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University of Augsburg
Faculty of Applied Computer Science
Department of Computer Science
Bachelor Program in Computer Science

Bachelor Thesis

Brief Title

Development of a Multi-User, Multi-Display application to increase Energy Awareness

submitted by
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This work is dedicated for my brothers who died in rabaa massacre.

Abstract

Energy is now a trending issue that the whole world is talking and is worried about , the energy consumption is increasing and the resources are limited so the world has to find other ways to produce energy and decrease the level of energy consumption by people and in order to solve such a problem, the problem has to be identified. So by knowing this fact and using the new modern ways as pubic displays and multi-user applications which was proven to motivate people to interact with it regularly in a fun and innovative way and that's how the idea of creating a multi-user, multi-display application to motivate people to save more energy and let them know how much energy they use came.

Acknowledgments

I would like to thank Ahmed Mohamed for helping me in understanding some concepts in the pusher service also Gasser Akila and Youssef Madkour for their support.

Statement and Declaration of Consent

Statement

Hereby I confirm that this thesis is my own work and that I have documented all sources used.

Karim Aly

Augsburg, 25.08.2013

Declaration of Consent

Herewith I agree that my thesis will be made available through the library of the Computer Science Department.

Karim Aly

Augsburg, 25.08.2013

Contents

Chapter 1

Introduction

1.1 Motivation

Energy is now one of the main concerns the world is worried about , energy resources are running out and people energy consumption is increasing dramatically it was expected that from 2008 to 2030 world energy consumption is expected to increase more than 55% (Refer here).

One of the comments that was online about this topic stated "It's weird how unaware we are as to how much energy we're really using" and this is very true people in their daily lives doesn't seem to know anything about their energy consumption , while cooking in the kitchen or even taking a shower or while working. So people needed anything which tells them their energy usage in a daily basis also they can view and compare their usage to hope for a better energy consumption.

Concerning public displays and multi-user applications many cities around the world now began to install public displays in many places like shops,train stations, and many other since it was proven that public displays motivate the user more to interact with it and also help him in finding what he needs in a fun and innovative way. For example the public display in LOCATION1 (e7ky kesetha) also another one was placed at LOCATION2 (e7ky keset-ha).

1.2 Objectives

The aim of the project was first letting the people know how much energy they use on daily basis because the first step to solve the problem is knowing where the problem is. Also modern ways like public displays and smart phones had to be used in order to allow users to compete with each other and compare their usages in a fun and interactive way on public displays.

Moreover, helping the user in saving energy in their daily lives by giving them tips about the things they usually do every day on how to do the same things but more efficiently by using less energy and of coarse this helps if not by decreasing the energy the user consume , it helps by letting the user know ways about how the energy can be waisted so instead of doing the task in lets say a k amount of energy it ends up using double this amount.

Finally the system had to be robust and user friendly so in order to try to achieve that, privacy profiles were implemented in order to give the user an option to hide his data if he doesn't want anyone to check his consumption also to increase user trust in the application.

Chapter 2

Related Work

2.1 Theoretical Background

Many projects were done under this topic which is increasing the energy awareness and helping people to save more energy.

The first one was a treasure hunt game which used Augmented reality technology and adaptive virtual gardens to design a game to motivate people to save energy the game consisted of 2 parts the first one was the Augmented reality quiz which is some questions related to the environment issues and there were clues at every station in the building which helped the user to go to the next one and answer the questions, this was done to increase people awareness about the energy issue. The second part was a dynamic visualisation which converted each team score to a status of a personal virtual garden so the users first start with a good health garden and according to the score they get the health of the garden differs if they keep on getting more points the health of the garden improve and this part was responsible for the motivation by using the gaming principles like prize and score and the factor that all the teams or users scores where available on the public display as the garden status.

The second project was about a system which helps create more smart solutions and apply it to energy devices like creating scheduled tasks for each individual device and also being able to track the number of users in a house hold and the energy consumption of each user device to save more energy, the project mainly focus on dealing with the problem that most of the energy monitoring devices only allow people to reduce their total energy without knowing exactly which devices consumed which amount of energy so its very hard using this systems to know how much each device or each individual is actually using.

So the system developed was named USEM (Ubiquitous Smart Energy Management) which aimed to assist users to save more energy without caring too much on knowing how would the system accomplish that. The system classified the devices into 2 categories which are regular devices and continuous devices. Regular devices were represented in devices which only take a set of time like TVs,washer and oven while continuous devices were represented in devices that operate more automatically without interference from the user like air conditioners , refrigerators and water heaters. Also the system defined whats called by rules and tasks for regular devices and defined levels for continuous devices instead of rules and tasks. So the rule was about a set of conditions, once met the rule is executed while task is just a task which the user schedule the system to finish it. As for the level it is also about setting a set of conditions but for continuous devices and to be able to control and set all that from the USEM software user interface.

The third project was about the different interaction techniques that can be used to interact with personalized public displays in sensitive situations, mainly it compares 3 different interaction techniques which are direct,bodily and mobile-based. The project classified the whole process into three phases which are identification, navigation and collecting results. Also mentioned that using personalized public displays makes it easier for the user to extract his own data because it can be tailored to the user profile but on the other hand it may cause some privacy issues. The project simply explained the 3 main phases starting by the identification phase which is the logging in system and how the user logs in the system and his personal data is shown on the display then the navigation phase which is about the user being able to navigate through out the application to find the data he needs and finally the collecting results and logging-off phase which indicates that the user has found what he wants and whether or not the user wants to save it on his mobile then log off and the data is removed from the screen.

The project also discussed the 3 possible techniques when interacting with public displays which are direct,bodily and mobile-based, so lets take a glance at each of these techniques as discussed in the project. The direct interaction involves having an interactive tool to interact with the display which can be user's hand or NFC-enabled mobile phone , bodily interaction this technique is mainly about gestures and body postures and is usually supported by camera-based recognition and mobile-based technique which uses a mobile phone to control and interact with the public display. Each of them had their positive and negative sides also an experiment was made to test which interaction technique was preferred by the users in the 3 phases of interaction , the results were that users preferred mobile-based technique in Identification and Collecting results phase however users preferred direct technique in the navigation phase. Moreover it was recommended to have an auto-logout feature to increase security and trust in the system and using well known metaphors in interaction.

The fourth project was about how to protect and maintain user privacy on personalized public displays and the project investigates the possible profiles that can be created for the user to choose the best privacy option for him also it investigated how the relationship context affected user's choice in deciding his privacy profile. The project classified privacy protection to 5 groups ordered by ascending protection level and they are: do noting, minimize, mask, remove private part, remove all. Experiment was made to test which of the 5 privacy levels the users preferred when a stranger,colleague and a friend suddenly appears on the display and the results were that generally no protection is needed when the person appeared is a friend , the users tend to choose a more powerful privacy profile when the person is an acquaintance and finally the users tend to choose the strongest protection privacy level when the person is a stranger.

Chapter 3

Concept And Implementation

3.1 Technologies Used

The technologies used in the project were Django framework that was used to handle the backend code which was represented in writing the server code and creating the models or the tables of the database in order to be able to store the information needed to run the application as for the connection between the display and the mobile, we faced a major problem at the beginning, since web sockets technology was agreed to be used and it wasn't supported by the android native mobile browsers another solution had to be found and that what led us to pusher. Pusher is a tool which helps the developers to create applications which involves realtime in it, also phone gap was used to help in writing HTML5 code and javascript to make native applications for multiple platforms so it helped in developing the backend of the mobile code which was simply javascript. For the front end code or the user interface which was represented in the design and the looks of the application, HTML5 and CSS3 were used to design the application user interface and twitter bootstrap was used also for the public display user interface with jquery to reach a more powerful design also Jquery mobile was used on the mobile side for both handling the user interface and the server side functionalities on the mobile, moreover charts were needed in the application so canvasjs chart engine was used in rendering the charts with the given data using HTML5 canvas to draw the required charts.

3.2 Concept

So the concept was to create an application to help people to increase their energy awareness and help them to save more energy. Since the technology used was agreed to be HTML5 and Web sockets, the idea was to create a multi-user application in which each user can do actions in their specified space or slot on the screen and by using web sockets the connection were established between each user(mobile) and the display. Moreover charts is created for the user to check regularly to check their energy usage and they get to choose the duration they want to view their usage into.

3.3 Connection

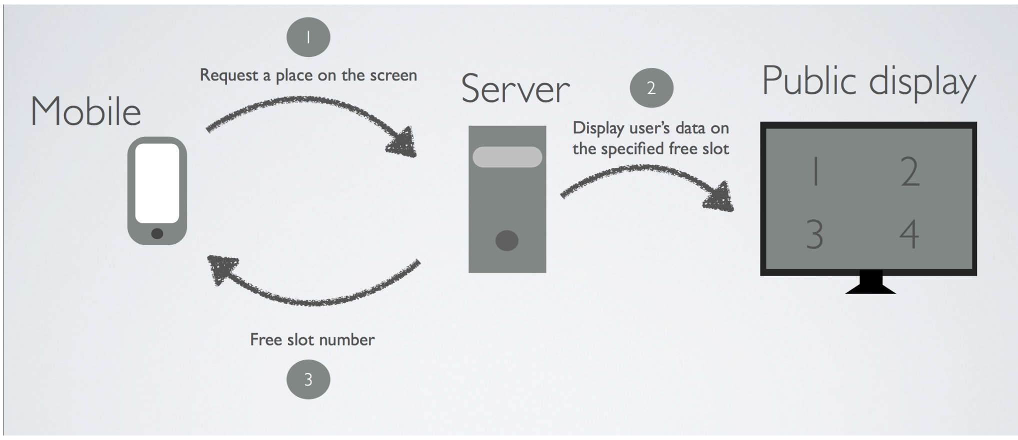

Figure 3.1: This figure showing the connections made between the mobile,server and the display.

The connections in the project was mainly done using pusher first the user approaches the screen to find an introduction to the application and then the user has to click connect in order to start using the application. Once the user presses connect on his mobile device a request is sent to the server which start executing the multi-user algorithm explained below in section 3.4 after finding the specified free slot on the screen it saves the slot number and sends a signal to the public display to display the login page in the specified slot using a 4 channel connection system which consists of a channel for each slot of the screen , when the multi-user algorithm finds the free slot it connects to the channel that corresponds to this slot (will be explained briefly in section 3.4) avoiding clashing between users requests since each user on the display will have his own channel to send and receive requests and will also help in identifying each user actions and interactions with the system as you can see in Figure 3.1.

As for the channels and the connections it can be seen in the following Figure 3.2:

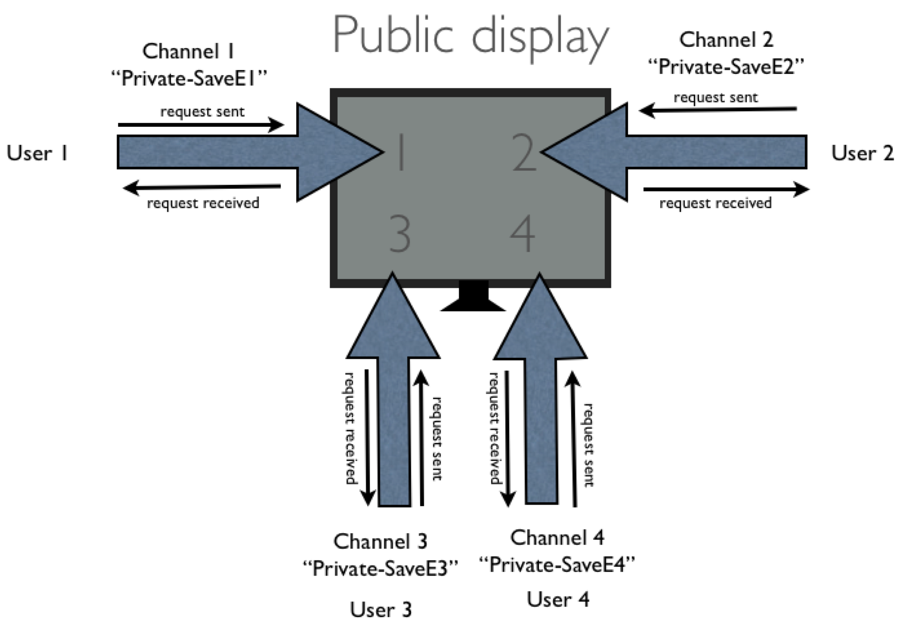

Figure 3.2: This figure showing the connections and the channels and how every user connects via his own channel.

3.4 Multi-user setup

The multi-user setup was one of the challenging part in the project because normally when a web application is opened in a window it will have a session for the user opening that window but to have a number of users doing some actions in the same window here the problem occurs because each user is supposed to have one session id which is stored by the browser window but when multiple-users start to navigate in one window the sessions replace each other, as a result the requests origin or the user who made that request will not be known. The problem was handled by passing the user id which is a unique key which identify a user to every page he visits once the user is

logged in and neglecting the session id so doing this for all the users on the screen solves the problem of the sessions replacing each other and making sure to know where does this request comes from or from which user to avoid colliding of requests.
The organising of the users on the display and the process of registering a user on the display in order to start interacting with it was done by implementing a simple algorithm it's goal is to organise the order of the users and their slots on the screen and to let the users interact on their specified slots and by saving the number of users currently on the display in a local storage variable by the browser.
As you can see the following figure **??**

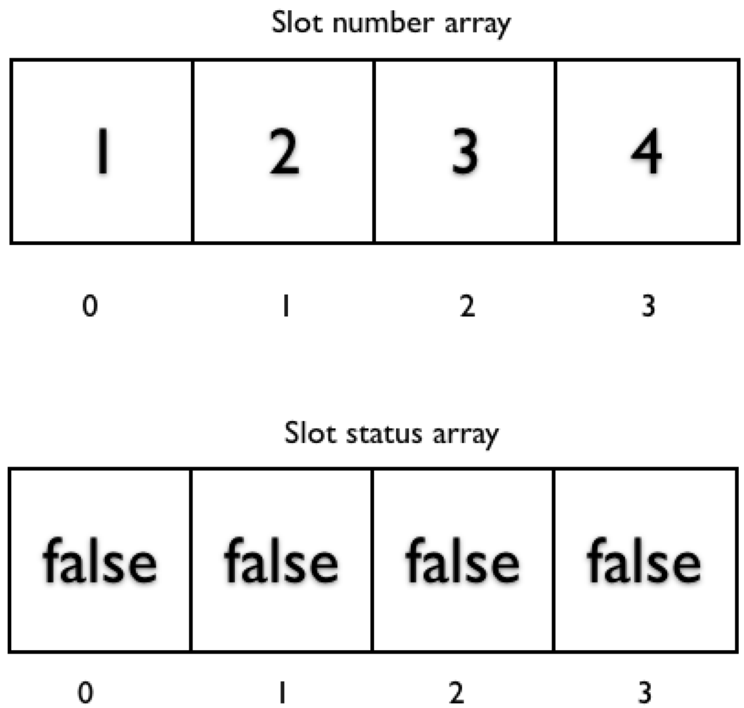

Figure 3.3: The figure shows the array of slot numbers on the display.

represents the array of screen slots numbers from 1 to 4 when a user press the connect button the mobile sends a signal via a general channel to the server which then loops on the slot status array in figure **??**.

And when it finds a free slot which means false it overrides the false value with a true one and take it's index to get the corresponding index in the slot numbers array in figure ?? then it sends the slot number which will be assigned to this user to the mobile device and connect to the channel of this number and display the content on the specified slot then it increment a local storage variable stored by the browser which keep track of the number of users on the display. For example imagine this situation : currently the public display has 3 users logged-in and another user wants to connect so as you can see in figure 3.4 the Boolean array which represents the current busy slots of the screen indicates that slot 1,2 and 3 are taken.

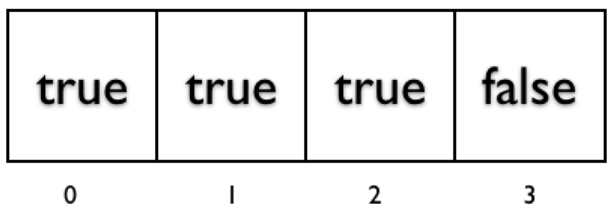

Figure 3.4: The figure shows an example of users available in slot 1,2 and 3 initially.

So once the user press connect what the system does is the following :

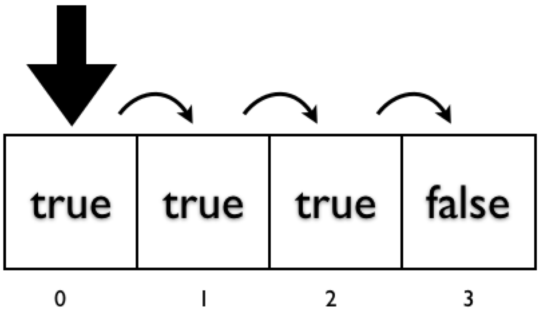

Figure 3.5: The system in the figure iterates on the array to find an empty slot or a false value in this case.

The system begin to loop on the array that contains the status of each slot on the screen until it find a cell in the array in which the cell is "false" which means at this index in the Slot number array the slot is free then the system stops and replace the status with true instead of false then sends this number to the mobile in order to connect on the channel of that slot to be able to interact so here is a figure when the algorithm executed.

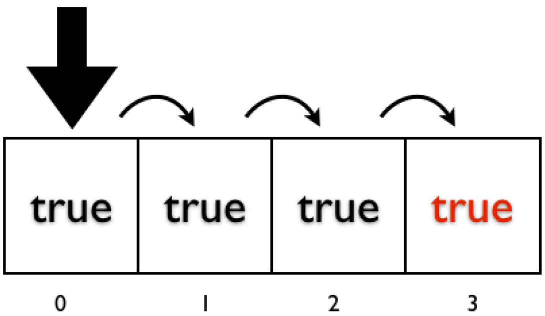

Figure 3.6: The figure shows that the system found an empty slot (false value) and will replace it with a true value to indicate that it is busy.

Then it sends the corresponding number in the slot numbers array which is 4 in this case to the mobile to be able to connect to slot 4 via its channel so as it appears in figure 3.7 the number is then sent to the mobile and concatenated to the default channel name which is "Private-SaveE" as mentioned in the previous section. And by that it prevents any conflicts between users and let the system distinguish between user requests.

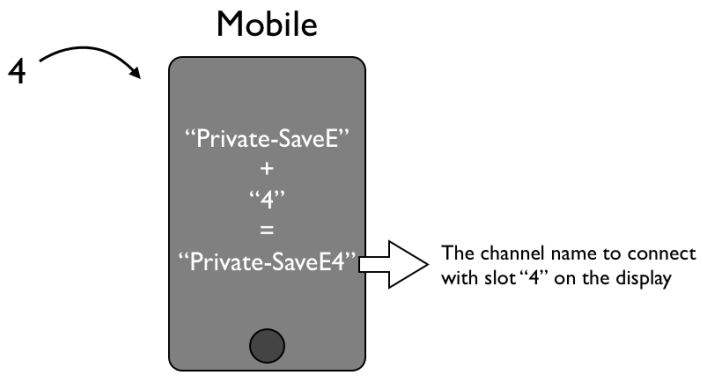

Figure 3.7: The figure shows when the number of slot is sent to the mobile then the mobile concatenate that number with the default channel name to connect to the corresponding channel.

3.5 Synchronization

Synchronization of the displays was done by also using the connections as mentioned in the Connections section 3.3 so the system once the user pressed any button on his mobile to navigate the system on the display the mobile pops-up the loading widget which tells the user what is the server trying to do in that moment so while the request reach the server, the server sends to the display what to show then an event is triggered on the channel which the user is connected to with a loading complete header which indicates that the request has successfully executed and the loading widget is removed from the user mobile screen and the page is changed to match the display contents. And here is an example to illustrate more :

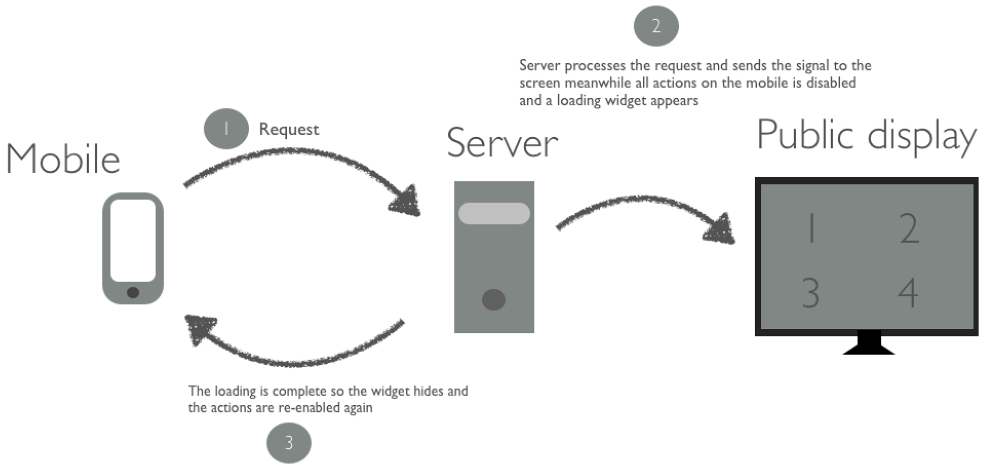

Figure 3.8: This figure illustrates the synchronization process.

3.6 Responsiveness And Interaction

One of the important milestones in the project were the responsiveness and the interactions since the application is a multi-user application so multiple user interface profiles had to be made in order to cover all the possible situations and combinations that might happen between users so for example when a user is on the display alone the user takes the whole screen alone to display his data but when 2 users are on the display the display in splitter between them and both user interfaces for each user have to be changed in order to match the new dimensions and space that each user have on the display. So for more understanding please refer to this figure 3.9 this is a situation when 1 user is navigating the display alone:

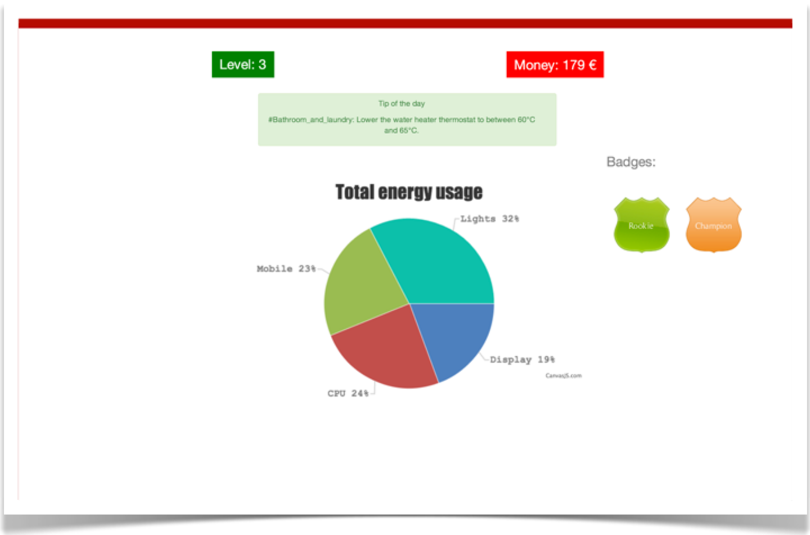

Figure 3.9: The figure shows only 1 user navigating the display.

Then if another user wants to log-in and navigates, the user interface of both users change according to the number of users which is stored by the browser in the local storage as mentioned in the connection section 3.3 and here is a figure to illustrate more:

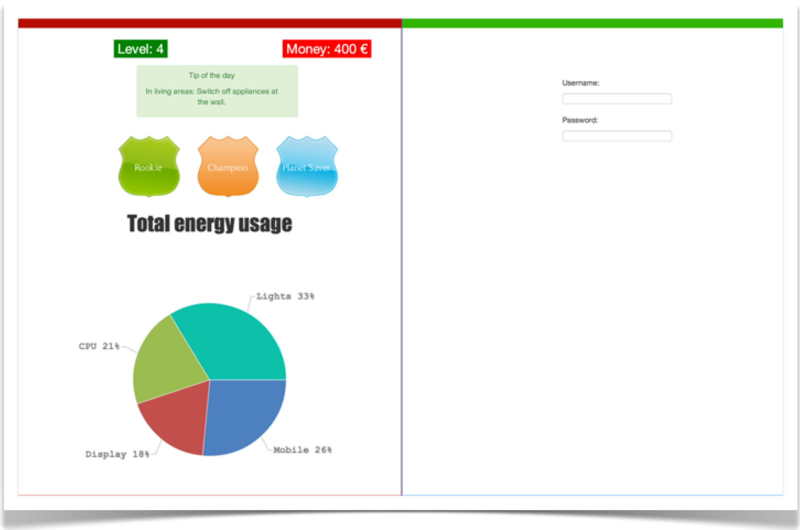

Figure 3.10: The figure shows the screen when another user connected.

This was made by implementing css classes for each element on the screen for each possible scenario for example when a user navigates on the display alone he is taking the whole screen alone and all the elements are given the css for that situation but then when another user signs in he trigger a function which then knows the page that each user is currently at and begin to change the css of each of the elements to the new situation so the css is all checked and changed when a user connects to the display and already there are other users. Also when a user navigates from one page to another, the same function is called but to only correct the css of any change happened and to maintain the correct user interface for all the users.

3.7 User Data

User data which is simply represented as charts in the project and letting the user know their energy consumption was one of the objectives to increase energy awareness and to help users save energy so user data had to be made in order to illustrate to the user his consumption also helps in 2 points:
the first point: user data helps the user to know their detailed energy consumption and as a result the user can know where does the problem come from or from which device he consumes energy the most.
the second point: users may take advantage of the multi-user setup and use the system to compare each other's data in order to motivate both of them to save energy as that can give them rewards as we will see in the game mechanics section3.9.

3.8 User Privacy

Privacy was one of the important aspects of the project since the project was not about creating an application to motivate people to save energy and increase their energy awareness only , but also a robust and trusted system, so privacy had to be implemented in the project in order to let the user feel safe at any time he doesn't want anyone to check his detailed energy consumption he just can hide his data from people and view it on his mobile screen instantaneously. So 2 privacy modes were created the high privacy mode which tells the system to hide the data from the public display and send the data to the mobile so the user only see his data on his mobile once he choose that option and the low privacy mode which is the normal mode , the data is kept at the display available for all users to see normally.

But while trying to implement privacy there were certain constraints:
first the size limit of pusher service used for the connection between the public display and the mobile was only 10KB so sending the whole page to the mobile from the screen was not an option.
second the css and user interface of the page on the screen was displayed using twitter bootstrap as mentioned in section 3.1 and on the mobile Jquery mobile was used , so 2 different technologies used as the interface for each the display and the mobile, as a result the data couldn't be sent directly to the mobile since the styles will replace each other.

The 2 problems were solved by just sending the crucial information which was the user data in this case because there is no point in hiding the level or the money you have because it already appears on the leader board and they are made to let people compete with each other not hide it from each other so the charts engine used were put on the mobile and the data of the charts was the only part sent so by that the first problem which was the size was solved also the second one was solved because nothing is required to be sent with the data and then the mobile gives the data to the charts engine on the mobile to render it and generate the charts on the mobile once the user chooses the high privacy option.

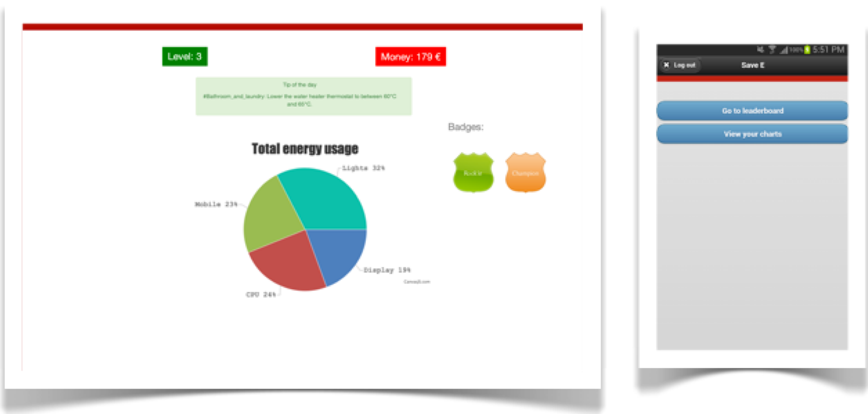

Figure 3.11: This figure shows the screen and the mobile in low privacy profile settings.

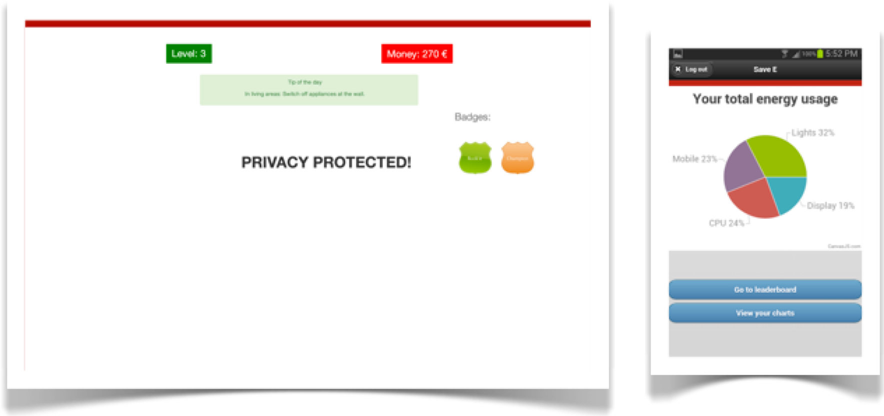

Figure 3.12: This figure shows the screen and the mobile when the user chooses high privacy profile settings.

3.9 Game Mechanics

Gamification or applying game mechanics is now widely used in many applications because it enhance the user experience with the application and involves more fun but in the same time it motivates users to challenge and compete against each other in order to be from the top 3 or the top 10 players so this concept was used in the project to bring more interaction between the users and increase their motivation to compete against each other to save energy and gain badges and virtual money to be able to make their way up the leader board as it will be explained later in this section.
So simply the game mechanics of the system consists of:

1- Levels: level is an indication about your total consumption also used by the leader board as the sorting key.
2- Badges: a badge is gained when you cross a certain amount of money and as long as you are saving more money you gain more badges.
3- Virtual Money: initially users have money then when the costs of their usages is calculated and deducted they loose them.
4- Leader board: the leader board is the place where you can see all the users and their levels,badges,money and ranks.

So simply users at first have a certain amount of money by default then when they start measuring their energy consumption day by day the cost is calculated and deducted from the money they have so the more you consume energy the less the money you have and vice versa. Also when the system detects that the data is for a new month the system adds new money to the users so when the users save more energy and pay less, their money increase and when they reach a certain amount of money which is decided by the system, they gain badges which leads to a level up and improving their ranks on the leader board.

Chapter 4

Conclusion

Chapter 5

Results And Future Work

Appendices

Appendix A

FirstAppendix

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List of Algorithms