# LUMIN

## CLIENT DELIVERABLE 1




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|---|---|
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# Executive Summary

The Ember Applications conceptual design for Lumin has been reviewed and some changes have been annotated. The document requirements and management aligned with our requirements, with the exception of some minor changes. Overall, we are satisfied with the direction Lumin is heading. In addition, we have included a set of tests to be performed, verifying that the system meets requirements when delivered.

# Findings

An overview of our findings on the design document are outlined below. Small edits to the proposal are not shown.

## Accelerometer

The document mentioned that the user's phone could potentially be used as the accelerometer. This is technically possible but does not meet the requirement that Lumin will track your sleep and trigger the alarm without a mobile device nearby, and it is also potentially dangerous to your device.

## Speaker

It was mentioned that the alarm sound quality does not matter. The final production version of Lumin should have a speaker comparable to one you would use to listen to music with. A good quality speaker is not a minimal requirement for EOT.

## Wake up Time

The alarm lighting should not turn on at the soft wake time. If there is a large difference between soft and hard wake time, this could be very annoying to the user. The lamp should turn on at the best possible time, with the sound turning on after a small delay. If the alarm is triggered at the hard wake time, both should turn on immediately.

## Colour Wheel

The colour wheel in the final system should have both RGB and HSV sliders, instead of just RGB. HSV allows much more control when choosing a colour, allowing changing hue, saturation, and luminance separately.

# Acceptance Tests

Considering the main functionality of Lumin is to act as a

- A bedside lamp, and
- Smart alarm clock

FixCode has provided acceptance tests to verify proper functionality of the product on delivery. These following tests verify that the system performs these main functions and meets our specification.

## Test 1

| | |
|---|---|
| **ID** | **Set alarm with colour sequence** |
| **DESCRIPTION** | The user creates an alarm and specifies a colour sequence. The Lumin devices acknowledges the creation and stores alarm data on device. |
| **INPUT** | Alarm time<br>Sequence of colours |
| **STEPS** | Open Lumin app on mobile device and navigate to the create alarm page |
| | Enter soft and hard wake up times for alarm |
| | Navigate to alarm colour page |
| | Select a colour sequence from pre-defined list of sequences |
| | Confirm creation of alarm |
| **EXPECTED OUTPUT** | Verification from Lumin that the alarm was created<br>The new alarm appears in the list of alarms |

## Test 2

| | |
|---|---|
| **ID** | **Alarm goes off when in lightest sleep stage** |
| **DESCRIPTION** | The user is sleeping and the current time is between the soft and hard wake up times. Lumin recognizes that the user is in a light sleep stage and triggers the alarm. |
| **INPUT** | Sleep tracking data from accelerometer |
| **STEPS** | User creates an alarm the night before to go off between 6am and 7am |
| | User places accelerometer on bed and goes to sleep |
| | The time is 6:30am and the user is in a light sleep stage, the alarm is triggered |
| **EXPECTED OUTPUT** | Alarm is triggered |

## Test 3

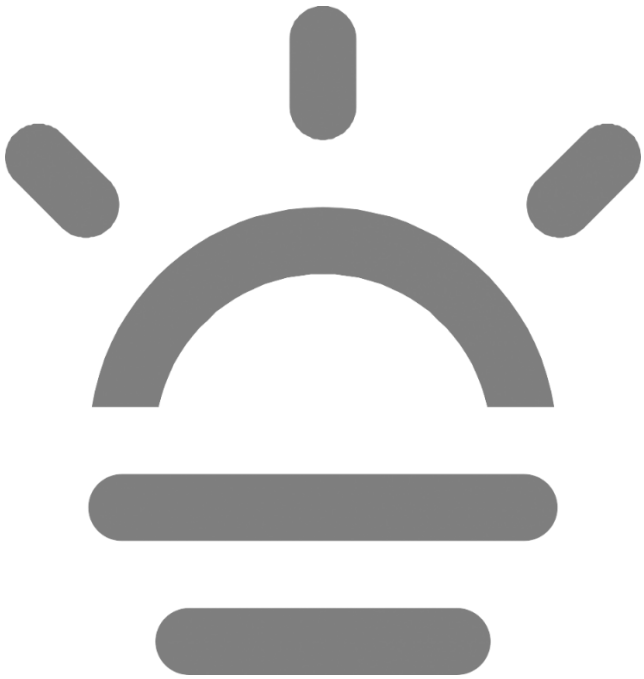
| | |
|---|---|
| **ID** | **Change colour of light on the fly** |
| **DESCRIPTION** | The light on the Lumin is turned on and the user changes the colour of it on the fly |
| **INPUT** | RGB colour |
| **STEPS** | Turn on the Lumin light using the mobile app |
| | Navigate to the colour wheel |
| | Change the colour of the light to red using the colour wheel |
| **EXPECTED OUTPUT** | The Lumin lamp changes colour to red. |

## Test 4

| | |
|---|---|
| **ID** | **Alarm eventually goes off regardless of sleep state** |
| **DESCRIPTION** | The alarm goes off at the set time, when the user does not enter into a light sleep stage during the time between a soft wake up and a hard wake up. |
| **INPUT** | User has set an alarm |
| **STEPS** | User creates an alarm the night before to go off between 7:30am and 8am |
| | User sets up accelerometer |
| | User goes to bed in the same room as the alarm |
| | User does not enter into a light stage of sleep during the half hour before the hard alarm |
| | Alarm goes off at 8am and wakes the user |
| **EXPECTED OUTPUT** | Alarm goes off at the hard wake time since the user was sleeping heavily |

# Appendix

The following pages contain a markup up of issues FixCode has found while reading the latest deliverable.



# Lumin

By Ember Applications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# Section A: Executive Summary

## Functional Specification

The Lumin project tackles the pain of using typical sound alarms. The Lumin will instead wake users gradually using a slowly rising light, and play a sound alarm during the lightest part of the user's sleep cycle, determined by an accelerometer attached to the bed. The colour of light used to wake is highly customizable, and can use local weather data to mimic the day's natural light. It also provides dynamic RGB lighting for general use. The user can specify sequences of colours that will rotate until turned off.

Connectivity between Lumin and a mobile device using Bluetooth/WiFi will allow the user to control the hardware from a mobile application, and facilitates features like the weather lighting. This lets the user-system interactions take place on a fine tuned GUI, and reduces the hardware costs of the device itself. The GUI will mostly comprise of a system of menus, with most input taking the form of button presses. Colours will be selected from a colour wheel, and RGB sliders for fine tuning the colour. Alarms settings will comprise of a name, a soft and hard wake up time, days of the week, a light colour setting, and a sound. Dismissing alarms and the Snooze button will be done through buttons on the hardware.

The hardware will comprise of a small microcontroller that can control the light functions. Several possible controllers have been made note of, including the Raspberry Pi, the Onion Omega, the Arduino Mega 2560, and the ARPI600. The sleep tracking accelerometer may take two possible forms:

The accelerometer on the user's mobile phohne

A special Lumin accelerometer designed to be unobtrusive to the sleeper

The minimal prototype for completion by the end of March will cover, at the very least, the following 3 features:

1) RGB Lighting Control
2) Combination Light/Sound based alarms
3) WiFi or Bluetooth connectivity with the mobile device

These are the core features that define the Lumin.

## Conceptual Design

The Lumin system will be divided across 3 components:

1) Mobile Application: This will be the main interface for the majority of user interactions with the system. It is from here that the user will configure their colours, sequences,

and alarms. During the first start up, the user will create an account. No details other than a username and password are required, as it is merely a label to which a device will be registered.

2) The Lumin Device: This is the physical hardware that the user purchases. It will be comprised of a microcontroller supporting WiFi, RGB LED lights, some simple audio speakers, and a control panel. The only controls supported from this panel are turning the light on and off, adjusting brightness and volume, the snooze button, and dismissing alarms. Part of the hardware is an accelerometer that will attach, or rest on the bed. Data from this sensor will be used to chart the user's sleep cycles, which will in turn be used to determine when the best time to wake the user is.
3) The Server: This will act as the intermediary between the mobile application and the Lumin device. It will store the master copy of the user's colour/sequence/alarm data. This data will be present on all 3 components, but will always reflect the server's copy. Immediate commands from the mobile app, like changing the active light colour, will be relayed to the Lumin through the server.

The active lighting can take 3 forms:

1) A single colour
2) A sequence of colours in a determined order
3) Weather lighting

The weather lighting mode uses current local weather data to determine the colour of the light.

The main functionality of the Lumin, the alarm, will behave as follows:

The user sets an alarm from their mobile device, then goes to bed. During the night, the Lumin device monitors both the time, and the user's sleep data. When it reaches the *soft wake up time* (see glossary), the light turns on. Between this point and the *hard wake up time,* the device will analyze the sleep data to determine if the user is in a light sleep stage. When they reach a light stage, the sound alarm will fire. It also fires if the time reaches the *hard wake up time* before the user enters light sleep. At this point, the alarm functions like any other alarm clock, with a snooze and dismiss options.

Does this imply no snooze otherwise?

# Section B: Functional Specifications

The Lumin Project will address the common pain of waking up in the morning. Traditional alarms are sudden and jarring, taking the user from deep sleep to consciousness over the course of a few painful seconds. These alarms often leave users feeling groggy and resentful of morning's arrival. It's no surprise that many users abuse the the snooze button to try to get a few extra minutes of sleep. Lumin will solve this by providing a far gentler waking experience.

The Lumin is a bedside solution that combines the features of a colour changing bedside lamp, an alarm clock, and a sleep monitoring system. Instead of using only harsh sounds or music to rouse the subject, Lumin will use a variety of techniques to wake the user gradually and comfortably. Long before the sound alarm fires, the light will turn on and slowly increase in intensity. By tracking the user's sleep cycles, the Lumin will wait for the best moment to fire off a sound alarm to bring the user to full consciousness. The system will be useful to anyone who regularly needs to wake up early in the morning, and will be particularly handy for those that struggle to drag themselves out of bed.

## 1.0 Important Features

### 1.1 Customizable Lighting

The most noticeable feature of the Lumin will be the dynamic lighting. While it's primary purpose is an alarm, it will also provide a customizable lighting experience for use while awake. By using dynamic RGB lights, it will provide a broad spectrum of possible colours, which can be chained together in sequences. A sequence will rotate through a set of chosen colours. One could be a chain of soft, warm, sunset colours for an evening wind down, and another could rapidly change between bright, solid colours to make a high energy party sequence.

What does rotate mean? Perhaps switch vs fade?

### 1.2 Sleep Tracking

Over the course of the night, a person goes through numerous sleep cycles. Some parts of this cycle are more pleasant to wake up from than others. By measuring the certain body movements, its possible to determine what stage of sleep a person is in. Typically, people do more tossing and turning during the lighter stages of sleep, which is the better time to wake. The Lumin will track the user's sleep cycle using an an external sensor attached to the bed. This allows the Lumin to choose the best moment to fully wake the user with a sound alarm.

### 1.3 Connectivity and Control

The Lumin will have some controls as part of the hardware, but most of the controls will be done through a mobile application. From the app, alarms can be set, colours can be chosen,

What about the controls on the device itself?

and lighting sequences can be specified. The two devices will most likely communicate via Bluetooth or WiFi. The night's sleep tracking data will also be sent here for storage and review.

To the phone?

### 1.4 Hardware

The product will make use of 6 main hardware components:

1) A microcontroller will control the functionality of the Lumin. It must be capable of interacting with the user's mobile device through either Bluetooth or WiFi, and ideally support USB as a back up. It will need to have enough memory to store the users alarm and light configurations.
2) An RGB light that can provide a variety of colours and brightness levels, and transitions smoothly between them. It must not flicker noticeably during any part of these processes. This answers the question on rotation.
3) ~~A speaker loud enough to wake a deep sleeper. The sound quality is not a major concern, as it's purpose is to wake the user, not fill the role of a sound system.~~
4) An accelerometer for movement tracking. It needs to be small and unobtrusive such that it doesn't interfere with the user's sleep, but must be sensitive to pick up movement transferred through the bed from subtle body movements.
5) External casing for both structure and aesthetic value. The form must be attractive enough that a user would want it clearly visible in their bedroom. This will not be present on the prototype.
6) A digital clock face to display the current time. The brightness must be adjustable, or at least able to be turned off to prevent sleep interference. This won't likely be present in the prototype due to time constraints.

The speaker should be of adequate quality to casually listen to music with Lumin, as is possible with any other bedside alarm.

# 2.0 User Interaction and Interaction Dialogues

When interacting with the Lumin, the user will use one of two interfaces. First are the controls built directly into the Lumin's hardware. Here, only the most basic of interactions will be carried out. This includes turning the light on and off, hitting the snooze button, and dismissing an actively ringing alarm. Depending on the final implementation, it may also have a button to turn the digital clock face on and off. The rest of the operations will be carried out through the mobile application, a choice which has the added benefit of reducing production costs. Many of the interactions, such as colour selection, require a much more fine-tuned interface, which would require a GUI on the device itself. Instead, these controls will be located on a mobile device that most customers will already have access to.

Through the mobile application, the user will carry out most of the Lumin's interactions:

- setting alarm soft and hard wake up times
- setting waking colours and alarm sounds

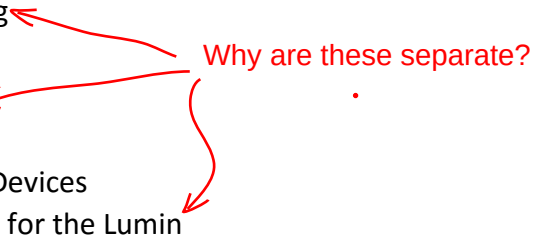
Custom or included sounds?

This answers the question on hardware control

- changing the active colour of the light
- creating colour sequences
- reviewing sleep tracking data
- creating and account
- registering a Lumin device to your account

From the main menu, the user will be presented with a 6 options:

1) Active Lighting
2) Alarms
3) Edit Colours
4) Sleep History
5) Account and Devices
6) On/Off switch for the Lumin




Almost every interaction with the system will begin at this menu.

## 2.1 Setting the alarm

The user, Janine, wants to set a routine alarm that wakes her up at 6:30am every weekday for work.

> *From the main menu, Janine presses the Alarms button*

This takes her to a list of existing alarms. Each one takes the entire width of the screen, displaying the time, and days of the week that it fires. It also shows an icon representing the light colour/sequence and sound associated with the alarm. To the right of each one is a checkbox that toggles the alarm between active and inactive. The user can see more alarms by swiping her finger up or down. At the top of the list is a wide button with the text *New Alarm.*

> *Janine presses New Alarm.*

Janine is presented with the Alarm Configuration Menu. In the top right corner are the Save and Delete buttons. The next row has a text field for the alarm's name. In the row below, she sees two times. The first of these is the *soft wake up* time. This determines the earliest possible time for the alarm to wake the user, and is used to calculate when the light will turn on. The second is the *hard wake up* time. Through sleep cycle tracking, the Lumin will try to wake the user at the best possible time between the soft and hard wake up times. If the user never enters the light portion of their sleep cycle, then the alarm will fire at the hard wake up time.

> *Janine enters the name "Work" into the text field. Next she presses on the soft wake up time and is presented with a typical time selection screen. She enters 6:00am, then repeats for the hard wake up time, for which she selects 6:30am.*

Under the alarm times, the days of the week are listed horizontally. The alarm will fire on highlighted days, and this is toggled by tapping on the day. Immediately underneath is a checkbox that says *repeat.* If checked, the alarm will continue to fire on those days even after the first weekly cycle.

*Janine taps every day from Monday to Friday and checks the repeat checkbox. She scrolls down to see more options.*

Under the weekday selection are two more icons: a colour wheel and a speaker representing light colour selection and sound selection respectively.

*Janine taps the colour wheel icon.*

The user is presented with 4 options:

1) Choose Colour – Allows the user to choose a single colour of their choice
2) Presets – Leads to a list of preset colours
3) Sequences – Allows Janine to choose from any of the preset, or user defined sequences that she made herself
4) Weather – The colour of the alarm light will reflect the current weather in Janine's region

*Janine presses Presets.*

She is presented with a list of options. On the left is the title of the colour, and on the right is a circle filled with the colour itself. The first 3 items on the list are Sunrise, Forest, and Dark Sky. (Subject to change)

*Janine presses Sunrise, a soft light blue colour.*

The menu darkens, and a dialogue window opens with 3 options on it:

1) Confirm – Selects the colour for the new alarm
2) Demo – Turns the lamp onto the selected colour so that the user can sample it before making a decision
3) Cancel – Dismisses the dialogue window, returning the user to the list of preset colours

*Janine presses Demo. The dialogue window stays open, and her Lumin turns a pale blue colour. Liking her choice, she presses Confirm.*

She is returned to the Alarm Configuration Menu. The only remaining task is to choose a sound.

*Janine taps on the speaker icon.*

A new menu opens, listing every available alarm sound by title.

*Janine presses wolf howl.*

She is presented with the same dialogue menu as when she pressed Sunrise during colour selection. The options are still Confirm, Demo and Cancel. When Demo is pressed, the sound plays on the mobile device.

> *Janine presses Demo, listens to the sound, then presses Confirm. Her alarm is now fully configured. After being returned to the Alarm Configuration Menu, she presses Save.*

The user's alarm has been saved, and she is returned to the Alarms Menu. She can now exit the app knowing her alarm is set.

Which of these options is the light button?

1) Active Lighting
2) Alarms
3) Edit Colours
4) Sleep History
5) Account and Devices
6) On/Off switch for the Lumin

## 2.2 Setting a Colour and a Colour Sequence

The user, Brock, wants to set a colour to read to.

> *From the Main Menu, Brock presses the Light button.*

Brock is taken to the Light Menu, which has 3 buttons, Colour, Brightness, and Sequences. The first two buttons control the current light colour and level, which will remain as a solid, unchanging colour. Sequences will take the user to a new menu to turn on and edit sequences.

> *Brock taps the Colour button.*

The user is presented with a colour wheel like such as in *Figure 1.*

*Figure 1:* Colour Wheel

Beneath the wheel are 3 numerical values, one each for red, green, and blue. Each can be adjusted by swiping them up and down. The user can press on the colour wheel to get close to the colour he wants, then fine tune the individual colours to get precisely the colour he wants.

> *Brock taps somewhere on the green section of the colour wheel. He likes the colour, but decides to reduce the level of blue by swiping down on the blue value.*

Under the colour selection controls are the Demo and Confirm buttons. Demo will put the currently selected colour on the lamp without overwriting your previous setting, whereas Confirm will apply the colour and return the user to the Light Menu. Above the colour selection, in the top right corner, is a save button. Pressing this will prompt the user to type in a name for the newly selected colour.

> *Brock presses the Demo button and looks at his room lit up with green. Happy with what he see's, Brock presses the save button and enters the name "Forest Green" into the new text field. Next he is presses Confirm to apply the colour now. He is returned to the Light Menu. From here he turns up the light level*

*using the brightness slider. Next he wants to create a rotating colour sequence, so he presses the Sequences button.*

Brock is now looking at the Sequences Menu. Here all the sequences are listed, both the presets and the user defined. Each sequence shows a row of circles containing the colours in the order that the sequence displays them. A New button sits at the top of the list.

*Brock presses the New button.*

Brock is taken to a new menu with two options, Start Fresh, and Base Off Existing. Both will take the user to the sequence editor, but the Base Off Existing button will populate the editor with the colours a sequence you select.

*Brock presses the Base Off Existing button. He is show the same list of sequences as before, and selects one that has 4 colours: purple, orange, green, and red, all of them bright.*

The editor opens, showing a list of colours. On the left is a circle containing the colour, and on the right is an X button that deletes the colour. The order can be changed by holding your finger on a colour, then dragging it to where you want the colour to be. At the bottom, a New button creates a new colour slot when pressed. In the top right corner are the Save and Delete buttons for the entire sequence.

*Brock decides to remove purple because it doesn't quite fit with the others. He moves green to the top of the sequence. Brock presses the New button. A new colour is added to the sequence, a default white. He tabs on the new white colour.*

Tapping on any of the colours in the sequence opens up a new menu with 3 options: Colour, Brightness and Duration. The brightness option is a simple slider. Pressing Colour opens the same colour selection window that Brock used to make “Forest Green.” Pressing Duration lets him choose how long the sequence will spend on that colour. You can adjust the time in hours, minutes, or seconds.

*Brock leaves the colour and brightness of the new white colour alone, but changes the duration to last 5 minutes. He goes back to the other colours in the sequence and changes all of their durations to 5 seconds. Brock now has a sequence that rotates quickly through green, orange, and red, then relaxes with 5 minutes of white light. Happy with his new sequence, he presses save, and closes the app.*

### 2.3 Sleep History

The last Main Menu option, Sleep History, takes the user to a page listing all the nights for which the sleep tracker has gathered data. Each night is listed as a line graph, who's up and down waves represent your sleep cycles. This gives the user an idea of how restless their sleep was. By scrolling, you can see the graphs from previous days.

### 2.4 Dismissing Alarms

When an alarm fires, it can be dismissed by pressing a large button on the hardware. A separate, but equally large button acts as Snooze, giving the user 5 minutes before the sound alarm will fire again. Snooze and Dismiss may be operable from the mobile application as well, but this is undecided.

# 3.0 Management Plan

## 3.1 Features

The feature set of the Lumin will be split between the hardware system and the mobile application. Each play an important role in delivering the feature set that FixCode requires for this product.

### 3.1.1 Physical System

The physical Lumin device will be a small microcontroller that is capable of controlling the light functions. So far, the micro computer's capabilities require it to have WiFi and Bluetooth connections, as well as a USB port. The more minimal the features, the lower the cost to the user when purchasing the finished product. To control the light functions, it will be able to take commands from the user via the smartphone application. This will allow the user to set different color and brightness schemes for separate alarms, or for idling at different parts of the day. The Lumin will also include some presets out of the box. In order to provide the best lighting experience, the Lumin will have the lights behind a diffuser, to better spread the outgoing light more easily and provide a softer look. The main premise is to help the user to wake up refreshed, and harsh light will not do.

Each alarm can be set with it’s own sound and volume settings, set again from the integrated smartphone app. It may have the ability to use the user's’ smartphone music, through the Bluetooth, WiFi, or USB connection.

Lumin will also have an included accelerometer attachment, to monitor the user's’ sleep cycle, and wake the user up in the lightest part of the sleep cycle. The system will sync this data to provide historic data for the user via the app. ~~Ideally the system can just use a smartphone~~

The phone should not be considered as a sensor for Lumin. A person may move during their sleep and this may damage the phone.

~~accelerometer for this purpose, but an accelerometer attachment is many people want to charge their phones in during the night.~~

### 3.1.2 Smartphone App

The smartphone app will be available for the Android and iPhone platforms. The functionality will be the same across both. If the user base demands it, a Windows Phone app could also be considered for development. The app will have access to the user's calendar and sync alarms accordingly. The user can set automatic alarms based on mornings or inputted commute or wake up data.

The app will also have complete control over the base station's features using simple sliders and settings. The app will have a demo mode to test out various alarm and color schemes, as well as to be able to adjust the settings in real-time.

This app will communicate to the station via WiFi and Bluetooth. To ensure no one else on the network can mess with your Lumin's settings, a simple password system will be introduced between the app and the Lumin base station.

## 3.2 Possible Implementations

The choice of implementation rests a lot on the choice of microcontroller to run the system. As stated above, the important features of the system are the WiFi/Bluetooth, USB and lighting systems. The trade-off will be needed to balance features and cost. Upping the computer's feature set usually results in excess ones, that are not a part of Lumin's use cases. Finding that balance will be important. That said, the Lumin team have looked at a few different microcontrollers that have been earmarked for possible selection. The Raspberry Pi, Onion Omega, Arduino Mega 2560 and ARPI600 microcontrollers will be evaluated for this project based on these criteria.

Another large divergence in implementation will be the integration of the sleep tracking accelerometer, as it can come in several forms. Firstly, the user can allow the app to access to accelerometer on their smartphone, and transfer the data to the base station while they are sleeping, provided their phone is in a position to record the relevant data. However, this implementation may hinder the ability to comfortably charge the phone overnight, and drain battery. The Lumin could include its own accelerometer, and be attached in a wireless or wired fashion to the base station, and placed underneath or on top of the mattress. This would provide the most consistent data, but increase the cost of the system. It also does not provide the user with choice of whether or not they wish to use the feature in the first place. The wireless strategy would be more convenient, with the exception of when the batteries die. Promised longevity would be key to the success with this device.

The use of the user's phone should not be considered for its accelerometer. This may result in damage to the phone. Since Lumin is not a portable device, a hardwired sensor is preferred.

The lighting systems are robust in terms of color depth. A decision will have to made on how many colors is a reasonable amount before becoming too cumbersome or expensive for the average user. Most RGB lights can display over sixteen million colors, but some are capable of sixty-eight million different colors.

## 3.3 Minimal System by End of March

The system that will be delivered by month's end will at least cover the three key functions, RGB control, WiFi connectivity and alarms. However, the smartphone application will be bare bones at best, as it is expected the smartphone app development and sleep tracking will consume most of the timeline.

In terms of building the physical system, a fully functional engineering sample is completely possible by the end of term. Once a microcontroller has been selected with its peripherals, construction of the Lumin and the programming of the related embedded software is expected to take around a month. However, the construction will be very basic and not indicative of the final product's look or build quality. It is meant to be a platform to present to FixCode for feedback and criticism.

After basic functionality is completed, and the product is presented to FixCode before the deadline, we can begin to add a number of improvements and functions, as well as FixCode's design changes. On the long-term road map for this product is further development of the smartphone app, as well as its sleep tracking and waking functionality. Sleep tracking is expected to have a high testing overhead, along with a selection phase for the implementation of the sensor. The waking functionality is also expected to have a large testing phase. As it is tied to the app and requires synchronization of data, it could take a significant amount of time to iron out problems that take away from the user experience. This large time constraint is why these features are not guaranteed for March.

Later along the timeline will be the calendar, weather and related synchronization features. This functionality is not deemed as integral to the Lumin's functionality, and is considered as 'nice-to-have'. Other nice-to-have features include the USB connectivity for music and radio features of the clock. Delivery of these features would be considered above and beyond on this timeline.

In the FixCode's request for RFP, it is stated a mock website is acceptable to simulate the features of the app. This will be considered from a time-saving perspective in order to focus resources on the delivery of the physical system.

## 3.4 Section Summary

The implementation of all the proposed features in the Lumin product will create something that has never been done before in this field of electronics. Most products struggle with connectivity or lighting features, or are not to be used as bedside sleep solutions at all. The first iteration of the Lumin is expected to be delivered by March 31st, 2016, covering all the fundamental features of the system. The are future plans to add more functionality and have rigorous testing of the sleep cycle and waking features. There is also plenty of time allotted for feedback from FixCode.

The Lumin design team consists of four skilled engineers: Brian Pattie, Chenchen Guo, Cameron Long, and Thinh Nguyen. The project will be split as follows:

| Group Member | Responsibilities |
|---|---|
| Chenchen Guo | Hardware design/implementation, and website management |
| Cameron Long | Documentation, mobile application/hardware interaction |
| Thinh Nguyen | Interface design and implementation for the mobile application |
| Brian Pattie | Group coordination, documentation, minor website management, and interface design |

# Section C: Conceptual Design

## 4.0 Core Functionality

The Lumin System will provide two core pieces of functionality, outlined in this section. The device itself will resemble a combination of a bedside lamp and a clock radio. It will be comprised of a microcontroller supporting WiFi, a set of RGB LED lights behind a diffusor, a simple set of audio speakers, and control panel.

### 4.1 A gentle alarm system that combines light, sound, and sleep tracking to wake the user gently

The alarm works by starting with low level lighting. This doesn't wake the user outright, but decreases the production of melatonin, the hormone that keeps the human body asleep. In doing so, the user will slowly begin to wake up. The colour of the light is completely configurable, and is explained in greater detail in the next section. The time that the light turns on is referred to as the *soft wake up time*. This is specified as part of the alarm's settings, along with the *hard wake up time.* The Lumin will set off a sound alarm to fully wake the user between these two times based on where the user is in their sleep cycle. A person that wakes during the lighter portion of their sleep cycle feels refreshed, while waking a person in the deep stages leaves them feeling groggy. The goal of the Lumin is to wake the user during the lightest possible point. It accomplishes this by tracking the user's sleep cycles by means of an accelerometer attached to the bed. Should the sleep tracking system fail, or the user remain in deep sleep until the *hard wake up time*, a sound alarm will fire, waking the user regardless of their cycle.

### 4.2 A dynamic RGB lamp that provides ambient lighting

The colour of light produced by the Lumin is determined by RGB values. Several preset colours will be pre-programmed into the mobile application, and the user can select and save as many new ones as they please using the colour panel. The user can also create *sequences*, which are a specified chain of colours. When a sequence is active, the Lumin will rotate through the colours of the sequence, returning to the first colour when it has reached the end. As a third option, the user can select *weather lighting*. This mode will choose a colour based on the current weather. Colours, sequences, and weather lighting can all be used as wake up lighting. Using the weather setting as part of the alarm gives the user additional context for their wake up routine by providing them immediate knowledge about the weather outside.

# 5.0 User Interactions

The user's interactions with the system will revolve around specifying colours and sequences, configuring alarms, and being monitored/woken by the Lumin. This section will outline the processes by which the user will carry out these actions. There are two interfaces by which the user can interact with the system: The Lumin device:

1) The Lumin device which has only the simple controls for on/off, brightness, volume, snooze, and dismiss alarm.
2) The accompanying mobile application, for all complex interactions. This includes all configuration options for colours, sequences, and alarms, and light control.

## 5.1 Creating Sequences

From the sequences menu in the mobile application, the user can browse and edit their sequences (*Figure 1*). Pressing the *New Sequence* button at the top of the list will create a new one, which can either be built out from scratch, or based off of an already existing sequence. This prevents the user from having to start fresh when they just want to make a variation of a long sequence. After creating the new sequence, the user will see a list of colours. They can add colours, modify existing colours, remove colours, or adjust the order of the colours until they are content with the configuration. The user can choose to both add previously saved colours, or select a new colour from the colour panel (*Figure 2*). Finally, the user provides a name for the sequence, then saves it, returning to the sequences menu.

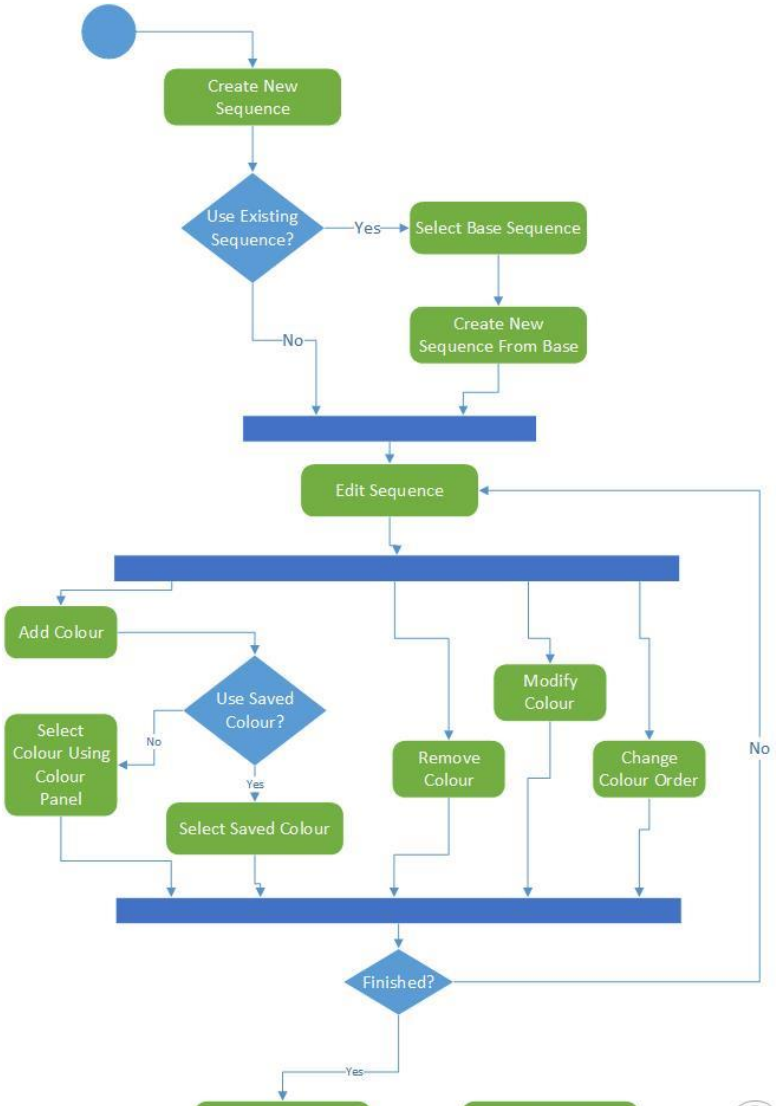



*Figure 1: Sequence Creation Activity Diagram*


*Figure 2: Colour Panel*

## 5.2 Change Active Light

The Lumin can be used as an RGB lamp for purposes beyond light alarms. To do so, the user presses “Active Light” from the main menu. From here, there are 4 options:

1) Select a new colour from the colour panel (*Figure 2*).
2) Select a previously saved colour.
3) Select a sequence of colours.
4) Activate weather lighting.

Options 2 and 3 take the user to submenus that list the saved colours and sequences respectively.

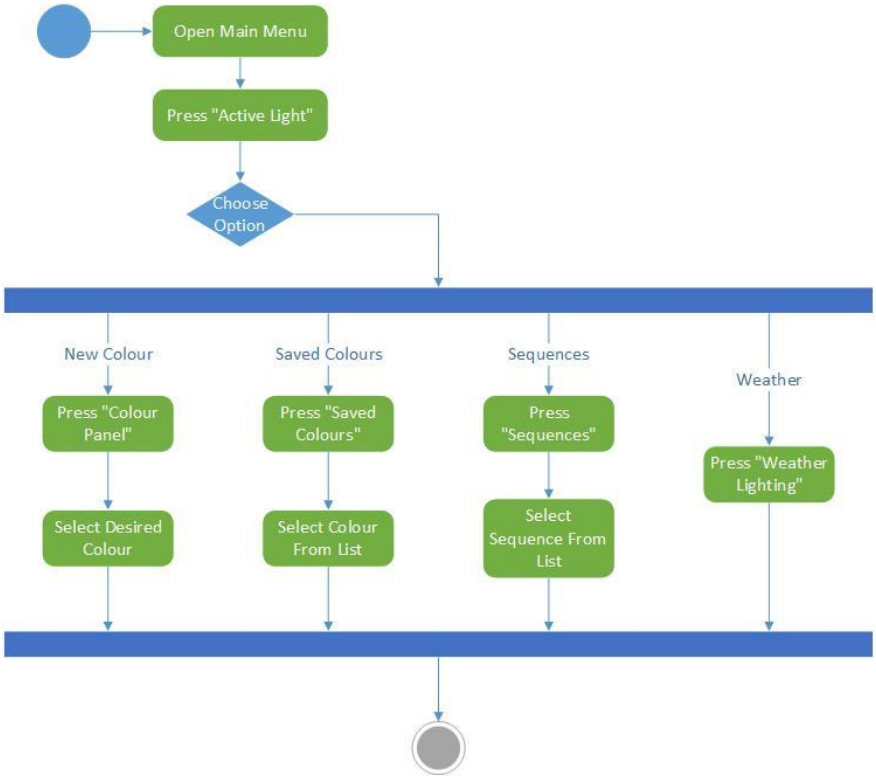



*Figure 3: Change Active Light Activity Diagram*

## 5.3 Set an Alarm

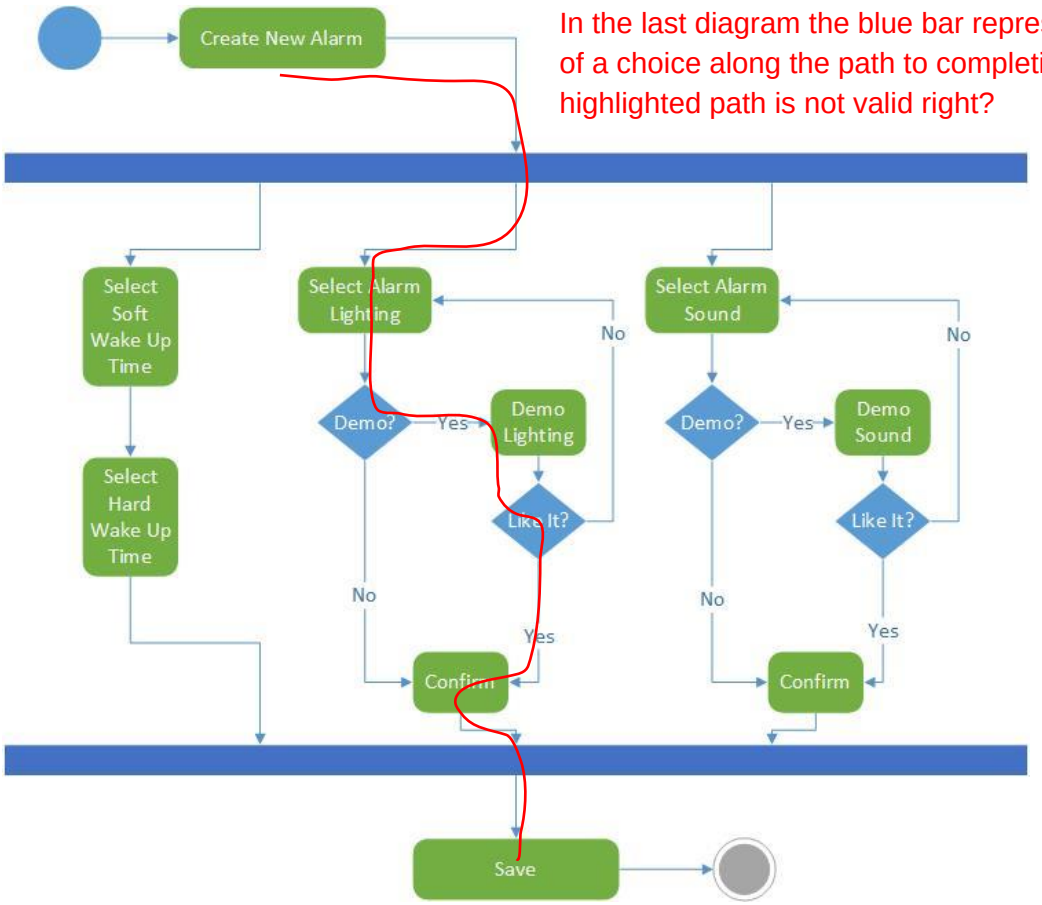



*Figure 4: Setting an Alarm Activity Diagram*

*Figure 4* demonstrates the alarm creation process. To create a new alarm, the user selects *Alarms* from the main menu. In the alarms menu, the use will see a list of all their saved alarms, topped with a *New Alarm* button. After pressing *New Alarm,* the user will be taken to an editing screen where they can specify all the necessary values. The *soft wake up time* determines when the light will turn on, and the earliest possible point that the sound alarm can fire. Likewise, the *hard wake up time* is the latest point, and will be used when the sleep tracker either fails, or determines that you were in deep sleep for the entire duration between the two times.

Next the alarm lighting must be selected. The available options are the same as changing active lighting, but the workflow is slightly different. When the user selects a lighting option, they are asked if they want to demo it before confirming their selection. This gives the user an

opportunity to test out the colour on the Lumin device before making a decision. Selecting the alarm sound is as simple as choosing from a list of predetermined sounds. Like alarm lighting, the user can demo it on the Lumin before confirming their selection.

## 5.4 Alarm Use Process

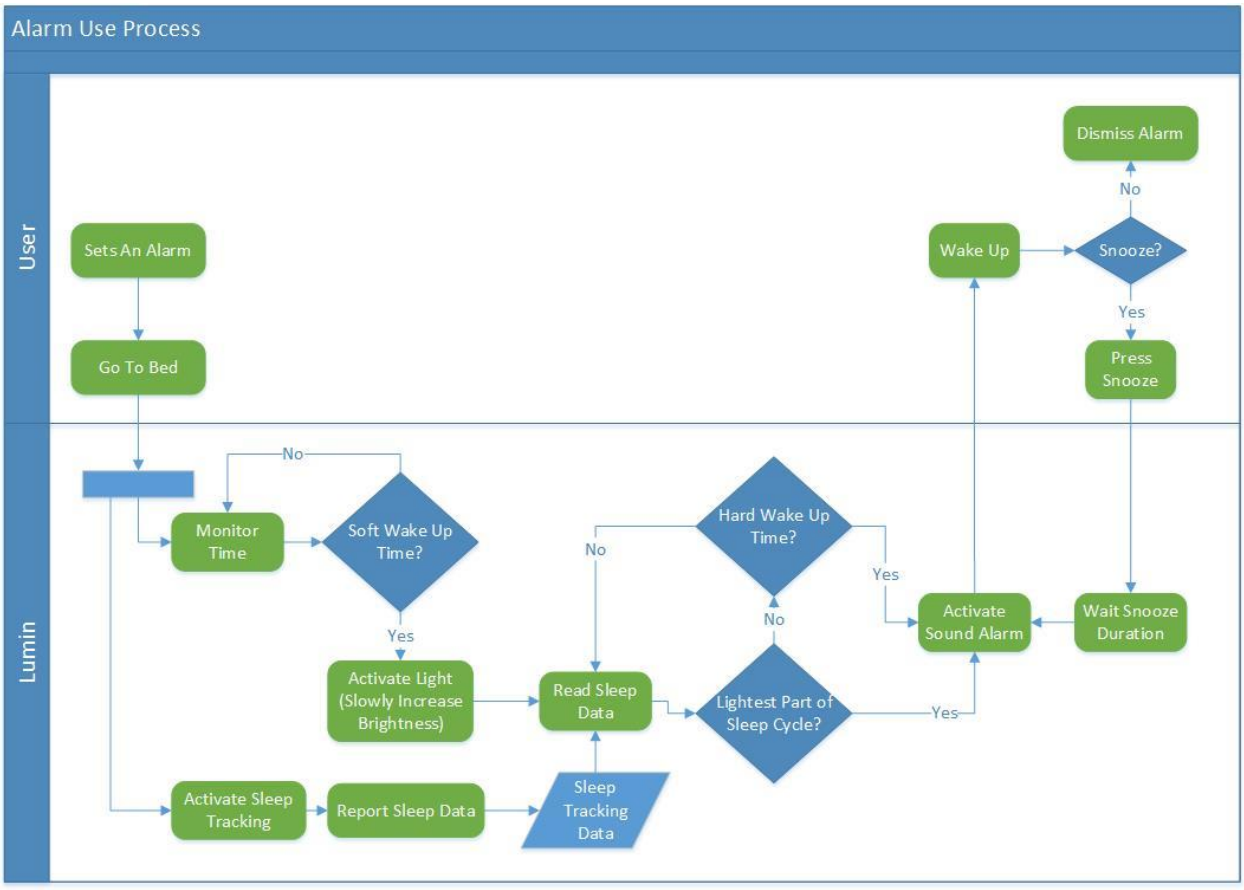



*Figure 5: Alarm Use Process Activity Diagram*

*Figure 5* demonstrate the activity of the Lumin device over the course of the night. After setting an alarm and going to bed, the Lumin begins monitoring the time, and the user's movement through an accelerometer attached to the bed. Over the course of the night, a graph will be produced of the amount of movement (within the last X minutes) over time. This will approximate the user's sleep cycle. The method is crude, but will be sufficient for the prototype. Existing sleep trackers use a much more sensitive sensor, and determine sleep cycles through complex signal analysis that separates cardio, respiratory, and small body movements.

When the soft wake up time is reached, the light is activated, starting at a dim level, and building in brightness until maxing out, or the alarm is dismissed. After soft wake up, the Lumin check's the current sleep data to determine where the user is in their cycle. When they reach

the lightest part, the sound alarm will fire, waking the user. If the user doesn't enter the light sleep stages, the Lumin will instead fire the alarm at the hard wake up time. When the alarm is fired, the user chooses to snooze, or dismiss the alarm. This action is performed either through the hardware, or from the mobile application. If snooze is pressed, the Lumin will wait a short period before firing the alarm again. This process repeats until the alarm is dismissed.

# 6.0 Component Interactions

The Lumin system is divided into 3 pieces

1) The Lumin device hardware
2) The mobile application
3) The main server

The only interaction with components outside the system with internet infrastructure, and a Weather API. The interactions between these components will be described in this section.

## 6.1 Account Registration / Login

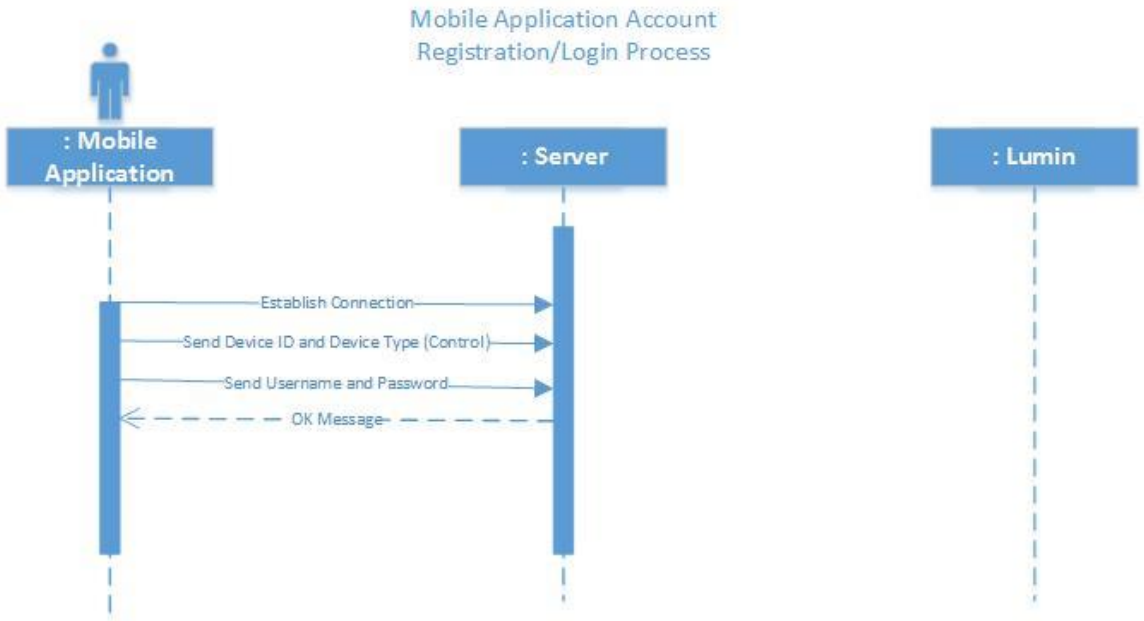



*Figure 6: Mobile Application Account Registration/Login Process*

The account registration and login processes follow extremely similar procedures. The user simply enters a name and password, and they are registered/logged in. The account doesn't need any details like the user's email, as the account is merely a way connect to the Lumin device and store configuration information. The user's device establishes a connection with the

server, then sends their username and password. Once login credentials are created or confirmed, the server responds with a confirmation message.

## 6.2 Lumin Hardware connecting to Server

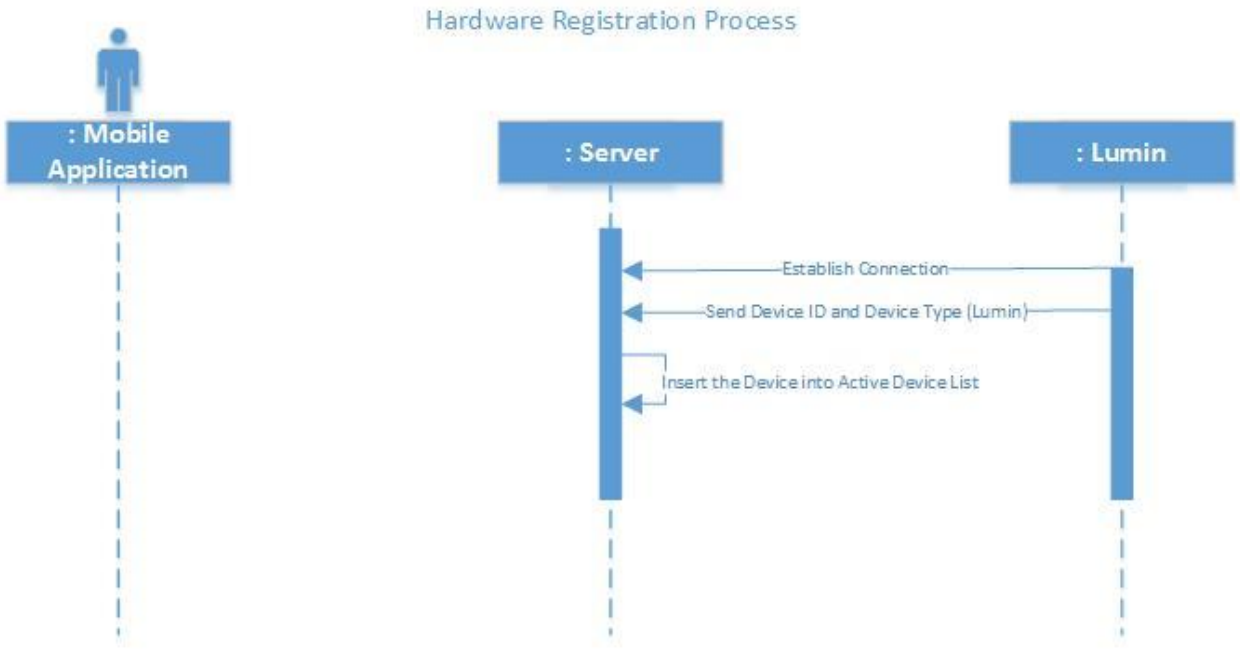



*Figure 7: Registering Hardware with the Server*

When the Lumin device connects to WiFi, it immediately establishes a connection with the server. It sends its device ID, which is added to the servers list of active devices. The user will have a copy of the device ID as part of the Lumin package, and will use it to add their device to their account.

## 6.3 Registering the Lumin device to a User Account

The Lumin device will have an associated device ID. After the Lumin has established its connection to the server, the user must log in to their account and enter the device ID (*Figure 8*). The server will query its list of registered devices to find the one belonging to the user. Once it is found, it will be applied to that user's account. Any commands made through the

mobile application will be sent to the server with the corresponding device ID. This set up opens the door for users to have multiple devices controlled from the same account.

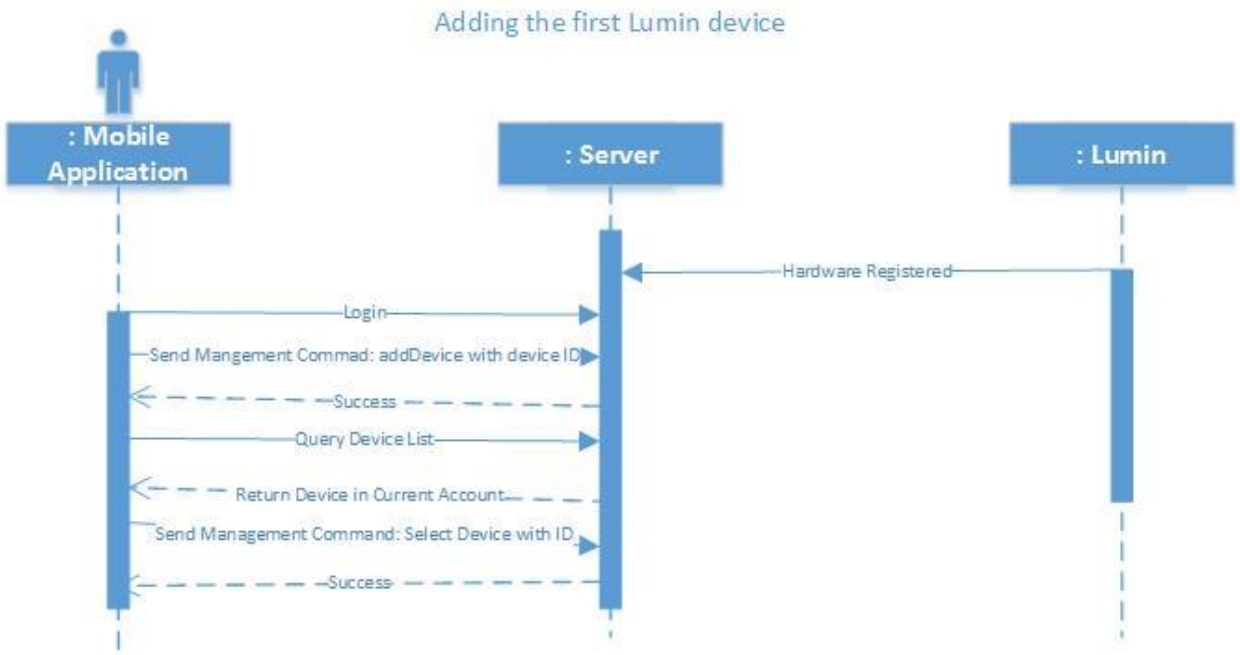



*Figure 8: Registering the Lumin device to an account*

## 6.4 Sending Immediate Updates to Lumin

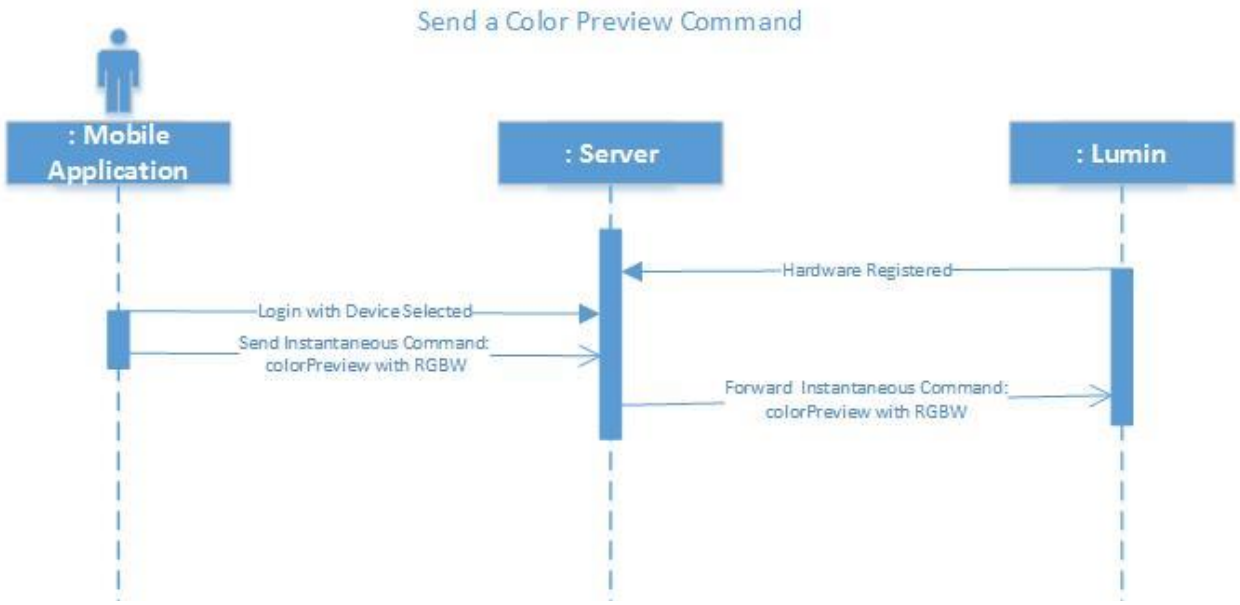



*Figure 9: Sending a Colour Preview Command*

Some commands from the mobile application to the Lumin take the form of simple update request, such as demoing colours and sounds, and changing the active light. Figure 9 outlines the process of demoing a colour. The user, who is logged in on their mobile app, sends an instantaneous command to colour preview, paired with the corresponding device ID. The server then relays this command to the appropriate device. The Lumin changes its active colour. The demo will end when another request of this form is relayed to the device.

## 6.5 Update Saved Colours, Sequences, and Alarms

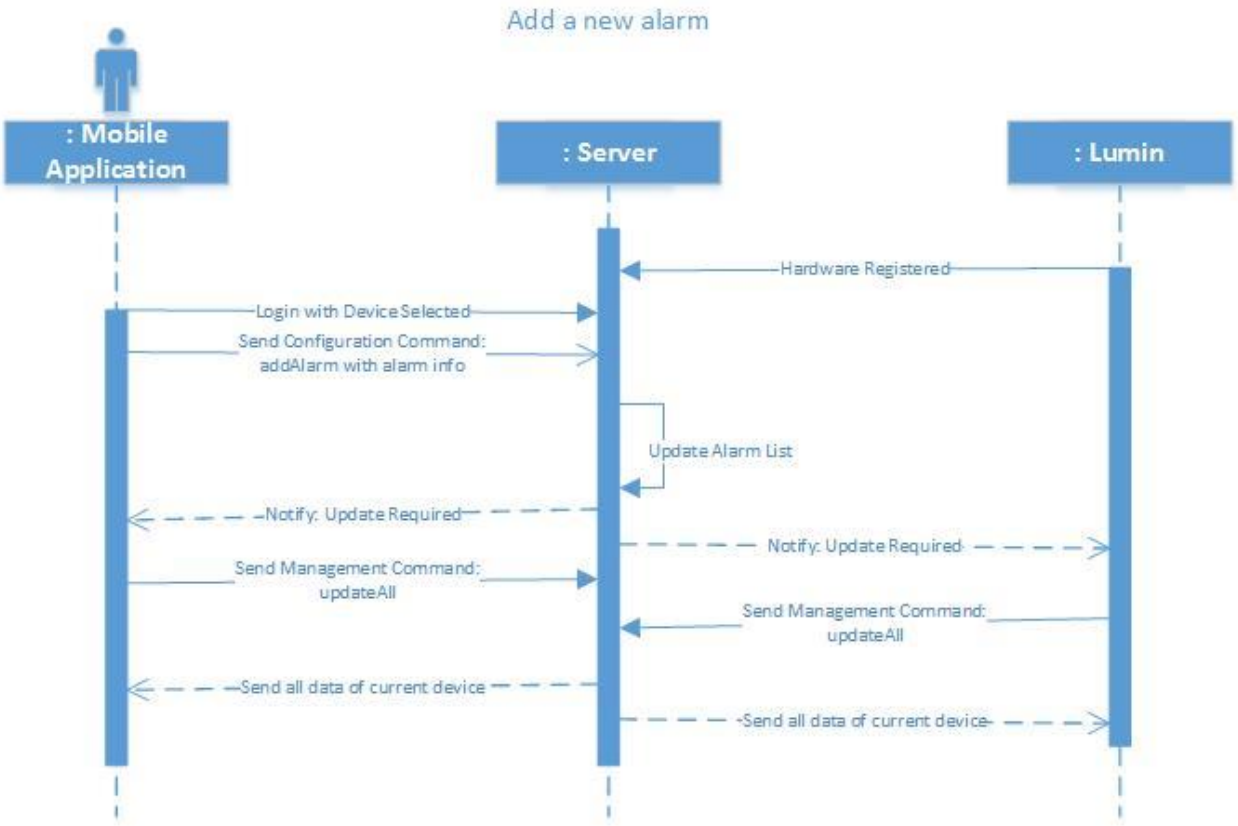



*Figure 10: Adding a New Alarm*

The Lumin stores its colour, sequence, and alarm data in the form of one large data structure, visible in *Appendix A*. A copy of the data structure is present on the mobile application, the server, and the Lumin hardware. The server copy serves as the master version to which the mobile app and hardware copies are compared. Updates for colours, sequences, and alarms all follow the same process as demonstrated in *Figure 10,* which shows an alarm being added. The Mobile application sends an *addAlarm* command to the server. The server updates its internal alarm list, then notifies both the mobile app and the Lumin device that their copies are out of date. Each returns with an *updateAll* command which. The Server then sends each device a full

copy of the previously mentioned data structure. This process keeps all 3 instances of the data up to date, and will correct issues brought about by missed commands.

## 6.6 Transfer of Sleep Tracking Data

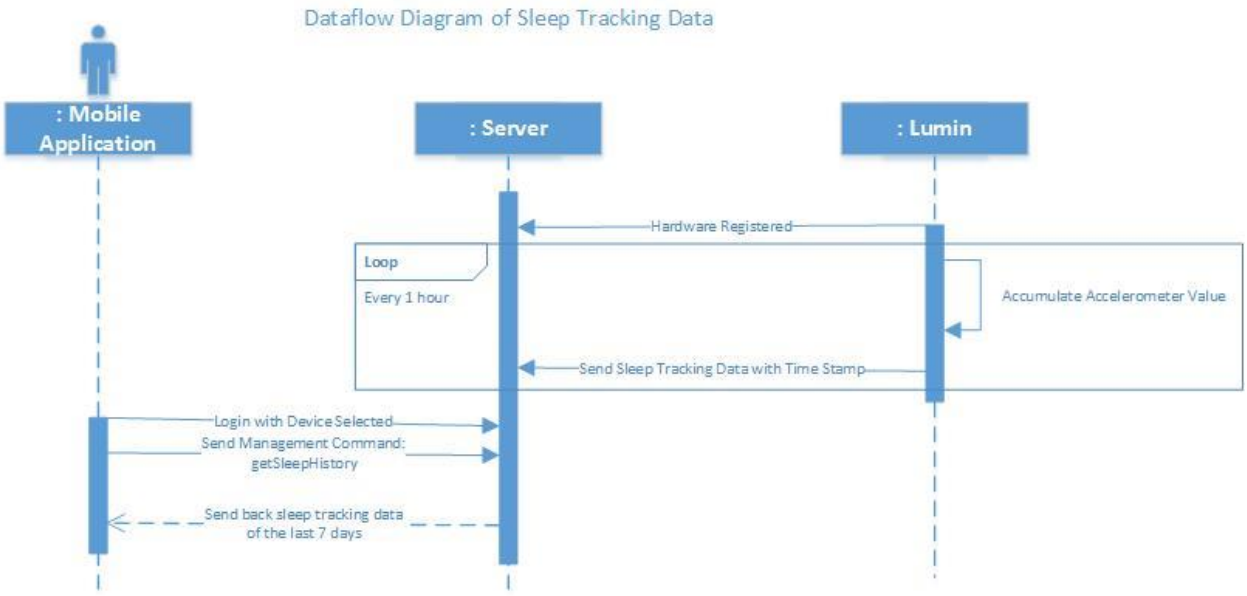



*Figure 11: Transfer of Sleep Tracking Data*

Every hour, the Lumin will update the server with an hour of sleep tracking data. The server will aggregate this data. The user can view this data from the mobile application by selecting *Sleep Data* on the main menu. The mobile app will send a *getSleepHistory* request to the server along with the device ID. The server will respond with tracking data for the last 7 days.

## 6.7 Weather API Interaction

To support *Weather Lighting* functionality, the Lumin device gets data from a weather API (*Figure 12*). The hardware will routinely query this API to get updated weather conditions. The colour of the LED will change to reflect the current weather.

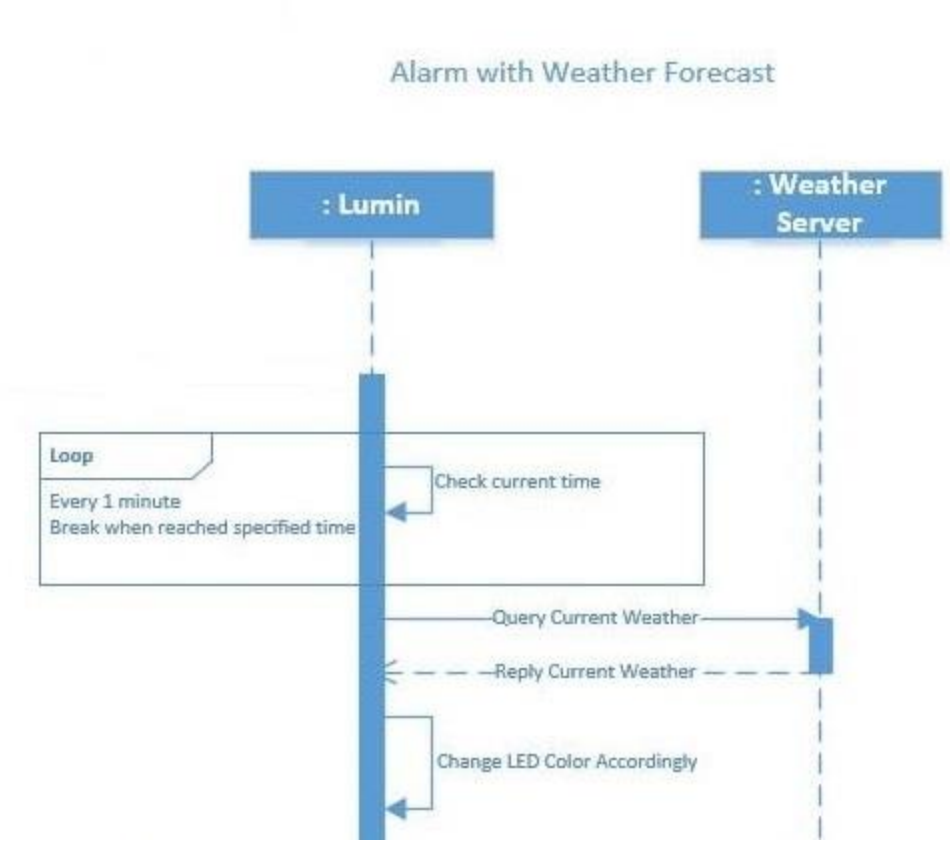



*Figure 12: Acquiring Local Weather Data*

# Glossary

| | |
|---|---|
| Accelerometer | A sensor that detects motion in 3 dimensions. |
| Active Lighting | Refers to the light being output by the Lumin that is not tied to an alarm. |
| Alarm lighting | The colour, sequence of colours, or weather lighting used in the alarm to wake the user. |
| API | Application Program Interface. The set of protocols through which a system is interacted with. |
| Colour panel | The panel used to select a colour. Functions similarly to a colour wheel, but has 2 controls: one for colour, and on for brightness/saturation. |
| GUI | Graphical User Interface. Designed for human users to interact with. |
| Hard wake up time | Specified as a part of the alarm configuration. This is the latest time that the sound alarm will fire. |
| LED | Light Emitting Diode. The type of light used by the Lumin. |
| RGB | Red Blue Green. The three colours of light that are combined by the LED to form the rest of the colour palette |
| Sequences | A chain of colours that will be rotated through using the Lumin's RGB lighting. They can be created, modified, and activated by the user through the mobile application. |
| Soft wake up time | Specified as a part of the alarm configuration. Marks the time that the light will first turn on, and the earliest point that the Lumin can fire the sound alarm. |
| Weather lighting | A lighting option that chooses its colour based on the local weather, as determined using weather API. |
| Weather API | An external system that supplies the Lumin device with local weather data. |

# Appendix A: Main Data Structure