

Analysis and Design of Computer Network in a Petshop

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I. INTRODUCTION

A. Problem Statement

An Indonesian Petshop has recently gone through a store expansion and has bought several computers and devices. However, there are still some troubles in connecting them with a computer network.

B. Background

A computer network is a system that connects two or more computing devices for transmitting and sharing information. One example of a computer network is LAN. LAN is a connection of a group of devices in a local area [4]. Computing devices include everything from a mobile phone to a server. These devices are connected using physical wires such as fiber optics, but they can also be wireless. Many devices also need to be connected to form a Computer Network, such as routers, switches, and also servers. Those devices are needed to implement a LAN for businesses. This problem poses a challenge for SMEs such as our Pet Shop enterprise.

The purpose of this project is to design a suitable computer network system for the Pet Shop store. The aim is to design a network with low cost, high quality, and scalable computer network that meets the business grade standard. It is important for shops to implement networking computers because it increases the efficiency of the store. For example, it allows the store to have remote access to shared resources such as printers, fax machines, scanners, among others. This gives employees a more organized and convenient way to access the resources. In addition, LAN also enables centralized real-time data management, allowing computers connected to the network to have access to shared files, databases, spreadsheets, and software [4]. Attention is also paid to network security systems by applying firewall security within the network to provide security to Business' data.

C. Related Works

The paper written by Yousef M. Alshehri proposes the implementation of wireless mesh networks for backup network access, although it could also be used as the primary network access. A mesh topology has self-organization and self-configuration properties which allows it to function even if one of the connected nodes no longer works. The implementation

of this topology allows the impact of physical obstructions such as walls and other solid objects towards the wireless signals to decrease, minimizing loss of inter-node throughput [16].

The paper written by Nurul Absar, Mohammad Jahangir Alam, and Tasnuva Ahmed studies the performance of another topology, the star topology. The research simulated several implementations of this topology. The paper uses normal star topology to connect multiple devices across a floor and uses an extended star topology to connect multiple devices across several floors [1].

D. Proposed approach

This research aims to create a computer network of client-to-peer LAN that will be able to solve the Pet Shop's connectivity problem within its store. The computer network should meet the standard of creating a high quality but low cost and a secure system to prevent any unfavorable access.

Star topology will be implemented with TCP/IP Routed Protocol. A Star topology was chosen due to multiple reasons. To be more organized the extended star topology will be utilized. For starters, the this topology is easy to setup and maintain, which is perfect for the Petshop. It is also simple to extend the network as all it requires is to connect a device to one of the already existing switches. In addition, more switches could be connected to the central switch if it were needed, for example, perhaps connecting a group of other type of devices or connecting devices from another floor. In addition, having a wired connection instead of a wireless one increases the security of the network as only devices directly connected through an Ethernet connection would have access to the network [8].

An alternative approach is by utilizing a mesh topology. However due to some of the drawbacks it brings and its benefits not being able to be fully taken advantage of is why the star topology was chosen over the mesh topology. Mesh topology is very cost-inefficient as all devices are connected to each other via a dedicated link. In essence, when there are N nodes, there will be $N(N-1)/2$ links between nodes. Although it is highly robust and is not completely reliant on a central node like in the star topology, it has burdensome to extend and difficult to install and reconfigure [8].

II. METHOD

A. Network Analysis

1) *Local Area Network (LAN)*: Local Area Networks or LANs are frequently used among retail stores worldwide. A LAN network connects a limited number of devices together, typically in one single physical area. Such a network allows connected devices to utilize a single internet connection, share files among network users, and utilize shared resources.

In order to implement a LAN network, several components are required. Based on existing LAN networks, the hardware components required include; Unshielded twisted pair, RJ-45 connector, a LAN card or a Network interface card installed on all of the devices connecting to the network, switches, and servers to handle requests from clients. While the software requirements include; Server operating system for a centralized network control, File and Printer sharing enabled on connecting devices, TCP/IP for the transport and network layer, as well as Address Resolution Protocol to handle IP addresses and MAC addresses [12].

2) *TCP/IP*: Transmission Control Protocol/Internet Protocol or TCP/IP is a set of standardized rules that allow computers to communicate on a network such as the internet. TCP/IP was developed to specify how computers transfer data from one device to another. It puts a lot of emphasis on accuracy.

TCP/IP is a data link protocol that is used on the internet. Its model is split into four layers which are data link layer, internet layer, transport layer, and application layer. Each layer has its own function. The purpose of layers is to keep things standardized, without numerous hardware and software vendors having to manage communication on their own. It also means that certain layers can be updated, such as to improve performance, without having to upgrade the entire thing [2].

3) *Topology*: Topology is divided into two categories. Physical topology deals with the physical connections between end and intermediary devices, while Logical topology deals with how the network transfers data from one device to another [5].

4) *Hierarchical Network*: Implementing a hierarchical network model can help ease management of devices on the network. Hierarchical design model is partitioned into three categories; the categories are Core Layer, Access Layer, and Distribution Layer. Core Layer provides fast transport between switches, Distribution Layer provides policy based connectivity, while Access Layer provides user access to the network [6].

B. Network Design

1) *Network Requirements*: In order to accommodate the requirements of the network, and be able to handle heavy workloads, a client/server LAN will be designed. From the analysis it has been determined that the Petshop requires the following devices to be connected to the newly made LAN network:

No	Equipment	Amount
1	Cash Registers / POS registers	3
2	Receipt Printers	3
3	Self-Scan Price Scanner	1
4	Personal Computers	2
5	Wireless Modem	1
6	Card Reader	1

2) *Network Topology Map*: Based on the needs and requirements of the company, an extended star style topology is more fitting compared to its alternatives due to its high performance and ease of expansion and scalability [13]. As such, the following topology map is expected to be ideal for the computer network being constructed.

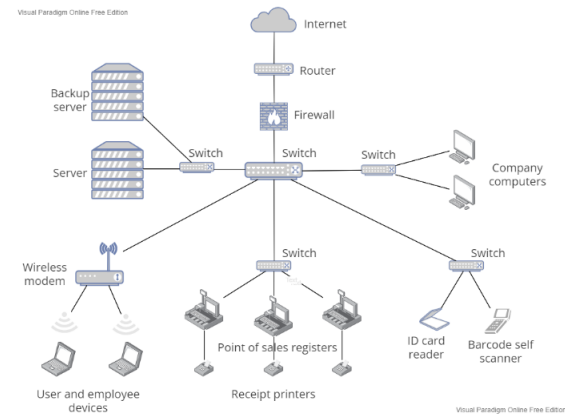


Fig. 1. Designed Network Topology

3) *IP addressing structure*: An IP address is a unique address that identifies a device on the internet. It is a string of numbers separated by periods. It is typically written in decimal digits, formatted as four 8-bits fields separated by periods. Each 8-bit field represents a byte of the IP address. This form of representing bytes of an IP address is often referred to as the dotted-decimal format. The IP addresses are classified into two parts, which is the network part and the host part. The network part specifies the unique number assigned to the network. It also identifies the class of network assigned. while, the host part is part of the IP address that is assigned to each host. It uniquely identifies the machine to the network. As the size of the network and the rate of growth of devices in the network will not be too big, Static IP Addressing of 12 numbers address (xxx.xxx.xxx.xxx) is used to assign each device in the network [11].

4) *Additional Hardware and Software requirements*: In addition to the hardware devices already owned by the company, additional hardware is required for the network to work. These hardware devices are a server, a back-up server, 4 switches, a router, and the necessary cables. Besides that, some additional software is also needed for the network to work. The software devices that are needed are the network operating system and protocol suite. The Network Operating System planned to be installed on the Servers is Microsoft Windows Servers. This OS has long term support from Microsoft and is more beginner

friendly to use, given that it provides a GUI for the server operators to more easily access all of the server's features. In addition, the software provides extensive documentation, allowing operators to identify and deal with bugs and other issues [7]. Protocol Suite in this network is TCP/IP, this set of protocols is used in most of network today, and it contains Internet Protocol that responsible for IP Addressing, host-to-host communications, packet formatting, and fragmentation [11].

5) *Network Security*: In order to maintain the security of the newly built network, the strong security measures need to be put in place during the planning and design phase in order to minimize the possibility of an unauthorized third-party accessing the network. In order to do so, a firewall is to be implemented in the LAN. Firewall is a device or software that links Wide Area Network (WAN) and Local Area Network (LAN) that prevents outside users from accessing the network. Firewall works by acting like a filter that forces communication between local network and outside network.

A Back-up and Recovery system using Incremental back-up is necessary to be applied to the network. Through creating duplicates of the data which is saved on a back-up server in the network in a regular and automated manner, the possible damage to the network system can be reduced drastically. Incremental back-up only uploads files that have been updated since the previous backup. This method doesn't require us to back-up the whole database if a certain file is updated [10] [9].

C. Implementation

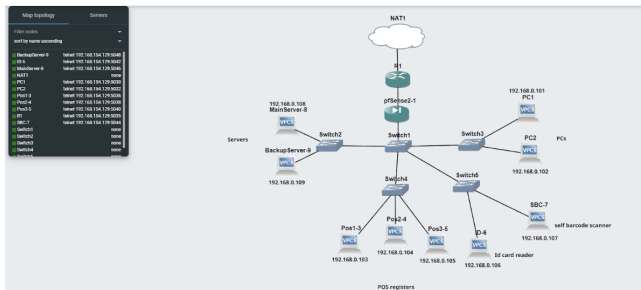


Fig. 2. GNS3 Simulation Design

In this section of paper, we are going to simulate the process inside the network, including packet. In above simulation, all devices including servers and POS registers are simulated as VPC, which the IP Addresses of the devices are statically assigned, except of the Router interface which is connected to the NAT (Network Address Translation) with DHCP (Dynamic Host Configuration Protocol) system. The simulation was conducted using the GNS3 simulation running on its VMWARE virtual machine.

III. RESULTS

A. Simulation Testing

In Figure 3, we try to give the ping command in PC1 Command Prompt to PC2. A total of 5 packets are sent and

```
PC1> ping 192.168.102

84 bytes from 192.168.0.102 icmp_seq=1 ttl=64 time=0.163 ms
84 bytes from 192.168.0.102 icmp_seq=2 ttl=64 time=0.180 ms
84 bytes from 192.168.0.102 icmp_seq=3 ttl=64 time=0.161 ms
84 bytes from 192.168.0.102 icmp_seq=4 ttl=64 time=0.193 ms
84 bytes from 192.168.0.102 icmp_seq=5 ttl=64 time=0.183 ms
```

Fig. 3. Ping Testing from PC1 to PC2

successfully received by a peer device which sends acknowledgements.

```
Pos1-3> ping 192.168.0.108

84 bytes from 192.168.0.108 icmp_seq=1 ttl=64 time=0.168 ms
84 bytes from 192.168.0.108 icmp_seq=2 ttl=64 time=0.184 ms
84 bytes from 192.168.0.108 icmp_seq=3 ttl=64 time=0.231 ms
84 bytes from 192.168.0.108 icmp_seq=4 ttl=64 time=0.203 ms
84 bytes from 192.168.0.108 icmp_seq=5 ttl=64 time=0.254 ms

Pos1-3> |
```

Fig. 4. Ping Testing from POS to main server

In Figure 4, we try to give a ping command in Pos1 Command Prompt to the main server. 5 packets are sent and successfully received by the main server which sends acknowledgements.

```
PC1> ping 192.168.0.1

84 bytes from 192.168.0.1 icmp_seq=1 ttl=255 time=9.458 ms
84 bytes from 192.168.0.1 icmp_seq=2 ttl=255 time=10.942 ms
84 bytes from 192.168.0.1 icmp_seq=3 ttl=255 time=1.719 ms
84 bytes from 192.168.0.1 icmp_seq=4 ttl=255 time=2.204 ms
84 bytes from 192.168.0.1 icmp_seq=5 ttl=255 time=4.198 ms

PC1>
```

Fig. 5. Ping testing from PC to router

In Figure 5, we try to give a ping command in pc1 Command Prompt to the router with 5 packets sent. This result shows a longer response time compared to the previous ping attempts.

```
R1#ping google.com

Translating "google.com"...domain server (8.8.8.8) [OK]
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 142.250.4.101, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/35/60 ms
```

Fig. 6. Router Ping Testing to google.com

In this case, we tried to simulate a communication between the router with www.google.com, in which the router sent five packets to the google server and also received five acknowledgements. So all packets are successfully sent with zero percent of loss rate. Pinging to other domain servers will provide the similar results.

B. Network Usability

The network seems to be able to be used effectively by the business. All of the devices connected are able to communicate to each other. In addition, configuring new devices to the network is not very complicated.

C. Network Usefulness

The implementation of a computer network for the business will allow it to operate more efficiently. It allows the store to have remote access to shared resources, giving employees a more organized and convenient way to access the resources. This network also allows centralized real-time data management, allowing computers connected to the network to have access to shared files, databases, spreadsheets, and software that are located in the server.

D. Network System Performance

Looking at the graph below, the average latency of ping testing from PC1 to PC2 is 0.176 ms. The average latency of ping testing from POS to Main server is 0.208 ms, while the average latency of ping testing from PC to Router is 5.7042 ms. In addition to the speeds, no packages have been lost during transfer. All of the pings issued by a computer pings the correct device. Each ping response sent a total of 5 packages, all which have been received properly by the issuing computer.

Packet No.	PC1 to PC2 Latency (ms)	POS to Router Latency (ms)	Router to internet Latency (ms)
1	0.163	0.168	9.458
2	0.180	0.184	10.942
3	0.161	0.231	1.719
4	0.193	0.203	2.204
5	0.183	0.254	4.198
Average	0.176	0.208	5.7042

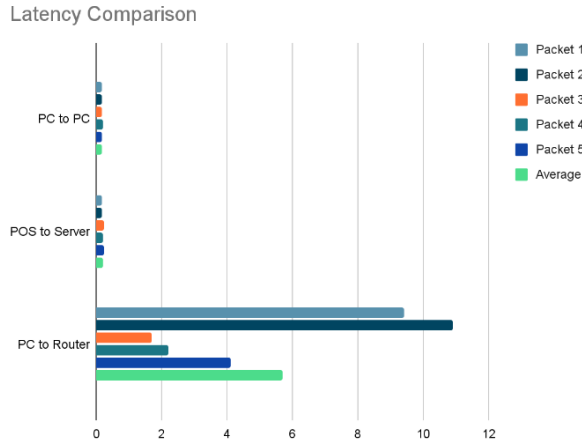


Fig. 7. Ping Testing from POS to main server

E. Network Accuracy

The success rate of the ping test from the router to the internet also has a 100% success rate. During the PC to Router ping test, the latency varies with the highest being 10.942 ms and the lowest 1.719 ms. This latency variety might happen due to several reasons, such as traffic, load on pinged devices, or devices that are passed by packet. The results show that the computers were able to accurately ping the desired and correct computer.

F. Network Security

The computer network being designed theoretically fulfills the security requirements. Having a backup server will allow the data to be safeguarded in case the normal server encounters some issues. The firewall will also prevent unauthorized access into or out of a computer network. In addition, adding DHCP to the router's interface connected to the internet will aid in preventing hackers from hacking the router.

IV. DISCUSSION

A. Limitations and Evaluation

There are several limitations to the networked computer simulation presented in this paper. For instance, all of the devices on the simulation are all simulated using VPCs or Virtual Personal Computers. The servers, POS systems, id card readers, etc. are all simulated as VPCs. While this approach provides a general simulation of the real-case scenario, it is still not a 1:1 comparison. In addition, there is another component, the firewall, that is still unable to work in the simulation. In the simulation, the firewall is actually not connected to the network but the firewall component is just placed on top of the cable. Another limitation is the connectivity of the VPCs. As they only allow a single connection to be made, this made simulating the printers difficult as there was no method to connect them directly to the POS system simulated as a VPC. To work around this, we are assuming the printer is already a component of the POS system.

From the simulation that has been simulated, what can be improved is implementing more devices into the network using their respective software images. This would include implementing real servers, firewalls, POS systems, scanners, printers, and modems into the network as opposed to only virtual pcs.

As for the design of the network, there are several improvements that could be made to make the network more efficient and optimized, especially if the number of devices connected to the network were to be increased. A main disadvantage of Star Topology and Extended star topology is that the network is highly dependent on the central device. As a result, this device were to encounter some issues that would prevent it from working, then the network would not be able to operate. As such, it would be more optimal if instead of one device as the core, several devices connected together would act as a core. This would allow the network to still operate even when one of the core devices is down.

B. Performance Comparison

In a study published in the International Journal of Computer Applications, it is found that the average ping latency on a simulated computer network with a star topology averaged at 0.0004 seconds, or 0.4 milliseconds [1]. As the result obtained in this research is lower than this average, it can be concluded that the networked design meets the standards of similar designs in terms of network speed.

C. Conclusion

The implementation of the proposed computer network for the pet shop would result in a positive impact for the business. By using a computer network for the pet shop, it is more efficient and also it could reduce cost. The data of the petshop can be easily shared to different users. Computer networks can also connect computers, printers, id card readers, etc. By having it connected to each other and having the data in one database, it could reduce the cost. The average performance of the ping testing from PC to the router showed the highest with the average speed of 5.7042 ms. Each ping testing sends 5 packets to their respective destinations and all ping testing has a 100% success rate, so it can be concluded that the network is reliable for sending data from one computer to another. In addition, all of the computers are connected through a high-performance and fast connection. Most device-to-device communications will take less than 1ms, which is incredibly fast. In addition, the implementation of a firewall and backup server will provide security to the Pet Shop.

REFERENCES

- [1] Absar, N., Jahangir Alam, M. and Ahmed, T., 2014. Performance Study of Star Topology in Small Internetworks. *International Journal of Computer Applications*, 107(2), pp.45-53.
- [2] Avast, "What is TCP/IP and How Does It Work?"
- [3] A. Networks and S. Petryschuk, "Network Design and Best Practices", Auvik Networks Inc., 2022.
- [4] Cisco. "What is Local Area Network." accessed August 31, 2022
- [5] Cisco Edu, "Media Access Control: Topologies", Cisco.
- [6] Cisco Press, "Hierarchical Network Design" Cisco.
- [7] D. Tucakov, "Linux vs. Microsoft Windows Servers, The Ultimate Showdown", phoenixNAP Blog, 2022. [Online]. Available: <https://phoenixnap.com/blog/linux-vs-microsoft-windows-servers>. [Accessed: 08- Sep- 2022]
- [8] "Difference between Star and mesh topology," GeeksforGeeks, 02-Aug-2022. [Online]. Available: <https://www.geeksforgeeks.org/difference-between-star-and-mesh-topology>. [Accessed: 05-Oct-2022].
- [9] ENISA, "Secure Backups", European Union Agency for Cybersecurity,
- [10] IBM Documentation, "Incremental Backups and Recovery", IBM, <https://www.ibm.com/docs/en/db2/11.5?topic=recover-incremental-backup-recovery> [Accessed 8 Sept 2022]
- [11] Oracle, "Introducing to TCP/IP Protocol Suite", https://docs.oracle.com/cd/E18752_01/html/816-4554/ipov-6.html [Accessed 8 Sept 2022]
- [12] P. Devgun, "Requirements For LOCAL AREA NETWORK (LAN) – Byte to Learn", BytetoLearn.com, 2020.
- [13] R. Bhardwaj, "Extended Star Network Topology", Network Interview, 2022. [Online]. Available: <https://networkinterview.com/extended-star-network-topology/>. [Accessed: 08- Sep- 2022]
- [14] Sandeep Subbaiyan, "Uncover the Benefits of Topology in Network Monitoring". Available: <https://thwack.solarwinds.com/resources/b/geek-speak/posts/uncover-the-benefits-of-network-topology-in-network-monitoring> [Accessed: 08 Sept 2022]
- [15] S. Dandamudi and T. Eltaeib, "Firewalls Implementation in Computer Networks and Their Role in Network Security", *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, vol. 2 issue 3, March 2015.
- [16] Y. Alshehri J. Chung, 'Evaluation of Wireless Mesh Network Implementation for Backup Network Access', *International Journal of Networks and Communications*. 9. 103–114, 11 2019.