



**ASHESI UNIVERSITY
COLLEGE**

IMPLEMENTING AN ONLINE AUCTION SYSTEM

APPLIED PROJECT

B.Sc. Computer Science

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2017

ASHESI UNIVERSITY COLLEGE

Implementing an Online Auction System

APPLIED PROJECT

Applied Project submitted to the Department of Computer Science,
Ashesi University College in partial fulfilment of the requirements for the
award of Bachelor of Science degree in Computer Science.

Youssouf J. O. da Silva

April 2017

DECLARATION

I hereby declare that this applied project is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

.....

Candidate's Name:

.....

Date:

.....

I hereby declare that preparation and presentation of this applied project were supervised in accordance with the guidelines on supervision of applied project laid down by Ashesi University College.

Supervisor's Signature:

.....

Supervisor's Name:

.....

Date:

.....

ACKNOWLEDGEMENT

I would like to first give thanks to God for the completion of this project. I would like to thank Him for the strength He gave me during my four years at Ashesi University College and the execution of this project.

I would like to express my profound gratitude to my project supervisor Mr. David Amatey Sampah, for his invaluable guidance, suggestions and criticisms through the successful completion of this project.

I also wish to thank my parents for their support in all areas. They provided resources and support that facilitated the successful completion of the project.

The completion of this project was especially made possible thanks to the knowledge acquired over the years. Consequently, a special appreciation goes to all my lecturers at Ashesi University College. I would like to appreciate the effort of all my classmates who assisted me whenever I needed some form of help in various aspects of the project development.

To all of you, I say thank you.

ABSTRACT

Research shows that Africa's growth in international Internet capacity outpaces all other regions of the world. Between 2014 and 2015, the internet bandwidth in Africa grew by 41% and by 51% when compounded annually over the past five (5) years ("Africa leads world in Internet growth | TechCentral", 2017). This has led to the proliferation of online applications and electronic commerce. This project seeks to develop an online auction application for the Ghanaian market in an effort to bridge the gap between sellers and buyers.

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Chapter 1: Introduction

1.1. Background Information

The internet usage in Africa is growing fast. According to Forbes, “Africa's internet growth is faster than anywhere else...” (Shapshak, 2016). This phenomenon does not leave Ghana unaffected. The advancement of the internet brings various business opportunities such as online stores, online marketing through blogs and websites where anyone can buy and sell products. One of such business opportunity is the online auction to be implemented in this paper.

To function properly, businesses need equipment, including appliances like air conditioners, fridges and furniture like chairs, tables, etc. In Ghana, like many other countries, the process of acquiring and disposing of these equipment is stressful and limited.

For acquisition, options include:

- to order for the furniture to be built
- to purchase the equipment:
 - ✓ In a shop
 - ✓ From abroad and import it
 - ✓ From a seller by the street

For disposal, most companies simply:

- Throw old equipment away
- Sell them to employees willing to purchase them.

In the case of computers, services in the U.S. “are available to wipe hard drives and eliminate any residual information on your IT equipment before it is thrown out.” (Sutter, 2014).

1.2. Problem Statement

The cost of buying new equipment is usually high. Normally, it is better to purchase new business equipment as they are more likely to last long and perform very well. However, when the budget is limited, it is preferable to buy slightly used items. “Keep in mind that you can expect to find savings of at least 25 to 50 percent on used equipment” (Trade, 2015). This results in many companies not buying new or used business items with high prices.

In addition, companies in need of business items lose the ability to buy slightly used ones when other companies dispose or throw away old but usable items. On the other hand, some companies sell their items at very low prices. These are examples of companies that could make more profit from their unused items.

The solution to this problem is to develop an online auction application where businesses can upload old but usable equipment and other businesses can buy needed equipment.

1.3. Project Objectives

This project seeks to undertake the following objectives:

- Give businesses multiple options to choose from during acquisition or disposal of equipment
- Reduce the time taken when searching for equipment
- Give product manufacturers a platform where they can reach a large number of businesses directly to market their products

- Reduce the cost incurred by acquiring equipment
- Provide a strategy to price for old usable equipment

1.4. Motivation

One summer, the company where I was doing my internship was trying to acquire new furniture and business items for their new office. We toured stores in Ghana, but everything was too expensive for our limited budget. We then went online and found what we were looking for within our price range. However, we found the items on foreign auction websites. The cost incurred from shipping the items and the time we would have to wait before they arrive in Ghana made us reconsider buying from a foreign auction website. We had to settle for the new and expensive items we found in the stores and buy the bare minimum we needed. That was when I realized that an auction website for Ghanaians was a necessity.

1.5. Assumptions

In developing this solution, I am making a few assumptions:

- The user of the system can read and understand basic English.
- The user has access to and knows how to use a computer.
- The user has access to an internet connection.

1.6. Significance of the Project

This project attempts to bridge the gap between companies that have or are looking for reusable business equipment. This will make equipment available for other companies at a cheaper price on a platform to generate profit.

Chapter 2: Background and Related Work

2.1. Introduction

Auction is a term used to refer to types of sales where the price is neither set nor arrived at by negotiation, but discovered through the process of competitive bidding. ("BusinessDictionary.com", 2017) An auction is complete when a bid is accepted by the seller (or the buyer for a reverse auction).

The Cambridge Dictionary defines a bid as being the act of offering “a particular amount of money for something that is for sale and compete against other people to buy it, especially at a public sale of goods or property” (Dictionary, 2017).

An online auction is a computerized system that facilitates the use of auctions on computers through the use of websites. This is clearly captured by the following Business Dictionary sentence when they state that, “The internet age has transformed auction into a truly open process in which thousands of goods (from books to ships) and services (from air travel to legal advice) may be offered for bidding by anyone from anywhere and at any time on websites such as eBay.com.” ("BusinessDictionary.com", 2017)

The application under development is a business-to-business online auction targeted at two businesses: businesses with old but usable equipment they wish to dispose of and businesses wishing to acquire usable equipment at a low price.

2.2. Online Auction Technologies

Online auctions exist because of the possibilities created by the internet. Thus, web applications are the only major technologies used in developing online auctions. Through the internet, online auctions connect buyers and sellers regardless of their geographic location.

The main programming language used for developing this online auction application is JavaScript. This was possible with the use of the MEAN stack. MEAN stands for MongoDB, ExpressJS, Angular 2 and NodeJS. MongoDB was used for storing information (the database), NodeJS was used to query the database (the back-end server), ExpressJS was used to send the queried information to the front-end using JSON objects (the routing framework) and Angular 2 was used to display information to the user (the front-end server).

MongoDB:

MongoDB is an open source database that stores data using a flexible document model called BSON that is a binary version of JSON (JavaScript Object Notation). As explained by MongoDB.com, “BSON extends the JSON model to provide additional data types, ordered fields and to be efficient for encoding and decoding within different languages.” (“JSON and BSON”, 2017)

ExpressJS:

ExpressJS is a lightweight server side JavaScript framework that adds routing capabilities a website using NodeJS on the server side. (WODEHOUSE, 2017).

Angular 2:

Angular 2 is an open-source framework written in JavaScript for developing client-side websites. As put by its official documentation, “Angular 2 is a structural framework for dynamic web apps. It lets you use HTML as your template language and lets you extend HTML's syntax to express your application's components clearly and succinctly.” (“AngularJS: Developer Guide: Introduction”, 2017)

NodeJS:

NodeJS is an open-source runtime environment written in JavaScript for developing networking and server-side applications. Its official documentation states that, “Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient.” (“Node.js”, 2017)

2.3. Online application features

An online application should have some of the features listed below:

- I. The website should be user friendly
- II. The website should be available at all times
- III. The website should be secured
- IV. The website should always perform effectively, efficiently and accurately

2.4. Existing Solutions

The internet is an interconnected network of computers and it has been used for commerce more and more in recent years under the term of electronic commerce (e-commerce). The focus of this project is an online auction e-commerce that enables the buying and selling of goods through a dynamic pricing strategy. In this section, some of the existing implementation of e-commerce will be discussed.

One of the implementations of online auctions was done by Henry Chan, Irene Ho and Raymond Lee at the Hong Kong Polytechnic University. (Chan, Ho, & Lee, 2001) Their approach was to implement a mobile agent-based auction system. In their implementation, they used the following architecture: Access, Auction logic, Database, Management System and other support systems. The access level is to provide access to the system through the web and mobile devices. The auction logic handles different types of auction techniques. The database is used to store auction-related information. The management system is where

a unified interface is created to provide the administrator with a means of managing the system.

This implementation also supports six (6) different types of auctions. These are the English auction, the Dutch auction, the 1st price sealed-bid auction, the 2nd price sealed-bid, the Yankee auction and the sealed bid auction with multiple units. The auction process of each types of auction is controlled by an auction protocol.

Another interesting implementation of an online auction application is the distributed auction system designed by Paul Ezhilchelvan and Graham Morgan from the University of Newcastle. (Ezhilchelvan, & Morgan, 2001) Their approach is that of a decentralized system design as opposed to a centralized design used by companies like eBay. Their design supports only the English auction and tries to minimize the inter-server communication. They also replicate servers as backup to ensure more reliability on their system. They use two (2) basic services: the reliable multicast and the group membership service.

Our take-away from these two (2) papers is that an implementation that handles multiple types of auctions and one that is not centralized on one server is ideal for an online auction.

Chapter 3: Design

3.1. Requirements

3.1.1. User Classes

This section outlines the different user classes

- A. Auction Seller: These users are the people who create auctions and can upload images of the item as well as set the properties of the auction
- B. Auction Buyer: These users are the people who participate in auctions. They bid on auctions and when successful, they win the bid.
- C. System Administrator: These users are responsible for maintaining the software and making sure everything works well

3.1.2. User Requirements

- A. The auction application will provide an interface to add an Auction
- B. The auction application list all auctions created by Auction Sellers
- C. The auction application will store information about all its users
- D. The auction application will allow auction buyers to add auctions to a watch list
- E. The auction application will provide a way for users to register and login.
- F. The auction application will allow auction sellers to edit and delete auction they have added

3.1.3. System Requirements

A new user can register, or login to the auction application if he/she has already registered. After the user enters the login credentials, verification takes place to make sure the user has the correct credentials. Once that is verified, the user's information is going to

be stored in the browser's local storage. This information is going to facilitate authenticating the type of user on other pages of the auction application.

Any new user can buy and sell auctions by default. However, an auction seller cannot bid on his or her own auction. The auction seller can add an auction, choose the preferred auction type and other information about the auction such as the starting price, the duration of the auction and the preferred payment method.

An auction buyer can add any auction to his or her watch list and remove auctions from his watch list as well.

3.1.4. Functional Requirements

In order to create an auction, the auction seller will enter the title of the auction and its description. The seller will choose an auction type, enter the appropriate price and price increment if available. The seller will set a duration for the auction or set a custom start and end date and time for the auction. The user can upload a picture that describes the auction. The seller can then publish their auction.

The auction seller can still make changes to the auction even after publication. The seller can also delete any auction he has created. Users can also search and browse through various auctions in the application.

3.1.5. Non Functional Requirements

3.1.5.1. Usability and learnability

The application should be easy to understand and use. A new user should be able to navigate the application easily. The user interface and user experience should facilitate the interaction between the user and the application.

3.1.5.2. Security Requirements

Users of the auction application should be able to trust that their personal information is safe, secured and protected from any sort of attack. All communications with the database is performed at the NodeJS server side and the information is sent using prepared ExpressJS routes. This protects the site from any potential MySQL Injection attack.

A token is created when the user logs in. This token times out after some amount of time. This ensures protection, as that the user will have to log in again to confirm his or her identity. Access to specific pages is restricted to users only to prevent anonymous users from creating, editing or deleting auctions if they are not the seller who created them.

3.1.5.3. Scalability

The application should be able to sustain a steady growth of customers. The servers hosting the application should be running at all times in order to accommodate all the user at any time.

3.1.5.4. Dependability

The application should be reliable at any point in time. This will allow the users to trust the application. In case of failure, a graceful degradation system should allow the auction application to still be able to provide basic functionality.

3.1.6. System Constraints

The users can register as buyers, as sellers or as both. Users are subject to a few constraints listed below:

- A. Although auction sellers can create, edit and delete auctions, they cannot change the type of auction once the auction has been created.
- B. The auction application is a web application and thus it cannot be access on devices that do not have an internet connection.

C. For security reasons, some pages cannot be accessed without the right permission. For example, a user that has only registered as a buyer cannot create an auction. Similarly, an auction seller cannot bid on an auction he or she has created.

3.2. System Modeling

This section shows different diagrams that outline the flow and sequence in which events occur within the auction application

3.2.1. Activity Diagram

The figure below (figure 3.1) shows an activity diagram for the seller of an auction.

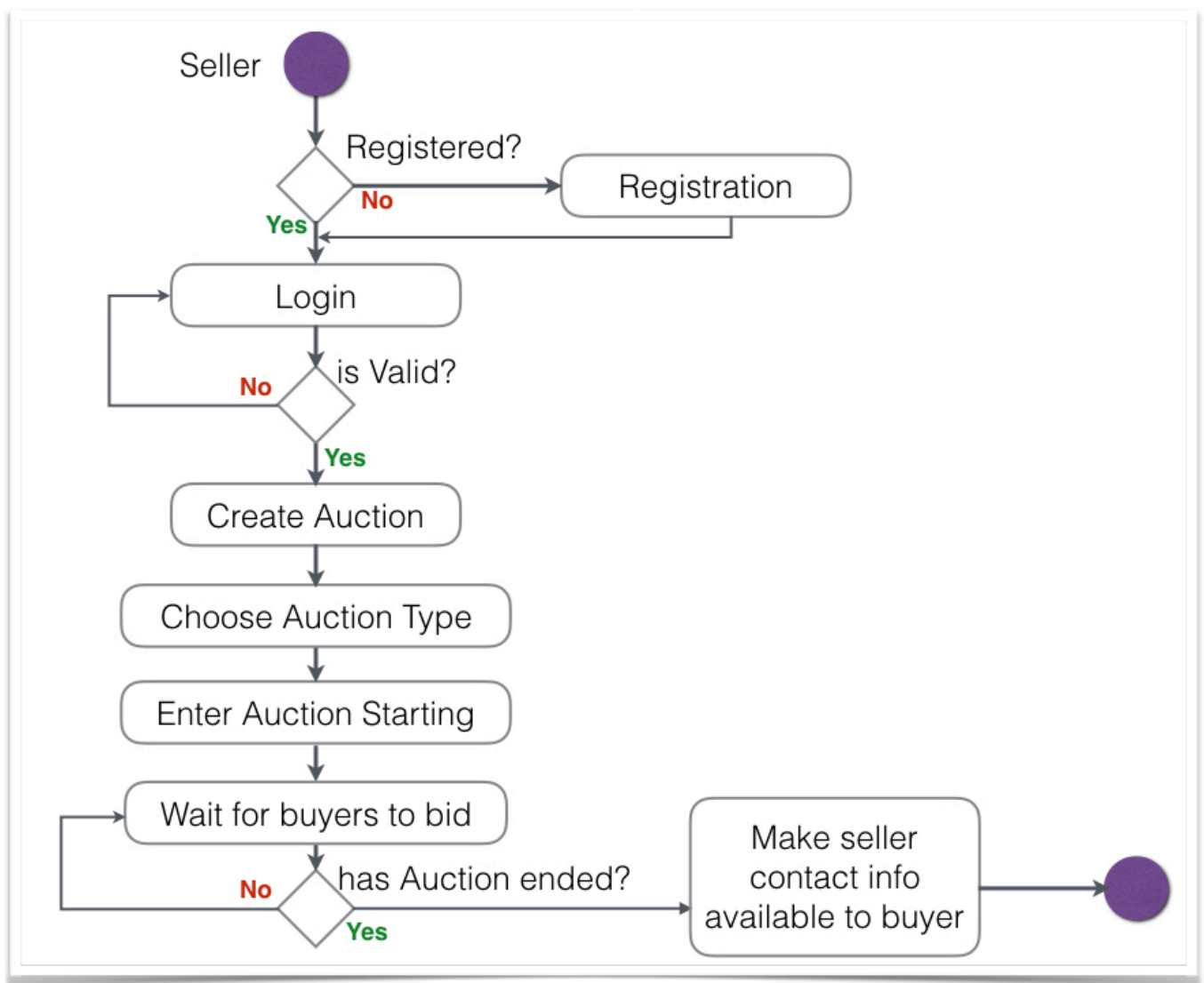
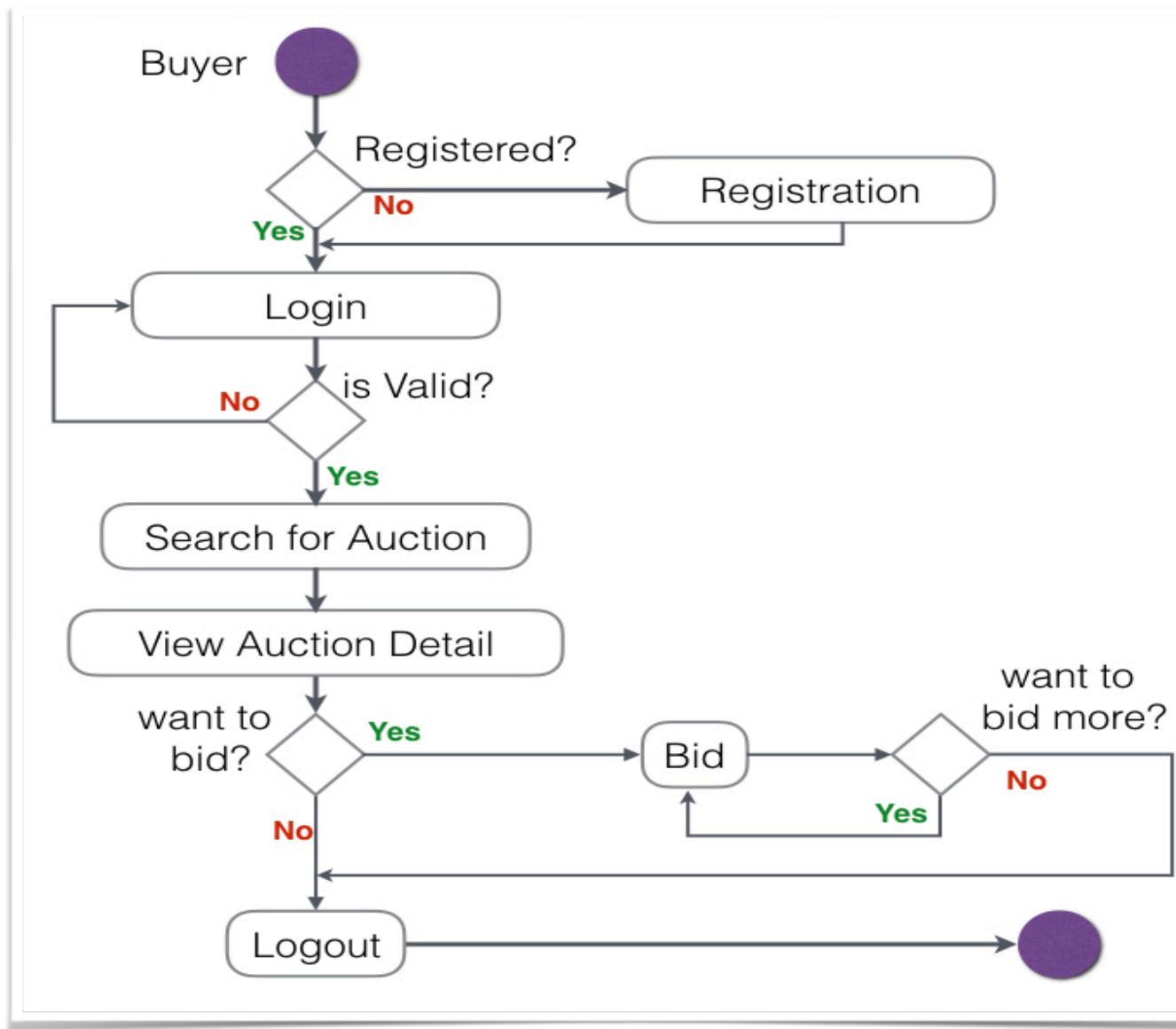


Figure 3.1: Activity Diagram for seller



Similarly, the figure above (figure 3.2) shows an activity diagram for the buyer during an auction

Figure 3.2: Activity Diagram for buyer during auction

3.2.2. Use Case Diagram

The figure below (figure 3.3) shows a use case diagram for users of the auction application.

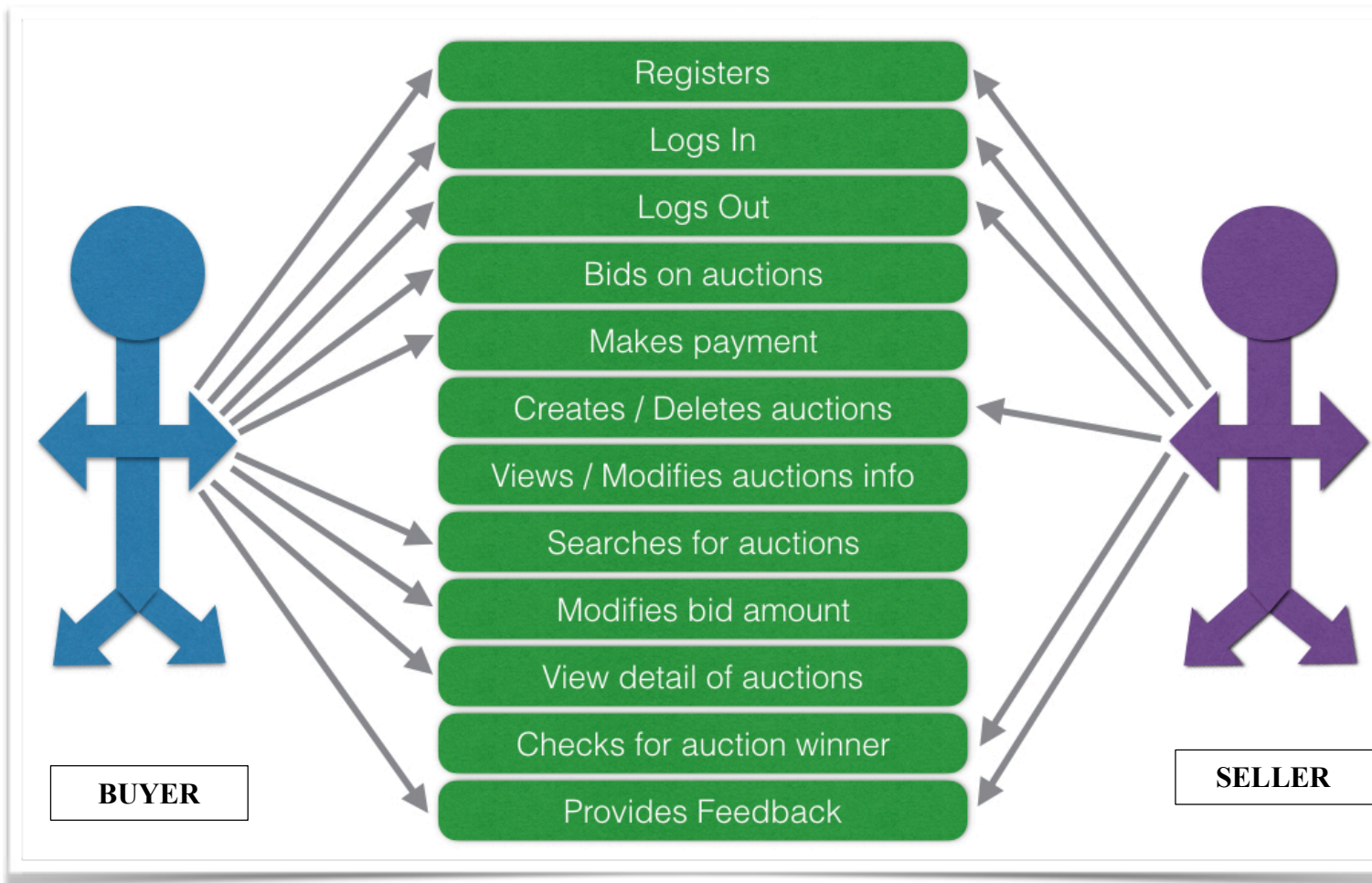


Figure 3.3: Use Case Diagram

3.2.3. Sequence Diagram

The figure below is a sequence diagram showing how an auction seller would add an auction.

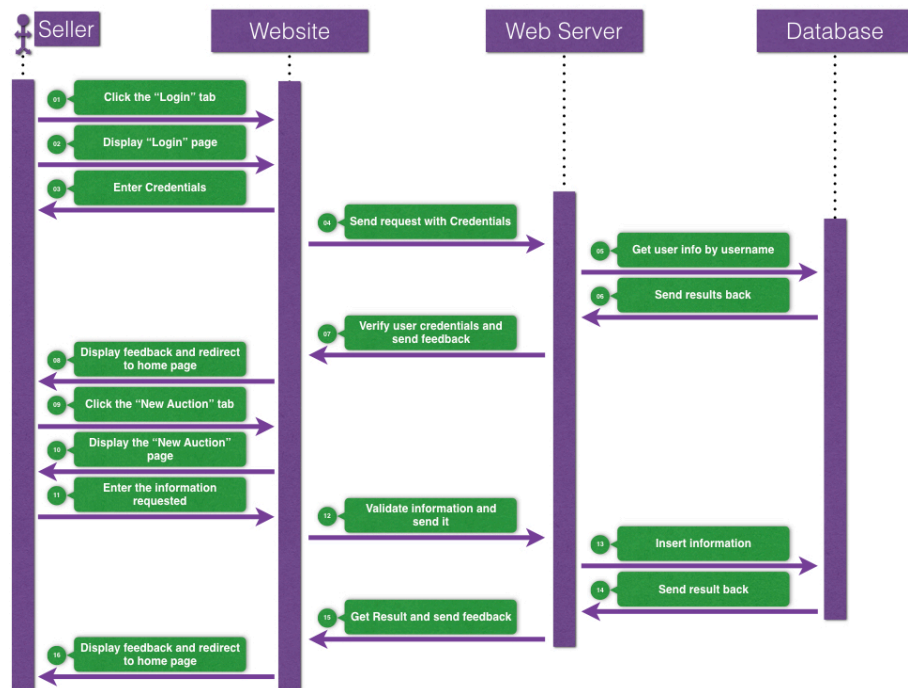


Figure 3.4: Sequence Diagram for seller when creating an auction

The figure below is a sequence diagram showing how an auction seller would bid on an auction.

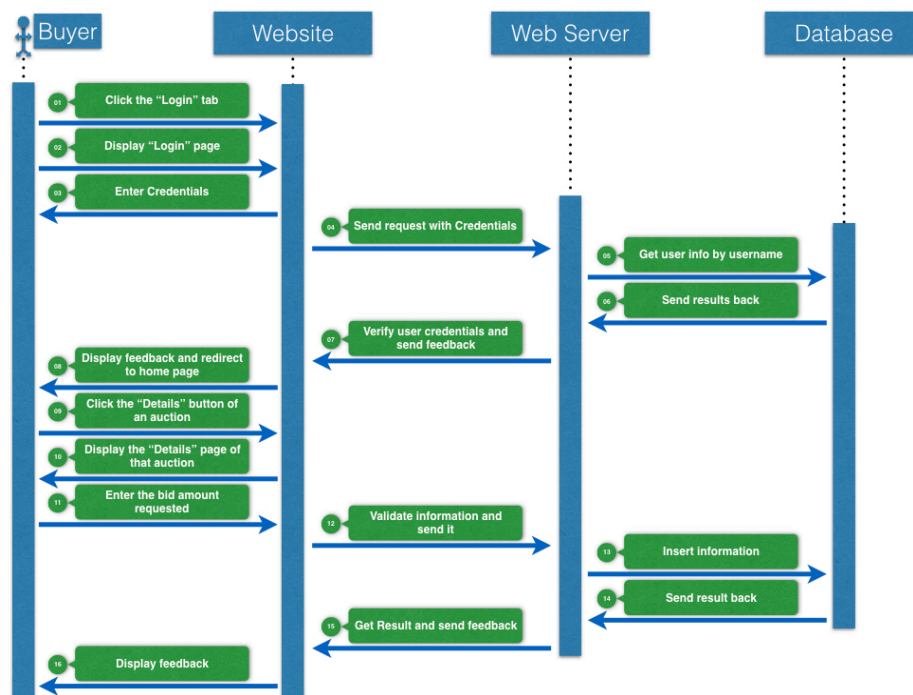


Figure 3.5: Sequence Diagram for buyer when bidding

Chapter 4: Implementation

This section provides an overview of the implementation of the auction application.

4.1. Application Organization

The auction application is a web application that is separated into 3 main components: auction creation, bidding process and auction completion.

The auction creation is done by the auction seller. The seller creates the auction by entering the information requested depending on the type of the auction. We define type of auction as the mechanism through which the seller wants to decide on the auction winner. For example, there is a type of auction called “English Auction” where the information requested is the title, the description, the duration, the starting price and the bid interval. Another type of auction called “Dutch Auction” requires the seller to enter additional information such as the “reserve price”. The reserve price is the lowest price the seller is willing to accept.

The bidding process is executed by the buyers. They search for an auction, and when they find the one they like, they may decide to add it to their watch list to start bidding at a later date or simply start bidding right away.

The auction completion component process is carried out by both the seller and the buyer. Once the auction has ended, the contact information of the seller becomes available to the buyer. This is when payment is discussed between the parties. This is also where feedback can be given. The buyer can give a positive, negative or neutral feedback to the seller depending on the quality of service demonstrated by the seller. The seller can also

give feedback to the buyer depending on how effortlessly the buyer sent payment, for example. The combination of these 3 components form the complete auction application.

4.2. Technologies used for Development

The auction application is written in NodeJs on the server side. As explained above, NodeJs is an open-source runtime environment. The project was developed on NodeJs because it is written in JavaScript and using the MEAN stack makes for efficient programming. i.e., it is open-source and thus, it is free and has a large support on the internet which reduces development time.

The client side of the auction application is written in Angular 2. Angular 2 is also an open-source framework written in JavaScript. It has extensive documentation and a large support system online which makes it relatively easy to use and get help when difficulties arise. The user interface is designed using Bootstrap, a framework designed by Twitter. It is popular for its responsiveness among many other advantages. One of these advantages is the extensive support it has, as well its customizability and support for mobile devices.

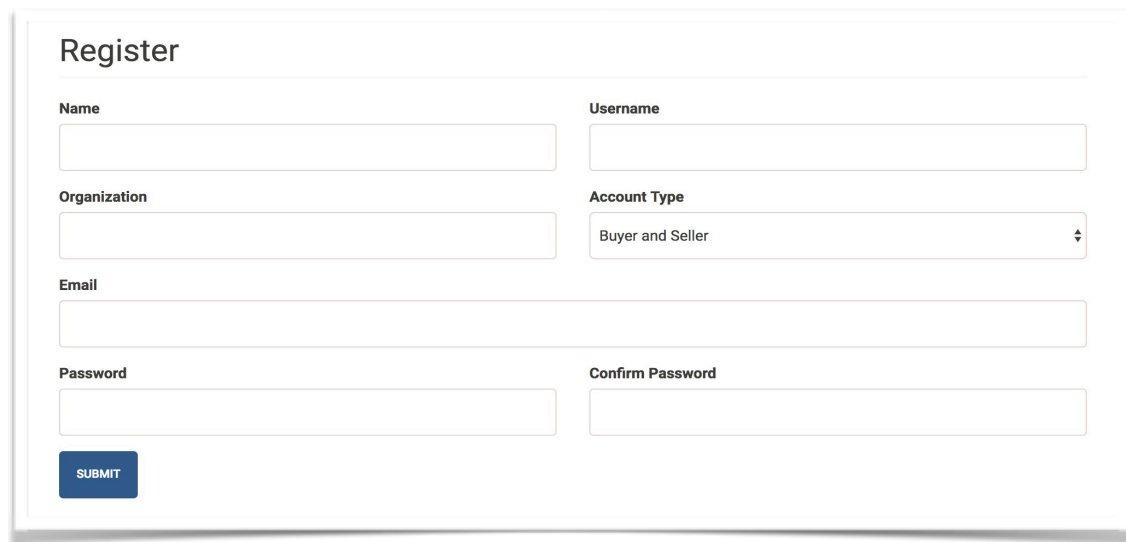
The Angular 2 client is connected to the NodeJS server using ExpressJS. ExpressJS adds routing to the NodeJS server such that it becomes possible for Angular 2 to access specific areas of the server when needed for specific requests. These requests are then processed by NodeJS and the response is sent to Angular 2 in a JavaScript Object Notation (JSON) format.

The information requested by Angular 2 is stored in the MongoDB database. When the request comes to NodeJS, MongooseJS, a NodeJS framework for MongoDB, is used to access the database and performs the query requested.

4.3. Modules Implemented

Listed below are the different modules implemented in this project.

User Registration: This module takes the user name, the username, organization name, the email and password to create an account for the user



The registration form is titled "Register". It contains several input fields: "Name", "Organization", "Email", "Password", "Username", and "Confirm Password". There is also a dropdown menu for "Account Type" with the option "Buyer and Seller" selected. A blue "SUBMIT" button is located at the bottom left of the form.

Figure 4.1: Registration Module

User Login: This module takes the user's username and password, and if an account already exist with these credentials, it creates a session for the user and generates a token that allows the user to be active for a certain period of time before logging in is required again.



The login form is titled "Login". It contains two input fields: "Username" and "Password". A blue "LOGIN" button is located at the bottom left of the form.

Figure 4.2: Login Module

User Profile: This module displays the information of the user that is currently logged in.



Figure 4.3: Profile Module

Search: This module allows the user to search for auctions based on titles

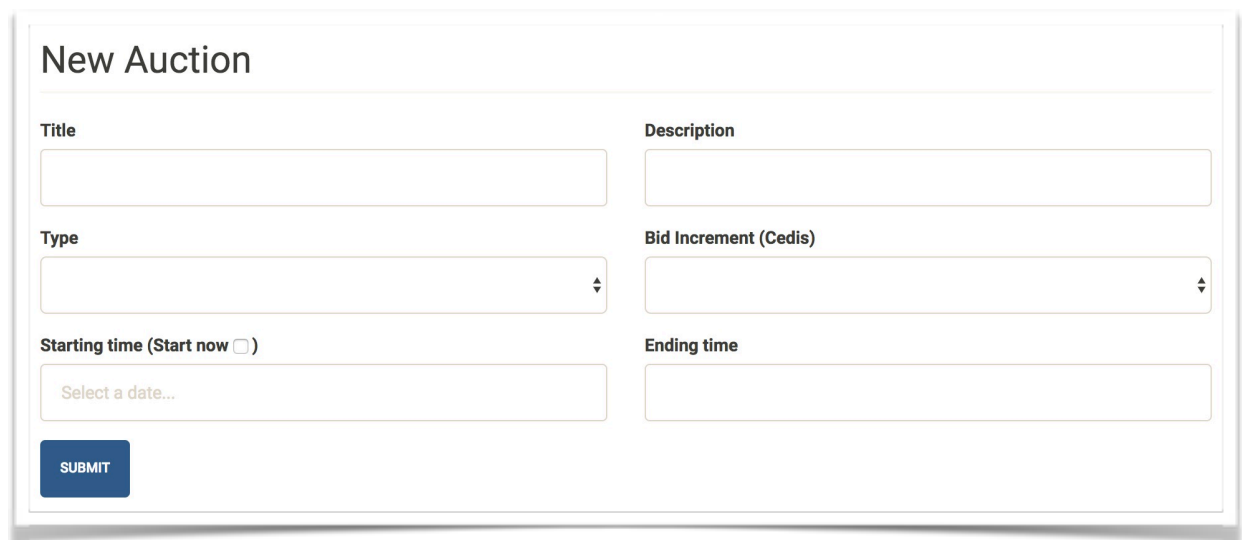
Watchlist: This module allows the user to “bookmark” auctions and revisit them from his dashboard without searching.

Dashboard: This module displays essential information concerning the user of this auction application. It is divided into two (2) sections: Buyer & Seller.

- The Buyer section displays:
 - A list of active auctions: These are auctions where the user has started bidding and the auction is still open and ongoing.
 - A list of closed auctions: These are auctions where the user has bided at least once but the auction is closed and a winner has been decided.
 - A list of watched auctions: These are auctions “bookmarked” by the buyer for ease of access. The user need not to bid on these auctions.

- A feedback section: This section provides a list of feedback received from sellers. The user can give feedback to the Seller once the auction is closed.
- The seller section displays:
 - A list of auctions created: These are auctions created by the user. Each auction contains statistics about the auction. The seller can also edit auction information here or delete the auction.
 - A feedback section: This section provides a list of feedback received from buyers. The seller can give feedback to the buyer who has won the auction.

Auction Creation: This module takes the title, description, type, increment and duration of the auction. This auction is automatically added to the home page of the auction application.



The screenshot shows a web form titled "New Auction". It contains several input fields and a submit button. The fields are arranged in two columns. The left column has "Title", "Type", and "Starting time (Start now ☐)". The right column has "Description", "Bid Increment (Cedis)", and "Ending time". The "Starting time" field has a placeholder text "Select a date...". At the bottom left, there is a blue "SUBMIT" button.

New Auction	
Title	Description
<input type="text"/>	<input type="text"/>
Type	Bid Increment (Cedis)
<input type="text"/>	<input type="text"/>
Starting time (Start now <input type="checkbox"/>)	Ending time
<input type="text" value="Select a date..."/>	<input type="text"/>
<input type="button" value="SUBMIT"/>	

Figure 4.1: Auction Module

Bidding: This module allows the user to post a bid on an auction.

Feedback: This module appears at the end of each auction and allows users (buyers and sellers) to rate the service provided.

4.4. Testing Tools

During the development of the application, certain tools were used to test the application. Postman is a Google Chrome app used to test the API created on the NodeJs server. Protractor is a framework for Angular 2 that is used to automate end-to-end tests that interact with the application as a user would. These two are the main tools used for testing

Chapter 5: Testing and Results

Observation and automated testing were used to carry out component, system-level and user testing.

5.1. Observation Testing

Observation (or manual) testing is used to show how an auction is added to the database using Postman. Below is figure 5.1 showing the current display of the home page.

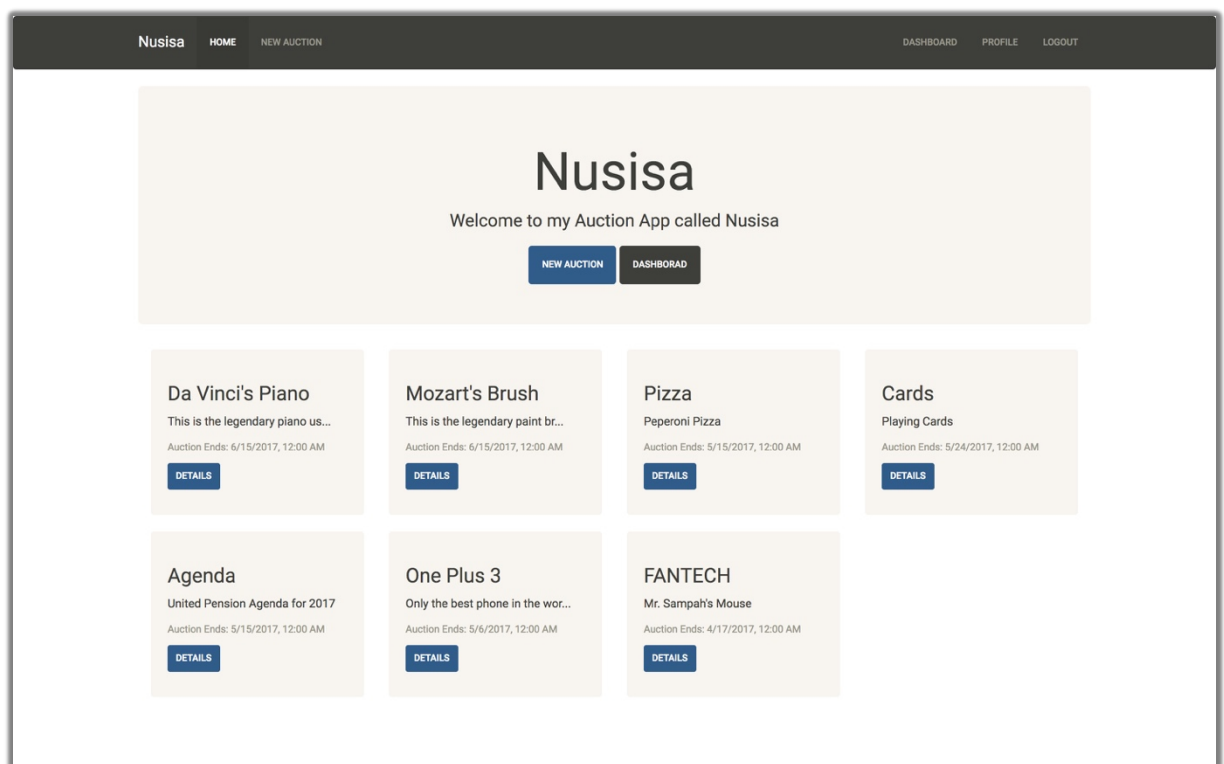


Figure 5.1: Home Page Screenshot

Below is figure 5.2 showing an auction being added to the database using *Postman*

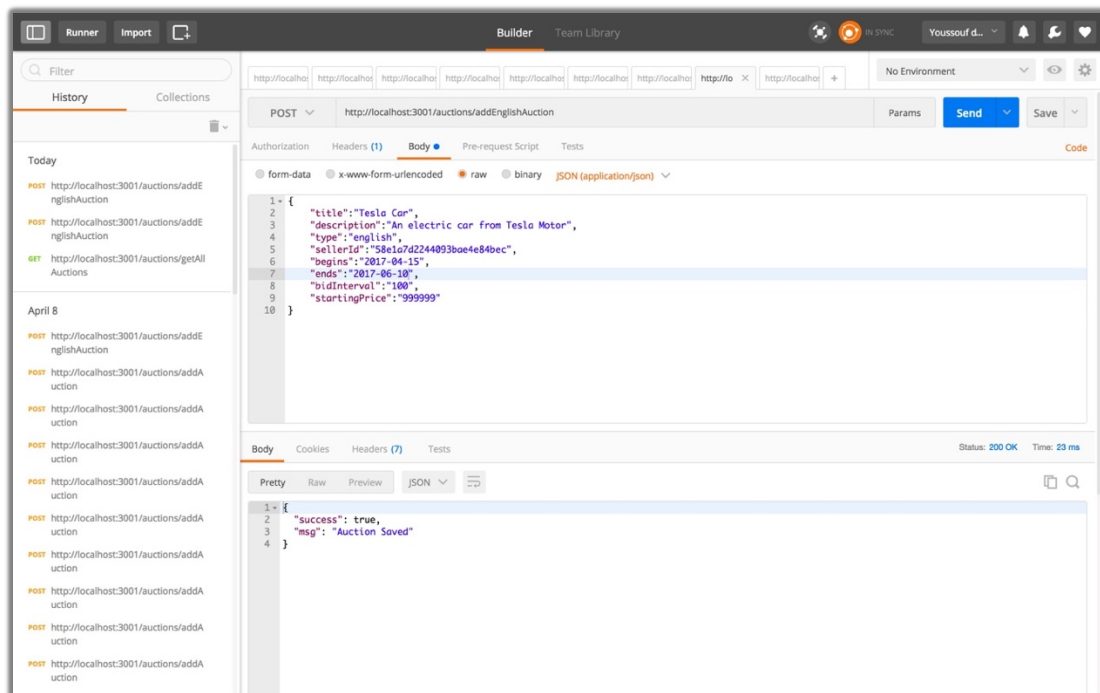


Figure 5.2: Adding an English Auction using Postman (Screenshot)

As displayed in the figure above, the server responded with a success message.

Below is the result displayed on the client side when we add an auction.

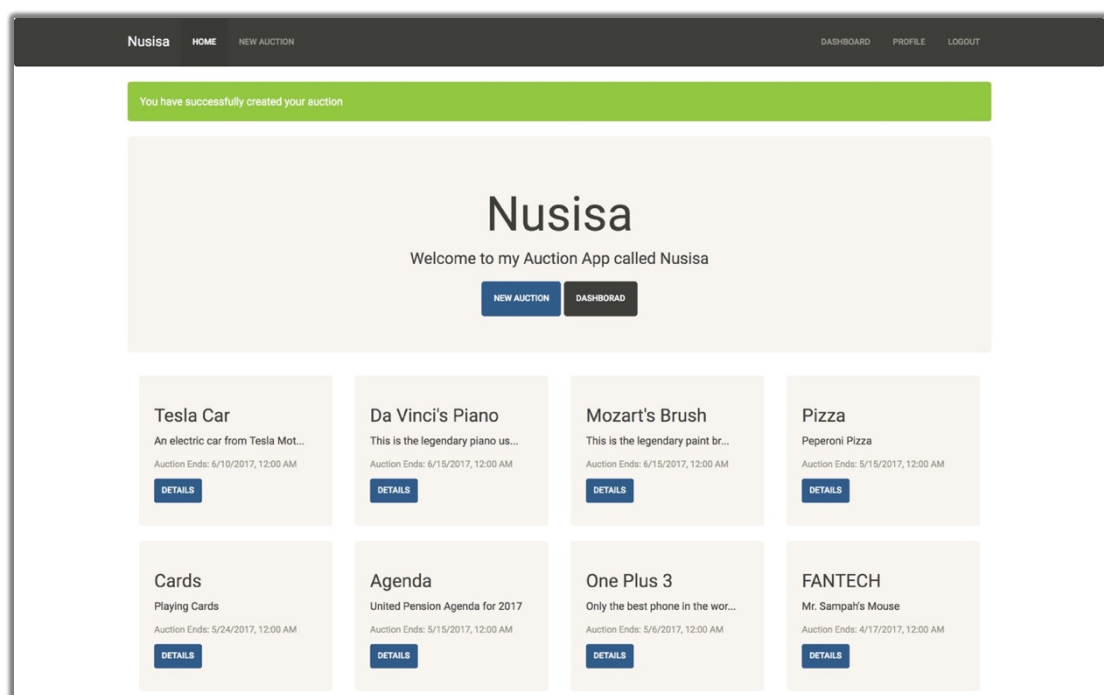


Figure 5.3: Home Page Screenshot after adding an English Auction

As displayed in the figure above, the server sent a successful response to the browser as well.

Once the home page is reloaded, the auction is added to the list of auctions.

Observation testing is also used to demonstrate how the auctions are queried from the database. The request that is sent from the client to the server is a GET request. Again, *Postman* was used to test the NodeJS route associated with getting the auctions. As seen below, when the route url is entered in *Postman* and sent, the response is in an array of JSON objects.

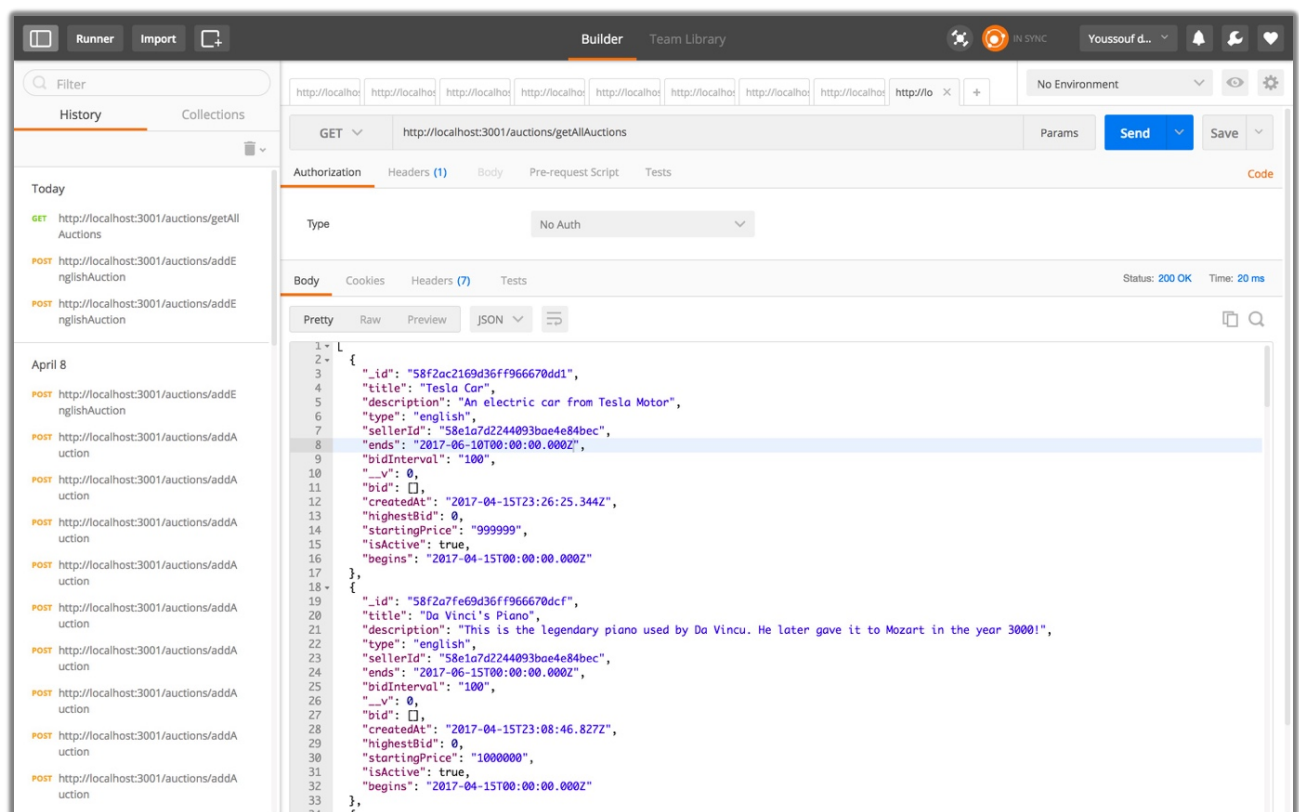


Figure 5.4: Getting all auctions using Postman

These objects are then sent to Angular 2 on the client side in the JSON format and displayed to the user.

5.2. Automated Testing

Automated testing tests some scenarios the users will go through when using the application. This test was performed using the Protractor framework for Angular 2. Below is the code that for the automated testing.

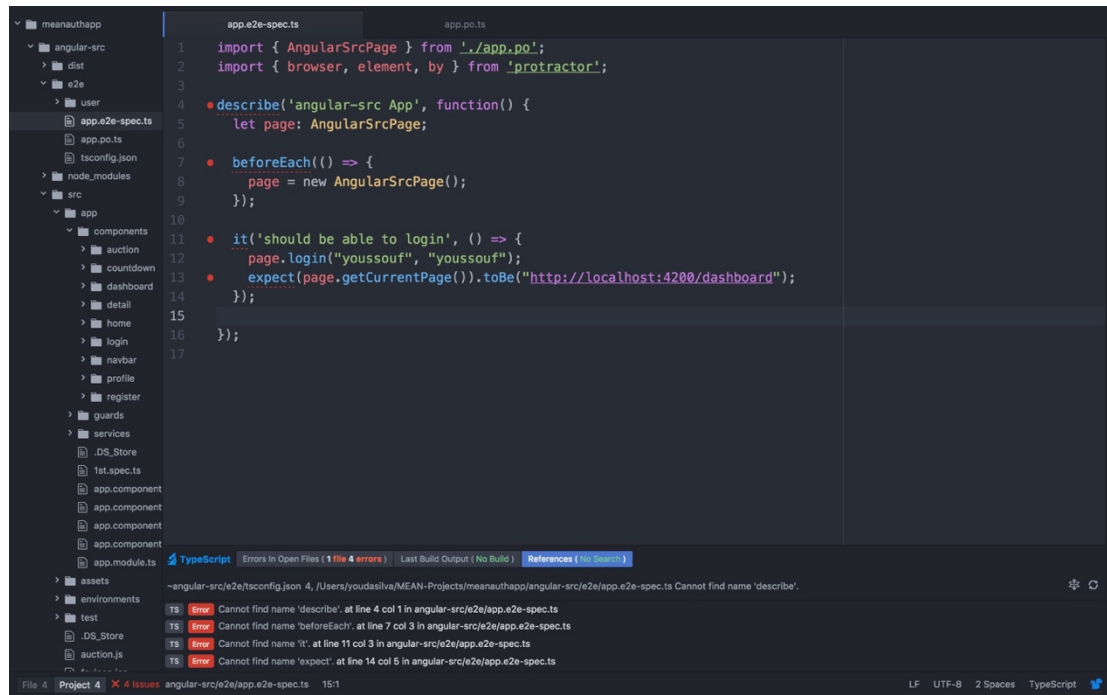


Figure 5.5: Protractor login test

Add next is where all the helper functions reside.

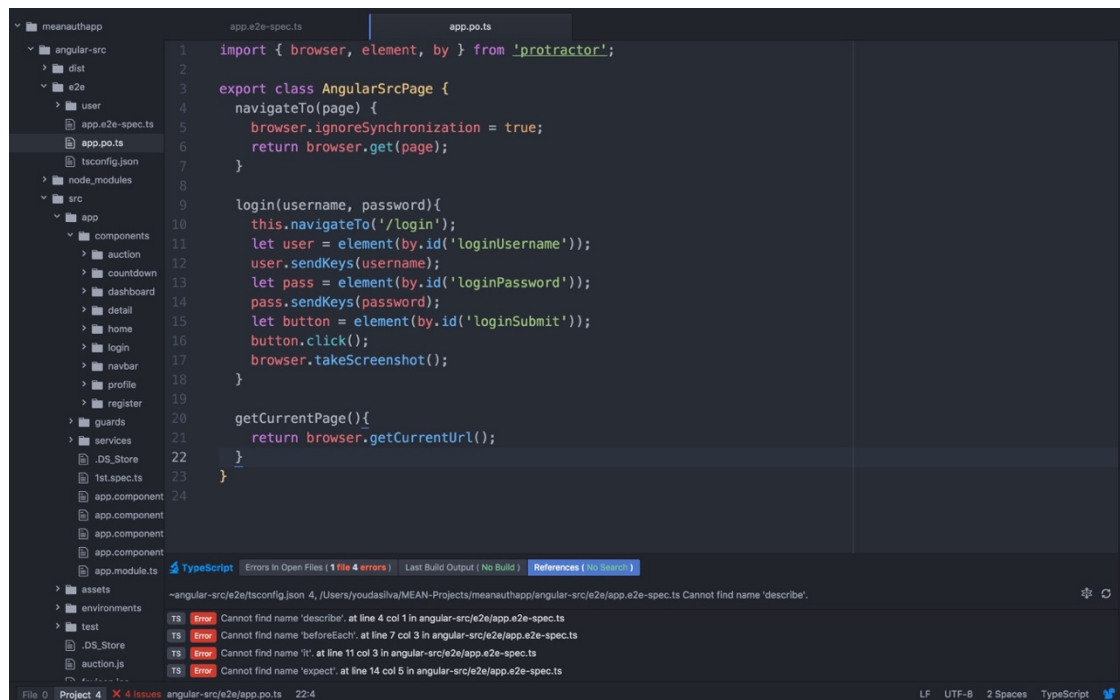


Figure 5.6: Protractor login test helper functions

This test when run from the terminal produces the following result.

```
Youssoufs-MacBook-Pro:angular-src youdasilva$ protractor
[00:38:17] I/launcher - Running 1 instances of WebDriver
[00:38:17] I/direct - Using ChromeDriver directly...
Spec started

  angular-src App
    ✓ should be able to login

Executed 1 of 1 spec SUCCESS in 4 secs.
[00:38:22] I/launcher - 0 instance(s) of WebDriver still running
[00:38:22] I/launcher - chrome #01 passed
Youssoufs-MacBook-Pro:angular-src youdasilva$ █
```

Figure 5.7: Test results in terminal

This result in figure 5.7 shows that the test was successful.

Chapter 6: Conclusions and Recommendations

6.1. Conclusion

The goal of the auction web application is to bridge the gap between companies that have equipment to sell and companies looking for used but in good condition business equipment to buy.

The project objectives set in Chapter 1 have been successfully met. Once the application goes live, businesses will have the opportunity to post auctions of items, while other businesses bid and eventually purchase at a winning bid price.

The process of meeting the objectives set in Chapter 1 was a really good learning experience. It has helped the developer improve on website development skills. New technologies such as the MongoDB database, the ExpressJS framework, Angular 2 and NodeJS were also explored.

6.2. Recommendation & Future Works

The auction application can be improved by including the following features:

- Implementing an administrator dashboard. An administrator dashboard is a centralized page where information is organized and presented in a way that is easy to read for the system administrator.
- Checking the number of login attempts. At the moment anyone can try logging in as many times as he or she wishes. However, checking the number of times a wrong username and password combination is used can allow that account to be disabled until the “real” user performs some verification to confirm that the account really belongs to him or her.

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