

Classroom Exercises for Client-Server Infrastructure Creation

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Abstract

The demand is increasing for client-server developers and personnel that can create an infrastructure to support these types of applications (Scarsella & Stofega, 2021). To keep pace with the demand, educators and schools are increasingly required to provide the necessary skills and training. In this research article, the demand and career pathways for client-server application development, client/server environments and infrastructures, and classroom exercises to teach client-server application development are presented.

Introduction

The goal of this article is to provide educators the necessary tools and information in order to teach students how to create their first client-server application. The article begins by providing a common set of definitions related to client-server application development. Next, a literature review specific to application development (e.g., history, demand, careers, and market space) is presented. Within the literature review, the history of client server programming and modern client server architecture is presented. This will set the context for further discussion of the domain. Then the importance of teaching application development is discussed in the context of career pathways within the field. Finally, four classroom exercises are presented that will engage students in learning about client-server infrastructure, database deployment, and application development. Although the focus of this research article is on the pedagogical aspects of client-server application development, it is important to note that the application development exercises will result in a fully functional application on a local Windows machine that connects to a MySQL database on a Windows Server.

Definitions

Application development - The process of designing (software development) for a computational system. This process may include programming, designing, testing, debugging, and maintaining software.

Client (or Client Application) - An application either on a desktop, laptop or mobile (i.e, phone) device that makes requests to a server.

Client server - A distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters called clients.

Database - An organized collection of structured information, or data, typically stored electronically in a computer system.

Integrated Development Environment (IDE) - A comprehensive software development environment that provides editing, publishing, debugging, and compiling features all in one package.

Server - The back-end system of a database application in a client-server architecture that performs tasks such as data analysis, storage, data manipulation, archiving, and other non-user-specific tasks.

Literature Review

In this section, the authors will present a review of the literature pertinent to the discussion on client-server and mobile application development. This review will begin by describing the history and evolution of mobile applications then exploring the demand for client-server applications as well as their market space. Following that, career pathways and educational requirements for client-server application developers will be discussed. Finally, the income potential, as well as the responsibilities of the developers, will be explored.

Technology has always been evolving and changing for years and will continue to do so in the virtually driven world. The history of the mobile app began with the first development of the mobile device and the first mobile phones whose microchips required the most basic of software to send and receive voice calls in 1973 (Suihi & Mwakalonge, 2016). Mobile phones were initially designed for functions like calling and sending texts, however, over the years phones were designed with some simple mobile applications like calculators, calendars, and simple games developed in the Java Framework. The first-ever developed smartphone was from IBM in 1973 that had simple mobile application functions (Jamsheer, 2019).

Even in the modern era, client server architecture is a popular architecture in many respects and is implemented in a variety of ways. Sharma and Kumar (2021) discuss the architecture in terms of facilitation of input from a large number of users providing a large amount of data. In their system, they provided online students a way to provide course feedback. The system saved months in terms of manual (i.e., human) processing of the traditional paper feedback forms. Additionally, no postage was required. This resulted in a faster and less expensive system. This phenomenon tends to be a driving force behind the architecture: better, faster, more agile, and less expensive than other alternatives.

Pathways to careers in application development.

Demand for mobile applications. The demand for mobile application developers is expected to grow dramatically over the next several years. Estimates expect the market to reach between \$407 billion (Allied Market Research, na) and \$653 billion (Technavio) industry by 2026. That is an annual growth rate of 18% to 21%, respectively. Fueled by this expected growth in the market, the demand for mobile application developers is high.

The Bureau of Labor Statistics (2021) indicated that there were 1,469,200 mobile application developers in 2019. That number of jobs for mobile application developers is expected to increase by 22% through 2029. The median salary for the job has been estimated to be between \$77,000 - \$110,00 (Bureau of Labor Statistics, 2021, Payscale.com, 2021, Salary.com, 2021). This demand is why CNN Money (2017) identified mobile application developers as the number one job in their list of 100 best jobs in America.

The market space for mobile application development has increased significantly over the very

short term and is projected to grow substantially in the future. According to Statista (2021), mobile application downloads worldwide in 2020 were 218 billion and are projected to reach 297.8 billion by 2023. This represents a large-scale demand-side pull for mobile application programmers.

Pathways to careers in mobile application development.

Responsibilities. While coding is at the heart of an application developer's work (either on the client side or the server side), it is not their only responsibility. Indeed.com (2021) provides a comprehensive breakdown of these responsibilities:

- Working with the client to identify the application requirements
- Developing a prototype of the application
- Testing prior to the launch of the application
- Troubleshooting and debugging
- Updating existing applications
- Developing documentation

Education. In order to be a mobile application developer, it is best to be able to code in a variety of programming languages such as JavaScript, Kotlin, C++, C#, Python, PHP, and Swift (Moyers, 2021). Most mobile application developers have received a bachelor's degree in computer science (Zippia.com, 2020). The Bureau of Labor and Statistics (U.S. Bureau of Labor Statistics, 2021b) does note, though, that companies also hire programmers who have only earned an associate's degree.

Earning potential. The earning potential for mobile application developers is quite good. Entry-level mobile application developers can expect to earn around \$60,000 - \$65,000 (Glassdoor, 2021; Payscale.com, 2021; Salary.com, n.d.). As they progress in their careers, mobile application developers have the potential to earn as high as \$120,000.

Pathways to careers in database developer/administrator.

Responsibilities. The lifeblood of any organization is information. Access to relevant data in a timely fashion and appropriate format is what allows organizations to make informed, strategic decisions. It is expected that the amount of data created, consumed, and stored globally will reach 79 zettabytes in 2022 and exceed 181 zettabytes by 2025 (Holst, 2021). It is the responsibility of database developers to design and secure the databases that will host this enormous volume of data in a format that facilitates queries and analysis. Specific duties defined by the U.S. Bureau of Labor Statistics (2021a) include:

- Ensure that data is secure
- Identify needs for databases
- Conduct testing and implement improvements
- Provide users with access and permissions
- Merge old databases into new ones
- Monitor database performance
- Troubleshoot and fix problems

Education. Most companies expect database developers to have earned at least a bachelor degree that contains relevant database coursework (DiscoverDataScience.org, 2021; U.S. Bureau of Labor Statistics, 2021a). Typically, the degree will be in computer science, information technology, or in business. In addition to the degree, there are many industry certifications that evidence knowledge of vendor-specific database applications from companies like Microsoft, Oracle, and IBM .

Earning potential. Being a database developer is another lucrative career. Entry level database developers can expect to earn \$60,000 - \$66,000 (Glassdoor.com, n.d.; Salary.com, 2021). Experience and certifications can quickly increase earning potential to an average salary of \$90,000 - \$95,000 (Glassdoor.com, n.d.; Indeed.com, 2021a; Salary.com, 2021). It is expected that the demand for database developers will grow 10% from 2019 through 2029 (U.S. Bureau of Labor Statistics, 2021a)

Classroom Activities

1. **Windows Server (free trial) setup**
2. **Install MySQL (free, open source)**
3. **Install Visual Studio Community Edition (free) on the client machine**
4. **Program the SQL select on the client**

The following classroom activities are designed to engage students in the exploration of client-server programming. There is no *a priori* knowledge of mobile application development required for either instructors or students. However, basic computer, mathematics, proficiency with personal computers, and some knowledge of application development environments are required. Some knowledge of networking (TCP/IP) as well as basic operating system setup and administration is required.

The setup and lab environment is crucial to success. The exercises are predicated upon their order of precedence. Each exercise is dependent upon the successful completion of the previous exercise. All software is provided for free, Open Source, or a free trial for 180 days.

These activities are meant to build upon each other. The first exercise sets up the server in which the data will reside. The second exercise installs the specific database (MySQL) in which the data from the client will reside on the server. The third exercise is an activity that will set up Visual Studio and ready the environment for programming a client within the IDE. The final activity will teach students how to write a client program that selects data from the above database and displays it on the local machine.

Learning Objectives

1. Students will demonstrate the ability to set up a Windows Server.
2. Students will demonstrate the ability to install MySQL.
3. Students will demonstrate specific knowledge of an application development environment.
4. Students will synthesize knowledge gained in the previous learning objectives to create a client application.

Required Materials

1. Windows PC with Web Browser
2. Internet Connectivity
3. MS Visual Studio IDE

Classroom Exercises

1. Installation of Windows Server 2019.
 - a. The instructor begins the discussion on Server machines. The following definitions and concepts should be explained:
 - a. Explain the role of a server
 - b. Data repository
 - c. High availability
 - b. Students may review the literature on the Internet for further information and discussion on the function of a server.
 - c. The instructor will then demonstrate the download and install of MS Windows Server: <https://www.microsoft.com/en-us/evalcenter/evaluate-windows-server-2019> .
 - d. Students should familiarize themselves with the System Requirements for installing Windows Server (Microsoft, 2020).
 - e. Students will then download/install Windows Server Standard edition using the following step-by-step instructions: <https://www.c-sharpcorner.com/article/step-by-step-installation-of-windows-server-2019-standard2/>
2. Installation of MySQL
 - a. The instructor begins the discussion on Server machines. The following definitions and concepts should be explained:
 - a. Explain the role of a database
 - b. SQL
 - c. Queries
 - b. Students may review the literature on the Internet for further information and discussion on SQL and databases.
 - c. The instructor will then demonstrate the download and install of MySQL and MySQL workbench <https://dev.mysql.com/downloads/installer/> .
 - d. Students should familiarize themselves with the System Requirements for installing MySQL and MySQL workbench (Oracle, 2010).
 - e. Students will then download/install MySQL and MySQL Workbench on Windows using these instructions:
 - a. MySQL for Windows Server:
<https://dev.mysql.com/doc/refman/8.0/en/windows-installation.html>
 - b. MySQL Workbench for Windows Server:
<https://docs.oracle.com/cd/E19078-01/mysql/mysql-workbench/wb-installing.html>
 - f. The default installation will install a sample database named “sakila”
3. Installation of MS Visual Studio.
 - f. The instructor begins the discussion on IDEs. The following definitions should be explained:

- a. Application development
 - b. Mobile application development
 - c. Integrated Development Environment
 - g. Students may review the literature on the Internet for further information and discussion on IDEs.
 - h. The instructor will then demonstrate the download and install of MS Visual Studio 2019 Community Edition:
<https://visualstudio.microsoft.com/vs/community/> .
 - i. Students should familiarize themselves with the System Requirements for installing Visual Studio and reference the systems requirements in the References section (Microsoft, 2019)
 - j. Students will then download/install MS Visual Studio 2019 using the instructions found on: <https://visualstudio.microsoft.com/vs/getting-started/>
4. Client-side programming in MS Visual Studio.
 - a. The instructor begins the discussion on client-server architecture. The following definitions should be explained:
 - a. Programming
 - b. Algorithms
 - c. Client vs. Server concepts
 - b. Students may review the literature on the Internet for further information and discussion on client-server programming.
 - c. Students will start Visual Studio.
 - a. Select “Create a new project”
 - b. Select “Windows Forms App (.Net) in C#”
 - i. The instructor/students can select another language (depending upon familiarity). However, the code in this article is programmed in C#.
 - ii. Name and create the project being mindful of the location on disk in which the project is stored.
 - iii. A blank form within the VS IDE will show.
 - d. In order to attach to a MySQL database, a database connector must be added to the project.
 - a. Select Tools, NuGet Package Manager, Manage NuGet Packages.
 - b. Select MySqlConnection (see Figure 1).

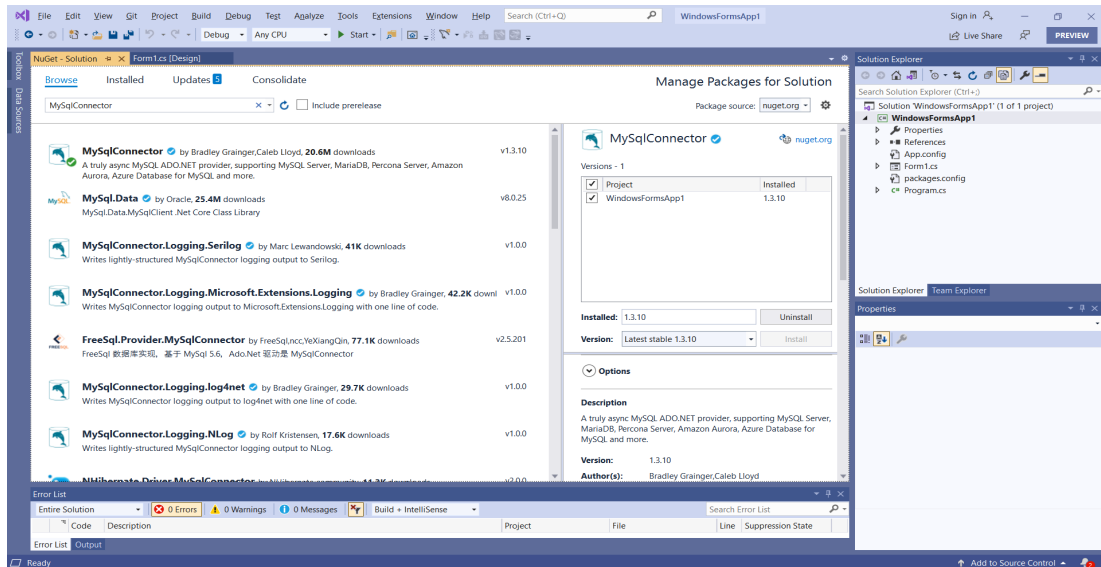


Figure 1. Nuget MySQLConnector Package.

- e. From the toolbox select the following and drag them to the black Windows Form:
 - a. Button
 - b. TextBox
- f. Doubleclick the Button1 on the form.
- g. In the Form1.cs (programming code), add the following in the using statements area:
 - a. Using MySqlConnection;
- h. In the Button1_Click module are the following statements:
 - a. `MySqlConnection con = new MySqlConnection("server=nnn.nnn.nnn.nnn;user id=youruser;password=yourpassword;persistsecurityinfo=True;database=sakila");`
 - i. Where server=... Is the IP address of your Windows Server.
 - ii. Where id= a valid userID of that sakila database
 - iii. Where password= a valid password for the user
 - b. Seven other statements shown in Figure 2.
- i. Click on the green Start arrow in the Visual Studio Toolbar. The program should run.
- j. Then click on button1 in your program and it will select (from the MySQL database) the actress Penelope Guinness (see Figure 2).

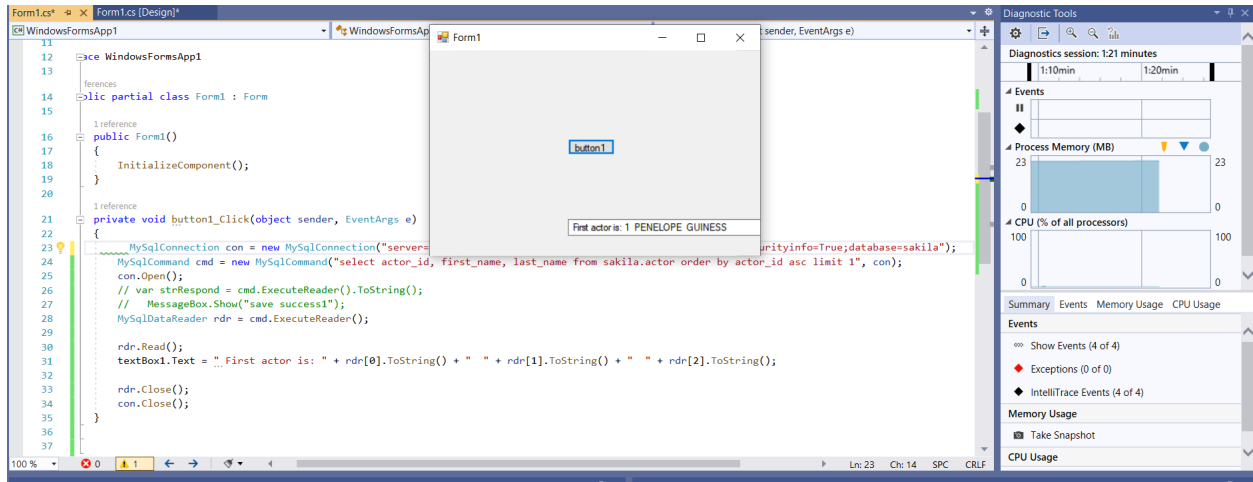


Figure 2. Running client application.

Conclusion

In this article, the authors begin by providing a literature review and definitions specific to client-server application development and teaching application development in the classroom. Definitions of terms pertinent to client-server application development were provided. A discussion of the importance of teaching application (client-server) development was presented as well.

At the culmination of this article, four classroom exercises were presented that will engage students in learning about client-server application development. Instructions for setting up a complete Windows Server with a MySQL database were provided. Additionally, instructions to write an application that selects data from a MySQL database were provided. Instructors can follow the steps outlined above and students will create their own local client-server application.

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