Role of packet tracer in simulating server services on the client-server computer network

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Abstract. In a client-server architecture, a server is dedicated to providing various services, functions, and resources to serve its clients' requests over a computer network. To understand and expertise this concept, a lot of exercises are critically needed. This aims to improve learners' practical skills as well as to expand their knowledge. However, a real client-server network with the representative servers and network devices is costly. It is sometimes not available for the experiment and trial. In this case, a network simulator can be a reasonable substitute. This study uses Cisco Packet Tracer to simulate various server services such as DHCP, HTTP, DNS, FTP, Email, NTP, Firewall and IoT Registration Server. The mini-project simulation is proposed to explore the capabilities of the simulator to providing a wide range of server services. All settings and testing are visualized followed by the discussion of each result. It is expected that by practicing and mastering this mini-project simulation, learners can first build the client-server network using proper devices, wiring, naming, and addressing on a single monitor. Second, they can understand all the server parameters and then able to configure them step by step. And third, they can easily conduct testing, tracing and troubleshooting afterward. Furthermore, this work has a goal to build a bridge between network theory and practical aspects simultaneously so that learners will have a lot of confidence when working on a real network.

1. Introduction

The computer network has currently become important for the business performance of any corporations across the globe. It is a fundamental infrastructure for sharing data and automation [1,2]. Many present applications need such structures to operate. This creates a growing demand for computer networking experts that leads to the increasing popularity of the computer networking field. As this field relies on the skill, a lot of practices are essentially required [3]. Yet, it is often difficult to have real networking devices for experiment purposes. The lack of these devices makes the network simulator as a reasonable option for a substitute [4]. Using a simulator, device failure can be avoided. It is safer and more cost-effective [5]. In this study, Cisco Packet Tracer 7.2 is used to investigate the server services due to the widely used of this simulator which provides a lot of updated features such as IoT and Websocket.

The effectiveness of using Packet Tracer as a learning tool was investigated by [6]. They made a case study of routing protocols to ensure all students graduated with sufficient networking competency. The ability of Packet Tracer in comparing various routing protocols tells that this simulator is effective as a learning tool for computer network [6]. The role of Packet Tracer in learning wireless network and IoT devices was studied by [7]. They discussed the importance of the Internet of Things (IoT), Internet of Everything (IoE), and smart home in present-day life. A more specific IoT study using Packet Tracer is the simulation of internet surveillance which connects with different

security devices and sensors conducted by [8]. There are many other studies using Packet Tracer. However, there is still room for an investigation which is simulating various server services with various client types and scenarios.

In designing a computer network, dedicated servers are usually required, for example, the smart campus design by [9] and [10]. Servers can be utilized for various purposes, mainly for storing data, sharing resources, and fulfilling client requests when they come in. Servers can also create a layer of security for clients so that servers only serve the client requests that have the authorization. As servers have an important role on the computer network, this work will focus on simulating the available server services in Packet Tracers such as DHCP, HTTP, DNS, FTP, Email, NTP, Firewall and IoT Registration Server. How they are set, what parameters are required, how their services are tested and are there any correlation between services will be investigated for learning purposes. To conduct these tasks, the mini-project of client-server simulation that covers various types of servers and clients will be proposed.

From the aforementioned context, this paper aims to investigate the role of packet tracer as a widely used simulator in simulating server services on the client-server computer network. It is expected by practicing and mastering the proposed mini-project simulation, learners will be able (1) to gain the understanding of server services concept and its implementation, (2) to make proper configuration, wiring, naming and addressing, and (3) to conduct appropriate testing, tracing and troubleshooting.

2. Material and Methods

This section describes the proposed client-server topology used in this paper, Figure 1. It is followed by the method used to experiment. The proposed network is grouped into four segments based on their functionality. The first is wireless clients which consist of laptops, tablet PC and smartphones. They are assigned with Net-ID 192.168.1.0 and connected wirelessly to an access point. The second is wired clients which consist of Desktop PC and Printer. Their Net-ID is 192.168.2.0 and connected to a switch using UTP cable. The third is IoT devices for home automation. Similar to wireless clients, they are also connected wirelessly to an access point with Net-ID 192.168.3.0. All these three clients are intended as devices to access and test all the services of the servers.

The fourth segment is the server-side with Net-ID 192.168.0.0 where each service is configured in different dedicated computer servers. This aims to see each service setting and operation more clearly, even though all those services can be placed in one computer. Here, the observed server services are DHCP, Firewall, Email, FTP, HTTP, DNS, NTP, and IoT Registration server. Two routers are used to connect the segments. Using these routers, the Net-ID of each segment can be separated.
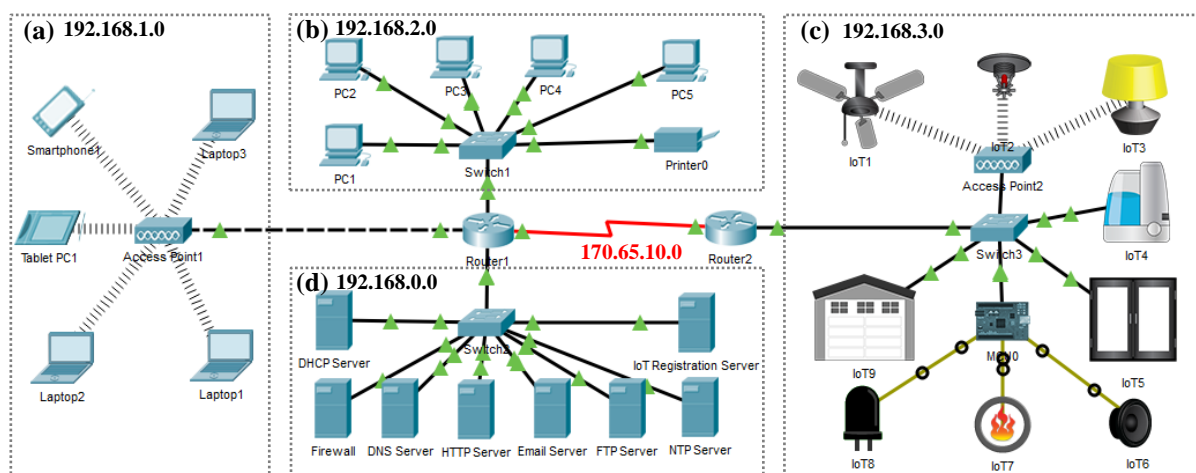
Figure 1. The mini-project (a) wireless clients, (b) wireline clients, (c) IoT clients, (d) Servers

To begin with the experiment, each related service must be activated first on the server based on its functionality. Then, the proper setting and parameter need to be assigned, followed by testing the service from clients. This will ensure whether the service is running properly. Among others, the DHCP server has to be configured first because it will supply IP address automatically for each computer. IP helper-address and routing protocol have to be set in both routers so they can connect the different Net-IDs of clients. Once all computers have been connected, other services can then be applied consecutively.

3. Results and Discussion

This section displays the server services setting and parameters, then discuss their functionality and results significances. The testing visualization example of each service is given from the client-side.

3.1. DHCP (Dynamic Host Configuration Protocol) Server

Figure 2 (a) shows four pool names that are created for each network segment. They are namely serverPool for server-side (192.168.0.0), VLAN1 for wireless clients (192.168.1.0), VLAN2 for wireline clients (192.168.2.0), and VLAN3 for IoT clients (192.168.3.0). The default gateway is the IP address of the router interface that connects to each LAN segment, while Subnet Mask is 255.255.255.0 (default C class), and the DNS server is set to 192.168.0.3. Since the DHCP server is set to 192.168.0.2, then the IP helper in the router is set using command line: (router-config-if)#ip helper-address 192.168.0.2.
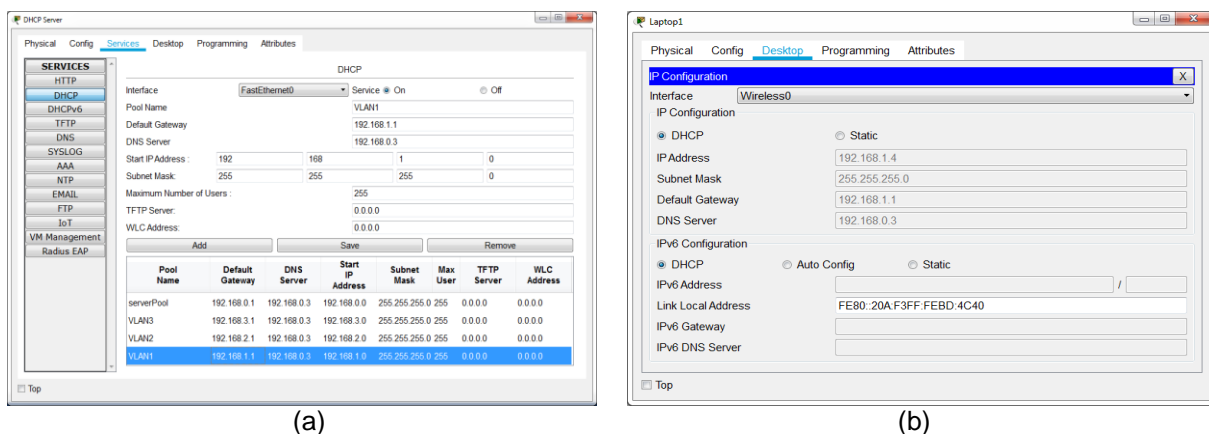

Figure 2. (a) DHCP Server setting, (b) Result of IP address in Laptop1 based on DHCP

On the client-side, this DHCP can be requested in Desktop Tab > IP Configuration, Figure 2 (b). By selecting DHCP option, clients make a request and should get the IP address, Subnet Mask, Default Gateway, and DNS Server dynamically. In this case, its IP address should be in the range of their pool. This DHCP system reduces the need for manual assignment of network parameters to all network devices with the lease concept. This is good for handling a big network with many temporary connections because IP can be reallocated.

3.2. Firewall System

Firewall aims to prevent unauthorized access to or from a private network where, in Packet Tracer, it is designed based on the inbound rule. Two actions, *allow* and *deny*, are provided for protocol IP, ICMP, TCP, and UDP. As shown in Figure 3 (a), a *deny* action to a remote IP will make that computer could not connect to the server. In this case, the *Request Time Out* response will be received both by *ping* and *tracert*, Figure 3 (b). Conversely, a *reply* response will be received for the *allow* action, Figure 3 (c). In TCP protocol, deny of remote port 80 will make that client could not browse any website.
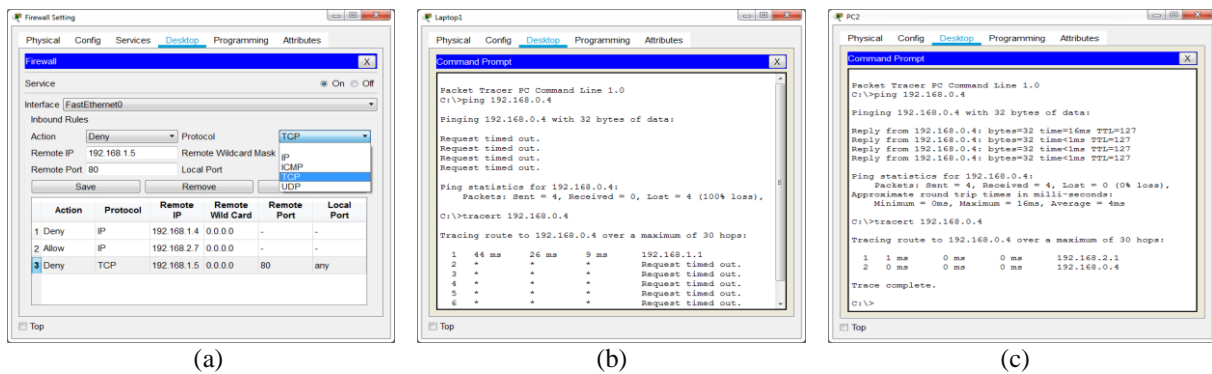
Figure 3. (a) Firewall setting, (b) RTO ping and tracert (deny), and (c) Reply ping and tracert (allow)

3.3. Email Server

Packet Tracer provides Email Server Service to allow composing, sending, and receiving of email. To begin with, SMTP (*Simple Mail Transfer Protocol*) and POP3 (*Post Office Protocol 3*) service should be enabled to ON first. SMTP is a protocol for sending an email, while POP3 is the 3rd version protocol for holding and receiving an email. Then, a domain name has to be created, for instance, *el-pnb.ac.id*, Figure 4 (a), followed by making a user account and password. Instead, on the client-side, the email configuration for an account has to be set. For example, user2 is set in Laptop2, Figure 4 (b), while the incoming and outgoing mail server is set to *el-pnb.ac.id*. This can be done only if *el-pnb.ac.id* has been listed in the DNS server. Otherwise, it can be set using the email server address. To use email, the browser provides features to compose, reply, receive, and delete email, Figure 4 (c).

It can be seen that the email server simulation in Packet Tracer covers almost all steps, requirements and features of the real email server conveniently. As email is an essential part of most organizations today, this email server simulation scenario can be used as a good practice, especially for ones who want to enhance their network administration skills in managing all aspects of email.
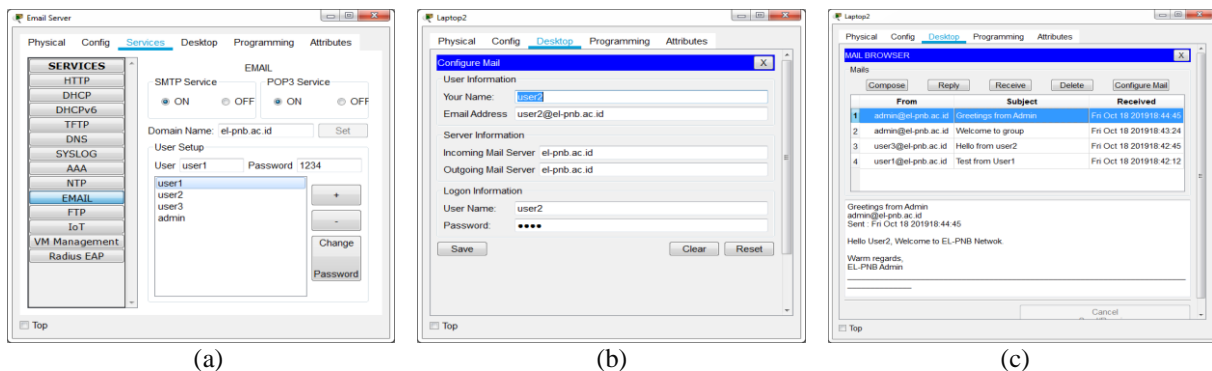
Figure 4. (a) Email Server account setting, (b) Configure Mail, and (c) Email browser in client-side

3.4. FTP (File Transfer Protocol) Server

FTP is a standard network protocol built on a client-server model architecture for transferring computer files between a server and a client. It also can be used to backup and restore router configuration. To use FTP in Packet Tracer, its service must be enabled first. Then, a username, password, and permission (*write, read, rename, delete, and list*) have to be created, Figure 5 (a). To test this service, using a command prompt of a computer client, FTP can be accessed from c:\ by typing ftp with the ftp server's IP address, for example, *c:\ftp 192.168.0.3,* or it can be a registered name in the DNS server. Then, a username and password need to be supplied, Figure 5 (b). After connected, FTP command such as *put, get, rename, dir,* and *delete* can then be applied for the file operation. They will work based on the given permission to the username. In the real-world, for secure

transmission, FTP is often secured with *SSH File Transfer Protocol* (SFTP) to protect username and password, as well as to encrypt the file content.
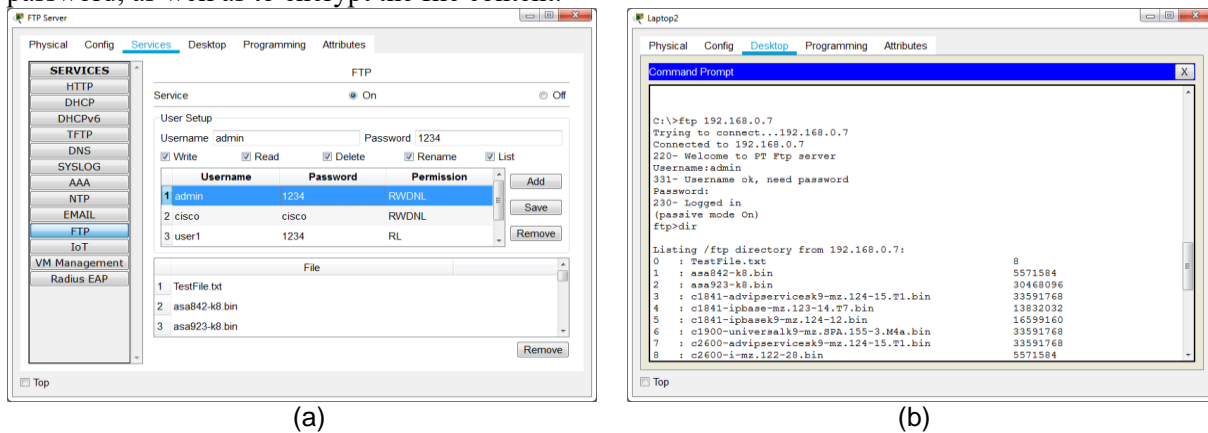

Figure 5. (a) FTP Server account setting, (b) Result of FTP access in client-side

3.5. HTTP (Hypertext Transfer Protocol) and DNS (Domain Name Services) Server

A web server can refer to software or hardware, or both, that work together responding to the incoming user requests for accessing the hosted files. They are processed by a web server over HTTP and other related protocols. The HTTP server in Packet Tracer will store, process and deliver web pages to clients that most frequently in HTML documents. Website components such as images, style sheets, and scripts may include in HTML files in addition to text content, Figure 6 (a). Here, the default file name for a website home page is *index.html* which can link to any number of other pages, Figure 6 (b).
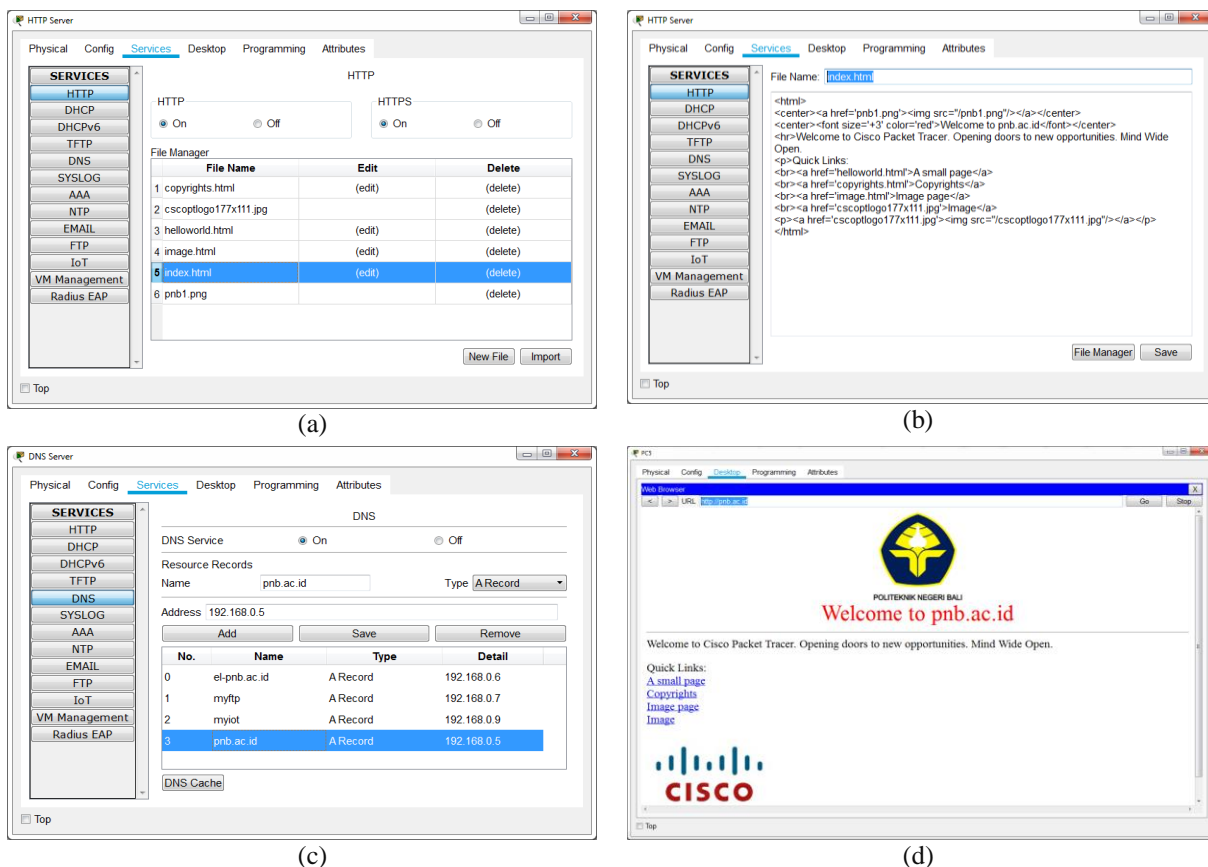

Figure 6. (a) HTTP files manager, (b) Index.html syntax, (c) DNS server, and (d) Result of web

Using only the HTTP server, a webpage can be already accessed by its IP address from a client web browser. However, remembering the IP address is quite difficult. Therefore, the DNS server is needed to translate the address to a name that can be easily understood. It is a naming system for services or resources that are connected to a private or public network. In this case, the HTTP server IP 192.168.0.5 is registered to *pnb.ac.id* as shown in Figure 6 (c). This domain name makes it can be accessed easier than putting HTTP server IP in the browser, Figure 6 (d). Additionally, not only HTTP but also email account, FTP, and IoT server can be registered in the DNS server. As can be seen in Figure 6 (c), 192.168.0.7 is named to *myftp* and 192.168.0.9 is named to *myiot*.

3.6. NTP (Network Time Protocol) Server

Date and time synchronization is crucial for network-based services or applications which depend on time functionality. They will not work properly or deliver unexpected results if devices linked to each other in different time settings. In this case, Packet Tracer provides NTP server for handling this issue. After NTP service is set to ON, Figure 7 (a), then date and time in the router can be synchronized to NTP server date and time setting, Figure 7 (b). It can be seen that the date before connecting to NTP was *Sun Nov 17 2019*, then after synchronizing it becomes *Wed Nov 19 2019*. This means the router reads clocks from NTP source otherwise it will use its own clock. NTP also can be used for limiting access times of users to the server. For example, users only can access the server in the office hours.
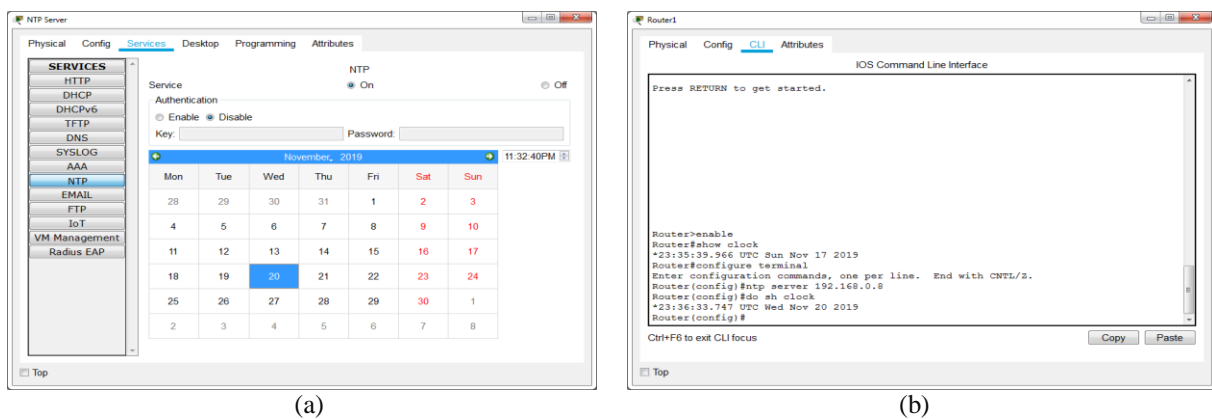

Figure 7. (a) NTP server date and clock, (b) Router time configuration based on NTP

3.7. IoT (Internet of Things) Registration Server

In addition to traditional network devices such as hub, switch, and router, Packet Tracer supports a wide variety of smart things and components (sensors and actuators) that can be connected both wired and wirelessly. The dynamic environment management was introduced in Packet Tracer to make IoT devices simulation more realistic where those devices will respond to the environment change.

Figure 8. (a) IoT smart things setting, (b) IoT Server login, and (c) Results of IoT Devices Monitoring

In this work, after each of the things get into the network by putting the required IP setting, Figure 8 (a), the devices need to be remotely connected to the IoT registration server. Their status can then be monitored and managed by login into a dedicated IoT webpage, Figure 8 (a) and (b). In addition, the advantage of using this feature is not only for listing devices but also it is possible for interacting with them remotely.

3.8. Server Services Key Points Summary
Most of the commonly used servers in the real world have been simulated in this work based on the proposed mini-project in Figure 1. To be able to work with the proposed scenario, basic knowledge of IP address, interfacing, and wiring are required because most of the server configuration is related to the setting of IP address on the proper network interface. Furthermore, the basic understanding of CLI commands will also help especially for testing of the intended services on the clients or routers command prompt. For each generic server service, some key points can be highlighted as summarized in Table 1.

Table 1. Server services parameters and key points summary

No	Server Services	Highlighted parameters and key points
1	DHCP	pool name, default gateway, DNS server, start IP address, maximum number of users
2	Firewall	allow action, deny action, protocol, remote IP, wildcard, port, ICMP, TCP, UDP, RTO
3	Email	SMTP, POP3, domain name, username, configure account, compose, send, receive
4	FTP	user permission (write, read, delete, rename, list), command (put, get, dir, pwd, passive)
5	HTTP	store, process, deliver html documents, webpage, world wide web (www)
6	DNS	naming system, IP to name translation, web browser
7	NTP	server clock, time synchronization, do sh clock
8	IoT Reg.	smart things, components (sensor, actuator), remote server, home gateway, MCU

4. Conclusion

This paper has investigated the role of Packet Tracer in simulating server services on the client-server computer network. It is shown that the proposed mini-project can give a comprehensive simulation of server services by visualizing them separately based on their functionalities. The various scenarios including the DHCP server, FTP server, HTTP server, DNS server, Email server, Firewall service, NTP server, and IoT registration server can be completely simulated in a convenience way. Numerous parameters of configuration from the pool and naming system to time synchronization and smart things have been also highlighted. It can be stated that this mini-project has been able to provide a wide-range exercise to explore the full potential of Packet Tracer, especially in providing an understanding of server services concept and implementation. It is expected that the flexibility of this mini-project will make the learning process can run effectively and efficiently without bothering with the availability of the expensive real equipment. A lot of recurrent practices are suggested for learners using this mini-project. This aims they can gain a lot of confidence when working on a real network.

As future work, this mini-project will be tried in another widely used network simulator namely GNS-3 (Graphical Network Simulator 3). The evaluation with Packet Tracer will be conducted to find their pros and cons based on the comparative study of [11]. Having results from both simulators will be good to complement each other.

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