Development of remote laboratory based on HTML5

A T Nugraha and E Haritman

Department of Electrical Engineering Education, Faculty of Technology and Vocational Education, Universitas Pendidikan Indonesia, Jalan Dr. Setiabudhi No.229 Bandung 40154

*erikharitman@upi.edu

Abstract. The Laboratory is an important means for engineering students and the researchers to do various kinds of experiments. Amount of equipment and time to be able to access the laboratory is limited. Therefore, in this research developed of remote labs that can be accessed via web anytime and anywhere as long as available internet network. This is in line with the development of Industry 4.0 which introduces cyber physical technology based on internet or wireless network. This technology is not only used for communication but also includes controls and remote control. The results of this research showing the remote lab can be accessed by web via internet and via localhost and compatible with web browser as google chrome, Mozilla, opera etc.

1. Introduction

Remote Lab (Rlab) is a future of laboratory, because it provides opportunities for effective and holistic learning for students and researchers to provide the flexibility and additional time needed to complete an experiment or exciting breakthrough [1].

Rlab is also one of online learning, in this case practical learning can access physical laboratories via the internet (Cyber Physical). This learning in the line with development of industry 4.0 who introduce a system cyber-physical based on internet or wireless network, this technology is not only for communication but includes controls and remote control [2]. Rlab also one of the open educational resources, interactive. The main purpose of this Rlab is to provide a real physical laboratory from afar.

Universities such as the University of Deusto made the Rlab Called WEBLAB DEUSTO, Sydney University of Technology made LABSHARE (SAHARA) and the Massachusetts Institute of Technology create iLAB (ISA) accessible to everyone in the world. Some Rlab had been cross-platform means that can be accessed in different devices such as PC, Laptops even Smartphones and most client server communications are HTTP-based.

Universitas Pendidikan Indonesia (UPI) has an Rlab which is placed at the Industrial Electronics Laboratory (Rlab Elind) which can be used for industrial automation practice remotely. The Rlab model used is still application-based, where the user must install the third-party application, TeamViewer. Events where a PC or computer device that exists in a particular location, can be accessed and used from a different place called the Remote Desktop [3]. TeamViewer is one of the Remote Desktop applications that is compatible to remote a PC. As stated earlier that in order to be able to remotely, the user must install TeamViewer first. So, Rlab Elind becomes less flexible in terms of access. To resolve these problems, researchers will develop Remote labs based on HTML5.
2. Methodology

The study was conducted using the waterfall model which has severa1 sequential steps, i.e.: requirement design system, coding and Testing.

![Research methodology diagram]

Figure 1. Research methodology.

Description on figure 1:
- Requirement, conducting literature study and identification of problems related to the development of Lab based on HTML5.
- Design system, make the Rlab architecture that will be developed.
- Coding, modify from the thinVNC a remote desktop based on HTML5.
- Testing, do a trial by user from Rlab that has been made and do the testing using Apache Jmeter™.

2.1. Architecture of remote lab based on HTML5

![Architecture of Rlab diagram]

Figure 2. Architecture of Rlab.
The general architecture of an RLab depends on the experiments carried out with a structure consisting of a computer and hardware connected to the computer such as a webcam, microphone and feedback from the result of the experiment back to the computer [4]. Figure 2, shows the architecture of RLAB that is being developed based on HTML5, where users can use Laptop, PC, Netbook or smartphone to remote the PC in lab then the webcam is used to display changes in conditions from the PLC.

Medium of long distance communication between the user and PC lab use via the internet while connecting the two platforms is needed a Remote Desktop (RD). From figure 2 the PC Lab connected to the router so that it has an IP Address: 192.168.18.xxx:xxxx (port), and then the PLC used in the Rlab is Omron CP1L and the webcam used to see changes in PLC conditions after the program has been loaded by the user.

2.2. Remote desktop
ThinVNC is a remote desktop based on HTML5 by taking full control or by sharing their windows desktop. This application supports Internet Explorer 9, Firefox, Chrome, Safari, and web browser other HTML5 abilities. IE8 and previous versions can be upgraded with HTML5 features by adding the Frame Chrome plug-in [5]. Remote Desktop (RD) used in this research is thinVNC. Through the application RD of thinVNC, Rlab Industrial Electronics can be accessed by users with real-time anytime and anywhere without the distance and time limit as long as the user is connected to the internet through electronic gadgets such as: smartphone, tablet, notebook, or the other electronic gadgets that support and have web browser applications [6,7].

3. Results and discussion
In this section will discuss the testing Remote Desktop is accessed through the web. There are several tests that are carried out, namely comparing access via the Internet to localhost, testing based on the number of users who access the web, testing based on network traffic and check browser compatibility. The tests uses software Apache JMeter™, JMeter is a Java-based open source application that can be used for performance test. JMeter usually used to perform load/stress testing Web Application, FTP Application dan Database server test. The following are the results of testing using Apache JMeter™:

3.1. Testing number of users
Testing the number of users is done in stages where the first test is by 1 user, both 2 users, 3 users and so on. The user here is a virtual user from software Apache JMeter™, The following is the result of testing the number of user:

| Number of Users | Time  | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency | Connect Time (ms) |
|-----------------|-------|------------------|--------|-------|------------|---------|------------------|
| 1               | 09:19 | 4879             | 124    | 3556  | 118        | 9       | 3                |

Table 1. Access 1 user via internet and localhost.
Table 2. Access 2 user via internet and localhost.

| Number of Users | Jam | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency | Connect Time (ms) |
|-----------------|-----|------------------|--------|-------|------------|---------|-------------------|
| 1               | 09:21 | 787             | ok     | 5426  | 124        | 787     | 259               |
| 2               | 09:21 | 826             | ok     | 5426  | 124        | 826     | 277               |
| 1               | 09:21 | 28              | ok     | 5426  | 118        | 7       | 2                 |
| 2               | 09:21 | 9               | ok     | 5426  | 118        | 7       | 2                 |

Table 3. Access 3 user via internet and localhost.

| Number of Users | Jam | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency | Connect Time (ms) |
|-----------------|-----|------------------|--------|-------|------------|---------|-------------------|
| 1               | 09:30 | 1316             | ok     | 5426  | 124        | 1316    | 436               |
| 2               | 09:30 | 1093             | ok     | 5426  | 124        | 1091    | 387               |
| 3               | 09:30 | 4103             | ok     | 5426  | 124        | 4092    | 3303              |
| 1               | 09:30 | 878              | ok     | 5426  | 118        | 812     | 12                |
| 2               | 09:30 | 447              | ok     | 5426  | 118        | 447     | 6                 |
| 3               | 09:30 | 419              | ok     | 5426  | 118        | 419     | 5                 |

Table 4. Access 5 user via internet and localhost.

| Number of Users | Jam | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency | Connect Time (ms) |
|-----------------|-----|------------------|--------|-------|------------|---------|-------------------|
| 1               | 13:41 | 926              | ok     | 5426  | 124        | 926     | 336               |
| 2               | 13:41 | 868              | ok     | 5426  | 124        | 868     | 303               |
| 3               | 13:41 | 788              | ok     | 5426  | 124        | 788     | 262               |
| 4               | 13:41 | 929              | ok     | 5426  | 124        | 929     | 278               |
| 5               | 13:41 | 3842             | ok     | 5426  | 124        | 3842    | 3296              |

3.2. Access via the internet and localhost by time

Testing internet access using Ngrok, a proxy server to create or open a private network through NAT or a firewall to connect localhost with a secure tunnel. So when testing using JMeter then, the address from Ngrok will be entered into server name or IP in JMeter. Whereas, testing on localhost only needs to enter the IP Address from the server computer (PC Lab). Than, the scenario created during the test is the number of users as many as 20 people every 1 second (20/20), will sending 1 request to server then the total number of samples = 20 (20x1). The scenario of performance test can be changed in value as
needed. The following table test results between access via internet and localhost, testing performed 10 times at different hours, taken value - average of latency, sample time (ms) and the connect time (ms):

**Table 5.** Access via internet (Ngrok).

| Time  | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency (ms) | Connect Time (ms) |
|-------|------------------|--------|-------|------------|--------------|------------------|
| 12:48 | 840.4            | ok     | 5426  | 124        | 840.2        | 280.65           |
| 13:34 | 908.9            | ok     | 5426  | 124        | 908.8        | 363.25           |
| 14:13 | 855.9            | ok     | 5426  | 124        | 855.75       | 314.85           |
| 15:04 | 857.8            | ok     | 5426  | 124        | 857.5        | 319.5            |
| 15:30 | 928.85           | ok     | 5426  | 124        | 928.8        | 391.5            |
| 20:43 | 1665.85          | ok     | 5426  | 124        | 1658.65      | 553.9            |
| 21:21 | 1972.9           | ok     | 5426  | 124        | 1756.6       | 850              |
| 22:06 | 1423.85          | ok     | 5426  | 124        | 1375.5       | 557.35           |
| 22:30 | 1536.15          | ok     | 5426  | 124        | 1303.15      | 420.15           |
| 8:22  | 1345.65          | ok     | 5426  | 124        | 1345.45      | 576.25           |

**Table 6.** Access via localhost.

| Time  | Sample Time (ms) | Status | Bytes | Sent Bytes | Latency (ms) | Connect Time (ms) |
|-------|------------------|--------|-------|------------|--------------|------------------|
| 14:13 | 46.9             | ok     | 5426  | 118        | 39.75        | 21.85            |
| 15:04 | 213.95           | ok     | 5426  | 118        | 213.85       | 177.45           |
| 15:30 | 26.2             | ok     | 5426  | 118        | 24.6         | 8.65             |
| 8:24  | 435.45           | ok     | 5426  | 118        | 372.3        | 312.2            |
| 8:58  | 52.75            | ok     | 5426  | 118        | 44.2         | 24.6             |
| 9:07  | 378.45           | ok     | 5426  | 118        | 317.45       | 196.1            |
| 9:09  | 213.2            | ok     | 5426  | 118        | 210.35       | 173.7            |
| 9:10  | 53.3             | ok     | 5426  | 118        | 49.55        | 29.6             |
| 9:12  | 659.3            | ok     | 5426  | 118        | 649.75       | 609.2            |
| 9:14  | 2846.2           | ok     | 5426  | 118        | 2059.9       | 1604.65          |

*Latency* (delay) is the time needed for data to travel the distance from origin to destination. Delay can be influenced by distance, physical media, congestion or long processing time [6]. From the results of testing the average value generated via the internet latency is higher than the latency of localhost, the higher of latency value, the higher of access failure.

### 3.3. Browser compatibility

As explained in the previous chapter, HTML5 can be accessed through popular web browsers such as *Google Chrome*, *Mozilla Firefox*, *Opera* etc. Tests carried out at this stage are any browser that can access this web-based Remote Desktop, along with the results of testing browser compatibility:

**Table 7.** Browser compatibility.

| Browser       | Status  |
|---------------|---------|
| Google Chrome | Connect |
| Mozilla Firefox | Connect |
| Opera        | Connect |
| Maxthronhe   | Connect |
| Internet Explorer | Not connect |
| Safari      | connect |
4. Conclusion
The conclusion that can be drawn from the results of developed Remote Lab based on HTML5 are, Rlab is successfully accessed via the web in two ways, namely via the internet and localhost using a web browser such as: google chrome, Mozilla Firefox, Opera and Maxthon. Based on the results of testing using Apache JMeter software are as follows:

- The value of latency via the internet is greater than localhost, because there are several factors, namely the quality of the network between the user and server, time, distance and the software used is still free, the features are also limited.
- The value of latency via localhost is smaller than via the internet, because localhost is only one network between user and server but if many platforms enter the same network, the latency value will increase so that when in the remote process it will feel slowly.
- Response time when remote is still slower compared to Teamviewer's remote desktop, but its high flexibility can be accessed anywhere and anytime provided there is a good internet network available.

References
[1] Pruthvi P, Jackson D, Hegde S R, Hiremath P S and Kumar S A 2015 A distinctive approach to enhance the utility of laboratories in Indian academia Proceedings of 2015 12th International Conference on Remote Engineering and Virtual Instrumentation (REV) 238-241
[2] Kagermann H, Wahlster W and Helbig J 2013 Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group 8
[3] Pardede J, Hermana A N and Swarghani G 2017 Perbandingan Metode Breadth First Search dan Backlink pada Web Crawler MIND Journal 2(2) 61-69
[4] Gowripeddi V V, Ram B K, Pavan J, Devi C Y and Sivakumar B 2018 Role of Wi-Fi data loggers in remote labs ecosystem Online Engineering & Internet of Things 235-249
[5] Wang V, Salim F and Moskovits P 2013 The definitive guide to HTML5 WebSocket Vol 1 (New York: Apress)
[6] Wulandari R 2016 Analisis Qos (Quality Of Service) Pada Jaringan Internet (Studi Kasus: Upt Loka Uji Teknik Penambangan Jampang Kulon LIPI) Jurnal teknik informatika dan sistem informasi 2(2) 170
[7] Fushshilat I, Rahmat A, Somantri Y and Haritman E 2018 Laboratory management: digital laboratory information system (DLIS) concept IOP Conference Series: Materials Science and Engineering 434(1) 012286