

# IMPLEMENTATION OF A WIRELESS NETWORK FOR INTERNET SERVICE FOR COVERING THE UWC ISAK JAPAN CAMPUS

<b>Company Profile.....</b>	<b>3</b>
<b>Problem definition &amp; Justification.....</b>	<b>4</b>
Problem.....	4
Design Statement.....	4
Design Justification.....	4
<b>Network Diagram &amp; Topology.....</b>	<b>5</b>
Campus Distances.....	5
Network Topology.....	6
Network Infrastructure.....	8
<b>Plan for IP addressing.....</b>	<b>10</b>
Classes.....	10
Addressing Scheme or Standards.....	10
Subnetting and Range.....	10
Allocate IP Space.....	11
DHCP Configuration.....	11
<b>Components and Justification.....</b>	<b>11</b>
Router & Core Switch.....	14
Distribution Switch.....	17
Residential Building Access Points.....	19
Academic Building Access Points.....	21
Uninterrupted Power Supply.....	22
Fiber Optic Cables.....	23
Ethernet Cables.....	23
<b>Budget.....</b>	<b>23</b>
<b>Timeline.....</b>	<b>25</b>
<b>Maintenance Plan &amp; Schedule.....</b>	<b>26</b>
<b>Scalability.....</b>	<b>27</b>
<b>Reliability.....</b>	<b>27</b>
<b>Security.....</b>	<b>28</b>
<b>References of other Networks.....</b>	<b>28</b>
<b>Works cited.....</b>	<b>30</b>

# Company Profile

Company name: **AMZ and Ko®**

Established year: **2018**

AMZ and Ko is a leading technology firm specializing in designing and implementing cutting-edge network solutions. With a passion for enhancing learning environments through robust and secure network infrastructure, AMZ and Ko is dedicated to transforming schools into connected, modern, and digitally empowered communities where no one experiences lag or buffers.

## Experience:

AMZ and Ko possess an impressive track record of successful network redesign projects. Some notable experiences include:

1. **American School in Japan:** We revamped the network system at the American School in Japan. This resulted in enhanced online learning experiences, streamlined administrative processes, and increased overall network reliability.
2. **Ikebukuro Station:** We redesigned the public network at Ikebukuro station. This project involved improving wireless coverage, enhancing security, and ensuring uninterrupted connectivity for commuters. It resulted in a significantly improved passenger experience and helped decrease lost tourists.
3. **Prince Hotel Karuizawa:** AMZ and Ko updated the network at a 5 star hotel in Karuizawa. This project helped in improving network connectivity in seminar rooms where businesses could seamlessly connect online and in the hotel rooms ensuring thousands of seamless connections.

## Expertise:

Our team is composed of professionals with diverse skills and knowledge in network design, implementation, and security. Their expertise includes network architecture, security, wireless connectivity, and cloud integration. The certifications held by our experts are as follows:

- Maria: Certified Wireless Network Professional (CWNP)
- Ainee: Certified Information Systems Security Professional (CISSP)
- Zee: Cisco Certified Network Professional (CCNP)
- Krish: Amazon Web Services Certified Solutions Architect, Cisco Certified Design Associate (CCDA)

# Problem definition & Justification

## Problem

UWC ISAK JAPAN campus requires a new wireless network infrastructure to support the 300+ devices connected to the network. The campus has been recently experiencing challenges with the network such as slow internet connection and not all devices are capable of being connected at the same time. Thus, students, faculty and staff have been having difficulty in fulfilling their activities that require internet connectivity. The client is needed for a new network infrastructure proposal to improve their current network provided by a dual 100Mgbs fiber optic connection, that is ready to support their current users and further scalability.

## Design Statement

We aim for the Installation of both active and passive equipment needed for providing wireless internet service using mesh technology, where all nodes are connected via a network cable, covering the area of the UWC ISAK JAPAN campus.

## Design Justification

For this project, Ubiquiti devices will be used mostly for the switches and wireless access points due to their lower cost compared to their competitors such as Cisco or Aruba. Additionally, Ubiquity does not require to pay a yearly license which also significantly reduces costs without sacrificing much of the quality and performance of the equipment (1). Then, a Fortinet device (FortiGate 200F) will be used for its firewall capabilities to ensure security for the school's network (2). Additionally, the 3 different types of Wireless access points have been selected to meet each of the building's requirements in terms of simultaneous users. Also, a UPS device has been selected to prevent connection loss in case of a power malfunction (3). Furthermore, a CAT6 cable will be used to connect for shorter distances than 100 meters between the equipment, whereas a fiber optic cable will be used for longer distances. This is because CAT6 cables will present issues after the 100 meter mark. Lastly, a hybrid network infrastructure in a star topology will be used to allow support if a cut is done in one cable on another sector of the network and other parts continue to work, regardless of one shutting down (4).

## Network Diagram & Topology

## Campus Distances

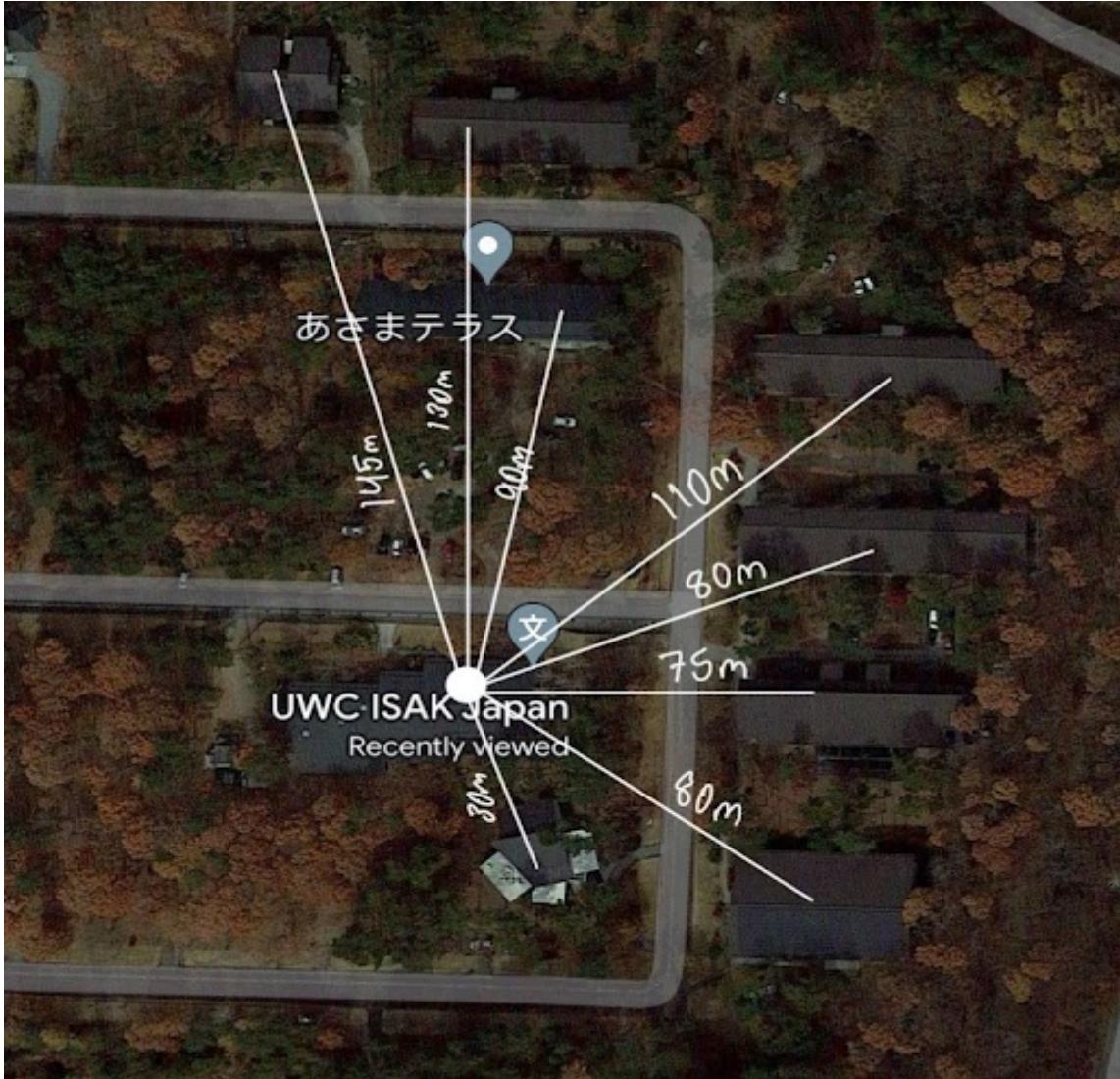


Fig 1. Distances from KAC library to all the buildings on campus.

Figure 1 shows the distances between KAC library, the “main” building where the fiber optic cables will reach, to the rest of the residences and buildings on campus. The distances and overall locations of the buildings are important to consider to select accordingly which type of cables, devices and topology will be used. Some main point to consider out of Figure 1 are:

- Most buildings are at similar distances from each other and from KAC.
- Most buildings are further than 100 meters from KAC library.
- Each building will need support for different amounts of users, as it is not the same to supply internet to the classroom area than to the residences.

## Network Topology

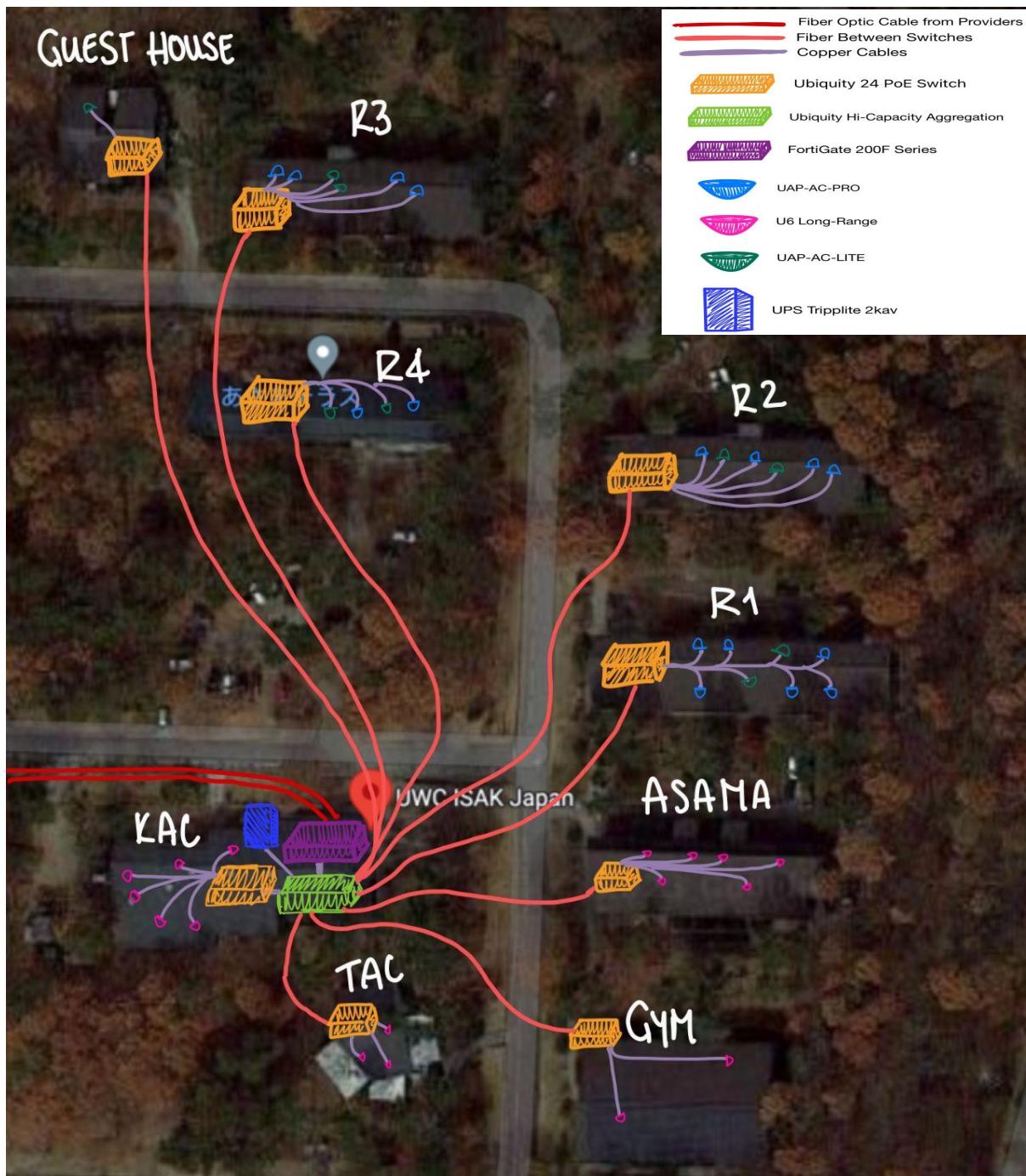


Fig 2. Hybrid Star Network topology for the UWC ISAK JAPAN Campus and the legend of the devices used. This figure shows the fiber optic cables, CAT6, switches, firewall and wireless access points.

For the Network Topology, a hybrid star topology was selected. The reason for a hybrid system was due to some equipment in the initial considered solution from Ubiquity did not perform as well in some aspects such as security or some things were lacking like a power malfunction protection. Thus, FortiNet and UPS devices are being included. A star topology was selected due to its multiple benefits in terms of functionality and reliability. The first benefit is its centralized control, which makes it easier to manage and monitor network traffic. This simplifies tasks such as adding or removing devices, troubleshooting, and implementing security policies. Secondly, star topologies are highly scalable. You can easily add or remove devices without affecting the rest of the network. This scalability makes it a flexible choice for both small and large networks. Additionally, if one device gets cut down from the network others will not be affected. Lastly, star topologies often provide better performance compared to other topologies like bus or ring because devices communicate directly with the central hub, reducing the chances of collisions and improving data transfer rates.

## Network Infrastructure

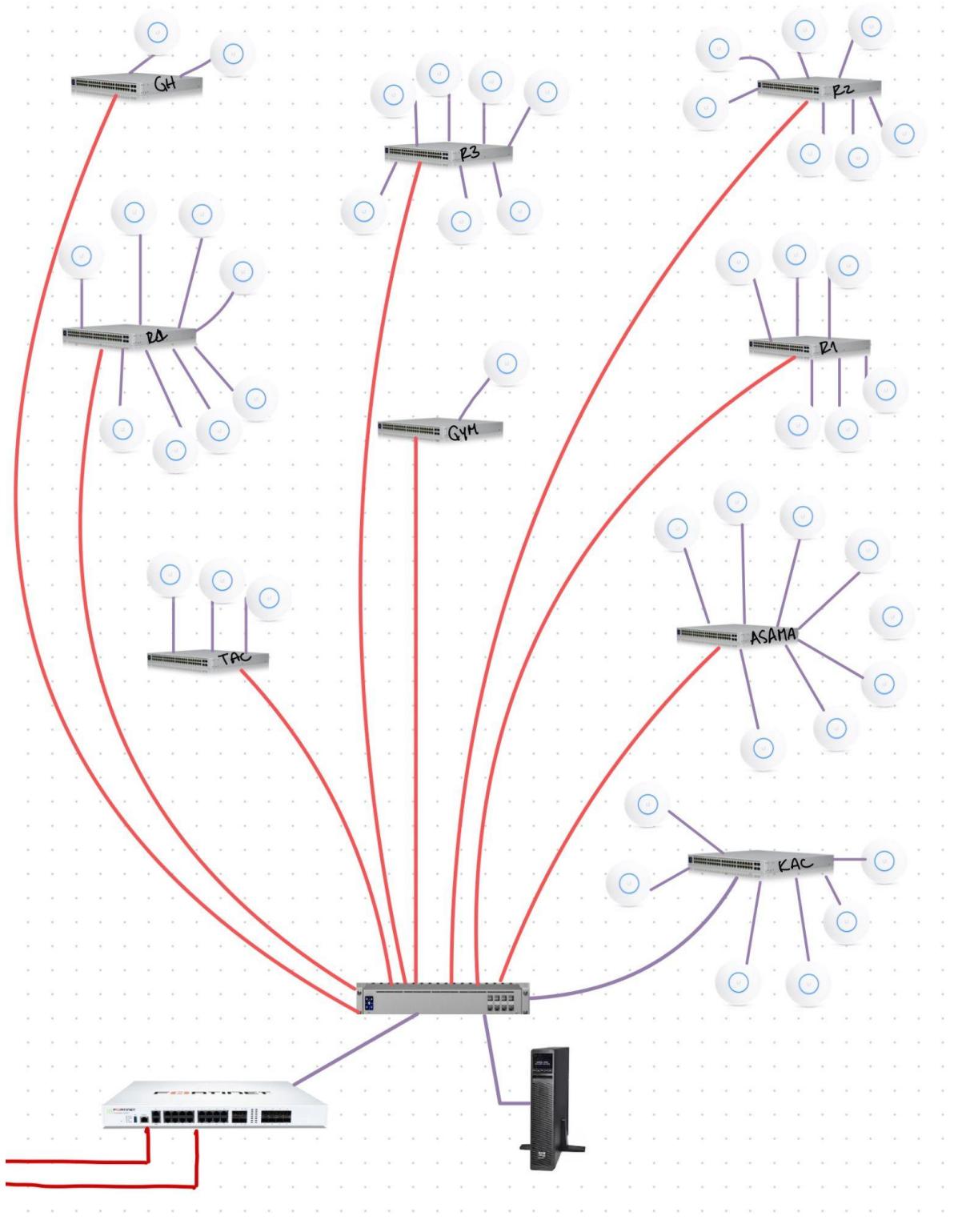


Fig. 3 Network Infrastructure regarding the equipment used. This figure shows the firewall, cables, switches, ups and wireless access points.

For the Network infrastructure we are using the following devices and path to connect the UWC ISAK JAPAN campus to the internet.

1. Both Fiber Optic Cables from the providers reach the FireGate 200F (Firewall) which is in charge of transforming the public network into a private network for the ISAK campus. The FortiGate 200F includes the SD-WAN technology, which allows it to act as a router and receive the fiber optic cables.
2. Then, the FireGate 200F connects through a CAT6 cable to the Ubiquity Hi-Capacity Aggregation Switch, which allows for a Star topology to be utilized with the ubiquity devices by connecting to the switches with fiber optic cables (because houses are further than 100 meters).
3. A UPS TrippLite 2KAV is connected to the Ubiquity Hi-Capacity Aggregation Switch to support in case of power malfunction.
4. Ubiquity Hi-Capacity Aggregation Switch connects to the switches in other houses through fiber optic cables, and through a CAT6 cable in the KAC library switch (because the distance is less than 100 meters from the main switch).
5. Wireless Access Points connect to the switch that reach the house through CAT6 cables and that provides internet connection to the devices in the multiple buildings.

## Plan for IP addressing

### Classes

In this network, we'll adopt a Classless Inter-Domain Routing (CIDR) addressing scheme, which provides more flexibility in allocating IP addresses. CIDR allows for the efficient use of IP address space, especially for a network of this size.

### Addressing Scheme or Standards

The addressing scheme will be based on IPv4 due to its widespread compatibility and support. We'll employ a private IP address ranging from the RFC 1918 address space. We can use the 10.0.0.0/16 private address range. This range provides a substantial number of IP addresses (65,536 addresses) and can accommodate the school's devices and future growth effectively. By assigning unique private IP addresses within this range to each subnet of the school's network, we ensure that all devices can communicate internally while maintaining a secure and scalable network environment.

### Subnetting and Range

Subnetting will be used to logically divide the network into smaller, manageable segments. We'll create subnets based on the following:

1. Administration: 10.0.0.0 - 10.0.0.254
2. KAC: 10.0.1.0 - 10.0.1.254
3. TAC: 10.0.2.0 - 10.0.2.254
4. Gym: 10.0.3.0 - 10.0.3.254
5. Asama: 10.0.4.0 - 10.0.4.254
6. R1: 10.0.5.0 - 10.0.5.254
7. R2: 10.0.6.0 - 10.0.6.254
8. R3: 10.0.7.0 - 10.0.7.254
9. R4: 10.0.8.0 - 10.0.8.254
10. Network Infrastructure 10.0.9.0 - 10.0.9.254

## Allocate IP Space

Reserve a portion of each subnet for static IP assignments to devices like servers, network equipment, and printers.

Configure DHCP servers for dynamic IP assignments to client devices, such as computers, smartphones, and tablets.

## DHCP Configuration

Set up DHCP servers for each subnet to automate IP address assignments.

Configure DHCP pools for dynamic IP allocation, ensuring devices receive IP addresses dynamically.

Implement DHCP reservations for critical infrastructure devices requiring fixed IP addresses.

## Components and Justification

Component	Provider & Product Name	Justification
Router, Firewall	<a href="#">FortiGate 200F Series</a> 	<ul style="list-style-type: none"> <li>• Unified Threat Management (UTM) device that combines firewall, antivirus, intrusion prevention, VPN, and other security features into a single platform.</li> </ul>
Distribution Switch	<a href="#">Ubiquiti Hi-Capacity Aggregation</a> 	<ul style="list-style-type: none"> <li>• Fully manages layer 2 switch to enhance network's switching capabilities with high bandwidth aggregation links.</li> <li>• Allows multiple Ethernet ports to be</li> </ul>

		combined and increases bandwidth and redundancy.
Professional 24 PoE Switch	<a href="#">Switch 24 PoE Switch</a>  	<ul style="list-style-type: none"> <li>• Expand and power your network</li> <li>• capacity to process traffic on all ports without any packet loss</li> <li>• 24 PoE ports</li> </ul>
Access Points (Residential Buildings) x 11 student residences	<a href="#">UAP-AC-PRO</a>  	<ul style="list-style-type: none"> <li>• Expands wireless network coverage indoors and outdoors with weather proof designs</li> <li>• Dual-band (operate on two different frequency bands simultaneously: 2.4 GHz and 5 GHz band)</li> <li>• 3x3 MIMO (Multiple Input, Multiple Output Technology)</li> <li>• compatible for 802.3af PoE/802.3at PoE+ sources</li> </ul>
Access Points (Faculty Houses) x 15 (1-4 people)	<a href="#">UAP-AC-LITE</a>  	<ul style="list-style-type: none"> <li>• Expands wireless network 115 m<sup>2</sup> (1,250 ft<sup>2</sup>) coverage</li> <li>• Compatible WiFi5 standard</li> <li>• 2x2 MIMO (Multi input, multi output)</li> </ul>
KAC, TAC & Asama (Academic buildings)	<a href="#">U6 Long-Range</a>  	<ul style="list-style-type: none"> <li>• A high-performance indoor/outdoor access point that can cover long distances and wide areas.</li> <li>• compatible with Wi-Fi 6 standard</li> <li>• Dual-band (operate on two different frequency bands simultaneously: 2.4 GHz and 5 GHz band)</li> <li>• 4x4 MIMO (Multiple Input, Multiple Output Technology)</li> <li>• PoE+ Power supply</li> </ul>
Uninterrupted Power Service - Tripp Lite 2KVA	<a href="#">SmartOnline 230V 2kVA 1800W On-Line DoubleConversion UPS, Tower, Extended</a>	<ul style="list-style-type: none"> <li>• Provides battery backup and power protection against blackouts, brownouts, power surges and line noise that can damage electronics or</li> </ul>

	<a href="#">Run, Network Card Options, LCD, USB, DB9</a>  	destroy that can damage electronics or destroy data
Fiber Optic Cables	<a href="#">FLYPROFiber 30M OM1 LC-LC Optical Wiring Cord, Fiber Optic Cable, Length 0.2m-50m, 1GB Duplex, with LC Connectors on Both Ends, 62.5/125um Multimode, Domestic Wiring Cable, LSZH Jacket</a>  	<ul style="list-style-type: none"> <li>• Fiber Optic Cable is designed for high density applications</li> <li>• Light cord that allows for high data transmission.</li> <li>• Excellent pulling force, 7.5mm minimum bending radius</li> </ul>
Ethernet Cables	<a href="#">Cat 6</a>  	<ul style="list-style-type: none"> <li>• Ethernet cable used for connecting devices to a local area network (LAN)</li> <li>• Commonly used in homes, office buildings to connect routers, switches, and other devices</li> </ul>
Small Form-Factor Pluggable (SFP)	<a href="#">10 Gbps Multi-Mode Optical Module</a>	<ul style="list-style-type: none"> <li>• SFP modules enable the switch to connect to fiber optics and Ethernet cables of different types and speeds</li> </ul>

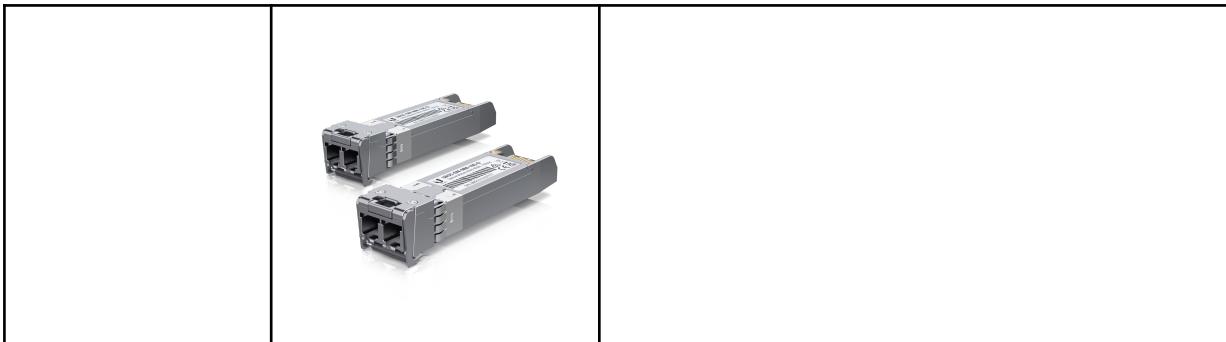


Fig.4 Table of List of Components and Justification

## Router & Core Switch

The FortiGate 200F Series emerges as the top choice among the listed products due to its exceptional blend of features, performance, and security capabilities. Priced at \$4000, the FortiGate 200F justifies its cost with a comprehensive range of functionalities crucial for safeguarding a school network of 300 people. It excels in content filtering, enabling precise web access policies and protecting against web-based threats. The robust VPN support ensures secure connections for remote users and branch offices, a critical requirement in today's remote learning environment. Deep packet inspection and stateful packet inspection mechanisms offer advanced threat detection and prevention, safeguarding the network against a wide range of attacks. Its centralized management through the Fortinet Security Fabric simplifies network administration, enhancing efficiency. Moreover, the FortiGate 200F's redundancy and failover capabilities guarantee uninterrupted network availability, a paramount consideration for educational institutions. Overall, the FortiGate 200F's feature set, performance, and robust security posture make it a sound investment, justifying its \$4000 price tag by ensuring the integrity, reliability, and security of the school's network infrastructure.

The FortiGate 200F possesses the SD-WAN software which allows it to receive the Fiber Optic Submarine Cables from the providers and act as router. SD-WAN is a software-defined approach to managing Wide-Area Networks (WAN). It consolidates the physical transport connections, or underlays, and monitors and load-balances traffic across the links. VPN overlay networks can be built on top of the underlays to control traffic across different sites.

Some of the key benefits of SD-WAN include:

- Reduced cost with transport independence across MPLS, 4G/5G LTE, and others.
- Reduced complexity with a single vendor and single-pane-of-glass management.
- Improve business application performance thanks to increased availability and agility.
- Optimized user experience and efficiency with SaaS and public cloud applications (23).

The table below shows the research conducted by the company to allocate the security needs of the client, a 300-person school campus.

Firewall Device	Content Filtering Description	VPN Support Description	Deep Packet Inspection (DPI) Description	Stateful Packet Inspection (SPI) Description	Centralized Management Description	Redundancy & Failover Description
<b>Cisco ASA 5500-X Series</b>	Cisco ASA firewalls offer content filtering to control access to websites and applications based on categories, helping enforce acceptable use policies.	They support both site-to-site and remote access VPNs, allowing secure connections for remote users or branch offices.	Cisco ASA firewalls perform deep packet inspection to inspect and analyze network traffic at the application layer, identifying and mitigating threats.	They provide stateful packet inspection, tracking the state of active connections to allow legitimate traffic and block unauthorized access.	Cisco ASA firewalls offer centralized management through Cisco Firepower Management Center, simplifying configuration and monitoring.	Redundancy and failover capabilities are available, ensuring high availability and minimizing network downtime.
<b>Fortinet FortiGate Series</b>	Fortinet FortiGate firewalls offer content filtering to control web access and applications, enabling administrators to create usage policies.	They provide comprehensive VPN support, including IPsec, SSL, and SSL inspection, ensuring secure connections for remote users and branch offices.	FortiGate firewalls perform deep packet inspection to identify and block threats at the application layer, protecting against advanced threats.	They feature stateful packet inspection, tracking the state of connections to allow legitimate traffic and prevent unauthorized access.	FortiManager provides centralized management for streamlined configuration, monitoring, and reporting across multiple devices.	Fortinet FortiGate firewalls offer high availability options, including active-active and active-passive deployments, for reliable failover and uninterrupted network access.

<b>Palo Alto Networks PA Series</b>	Palo Alto Networks PA Series firewalls offer content filtering to enforce web access policies based on applications, users, and content categories.	They support secure VPN connections, including GlobalProtect for remote users and site-to-site VPNs, ensuring encrypted traffic for remote offices.	Palo Alto firewalls use deep packet inspection to identify applications and threats, providing granular control and threat prevention at the application layer.	They provide stateful packet inspection, tracking the state of connections to allow legitimate traffic while blocking malicious activity.	Palo Alto Panorama offers centralized management for global policy control and monitoring, simplifying network management at scale.	Palo Alto Networks PA Series firewalls offer active/passive and active/active high availability configurations for continuous network uptime and resilience.
<b>Sophos XG Firewall Series</b>	Sophos XG Firewalls offer content filtering with web category-based policies, application control, and HTTPS scanning to manage web access and protect against threats.	They support IPsec and SSL VPNs for secure remote access, providing options for remote users and branch offices to connect securely.	Sophos XG Firewalls use deep packet inspection to identify and manage applications, threats, and content, ensuring comprehensive security.	They provide stateful packet inspection, tracking the state of connections to enforce security policies and prevent unauthorized access.	Sophos Central provides centralized management with a cloud-based platform for easy policy configuration, monitoring, and reporting across devices.	Sophos XG Firewalls offer high availability options, including active/passive and active/active clustering, to maintain network availability and minimize downtime.

<b>WatchGuard Firebox Series</b>	WatchGuard Fireboxes offer content filtering with web category-based controls and HTTPS inspection to manage web access and protect against web-based threats.	They support IPsec and SSL VPNs for secure remote access, ensuring encrypted connections for remote users and branch offices.	WatchGuard Fireboxes use deep packet inspection to identify and control applications, threats, and content, enabling precise security policies.	They provide stateful packet inspection, tracking connection states to allow legitimate traffic and block unauthorized access attempts.	WatchGuard System Manager (WSM) provides centralized management for configuration, monitoring, and reporting, simplifying network administration.	WatchGuard Fireboxes offer high availability with active/passive and active/active clustering options, ensuring network reliability and failover protection.
<b>SonicWall TZ Series</b>	SonicWall TZ firewalls offer content filtering with application control, web filtering, and SSL inspection to manage web access and block threats effectively.	They support both SSL VPN and IPsec VPN options for secure remote access, catering to remote users and branch offices' connectivity needs.	SonicWall TZ firewalls use deep packet inspection to inspect and manage applications and threats, providing real-time threat protection.	They provide stateful packet inspection, tracking connection states to allow legitimate traffic and block malicious activity.	SonicWall Global Management System (GMS) offers centralized management for policy configuration, monitoring, and reporting across multiple devices.	SonicWall TZ firewalls feature high availability options, including active/standby and active/active modes, ensuring network uptime and resilience.

Fig 5. Comparison between firewalls and other components

## Distribution Switch

The following table showcases the research conducted by the company considering the following features.

1. Port Speeds: Indicates the supported port speeds such as 1 Gbps, 10 Gbps, etc.
2. Layer 3 Routing: Whether the switch supports Layer 3 routing capabilities.
3. Redundancy Support: Indicates if the switch supports redundancy features.

4. Management Options: The available management interfaces such as Command Line Interface (CLI), Graphical User Interface (GUI), or other management software.

Manufacturer	Model	Ports	Port Speeds	Layer 3 Routing	Redundancy Support	Management Options
Cisco	Cisco Catalyst 9300	24/48	1/10/25/40/100 Gbps	Yes	VRRP, HSRP	Cisco DNA Center, CLI
Juniper	Juniper EX3400	24/48	1 Gbps / 10 Gbps	Yes	VRRP	Junos CLI, Junos Space
Aruba (HPE)	HPE Aruba 3810M	24/48	1 Gbps / 10 Gbps	Yes	VRRP	ArubaOS-Switch, WebUI
Ubiquiti	Ubiquiti Hi Capacity Aggregation	32	28x 1 Gbps / 10 Gbps & 4x 1/10/25 Gbps	Yes	Yes	UniFi Controller, CLI
Dell EMC	Dell EMC PowerSwitch	24/48/96	1 Gbps / 10 Gbps	Yes	VRRP	Dell EMC NOS, WebUI
Extreme Networks	ExtremeSwitch X440	24/48	1 Gbps / 10 Gbps	Yes	VRRP	ExtremeXOS, WebUI
Brocade (Ruckus)	Brocade ICX 7250	24/48	1 Gbps / 10 Gbps	Yes	VRRP	FastIron CLI, WebUI
Allied Telesis	Allied Telesis x930	24/48/96	1 Gbps / 10 Gbps	Yes	VRRP	AlliedWare Plus CLI, WebUI

Fig 6. Comparison between distribution switches.

Among the above listed distribution switches. The Ubiquiti Hi-Capacity Aggregation switch stands out as an excellent choice when designing a network for a school with approximately 300 people due to its compelling combination of features and performance. With a generous 32 ports that include 28 ports of 1 Gbps/10 Gbps and 4 ports of 1/10/25 Gbps, this switch offers ample room for scalability. Its Layer 3 routing capabilities enable efficient traffic management within the school network, ensuring optimized data flow. The switch's redundancy support, with features like VRRP, enhances network reliability, reducing the risk of downtime and interruptions in a critical educational environment. The availability of management options, including the UniFi Controller and CLI, provides network administrators with flexibility and control. All of these features make the Ubiquiti Hi-Capacity Aggregation switch a robust and scalable solution for schools, catering to both current needs and future growth while ensuring seamless and reliable network connectivity for students and staff.

## Residential Building Access Points

Access Point Model	Throughput Rate (2.4GHz)	Throughput Rate (5GHz)	Gigabit Ethernet Ports	Use Case	Gigabit Ethernet Ports	Use Case
Cisco Aironet 1850 Series	Approximately 600 Mbps	Approximately 1.3 Gbps	2 (on some models)	Enterprise wireless networking	2 (on some models)	Enterprise wireless networking
Cisco Aironet 2800 Series	Approximately 600 Mbps	Approximately 1.3 Gbps	2 (on some models)	Enterprise wireless networking	2 (on some models)	Enterprise wireless networking
TP-Link EAP245	Approximately 300 Mbps	Approximately 867 Mbps	1	Small to medium-sized business networks	1	Small to medium-sized business networks
Ubiquiti UAP-AC-PRO	Approximately 450 Mbps	Approximately 1300 Mbps	1	Versatile business and home networks	1	Versatile business and home networks
Ubiquiti UAP-AC-HD	Approximately 800 Mbps	Approximately 1733 Mbps	2	High-density environments	2	High-density environments
TP-Link EAP245	Approximately 300 Mbps	Approximately 867 Mbps	1	Small to medium-sized business networks	1	Small to medium-sized business networks
TP-Link EAP330	Approximately 450 Mbps	Approximately 1300 Mbps	2	Medium to large-sized business networks	2	Medium to large-sized business networks
Aruba AP-303 Series	Approximately 300 Mbps	Approximately 867 Mbps	1	Small to medium-sized business networks	1	Small to medium-sized business networks
Aruba AP-315 Series	Approximately 300 Mbps	Approximately 1300 Mbps	1	Medium to large-sized business networks	1	Medium to large-sized business networks

Figure 6. Comparison between residential building access points

Among the devices listed in the table, the Ubiquiti UAP-AC-PRO stands out as the best choice for residential houses with around 20 members. It excels in multiple aspects, making it the preferred option for homeowners. First and foremost, the UAP-AC-PRO strikes a

remarkable balance between performance and versatility. With competitive throughput rates in both the 2.4GHz and 5GHz bands, it can effortlessly handle the demands of multiple devices concurrently, ensuring a smooth online experience for all residents.

The technicalities and features of the Ubiquiti UAP-AC-PRO make it well-suited for serving about 20 students in a residential house.

Scalability is a crucial factor, and the UAP-AC-PRO seamlessly integrates into the Ubiquiti UniFi ecosystem. This feature allows homeowners to expand their network by adding more access points as necessary, maintaining centralized management and control.

Ease of use is another significant advantage, as the UAP-AC-PRO boasts a user-friendly setup and management process through the UniFi Controller software. This simplicity ensures that individuals with varying levels of technical expertise can effortlessly configure and maintain their network, eliminating potential complications.

Cost-effectiveness is a notable highlight, as the UAP-AC-PRO offers an array of robust features, typically found in higher-priced access points, without breaking the bank.

## Academic Building Access Points

Manufacturer	Model	Maximum Data Rate	Frequency Bands Supported	Antenna Configuration	Range	Number of Potential Connected Devices	Management Options
Ubiquiti	U6 Long Range	1.77 Gbps	2.4 GHz, 5 GHz	4x4 MIMO	Up to 600 feet (183 meters)	Up to 250 devices	UniFi Controller, CLI
Cisco Meraki	MR56	3.5 Gbps	2.4 GHz, 5 GHz	4x4 MIMO	Up to 800 feet (244 meters)	Up to 200 devices	Cloud Dashboard
Aruba (HPE)	Aruba AP-505H	2.5 Gbps	2.4 GHz, 5 GHz	4x4 MIMO	Up to 800 feet (244 meters)	Up to 250 devices	Aruba Central, WebUI
Ruckus (CommScope)	Ruckus R750	3 Gbps	2.4 GHz, 5 GHz	4x4 MIMO	Up to 300 feet (91 meters)	Up to 512 devices	Ruckus Unleashed, WebUI
TP-Link	TP-Link EAP660 HD	3 Gbps	2.4 GHz, 5 GHz	4x4 MIMO	Up to 200 feet (61 meters)	Up to 300 devices	Omada Controller, WebUI

Fig.7 Comparison between academic building access points

The Ubiquiti U6 Long Range access point emerges as an outstanding choice when considering long-range wireless connectivity, especially for academic buildings. Its impressive features, including a maximum data rate of 1.77 Gbps and robust 4x4 MIMO antenna configuration, provide high-speed, reliable Wi-Fi coverage over a significant distance. It has a range of up to 600 feet (183 meters).

What sets the U6 Long Range apart is its remarkable capacity to accommodate up to 250 potential connected devices simultaneously. This is particularly crucial in an educational environment, where numerous students and faculty members rely on network access for learning and administrative tasks.

The Ubiquiti U6 Long Range can be managed through the user-friendly UniFi Controller or the CLI, offering administrators flexibility and control over network management. Its well-rounded combination of speed, range, and device capacity makes it an excellent choice for ensuring robust, long-range wireless connectivity in educational settings, ultimately enhancing the learning experience for all users.

## Uninterrupted Power Supply

Manufacturer	Model	Capacity	Output Voltage	Battery Runtime (at full load)	Outlet Types	Management Options
APC (Schneider Electric)	APC Smart-UPS SMT1500C	1500VA / 900W	230V	5 minutes	NEMA 5-15R	LCD Panel, Network Card
CyberPower	CyberPower CP1500AVRLCD	1500VA / 900W	120V	11 minutes	NEMA 5-15R	LCD Panel, PowerPanel Software
Tripp Lite	Tripp Lite SMART1500LCDT	1500VA / 900W	120V	10 minutes	NEMA 5-15R	LCD Panel, PowerAlert Software
Eaton	Eaton 5P 1500 Rackmount UPS	1440VA / 1100W	120V	8 minutes	NEMA 5-15R	LCD Panel, Intelligent Power Software
APC (Schneider Electric)	APC Smart-UPS SRT2200XLA	2200VA / 1980W	230V	10 minutes	IEC C13/C19	LCD Panel, Network Card
Tripp Lite	SmartOnline 230V 2kVA 1800W	2000VA / 1800W	230V	Custom (based on external battery packs)	IEC C13/C19	LCD Panel, USB, SNMP Card

Fig 8. Comparison between UPS

The SmartOnline 230V 2kVA 1800W On-Line Double-Conversion UPS is a compelling choice for critical applications requiring seamless power protection. With a capacity of 2000VA/1800W, it offers robust power backup and ensures stable, clean power delivery at all times. What sets it apart is its double-conversion technology, which provides continuous power, making it ideal for sensitive electronic equipment. The UPS is versatile and adaptable, allowing us to connect external battery packs for extended runtime as needed. With a variety of IEC C13/C19 outlets, it accommodates various devices, and its LCD panel provides real-time status and configuration information. Management options include USB connectivity and SNMP card support for remote monitoring and control. Whether safeguarding servers, networking equipment, or critical systems, this UPS offers reliable and efficient power protection, making it an excellent choice for businesses seeking uninterrupted operation and peace of mind.

## Fiber Optic Cables

Fiber optic cables are preferred over Ethernet cables for distances greater than 100 meters due to their superior capabilities. They excel in long-distance data transmission thanks to minimal signal loss, high bandwidth, and immunity to electromagnetic interference (EMI). These cables use light signals, enabling data to travel farther without degradation. More importantly, fiber optics' resistance to environmental factors and scalability make them the go-to choice for reliable, high-performance connectivity over extended distances, ensuring data integrity and uninterrupted communication.

## Ethernet Cables

Although Cat7 cables offer higher bandwidth capacity compared to lower categories like Cat5e and Cat6, Cat6 is more preferred in the case of the school network as we will be using Fiber Optic cables for distances more than 100 meters and ethernet cables will be used for those using less than that distance. With this, Cat6 cables still offer ample bandwidth for most school network applications. They can support data rates of up to 10 Gbps at shorter distances (up to 55 meters), which is more than adequate for typical classroom and residential needs.

## Budget

Component (Linked to product)	Unit	No. of units	Price per unit (¥)	Total (¥)
<a href="#"><u>SmartOnline 230V 2kVA 1800W On-Line DoubleConversion UPS, Tower, Extended Run, Network Card Options, LCD, USB, DB9</u></a>	Device	1	63,420	63,420
<a href="#"><u>FortiGate 200F Series</u></a>	Device	1	598,832	598,832
<a href="#"><u>10 Gbps Multi-Mode Optical Module</u></a>	Piece	16	2,792	44,672
<a href="#"><u>Ubiquiti Hi-Capacity Aggregation</u></a>	Device	1	131,997	131,997
<a href="#"><u>Switch 24 PoE Switch</u></a>	Device	9	62,099	558,891
<a href="#"><u>Cat 6</u></a>	Meter	90	14	1,260
<a href="#"><u>FLYPROFiber 30M OM1 LC-LC Optical Wiring Cord, Fiber Optic</u></a>	100 Meter	8	6650	53,200

<u>Cable, Length 0.2m-50m, 1GB Duplex, with LC Connectors on Both Ends, 62.5/125um Multimode, Domestic Wiring Cable, LSZH Jacket</u>				
<u>U6 Long-Range</u>	Device	18	114,399/5 pack, 24,399/single	416,394
<u>UAP-AC-PRO</u>	Device	14	24,399 / single 114,399 / 5-pack	326,394
<u>UAP-AC-LITE</u>	Device	14	13,000	182,000
<b>TOTAL</b>				2,313,640

Fig.9 Budget table

# Timeline

Task	Timeframe	Responsible	Deliverable
Network Design and Planning	Month 1	Network Engineers	Create an overall network design and IP addressing plan. Identify network segments, VLANs, and security policies.
Procurement of Network Equipment	Month 2	Procurement Team	Order FortiGate 200F Series, Ubiquiti switches, access points, UPS, fiber optic cables, Cat 6 cables, and SFP modules based on design specifications.
Preparing Network Infrastructure	Month 3	IT Team	Ensure proper power and data cabling in each building, including faculty houses, academic buildings, and residential houses.
FortiGate 200F Deployment	Month 4	IT Team	Install and configure the FortiGate 200F Series as the core router and firewall. Set up WAN and LAN interfaces, security policies, and VPN settings as needed.
Ubiquiti Hi-Capacity Aggregation Deployment	Month 4	IT Team	Install and configure the Ubiquiti Hi-Capacity Aggregation switch as the distribution switch. Configure VLANs and interconnectivity to FortiGate.
Switch 24 PoE Switch Deployment	Month 5	IT Team	Install and configure PoE switches where needed, ensuring proper power delivery to devices such as IP phones, cameras, and access points.
UAP-AC-PRO Deployment	Month 6	IT Team	Deploy UAP-AC-PRO access points in residential houses (14 in total), ensuring optimal coverage for each building. Configure SSIDs and security settings.
UAP-AC-LITE Deployment	Month 7	IT Team	Deploy UAP-AC-LITE access points in faculty houses (15 in total) and configure them according to specific needs.
U6 Long-Range Deployment	Month 8	IT Team	Install U6 Long-Range access points in academic buildings, ensuring excellent Wi-Fi coverage. Configure SSIDs and security settings.
Fiber Optic Cable Installation	Months 9-10	Network Engineers	Lay and connect fiber optic cables across the campus to interconnect key network components. Test for signal quality and reliability.
Cat 6 Cable Installation	Months 11-12	IT Team	Deploy Cat 6 cables for Ethernet connectivity in all buildings, connecting network devices and access points. Ensure cable management and labeling.
SFP Module Installation	Months 13-14	IT Team	Install SFP modules in switches and other compatible devices for high-speed fiber optic connections. Verify compatibility and settings.
SmartOnline UPS Deployment	Months 15-16	IT Team	Install SmartOnline UPS units at critical network locations, ensuring uninterrupted power supply for network equipment. Configure alert notifications.
Network Testing and Optimization	Month 17	Network Engineers	Thoroughly test the entire network for connectivity, performance, and security. Optimize configurations for efficient operation.
Training and Documentation	Month 18	IT Team	Provide training to IT staff and end-users on network usage, security protocols, and troubleshooting procedures. Document network configurations and procedures.
Network Go-Live and Monitoring	Month 19	IT Team	Transition to the new network environment. Continuously monitor network performance and security. Address any issues that arise.
Ongoing Maintenance and Upgrades	Ongoing	IT Team	Implement a schedule for routine network maintenance, updates, and upgrades to ensure the network remains secure and up to date.

Fig 10. Timeline of Network installation.

## Maintenance Plan & Schedule

It is recommended for the school's Information and Technology Center to conduct a quarterly maintenance on the school's technology infrastructure. This maintenance is critical to ensure the security, stability and reliability of the University's technology. These important tasks may necessitate a partial or complete campus-wide service outage. To minimize the impact on our campus community, upgrades will be performed outside of normal operating hours.

Quarter	Timeframe	Maintenance Plan
Quarter 1	Juy to Early August <i>(Back to School Preparation)</i>	<ul style="list-style-type: none"> <li>Conduct a full backup of network configurations and critical data.</li> <li>Review and update user accounts, permissions, and access controls.</li> <li>Ensure the firewall and switches have the latest firmware and software updates.</li> <li>Perform a security audit and review firewall rules and security policies.</li> </ul>
	Late September (Mid-Term Checkup)	<ul style="list-style-type: none"> <li>Monitor network performance, including bandwidth utilization and latency.</li> <li>Review and update firewall rules and access controls if necessary.</li> <li>Check the status of UPS systems and replace batteries if needed.</li> </ul>
Quarter 2	Early November (Fall Break)	<ul style="list-style-type: none"> <li>Conduct a disaster recovery test to ensure data recovery procedures are effective.</li> <li>Physically inspect network hardware components for signs of wear or failure.</li> <li>Address any hardware issues and replace faulty components.</li> </ul>
	December (Winter Break Update)	<ul style="list-style-type: none"> <li>Apply firmware and software updates to network devices, including access points.</li> <li>Perform a comprehensive review of network documentation and update as needed.</li> <li>Conduct a review of compliance with regulatory requirements.</li> </ul>
Quarter 3	Early February (Mid-Year Review):	<ul style="list-style-type: none"> <li>Monitor network traffic and performance, paying attention to any anomalies.</li> <li>Review and optimize Quality of Service (QoS) policies for network performance.</li> <li>Conduct user training sessions on</li> </ul>

		network security best practices.
	Late March (Spring Break Maintenance)	<ul style="list-style-type: none"> <li>Test the SmartOnline 230V 2kVA UPS system to ensure it can provide uninterrupted power. Replace batteries if needed.</li> <li>Review and update security policies and access controls on the FortiGate firewall.</li> <li>Perform a security audit to identify and address vulnerabilities.</li> </ul>
Quarter 4	Early May (End of School Year):	<ul style="list-style-type: none"> <li>Conduct a final backup of network configurations and critical data.</li> <li>Prepare for any necessary updates or improvements over the summer break.</li> <li>Review capacity planning and plan for any network growth or changes.</li> </ul>

Fig 11. Maintenance Schedule

## Scalability

This project support scalability for the following reasons:

- Devices: Most devices that have been selected for this project have the capacity for more than what has been requested, so in any case that more people come to campus and more devices need to be connected, then the network will be capable of adjusting to such change.  
For example: The switches utilized have 24 ports, currently not 24 ports are in use, so in the future if more ports are required for further coverage this will be possible.
- Star Topology: Devices can be easily added or removed from the network by connecting or disconnecting them from the central hub or switch. This makes it a flexible choice for growing networks. Additionally, when adding or removing devices in a star topology, the changes typically do not affect the rest of the network. This means that the network can be modified or expanded without causing disruptions to other connected devices.

## Reliability

- Star Topology: In a star topology, if one device or cable connection fails, it usually does not impact the rest of the network. Each device has its own dedicated link to the central hub, so failures are isolated. This makes troubleshooting and maintenance more manageable. Additionally, each device has its dedicated link to the central hub

or switch. As a result, network traffic from one device does not interfere with the traffic of other devices. This predictability in performance is especially important in scenarios where consistent and reliable data transfer is critical, such as in campus environments.

- Fiber Optic Cable connections: Fiber optic cables can transmit data over much longer distances without signal degradation compared to copper cables. While CAT 6 and CAT 7 Ethernet cables are limited to a maximum distance of 100 meters for Gigabit Ethernet, fiber optic cables can cover several kilometers without a significant loss in signal quality. This makes fiber ideal for interconnecting switches in large facilities or across campuses. Additionally, Fiber optic cables are inherently more secure than copper cables. They do not emit electromagnetic signals that can be tapped or intercepted easily, making them more resistant to eavesdropping and data breaches. This added security is especially valuable for organizations with strict data privacy and security requirements. For example in this case, protecting students and faculty's private information. Lastly, Investing in fiber optic infrastructure provides a level of future-proofing for the network. As data rates continue to increase, fiber optic cables can support higher speeds without the need for a complete cable replacement, unlike copper cables that may require upgrades to higher-category cables.

## Security

- FireNet FireGate 200E: Allocating a Firewall to protect the school's network is crucial for security and data protection. This device offers content filtering to control web access and applications and enables administrators to create usage policies. The specific selected firewall has: 1. Interactive drill-down and topology viewers that display real-time status. 2. On-click remediation that provides accurate and quick protection against threats and abuses. 3. Unique threat score system correlates weighted threats with users to prioritize investigations (22). Additionally, it allows VXLAN segmentation, has advanced security technologies and is optimized to monitor and protect IT, IIoT, and OT (Operational Technology) devices against vulnerability and device-based attack tactics and also has advanced cloud-delivered URL, DNS (Domain Name System), and Video Filtering providing complete protection for phishing and other web born attacks while meeting compliance (22).

## References of other Networks

According to a University of Michigan Information and Technology Services, the university's campus network is a mix between a mesh and a star topology which is called a hybrid topology. We investigate that this topology matches the campus size that is bigger than UWC ISAK Japan's size. However, we have used this as a reference to use a star topology as we do not have as many points that are too far away and need direct connections. We

see that all the connections can go back to one main central router which is located in the KAC in UWC ISAK Japan's case.

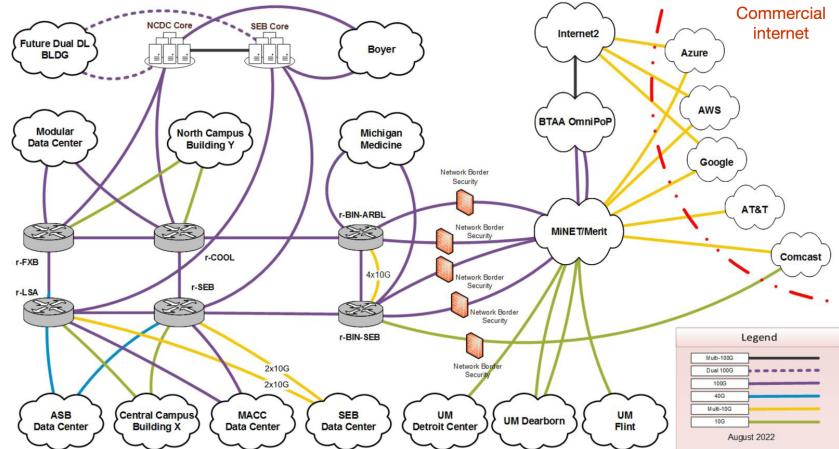


Fig 12. University of Michigan Network Topology.

We researched other network diagrams that use the same star topology as ours. There are many layers to the network with only one main campus router.

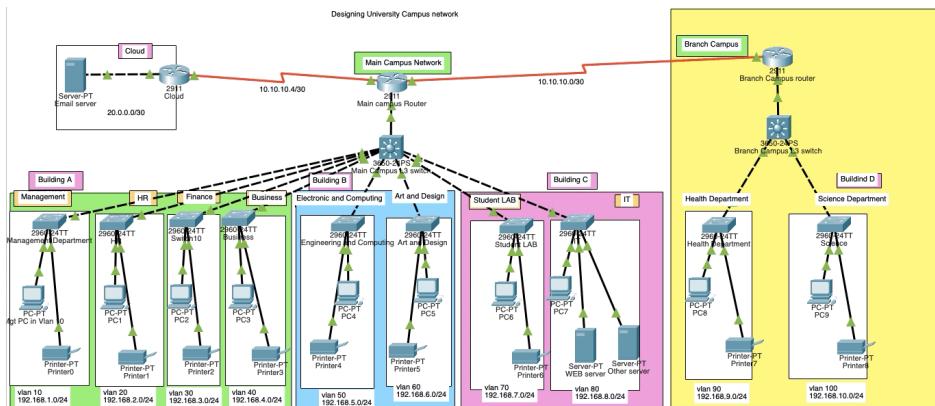


Fig 13. Network diagram with one main router

Then we looked into university campus networks which have different types of network usage other than for academic buildings. These are such as those with residential areas which might require different methods and devices to fix the purpose of use.

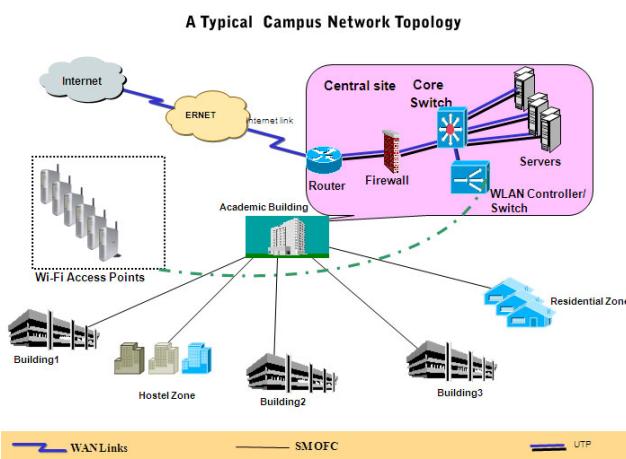


Fig 14. Campus network diagram with residential area

## Works cited

1. Ui.com, 2023, [community.ui.com/questions/Questions-about-Ubiquiti-UniFi-license/26dd8236-238b-431d-af47-56e59d4552a4](https://community.ui.com/questions/Questions-about-Ubiquiti-UniFi-license/26dd8236-238b-431d-af47-56e59d4552a4). Accessed 11 Sept. 2023.
2. FortiGate 200F. Accessed 11 Sept. 2023.
3. “Telecom UPS & Critical Power Services.” Unified Power, [unifiedpowerusa.com/telecom-critical-power-services/#:~:text=With%20a%20UPS%20C%20telecom%20companies](https://unifiedpowerusa.com/telecom-critical-power-services/#:~:text=With%20a%20UPS%20C%20telecom%20companies). Accessed 11 Sept. 2023.
4. “Star Topology Advantages and Disadvantages - Javatpoint.” [www.javatpoint.com/star-topology-advantages-and-disadvantages](https://www.javatpoint.com/star-topology-advantages-and-disadvantages).
5. “#1 University Campus Network Design.” *My Site*, [www.joeysitlab.com/university-campus-network-design](https://www.joeysitlab.com/university-campus-network-design). Accessed 11 Sept. 2023.
6. “10 Gbps Multi-Mode Optical Module.” *Ubiquiti Store United States*, [store.ui.com/us/en/pro/category/accessories-cables-dacs/products/10-gbps-multi-mode-optical-module?variant=uacc-om-mm-10g-d-20](https://store.ui.com/us/en/pro/category/accessories-cables-dacs/products/10-gbps-multi-mode-optical-module?variant=uacc-om-mm-10g-d-20). Accessed 11 Sept. 2023.
7. “Access Point AC Lite.” *Ubiquiti Store United States*, [store.ui.com/us/en/pro/category/all-wifi/products/uap-ac-lite](https://store.ui.com/us/en/pro/category/all-wifi/products/uap-ac-lite). Accessed 11 Sept. 2023.

8. “Access Point AC Pro.” *Ubiquiti Japan Online Store*, [jp.store.ui.com/products/unifi-ac-pro](http://jp.store.ui.com/products/unifi-ac-pro). Accessed 11 Sept. 2023.
9. “Access Point WIFI 6 Long-Range.” *Ubiquiti Store United States*, [store.ui.com/us/en/products/u6-lr](http://store.ui.com/us/en/products/u6-lr). Accessed 11 Sept. 2023.
10. “Campus Wide Networking.” *Official Website of ERNET India Education & Research Network*, [ernet.in/content/campus-wide-networking](http://ernet.in/content/campus-wide-networking). Accessed 11 Sept. 2023.
11. “Computer Science Learning for School Students.” *Teach*, [www.teach-ict.com/gcse\\_new/networks/topologies/miniweb/pg4.htm](http://www.teach-ict.com/gcse_new/networks/topologies/miniweb/pg4.htm). Accessed 11 Sept. 2023.
12. *F Ortigate 200F Series*, [www.fortinet.com/content/dam/fortinet/assets/data-sheets/fortigate-200f-series.pdf](http://www.fortinet.com/content/dam/fortinet/assets/data-sheets/fortigate-200f-series.pdf). Accessed 11 Sept. 2023.
13. “FLYPROFiber 100m OM2 LC-LC Optical Cable, in-Home Optical Wiring Cord, Fiber Optic Cable, Length 0.2m-100m, 1GB Duplex, Both Ends LC Connector, 50/125um Multimode, LSZH Jacket (100m, Orange) : Electronics.” *Amazon.Co.Jp: FLYPROFiber 100M OM2 LC-LC Optical Cable, In-Home Optical Wiring Cord, Fiber Optic Cable, Length 0.2m-100m, 1GB Duplex, Both Ends LC Connector, 50/125um Multimode, LSZH Jacket (100m, Orange) : Electronics*, [www.amazon.co.jp/-/en/FLYPROFiber-Optical-0-2m-50m-Connector-Multimode/dp/B095HT93TF?ref\\_=Oct\\_d\\_obs\\_d\\_3332597051\\_4&pd\\_rd\\_w=YmzNG&content-id=amzn1.sym.624fec3f-b263-4aae-abd7-e38211ddac50&pf\\_rd\\_p=624fec3f-b263-4aae-abd7-e38211ddac50&pf\\_rd\\_r=4BXN1MX3S1VEJW91RBG5&pd\\_rd\\_wg=UUFLG&pd\\_rd\\_r=bd348e5c-a41d-4119-aa28-12d5f27cef5d&pd\\_rd\\_i=B095HSTYYD&th=1](http://www.amazon.co.jp/-/en/FLYPROFiber-Optical-0-2m-50m-Connector-Multimode/dp/B095HT93TF?ref_=Oct_d_obs_d_3332597051_4&pd_rd_w=YmzNG&content-id=amzn1.sym.624fec3f-b263-4aae-abd7-e38211ddac50&pf_rd_p=624fec3f-b263-4aae-abd7-e38211ddac50&pf_rd_r=4BXN1MX3S1VEJW91RBG5&pd_rd_wg=UUFLG&pd_rd_r=bd348e5c-a41d-4119-aa28-12d5f27cef5d&pd_rd_i=B095HSTYYD&th=1). Accessed 11 Sept. 2023.
14. “HKUST Campus Network: Information Technology Services Center.” *INFORMATION TECHNOLOGY<br /> SERVICES CENTER*, [itsc.hkust.edu.hk/services/it-infrastructure/network-infrastructure/schematic](http://itsc.hkust.edu.hk/services/it-infrastructure/network-infrastructure/schematic). Accessed 11 Sept. 2023.

15. "Https://External-Preview.Reddit.it/CPABwWHlyRjPfPCejTWU2Bfi3b8et4PoE8HmfzgEZvM.jpg?Auto=webp&s=64467503ae0465d02a32879e54c946bb7ebed664." *Reddit*, [www.reddit.com/media?url=https%3A%2F%2Fexternal-preview.redd.it%2FCPABwWHlyRjPfPCejTWU2Bfi3b8et4PoE8HmfzgEZvM.jpg%3Fauto%3Dwebp%26s%3D64467503ae0465d02a32879e54c946bb7ebed664&rdt=61267](https://www.reddit.com/media?url=https%3A%2F%2Fexternal-preview.redd.it%2FCPABwWHlyRjPfPCejTWU2Bfi3b8et4PoE8HmfzgEZvM.jpg%3Fauto%3Dwebp%26s%3D64467503ae0465d02a32879e54c946bb7ebed664&rdt=61267). Accessed 11 Sept. 2023.
16. "M Campus Network Diagram & Description." *U*, [its.umich.edu/enterprise/wifi-networks/campus-network-diagram-description](https://its.umich.edu/enterprise/wifi-networks/campus-network-diagram-description). Accessed 11 Sept. 2023.
17. *Network Upgrade: Campus Network Gets a Boost*, [www.cityu.edu.hk/csc/netcomp/dec2007-3p.htm](http://www.cityu.edu.hk/csc/netcomp/dec2007-3p.htm). Accessed 11 Sept. 2023.
18. "Price per Meter: Cat6 Unshielded Twisted Pair (UTP) CCA Gigabit Network Cable." *HDCabling Centurion & Boksburg | Online & Walk-in Networking, Electronics and Cables Store*, 23 Aug. 2023, [www.hdcabling.co.za/product/price-per-meter-cat6-unshielded-twisted-pair-utp-23awg-1-gigabit-s-cable-gray/](http://www.hdcabling.co.za/product/price-per-meter-cat6-unshielded-twisted-pair-utp-23awg-1-gigabit-s-cable-gray/).
19. *SmartOnline 230V 2kVA 1800W On-Line Double- Conversion Ups, Tower ...*, [assets.tripplite.com/product-pdfs/en/suint2000xlcd.pdf](http://assets.tripplite.com/product-pdfs/en/suint2000xlcd.pdf). Accessed 11 Sept. 2023.
20. "Switch 24 Poe." *Ubiquiti Japan Online Store*, [jp.store.ui.com/products/usw-24-poe?\\_pos=1&\\_sid=c976bfe4b&\\_ss=r](http://jp.store.ui.com/products/usw-24-poe?_pos=1&_sid=c976bfe4b&_ss=r). Accessed 11 Sept. 2023.
21. "Switch Hi-Capacity Aggregation." *Ubiquiti Store United States*, [store.ui.com/us/en/collections/unifi-switching-enterprise-aggregation](http://store.ui.com/us/en/collections/unifi-switching-enterprise-aggregation). Accessed 11 Sept. 2023.
22. FortiGate ® 200F Series FG-200F and FG-201F. Accessed 11 Sept. 2023.

23. "SD-WAN Overview | Administration Guide." Fortinet.com, 2023, [docs.fortinet.com/document/fortigate/7.4.1/administration-guide/431448/sd-wan-overview](https://docs.fortinet.com/document/fortigate/7.4.1/administration-guide/431448/sd-wan-overview). Accessed 11 Sept. 2023.