

FireTech Productions Phones and Cameras

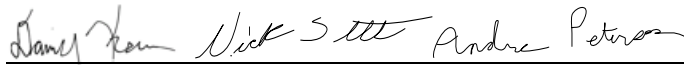
by

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Submitted to
the Faculty of the School of Information Technology
in Partial Fulfillment of the Requirements for
the Degree of Bachelor of Science
in Information Technology

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ACRONYMS AND ABBREVIATIONS

BLF	Busy Lamp Field
CCTV	Closed Circuit Television
CD	Compact Disc
DVD	Digital Video Disc
DVR	Digital Video Recorder
IP	Internet Protocol
NVR	Network Video Recorder
PBX	Private Branch Exchange
PoE	Power over Ethernet
RAID	Redundant Array of Independent Disks
SSL	Secure Sockets Layer
USB	Universal Serial Bus
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAP	Wireless Access Point

ABSTRACT

According to a recent Microsoft survey, over 90 percent of people say that dealing with a company that *uses outdated* technology would cause them to reconsider business relations due to concerns over security, privacy or user-friendly convenience.(www.microsoft.com) This is the problem for which the Use Case was developed. With modern network infrastructure, businesses are able to operate more efficiently and securely as well as improve the quality of life of both their customers and employees. The solution being implemented is a modern VoIP solution and additionally an IP-Based NVR system. This will maximize workplace security and provide a unified communications solution for employee/customer collaboration. With the solution, a business will be able to focus solely on business, and not all the headaches that can come with outdated unsupported system. Customer relations will greatly improve, and the business itself will have better communications equipment and security.

1. PROBLEM STATEMENT

1.1 Introduction

According to a recent Microsoft survey, over 90 percent of people say that dealing with a company that *uses outdated* technology would cause them to reconsider business relations due to concerns over security, privacy or user-friendly convenience. This is the problem for which the Use Case was developed. With modern network infrastructure, businesses are able to operate more efficiently and securely as well as improve the quality of life of both their customers and employees. The solution being implemented is a modern VoIP solution and additionally an IP-Based NVR system. This will maximize workplace security and provide a unified communications solution for employee/customer collaboration. With the solution, a business will be able to focus solely on business, and not all the headaches that can come with outdated unsupported system. Customer relations will greatly improve, and the business itself will have better communications equipment and security.

1.2 Problem

FireTech Productions Inc. is a Small Business located just south of Dayton in Centerville, OH. The company has been growing steadily over the past 10 years and has just purchased additional building space within the commerce park they are currently located in. The company does not currently have a Private Branch Exchange (PBX) and most of the systems in the office are connected wirelessly, which causes poor performance when transferring files, printing, and connecting to the Web. Additionally, the company performs many web-based training seminars for students that are seeking certification in fire sprinkler system installations. The company would like to have an on-site Web Conferencing solution that will allow students to easily connect in to view the classes. The company is also interested in security cameras to help monitor the location.

1.3 Solution

The solution developed for FireTech Productions consists of several components. The phone system will be connected and installed on-site while providing for remote accessibility external to the offices in the event staff is away or on business trips. This will include a networking and security component for the system's installation. Additionally, there will be a development component in the form of a network management server to coordinate the networking hardware, and SSL certificates to secure the connections to the management system and to the remotely accessible Network Video Recorder (NVR). There will also be physical wiring involved and all of the cabling will be tested to ensure connectivity.

The PBX being implemented offers greater customization than IaaS providers like Vonage or 8x8, because the PBX is hosted onsite or on the customer's private cloud environment. Additionally, scaling to more extensions does not cost extra like these other services. Once the license for 3CX is acquired, all of the benefits are fully realized without paying a la carte pricing. The NVR is the same, as the software includes all functionality. There is no tiered pricing as some DVR services have. If the system running the NVR has the storage and performance, as many cameras as required for the site can be connected. Other DVRs limit the configuration to 8,16,24,32, or 48 cameras per server.

1.4 Project Description

The team will implement a fully functional VoIP system, migrate the customer's existing phone numbers to a SIP trunk service, install desk phones, install structured wiring, install a network video recorder, security cameras, web conferencing solution and configure cloud servers with security and virtual LANs (VLANs) to support the new infrastructure.

1.5 User Profile

1.5.1 Project Title

FireTech Productions Inc. New Office Network

1.5.2 Potential Users

A company's employees who have implemented the IT system with varying levels of tech experience and comfortability

1.5.3 Software, Interface, and Related Experience

This project will focus on making a seamless and efficient experience for users of all technological experience levels. The solution will be simple yet packed full of advanced modern features that will increase efficiency for all users. Because the system will be used by such a wide variety of individuals usability will be the utmost concern.

1.5.4 Experience with Similar Applications

It is expected that all FireTech users will be familiar with a basic PBX phone system but many of the advanced feature sets will need to be taught. Technologically proficient individuals will be able to quickly understand the system, while for others it may take longer to take advantage of the full feature set. The security system will primarily be used by those in security so the system should be easily understood and utilized. The great thing about the solution is that, from a mobile use perspective, it is no different than using any other app on a smartphone. There is a user login page, and then the app immediately loads into the camera system. Users can pinch and zoom the video just as they would other content viewed on the device.

1.5.5 Task Experience

- Securely gaining access to a company's wired or wireless network
- Basic PBX system functionality
- Viewing a video stream online
- Some users may already have a similar camera system at home
- Employees already familiar with checking voicemail will be able to easily check it on the new phone system
- Scheduling web meetings using the phone system with Office 365 is the same task process as scheduling a meeting in Microsoft Outlook
- Users will already be familiar with connecting to wireless networks and the new internal wireless network will be no different. Users will also see a visitor network which they may be familiar with from other businesses and publicly accessible WiFi

1.5.6 Frequency of Use

It is expected that the system will be used daily by users with varying backgrounds and from all sectors of the business. This includes internal communications and business to business communications.

1.5.7 Key Project Design Requirements That The Profile Suggests

- Quick start device setup and features lists
- A system that is easy to use for all users
- Training workshops
- Easy to access help for technical needs down the line

1.5 Use Case Diagram

The following diagrams, Figure 1: Use Case Diagram #1, Figure 2: Use Case Diagram #2, and Figure 3: Use Case Diagram #3, displays the use case for the solutions to FireTech's Phone and Camera systems. The three diagrams depict all the users of each component (the Guest Network, the Camera System, The Phone Systems, and Network Infrastructure), and depict the corresponding tasks each user will have access to while interacting with each of the systems.

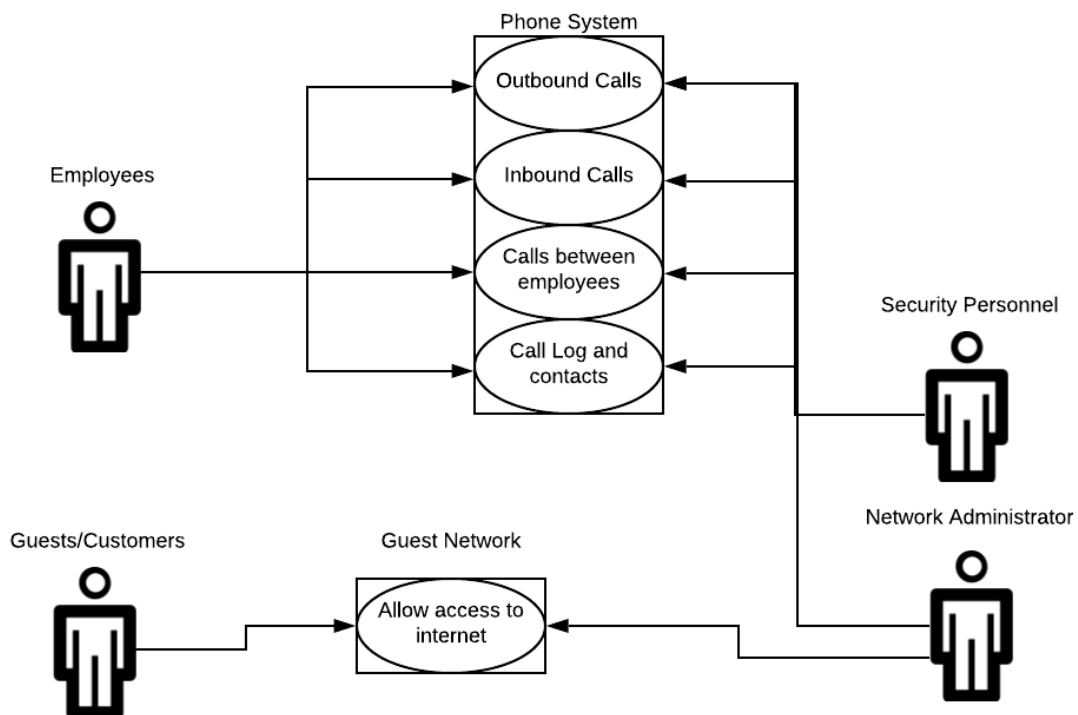


Figure 1. Use Case Diagram #1

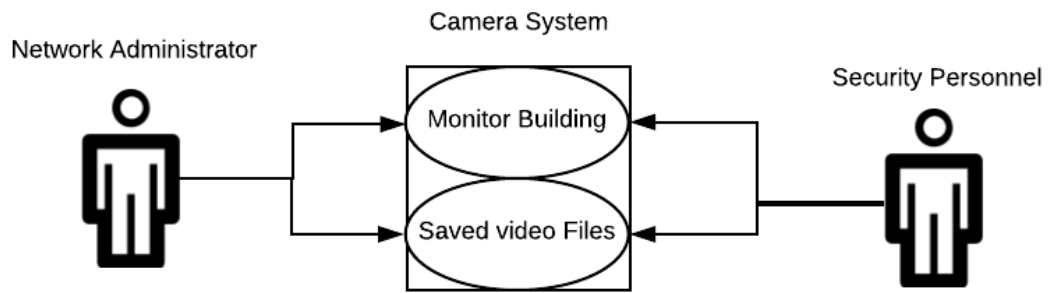


Figure 2. Use Case Diagram #2

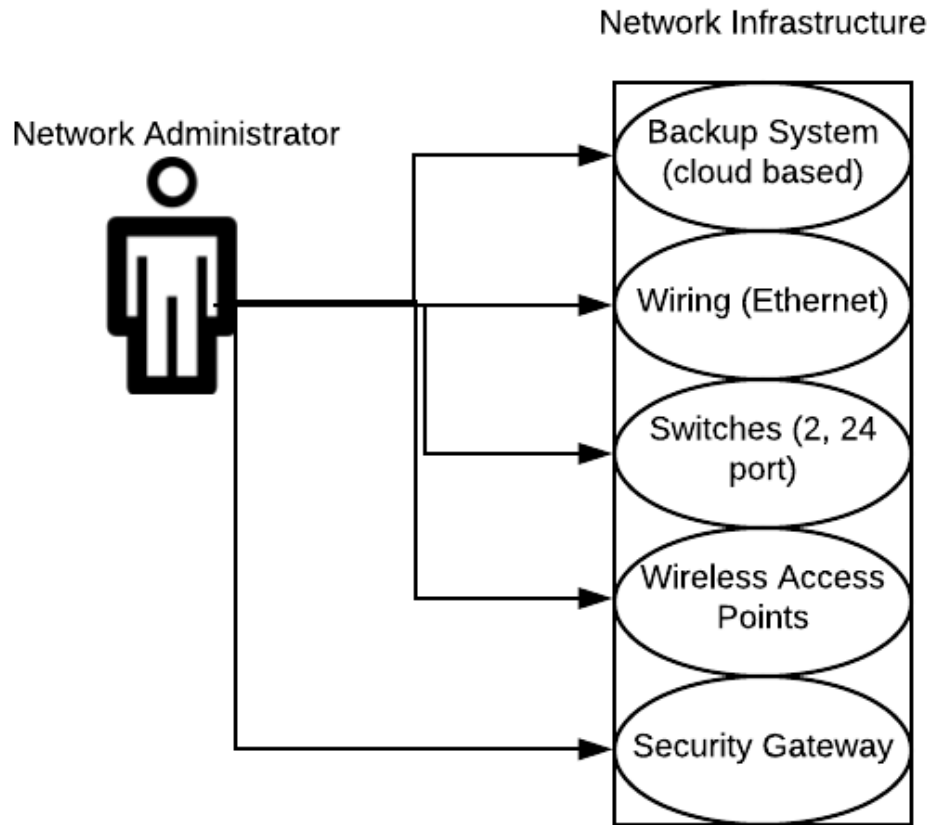


Figure 3. Use Case Diagram #3

2. PROJECT MANAGEMENT

2.1 Budget

The budget, depicted in Table 1: Project Budget, is to be divided up as Phone System and Camera System. Currently, three quotes were provided to FireTech, a low-end, mid-range, and high-end configuration for the phone system.

Description	Quantity	Unit Cost	Total
Grandstream Single Line PoE Phone	14	\$55.00	\$770.00
Ubiquiti 24-Port PoE 250W	2	\$399.00	\$798.00
Ubiquiti Security Gateway	1	\$100.00	\$100.00
Ubiquiti Access Point	3	\$149.00	\$447.00

Dell Refurbished Server (PBX)	1	\$300	\$300.00
3CX Pro License (Per Year)	1	\$325	\$325.00
		Grand Total	\$2,740.00
Grandstream Midrange PoE Phone	14	\$85.00	\$1,190.00
Ubiquiti 24-Port PoE 250W	2	\$399.00	\$798.00
Ubiquiti Security Gateway	1	\$100.00	\$100.00
Ubiquiti Access Point	3	\$149.00	\$447.00
Dell Refurbished Server (PBX)	1	\$300	\$300.00
3CX Pro License (Per Year)	1	\$325	\$325.00
		Grand Total	\$3,160.00
Grandstream Highend PoE Phone	14	\$99.00	\$1,386.00
Ubiquiti 24-Port PoE 250W	2	\$399.00	\$798.00
Ubiquiti Security Gateway	1	\$100.00	\$100.00
Ubiquiti Access Point	3	\$149.00	\$447.00
Dell Refurbished Server (PBX)	1	\$300	\$300.00
3CX Pro License (Per Year)	1	\$325	\$325.00
		Grand Total	\$3,356.00
SIP Trunk (Unlimited Channels)		\$75.00	
4000 Monthly Minutes			
5 DIDs			
Monthly Controller Cost		\$25.00	

Table 1. Project Budget

2.2 Objectives/Deliverables

The configuration, installation, and training of the new IP-based PBX phone system. Team members will review the installation requirements for the desk phones and then install and configure IP-based desk phones for each FireTech employee. The configuration and installation of the IP-based CCTV security camera system and the configuration of the VLANs that will separate the network traffic for internal wireless/wired traffic, visitor, phone, and security. Configuration of VPN for remote access to the network, and installation of SSL certificates for all web-facing services such as the network management controller and IP-based Network Video Recorder.

The features of the FireTech network will include:

- On-site IP-based PBX
- PoE IP Desk Phones
- ATA Fax adapter
- Structured Wiring the network drops
- Patch Panel for wire management
- Secure Wireless internal network
- Visitor Wireless network
- Network Video Recorder
- IP-Based Security Cameras
- Separate VLANs for phone, data, security, and visitor
- Cloud-based Network Management Controller
- SSL certificates to secure network management controller and NVR
- Web Conferencing solution that integrates with the IP-PBX phone system

2.3 Project Schedule

Figure 4: Fall Semester 2019 Gantt Chart and Table 2: Work Breakdown Structure outline the projected schedule for completion of this project.

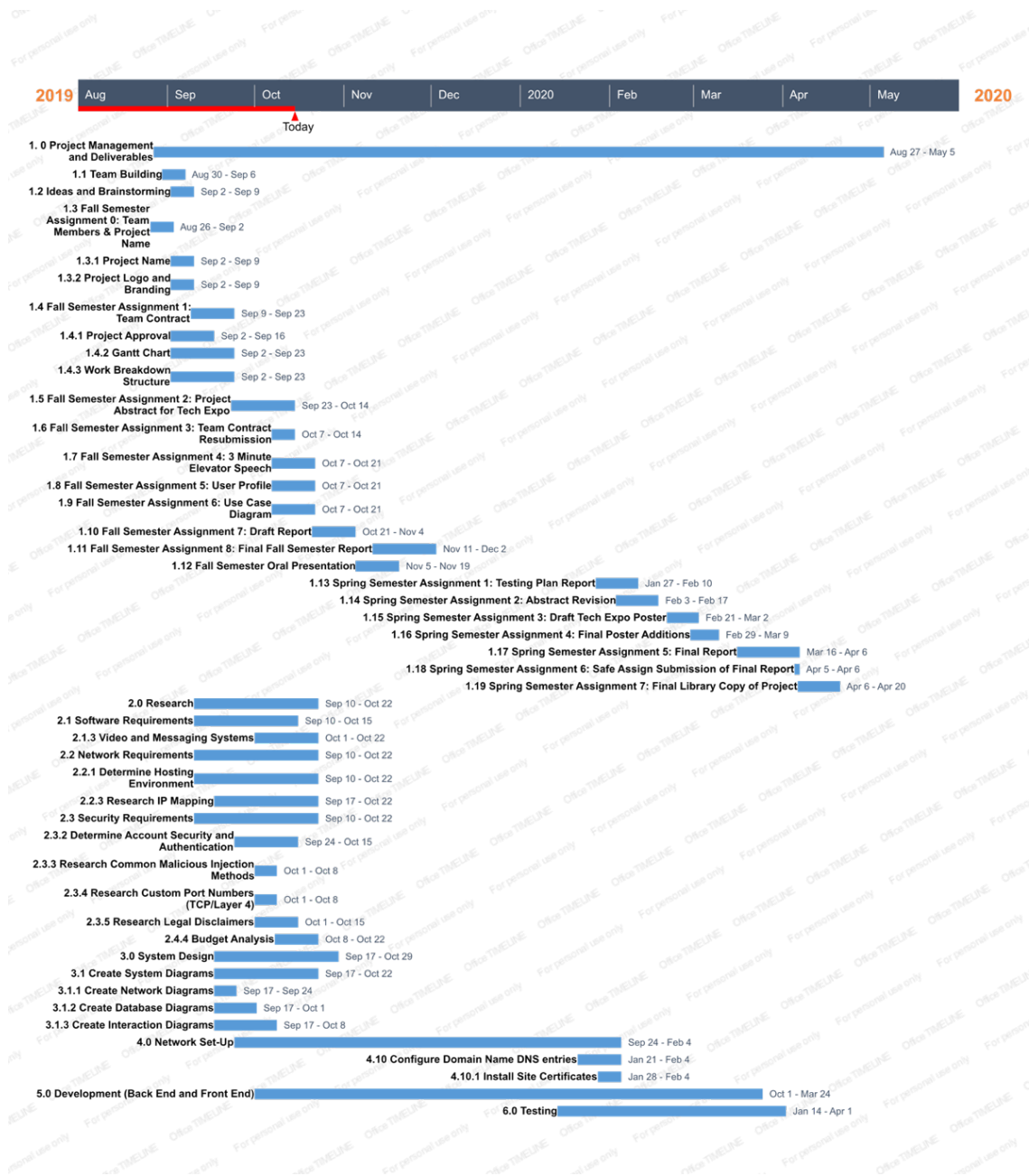


Figure 4. Fall Semester 2019 Gantt Chart

Task Name	Duration (Days)	Start Date	End Date
1. 0 Project Management and Deliverables	252	8/27/19	5/5/20
1.1 Team Building	7	8/30/19	9/6/19
1.2 Ideas and Brainstorming	7	9/2/19	9/9/19

1.3 Fall Semester Assignment 0: Team Members & Project Name	7	8/26/19	9/2/19
1.3.1 Project Name	7	9/2/19	9/9/19
1.3.2 Project Logo and Branding	7	9/2/19	9/9/19
1.4 Fall Semester Assignment 1: Team Contract	14	9/9/19	9/23/19
1.4.1 Project Approval	14	9/2/19	9/16/19
1.4.2 Gantt Chart	21	9/2/19	9/23/19
1.4.3 Work Breakdown Structure	21	9/2/19	9/23/19
1.5 Fall Semester Assignment 2: Project Abstract for Tech Expo	21	9/23/19	10/14/19
1.6 Fall Semester Assignment 3: Team Contract Resubmission	7	10/7/19	10/14/19
1.7 Fall Semester Assignment 4: 3 Minute Elevator Speech	14	10/7/19	10/21/19
1.8 Fall Semester Assignment 5: User Profile	14	10/7/19	10/21/19
1.9 Fall Semester Assignment 6: Use Case Diagram	14	10/7/19	10/21/19
1.10 Fall Semester Assignment 7: Draft Report	14	10/21/19	11/4/19
1.11 Fall Semester Assignment 8: Final Fall Semester Report	21	11/11/19	12/2/19
1.12 Fall Semester Oral Presentation	14	11/5/19	11/19/19
1.13 Spring Semester Assignment 1: Testing Plan Report	14	1/27/20	2/10/20
1.14 Spring Semester Assignment 2: Abstract Revision	14	2/3/20	2/17/20
1.15 Spring Semester Assignment 3: Draft Tech Expo Poster	10	2/21/20	3/2/20
1.16 Spring Semester Assignment 4: Final Poster Additions	10	2/29/20	3/9/20
1.17 Spring Semester Assignment 5: Final Report	21	3/16/20	4/6/20
1.18 Spring Semester Assignment 6: Safe Assign Submission of Final Report	1	4/5/20	4/6/20
1.19 Spring Semester Assignment 7: Final Library Copy of Project	14	4/6/20	4/20/20
2.0 Research	42	9/10/19	10/22/19
2.1 Software Requirements	35	9/10/19	10/15/19
2.1.3 Video and Messaging Systems	21	10/1/19	10/22/19
2.2 Network Requirements	42	9/10/19	10/22/19
2.2.1 Determine Hosting Environment	42	9/10/19	10/22/19
2.2.3 Research IP Mapping	35	9/17/19	10/22/19
2.3 Security Requirements	42	9/10/19	10/22/19
2.3.2 Determine Account Security and Authentication	21	9/24/19	10/15/19
2.3.3 Research Common Malicious Injection Methods	7	10/1/19	10/8/19
2.3.4 Research Custom Port Numbers (TCP/Layer 4)	7	10/1/19	10/8/19
2.3.5 Research Legal Disclaimers	14	10/1/19	10/15/19
2.4.4 Budget Analysis	14	10/8/19	10/22/19

3.0 System Design	42	9/17/19	10/29/19
3.1 Create System Diagrams	35	9/17/19	10/22/19
3.1.1 Create Network Diagrams	7	9/17/19	9/24/19
3.1.2 Create Database Diagrams	14	9/17/19	10/1/19
3.1.3 Create Interaction Diagrams	21	9/17/19	10/8/19
4.0 Network Set-Up	133	9/24/19	2/4/20
4.10 Configure Domain Name DNS entries	14	1/21/20	2/4/20
4.10.1 Install Site Certificates	7	1/28/20	2/4/20
5.0 Development (Back End and Front End)	175	10/1/19	3/24/20
6.0 Testing	77	1/14/20	4/1/20

Table 2. Work Breakdown Structure

3. Technical Elements

3.1 Network Infrastructure

FireTech Productions at the start of this project did not have the necessary equipment to run the IP Phones, PBX Server, IP Cameras, or NVR. Part of the group project was to build out this infrastructure for the business. The network consists of a security gateway which is at the demarcation between the ISP and the business LAN. The gateway then connects to a 24-Port PoE Switch in the first office suite. That switch has a trunk line that connects the second PoE switch in the new office suite. The location for the first switch, gateway, patch panel, and cable modem from the ISP are referred to as the Main Distribution Facility (MDF). The second switch and associated patch panel are referred to as the Intermediate Distribution Facility (IDF). The business also requested 3 Wireless Access Points as part of the infrastructure build out. These access points are PoE and draw power from the switches. Two wireless networks were created, an internal business network, and a visitor network for customers, vendors, and contractors to use when on-site. Both networks have been secured using WPA2 Pre-Shared Key encryption.

3.2 Network Management Server

The FireTech Infrastructure is configured using Software Defined Networking (SDN). The hardware is from Ubiquiti Networks and is part of their UniFi Networking platform. The hardware operates based on provisioning instructions received from a cloud-hosted network controller. This controller is configured on Digital Ocean's cloud-hosting platform using a virtual machine (a Digital Ocean Droplet) running Debian 9.7 "Stretch" Linux. The UniFi network controller contains all of the information the hardware devices need to run the network, such as subnet and vlan information, firewall information for the gateway, wireless network information for the wireless access points, and provides statistical data for the network.

3.3 PBX Server

The PBX server runs the phone system software. The software chosen is 3CX IP-PBX. There are other IP-PBX software platforms available, such as Asterisk, or FreeSwitch, however 3CX has the most intuitive user interface, seamless phone provisioning and a wealth of other features including a free to use mobile app. The software runs on Debian 9.7 "Stretch" Linux just like the UniFi controller and can be installed as an APT package, or as a downloadable ISO burned to CD/DVD or USB Flash Drive. The system runs on a physical server, a Dell PowerEdge T310. The system has 12GB of RAM, dual 500GB SATA hard drives configured in RAID 1 Mirroring for redundancy, dual 400W power supplies, and a Quad Core Intel Xeon Processor.

3.4 IP Phones

FireTech went with the Grandstream GXP1782 model IP Phone. (www.grandstream.com) They purchased a total of 15 units currently but may expand in the future. This phone features Gigabit Ethernet connectivity as well as a pass-through Gigabit port to connect an additional device such as a desktop computer. The unit can be placed on a desktop or wall-mounted with the optional wall-mount bracket. FireTech purchased a single wall-mount bracket for the phone that will be in their conference room. The

phones can handle up to 8 calls at a time and have assignable keys for Busy Lamp Field (BLF) setup or additional Line keys for more on-hold calls.

3.5 Network Video Recorder

The network video recorder for FireTech will run on another physical server, a Dell PowerEdge T310. The requirements are currently being reviewed with the business, however this system will likely include 12TB of disk storage, 32GB of RAM and a quad-core Xeon processor.

3.6 IP Cameras

FireTech is planning for 4-8 cameras to cover entrances to the office areas. These cameras are Ubiquiti G3 bullet-style cameras that record in 1920x1080 (1080p) resolution at 30 frames per second. This is equivalent to real-time in analog camera systems. The cameras are PoE and each unit will receive an IP Address from the security gateway on the security camera subnet.

4. Technical Diagram

4.1 Network/Hardware Infrastructure

Figure 5 represents the network and hardware infrastructure diagram for FireTech Productions. The diagram includes references to the Internet connection from the provider, Spectrum Business. The connection terminates into the UniFi Security Gateway Pro (USG-Pro-4), which then passes the connection to the core switch (US-24-250W) connected directly to the gateway. A secondary switch (US-24-250W) is also connected to the core switch via an ethernet connection. There are two wireless access points (UAP-AC-Pro) each connected to one of the switches providing wireless connectivity throughout the business suite. Also connected to the switches are the GXP1782 IP desk phones and UVC-G3-Dome security cameras. Both types of devices receive power and data over a single ethernet cable per device using PoE. Additionally, the PBX and NVR are connected to the LAN.

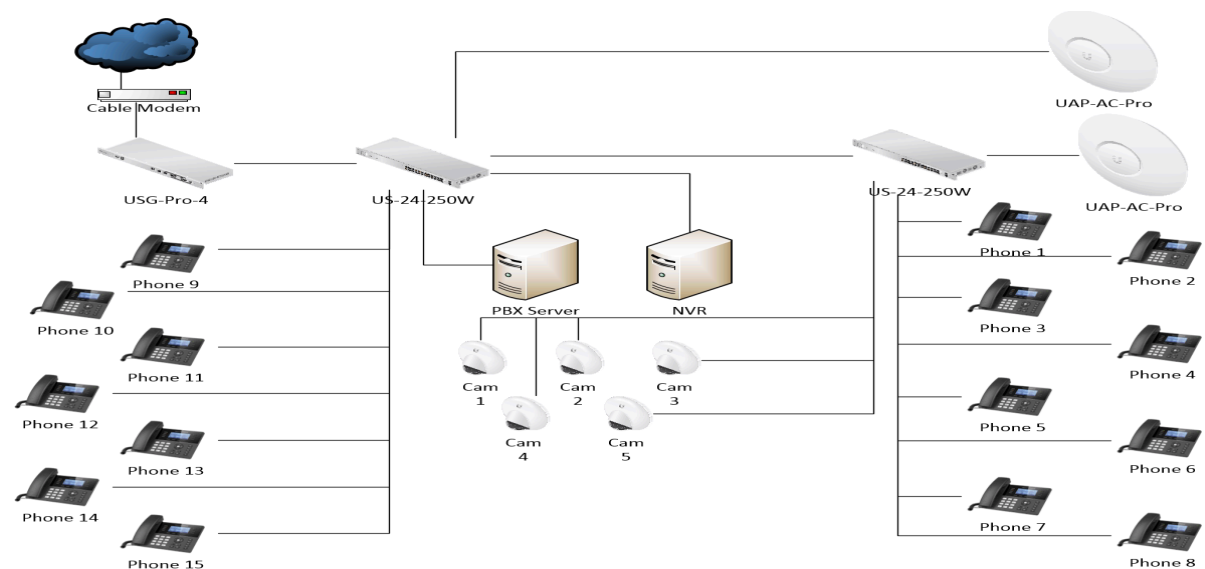


Figure 5: Network/Hardware Infrastructure Diagram

4.2 Screenshots & Visuals

4.2.1 PBX Dashboard View

Phone system management will take place within the PBX server's web page. Once a user has logged in, they will be presented with the admin dashboard view as shown in Figure 6. Access to the admin dashboard is limited to users who have been granted administrative access to the PBX.

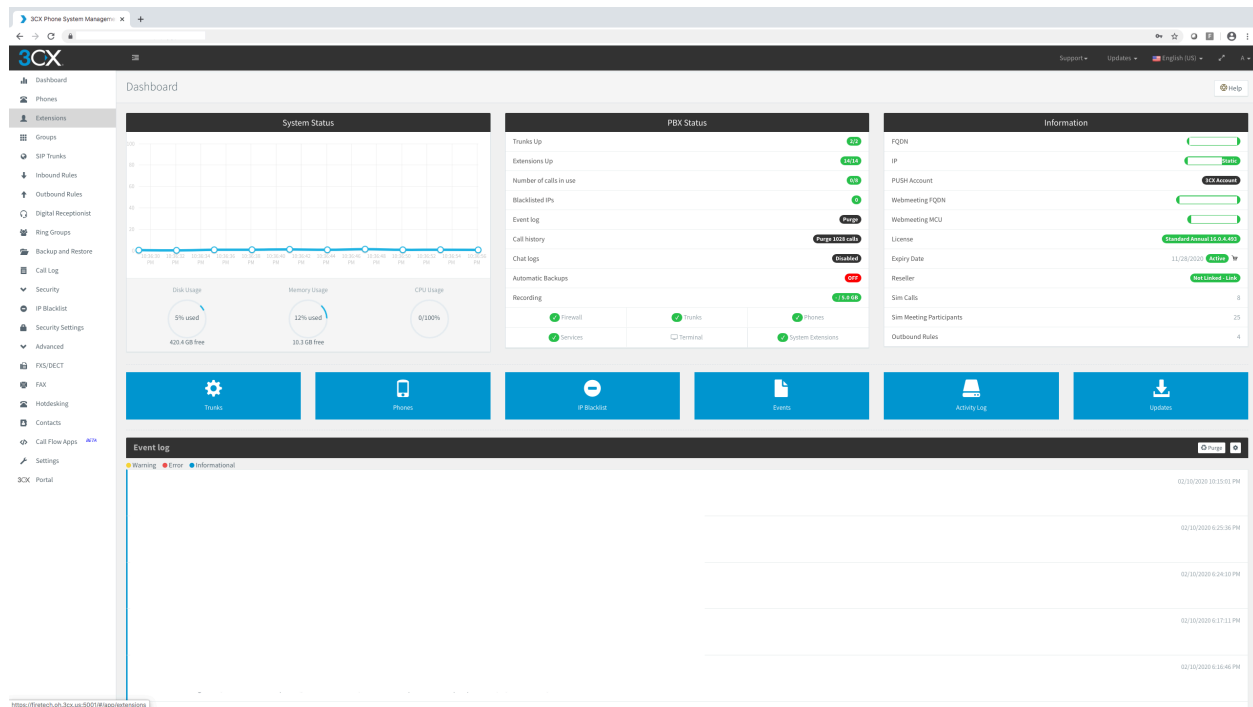


Figure 6: PBX Dashboard View

4.2.2 NVR Dashboard View

CCTV system management takes place on the NVR server's web page. Once a user has logged in, they will be presented with the dashboard view as shown in Figure 7. Access to the dashboard is limited to administrative access to the NVR.

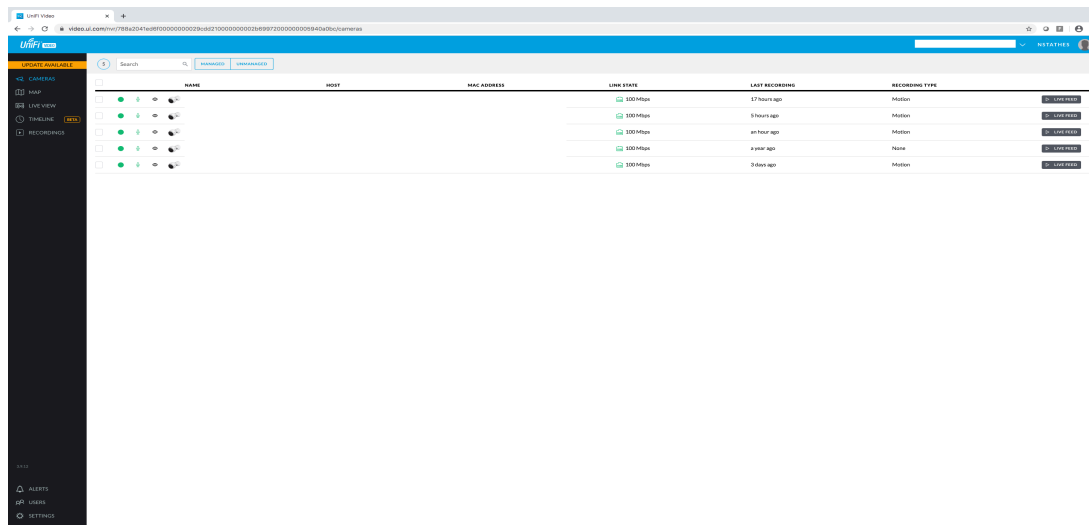


Figure 7: NVR Dashboard View

5. Test Plan

5.1 Overview/Methodology

Our testing really covers 3 specific areas which we will go into further below. The testing is split up because not all of the systems were installed at the same time, and each system performs a different function for FireTech Productions Inc. The User Experience Testing will consist of functionality testing for each area and configuration testing to ensure that the settings desired by the organization have been implemented and are working in the manner that was requested by the company. Since each of these systems operates uniquely from the other two, it is necessary to approach each system individually in order to accurately test that system's functions.

5.2 Scope of Testing

5.2.1 Area 1: Network Infrastructure

This is the backbone of the network and provides a median for which the IP Phone System can be connected. It is also the median for which the IP Security Camera System can be connected.

This includes the physical cables, network switches, security gateway, and wireless access points that will be configured to be access by users.

5.2.2 Area 2: IP Phone System

This is the communication technology that is a combination of hardware integrated with software and firmware to function together for users to make and receive telephone calls, voicemails, and other audio & video communications between the business and potential customers, vendors, and other third parties.

5.2.3 Area 3: IP Security Camera System

This is the security camera system that consists of a network video recorder containing disk storage, a camera management software application and the cameras themselves, which when combined together create a digital recording system for the business to log activity on the company premises.

5.3 Objectives

Area 1 consists of users verifying they can continue to access any previously configured network resources in a pass/fail scenario. There was validation testing against the new wireless networks created with the infrastructure. Configurations were compared to the previous network, to ensure a seamless transition from old to new with negligible downtime. New hardware was inspected to ensure it is functioning properly, that there are no defects, that firmware is up to date, and that all documentation for the function of the hardware has been created and provided to the customer. The testing involves the tools contained within the UniFi Controller that displays network traffic statistics, performance of hardware, and more.

Area 2 consists of functionality of the IP Phone system. This includes connection of the Phone Server to the SIP Trunk Provider (Phone Company), the connection of the IP Phones to the LAN, and the logical connection of the IP Phones to the Phone Server that is onsite. This is confirmed through the IP Phone System's web interface, displaying the phone extension status (up or down), connection of the SIP Trunk (up or down), and the resource load on the server.

Area 3 consists of the validation that the IP cameras are functioning, that they are capable of recording video to the network video recorder, and that the camera settings are configured for the best video resolution possible.

5.4. Logging Test and Procedures

Figures 8 through 17 show the results of our testing for the network infrastructure, PBX, IP Phones, NVR, and Cameras.

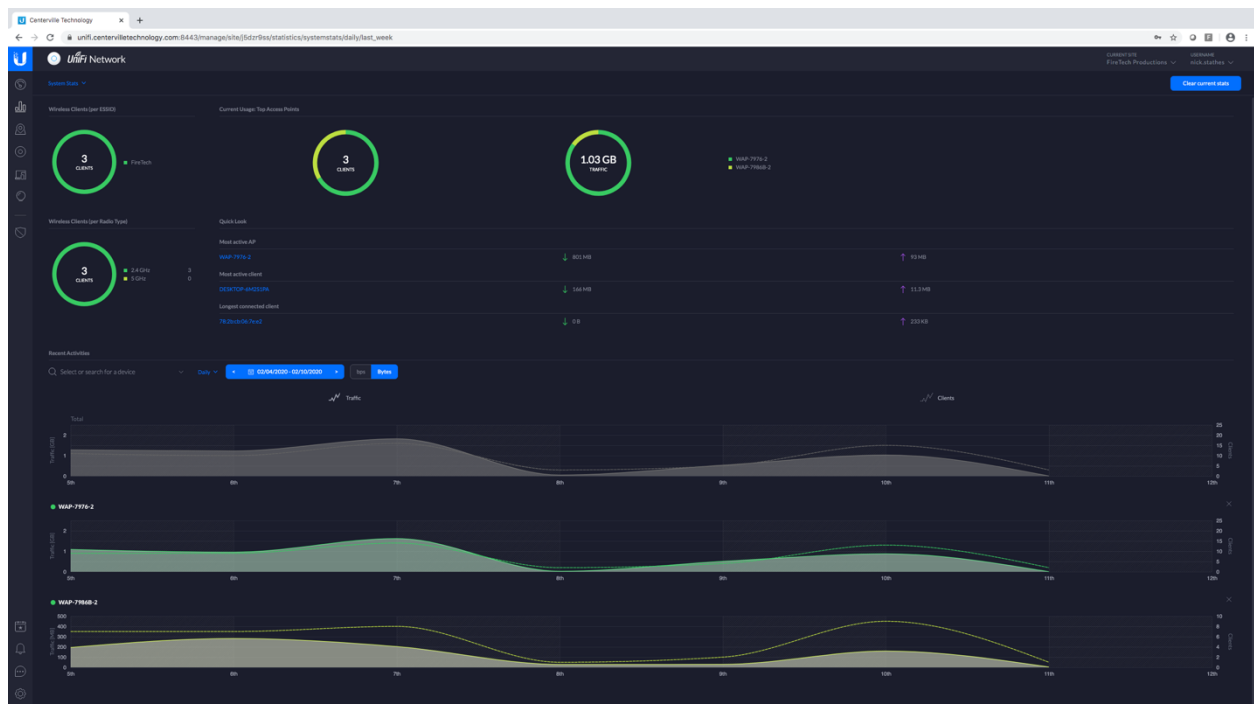


Figure 8: Overall System Statistics for the network



Figure 9: Network Performance Statistics



Figure 10: Wireless Access Point Performance Statistics

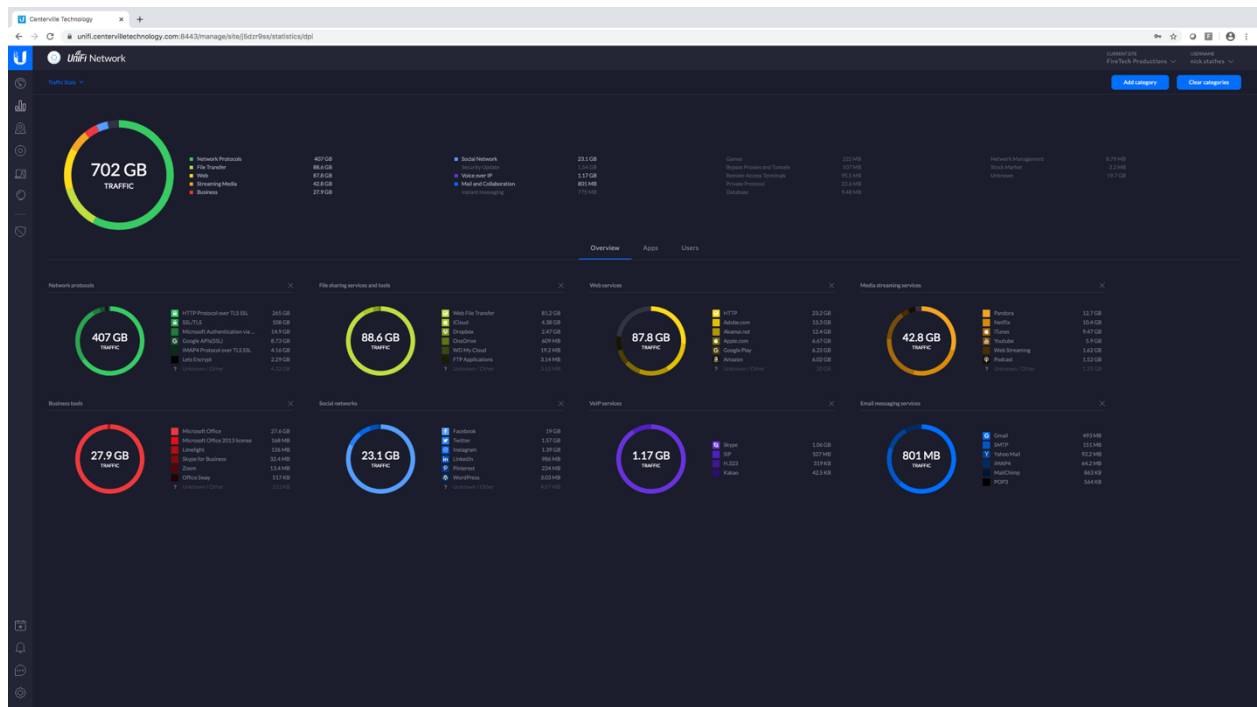


Figure 11: Network Traffic Statistics

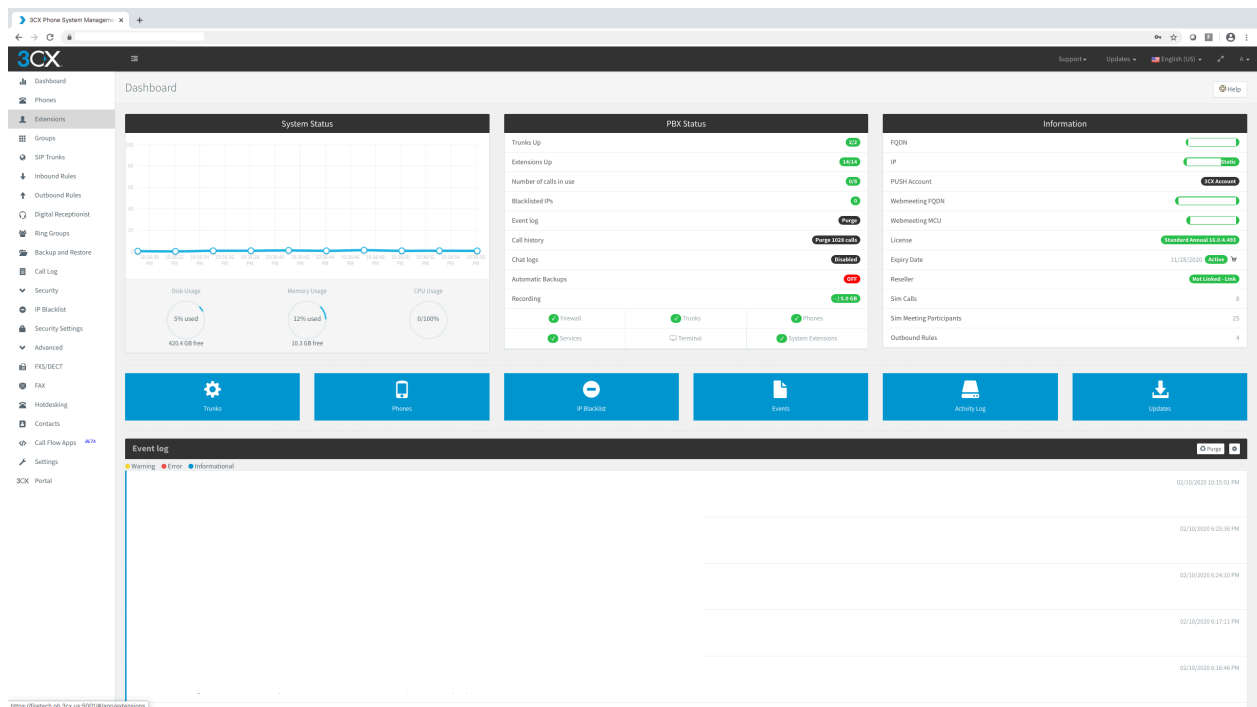


Figure 12: IP Phone System Status (Note: Customer information has been blanked for privacy)

SIP Trunks				
SIP Trunks				
+ Add SIP Trunk + Add gateway + Add SBC + Add Bridge Edit Delete Enable All Disable All Refresh Registration Import Provider Export Provider				
Search ...				
☐	Name	Host	Type	Sim Calls
☐	SIPTRUNK.com	gw.siptrunk.com	Provider	2
☐	WebMeeting bridge	--	Bridge Master - Direct	50

Figure 13: SIP Trunk Status

Extensions				
Extensions				
+ Add Edit Delete Import Export Password Regenerate Send Welcome Email Status Copy Extension				
Search ...				
☐	Ext	First	Last	Email
☐				
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Figure 14: Phone Extension Status (Note: All customer information has been blanked for privacy)

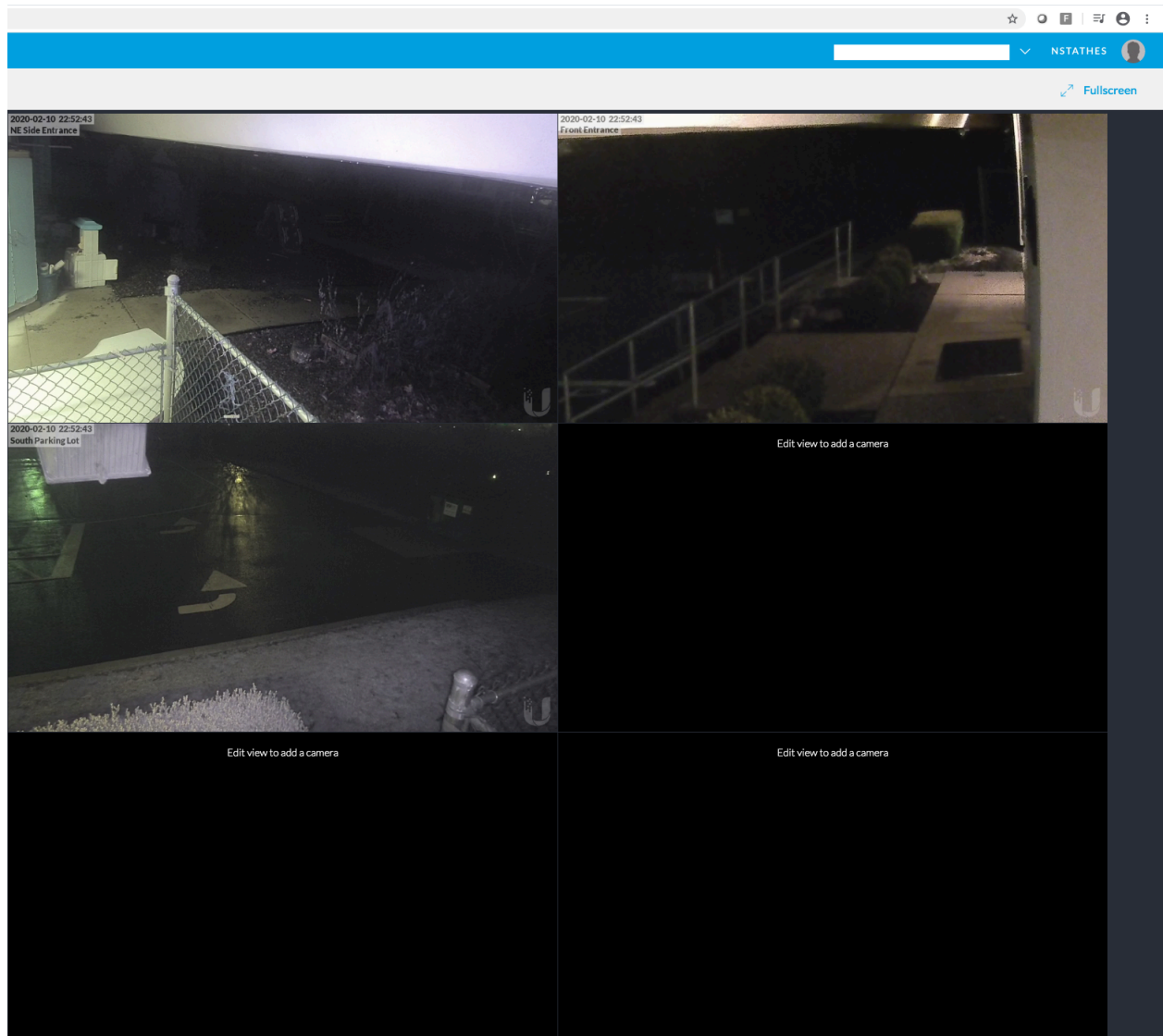


Figure 17: Live Camera View (Note: All customer information has been blanked for privacy)

6. Conclusion

6.1 Fall Semester 2019

The process of creating technological solutions for an existing company has definitely been struggling at times, but it has also been very rewarding. At the beginning of the semester the idea was to locate a real company to develop a network solution, but didn't have the company to do it for. After finding a company the scope of work was determined for the project. The decision was made to create a new IP-based phone system using the 3CX phone system, and using Grandstream GXP1782 phones. The company would need implementation of these new phones, as well as a new firewall deployed, a BDX server to handle the load of the new phone system, and multiple switches to handle the functionality of the IP-based phone systems. A Wireless Access Point (WAP) would be deployed for access to the guest network. A new camera system would be implemented by using IP based cameras, and a video recorder to keep logs of all video files. So far all of the necessary equipment for the phone system has been ordered, and began laying the ethernet wire, and installing the ports needed for the 3CX phone system.

6.2 Spring Semester 2020

The spring semester will see the completion of the phone system installation, with the desk phones installed and the extensions from the phone system tied to each desk phone. This will include testing to ensure each phone functions as FireTech is expecting. Additionally, the NVR and cameras will be installed. Recording schedules will be configured and motion zones will be set up on each of the cameras. Prior to this, the final camera count will be received from FireTech and the order placed for the hardware. Once the server for the NVR arrives, work can begin installing the operating system and the camera application for provisioning the individual cameras. This will be followed by testing of all systems to ensure satisfaction for the customer.

APPENDIX A. RESOURCES

[1] Outdated Technology Can Cost Smbs a Lot More Than a Slow Boot Up

the team - <https://www.microsoft.com/en-us/microsoft-365/blog/2014/04/02/outdated-technology-can-cost-smbs-a-lot-more-than-a-slow-boot-up/>

[2] Gxp1780/gxp1782

<http://www.grandstream.com/products/ip-voice-telephony/mid-range-ip-phones/product/gxp1780/gxp172>

[3] Pbx Vs. Voip: What Separates These Common Phone Systems

<https://www.marconet.com/blog/pbx-vs.-voip-what-separates-these-common-phone-systems>

[4] 7 Benefits Of Having an Integrated Security System

SSI Staff - https://www.securitysales.com/integration/7_benefits_integrated_security_system/