

Group 2 - Project Deliverable 3

Network Design Project

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Nomenclature

- P1 - TYPICAL PC
- CS - CORE SWITCH
- MS - MAIN SWITCH
- WCS - WAREHOUSE CENTRAL SWITCH
- PR - PRINTER
- SAN - STORAGE AREA NETWORK
- AP - ACCESS POINT
- DC - DATA CENTER
- SW - SWITCH
- VPN - VIRTUAL PRIVATE NETWORK
- PS- PHYSICAL SERVERS
- CAM - CAMERA
- TV - TELEVISION
- R - ROUTER
- VDS - VIDEO DISTRIBUTION SYSTEM
- NVR - NETWORK VIDEO RECORDER
- DS - DOOR SCANNER
- 2F - SECOND FLOOR

Executive Summary

SHFL Entertainment (Shuffle Master, Inc.), a global gaming supplier, is embarking on an expansion and relocation project to consolidate its operations into a new Las Vegas facility. This move presents an opportunity to redesign the company's information technology infrastructure. In response to the Request For Proposal, (RFP), we present a comprehensive plan to meet the needs of SHFL Entertainment's new Las Vegas location. The three design options discussed in this report takes into account our analysis of the network needs for the company, providing a design differing in terms of expense and sophistication. After careful evaluation of the internal and external needs of the company/users, building design, financial considerations, and overall suitability, we recommend SHFL adopt the most likely design as their new network architecture.

The three different technical IT network infrastructure designs included in this document are characterized as follows: the "cheapest" design, the "most likely" design, and the "gold-plated" design. Each design considers SHFL's need for global connectivity to the offices in Eden Prairie, MN, Australia, and Vienna. In addition, the Las Vegas location will act as a secondary data center. While all three designs share similar attributes, they differ considerably in terms of characteristics, cost, and implementation.

The cheapest design, as aptly titled, allows for the basic networking needs of SHFL to be met while keeping costs low. The first design utilizes the first floor of the new facility as a critical hub for SHFL Entertainment's network infrastructure. The network is designed in a star topology to ensure simplicity. A router at the network edge directs traffic and establishes site-to-site VPN connections, taking into account network security. In addition, a SAN and data center are connected for data replication and backups. The estimated total cost for this design is \$799,288.35.

The most likely design, our recommendation, provides higher quality characteristics, while keeping costs within a desired range. This design maximizes the use of a star topology; and the configuration not only guarantees seamless network operation, but also minimizes the impact of failures by effectively mitigating single points of failure. With this design, the network ensures high-speed and reliable connections and exceptional data transfer rates and low latency. The estimated total cost for this design is \$863,429.91.

The gold-plated design will build upon the most likely design by implementing the best-of-the-best technology; however, this drastically increases the cost of implementation. Through strategic connections, such as linking APs and core switch, this design optimizes resilience, ensuring seamless operations regardless of disruption. The gold-plated design is the ultimate culmination of comprehensive and robust network architecture. The estimated total cost for this design is \$1,265,497.98.

With this new era of expansion, centralized at the gaming capital of the world, the new SHFL headquarters deserves a secure, efficient, and expansive IT network to usher in this time of growth. Each of our designs ensure SHFL is ready to meet the needs of today and adapt to the changes of the future. By committing one of the designs in our proposal, SHFL is guaranteed to come out on top.

The Networking Topics

In all of our network designs, two essential topics that we have considered are "Convergence" and "Network Storage"

- The company operates across the globe, with regional offices situated in key locations such as Las Vegas, Nevada, Australia, South Africa, Austria, Macau, and Mexico. Given this, it's important for employees to maintain constant communication and collaboration, regardless of where they are located. To facilitate this seamless communication, we have chosen to implement Zoom, a versatile Software as a Service (SaaS) solution. Zoom encompasses a wide range of communication tools, including voice calls, video conferencing, and online meetings. By using Zoom, employees in various corners of the world can connect effectively and stay in touch.

To incorporate this, we have chosen the Zoom Rooms package. The Zoom Rooms package presents an ideal solution for SHFL, catering to the communication and collaboration needs of its wide range of employees. With the capacity to host meetings for up to 300 participants, SHFL can seamlessly conduct company-wide gatherings and department-specific meetings. The package's unlimited meeting duration, coupled with 5 GB of cloud recording storage per license, ensures uninterrupted discussions and secure archiving of important meeting recordings.

- For SHFL, a cloud-based storage solution can offer significant advantages, given their global operations. Network Storage serves as a centralized repository for the company's valuable data resources. With a presence in multiple global locations, having a single repository eliminates data silos and ensures that critical information is stored, managed, and accessible from a common platform. With this, employees from different regions can access and collaborate on documents and resources effortlessly, regardless of their geographic location. We recommend Amazon S3 Express One (Simple Storage Service) as our cloud-based Network Storage solution. For a gambling company that relies on real-time data processing, such as live gaming updates, transaction data, and security feeds, consistent low-latency access is crucial. S3 Express One Zone provides single-digit millisecond data access, ensuring that the company's applications can respond rapidly to user interactions, delivering a seamless and responsive experience.

The automatic scaling feature of S3 Express One Zone also aligns with the dynamic nature of a SHFL data storage needs. As the volume of data fluctuates based on user activity, the storage capacity scales up or down automatically. The product also has a co-location feature where we can select a specific AWS Availability Zone within an AWS Region to store the data. This means that the main branch in Las Vegas will establish the primary data center with S3 Express One Zone storage using a global network. The Las Vegas data center will be interconnected with subsidiary locations in Vienna, Australia and Eden Prairie with each subsidiary maintaining its local compute resources, including gaming servers, databases, and application servers, and other necessary files. By

co-locating storage with compute resources in the same Availability Zone, the company minimizes data transfer times and reduces latency. This results in optimal performance for applications, particularly those requiring real-time data access, such as online gaming platforms.

Design Considerations

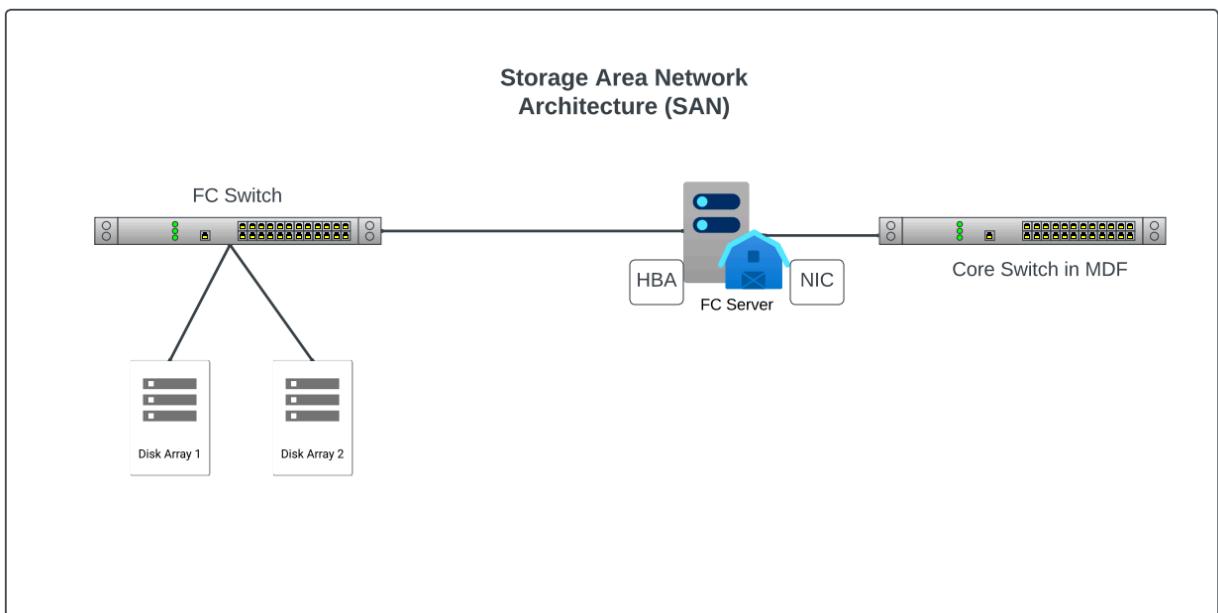
In this section, we mention all the considerations applicable to all or some of the three designs that will remain the same in all of those designs:

- We choose Star topology for all three designs because it is straightforward and easy to install. Each device in the network connects directly to a central hub (like a switch or router), eliminating the complexity associated with other topologies and allowing centralized management of network devices.
- The copper cable standard chosen for the implementation of horizontal connections for the first two designs is cat6. This cable type is capable of supporting speeds of up to 1 Gbps. As we increase our internet throughput for the third design, the standard chosen for this is cat6A, which supports speeds up to 10 Gbps.
- The fiber cable standard chosen for the implementation of vertical/backbone connections i.e. connection between networking equipment such as switches and routers, across all three designs is an OM3 cable type (Multi-mode fiber) with the specification being 1000BASE-SX. We are connecting the cable to the switches with a sfp-sx transceivers situated at all the network switches. Fiber-optic cables offer rapid data transfer rates due to the speed of light transmission, ensuring faster, more efficient connectivity. Moreover, they can span long distances without compromising data integrity. To accommodate this, we have chosen appropriate switches that support the fiber optic cables.
- We have meticulously selected hybrid switches for all the designs so that both copper cabling and fiber cabling can be facilitated.
- Workstations in the network are categorized into two types: P1 and P2. P1 is designed for general usage with lower speed and power requirements, while P2 is a high-speed, high-power workstation. Allocation of workstations is based on department needs, with those requiring high-performance assigned P2, while others receive P1 based on their usage and requirements.
- There are different kinds of switches used in all three designs. Some switches connect to the workstations, printers, APs and other components, while some switches connect to other switches such as the main switch. Therefore, all the switches have the Auto-MDI/MDIX (Medium Dependent Interface Crossover) feature enabled to automatically detect and adjust for the correct cable type allowing for easy switch-to-host or switch-to-switch connections.

- The Ruckus R750 wireless access point with WiFi 6 will be used in all the three designs to ensure Gigabit wireless connection throughout the building. This access point is selected as it supports Power over Ethernet (PoE), and can also accommodate up to 200 concurrent clients at a time. This capability streamlines the cabling infrastructure and enhances flexibility in deployment.
- Some of the departments in all the three designs have security cameras installed for the security purpose. To collect and manage the video feeds from the camera, we have also implemented a Network Video Recorder (NVR) to the core switch. The NVR is connected to the core switch via an Ethernet cable and all the cameras in the building are connected to the same network as the NVR. This will allow the NVR to communicate with all the cameras in the network. A separate computer is also connected to the core switch in the second floor to access the NVR web interface, view camera feeds, and review recorded footage.
- In all the three designs, various switches with different port numbers have been used to cater the needs of different departments. The allocation of switches and ports is based on the requirement of each department, as well as the speed and throughput required for the department.
- In all three designs, a diverse array of switches with varying port capacities has been employed to meet the specific needs of different departments within the organization. The allocation of switches and ports is designed to align with the unique requirements of each department. This includes considerations such as the scale of operations, data traffic demands, and the desired speed and throughput essential for the seamless functioning of each department.
- For the internet connection, we have chosen COX Business Fiber Internet, which provides internet through the fiber-optic connection, with a maximum speed of 1 Gbps. The design 1 and 2 will have the same internet connection provided by COX, whereas design 3 will have Google Fiber Internet (2 Gbps) as the primary connection while COX Business Fiber Internet will be a backup. This change was made to cater to the high network throughput demands of design 3. All three designs will have a router that can support up to 10 Gbps for future scalability.
- All of the three designs will use fibre channel for SAN replication. As per the requirement from SHFL, the data center will be replicated between the off-site and on-site data center by SAN replication and the capacity of the SAN is roughly 80 TB.
 - Since all the three designs require a SAN for replication, all the designs will feature two storage arrays (Tier 1 and Tier 2), each with a capacity of 40 TB, totaling the required capacity of 80 TB for the SAN. Tier 1 storage array will store time-sensitive data that include real-time gaming data, transaction and payment data, security and surveillance feeds, and electronic table game data. Similarly, the tier 2 storage array is designated for crucial yet less time sensitive data such as historical gaming data, monthly financial reports, server backup logs

and so on. Time-sensitive data, such as real-time gaming transactions and critical operational information, often requires immediate access. By segregating it onto a dedicated storage array, the system can prioritize and optimize performance for this data, ensuring low-latency access.

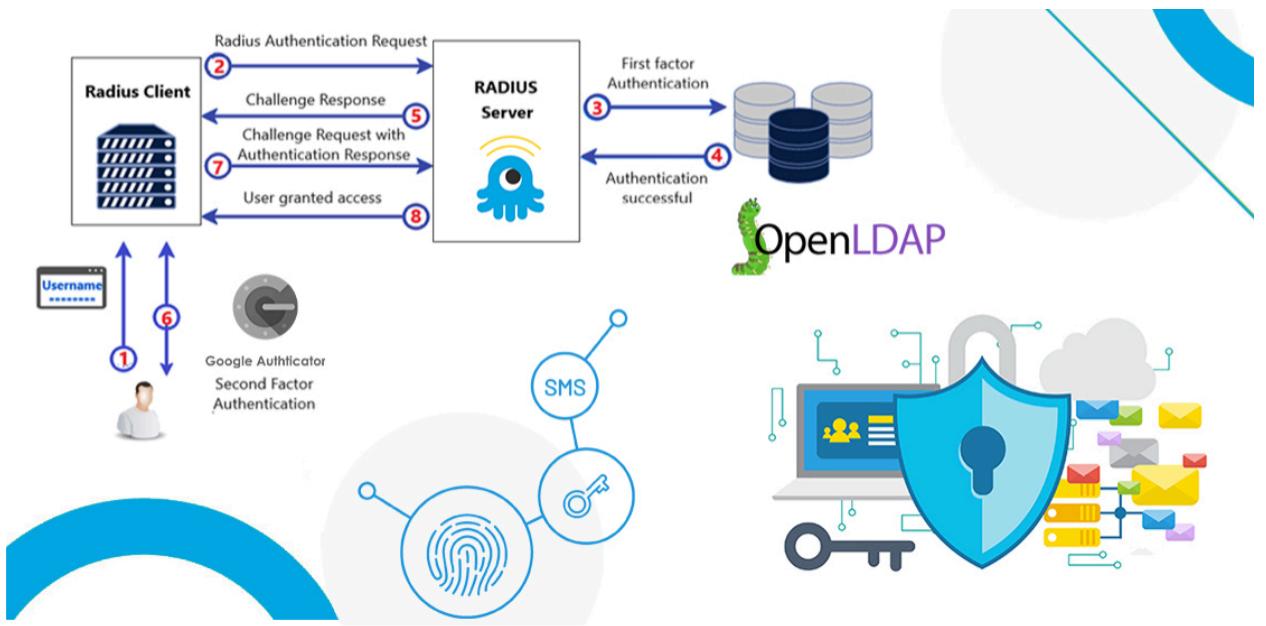
- Fibre Channel protocol, which is one of the most commonly used industry standards for large-scale storage solution and data replication will be used for data replication and data storage. The fibre channel architecture will consist of Fibre Channel Protocol Server, Fibre Channel Protocol Switch, and Storage Arrays. The fibre channel protocol server will be equipped with a network interface card (NIC) and a host bus adapter (HBA). The host bus adapter will establish the connection between the server and the fibre channel protocol switch. The fibre channel protocol switch will connect to two storage arrays.
- The network interface card (NIC) connects the server to the core switch in the local area network. Requests to access storage or place data in storage from the local area networks will be communicated through the NIC card to the fibre channel protocol server. Data replication will occur through a synchronous method and be carried out within this SAN. This SAN will be maintained inside a room within the MDF that is accessible only by system administrators.



- In the second floor of the network diagrams, we connected the core switch to a block which represents the on-site SAN architecture. This block represents the diagram attached above i.e. the FC Server and the FC Switch with two Disk Arrays.
- Eight physical servers, specifically VMware ESX servers, will be used to host a total of 100 virtual servers, as per the requirement by Shuffle Master. These virtual servers

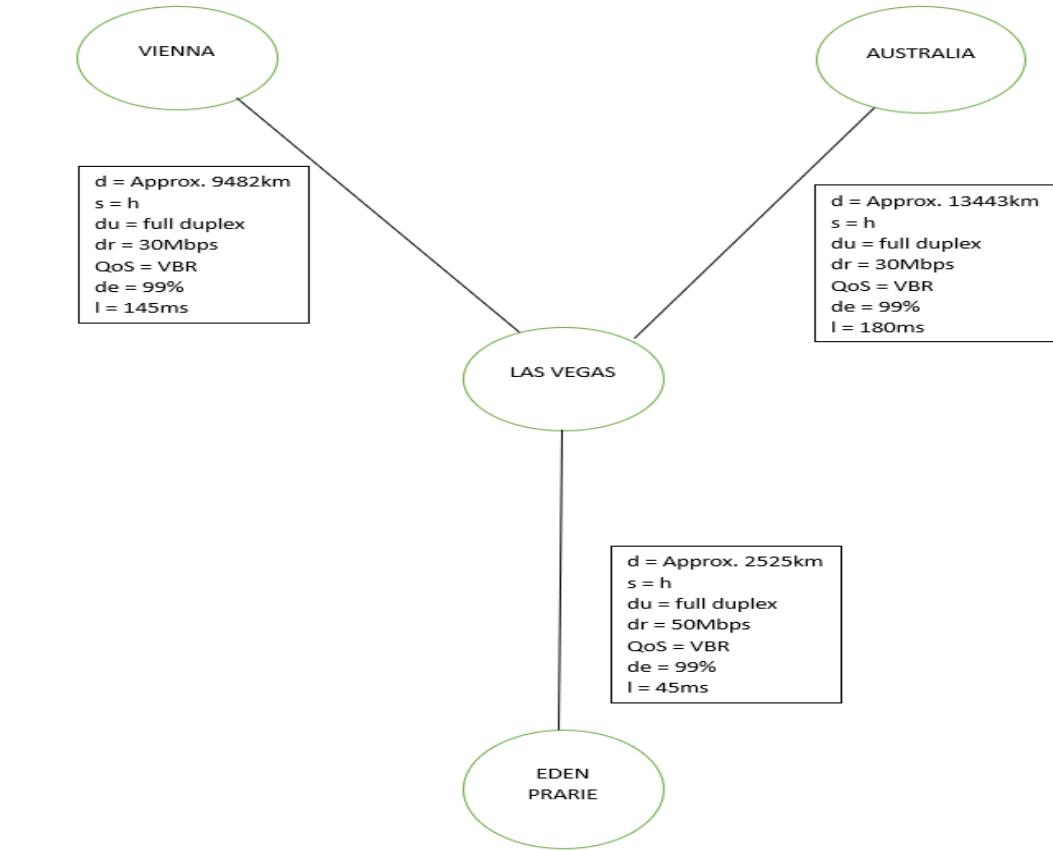
encompass various functionalities, including the RADIUS server, file server, mail server, web server, SQL server, and other relevant components.

- In the designs 2 and 3, door scanners serve as access control systems, providing employees in each department with entry privileges. These scanners play a crucial role in securing the business, especially within departments that house sensitive information and valuable resources. For Design 2, a card-based door scanner has been integrated near the entrance. Employees can use their assigned badges, provided by the security team, to access the designated area. Meanwhile, in Design 3, biometric door scanners have been implemented near the doors, allowing employees to gain access by scanning their thumbprints. The door scanners ensure that only authorized users can enter specific areas. And they also facilitate enhanced security by keeping a record of the employees who enter the department.
- In the Warehouse, To scan and store the barcodes, we have chosen a wifi barcode scanner. The wifi-connected barcode scanner supports a high scan range, which will be sufficient for SHFL to scan the barcodes in every warehouse area. Once a barcode is scanned, the scanner wirelessly transmits the captured data using its wifi connectivity to a server that houses SHFL's inventory management and order processing systems. Additionally, the data will also be stored in a database for future reference and analysis.
- To safeguard the confidential work conducted by SHFL, a Remote Authentication Dial In-User Service (RADIUS) protocol will be implemented across all three network designs. In each design, all the staff must undergo RADIUS authentication facilitated by a virtual RADIUS server installed on one of the eight physical VMware ESX servers linked to the MDF core switch. For the RADIUS authentication, we have chosen FreeRADIUS server, which is one most widely used RADIUS server in the world. The FreeRADIUS product suite includes a server, radius client, development libraries, and numerous additional RADIUS and IP address-related utilities. This RADIUS server configuration ensures exclusive acceptance of requests from authorized devices and automatically denies access to unauthorized users. Additionally, for enhanced security, authorized users will also undergo multi-factor authentication, for better security of accessed users. Below is a diagram of how RADIUS server and Multi-factor authentication works.



- All three designs will have an internet-based Site-to-Site Virtual Private Network (VPN). The internet-based Site-to-Site VPN will facilitate the connection between the Las Vegas headquarters and its subsidiaries in Vienna, Australia and Eden Prairie. The VPN connection will be established using the company network and the public internet (COX). We have opted for a NordLayer VPN, which is a software based VPN solution. We choose a software-based VPN as it is generally more flexible and scalable and is easier to manage and deploy compared to traditional hardware solutions. Using the software-based VPN, employees can connect to the VPN virtually from any location with an internet connection, making this an ideal solution for employees working from Vienna, Australia and Eden Prairie.
- In the gold-plated design, we have placed Access Points (APs) in each department to ensure optimal coverage. Each AP is connected to the main and the backup switch in the second floor using Ethernet cables, establishing a wired backbone for the wireless network. Access Points are configured with unique Service Set Identifiers (SSIDs) to serve as network names. This allows workstations to identify and connect to the wireless network seamlessly.
- The black, solid lines in the network diagrams represent the traditional option whereas the red lines represent the redundant option wherever it is applicable.

SITE-TO-SITE Diagram



The company needs to establish and maintain site-to-site connection with three locations: Vienna, Australia and Eden Prairie, MN. This network architecture follows a hub-and-spoke topology with Las Vegas serving as the central hub. In this configuration, Las Vegas acts as the primary point of contact for the remote sites, facilitating secure communication and data transfer. This site-to-site diagram will be consistent for all the three network diagrams because the employees in Las Vegas are required to communicate and transfer files with the employees in Vienna, Australia and Eden Prairie, MN.

In terms of security, all three locations are set to a high-security level as the company needs to transfer sensitive accounting information, and engineering drawing files, which needs to be secured at any cost. This ensures that valuable information, including accounting data and engineering drawings, remains safeguarded. Similarly, full-duplex connections are used for all three locations, allowing bidirectional data transfer, meaning data can flow in both directions simultaneously. This connection offers higher throughput, which is essential for handling large

files (engineering drawing), video conferencing, and other data-intensive tasks. Additionally, With full duplex, there is minimal delay in data transmission since both parties can communicate concurrently. This low latency is essential for accessing and transferring the real-time information within the company and its subsidiaries.

For the Quality of Services (QoS) we have opted for a VBR (Variable Bit Rate) for all three locations. The reason we choose VBR for all three locations is because SHFL data center will host documents as well as CRM system, ERP system, Inventory management system and many more for all the employees across the country and these applications often involve real-time data updates, interactions with customers, and data retrieval. With VBR, SHFL can allocate higher bandwidth when needed for real-time CRM operations (e.g., customer support calls, live chat) while efficiently using network resources during lower activity periods. Similarly, large engineering files also typically require substantial bandwidth for efficient and timely transfer. VBR is suitable because it allows for high data transfer rates when sending large files. During these transfers, more bandwidth can be allocated and after file transfers, the network can return to a lower data rate, allowing other applications to use the available bandwidth effectively.

Additionally, all locations are allocated a throughput percentage of 99% to maximize uptime. This high availability is vital for regular communication and to address any potential product-related issues promptly.

Need Analysis

User Needs Analysis

This section below breaks down the number of devices used by internal employees in each department within the building, the network specific devices, and other hardware devices needed such as printers, scanners, security devices, etc.

The user needs to account for all current staff, as well as accommodate for future expansion. In addition, for security measures an access control system will restrict entry to certain areas throughout the design. Along with the security initiative, security camera systems with video recording and storage capabilities will be accounted for in the network.

First Floor User Needs

The first floor of SHFL Entertainment's new consolidated facility is a dynamic hub that accommodates a total of 189 users across various departments and essential spaces. Here, the Research and Development (R&D) and Compliance departments house 119 workstations, with 95 dedicated to R&D and 24 to Compliance. The Sales and Operations department is composed of 60 workstations. The Showroom has 3 workstations, Human Resources has 6 workstations, the Lobby has one workstation, and the Restroom, Lunch, and Training Room combined have one workstation.

1. R&D and Compliance (119 Workstations):

The Research and Development (R&D) team is tasked with innovating and developing new gaming products while compliance ensures that all gaming products meet legal and regulatory standards. The research and development department is comprised of 5 managers, who oversee and supervise the various kinds of R&D projects, and 70 other staff members, who work on the projects. They require 80 PCs and 2 printers to support their work in innovation and product development. R&D work often involves collaboration and teamwork on complex projects, therefore, having at least one workstation for every department member is warranted. R&D also requires physical testing and prototyping of products. Therefore, the five extra workstations can be dedicated for these activities. These workstations also help the department in undertaking multiple projects simultaneously. As for the printers, R&D involves working with sensitive and confidential information, such as proprietary product designs, research data, and prototypes. Therefore, having 2 printers can facilitate a clear separation between confidential and non-confidential printing. One printer is dedicated to printing highly sensitive materials to maintain security and access control, while the other can handle standard documentation and reports. The compliance department is comprised of 2 managers and 23 staff members. They need 25 PCs and 1 printer to facilitate their compliance-related tasks. The Compliance Department often generates a significant amount of regulatory documentation, which may require occasional printing. Therefore, one printer and 25 PCs can suffice for their typical printing and computing needs. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in the department for employees, contributing to their convenience and connectivity. The other

14 workstations for the departments are currently unoccupied and can be used for future growth.

- **Hardware:** 119 PCs, 3 Printers, 1 AP
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, JIRA, Gaming Analytics

2. Sales and Operations (60 Workstations):

Sales teams engage with clients, fostering relationships and generating revenue and the Operations teams oversee the efficient execution of day-to-day activities to meet customer demands. The sales team is comprised of 30 employees, including 5 managers. As Sales deal with various kinds of clients with various needs , it would be very efficient for SHFL to have 5 managers, each having their own sets of clients to deal with. The department utilizes 30 PCs for purposes such as client relationship management and sales data analysis and 1 printer to print various documents, including sales contracts, proposals, and invoices. The Operations team, with 2 managers and 28 other employees, requires PCs which are used for data entry, logistics, and record-keeping tasks, and 1 printer for any necessary paperwork for the efficient execution of day-to-day activities of overseeing operational processes.

- **Hardware:** 60 PCs, 2 Printers.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, Salesforce, Oracle SCM

3. Showroom (3 Workstations):

The Showroom plays a pivotal role in presenting the company's products to potential clients, creating a visual and interactive platform for showcasing the company's offerings and capabilities. The Showroom consists of 3 dedicated workstations equipped with the following hardware resources: 3 PCs, which serve as individual workstations for team members to interact with clients effectively; 1 TV, a central display unit used for visually presenting the company's products and enhancing client presentations; and 1 camera, essential for recording product demonstrations, client interactions, and showroom activities, enabling the team to capture valuable content for training, promotion, and future reference.

- **Hardware:** 3 PCs, 1 TV and 1 Camera.
- **Software:** Microsoft 365 Apps, Zoom Rooms

4. Lobby (1 Workstation):

The Lobby requires 1 dedicated workstation equipped with the following hardware resources: 1 PC, which serves as the central tool for handling reception, visitor registration, and security functions, allowing staff to efficiently manage incoming visitors and ensure the security of the premises; and 1 camera, which is essential for monitoring the lobby area and enhancing security measures. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in the lobby for guests and visitors, contributing to their convenience and connectivity.

- **Hardware:** 1 PC, 1 Camera, 1 AP

- **Software:** Microsoft 365 Apps, Rhombus Video Surveillance Software

5. Human Resources (6 Workstations):

The HR department plays a central role in managing personnel, recruitment, training, and ensuring compliance with labor laws and company policies. This department consists of 6 employees, including a head HR officer. This department requires 6 PCs, serving as essential tools for HR personnel to manage personnel records, recruitment processes, training documentation, and compliance-related tasks. Additionally, 1 printer is required to produce HR-related documents, including employment contracts, training materials, and compliance documentation.

- **Hardware:** 6 PCs, 1 Printer.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms

6. Restroom, Lunch, and Training Room:

This area provides essential facilities for employees and visitors, including restrooms, lunch spaces, and training rooms. The Training Room area needs 1 PC and 1 TV to support training and development to enhance the overall experience of employees. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in-room, contributing to the users' convenience and connectivity.

- **Hardware:** 1 PC, 1 TV, 1 AP
- **Software:** Zoom Rooms

Second Floor User Needs

The second floor of SHFL Entertainment's consolidated facility acts as a central point of data flow for the entire building, which is made possible by the Main Distribution Frame (MDF). The floor is designed to cater to the needs of various departments and functional areas, accommodating a total of 183 workstations. Here is a breakdown of the second-floor layout:

1. Executive Offices (7 Workstations):

The Executive Offices serve as the nerve center for senior leadership and decision-makers, housing a total of 7 PCs providing essential tools for executives to manage their leadership responsibilities, make informed decisions, and facilitate effective communication. Additionally, 1 printer is allocated to the Executive Offices, enabling executives to produce hard copies of important documents and reports when necessary, further supporting their decision-making processes. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in the department for employees, contributing to their convenience and connectivity.

- **Hardware:** 7 PCs, 1 Printer, 1 AP
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms

2. Marketing (12 Workstations):

The Marketing department serves as the driving force behind promoting SHFL Entertainment's products and brand, with a total of 12 dedicated workstations for marketing professionals. The department consists of 12 employees, including a Marketing manager. Each of these workstations is equipped with a PC, providing the essential tools for marketing experts to execute their tasks, including creating, designing, and analyzing marketing campaigns. The department also requires 2 printers to facilitate the production of marketing materials, reports, and promotional documents, ensuring that marketing initiatives are effectively executed and promoting the company's products and brand.

- **Hardware:** 12 PCs, 2 Printers.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, HubSpot Marketing Hub

3. Offices (10 Workstations):

The Offices area provides private workspace for staff members who require individual and focused work environments. This area comprises 10 individual offices, each thoughtfully furnished with a desk, a chair, and a PC. The PCs are essential tools for office occupants to carry out their tasks, including data analysis, document creation, and communication. Additionally, 1 printer is allocated to the Offices area, facilitating the production of hard copies of documents and reports when necessary. It's worth noting that all 10 workstations within the Offices area are allocated with PCs because this is the sole space where staff members can work privately, distinct from their respective desks elsewhere in the organization.

- **Hardware:** 10 PCs, 1 Printer.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms

4. Project Management, IT, Investor Relations (44 Workstations):

This dedicated section of the second floor is a hub for Project Management, IT, and Investor Relations teams. This department consists of 44 employees, including one manager for each of the three fields. It features 44 workstations thoughtfully equipped with a PC at each desk. These PCs are fundamental tools for team members to carry out their respective responsibilities, such as project planning, software development, network management, and investor communications. In addition, 2 printers are allocated to this section, facilitating document production, report generation, and administrative tasks for these teams. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in the department for employees, contributing to their convenience and connectivity.

- **Hardware:** 44 PCs, 2 Printers, 1 AP
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, JIRA, Gaming Analytics

5. Account & Finance (38 Workstations):

The Account & Finance department plays a pivotal role in managing financial transactions and overseeing financial management for the organization. This department consists of 38 employees, including three managers to supervise finances. This department is comprised of 38 workstations, with each workstation thoughtfully equipped with a PC. These PCs are indispensable tools for the financial professionals within the department to execute tasks related to accounting, financial analysis, budgeting, and financial reporting. Furthermore, 2 printers are allocated to the Account & Finance department, supporting the need for document production, financial reporting, and administrative documentation.

- **Hardware:** 38 PCs, 2 Printers.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, Oracle NetSuite

6. Legal (32 Workstations):

The Legal department is entrusted with the vital responsibility of handling legal matters and ensuring compliance with relevant laws and regulations. This department consists of 32 employees, including 2 managers who oversee the legalities. This department comprises of 32 workstations, with each workstation thoughtfully equipped with a PC. These PCs serve as fundamental tools for legal professionals to conduct legal research, document preparation, case management, and compliance tasks. Furthermore, 4 printers are allocated to the Legal department, supporting the need for extensive document production.

- **Hardware:** 32 PCs, 4 Printers.
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, Clio

7. Lobby and Conference Rooms:

The second floor of the facility hosts both an exposed lobby area for guests and visitors, as well as conference rooms designed for meetings and presentations. The lobby is equipped with a workstation dedicated to reception and security functions, featuring a PC and a camera. The PC in the lobby is essential for managing visitor registration, security monitoring, and providing assistance to guests, ensuring a smooth and secure experience. Additionally, the camera serves as a valuable tool for monitoring the lobby area and enhancing security measures. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity in the lobby for guests and visitors, contributing to their convenience and connectivity.

- **Hardware:** 1 PC, 1 camera, 1 AP
- **Software:** Microsoft 365 Apps, Rhombus Video Surveillance Software

Warehouse User Needs (First Floor)

The warehouse floor at SHFL Entertainment's consolidated facility is a primary location for storage, logistics, and administrative operations. It accommodates a total of 61 workstations across various departments and essential spaces. Here is a breakdown of the warehouse layout:

1. Warehouse Offices (40 Workstations):

The Warehouse Offices serve as the administrative hub for warehouse operations, playing a central role in the management of inventory, logistics, and related tasks. Of the 40 workstations, 30 are equipped with a PC. The rest are unoccupied and can be used for future growth. These PCs are essential tools for the staff members responsible for administrative functions within the warehouse offices, enabling them to manage inventory and process orders which helps in maintaining efficient warehouse operations. In addition, 1 printer is allocated to this area, supporting the need for document production, order processing, and record-keeping.

- **Hardware:** 30 PCs, 1 Printer
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, Oracle WMS

2. Warehouse Office 2 (5 Workstations):

Warehouse Office 2 (5 Workstations): Warehouse Office 2 serves as additional workspace for warehouse personnel, including supervisors and administrators. This area features 5 workstations, all of which are currently vacant. The reason for the vacancies is that other warehouse offices are already equipped with PCs, and the current workforce is effectively supported by those existing workstations.

- **Hardware:** N/A
- **Software:** N/A

3. Shipping (6 Workstations):

The Shipping department holds the critical responsibility of managing outgoing shipments and overseeing logistics. This department consists of 6 shipping staff including a supervisor. This department comprises 6 workstations dedicated to the shipping staff and supervisor, with each workstation equipped with a PC. These PCs are handy tools for the shipping staff to coordinate shipments and track outgoing orders. Additionally, 1 printer is allocated to the Shipping department, facilitating the production of shipping labels, documents, and other shipping paperwork.

- **Hardware:** 6 PCs, 1 Printer
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, FedEx Ship Manager

4. Inventory (10 Workstations):

The Inventory department holds a pivotal role in the organization, responsible for managing and tracking inventory levels to ensure smooth operations. This department is comprised of 10 employees with one manager amongst them. This department comprises 10 workstations designated for inventory management personnel, with each workstation equipped with a PC. These PCs are essential tools for the inventory management professionals to track inventory levels, manage stock, and facilitate efficient inventory processes. Additionally, 1 printer is allocated to the Inventory department, supporting the need for document production and inventory records. An Access Point (AP) is also provided to ensure seamless Wi-Fi connectivity.

- **Hardware:** 10 PCs, 1 Printer, 1 AP
- **Software:** Microsoft 365 Apps, Workday, Zoom Rooms, Oracle WMS

Application Need Analysis

Microsoft 365 Apps

- Scope: All Employees
- For enterprise, this cloud-based subscription service offers the always up-to-date suite of desktop apps popularly used (Word, PowerPoint, Excel, Outlook, and Teams).

Workday

- Scope: All Employees
- This cloud-based human resources and financial management system manages a company's workforce, such as payroll, timesheets, benefits, etc.

Zoom

- Scope: All Employees
- Specifically, Zoom Rooms, is a business video conference software used for all video conference communications. Zoom Rooms is designed and ideal for shared spaces and collaborative environments.

JIRA

- Scope: Research & Development Dept., Project Management, IT, and Investor Relations
- The Jira Software Standard Package is a project management tool that allows for personalized, strategic project tracking, and allows for up to 35,000 users.

Gaming Analytics

- Scope: Research & Development Dept., Project Management, IT, and Investor Relations
- Gaming Analytics is an AI-powered solution offering performance analytics, predictive maintenance, and personalized gaming experience. This data can help drive business decisions and development.

Salesforce

- Scope: Sales & Operations Dept.
- This cloud-based CRM solution is applied to align the company with its customers through sales and marketing. Salesforce also acts as an Order Management Console, allowing the company to track, manage, and service orders throughout the entire order lifecycle. Salesforce can also serve as an Inventory Management with its Field Service package, which is part of the Service Cloud module.

Oracle

- Oracle Supply Chain Management (SCM) & Manufacturing:
 - Scope: Sales & Operations Dept.
 - A cloud-based solution that allows for quick response to changing demand, supply, and market conditions. It can also work as an Inventory Management software if needed.
- Oracle NetSuite
 - Scope: Account & Finance Dept.
 - NetSuite is an integrated cloud-based software that helps manage financials, operations, and customer relations. For accounting, it can simplify the process of recording transactions, manage payables & receivables, collect taxes, and gain greater control over financial asset management.
- Oracle Warehouse Management Software (WMS)
 - Scope: Warehouse Offices & Inventory Dept.
 - Description

Rhombus Video Surveillance Software

- Scope: Lobby (First & Second Floor) & Conference Room
- Rhombus software will remotely manage cameras, sensors, access control, alarms, and integrations from a centralized platform to allow for enhanced physical security measures.

HubSpot Marketing Hub

- Scope: Marketing
- This is a marketing software, which can integrate with Salesforce, provides market analytics, personalized streamline campaigns, and managed interactions with leads and customers, all in one centralized location.

Clio

- Scope: Legal Dept.
- This case management, web-based software will handle document management, case management, accounting needs with clients, tracking each step of the legal process, and work in compliance and regulation standards.

FedEx Ship Manager

- Scope: Shipping Dept.
- FedEx Ship Manager is a desktop shipping solution that automates and manages the entire shipping process, both domestically and internationally.

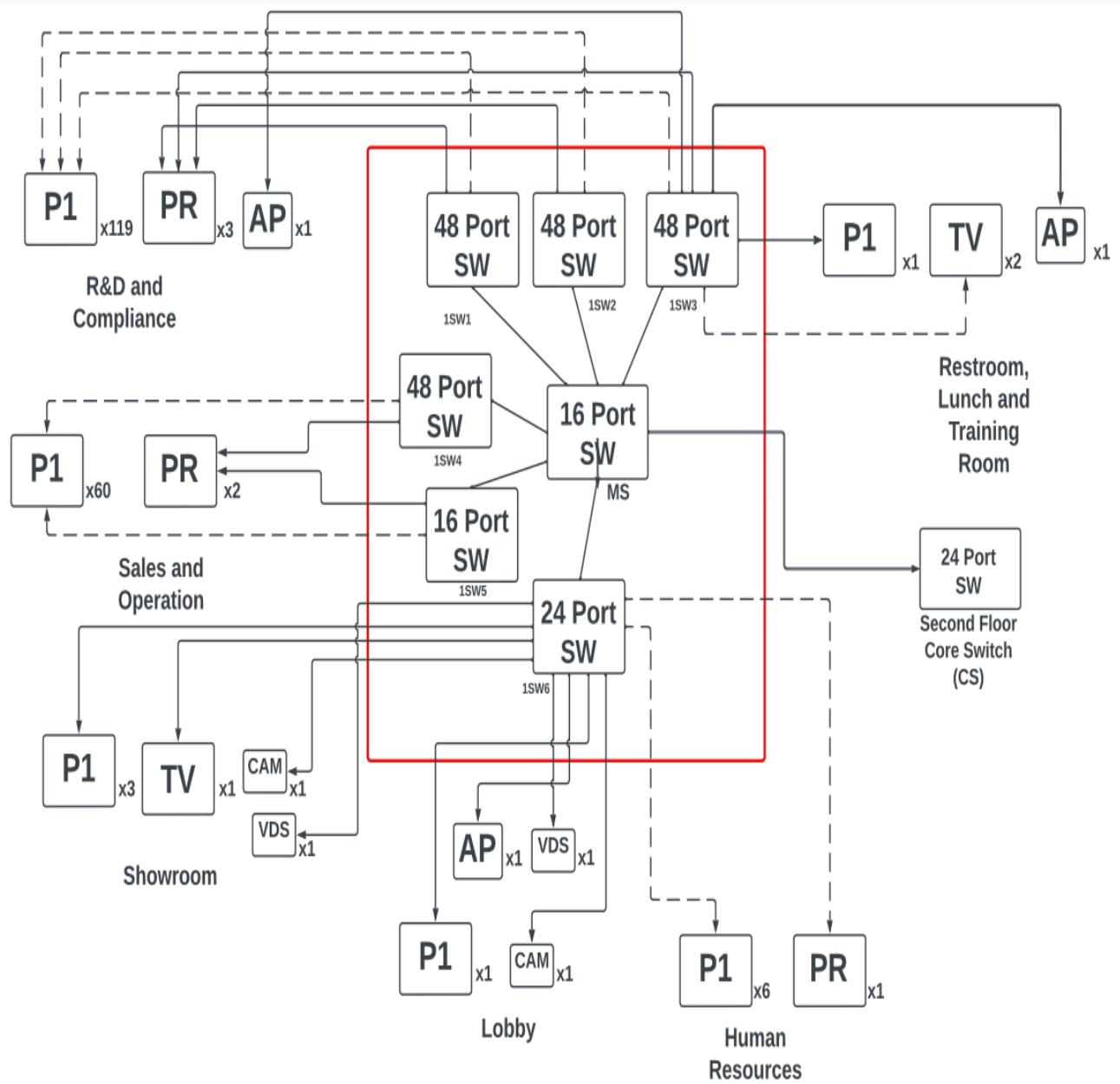
DESIGN 1 - Cheapest Design

Summary

The Cheapest network design presents a cost-efficient solution for SHFL's new facility, prioritizing affordability while meeting fundamental networking needs. This design incorporates economical hardware components, such as budget-friendly routers and switches, relies on standard cabling options, and basic hardware components for the workstations to minimize expenses. This design utilizes a star topology focused around the first floor server room which houses the Intermediate Distribution Frame (IDF). All other switches and devices, across various departments like R&D, Sales, HR, etc. connect directly to this Main Switch. The connections rely primarily on cost-effective cat6 cables to ensure simplicity and affordability.

The Main Switch in the first floor links to the second floor's Core Switch (in MDF room), facilitating communication with the upper floor. The cat6 cabling provides Gigabit Ethernet speeds to accommodate most day-to-day operations. The network features dedicated switches for each major department based on their bandwidth and connectivity requirements. However, there is no redundancy built-in at this design. Though this design meets basic needs, a single point of failure at the Main Switch could disrupt connectivity for multiple departments. While it may sacrifice some scalability and resilience, it remains a viable option for organizations with tight budget constraints. The key principle for this design is to strike a balance between affordability and essential functionality, ensuring that the network meets basic operational needs within a limited financial scope.

First Floor Network Design (Cheapest Design)



First Floor Network Design Justification

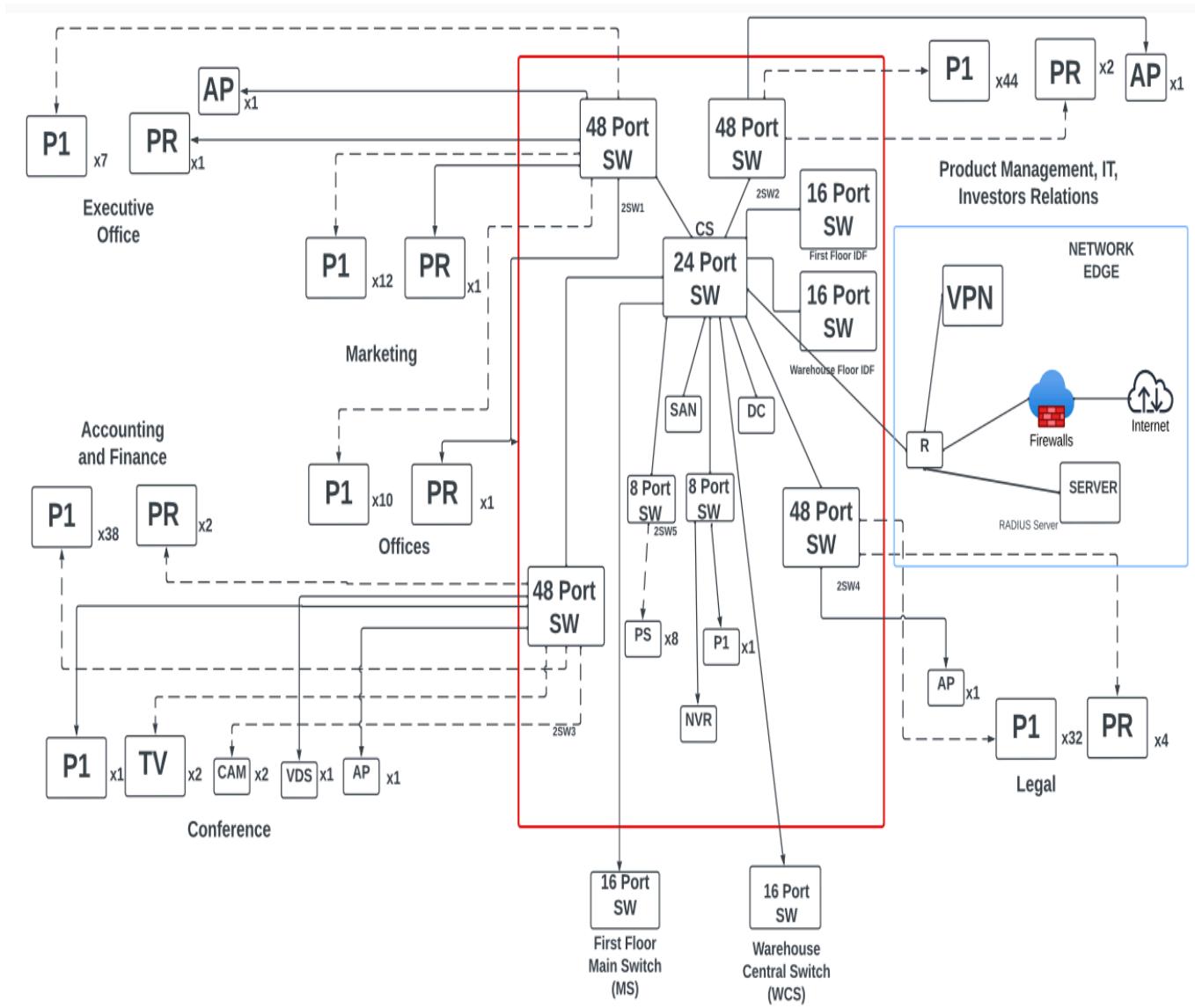
The first floor of our facility is a critical hub for our network infrastructure. It houses the Intermediate Distribution Frame (IDF) that contains one Main Switch (MS) for the first floor which serves as the backbone of our network, ensuring seamless connectivity across various departments and devices. At the heart of our first-floor network is a robust 16-port main switch. This main switch is responsible for managing and directing data traffic throughout the entire floor. To efficiently connect our various workstations and devices, we have deployed four 48-port switches, one 24-port switch, and one 16-port switch. This network is structured in a star topology, which ensures simplicity. Additionally, all switches and devices are connected directly to the main switch, forming a central point of control and distribution. Our network infrastructure relies on Category 6 (cat6) cables, known for their reliability, stability, and support for high data transfer rates with Gigabit Ethernet (1000 Mbps). This choice of cabling ensures consistent and efficient data connectivity throughout our first-floor network.

The R&D and Compliance department, with a total of 119 workstations and 3 printers, is allocated specific switches and ports for optimal performance. From SW1, out of its 48 ports, 46 are dedicated to workstations, guaranteeing high-speed connectivity for the diligent teams, and one port is dedicated for one printer. The remaining port is designated for the main switch. Similarly, from SW2, 46 ports are reserved for workstations, one port is reserved for a printer and the final port connects to the main switch. Finally, from SW3, 27 ports are allocated for additional workstations, while one port is dedicated to the printer and one port is dedicated to the Access Point (AP). One port connects directly to the main switch. For the 14 unused PCs in the R&D and Compliance department, we decided to disable the links to those ports to preserve energy and to improve network efficiency and resource utilization. We will turn on those ports when we decide to use the vacant PCs. The Restroom, Lunch, and Training Room utilize 3 ports from SW3 and are allocated for the connection of one workstation, a TV, and one Access Point (AP). The remaining ports are made available for future extension of PCs, Printers of Access Points.

In the Sales and Operations department, consisting of a total of 60 workstations and 2 printers, we have allocated two switches, SW4 and SW5 respectively. From SW4, a 48-port switch, 46 are dedicated to workstations, ensuring high-speed connectivity. One port is connected to the printer and one port serves as a connection to the main switch. Additionally, from SW5, a 16-port switch, 14 ports are assigned to workstations, one port is dedicated for printers to simplify document management, and one port connects to the main switch.

In the Showroom, we have a setup that includes 3 workstations, a television, a camera, and a Video Distribution System (VDS). The Lobby area is equipped with a personal computer, a camera, an Access Point (AP), and a Video Distribution System (VDS). The Human Resources department consists of 6 workstations and a printer. All of these devices are allocated to SW6, a 24-port switch.

Second Floor Network Design (Cheapest Design)



Second Floor Network Design Justification

On the second floor, we have a housing a 32-port central Core Switch (CS). This network is structured in a star topology ensuring simplicity. The CS plays an important role as the central distribution point for our network throughout the entire building. As part of the floor design, we have a collection of switches, including three 48-port switches, one 32-port switch, and one 16-port switch. The CS, a key part of our network infrastructure, is also connected to the first-floor's Main Switch (MS) and the warehouse's Warehouse Central Switch (WCS), ensuring seamless connectivity with the OM3 fiber cable.

The router, which is situated on the network edge, is connected to the CS and helps direct traffic between the SHFL inner network and the outside internet. One port of the router is dedicated to establishing site-to-site VPN connections with the subsidiaries in Vienna and Australia, as well as the remote engineering department in Eden Prairie, MN. Furthermore, one of the router's ports serves as the gateway to the internet, for access to the SHFL subsidiaries in Vienna and Australia, as well as the remote engineering department, and the entire building. To enhance security, this connection is secured by a firewall. The router along with Firewall, VPN, and the RADIUS Server are all situated on the Network Edge. This is to ensure proper security control over the network.

The core switch is also connected to a SAN and data center for the replication and data backups for off-site and on-site data centers. Both the "Off-Site Data Center" and "On-Site Data Center" will be equipped with their Storage Area Networks (SANs) with a capacity of roughly 80TB. These two data centers are connected via high-speed fiber optics, ensuring real-time synchronization of data between the two locations.

Moreover, the core switch is also connected to a dedicated 16-port switch for the 8 physical servers, providing high-speed data transmission. This setup guarantees optimal server performance. These physical servers host 100 virtual servers on VMware ESX servers, all seamlessly interconnected using OM3 cables. This will ensure that the servers operate at peak efficiency.

The core switch is also connected to another dedicated 8-port switch that houses a NVR and a PC. The NVR is used to manage and store the footage from all the security cameras , and the P1 is used to monitor and configure the security camera within the building.

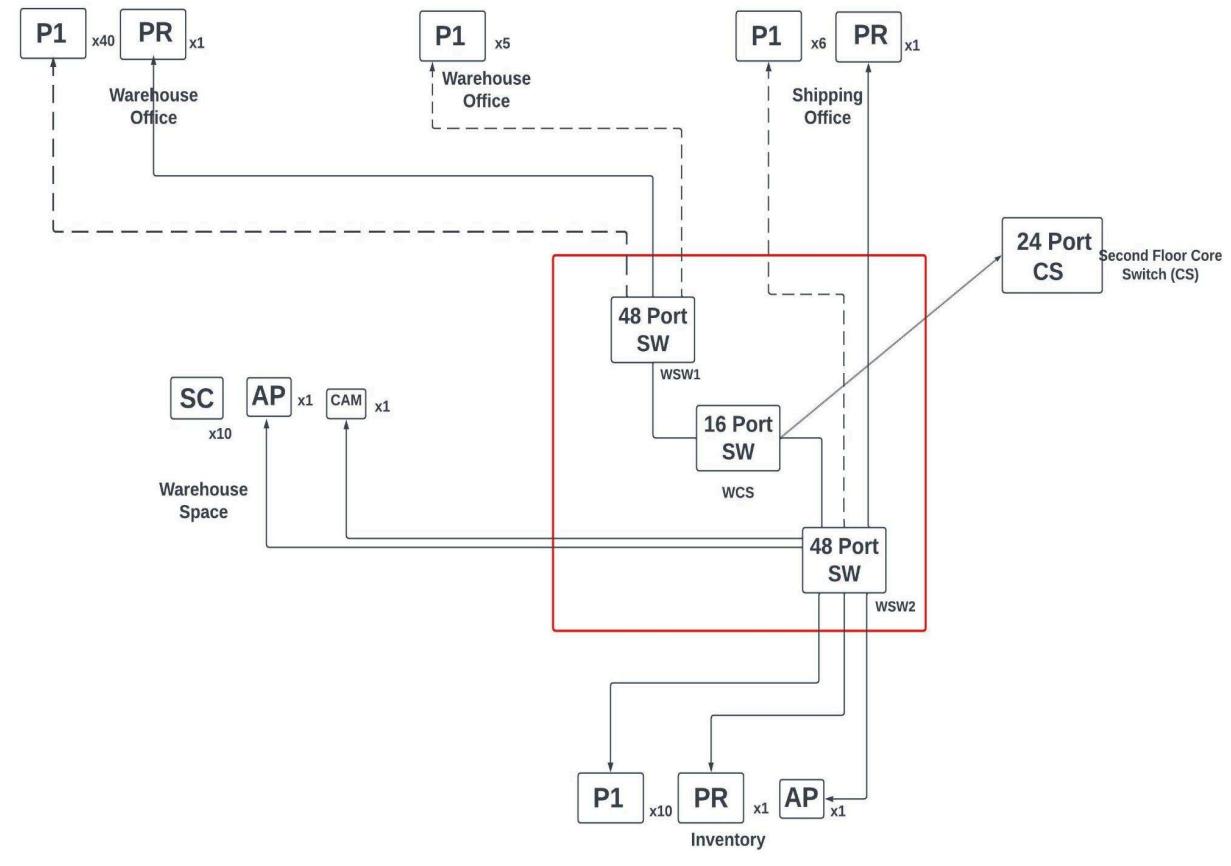
The Executive Office consisting of 7 workstations, one printer, and an Access Point (AP), is connected to a 48-port switch (2SW1). The 48-port switch (2SW1), will also be connected to the marketing office, consisting of 12 workstations and one printer. In addition, this switch will also be connected to the office, which consists of 10 workstations and one printer. One port will be dedicated to the connection to the core switch. The remaining 14 ports will be kept for future use. For the 2 unused PCs in the executive office, we decided to disable the links to those ports to preserve energy and to improve network efficiency and resource utilization. We will turn on those ports when we decide to use the vacant PCs.

The Product Management, IT, and Investors Relations office will have a separate dedicated 48-port switch (2SW2). This office will have a total of 44 workstations, two printers, and one Access Point. All of these devices will be connected to the 48-port switch (2SW2). One port will be allocated for the connection to the core switch through the fiber optic cable.

The Accounting and Finance office, with a total of 38 workstations, and two printers will be connected to a 48-port switch (2SW3). The conference hall, which consists of one workstation, one TV, one camera, one Video Distribution System, and one Access Point (AP) will also be connected to switch 2SW3. One port from this switch will be used to connect to the core switch.

In the Legal office, we have a setup that includes 32 workstations, four printers, and one Access Point (AP). We have allocated one 48-port switch (2SW4) for the Legal office. 37 of the 48 ports are allocated to these devices; one port serves as a connection to the main switch. and the remaining 10 ports are allocated for future use.

Warehouse Network Design (Cheapest Design)



Warehouse Network Design Justification

On the first floor, we also have a warehouse. The warehouse houses the Intermediate Distribution Frame (IDF) that contains one main (16-port) switch called the Warehouse Central Switch (WCS) for the warehouse which serves as the backbone of our network. The WCS is connected to two 48-port switches. This network is structured in a star topology ensuring simplicity. Additionally, the WCS is also connected to the Core Switch (CS) on the second floor. Our network infrastructure relies on Category 6 (cat6) cables, known for their reliability, stability, and support for Gigabit Ethernet (1 Gbps or 1000 Mbps). This choice of cabling ensures consistent and efficient data connectivity throughout our third-floor network.

Warehouse office 1, with a total of 40 workstations and one printer is connected to the 48-port switch (WSW1). Similarly, warehouse office 2, with a total of 5 workstations, is also connected to this switch. One port is designated for the main switch and the other is vacant. For all the unused PCs in the two warehouse offices, we decided to disable the links to the ports to preserve energy and to improve network efficiency and resource utilization. We will turn on those ports when we decide to use the vacant PCs.

The Inventory office, consisting of 10 workstations, one printer, and one Access Point (AP) is connected to a 48-port switch (WSW2). In addition to this, the switch is also connected to the shipping office, which consists of 6 workstations, and one printer. Moreover, this switch also connects the components inside the warehouse space such as the AP and the camera. Whereas, the scanners are connected to the AP inside the space. The remaining ports of the switch are allocated for future growth.

DESIGN 2 - Most Likely Design

Summary

The "Most Likely" network design is an enhancement of the previous design, aimed at ensuring greater network availability and redundancy. We've introduced additional switches and connected fewer devices to each switch, which not only aids network management but also minimizes the risk of widespread network disruptions in case of a switch failure.

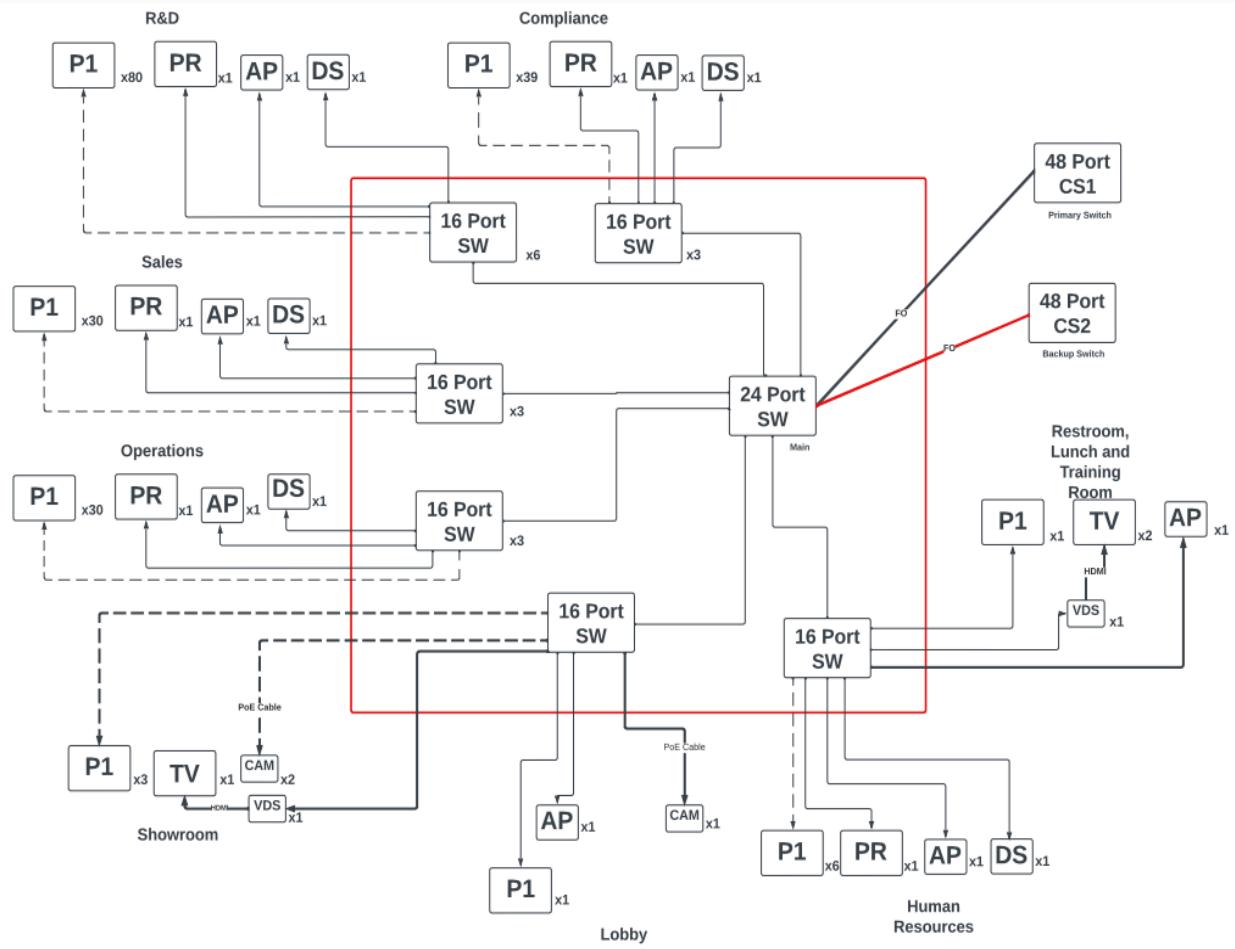
The main addition to this design is the addition of a 48-port backup switch in the second floor to ensure that the operation continues uninterrupted even in the event of the primary 48-port core switch failure.

We have chosen a star topology for connecting the network switches, similar to the cheapest design, to mitigate the impact of single points of failure. This setup isolates each node or department, meaning if one goes down, it won't affect the performance of other nodes. This topology provides the assurance that other departments can function even if one department's switch fails.

We have also introduced a Network Video Recorder (NVR), which is directly connected to the core switch on the second floor. The NVR's primary function is to efficiently manage and store the footage from all the security cameras throughout the building. This ensures that all camera recordings are stored, organized, and easily accessible for security monitoring and investigative purposes. The NVR installed in the campus is a low maintenance component as it supports very limited number of cameras. Therefore, we feel that the network capacity allocated to the NVR would be sufficient. In addition to this, we are installing an additional security camera in the Main Distribution Frame (MDF) area. This camera provides an extra layer of security for the MDF, which is a critical part of the network infrastructure. By monitoring this area, we can prevent unauthorized access and potential physical security breaches.

Furthermore, we have also placed an emphasis on security by adding extra door scanners to control access to every department within the building. Door scanners are crucial for regulating access levels to protect sensitive information and resources, ensuring the company's safety and security. Wireless connectivity has also been improved by adding separate access points for each department, reducing the load on each access point and optimizing bandwidth usage. This upgrade aims to provide a smoother experience for the employees.

First Floor Network Design (Most Likely Design)



First Floor Network Design Justification

The network design for the first floor is shown above. In this setup, the Intermediate Distribution Frame (IDF) hosts seventeen 16-port interconnection switches that connect to a central 24-port main switch using a star topology. This configuration allows for each department to have their own dedicated switch. In the event of a switch failure within a particular department, the impact is localized, causing a disruption only to the operations of that specific department. Crucially, other departments can continue their operations seamlessly, ensuring uninterrupted functionality across the broader network. This design enhances the network's resilience by isolating potential issues and minimizing the scope of disruptions.

The main switch (24 port main switch) will be connected to the Core Switch on the second floor with the OM3 fiber optic cable, as it offers high data transfer rates with low latency and it also offers long distance connectivity. In addition to this, we also have a backup 48-port switch in the second floor, which is connected to the main (24-port) switch in the first floor. The reason we added a backup switch is that the second floor houses servers, SAN, NVM, and the data center which holds significant importance for the business operations, and if the core switch fails, the entire operation for the entire building fails. Keeping this in mind, we have placed a 48-port backup switch in the second floor to mitigate the risk of primary switch failure and to ensure business continuity. From a business perspective, this configuration safeguards against potential financial losses and operational downtimes that could result from a core switch failure.

The R&D and Compliance department will have a total of nine 16 port switches connected to the 24-port main switch. The R&D department consists of 80 P1, 1 PR, 1 AP, and 1 DS. To accommodate this, we have allocated a total of six 16-port switches to the R&D department. The R&D department will have a total of 83 devices connected between the six 16-port switches, which will leave a total of 13 spare ports. The compliance department consists of 39 P1, 1 PR, 1 AP, and 1 DS. To accommodate this, we have allocated a total of three 16-port switches. The Compliance department will have a total of 42 devices connected between the three 16-port switches, which will leave a total of 6 spare ports. The spare ports can be used to expand the network if more devices are needed in the department. Since the PR, and APs will potentially have a higher traffic as compared to the PCs, they will be connected to the switch with less number of PCs.

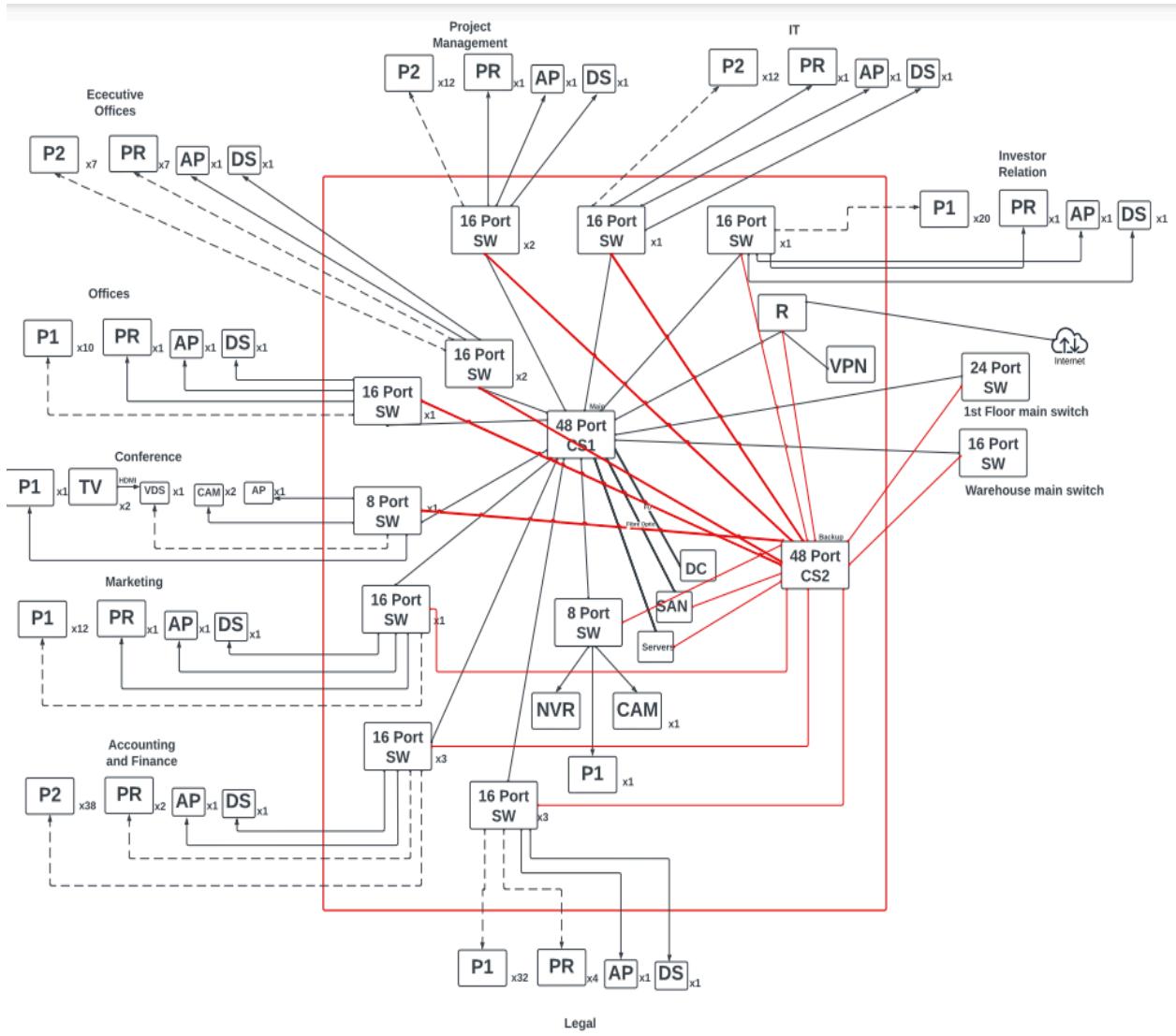
In the operation department, we have assigned three 16 port access switches. 30 ports are dedicated to the P1 devices, 1 port for the PR, and 1 port each for AP and DS. Each of these 16-port switches will be connected to the 24-port main switch. Similarly, the sales department is also assigned three 16-port access switches. Here, 30 ports are allocated for P1 workstations, 1

port for PR, and an additional port for the AP and DS. The three 16 port switches in the sales department will be connected to the 24-port main switch.

In the lobby and showroom areas, we have allocated a 16-port switch. Within the showroom we have 3 P1 workstations, 1 TV (which is connected to a Video Distribution System (VDS) via an HDMI cable), and 2 CAMs. The TV in the showroom will be used to showcase products and promotional videos to the customers in the showroom area. In the lobby area, we have allocated 1 P1 workstation, 1 AP, 1 CAM. The camera will be used for security monitoring and customer safety and will be placed right in front of the entrance. With this, the company can monitor who is entering through the entrance to the lobby. All the CAMs in the lobby and showroom will be connected to the switch with a an ethernet cable with PoE capabilities. The access point in the lobby is shared with the showroom, as these areas require less internet coverage.

The Human Resources department will contain 6 P1, 1 PR, 1 AP, AND 1 DS, which will be connected to the 16-port switch. The 16-port switch will be connected to the 24-port main switch. The same 16-port switch is also used for the Training area, which consists of 1 P1, 2 TVs, 1 AP, and 1 VDS. The TVs will be connected to the VDS via HDMI cable. The reason we connected Human Resources and the Training area with the same switch is to optimize resource utilization and promote cost-effectiveness.

Second Floor Most Likely Design (Most Likely)



Second Floor Network Design Justification

The second floor design is shown above. The Main Distribution Frame (MDF) on the second floor hosts fifteen 16 port switches, and two 8 port switches which are connected to a central 48-port main switch using a star topology. Additionally, we also have a 48 port core switch as a backup, which is connected to all the switches in the second floor. With this, if the main core switch fails, the business can still operate using the alternative core switch. This setup helps the business to provide high availability in case of any disaster. To connect the two Intermediate Distribution Frame (IDF) switches on the first floor and in the warehouse to the core switch on the second floor, fiber optic cables are used. Fiber optics offer high-speed, low-latency, and long-distance coverage. It's a reliable choice for interconnecting different parts of the building.

A VPN-capable router is placed on the second floor. This router is chosen to establish and manage VPN connections, enabling site-to-site connectivity with employees in Vienna, Australia, and Eden Prairie. The router includes security features like IPSec, which is a commonly used protocol for securing VPN connections. IPSec provides a secure framework for VPN communication by encrypting data and authenticating the parties involved, ensuring confidentiality and integrity. It also serves as the gateway for the selected ISP (COX 1Gbps), ensuring high-speed internet access.

The core switch on the second floor is a central component that connects various parts of the network. It is also linked to the Storage Area Network (SAN), which replicates data between the off-site and on-site data centers. The proposed SAN solution for SHFL incorporates Fiber Channel technology to facilitate SAN replication between the off-site and on-site data centers. The SAN comprises two distinct storage arrays, Tier 1 and Tier 2, each with a capacity of 35 TB, resulting in a combined SAN capacity of 70 TB. The Fibre Channel Protocol Switch, a central component of the SAN architecture, is physically installed within the MDF. The Fibre Channel Protocol Server is also equipped with a network interface card (NIC) and a host bus adapter (HBA) to establish a direct link to the core switch within the local area network (LAN). The core switch in the second floor serves as a central point for network connectivity. It plays a crucial role in linking the Fibre Channel Protocol Server to the broader network, allowing data requests and transmissions between the SAN and other networked devices.

Each department on the second floor has its dedicated switches. This approach minimizes the risk of a single point of failure and enhances network efficiency.

The project management department is allotted two 16-port switches, which accommodate 12 high-performance workstations (P2), a printer (PR), an access point (AP), and a door scanner (DS). Given the nature of their work, these high-performance workstations are essential. Project management involves resource-intensive applications, software development environments, and complex projects such as infrastructure upgrades, cloud migrations, and network redesigns.

These tasks demand high computational resources, which are effectively provided by the P2 devices. Additionally, the presence of software developers in the IT department necessitates powerful workstations to compile code, conduct simulations, and test software across various environments. The IT department has one 16-port switch, housing 12 P2 devices, a printer (PR), an access point (AP), and a data analyst workstation (DA). Both these departments work in close collaboration and share an 8-port switch connected to the core switch, ensuring efficient network connectivity. The Investor relation department also has a 16 port switch allocated. This department has 10 P1, 1 PR, 1 AP and 1 DS. All the switches in these departments are connected to the same 8-port switch, which is connected to the core switch.

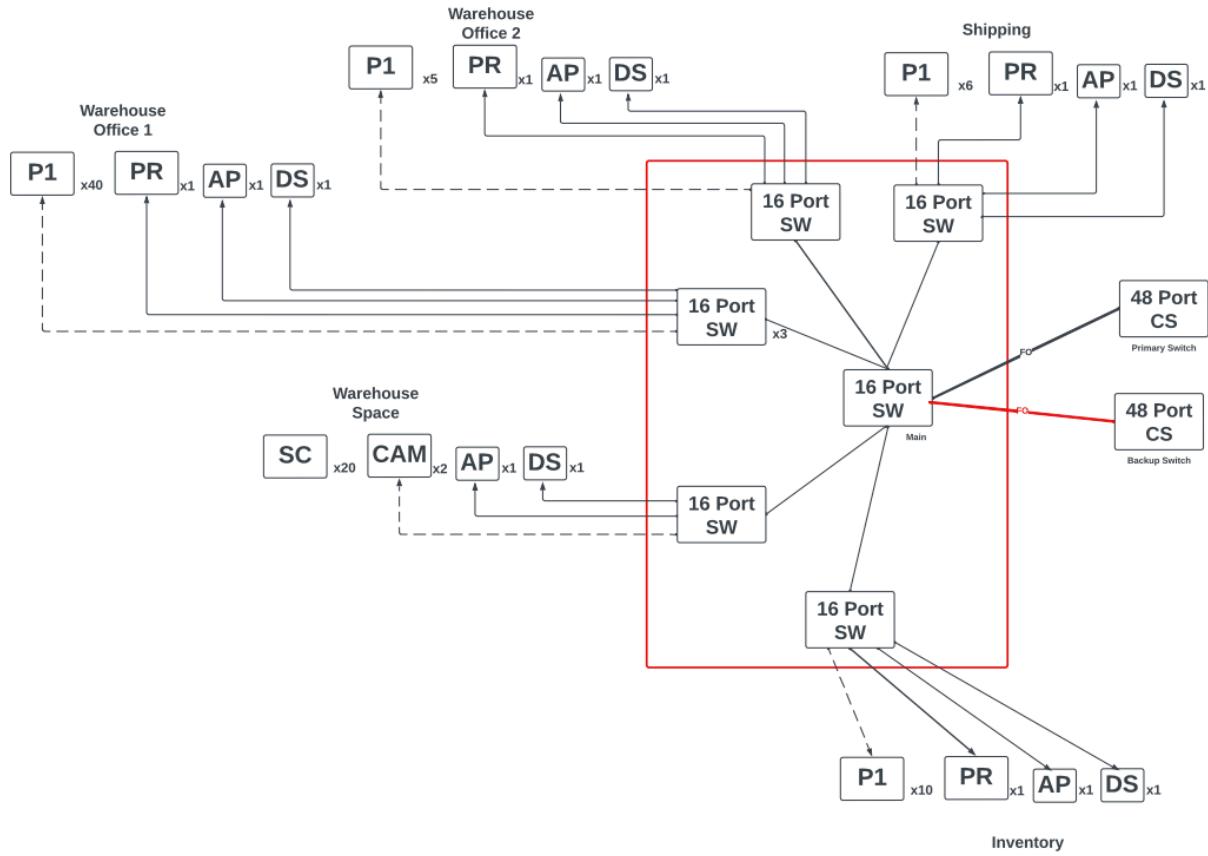
The executive office also has its own dedicated 16 port switch. Executive level officers including top management, CEOs, and senior leadership, deal with complex and time-sensitive tasks, which requires a high performance PC (P2). Similarly, this department also has a single printer for each of the officers. Executives often deal with sensitive and confidential documents, such as financial reports, strategic plans, legal agreements, and proprietary information. The nature of CEO responsibilities may involve reviewing personnel files, performance reports, or other HR-related documents. Printing such materials in a dedicated office printer adds an extra layer of confidentiality, preserving the privacy of employee information. By having an individual printer in their office, they can significantly reduce the risk of unauthorized access to these documents and can secure the confidential and personnel files. This department also has 1 AP and 1 DS.

The office space is equipped with a 16-port switch to support its operations, serving 10 P1 workstations, 1 printer (PR), 1 access point (AP), and 1 door scanner (DS). This setup ensures seamless connectivity for regular office tasks. For the conference room, there is a dedicated 8-port switch, designed to accommodate 1 P1 workstation, 2 TVs connected to a Video Distribution System (VDS) via HDMI cables, 2 security cameras (CAMs), and 1 access point (AP). This configuration facilitates effective communication and presentations within the conference room while maintaining security with the door scanner (DS).

The marketing department is allocated with a 16-port switch, serving its 12 P1 workstations, 1 printer (PR), 1 access point (AP), and 1 door scanner (DS). This setup ensures efficient connectivity for marketing tasks and enhances security with the door scanner. The accounting and finance department has a 16-port switch allocated to meet its more extensive needs. The department has 38 P2 workstations, 2 printers (PR), 1 access point (AP), and 1 door scanner (DS). The nature of financial and accounting work involves dealing with complex models, data analysis, and large datasets. High-performance workstations (P2) help process and analyze these datasets easily, improving productivity. Additionally, there are two printers allocated to this department - one for the managers for printing confidential and sensitive financial data, and another for all the staff.

Finally, the legal department also has a 16-port switch allocated. Within this department, there are 32 P1 workstations, 4 printers, 1 access point (AP), and 1 door scanner (DS). This department has a total of 4 attorneys which require a separate printer as they have sensitive and confidential information to print.

Warehouse Network Design (Most Likely Design)



Warehouse Network Design Justification

The warehouse network design is shown above. The warehouse houses the IDF, which contains one 8-port main switch, two 8-port interconnection switches and seven 16-port access switches. To ensure high-speed connectivity between the warehouse and the first and second floor, the 8-port main switch in the warehouse is connected to the second-floor core switch via a fiber optic cable. All other internal connections within the warehouse are established using reliable cat6 cables.

Within the warehouse, we've allocated dedicated switches for different departments to streamline network management. The shipping department, responsible for handling goods, utilizes a 16-port switch to efficiently manage its network. This switch accommodates 6 P1 workstations, a printer (PR), an Access Point (AP), and a Door Scanner (DS), resulting in 6 available unused ports, providing room for future expansion.

In addition, we have two warehouse offices, Warehouse Office 1 and Warehouse Office 2. Each office has its dedicated 16-port switches to cater to its unique network requirements. Warehouse Office 1 is equipped with three 16-port switches, supporting 40 P1 workstations, a printer (PR), an Access Point (AP), and a Door Scanner (DS). Meanwhile, Warehouse Office 2 has its 16-port switch, which accommodates 5 P1 workstations, a printer (PR), an Access Point (AP), and a Door Scanner (DS). The switches in Warehouse Office 1 and Warehouse Office 2 are then connected to the 8-port interconnection switch to ensure seamless connectivity.

For the inventory department, we've allocated a 16-port switch, which is designed to manage a total of 13 devices. This includes 10 P1 workstations, a printer (PR), an Access Point (AP), and a Door Scanner (DS), leaving 2 available ports for potential expansions. The 16-port access switch in the inventory department is also connected to the 8-port interconnection switch.

The warehouse space stores valuable inventory and equipment, making security a top priority. To ensure safety and monitor activities, we've incorporated security cameras (CAM) into the area. These cameras help prevent potential threats, and can also assist in investigations during security breaches or accidents.

Moreover, the warehouse operations rely on the use of 20 handheld wireless scanners, essential for capturing and processing barcode data efficiently. Since these scanners are wireless, they do not require a physical Ethernet connection. Instead, they connect wirelessly to an Access Point (AP) that provides internet access. These APs are, in turn, connected to the switch, ensuring network connectivity for the wireless scanners, enhancing productivity in the warehouse operations.

DESIGN 3 - Gold-Plated Design

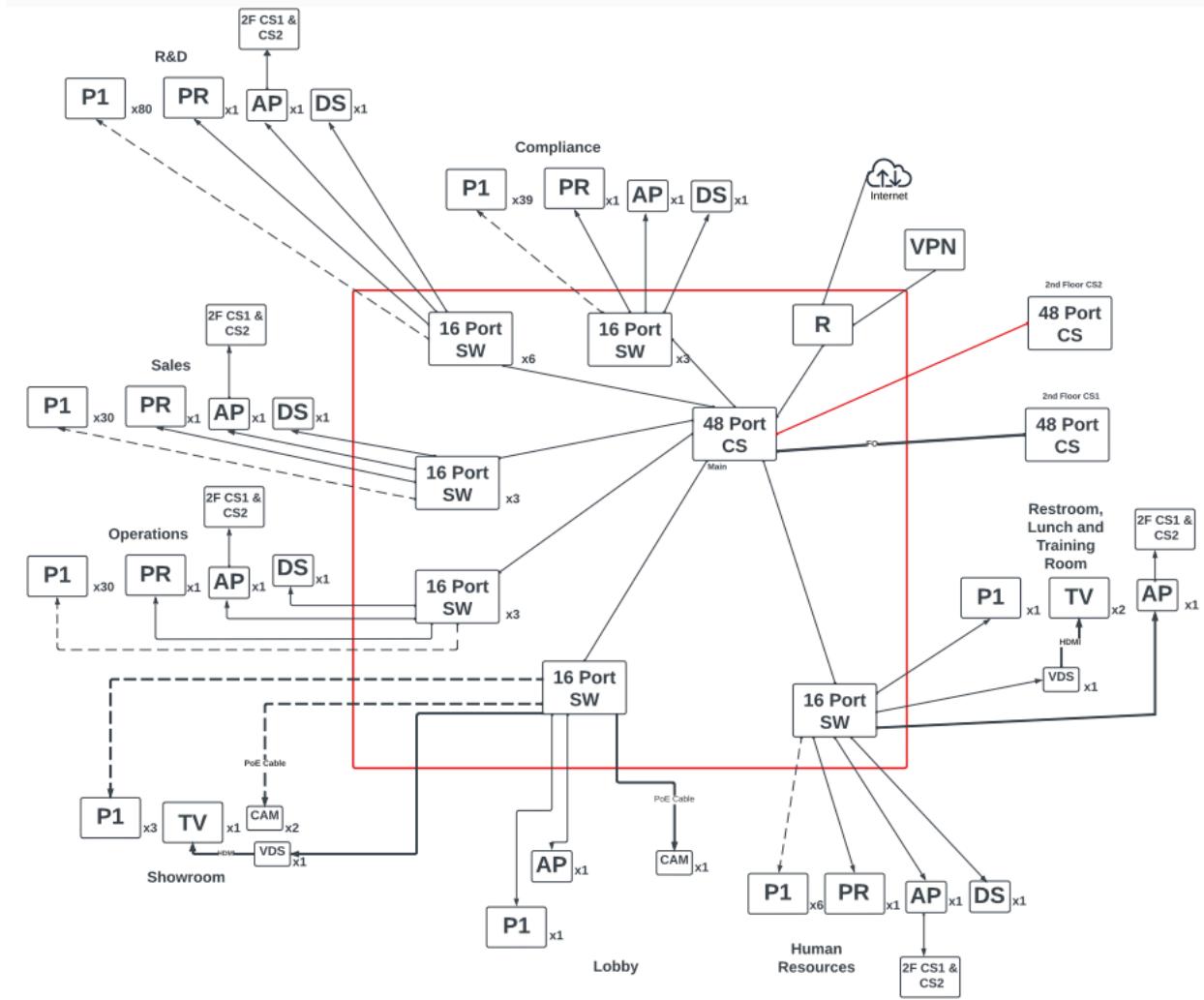
Summary

The gold plated design is an improvement over the most likely design where we have added a level of redundancy and high availability to the network architecture. For redundancy and high availability, we have connected every AP in the first floor and the warehouse to the core switch in the second floor. With this, if the hard-wired (physical connection) between the first floor and the second floor is down, we still have connection via the APs between the first floor and the second floor. This configuration improves the network's resilience, allowing for the business to operate even if the direct wired link has issues.

Moreover, recognizing the critical role of the second-floor core switch in facilitating connections for business operations to both the first floor and the warehouse, we have opted for a backup core switch on the second floor. While this backup core switch is connected to all switches on the second floor, it remains inactive under normal circumstances. Its activation is reserved for specific scenarios, such as a malfunction in the primary core switch or a failure in the main switch. This ensures that the business can seamlessly continue its operations, even if the primary core switch on the second floor experiences a failure. The backup core switch acts as a fail-safe mechanism, stepping in to sustain connectivity and maintain network functionality in the face of unforeseen disruptions.

In this design, three different routers are positioned on each floor, establishing connections with their respective core switches. This multi-router setup serves the dual purposes of providing redundancy and enhancing network resilience in the face of potential router failures. In the event of a router malfunction, connections can be redirected to routers on alternative floors, maintaining continuous access. Moreover, for internet connectivity, the design incorporates dual Internet Service Providers (ISPs): Google Fiber (2Gbps) as the primary connection and COX (1Gbps) as a backup. We have placed switches with multi-gigabit speeds to accommodate for the enhanced internet speed. The routers and switches are configured to automatically switch to the backup connection if the primary ISP (Google Fiber) experiences a failure. Once the primary connection is restored, the system automatically transfers the load back, ensuring minimal downtime and uninterrupted business operations. This configuration safeguards against potential core switch failures, offering a reliable and resilient network for sustained business activities.

First Floor Network Design (Gold-Plated Design)



The first floor gold plated design is similar to the most likely design with some improvements to achieve redundancy and high availability. In the first floor design, we have implemented both hardwired and wireless configuration to ensure reliable connectivity for all the workstations and wireless devices within the first floor:

Hardwired Configuration

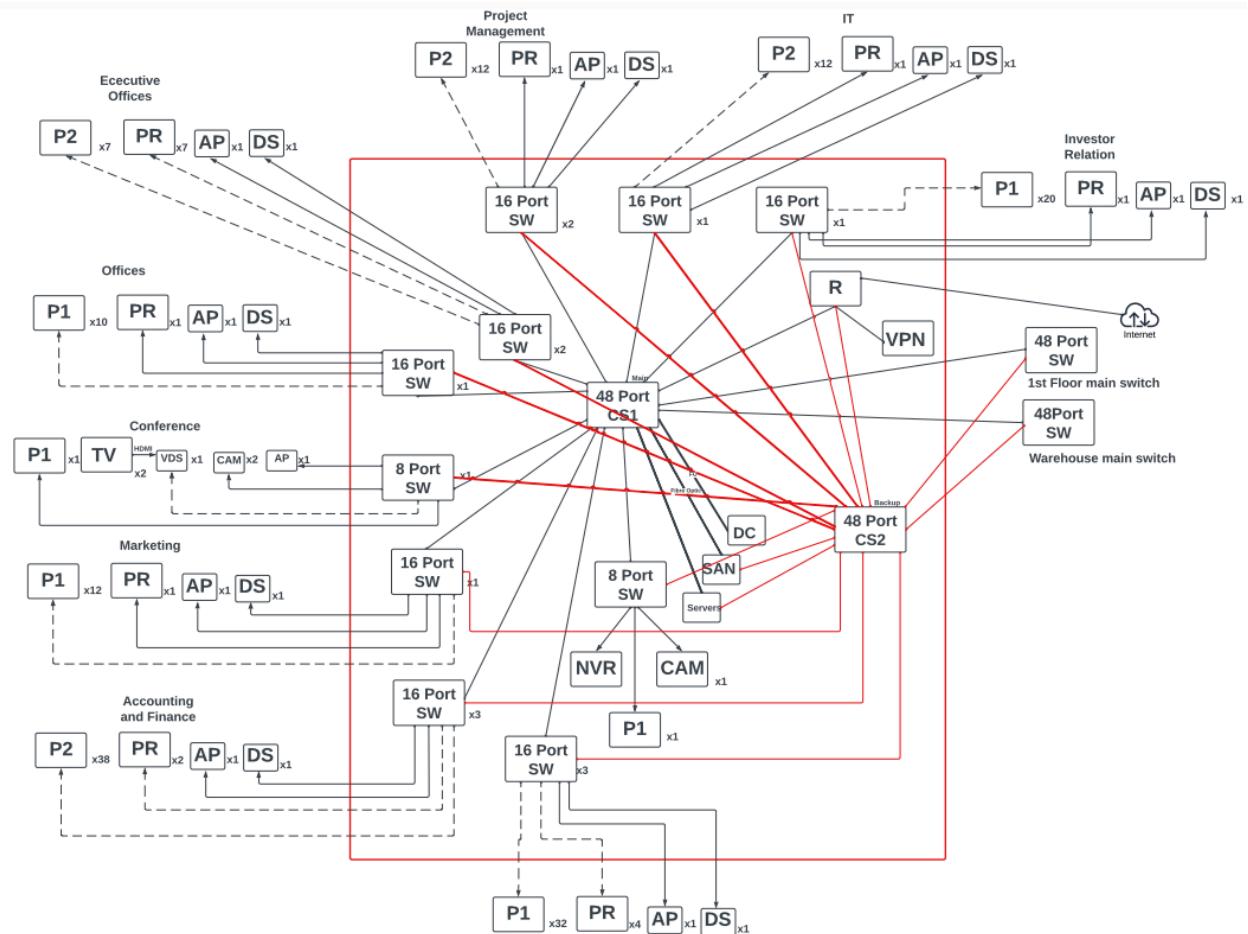
All workstations in the first floor are hardwired and connected to dedicated switches within their respective departments. This setup optimizes local network performance and allows for efficient

management of department-specific connections. Additionally, these departmental switches are interconnected to the main switch on the first floor, creating a centralized network hub for local operations. To enhance redundancy and minimize the impact of switch failures, we've established dual connections to the second-floor switches (main and backup). By connecting both the main and backup switches on the second floor to the first floor core switch, we create a failover mechanism. In the event of a primary switch failure in the second floor, the backup switch can take over, ensuring continuous connectivity for all workstations on the first floor.

Wireless Configuration

For wireless connectivity, we have placed Access Points (APs) in each department on the first floor. Primarily, all the APs in the first floor are connected to the main switch in the first floor. However, To ensure redundancy and reliability in wireless connections, each AP is also connected to both the main and backup switches on the second floor. This dual connection setup ensures that even if one switch encounters issues, the wireless devices can seamlessly switch to the alternative connection, maintaining uninterrupted connectivity.

Second Floor Network Design (Gold-Plated Design)

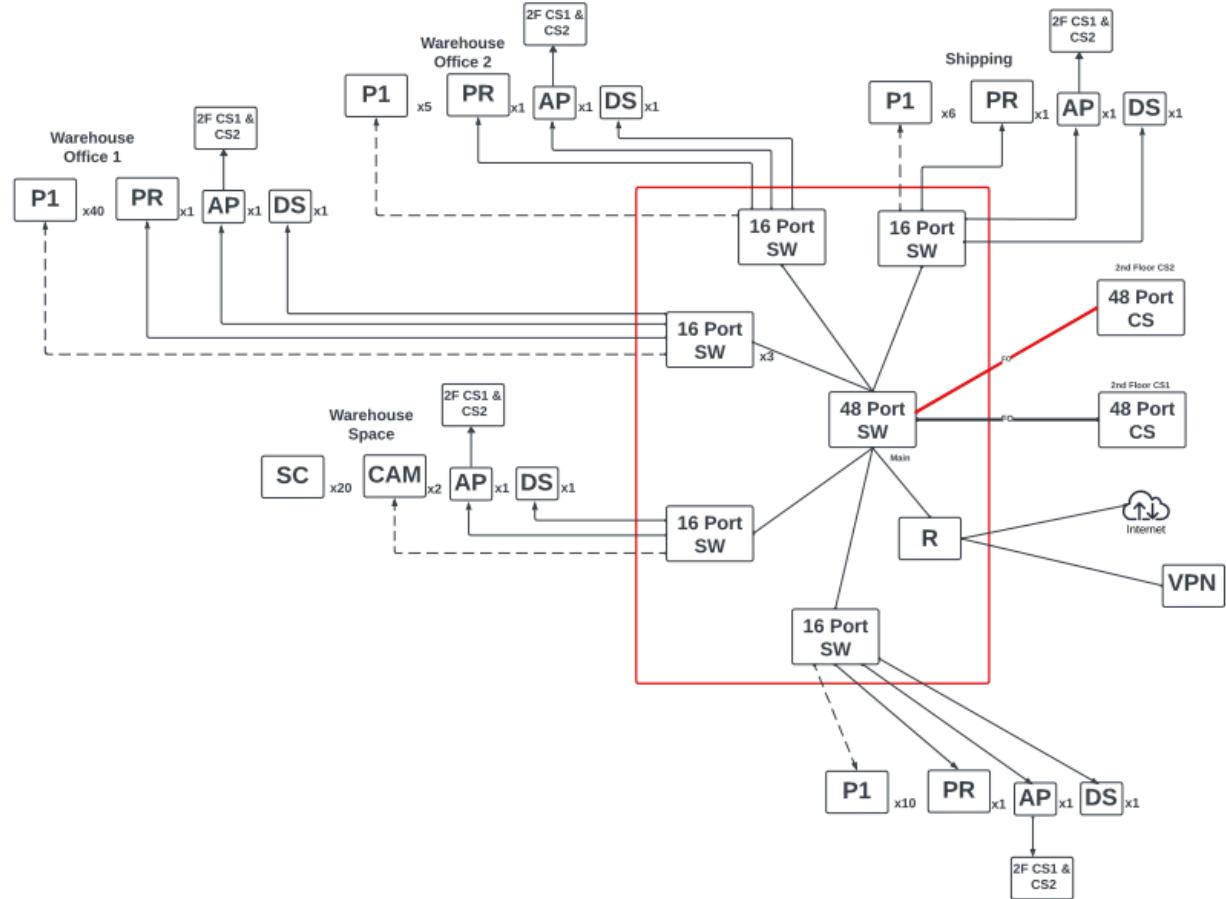


The network for the second floor gold-plated design is shown above. This design closely resembles the most likely design, with a key enhancement: the incorporation of a 48-port backup core switch. The second floor, being the home to servers, SAN, NVM, and the data center, holds significant importance for the business operations. Keeping this in mind, we have placed a backup 48-port core switch to mitigate the impact of a potential failure in the primary core switch. The primary objective of adding the backup switch is to ensure uninterrupted network access for all staff members, even in the event of a failure in the primary 48-port switch. This configuration adds a layer of redundancy to the overall design. In practical terms, if the primary switch encounters issues or fails, the backup switch seamlessly takes over, maintaining network functionality and access for all staff on the second floor. The addition of a backup core switch enhances the reliability of the network infrastructure, safeguarding against potential disruptions and contributing to the overall resilience of the business operations.

The backup switch (48-port CS) will also establish connections with all the switches on the second floor, interconnecting the workstations, printers, Access Points (APs), and Door Scanners (DS). In this design, both the primary and backup switches utilize fiber optic cables,

guaranteeing consistent network speed even in the event of a malfunction in the primary 48-port core switch. Additionally, the backup switch will also be connected to the router, Storage Area Network (SAN), physical servers, data center, the main 48-port switch on the first floor, and the 48-port switch in the warehouse. This comprehensive connectivity ensures a resilient and reliable network structure with redundancy for critical components.

Warehouse Network Design (Gold-Plated Design)



The gold plated design for the warehouse is shown above. The design is an improvement over the most likely design. In this design, all Access Points (APs) within the warehouse are strategically connected to both the core switch and the backup core switch located on the second floor. This dual connection ensures continuous network access even in the event of a potential failure of the primary switch within the warehouse. In addition to this, the 48 port main switch from the warehouse is also connected to the 48 port core switch and the 48 port backup switch in the second floor. The 48 port backup switch connected to the main switch in the warehouse ensures network reliability and minimizes downtime in case of unforeseen failures or issues.

Additionally, in this design, we also have a dedicated router just for the warehouse. Each floor is now equipped with its dedicated router, ensuring a distributed and resilient architecture. In the event of a router failure, the network can seamlessly transition to alternative routers on other floors, guaranteeing uninterrupted operations. This setup significantly enhances network robustness and business continuity.

Appendix

Design 1

| Device | Description | Product Screenshot | Ind. Price | Qty | Total | Link |
|--------|---|---|------------|-----|--------------|--------------------------------|
| P1 | Lenovo ThinkStation P360 - tower - Core i7 12700K 3.6 GHz - vPro Enterprise - 16 GB - SSD 512 GB - US |  | \$1,687.99 | 396 | \$668,444.04 | P1 Workstation |
| PR | HP LaserJet Enterprise M480f Laser Multifunction Printer - Color |  | \$969.99 | 23 | \$22,309.77 | Printer |
| TV | LG 55UR340C9UD UR340C Series - 55" LED-backlit LCD TV - 4K - for digital signage |  | \$875.00 | 5 | \$4,375 | TV |
| AP | Ruckus R750 - wireless access point - Wi-Fi 6 |  | \$1,156.99 | 7 | \$8098.93 | AP |

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|----------------|---|---|------------|----|------------|---|
| DS | ALLEGION MT15 (aptiQ) Multi-Technology Single Gang Reader |  | \$279.00 | 18 | \$5,022 | <u>Door Scanner</u> |
| CAM | Ubiquiti UniFi Protect G4 PTZ - network surveillance camera |  | \$1,958.99 | 5 | \$9,794.95 | <u>Security Camera</u> |
| NVR | Fortinet FortiRecorder 400F - standalone NVR |  | \$3,213.99 | 1 | \$3,213.99 | <u>Network Video Recorder</u> |
| Scanner | Zebra DS8178 2D Wireless Barcode Scanner |  | \$1,338.99 | 10 | \$13,389.9 | <u>Barcode Scanner</u> |

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|-----------------------|---|---|-------------|----|-------------|---------------------------------------|
| Router | Cisco Integrated Services Router 4461 - router - rack-mountable |  | \$22,127.99 | 1 | \$22,127.99 | Router |
| 8 Port Switch | Ubiquiti UniFi Switch US-8-150W - switch - 8 ports - managed |  | \$238.99 | 2 | \$477.98 | 8 Port Switch |
| 16 Port Switch | Ubiquiti UniFi Switch US-16-150W - switch - 16 ports - managed - rack-mountable |  | \$349.99 | 5 | \$1,749.95 | 16 Port Switch |
| 24 Port Switch | Ubiquiti UniFi Switch USW-24-POE - switch - 24 ports - managed - rack-mountable |  | \$455.99 | 2 | \$911.98 | 24 Port Switch |
| 48 Port Switch | Ubiquiti UniFi Switch USW-PRO-48-POE - switch - 48 ports - managed - rack-mountable |  | \$1,229.99 | 10 | \$12,299.9 | 48 Port Switch |

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|-----------------------------|--|---|------------|----|------------------|--------------------------------------|
| Transceiver | Proline Cisco GLC-SX-MM D Compatible SFP TAA Compliant Transceiver - SFP (mini-GBIC) transceiver module - GigE - TAA |  | \$78.00 | 58 | \$4,524.00 | Transceiver |
| Fiber Channel Switch | Cisco MDS 9132T - switch - managed - rack-mountable |  | \$4,735.99 | 1 | \$4,735.99 | Fiber Channel Switch |
| Disk Array | OWC 92TB Flex 1U4 4-Bay Thunderbolt 3 Storage Array (3 x 20TB HDDs + 4 x 8TB SSDs) |  | \$7,999.99 | 2 | \$15,999.98 | Disk Array |
| VDS | Kramer VM-24HC 2x1:4 HDMI Switcher & Distribution Amplifier |  | \$604.00 | 3 | \$1,812.00 | VDS |
| Total | | | | | \$799,288. 35 | |

Design 2

| Device | Description | Product Screenshot | Ind. Price | Qty | Total | Link |
|--------|---|---|------------|-----|--------------|--------------------------------|
| P2 | Lenovo ThinkStation P360 - tower - Core i9 12900K 3.2 GHz - vPro Enterprise - 32 GB - SSD 1 TB - US |  | \$2,219.99 | 69 | \$153,179.31 | P2 Workstation |
| P1 | Lenovo ThinkStation P360 - tower - Core i7 12700K 3.6 GHz - vPro Enterprise - 16 GB - SSD 512 GB - US |  | \$1,687.99 | 327 | \$551,972.73 | P1 Workstation |
| PR | HP LaserJet Enterprise M480f Laser Multifunction Printer - Color |  | \$969.99 | 27 | \$26,189.73 | Printer |
| AP | Ruckus R750 - wireless access point - Wi-Fi 6 |  | \$1,156.99 | 21 | \$24,296.79 | AP |
| TV | LG 55UR340C9UD UR340C Series - 55" LED-backlit LCD TV - 4K - for digital |  | \$875.00 | 5 | \$4,375 | TV |

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|---------|---|---|------------|----|-------------|--|
| | signage | | | | | |
| DS | ALLEGION MT15 (aptiQ) Multi-Technology Single Gang Reader |  | \$279.00 | 18 | \$5,022 | Door Scanner |
| CAM | Ubiquiti UniFi Protect G4 PTZ - network surveillance camera |  | \$1,958.99 | 7 | \$13,712.93 | Security Camera |
| NVR | Fortinet FortiRecorder 400F - standalone NVR |  | \$3,213.99 | 1 | \$3,213.99 | Network Video Recorder |
| Scanner | Zebra DS8178 2D Wireless Barcode Scanner |  | \$1,338.99 | 10 | \$13,389.9 | Barcode Scanner |

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|-----------------------|--|---|-------------|----|-------------|--------------------------------|
| Router | Cisco Integrated Services Router 4461 - router - rack-mountable |  | \$22,127.99 | 1 | \$22,127.99 | Router |
| Transceiver | Proline Cisco GLC-SX-MM D Compatible SFP TAA Compliant Transceiver - SFP (mini-GBIC) transceiver module - GigE - TAA |  | \$78.00 | 86 | \$6,708.00 | Transceiver |
| 8 Port Switch | Ubiquiti UniFi Switch US-8-150W - switch - 8 ports - managed |  | \$238.99 | 2 | \$477.98 | 8 Port Switch |
| 16 Port Switch | Ubiquiti UniFi Switch US-16-150W - switch - 16 ports - managed - rack-mountable |  | \$349.99 | 38 | \$13,299.62 | 16 Port Switch |
| 24 Port Switch | Ubiquiti UniFi Switch USW-24-POE - switch - 24 ports - managed - rack-mountable |  | \$455.99 | 1 | \$455.99 | 24 Port Switch |

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|-----------------------------|---|---|------------|---|---------------------|---|
| 48 Port Switch | Ubiquiti UniFi Switch USW-PRO-48-POE - switch - 48 ports - managed - rack-mountable |  | \$1,229.99 | 2 | \$2,459.98 | 48 Port Switch |
| Fiber Channel Switch | Cisco MDS 9132T - switch - managed - rack-mountable |  | \$4,735.99 | 1 | \$4,735.99 | Fiber Channel Switch |
| Disk Array | OWC 92TB Flex 1U4 4-Bay Thunderbolt 3 Storage Array (3 x 20TB HDDs + 4 x 8TB SSDs) |  | \$7,999.99 | 2 | \$15,999.98 | Disk Array |
| VDS | Kramer VM-24HC 2x1:4 HDMI Switcher & Distribution Amplifier |  | \$604.00 | 3 | \$1,812 | VDS |
| Total | | | | | \$863,429.91 | |

Design 3

| Device | Description | Product Screenshot | Ind. Price | Qty | Total | Link |
|--------|---|---|------------|-----|--------------|--------------------------------|
| P1 | Lenovo ThinkStation P360 - tower - Core i9 12900K 3.2 GHz - vPro Enterprise - 32 GB - SSD 1 TB - US |  | \$2,219.99 | 327 | \$725,936.73 | P1 Workstation |
| P2 | Lenovo ThinkStation P360 - tower - Core i7 12700 2.1 GHz - vPro Enterprise - 32 GB - SSD 1 TB - US |  | \$3,203.99 | 69 | \$221,075.31 | P2 Workstation |
| PR | HP LaserJet Enterprise M480f Laser Multifunction Printer - Color |  | \$969.99 | 27 | \$26,189.73 | Printer |
| AP | Ruckus R750 - wireless access point - Wi-Fi 6 |  | \$1,156.99 | 21 | \$24,296.79 | AP |

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|------------|---|--|------------|----|-------------|---|
| DS | IRIS ID SYSTEMS Dual Iris Recognition Biometric Reader, Face Image Capture, AutoTilt, LCD Touchscreen/ Keypad |  | \$4,470.23 | 18 | \$80,464.14 | Door Scanner |
| CAM | Ubiquiti UniFi Protect G4 PTZ - network surveillance camera |  | \$1,958.99 | 8 | \$15,671.92 | Security Camera |
| TV | Samsung QN65QN800 CF QN800C Series - 65" Class (64.5" viewable) LED-backlit LCD TV - Neo QLED - 8K |  | \$3,499.99 | 5 | \$17,499.95 | |
| NVR | Fortinet FortiRecorder 400F - standalone NVR |  | \$3,213.99 | 1 | \$3,213.99 | Network Video Recorder |

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|--------------------|--|---|-------------|-----|-------------|---|
| Scanner | Wasp DR5 2D Android Mobile Computer - data collection terminal - Android 10 - 64 GB - 5.45" - 4G |  | \$1,211.99 | 10 | \$12,119.9 | <u>Barcode Scanner Mobile</u> |
| Router | Cisco Integrated Services Router 4461 - router - rack-mountabl e |  | \$22,127.99 | 3 | \$66,383.97 | <u>Router</u> |
| Transceiver | Proline Cisco GLC-SX-MM D Compatible SFP TAA Compliant Transceiver - SFP (mini-GBIC) transceiver module - GigE - TAA |  | \$78.00 | 100 | \$7,800.00 | <u>Transceiv er</u> |

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|-----------------------|---|---|------------|----|-------------|---------------------------------------|
| 8 Port Switch | EnGenius ECS2512 Cloud Managed 8-Port Multi Gig Switching 2.5G with 4 10G SFP+ Uplink Ports |  | \$499.00 | 2 | \$998.00 | 8 Port Switch |
| 16 Port Switch | Netgear 10-Gigabit Smart Managed Pro Switch Series - XS716T-100NES |  | \$349.99 | 38 | \$13,299.62 | 16 Port Switch |
| 48 Port Switch | Netgear ProSafe M4300 48G Managed Switch 48 x 10GbE |  | \$6,999.99 | 4 | \$27,999.96 | 48 Port Switch |
| Disk Array | OWC 92TB Flex 1U4 4-Bay Thunderbolt 3 Storage Array (3 x 20TB HDDs + 4 x 8TB SSDs) |  | \$7,999.99 | 2 | \$15,999.98 | Disk Array |

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|-----------------------------|---|---|------------|---|----------------|---|
| Fiber Channel Switch | Cisco MDS 9132T - switch - managed - rack-mountable |  | \$4,735.99 | 1 | \$4,735.99 | <u>Fiber Channel Switch</u> |
| VDS | Kramer VM-24HC 2x1:4 HDMI Switcher & Distribution Amplifier |  | \$604.00 | 3 | \$1812 | <u>VDS</u> |
| Total | | | | | \$1,265,497.98 | |

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