**6. Testing**

In this section, several test mechanisms are applied to the prototype to verify that it has met the functional requirements and the design constraints mentioned in section 3. This section also proves how our prototype provides the solution to the problem stated in section 1.

**6.1. Functional Testing**

Functional testing is part of black box testing that tests the system functionalities without inspecting the internal process. The test ensures that the functional requirements of the system has been met.

(paste table here)

**6.2. Connectivity Testing**

The connectivity test measures the average time it takes for a connection to pass data between a certain component in the system and Firebase. This test shows to which extent is our system real time and in what speed. The whole tests were done in the same environment, internet connection and around the same time. The time was recorded by the following algorithm:

* Step 1: read system time and store it in a variable called startTime
* Step 2: Preform needed operation with Firebase
* Step 3: read system time again and store it in variable called endTime
* Step 4: subtract the startTime from endTime and display result in the console

Four trials were computed for each connection, and then the average test time was calculated.

The test is done through several levels:

* Between NodeMCU and Firebase
* Between Application and Firebase
* Between Website and Firebase

6.2.2. Between NodeMCU and Firebase

The internet connection between NodeMCU and Firebase was tested by measuring the time NodeMCU needed to read from or write to the Firebase database.

The system requires NodeMCU to deal with two main operations when communicating with the Firebase. First operation is to get all reservations in the database and second operation is to get or update (set) a specific value in a node. Both operations have different data sizes and thus the time taken for each operation differ. Table 6.x shows the final results, and the detailed test is provided in the appendix.

|  |  |  |
| --- | --- | --- |
| NodeMCU connection time to Firebase | |  |
| Trials | **Get** | **Set** |
| Reservation (177 bytes) | 0.353489 s |  |
| Update a value (15 bytes) | 0.301054 s | 0.388572 s |

6.2.3. Between Application and Firebase

The internet connection between Application and Firebase was tested by measuring the time Application needs to read from or write to the Firebase database for several data sizes.

|  |  |  |
| --- | --- | --- |
| *Application Average Connection Time to* | | |
|  | **Post** | **Get** |
| Reservation (177 bytes) | 0.011777 s | 0.007429 s |
| Currently Looking (52 bytes) | 0.012627 s | 0.007296 s |
| User (113 bytes) | 0.012112 s | 0.007586 s |
| Zone (8606 bytes) | 0.017236 s | 0.008666 s |
| Spot (49 bytes) | 0.011526 s | 0.007123 s |

In general, we observe that reading (get) data from Firebase database is much faster than posting data in the Firebase regardless of the data size. The results are to our advantage since our system is real time, we care more about fetching updated data from the Firebase and reflecting it to the UI as quick as possible than we care for sending data to the Firebase.

which is good as our system should be in real time which mean that any changes in the data will be fetched and reflected to the UI very quickly.

6.2.4. Between Website and Firebase

To test internet connection to and from Application and Firebase in several data sizes

**6.3. Outdoor Testing**

ParQU is a system that should be able to be implemented outdoor in a real parking area. As an initial test to verify that our sensors are able to withstand the harsh environments of being outdoors in Qatar University and satisfy its purpose, we tested the Ultrasonic Sensor outdoors to check the availability of a parking spot.

The sensor was placed below the parking spot. Figures 6.x and 6.x shows our test accompanied with the database showing the current status of the parking spot. Figure 6.x the parking is empty so the database shows that the status is “available”, while Figure 6.x has a car so the database shows that the current status is “not available”.

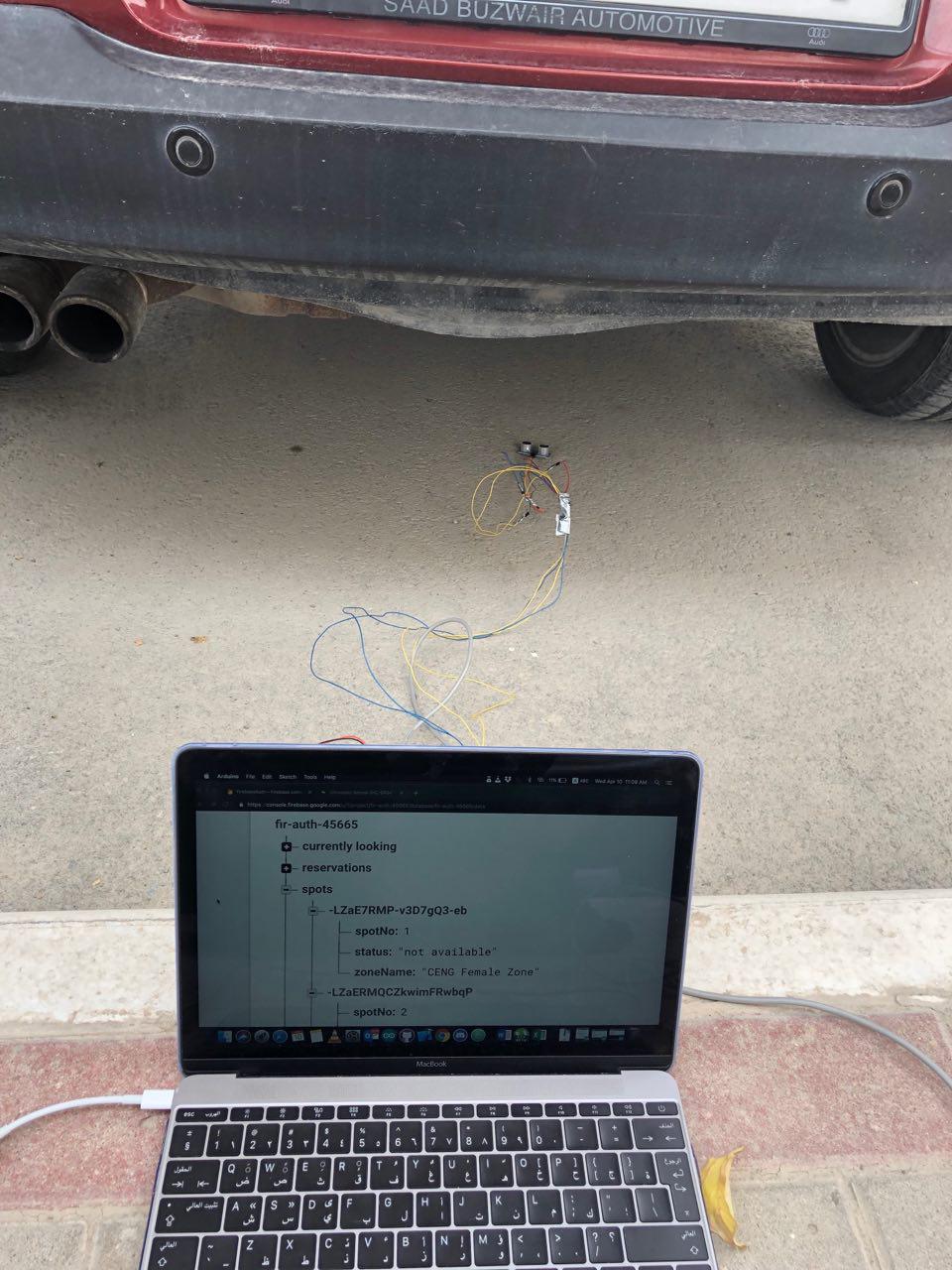
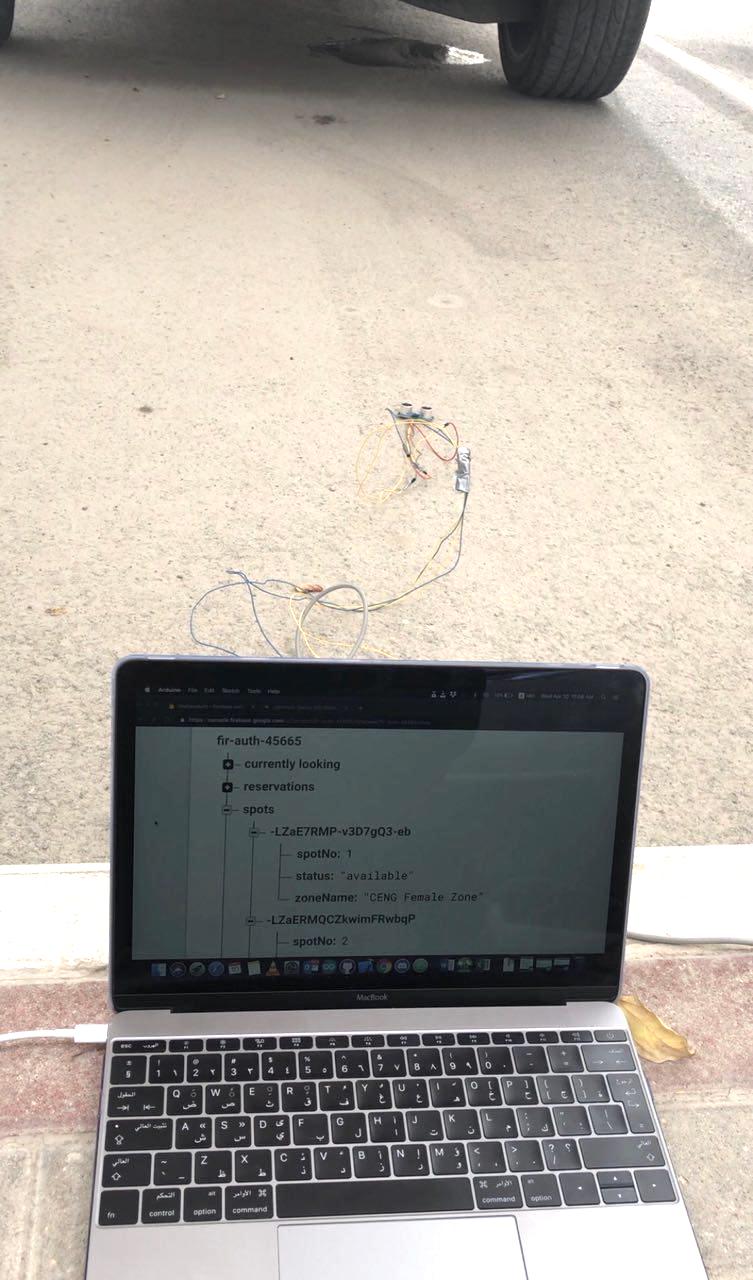
****

Figure Status "not available"

Figure Status "available"

Furthermore, when the system is implemented in real life, the sensor installation positions must be studied to pick the best position with the environment taken into consideration. Table 6.x summarizes the different positions a sensor could be placed in real life along with its pros and cons.

Possible installation positions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Position in a parking spot | Distance limit | Where | Pros | Cons |
| Above | Shortest possible car height | Indoors and outdoors | Suitable for indoors and outdoors  مايتعرض للمطر ولا للاوصاخ  مايتعرض للكسر | Needs a parking spot shade to place the sensor under it |
| Below | Highest possible car height | Indoors | Cheapest choice | Easily subjected to dirt if outdoors (Sensor needs some kind of shield)  ممكن يتكسر |
| In front | Farthest possible distance a car could park | Indoors and outdoors | no pros | -Cars may bump the sensor (Sensor needs some kind of shield which is costly)  -needs a stand (Costly) |

Sensors placed below the parking spot is most suitable for indoors because

Both above and below are suitable for indoors but the best choice is above because مايتعرض للكسر Indoor best choice is above because it does need a shade and can be installed on the rooftop ومارح تتعرض للكسر مقارنة بال بيلو

Outdoors best choice is above because most parkings have shade and so will not be subjected to rain or break

**6.4. Acceptance Testing**

(To do now: write intro to the subsection)

(To do after getting feedback from professor: do the test, write review on the results)

**6.5. Design Constraints Evaluation**

(paste table here)

Appendix

1st Operation: Get reservations (Node of Objects)

|  |  |
| --- | --- |
| NodeMCU connection time to Firebase | |
| Trials | **Get Reservation**  **(177 Bytes)** |
| 1 | 0.350258 s |
| 2 | 0.401654 s |
| 3 | 0.330333 s |
| 4 | 0.331711 s |
| Average | **0.353489 s** |

2nd Operation: Update a value

|  |  |  |
| --- | --- | --- |
| NodeMCU connection time to Firebase | |  |
| Trials | **Get a value**  **(15 Bytes)** | **Set a value**  **(15 Bytes)** |
| 1 | 0.306381 s | 0.383343 s |
| 2 | 0.295115 s | 0.390443 s |
| 3 | 0.296623 s | 0.387329 s |
| 4 | 0.306095 s | 0.393172 s |
| Average | **0.301054 s** | **0.388572 s** |

Between Arduino and NodeMCU

The serial communication between the Arduino and NodeMCU is tested by measuring the time the Arduino or NodeMCU takes to transfer or receive data. This test transfers a 131 bytes JSON object from Arduino to NodeMCU and vice versa. The time taken for each trial is specified as follows