2022

Network Design

CIS 3347-16667

TRINITY KLEIN

UNIVERSITY OF HOUSTON | Professor Jose Martinez

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Professor Jose Martinez
4 December 2022

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Contents

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Overview

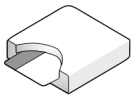
This design is meant to be the best possible scenario for a college apartment network, for it to give high speed and reliable performance for as many students, staff, and guests as possible. It was made to function like a hotel-type network where hospitality would be important over cost-effectiveness because of the luxury nature of the apartments. This network design will mostly follow the Cisco Hybrid Campus LAN Design Guide and other field deployment guides seen on the Cisco website.

All my recommendations for both network devices and accessories will be included in the total cost of the network design section. The diagram will be a general guide to my network design, including the placement of the access points, switches, routers, and ethernet cables. It is not meant to be a very detailed diagram only a rough summary.

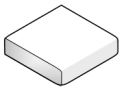
The general notation used for the IP subnets will follow the recommendations set out by IPCISCO (IPCISCO, 2022).

The following key will be used to graphically depict all parts of the network:

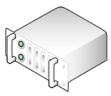
Network Design Key



This is used to represent a MR30H Wireless Access Point.



This is used to represent a MR53 Wireless Access Point.

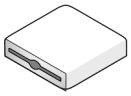


This is used to represent a MX250 Router.

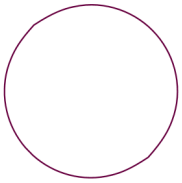
The Red Lines are Ethernet Cables.
The Black Lines are the cables that connect multiple of the switches together.
The Purple Lines are the cables to external power supplies.

This pictures is used to represent a stack of C9500 Switches.

This pictures is used to represent multiple power supplies.



This is used to represent either a MS930 or C9300 Switch.



This is used to represent the approximate coverage area of the wireless access points.

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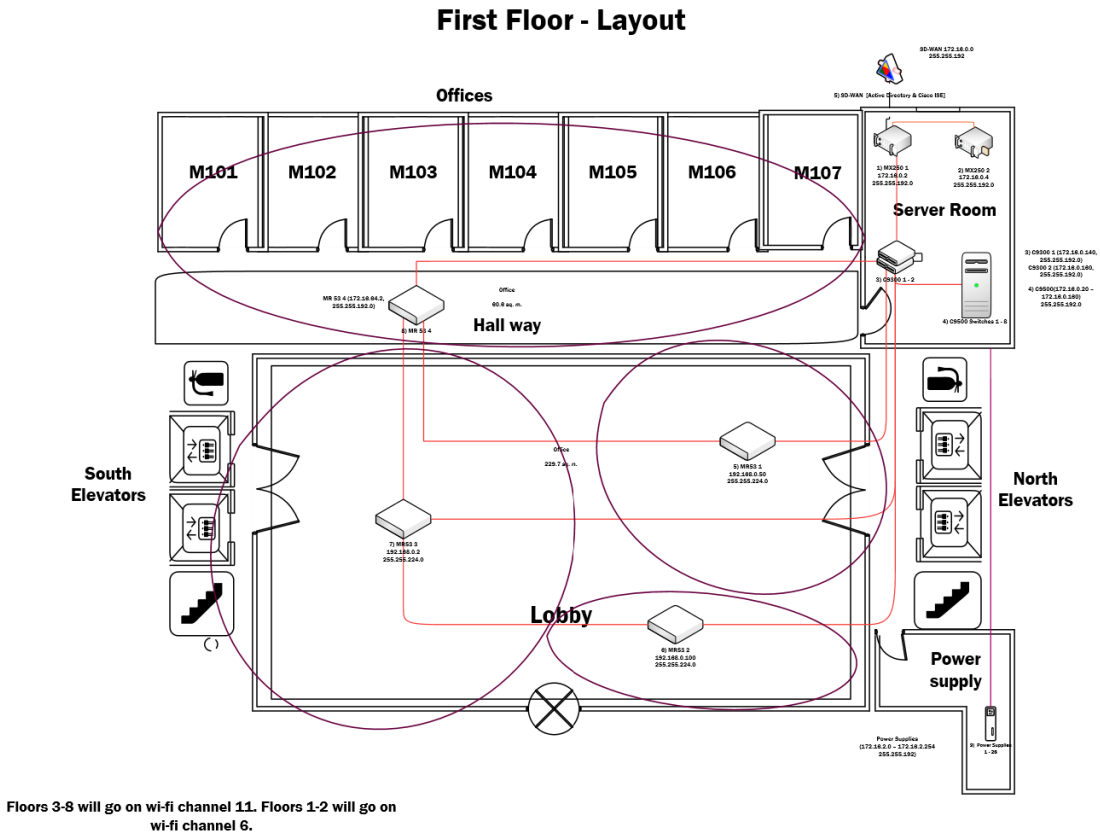
First Floor Layout



According to the Cisco Hybrid Campus LAN Design Guide (CVD), it's meant to create a campus network by interconnecting a group of LANs that are spread over a local geographic area (*Hybrid Campus LAN Design Guide (CVD)*, 2022). Its design is meant to provide a network foundation and services that enable tiered LAN connectivity, Wired network access for employees, IP Multicast for efficient data distribution, and Wireless and Wired infrastructure ready for multimedia services (*Hybrid Campus LAN Design Guide (CVD)*, 2022). The Meraki Dashboard is used cloud monitor all Cisco Catalyst devices (*Hybrid Campus LAN Design Guidinto(CVD)*, 2022). It will offer valuable insight into visibiintoty and configuration items (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

Layer 2 Access with a Native VLAN Design should offer flexibility in terms of network segments as the VLANs span over different stacks and closets (*Hybrid Campus LAN Design Guide (CVD)*, 2022). The Layer 2 Access with a Native VLAN will facilitate wireless roaming across the whole campus, easy deployment,

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consistent configuration across the entire campus LAN, and flexibility in the VLAN design, at the expense of slow convergence, tricky STP configuration, the possibility of VLAN hopping, and non-deterministic route failover (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

Layer 3 access design should extend the OSPF domain to the core layer and offer fast convergence because it will rely on ECMP and not on STP later 2 paths (*Hybrid Campus LAN Design Guide (CVD)*, 2022). But Layer 3 access will not offer great flexibility in the VLAN because it cannot span between multiple stacks and closets (*Hybrid Campus LAN Design Guide (CVD)*, 2022). It will have deterministic router failover, and fast convergence, and will rely on stacking or gateway redundancy at the upper layers (*Hybrid Campus LAN Design Guide (CVD)*, 2022). But it will also VLANs will not be able to span multiple stacks, and the backbone areas can be unmanageable and will be a concentrator for layer 3 roaming (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

Also, it recommends the deployment of an SD-Wan, which would include a cloud active directory and Cisco ISE as a part of a license (*Hybrid Campus LAN Design Guide (CVD)*, 2022). This will help secure the network to prevent unwanted traffic or IP addresses (*Hybrid Campus LAN Design Guide (CVD)*, 2022). All licenses are generally deployed by device and not by the whole network (*Meraki Per-Device Licensing Overview*, 2022).

The networks' structure would include two MX250, one functioning as the main router and the other being a warm spare (*Hybrid Campus LAN Design Guide (CVD)*, 2022). Because of the luxurious nature of the apartment, it would be expected that if any problems happen with the router, there will be a spare that is constantly ready (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

The rack of C9500 will be the main switch rack that will connect all the floor switches to the main router to properly distribute potential network traffic throughout the building (*Hybrid Campus LAN Design Guide (CVD)*, 2022). The C9300 switches and MS390 switches will be the floor switches that will connect to all the access points used (MR30H and MR53) to the main rack of switches that then connect to the router (*Hybrid Campus LAN Design Guide (CVD)*, 2022). The number of switches and access points deployment is made based on the assumption of about two thousand users being in the building at once, which is about the highest number of people that will be in the building at once (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

The Wi-Fi Channels used should be 1, 6, or 11 to help better distribute network traffic (*Why Channels 1, 6 and 11? | MetaGeek*, n.d.). The reference tables will define all IP addresses and subnets. Cloud monitoring will be included to check the visibility

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and configuration of items for the switches (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

Reference Tables

Table 1: 176.16.0.0 Subnet Results

Network Address	172.16.0.0
Usable Host IP Range	172.16.0.0 – 172.16.63.254
Broadcast Address	172.16.63.255
Total Number of Hosts	16,834
Number of Usable Hosts	16,832
Subnet Mask	255.255.192.0
Binary Subnet Mask	11111111.11111111.11000000.00000000
IP Class	B
CIDER Notation	/18
IP Type	Private

Table 2: All Possible Networks for 172.16.x.x

Network Address	Usable Host Range	Broadcast Address
172.16.0.0	172.16.0.1 - 172.16.63.254	172.16.63.255
172.16.64.0	172.16.64.1 - 172.16.127.254	172.16.127.255
172.16.128.0	172.16.128.1 - 172.16.191.254	172.16.191.255
172.16.192.0	172.16.192.1 - 172.16.255.254	172.16.255.255

Table 3: 192.168.0.x Subnet Results

Network Address	192.168.0.0
Usable Host IP Range	198.168.0.1 – 192.168.31.254
Broadcast Address	192.168.31.255
Total Number of Hosts	8,192
Number of Usable Hosts	8,190

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Subnet Mask	255.255.224.0
Binary Subnet Mask	11111111.11111111.11100000.00000000
IP Class	B
CIDER Notation	/19
IP Type	Private

Table 4: All Possible Networks for 192.168.x.x

Network Address	Usable Host Range	Broadcast Address
192.168.0.0	192.168.0.1 - 192.168.31.254	192.168.31.255
192.168.32.0	192.168.32.1 - 192.168.63.254	192.168.63.255
192.168.64.0	192.168.64.1 - 192.168.95.254	192.168.95.255
192.168.96.0	192.168.96.1 - 192.168.127.254	192.168.127.255
192.168.128.0	192.168.128.1 – 192.168.159.254	192.168.159.255
192.168.160.0	192.168.160.1 – 192.168.191.254	192.168.191.255
192.168.192.0	192.168.192.1 - 192.168.233.254	192.168.223.255
192.168.224.0	192.168.224.1 - 192.168.155.254	192.168.255.255

Table 5: All Possible DCHP Range for 172.16.x.x & 192.168.0.x

Network Component	Host Range
Visitors Wi-Fi	192.168.0.2 – 192.168.0.254
Wired Network	172.16.64.1 – 172.127.254
Employees & Residents	172.16.192.2 – 172.16.255.254

Table 6: Floor 1 Hardware Recommendations

Hardware	IP	Subnet	Type	Location
MX250 1	172.16.0.2	255.255.192.0	Network	Floor 1
MX250 2	172.16.0.4	255.255.192.0	Network	Floor 1
SD-WAN	172.16.0.0	255.255.192.0	Network	Floor 1
C9300 1	172.16.0.140	255.255.192.0	Network	Floor 1
C9300 2	172.16.0.160	255.255.192.0	Network	Floor 1
C9500 1	172.16.0.20	255.255.192.0	Network	Floor 1
C9500 2	172.16.0.40	255.255.192.0	Network	Floor 1
C9500 3	172.16.0.60	255.255.192.0	Network	Floor 1
C9500 4	172.16.0.80	255.255.192.0	Network	Floor 1
C9500 5	172.16.0.100	255.255.192.0	Network	Floor 1

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C9500 6	172.16.0.120	255.255.192.0	Network	Floor 1
C9500 7	172.16.0.140	255.255.192.0	Network	Floor 1
C9500 8	172.16.0.160	255.255.192.0	Network	Floor 1
MR53 1	192.168.0.50	255.255.224.0	Network	Floor 1
MR 53 2	192.168.0.100	255.255.244.0	Network	Floor 1
MR 53 3	192.168.0.2	255.255.244.0	Network	Floor 1
MR 53 4	174.16.64.2	255.255.192.0	Network	Floor 1

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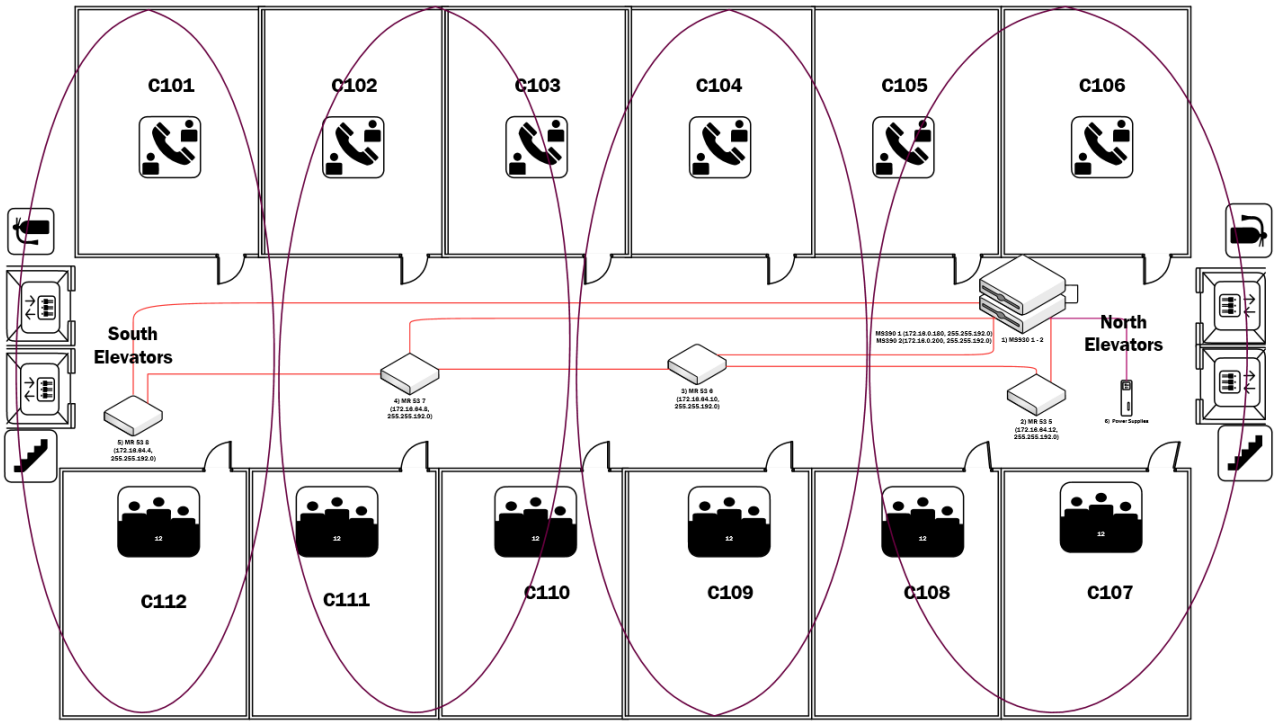
Second Floor – Conference & Office Area Layout

Second Floor - Layout



According to the Cisco MR Hospitality Deployment Guide, for the best wired and wireless experience in conference facilities, the MR53 needs to be deployed (*MR Hospitality Design Guide (CVD)*, 2022). This is because conference rooms need to be able to handle from ten to two-hundred people at once (*MR Hospitality Design Guide (CVD)*, 2022).

The MR53 access points are made to handle higher amounts of network traffic that may include the use of virtual conferencing applications, film editing software, or high-graphic applications in general (*MR Hospitality Design Guide (CVD)*, 2022). Thus, they are the ideal candidate for use in conferencing rooms (*MR Hospitality Design Guide (CVD)*, 2022).

To get the best coverage and high-performance access points, ideally, the access points should be placed on the ceiling and in the hallways to prevent any object that will block the coverage (*MR Hospitality Design Guide (CVD)*, 2022). The two MR390 switches help handle all possible network traffic, because of the possibility of people using high data-consuming applications (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

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There will be four MR53 that will connect to two MS390 switches that will then connect back to the main rack of switches on the first floor.

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Reference Tables

Table 7: Floor 2 Hardware Recommendations

Hardware	IP	Subnet	Type	Location
MS930 1	172.16.0.180	255.255.192.0	Network	Floor 2
MS 390 2	172.16.0.200	255.255.192.0	Network	Floor 2
MR 53 5	172.16.64.12	255.255.192.0	Network	Floor 2
MR 53 6	172.16.64.10	255.255.192.0	Network	Floor 2
MR 53 7	172.16.64.8	255.255.192.0	Network	Floor 2
MR 53 8	172.16.64.4	255.255.192.0	Network	Floor 2

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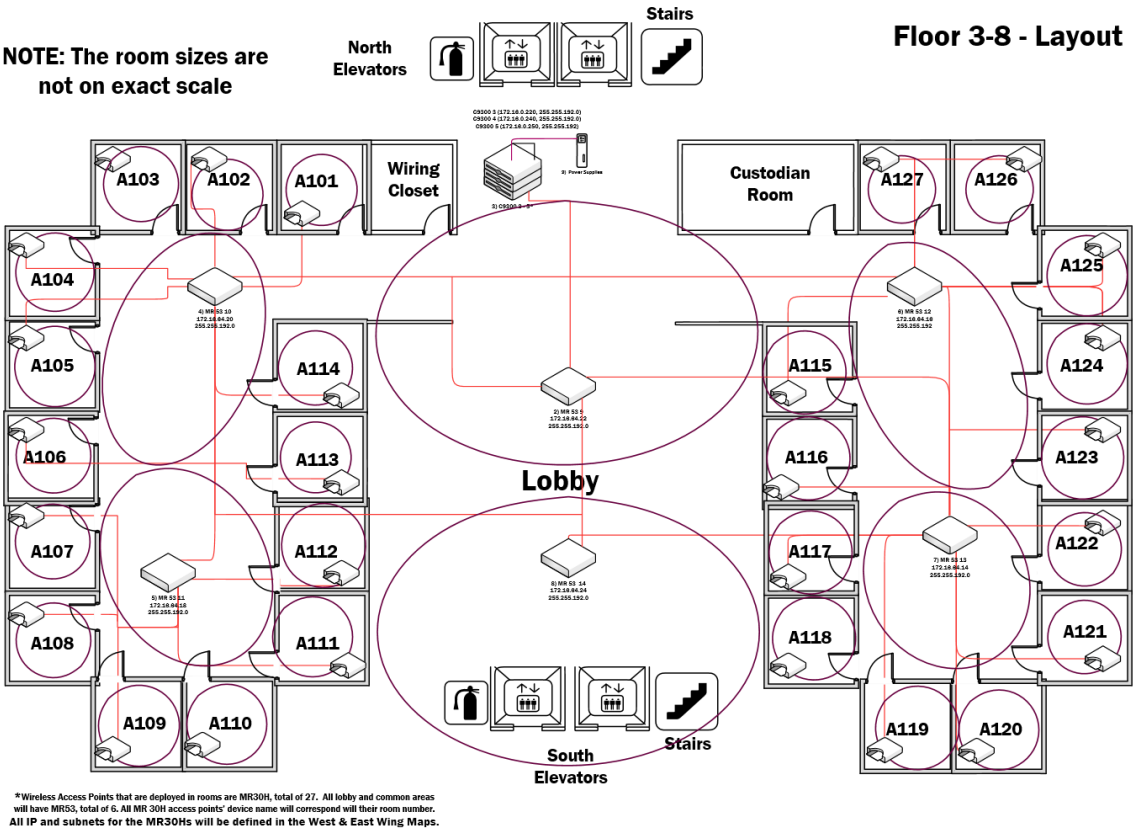
Floor 3 to 8 Layout



According to the Cisco MR Hospitality Deployment Guide, for the best wired and wireless experience will be achieved by putting the access points directly into every dorm (MR Hospitality Design Guide (CVD), 2022). It allows for every student to have the highest signal strength and performance in their room (*MR Hospitality Design Guide (CVD)*, 2022). Also, it saves on cabling costs since it only requires only a single Ethernet cable to run to the desk area of each guest room (*MR Hospitality Design Guide (CVD)*, 2022). The MR30Hs that are deployed can provide both wireless and wired network access over a single Ethernet that runs into each room (*MR Hospitality Design Guide (CVD)*, 2022). To provide coverage in the lobby or common area, infrastructure-based access points are deployed for seamless roaming, in this case, they are the MR53 (*MR Hospitality Design Guide (CVD)*, 2022).

To reduce co-channel contention between rooms, Auto Channel and Auto Transmit power is used (*MR Hospitality Design Guide (CVD)*, 2022). Cisco Meraki MR access points have a third dedicated scanning radio that will help optimize the RF performance of each access point, which a minimum bitrate of 18Mbps or 24Mbps (*MR Hospitality Design Guide (CVD)*, 2022). To prepare for a large amount of network traffic due to online schooling and

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assignments, a stack of three C9300 switches will be deployed on each floor (*Hybrid Campus LAN Design Guide (CVD)*, 2022).

The IP address and subnets inside the room will be defined in the west and east wing maps.

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Table 8: Floor 3– 8 Hardware Recommendations

Hardware	IP	Subnet	Type	Location
C9300 3	172.16.0.220	255.255.192.0	Network	Floors 3 - 8
C9300 4	172.16.0.240	255.255.192.0	Network	Floors 3 - 8
C9300 5	172.16.0.250	255.255.192.0	Network	Floors 3 - 8
MR 53 9	172.16.64.22	255.255.192.0	Network	Floors 3 - 8
MR 53 10	172.16.64.20	255.255.192.0	Network	Floors 3 - 8
MR 53 11	172.16.64.18	255.255.192.0	Network	Floors 3 - 8
MR 53 12	172.16.64.12	255.255.192.0	Network	Floors 3 - 8
MR 53 13	172.16.64.14	255.255.192.0	Network	Floors 3 - 8
MR 53 14	172.16.64.24	255.255.192.0	Network	Floors 3 - 8
MR 30H A101	172.16.1.101	255.255.192.0	Network	Floors 3 - 8
MR 30H A102	172.16.1.102	255.255.192.0	Network	Floors 3 - 8
MR 30H A103	172.16.1.103	255.255.192.0	Network	Floors 3 - 8
MR 30H A104	172.16.1.104	255.255.192.0	Network	Floors 3 - 8
MR 30H A105	172.16.1.105	255.255.192.0	Network	Floors 3 - 8
MR 30H A106	172.16.1.106	255.255.192.0	Network	Floors 3 - 8
MR 30H A107	172.16.1.107	255.255.192.0	Network	Floors 3 - 8
MR 30H A108	172.16.1.108	255.255.192.0	Network	Floors 3 - 8
MR 30H A109	172.16.1.109	255.255.192.0	Network	Floors 3 - 8
MR 30H A110	172.16.1.110	255.255.192.0	Network	Floors 3 - 8
MR 30H A114	172.16.1.111	255.255.192.0	Network	Floors 3 - 8
MR 30H A115	172.16.1.112	255.255.192.0	Network	Floors 3 - 8
MR 30H A116	172.16.1.113	255.255.192.0	Network	Floors 3 - 8
MR 30H A117	172.16.1.114	255.255.192.0	Network	Floors 3 - 8
MR 30H A118	172.16.1.115	255.255.192.0	Network	Floors 3 - 8
MR 30H A119	172.16.1.116	255.255.192.0	Network	Floors 3 - 8
MR 30H A120	172.16.1.120	255.255.192.0	Network	Floors 3 - 8
MR 30H A121	172.16.1.121	255.255.192.0	Network	Floors 3 - 8
MR 30H A122	172.16.1.122	255.255.192.0	Network	Floors 3 - 8
MR 30H A123	172.16.1.123	255.255.192.0	Network	Floors 3 - 8
MR 30H A124	172.16.1.124	255.255.192.0	Network	Floors 3 - 8
MR 30H A125	172.16.1.125	255.255.192.0	Network	Floors 3 - 8
MR 30H A126	172.16.1.126	255.255.192.0	Network	Floors 3 - 8
MR 30H A127	172.16.1.127	255.255.192.0	Network	Floors 3 - 8

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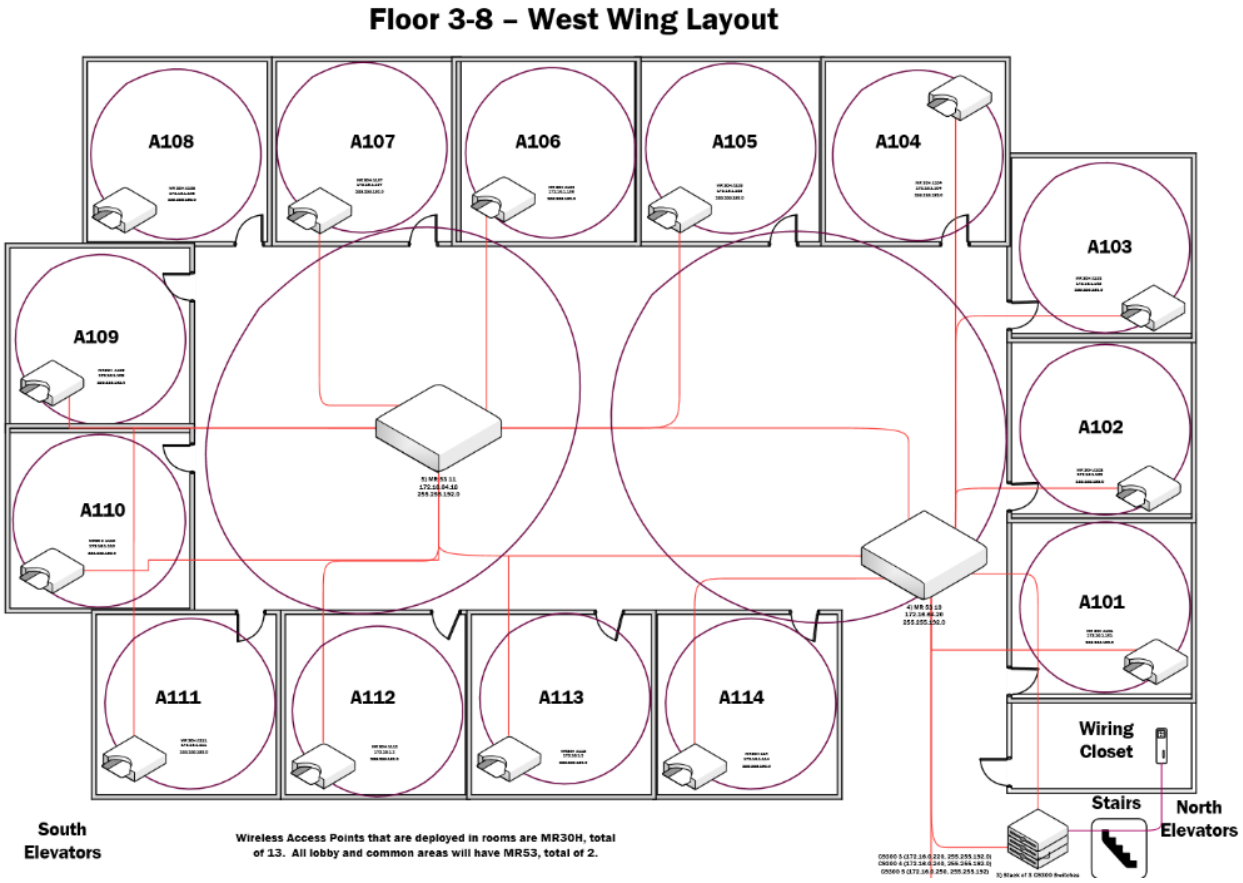
Floors 3 to 8 West Wing Layout



In the West Wing, there will be two MR53 access points and about fourteen MR30H will be in the rooms. The MR53 access points will be deployed in common areas and hallways while the MR30H will be deployed in the rooms. All of the access points will connect to a stack of three C9300 switches.

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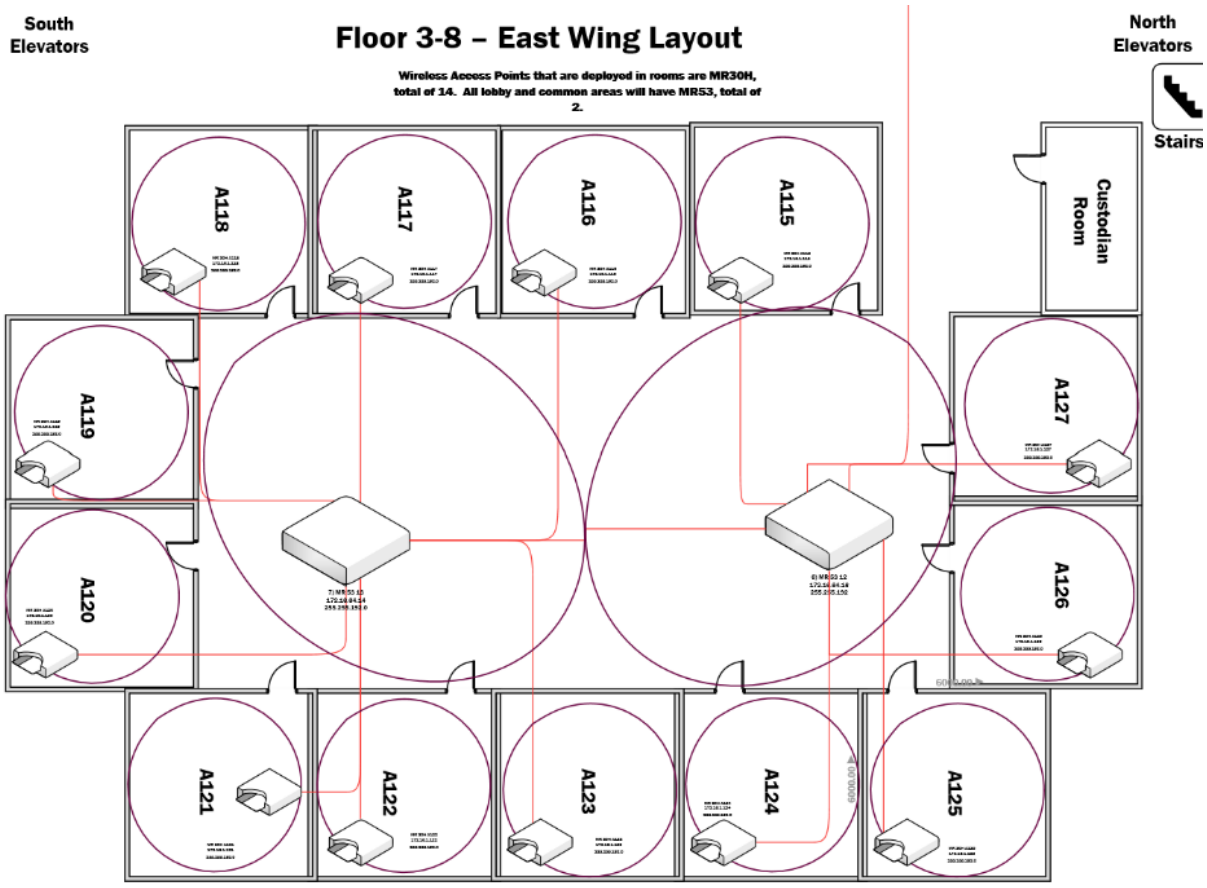
Floors 3 to 8 East Wing Layout



In the East Wing, there will be two MR53 access points in the west wing, and about fourteen MR30H will be in the rooms. The MR53 access points will be deployed in common areas and hallways while the MR30H will be deployed in the rooms. All the access points will connect to a stack of three C9300 switches.

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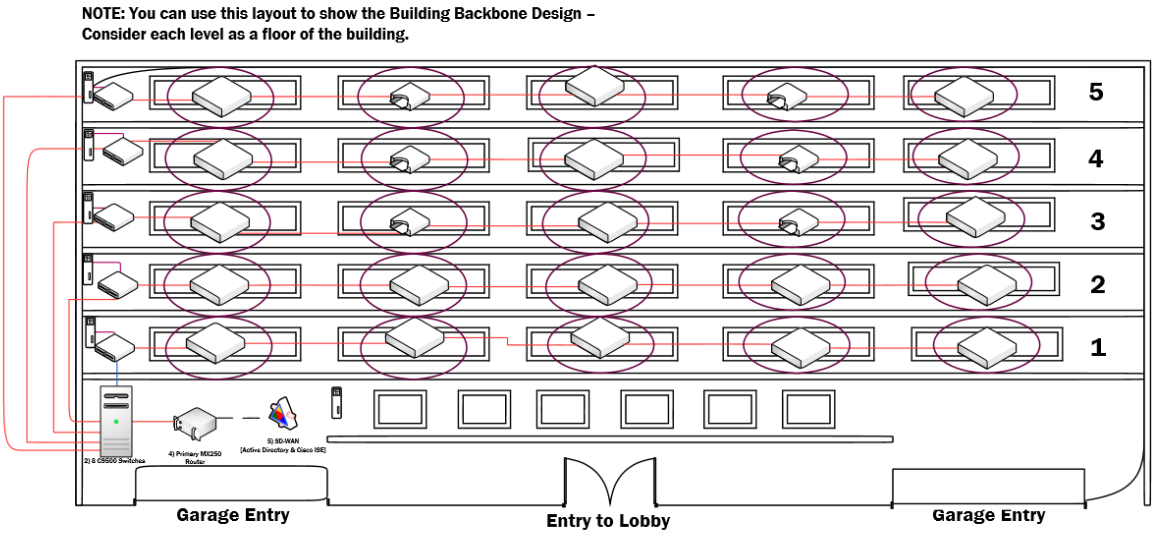
High-Level Map of All Floors



This graph is an approximate representation of the backbone network. Some floors will have more Wireless Access points than are shown. The Switch and router on the garage floor are placed there because there was not any room in the first floor. All the IP address and subnet information will be on the appropriate map.

This diagram will show the general design of the backbone network that includes multiple floors of the apartment building. The overall design of the networks is meant to be able to handle massive amounts of data that may potentially cram the network like video games, film editing software, augmented-reality games, and teleconferencing applications. It is meant to be a general diagram as for the third floor up all of the literal numbers of access points would not be possible to include cleanly.

The SD-WAN will connect to the main router, which will connect to the main rack of the switches. Then, on each floor, there will be about two or three switches that will connect to the access points. The ethernet cables should be a cat6 to support all data traffic. The Total Cost and product of Network section include all the extra cables and licenses that the network may need.

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Total Cost & Products of Network

Devices & Licenses

Item Number	Type	Cost of 1	Number	Total Cost	Product Link
MX250	*Integrated Router*	$13,124.11	2	$26,247.22	https://www.cdw.com/product/cisco-meraki-mx250-cloud-managed-security-appliance/4791011
LIC-MX250-SDW3	*License (3 Year)*	$38,594.99	1	$38,082.83	https://www.cdw.com/product/cisco-meraki-secure-sd-wan-plus-subscription-license-3-years-support/6147590
C9500-24Y4C	*Main Switch*	$18,501.99	8	$148,015.92	https://www.cdw.com/product/cisco-catalyst-9500-switch-24-ports-managed-rack-mountable/5305590
C9300-24P	*Stack Switch*	$7,071.41	6	$42,428.46	https://www.cdw.com/product/cisco-catalyst-9300-network-advantage-switch-24-ports-managed-rac/4914898
MS390-24P	*Single Switch*	$7,108.26	2	$14,216.52	https://www.cdw.com/product/cisco-meraki-cloud-managed-ms390-24p-switch-24-ports-managed-rack-m/5893161
LIC-MS390-24A*	*License (3 Year)*	$3,159.50	8	$25,276	https://www.cdw.com/product/cisco-meraki-ms-series-advanced-subscription-license-3-years-3-years/5903840
MR53	*Wireless Access Point*	$1,537.99	44	$67,671.56	https://www.cdw.ca/product/cisco-meraki-mr53-wireless-access-point-wi-fi-5-cloud-managed/4139116
MR30H	*Wireless Access Point*	$476.99	166	$79,108.34	https://www.cdw.com/product/cisco-meraki-mr30h-cloud-managed-wireless-router-bluetooth-4.0-802.11a/4404482?pfm=srh

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LIC-ADV*	*License (3 Year)*	$708.67	210	$148,820.7	https://www.cdw.com/product/cisco-meraki-mr-series-advanced-subscription-license-3-years-3-years/5794974

Subtotal: $589,867.55

Cables & Accessories

Item Number	Type & Where	One Cost	Quantity	Cost	Product Link
N201-010-BK	*Cat6 RJ45 M/M Black 10'*	$11.45	150	$1717.5	https://www.cdw.com/product/tripp-lite-10ft-cat6-gigabit-snagless-molded-patch-cable-rj45-m-m-black-10ft/934322
N201-007-BL	*SMP Cat6 RJ45 7' M/M Blue*	$9.10	150	$1365.0	https://www.cdw.com/product/tripp-lite-cat6-gigabit-snagless-molded-patch-cable-rj45-m-m-blue-7ft/415021
SFP-H10GB-CU3M-BB	*10GBase Cisco DAC Twinax Cables 3m - Black*	$41.99	25	$1049.75	https://www.cdw.com/product/black-box-sfp-10gbase-cisco-sfp-h10gb-cu3m-twinax-dac-cable-3m/5896297
C9500-NM-8X	*C9500 Network Expansion Module 8 Port*	$4,991.77	8	$39,934.16	https://www.cdw.com/product/cisco-catalyst-9500-series-network-module-expansion-module-8-port/4742570
SFP-10G-LRM=	*SFP+ Transceiver Module*	$973.99	28	$27,271.72	https://www.cdw.com/product/cisco-sfp-10g-lrm-sfp-

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					transceiver-module/2094514
SFP-10G-SR=	*SFP+ Transceiver Module 10 GigE*	$844.99	28	$ 23,659.72	https://www.cdw.com/product/cisco-sfp-transceiver-module-10-gige/1658993
PWR-C4-950WAC-R/2	*Config 4 Power Supply 940 Watt – C9500*	$2,484.06	8	$19,872.48	https://www.cdw.com/product/cisco-config-4-power-supply-hot-plug-redundant-950-watt/4712845
CAB-C15-CBN=	*2.3' Jumper Power Cord*	$29.99	30	$899.70	https://www.cdw.com/product/cisco-2.3ft-jumper-power-cord/1248896
P022-015	*Power Extension Cord 10A 18AWG 5-15R to 5-15 Black 15'*	$19.86	28	$556.08	https://www.cdw.com/product/tripp-lite-computer-power-extension-cord-10a-18awg-5-15p-to-5-15r-black-15ft/2481421
MA-CBL-40G-50CM	MX250 Stacking Cable	$130.06	2	$260.12	https://www.cdw.com/product/cisco-meraki-stacking-cable-1.6-ft/4118845
PWR-C1-715WAC-P/2	*Config 1 Secondary Power Supply*	$1,478.61	6	$8,871.66	https://www.cdw.com/product/cisco-config-1-secondary-power-supply-power-supply-hot-plug-redundant/5428371
STACK-T1-50CM	*StackWise 480 Cable 1.6' – C9300*	$118.29	18	$2129.22	https://www.cdw.com/product/cisco-stackwise-480-

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					stacking-cable-1.6-ft/4752735
C9300-NM-8X=	*Series Network Module Expansion – C9300*	$3,128.17	12	$27,538.04	https://www.cdw.com/product/cisco-catalyst-9300-series-network-module-expansion-module-10-gigabit-s/4712833
SFP-10/25G-CSR-S=	*SFP26 Transceiver Module – C9300*	$921.99	12	$11,063.88	https://www.cdw.com/product/cisco-sfp28-transceiver-module-10-gige-25-gigabit-lan/5293712
MA-CBL-120G-50CM	*Stacking Cable 1.6' MS390*	$147.87	2	$295.74	https://www.cdw.com/product/cisco-meraki-stacking-cable-1.6-ft/5876980
MA-PWR-1100WAC	*Power Supply 1100 Wat – MS390*	$2,329.87	2	$4628.4	https://www.cdw.com/product/cisco-meraki-power-supply-hot-plug-1100-watt/5863693

Subtotal: $169,567.17

Total Cost: $759,434.72

Trinity Klein
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4 December 2022

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