TEC Residential Network Installation

Diego Iván Morales Gallardo

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Contents

1 Introduction

This report details the process I undertook to install the network system in one of the buildings at Tecnológico de Monterrey. The focus was on ensuring a robust, secure, and efficient infrastructure that meets the digital needs of students, faculty, and administrative staff. This initiative is part of the institution's ongoing efforts to adopt advanced technologies to enhance the educational and operational environment. I address aspects such as the design and implementation of the network, equipment selection, security configuration, and the integration of online services. This ensures fast and reliable internet access, as well as compatibility with a wide range of digital educational resources. This document not only captures the technical specifications and challenges overcome during the installation but also reflects Tecnológico de Monterrey's commitment to innovation and educational excellence.

2 Problem Context

I initiated a significant project for the construction of a new Residential Building. This project aims not only to expand the campus's accommodation capacity but also to improve the digital experience of students, collaborators, and guests by implementing a high-quality network. I was requested to develop design proposals for this network infrastructure, basing them on the current Residential Building model and developing a Proof of Concept that ensures functionality and integration without affecting existing operations. The success of this implementation depends largely on the compatibility of the new network with the campus's IT infrastructure, avoiding interruptions or service degradations. To navigate this complex challenge, the National IT department was designated as a key partner, responsible for guiding the project by providing critical data such as IP assignments and connectivity guidelines.

3 Challenge Objectives

3.1 Phase 1: Analysis

- Gather the requirements of the new network.
- Conduct a feasibility analysis of the installation, considering different physical spaces within the organization.

3.2 Phase 2: Design

- Design the physical layout of the network.
- Develop an economic proposal for the network implementation.
- Design the logical configuration of the network, including the use of specific IP addresses for the project.

3.3 Phase 3: Implementation

- Configure the network and its equipment.
- Perform connectivity tests to ensure the correct functioning of the network.

3.4 Phase 4: Proposal Delivery

- Deliver all the required documentation of the proposal, starting with the justification of the selected physical spaces.
- Integrate the connectivity tests that demonstrate the effective solution to the challenge.

4 Problem Statement

To begin the project, I first toured the current residential facilities at Tecnológico de Monterrey, Campus Guadalajara. The purpose was to observe and analyze the quantity and positioning of equipment within the building needed for the network infrastructure. I was able to visit the ground floor and the room where the router that distributes internet to the entire building is located. Then, I analyzed the basement and the room floors using the building's blueprints.

5 Project Scope

The objective of my first deliverable was to analyze which devices need to be connected to the network via wired connections and which should have constant connectivity. The positioning of these devices was chosen according to the building's needs. I also had to analyze the network infrastructure. To choose the number of devices such as access points, I considered how many people would be within the facility and what their network traffic would be. I decided that the number of users within the network would be 1,000 people, including "non-fixed" users like visitors who briefly visit the residents. The position of the access points was decided to ensure network coverage throughout the new residential facilities.

6 Initial Solution Proposal

The initial proposal of the project was as follows:

Device	**Space / Floor**	**Function**	**Qty**	**Connectivity Type**	**Service Device**	**Infrastructure / Resident Use**
Security Cameras	Basement	Surveillance	4	Wired	100 Connected to the network	Infrastructure

Access Point	Basement	Internet Connection	9*	Wired	100 Connected to the network	Resident Use
Access Controls	Basement	Security / Access Control	3	Wired	100 Connected to the network	Infrastructure
Smoke Detectors	Basement	Fire Safety	11*	Wired	100 Connected to the network	Infrastructure
Access Controller	Security Booth	Access Control System Management	1	Wired	100 Connected to the network	Infrastructure
Access Controls	Security Booth	Access Control System Management	3	Wired	100 Connected to the network	Infrastructure
Intercom	Security Booth	Communicati	1	Wired	100 Connected to the network	Infrastructure
IP Phone	Security Booth	Communicati	1	Wired*	100 Connected to the network	Infrastructure
PC	Security Booth	Security and Administrative Operations	1	Wired	100 Connected to the network	Infrastructure
Video Recorder (DVR)	Security Booth	Security Video Recording	1	Wired	100 Connected to the network	Infrastructure
Security Cameras	Security Booth	Surveillance	2	Wired	100 Connected to the network	Infrastructure

Access Point	Security Booth	Internet Connection	1	Wired	100 Connected to the network	Resident Use
Access Point	Left Terrace	Internet Connection	1*	Wired	100 Connected to the network	Resident Use
Access Point	Right Terrace	Internet Connection	1*	Wired	100 Connected to the network	Resident Use
Access Point	Garden	Internet Connection	2*	Wired	100 Connected to the network	Resident Use

Table 1: Initial Device Proposal (Part 1)

Device	**Space / Floor**	**Function**	**Qty**	**Connectivity Type**	**Service Device**	**Infrastructure / Resident Use**
Access Point	Ground Floor	Internet Connection	9*	Wired	100 Connected to the network	Resident Use
Access Controls	Ground Floor	Access Control System Management	3	Wired	100 Connected to the network	Infrastructure
IP Security Cameras	Ground Floor	Surveillance	5	Wired	100 Connected to the network	Infrastructure
IP Phone	Ground Floor	Communicati	2	Wired*	100 Connected to the network	Infrastructure
Printer	Ground Floor	Printing	2	Wired	Periodic Use	Resident Use

Console	Ground Floor	Entertainmen	3	Wired	Periodic Use	Resident Use
Smart TV	Ground Floor	Entertainmen	4	Wired	Periodic Use	Resident Use
Smart TV	Ground Floor	Entertainmen	1	Wireless	Periodic Use	Resident Use
Video Recorder (DVR)	Ground Floor	Security Video Recording	1	Wired	100 Connected to the network	Infrastructure
Access Control System Controller	Ground Floor	Access Management	2	Wired	100 Connected to the network	Infrastructure
Lighting System Controllers	Ground Floor	Lighting Control	2	Wired	100 Connected to the network	Infrastructure
Fire Detection System Controllers	Ground Floor	Fire Detection	2	Wired	100 Connected to the network	Infrastructure
Smoke Detector	Ground Floor	Fire Safety	11*	Wired	100 Connected to the network	Infrastructure
Access Controls	Rooms	Access Control System Management	21	Wired	100 Connected to the network	Infrastructure
IP Phone	Rooms	Communicati	14	Wired*	100 Connected to the network	Infrastructure
Security Cameras	Rooms	Surveillance	28	Wired	100 Connected to the network	Infrastructure

Smoke Detector	Rooms	Fire Safety	168*	Wired	100 Connected to the network	Infrastructure
Fire Alarm	Rooms	Fire Safety Alert	14*	Wired	100 Connected to the network	Infrastructure
Light Switch	Rooms	Lighting Control	168*	Wired	100 Connected to the network	Infrastructure
Access Point	Rooms	Internet Connection	56*	Wired	100 Connected to the network	Resident Use
Student Devices	Rooms	General Use	1008*	Wireless	Periodic Use	Resident Use

Table 2: Initial Device Proposal (Part 2)

7 Solution Proposal

7.1 Proposed Physical Spaces (Layout)

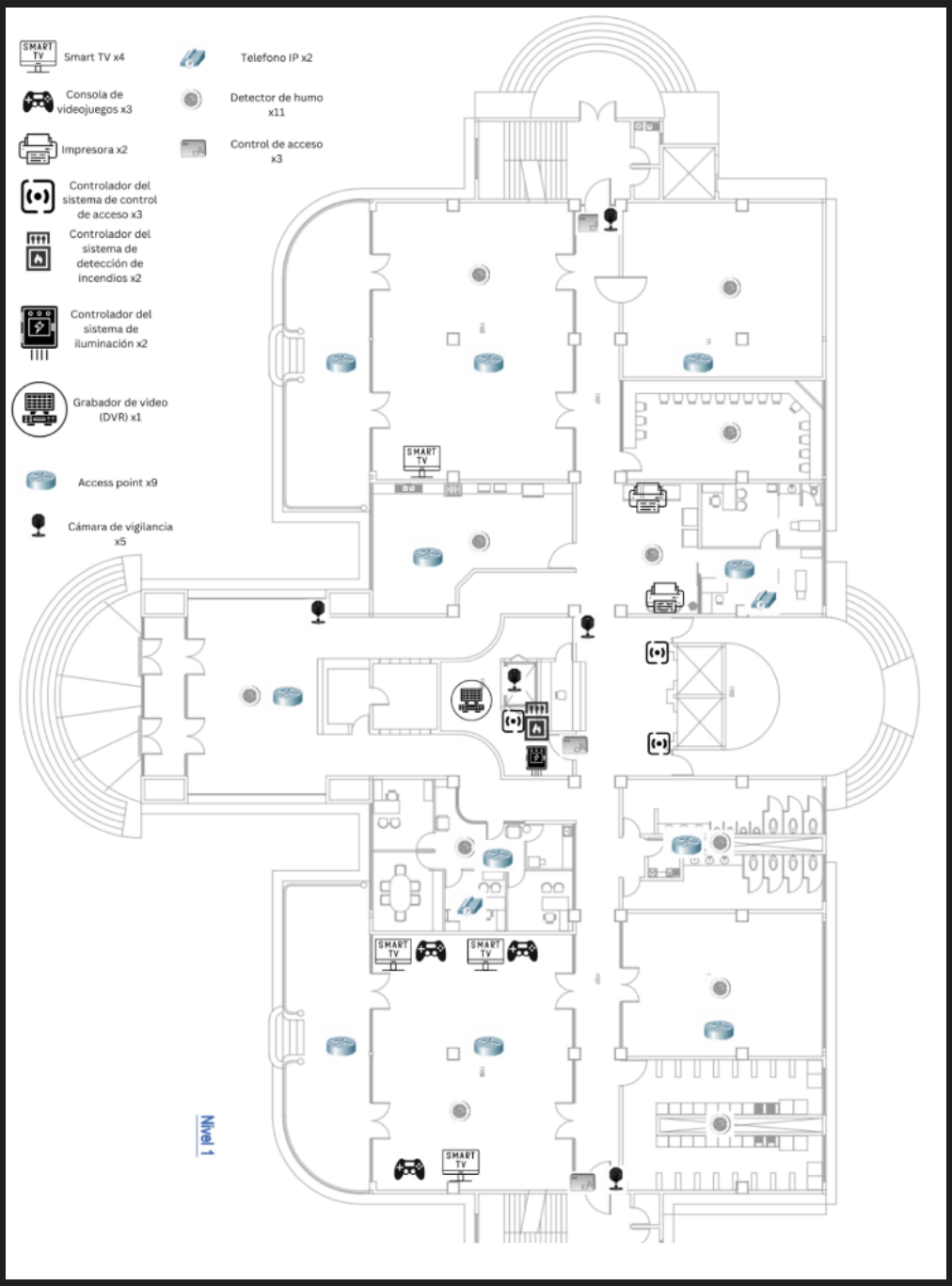

Figure 1: Ground Floor Layout

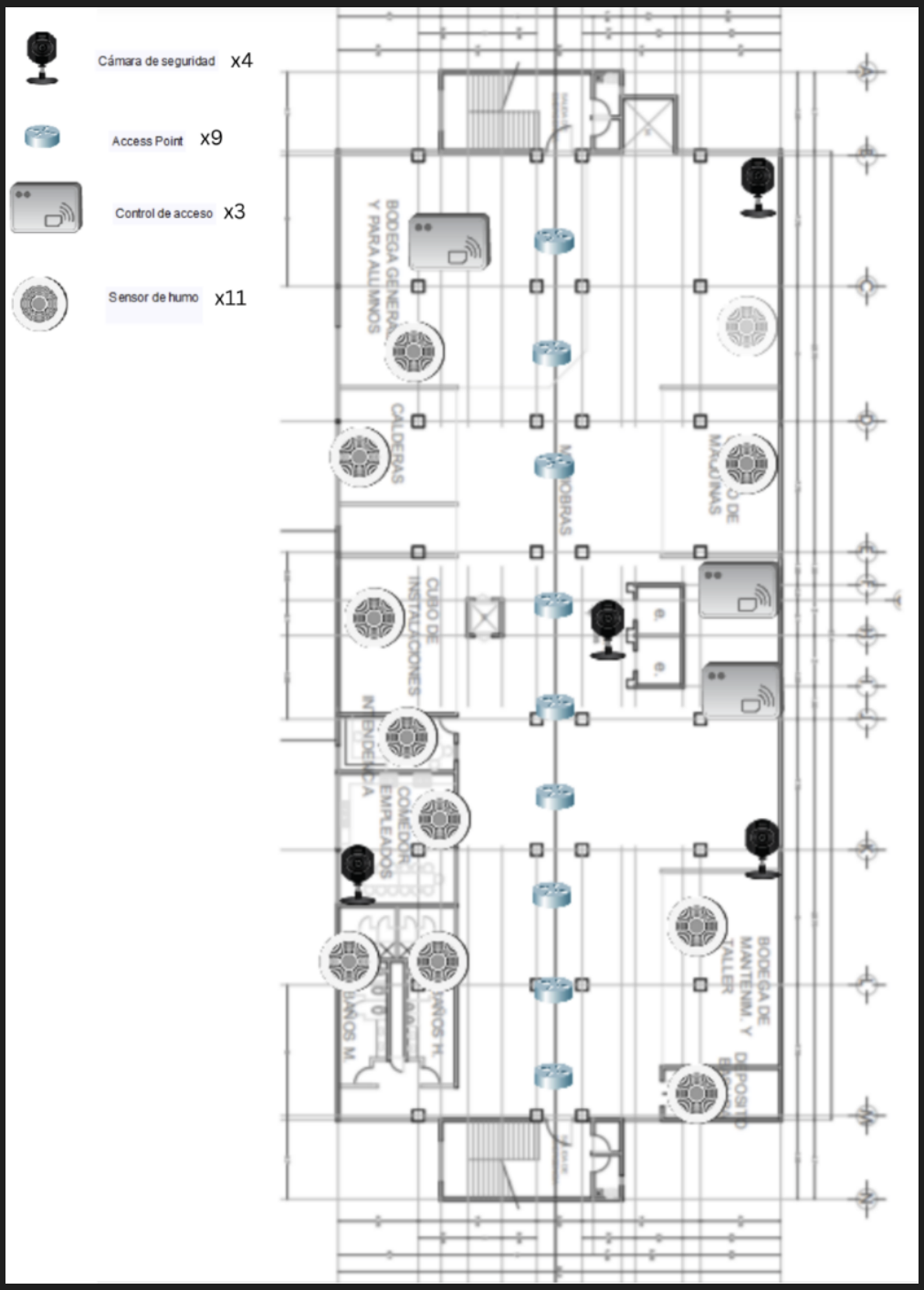

Figure 2: Basement Layout

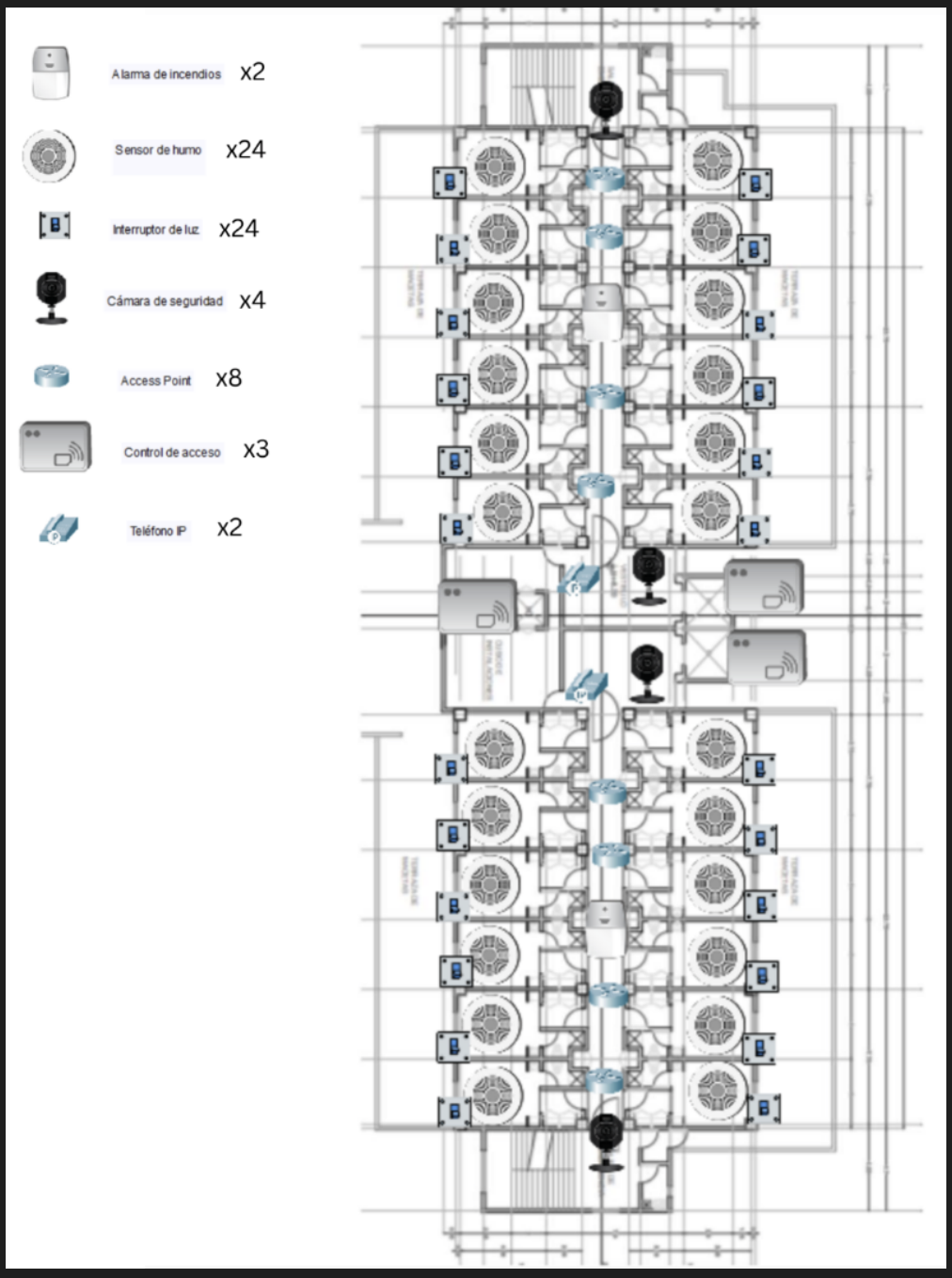

Figure 3: Rooms Layout

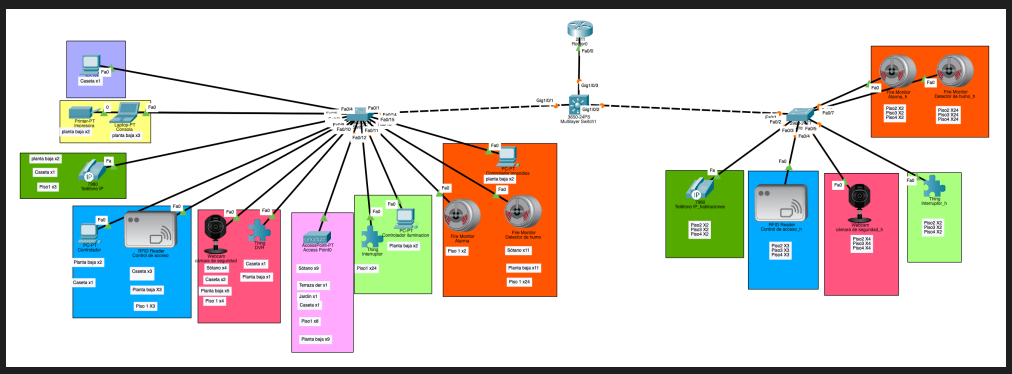

Figure 4: Physical Network Design with Switches, APs, Sensors, and Terminal Equipment

7.2 Logical Network Design

7.2.1 Final Addressing Table

Logical Network Design - IPv4 Address Allocation with Variable Length Subnet Mask (VLSM)

Network IP Address: 172.24.32.0/19

VLAN	Device Group Name	Required Hosts	Hosts Including Growth	Netmask (Bits)	Netmask (Decimal)	Total IPs
30	Administratior (PC)	1	2	/30	255.255.255.2	4
2	Entertainmen and Services (Smart-TV + Console + Printer)	10	20	/27	255.255.255.2	32
3	Switches	16	32	/26	255.255.255.1	64
4	Communicatic (Intercom + IP Phone)	17	34	/26	255.255.255.1	64
5	Security Controls (Access Control System + Access Controllers)	33	66	/25	255.255.255.1	128
6	Security (Security Cameras + Video Recorder (DVR))	41	82	/25	255.255.255.1	128

7	APs (Access Points)	77	154	/24	255.255.255.(	256
8	Lighting Control (Light Switch + Lighting System Controllers)	170	340	/23	255.255.254.(	512
9	Fire Detection (Smoke Detectors + Fire Alarm + Fire Detection Controllers)	206	412	/23	255.255.254.(	512
10	Connectivity (Student Devices)	1008	2016	/21	255.255.248.(	2048

Table 3: IPv4 Address Allocation - Part 1

VLAN	**Assignable IPs**	**Subnet IP**	**First Assignable IP**	**Last Assignable IP (Gateway)**	**Subnet Broadcast IP**
30	2	172.24.46.160	172.24.46.161	172.24.46.162	172.24.46.163
2	30	172.24.46.128	172.24.46.129	172.24.46.158	172.24.46.159

3	62	172.24.46.64	172.24.46.65	172.24.46.126
172.24.46.127				
4	62	172.24.46.0	172.24.46.1	172.24.46.62
172.24.46.63				
5	126	172.24.45.128	172.24.45.129	172.24.45.254
172.24.45.255				
6	126	172.24.45.0	172.24.45.1	172.24.45.126
172.24.45.127				
7	254	172.24.44.0	172.24.44.1	172.24.44.254
172.24.44.255				
8	510	172.24.42.0	172.24.42.1	172.24.43.254
172.24.43.255				
9	510	172.24.40.0	172.24.40.1	172.24.41.254
172.24.41.255				
10	2046	172.24.32.0	172.24.32.1	172.24.39.254
172.24.39.255				

Table 4: IPv4 Address Allocation - Part 2

7.2.2 Network Division

Network IP Address: 172.24.0.0

Subnet Mask: 255.255.0.0 (/16)

Net ID	First Usable IP	Last Usable IP	Broadcast ID
0	172.24.0.0	172.24.31.254	172.24.31.255
1	172.24.32.0	172.24.63.254	172.24.63.255
2	172.24.64.0	172.24.95.254	172.24.95.255
3	172.24.96.0	172.24.127.254	172.24.127.255

4	172.24.128.0	172.24.159.254	172.24.159.255
5	172.24.160.0	172.24.191.254	172.24.191.255
6	172.24.192.0	172.24.223.254	172.24.223.255
7	172.24.224.0	172.24.255.254	172.24.255.255

Table 5: Network Division Table - Part 1

Net ID	3rd Octet (Binary)	4th Octet (Binary)
0	00000000	00000000
1	00100000	00000000
2	01000000	00000000
3	01100000	00000000
4	10000000	00000000
5	10100000	00000000
6	11000000	00000000
7	11100000	00000000

Table 6: Network Division Table - Part 2

Network IP Address: 172.24.32.0

Subnet Mask: 255.255.224.0 (/19)

Group	Hosts	Subnet ID	Net ID
A	2016	1.0	172.24.32.0
B, C, D, E	1054	1.1	172.24.40.0
F	34	1.2	172.24.48.0
G	20	1.3	172.24.56.0

Table 7: Group Division for /19 Subnet - Part 1

Group	First Usable IP	Last Usable IP	Broadcast ID
A	172.24.32.1	172.24.39.254	172.24.39.255
B, C, D, E	172.24.40.1	172.24.47.254	172.24.47.255
F	172.24.48.1	172.24.55.254	172.24.55.255
G	172.24.56.1	172.24.63.254	172.24.63.255

Table 8: Group Division for /19 Subnet - Part 2

Subnet Mask: 255.255.248.0 (/21)

Group	Hosts	Subnet ID	Net ID
B	412	1.1.0	172.24.40.0
C	340	1.1.1	172.24.42.0
D	156	1.1.2	172.24.44.0
E	146	1.1.3	172.24.46.0

Table 9: Group Division for /21 Subnet - Part 1

Group	First Usable IP	Last Usable IP	Broadcast ID
B	172.24.40.1	172.24.41.254	172.24.41.255
C	172.24.42.1	172.24.43.254	172.24.43.255
D	172.24.44.1	172.24.45.254	172.24.45.255
E	172.24.46.1	172.24.47.254	172.24.47.255

Table 10: Group Division for /21 Subnet - Part 2

7.3 Economic Proposal

7.3.1 Switch Costs

List of Interconnection Equipment and Required Materials

Quantity	Device Type or Concept	Model	Function Description or Justification
7	Switch	C9300L-48UXG-4X-M	Switch connecting access points in rooms to leverage MultiGigabit for heavily used resident access points
8	Switch	C9300L-48PF-4X-M	Switches for various devices (Cameras, controllers, sensors, etc.) with one in each TR for backup
1	Core Switch	MS425-16	Switch considering backup
1	Connection Medium	MA-CBL-TA-3M	Copper usage for horizontal access point connections
4	Fiber Optic	MA-SFP-10GB-LRM	Fiber optic to connect switches for high-speed capability
1	Router	MX105	Router with sufficient port capacity for core switch and ISP backup
56	Access Point (Rooms)	CW9164	Robust access points for multiple device usage, considering wall blockage
18	Access Point (Common Areas)	CW9162	Access points suitable for less populated common areas

5	Access Point (Outdoor)	MR78	Access points dedicated for outdoor use (Terraces, garden, shed)

Table 11: Equipment and Cost Breakdown - Part 1

Quantity	Unit Cost (USD)	Subtotal (USD)
7	$14,589.00	$102,123.00
8	$11,089.00	$88,712.00
1	$18,548.00	$18,548.00
1	$196.00	$196.00
4	$1,177.00	$4,708.00
1	$5,909.00	$5,909.00
56	$2,195.00	$122,920.00
18	$1,595.00	$28,710.00
5	$1,499.00	$7,495.00

Table 12: Equipment and Cost Breakdown - Part 2

Total Cost before VAT (USD): $379,321.00

7.3.2 Cost Justification

For the equipment quotation, I considered the C9300L-48UXG-4X-M model as the switch to connect the access points on the floors where the rooms are located, as the bandwidth demand per AP (Access Point) was higher than in other areas. By having MultiGigabit ports for connection, the capacity of the APs is better utilized. Subsequently, I chose an additional 48-port switch for wired electronics on each floor, considering that having two or more smaller capacity switches increased the total price due to the number of switches.

The core switch used, which connects to the main router, is the MS425-16. This was chosen due to the adequate port size for the switches connected to it, avoiding unnecessary expenditure on a larger size. This switch would be connected to a Cisco MX105 router, with a processing capacity of 3 Gbps, which I

considered sufficient and efficient for the local network being managed. This router is at the sweet spot of processing power and price for our needs.

For the access points, I first considered those with less traffic and those that could have higher saturation. The access points located outside the building will be the MR78 model, designed mainly for outdoor use by Cisco. The second set of access points will be dedicated to common areas located on the building's ground floor and basement. For this, I will use CW9162, which have a decent reach and excellent capacity for broad coverage in less populated areas than the residential floors. Lastly, I prioritized the budget for the access points in the rooms, as they will be the most used, demanded, and obstructed by construction. This necessitates the use of a higher-end model like the CW9164, which are robust and very useful to provide sufficient bandwidth for a large device population.

7.4 Bandwidth Solution

Device	**Local Bandwidth**	**Internet Bandwidth**
Security Cameras	5 Mbps	0 Mbps
Access Points	N/A	N/A
Access Controls	<1 Mbps	0 Mbps
Smoke Detectors	<1 Mbps	0 Mbps
Access Controller	<1 Mbps	0 Mbps
Intercom	1-2 Mbps	0 Mbps
IP Phone	100 Kbps - 1 Mbps per call	100 Kbps - 1 Mbps per call
PC	Up to 1 Gbps	Up to 25 Mbps
Video Recorder DVR	2-5 Mbps per connected camera	0 Mbps
Printer	<1 Mbps	0 Mbps
Console	0 Mbps	3-6 Mbps for online gaming
Smart TV	0 Mbps	5 Mbps for HD, 25 Mbps for 4K
Lighting Controllers	<1 Mbps	0 Mbps
Fire Detection Controllers	<1 Mbps	0 Mbps
Fire Alarm	<1 Mbps	0 Mbps
Light Switch	<1 Mbps	0 Mbps
Student Devices (Laptops, Phones)	Varies	Varies

Table 13: Bandwidth Requirements - Part 1

Device	**Total Devices**	**Total Local Bandwidth**	**Total Internet Bandwidth**
Security Cameras	39	195 Mbps	0 Mbps
Access Points	77	N/A	N/A
Access Controls	31	31 Mbps	0 Mbps
Smoke Detectors	168	168 Mbps	0 Mbps
Access Controller	2	2 Mbps	0 Mbps
Intercom	1	2 Mbps	0 Mbps
IP Phone	17	17 Mbps	17 Mbps
PC	1	1 Gbps	25 Mbps
Video Recorder DVR	2	10 Mbps	0 Mbps
Printer	2	2 Mbps	0 Mbps
Console	3	0 Mbps	18 Mbps
Smart TV	5	0 Mbps	125 Mbps
Lighting Controllers	2	2 Mbps	0 Mbps
Fire Detection Controllers	2	2 Mbps	0 Mbps
Fire Alarm	14	14 Mbps	0 Mbps
Light Switch	168	168 Mbps	0 Mbps
Student Devices (Laptops, Phones)	1008	1 Gbps	4 Gbps

Table 14: Bandwidth Requirements - Part 2

8 Conclusion

Through careful analysis and planning, I have developed a comprehensive network design for the new Residential Building at Tecnológico de Monterrey. The proposed solution addresses all the necessary aspects, from physical layout to logical network configuration and bandwidth requirements. The equipment selection and economic proposal are justified based on the building's specific needs and future scalability. This project not only enhances the digital experience for all users but also aligns with the institution's commitment to technological advancement and educational excellence.