Labview and Internet of Things (IoT) Based Remote Monitoring of Lab Experiments to Enhance Collaboration between Universities

Arshad Ali

Abstract: This paper presents the implementation of Remote Monitoring Laboratory system that is used to perform experiment remotely by using Internet of Things. This paper discusses required hardware equipment and software developments for Remote Laboratory. To verify the proposed framework, a room temperature control experiment made available remotely to control the parameters and hardware. The experiment which is made online accessible for students is named Temperature Control System (TCS). The basic idea presented in this paper is to acquire and present data in Lab View and control it by sitting on remote computer. As the experiments take long time to take place in laboratory and during that time a person needs to be present in laboratory to supervise the running experiment. But by making remotely accessible it become easy to supervise by sitting own office and during that time the person can do other tasks meanwhile experiment is running. Live video is also published with remote panel for hardware observation which is setup in laboratory. The results presented in this paper are very satisfactory and reliable.

Keywords: Remote Control, Internet of Things, Laboratory, Lab View.

I. INTRODUCTION

With the increasing number of things on the internet the concept of providing integrated services as a result of communication amongst heterogeneous networks is gaining momentum [3]. In last half century, advancement in electronics and communication technology enable the scientist to connect the machineries with computer system which can be operated over the internet remotely. With increasing the use of internet in the globe, many people work from home instead of going to office premises. It saves time as well as cost for both employer and employee. These technologies are also beneficial for students to perform experiments remotely instead of going into laboratories. In this way students do not have to wait for the equipment time slot but they need to register for an online experiment slot according to their convenience. By registering, system allocate time slot to each user for conducting experiment.

In this context National Instruments has great contribution by developing Lab View which is graphical programming and Lab View has built in servers and can be configured those servers according to the requirements. After configuring the servers one can perform experiments from a remote computer [1].In most of the organization the National Instruments equipment is also used in laboratories with Lab View software, but in various organizations this software is not used in this context.

With the traditional laboratories this is not possible for all students to perform the experiment at the same time because experiment equipment limitation. By using the IoT based resources it is possible that all the students perform experiment sitting remotely from home or from anywhere in the world. In this way distant learning students can also perform their experiments from their residences.

The major aim of this research work is to make it able to perform and monitor experiments remotely and collaboration between the organizations to share the resources by using Internet of Things (IoT).

For monitoring purposes live video is also published in the panel by using web cameras to facilitate the experiment performer to monitor the hardware setup and other things in the laboratory while performing the experiments.

II. RELATED WORK

In last few decade, the technology especially Internet of Things (IoT) gained lot of attention from researcher who developed new models and architecture to build smart services, home and cities. Traditional laboratories are not enough for all students to perform the experiment at the same time. Most of the laboratories have limited hardware and connectivity due to lack of funding. Due to this limitation it results in a limited number of students which could perform the experiment at the same time and for utilizing all the students. Tutors need to make groups to perform experiments and during the experiment the laboratory supervisor needs to be in the laboratory. However there is another option that we can create virtual laboratories and at the same time many students can access that virtual experimentation but the drawback of this type of labs are that the experiment results of virtual lab are entirely different as compared with the real world experiments results.

By implementing the Remote Labs it gives more opportunities to perform experiments more than once and gain the correct results of the experiments. The major benefit is for the distance learning students who learn from home and they cannot come into the university every day or even once a week and making remote labs in universities, the student can get more practical knowledge than relying on theory [4]. Technologies are rapidly growing and penetrate in every field of life in last few decades. In the education field it provides the new teaching techniques like Remote Monitoring or Tele Labs and etc. (e.g. a microscope is set up in NASA America and that is accessible from Russia and one benefit of this setup is that when Russian Scientists access that microscope at that time it is night time in USA).
In this system both countries can utilize that microscope and other hardware. And there is no time clash between two countries because when it is day time in Russia it is America’s night time. Due to this time difference, scientists of both of the countries utilize that microscope with no time problem [26]. Traditional laboratories are not enough for all students to perform the experiment at the same time. Most of the laboratories have limited hardware. Due to this limitation it results in a limited number of students which could perform the experiment at the same time and for utilizing all the students, the tutor need to make groups and due to this grouping this time spans to a longer length and during the experiment the laboratory supervisor needs to be in the laboratory. However there is another option that we can create virtual laboratories and at the same time many students can access that virtual experiment but the drawback of this type of labs are that the experiment results of virtual lab are entirely different as compared with the real world experiments results.

Making the real setup of hardware in the laboratory and making it online for students to perform the experiment from anywhere in the globe. This reduces the costs and the time of the students. By making the Remote Labs it gives more opportunities to perform experiments more than once and gain the correct results of the experiments. The major benefit is for the distance learning students who learn from home and they cannot come into the university every day or even once a week and making remote labs in universities, the student can get more practical knowledge than relying on theory [4]. The operation modal of remote lab is show in figure 1. The figure shows that students present at different geographical location can access remote lab via internet to perform desired experiments. The hardware is setup for an experiment in remote lab. Multiple students can access the experiment at same time but only one student can control the experiment at same time. Every student can perform experiment in his allocated time slot and the results of experiments are stored in database and can be retrieved and analyzed later. [2]

Fig. 1. Lab experimentation by using IoT

The software design for remote lab for client/server Java based software model. The figure 2 shows major component of java based remote lab. The complete software is composed of two parts. One is client which is designed for the end user and the second part is remote lab that server part. Using JDBC the server objects are allowed to talk with the database. Any client who wants to talk with the database can do so by talking with the stub, which is in turn interacting with the skeleton. The following figure shows the actual experiment running in remote lab at Atlantic University. [2]

III. REMOTE LAB ARCHITECTURE AND HARDWARE WORK

A. Architecture

Basically when any client is connected with the server for performing an experiment through web browse by using user name and password. The server sends confirmation to the client, that username and password is correct. Then the client clicks on the remote panel for performing the experiment through web browser. Web browser sends a request to the experiment server and remote panel is downloaded for remote client and the whole system as shown in the following figure 3.

B. User Datagram Protocol:

UDP is a connectionless protocol and it does not establish a connection with destination before sending data.
It also provides ability to sending data to other programs with minimum handling.

<table>
<thead>
<tr>
<th>Application</th>
<th>Client</th>
<th>Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>IP</td>
<td>IP</td>
</tr>
<tr>
<td>Network</td>
<td>Eth</td>
<td>Eth</td>
</tr>
<tr>
<td>Data Link</td>
<td></td>
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<tr>
<td>Physical</td>
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</tbody>
</table>

**Fig. 4. Client/server communication model**

It contains eight bit header information and it does not guarantee to the destination for reliable data. The working of UDP is as follow. [18]

**C. Hardware**

To perform the experiment remotely, a sample experiment is performed. To setup the experimentation following hardware is needed

**Transistor:**
The BDW93C is a silicon epitaxial-Base NPN power transistor in monolithic Darlington configuration mounted and is shown in the figure below

**Resistor:**
Light Bulb: 5 volt light bulb is used for increasing or decreasing the intensity of light and by varying the light of the bulb through DAQ input voltage, it varies the resistance of the Thermistor and by varying the resistance of the Thermistor temperature varies.

**Power Supply:** Power supply is needed to provide voltage to drive the circuit.

**DAQ NI-USB 6008:** DAQ is used for attaching all the hardware with the computer. The DAQ which is used in this project is shown below: [1]

**Fig. 5. Data Acquisition card (DAQ)**

**A. Hardware Design:**
The block diagram of hardware design shown below.

**Fig. 6. Block diagram of experimentation hardware**

The working of the hardware is as follow:

To turn on the hardware 5volt supply is connected with hardware through the transistor with +ve end and –ve end is connected with the resistor to complete the circuit and a 5volt is supplied through the DAQ and it can be varied between 1volt and 5volt to vary the brightness of the bulb. Designed hardware is shown in the figure below

**Fig. 7.Experiment setup for temperature control**

**Thermistor Theory:**
Mathematical calculation of the VI is given below:

\[ V = \text{Voltage from supply}, \ V_{in} = \text{Voltage cross Thermistor}, \ R_A = \text{Resistor Resistance}, \ R_B = \text{Thermistor Resistance} \]

\[ r = R_0 \times e^{-B/T_0} \]

Where \( R_0 \) resistance at \( T_0 \) (room temperature 289.15K) [25] \( T =\) Temperature, \( B = \)Parameter at room Temperature,

By using the following equations

\[ R_B = \frac{V_{in} \times R_A}{(V-V_{in})} \]

Here \( R_B \) is Thermistor resistance and it now equal to \( R \)

\[ T = \frac{B}{\ln(R/r)} \]

Temperature is in Kelvin.To calculate resistance across Thermistor

\[ R_B = \frac{(2.4 \times 10000)}{(5-2.4)} = 9231 \]

By using the second equation, Here \( R_B \) is a Thermistor resistance and it is now equal to \( R \)
T = B/ln(R/r)
= 3450/ln (9231/0.0943296)
= 3450/ln (97859)
= 3450/11.4913
= 300.228 Kelvin

IV. REMOTELY CONTROLLED EXPERIMENT SETUP

Experiment setup shown in the figure 8 is designed in LabView to perform the experiment remotely, the designed system enable the performer to control the experiment parameters remotely. The performer can control the hardware remotely, the user can change the voltage of the bulb by varying voltage supply by the DAQ. The DAQ assistant is used to read voltage across the thermistor, supply voltage and voltage cross resistor. The voltage across the thermistor and supply voltage is also used to calculate temperature, after implementing the formula which is explained section III. To read the values from hardware through the DAQ we need to configure the DAQ, the number of samples, sample rate and timeout or delay between reading the samples from the circuit. If more samples are read from the circuit then the update becomes too slow and therefore, different values sets are used and based on the experimentation results the number of samples is less than 100 are fairly good.

The DAQ assistant 2 is used to change the voltage which is supplied through the DAQ and due to this change in voltage to the circuit the brightness of the bulb is changed and due to this change the temperature of the surrounding is also changed which is read through the Thermistor. The voltage timeout can be changed and by changing the timeout, the speed of the system varies and this is measured in seconds. By increasing the timeout the update becomes slow and decreasing the timeout update becomes fast. It is tested by using different values and by analyzing the results;

Fig. 8. Block diagram in Lab View for online experiment

Based on the data set used and series of experiment done, 0.005 second is an ideal value for update.

In the figure 9, front panel of the designed application is presented which showing different modules including the live video streaming.

Fig. 9. Front Panel of experiment designed in Lab View

V. RESULTS AND DISCUSSION

Experiment results and analysis of the presented in this section based on the obtained result by using the designed experiment bed. The designed experiment control the room temperature remotely with varying the voltage supplied to the bulb and due to variation in voltage, the surrounding temperature also varies. The following figure shows recorded readings of the experiment while changing of DAQ voltage. By increasing the DAQ voltage the temperature increases because of the brightness of the light bulb. Figure 10 shows that by increasing the voltage, the temperature increases and Vice Versa.

Fig.10. Average temperature vs voltage variation

This graph in figure 11 shows the relationship between Thermistor resistance and DAQ voltage. DAQ voltage is taken along the x-axis and Thermistor resistance is along the y-axis. As the DAQ voltage increases the Thermistor resistance decreases and by decreasing DAQ voltage Thermistor resistance increase.
According to graph resistance decreases as the relationship is shown in Figure 13. The results over all temperature decreases. The graph in figure 12 explains the relation between DAQ voltage and temperature. In this graph DAQ voltage is taken along the x-axis and temperature is along the y-axis. By analyzing the graph it concludes that by increasing the DAQ voltage to the circuit temperature increases and by decreasing the DAQ voltage to circuit temperature decreases.

In 21st century, it is need of the universities to collaborate and benefitted from the equipment by using online laboratories. In this paper an efforts is done to design a sample experiment by using LabView integrated with IoT for remote handling of lab experiments. The results presented in this paper is very much satisfactory and this model can be used to enhance collaboration between academia. By using this model, the universities which are lack of the latest experimental bed can be benefitted from other universities labs. Based on this the lab experiment can be done any time even out of hours from home or anywhere from the globe.

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Dr. Arshad Ali, is Associate Professor of Information Technology since May 2018 in Faculty of Computer and Information Systems, Islamic University of Madinah. He finish his BSc in Mathematics and Statistics from University of Punjab, Lahore, Pakistan in 2000 and completed his Masters in Computer Sciences from Iqra University, Lahore, Pakistan.

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