, software image management.
11) Cisco network plug and play is present.
12) FlexStack-Plus provides 80 Gbps stack bandwidth and supports upto 8 switch stack.

13) Flex Stack Extended provide stack bandwidth of 40 Gbps and stack limit upto 8.

14) The Full Netflow and Netflow lite gives provision to IT teams to understand the mix of traffic on their Network.

15) The DNS-AS provides a centralized means of controlling the identification and classification of trusted Network

16) OSPF, PIM, PBR, RIP V1 and V2 is supported.

17) The RIPng, EIGRP stub, EIGRP V3 stub and PIM V6 stub for IPV6 also supported.

18) Intelligent POE+ IEEE 802.3af and IEEE 802.3at are supported.

19) MAC based VLAN Assignment.

20) Uses security Group Exchange protocol to simplify security and podicy Enforcement throughout the network.

21) 802.1x feature to control access on the network.

22) Cisco threat Defence features which including Port security, Dynamic ARP inspection, IP source guard.

23) Supports Unicast Reverse Path Forwarding.

24) Have access control list for VLAN, Router, Port-based,

25) SPAN to allow cisco IDS to take action for intruder.

26) BPDU Guard to shut down SP Tree Port Fast - enabled interfaces when BPDU's are received to avoid ~~congestion~~ topology loops.

27) Eight egress queues per port and the queues are priority queue which highest priority packet gets served first.

28) Shaped Round Robin and Weighted Tail Drop to avoid congestion.

29) Flow-based rate limiting.

30) Supports 802.1p COS and DSCP classification.

31) CIR function, provides bandwidth in increments as low as 8 Kbps.

32) Rate limiting based on source and destination IP address, source and destination MAC address, TCP/IP information.

33) Cisco HSRP to create redundant, fail safe routing topologies.

34) Switch-port auto-recovery automatically attempts to reactivate a link that is disabled because of network error.

35) Power Redundancy with an option to power supply alternatively.

36) DTP • enables trunking accross all ports.,
37) Forwarding bandwidth - 108 Gbps
38) Switching bandwidth - 216 Gbps.
39) MTU - L3 packet - 9198 bytes.
40) Maximum - Active VLAN - 1023.
41) Forwarding Rate - 71.4 Mpps.
42) Operating temperature upto 1500m - -5°C to 45°C. and upto 3000m is -5°C to 40°C.
43) Storage temperature upto 4573 m is -25°C to 70°C.
44) Operating Relative humidity is 10% to 95%. and storage relative humidity is 10% to 95%.
45) Acoustic noise, the maximum sound pressure is 43 dB and sound power is 5.5B.
46) MTBF - 321, 290 hours.

Core Layer Switches :-

Core Layer switches should include 1 Gaigabit or even 10 gigabits per seconds link to accomodate large traffic. that will traverse the network backbone. It should also support Layer 3 support, Link aggregation and very high forwarding rates should also be implemented.

Keeping all these in mind I have decided to use the switch -

Cisco Catalyst WS-C6503-E

The reason behind chosing this switch is -

1) 3, 4, 6, 9, 9-V and 13-slot modular chassis.
2) Delivers upto 2 terabits per second of system bandwidth and 80 Gbps per-slot for all slots.
3) This switch scales to high density 40 gigabit Ethernet, 10 Gigabit Ethernet and Gigabit Ethernet configurations.
4) It supports Redundant control channel.
5) It supports Redundant supervisor engine option.
6) It supports Redundant power supply option.
7) Supports hot-swapable fan trays.

~~The 6500-V-E provides for redundant, hot-swapable fan trays.~~

~~8) It has 6509-V-E~~

8) Supports both AC and DC power supply. Supports mixing of both also.

9) MTBF - 860,868 hours.

10) Input Voltage needed 100 to 240 VAC

11) Operating Temperature 0 to 40°C

12) Storage Temperature -20°C to 65°C

13) Thermal Transition is 0.5°C per minute while hot to cold and 0.33°C per minute while cold to hot.

14) Relative humidity - 5% to 90% noncondensing. for operating. And for non operating and storage it is 5% to 95% noncondensing.

15) A system configured for VSS has a system capacity of 4 terabits per second of system bandwidth and 480 Gbps of per slot bandwidth.

4. IP Addressing Scheme :-

Routing Protocol :-

I have break up my topological design in multiple areas. The area under distribution layer switches D_1, D_2 is one area, the area under D_3, D_4 is another area and the area under D_5, D_6 is another area.

Based on this I have used multiarea OSPF as my rounting protocol.

The area under D_1, D_2 belongs to Area 1.

The area under D_3, D_4 belongs to Area 2.

The area under D_5, D_6 belongs to Area 3.

These area needs to communicate with each other through an Area 0 backbone area. This Area 0 backbone area is through core layer. These areas will core layer as backbone Area 0.

Switch D_1, D_2 will work as ABR for Area 1.

Switch D_3, D_4 will work as ABR for Area 2

Switch D_5, D_6 will work as ABR for Area 3.

IP Addressing and Subnetting:

So I have divided the topological design in OSPF area.
The area under D1, D2 switches belongs to Area 1.
The area under D3, D4 switches belongs to Area 2.
The area under D5, D6 switches belongs to Area 3.

The unregistered class C Addresses range from 192.168.0.0 through 192.168.255.0.
Consider Area 1 ⟹
The distribution switches D1 and D2 is aware all the VLANs under them ie. VLAN. 11, 12, 13, 21, 22, 23, 41.
I have given 192.168.1.0/24 subnet Area 1.
All the End Devices are logically grouped to VLANs
Each VLAN will be assigned with subnet for its use.
Now consider the VLANs and their number of End devices

VLAN	Number of Devices	IP Subnet
11 →	10	→ 192.168.1.32/28
12 →	10	→ 192.168.1.48/28
13 →	20	→ 192.168.1.0/27
21 →	7	→ 192.168.1.184/29
22 →	5	→ 192.168.1.176/29
23 →	18	→ 192.168.1.128/27
41 →	10	→ 192.168.1.160/28

Consider Area 2 ⟹
The distribution switches D3, D4 in Area 2 is aware of all its VLANs. i.e. VLAN 31, 32, 33, 81, 82, 83, 91.
& have given the subnet 192.168.2.0/24 to Area 2.
All the end devices are logically grouped to VLANs.
Each VLAN is assigned with subnet for its use.
Now consider the VLANs and their number of end devices.

VLAN	Number of Devices	IP Subnet
31 →	10 →	192.168.2.32/28
32 →	10 →	192.168.2.48/28
33 →	20 →	192.168.2.0/27
81 →	7 →	192.168.2.184/29
82 →	5 →	192.168.2.176/29
83 →	18 →	192.168.2.128/27
91 →	10 →	192.168.2.160/28.

Consider Area 3 ⟹
The distribution switches D5, D6 in Area 3 is aware of all its VLANs i.e. VLAN 51, 52, 53, 61, 62, 63, 71, 72.
& have given the subnet 192.168.3.0/24 to Area 3.
All the end devices are logically grouped to VLANs.
Each VLAN is assigned with subnet for its use.

Now consider the VLANs and their number of end devices.

VLAN		Number of Devices		IP Subnet
51	→	10	→	192.168.3.32/28
52	→	10	→	192.168.3.48/28
53	→	20	→	192.168.3.0/27
61	→	7	→	192.168.3.184/29
62	→	5	→	192.168.3.176/29
63	→	18	→	192.168.3.128/27
72	→	18	→	192.168.3.192/27
71	→	2	→	192.168.3.224/30

Broad Casting :-

Here the whole network is subdivided into multiple small networks i.e. sub network assigned to each VLAN.

Similar kind of end devices, in a area are grouped into VLANs and kept under same subnetwork.

So it becomes easy for ISP to broadcast any packet intended for a set of users not broadcasting the whole network which greatly reduces from using bandwidth for broadcast packets.

DNS

The DNS name-to address maps are stored in the local cache of end devices.

DHCP

At distribution layer, the switches have knowledge about all the VLANs and the subnets assigned with those VLANs.

So, I prefer to keep DHCP server at Distribution Layer switches rather than having a DHCP server for the whole network.
This gives modularity to the network and enhances the manageability.

Suppose, one end device has been connected to the VLAN 11 under access layer switch AC$_{11}$.
The end device broadcasts to all-hosts to find the DHCP server with setting source address as 0.0.0.0 as it does not know its IP address till now.
The access layer switch forwards this request and this switch with its DHCP option, obtains IP address from DHCP server in Distribution Layer for the End device.
So free IP address from 192.168.1.32/28 subnets get assigned to the end device

Default Gateway :-

In this design, while end device wants to send the packet to destination which not in local LAN segment and sends out ARP packet, it doesn't receive any response.
So, the switch allows the end device to use its own interface as Proxy ARP to send the request to find the destination.