A WEB-BASED TEMPERATURE MONITORING SYSTEM FOR THE COLLEGE OF ARTS AND LETTERS

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A WEB-BASED TEMPERATURE MONITORING SYSTEM FOR THE COLLEGE
OF ARTS AND LETTERS

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
in
Computer Science

by
Rigoberto Solorio
March 2015
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March 2015
Approved by:

David Turner, Advisor, Computer Science and Engineering

Ernesto Gomez, Committee Member

Josephine Mendoza, Committee Member
ABSTRACT

In general, server rooms have restricted access requiring that staff possess access codes, keys, etc. Normally, only administrators are provided access to protect the physical hardware and the data stored in the servers. Servers also have firewalls to restrict outsiders from accessing them via the Internet. Servers also cost a lot of money. For this reason, server rooms also need to be protected against overheating. This will prolong the lifecycle of the units and can prevent data loss from hardware failure.

The California State University San Bernardino (CSUSB), Specifically the College of Arts and Letters server room has faced power failures that affected the Air Conditioning Unit (AC) and as a result the room became overheated for a long time, causing hardware failure to server units. This is why this project is important for the College and needs to be implemented as soon as possible.

The administrator’s old method of controlling server room temperature was by manually adjusting the temperature box inside of the server room. Now it can be controlled and monitored using remote access.

The purpose of A Web-Based Temperature Monitoring System for the College of Arts and Letters proposed in this project is to allow users to monitor the server room temperature through a website by using any computer or mobile device that has Internet access. Also, this system notifies users when the room attains a critical temperature by sending an email/text to the server room administrator.
A Web-Based Temperature Monitoring System for the College of Arts and Letters project is for the exclusive use of the College of Arts & Letters (CAL) server room. The administrator is the only person that can grant access to others by creating a proper account.

For this project three prototypes will be implemented, first to measure the current server room temperature, the second to show the temperature history of the room, and third to use the built-in search system to locate times that given temperatures were attained.
ACKNOWLEDGMENTS

I am dedicating my work to my wife, Graciela Lopez, my daughters Stephanie Solorio, Karen Solorio, Itzel Solorio and my boy Rigoberto Solorio Jr. who always believe in me. And of course to my mother, Rosa Zendejas, and my father, Alfredo Solorio. Also to my brothers Gilberto Solorio, Victor Solorio and Carlos Solorio I could not have done this work without them.

To my adviser Dr. David Turner, who always gave me great ideas and helped me to improve my skills. I believe strongly that a person can only go so far unless they surround themselves with great people. I would also like to thank my constant friend, Ken Han, for his motivation and unconditional support. I cannot thank my great friend, Alysha Timmons, enough for her numerous hours spent editing. I would also like to thank Dr. Jaqueline Rhodes and Nick Valentin for being very nice to me and for all their help. I thank my valuable committee members Dr. Ernesto Gomez and Dr. Josephine Mendoza. Also I would like to thank the CAL Deans for their support.

Lastly I thank all my friends and professors who in one way or another encourage me to continue my education. Thank you to Robert Clinton who was my first mentor at RCC and encouraged me to get my Master’s degree. Being the first family member graduating from college is an amazing experience for me – an experience that I want to pass on to my family. Here it is!

Rigoberto Solorio
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CHAPTER ONE
SOFTWARE REQUIREMENTS SPECIFICATION

1.1 Introduction

The purpose of this project is to improve the current form of monitoring the
temperature in the College of Arts & Letters server room. Currently, the
temperature can only be read from the box attached to the wall. The technician
must physically visit the server room throughout the day adjusting the
temperature, as needed. Another reason to implement this prototype is due to
the fact that the A/C unit is constantly failing causing the server room to overheat,
especially during the summer.

Keeping server room temperature at low level helps hardware equipment
to function better and to prolong the life of units. Maintaining units in a cooler
environment also increases the company’s revenue by avoiding overheating of
the hardware equipment, which in many cases is the main cause of hardware
failure.

In order to address the issue, Management has to choose to place a
person in the server room to monitor the temperature, or develop a system that
can monitor the temperature from remote places at any given time (to save on
human capital) [8].

The main purpose of this system model is to make it easy for the user to
view the current server room temperature by remote access. A Web-Based
Temperature Monitoring System for the College of Arts and Letters can be accessed anywhere and anytime through the Internet, thus saving human expenses. A Web-Based Temperature Monitoring System for the College of Arts and Letters is one type of temperature recorder that monitors a temperature in a room, stores the data into a database, and displays the current temperature on the website through a web server. The system will continuously monitor the temperature condition of the server room allowing the data to be monitored at anytime and anywhere from the Internet [8].

Similar temperature monitoring systems are widely used in many organizations with the purpose of maintaining goods, such as food warehouses, drink industries, vegetable refrigeration units, etc.

1.2 Purpose of this Project

The purpose of A Web-Based Temperature Monitoring System for the College of Arts and Letters project is to allow users to supervise the College of Arts and Letters server room temperature 24/7 from anywhere through internet log in. This project of Temperature Monitoring System also has an email warning notification feature to inform technician staff when a critical temperature has been reached in the room.

By monitoring this interface, IT staff can view the current CAL server room temperature in numeric digital format and graphical display. In addition, the user
can use the search engine to search the historical temperature records saved in the database.

A Web-Based Temperature Monitoring System for the College of Arts and Letters is to function as a standalone website, it means that it can be functioning without close supervision 24/7.

Research for the best technology that can be used to achieve the above description was be conducted. The following documentation represents a client-server based approach.

1.3 Context of the Problem and Previous Research

Since the beginning of the College of Arts and Letters, the server room temperature has being facing power crises, causing hardware failures and minimizing the equipment life cycle. Now with the Web-Based Server Room Temperature project, we expect fewer downtimes and increased functionality.

The crux of the problem is how to supervise the server room temperature 24/7 from a remote location. It is inefficient to track server room temperature in manual ways. Currently, the technician must physically visit the server room throughout the day adjusting the temperature, as needed. The system and technician needs to be in communication with the server room constantly. The availability of a web-based system to enable viewing of the temperature performance and records is more reliable and efficient.
1.3.1 Other Projects Results

The purpose of comparing is to make sure that my project has similar results using different software and different hardware applying same concepts of previous projects. According of In M. Kassim, M.N. Ismail and C.K.H. Che Ku Yahaya article, they mention that measuring temperature using an iButton sensor allows access to data using LAN network protocols, and is not accessible through the Internet compared to Web-Based Temperature Monitoring [8].

Another prototype is the Speech Synthesized Temperature Sensor alerts which measure temperature changes using a verbal message when a change occurs, but it is not accessible through a web browser. This sensor is mostly used to monitor temperature changes in a car, power plant [8] or laboratory facilities.

The last comparison prototype is X-10 Based Remote Temperature Monitoring System, which gives the same results as the Web-Based Temperature Monitoring. The main difference is that it uses different devices to monitor the temperatures and the temperature changes are updated automatically in the browser without needing to refresh a web page. Table 1 shows the comparison of the three analyzed systems with this project. This is an extension of a table presented in [8].
Table 1. Comparison Results with this Project

<table>
<thead>
<tr>
<th>Project /Description</th>
<th>Web-based Temperature Monitoring System for the CAL</th>
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<tr>
<td>Software</td>
<td>MySQL PHP Apache/Centos CSS JavaScript</td>
<td>Java ApacheTC JavaSevlet Pages MySQL</td>
<td>Java JavaSevlet JavaSever Pages</td>
<td>MySQL PHP Apache</td>
</tr>
</tbody>
</table>
1.4 Project Products

This project resulted in the following products:

- **Web Application**: A web application with a system interface, using a MySQL database for storing data, CentOS operation system platform, Arduino Uno cell ship unit, and Hypertext Preprocessor (PHP) source scripting language. This web application should achieve the needs of a communication interface between users and technicians/managers. Its use as an online service will be exclusive to the College of Arts and Letters’ technician and Dean’s office.

- **System Manual**: this project with design details and specifications will be kept by the Computer Science and Engineering Department of CSUSB.

1.5 Definition of Terms and Abbreviations

This section presents the definitions and acronyms that will be used further in this document.

**API** – Application Programming Interface

**Arduino Uno** – a USB single-board microcontroller, intended to make building interactive objects or environments more accessible.

**Browser** – A program that accesses and displays the website to view the current server room temperature chart.

**CAL** – College of Arts and Letters
**CentOS** – Linux based Red Hat operating system

**CSUSB** – California State University of San Bernardino

**Hypertext Markup Language (HTML)** – A markup language used to structure text and multimedia documents and to set up hypertext links between documents.

**IEEE** – Institute of Electrical and Electronics Engineers

**ITC** – Information Technology Consultant

**MySQL** – structured query language. Is the most popular database system used with PHP that synchronizes with the web and runs on the server

**PHP** – Hypertext Preprocessor, scripts that are executed on the server

**PWM** – Pulse Width Modulation

**SRS** – Software Requirements Specification

**SSH** – Secure Shell

**VPN** – Virtual Private Network
1.6 Preliminary Design

There are two types of user classes implemented in this project:

1. User/Viewer.

2. System administrator.

A menu page is associated with each type of user.

1.6.1 Users Characteristics

Users of the Web-Based Temperature Monitoring System for the College of Arts and Letters would fall into one of the following groups:

1.6.1.1 User. The user in the system is like a customer. To use the system, the user needs to obtain a login name and password from the administrator.

The user’s view after login is the main page of Web-Based Temperature Monitoring System for the College of Arts and Letters (CAL) project. User can read and monitor current temperature, search for old temperature at specific day and time by using the search engine, and to logout after all. See Figure 1.
1.6.1.2 Administrator. The administrator has the functionality of a user with the additional privileges to add/edit a user account and update the system.

Admins also have the ability to add, edit, and delete user accounts. See Figure 2.
Figure 2. Administrator Use Case Diagram
CHAPTER TWO

SOFTWARE DESIGN AND USERS ACCESS

2.1 Architecture

A Web-Based Temperature Monitoring System for the College of Arts and Letters project has 3 main components: web-browser, Client side, and Arduino unit. Figures 3 and 4 best describe the architecture sides:

A WEB-BASED TEMPERATURE MONITORING SYSTEM FOR THE COLLEGE OF ARTS AND LETTERS

Figure 3. Deployment Diagram
2.2 User Access

2.2.1 Client Side

Client side connect to the Internet thought the browser using javascript code. In order to the user to access the Web-Based Temperature Monitoring System for the College of Arts and Letters, he or she has to have a proper account created by the system administrator. The piece of code that enables the user to login is in Figure 4.

```html
<html>
<body>
    <form id='login' action='login_proc.php' method='post' accept-charset='UTF-8'>
        <fieldset>
            <legend>Login</legend>
            <input type='hidden' name='submitted' id='submitted' value='1'/>
            <label for='username' >UserName:</label>
            <input type='text' name='username' id='username' maxlength='50' />
            <label for='password' >Password:</label>
            <input type='password' name='password' id='password' maxlength='50' />
            <input type='submit' name='Submit' value='Submit' />
        </fieldset>
    </form>
</body>
</html>
```

Figure 4. Client Side Login Code

2.2.2 Server Side

Server side controls the content or appearance of Web pages through the use of php code, small programs that run on the Web server to modify the Web page before it is sent to the user who requested it.
The server side is the server that contains the CentOS apache web server module, which runs the application’s php code. The php page is responsible for processing the login request and restricting access to users. The php code is showing below in Table 2.

Table 2. Server Side login_proc.php Code

```php
//login_proc.php to login
// sess.php for session data and db connection
//url on successfull redirect
$url = 'portal.php';
//include session
include 'tools/login/login_sess.php'; //starts the session
//check to see if username or password was left blank
if(empty($_POST['username']))
{
    echo '<meta http-equiv="refresh" content="2; URL=monitor.php">';
    die('username blank');
}
if(empty($_POST['password']))
{
    echo '<meta http-equiv="refresh" content="2; URL=monitor.php">';
    die('username blank');
}
```
die('password blank');

} /*This is the new way to connect to mysql as compared to the methods used in*/

// /var/www/html/monitor/tools/db_connections_dbuser.php

$login = mysqli_connect("localhost", "login", "i0836v97KuPE1c");
mysqli_select_db('phpuser', $login);
// and the new way to scrub input
$un = mysqli_real_escape_string($login, htmlspecialchars($_POST['username']));
$pw = mysqli_real_escape_string($login, htmlspecialchars($_POST['password']));

// the new way to disconnect from mysql
mysqli_close($login);
// include the connection to the users table
include 'tools/db_connections/dbuser.php';

// get all users from database
$uresult = mysql_query("select username from user");
// close connection to user database
mysql_close($login);
// check to see if input matches existing user
while ($users = mysql_fetch_row($uresult))
{

    //check if username exists in database

    if ($users[0] == $un)
    {

        /*check for login attempts ## consider moving this out of loop to get ALL attempts!!! */

        //include attempt.php page

        include 'tools/login/attempt.php';

        //calls attempt function given username

        $check = attempt($users[0]);

        //if too many bad attempts have been made

        if ($check == false)
        {
            echo '<meta http-equiv="refresh" content="2; URL=index.php">';

            die('too many login attempts');
        }
    }

    //######grab password list### connect to user database

    include 'tools/db_connections/dbuser.php';

    //get password given confirmed username(not using direct input form user)
$result = mysql_query("select username, user_type, password as 'pw' from user where username = '$users[0]'") or
die(mysql_error());

$array_r = mysql_fetch_array($result);

//close user db connection
mysql_close($login);

/*############if user and pass match, initialize session and proceed########*/

//recreate hash using password
$hash = crypt($pw, $array_r['pw']);

//check to see if hashes match
if ($hash == $array_r['pw'])
{
    /*passwords match then create session and set variables*/

    $type = $array_r['user_type'];
    $uname = $array_r['username'];
    $_SESSION['type'] = $type;
    $_SESSION['user'] = $uname;

    echo '<meta http-equiv="refresh" content="0;
URL='.URL.'"'>';

}

/*if the passwords dont match then log the attempt, kill the page, and redirect*/
else
{
    include 'tools/db_connections/dbattemp.php';
    $check = addattempt($users[0]);
    echo '<meta http-equiv="refresh" content="2; URL=index.php">';
    die('bad password');
    mysql_close($attmpt);
}
//else bad username
/*include 'tools/db_connections/dbattemp.php';
$check = addattempt($users[0]);
mysql_close($attmpt);*/
echo '<meta http-equiv="refresh" content="2; URL=index.php">';
die('bad username');
?>
2.2.3 Database Interaction

This application shares the same phpuser and login_attempt databases used by other system administration applications in the College of Arts and Letters. This application also uses the monitor database to store historical temperature data. See Table 3. See also Table 4 for the other database located in the server.

Table 3. Server Databases

```
mysql> show databases;
+-----------------------------+
| Database                    |
+-----------------------------+
| information_schema          |
| inventory                  |
| login_attempt               |
| monitor                    |
| mysql                      |
| phpuser                    |
| test                       |
+-----------------------------+
```
Table 4. Relevant Databases and their Tables

mysql> use login_attempt;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> show tables;
+------------------------+
| Tables_in_login_attempt |
+------------------------+
| login_attempts         |
+------------------------+
1 row in set (0.00 sec)

mysql> desc login_attempts;
+------------------------+---------------+------+-----+---------+-------+
| Field      | Type    | Null | Key | Default | Extra |
+------------------------+---------------+------+-----+---------+-------+
| user_id     | varchar(30)| NO   |     | NULL    |       |
| time        | int(30)   | NO   |     | NULL    |       |
+------------------------+---------------+------+-----+---------+-------+
2 rows in set (0.00 sec)

mysql> use phpsuser;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> show tables;
+------------------------+
| Tables_in_phpsuser     |
+------------------------+
| user                   |
+------------------------+
1 row in set (0.00 sec)

mysql> desc user;
+------------------------+-----------------+------+-----+---------+-------+
| Field      | Type            | Null | Key | Default | Extra |
+------------------------+-----------------+------+-----+---------+-------+
| username    | varchar(255)   | NO   | PRI | NULL    |       |
| password    | varchar(255)   | NO   |     | NULL    |       |
| user_type   | varchar(255)   | NO   |     | NULL    |       |
+------------------------+-----------------+------+-----+---------+-------+
3 rows in set (0.00 sec)

mysql>
The database interaction is performed within three php files that allow users to login a secure way. These files are named sess.php, login_sess.php and login_proc.php (Table 2) files.

The login_sess.php file is responsible to create a new login session each time the user logs in and to delete the old session. See Table 5.

Table 5. Database Side login_sess.php Code

```php
* Description: session for the login_proc script
* creates a secure session
*/

ệnh_session_name = 'sec_monitor_session'; /* Set a custom session name*/

$secure = false; // Set to true if using https.
$httponly = true; /* This stops javascript being able to access the session id*/

ini_set('session.use_only_cookies', 1); /* Forces sessions to only use cookies*/

$cookieParams = session_get_cookie_params(); /*Gets current cookies parameter*/

session_set_cookie_params($cookieParams["lifetime"], $cookieParams["path"], $cookieParams["domain"], $secure, $httponly);
```
The `sess.php` file is responsible for validating username and password. If the credentials are invalid a login error will be given. `Sess.php` file interacts with the `login_sess.php` file to create a user login session. This file also allows users to access the database depending on their authority level. The piece of code is shown in Table 6.

Table 6. Database Side `sess.php` Code

```php
if(isset($_SESSION['type'])) /* if type has value then load value into variable*/
{
    $type = $_SESSION['type'];
    $user = $_SESSION['user'];
    if ($type == 'senior')
        { 
```
include

'/var/www/html/monitor/tools/db_connections/dbsenior_monitor.php';

} else if ($type == 'junior')
{
    include

'/var/www/html/monitor/tools/db_connections/dbjunior_monitor.php';

} else if ($type == 'view')
{
    include

'/var/www/html/monitor/tools/db_connections/dbview_only.php';

}

} else
{
    echo '<meta http-equiv="refresh" content="2; URL=index.php">';
    die('error you are not logged in');

} //$_SESSION['table']
2.3 Database Design

2.3.1 Database Schema Conceptual Model

In designing the schema of this project, the following parts are identified:

1. Users: Users who have permission to view should be identified to the system. By entering valid user credentials, the system will allow users to view the Web-Based Temperature Monitoring System for the College of Arts and Letters website. Users are also allowed to use the search engine to recall historical data from the server database system.

2. System Response: The Arduino shell sensor generates data that is stored into the database system. The system is programmed to read temperature data and display it in numerical format reflected in a 2-dimensional x-y graphical chart.

   The system is also allowed to send an email notification to the ITC when the temperature reaches an administrator-specified value.

3. History: The system will maintain the history of each login request.

The Flowchart diagram in Figure 5 represents the user’s sequential steps that have to be followed in order to use the Web-Based Temperature Monitoring System for the College of Arts and Letters. The flowchart diagram has the following symbols:

   The flow line symbol is an arrow connector symbol which shows the direction of the process.
The Start/End symbol is an oval shape which represents the start/end of a process point.

The decision symbol is a diamond shape which indicates a question to be answered – could be yes/no or true/false.

The input/output symbol is a parallelogram shape which indicates input/output of data.

The process symbol is a rectangle shape which indicates a process, action, or function. It is the most widely used symbol in the flowchart model.
The system administrator uses the same process to log into the system. The difference between users and the administrator is that the administrator has the permission to access the database and the system source code to update or modify it, create/edit a username and grant users permission. See Figure 6.

The system is a standalone device, which means that it is able to function independently without close supervision.
2.3.2 Database Schema Logical Model

The Use Case diagram that is shown in Figure 1 maps to the following relational table design. The monitor database contains a table named Temp as showing in the Table 7.

Table 7. Temp Table

```
mysql> show tables;
+---------------------+
| Tables_in_monitor   |
+---------------------+
| Temp                |
+---------------------+
1 row in set (0.00 sec)
```

The Temp table contains a primary key PRI (id) for both the user and administrator as shown in Table 8.

Table 8. Temp Table Description

```
<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Null</th>
<th>Key</th>
<th>Default</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>int(11)</td>
<td>NO</td>
<td>PRI</td>
<td>NULL</td>
<td>auto_increment</td>
</tr>
<tr>
<td>timestamp</td>
<td>varchar(32)</td>
<td>YES</td>
<td></td>
<td>NULL</td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>varchar(10)</td>
<td>YES</td>
<td></td>
<td>NULL</td>
<td></td>
</tr>
</tbody>
</table>
```
The administrator of the Web-Based Temperature Monitoring System for the College of Arts and Letters (as shown in Figure 2) is in charge of managing and maintaining the system code, assigning user permissions, upgrading the system, and modifying the database. The User has restricted control and is only allowed to view the information online and search the database. See Table 9.

Table 9. Administrator and User Permissions

<table>
<thead>
<tr>
<th>Permissions</th>
<th>Administrator</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Control</td>
<td>- Add user/Delete user/Edit</td>
<td>-View current temperature and historical temperature</td>
</tr>
<tr>
<td></td>
<td>-View current temperature and historical temperature</td>
<td>-Use the search function</td>
</tr>
<tr>
<td>Restricted Control</td>
<td>-Use the search function</td>
<td></td>
</tr>
</tbody>
</table>
2.4 System Components

The following technologies were implemented into the project:

- MySQL is used to store data in the database system. MySQL is an open source software and is used as a multi-user database.
- JavaScript is an important application tool to sync between web pages and users through the browser.
- Internet Browser: Has no browser constraints.
- CentOS 6.4
- Database: MySQL.
- Web Server: Apache
- jQuery Library: jquery-1.10.2.js, jquery.thrmometer.js, jquery-ui-1.10.4.custom.js
3.1 Hardware

The Web-based Temperature Monitoring System for the College of Arts and Letters is built with Arduino Uno, Ethernet shield, thermistor, a carbon resistor, Web server, and database server.

The chapter focuses on describing the Arduino Uno, Ethernet shield, thermistor and carbon resistor. For descriptions of the Web server and database server see chapter 6.

3.1.1 Arduino Uno

Arduino Uno is an open source product and one of the most used microcontroller chips to measure environmental factors such as temperature, wind speed, and pressure, etc. The Arduino architecture is based on the ATmega328 (datasheet) [2]. It contains 14 digital input/output pins connector, a total of 6 analog inputs. Arduino Uno is built with USB connection, an independent power jack, and a reset button. Arduino Uno comes with a program in C programming language, which needs to be modified to measure and transmit room temperature data to the Web server. Figure 6 shows the Arduino board and its components.
3.1.1.1 Arduino Uno Components

The following hardware components are interconnected to provide temperature data to Web-Based Temperature Monitoring System:

1. Arduino Uno USB Board
2. Arduino Ethernet Shield
3. Semiconductor RC1/4103JB Temperature Sensor
4. Ohm resistor A 4.7 K
5. Server unit (Apache CentOS ver6.4)
6. Ethernet cable CAT 6
See Table 10 for more features of the Arduino Uno.

<table>
<thead>
<tr>
<th>Components</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>ATMega328</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input Voltage (recommended)</td>
<td>7-12V</td>
</tr>
<tr>
<td>Input Voltage (limits)</td>
<td>6-20V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>14</td>
</tr>
<tr>
<td>Analog Input Pins</td>
<td>6</td>
</tr>
<tr>
<td>DC Current per I/O Pin</td>
<td>40mA</td>
</tr>
<tr>
<td>DC Current for 3.3V Pin</td>
<td>50mA</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>32Kb</td>
</tr>
<tr>
<td>SRAM</td>
<td>2Kb</td>
</tr>
<tr>
<td>Clock Speed</td>
<td>16MHz</td>
</tr>
</tbody>
</table>
3.1.2 Arduino Ethernet Shield

The Arduino Ethernet Shield allows easy connection to the internet. This component enables Arduino to send and receive data from anywhere in the world with an internet connection.

The two parts (Arduino Uno board and Arduino Ethernet Shield) are assembled together for the purpose of this project. See Figure 6 and Figure 7. Both parts (Arduino Uno and Ethernet shield) are connected using the male pins of the Ethernet shield and the 14 digital input/output of Arduino Uno, as showing in Figure 7.
3.1.3 Carbon Resistor

The main advantages of the parts used to build the server room temperature monitoring system is that they are very low cost and easy to find in most local hardware stores.
Carbon Resistor is mainly made of a carbon clay composition covered with a plastic case. The lead of the resistor is made of tinned copper. One of main advantages of these resistors are that they are easily available in local markets at a very low cost and are very durable in extreme environment conditions. Its chemical composition of carbon clay and copper make it very temperature sensitive [6].

3.1.3.1 Resistor Color Code. In each carbon resistor cylinder are four different color bands, each color represents a unique output numerical digit. In this project I used a resistor with Gray, Black, Violet and Yellow color.

The overall color resistor pattern value are, $\text{Black} \Rightarrow 0$, $\text{Brown} \Rightarrow 1$, $\text{Red} \Rightarrow 2$, $\text{Orange} \Rightarrow 3$, $\text{Yellow} \Rightarrow 4$, $\text{Green} \Rightarrow 5$, $\text{Blue} \Rightarrow 6$, $\text{Violet} \Rightarrow 7$, $\text{Gray} \Rightarrow 8$, $\text{White} \Rightarrow 9$.

Defining the color we have that the first and second color bands indicate a two digit number, for example the number 80 comes from color Gray=>8 and color Black=>0, because 0 is a multiple of any positive integer so the combination with the third color (Violet=>7) which indicates the power of ten as multiplier, we have $10^7$. So the total electrical residence is $80 \times 10^7 \, \Omega$. And as a final color we have the fourth color band which indicates the tolerance or resistance which value varies between ± 5 % as margin error [6]. See Figure 8.
3.1.4 Thermistor

A thermistor is a very sensitive thermal mini-resistor whose main function is to perceive small energy changes in the surrounding area. Its cost is very low, easy to find at most electronic hardware stores, and its functionality is for a long period of time [10]. See Figure 9.

Figure 8. Resistor Color Code
3.1.5 Assembling Parts

In the assembly process of the four main parts I assembled the Arduino Uno, Ethernet shield, resistor and thermistor in four steps.

First, I assembled the Ethernet shield on top of the Arduino Uno making sure each pin of the Ethernet shield went inside of its respective Arduino hole or node. The connection between the two components is formed by putting each Ethernet shield pin or legs inside of the corresponding Arduino nodes. On the Arduino board, a node is the row of holes that is connected by the strip of metal underneath [6]. See Figure 10.
After the Arduino Uno and Ethernet shield were assembled together
(Ethernet shield on top of the Arduino Uno board) I proceeded to assemble the
resistor and the thermistor units. As you can see on Figure 11 and Figure 12.

To do this, as first step I numbered the holes or nodes from both Arduino
Uno and Ethernet shield to make it easy to understand. Second, by rolling one
leg of each unit (of the resistor and thermistor) together and sticking them into
the node nine of the Ethernet shield. Third, the other leg of the thermistor goes
into the node number five of the Ethernet shield. And fourth, the other single leg
of the resistor goes into the node number six of the Ethernet shield. See figure
11. Also Figure 12 shows all four components (Arduino Uno, Ethernet Shield,
Resistor, and Thermistor) assembled together and are connected to the running
server.
Figure 10. Arduino and Ethernet Shield Assembling
Figure 11. Arduino Uno, Ethernet Shield, Resistor, and Thermistor Assembled
3.2 Software

The project utilizes MySQL, Cascading Style Sheets (CSS), Hypertext Preprocessor (PHP), and Apache\CentOS to develop a system that will capture data from the Temperature Sensor, save it into the database and display it to the webpage. In order to monitor the temperature, specific programming needs to be used to allow the temperature sensor hardware to interface with the system and display it via the web. A Web-Based Temperature Monitoring System for the College of Arts and Letters consists of the Microcontroller Programming,
database system, and the web page development. Each of these require different languages for coding.

In the Web-Based Temperature Monitoring System for the College of Arts and Letters project, the following elements are implemented in order to reach the project mission.

1. Internet Browser – software application for displaying information on the World Wide Web. This project does not have any known browser constraints.

2. CentOS 6.4 Version – an open source operation system which is based on a Linux platform. CentOS has a high standard of readability interacting with MySQL databases and with PHP as well.

3. MySQL – an open source engine, whose main purpose is to store data in the form of a database.

4. Web Server – a PC computer system that processes requests via an HTTP protocol. Its main purpose is to distribute information through the internet.

5. JavaScript (Libraries) – is a code that runs inside the browser to display temperature graphs and view data from the webserver.

6. PHP – a server language to generate web pages that incorporate information from the database.
7. Arduino Uno Code— is written in C language and runs in the Arduino unit to control temperature data capture and transmission to the webserver.

3.2.1 Temperature Calibration

To measure the authentic server room temperature I had to modify the Arduino C code downloaded from the Arduino website. The temperature calibration is based on the Steinhart-Hart equation, which is a model of resistance measured by a semiconductor at different temperatures. The Steinhart–Hart equation is: Temperature (T) in Kelvin = \( \frac{1}{A + B \ln(R) + C \ln(R)^3} \)

where A = 0.001129148, B = 0.000234125, C = 8.76741E-08. Where A, B and C are the coefficients of the Steinhart-Hart equation, T is the temperature (in Kelvin) and R stand for the resistance of the semiconductor [2]. The original code downloaded from www.arduino.cc is in Figure 13.
Figure 13. Original Arduino Code

3.2.2 Complete Modified Arduino Code

The Modified Arduino code that is running in the server is shown in Table 11, next page.
### Table 11. Modified Arduino Uno Source Code

```c
#include <math.h>
#include <SPI.h>
#include <Ethernet.h>

//Schematic:
//                                       |
//                                 Analog Pin 0

//This is the pin the thermistor is on
#define ThermistorPIN 0

//Use these variables to tune the thermistor calculations
//uses the Steinhart-Hart equation
#define THERM_A 0.00001129148
#define THERM_B 0.00073990070
#define THERM_C 0.00090080019

//Output temp in Farenheit
char TempMode = 'F';
byte mac[] = {
  0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED
};
IPAddress ip(192,168,1,80);
EthernetServer server(80);
double Thermistor(int RawADC) {
```

long Resistance;

double Temp;

Resistance=((10240000/RawADC) – 1000);

Temp = log(Resistance);

Temp = 1/ (THERM_A + (THERM_B * Temp) + (THERM_C * Temp * Temp * Temp));

Temp = Temp – 273.15;

//Temp is now the temperature in Celsius

return Temp;

}

double GetTemp()
{

double temp;

temp = Thermistor(analogRead(ThermistorPIN));

if(TempMode == 'C') //if we want celcius
{
    return temp;
}
else{
    temp = (temp * 9.0)/ 5.0 + 32.0;
    return temp;
}
}
void setup() {
    Serial.begin(9600);
    Ethernet.begin(mac, ip);
    server.begin();
    Serial.print("Server is at ");
    Serial.println(Ethernet.localIP());
}

void loop() {
    EthernetClient client = server.available();
    if (client) {
        Serial.println("new client");
        boolean currentLineIsBlank = true;
        while(client.connected()){
            if(client.available()) {
                char c = client.read();
                Serial.writel();
                if(c == \n' & currentLineIsBlank) {
                    client.println("HTTP/1.1 200 OK");
                    client.println("Content-Type: text/html");
                    client.println("Connection: close");// the connection will be closed after completion of the response
                    client.println("Refresh: 5"); // refresh the page automatically every 5 sec
client.println();
client.println("<!DOCTYPE HTML>");
client.println("<html>");
client.println(GetTemp());
client.println("</html>");
break;
}
if(c == '\n') {
    currentLineIsBlank = true;
} else if (c != '\r') {
    currentLineIsBlank = false;
}
delay(1);
client.stop();
Serial.println("Client Disconnected");
After modifying and compiling the code, I installed a regular thermometer inside the server room to acquire the current temperature and to compare it with the one the source code is measuring. At the first time the temperature that the physical thermometer was reading was approximately 75 degrees Fahrenheit, so in order to the Arduino code to read the same temperature I had to change values with the A, B, C literals of the Steinhart –Hart equation given in the original code, and ended with the new A, B, and C values as follows: THERM_A = 00001129188, THERM_B = 0.00073990070 and THERM_C = 0.00090080019 which give me the same temperature as the thermometer did. See Figures 14 and 15.
Figure 14. Thermometer
#include <math.h>
#include <SPI.h>
#include <Ethernet.h>

// Schematic:
//               |                  Analog Pin 0

// This is the pin the thermistor is on
#define ThermistorPIN 0

// Use these variables to tune the thermistor calculations
// uses the Steinhart-Hart equation
#define THERM_A 0.00001129148
#define THERM_B 0.00073990070
#define THERM_C 0.0009080019

// Output temp in Farenheit or Celcius
char TempMode = 'F';

byte mac[] = {
  0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED
};
IPAddress ip(192,168,1,80);

EthernetServer server(80);

Figure 15. A, B and C Fixed Values
CHAPTER FOUR
IMPLEMENTATION

4.1 Introduction

In chapter Four, the system’s basic functionality is going to be explained with details from the beginning to the end of the system process. As a web programmer, the interface is important to maintain the user’s focus. The interface for the Web-Based Temperature Monitoring System for the College of Arts and Letters is a constant display feature with a graphical chart display. The page has a search engine to find the temperature at a specific day and time. The display shows the date and time versus the numerical temperature.

4.2 Basic Interface

4.2.1 Administrator/User Login Page

In order to access the Web-Based Temperature Monitoring System for the College of Arts and Letters, a user must request an account from the administrator. The administrator may create the user account as a standard user with limited privileges or an administrator with full privileges. The login page is shown in Figure 16.
4.2.1.1 Administrator/User Access. After logging in, the administrator/user has a full page view, as shown in Figure 17.

Figure 16. Web-Based Temperature Monitoring System for CAL Login

Figure 17. Web-Based Temperature Monitoring System for CAL Page
4.2.2 Search Engine Functionality

The search function allows the user to request old data to study changes in server room temperature. The function is located at the top of the main page (see Figure 17), it consists of a calendar with year, month and day selection. It also contains three dropdown menu options, which are hours, minutes, and AM/PM category to search for specific data. For example, the temperature underlined in red color (74.5) shown in Figure 20 is the same is showing in Figure 14 (Thermometer), which is the room temperature, and is the same reflected in the search function as the output, confirming that the Arduino code is calibrated and works. See Figure 18, Figure 19 and Figure 20.

Figure 18. A Web-Based Temperature Monitoring System for CAL Search
Figure 19. Temperature Searched for 17-10-2014 at 6:09 PM

Figure 20. Temperature Showing at 17-10-2014 at 6:09 PM
4.2.3 Remote Access

With an approved account, a user can access the Web-Based Temperature Monitoring System for the College of Arts and Letters using any web browser, including wireless devices. See Figure 21.

Figure 21. Access Topology
To remotely access the Web-Based Temperature Monitoring System for the College of Arts and Letters, I used the PuTTY application to connect to the CAL server. To access the Web page I need first to configure PuTTY SSH (Secure Socket Shell). See Figure 22.

Figure 22. PuTTy Login Interface
To access the system remotely, open PuTTy and select the hostname caltemp.csusb.edu and click open as shown in Figure 22. Then enter the credentials to login. See Figure 23.

![Screenshot of PuTTy login](image)

**Figure 23. Wireless Login for Remote Access**

After login, you will be able to navigate into the caltemp.csusb.edu webpage that is shown in Figure 17.

To access from home we need to install the VPN_Pulse client from [http://iso.csusb.edu/download/vpn](http://iso.csusb.edu/download/vpn), after VPN_Pulse is installed opened and type [https://vpn.csusb.edu](https://vpn.csusb.edu) as Server URL then click connect. See Figures 24 and 25.
Figure 24. VPN_Pulse Client Configuration
4.2.4 System Warning Notification

The system is programmed to send a text notification warning to the server administrator if the temperature goes above the programmed setting of 80 degrees Fahrenheit. See Figure 26.
$query = "SELECT temperature FROM Temp ORDER BY id DESC LIMIT 1";
$result = mysqli_query($con, $query);
mysqli_close($con);
$row = mysqli_fetch_array($result);
$temp = $row['temperature'];
if ($temp >= 80) {
    mail("solorir@csusb.edu,khan@csusb.edu", "Attention requires!!
    CAL server room is facing overheat conditions, do something!!")",
    "Ken or Rigo are you there?!", "From: caltechhelp.csusb.edu X-
    Mailer: My PHP Script");
}

Figure 26. System Server Email Notification
CHAPTER FIVE

VERIFICATION AND VALIDATION

The system validation test is an important task for most web development projects, which gives user's accessibility to guaranteed reliability in the use of the system. This validation testing insures credibility and trust between users and the system to reach the organization's goal. The system validation testing can meet the predetermined expectations between the two parts (users and the system).

5.1 Unit Test

The unit test is the basic level of system testing where each component is tested to ensure full functionality. These components can be tested as individual modules in the program code like classes and objects.

All modules were tested, such as the Menu Page for both user cases (Standard User and Administrator). The home page is the final stage that the user reaches to view the page features. Table 12 shows the unit test results.
<table>
<thead>
<tr>
<th>Module</th>
<th>Tests Performed</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Login</td>
<td>• Verify text fields work and displays properly&lt;br&gt;• Verify handling valid data input.</td>
<td>Pass</td>
</tr>
<tr>
<td>Wrong User Login</td>
<td>• Verify the system warning for the use or wrong credentials&lt;br&gt;• Verify system lock off after three login attempts.</td>
<td>Pass</td>
</tr>
<tr>
<td>Menu Page</td>
<td>• Check all the menus shown properly by the user.&lt;br&gt;• Check all the links take user wherever s/he wants to go.</td>
<td>Pass</td>
</tr>
<tr>
<td>Page Display</td>
<td>• Check the temperature displayed accurate and correct.&lt;br&gt;• Check the graph displays the correct dimensional values between x’s – y’s.</td>
<td>Pass</td>
</tr>
<tr>
<td>Search Engine</td>
<td>• Check months, days and time for the search engine.</td>
<td>Pass</td>
</tr>
<tr>
<td>Module</td>
<td>Tests Performed</td>
<td>Results</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Showing Body Page</td>
<td>• Check JavaScript function works properly.</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>• Check the Body Page works correctly.</td>
<td></td>
</tr>
<tr>
<td>Edit Page</td>
<td>• Check the administrator information displayed correctly.</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>• Check all the functions works properly.</td>
<td></td>
</tr>
<tr>
<td>Logout Page</td>
<td>• Check all the logout button works properly.</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>• Verify the page can return to the login screen after users click the logout button.</td>
<td></td>
</tr>
<tr>
<td>Home Page</td>
<td>• Verify the home page is stable and readable.</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>• Verify home page works in the most used browsers, like Google Chrome, Firefox, Internet Explorer, Safari and Opera.</td>
<td></td>
</tr>
<tr>
<td>Module</td>
<td>Tests Performed</td>
<td>Results</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| Wireless Connection | • SSH PuTTY connectivity  
                   | • VPN_Pulse Client connectivity          | Pass    |
This chapter is important for the future of the system. It covers the installation process and the maintenance guide. This project is developed for long term functionality. If the system is installed correctly and updates are performed, the system should work without issues. Below is the installation procedure.

6.1 Software Installation

This system requires CentOS Linux base platform as an operating system, MySQL as database, and Apache server to run the programs.

6.1.1 CentOS Installation

CentOS is one of the most widely used operating systems today, and for a good reason it is free and can be used in any Linux based architecture, and it also has a good performance. Based on my experience in Linux based platforms, I decided to use CentOS as my main operating system. The software was downloaded from the website:

http://isoredirect.centos.org/centos/7/isos/x86_64/CentOS-7.0-1406-x86_64-DVD.iso/, burned onto a DVD media, and used to install on the system, as shown in Figure 27.
1. Insert 1st CentOS 5.9 CD-ROM into the CD.

![CentOS Installation Begins](image)

Figure 27. CentOS Installation Begins

2. Type `linux text` from the boot: prompt. See Figure 28.
3. Select “skip” from Media check. (Here I am assuming that we have a right CD media). See Figure 29.
4. Press OK on Welcome Screen
5. Select **English** and press **OK** to continuing. See Figure 30.
6. Select **us** and press **OK**

7. Press **Yes** on Warning

8. Select “**Remove linux partitions on selected drives and create default layout**” and press **OK**.

9. Press **Yes** on Warning

10. Press **Yes** on Review Partition Layout

11. Press **OK** on Partitioning Screen

12. Select “**Use GRUB Boot Loader**” and Press **OK**
13. Type “selinux=0” on Boot Loader Configuration Screen and Press OK

14. Select “Use a GRUB Password” and Set your boot loader password, and Press OK

15. Press OK on Boot Loader Configuration Screen

16. Select “Master Boot Record (MBR)” and Press OK on Boot Loader

17. Press Yes on Configure Network Interface Screen

18. Select “Activate on boot” and “Enable IPv4 support” and Press OK

19. Select manually and Type hostname (hadrian) and Press OK

20. Select “America/Los Angeles” and Press OK

21. Set Root password. See Figure 31.
Figure 31. CentOS Installation Root Password

22. **Unselect everything** from the menu and **Select** the “**Custom software Selection**” and press **OK**

23. **Unselect everything except “Base”** from the menu press **OK**

24. Press **OK** on Installation to begin screen. See Figure 32.
Figure 32. CentOS Installation in Progress

25. **Reboot** the system
Figure 33. CentOS Reboot

6.1.2 System Updated

After Completed installation proceed to system update.

Login as root by typing # yum –y update. See Figure 34.
Reboot the system after update completed. See Figure 35.
6.1.3 Firewall Configuration

After reboot the system, select “Firewall configuration” and press “Run Tool” see Figure 36.
Select “Enabled” on Security Level and Unselect “Disabled” on SELinux and Press “Customize”

Press OK

6.1.4 Network Configuration

Select “Network configuration” and Press “RunTool”

Select “Edit Devices” and Press “Enter”

Select “eth0” and Press “Enter”. See Figure 37.
Unselect “Use DHCP” and type the Hostname (caltemp.csusb.edu), configure:

IP, Netmask and Gateway.
Figure 38. System Hostname Configuration

Press “Save”. See Figure 39
Figure 39. System Save Configured Settings

Select "Edit DNS configuration" and "Enter". See Figure 40.
Enter **Hostname** and

Primary and Secondary **DNS1: 139.182.2.1**  **DNS1: 139.182.2.6**

and Search as **csusb.edu** and

Press **OK**

Press “**Save & Quit**”

Press **Exit**

**Reboot** the system as final task. See Figure 41.
6.1.5 Apache Server Installation

To begin the installation, download the apache http server 2.2 source code from the Apache website (http://httpd.apache.org/download.cgi).

To unzip the downloaded file, go to the directory location and type:

- `# cp –p httpd-2.2.17.tar.gz /usr/local/src/`
- `# cd /usr/local/src`
- `# tar xvzf httpd-2.2.17.tar.gz`
After the files are unzipped, proceed with the formal installation by changing to the local directory as follows:

- `# cp –p httpd-2.2.17.tar.gz /usr/local/src/`
- `# cd /usr/local/src`
- `# tar xvzf httpd-2.2.17.tar.gz`

To make sure the installation goes successful in its configuration type:

- `# /usr/local/apache/bin/apachectl configtest`

Startup apache at the first time by typing:

- `# /usr/local/apache/bin/apachectl start`

Before testing the server, check if the IP address is displayed correctly by typing the following command as a root:

- `# /sbin/ifconfig`

For clearer details see Figure 42.
Figure 42. Apache Server IP Verification Screen

```
[root@caltemp ~]# /sbin/ifconfig
eth0 Link encap:Ethernet  HWaddr 00:19:B9:2E:09:B4
    inet addr:139.182.237.58  Bcast:139.182.237.255  Mask:255.255.254.0
    inet6 addr: fe80::219:b9ff:fe2e:9b4/64 Scope:Link
    UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
    RX packets:6436458 errors:599740 dropped:0 overruns:0 frame:599740
    TX packets:747859 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:1620235512 (1.5 GiB) TX bytes:101214339 (96.5 MiB)
    Interrupt:16

eth1 Link encap:Ethernet  HWaddr 00:10:4B:2F:4D:DE
    inet addr:192.168.1.1  Bcast:192.168.1.255  Mask:255.255.255.0
    inet6 addr: fe80::10:4bff:fe2f:4de/64 Scope:Link
    UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
    RX packets:612829 errors:0 dropped:0 overruns:0 frame:0
    TX packets:644955 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:37716495 (35.9 MiB) TX bytes:39585594 (37.7 MiB)
    Interrupt:10 Base address:0xc00

lo Link encap:Local Loopback
```

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To verify the IP of the Server, open a browser and type the IP address 139.182.237.58 into the address bar and click <enter>. You will be able to see the “hello” text which means the page works. See Figure 43.

Figure 43. Apache Server Test Successfully Works

6.1.6 MySQL Installation

For the Web-Based Temperature Monitoring System for the College of Arts and Letters project, I used MySQL for the same reasons I used CentOS. It is open source and is highly reliable. It is the widely used software for data storage.

To start installing MySQL, download my MySQL from the website. I used http://dev.mysql.com/downloads/mirrors.html. Change the current directory to:

$ cd /usr/local/

When the files were extracted, they were placed in the /tmp directory, so the command to unzip is:

After installation, I needed to change the ownership of all MySQL files, and to run MySQL server service.

To change the ownership, type the following commands:

- `# cd /usr/local/`
- `# chown –R mysql mysql -5.1.69-pc-linux-gnu-i686 mysql`
- `# chgrp –R root mysql-5.1.69-pc-linux-gnu-i686 mysql`

The MySQL database consists of two sample databases named ‘test’ which the internal database uses to keep track of users and their permissions and ‘mysql’ database. See Table 3 (Server Databases).

To ensure that MySQL can run properly, we need to interact directly with these databases, so this means that the first time login has to be as a new mysql user (this is only the first time). As follows:

- `# su mysql`
- `# cd mysql`
- `# scripts/mysql_install_db`
- `$ exit`

Now, we continue to start MySQL application, as follows:

`# /usr/local/mysql/support-files/mysql.server start`

By typing mysql in the screen we can test if it downloaded successfully or not. See Figure 24.

To login into MySQL, type:
- $ mysql –u <username> –p

By entering the correct credentials, we can successfully log in to the MySQL database. See Figure 44.

![MySQL Login Screen](image)

Figure 44. MySQL Login Screen
6.1.7 PHP Installation

PHP is an open source web script language that is widely used in the construction of dynamic webpages.

For PHP installation, a terminal window is opened and the following commands entered:

- $ sudo apt-get install php5 libapache2-mod-php5.3.3

It is important to add an index.php file to the beginning of the index file. index.php file acts like a homepage that uses a common menu to save time when I add new pages to the website.

Restart the server as a final task. See Figure 45.

After the PHP installation process is finished, you will be able to use the application.
6.1.8 jQuery Libraries

jQuery Libraries runs inside the browser to display temperature graphs and retrieve data from the webserver.

I located the jQuery libraries under /var/www/html/monitor/js/ directory.

See Figure 46.
6.2 Server Host Names

I had to modify some of the default environment variables in the Linux system and host files on the Apache server configuration directory in order to correctly map to the website used for the Web-Based Temperature Monitoring System for the College of Arts and Letters.

6.2.1 Caltemp.csusb.edu and Caltempsensor1.csusb.edu

To see the hosts file open a terminal window and type: $ vi /etc/ hosts then click <enter>
You can see the localhost.localdomain, caltemp.csusb.edu, with its IP address 192.168.1.1, and caltempsensor1.csusb.edu with its IP address 192.168.1.80. See Figure 47 and 48.

Figure 47. Linux Host Names Configuration

The temperature of 75.10 (Fahrenheit) that Figure 48, is the current server room temperature measured by the Arduino sensor. We can open the browser and type the caltempsensor1.csusb.edu host name into the address bar to view the current temperature inside the server room.
Figure 48. Accessing Temperature Data Directly

75.10
6.3 Backup and Restore

A backup is very important. For this project, I will be implementing two backups – one for MySQL database and one for the PHP, C++ and Java Script program files. For the MySQL database backup, I utilized the one used by the system. And for the program files, I used the second drive storage which is attached to the system.

6.3.1 System Backup

On the system backup, I need to back up all of the files, including all subdirectories that are located in the directory /var/www/html/monitor. In order to do it, we need to compress the program to a “tar” file. The following command is used to back up the entire directory:

```
tar czf monitor_backup.tar.gz var/www/html/monitor/
```

6.3.2 Database Backup

For database data backup, I implemented the tool that comes with the original MySQL software, which is mysqldump. Open a terminal and type the following command:

```
mysqldump monitor –u root –p > mysqldum.sql
```

Note: For the above command, you need to know the root password.
6.3.3. System Restore

System restore is an easy task when you have backed up the system periodically. To restore, extract the backup file by using the following command:

```
tar –xzvf monitor_backup /
```

Enter the following command to restore the extracted files into the proper directory system: `tar –xzvf monitor_backup /` command.

6.3.4 Database Restore

To restore the database, enter the following command into the terminal:

```
mysqldump monitor –u root –p < mysqldum.sql
```

Note: For the above command you need to know the root password.
7.1 Conclusion

The Web-Based Temperature Monitoring System for the College of Arts and Letters helps users keep track of the College of Arts & Letters’ server room temperature from a remote location. The project’s mission is to inform system administrators via email/text if a critical temperature has being reached inside the server room, as well as provide a method for displaying the current server room temperature.

This system will improve the productivity of system administrators by providing remote access to temperature information and will reduce the likelihood of costly hardware failures caused by heat.

The system can be accessed via the Internet through various browsers, including Google Chrome and Mozilla Firefox. The user must have an account to access the system.

The Web-Based Temperature Monitoring System for the College of Arts and Letters has been designed and implemented with highly effective contemporary hardware and software technologies, whose primary function is to make it flexible for future enhancements and improvements.
REFERENCES


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