CHAPTER 1

SYSTEM TESTING
This chapter describes the testing stage of the system. Testing ensures that the system is free of errors and bugs and delivers expected results. Different types of testing methods have been applied on the system which are: unit testing, integration and regression testing, performance and stress testing, test cases and user acceptance testing.
## 7.1. UNIT TESTING

### 7.1.1. WEBSITE

| Function Class          | Component to be tested | Component description                  | Result |
|-------------------------|------------------------|----------------------------------------|--------|
| **General Functions**   | C1                     | Register in the system                 | Pass   |
|                         | C2                     | Log in the system                      | Pass   |
|                         | C3                     | Update profile info                    | Pass   |
|                         | C4                     | Display LED(s) on map                  | Pass   |
|                         | C5                     | Display LEDs’ Statistics               | Pass   |
|                         | C6                     | Log out of the system                  | Pass   |
| **Region Management**   | C7                     | Add region                             | Pass   |
|                         | C8                     | Update region details                  | Pass   |
|                         | C9                     | Delete region                          | Pass   |
| **LED Management**      | C10                    | Add LED                                | Pass   |
|                         | C11                    | Update LED details                     | Pass   |
|                         | C12                    | Delete an LED                          | Pass   |
| **Content Management**  | C13                    | Upload content                         | Pass   |
|                         | C14                    | Update content details                 | Pass   |
|                         | C15                    | Delete content                         | Pass   |
|                         | C16                    | Link content with LED                  | Pass   |

*Table 1: Website Unit testing*

### 7.1.2. APPLICATION

| Function Class | Component to be tested | Component description | Result |
|----------------|------------------------|------------------------|--------|
|                | C13                    | Upload content         | Pass   |
|                | C14                    | Update content details | Pass   |
|                | C15                    | Delete content         | Pass   |
|                | C16                    | Link content with LED  | Pass   |
| General Functions | C1 | Register in the system | Pass |
|-------------------|----|------------------------|------|
|                   | C2 | Log in the system      | Pass |
|                   | C3 | Log out of the system  | Pass |
|                   | C4 | Edit profile           | Pass |
|                   | C5 | Contact Us             | Pass |
| Users/Admin content Functions | C6 | Upload content       | Pass |
|                   | C7 | View users contents    | Pass |
|                   | C8 | View admin contents    | Pass |
|                   | C9 | Save content to favorite list | Pass |
|                   | C10 | View favorite list | Pass |
| Region Functions | C11 | View all regions | Pass |
|                   | C12 | View region | Pass |

*Table 2: Mobile Application Unit testing*

### 7.2. INTEGRATION AND REGRESSION TESTING

#### 7.2.1. INTEGRATION TESTING
There are four groups of components that have been tested individually in the previous section (Unit Testing). These groups are: group 1, which contains general functions, group 2 includes the region functions, group 3 contains content functions and group 4 contains LEDs functions. In this section, we integrate the components one by one for each group and test the integration of the components to make sure it works as expected.

| Test sequence |
|---------------|
| Test Number   | Test 1 | Test 2 | Test 3 |
| Component     | Integrating C1 and C2 | Integrating C3 and Test1 | Integrating C4, C5 and Test2 |
| Description   | Test Register and Login. | Test Update profile info with component of Test1 | Test Display LED(s) on map and Display LEDs’ Statistics with component of Test 2 |

Table 3: Website Integration testing 1

| Test sequence |
|---------------|
| Test Number   | Test 4 | Test 5 | Test 6 |
| Component     | Integrating C6 and Test 3 | Integrating C7,C8 and Test4 | Integrating C9 and Test 5 |
| Description   | Test Logout with component of Test 3 | Test Add region ,Update region with component of Test 4 | Test Delete region with component of Test5 |
### Table 4: Website Integration testing

| Test sequence |
|---------------|
| **Test Number** | **Component** | **Description** |
| Test 7 | Integrating C10, C11 and Test6 | Test Add LED and Update LED details with component of Test 6 |
| Test 8 | Integrating C12 and Test 7 | Test Delete LED with component of Test 7 |
| Test 9 | Integrating C13, C14 and Test8 | Test Upload content Update content details, with component of Test 8 |
Table 5: Website Integration testing 3

| Test sequence |
|---------------|
| Test Number   | Test 10                                           | Test 11                                           |
| Component     | Integrating C15 and Test 9                        | Integrating C16 and Test 10                       |
| Description   | Test Delete content with component of Test 9      | Test Link content with component of Test 10       |
**Table 6: Website Integration testing 4**

**b. APPLICATION**

We applied the integration testing in the application by the following steps:
| Test Number | Test1 | Test2 | Test3 |
|-------------|-------|-------|-------|
| Component   | Integrate C1 and C2 | Integrate C3 and Test1 | Integrate C4 and Test2 |
| Description | Test Register and Log in. | Test Log out and component of Test1 | Test Edit profile and component of Test2 |
| Graph       | ![Diagram](image1) | ![Diagram](image2) | ![Diagram](image3) |
| Status      | Pass | Pass | Pass |

*Table 7: Application integration testing 1*
| Test Number | Component | Description | Graph |
|-------------|-----------|-------------|-------|
| Test7       | Integrate C8 and Tes6 | Test View admin content and component of Test6 | ![Graph](C1-C8-T1.png) |
| Test8       | Integrate C9 and Test7 | Test Save content to favorite list and component of Test7 | ![Graph](C1-C9-T1.png) |
| Tes9        | Integrate C10 and Test8 | Test View favorite list and component of Test8 | ![Graph](C1-C10-T1.png) |

**Table 8: Application integration testing 2**

| Test Number | Component | Description |
|-------------|-----------|-------------|
| Tes10       | Integrate C11 and Test9 | Test View all regions and component of Test9 |
| Tes11       | Integrate C12 and Test10 | Test View region and component of Test10 |

**Table 9: Application integration testing 3**
7.2.2. REGRESSION TESTING

Regression testing is a type of software testing carried out to ensure that previously tested code is still performing the way it should be after new changes. Changes may include enhancements, patches, configuration changes.

We applied the regression test by testing the whole functionalities of the system after any change or update, to make sure that the system functionalities are still working as expected.

7.3. TEST CASES
## 7.3.1. WEBSITE

### 1. Register Test Cases

| Test Case: #1         | Description                           | Action                | Expected Result                                                                 |
|-----------------------|---------------------------------------|-----------------------|---------------------------------------------------------------------------------|
| Leave empty fields    | The user leaves some or all fields empty | Click on Register button | An error message will be displayed prompting the user to complete all fields |

**Actual Result**

![Image of LumiComm registration page with empty fields error message]

**Pass?**

Yes

*Table 11: Register test case with empty field*

| Test Case: #2         | Description                           | Action                | Expected Result                                                                 |
|-----------------------|---------------------------------------|-----------------------|---------------------------------------------------------------------------------|
| Enter invalid email   | The user enters an email in an incorrect format. | Click on Register button | An error message will be displayed prompting the user to enter a valid email |

**Actual Result**

![Image of LumiComm registration page with invalid email error message]
Table 12: Register test case with empty field

| Pass? |
|-------|
| Yes   |

Table 13: Register test case with registered email

| Test Case: #3 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Enter email that is already registered | The user enters a registered email | Click on Register button | An error message will notify the user that the email is already registered |

Actual Result

![Image of login screen with error message]

| Pass? |
|-------|
| Yes   |

2. Login Test Cases

Table 14: Failed log in test case
### Log in Test Cases

| Test Case: #1 | Description       | Action             | Expected Result                               |
|---------------|-------------------|--------------------|-----------------------------------------------|
| Enter valid inputs | The user enters valid inputs | Click on Log in button | The user will be redirected to the dashboard.  |

### Actual Result

![Dashboard Image]

**Pass?**

Yes

| Test Case: #2 | Description       | Action             | Expected Result                               |
|---------------|-------------------|--------------------|-----------------------------------------------|
| Leave an empty fields | The user leaves some or all fields empty | Click on Log in button | An error message will be displayed prompt the user to complete all fields |

### Actual Result

![Login Error Image]

**Pass?**

Yes

*Table 15: Log in test case with empty field*
Enter invalid email or password | The user enters invalid inputs | Click on Log in button | An error message will be displayed prompt the user to enter valid inputs

Actual Result

Pass?

Yes

Table 16: Log in test case with invalid field

3. Manage Content Test Cases

These test cases show the different scenarios that a user may experience when trying to add or update a content in the system.

| Test Case: #1 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Enter valid inputs | The user enters valid information | Click on Add / Update content | The content will be added/updated and a success message will be displayed. If add: the user will be redirected to all content page. If update: The user will be redirected to view content page. |

Actual Result (Add)
### Test Case: #2

| Description                  | Action                                      | Expected Result                                                                 |
|-----------------------------|---------------------------------------------|---------------------------------------------------------------------------------|
| Leave empty fields          | The user leaves some or all fields empty    | Error messages will be displayed prompt the user to complete empty fields.       |

**Actual Result**

**Pass?**

Yes

### Test Case: #3

| Description | Action | Expected Result |
|-------------|--------|-----------------|

**Pass?**

Yes
Exceed the accepted number of characters of content description field

The user enters more than 255 character in content description field

Click on Add / Update content

Content description field will be blocked and its border color will be changed to red.

### Actual Result

![Image of Manage Content/Add Content page]

### Pass?

Yes

4. **Manage Content Test Cases**

These test cases show the different scenarios that a user may experience when trying to **create** or **update** a region in the system.

| Test Case: #1 | Description | Action | Expected Result |
|--------------|-------------|--------|-----------------|
| **Enter valid inputs** | The user enters valid information | Click on Create / Update region | The region will be added/updated and a success message will be displayed. If **add**: the user will be redirected to all regions page. If **update**: The user will be redirected to view region page. |

### Actual Result (Add)
Table 17: Manage Content test Cases

| Test Case: #2 | Description                                      | Action                                   | Expected Result                                                                 |
|---------------|--------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------|
| Leave empty fields | The user leaves some or all fields empty           | Click on Create / Update region          | Error messages will be displayed prompt the user to complete empty fields       |

Actual Result(Add)

| Test Case: #3 | Description                                      | Action                                   | Expected Result                                                                 |
|---------------|--------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------|
| Exceed the accepted number of characters in region | The user enters more than 90 character in region description field | Click on Create / Update region          | Region description field will be blocked and its border color will be changed to red |
### Table 18: Manage Content test cases 2

#### 5. Manage LEDs Test Cases

These test cases show the different scenarios that a user may experience when trying to **add** or **update** a LED information.

| Test Case: #1                     | Description                                      | Action                        | Expected Result                                                                 |
|----------------------------------|--------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------|
| **Leave empty fields**           | The user leaves some or all fields empty          | Click on Add / Update LED    | Error messages will be displayed prompt the user to complete empty fields.       |

#### Table 19: Manage Led Test Cases 1

| Test Case: #2                     | Description                                      | Action                        | Expected Result                                                                 |
|----------------------------------|--------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------|
| **Exceed the accepted number of characters in LED** | The user enters more than 100 character in region description field | Click on Add / Update LED    | LED description field will be blocked and its border color will be changed to red |
### Table 20: Manage Led Test Cases 2

#### 6. View (Region, content and LEDs)

| Test Case #1 | Description                                                                 | Action                        |
|--------------|------------------------------------------------------------------------------|-------------------------------|
| Delete (Region, Content or LED) | The user clicks on delete icon to delete a region/content/LED | Click on delete icon |

| Expected Result (Delete Region) | Expected Result (Delete Content) | Expected Result (Delete LED) |
|---------------------------------|----------------------------------|-----------------------------|
| A confirmation message will be displayed, if the user presses Yes, then the region will be deleted, and a success message will be displayed. If the user presses No, then the system will display the region | A confirmation message will be displayed if the user presses Yes, then the content will be deleted, and a success message will be displayed. If the user presses No, then the system will display the content | A confirmation message will be displayed if the user presses Yes, then the LED will be deleted, and a success message will be displayed. If the user presses No, the system will display the LED |

**Actual Result (Delete a Region)**
Table 21: View (Region, Content, Led) test cases

| Test Case: #2 | Description | Action |
|---------------|-------------|--------|
| Update (Region, Content or LED) | The user clicks on edit icon of an item | Click on edit icon of an item |

| Expected Result (Region) | Expected Result (Content) | Expected Result (LED) |
|--------------------------|----------------------------|-----------------------|
| The user will be redirected to update region page | The user will be redirected to update content page | The user will be redirected to update LED page |

Table 22: Update test cases

| Test Case: #1 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|

7. View All (Region, content and LEDs) Test Cases

These test cases show the different scenarios that a user may experience when exploring all region\content\LEDs pages.
Table 23: Select all checkboxes test case

| Select all checkboxes | The user clicks on select all checkbox | Check on select all checkbox | All checkboxes will be selected |
|-----------------------|---------------------------------------|-----------------------------|-------------------------------|

|          | Actual Result | Pass? |
|----------|---------------|-------|
| ![Image](image1.png) | ![Image](image2.png) | Yes |

Table 24:

| Test Case: #2 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Delete multiple regions | The user clicks on delete selected button | Click delete selected button | A confirmation message will be displayed if the user presses Yes then the selected regions will be deleted, and a success message will be displayed. If the user presses No, then the system will display All-regions page. |

|          | Actual Result | Pass? |
|----------|---------------|-------|
| ![Image](image3.png) | ![Image](image4.png) | Yes |

Delete multiple regions test case
| Test Case: #3 | Description | Action | Expected Result |
|--------------|-------------|--------|-----------------|
| **Delete selected Without selecting any region** | The user clicks on delete selected button without selecting any region | Click on delete selected button | An error message will be displayed prompt the user to select at least one region |

**Pass?**

Yes

*Table 25: Delete selected without selecting any region test case*

### 8. Link\uUnlink Content Test Cases

| Test Case: #1 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| **Click on link button** | The user clicks on a link button of a content | Click on a link button | The content will be linked with the selected LED and the link button will be changed to Unlink |

**Actual Result**

![Link Content Test Case Diagram](image-url)
Table 26: Link content test case

| Test Case: #2 | Description                  | Action                  | Expected Result                                                                 |
|--------------|------------------------------|-------------------------|---------------------------------------------------------------------------------|
| **Click on** | The user clicks              | **Click** on Unlink button | A confirmation message will be displayed, if the user clicks on Yes, then the content will be unlinked from the selected LED and the unlink button will be changed to link. If the user clicks on No, then the system will display link content page. |
| **Unlink button** | Unlink button of a LED | **on** Unlink button |                                                                      |

**Actual Result**

Pass? Yes
### Table 27: Click on Unlink button test case

#### 9. Manage Profile Test Cases

| Test Case: #1 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Leave an empty field | The user leaves empty fields | Click on Update Profile button | An error message will be displayed prompt the user to complete all fields |

#### Actual Result

![Manage Profile](image)

| Pass? |
|-------|
| Yes |

#### Table 28: Manage profile test case 2

| Test Case: #2 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Enter invalid email | The user enters invalid email | Click on Update Profile | An error message will be displayed prompt the user to enter a valid email |

#### Actual Result

![Manage Profile](image)

| Pass? |
|-------|
| Yes |

#### Table 29: Manage profile test case 3

| Test Case: #3 | Description | Action | Expected Result |
|---------------|-------------|--------|-----------------|
| Enter incorrect password | The user enters incorrect password. | Click on Reset Password | An error message will be displayed prompt the user to enter a valid email |
Enter incorrect confirm password

The user enters confirm password that doesn’t match with the new password

Click on Press Reset Password

An error message will be displayed prompt the user to enter correct confirm password

Pass?

Yes

Table 30: Manage profile test case 4

Test Case: #4 | Description | Action | Expected Result |
--- | --- | --- | --- |
Enter incorrect confirm password | The user enters confirm password that doesn’t match with the new password | Click on Press Reset Password | An error message will be displayed prompt the user to enter correct confirm password |

Table 31: Manage profile test case 5

7.3.2. APPLICATION

1. Register Test Cases

Test case#1 | Description | Action | Expected Result | Actual Result | Pass? |
--- | --- | --- | --- | --- | --- |


| Enter valid inputs | The user enters valid information | Click on Register button | A new account will be created and the user will be redirected to the main activity. | Yes |
|---------------------|----------------------------------|--------------------------|--------------------------------------------------------------------------------|-----|
| **Test case#2**    | **Description**                  | **Action**               | **Expected Result**                                                             | **Actual Result** | **Pass?** |
| Leave empty fields | The user leaves some or all fields empty | Click on Register button | An error message will be displayed prompting the user to complete all fields. | Yes |
| **Test case#3**    | **Description**                  | **Action**               | **Expected Result**                                                             | **Actual Result** | **Pass?** |
| Enter invalid email| The user enters an email in an incorrect format. | Click on Register button | An error message will be displayed prompting the user to enter a valid email. | Yes |
| **Test case#4**    | **Description**                  | **Action**               | **Expected Result**                                                             | **Actual Result** | **Pass?** |
| Enter email that is already registered | The user enters a registered email | Click on Register button | An error message will notify the user that the email is already registered. | Yes |

Table 32: Application register test case

2. Log in Test Cases

| Test case#1 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Leave empty fields | The user leaves some or all fields empty | Click on Log in button | An error message will be displayed prompting the user to complete all fields | | Yes |

Test case#2

| Description | Action | Expected Result | Actual Result | Pass? |
|-------------|--------|-----------------|---------------|-------|
The user enters invalid inputs with the email and password. Click on the Log in button. An error message will notify the user that the email or password is incorrect.

Table 33: Application log in test case

3. Edit Profile Test Cases

| Test case#1 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Leave empty fields | The user leaves some or all fields empty | Click on save changes button | An error message will be displayed prompting the user to complete all fields | | Yes |

| Test case#2 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
Enter invalid email

The user enters invalid email

Click on Update Profile button

An error message will be displayed prompt the user to enter a valid email

| Test case#1 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Click on LED Feed (in range of a LED) | The user clicks on LED Feed when he is in a range of a LED | Click on LED Feed | The linked admin content will be displayed. If no content linked with the LED, a message will be displayed indicating that no content has been linked with the LED. | Yes |

| Test case#2 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Click on LED Feed (not in range of a LED) | The user clicks on LED Feed when he isn’t in a range of a LED | Click on LED Feed | An error message will be displayed indicating that there is no Li-Fi signals found. | Yes |

| Test case#3 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Test case#4 | Description                  | Action                  | Expected Result                                                                                                                                                                                                 | Actual Result | Pass? |
|-------------|------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|
| Click on Timeline (in range of a LED) | The user clicks on Timeline when he is in a range of a LED | Click on Timeline       | The linked user content will be displayed. If no content linked with the LED, a message will be displayed indicating that no content has been linked with the LED.                                    | Yes          |       |

| Test case#5 | Description                  | Action                  | Expected Result                                                                                                                                                                                                 | Actual Result | Pass? |
|-------------|------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|
| Click on upload content button in Timeline | The user clicks on upload content button | Click on upload content button | The user will be redirected to upload content activity.                                                                                                                                                   | Yes          |       |

| Test case#6 | Description                  | Action                  | Expected Result                                                                                                                                                                                                 | Actual Result | Pass? |
|-------------|------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|
### Table 35: Application main activity test cases 1

5. **Favorite List Test Cases**

| Test case#1  | Description                          | Action            | Expected Result                                      | Actual Result                                      | Pass? |
|-------------|--------------------------------------|-------------------|------------------------------------------------------|----------------------------------------------------|-------|
| View favorite list (logged in) | The user clicks on Favorite when he is logged in. | Click on Favorite | The user’s favorite list will be displayed.          |                                                    |       |

| Test case#2 | Description                          | Action            | Expected Result                                      | Actual Result                                      | Pass? |
|-------------|--------------------------------------|-------------------|------------------------------------------------------|----------------------------------------------------|-------|
| View favorite list (not logged in) | The user clicks on Favorite when he isn’t logged in. | Click on Favorite | An error message will be displayed prompting the user to log in to view his favorites list. | ![Image](https://via.placeholder.com/150) | Yes   |

| Test case#3 | Description                          | Action            | Expected Result                                      | Actual Result                                      | Pass? |
|-------------|--------------------------------------|-------------------|------------------------------------------------------|----------------------------------------------------|-------|
6. Upload Content Test Cases

| Test case#1 | Description | Action | Expected Result | Actual Result | Pass? |
|-------------|-------------|--------|-----------------|---------------|-------|
| Enter valid inputs | The user enters valid inputs | Click on Share button | The content will be linked with the LED, and the user will redirected to the Timeline | ![Image](image.png) | Yes |

Table 37: Application upload content test cases

7.4. PERFORMANCE AND STRESS TESTING

7.4.1. PERFORMANCE TESTING

Performance testing is a type of testing intended to determine the responsiveness, throughput and reliability of an application under a given workload. It’s typically done to help establish a baseline to estimate the hardware configuration required to support the application when it goes live to production operation [49].

a. Test Environment
Android Profiler is a tool in android studio to provide real-time data for the application CPU, memory, and network activity. It is used to perform sample-based method tracing to time the application code execution, capture heap dumps, view memory allocations, and inspect the details of network-transmitted files [50].

Hardware used:
1. Huawei P9 Plus CPU: Hisilicon Kirin 995, RAM 4.0 GB, Android version 7.0
2. Geo-LiFi LED
3. Dongle

b. Performance acceptance criteria

1. Ensure the app under test is running in parallel with other apps; there should be no interference.
2. Ensure realistic user experience under several network conditions.
3. Ensure the application does not get crashed.
4. Ensure the RAM is required for utilizing this app does not exceed 10% of the mobile RAM.

a. Test results

During the run time of 15 min, we found that highest memory usage was 194.8MB, the lowest is 72MB and the average was 150MB. From these results we can see that the RAM does not exceed 10% of the mobile app so, we can safely say that the application is light on the devices memory. Also We tried to run the application in parallel with others apps and this does not affect in the app performance. In addition, we tried to perform all application functionalities and the application never crashed. Finally, the app gave a realistic user experience with a slow Internet connection, the
app receives contents but, the only multimedia contents take more time to appear on the screen. From the previous result we found that our application passed the performance testing.

7.4.2. STRESS TESTING

Stress testing determines the upper limits and the sizing of infrastructure by causing the application or its supporting infrastructure to fail. It is hard to perform stress testing manually, since it is difficult to simulate multiple user inputs and interrupts fast enough to strain the system. However, with the use of tools it can simulate these test scenarios easily. To perform stress testing, Neoload tool is used. Neoload is an automated test tool for measuring applications and web and API performance. Using Neoload tool, two tests have been applied to measure our application’s performance.

a. First result

```
| Name          | 16:15 - 28 Apr 2018 |
|---------------|----------------------|
| Description   |                      |
| Status        | Passed               |
| Start date    | Apr 28, 2018 4:15:25 PM |
| End date      | Apr 28, 2018 4:17:25 PM |
| Duration      | 00:02:00             |
| Termination reason | Execution policy          |
| LG Hosts      | localhost:7100       |

| Project     | LumComTest             |
|-------------|------------------------|
| Scenario    | scenario1               |
| Load Policy | - The population Population1 is constant with 10 users. |
| Stop Policy | - Population Population1 is constant with 10 users. |
| Filters     | None                   |
| Debug       | Disabled               |
```

Figure 2: first stress test result

It can be seen in Figure 107, that our application has passed the first test, under the user of 20 users within two minutes. 20% of the users used Motoral X android level 6.0, 30 % used Samsung Galaxy S7 android level 6.0 and the last 50% used Samsung Galaxy S6 Android level 5.0.

b. Second result
As we can see in Figure 108, the application handled a heavy load. The number of users have been increased from 20 to 40 active users, and the duration time has been increased to 15 min. The application showed no signs of bugs, or memory leaks and did not crash from the load.

![Figure 3: second stress test result](image)

7.5. USER ACCEPTANCE TESTING

The objective of the user acceptance testing is to confirm that the system under test meets its requirements and to provide confidence that the system works correctly and measure its usability before it is delivered to the end users [54].

The usability of the system was measured in three criteria:

- **Effectiveness**: by measuring the number of errors detected when the user performs a specific function.
- **Efficiency**: by measuring the time that the user takes to perform a specific function.
- **Satisfaction**: by using a survey to discover the users’ feedback about the system.

The total number of users who participated in the acceptance testing are ten users: five of them tested the website and the other five tested the application.
To test the efficiency and effectiveness of our system, the average time the users need to complete a specific task was computed and the average numbers of errors they have made was registered. The results are shown in Table.106 for the website and in Table.109 for the application.

To measure the user satisfaction of the system, a survey was made that measures different aspects of the system such as ease of use and learnability, feedback and errors, consistency and screen displays, efficiency and subjective satisfaction. The questions were constructed as seven-point rating scales. Users were asked to rate agreement with the statements, raging from strongly disagree to strongly agree. The questions were chosen based on several HCI rules measuring usefulness, reliability, usability, consistency, learnability, robustness and satisfaction. The questions included in the survey are as appears in Table 104.

| Survey Questions                        |
|-----------------------------------------|
| **Table: Survey Questions**             |
|                                         |
| **Ease of Use and Learnability**        |
| 1 It is easy to use                     |
| 2 I easily remember how to use it       |
| 3 It require the fewest steps possible to accomplish what I want to do with it |
| **Feedback and Errors**                 |
| 4 I can recover from mistakes quickly and easily |
| 5 System messages are meaningful and jargon free |
| 6 It makes it difficult to make mistakes |
| **Consistency and Screen Displays**     |
| 7 I can easily identify where I am      |
| 8 Suitable choice of screen and font colors |
| 9 Widgets locations and colors are consistent across displays |
| 10 Wording is consistent across displays |
11. Icons and symbols reflects intended task
12. I don't notice any inconsistencies as I use it

| Efficiency |
|------------|
| 13. It does everything as I expect it to do |
| 14. Shifting among windows is easy |
| 15. Guidance information always available |
| 16. I successfully accomplished tasks every time |

| Subjective Satisfaction |
|-------------------------|
| 17. I am overall satisfied with it |
| 18. It works the way I want it to work |
| 19. It is designed for all levels of users |

*Table 38: Survey Questions*

### 7.5.1. WEBSITE TESTING

The table below shows the testing users ages and genders:

| Participant No. | Age | Gender |
|-----------------|-----|--------|
| 1               | 28  | Male   |
| 2               | 45  | Male   |
| 3               | 31  | Male   |
| 4               | 24  | Female |
| 5               | 26  | Female |

*Table 39: Users’ ages and gender*

| Function                | Average number of errors | Average time in seconds |
|-------------------------|--------------------------|-------------------------|
| Register                | 0.2                      | 40.04                   |
| Log in                  | 0                        | 17.8                    |
| Update profile info     | 0                        | 12                      |
| Display LED(s) on map   | 0                        | 3                       |
| Display LEDs’ Statistics| 0                        | 1                       |

*Table 40: Average number of errors and average time in seconds*
The table above shows the average time users need to complete each function in the website and the average numbers of errors they have made in each function. It can be seen from the table that the average number of error occurred in register and add LED functions is 0.2, while it’s 0 in the other functions. The add region function took 53.48 second on average, and the related functions such as: update region details and delete region took between 23 to 33.48 second to be completed. The add LED function took 128.68 second on average, and the related functions such as: update LED details and delete LED took between 24.4 to 74.64 second to be completed. Finally, the add content function took 88 second on average, and the related functions such as: update content details, delete content and link content took between 48.8 to 66.76 second to be completed. Notice that adding LEDs to the system took the highest amount of time since it requires more steps to accomplish. This could lead to the consideration of enhancing the interfaces to make them easier and more accessible. In addition, since the interfaces of the main functions (add\delete\update) for the regions, LEDs and content are consistent among all windows, there’s a noticeable drop in the number of seconds taken to accomplish the tasks. For instance, the “update form” is identical to the “add form”, due that, the number of seconds taken to add a region (53 seconds) is relatively higher than updating it (23 seconds). While performing the test, we noticed that the number of seconds taken by all the test users to accomplish the same task is almost the same. From this we conclude that the easiness of use of the system is in the same level for different types of user, regardless of their skills and background.
Managing LEDs time taken dropped from approximately 128 seconds in “Add” to 33 seconds in “Update”. Which means once the user got familiar with the interfaces the easiness of use increase.

It can also be seen that the number of errors encountered while completing any if the tasks is almost zero. This indicates the level of ease and learnability of the system.

As mentioned earlier, the user must fill a survey after testing any of the subsystems. Some of the significant survey results regarding the admin web-panel appear in the tables below.

| Significant Survey Results |
|----------------------------|
| **Ease of Use and Learnability** |

| **It is easy to use** |
|-----------------------|
| 1                      |
| 2                      |
| 3                      |
| 4                      |
| 5                      |
| 6                      |
| 7                      |

1-2 Strongly disagree
3-5 Neutral
6-7 Strongly agree

| **Feedback and Errors** |
|-------------------------|
| **I can recover from mistakes quickly and easily** |
| 1                      |
| 2                      |
| 3                      |
| 4                      |
| 5                      |
| 6                      |
| 7                      |

1-2 Strongly disagree
3-5 Neutral
6-7 Strongly agree

| **Consistency and Screen Displays** |
|-------------------------------------|

1-2 Strongly disagree
3-5 Neutral
6-7 Strongly agree
Regarding the results of the survey, the majority of users “strongly agree” that the website is easy to use, requires the fewest steps possible to accomplish the tasks and they can easily remember how to use it. This relates to the results obtained from measuring time taken to accomplish the tasks. Consistency plays an important rule to gain these results, as it entails the ease of use, learnability and familiarity. It can be seen that 3 out of 5 users “strongly agree” that they can recover from mistakes quickly and easily. This sentence concerns how the system notifies the user about incorrect
input, missing fields and unintended actions. Add to that, 4 out of 5 users “strongly agree” that the messages provided to them in case of mistakes are meaningful and jargon free. When considering the screen displays style and consistency among windows, all of the user “agree” that the choice of screen and font colors is suitable, widgets locations and colors are consistent across displays, wording is consistent across displays, icons and symbols reflects the intended tasks. That verifies the result concluded from analyzing the obtained measurement in Table 106, which is the acceptable level of consistency achieved throughout the pages.

However, most users reported that guidance information is not always available in all pages which may highlight the need to provide more guidance on how to use the system. Finally, 80% of users overall satisfied with it.

7.5.2. APPLICATION TESTING

The table below shows the users ages and genders:

| Participant No. | Age | Gender |
|----------------|-----|--------|
| 1              | 28  | Male   |
| 2              | 24  | Male   |
| 3              | 23  | Female |
| 4              | 22  | Female |
| 5              | 22  | Female |

Table 42: users ages and genders

| Function                | Average number of errors | Average time in second |
|-------------------------|--------------------------|------------------------|
| Register                | 0                        | 40.2                   |
| Log in                  | 0                        | 19.5                   |
| Edit profile            | 0                        | 28.1                   |
| Upload content          | 0.2                      | 29.4                   |
| View users content      | 0                        | 4                      |
| View admin content      | 0                        | 5.2                    |
| Save content to favorite list | 0            | 3.3                    |
| View favorite list      | 0                        | 3.31                   |
| View all regions        | 0                        | 2.2                    |
The table above shows the average time that users need to complete each function in the application and the average numbers of errors they have made in each function. It can be seen from the table that the average number of error occurred in *upload content* is 0.2, while it’s 0 in all the other functions. That could refer to the fact that uploading content requires more steps than other tasks. The *upload content* function took 29.4 second on average. In addition, *view users and admin content* took between 4 to 5.2 second on average, and the related functions such as: *save content to favorite list and view favorite list* took between 3.3 to 3.31 second. Finally, *view all regions* and *view specific region* took between 2 to 2.2 second on average. Registering in the system required the highest number of seconds among the functions. When the user first downloads the application, the first function to interact with is registration. According to that, it requires some time until the user gets familiar with how the application works; justifying the gained result. The other functions took noticeable low amount time to accomplish.

Regarding the results of the survey, most of users “strongly agree” that the application is easy to use. However, all of them “strongly agree” that it requires the fewest steps possible to accomplish the tasks, and they can easily remember how to use it; confirming learnability and ease of use of the application. Concerning robustness of the application, it can be seen that most of users “agree” that they can recover from any mistakes they make quickly and easily and the the provided messages are meaningful and jargon free. 90% of users “strongly agree” that the choice of screen and font colors is suitable, widgets locations and colors are consistent across displays, wording is consistent across displays and icons and symbols reflects the intended task. Furthermore, most users “strongly agree” that the application does everything they expect it to do, and shifting among windows is easy. However, 4 out of 5 users reported that guidance information is not always available. Moreover, most of users “strongly agree” that it works as the way they want it to work, and that it is designed for all levels of users. Finally, 80% of users overall satisfied with the application.