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LI-FI Share (LFS): See What Light Can Do

Gamaliel Munoz
CCT College Dublin

Anant Tandon
CCT College Dublin

Juliana Sousa
CCT College Dublin

Zohaib Qaiser
CCT College Dublin

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LI-FI Share (*LFS*)

See what *Light can do*

A Project by *Alpha Tech*

<i>Members Name</i>	<i>Student ID</i>
• <i>Gamaliel Munoz</i>	2017092
• <i>Anant Tandon</i>	2017384
• <i>Juliana Sousa</i>	2017266
• <i>Zohaib Qaiser</i>	2017400

Year-Semester: 3rd Year – 6th Semester

Due Date: 19-05-2020

Supervisor: Mr. Michael Weiss

Download the LFS from:

LFS

Download the Feedback Web app from:

Fb-WA

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1 Abstract

This project presents an innovative way how the user of internet can manipulate data transfer in a faster and security way. The main idea is to use “LI-FI ” that means type of Optical Wireless Communication (OWC) technology, bi-directional which uses light emitting diodes (LEDs) to transmit data between devices. In technical terms LI-FI transmits data by electromagnetic spectrum, high speeds of data over the visible light, ultraviolet, and infrared, and Wi-fi for example uses radio waves as a transmitter of data. While we were researching about the technology, we found out a new thing that we could use the light of the mobile phone to transmit data between two devices through the light and camera sensors that act as a receiver of data. This innovation about LI-FI was discovery over 20 years ago, perhaps only a few years are being explored even more as we can see the Internet of Things growing exponentially. The purpose of the study was to explore and learn about a new technology that has never been studied deeply by us and to investigate a better way to transfer data, in a world that everything is growing faster around the technology field. We have developed and accomplished a project that will encourage next students’ study and build new things surround the new technologies. The main function of our project “LI-FI share” is to transfer data through the light to the other mobile phone, this functionally after a lot of troubleshooting made by the Alpha Group, we could make that happened only because we worked together. After all analysis, researches and feedbacks from the faculty supervisor we realize that it was essential that we all work together to complete this project and we did it.

2 Introduction

A human being would not imagine that exactly thirty years ago, the World Wide Web would become publicly available, and everyone could have access to internet. In the new era of "twenty-twenties" we are surrounded by many types of technologies; a significant population of the world cannot imagine their lives without having internet access.

The common way of connectivity over the internet today is through a Wi-Fi that was not used in the past. People had to network computers in their local area with wire, to access the Internet, a modem was used, to which we attached a phone line (since this was before cellular networks as well). So, the modem was attached to both the land line phone wire and to your computer. If you only had one phone line in your house, connecting to the Internet meant no one else could use the phone and anyone calling you would get a busy signal.

Nowadays, we are dealing with a huge amount of data which is increasing exponentially on a daily basis; however, the infrastructure cannot keep up with this high rate demanding data traffic, which frequently causes slow performance on the communication channels, thus, pushing the tech companies to invest more on research for better and more efficient ways to transfer data.

One of the ways was first presented by German physicist Harald Hass to the market in TED (Technology, Entertainment, and Design) Global talk on Visible Light Communication (VLC) in July 2011, by referring to it as "data through illumination", which is LI-FI a Visible Light Communications (VLC) system. It is a wireless communication type, which has theoretically proven evidence referring to a noteworthy increase in the performance. The rate of transmission of data is also in a much more secured way.

LI-FI uses LED lights to transmit data. Wi-fi technology uses radio frequency communication that requires radio circuit's, antennas and complex receivers, considering that LI-FI is much simpler and uses direct modulation methods similar to those used in low-cost infrared communications devices such as a remote-control unit. LED light bulbs operate in high intensities and for that reason can achieve very large data rates in a way that human beings cannot see.

Wi-fi uses router to transmit and receive data; LI-FI instead of a router uses transceivers fitted with LED lamps. LI-FI is 100 times faster than Wi-fi and can relieve the heavy loads of data

traffic which the current wireless system is facing. Also, the health concern about radio waves transmitted by Wi-fi will be banished with the use of LI-FI. By communication through visible light, LI-FI technology will change completely the way we are accessing the Internet, streaming videos, receiving emails etc.

In this project we aim to create a prototype to showcase this technology using something simple as our phones which we use daily. Our phone should be able to transfer and receive data using the flashlight at the back and the ambient light sensor at the front.

3 About “Alpha Tech”

A team of IT Students who are always ready to learn something new and try to implement all those things in real life. This time around, CCT has given its year 3 students a chance to build something by using all the skills that they have learnt in past 2 years and represent it to the faculty. This will encourage the students to do something out of their comfort zones and experience the gist of group work before taking their steps in an industry.

For us “**Alpha Tech**”, from the very beginning, we have always been thinking about building something different, something unique and most importantly something practical that can solve some sort of problem or something that can improve the current working systems by implementing the latest technologies. After doing some analysis and research on different things like applications in our Smart Phones, which are used almost on daily basis. We discovered something, when seen from our point of view had the potential to be improved. It is the way of sharing data locally from one smart phone to another. So, we “Alpha Tech” have decided to develop an application that will be faster and secure more than ever before.

3.1 Team Members

Alpha Tech comprises of **four** members, who will work on this Project:

<u>Anant Tandon</u>	<ul style="list-style-type: none">○ Expert in: Programming○ He has nice grip over java language (<i>which will be mainly used to develop the software</i>). The section of java development will be under his control. He is also the document reviewer. (<i>Any kind of changes in java section will be done after discussing with him</i>)
<u>Gamaliel Munoz</u>	<ul style="list-style-type: none">○ Expert in: Web Development○ The section of website and its development will be his responsibility (<i>Any kind of changes in web-development section will be done after discussing with him</i>)

<u>Zohaib Qaiser</u>	<ul style="list-style-type: none"> ○ Expert in: User Interface (Front-End) ○ The section of Developing an Easy to use and User-friendly interface for interacting with the System will be handled by him. He will also Handle the development of document. <i>(Any kind of changes in front-End i.e. user-interface will be done after discussing with him)</i>
<u>Juliana Sousa</u>	<ul style="list-style-type: none"> ○ Expert in: Management and analysis ○ She will play the Role of Manager in this Project, due to her amazing skills in Business Management and Analysis. Finalizing the Documents, managing and assigning the tasks to the team members and making sure everything runs smoothly will be her duty. <i>(changing the assigned tasks, adding or removing anything in this project will be done after discussing with her)</i>

4 Project Goals

4.1 *Main Android application*

The goal of this project is to transfer data by utilising light waves. The technology that will serve as the main backbone for this project is called LI-FI, which stands for Light-Fidelity.

We as a team will develop a mobile application called “**LI-FI Share**” that will:

- Use the flashlight of a smart phone as a transmitter.
- Use the built-in ambient light sensor in smart phone as a receiver.
- The user will be able to send all the files locally from one mobile to another, that they are sending today mostly by using Bluetooth or other applications like “Share-It” that uses Wi-Fi and mobile hotspot as the medium for data transfer.

4.2 *Dynamic Web Application (Additional & supporting web for main application)*

Complementary to the above mentioned, as a team we will develop as well a **dynamic Web Application** called “Feedbacks” which will help us

- to showcase our main “LI-FI Share” Application displaying its built-in functionality and special features. In that sense, any user will need to register in the Web App to be able to share comments in relation to our main App.
- Moreover, LI-FI share Application will be providing feedbacks through the same Web App. Finally, there is going to be some authorization features implemented in order to protect the author’s comments.

5 Rationale: *Purpose of pursuing this project and the problem that it could solve*

Since we know that everything with benefit's comes with its own drawbacks. There are some **Drawbacks** with Wi-Fi and as well as with Bluetooth which seem to be major when we researched deeply into these technologies.

5.1 *Wi-Fi*

Wi-Fi is a technology that allows us to connect two or more devices wirelessly, so that we can transfer data from one device to another. Following are the drawbacks that we discovered during our research:

• Slows down	The Data transfer rate decreases in a single computer, when the number of users or devices connected with Wi-Fi network increases
• Speed Depends on signal strength	It is important to mention that Wi-Fi devices work in full functionality and without any interruptions when they are within the range of the access point and receiving good signal strength. Nevertheless, Wi-Fi access only reaches about 30 to 100 meters.
• Harmful for health and environment	It produces a harmful effect on children and pregnant women. It has been said by the scientists that young children and pregnant women should avoid the exposure of Wi-Fi as it damages human environment (Solutions Review Wireless Networks, 2019.)
• Restrictions	The signal travels best through open space, but it is reduced by walls, glass and water.

5.2 Bluetooth

Bluetooth is also a wireless data network originally created as an alternative to the computer wires. This technology can also help us to connect to a few computers, cell phones and other devices in order to synchronize and swap files. Some drawbacks of Bluetooth are mentioned below:

<ul style="list-style-type: none">• Poor Security	Normally every network technology has some security built into it to prevent hackers from accessing the data without permission. However, Bluetooth security is weak compared to Wi-Fi, this means that an attacker can gain access to a wireless device through a Bluetooth connection, but hacker has to be nearby to have access
<ul style="list-style-type: none">• Slow Data	Generally, faster connections mean higher energy consumption and Bluetooth is intended to be very energy-efficient, but it sends data relatively slowly. Bluetooth devices send about three megabits per second, this means that it is lower than Wi-Fi, which is the other predominant wireless technology that transfers data at 54 Mbps Thus, Bluetooth is not a substitute for faster technologies such as Wi-Fi.
<ul style="list-style-type: none">• Should be taken care of	If we don't disable the Bluetooth feature when we are using it, security can be breached, as the connection can be hacked if it is on, because the device sends identification signals to other devices within range offering a connection, with this in mind an attacker can get access to any PC or a smartphone.
<ul style="list-style-type: none">• Distance Limitations	Bluetooth devices that use battery power are called Class 2 Bluetooth devices. These devices have a range of about 10 meters. While the Bluetooth signal can travel through walls, the more objects that are in between the devices the lesser the range is. On the other hand, Class 1 Bluetooth devices have a range of about 100 meters, but due to their size and power consumption small devices do not have the ability to use this type of category and they are better off using Class 2.
<ul style="list-style-type: none">• Interference	Regarding Bluetooth devices, they work using the 2.4 GHz radio band, which is the same frequency used by many other wireless devices. However, if many devices in the same area are all using this similar bandwidth, network problems can occur, because the signals interfere

between them and the information has to be resent, this happened even when the Bluetooth signal was indeed designed to change its frequency many times per second in order to reduce this interference. Even though Bluetooth 3.0 uses the 6-9 GHz spectrum, it has less interference issues though, it is still slow ([Solutions Review Wireless Networks, 2019.](#))

After investigating the problems and the disadvantages of Wi-Fi and Bluetooth. let's shed some light on LI-FI. What is LI-FI, how it works and what are the benefits of using LI-FI.

5.3 LI-FI: what LI-FI is and what the acronym LI-FI stands for

LI-FI is a wireless optical networking technology that uses LEDs for data transmission. LI-FI is based on light "LED bulbs" (Light Emitting Diodes) which uses light instead of radio waves like Wi-Fi to transmit data.

In technical terms LI-FI transmits data by electromagnetic spectrum, high speeds of data over the visible light, ultraviolet, infrared while Wi-fi uses radio waves as a transmitter of data. Like Wi-Fi, LI-FI is wireless and uses similar 802.11 protocols, but it uses ultraviolet, infrared and visible light communication (instead of radio frequency waves), which has much bigger bandwidth.

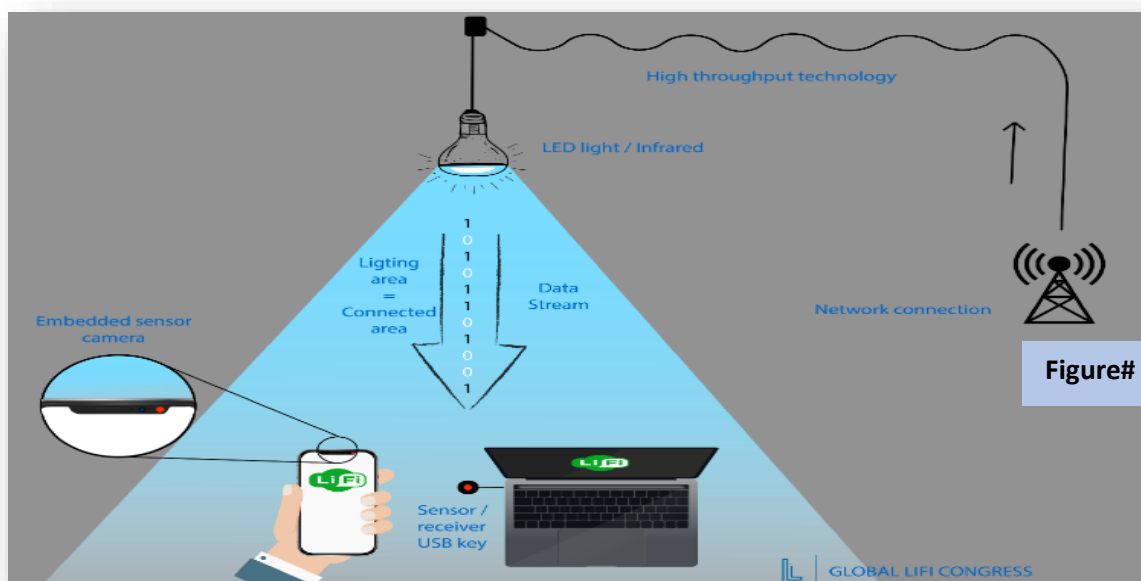
LI-FI can operate using off-the-shelf LED lights that are connected to transceiver access points. The LED lights transfer binary bits and bytes of data by intermittently flashing lights on and off.

This term "LI-FI" was introduced by "Harald Haas" during a 2011 TED Global talk in Edinburgh. Harald Hass, is a German Professor in Mobile Communications, that teaches about Electronics and Electrical Engineering subject at The University of Edinburgh

Nowadays, we are consuming a lot of data and it has developed the necessity to create new technologies to support or attend the end users. One discussion that was generated in ICT (Information and communications technology), surround Wi-fi is to reduce the carbon footprint. Unlike Wi-Fi network signals, LI-FI is based on light and cannot penetrate through walls, which makes it more secure from external sniffing. It is also meaning there is less interference from other devices.

Working (How it works)

The principle is based on the sending of data through subtly varying the brightness of light sources. An LED is able to flicker several million times per second, which enables data transfer. The light source must be directly connected to the Internet (LI-FIcongress.com (2019)). Digital data passes by the LED bulb where an electronic component controls it in order to make it flicker according to a predetermined rhythm. The digital data thereby passes into the light spectrum. Then a receiver, integrated into a smart phone or a computer, retrieves these flickers and transforms them into video files, text, etc. Here is a diagram to facilitate understanding of the LI-FI:



Advantages (benefits of LI-FI)

• Radiation	Indeed, safety has an important role when talking about radiation, therefore Gamma rays, X-rays and Ultraviolet light are harmful and dangerous due to their proven adverse effects on human health. Hence the Visible light of the electromagnetic spectrum does not cause any harm to the people as visible rays are safe to use and provide larger bandwidth
• Speed	LI-FI provides speeds around 100 times faster than current speeds in WiFi, which means faster communication, resulting in better service quality and better communication. Its transmission speed would be much higher than

	that Wi-Fi, it would reach the range of 10 to 20 Gbps, and maybe even more, in some tests it has even reached 224 Gbps
• Security	One of the most important features of LI-FI is about security. As a matter of fact, nobody likes intruders stealing personal information from the web, in that sense, LI-FI internet is only available to the users that are sharing the same space, such as a room and cannot be breached by users in other rooms or buildings, and this is because light cannot travel through solid and opaque structures.
• Availability	Now it is time to forget about dead spots, with LI-FI technology where there is light, for sure there is going to be a connection. It is very important to mention that due to the use of LED bulbs, LI-FI can be available everywhere
• Cost	There is no need any more about using cables, the LED-powered LI-FI connection could be used to beam the information straight to the destination. LI-FI is much more efficient when talking about cost and power consumption, because it can double the utilization of a regular lighting at any place making the most of the power consumption.
• Interference	LI-FI could be used in some places that are sensitive to electromagnetic areas, such as airplanes or hospitals without causing interference.

3 Finished Product Users: *who will benefit from using this application*

- As it was mentioned earlier that this is mainly going to be an android based application which will run on android devices. Any person who uses an android smart phone can use this application.
 - To be more exact, the aim of this application is to solve the problem of slow speed, weak security and improve user experiences of those user who transfer data locally from one device to another all the time or on daily basis
- Application will be released on Google Play Store (service of Google), as it is the main application market for android operating system. It provides it services to 154 countries
- User will be able to download this application from Google play store. (En.wikipedia.org. (2019). Google Play)

4 Required Technologies

4.1 *Android studio (Software)*

We will be using android studio.

- This is because initially we will develop our application for android since it is an open source operating system and hence easier to change according to specific requirements.
- It basically has everything built in it so we will work with:
 - Java environment
 - Scene builder
 - And Gradle
- The main reason of using Android Studio is that we can test as we go. Everything we require is present in there.

4.2 *Java (Language)*

- Although google declared Kotlin as the new official language for android. We decided to go for Java since we have been working on Java for quite a while now.
- Kotlin is also based on Java so there will not be much of a technical difference.

4.3 *Laptop (Hardware)*

- A Pc or Laptop is required to run “Android studio” software.
- The Pc or Laptop is required to have:
 - minimum 16 GB Ram or more.
 - minimum intel 6th generation core i5 or new intel core i5 or i7 CPU chips.

4.4 *Android based smartphone (Hardware)*

- An android based smartphone is required for testing the developed application (used in testing phase)
- The smartphone is required to have Android 8 or newer version to make sure that our application and the running operating system of the smartphone is compatible

4.5 For “Feedback Web Application”

The list below displays in detail all the languages, technologies, frameworks, packages, libraries and platforms that have been used in order to implement our Feedback Web Application for our project:

- Node.js (Node) that is an open source development platform for executing JavaScript code server-side.
- **NPM** (originally short for Node Package Manager) is a package manager for the JavaScript programming language.
- **Framework:** Express, which is very light with less constraints.
- **Bootstrap**, which is a popular CSS Framework for developing responsive and mobile-first websites.
- **Semantic UI**, being a development framework that helps create beautiful, responsive layouts using human-friendly HTML.
- Cloud based text editor called **goormIDE**, which provides an Integrated Development Environment.
- **MongoDB** which is a database that will allow us to store documents with dynamic structure saving them inside a collection and Mongoose as a JavaScript library.
- **jQuery** which is a JavaScript library designed to simplify HTML DOM tree traversal and manipulation, as well as event handling.

5 Innovation: Evolution from WI-FI to LI-FI Technology

LI-FI is considered the future of wireless Internet access and has been dubbed the next technology the whole world will be using after Wi-Fi.

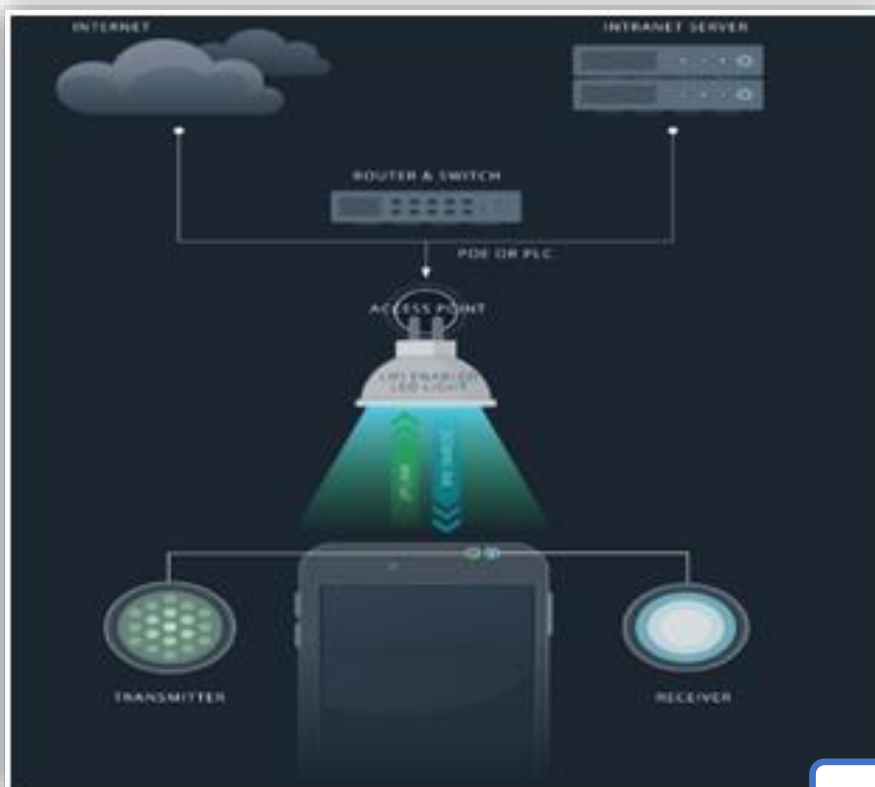
As the Tech Radar researched about LI-FI, By Jamie Carter in May 22, 2016, "By 2020, Wi-Fi will connect 1.7 billion devices, according to Cisco. However, by 2025 the growth of wireless data traffic could mean that the radio frequency (RF) spectrum Wi-Fi occupies will not be able to cope with demand."

As we could see in the research we have done so far, and by the article was mentioned above, the LI-FI will change completely our way to use internet in a short time, and will give more mobility and increase the speeds of that we are able to send today in 100 times faster.

While Wi-Fi technology effects data transfer on radio waves, LI-FI is the biggest revolution in wireless technology today, thus allowing LI-FI to take full advantage of the vastly greater light spectrum bandwidth capacity that is provided by the light spectrum.

5.1 *Are you ready for LI-FI Share?*

This new technology will change your life. As we use the light and the sensors in the mobile phone between ourselves to receive and send data, instead of waiting for Wi-fi slow speed you can save your time and send data very quickly using LI-FI.



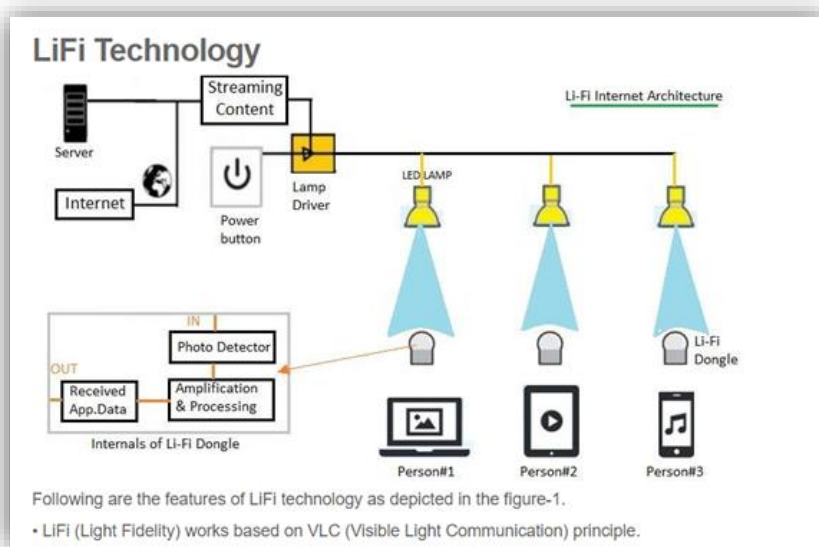
By: PureLi-Fi

5.2 Steps taken by Alpha Tech group in the project to develop the LI-FI share

- We had doubts about how we would develop that? Which language should we use to code that application? Which equipment are we going to use in order to transfer and receive data? Is it possible to create something new that was not demonstrated yet in the market? These questions were discussed between the Alpha Tech Group.
- At first it was thought to use two Arduino to transfer and receive data, perhaps, after doing research on that, we found that it included lots of hardware which was simply beyond our knowledge. Hence it did not turn up the way we expected. After all the trials our main programmer Anant suggested, we move from arduino to mobile phones instead. It was agreed by the Alpha Tech Group and we followed that path. We got back on researching about LI-FI and how would we make that work. After a lot of thinking and discussions with our supervisor we took a bold decision to do something which has never been done before.
- After a few days of deep diving on the internet we could not find anything raw regarding transfer of data through light. All we had were some scattered bits of information. This is what made our project new and innovative and perhaps hard enough too.
- After considering lot factors such as time complexity and work complexity. We decided to use java as the main language of the project, for the reason that we are confident with that language. Since java has been widely used for android development, it was beneficial for us as we did not have to learn a new language. Although Kotlin has been declared as the official language by Google for Android, Java is still widely used. We also decided to use Android studio which is a dedicated environment for android development.
- As a group we have decided to develop one new feature that will allow the user share their data between two handsets. The way we used to transfer data is using the back light “LED bulb” in one of the mobile phones to sending the data over the other mobile phone as a receiver of data through the camera compartment
- Dr. Hahald Haas the “Father of LI-FI” inspired us deeply as we were going further in our investigations though LI-FI documents.
- Everything based on LI-FI technology. The name chosen by Alpha Tech was LI-FI Share, because it is very intuitive as the name says already is to share data between two devices.
- First step we have researched about the new technology which we have got amazed by the new possibilities of transferring data much faster than have ever seen before.

5.3 Why would we use Li-Fi instead of Wi-Fi?

- Li-Fi is 100 times faster than Wi-Fi technology; it is safer than Wi-Fi. We know that because the light does not pass through the walls as Wi-Fi does. As the consuming of data is increasing day by day, we need a new solution to provide best services for the end user.
- Li-Fi stands for Light Fidelity and Wi-Fi stands for Wireless Fidelity. Both of them uses internet based. Li-Fi uses light as a transmitter of data communication in other side Wi-Fi uses electromagnetic waves in radio frequencies for data communication technology whereas Wi-Fi is a radio communication technology. Li-Fi will give us better quality of service with security.



- The way the Li-Fi works is through the LEDs at transmits ends and Photo-detectors at receive at the end.
- As we can see in the picture above, LEDs are connected with internet server though the lamp driver for internet connection. The light uses wavelength ranging between 380 nm to 780 nm for data communication between LEDs and photo detectors.
- Li-Fi technology works on three modes as peer to peer, star and broadcast and uses system modulation schemes such as OOK, VPPM, CSK. Li-Fi is IEEE 802.15.7-2011 standard. Li-Fi can be used in many applications which include street lights, sign boards, internet, by RF Wireless World (RF Wireless World).
- Light Fidelity is a technology that utilizes a wireless form of Visible Light Communication. A set of diodes emit light for high-speed communication. Binary data is transmitted to the photosensitive detector by regulating the intensity of LED light. The intervals between the light signals are nanoseconds so that the human eye cannot detect it.

6 Plan for Application Development: *Software–Java & Web-App*

Software - JAVA

6.1 *Basic design (Blueprints not the actual code)*

First step includes generating a basic layout of the idea that we have introduced. This layout is going to a simple version of the main application as we don't want to make things complicated right from the beginning. This basic design will act as a backbone our end goal. In this phase we will focus and talk about two main Areas:

- **Back End Development (working mechanism)**

In this area we will talk and plan about the logics and the functions or functionality that is needed and the working procedures that are required for proper working.

Following are the main area of concern for Back End Development:

- Transmitter
- Receiver

- **Front End (user interface)**

- User interface is one of the main areas, because if we want to use the application (give commands to the back end) we need an interface.
- We are planning to spend some good quality time on front end. We want to provide an easy to use application along with modern visual looks and intuitive features.

This application is mainly focused in transferring data from one device to another. For that purpose, there are two major things transmitter and receiver, both of them are part of Back End Development and are the crucial parts so we will spend most of the time on it to make sure everything works perfectly.

- **Transmitter**

A transmitter (sender) that will send out the data from one device. In our case, we are dealing with LED flash of the smartphone. Our objective is to develop a piece of code that will convert the data into binary formats (0,1,11,1) and then send it out to another device using the LED flashlight.

- **Receiver**

A receiver that will catch the light waves from the transmitter (from another device) to receive the transferred data. In this phase, light ambient sensor of the smartphone will be involved, and the goal is to be able to use it and fetch that binary formatted

data. For all this stuff we are going to generate a code that can first receive the binary data and then decode it to some information.

6.2 *Basic design “Feedbacks Web Application”*

Web - App

Initial setup of the Feedback Web Application:

- I started adding the landing page and the feedbacks page with two routes. The very first step was implementing the “npm install” command to set up all the App information such as the server name, version, description, the entry point, author etc. It is important to mention that at the very end when the Application was finished, I installed in total the following dependencies: body-parser, ejs, express, express-session, flash, method-override, mongoose, passport, passport-local and passport-local-mongoose.

Working on the layout and basic styling:

- In this part I added my header and footer partials, so I could dry up the codes, and have the HTML boiler plate, having the head, body, title, etc. Afterwards I included Bootstrap for my initial we app deployment.

Creating new feedbacks:

- I added the feature for a user to submit a new feedback, so I set up the post route that actually created the new feedback added into the array, I also install body-parser, and I did two more steps such as creating the form and creating the route for the form where the user can be able to send the post request.

Styling the feedbacks page:

- With regards to Bootstrap I style the header and title using Jumbotron. Moreover, I added a flexible grid storing some pictures; this will be used at the very end of the App to display all the feedbacks from different users.

Styling the navbar and the form

- Regarding to styling aspect of the App, I added my navbar to every single page, at the beginning it was pretty much empty but at the end it encompass buttons such as Home, comments, login, sign up and logout, so I only put some placeholder text for this purpose. Furthermore, I styled the new feedback form already centred where the user can be able to input the name and image url, and also the submit and go back button below the form.

Installing Mongoose to interact with MongoDB. Introducing data persistence

- In regards to the database App, I used a non-relational database (NoSQL) where I nested comments and added comments using an array to push objects in there, being a very flexible structure to work with. Therefore, I used MongoDB because is the most popular database now with node and express, as an example there is well known stack called MEAN which means Mongo, Express, Angular and Node, in this case I did not use angular just the others three. But the main reason is because it has really good tools inside of an Express App. In order to display the Web Application I am using the cloud based text editor called goormIDE where I installed mongo and started mongo demon which is basically a process that it is going to start mongo and keep it running in the background at all times, and the command that I always used is : `“./mongod ”` in a separate terminal and I leave it running while I am working with the app.
- I opted for Mongoose because it provides a straight-forward, schema based solution to model the application data, by this I mean that it is package/tool which I downloaded using npm that can help us to interact with MongoDB inside of our Javascript files, and it makes it easier to interact with the database.
- Complementary to this, I installed Mongoose into my Feedback Application in order to add data persistence, thus I configured Mongoose and connected to the Feedback database and setup for the Feedback the model and the schema which only had a name and an image, and ultimately, I used the feedback model inside of the routes.

Implementing the show page

- At this stage I added the show route and the template show.ejs. Besides, I changed the feedback schema adding a description for each feedback apart from only having the name and the image already mentioned previously.

Refactoring the mongoose code

- At this point I implemented a quick refactor, I used the feedback schema and the feedback model in order to put it into a separate models directory and a feedback file. In addition, with module.exports inside the feedback file and I required everything including requiring Mongoose and requiring the newly created feedback file.

Adding the seeds file

- Regarding this section, I started adding comments to the App, for this purpose I wanted to have a list of comments or reviews after I clicked the button “more info” which is located in the very bottom of each comment displayed in the comment page. At this point, I needed to create the comment model, which had to be associated with the feedback model, and required all the files correctly, and also I created all the routes and views.

Adding the comment model

- At this stage I was focused on making the comment model without any errors, so I created the comments file adding the correct model code, and then I also displayed the comments that are associated with the given feedback on the feedback show page.

Creating the comment new and create

- In this section, I tackled the comment creation functionality, and I added two routes in order to create comments, so I needed a route for the form which is new, and afterwards I needed a post route where I actually created the actual comment that is called create. And finally I set up the new comment form. Basically, I had the feedbacks directory and the comments director, so I created the new and create comment routes and in both of them I had to looked up for the correct feedback first, once we check the feedback on new, the following is

render the form, but when I looked up the feedback on create, I first created the comment then pushed that comment into the feedback and save it, then I redirected back to the feedback show page.

Styling the show page

- I made a costumed styled sheet for the feedback show page, so basically I could not address this with only pure bootstrap, I had to do it manually with the use of my main.css file to complete this task. In relation to the picture, its size was too small in comparison to the container, so I added a width of 100% to cover almost the full space, but it was not enough and then I added a padding of 0 to cover the entire space inside the container. Afterwards, I fixed the comment's area space because it was covering the whole space, so I added a padding of 9px regarding the thumbnail in order to obtain a good spacing.

Authorization Part 1 – Adding the user model

- In this section I installed all the packages such as passport, passport-local and passport-local-mongoose and express-session and then in my app.js file I imported them. Afterwards I created the user model which I required it in the same file, then I implemented the user schema having the username and password as strings.

Authorization Part 2 – Register section

- I continue adding authentication to the App, so I started with the configuration for Passport and then I implemented the logic for the sign up or register routes and the template. Basically, when I tried to register again with the same username and password I got redirected to the same register form because while using passport-local-mongoose I automatically obtained the functionality that did not allow me to register two times using the same credentials.

Authorization Part 3 – Login section

- I added the 2 login routes and the login template with the form. So I needed a get request to show the form and the post request to log in. Eventually when I successfully logged in, I was redirected to the feedbacks page, and when I tried to

log in with other credentials that not correspond to any user previously registered, I was redirected to the same login form. Thus, I used the same “passport.authenticate” already implemented in the register form, but the difference is that in the register form I was registering a new user, creating a new user, and if that worked It logged in the user, and for the login form the user is presumed to exist already, so the logic was checking for credentials and then log in the user. Finally, I created the login form in order to submit the form to the login route.

Authorization Part 4 – Logout and Navbar

- To start, I added the get “/logout” request that I also installed for free inside the packages and I redirected the user to the main page where all the comments are. Moreover, I made sure to redirect the user from the “Login” link to the login.ejs file, and I did the same for the “Sign Up” link being redirected to the register.ejs file. In this context, the 3 links now have the nav bar implemented when the user click on the Login, Sign Up and Logout tabs on the right hand side on top of the page, to reach this I added the partials folder functionality from the header and footer files to the register and login files. In relation to the logout route and preventing any user to create a new comment without being signed in, I included a middleware called “isLoggedIn”, which I added as well to the “create new comment” route form, where if a user is not logged in, is not going to be possible to add a new comment and then he/she will be redirected to the login page. Furthermore, I protected the route that actually adds the comment in, because theoretically, if a user uses e.g. Postman through the post request with the URL, a comment can be created, thus I put the same middleware in the route to avoid any unauthorized access without being logged in.

Authorization Part 5 – Showing and hiding links in the navbar

- I continued working regarding the authorization aspect, so I added more embed java script (EJS) to the header file in relation to the “/Login”, “/register” and “Logout” li’s tags in order to pass a user object which contained information about the logged in user or if it was not a user it would be undefined, then if the user is undefined it will show the “Login” and “Register” links, otherwise only Logout

would be displayed. Moreover, I used the variable “currentUser” inside the index route where I can show all the feedbacks, and then I added the same variable into the “header.ejs” file to see if it’s undefined or not as I mentioned above. Due to the importance of having this variable in all the routes, I decided to put it in the app.js file on top before all the routes, and I added it as a middleware that would run for every single route. Lastly, to implement the message “Signed In As ” on top of the page I put and EJS “ currentUser.username” inside the header.ejs file where the “/logout” is located.

Refactoring the routes

- I was working about the refactoring part for my code, so I created a new folder called routes with three new files which are: auth.js, comments.js and feedbacks.js, for this purpose I cleaned up the app.js having fewer lines of codes in order to be easy to read and interpret. Therefore, I implemented the app.use() inside the app.js file where I could require the route files by changing the name “app.” for “router.” inside these 3 new files, where I also used “module.exports = router;” to export the same files to the app.js, as well as I put on this file all the 3 prefixes that I was implementing inside the 3 files to shorten the code. Now when a new user signs up and makes click in the link called “new comment” the author input has to be filled, but because now the app displays who is already signed in, the user does not have to put the authors name, it has to be done automatically. Having said that, I added the “id” and “username” objects inside the “commentSchema” which is inside the comment.js file, as well as, I used “req.user._id” before the code where I push the comment inside the comments.js file and also I added the username in the show.ejs file.

Users and comments

- In this section I focused in the user model that is already created and the comment model in order to associate both models, so when I create a new comment it automatically gets associated to the current user with the user id and username. In that sense, I started going to the comment model and adding there the author field as an object having two properties, the “id” and the username. The “id” is a reference to the user model and the username is only a string name

of the current user. Afterwards, inside the comments route when a comment is created I used `"req.user._id"` and `"req.user.username"` and then I saved the comment. Finally, in the show page I displayed the `"comment.author.username"`. In a nutshell, when a user is logged in and is adding a feedback to a comment the form is not asking to input the name, because it automatically knows who is logged in, therefore, the name will be display in the comment after clicking submit.

Users and feedbacks

- In regards to this, I did not want a user submitting a new feedback if is not signed in unless he/she have an account, but anyone can view and read comments and feedbacks. And secondly, I wanted to make sure to save the username and `"id"` to the newly created feedback, just in the same way I did for the comment section. In that sense, in the feedback show page I can show who created it, and this will have further implications about who can delete or delete comments or feedbacks and I needed the username and the `"id"` to make it working. Additionally, in the `feedbacks.js` file I added the middleware called `"isLoggedIn"` inside the create route, and then I updated the feedback schema taking the author with the username and `"id"`, and finally I displayed it in the show page while using `"feedback.author.username"`.

Editing feedbacks

- In this part, I started integrating the full CRUD for feedbacks and comments and I added as well the user authorization. For this, I implemented the override method and configured it to be required inside the `app.js` file, and after I created the edit and update route in the feedbacks page. Regarding the edit route, I used a get request and created the form in a new file called `edit.ejs`. Ultimately, I added the edit button in the edit page to be redirected to the edit form.

Deleting feedbacks

- Regarding the deletion of feedbacks, I created a form that sends the delete request to the url and then when I make click it removes it using `"findByIdAndRemove"`. Therefore, inside the `feedback.js` I added a new route

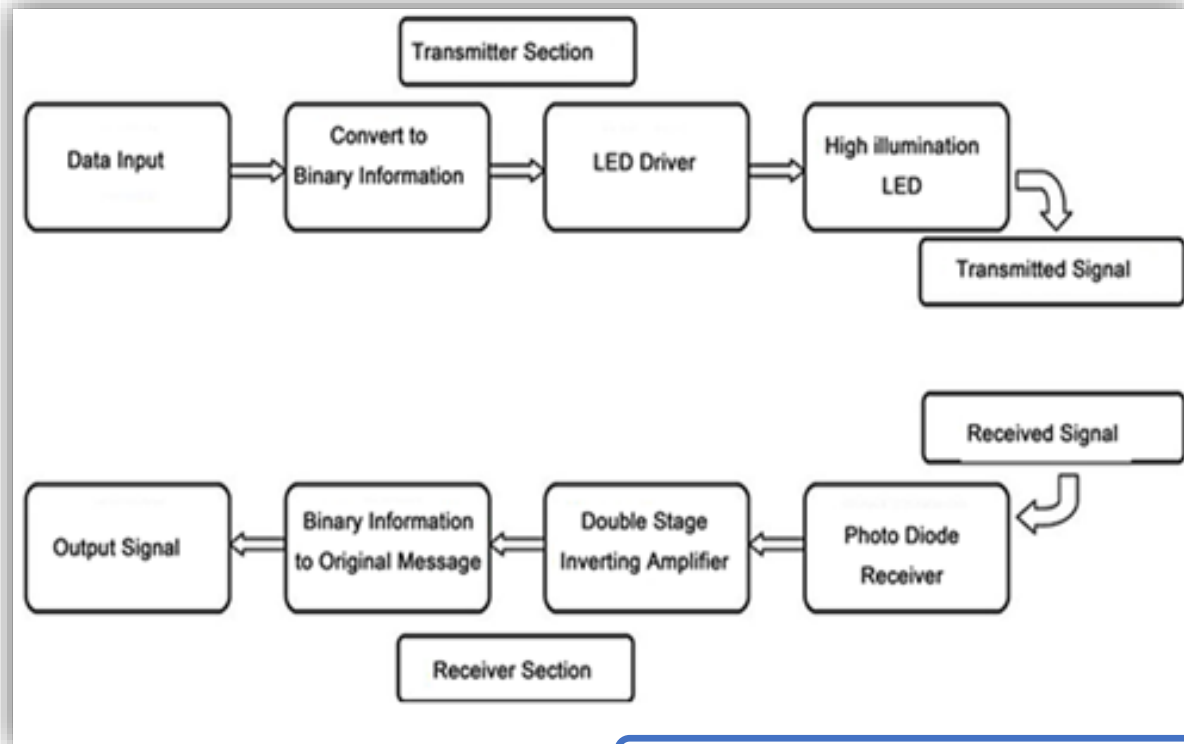
called “delete” and in the show page under the edit button, I created a form to send the post request that has the delete method, and also there I added the delete button. Afterwards, I had to use mongoose in the feedbacks page inside of the delete route while using “findByIdAndRemove” which takes the id, and then it will redirect the user to the feedbacks page. At the end, I styled the edit and delete buttons because they appeared one below the other, so to make this happened and place them in separate lines I used an inline display property inside the main.css file.

User authorization regarding feedbacks

- I made sure that a user cannot delete or edit a feedback that he/she has not created. This section is about authorization, which means who is allow to do some actions and it is related to permissions. So I was working with the feedbacks.js file where I protected three different routes such as edit, update and delete while using a middleware called “checkFeedbackOwnership”, and I defined this middleware at the very bottom of the file in order to check for authorization matching the “id” and author’s name and making sure that he/she is already registered. Finally, I hid the edit and delete buttons depending if the user is logged in or not. Thus, I was working in the show.ejs file and I added an if statement to check if the logged in user owns the current feedback on the show page, so I added the “currentUser._id” for the if statement.

7 Systems Analysis

7.1 *The Design of the System*

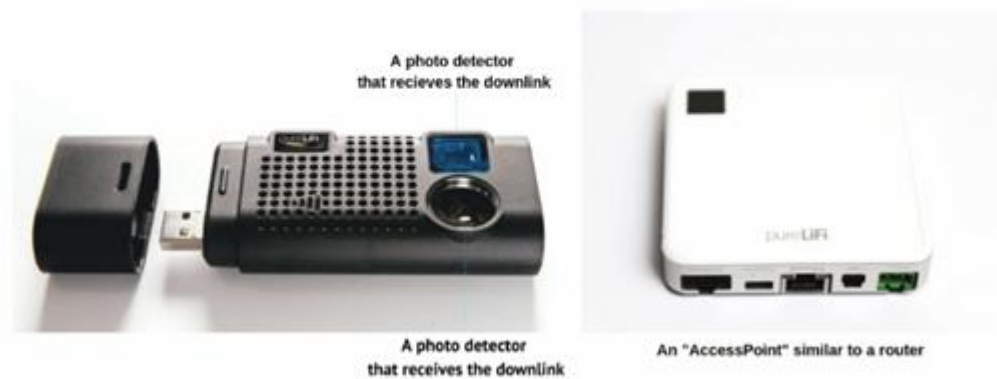


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The system was built in java language, using a mobile phone as a receiver and another mobile phone as a transceiver that transmits data from LI-FI technology. As the mobile phones has already built in the sensors that detects the light in front and back cameras, it was a great opportunity to us demonstrate that technology without have to spend a lot of money and time on it. We would like to be able to demonstrate that, and make that working for real.

We had the thought to use two laptops at the beginning; perhaps it was a bit harder because we need to have special equipment as a receiver in LI-FI to be able to make it work (as we can see the example of the equipment in the picture below | "Hqsoftware").

LiFi devices:



Another way would be using Arduino or Raspberry pi, it was trick to us go in that direction because we would not have enough time to learn how to use that as it would be involve electronics understandings.

The mobile transmits a set of diodes that emits light in high-speed communication. The binary data is transmitted to the photosensitive detector by regulating the intensity of LED light. The intervals between the light signals are nanoseconds so that the human eye cannot detect it.

Nevertheless, LI-FI and Wi-Fi are very similar technology. LI-FI through the optical spectrum sends data and Wi-Fi uses the radio spectrum.

- **Pros:**

In terms of range, you can receive data as long as you are in the range of the emitted light.

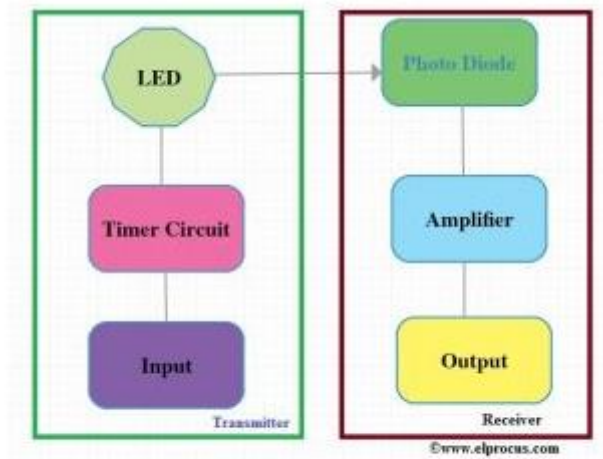
The range then depends on the strength of the light. Installation costs are low since LI-FI works with existing LED devices, which are widespread everywhere, work for years and consume little energy.

- **Cons:**

Any obstacle can interfere with the light signal. Compatible only with Infrared Data Association devices. It needs an LED system to be integrated with (Hqsoftware).

In the real life with the proper equipment as seen in the image below we could do the project with the laptops (Hqsoftware).

7.2 Block Diagram of LI-FI System



Li-Fi Block Diagram

LI-FI system works through transmitter and receiver. The input signal at the transmitter section can be modulated with a specific time period then send the data using LED bulbs in 0's and 1's form. Here, the flashes of LED bulbs are denoted with 0's and 1's. At the receiver end, a photodiode is used to receive the LED flashes strengthens the signal & gives the output.

The block diagram of LI-FI system is shown above, and the transmitter section includes the input, timer circuit, an LED bulb. The input of the transmitter can be any kind of data like text, voice, etc. The timer circuit in this section is used to provide the necessary time intervals among every bit, and these are transmitted to the receiver end in the form of LED flashes.

The receiver section includes photodiode as well as amplifier. Here, photodiode receives the LED bulb flashes then changes the flashes into electrical signals. Finally, the amplifier receives the signals from the photodiode and amplifies to provide the output. (By Elprocus).

7.3 Comparison between Li-Fi and Wi-Fi | Tabular difference between Li-Fi and Wi-Fi

Following table compares Li-Fi vs WiFi and derives difference between Li-Fi and WiFi technologies with respect to various features.

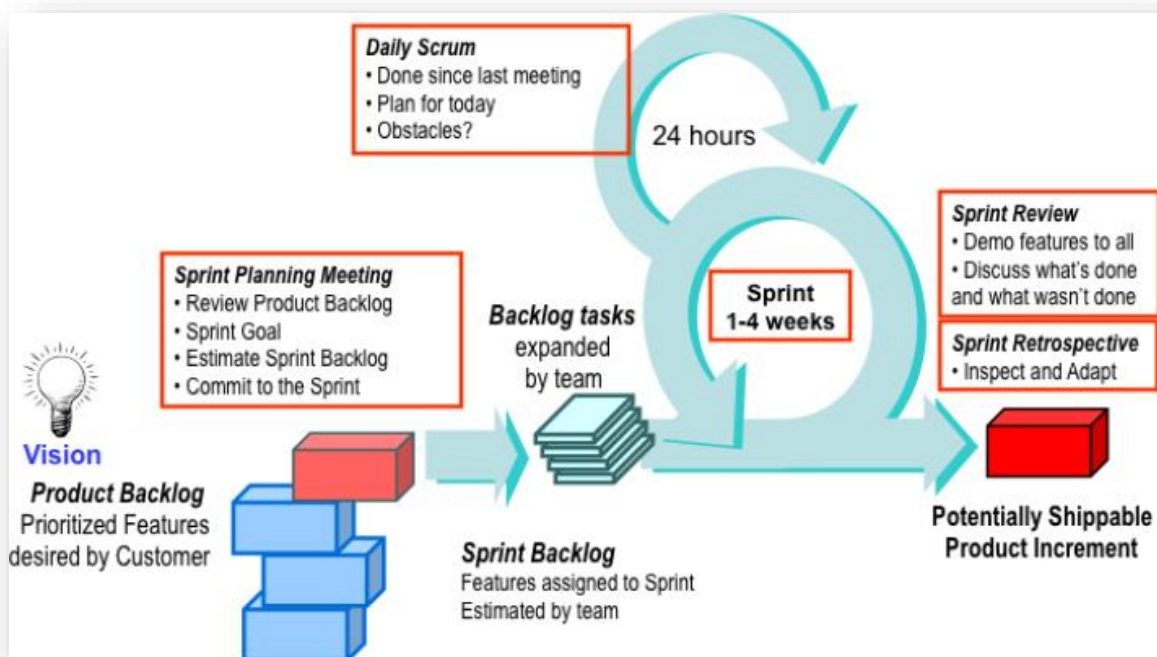
Feature	LiFi	WiFi
Full form	Light Fidelity	Wireless Fidelity
Operation	LiFi transmits data using light with the help of LED bulbs.	WiFi transmits data using radio waves with the help of WiFi router.
Interference	Do not have any interference issues similar to radio frequency waves.	Will have interference issues from nearby access points(routers)
Technology	Present IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard compliant devices
Applications	Used in airlines, undersea explorations, operation theaters in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of wifi kiosks or wifi hotspots
Merits(advantages)	Interference is less, can pass through salty sea water, works in dense region	Interference is more, can not pass through sea water, works in less dense region
Privacy	In LiFi, light does not pass through the walls and hence will provide a much secure data transfer	In WiFi, RF signal passes through the walls and hence there is a need to employ techniques to achieve secure data transfer.
Data transfer speed	About 1 Gbps	WLAN-11n offers 150Mbps, About 1-2 Gbps can be achieved using WiGig/Giga-IR
Frequency of operation	10 thousand times frequency spectrum of the radio	2.4GHz, 4.9GHz and 5GHz
Data density	Works in high dense environment	Works in less dense environment due to interference related issues
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type
System components	Lamp driver, LED bulb(lamp) and photo detector will make up complete LiFi system.	requires routers to be installed, subscriber devices(laptops,PDA's,desktops) are referred as stations

RF Wireless World

8 System Development Methodology

As a team we adapted the Scrum methodology from the Agile approach to build the Li-Fi share Application. It is a methodology that helped us to implement the design and also as a guide for our team as an iterative and incremental delivery of our product. This strategy is often referred to as “an agile project management framework,” which its main goal was using an empirical process that allowed us to respond rapidly, efficiently, and effectively to fixed time and cost issues to adapt our needs to the requirements we had to follow while developing our Application.

The Scrum approach is mainly based on the collaboration between our team members being focused in the customer needs to create an ideal product. The following diagram shows the basic Scrum framework:



Our project started with a clear vision provided by CCT College about all the requirements needed to build our Application, along with a set of features that our main product had to have in different order of importance to be completed due to its complexity of development.

These features were part of the product backlog, which was managed and organised by the Product Owner, and in this case was Anant who was in charge of the code development in order to implement the Li-Fi Share Application.

With regards to Scrum, a time box means a sprint which is the amount of time that our team had to complete the features of the product.

The Sprints that as a team we were following since the beginning of our project consisted of 4 weeks, where each team member selected different tasks from the product backlog that we believed it could have been completed according to our skills, in that sense, we formulated a sprint backlog consisting of the features and tasks as part of the sprint-planning meeting.

During the sprint, we were having meetings 3 times a week when we were attending classes in college, and we used to have a 15-20 minute meetings known as a scrum. In the meetings we always talked about what was already done, what were our plans to do for the same day and what would be the next task to be completed for the next meeting. At the end of each sprint, we gathered all the feedbacks that would affect our work for the next sprint along with different tools in order to improve the next tasks. They also hold a retrospective to learn how to improve.

In relation to the roles and responsibilities, the ScrumMaster was Zohaib, who knew how to manage the process and facilitated the team communication, while Anant as the Product Owner person owned the product backlog being responsible for communicating the vision to the team and defining and prioritizing backlog responsibilities, as well as, answering questions and providing guidance. It is important to mention that as a team we all collaborated and delegated responsibilities throughout the process, where Juliana and Gamaliel owned the estimates, made task commitments, and reported on a weekly and monthly basis the status for the whole team regarding the scrum program.

With regards to the Sprint Planning Meeting, which was held on the first day of every sprint, the work estimates were reviewed to see if the team had enough time to complete all the tasks required for every sprint. If so, the team committed to the sprint, otherwise, the lower priority responsibilities were added to the product backlog, until the workload for the sprint was small enough in order to obtain the team's commitment.

It is crucial to mention, that we used the Basecamp Application as our Tracking Progress to manage our project, and it was really helpful to work with tasks to do, schedules, uploading multiple files and sharing important information for the success of the project through multiple commitments. This application showed us the trend line of the amount of work left to do in the sprint, regarding the tasks that were defined in the sprint-planning meeting. Over the days of the sprint, the total tasks of the “to do” list indicated the amount of work we had left to complete, and thus, the trend went down to zero by the last days of the sprints.

Finally, the Release Planning was also part of our Scrum methodology, and it was a long-term planning for a time box that consisted of multiple sprints that were accomplished during 4 months, and the results were internally released just to confirm our integration and validation. The implementation of the Scrum approach was essential in order to accomplish the main goals to develop the Li-Fi Share Application.

9 Prototype and Development Phases

After setting a Development plan, Analysing the system and the after doing research on the working and logics of LI-FI, the next task was to convert theoretical work into practical and develop a proper working application that can be used in real world. Since before this project we have never developed any proper android application due to which we were uncertain about how to initiate the development of this application. Lack of proper knowledge and experience about how to develop an android app was a major hurdle, that we faced. So instead of starting the whole application at once, we distributed the application in to small bits and breakdown the development process in to different phases. Each phase has its own aim (part of main application) and a prototype. By using this approach, we were able to develop the application without any problem.

A few main advantages of this approach are following:

- Modularity means better concentration on specific part/phase of application rather than working on whole application at once.
- Better tracking of working and faulty code, as we can see that in which specific phase the application stopped working or not
- Helps a lot in trouble shooting relevant to code, as we can check which code is needed to be changed or update.
- If something goes wrong in a specific u can always go back to the previous phase and can start working from there instead of starting again from scratch.

9.1 *Phase 1 (sender side)*

This phase was bit difficult compare to other phase, as this was the starting point of the application prototype.

The main aim of this phase was:

- To be able to create a piece of code that can connect the flash light of smart phone with our application. So, we can use to in our second phase. In short in this phase our aim was to get access to the LED Light of smartphone.
- During this phase the main issue we faced was the testing or to more exact being not able to check whether the code that we have generated is working are not.
- For that purpose, we needed a smart phone in which we run the prototype every time after doing some changes in the code.

9.2 Phase 2 (sender side)

- After the completion of the first phase the next step was to **manipulate the LED flash light** according to our needs.
- Compare to the first phase this phase was a bit easy as all we wanted to do is to send signals to the flash light so can turn it on or off.
- After being able to manipulate the LED the next step of this phase was the frequency i.e. how many times, we want to turn the flash on or off.
- In short, the LED is going to act as sender.

9.3 Phase 3 (receiver side)

This phase was divided in to two parts. first part was based on getting access to the sensor. While the next part we did some work on how to use this sensor and how to control it.

- After working on the LED area, the next main area of concern was the proximity light sensor of smart phone just like the phase 1, the main aim if this phase was to generate a code in which we have the **access to the proximity sensor**. so,
 - we can use it, to take in / receive the signals transferred from the LED light.
 - These signals are the light particles knows as Photons. The amount of these particles and the for how long they hit the proximity sensor is considered as one signal.
- In the second half of this we developed a piece of code that can be used to
 - make the sensor to **receive the light signals** and store them as a stream of bits (0,1,1,0,0).
 - This part was giving us a hard time. Because this part was totally based on the adjustment of the intensity of light received by the sensor and how long does the sensor required the light to register it as a signal (on receiver side).

9.4 *Phase 4 (working module)*

This phase was the toughest one compare to the others and it took too much time to finish this one. This phase was more like the brain of the whole module. We divided this phase in two parts. As this phase was required to much trouble shooting so the main working mechanism of this phase is explained in the trouble shooting section.

- In first part we **encrypt** the commands that we wanted to send (transfer). So:
 - We developed a code that can convert the commands in to low level language that the hardware of the smartphone can understand and perform the function that we want.
 - In our case we wanted to convert the commands that we want to transfer and run on the other smartphone. To achieve it first we converted the commands in to a stream of Binary bits (0110101).
 - After that we develop a function for this phase, that can turn on the LED light if the bit that we want to transfer is 1 and turn off the LED light if the bit is 0.
- The second part of this phase was the opposite of first part as here we want to receive the data and then **decrypt** it. to achieve this:
 - First, we connected the proximity light sensor of smartphone with the application and then and make a function for the sensor, where the sensor was required to constantly examine the intensity of light.
 - The change in the intensity of light (on or off) was scanned by the sensor and was stored in the application (temporarily).
 - Then we converted the received data in to binary bits.
 - In the end the binary bits where converted into a proper binary stream which we used in the next phase.

[Further explanation can be found in the trouble shooting area](#)

9.5 *Phase 5 (functionality and features)*

In this phase we merged together all the prototypes that we developed during previous phases and developed one single proper working application. and after making a single working application it was the time to enter the features in this application. For the selection of features and options was not an issue as we had already selected them earlier so, here it was all about converting those theoretical ideas into something that works in real. Following are the features that we added in this phase to our previous working prototype

- Sending option, being able to send a code by using Led light of the smart phone
- Receiving option, being able to receive the data using the proximity light sensor in the front of smart phone

These two are the main options, after developing this two we added a series of code on the sender and receiver side.

- Each code was connected with a specific task. Whenever the receiver side receive any code the code will perform a specific programmed function. For example
 - Open emails
 - Open music
 - Open internet browser
 - Open device setting

9.6 *Phase 6 (front end)*

- This phase was something that took too much time.
- The development of this phase was not an issue.
- The main issue was the appearance and the impression that the user will get about this application after using it.
- After developing a graphical user interface and implementing it on android application we asked a few friend and family members to give us some review about the application and 9 out 10 suggested us to update (change) the front end. As it was not looking good.
- So, after getting the reviews we redesigned the whole graphical user interface

[Further explanation can be found in the trouble shooting area](#)

10 Limitations

10.1 *Hardware limitations*

Once our prototype started to work the way we wanted, we moved the project in stage two and this stage was about upgrading the current prototype and refine it to make sure it can be used by the users without any issues. In stage two we were planning to do following things:

- Upgrade the Graphical user interface.
- Upgrade the functions.
- Increase the speed of transmission.

Upgrading the GUI and adding new functions was not difficult and we able to finish these tasks without any problem.

The real problem that we faced was the **transmission speed**.

- **Sender Side:** As we were planning to increase the speed of the transmission so, we can transfer heavy files from phone to another. To achieve we need an LED light that can turn On and Off with minimum frequency of 80000 times per second. So that we can send one Kilo Byte in one second, But the LED in our current smart phones is not even close to 20 Hz per second. This frequency varies from smart phone to smart phone. As each smart phone manufacturer is using their own and different types Led technology for Flash light (on back of Smartphone) which is another hurdle for as we cannot set the speed of transmission according to our testing (unit) Smartphone.
- **Receiver Side:** We tried to increase the speed receiving by reducing the time taken to receive one bit, from 500 millisecond to 125 milliseconds so that we can receive at least one byte in one second. But again, smart phone light proximity sensors are not designed to receive this much data (not capable) we were not able to increase the receiving speed.

When we try to increase the speed of led light (on sender), we found that the light receiving sensor on the receiver side stop responding sometimes or start registering the wrong input (inaccurate input).

After doing some intensive research and testing we reached a point. Where no matter how much we change our code of application, we were not able to increase the speed of data transmission. As mentioned earlier the main reason was the hardware of the smartphone.

Usually the main purpose of the flash light in a smartphone is

- to act as an emergency/flash light,
- Or it is used by the camera system implemented in the smartphone to make subjects visible in low light by shedding light over them so that the camera can capture it.
- For this purpose, the commonly used led light on the smartphone is more than enough.
- But if wanted to use that led bulb to generate high frequency flickers (on and off), for that purpose it's not suitable as it is not designed to make variations in the frequency and intensity of light.
- Due to which it limits the speed of transmission of data to a few bits in one second

Even if somehow the led flash light of the smartphone was able to generate high frequency flickers.

Then the next main issue appears in front of us. Which is the proximity sensor. In smartphone the main purpose of this sensor is

- to adjust the screen brightness of the smartphone according to the light intensity, like in dark environment this proximity sensor will give a signal to the OS of the smartphone to reduce the brightness and in bright environment it will send the signal to OS to increase the screen brightness so that the user can see the screen in well-lit environment.
- This sensor in the smartphone is so tiny and slow that it can only perform simple or slow functions like turn on or off the screen of smart phone or adjust the brightness.
- It is not design to detect sudden and continuously change in intensity of light.

Due to all this hardware limitations in a smart phone. we are not able to reach the goal of fast data transmission speed, where we can transfer a file from one smartphone to other.

11 Plan for testing and Finalizing

11.1 *Testing*

Testing is also another important phase that is required to ensure that application will work properly in real world. This application will go through several tests:

- Performance test: the application must clear this test, because the speed is one of the main points of this application
- Security test: to make sure that the data of the end user is safe, and no one can get the access to it.
- Testing for Fault tolerance and Error handling: to make sure in case any unexpected event occurs the application doesn't crash and keep working (Anon, 2019).

11.2 *Finalizing*

This is going to be the last phase, where everything will be checked, all the small details or errors of the application will be fixed and finalized in this phase.

12 Time Management

12.1 Main Android application Time management

	Weeks														
Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Basic Design (Front-End)	✓														
Basic Design (Back-End)		✓	✓												
Transmitter			✓	✓	✓	✓									
Receiver							✓	✓	✓	✓	✓				
Testing												✓	✓	✓	
Finalizing														✓	✓

	Description
1. Basic Design (Front-End)	It will take 1 Week to complete to complete this Task
2. Basic Design (Back-End)	It will take almost 2 Week to complete to complete this Task
3. Transmitter	It will take a Month to complete to complete this Task
4. Receiver	It will take a Month to complete to complete this Task
5. Testing	It will take almost 3 Week to complete to complete this Task
6. Finalizing	It will take almost 2 Week to complete to complete this Task

There are total 6 tasks in total

12.1 Dynamic Web Application (Additional & supporting web for main application)

Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Basic Design (Back-End)	✓	✓	✓	✓	✓	✓	✓	✓							
Basic Design (Front-End)										✓	✓	✓	✓	✓	✓
Testing												✓	✓	✓	
Finalizing														✓	✓

1. Basic Design (Back-End)	It will take 2 Months to complete this Task
2. Basic Design (Front-End)	It will take 1 Month and 3 Weeks to complete this Task
3. Testing	It will take 3 Weeks to complete this Task
4. Finalizing	It will take 2 Weeks to complete this Task

There are 4 tasks in total

13 Troubleshooting and Problem Solving

As everyone can easily have an idea that building something new from scratch that is totally based on new technology which is under heavy research can be tedious and challenging. In our case there was nothing different. There were a number of problems that we faced while developing the first prototype of LI-FI share. Following are the problems that occurred in the development and testing phase:

13.1 *Application Design (blue prints)*

Software - JAVA

It is always challenging to design a complex application. It is quite difficult to build an application that will perform all the required complex tasks. Without designing it difficult to use is a tremendous job. In our second week after starting the project it was the first issue that our team faced.

Solution:

To overcome this challenge our team divided this task in two parts

- **Part A:** Selection of the right functions, this means which features that we want to add in this application like, do we want a function that let us to open the settings from a smart phone in other smart phone or adding an option for users where it can be used by the specific user (app lock) . To overcome this challenge our team members did research on some applications like Share it, Zappy and Easy Share, to get a basic idea about that which functions should be required for this project and what things should we exclude to make sure that the application is not over crowded.
- **Part B:** This part was mainly focused on the interaction between all the selected functions that were decided to be added in our application. Their working means we want to make sure that all the functions that are selected can be developed by us on time while making sure that they work properly.

It took almost 3 weeks to complete this task. Part A was done with in only one week but the Part B was quite difficult as making a design for an application that is totally based on a new technology and making functions in that application that is totally based on this new technology.

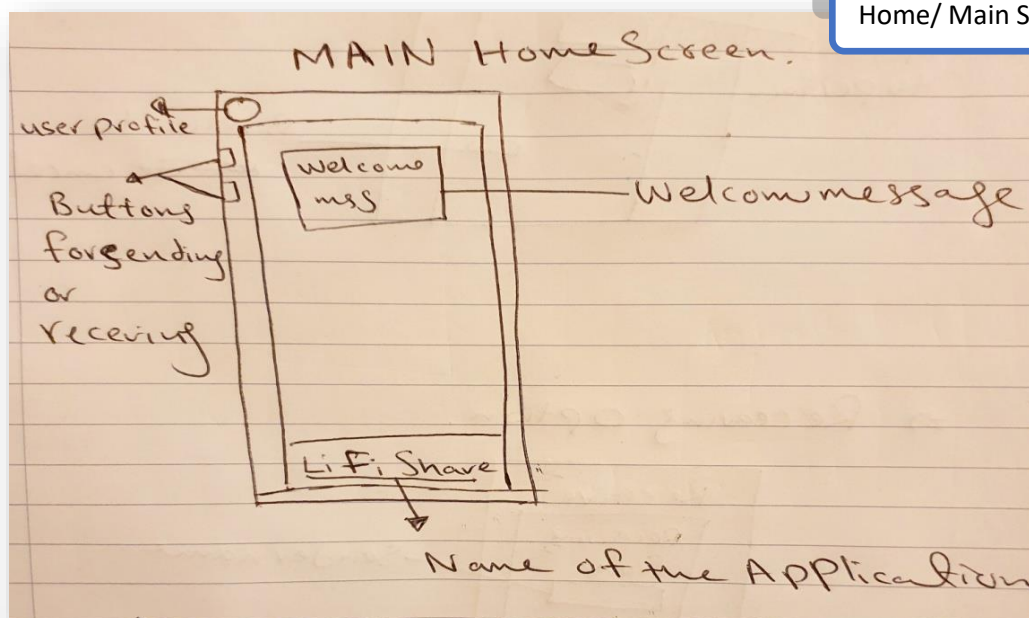
13.2 User Interface:

As we know a user interface is one of the more important part of the application that is mainly focused on the looks and style of the application, and how users will interact with the product that have been produced.

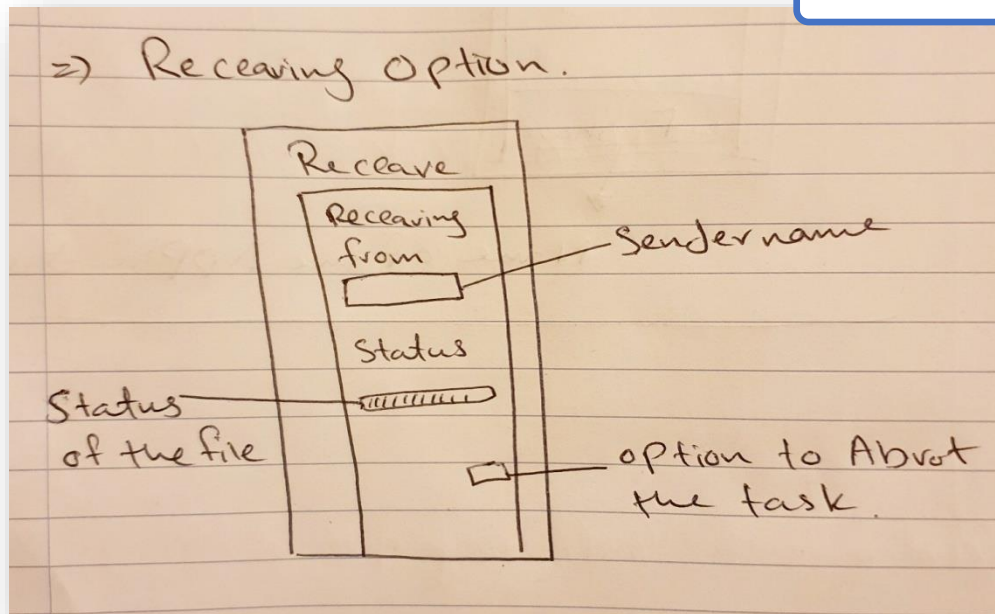
This time around the problem we faced was to make a UI that:

- Looks and Feels nice, nowadays, having a nice and well-polished interface is of paramount importance. If you have an amazing application that can perform all the functions, but the interface is not pleasing by the looks and feel of it, there is a 90% chance that the user will delete the application.
- Designing an Interface that is easy to use, this means a user can understand the interface and can use it without any problems. They can make full use of functionalities without any problem.
- Error free, responsive and consistent, means everything is working. When something is clicked or used the users expects that they work without crashing or any lag. No matter which function is being used or performed it should feel like it's the part of the application and making sure that is constant across the board.

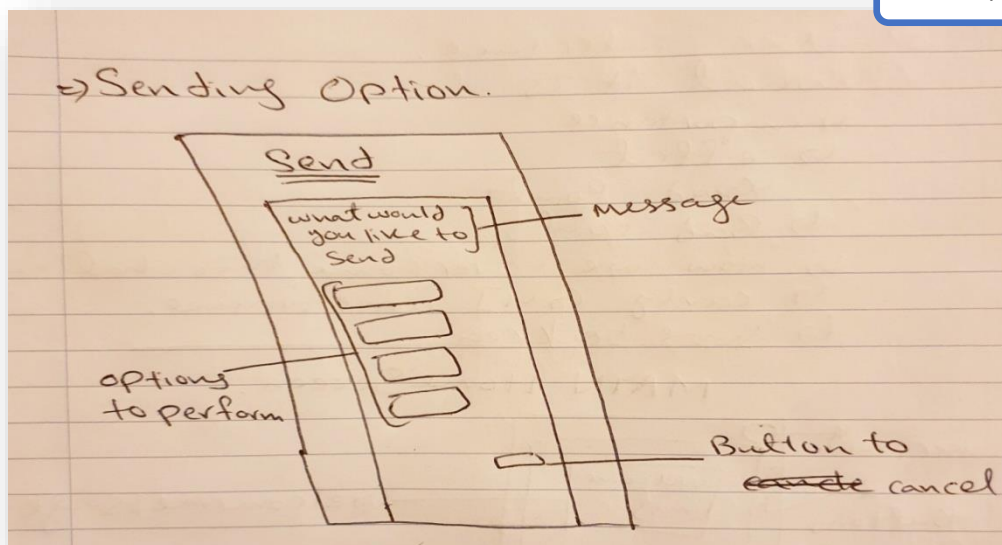
Having all these points in our mind we start working on the visual layout of the UI, Following are a few Wire frame of the UI



Receive Option Screen



Send Option Screen



13.3 *Encoding and Decoding*

Software - JAVA

The moment when our project reaches the stage of transmitting the data from one smart phone to another, we founded ourselves in a major problem, and it was the encoding and decoding of the data. As we have never developed any android application which aims to deal with the data it puts a lot of pressure on us. To overcome this hurdle our team started to study about the data manipulation to learn the basics, and searched for the suitable method of encoding and decoding for LI-FI Share.

Solution:

After doing a series of experiments we found the best algorithm for encoding and decoding the data. This algorithm involves two steps to encode the code (Data) on sender side and two steps to decode the code (Data) on receiver side.

- **Encoding:** First we covert the code in to decimal, and then convert it in Binary Base (stream of 1 and 0 i.e. 0110101) so it can be transferred using Led light (Flash light of Smartphone) by simply Turning it On and Off. When the Led light is on it means `1` and when Led is off It means `0`
- **Decoding:** It's totally opposite of what we did in encoding process. Simply on the receiver we receive 1 or 0 as an input after receiving the full stream of binary bit's, we convert it in to decimal base. And then compare the processed decimal values with the preinstalled decimal values on receiver side to perform the task.

13.4 *Inaccurate Output*

Software - JAVA

After sorting the issue of encoding and decoding, we finalized our first prototype. This prototype was designed to perform basic function of transmitting the data from one cell phone to another. When we start doing the testing, we found an error on the receiver side. It was the output that we were receiving.

Scenario:

In our first test we were trying to send a code i.e. a stream of bit's 10010.but the output that we were receiving was 11011. After going back and forth in the code, changing a lot of things, the problem remained the same and at a few spots it got worse. Thankfully, it took us only 3 weeks to isolate the problem, the problem lied both in the code and the hardware.

Since we know light travels at a great speed. The sensor was picking up a change in light as soon as the flashlight of the sender was turning on. At this point the flashlight hasn't even reached its brightest point and the sensor is receiving all the 1's, simply because it is brighter than the background light. The same was happening with the 0's. When there was no flashlight it was continuously receiving 0's. This could have stopped just by stopping the thread after meeting certain condition. But, the problem with continuous 1's bit was mind numbing as we were now being limited by the hardware. At the same time, it was quite graspable as we were doing something using a hardware which is not designed anywhere near to exchange data.

Debug:

To solve this issue our team started to rethink the whole logic and working module. To sort out this issue we start testing the program by sending one (1) bit and noted down the time that it takes to send and receive. Then repeat the same test. But this time with two bit's (11) the result we received on the receiver was 111 instead of 11. Then we again repeat the process but with three bit's that contains both 1 and 0 as a bit. So, we sent 101 and we received 110. What we found is that there was a delay on receiver side, due to which the receiver was registering 1 bit as 11 bits.

Solution:

To overcome this issue, we implemented the logic of a time counter. The purpose of this logic was to wait for a certain time and in that wait for a bit 1 if it receive any 1 bit in that certain time it will register it as 1 otherwise if no bit received it will register it as a 0 bit and restart the timer and look for next bit. By using this logic, we were somewhat able to overcome this issue, however, there was another catch. Whenever we were stopping the counter our application was crashing, some in built action listener we guessed, time was ticking as these issues were not being fixed in minutes or hours but, days. We decided to introduce a patch due to the limitation of our hardware which was transferring only the bits of 1's. Although this resulted in lengthening the bit streams but it was the only way to overcome the limitation and meet our goal.

13.5 Troubleshooting

A field that represented an issue was Data Associations, which was about finding the process in order to match all the models with each user, those models could be photos, posts or comments that need to be linked with every user in the server side. In order to solve this problem, I used object id's and queries to retrieve data and also post arrays with all the data related to the content and title fields.

Another problem that needed to be tackled was related to Authentication, where the user couldn't login, register and logout, with the aim of storing data in the database and to protect personal information against malicious users. In regards to this, the issue was fixed through implementing the user model and installing all the packages that were needed for authentication, such as passport, passport-local, passport-local-mongoose and express-session.

It was compulsory to find the best method in order to refactor and clean up the codes, just in a manner to make it more modular, at the beginning I couldn't find an appropriate way to do it, but when I did some research about a method called "module.exports" it helped me for this purpose. Therefore, I could organized my codes into files, so I used the references.js template that I already created having the same post and user schemas and models, so the objective would be separating both the user and posts into different files in order to be required independently, and if I want to have another application that uses the same user model or another file that use it, I wouldn't have to duplicate the code, I could just require the code in that file as well, and that made things reusable.

Another challenge was trying to implement the login part where I did not know how to add two login routes and the login template with the form. Besides, another difficulty was using the get and post method in order to display the form and handle the logic for the login functionality that I already used in the previous register form already created. So, to make it work, I set up two login routes along with the login template and the form. Therefore, I implemented the get request in order to show the form and the post request to login in. In this case, I created the login.ejs template which finally was the form that utilised with two types of inputs such as username and password, and I could complete this because I used the middleware called "passport.authenticate" for the login area.

It was really challenging working on the logout logic to prevent any other users from accessing a new comment form without being signed in. To solve this problem, I did some research and I included a middleware called "isLoggedIn", which I added as well to the "create new comment" route form,

where if a user is not logged in, is not going to be possible to add a new comment and then he/she will be redirected to the login page.

Another important issue related to the App is when it was showing the Login, Sign Up and Logout tabs on top of the page when a user was not logged in or even if he/she was logged in, so to fix this, I had to manage about how to use the correct logic/functionality in order to display only the Login and Sign Up tabs when the user has not Logged in, and when he/she has done it, the Logout tab will only appear on top of the page. In order to tackle this problem, I used the variable “currentUser” inside the index route where I could show all the feedbacks, afterwards I added the same variable into the “header.ejs” file to see if it’s undefined or not. Also due to the importance of having this variable in all the routes, I decided to put it in the app.js file as a middleware that would run for every single route.

Lastly, to make sure that a user cannot delete or edit a feedback that he/she has not created was a challenge. So I worked with the feedbacks.js file where I protected three different routes such as edit, update and delete, and for this purpose I had to use another middleware called “checkFeedbackOwnership”, moreover, I also setup this middleware at the very bottom of the file in order to check for authorization matching the “id” and author’s name to make sure that the user should be already registered.

14 Conclusion

After extensive research and work on LI-FI, we as a team (Alpha Tech) think that:

We wanted to develop something that is totally new, something, which has not been done by anyone before. In order to achieve that goal, the whole team passed through a positive learning curve which was full of new technologies. Just like any other project the phase of prototyping and testing is considered to be the most difficult step. Our team also faced the same challenges since we had never developed anything like that before. There were certain times when a wheel in our cart broke but we had nothing to lose instead everything to gain. Some development phases consumed more time than we expected but, we were prepared for such scenarios since the very beginning.

The ultimate outcome of this project was not exactly what we had aimed for but it was rather a more learning outcome. Our aim was to show some tremendous speed transferring a file. Due to some shortcomings in our current technology (Hardware. Some unexpected events like Covid-19) and some problems in the SDLC (system development life cycle) we went out of time. We believe that with proper hardware, and with more time we could have achieved our main goal.

We as a group take full pride to present what we have achieved, as we clearly met our overall goal of transferring data through light regardless the speed of it. Besides learning new technologies, by working in group as a team we have gain valuable experience on how things work in real World. Not only that, we also developed soft skills such as communication which is the key for any teamwork.

We hope to continue working on this project as we genuinely see some potential in it looking 6-10 years from now.

We the Alpha Tech are really Thankful of CCT and the faculty of CCT, for providing as an amazing chance to gain real world experience during our studies.

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****This document was developed based on the research from those given references above. AS most of them are web-based material, the links provided might be updated or changed over time****

16 Appendix: Distribution of task and labour between group members

16.1 *Anant Tandon (2017384)*

- ✓ I did all the programming for LI-FI share app.
 - ✓ I was responsible for telling the group members what they have to do as far as research was concerned.
 - ✓ I told them the areas (benefit's, Wi-Fi drawbacks, Bluetooth drawbacks) they needed to go deeper into and collect authentic information that was relevant to the topics assigned and also to our project.
 - ✓ After getting all the information I was responsible to go through the material and decide what goes in the final document.
 - ✓ I made a raw document that went to the other member of the team for further working.
-

16.2 *Gamaliel Munoz Friginals (2017092)*

- ✓ Working on the research part regarding the benefits of and drawbacks with regards to Bluetooth and Wi-Fi along with the referencing aspect.
- ✓ Developing the backend and frontend in relation to the "Feedbacks" Web Application that we will be using in order to display and show case our main Application called "Share".
- ✓ Implementing the System Development Methodology section in the main document.
- ✓ Carry out the Application Development and Problem Solving and Troubleshooting section of the main document with regards to the "Feedbacks" Web Application.
- ✓ Correcting references, grammar, spelling, and punctuation mistakes as well as sentence structure problems, misused words and typos in the final version of the document.

16.3 *Juliana Sousa (2017266)*

My main contribution is research about the technology that:

- ✓ How it works? Like how the transmitter sends out the light waves through LED and how the receiver receives it using the ambient light sensor.
 - ✓ Why we should use it?
 - ✓ Benefits of using it, better security and faster speed and reliable compare to the others available technologies
 - ✓ How it is better than the other technology in terms of daily usage
 - ✓ The Introduction, Innovation and Systems Analysis topics were written by me.
 - ✓ As a Project Manager I have scheduled the meetings, group activities, and goals of the project.
-

16.4 *Zohaib Qaiser (2017400)*

Following are the tasks that are done by me:

- ✓ Main report of the project is developed by me, after the raw document that Anant provided me.
- ✓ All the arrangements, styling and changing regarding to this document was part of my duty
- ✓ The section of:
 - "Limitations"
 - "Time management"
 - "Finished Product used by"
 - "Testing and Finalizing"
 - "Prototype Development phases"
 - "Troubleshooting and Problem solving"
 - And "Conclusion"

Regarding to LI-FI share, are done by me.