Remote desktop system in IoT and HTML 5-based virtual laboratory for HMI (Human Machine Interface) practicum and hydraulic simulation

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Abstract. A virtual laboratory is a facility that allows access to laboratory equipment from anywhere and anytime while connected to the internet. Remote desktop systems are the basis of the development of a virtual laboratory where users can access hardware connected to the lab computer from anywhere with the agreed time. The virtual laboratory can overcome the problem of the imbalance of the number of tools available in the lab with the number of students who will do the practicum, especially the PLC, HMI, and hydraulic simulation. For accessing the lab computer, this tool uses web-based HTML and VNC (Virtual Network Computing) techniques. On the server computer, the ThinVNC server is installed, and the user, password, and port are set. ThinVNC functions as a tool that makes it easy for users to access the lab because it merely provides a web browser that supports HTML 5 such as chrome, firefox, and edge without having to install any browser plugins and does not need to install RDP, so tablet or smartphone can access the lab. When it is connected, the user can access the available lab equipment and can see the results made because there are cameras that monitor the course of the practicum.

1. Introduction
Practicum is very important in the world of engineering, where every student must feel how to use practical tools to form abilities that are not only theoretically but also grow ability in terms of practice [1]. Even so, the limitations of practicum equipment often become obstacles, this is due to the imbalance of the number of tools available with the number of students who have to do a practicum, especially in practicums such as PLC and HMI where the equipment needed is quite expensive. While for hydraulic simulation, the application used is a paid application [2].

A virtual laboratory may be one solution to solve the problem where students can access the lab from anywhere and at any time according to the agreed schedule. This is certainly directly proportional to the definition that "virtual laboratory is a means to conduct real experiments remotely from any location, through the website. The remote lab can be accessed like an original hardware lab" [1].

This tool gives remote users a way to share resources and tools, which can lead to reduced costs and access to some learning resources that are more specialized and not available locally [3]. In this way, students can access lab equipment at any time, from any computer, not only from the university but from their home [2]. Especially in Indonesia, a remote lab system must be developed, to share laboratories (collaboration) between universities [3].
The basis for creating a virtual lab is a remote desktop system where lab computers can be accessed from anywhere and at any time. Following the functions of remote desktops, Remote desktop protocols (RDPs) are usually used to connect and interact with computers remotely. These protocols generally consist of two software components, namely client and server. The server component runs on the remote computer and shares the desktop (screen) with the client component that runs on the end-user device. The client component allows the user to remotely control the machine by sending server I/O events (Click pointer/mouse and keyboard presses) [4].

On this occasion, the author aims to make a design of the Remote Desktop System in the Virtual Laboratory Based on IoT and HTML 5 for the Human Machine Interface (HMI) Practicum and Hydraulic Simulation [5]. The discussion is only limited to the design of a remote desktop system that functions as a medium of user communication with the lab computer.

2. Methods
The design of this tool used an experimental method which includes the study of literature, design and testing. The first stage in this research is to conduct a literature study by opening several scientific journals related to remote labs. This stage is also the stage of determining the remote laboratory model to be made.

The second stage is the design, the design is done first is the hardware design by making a moving actuator on the PLC trainer using a conveyor and capacitive proximity sensor. After designing the actuator that will be controlled and displayed on the HMI, the design of the connection system between the server computer and the user is carried out, beginning with the website creation and the server activation method following the specified time. In this process, local server publications are also made public so that they can be accessed via the internet using Ngrok to get a public IP.

The modification process on ThinVNC is done by changing the code on the ThinVNC server. The process is done by replacing the post data process taken from the input data form into a label with a fixed value and contains the IP address of the server computer so that students do not have to enter the IP address, but if they have registered the practicum schedule the student can directly access the lab computer by pressing the button just connect. This step begins with designing the flowchart first.

![Figure 1. Flowchart of laboratory computer access.](image-url)
After making a flowchart, proceed with the trial by installing a webcam camera that will display the lab equipment that is accessed and continued with the prosecution using local and public servers. Each component compiled refers to the flowchart shown in Figure 1.

3. Results and discussion

3.1. Design results
The main components of the virtual lab are remote users, server settings, internet, laboratory settings.

![Figure 2. Laboratory virtual architecture.](image)

The virtual lab system utilizes a remote desktop system as a means for users to control lab computers that are already connected with lab equipment. This can be seen from the architecture of the remote lab system created, as shown in Figure 2.

![Figure 3. Remote desktop system.](image)

Unlike the remote desktop system in general that uses the default RDP of the operating system, this tool uses VNC (virtual network computing) as a medium of communication between client or user and the server computer. As for the type of VNC used, ThinVNC is based on HTML 5 [6].
The reason for using ThinVNC on this tool is that ThinVNC is a web remote access client (browser-based, HTML5) [7]. This is an enhanced version of the standard VNC protocol and covers all the same scenarios, but with much better performance and without the need to install a PC client or any browser plugin [6].

After installing ThinVNC on a PC or laptop that acts as a server, then only need a web browser to connect [8]. Access the desktop and files remotely (even from a mobile device) and function as if they just entered the computer. ThinVNC is a pure web Remote Access implementation (based on HTML5 & AJAX). The web client works on browsers that support HTML5 such as Chrome, Firefox, Safari, Opera, IE or Edge [7].

As mentioned above that ThinVNC is a website-based RDP, many modifications were made to the webserver where students can directly select the computer they want to access without having to enter the server's IP address. The process can be seen from Figure 4, which is the process of selecting computers and logging into the server computer.

![Figure 4. Server access.](image)

Meanwhile, to make a local server accessible via the internet, it is used to get a public IP address.

Steps to activate the server computer:
- Open the ThinVNC server
- Set user, password and port
- Run the server
- Open the command prompt and look for the Ngrok directory
- Open the Ngrok and enter "https: server IP address"
- Public IP has been obtained and can be accessed through the website

3.2. Trial

Here are the results of the design that has been made on the server and accessed by users.

3.2.1. HMI practicum experiment. HMI (Human Machine Interface) here aims to display a PLC program (Programmable logic controller) as an interface that displays PLC data, both input, output, sensor data [9]. In addition, HMI can also be used as a substitute for a button, for example, in the use of emergency buttons [10].

Students do practicum to design HMI by adjusting the address on the HMI with the address used by the PLC. After that, students can transfer programs that have been made on the PLC and see their input and output through the HMI that has been made.

At the same time, students can also see the device being run through a mounted camera. Figure 5 (a) is a display of HMI practicum using the Cx-Designer or Sysmac Studio application on the user's device. Figure 5 (b) is a display of making a PLC program on Cx-Programmer or Sysmac Studio PLC.
3.2.2. Hydraulic simulation practicum trial. In a hydraulic simulation practicum, a hydraulic Festo Fluidsim application that is available on a server computer can be used. Students can directly open an app that has been facilitated with a GUI (Graphical User Interface). The display of the practicum can be seen in Figure 6, which is an example of accessing a lab computer for a hydraulic simulation practicum.

3.3. Specifications and security

3.3.1. Internet. Any computer, tablet, or cellular with an internet connection can be connected remotely. The following are specifications for optimal and recommended performance:

- 5Mbps or higher download and upload bandwidth are required for optimal performance.
- 1500Kbps download and upload bandwidth recommended for this system [1].

3.3.2. Security. Some security anticipations have been used in this system where a multi-layered security system is implemented, namely:

- User account (password has been encrypted)
- Firewall
- Server user and password
- Permissions and privileges [1]
4. Conclusions
Based on the results and discussion, it can be concluded that the design of the Remote Desktop System on IoT and HTML 5-based Virtual Laboratory was successfully made according to plan. The trial results show that each section runs well where the lab computer can be accessed from anywhere, but with the rules of access that have been arranged and the ultimate purpose of designing the tool that is met. All systems are running well like Ngrok and ThinVNC, which has been modified, can communicate well.

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