IT Infrastructure Project: Kyle Stevens Global Hospital

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# Introduction

Kyle Stevens Global Hospital is due for an upgrade. For this, the hospital is creating a Healthcare Enterprise Resource Planning (ERP) system to design a new Wide Area Network (WAN) to meet the needs of a globally capable hospital IT infrastructure. According to Bates et al. (2018), “the health IT industry has not developed fail-safe software design, development, or testing methodologies for isolated, self-contained systems, let alone the massively interconnected systems that will be required to enable seamless sharing of patient data across EHRs, organizations, communities, and eventually nations.” Also, “the adoption rate of the IT-based integrated system in the healthcare sector is quite slow as compared to other sectors, such as commerce and finance, especially in the case of emerging economies. This calls for an empirical investigation of the healthcare sector concerning problems being faced in the implementation of the Enterprise Resource Planning (ERP) system” (Fiaz et al., 2018). The new design must focus modularity, redundancy, and flexibility, prepare for future growth and development. Faith et al. (2019) writes, “Modularity is a measurement of the strength of dividing a system into groups of communities and is related to the degree of connectivity within a system.) Since the network will contain web servers, load balancers, database servers, storage areas, and handle network traffic for at least four buildings, the network will need to be modular enough to incorporate these aspects. The network will be “responsible for monitoring patients and notifying physicians in cases of emergency. However, these systems can not face request failures or high latency since they can compromise a specific person’s health” (Endo et al., 2021). Since the hospital accesses patient records and life-saving systems, redundancy will be a main factor to consider as well. Thirdly, flexibility will be a factor to consider as Kyle Stevens Global Hospital continues to grow and add more specialized sectors. Key components of the WAN include the core layer, distribution layer, and access layer. According to Cisco.com, wide area networks serve to link multiple Local Area Networks (LANs), in this case multiple buildings, together for the purpose of information sharing. A standard communication system has five components: an information source (which produces a message), a transmitter (which encodes the message into a signal), a channel (the medium used to transmit the signal), a receiver (which does the inverse operation of the transmitter, that is, decodes the signal to reconstruct the message), and a destination (the person or thing for which the message is intended) (Grama et al., 2021). By connecting the buildings of Kyle Stevens Global Hospital, an efficient and productive telemedicine communication system will be implemented, providing better patient care. Telemedicine is “the whole collection of deliverables designed to enable patients and their physicians or healthcare providers” (Haleem et al., 2021). It permits faster and easier information sharing, so that patient and doctors can communicate better, while also being safer for doctor and patient interaction. Doctors do not need to be in the room as sick patients for communication, and they can also reach more patients this way.

# WAN Core

The core layer of the WAN network serves to connect each local access network together. It is the building block from which the general network is created. One of the main factors to consider within Kyle Stevens Global Hospital network pertains to the speed of data transfer. For this reason, an Open Shortest Path First (OSPF) protocol will be implemented. “OSPF protocols produce better throughput than any of the other protocols…” (Islam et al., 2021). OSPF is a “dynamic, hierarchical routing protocol designed to support routing in TCP/IP networks” (Fu et al., 1993). The algorithms within OSPF distribute routing information within the network. They then synchronize the routes via an autonomous system, essentially determining the quickest way to reach from point A to point B. Since the hospital required data to be transmitted as fast as possible for patient needs, OSPF works well in this case. OSPF also serves as a load balancer for each destination, disseminating traffic so that it does not get bottlenecked through a certain route. OSPF uses a link-state routing protocol, which is a gateway protocol that operates within a single autonomous system (Darville et al., 2022). Having a multi-node core will allow the services to be highly available and always be on. It will also provide scalability for future building and networks to be added to the hospital system.

# Control Signaling

Control signaling can be performed through packet switching. Network switches are able to route terabytes of data while offering a programmable data plane for the flow of information (Bal et al., 2021). This access provides in-network computing, which reduces latency and improves throughput, both of which are necessities for Kyle Stevens Global Hospital. In-network computing works to define the routing, forwarding and protocol encoding of the network. The more of this that can be automated, the better optimization will be made. An excellent way to automate these tasks is with dynamic host configuration protocol (DHCP). DHCP can be implemented in each LAN to assist with configuring IP addresses, subnet masks, and default gateways to each device on the network. It is an internet protocol that lets network administrators centrally manage the network (Younes, 2016). Were it not for DHCP, IP addressed would need to be manually assigned for each host in the network, and with a large LAN, this would be quite an extensive task. It also creates potential for error. The automated assignment of IP address and network parameters are not permanent to the host device; rather, they are used for only a period of time. If the host is taken offline, its IP address is removed for reuse. with mobile hospital devices that might move in and out of the network, this is especially helpful by reducing the amount of unnecessary traffic on the network. Secure DHCP is used to authenticate the DHCP client and server to protect against attacks. The server pool only has a limited number of addresses; therefore, a proper routing table must be implemented that can accommodate for future expansion. Another way to avoid reaching the maximum number of connections is through switches.

# Bandwidth

Kyle Stevens Global Hospital will be maintaining both real time and near-real time services. Real time services include telecommunications such as video conferencing, while near real time services pertain to data transfers. Real time services use a fixed data rate that is continuously available during the connection lifetime; it also maintains a relatively tight upper bound on transfer delay. For a constant bit rate, a bit rate profile will need to be introduced. The main goal is the quality of service for the communications. Streaming dominated 80% of global Internet traffic in 2019 (Gao & Wen, 2020). With the exponential increase in streaming, resource allocation is a potential problem. A good strategy for dynamically allocating bandwidth resources within the WAN is a cloud content delivery network. This will provide resource obtainment at each building within the network for doctors and patients to communicate in real time. The rate profile is an important function of real time streaming. It must “take the computational resource consumption and the storage resource consumption into consideration” (Gao & Wen, 2020). A consideration is whether video conferences will be stored. If they are stored, the data will take up a lot of storage space. This might even necessitate another database just for storing video messages. When creating the channels within the WAN, “if the rate of information transmission (bit rate) is higher than the channel capacity, then another more efficient encoding method can be found, but the channel capacity cannot be exceeded (Grama et al., 2021). From this conclusion, data can only be transferred as fast as the source permits it to and can overcome network noise. A method of using convolutional neural networks (CNNs) has been used for reducing network noise in images and videos, according to Huber et al. (2021). This will be especially helpful when transmitting patient images, such as x-rays, over the hospital network to improve data integrity.

# Protocols

A major factor in creating the network system for Kyle Stevens Global Hospital will be the protocols that define how data is shared across the network. Several frameworks exist and are commonly used: frame relays, integrated services digital networks, point-to-point networks, and X.25. X.25 is a “standard suite of protocols used for packet-switched communications of a wide area network” (Mitchell, 2020). Call control packets for setting up and terminating virtual circuits are carried on the same channel and same virtual circuit as data packets. Frame relay eliminates much of the overhead that X.25 imposes on end-user systems and on the packet switching network. It takes “advantage of the reliability of data communications networks to minimize the error checking done by the network nodes. This provides a packet-switching protocol similar to, but much faster than, X.25” (IBM.com, 2021). The call control signal is carried on a separate logical connection from user data. This serves to increase data security and performance by reducing the packet sizes across the network. There is no hop-by-hop flow control and error control; rather, the data frame is sent directly from the source to the destination, and an acknowledgement is sent back is a response frame. Each link has a locally unique data link connection identifier (DLCI), which is the number of a private or switched virtual circuit in a frame relay network (Agrawal & Suman, 2016).

# Reliability, Availability, Serviceability

Reliability of Kyle Stevens Global Hospital is paramount to providing life saving resources. Therefore, the hospital will need to maintain a working order is all circumstances. Reliability and resilience are two aspects that the hospital must consider for performance (Zuo, 2021). By having multiple resources and paths for information to travel, the network will be reliable for transferring information. However, if the system is vulnerable to outside attacks and environmental factors, then its resiliency well be decreased. For a local WAN system, such that the hospital buildings are close enough for cabled connections, running the cables underground and ensuring proper hardware fault tolerances is a necessity. This will ensure that the system performs in any condition. Network topology is also important to maintain reliability. The system must not be so complex that there are many points of failure. However, this might be unavoidable to an extent, since the system in place will be rather large. Therefore, serviceability must be easy. Easy serviceability will ensure that devices and software can easily be accessed and updated, should the need occur. This is where a software defined network will work well. It will reduce the manual overhead and allow the hospital to function reliably.

# Architecture

Kyle Stevens Global Hospital will utilize a WAN network. Due to the network’s size, four front-end web servers will be implemented, and traffic will be sent through load balancers. The load balancers will maintain the bandwidth at a constant rate, as to not overload a singular server. Each building will reside behind a firewall for protection of patient information. The firewalls will add necessary security to the system. An OSPF protocol will be used between the building to ensure low latency as well as security. By having multiple devices and resources, such as databases and storage area networks, the hospital will maintain redundancy, should a device or portion of the network fail. The design of this enterprise resource system will advance the organizations ability to generate accurate information in a timely manner. The databases and storage area networks will contain all of the patient information. Routes will be created so that every campus will have access to the data. The hospital will utilize an IPv4 addressing system for simplicity.

# Conclusion

By creating a software defined healthcare enterprise resource system, Kyle Stevens Global Hospital will be better able to serve its community and the surrounding areas. The hospital will create a wide area network with the capability of serving at least four buildings. Redundancies will be in place by utilizing multiple data serves and storage area networks. Multiple web servers will also be implemented to handle the network traffic. With the widespread adoption of software defined networks, a precedent has been set that will propel Kyle Stevens Global Hospital to reach more patients and provide better care. One thing it will consider as future development is a stronger presence in telemedicine. Over 60% of patients and doctors found that remote telemedicine would be more convenient than face-to-face consultation (Krusche, 2022). These considerations will be researched more heavily in the future.

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# Appendix



