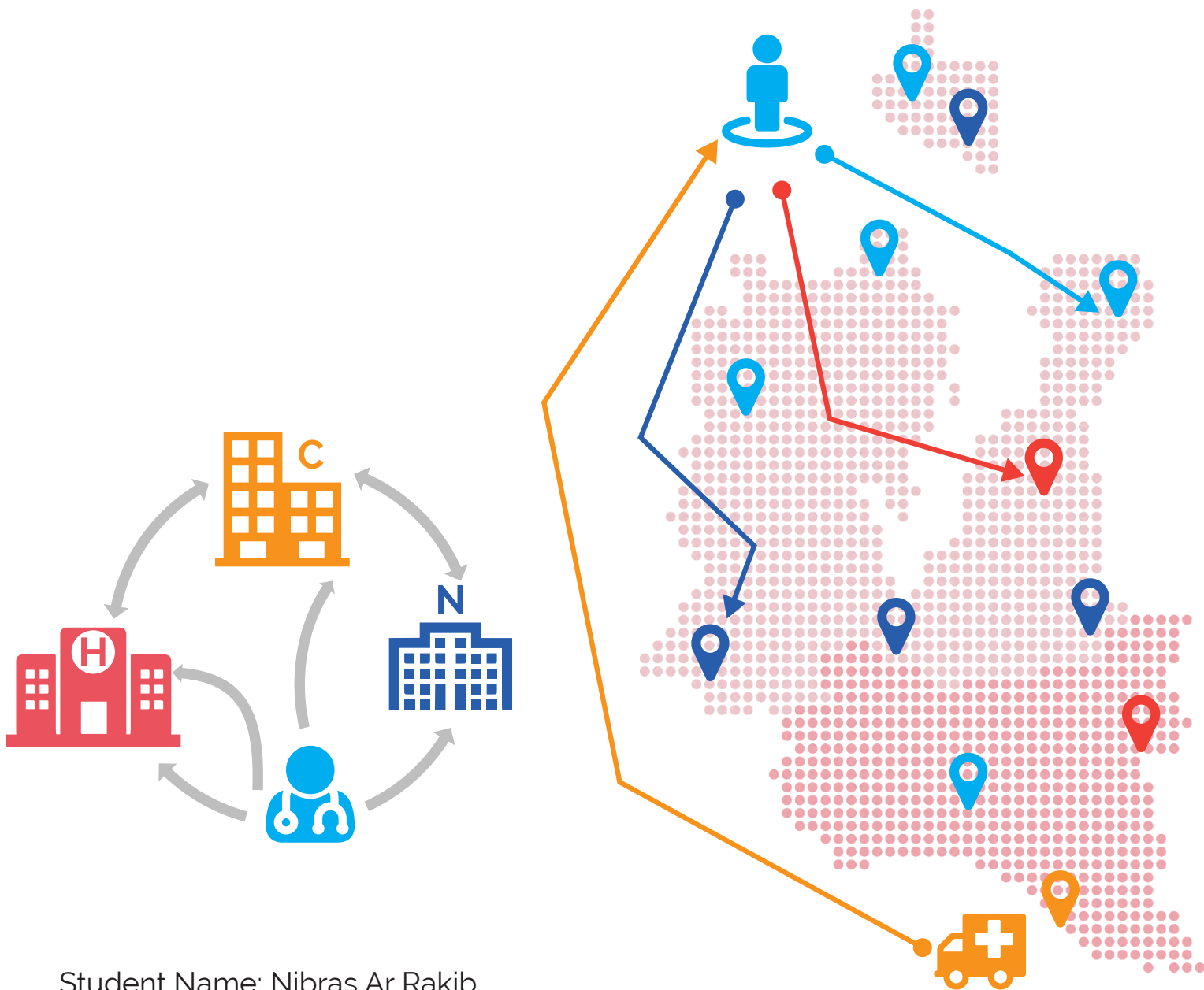


Referral System —

A mobile application that can provide health service manager or patient to choose nearest health facility for required services.



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I n s p i r i n g E x c e l l e n c e

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Abstract

In Bangladesh there is scarcity of proper online referral system that can identify appropriate health facility while a primary or tertiary health facility could not provide the necessary service to the patient. Such tool can be very useful that can provide the service list that are required by the patient and appropriate road direction from patient's location. According to WHO referral guide, a large portion of health seeking clients in many developing countries are seen at the outpatient clinic at secondary facilities which can be looked after at primary health care centers at lower overall cost. The model of this application can determine the proper service of facilities or diagnostic test for given disease which also able to direct the patient which road is closer to his/her location. This referral system is opened to any discussion in the light of practical experience and in order meet the goal of overall health facility system. This system may need to analyze periodically in order to meet the changes of user requirement and apply appropriately.

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Chapter 1

Introduction

1.1 Background

Access to quality health services and associated costs are a threat to Bangladesh's current momentum for universal health coverage (UHC). The existing health system is largely (>60%) dependent on out-of-pocket payments [1]. Among many health system concerns, a serious lack and unequal distribution of qualified health human resources (HHR) [2] is a harsh reality. Furthermore, high population density and rapid urbanization is resulting in new and unfamiliar public health challenges [3]. Given the assumption that a combination of tools can better equip health care providers, enhance the quality of care and reduce existing disparities in health, electronic health (eHealth) and mobile health (mHealth) have rightly gained considerable attention as a potential tool for healthcare delivery. Globally, there is a close correlation between the concentration of qualified health workers (doctors, nurses, dentists and midwives together) and key health outcomes such as immunization coverage, primary health care outreach, and infant, under-5 and maternal survival. This is because "in health systems, workers function as gatekeepers and navigators for the effective, or wasteful application of all other resources such as drugs, vaccines and supplies" [4].

Mobile health, better known as mHealth is an emerging discipline for medical and public health practice. The Global Observatory for eHealth (GOe) of the World Health Organization (WHO) defined mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. mHealth applications include the use of mobile devices in

- Proper referral system
- Medical tele-consultations even from the most remote areas within the telecom network
- collection of clinical data for monitoring of patients' vital signs/test results real-time
- supporting treatment and medication compliance
- collecting community health data
- advising on health issues
- sending health alerts and reminders, and
- communicating between health-care workers

Mobile Health may catalyze the healthcare delivery model from a historical, episodic model into a tangible, patient-centric model. mHealth is being viewed increasingly by many as an important technology metaphor to achieve rich, robust patient engagement; ultimately, achieving a patient-centric paradigm change.

As mHealth expands access, availability and/or delivery like no other technology solution—health outcomes across the entire care continuum can be transformed. mHealth solutions hold the promise to provide new, innovative care access and delivery models that produce better outcomes, with reduced healthcare costs and innovative patient safety practices. To determine why mHealth is such an important Health Informatics topic today, a working mHealth context is necessary. Given the complexity and multiplicity of industry interests, there are as many definitional permutations as there may be organizations. As an emerging field, however, mHealth may be best defined as the access, provision and/or delivery of healthcare interactions—anywhere, anytime—facilitated by mobile and/or wireless technologies.

1.2 Motivation

The lack of proper information about the health service providers in urban areas remains a huge challenge in public health sector. As Dhaka is one of the dense capital in the world, it is important to provide proper information to new comers. Bangladesh is currently facing huge challenges of rapid urbanization [14]. As the migrant is increasing in urban areas, public health is becoming more important. Till now there is lack of proper health system in urban areas of Bangladesh. There are many facilities in urban areas, but there is lack of information about them. This project aim towards to consumers, health managers and policy makers to get proper information of health care facilities so that overlapping can be avoid.

1.3 Problem statement

There is a major lack in referral system in Bangladesh. Major people who seeks health care does not know which facility should they visit or which road to use to reach that facility. When a patient need refer from a small health care facilities, most of the time the referred to the biggest hospital of the district when relative closer clinic or hospital can serve the purpose. That is why tertiary level facilities are becoming overcrowded. If a proper referral system can be introduced to these lower level facilities, there is a huge chance to change the situation dramatically.

1.4 Solution

This project aims to propose a prototypical implementation of a system that can be reduce confusion regarding health facilities and avail information to urban citizens. This system contains exact geo-coordinates of health care facilities so that any user can easily reach to required health facility.

1.5 Methodology

A mobile application that can be used by mass people so that when an emergency health situation occurs, users can get the proper information regarding health services. This application provide a detail information regarding health facility along with some other major information (i.e. facility type, contact number, address etc.) on the actual Google map so the user may get familiar flavor in terms of his/her current location.

1.6 Who are the stakeholders?

Mobile health (mHealth) facilitates linking patient-generated data with electronic health records with clinical decision support systems. MHealth can transform health care, but to realize this potential it is important to identify the relevant stakeholders and how they might be affected. Such stakeholders include primary stakeholders, such as patients, families and caregivers, clinicians, health care facilities, researchers, payer's and purchasers, employers, and miscellaneous secondary stakeholders, such as vendors, suppliers, distributors, and consultants, policy makers and legislators. The breadth and depth of the mHealth market make it possible for mHealth to have a considerable effect on people's health. However, many concerns exist, including privacy, data security, funding, and the lack of case studies demonstrating efficacy and cost-effectiveness.

1.7 Outline of project

Figure 1 shows a quick overview of the report structure. To meet the objectives, a literature review was conducted, of which the results can be found in Chapter 2. The part of the literature review focuses on

overall concept of e-health/ m-health and the factors that shape digital health scenario the second part focuses into software engineering challenges to develop a mobile application identified by current researches.

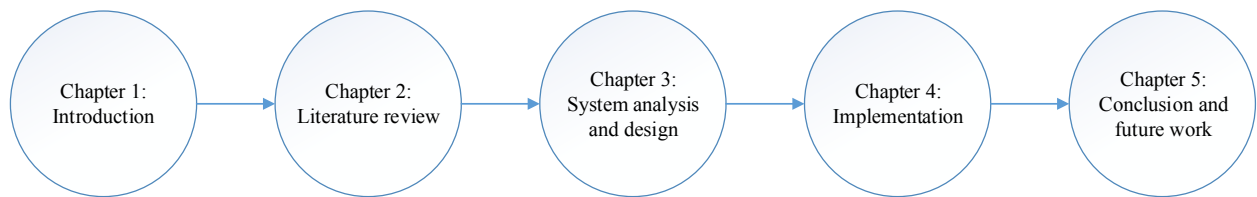


Fig 1: Report outline

Chapter 3 states the methodological approach to this paper. The functional and non-functional requirements, including the data model, system design of the proposed tool are introduced in Chapter 3. The implementation of the mobile application, user interface involvement, is subject of Chapter 4. Chapter 5 concludes the report by discussing the findings and proposing future research endeavors in the area of mobile healthcare application.

Chapter 2

Literature Review

2.1 Referral system (a brief overview)

Knowledge regarding the best approaches to improving the quality of healthcare and their implementation is lacking in many resource-limited settings. The desire to improve on health systems and healthcare delivery is common in many low and middle income countries (LMIC) [6]. However, the resources required to drive the 'quality agenda' and the sustainability of quality interventions have encountered major challenges [7]. WHO (World Health Organization) have made some fine-tuned guidelines so that low and middle income countries (LMIC) can improve their health system by following the guidelines. This guideline has proven correctly in many countries.

An effective referral system ensures a close relationship between all levels of the health system and helps to ensure people receive the best possible care closest to home. It also assists in making cost-effective use of hospitals and primary health care services. Support to health centers and outreach services by experienced staff from the hospital or district health office helps build capacity and enhance access to better quality care. In many developing countries, a high proportion of clients seen at the outpatient clinics at secondary facilities could be appropriately looked after at primary health care centers at lower overall cost to the client and the health system. A good referral system can help to ensure:

- Clients receive optimal care at the appropriate level and not unnecessarily costly
- Hospital facilities are used optimally and cost-effectively
- Clients who most need specialist services can accessing them in a timely way
- Primary health services are well utilized and their reputation is enhanced

Being a system, examination of a referral system requires consideration of all its parts. Important components of a referral system are listed in Box 1 and referral flows are depicted in Figure 1. These can be adjusted as relevant to the local situation. The design and functioning of a referral system in any individual country will be influenced by:

- Health systems determinants: capabilities of lower levels; availability of specialized personnel; training capacity; organizational arrangements; cultural issues, political issues, and traditions

- General determinants, such as: population size and density; terrain and distances between urban centers; pattern and burden of disease; demand for and ability to pay for referral care

2.2 Benefits of proper referral system

1. It enhances provider to provider communication. A big part of healthcare is contingent upon providers talking to providers on an efficient and timely basis. With the addition of a de facto case manager via the referral system, specialists have a clearer understanding of the cases before them when they first see the patients, and PCPs have been able to provide more comprehensive care before reaching out for consultation.
2. It enables providers "to fill in the inevitable blanks. The time constraints providers are under as they move from patient to patient throughout the day. That pressure can lead to oversights in case documentation, but the additional eyeballs in the form of the specialist reviewer means those blanks will be noticed and corrected, and additional information can be requested as the reviewer deems necessary.
3. It makes first visits more effective, and within 72 hours, referring providers are getting feedback from reviewing physicians.

2.3 Components of referral system (From WHO guidelines)

A referral system can be defined as a comprehensive institutional framework that connects various entities with well-defined and delineated (albeit in some cases overlapping) mandates, responsibilities and powers into a network of cooperation, with the overall aim of ensuring the protection and assistance of survivors. Referral mechanisms work on the basis of efficient lines of communication and establish clearly outlined referral pathways and procedures, with clear and simple sequential steps. Referral systems should involve governmental, non-governmental and, as appropriate, relevant international organizations. Their work, at the levels of both the multi-sectoral structure and individual agencies, should be normatively based on international human rights principles and. In order to ensure that cooperation among stakeholders is grounded in sustainable structures, rather than relying on the contributions of committed individuals, the operation of referral mechanisms should be grounded in legislation or standardized protocols that define the roles and responsibilities of all organizations involved.

For many patients, a visit to a primary care provider is just the first stop on a long journey through the healthcare system. Getting to the second -- moving from the PCP to a suggested specialist -- can take a very long time. For example, according to a recent article in the New England Journal of Medicine, a 2005 internal study at the San Francisco General Hospital found that patients were waiting an average of 11 months for an appointment in the hospital's gastroenterology department, 10 months for nephrology and seven months for endocrinology [5].

1. Health System
 - a. Service providers (public and private sector) and quality of care
 - i. Strengthened primary health care services
 - ii. Clarity of level and role of each facility
 - iii. Availability of protocols of care for conditions for each level of facility
 - iv. Availability of communication and transport
 - b. Performance expectations
 - i. Expectation to refer appropriately and follow protocols of care
 - ii. Expectations that health workers and clients adhere to the referral discipline
 - iii. Regular supervision and capacity building
 - c. Involvement of organizations
 - i. Ministry of Health
 - ii. Medical and nursing schools
 - iii. Medical and nursing professional associations
2. Initiating facility
 - a. The client and their condition
 - b. Protocol of care for that condition at that level of service
 - c. Treat and stabilize client – document treatment provided
 - d. Decision to refer
3. Referral practicalities
 - a. Outward referral form
 - b. Communication with receiving facility (make arrangements as appropriate)
 - c. Information to the client and their family/support network
 - i. Reasons and importance of referral, risks of non-referral
 - ii. How to get to the receiving facility – location and transport
 - iii. Who to see and what is likely to happen
 - iv. Follow-up on return
 - d. Empathy - understanding of implications for client and family/support network
 - v. Overall fear
 - vi. Cost of transport, treatment and family accommodation
 - e. Referral register to monitor follow-up and gather statistics
4. Receiving Facility
 - a. Anticipate arrival and receive client and referral form
 - b. Provide care – document treatment provided
 - c. Plan rehabilitation or follow-up with client and family/support network

- d. Back referral form
 - e. Feedback to initiating facility on appropriateness of referral
 - f. Referral register to monitor follow-up and gather statistics
5. Supervision and capacity building
- a. Monitor outward and back referrals
 - i. Number and appropriateness of referrals – compliance with protocols
 - ii. Quality of documentation
 - iii. Consistency of follow-up
 - b. Provide feedback, support and training for health staff
 - c. Provide feedback to central level

2.4 Electronic referral system (eReferral)

Poor communication between primary care and specialists often leads to delays, inefficiencies and suboptimal patient outcomes. Primary care providers had favorable attitudes despite a number of challenges including increased workload due to a shift in tasks from specialists and administrative personnel, poor connectivity, and insufficient hardware [8]. eReferral is widely viewed as a success, by specialists and referring physicians alike. The system has substantially improved access to specialty care and communication between specialists and referring physicians. Both specialty and referring physician users perceived any differences in the time needed to for the eReferral process as valuable contributions to patient care. However, our model of the eReferral work process predicted that, on average, the time saved from avoidable appointments and other efficiencies was less than the time required to review the eReferrals. Thus, eReferral was predicted as net cost-saving only for clinics in which reviews could be conducted by less-expensive mid-level providers. A limitation is that the work process models have not been prospectively validated, for example, testing whether system design changes result in actual time and cost tradeoffs as predicted by the model. Establishing valid simulation models that can predict the costs and benefits of electronic referral system designs will be important for creating successful electronic referral systems in other settings of care [9].

2.5 Referral system in Bangladesh

Primary health care centers need to maintain a close relationship between all the levels of a health system. This linkage between primary health care services and first referral units upwards is crucial in providing health care for the people of any country. Continuous collaboration between health care personal at primary health care level and those of referral facilities is very essential. This kind of coordination not only will be beneficial for the patients but also it will built professional relationships between health care workers at the community level with health professionals at first referral facility.

Although a limited number of patients will develop life threatening complications, very few of these can be predicted. Therefore the system of referring any of the patients to the next referral center needs to be improved. However, the first care referral centers need to be provided with essential equipment's and facilities to handle any such complications of those referred patients. It also recognizes the importance of support and linkages with the household and community for safe care.

Referral system network need to start from the Union sub center (USC), Upazilla Health Complex (UHC) & upwards. In order to bring down mortalities and disabilities following any disease condition or accidental injuries, availability of an operational referral system is one of the prerequisites where it will help the patient to receive optimal Health care from the next level of referral care. The referral system need to aim at connecting each patient through different levels of services and should assure at the appropriate level where he or she will receive optimal health care for any kind of illness.

When discussing about a referral system it does not mean only the forward referrals. Equal importance should be given to the downward referrals as well. If the patients are treated at the first level referral center they may be referred back to the original primary health care center with the necessary follow-up advices. This will enhance the trust towards the primary care centers by the patients from the catchments areas. Effective referral requires clear communications to assure that the patient receives optimal care at each level of the system. This communication need to be on both directions, forward , describing the problem ascend at the lower level facility and backward, information back to the lower level facility describing the findings and the actions to be taken and the follow up needs. Introduction of a well plan referral care mechanism could contribute to overcome some of the short comings and to minimize the prevailing deficiencies which ultimately leads to provide health care services to the people on an equitable basis.

For example, if a health facility was placed nearer to patient's homes to improve the distribution of services, it is possible that access to a phone or specialized emergency vehicle might also be improved. It is also likely that travel time to that facility will be affected. This may have positive consequences (such as decreased travel time or increased utilization of the service) but may also have negative or

unintended effects (for example, if the health provider in the facility is over-worked and does not effectively carry out triage of cases, s/he may cause delays in referring the most urgent cases).

2.6 How electronic referral system can improve the public health

The population density of Bangladesh's capital, Dhaka, is about 19 380 per km² (50 000/square mile) [10], and the total population is 14.5 million [11]. There is a basic health care delivery system in Dhaka City, with designated areas where non-governmental organization (NGO) clinics provide primary health care. The NTP adopted the DOTS strategy for the country in 1993, and expanded DOTS services to Dhaka Metropolitan Area in 2002 through mixed public-private activities. The NTP has set up a referral system across providers designed to enable early diagnosis and convenient treatment.

2.6.1 A cornerstone for healthcare service delivery

By way of background, almost all specialty services provided in healthcare organizations around the world are managed through a complex system of referrals. A referral is used to safely transfer patient care and service delivery across a variety of departments and care settings; such as referring to a specialist, conducting assessments, enlisting opinions, conducting treatments, enabling specialized clinical workflow (e.g. cancer care) and coordinating services for complex patients. Knowing this, the referral can be viewed as a strategic enabler – if you can improve the referral process, you can significantly improve the healthcare system.

2.6.2 Fax machines and the referral

The fact is that healthcare is one of the few remaining industries today that still relies on fax machines. This presents challenges since the majority of referrals are often handwritten on pre-printed forms that are then faxed or mailed. The inconsistency in this process opens the door to a litany of issues including:

- Lost or misdirected referrals
- Illegible referrals, resulting in mistakes and patient safety issues
- Inappropriate referrals
- Incomplete or missing pre-requisites
- Requesting tests/procedures that have recently been completed
- Wasteful re-work, call-backs, and confirmations
- Manual status updates

- Delays in receive results of referrals
- Patients lost in transition, no follow-up
- Lack of visibility to the referral status by the referring clinician

This list, while not comprehensive, clearly shows that there are dangers, waste, and barriers associated with manually sharing patient information throughout the referral process.

2.6.3 Putting the "e" in eReferral

Fundamentally, eReferral enables the end-to-end management and tracking of referrals through electronic means across a defined healthcare system. The “e” allows for the closed-loop process of a referral: creation, submission, acceptance, and closure of service requests between clinicians. It sounds simple enough; however, eReferral includes some very sophisticated capabilities.

2.6.4 Health services/provider directory:

This enables the selection of the most appropriate service to meet patients’ needs including: service specialty, availability, location, and in-network referrals. Too many doctors today, restrict patient-referrals to the same personal network of people and services that they are aware of.

2.6.5 Integration with electronic health records (EMR, EHR):

This enables auto-population of both patient demographic and health information in the referral, saving clinicians significant time and reducing errors made through data entry.

2.6.6 Auto generation of continuity of care documentation (CCD/CDA):

Similar to the integration with Electronic Medical Records (EMR) above, this enables the auto-generation of required patient contextual information as part of a referral and/or transition of patient care across care settings. This capability would also satisfy CCD/CDA Meaningful Use requirements in the US.

2.6.7 Standardized referral forms by specialty:

This enables standard forms by specialty that includes mandatory fields, pre-requisites, and associated clinical workflow or care pathways. It also means that patients and their data are transitioned together from one care setting to another within a closed-loop process. The receiving specialist understands why

a patient is being referred to them and has the relevant information to initiate care, which in turn saves significant time and reduces re-work. This capability also impacts clinical outcomes by reducing re-admissions or acute episodes and ensuring appropriate care is provided while reducing the wait-time associated with patient transition across care settings.

2.6.8 Automated and secured processing:

Automated send/receive/acknowledgment messages mean no more lost referrals. Automated scheduling allows the patient to leave their doctor's office with a booked appointment to meet a specialist. Real-time referral updates, ensure that the status of the referral is available to all parties involved throughout the entire process, significantly improving both clinician and patient inquiries regarding status and allowing appropriate follow-ups from the referring clinician. Wait list and priority setting controls also allow service providers to manage their referrals more effectively.

2.6.9 eReferral as a strategic enabler

From a strategic perspective, the eReferral also provides healthcare managers and policy makers with a fundamental decision-making tool which they don't have currently. Although information on healthcare claims have been available for decades, imagine for the first time, having a clear picture of healthcare medical transactions for analysis, as well as providing a better understanding of the daily operations of healthcare service delivery.

There are no easy “silver bullets” in healthcare; however it's hard to see how the healthcare system can address waste without region-wide, process-automation solutions like eReferral. Additionally, given the broad appeal of the solution to clinicians, as well as healthcare managers and policy makers alike, eReferrals should have a place in every Health IT organizations' strategic plan.

Chapter 3

System Analysis and Design

Mobile health (mHealth) technology has been proposed to alleviate the lack of sufficient medical resources for personal healthcare. However, usage difficulties and compliance issues relating to this technology restrict the effect of mHealth system-supported self-management. In this project, a mHealth framework is introduced to overcome these drawbacks and improve the outcome of self-management. -Mobile phones have proven to be the best way of providing reliable access to information to people in low and mid income countries where other forms of communication perform poorly [8, 12]. As a result of the wide spread of mobile phones, there has been an increase in number of Mobile Application (M-Services) which are being used as a tool for disseminating different type information to people. Services of this nature are established to address informational challenges that are faced by people especially low income people. Because of this then, these projects must be sustained so that people can enjoy the benefits of it. Contrary to this, evidences show that most of M-Services are facing the challenge of cost of operating them, which in a direct way affects the sustainability of these services [12]. This section introduces the minimal requirements for the prototypical implementation of a mHealth referral app.

3.1 Roles of the proposed application

Knowing what services exist in a community is not enough for a referral network to be effective. In addition, a collective network identity and ongoing collaboration are needed to reach the common goal of helping clients receive relevant services. Local ownership and agreement on standardized processes and communication channels amongst service providers are vital to the success of a referral network. This mobile application will be beneficial for both patients and health care manager along with policy maker. When a patient knows where all the facilities located near to him, s/he can use the application when emergency situation occurs to locate the desired facility. A policy maker will also understand where should s/he should establish new hospital in terms-of population density. A facility who are the first point of contact for emergency patient, if the patient required high care services, the facility owner or care giver can go through this application and get the nearest required hospital. Following diagram shows the services and activities of the referral application.

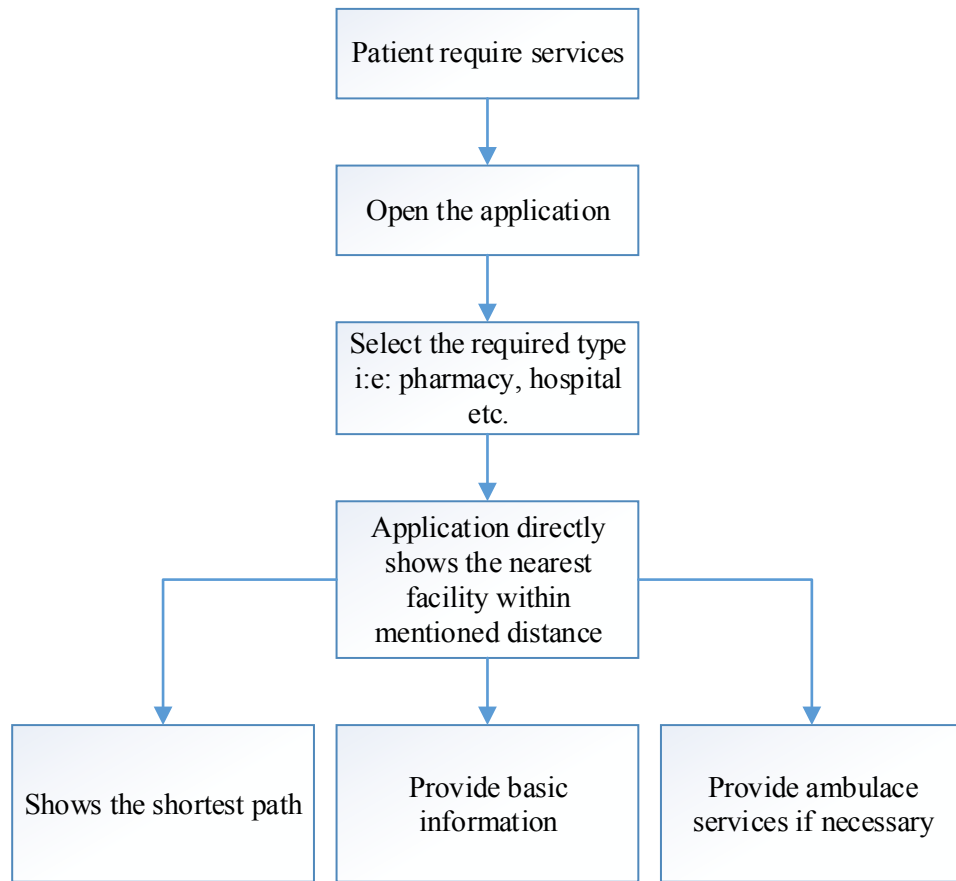


Fig 2: basic flow diagram for referral application.

As shown in figure 1, this mobile application will be able to provide all the location of required facility when a user mention his location. This application also use several type of Google map so user can move around easily. All the nearest facility of given type will be visible to the user. Which will provide fast and accurate response to the user. This application also have the ability to provide shortest path from Google. The data uses in this application is directly coming to SQLite database so there is no required to use active internet. But to load the map, one time internet connection is required. Also user will be able to watch the basic information of the facilities i.e: facility name, address, phone number and directly call to the facility using the phone number.

Another important feature of this application is to call ambulance. If a user select a button to call ambulance, an ambulance will start from the facility and it will show the current location of the map. Although this whole scenario is simulated but to implement this in live, a details information of emergency ambulance provider is required and some GPS tracker need to be installed on the vehicle. If the information can be gathered properly, then this will help lot of people who doesn't have to worry about the current location of ambulance. Using this application, health system of Bangladesh can be change radically.

3.2 Designing mobile applications

This chapter will help to understand when and how mobile applications are an appropriate solution, and the key design considerations for mobile applications. This includes learning about the components found in a mobile application; specific issues for mobile applications such as deployment, power usage, and synchronization; and the key patterns and technology considerations.

A mobile application will normally be structured as a multilayered application consisting of presentation, business, and data layers. When developing a mobile application, you may choose to develop a thin Web-based client or a rich client. If you are building a rich client, the business and data services layers are likely to be located on the device itself. If you are building a thin client, all of the layers will be located on the server. Figure 2 illustrates common rich client mobile application architecture with components grouped by areas of concern.

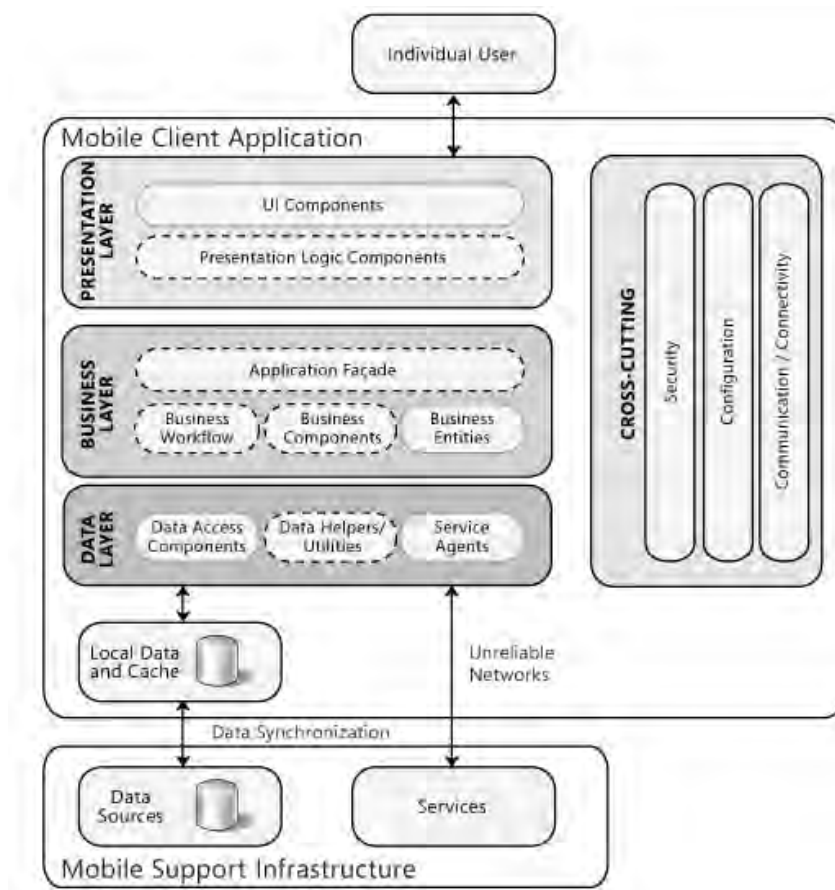


Fig 3: The typical structure of a mobile application

Before designing this application, figuring out the level of users is an important task. As this system have been proposed for everyone (from literate to illiterate) the user interface of this application need to design in a very simple way so that mass people can understand the application smoothly.

3.2.1 Presentation layer

In this referral application, presentation layer is the main focus goal. As the user needs the feedback as fast as possible with readable contents, so the presentation layer should be simple as possible. Following guidelines have been used to develop this user interface of this application.

- Design for a single window, full screen UI. If the device will be a single user device running only the main application, consider using kiosk mode. Keep in mind that Windows Mobile does not support a kiosk mode, so you will need to use Windows CE.
- Take into account the various screen sizes and orientations of your target devices when designing your application UI. Also, consider the limitations imposed by the small screen size, limited API, and reduced range of UI controls compared to desktop environments.
- Design for usability by supporting touchscreen or stylus-driven UI. Place menu bars and other controls at the bottom of the screen (expanding upwards when required) to prevent the user's hands from obscuring the display. Support touchscreen input by making buttons large enough, and lay out controls so that the UI is usable using a finger or stylus for input.
- Give the user visual indication of blocking operations; for example, an hourglass cursor.

3.2.2 Business layer

Following guidelines have been used to develop the business layer of this application.

- Design asynchronous, threaded communication to improve performance and usability in occasionally connected scenarios. Limited bandwidth connections common on mobile devices can reduce performance and affect usability, especially if they block the user interface. Use appropriate communication protocols, and consider how the application will behave when multiple connection types are available. Consider allowing users to choose the connection to use, and to switch off communication to preserve battery life when appropriate.
- Designing an application that will run on a mobile phone, consider the effects of receiving a phone call during communication or program execution. Design the application to allow it to suspend and resume, or even exit the application.

- Protect communication over untrusted connections, such as Web services and other over the air methods. Consider using encryption and digital signatures for sensitive data, and ensure that data passed over a VPN is protected. However, consider the effects of communication security on performance and battery life.
- If application must access data from multiple sources, interoperate with other applications, or work while disconnected, consider using Web services for communication. Ensure you manage connections efficiently, especially in limited bandwidth communication scenarios.

3.2.3 Data layer

Data access on a mobile device is constrained by unreliable network connections and the hardware constraints of the device itself. When designing data access, consider how low bandwidth, high latency, and intermittent connectivity will affect your design. Consider the following guidelines when designing data access:

- Consider using a local device database that provides synchronization services, such as SQL Server Compact Edition. Only design a custom mechanism to synchronize data if the standard data synchronization features cannot meet your requirements.
- Program for data integrity. Files that remain open during device suspend and power failures may cause data integrity issues, especially when data is stored on a removable storage device. Include exception handling and retry logic to ensure that file operations succeed. To ensure data integrity in cases where the device loses power or connectivity, consider using transactions with SQL Server Mobile.
- Do not assume that removable storage will always be available, as a user can remove it at any time. Check for the existence of a removable storage device before writing to it or using `FlushFileBuffers`.
- If you use XML to store or transfer data, consider its overall size and impact on performance. XML increases both bandwidth and local storage requirements. Use compression algorithms or a non-XML transfer method.
- Minimize performance impact by designing for efficient database access and data processing. Consider the use of typed objects instead of data sets to reduce memory overhead and improve performance. If you are only reading and not writing data, utilize data readers. Avoid process intensive operation such as navigating through large data sets.

3.3 Data set

The database (named Urban Health Atlas) used in the referral application, has been provided by icddr,b (International Centre for Diarrhoeal Disease Research, Bangladesh). They have collected the data by visiting each and individual facility. They have collected exact GPS coordinates of each location of corresponding facility. They have interviewed the facility owner or manager who is responsible for maintaining the facility. Facility owner or manager provided all the basic information regarding the facility. They have listed all the health facilities in Dhaka city corporation (both north & south) i.e. pharmacy, hospital, clinic, diagnostic centers etc. on 2013-2014. They have conducted similar survey on six City Corporation: Dhaka, Narayanganj, Sylhet, Rajshahi, Khulna and Chittagong. Facility definition has been provided below:

Facility Type	Definition
Hospital	Any formal institution providing both outdoor and indoor services with more than 30 beds (≥ 31).
Clinic	Any formal institution with or without indoor services having less than or equal 30 beds (≤ 30).
Diagnostic Centre	Provides medical testing and imaging facilities. In addition some also provide out-patient services.
Drop-in Centre (DIC)	Serves only specific vulnerable groups such as sex workers, intravenous drug users, street children. Largely focused on health education, with clinical care available only 1 or 2 days a week. Can be either static or satellite.
Blood Bank	Facility that offers blood collection, preservation and transfusion service. Clinical services are not provided.
Delivery Centre (DC)	Informal MNCH facilities run by BRAC and Caritas where poor women can receive ANC and PNC services and have normal deliveries assisted by trained birth attendants or midwives.
EPI centre	Provide immunization services for children under the Government's Expanded Programme of Immunization.
Satellite clinic	Limited services offered by NGOs at the community level during particular hours and days of the week at a specified location

Fig 4: Definition of health facilities that are being surveyed

3.4 Database diagram

An entity–relationship model (ER model) describes inter-related things of interest in a specific domain of knowledge. An ER model is composed of entity types (which classify the things of interest) and specifies relationships that can exist between instances of those entity types.

In software engineering an ER model is commonly formed to represent things that a business needs to remember in order to perform business processes. Consequently, the ER model becomes an abstract data model that defines a data or information structure that can be implemented in a database, typically a relational database. An entity–relationship model is usually the result of systematic analysis to define and describe what is important to processes in an area of a business. It does not define the business processes; it only presents a business data schema in graphical form. It is usually drawn in a graphical form as boxes (entities) that are connected by lines (relationships) which express the associations and dependencies between entities. This diagram corresponds the urban health atlas data set which have been provided by icddr, b.

From the below e-r diagram, location table corresponds the related information of the facility establishment. The location table contains the GPS coordinates of the facility. One important note to mention, one location can represent multiple facilities.

The facility table contains the basic information of the health facility i.e. name, facility type, managed by etc. The facility table relate with location table. Location table has a primary key name location_id which is also treated as foreign key in facility table. The GPS field in the location table contains the GPS coordinates of the location.

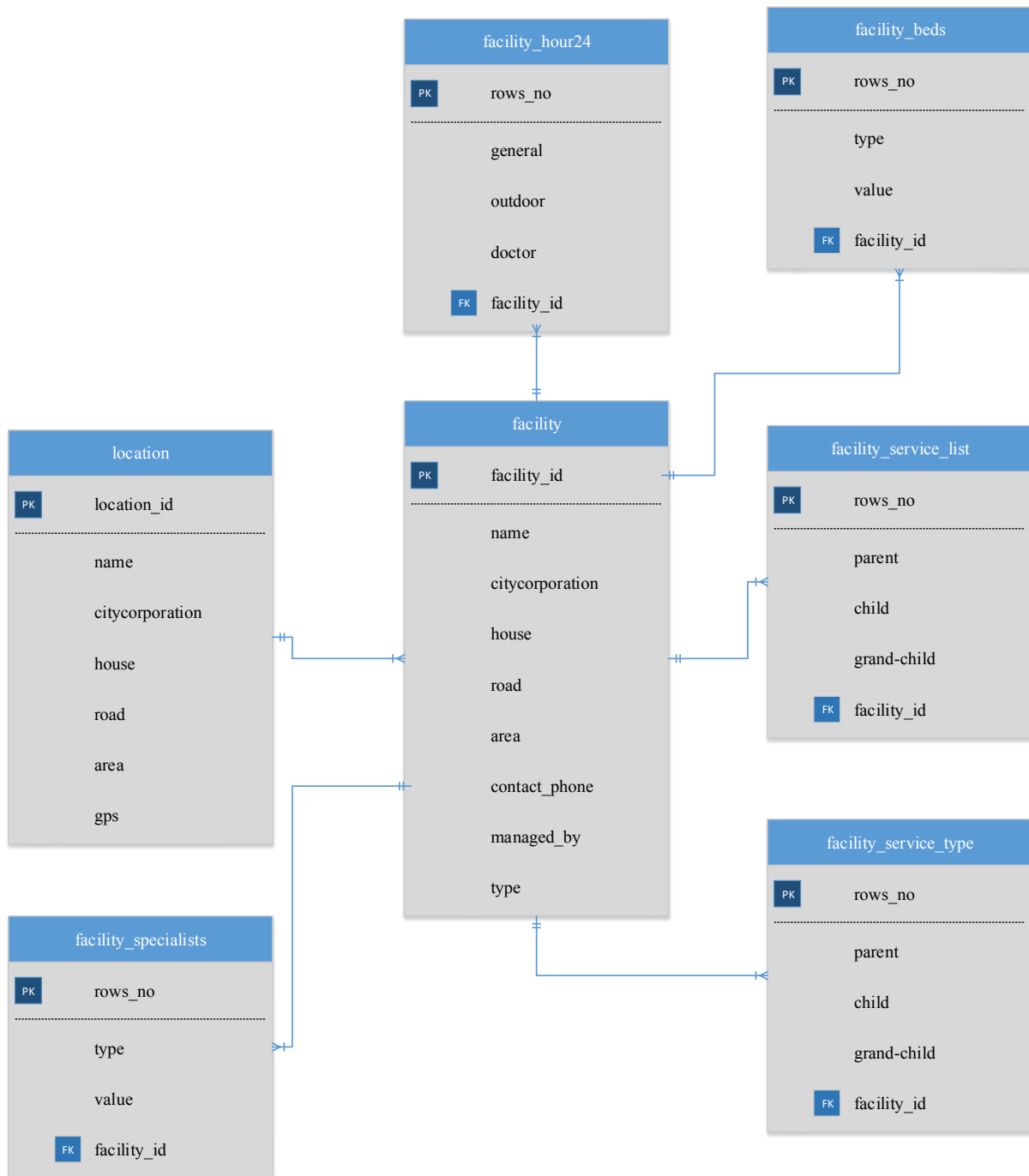


Fig 5: Entity relationship model

There are some other table in this e-r model which are responsible to hold various type of data. Such as facility_specialists hold data for different types of specialists that the facility have. Facility_service_list table contains data for different services of the facility such as CCU, ICU etc.

3.5 Platform used for developing referral application

As the role of mobile devices in people's lives expands even further, mobile app developers have become a driving force for software innovation. The question of "which platform to build an app for first" has been a popular one for the past five years. Often ideological or headline-focused, the platform wars may be over for now but the need to answer this particular question remains. To develop the referral application Xamarin has been used.

3.5.1 What is Xamarin

In conjunction with Visual Studio, Xamarin provides a rich mobile development offering that enables developers to build mobile apps using C# and deliver fully native mobile app experiences to all major devices – including iOS, Android, and Windows. Xamarin's approach enables developers to take advantage of the productivity and power of .NET to build mobile apps, and to use C# to write to the full set of native APIs and mobile capabilities provided by each device platform. This enables developers to easily share common app code across their iOS, Android and Windows apps while still delivering fully native experiences for each of the platforms. Xamarin's unique solution has fueled amazing growth for more than four years.

3.5.2 Why use Xamarin

Less to learn

- Becoming an effective mobile application developer always involves a learning curve. There are things like process lifecycle, UI norms, the platform SDK, etc. that one must learn.
- If you're an experienced .NET/C# developer you will be immediately at home working with Xamarin. It provides a complete implementation of C# and incredibly thorough implementation of the .NET class libraries. It's not uncommon for well over 80 percent of one's existing desktop or server .NET/C# code to be compatible with Xamarin (your mileage may vary).
- Even if you're not an existing .NET/C# developer, Xamarin will likely reduce the time you spend learning. Android and iOS normally require the use of two separate programming environments: Java and Objective-C respectively. Very few developers are highly skilled in both of these environments (yes, I know there are some of you out there) which means the overwhelming majority of developers will have to learn one or both of these environments before beginning a cross-platform project.

- Learning the Java and Objective-C environments is not limited to just the programming languages. There's also the issue of the underlying core classes such as collections, etc. that will require you to understand two different ways of doing the same things.

Native

Xamarin allows you to develop apps for iOS, Android and Mac from a single code base. When I say this I don't mean in a web view or customized API, it actually uses the Native APIs. So for example when developing on Xamarin.iOS you'll be using UIKit which is the same API that a native developer would be using.

Fast and stable

From personal experience the Xamarin traditional (Xamarin.iOS and Xamarin.Android) platform is solid, fast and stable. You'd be hard pressed to find a problem with the core parts of the platform, any app bugs will likely be your own bugs.

Native user interfaces

Xamarin apps are built with standard, native user interface controls. Apps not only look the way the end user expects, they behave that way too.

Technology stack to code for all platforms

Xamarin uses C# complemented with .Net framework to create apps for any mobile platform. Thus, you can reuse up to 96% of the source code speeding up the engineering cycle. Xamarin also does not require switching between the developments environments as it works with both Xamarin IDE (for Mac) and Visual Studio (for Windows).

Chapter 4

Implementation

4.1 Database used for mobile application

SQLite is a relational database management system contained in a C programming library. In contrast to many other database management systems, SQLite is not a client–server database engine. Rather, it is embedded into the end program.

SQLite is ACID-compliant and implements most of the SQL standard, using a dynamically and weakly typed SQL syntax that does not guarantee the domain integrity.

SQLite is a popular choice as embedded database software for local/client storage in application software such as web browsers. It is arguably the most widely deployed database engine, as it is used today by several widespread browsers, operating systems, and embedded systems (such as mobile phones), among others. SQLite has bindings to many programming languages.

4.2 Activity diagram for access urban health atlas data

The referral application used urban atlas data which is collected by Health System and Population Studies Division of icddr,b. They provided this data from a web API which requires a specific username and password. If the user is valid then it provide response based on request. The request has made using specific facility type i.e. facility_type:6. This request must be made via JSON string which should be

```
{  
    Facility_type: 6  
}
```

Here value 6 represents the hospital.

Also user's current location need to be sent with mentioned distance. The proper process diagram has been shown below.

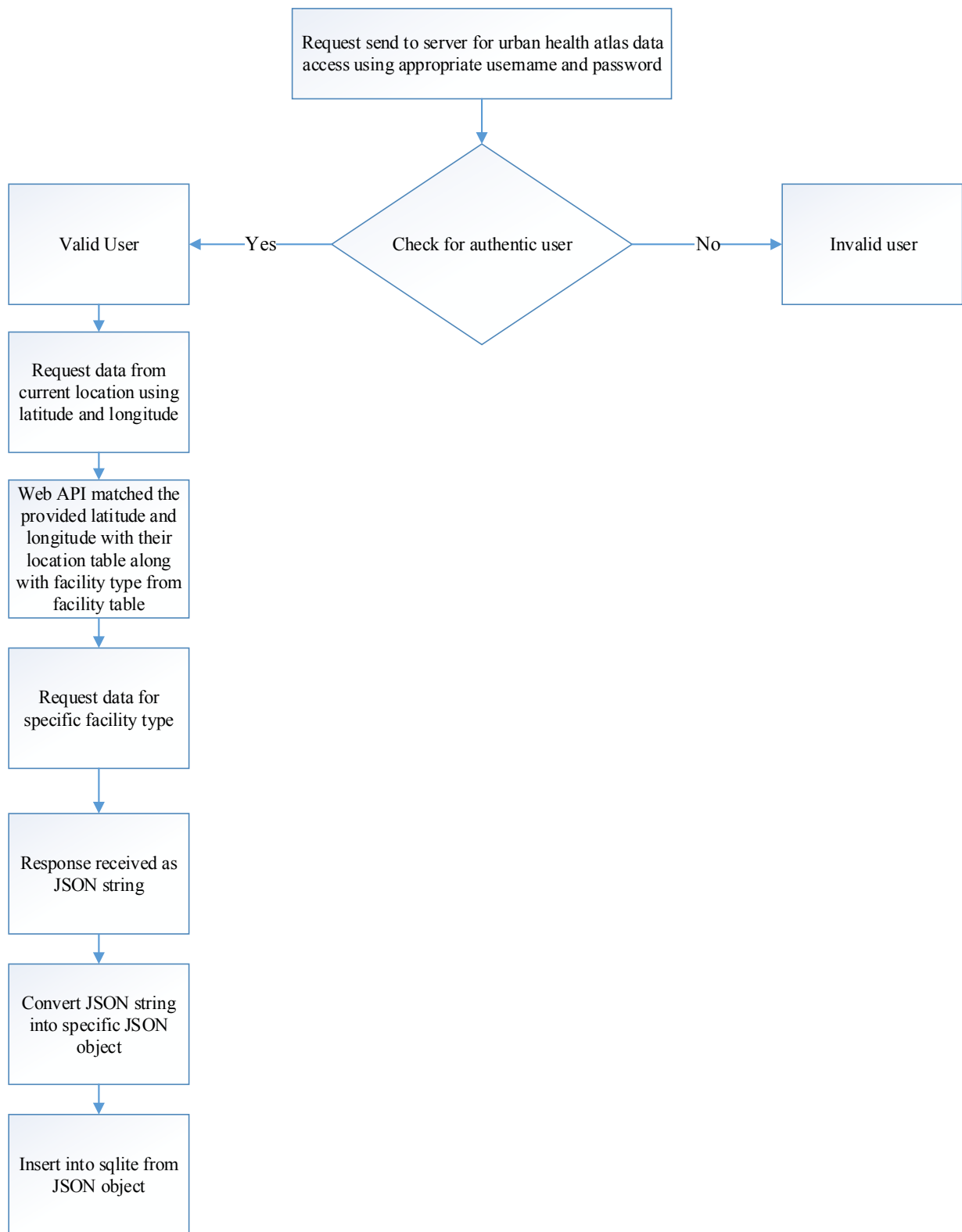


Fig 6: Activity diagram for urban health atlas data transfer

4.3 User Interface

4.3.1 Facility type screen actual & mockup (home page)

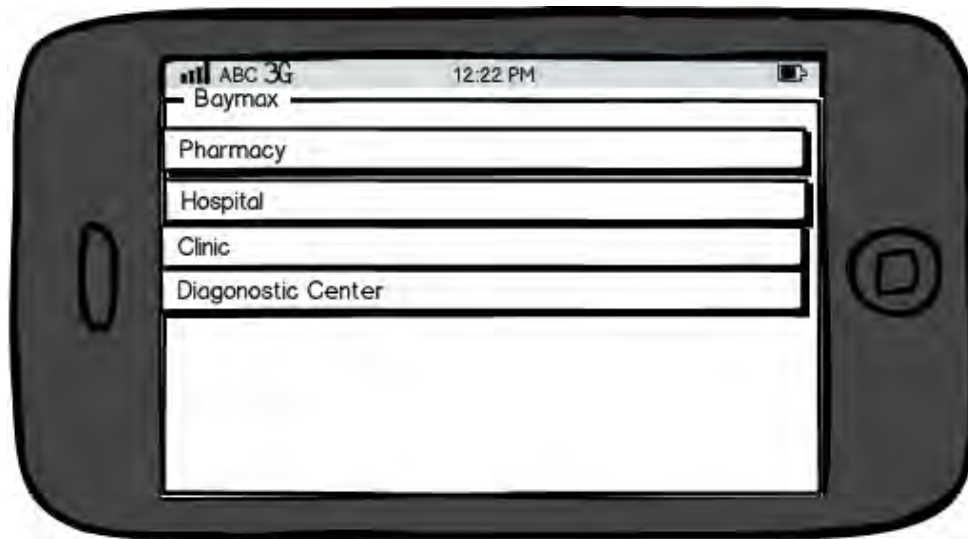


Fig 7: Homepage (mockup)



Fig 8: Homepage (device)

For generating a feeling for the application without having to write any code, the first version of the user interface was simply mocked-up using Balsamiq Mockups. Trying out the application as a simple PDF file with clickable buttons resulted in noticing and resolving a number of shortcomings. Since the

application targets novice users with little to no experience to search medical entities, its user interface needed to be as intuitive and easy-to-use as possible. Therefore, a few different alternatives were reviewed that structured the content of the application differently. A few examples of this user-friendly restructuring can be seen in the screens above.

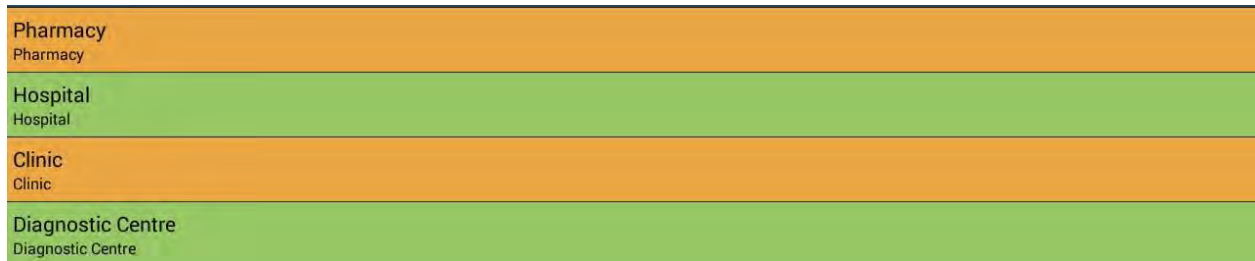


Fig 9: Homepage list view (device)

Each content of the list view represent the category of the facility. If a user select hospital, application will redirect the user to a map where all the hospital is located.

4.3.2 Facilities on the map



Fig 10: Nearest facilities (mockup)

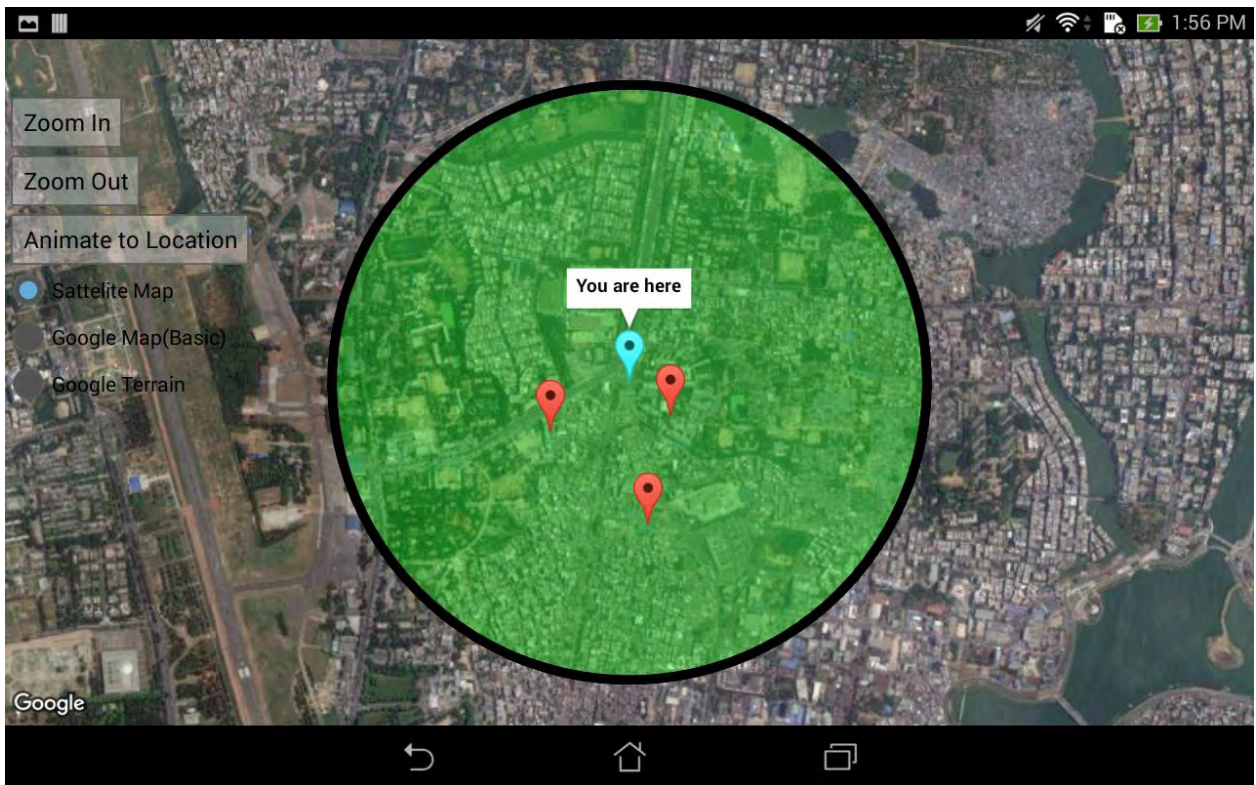


Fig 11: Nearest facilities (hospital) on the map (device)

This scenarios has been created selecting hospital from the homepage. User select hospital from the homepage to find out nearest hospital (user is represent using cyan marker). Red marker (represent hospital) are the closest hospital to the user. The circle with black border represent the two kilometer radius. User can also change the map type (which are located on the left side corner of the application). Following types of map can be selected when user wishes to.

1. Google satellite map
2. Google map basic
3. Google terrain

Also user can zoom in or out the map to get the clear view. If the current location is out of the window, using animate to location, will return the user to current location.

When a user click on any facility following pop up will appear on the screen with location name, options for showing nearest path and emergency call for ambulance.

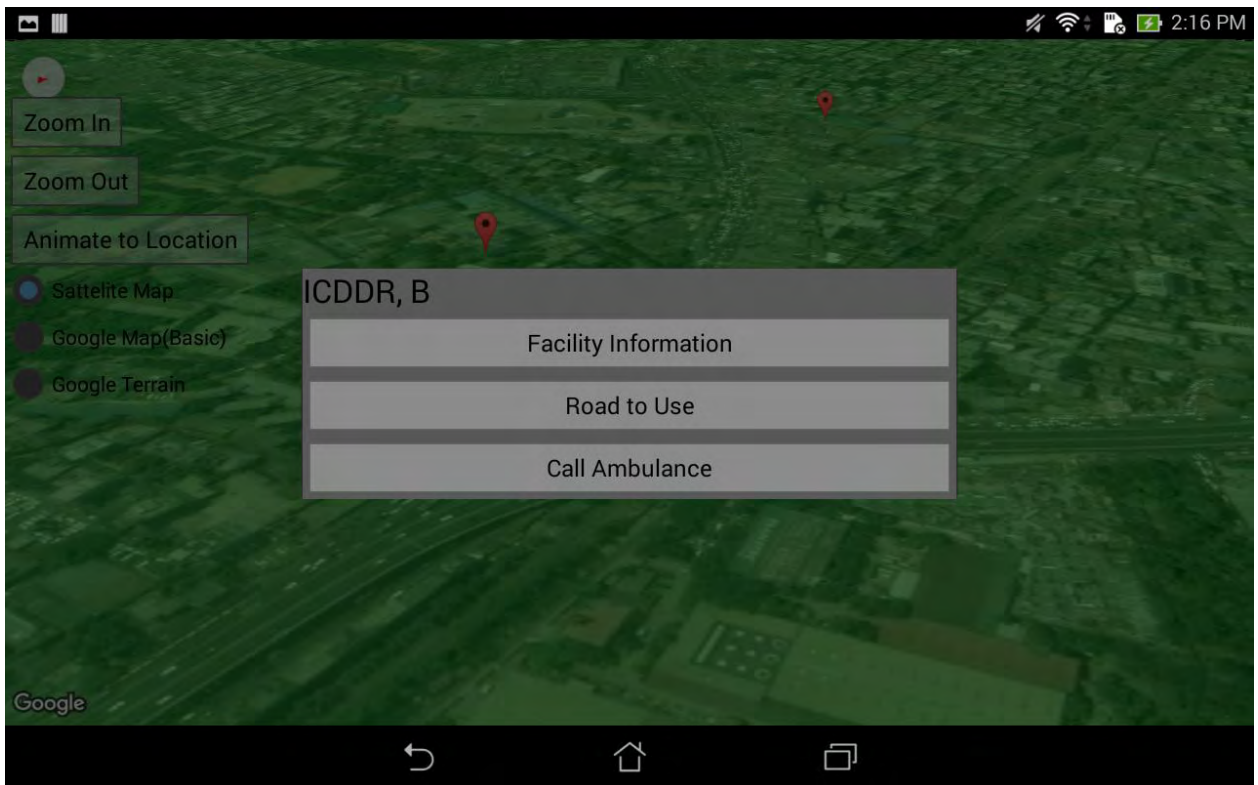


Fig 12: Location information (device)

From the above view when user click on facility information, a list of all the facilities of that location will pop up where their name and contact number will be listed (image showing in below). Now if user click on the number which is mentioned under facility name, the application will automatically start calling the facility which means the user don't have to look up for facility phone number to know when the facility open or close, or which kind of service s/he looking for. From the below image, this location is holding two facility. One is a medical hall (pharmacy) and another is diagnostic center.

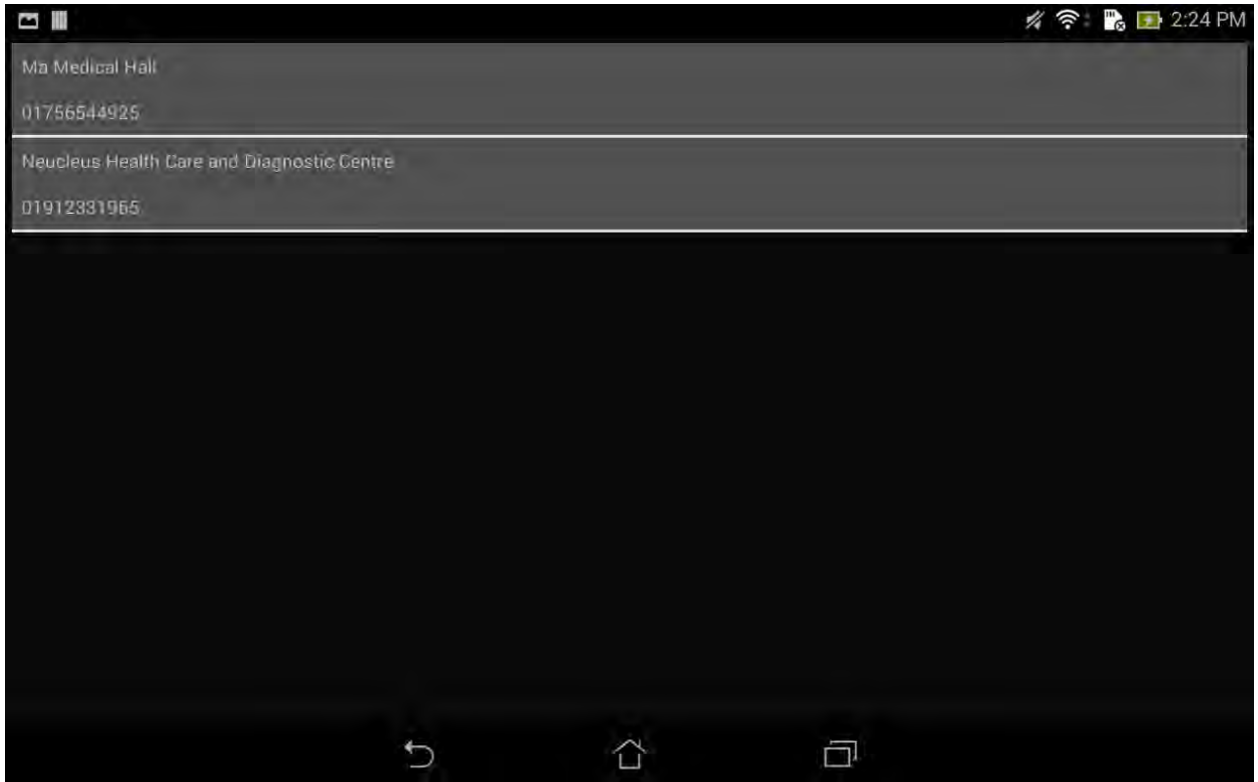


Fig 13: Facility information (device)

4.3.3 Shortest path to the facility

When user click on road to use (from Fig 10), the application will calculate the shortest path from the Google API and draw on the map using red line (as shown in below image). Following this line, user can navigate to the facility very easily.

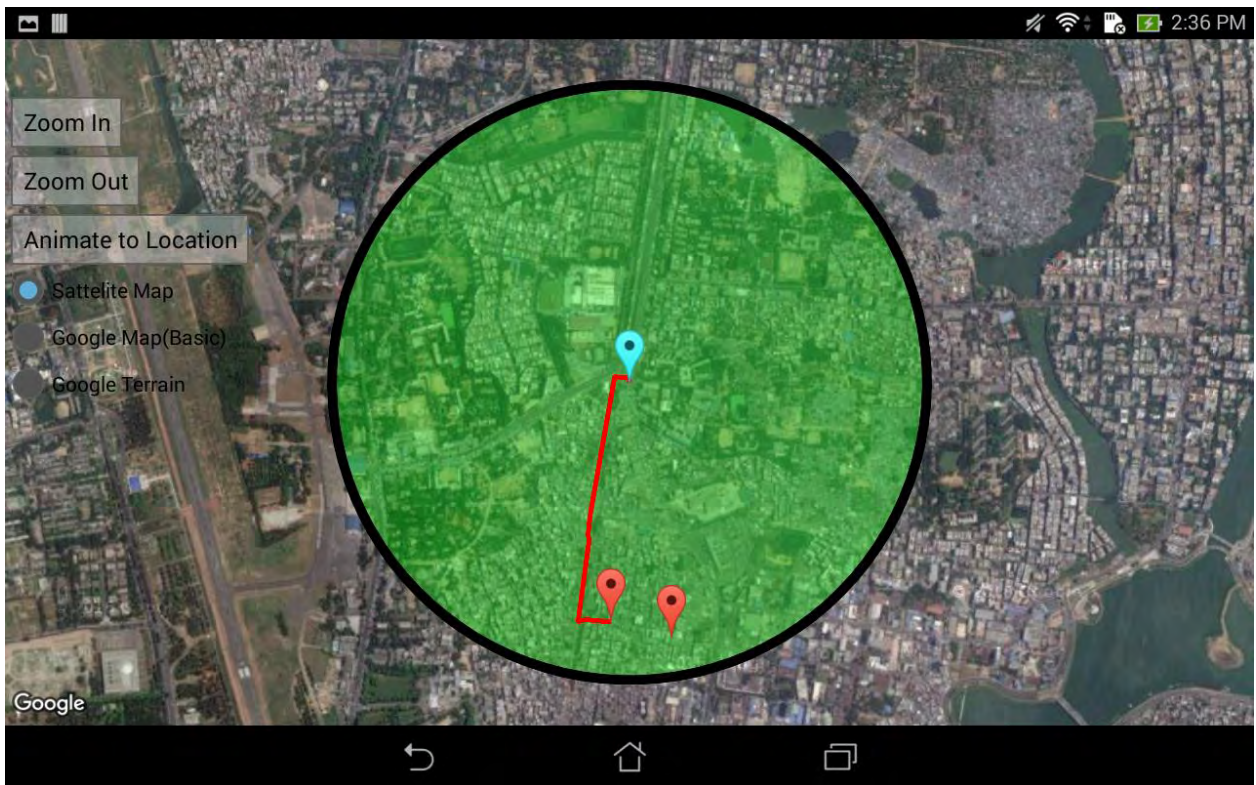


Fig 14: Shortest path to the facility

4.3.4 Call for ambulance

The feature call for ambulance have most importance. Though it is a simulation, but it is possible to make a call for ambulance for emergency basis. In this simulation an ambulance start from the facility and start travel to user's location (as shown in Fig 13). In near future, this application may need to extend to put requisition for ambulance and the current location of ambulance. This will help user to understand, how far the ambulance is currently. If user change his location, the ambulance can also understand his location which will be visible on the map.

This system can be easily extend by installing a GPS device on the vehicle. As user already have a smart phone, it is always possible know his current location.

Now if any one click on the ambulance icon (from Fig 13), another pop up will appear (from Fig 14) where name of the ambulance service and the phone number of the drive will be shown.

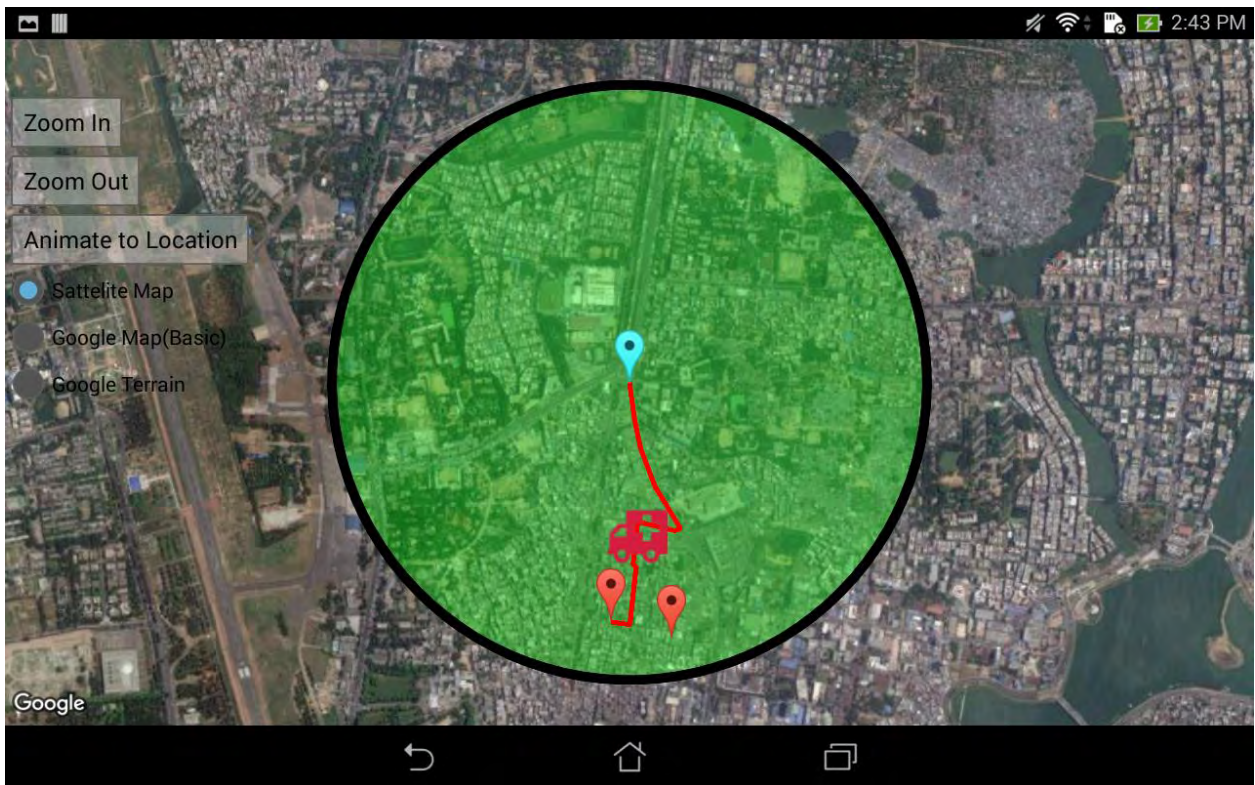


Fig 15: Ambulance location on the map (device)

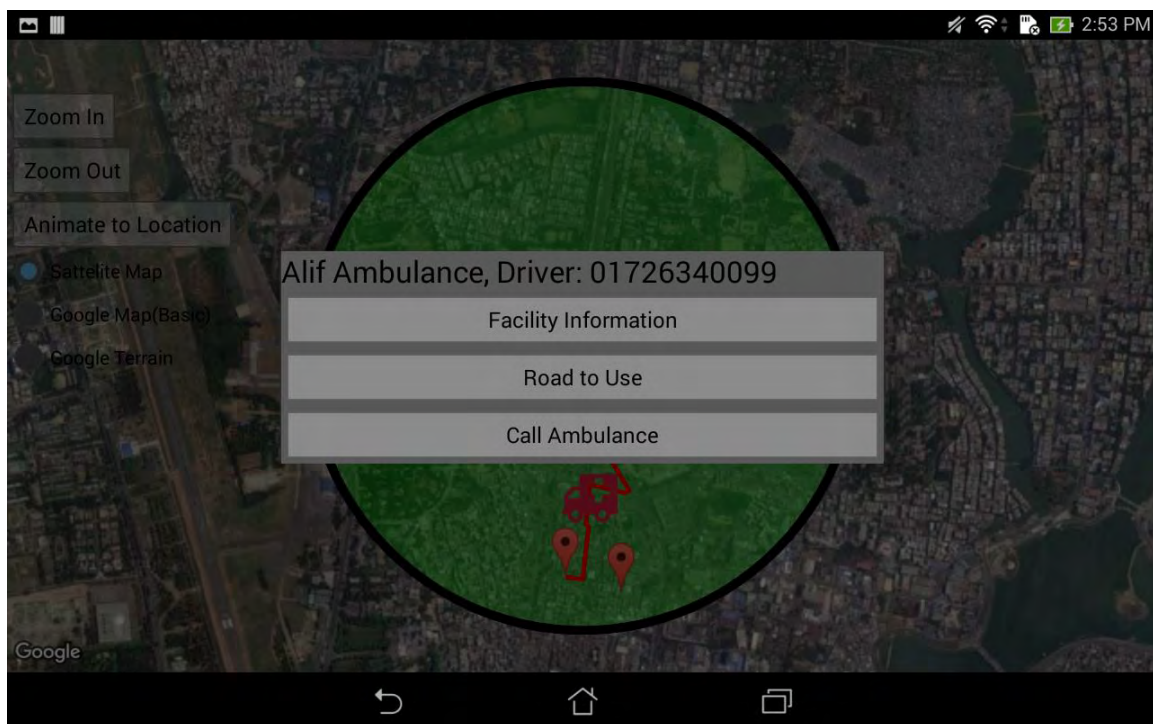


Fig 16: Information regarding the ambulance service

4.4 Requirements to run the referral system

The proposed mobile application can be run on any android device that have minimum android SDK version 12. Any mobile processor along with 512 MB ram can run this application smoothly. A proper internet connection is needed to load the map and updating the current location. 512 kbps bandwidth is sufficient to run this application. Higher configuration will load the map more quickly that older device. Google services need to be enabled in the device in order to access Google map.

Chapter 5

Conclusion & Future Work

In conclusion, the work and contribution of this paper is summarized below. A literature review was conducted that revealed a need for applying modern technologies to practice the proper referral system as per WHO guideline. This application can be easily use by any facility manager along with stakeholders. If a situation occurs like a patient comes to local clinic and s/he need to refer immediately to nearest large hospital, doctor can easily check this application and refer the patient to nearest large hospital.

Even on the WHO guideline, if a facility refers a patient another hospital, the initiator facility must log the patient's history. This application can be extend that further. A questionnaire can be included for the initiated facility and doctor can refer the patient immediately. And also the recipient facility will be aware before the patient have arrive.

Furthermore a literature review was also conducted to identify what are the major software engineering challenges to develop and mobile application to solve healthcare problems. Four major issues that were identified are Creating Universal User Interfaces, Enabling Software Reuse across Mobile Platforms, Designing Context-Aware Mobile Applications, Balancing Agility and Uncertainty in Requirements.

Yet a prototype have been proposed in this report, a major work need to be done in order to branding this application. Stakeholders, facility owner, facility manger and policy maker need to understand the proper requirement to implement this application. According WHO path toolkit [13], many projects fall just because stakeholders and software engineer failed to understand the proper requirement. Before implementing this project in community level, need to discuss thoroughly with the people related with public health. It is also important to find out where are the barriers in community level to implement this application. There several technical problem may arises such as in production, there might be multiple servers required to update the data feed properly. As there are several live situation relate with project, we also need to ensure the quality of service. For an example, if an ambulance has started to receive patient, we need to make sure the GPS on the vehicle need to function properly. There are some quality work need to done correctly to provide the service to community level. It is very much necessary that in future an evaluation is conducted to find out potential shortcomings of the application both from software and hardware perspectives.

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