FLUX: A CLOUD-BASED NAVIGATIONAL SYSTEM USING FRAME DIFFERENTATION AND TRAFFIC DENSITY DETECTION

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ABSTRACT

Through the years, traffic congestion has been a recurring road condition problem. Drivers and passengers alike would get stressed out by the long travel time, wasting their time and preventing them from doing some other productive activity instead. Majority of the people nowadays travel at an earlier time to avoid traffic conditions that would hinder them from following their premediated agendas. If these people were able to identify the route situations and conditions at an earlier rate, they may be able to avoid being able to encounter their fears. To solve this, the researchers will develop an android application that would ease the navigation experience of its users and would aid them in choosing the most efficient route to be taken with great consideration to traffic conditions and the amount of time it would take them. It will not only be beneficial to commuters and drivers but also to the different departments of the government such as those in charge of traffic, road and railways and accidents since the system automatically stores and keeps images and information of the different road channels. As a result, people will now be able to monitor the highway situations real-time.

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CHAPTER 1
INTRODUCTION

1.1 Rationale of the Study

Today, commuting has become a norm to our society. Students, professionals and even common people alike travel from one place to another more frequently than before. At times, the distance is short enough where it is deemed unnecessary to ride a vehicle.

In the Philippines, there are a total of 7, 463, 393 registered vehicles and a total of 13,000,000 registered drivers. (MegaCebu, 2014) According to statistics recorded by the Land Transportation Office, in 2011, there were only 574, 640 vehicles registered in Region-7 alone. This figured has since then increased to 652, 828 vehicles as of December of 2013 where majority of these vehicles operate in Cebu alone. (Borromeo, 2014)

The average width of a car is 2 meters. In Cebu, the average number of lanes are 3 and in some areas 2. So in one direction, there is an average road width of 4 to 6 meters and around 8-12 meters if we cover both lanes of a route. In a city, there are a vast amount of routes leading to different places. Unbeknownst to the people, there are actually more than one route that could get them to their desired destinations. Often times, people would opt to use routes that they are familiar with or routes that are widely used because it's the only one they know of. Some people though, despite being knowledgeable of other routes, would choose to ignore these facts and would travel using a common route known to all because of fear of getting lost or experiencing discomfort. Because of this, congestion happens in one area, and a sparse number of people gathered in other areas especially those that are ignored or unknown to the public.

According to Schmitt and et al, unfamiliar travel is associated with more negative experiences including increased anxiety and trouble with way finding, transferring and ticketing. (Schmitt, Currie, & Delbosc, 2013) Impressions of unfamiliar travel (or 'first trips') were also found to influence overall attitudes about services particularly for non-captive users (those with the option to drive). (Forgas, 2011)

Despite how unfamiliar travel would become uncomfortable, long waiting time could also deem to be another factor that would cause negative experiences, or anxiety. When the sources of problems for commuting experience are collated, the researchers have observed that it has been greatly affected by traffic congestion. Traffic congestion increasingly leads to significant delays. (Yoon, Noble, & Liu, 2007) Considering these factors, this study aims to create a technology that assists its users in having an efficient and comfortable commuting experience.

In solving the problems presented, there is a need to eliminate traffic congestion by revising the traffic system or even reinventing the whole commuting process of passengers and drivers. It would really be a very costly job for sure. Hence, it is a must to find an alternative solution to this.

In formulating the alternative solution, the researchers have cut down the ideas piece by piece and checked all the factors affecting such. The researchers have observed the possibility of solving such problem through the people participating in the commuting process, the commuters. The traffic may not only be the one congested, maybe it’s the commuters too. There is a need for proper and even distribution of commuters throughout the different routes towards a single destination. Thus this research aims to solve this problem.

1.2 Statement of the Problem

1.2.1 General Objective

To develop a cloud-based navigational system using frame differentiation and traffic density detection.

1.2.2 Specific Objectives

By the end of the study, this research will:

1. Identify destination points and routes.

2. Gather and simulate various traffic and routing data.
3. Develop a route determination algorithm using shortest-path methods.
4. Develop a mobile application system.
5. Test and evaluate the algorithm.

1.3 Significance of the Study

This study will create an application that would ease the navigation experience of its users and provide them with information regarding the different traffic situations of the different routes that they may possibly use from their current location to their desired destination. The system will also provide alternative routes and would recommend the best route to be used with great consideration to the traffic situation and the estimated time of travel.

This study is beneficial to:

The researchers, as they will be able to apply their knowledge and skills in the computer science field.

The students, as the study would inspire them to create solutions for traffic congestion using common tools such as smartphones.

The school, as the study would provide a credibility on the quality education it has provided.

The commuters and drivers, as they will be made more aware and vigilant of the traffic situations in real-time. They would also be guided on more efficient routes towards their destinations.

The various government sectors involved in roads and highways, as they will have an easier time in monitoring the traffic and road situations of the city.

1.4 Scope and Limitation

This study will produce a system that would provide its users with various alternative routes ranked according to their time efficiency. It will also inform its users of the various traffic conditions of the different routes. The best route with consideration to time and traffic will be highly recommended to the user.

There will be three layers comprising the system. The channels, the server and the user.

The user and channel will be rendered through an Android mobile operating system based on Lollipop (Android 5.0) and shall benefit from Global Positioning System (GPS) from Android's Location based Services (LBS) in order to gather their various locations. The server on the other hand will be rendered through a Microsoft operating system based on Windows.

The channels will gather the data needed for the traffic monitoring system and will then send it to the server. Each channel will be programmed to be able to capture photos simultaneously and at a certain time interval therefore each channel's camera should have a minimum of 5 megapixels. Possible smartphones to be used as channels during the simulation process are Samsung, LG, Xiaomi or myphone. The channels will be positioned in the middle of two lanes and the images it captures will therefore span both lanes of the road. Although two lanes will be covered, only one lane will be processed.

The server otherwise known as the cloud, after receiving the data from the channels, will process each data in the form of images to determine the travel time needed to cover each channel. Furthermore, the server will also determine the traffic density of each channel from the said data. Each and every data that the server receives and processes will be stored into the database, to keep a record of each and every traffic situation which may be used for future references.

The user, will be allowed to request data about the different routes that they may use towards their desired destinations. The system will request from the user data input on their current location and their desired destination. If in any case the user is unable to enter their current location due to it being an unknown area to them, they may use GPS to determine it. The user application will involve API integrations form Google Maps, in order to display a visual route to its users.

The study's limited only to the preparation, creation and evaluation of the system. In developing the system, the researchers will only be simulating the different routes usually take from Fuente Osmeña to Ayala. The simulation will compose of a miniature model of the current traffic situation. The system will therefore assume that all other routes where a channel is not placed will be free flowing or free of traffic congestion. Actual implementation of the system would depend entirely on external forces such as the government or various organizations interested in it.

Although the researchers will only a few selected routes from Fuente Osmeña to Ayala, the system will be fully capable of covering the entire city or province, as long as channels are placed around it.

Since the tool used would only be a mobile phone and the simulated environment is controlled, it is deemed to be necessary that each and every channel will be placed in a well-lit location.

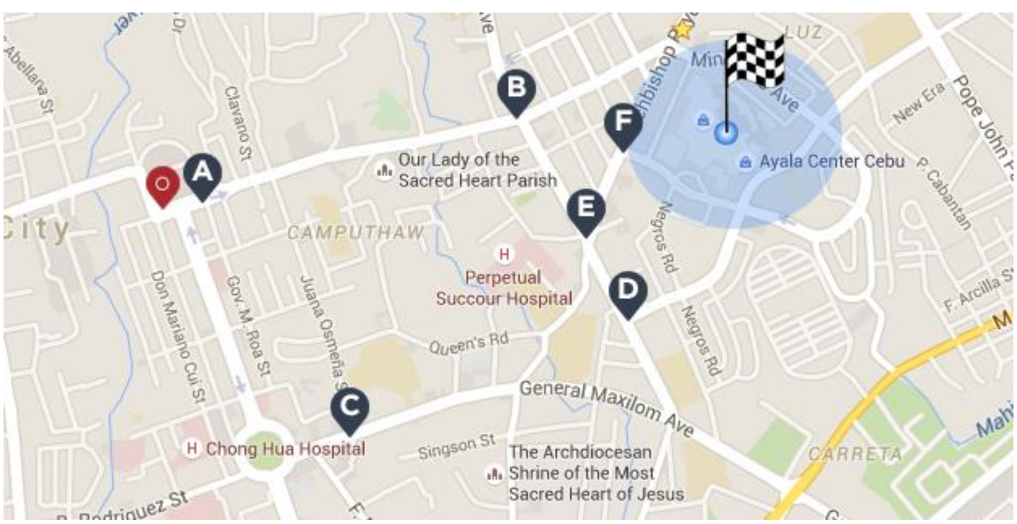

Figure 1.1 Channel Key Points plotted on map

Table 1.1 Channel Key Location Points

CHANNEL	LOCATION
A	Cebu Capitol facing Jones Avenue
B	Escario near Golden Peak Hotel facing Capitol
C	Mango Jollibee facing Fuente
D	Gorordo, facing CIC
E	Near Perpetual Soccour Hospital facing Golden Peak
F	Near Tune Hotel facing Golden Peak

CHAPTER 2

REVIEW OF RELATED LITERATURE

Advanced Traffic information Systems

Advanced Traffic Information Systems (ATIS) is an area of Intelligent Transportation System (ITS) applications. Recent advances in electronics and micro-computing have led to the feasibility of functionally powerful, computer-based advanced traffic information systems as part of the automotive environment. Although these systems range in functionality, they all have the goal of acquiring, analyzing, communicating, and presenting information to assist commuters in moving from a starting location to a desired destination. The systems improve travel safety, efficiency, and comfort and represent a new frontier in ground transportation (Xu, 2006).

Two types of ATISs:

- Centralized Traffic Information Systems – involves a central authority that collects data from the street network, processes them in traffic management centers and disseminates traffic analysis result to drivers (Xu, 2006). The data is disseminated via radio broadcasts, internet, variable message signs and direct to user on demand (Chhotu, 2013). This approach aims to limit communication overhead by providing vehicles with real-time values instead of predictions for the link travel times. This ATIS is based on real-time information. Real-time information is gathered from all roads in the network (Claes & Holvoet, 2012).

- Decentralized Traffic Information Systems – is a concept of a zero public infrastructure vehicle based traffic information system (Chhotu, 2013). This ATIS uses link travel time prediction systems that rely on information sent by the vehicles indicating their intentions and plans. The link travel time predictions are generated using delegate multi-agent systems and an online embedded simulations.

> The generated link travel time predictions can lead to faster throughput times and shorter travel times for the vehicles participating in the system (Claes & Holvoet, 2012).

Location Based Services

Location-based services (LBS) is emerging as a killer application in mobile data services with the rapid development of wireless communication and location positioning technologies (Kushwaha & Kushwaha, 2011).The term itself is a recent concept that denotes applications integrating geographic location (i.e. spatial coordinates) with the general notion of services. Examples include emergency services, car navigation systems, tourist tour planning or “yellow maps” (combination of yellow pages and maps) information delivery (Schiller & Voisard, 2004). According to Ian Koeppel, there are five definitions in LBS, two of them are the Pull & Push Definition. The Pull definition is defined as services that utilize the geographic position of a wireless device to derive information related to that location enable users to "pull" information to them wherever and whenever it is needed. This includes Travel Directions, Taxi Hailing, Mobile Yellow Pages, Buying Services and Instant Information. The Push definition refers to location services that utilize the position of the wireless device to qualify the holder as a potential customer or recipient of a service. Applications and services include target marketing with advertisements for wireless devices, friend finders, traffic alerts, and zone alerts. This includes Mobile Advertisements, Friend Finders, Zone Alerts and Traffic Alerts (Koeppel, 2000).

Meanwhile, mobile phones with LBS, make them fundamentally different and advantageous from computers is their inherent mobility. They provide anytime, anywhere, instant access to applications. They travel with you, they do not let you wait to boot and dial an Internet Service Provider (ISP) (Jagoe, 2003).

Smartphone as Medium

The spread of mobile communication, most obtrusively as cell phones but increasingly in other wireless devices, is affecting people's lives and relationships. Cell phones speed the pace and efficiency of life, but also allow more flexibility at business and professional levels as well as in family and personal life. (Katz & Aakhus, 2002)

An important factor in the decision to adopt mobile systems is user perception of their value. However, behavioral theory suggests that context affects user attitude and therefore influences acceptance. (Mallat, Rossi, & Tuunainen, 2009) As a result of the mobile phone's extensive impact, rich stores of everyday discourses have accreted about the meaning of the mobile telephone for individuals and society. (Katz & Aakhus, 2002)

Traffic Detection using Image Processing

Most of the city traffic is controlled by sensors and cameras shall be installed in big highways and streets. But existence of a system for detecting the size of traffic automatically will be felt. Such systems can allows to extract information from the bigger traffic issue and helps us decide to improve the traffic policy. (Niksaz, Autommatic Traffic Estimation Using Image Processing, 2012)

CHAPTER 3
TECHNICAL BACKGROUND

Location Based Services

Geographical positioning and wireless communication technologies enable centralized, continuous position tracking of moving vehicles. A number of applications in the areas of logistics, transit services, cargo delivery, and collective transport involve the management of fleets of vehicles that are expected to travel along known routes according to fixed schedules. (Tiesyte & Jensen, 2008)

Geographic information systems (GIS) play a crucial role in the success of location-based services (LBS). GIS is defined as a "set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes". A location based service is the ability for an information system to denote the position of a user, based on a device they are carrying or their position in a given context. LBSs have the ability to provide specific, relevant information according to a given "spatial location associated with a physical point or region relative to the surface of the earth (Dawson et al., 2006, p. xv). (Michael & Michael, 2009).

Traffic

Traffic congestion increasingly leads to significant delays. (Yoon, Noble, & Liu, 2007). Rising traffic demand continues to fuel development of advanced traffic information systems that improve the performance of the traffic networks. Performance of these networks can be improved by making better use of the network capacity and avoiding congestions (Claes & Holvoet, 2012).

The most important task of a traffic surveillance system is determining reliability whether the facility is free flowing or congested. The second most important task is responding rapidly when the facility becomes congested. Other tasks, such as quantifying the magnitude of congestion, are desirable, but tertiary (Coifman, 2012).

Shortest Path

Shortest path algorithms are commonly used to calculate the shortest, fastest, and the most optimal path from an origin point to a destination point. A shortest path problem is to find a path with minimum travel cost from one or more origins to one or more destinations through a network (Panahi & Delavar, 2008).

Shortest path helps calculate the most optimal route, and optimal routing is the process of defining the best route to get from one location to another. The best route could be the shortest or fastest depending on how it is defined (Naqi, Akhter, & Ali, 2010). When applied to a routing problem in a transportation network it can calculate the path with minimal travel cost or least impedance from an origin to a destination. Depending on the type of cost, the shortest path can be referred to as the shortest, fastest, or most optimal path or route (Winn, 2014).

The shortest path can be computed either for a given start time or to find the start time and the path that leads to least travel time journeys. The classic shortest path problem and finding the best route for vehicle routing in static road networks based on Dijkstra’s algorithm has been examined extensively over the years (Alivand, Hauser, Minor, & Walsh, 2011). According to George et al., developing efficient algorithms for computing shortest paths in a time-varying spatial network can be challenging (George, Sangho, & Shekhar, 2007).

Cloud Computing

A new wave of user demands for rich mobile service has been fuelled with regards to recent advances in mobile communication technologies. Mobile users seek ubiquitous access to a wealth of media-based contents and services wherever they go (Chen, Wu, & Vasilakos, 2014). The mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., mobility and security) (Satyanarayanan, 1996). The limited resources significantly impede the improvement of service qualities (Dinh, Lee, Niyato, & Wang, 2011). Because mobile devices are resource limited inherently, it is essential for the cloud to provide computational support for many media-rich applications (Chen, Wu, & Vasilakos, 2014). Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services (Armbrust, et al., 2010). Mobile cloud computing at its simplest, refers to an infrastructure where both the data storage and data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud (Dinh, Lee, Niyato, & Wang, 2011).

Image Processing

Image processing is an intrinsic and essential component of tomographic and non-tomographic medical imaging. The increasing availability of digital images offers the opportunity to explore a wide variety of image processing techniques. Such techniques can be as simple as reassigning grey level values in an image to facilitate identification of interesting features or as complex as combining multiple images to perform tissue segmentation and identify areas of pathology. While relatively a few image processing techniques have been validated in sufficient detail to be considered for routine clinical use, a large number of excellent processing tools are available for use on personal computers. (Russ, 1995)

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually **Image Processing** system includes treating images as two dimensional signals while applying already set signal processing methods to them.

The two types of methods used for Image Processing are Analog and Digital Image Processing. Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So analysts apply a combination of personal knowledge and collateral data to image processing.

Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction.

The purpose of image processing is divided into 5 groups. They are:

1. Visualization - Observe the objects that are not visible.
2. Image sharpening and restoration - To create a better image.
3. Image retrieval - Seek for the image of interest.
4. Measurement of pattern – Measures various objects in an image.
5. Image Recognition – Distinguish the objects in an image.

(Introduction to Image Processing, 2012)

CHAPTER 4
DESIGN AND METHODOLOGY

4.1 Concept

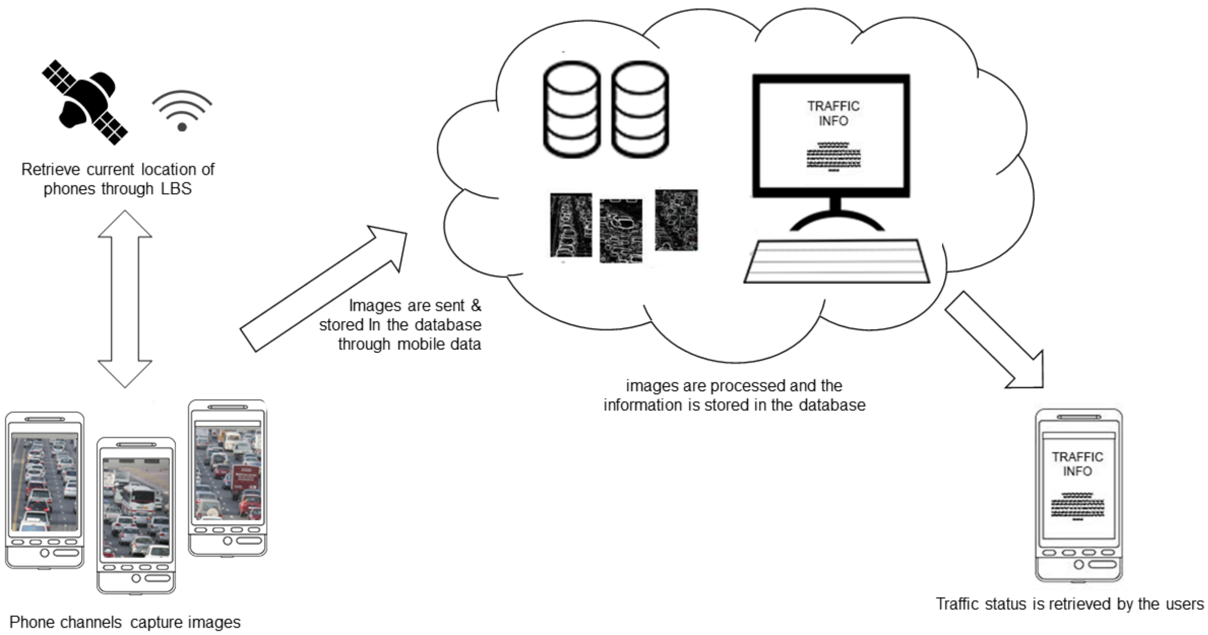

Figure 4.1 Conceptual Framework

The system is made in a small scale using simulation tools like road traffic miniature and the use of toy cars. The materials mentioned will be used to simulate real-life traffic situations. The system is composed of 3 layers, the channel, the server and the user layer.

Channel. The phones used to capture image of the current road situation are called channels. These channels are to be mounted at the on top and at the center of the road, which will give a top view of the road. These channels capture images at a certain time interval and retrieves the location point of the channel through GPS or wireless access points. The location point together with the timestamp of the image captured are embedded to the image file to lessen the number of files stored temporarily in the phone. With the use of mobile data, the image file is then uploaded to the server for further processing.

Server. The heart of the whole system is in the server. The server retrieves, process and deploy the data being received and requested by the channel and the user. As soon as the images are retrieved from the different channels, the raw data extracted from the image properties of the image file together with the path of the file in the storage space are then stored in the database. The raw data together with the image files (with the same timestamp, meaning one image is unique from one channel) are then queued for batch processing. The raw data queued undergo a series of procedure which will output the estimated time of arrival (ETA) and traffic condition of the images. The batch output then undergoes to a ranking system which will analyze and decide the overall traffic condition and ETA of the route. The information analyzed and gathered are then stored to the database.

The server also has the functionality to display the entire traffic log of the system. It will be able to display every information logged into the system such as the images and its corresponding interpretation. This can be used for backtracking traffic data and traffic history.

User. The user layer is the application to be deployed and distributed to the target users. It is the window to what has been done and processed from the channel and the server layer. The user layer displays the overall current traffic data from ranked data from the server. It will also display the current traffic data from the different channels of the route.

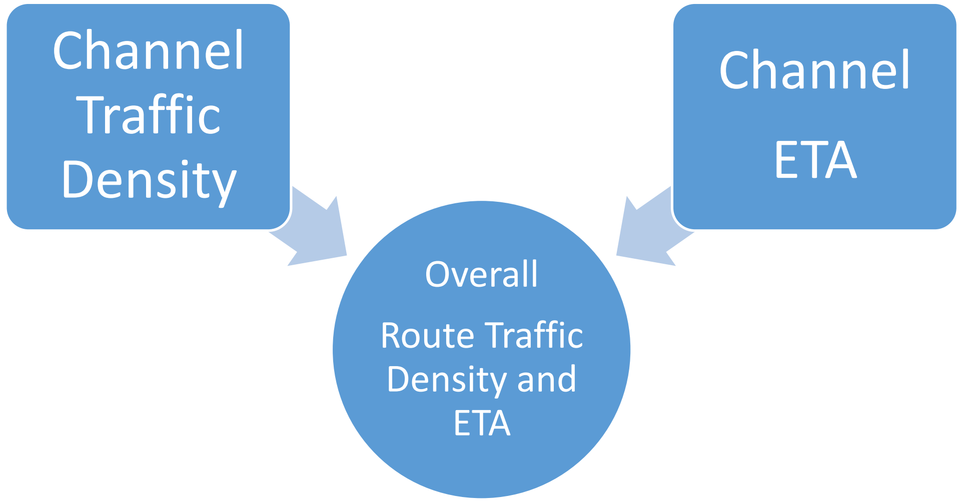

Figure 4.2 Overall Concept

Overall, the system outsources its raw data through the channels and the data outsourced are then processed by the server to which its output information is sent and retrieved by the users.

4.2 Analysis and Design

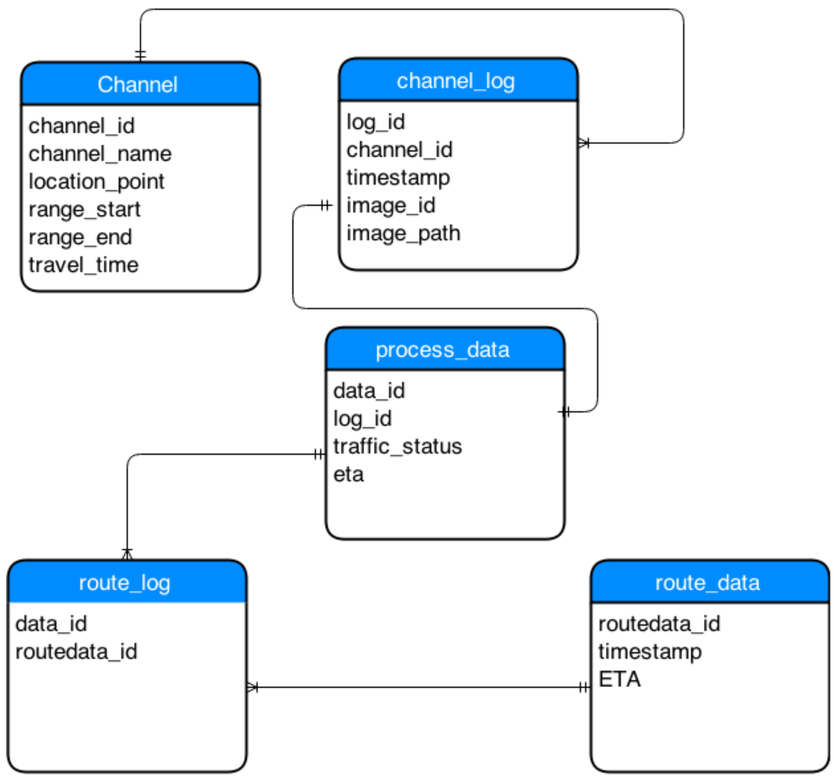

Figure 4.3 Entity Relationship Diagram

The figure shown above is the entity relationship diagram which will be the basis on what will be the contents that will be stored in the database.

4.3 Development Model

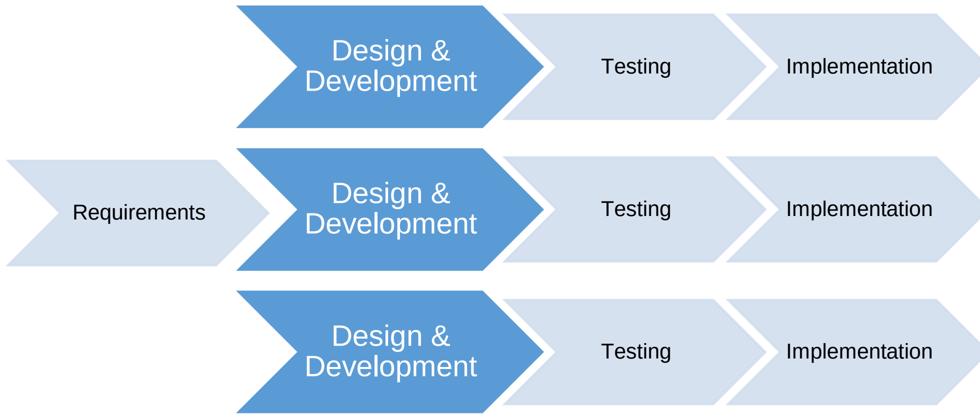

Figure 4.4 Incremental Development Model

The proponents of the study adapt the Incremental Development Model shown in Figure 4.4. In accordance to the practice of this model, the researchers agreed to develop the research module by module. The development of the study shall start with the complete conceptualization and definition of the whole system and document it before it could be broken down module by module and build the system incrementally. The conceptualization and definition shall yield to the specification of the requirements of the system of the research which shall progress to the breaking down and disintegration of the functionalities and features of the system module by module. Moreover, after the breaking down of the functionalities, it shall proceed to the designing and development of the module which will eventually be followed by testing and evaluation. Implementation & integration of the module to the whole system is then followed which would finally finish and accomplish the goals of the research and the research itself. The incremental model benefits the researchers since it is more flexible and less costly to change scope and requirements. It would also lessen the risk of damaging the whole system since the risky modules are identified and handled during iteration. Efficient testing and debugging is also expected due to the modular approach in building the system.

Table 4.1 Traffic Miniature Creation Increment

Increment 1: Traffic Miniature Creation
Building and Designing

Table 4.2 User Interface Module Increment

Increment 2: User Interface Development
Channel Application User Interface (Mobile)
Server Application User Interface
User Channel Application User Interface (Mobile)

Table 4.3 Channel Application Development Increment

Increment 3: Channel Application Development
Location Retrieval
Contiguous Image Capturing
Data Embedding to Image File
Image Upload Tool

Table 4.4 Serve Application Development Increment

Increment 4: Server Application Development	
File retrieval	
Data Extraction	
Image Processing	1. ETA 2. Traffic Density Detection

Table 4.5 User Application Development Increment

Increment 5: User Application Development
Information Retrieval
Data Display in Map View

4.4 Development Approaches

The researchers of the study will follow the Bottom-up development approach to prove the feasibility through the fulfillment of the research. In this approach, both researchers shall be proactive in the creation and planning stage of the research. The planning process, which includes the scheduling, budgeting and proposing solutions are facilitated by both researchers. The decision on a course of action such as issues arising is to be decided by the researchers. The researchers shall motivate and empower each one through their active participation and being hands-on with the project development. Each researcher has an equal opportunity to discuss and come up with project solutions that are focused more on practical requirements than on abstract and illogical concepts. The researchers shall communicate constantly in meeting the goals and objectives of the research. The choice of methods in fulfilling the research are up to them and each decision shall be made according to their assessments. With such, each of them shall have proper guidance throughout the course of the research.

4.5 Software Development Tools

Table 4.6 Software Development Tools

Tool	Platform	Version	Developer	Use	Source
Trello	Android / Web	3.1.0	Oracle	Project Management Tool	https://trello.com/
Android Software Development Kit	Windows	24.0.2	Google	For application deployment for apps written for Android	http://developer.android.com/sdk
Android Studio IDE	Windows	1.0	Google	For development & testing app for Android platform	http://developer.android.com/sdk

Java Development Kit	Windows	8	Oracle	For application deployment for apps written in Java	http://www.oracle.com/technetwork/java/javase
NetBeans	Windows	8.0	Google	For development & testing app written in Java	https://netbeans.org/
Adobe Photoshop	Windows	CC (14.0)	Adobe	For image manipulation and creation of UI components	http://www.photoshop.com/products/photoshop
OpenCV	Windows	3.0	Itseez	Library of programming functions for real-time computer vision,	http://opencv.org/

The data shown in Table 1.1 indicates the different tools with their latest version as of writing and their respective uses in the development process. The following list of software are mostly open source except for Adobe Photoshop which is legally acquired by the researchers. Most of the software mentioned are in Windows since the researchers will develop the system using Windows.

4.6 Project Management

Schedule and Timeline

The scheduling and the creation of the timeline is divided into four different increments as the study follows the incremental development model. The system is broken down into the different modules as defined in the development model.

Table 4.7 Traffic Miniature Creation

Increment 1: Traffic Miniature Creation	
Building and Designing	25 hours

Table 4.8 User Interface Module Increment

Increment 2: User Interface Development	
Research & Learn Phase	20 hours
Channel Application User Interface (Mobile)	30 hours
Server Application User Interface	30 hours
User Application User Interface (Mobile)	30 hours
Total	110 hours

Table 4.8 contains the tasks under the first increment which is the user interface module increment. It comprises the building blocks in the completion of the user interface of the 3 layers of the system.

Table 4.9 Channel Application Development Increment

Increment 3: Channel Application Development	
Research & Learn Phase	20 hours
Location Retrieval	30 hours
Contiguous Image Capturing	30 hours
Data Embedding to Image File	30 hours
Image Upload Tool	30 hours
Testing & Validation	10 hours
Total	150 hours

Table 4.10 Serve Application Development Increment

Increment 4: Server Application Development		
Research & Learn Phase		60 hours
File retrieval		60 hours
Data Extraction		60 hours
Image Processing	1. ETA	200 hours
	2. Traffic Density Detection	200 hours

Testing & Validation		20 hours
	Total	680 hours

Table 4.11 User Application Development Increment

Increment 5: User Application Development		
Research & Learn Phase		20 hours
Information Retrieval		50 hours
Data Display in Map View		60 hours
Testing & Validation		10 hours
	Total	140 hours

Table 4.12 Testing & Validation Increment

Increment 6: Testing & Validation	
Testing & Validation	30 hours

Table 4.13 Summary of Increments

Summary of Increments		
Increment 1: Traffic Miniature Creation		25 hours
Increment 1: User Interface Development		110 hours
Increment 2: Channel Application Development		140 hours
Increment 3: Server Application Development		580 hours
Increment 4: User Application Development		130 hours
Increment 6: Testing		30 hours
	Grand Total	1,015 hours

Responsibilities

Table 4.14 Assignment of Responsibilities

	Proponent 1	Proponent 2
Assembly of the road simulation tool	✓	✓
Mobile App User Interface Development		✓
Desktop App User Interface Development	✓	
Image Processing Development	✓	✓
Client-Server Communications Development	✓	✓
Testing and Evaluation	✓	✓

Documentation	✓	✓
Budgeting of expenses		✓
Traffic image collection	✓	
Decision making and assessments	✓	✓

The table above shows the responsibilities of the researches during the development of the study. The Bottom-up development approach is greatly considered in the process of distributing the responsibilities. The approach is significantly seen in the involvement of the researchers in every task that needs to be well decided and which is a major part of the study.

Budget and Cost Management

Table 4.15 Budget and Cost Estimates

	Price	Quantity	Total
Road simulation miniature	1,500.00	1	1,500.00
Android Mobile Phones	2,500.00	6	15,000.00
Printing Costs	500.00	N/A	500.00
	Grand Total		17,000.00

The data shown in Table 4.15 are the estimated costs of the materials needed in the fulfillment of the research. The researchers shall provide the amount needed by equally dividing the total amount needed to each of them.

4.7 Verification, Validation and Testing

The system must undergo a series of simulation. Since the approach in the creation of the system is incremental, the modules must undergo verification and validations before it is to be incremented in the system. Each module is required to be tested under different conditions and scenarios it might encounter after its deployment. Before the system deployment, it must also be tested under different traffic conditions.

BIBLIOGRAPHY

Alivand, M., Hauser, E., Minor, L., & Walsh, S. (2011). An optimal transportation routing approach using GIS-based dynamic traffic flows. 172-178. Retrieved February 24, 2015

Armbrust, M., Fox, A., Griffith, R., Joseph, A., Katz, R., Konwinski, A., . . . Zaharia, M. (2010). A View of Cloud Computing. 9.

Chen, M., Wu, Y., & Vasilakos, A. (2014). Advances in Mobile Cloud Computing. 2.

Chhotu, A. K. (2013, February 21). *Traffic Information System.* Retrieved February 20, 2015, from slideshare: http://www.slideshare.net/pranavmishra22/traffic-information-system

Claes, R., & Holvoet, T. (2012). Weighing communication overhead against travel time reduction in advanced traffic information systems. 1-2. Retrieved January 29, 2015

Coifman, B. (2012). Weighing Communication overhead against travel time reduction in advanced traffic information systems. Retrieved December 29, 2014

Dinh, H., Lee, C., Niyato, D., & Wang, P. (2011). A survey of mobile cloud computing: architecture,. 25.

Forgas, J. (2011). Can negative affect eliminate the power of first impressions? Retrieved February 8, 2015

George, B., Sangho, K., & Shekhar, S. (2007). Spatio-temporal network databases and routing algorithms: a summary of results. 460-477. Retrieved February 22, 2015

Jagoe, A. (2003). *Mobile Location Services: The Definitive Guide, Volume 1.* New Jersey: Pearson Education Inc.

Koeppel, I. (2000). What are location services?–from a GIS perspective. 7.

Kushwaha, A., & Kushwaha, V. (2011). Location Based Services using Android Mobile. 7.

Michael, K., & Michael, M. (2009). Geographic Information Systems & Location-Based Services. In K. Michael, & M. Michael, *Innovative Automatic Identification and Location-Based Services: From Bar Codes to Chip Implants* (p. 38). Australia: IGI Global.

Naqi, A., Akhter, N., & Ali, N. (2010). Developing components of web GIS for shortest path analysis "Find Shortest Route". *Sindh University Research Journal*, 23-30. Retrieved February 25, 2015

Panahi, S., & Delavar, M. (2008). A GIS-based dynamic shortest path determination in emergency vehicles. *World Applied Sciences Journal*, 88-94. Retrieved February 22, 2015

Russ, J. C. (1995). The Image Processing Handbook. *Journal of Computer Assisted Tomography*. Retrieved March 14, 2015

Satyanarayanan, M. (1996). Fundamental challenges in. *Proceedings of the 5th annual*, 7.

Schiller, J., & Voisard, A. (2004). *Location-Based Services.* San Francisco: Elsevier.

Schmitt, L., Currie, G., & Delbosc, A. (2013). Measuring the impact of unfamiliar transit travel using a university. Retrieved February 8, 2015

Tiesyte, D., & Jensen, C. S. (2008). Similarity-Based Prediction of Travel Times for Vehicles Travaelling on Known Routes. Retrieved February 15, 2015

Winn, M. T. (2014). A Road Network Shortest Path Analysis: Appluing Time-Varying Travel-Time Costs for Emergency Response Vehicle Routing, Davis County, Utag. 1-14. Retrieved February 23, 2015

Xu, H. (2006). Decentralized Traffic Information System Design Based on Inter-Vehicle Communication. 11-13. Retrieved February 22, 2015

Yoon, J., Noble, B., & Liu, M. (2007). Surface Street Traffic Estimation. 220-232. Retrieved February 20, 2013

APPENDIX A SOFTWARE REQUIREMENTS SPECIFICATION

Users

Table A.1 User – Application Table

User	Application
Admin	Server
Remote Admin	Channel App
General Users	User App

Each application of the system is defined by a kind of user. The table above shows the users and its equivalent application.

Application Capability

Table A.2 Application Capability Table

App Capability	Server	Channel	User
Capture Images		√	
Send Data		√	
Retrieve Data	√ (Data from Channel)		√ (Data from Server)
Process Data	√		
Display Processed Data			√

The table shown above shows each application's capability or features. The capability is defined by application since the functionalities are varied by the user and the application itself.

Data Access Rights

Table A.3 Data Access Rights

Data Access	Server	Channel	User
Create	√	√	
Retrieve			√
Edit	√	√	

The table shown above shows the data access rights of each application. The proponents defined the access rights by application since each application is represented by each type of user.

User Interface

UI Basics

Figure A.1 Status Bar

The figure shown in Figure A.1 is the status bar that will be present in all the applications. Color of the status bar may vary depending on the screen activity.

Figure A.2 Header Bar

The figure shown in Figure A.2 shows the header bar which is present in the User Application. The Hamburger button represented by three lines is a button used to expand the sidebar menu.

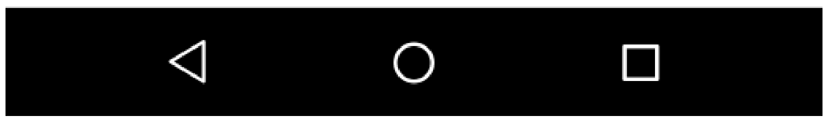

Figure A.3 Navigation Bar

The figure shown in Figure A.3 is the navigation bar which is present depending on the phone being used. Phones with hard keys for navigation will not show this onscreen.

Channel Application User Interface

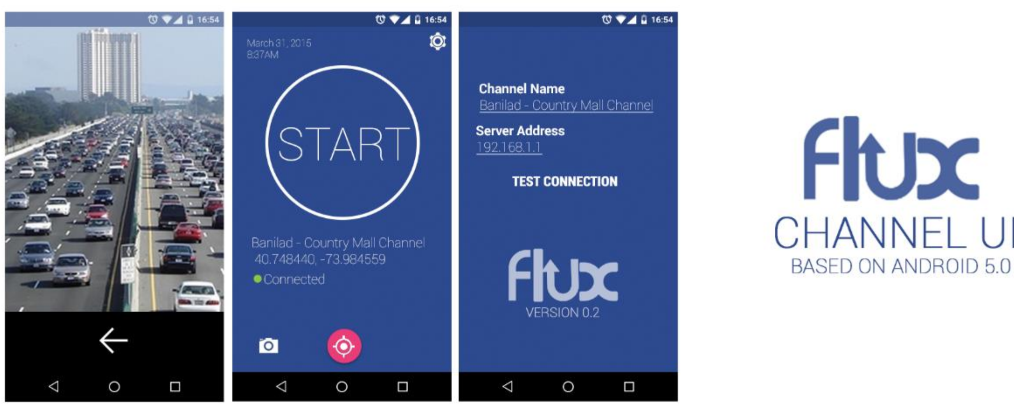

Figure A.4 Overall UI for Channel Application

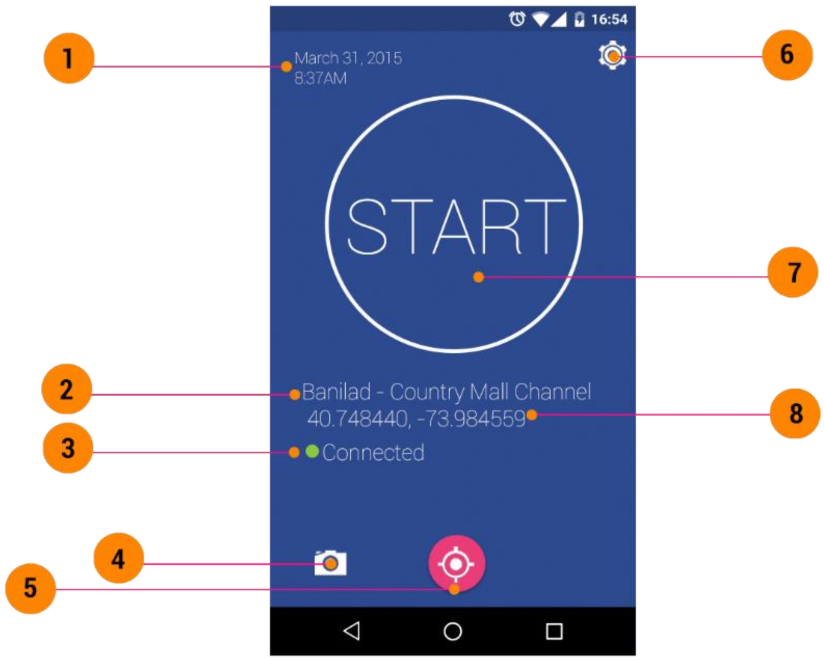

Figure A.5 Channel App Homepage

1 – Time and Date Display

2 – Channel Name

3 – Connection Status

4 – Camera Preview

5 – Calibrate location button

6 – Settings

7 – Start Button

8 – Location Coordinates

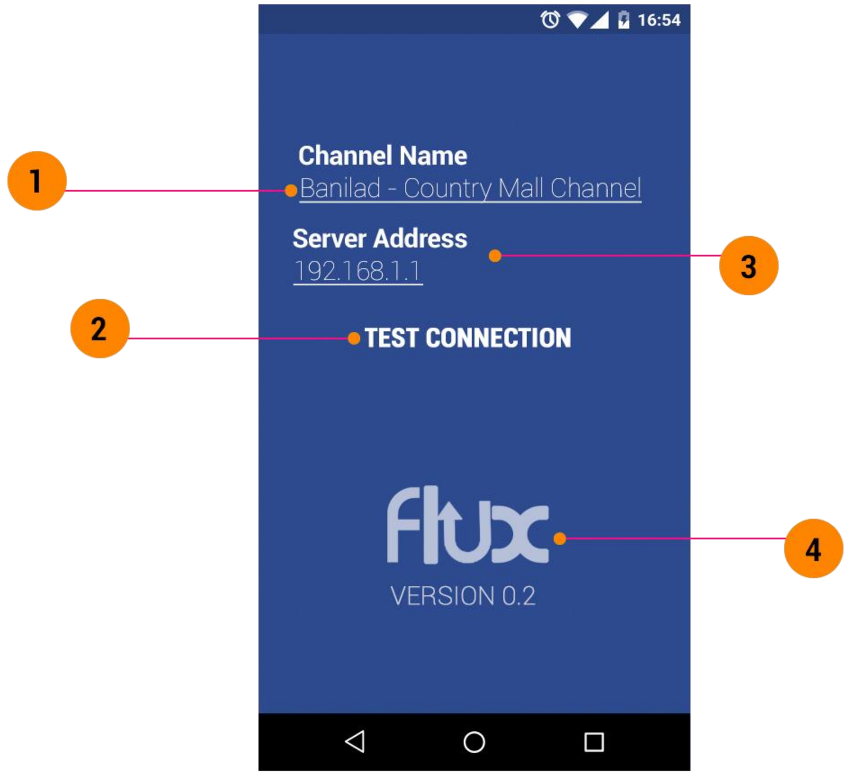

Figure A.6 Channel App Settings

1 – Channel Name

2 – Test Connection Button

3 – Server Address

4 – About

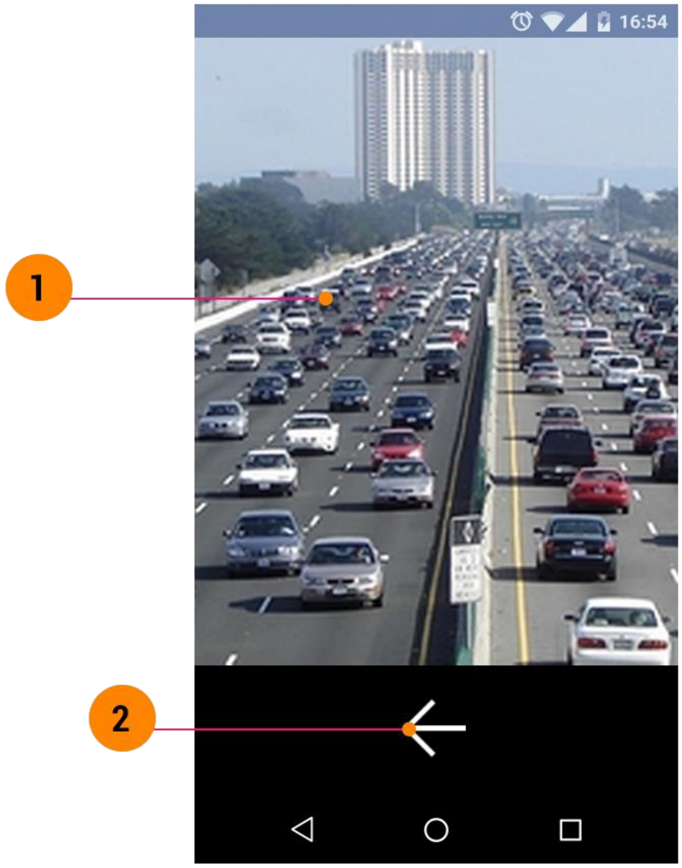

Figure A.7 Channel App Camera Preview

1- Camera Preview
2- Back button

User Application User Interface

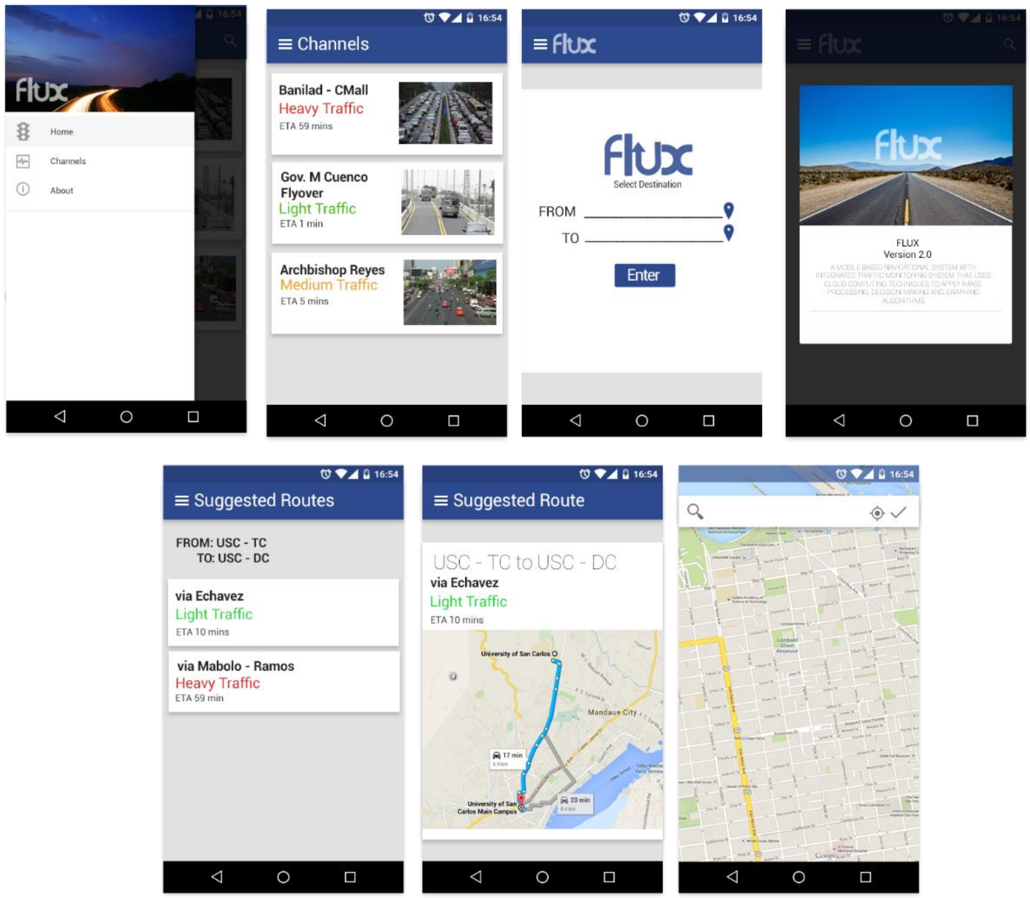

Figure 4.8 User Application Overall UI

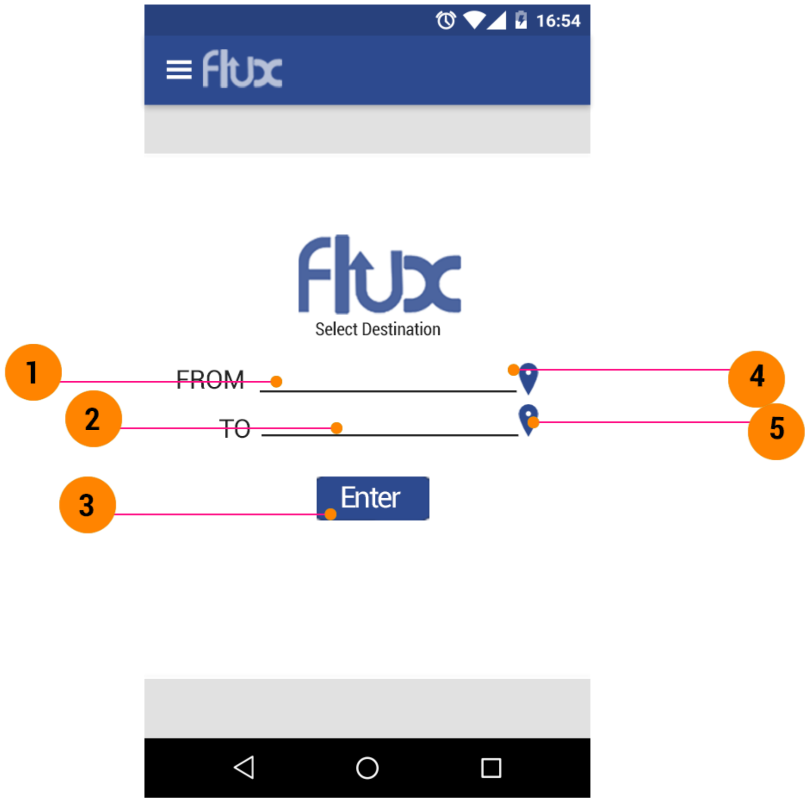

Figure A.9 User Application Homepage

1- Input for place of origin address

2- Input for destination address

3- Open Maps to point location for destination

4- Open Maps to point location for destination

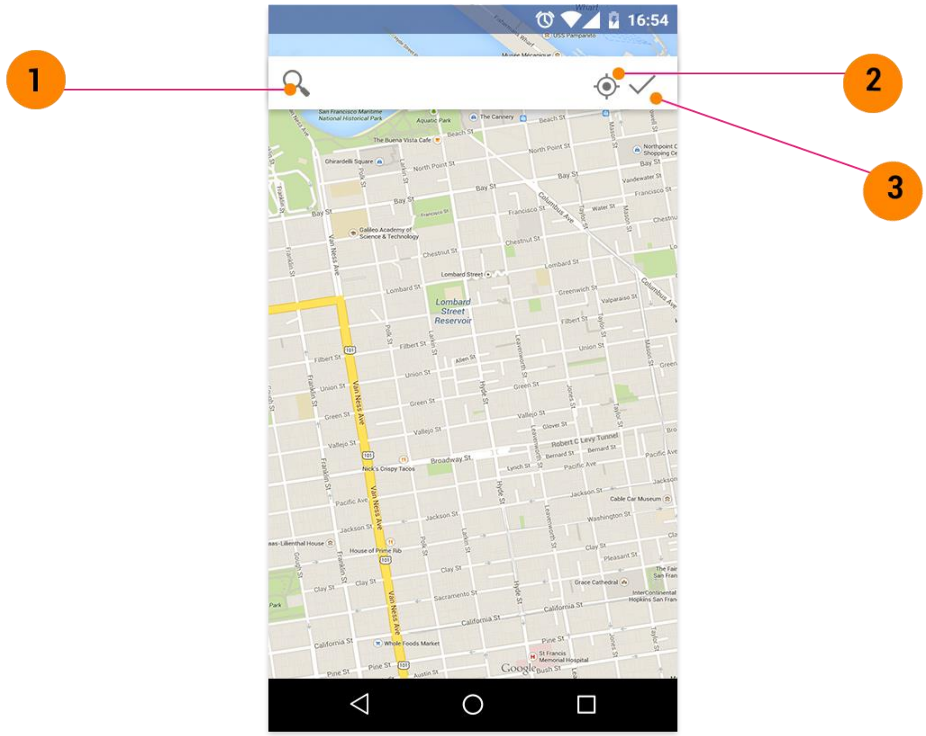

Figure A.10 Maps Screen

1- Search button
2- Detect current location
3- Confirmation button

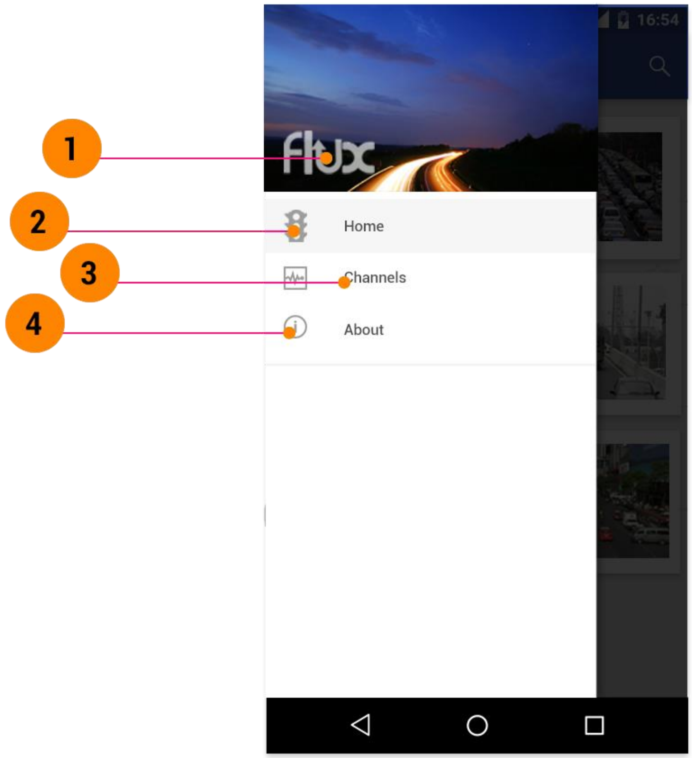

Figure A.11 Sidebar

1- Flux logo
2- Home button
3- Channels button
4- About button

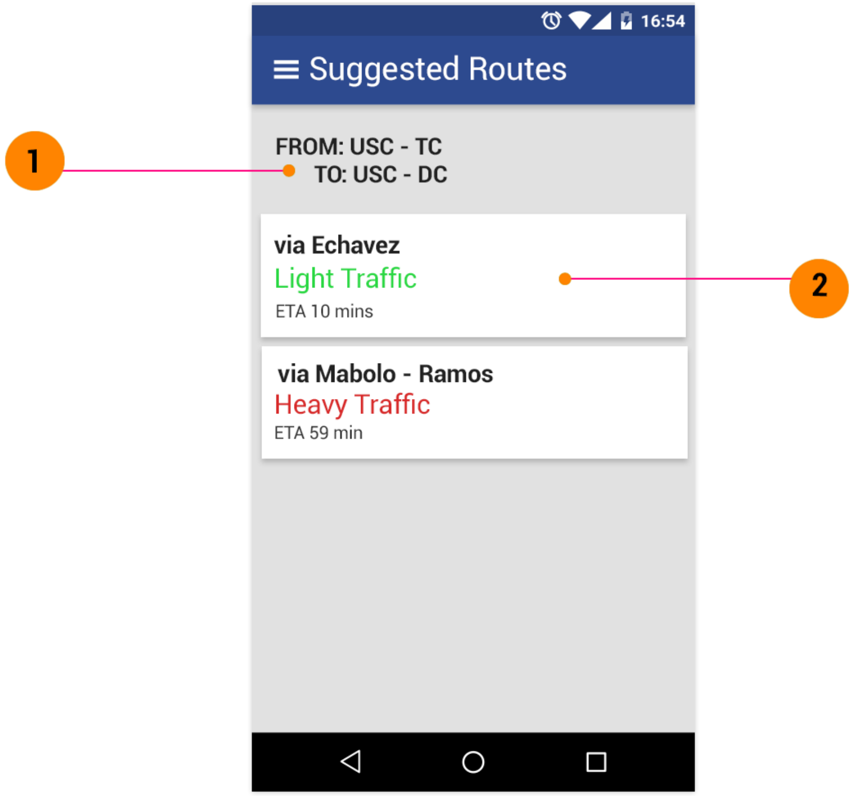

Figure A.12 List of Suggested Routes Screen

1- Route Destination and Place of origin
2- Suggested route cards

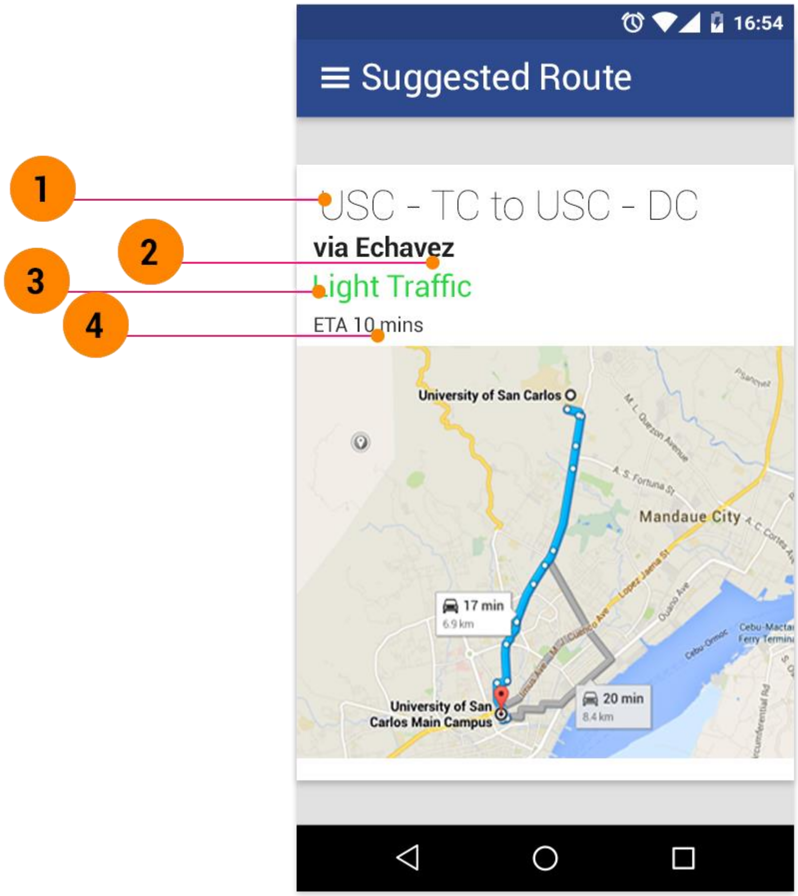

Figure A.13 Suggested Route Screen

1- Route Destination and Place of origin
2- Route Title
3- Traffic Status
4- Estimated Time of Arrival

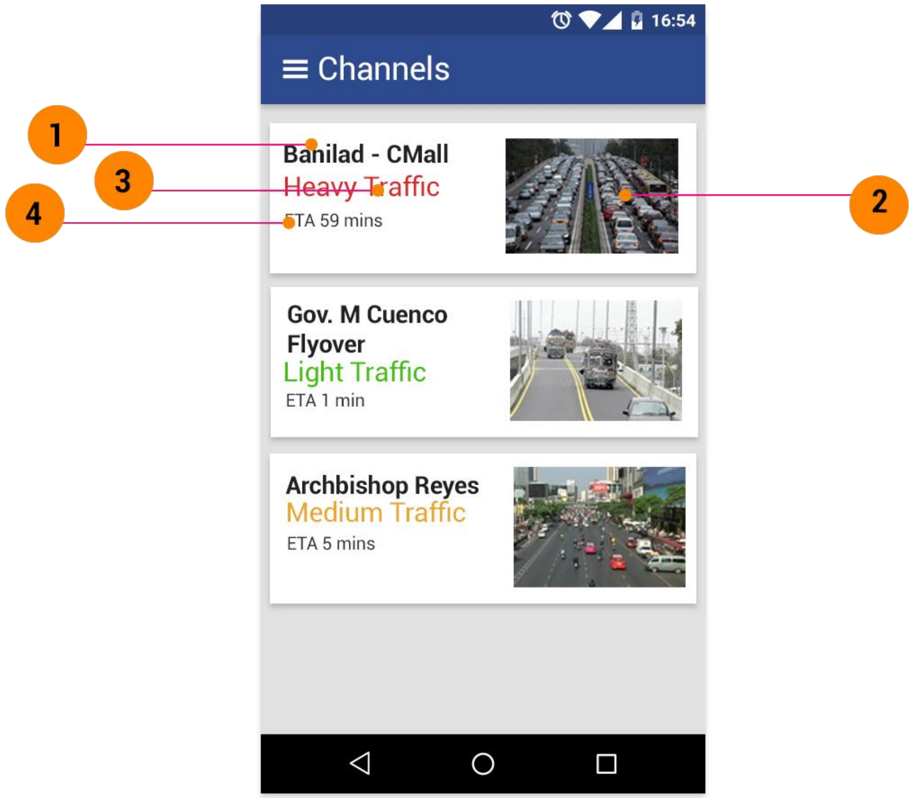

Figure A.14 Channels List Screen

1- Channel Name
2- Channel's Current Image
3- Channel Traffic Status
4- Channel ETA

Figure A.15 About Screen

1- App Name
2- Version Number
3- App details

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