
AC 2012-4815: REMOTE CONTROL MONITORING OF BIOREACTORS

Ms. Kavya Mandhadi, University of Houston

Kavya Mandhadi is a graduate student at University of Houston. She is pursuing her degree in engineering technology at the College of Technology. Her objective for graduate thesis has been to make the existing network in bioprocessing lab a more secure one. Rupa Iyer, Ph.D., is an Associate Professor in the Department of Engineering Technology, in the College of Technology at the University of Houston. She is the founding director of Biotechnology programs and also directs the Center for Life Sciences Technology. In this capacity, she has been responsible for developing the biotechnology degree program and the core initiatives of the center that include, education, research workforce development, and outreach. Her research interests are in environmental biotechnology and interdisciplinary research- based education.

Dr. Rupa Iyer, University of Houston

Rupa Iyer, Ph.D., is an Associate Professor in the department of Engineering Technology, in the College of Technology at the University of Houston. She is also the founding director of Biotechnology programs and the Center for Life Sciences Technology. In this capacity she has been responsible for developing the Biotechnology degree program and the core initiatives of the center that include, education, research, workforce development and outreach. Her research interests are in environmental biotechnology and interdisciplinary research- based education.

REMOTE MONITORING OF BIOREACTORS

Kavya Mandhadi, Rupa Iyer
Engineering Technology Department
University of Houston

Abstract

A Bioreactor is a system or a device that supports a biologically active environment. Bioreactors are used as the primary device for fermentation by biochemical engineering researchers to grow various cells and tissues and analyze them. The University of Houston uses New Brunswick Scientific Bioflow 110 bioreactor to grow transformed bacterial cells in the context of cell culturing. This paper details a study of the existing system network architecture of the bioreactor system. The Primary control unit (PCU) is the heart of BioFlo110 and its parameters can be accessed alternatively through a serial connection between the bioreactor and the desktop. Data sharing and exchange is done between the onsite desktop and a remote server. This paper proposes the use of databases for retrieving and sharing data between the onsite desktop and the server for achieving the bioreactor generated data unlike in the existing system.

Introduction

Bioreactors are used as a primary device for fermentation by biochemical engineering researchers, to grow various cells and tissues and analyze them in the context of cell culturing. The BioFlo 110 is a fermenter/bioreactor system specifically designed for simple, intuitive operation with the power and versatility to meet the ever-changing needs of busy research labs. The Primary Control Unit (PCU) is critical to the bioreactor, which provides a highly controlled environment for biological systems for the development of cells.

Currently the data transfer and retrieving between the University of Houston server and the onsite desktop are done using a standard network protocol called File Transfer Protocol (FTP), which in general is

used to transfer files from one host to another over a network. FTP was not designed to be a secure protocol—especially by today's standards—and has many security weaknesses. FTP was not designed to encrypt its traffic; all transmissions are in clear text, and user names, passwords, commands and data can be easily read by anyone able to perform packet capture (sniffing) on the network. A common solution to this problem is use of the "secure" alternative discussed further in the paper that can handle this.

This paper proposes a technique for alteration of the data transfer through a more reliable alternative for archiving the data generated and improved security of data exchanges between the onsite desktop and a remote server. Without security any outsider other than the lab personnel or students may break into the bioreactor website and make undesired changes which leads to different results than expected. Hence there is a need to secure the file transfers. The bioreactor generated data can be achieved by using databases for data transfer and retrieval between the remote server and the onsite desktop. MySQL Databases provide strong data protection and offers exceptional security features that ensure absolute data protection. In terms of database authentication, MySQL provides powerful mechanisms for ensuring only authorized users have entry to the database server.

System Description:

This section expands upon the overall existing architecture and the method of communication among the components of the system.

Figure 1 represents the architecture of the overall system of the bioreactor and communication among the components. The desktop computer is serially connected to the bioreactor via RS-232 serial cable. The bioreactor data from the onsite desktop is communicated to the server using FTP through the University of Houston network.

The PCU parameters of BioFlo 110 can be alternatively accessed through that serial connection existing between the desktop and the bioreactor itself. A set of pre-defined commands are used by the desktop to capture and store the bioreactor information in the form of text files on its hard drive.

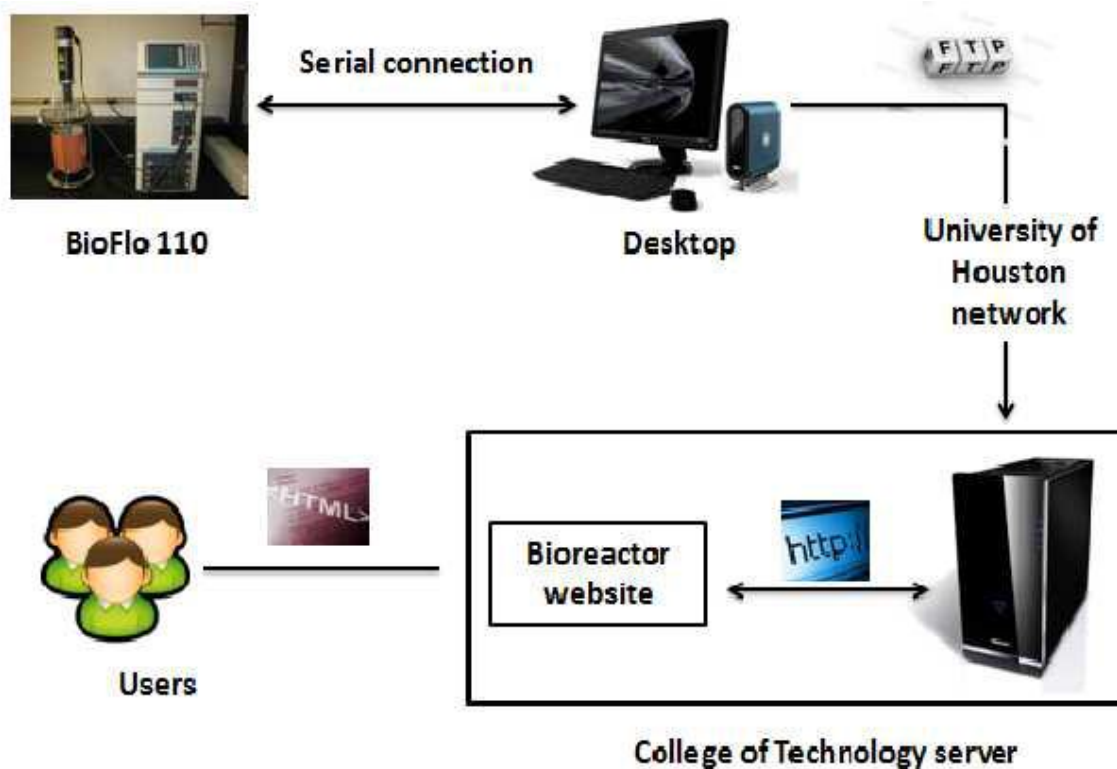
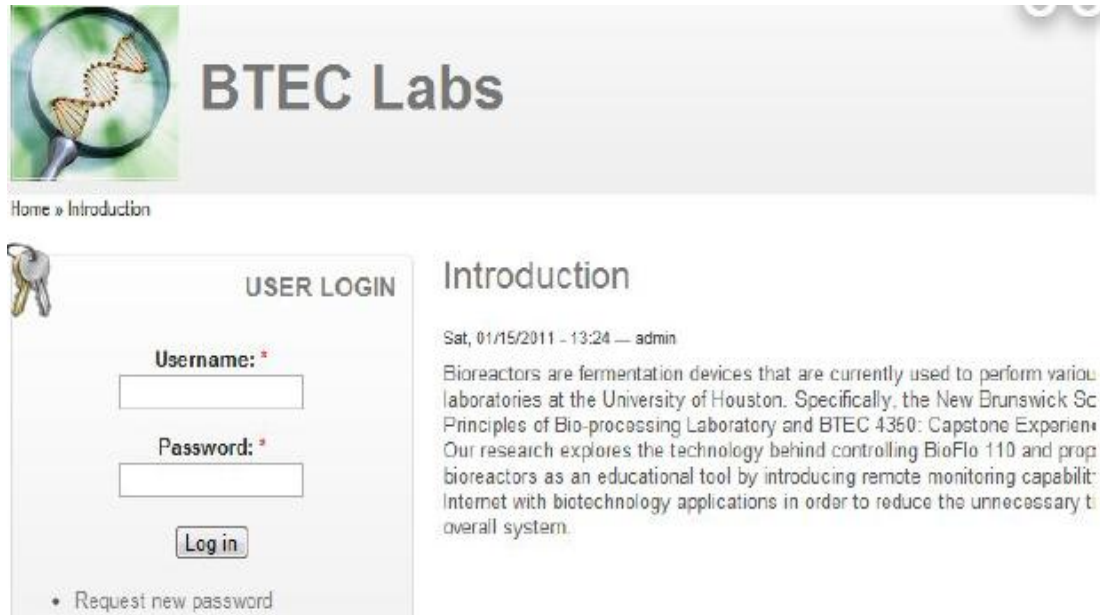


Figure 1. Existing System Network Architecture

The existing application converts the stored information into a unique format and transfers the files through the University of Houston network to the web server in the College of Technology. The users can utilize the application settings to store the bioreactor parameters and adjust their experimental parameters. The server updates the web page contents dynamically with live experimental data every time a user connects to bioreactor website. A bioreactor website was created to allow the lab instructors and students to remotely view and edit their experiment parameters and settings reducing the overall time spent in the laboratory providing flexibility to the overall system.

As shown in the above figure, the communication between the desktop and the College of Technology server exists through an FTP. Bioreactor website in Fig. 1 is designed to facilitate the students and lab personal to log in into the site and monitor the bioreactors remotely.

Below is the picture of the website students can log in and view the bioreactor values.



The screenshot shows the BTEC Labs website interface. At the top left is a logo featuring a magnifying glass over a DNA double helix. To its right is the text "BTEC Labs". Below the logo is a breadcrumb trail: "Home » Introduction". The main content area is split into two columns. The left column contains a "USER LOGIN" form with a key icon, fields for "Username:" and "Password:", a "Log in" button, and a link for "Request new password". The right column is titled "Introduction" and contains a post dated "Sat, 01/15/2011 - 13:24" by "admin". The text of the introduction reads: "Bioreactors are fermentation devices that are currently used to perform various experiments in the laboratories at the University of Houston. Specifically, the New Brunswick Science and Technology Center (NBSTC) Principles of Bio-processing Laboratory and BTEC 4360: Capstone Experience. Our research explores the technology behind controlling BioFlo 110 and proprietary bioreactors as an educational tool by introducing remote monitoring capabilities. We are currently working on Internet with biotechnology applications in order to reduce the unnecessary time and cost of the overall system."

With the help of the website only current values can be viewed. That is, a live view of the data is provided as shown in the below figure. The values for all the bioreactors in the lab can be seen with the help of live view.



BTEC Labs

Home » BioFlo "A"

LIVE VIEW

- BioFlo "A" ✓
- BioFlo "B"
- BioFlo "C"

STUDENT 1

- My account
- Log out

BioFlo "A"

Tue, 02/15/2011 - 20:11 — admin

BioFlo A
Time: 8:41:48 pm

	Temp	Agit	PumpA	PumpB	PumpC	pH	dO2
Control	Auto	dO2	Off	Off	Off	Auto	Auto
Cur-Value	29.977	200.03	0.0000	0.0000	0.0000	7.0093	114.61
OP Points	30.000	200.00	100.00	20.000	50.000	7.0000	100.00
Output%	9.0256	25.872	0.0000	0.0000	0.0000	0.0000	0.0000
Unit	DegC	rpm	%	%	%	pH	%

Refresh

But, the disadvantage here is that the values previously generated cannot be viewed as the data is not being archived. The proposal to use databases provides a solution for this. With the help of databases all the data generated by the bioreactor will be saved for any future reference.

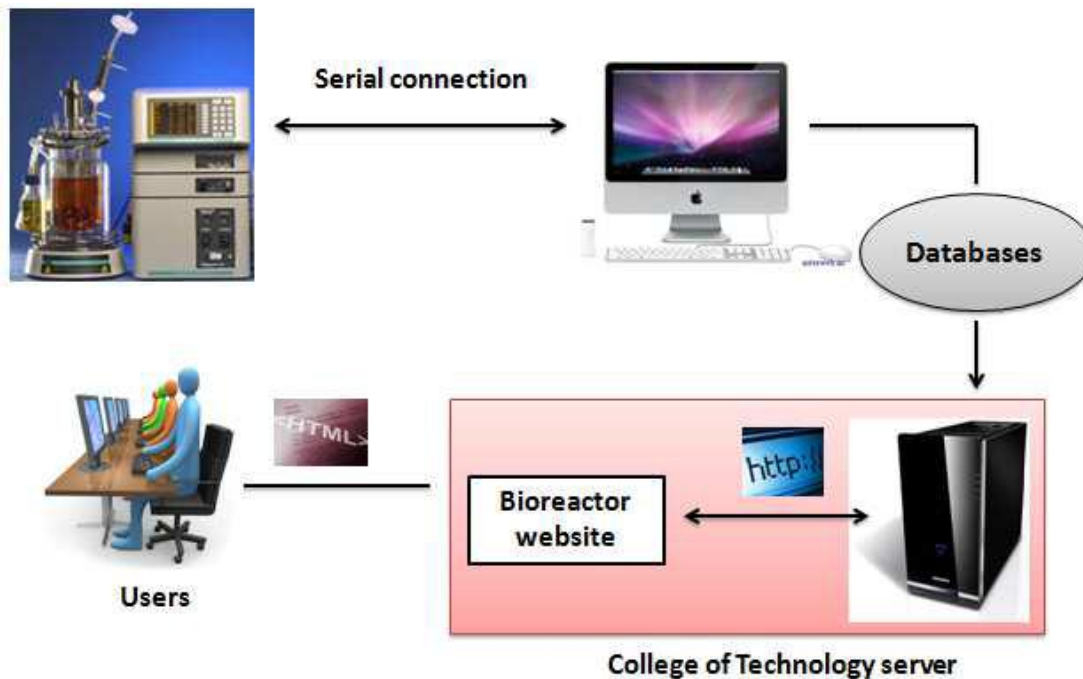


Figure 2. New System Architecture

This paper proposes a new system with databases in place of FTP to exchange data to store the data and to improve the security. This alternate is important for another reason of providing Backup and Recovery. A Database provides recovery and backups from the system failures including disk crashes and power failures, which may help the database to recover though methods are very complex to the state that existed prior to the occurrence of the failure.

However, when working with the Databases, the MySQL connector actually fetches the ENTIRE dataset into memory. The MySQL Connector is a driver for connecting to a database server through the standard Open Database Connectivity (ODBC) application program interface. This, of course, would probably result in OutOfMemoryErrors when working with large datasets. It may not be able to handle this situation.

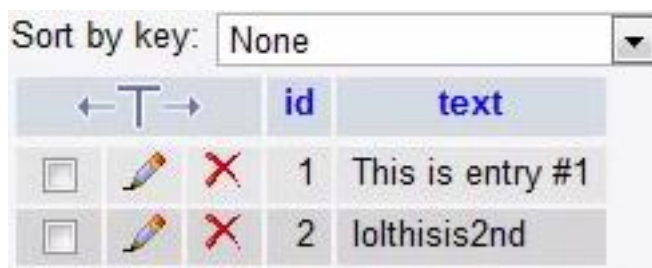
As the data generated by the bioreactors is saved every time it is generated storage space could become an issue. In the long run data older than a certain period can be erased so that new data can be saved.




A C# program is used to create, write, select and read from a database and was tested on a sample table.

Steps involved:

1. Creating a database
2. Selecting data from the database
3. Inserting data into the database
4. Updating the existing database

A sample is created with rows as shown in the below figure. That table is created using MySQL.



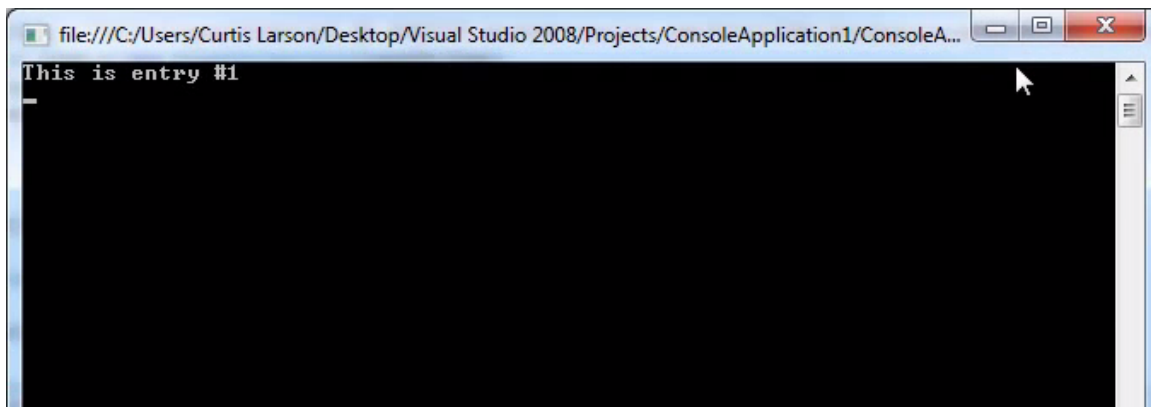
Sort by key: None			id	text
<input type="checkbox"/>			1	This is entry #1
<input type="checkbox"/>			2	lolthisis2nd

The manipulations such as selecting, inserting and updating of the table can be done by the following code. Data from the table is selected using a “Select from table”. Similarly, “Insert” and “Update” for inserting and updating the table.

```
MySQLConnection conn = new MySqlConnection(connString);
MySQLCommand command = conn.CreateCommand();
command.CommandText = "Select text from tutorialTable where id=1";
try
{
    conn.Open();
}
catch (Exception ex)
{
    Console.WriteLine(ex.Message);
}
MySQLDataReader reader = command.ExecuteReader();

while (reader.Read())
{
    Console.WriteLine(reader["text"].ToString());
}
Console.ReadLine();
```

As shown in the below figure, the text from row #1 is selected and displayed.



A bioreactor table as shown below is created. Operations like updating, selecting and inserting can be done within the table.

	Temp	Agit	PumpA	PumpB	PumpC	pH	dO2
Control	Auto	dO2	Off	Off	Off	Auto	Auto
Cur:Value	29.977	200.03	0.0000	0.0000	0.0000	7.0093	114.61
OP Points	30.000	200.00	100.00	20.000	50.000	7.0000	100.00
Output%	9.0256	25.872	0.0000	0.0000	0.0000	0.0000	0.0000
Unit	DegC	rpm	%	%	%	pH	%

Providing the students and instructors with remote monitoring of bioreactors reduces the time spent unnecessarily in the laboratory assuring the experiment is being carried out properly without onsite supervision. In case of any modifications the desktop data can be used to make necessary changes. All the information being sent and received can be assured of safety by using the databases for information exchange instead of FTP as proposed in the paper.

Conclusion

Cell culturing and bioprocessing requires sensitive and highly controlled environments. The produced results require tracking and archiving of all the parameters. It is necessary that this important data is being sent and received securely over a network. The alternative introduced in this paper allows the data to be exchanged securely and reliably over a network offering improved security of data exchanges between the onsite desktop and a remote server. This can be achieved by the use of databases for data transfer and retrieval between the remote server and the onsite desktop.

References

1. Givmanesh, A., Iyer, R. (2011) "Enhancing Bioreactor Functionality in Bio- Processing Courses", Computers in Education Journal, Vol 2, (4), 2-12.
2. Givmanesh, A., Iyer, R., Benhaddou, D. (2011) "Integrated Remote Management for Bioprocessing Experiments", International Journal of Engineering Research and Innovation, Vol 1, (1), 75-77.
3. Widenius, M., (2002) "MySQL reference manual: documentation from the source", O'Reilly Media.
4. Abrams, MD., (1995) "Information Security: An Integrated Collection of Essays", IEEE Computer Society Press Los Alamitos.