Sports Competition Network

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Introduction

The IST 220 final project is to create a state-wide sporting event and create live streaming for people at home. The sporting event includes different venues such as soccer, field hockey, track and field, tennis, and basketball that all go on simultaneously in a 10-acre square area field. As a group, we must map out and create a hypothetical sports event that will be run using the necessary network equipment. Additionally, we will implement an internet service for people watching the games on the field whether they want to watch it live or not. We will need to determine the amount of software and hardware components necessary to create a live streaming video and components to video the sports games.

As a team, we designed a blueprint of the entire field to include the different fields like soccer, basketball, tennis, and the track stadium. During the design phase, our group went through various implementations as we learned more about the specific requirements and needs of the sporting event. After different risk assessments and estimations, we decided upon a particular framework that would allow us to provide WIFI, streaming, and in-person viewing efficiently and comfortably. We then moved on to the network specifics to allow for in-person viewers to watch the live streams of different games happening simultaneously. This portion of the design phase complicated our project as we had different scenarios that called for different implementations and needs. Due to this, most of our time was spent creating a network topology that physically and logically could provide efficient services for the clients. In addition, as network designers, we needed to account for redundancy and resiliency in our network to face unexpected challenges. However, after multiple meetings and design, we decided upon a network topology that fit the client’s needs best. Finally, we agreed upon a physical design to connect cameras videotaping the game to the main computers that will be at the system headquarters in the middle of the 10-acre by 10-acre area.

Through this project, our goal is to provide an efficient and working framework for the client to use for their sporting event. Firstly, we want to provide a design of the field to show where the games will be played. Next, we want to provide a network topology to produce Wi-Fi and live-streaming viewing to the guests of the event. Finally, we want to recommend products and services that can be used by the clients. As a team, we also account for resiliency and redundancy in our network.

In this project, we are enforcing certain assumptions. Firstly, as we are outdoors and using routers with 2.4GHz bands, they have a coverage of around 300 ft. Additionally, we are assuming that each person in the sports game brings one device each, which would be their phone. Since roads are coming from each side of the field, we assume that there will be a parking lot that will let people park their cars before entering the field where the games are held. The parking lot will then be 1500 feet by 1500 feet which will be enough space to fit 500 people. We can then assume that the field inside the parking lot, where all the games will be going on, will be 3600 feet by 3600 feet. Therefore, we will allow people to let their devices connect to the network in the field, assuming there won't be any internet connection at the parking lot. Another enforcement that we are placing based on the 10 by 10-acre field is that it is all flat land without any obstacles such as hills or trees that would stop WIFI connectivity.

Background

This project requires a variety of different hardware elements, software elements, and logical spacing to properly run the sporting event. Every event will require a camera to record and send video to an encoder which will then communicate to routers and allow that video to be streamed from our HQ. Each field must have bleachers for viewers and viewers need to be able to access the video from any sporting event at any point in time. This requirement also speaks to the need for wireless access points and cell towers which will provide the field with a proper network for viewing the live-streamed video.

Due to the differing nature of each sporting event, different equipment will be used to record, send, and stream each event. For example, we will be implementing a Sky Cam into the track dome which will use a wireless encoder, however for other sports there will be stationary or rotating cameras that connect to multi-port wired video encoders. Different cameras and mounts will also have to be used depending on the nature of the sport where it is taking place. We have pointed out in diagrams the different cameras, routers, locations, and connections we will use to build a strong, fault-tolerant network. These routers will be a mesh system and work together to send video and data to the HQ workstation, which then oversees live streaming of the video through YouTube Live.

As a team, this project raises many concerns with fault tolerance and potential issues at the event, which will be discussed and accounted for in our planning. Through research and weeks of discussion, we were able to choose products and configurations that should account for any extenuating circumstances. We will connect these products to the cameras and the routers to configure the footage into the computer so that the video can be streamed to anyone watching. We will be able to find vulnerabilities in the connections between the hardware and software to go around the possibilities of the live stream not working. This would allow us to plan out a more accurate and high-performing network that can stream at least 10 simultaneous events.

Hardware

As the client is looking for a high-performance network that can live stream up to 10 events, we will need to utilize certain hardware that provides highly efficient networking and live streaming capabilities. As budgets are not considered, we will be using industry-standard products that are the best fit for each need discovered.

1. Routers
    a. Motorola MG7550 Cable Modem/Router
        i. The Motorola MG7550 Cable Modem/Router is a router that supports both wired and wireless connections. As it supports both Modem and Router capabilities, it can be used as the central node desired in our network topology. It will be configured to use Comcast's Xfinity for internet access. This router costs around $150.00.
2. Access Points
    a. Ruckus Wireless ZoneFlex T710 Outdoor Access Points
        i. We will be using the Ruckus T710 Outdoor Access Points to create a mesh WIFI system at the event. We will have about 17 AP, one acting as the central node in the HQ. This Ruckus Wireless Zone flex cost around $4,345.
3. Encoder
    a. Teradek VidiU Go
        i. The Teradek VidiUGo is the perfect encoder for our live streaming and recording needs. This encoder has a dual video input system so

that both professional cameras can access it through a 3G-SDI port and consumer cameras can (such as our GoPro) through HDMI. This encoder also works directly with YouTube Live which is the live-streaming service we are using. The configuration of this encoder can be set either through the OLED interface on the device, or the VidiuGo web interface. The VidiuGo will send the encoded video to our workstation wirelessly across our network using the mesh router system. The Teradek VidiU Go costs around $990.

2. Power over Ethernet Switch
    a. Ubiquiti Networks UniFi Switch 8 (US-8-150W)
        i. The Ubiquiti Networks UniFi Switch 8 can power up to 8 devices. This should be enough as we plan to have one switch used in each quadrant and have the routers be either connected directly to the switch for power or will be powered through daisy-chaining meaning one router will be wired connected to another using a PoE cable and help power some of the farther access points (*Ubiquiti Switch 8 P0E*).

4. Camera
    a. Soccer/Field Hockey/Baseball
        i. Sony HDC-4800 Camera
            1. The Sony HDC-4800 is the camera we will be using to record soccer, field hockey, and baseball. We chose this camera as it can employ motion tracking and automatically

capture the focal point of action in the game it is recording. It will connect to the encoder through the 3G-SDI port. This camera is said to be good for capturing fast movement, meaning it will allow for a good video of sporting events. We are using this camera specifically for soccer, field hockey, and baseball as these fields are bigger and require a camera to move and capture each side/movement. The Sony camera cost around $2,799 and the video resolution on this camera is 4K (2160p).

b. Tennis

i.GoPro Hero09 Black

2. We are using the GoPro Hero09 to record tennis as we feel it meets any requirements to record this sport. Tennis is a sport that only requires one camera angle, and the GoPro will be perfect for this as it will not move or track motion, while still capturing high-quality video. This will connect to our encoder through HDMI using the GoPro Media Mod attachment. The Media Mod is a frame that plugs into the side of the camera and has an HDMI port to allow for connection to the encoder. The GoPro will be mounted on the wall/fence of the tennis courts so it can capture the entire surface. The GoPro Hero camera cost around $299.99, and the video resolution is 5.3K

(2880p). The video frame rate on the camera is up to 60fps (*GoPro Hero09 Black 5K).*

c. Track/Basketball

i. Sony HDC-4300 Camera

3. For the track dome and baseball stadiums, we will be using the Sony HDC-4300 camera which is like the HDC-4800, however, it does not have motion-tracking capabilities. We chose this camera for these sports because we feel we do not need motion tracking as the camera lens can span wide enough to comfortably capture the sport. The Sony HDC-4300 camera costs around $2,190, and the video resolution is 4K (*Sony Pro HDC-4300 4K*).

5. Cable

a. HDMI Cable

i. HDMI cables will be needed primarily for the connection of devices (GoPro) to the encoder if the device lacks a 3G-SDI port. The price for one HDMI cord is around 6 dollars.

b. 3G-SDI Cable

i. This cable will be used for our professional-grade cameras as they send RAW video files to encoders through the 3G-SDI connection. The price for one 3G-SDI Cable is around 99 dollars.

c. Power Over Ethernet (PoE) Cables

i. PoE cables will be needed to provide power and an internet connection to each router. The price for one Power Over Ethernet Cable is 25 dollars per foot.

6. Computer
    a. Dell Precision 7820 Tower Workstation
        i. We will be using a Dell computer running Windows Server 2019 as our main computer in the HQ. We feel a computer running Windows Server 2019 will be the correct choice as it will be able to effectively utilize the applications and software, but we need to configure our hardware and network. After adding various upgrades, the cost ends up being around $2,200 (Dell, 2021).
7. Generator
    a. Harbor Freight Gas Powered Portable Generator (9000 Watt)
        i. To power our PoE switches, we will need generators as there will be no outlets or power sources in the field. The switches will use this power and since they are PoE, they will power the rest of our hardware connected to them. The cost of one of these generators is $879.

Software

As we plan to use a variety of different hardware components to make a fully functioning network and live stream, we must utilize the proper software to configure each component.

1. Open Shortest Path First (OSPF)

a. OSPF is a protocol that allows routers to communicate with each other and create paths for network packets to traverse. OSPF uses the cost metric to determine the best path for data to traverse to get to the desired location. As we aim to have our routers dynamically configured OSPF can do the dirty work while allowing us to monitor the connections. We plan to use the PuTTY application in our workstation computers. Using the PuTTY application in our workstation computers, we will enable OSPF in our mesh routers and monitor the connections between the routers for any obstacles.

2. SolarWinds Performance Monitor

    a. SolarWinds Performance Monitor is an application that utilizes Simple Network Management Protocol (SNMP), a protocol used to configure and monitor the devices on the network. As we are working with over 15 mesh routers for this event, SolarWinds provides us with a simple and singular method to monitor and configure the devices connected to the network. Purchase the SolarWinds Performance Monitor it costs around $5,000.

3. Cisco Firepower Next-Generation IPS

    a. The Cisco Firepower Next-Generation IPS is a software application that provides visibility, intelligence, and threat protection in the network. It acts as an IDS and IPS, providing security to the network. It utilizes various techniques and mechanisms to prevent complicated attacks and can be beneficial in protecting a network that may be working fully wirelessly. To purchase the Cisco Firepower IPS it costs around $1,413.

4. Amazon S3

a. Amazon S3 is a cloud storage service that can be used to house live-streamed videos. Guests who attended the events can access these videos for free while others will need to pay an amount to access them. Using this software, we can avoid the need for physical storage hardware on-site while transferring all the data to AWS for later access. It costs around $0.02 per GB used on the Amazon S3.

5. YouTube Live ($72)

    a. YouTube Live is the streaming platform that we will be using for this. It provides a CDN that we can use to transfer the bits of video to the platform. We will need to just start the stream on an account. Once started, we will need to copy the URL and the streaming key into the video encoder so that the video data is encoded in the encoder and will be sent to YouTube Live's CDN. In addition, YouTube Live provides much of the live streaming capabilities, allowing us to solely focus on getting the video from the camera to its CDN. Purchase the YouTube Live license, which costs around $72.

6. Comcast Xfinity

    a. Xfinity is an internet service provider (ISP) that we will need to use to gain access to the internet. As it provides exceptional performance and easy access to the Internet, it seems the most suitable for this event. To purchase a membership with Xfinity it costs around $90 solely for this event.

Design of Field and Network

The practicality of using a 10-acre field for a state-wide sports venue is an interesting topic to consider. On the one hand, this space provides ample room for various sporting events and can accommodate a substantial number of people. However, the venue's specific layout and its amenities may present some practical challenges. Let us consider the various aspects of the venue and their potential advantages and disadvantages.

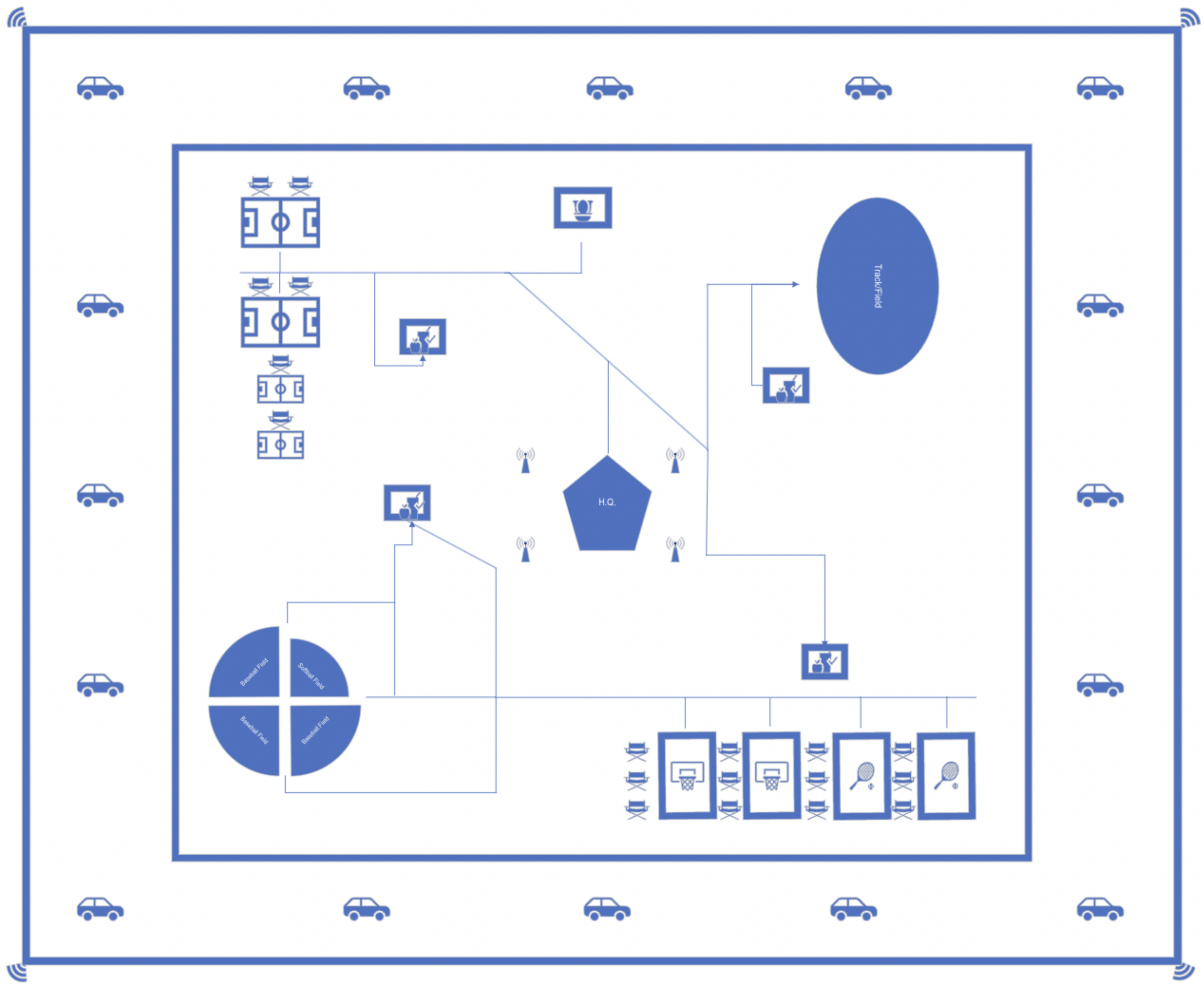

Figure 1: Diagram of the Field

Firstly, the parking area is an essential aspect of any large-scale sports venue. In Figure 1, a third of the outer part of the field is designated for parking (3000 feet by 3000 feet), which should accommodate an estimated 2000 vehicles on each side. However, it is worth considering the proximity of the parking area to the venue's central location. If it is too far away, people may have difficulty getting to and from the venue, which could be a significant drawback.

The layout of the sporting fields and courts is also essential to consider. To make the designing phase easier, our team decided to break the area into four quadrants. As shown in Figure 1, we have three baseball fields and one softball field in the bottom left corner, prioritizing convenience, and an intimate atmosphere for spectators with the circular shape. Similarly, two soccer fields and two field hockey fields in the upper left section provide ample space for these high-activity and demanding sports. Having their quadrant together also allows us to utilize the same cameras for live streaming the games because of their similarities. However, the vertical alignment of the fields may not be practical as spectators would have to move between different areas to watch different sports. Two basketball courts and two tennis courts in the bottom-right section are also conveniently located. As both sports have significantly less distance and motion, we decided to group them. Finally, the 400-meter track in the upper-right corner is a unique feature of the venue with stands on the polar sides providing a relaxing view of the action. To be able to maintain and manage all four quadrants, we decided to create a main headquarters that would house the main routers, PoE switches, cables, and IT staff. The headquarters would be in the center of the venue as a practical feature. We believe it is essential to have this entity in a centralized location for better event management. The concession stands in the four respective corners of the venue are also practical, and they can provide refreshments to spectators throughout the event. The two-bathroom stations with multiple bathrooms are also a practical feature, as they can accommodate a considerable number of people.

The baseball portion of the venue almost got added by our team. We believed it would occupy an efficient amount of room and might draw many spectators from some of the other sports. After much consideration, we concluded that baseball would be a fantastic addition to the facility, both for its entertainment value and its capacity to draw a sizable audience. We recognized that baseball is a well-liked sport in the area and that many people would be eager to attend games, particularly if they were played in an advanced venue like ours.

To guarantee that there was sufficient room for spectators to move about and that there was no interference between games, we took care to distance the fields from one another by around 100 feet. Additionally, this distance made it possible for each game to have its own designated area and decreased the risk of any mishaps or injuries. Additionally, this spacing establishes a sense of division between the various activities and enables every event to have its own designated area. Distractions can be lessened and players' ability to concentrate on their game may be improved by this separation.

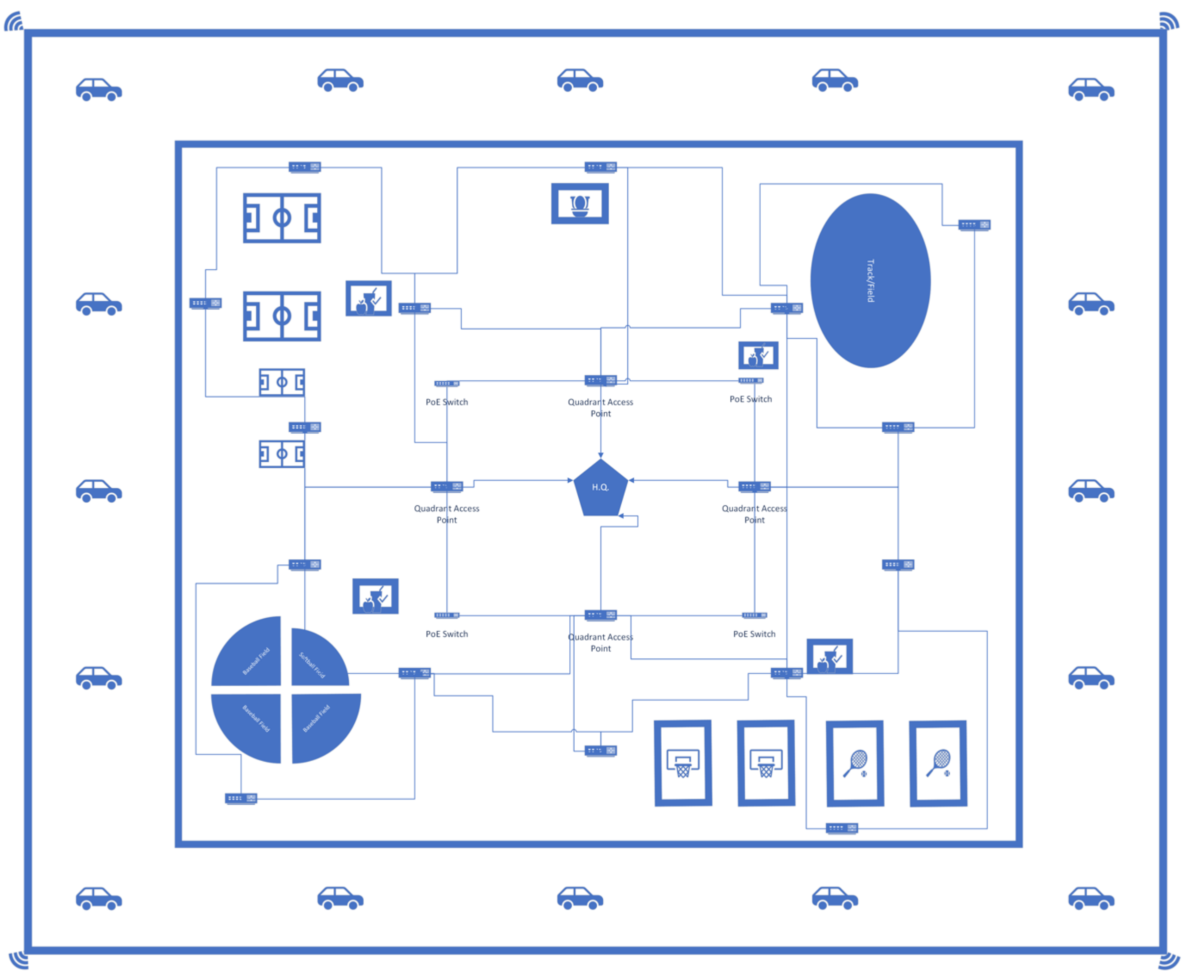

Figure 2: Diagram of Network Components

The mesh router map with 20 routers and four cell towers is an impressive technological feature that can provide internet access to many people. However, it is worth considering the practicality of using this technology in a sports venue. If there are too many people using the network simultaneously, it may become overwhelming, and internet access may be limited.

We chose a mesh topology for this project because of its redundancy and resiliency. As each router is connected to two-three other routers, this design feature provides redundancy. As each router is not dependent on just one connection, it allows us to have leeway with maintaining the network (a router going down does not completely take the network down). Because we have redundancies, our network is resilient to a considerable extent. The mesh topology allows other routers to handle the traffic load that is met when a router goes down. As we will be consistently monitoring the routers and their status, we will be able to work efficiently to get them back online if any issues occur.

During our planning phase, we cut the area up into four different quadrants and decided to allocate one main router to each quadrant. From there, we created the mesh topology to allow routers to connect. This creates more organization and allows us to separately monitor the router with different priorities. Even better, we can configure each quadrant differently depending on the Quality of Service (QoS) and size of the transmission. With the Quality of Service, we will prioritize the overall performance of the router to limit the amount of network traffic that is being sent from the fields to the headquarters. This will ensure and guarantee that the live stream will run smoothly with very few issues that will be computed during each game.

Inside the HQ, it is essential to have a reliable power source to ensure uninterrupted connectivity and provide power to the facility's main router. That is where a generator comes in.

The generator will have cables connecting it to power the main router and 4 PoE switches. The PoE switches provide power and connectivity to the venue's access points.

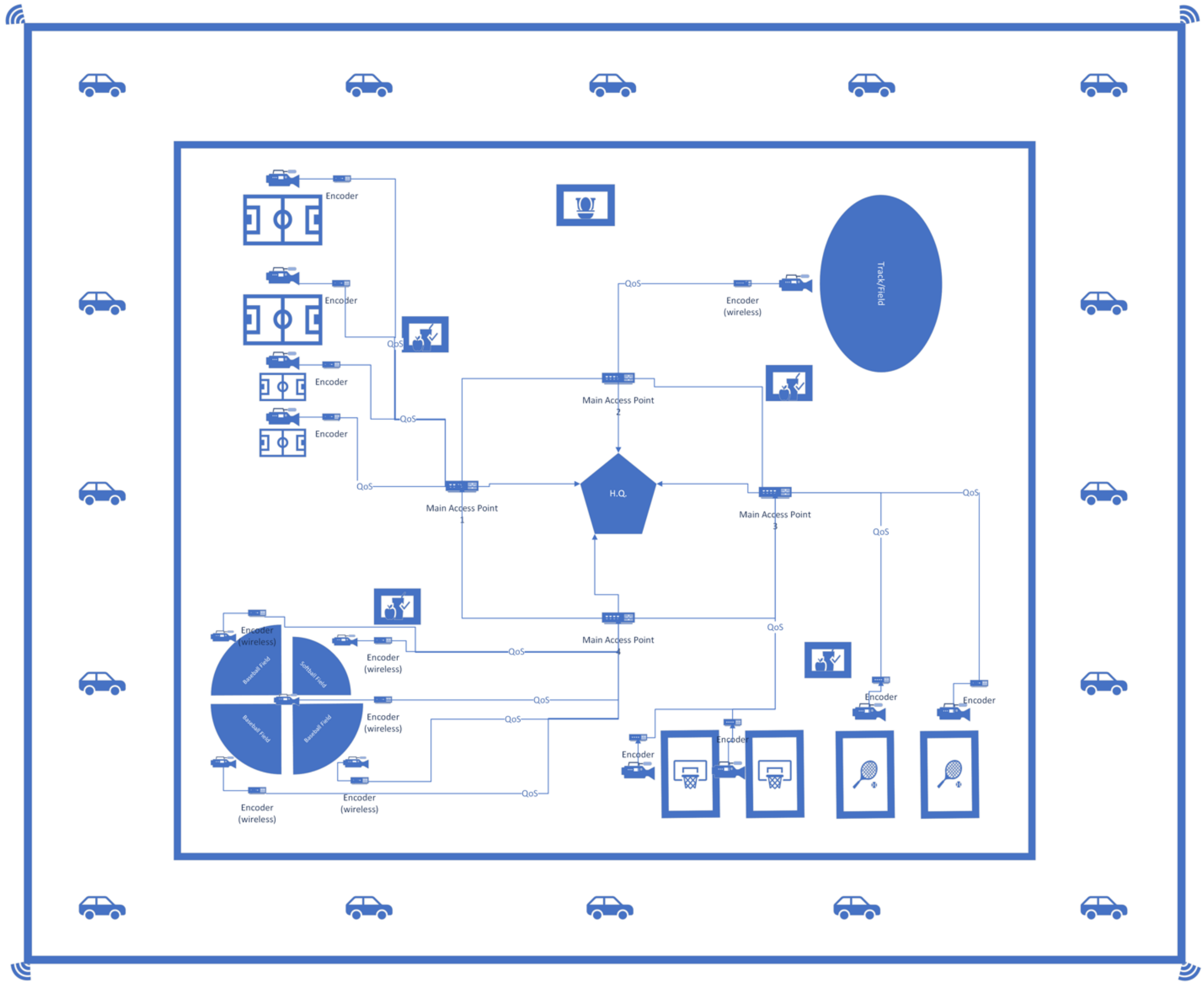

Figure 3: Diagram of Cameras and Encoders

Lastly, the cameras on each field and area, wired to an encoder and connected to a quadrant router, are a practical feature for broadcasting events online. The wireless encoder used for baseball and track is a practical technological solution for these sports, as it allows for the use of a sky-cam to capture dynamic angles and provide viewers with a more immersive viewing experience. Sky cams are typically suspended from cables and can move freely around the playing field, providing viewers with unique angles that would be difficult to capture with traditional cameras.

Using a wireless encoder to connect the sky-cam to the encoder eliminates the need for cables, allowing the sky-cam to move around the field more freely and capture more interesting angles. Additionally, because the wireless encoder is connected to the quadrant router, which is in turn connected to the main router, it can easily transmit the footage to the cloud for streaming on YouTube TV. This technology is particularly useful for baseball and track, as it allows viewers to see the action from above and track the movement of the ball or the athletes more easily. It also adds an exciting element to the viewing experience, making it more engaging and entertaining.

In conclusion, the 10-acre field has the potential to be a practical and functional space for a state-wide sports venue. The layout of the fields and courts, as well as the amenities provided, may present some practical challenges, but overall, the space can accommodate a substantial number of people and provide a great atmosphere for sporting events. The technological features of the venue are impressive, but it is important to consider their practicality and cost before implementing them.

Configuration of Network/Implementation Plan

Firstly, we set up headquarters in a centralized location. This would allow us to reach all four areas with ease. As stated earlier, we plan to have our headquarters in a pentagon shape and a total of 6,193 square feet which is 60 feet on the sides. Within our headquarters, we will have our Dell Precision PC, running Windows Server 2019, our Motorola MG7550 Router/Modem device, and our Harbor Freight Gas Powered Portable Generator. We will connect the PC and router to the generator for power. We will utilize PoE cables to power up the four main quadrant access points. We opted for a wired connection because it would be more reliable and physically securable than wireless connections. In addition, we will have a Power over Ethernet (PoE) switch in the headquarters that will be connected to a large power source. After setting up the router inside the headquarters, we will configure the router using our workstation computer. SolarWinds Monitoring Performance provides a GUI (Graphic User Interface) that can be used to configure the main router and enhance QoS. Our main priority is uploading the video feed from the cameras to YouTube Live's CDN. Because of this, we would prioritize this traffic over others and limit user downloads to utilize more bandwidth/transmission rate. We can use PowerShell on our computer to set the main router as the default gateway (this router will transmit the video feed to YouTube Live CDN). As the router will be connected to the main access points through cables, we do not need to enable OSPF on it. Finally, we will configure the router to use Comcast Xfinity as they are compatible, meaning we do not need to Xfinity router to access the internet.

The rest of the access points will create a mesh topology and determine the best path routes dynamically through OSPF. It configures the routers to dynamically communicate with each other to determine the best path for packets to take during data transmission without having to worry about network traffic and the efficiency of the status route.

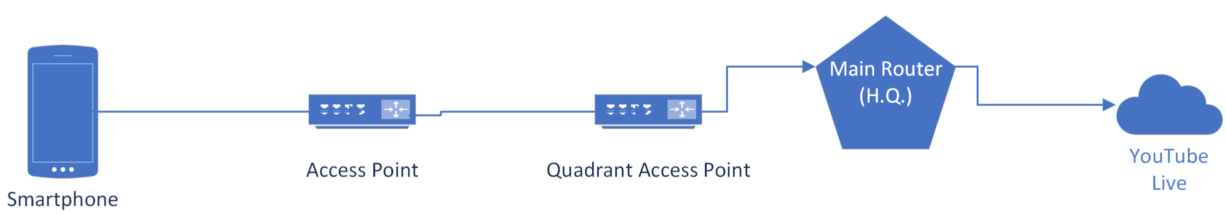

Figure 4: Connection Between User Device and Internet

Firstly, we split the area into four different quadrants with one central quadrant access point. As stated earlier, the four central access points will connect through PoE cables to the central router for easier implementation. We have more control over the network and can ensure more security, QoS, and power on the network devices. Once the four access points are placed, we will set up two other generators near the access points to power the PoE switches. We plan to allocate one generator to two quadrants and connect them to the PoE switch using Ethernet cables. Each cable would be about 200-300 ft long and would supply power to the switches. The rest of the access points (secondary access points) would connect to the PoE switch through PoE cables about 200-300 feet long. For the access points that may exceed distances of 700 feet from the PoE switches, we plan on using the daisy-chaining method (connect the access points input source to another access points output source for power). As we cannot connect every single router to a different PoE switch port, we made sure to utilize access points that have both an input and output source for PoE. This would allow us to connect the routers through Ethernet cables. We are estimating a total of 2600 feet of Ethernet cabling.

From here, the secondary access points wirelessly connect to create the mesh network. The mesh network provides redundancy and resiliency. As each router will have several connections with other routers, we are ensuring redundancy. Because these several connections can avoid a single point of failure, we are ensuring resiliency. Regarding QoS and access controls, we will use SolarWinds Monitoring Performance software to configure and monitor all the different network devices being used to transport network traffic, provide viewers WIFI to watch the live stream and transmit the video feed to the YouTube Live CDN. As shown in Figure 4, the user should be able to connect their mobile device to any one of the access points. When the user wishes to access the live stream, they should be able to traverse through the network and gain access to YouTube Live where the sports games will be live-streamed.

Using our network topology, Figure 4 shows the desired connection that a user's device would experience when a user tries to watch a live stream.

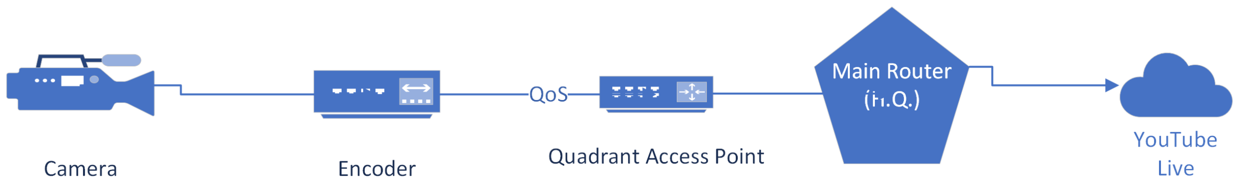

Figure 5: Connection Between Camera to YouTube Live

With the routers in place, we then place the cameras in their respective locations. As each sport is different, we utilized three different cameras. As soccer, field hockey, and baseball sports have more motion and larger fields, we decided to use the Sony HDC-4800 Camera for its motion tracking capabilities. We would place this camera by the scoreboard so that it can be maintained and monitored by the members of the sporting event. For the basketball and track events, we decided to use the Sony HDC-4300 Camera. While the track does have much more motion than basketball, we believe that it may be better suited for the camera to be turned manually by an employee in the center of the arena so that the motion of other runners does not interfere with the viewing of the event. Regarding basketball, it is a much smaller field that could be encompassed with the camera having a larger lens to capture more at the scoreboard box. Finally, as tennis is played on an exceedingly small field and has fences on all four sides, we plan to attach the GoPro Hero09 Black go-pro to the fences. This would provide a high-quality video feed along with a simple setup. In addition, it requires little to no human activity to record the live feed smoothly.

As the video feed needs to be sent to YouTube Live's CDN, we need to use an encoder that can convert our video feed efficiently and transmit our video data to the live stream URL for proper viewing. However, as the fields are all distant from the headquarters, we would need multiple encoders which could be wired or wirelessly connected to the cameras. Either way, there is little guarantee that it would be efficient enough. For that reason, we decided on using the Teradek VidiU Go encoder. This encoder just attaches itself to the camera using either HDMI or SDI cables and transmits the data wirelessly to the closest router. This removes the need to cable each camera to the specific port on the encoder. In total, it reduces a large burden on the team.

As shown in Figure 5, the camera should be able to connect to an encoder that can connect and transmit data to any one of the access points. When the camera begins to record the live feed of the game, the encoders should be able to convert the video feed into bits and transmit them to access points to reach the main router at headquarters. From here, the router should transmit the data to YouTube Live CDN for data conversion and put the video into the URL viewing link. Using our network topology, Figure 5 shows the desired connection that a camera would experience when it tries to get the live feed to YouTube Live.

With all the connections in place, we would only have to set up the firewall, IDS/IPS, and configurations of the network devices. First, it would be easier to configure the network devices (routers, access points) like their IP address, OSPF, default gateway, and Subnet Mask. We could also utilize DHCP to automatically configure the IP address/Subnet Mask. Once, the configuration is done, we can utilize the software to monitor and manage the connections/status of the router and access points. To configure the encoders that will transmit the data to the CDN, we utilize the manufacturers' GUI to specify the live stream URL and streaming key provided by YouTube Live. When we choose to start the live stream, we will be given the URL and key which we can specify using the GUI site of the encoders. Once completed, we can then implement the Cisco Firepower Next-Generation IPS into the network to ensure security within the network traffic. We would keep the IPS on the DMZ portion of the network (the part that users will connect to) and monitor incoming traffic for malicious data or action. Due to this, we do plan to have most of the IPS software used for the four main access points that will transmit data to the gateway router in the headquarters.

Finally, we plan on keeping the full-length recorded games on Amazon S3 for later access. This comes free for guests who bought tickets to attend the sporting event. However, individuals who did not buy tickets will need to buy the "license" to access the videos. While we do not provide the live streaming ability for the outer public, our team found it beneficial and profitable to provide them an opportunity to watch the recorded version of the games kept on Amazon S3 cloud storage.

Issues

Within each design, we pinpointed various issues that could hinder the true performance of the network. Firstly, the use of cabling provides little redundancy and resiliency. Because the PoE switches connect to the routers via cabling, it causes the router to have little Resiliency if the cables were to be damaged for some unforeseen reason. However, we believed that accepting the risk was the best choice because it would be difficult to provide Redundancy in a situation. Each router contains only one Ethernet source. Because of this, only one Ethernet cable can be used as the input. For this reason, we decided to accept the risk and act only when an issue arose with the specific product.

Another issue the design has is traffic issues. Because we will be live streaming about 10 different events, the amount of network traffic specifically from the encoders on the cameras could slow down the connection of the other devices on the network. As the capacity of the event field may be about 500-750 people, slow traffic can slow down live streams and agitate guests in the area. While QoS is set to prioritize data coming from the encoders, we still tried to ensure the best network performance that our guests can experience. Again, we accepted this risk as our network configurations were set to prioritize live streaming data over all other data like messages, downloads, and lookups.

In addition to these issues, we believe routers could have connectivity problems as well. Because we are dealing with a large area of about 10 by 10 acres squared, we will need to use about 20-25 routers to provide network connectivity to each part of the area. However, as described in the previous section *Configuration of the Network,* the distance between each router could reach up to 250 feet. While routers on a flat area outside have coverage of distances up to 300 feet, the strength of the signal tends to be extremely weak in those areas. For this reason, it may be difficult to trust the signal at those distances. By using a mesh topology, we rely on the router's connectivity to each other for an efficient and high-performance network. Because of the high number of routers that may have to be used, we also must connect the routers tirelessly. For this reason, distances that high may affect the strength of the signal that these routers can connect with because the routers can disconnect, breaking off a potential connection and forcing unnecessary traffic onto other routes. For this reason, we plan to have high priority in monitoring the routers and their status in the network. Another small issue that we may come across is not having any backup hardware. As a group, we decided to try and cut down on as many costs as we could. This is not an issue that we think we will have to confront during the sporting event. Finally, the largest issue that may be the most non-avoidable is guest interference. Guests may run into wires, cameras, or even routers. It will be difficult to safeguard every hardware component in the field because it would require taping, manual labor, and even potential fencing.

For that reason, we planned on setting up quarters in each quadrant that allow us to break all responsibilities off the main headquarters and distribute them to each of the four quarters. We could try to control people and mitigate the risk of them causing interference in the hardware components. However, this still would not guarantee the safety of the hardware components, calling for the need for constant monitoring.

Cost

Hardware	Name	Price	Quantity	Total Price	Total Cost
Router	Motorola MG7550 Cable Modem/Router	$150.00	1	$150.00	$89,087
Access Points	Ruckus Wireless ZoneFlex T710 Outdoor Access Points	$1,895	19	$36,005	
Encoder	Teradek VidiU Go	$990	12	$11,880	
PoE Switch	Ubiquiti Networks UniFi Switch 8 (US-8-150W)	$220	4	$880	
Camera (Soccer, Field Hockey, Baseball)	Sony HDC-4800	$2,799	7	$19,593	
Camera (Tennis)	GoPro Hero09 Black	$300	2	$600	

Camera (Track, Basketball)	Sony HDC-4300	$2,190	3	$6,570
Cable	HDMI	$6	2ft*	$12
Cable	3G-SDI	$99	10ft*	$990
Cable	Power Over Ethernet (PoE)	$5/foot	2,600ft*	$13,000
Computer	Dell Precision 7820 Tower workstation	$2,200	1	$2,220
Generator	Harbor FreigGas-Poweredred Portable Generator	$879	3	$2,637

*Cabling length is estimated.

The total cost with all the hardware needed to plan this sporting event would be around $89,087. As a group, we believe this is a reasonable price considering this is a state-wide event with multiple sports, activities, and concessions being offered to fans. Some ways we believe we can cut costs for future events we may plan would be limiting the number of cables we would have to use. $13,000 for Power Over Ethernet cables is very pricey, and we believe it could be cut down if we had a better estimate of how much quantity we needed for the event. The total cost of all the software needed to plan this sporting event would be around $6,580. As a group, we believe this is a reasonable price considering this software is powering a state-wide sporting event.

Conclusion

In conclusion, our project aimed to create a hypothetical sporting event that would run efficiently with the necessary network equipment and provide live streaming for guests at the event. We designed a blueprint of the field, including different venues such as field hockey, basketball, tennis, soccer, and track and field. Our group went through various implementations during the design phase, considering the specific requirements of the sporting event, estimations, and risk assessments. We decided upon a particular framework that would allow us to provide streaming, in-person viewing, and WIFI. Our focus during the project was on creating an efficient and working framework for the client to use for their sporting event. We provided a design of the field to show where the games would be placed, a network topology to produce WIFI, and a physical topology for live-streaming viewing. We also accounted for resiliency and redundancy in the network.

This project was challenging as we had different scenarios that called for unique needs and implementations. Most of our time was spent creating a network topology that physically and logically could provide efficient services for the viewers. As network designers, we needed to account for redundancy and resiliency in our network to face unexpected conflicts. After multiple meetings and design, we decided upon a network topology that fit the client's needs best, connecting the live streaming cameras to YouTube Live CDNs through encoders. This project taught us valuable skills in network design, project management, and risk assessment. We had to work together as a team, incorporating each member's strengths and weaknesses to produce a successful outcome. We learned how to make assumptions and account for different scenarios, ensuring our framework could provide efficient services for our clients.

Overall, our project successfully created a hypothetical sporting event that would run efficiently with the necessary network equipment and provide live streaming for people not able to make the event. We provided a design of the field, a network topology to produce WIFI and live-streaming viewing, and recommended products and services that could be used by the clients, accounting for resiliency and redundancy in our network. We faced challenges during the project, but we learned valuable skills that will benefit us in future IST projects.

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