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Information And Communications Technology Based Solution To Rank Emergency Hospitals

Taneaka Anesha Jenkins
North Carolina Agricultural and Technical State University

Information and Communications Technology Based Solution to Rank Emergency Hospitals

Taneaka Anesha Jenkins

North Carolina A&T State University

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Taneaka Anesha Jenkins

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Approved by:

Dr. Rajeev Agrawal
Major Professor

Dr. Cameron Seay
Committee Member

Dr. Ibraheem Kateeb
Committee Member

Dr. Clay Gloster Jr.
Department Chair

Dr. Sanjiv Sarin
Dean, The Graduate School

Biographical Sketch

Taneaka Anesha Jenkins earned her Bachelor of Information Technology degree from American InterContinental University in 2009. In 2011, she joined the graduate program of Information Technology at North Carolina Agricultural and Technical State University.

Taneaka was inducted into Epsilon Pi Tau, International Honor Society for Technology Professionals, at North Carolina Agricultural and Technical State University in 2012.

Taneaka has presented her research at international conferences including the 2012 International Conference on Advances in Interdisciplinary Statistics and Combinatorics (AISC). A research paper has also been accepted at the IEEE SoutheastCon Conference 2013.

Taneaka's thesis entitled, "Information and Communications Technology Based Solution to Rank Emergency Hospitals," was supervised by Dr. Rajeev Agrawal.

Dedication

I dedicate this thesis to my children, Asia and Brianna, and my significant other, Lendrick. I give my deepest expression of love and gratitude for the encouragement that you gave and the sacrifices you made during this graduate program. Thank you for the support and company during the long nights of typing. Lendrick, thanks for keeping me grounded and picking me up emotionally when I couldn’t see the light at the end of the tunnel during this long process.

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Abstract

With the advent of smart phone technologies, the healthcare industry finds it challenging to keep up with technology demands. In the medical domain, patients are experiencing longer wait times for medical treatment. A basis of dissatisfaction with healthcare, often observed by patients, is the amount of time they wait during a visit. The wait times have a greater delay within medical emergency facilities. Current medical wait time applications may encourage patients to be seen quickly but does not necessarily offer quality care or other aspects of their visits. The amount of time a patient experiences in an emergency facility could influence the patient's perspective and could be contingent upon other qualities. We sought to investigate the association between patient perception of the hospital, time to reach the hospital, patient wait time, patient reviews, and average service time of various North Carolina hospitals using product moment correlation analysis. Analyses were performed of the various hospitals based upon each parameter. In this thesis, we propose a smart phone based service to optimize travel time to a medical facility utilizing patient wait time, service time, time to reach the hospital, patient reviews, and patient perception of the facility and Global Positioning System (GPS) data. Various hospitals were compared ranking in according to the parameters individually, relative to other hospitals in neighboring counties and cities. Each constraint is assigned a weight to be used in the overall ranking of the hospital. We have established relationships about correlation parameters. The parameters were assessed to determine correlations between any two given parameters.

CHAPTER 1

Introduction

In the case of medical emergencies, where medical treatment is needed right away, an individual needs the proper care. In the technology-driven society today, people expect rapid and speedy service in spite of the situation. In the case of true emergencies, we would like to have the quickest service possible to elude any catastrophes and danger. In regards to technologies being able to share location information with the intentions of providing medical care, location-based services can play an important role.

Location-based services (LBS) are centered on detecting a resource, person, object, or automobile at any given time. Objects and individuals can be detected by method of global positioning system location and telecommunications based location as well as with Bluetooth and Wi-Fi. Most mobile applications present distant accessibility to data sources from a mobile mechanism. A crucial constituent of location based services is the location information. Numerous functional applications utilize location-based information. Togt, Beinat, Zlatanova, and Scholten (2005) explained that the United States uses location services to carry out emergency medical services for 911 calls. In the 2006 report from the Institute of Medicine, Hospital-Based Emergency Care: At the Breaking Point, the study discussed the overstrained, underfunded, and overcrowded emergency room and ambulance services. As a result, ambulances are being turned away from emergency departments due to patients waiting for extremely long periods of time to receive care (“Hospital-Based,” 2006).

The appropriate care needs to be assessed in a manner in which wait time, traffic information, and travel time can be explored quickly. In serious situations, time is imperative. It is mandatory to have medical treatment in an emergency situation and accurate decisions have to be made. In some instances, a person may be under pressure and cannot think clearly. If this happens to occur, then selecting the nearest emergency facility would be logical. Emergency facilities are presumed to be medical treatment facilities focusing on critical care of patients with or without an appointment, either by their own means of transportation or by ambulance.

Medical urgent care facilities and hospitals embody a favorable environment in which wait times and average treatment times can be resourceful in exploring patient accessibility and patient care principles and productivities. In many occurrences, the functions of an urgent care or emergency facility are taken advantage of, as they imply the essential mediation between opposing urgencies. While procedures and practices continue with time and great efforts are proposed to decrease patient wait time and other patient care dynamics, often there is little or no computable examination or response in the process. Considering the advancement of smartphones and applications, engineers are capable of constructing mobile paradigms to offer meaningful potential for patient healthcare and their well-being. There is no uncertainty regarding whether or not emergency facilities should be focusing initially on diminishing patient wait time to improve patient care satisfaction, but what can be done to optimize travel time in route to the emergency facility?

This research analyzed the means of utilizing smart phones to assist in optimizing patient travel time while providing technological tools to aid patient in their medically necessary treatments. The research theorized that smart phone applications are capable of improving the quality of healthcare service by means of constant, interactive, and a tailored patient wait time model that enriches patient-urgent medical communication and accessibility. The wait time in an emergency facility setting is usually a significant factor regarding a patient’s experience during the emergency visit. Patient wait time is also a vital element of healthcare service and an evident degree of healthcare productivity. Leddy, Kaldenberg, and Becker (2003) state a medical practice survey concluded that 40% of patients' discrepancies in patient satisfaction could be clarified merely by the wait time to see the physician.

This study proposes emergency facility ranking model through the use of a smart phone. This paradigm could be accessible through smart phones where data is presented to patients through wait time, average service time, patient perception, patient reviews, and time to reach the hospital. In this thesis, we apply five parameters to analyze and form a model to rank emergency facilities. We are interested in identifying relationships between different parameters affecting the ranking. We will use the Pearson correlation coefficient to identify these relationships. The correlation coefficient can be assessed by using the values of the wait times, average service times, travel time to reach the hospital, patient perception, and review rating. Once the correlation is computed, we can determine which parameters have strong associations, as well as which parameters have weak correlations.

CHAPTER 2

Motivation and Problem Definition

A prevalent public demand exists for enhanced access. Supporting pressures for decreased wait times extended work environments, a maturing population and over usage of equipment and facilities are a few conditions that healthcare organizers are faced with in order to embrace innovative methodologies. Healthcare facilities all over the world face lengthy and escalating wait times for medical services. In some cases there are little medical effects and in other cases the extreme delays may be harmful to patients' health.

Typically, wait times are assessed and documented from the initial service request until the services are rendered by the provider. Unfortunately, computed wait times do not capture and reveal the entire issue. Wait times vary amongst patients, time, and calculations. Technology will play a role of elevating patient care to the next level, as far as healthcare is concerned.

Mobile devices can be examined to identify vehicle rapidity. Traffic jams, typical flow rates, means of transportation tenure and related traffic status can be collected from a diverse array of sources; such as highway assistance programs and highway telecommunication devices. Location based services allow individuals to obtain information in which the data is sorted dependent upon the site of the requester's location. The objective of the travel time application is to direct the smartphone user to their proper emergency facility destination by optimizing travel time through the parameters of wait time, average service time, patient perception, review rating, and the time to reach the hospital.

The optimization travel time may have various effects on different users depending on the urgency of the treatment needed. The method can be viewed as a way to solve shortest path issues by using links and nodes. Each point combines wait time, travel time, and distance to location. In some cases, presume travel times are not fixed and dependable upon traffic status. Fig.1, the visual idea would be a highway system with GPS and fixed points or connections. The fixed points are shown as red lettered circles and the GPS signals are shown with the yellow cross circles.

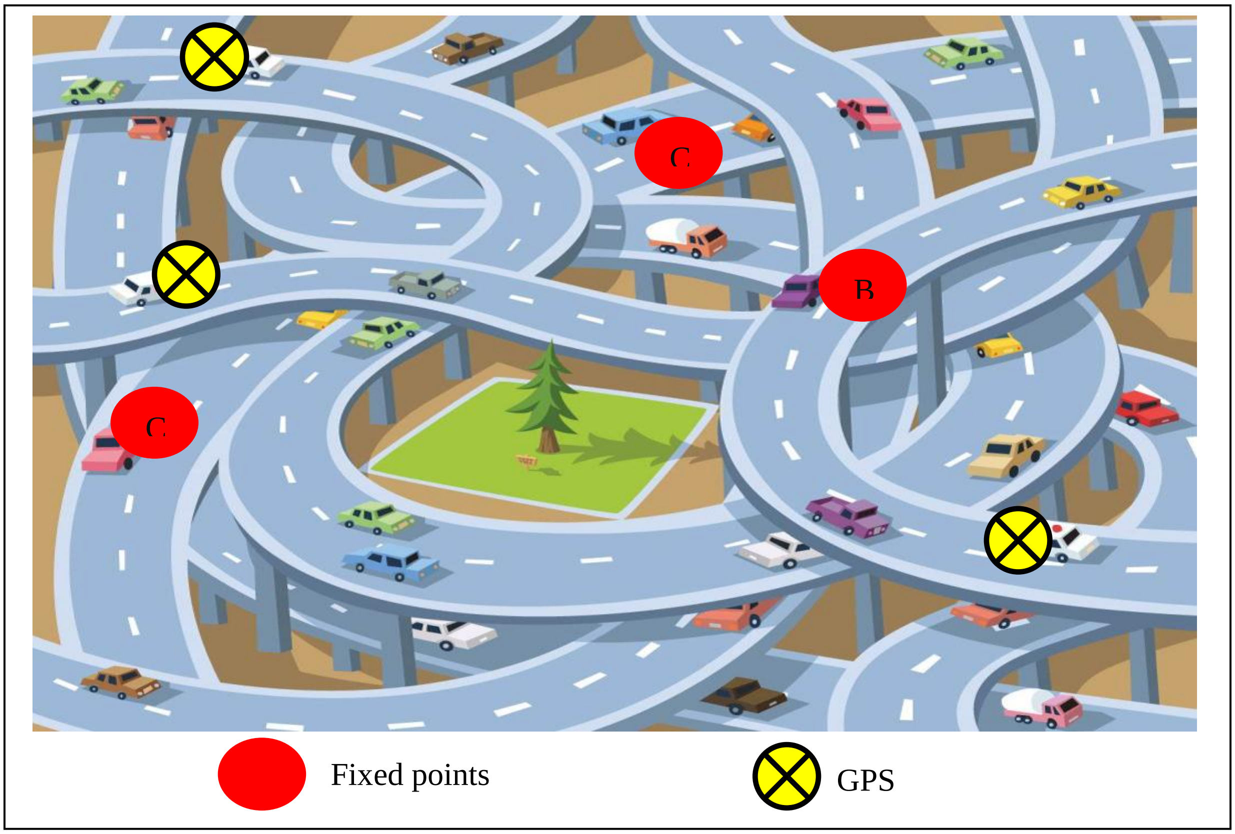

Figure 1. Example of the GPS and fixed connections

We are interested in constructing a model to score medical facilities to evaluate and decrease patient wait times, such as creating shorter patient wait times along with average wait time for treatment, and also providing the patient with traffic updates with the help of global positioning system (GPS). We are interested in identifying relationships between different parameters affecting the ranking. We will use the Pearson correlation coefficient to identify these relationships. The correlation coefficient will be a range of values from +1 to -1. A value that is greater than 0 signifies a positive relationship. A value that is less than 0 denotes a negative relationship. We can measure the relationship among patient wait time and the review rating of the hospital. The question of whether or not the wait time at the hospital affects the rating of the hospital can be determined. We are able to do the same analyses for other parameters. The correlation coefficient can be assessed by using the values of the wait times, average service time, time to reach the hospital, patient perception, and review rating. Once the correlation is computed, we can determine which parameters have strong associations, as well as which parameters have weak correlations.

CHAPTER 3

Literature Survey

Several attempts have been made to reduce emergency room wait times. A number of hospitals are shifting the urgency of the visit from their facility to substitute providers. In 2006, Aurora-Sinai decreased its yearly emergency room visits by approximately 23%, by implementing a program that coordinates non-urgent patients with alternate caregivers (Martin, 2011).

The agent based modeling system of ABM (agent based model) and QM (queuing model) are methods to the functions of an emergency room, particularly with value to patient access and flow throughout the course of the emergency room visit. These two models are built on comparatively minimal models of the physical outlines and social developments within emergency departments. Laskowski, McLeod, Friesen, Podaima, and Attahiru (2009) observes this framework along with the genetic programming model as a way of calculating patient wait times and as a method of developing healthcare policy, respectively. Additionally, different conceptions taken from telecommunications engineering are also transformed into this modeling framework.

The simulation optimization model of an emergency department unit at a government hospital in Kuwait is designed to evaluate patient flow throughout and evaluate the influence of different staffing distribution. Ahmed and Alkhamis (2009) state that the experimental outcomes indicate that by utilizing existing hospital resources, the optimization simulation model produces ideal staffing distribution that would permit 28% increase in patient output and an average of 40% decline in patients' waiting time. The representation of this model is a methodology in which system replication is joined with optimization to establish the optimum number of physicians, lab technicians and nurses necessary to take full advantage of patient throughput and to decrease patient time in the system dependent on budget constraints.

Sinreich, Nico, and Dellaert (2012) state that focusing on improving proficient work shift schedules that optimizes the usage of existing resource capacity with the intentions of decreasing patient waiting time and leveling resource usage has also been considered. The study presents two repetitive experimental algorithms, which conjoins imitation and optimization models for organizing the work shifts of the emergency department resources: doctors, technicians and nurses. The systems are distinct considering they justify for patients being treated by many care providers, for several hours, frequently with scattered waiting. Arkun et al. (2010) state that the significance and need for real-time emergency departments flow paradigms have definitely become evident. Medical emergency departments have been experiencing an omnipresent problem with critical public health repercussions. Devkaran, Parsons, Dyke, Drennan, and Rajah (2009) state that the fast track area method was designed to target the reduction of wait times, patient frustrations, and illnesses. The goal of the investigation was to identify the effect of a fast track environment on both efficiency degrees such as wait times, length of the visit and quality measures in non-emergency patients. The analysis of occupying wait time by using health education through smartphones to improve the wait time, enhance patient accessibility and enrich the condition of outpatient service has been performed as well (Al-haratani, 2010).

Various research methods have been performed regarding the correlation of care from patient's hospital ratings. The concentration of hospital treatment delivered to chronically ill Medicare patients fluctuates between districts, impartial of illness. The correlation was measured amongst hospital treatment intensity, the methodical quality of hospital treatment, and patient's scores of their hospital occurrences. Better inpatient treatment concentration was linked with poorer quality scores and poorer patient ratings; poorer quality grades were linked with poorer patient ratings. Wennberg, Bronner, Skinner, Fisher, and Goodman (2009) explain that the mutual connection between better treatment intensity with poorer quality and unsatisfactory patient experiences could be inadequate managed care.

Two associated theories were tested from previous studies from the means of joining the outcome of Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) and trials of methodical process quality provided with data from Dartmouth Atlas of Health Care. One theory tested, on the topic of patients residing in provinces with insistent displays of inpatient treatment, inclined to rate their patient experiences unsatisfactory. The second tested on patients' scores of their hospitals and impartial actions of technical quality being naturally correlated. The HCAHPS surveyed random patients about their hospital visits. The survey consisted of 10 quantities: their rate of the hospital on a scale of 0 to 10; their recommendation of the hospital to family and friends; the cleanliness of the patient rooms; the noise level of the rooms at night; educating the patient about the medication before administering ; whether post discharge care and information was provided; how well the staff assisted in pain management of the patient; how attentive was the staff to the patient needs; physicians interactions; and nurses interactions.

Hospitals were evaluated by the Centers for Medicare and Medicaid Services (CMS) in proportion to the percentage of discharged patients who graded the hospital with a "high" rating, consisting of a score of 9 or 10; a "medium" rating with a score of 7 or 8; or a "low" rating of a 6 or lower. Patients who provided their hospital with a high rating varied from 12 percent to 94 percent; the patients that provided a medium rating fluctuated from 5 percent to 54 percent; the patients that provided a low rating varied from 0 percent to 75 percent. The hospital care intensity (HCI) index was utilized to indicate the total hospital visit time and the intensity of physician involvement while the patient was in the hospital. Wennberg et al. (2009) explains that the hospital care intensity was centered on two parameters: the number of days that the patient was hospitalized and the number of inpatient physician visits, in which the patient experienced.

The liaisons amid methods of technical process quality, methods of labor involvement, care intensity, and HCAHPS patient reports were explored using product-moment correlation analysis. Assessments were performed at the state, region, and hospital-restricted degrees of collection. The theory of patients residing in provinces with more aggressive form of inpatient care inclined to evaluate their experiences unsatisfactory. Simultaneously, the theory was validated in regards to patients residing in regions with docile care were more inclined to give their hospitals a low grade. The correlations amongst the HCI index and HCAHPS evaluations were also examined. The percentage of patients giving their hospitals a low inclusive rating of 6 or less on a scale from 0 to 10 varied from 3.8 percent to 29.8 percent. The second theory was validated by the findings of patients' grades of their hospitals and impartial measures of technical quality are correlated. Amongst districts, hospitals with poorer inclusive ratings by their patients also inclined to have poorer quality measures. -0.40 ($p<0.001$) was the correlation coefficient amid the 306 regions between the proportion of patients providing their hospitals with a negative inclusive rating and the CMS "Compare" composite quality score. Wennberg et al. (2009) state that patients hospitalized in provinces with greater inpatient care intensity inclined to grade their hospitals unsatisfactory for concrete reasons, such as unclean rooms and lack of communication with physicians and nurses.

Hospital-specific rates of early death or urgent readmission have been measured with consistently gathered data. From 2005 to 2010, all discharges in Ontario hospitals were recognized to determine whether a patient died or were immediately readmitted within 30 days. Readmission ratios shifted for age and gender displayed the lowest correlation (Spearman correlation coefficient 0.48-0.68). Hospital rankings centered on the different measures had an average range of 47.4 out of 162, with a standard deviation of 32.2). Prominent changes were revealed in death rates or urgent readmission within 30 days depended upon the level of adjustment for confounders and the unit of analysis. Insignificant changes in the techniques used to compute hospital-specific readmission rates affect their values and the consequent rankings of hospitals. Four separate measures were used to rank the hospitals: all admissions, adjusted for patient age and sex; a single admission per patient, adjusted for patient age and sex; all admissions, adjusted for all factors in the LACE + index; and a single admission per patient, adjusted for all factors in LACE + index. The relationship among the four measures was established, and the consequent rankings, using Spearman correlation coefficient. Walraven, Wong, Hawken, and Forster (2012) insist that consistent ranges were used to compute variation among and within the measures.

Motivated by the need to increase the lucidity of the U.S. healthcare system, hospitals confront emergent requirements to disclose performance data to the public. As a result, consumer-oriented web sites have been created to provide hospital ratings. Four websites were compared to measure the level of conformity in their rankings of local hospitals for four diagnoses. In August 2007 each hospital within a thirty-mile radius of Boston, Massachusetts was recognized. The investigation was focused on hospitals contending for consumers who would be in agreement with traveling an hour away to receive superior care. For each condition, all the hospitals were ranked within each database, using the assessments provided by that database. Rothberg, Morsi, Benjamin, Pekow, & Lindeaur (2008) state that the relationship amongst ratters for the equivalent diagnosis by Spearman rank correlations of hospital scores; Spearman correlations were also used to measure the relationship of ratings for diagnoses within each hospital.

There have been numerous practical involvements created to enhance emergency facility patient wait time and flow. Some of these represent enhancement plans to be used by emergency facilities wanting to decrease wait times. Willoughby, Chan, and Strenger (2010) state that Ng's research embraced method modifications such as identifying supplies and equipment, systematizing charts, and utilizing certain nurses to bring in a patient as soon as a bed was ready. There was a proposal to the solution of ambulance management in Attica, Greece. Derekenaris et al. (2001) state that this proposal was based on the combination of global system for mobile communication, geographic information system, and global positioning systems to assist in organizing and routing emergency vehicles to proper hospitals as well as provide medical care throughout the transporting to the hospital.

Studies have been performed regarding various hospitals in different regions in the United States. From 2002 to 2007, a study was conducted on hospitals in North Carolina, by Dr. Christopher Landrigan and an assistant professor at Harvard Medical School. Within the results of this investigation, it was not shocking to find patients injured and that the amount of occurrences did not diminish over time. Most of the usual injuries were impediments from procedures or medications and hospital-developed infections. Severe hemorrhaging during an operation, serious breathing complications from a procedure performed incorrectly, and a fall that dislodged a patient's hip and caused nerve damage are a few inevitable problems that were identified. Dr. Landrigan converged on North Carolina considering its hospitals, paralleled to those in most states, have been more engaged in programs to enrich patient well-being. Instead of enrichments, the researchers found an elevated rate of problems. The study examined records of 2,341 patients admitted to ten hospitals, both in rural and urban provinces and consisting of large and small medical centers. According to Leah Binder, an executive of the Leapfrog Group, every individual should have the ability to be aware of the infection rate of every hospital in their community and hospitals with poor scores should have repercussions (Grady, 2010).

Emergency facilities and hospitals epitomize a promising subject in which agent based modeling could be viewed as an efficient means of determining policy and enhancing competences. Laskowski and Mukhi (2008) state that one agent based model permits a replication of various emergency departments while presenting a technique of obtaining synchronized patient data from emergency facilities within a city permitting for the assessment of patient diversion policies. InQuicker.com was created as a resolution to assist focus in emergency room and urgent care facility congestion by reorganizing low-acuity patient traffic during the greatest hours spreading across a wider time period (Dennard, 2011) This web based service was created to enhance patient satisfaction by allowing patients with non-life threatening emergencies to reserve a spot at the emergency room online. The InQuicker system approximates treatment contingent upon traffic conditions.

Traffic accidents and other roadway occurrences have impacts on traffic functions in emergency situations, often congestion. Congestion may delay the traveler in route to an emergency facility. The North Carolina Department of Transportation (NCDOT) retains one of the largest public road systems in the country. North Carolina Department of Transportation’s traffic survey group is North Carolina’s main provider of traffic data. This traffic group's purpose is to supply the state of North Carolina with valuable traffic data. This data is supplied by using new testing and techniques of gathering data to support the functions, research activities, planning, building, layout, and up keeping required to control the North Carolina's transportation system. The AADT (Annual Average Daily Traffic) Volume Map is one of the Traffic Survey Products that consists of the volume of all lanes in both directions that pass a point on the highway system (“North Carolina Department of Transportation,” 2012).

NCDOT has various resources for anyone traveling the state’s highways. One resource is the Traveler Information Management System (TIMS). This system permits a user to search by accident, weather conditions, region, counties for road construction, and other events that may influence travel time. TIMS information is provided in real-time in major urban areas through live traffic surveillance devices and speed sensors. 511, the state of North Carolina’s toll-free travel information line that provides travel conditions over the phone (“North Carolina Department of Transportation,” 2012). In utilizing the TIMS, it shows the county chosen, the highway having traffic issues, which lane is closed, and traffic expectations to be aware of. Therefore using this system, a person on the way to an emergency facility can be aware of the traffic status to make necessary adjustments (if possible).

North Carolina Department of Transportation also has an Intelligent Transportation System (ITS) created to provide a unified and cutting-edge transportation infrastructure. The ITS integrates modern and developing computer and communication technologies with the purpose of refining traffic conditions, reducing delays and increasing safety for all travelers in the state. Lane control signs, traffic cameras, and ramp meters are used in harmony with lane control signs to provide synchronized traffic flow in urban areas. Traffic management and information devices is another category of the ITS, which consists of devices that operate 24 hours a day by providing travelers with current information on traffic and weather conditions, as well as construction. The devices consist of dynamic message signs, surveillance cameras, roadway weather information systems, and reversible lane systems. The dynamic message signs are placed above major highways, providing up-to-date traffic information and supporting law administration as a division of the Amber Alert System. The message signs provide awareness to travelers regarding occurrences, information on the occurrences, where the occurrences are taking place and what to expect. Dynamic message signs enhance safety and permits alternatives for travelers to take different routes. Closed circuit television camera surveillance permits observation and assessing of traffic conditions and confirming data to observe congestion. The Roadway Weather Information Systems (RWIS) consists of an assortment of roadway and atmospheric devices that observe and detect weather-related events that could affect highway traffic conditions. The reversible lane systems take full advantage of the highway use by modifying the direction of individual traffic lanes in regards to traffic demands.

3.1 Location-Based

Location-based services consist of a common division of computer program-level services utilized to incorporate particular constraints location and time data as control elements in computer programs. There is pertinent literature regarding location-based effects of social networking between people. Three areas of literature are being reviewed: the domain of social informatics, social informatics based on online social networking, location based services, location based social networking, and the third area is regarding trust and friendship. Fusco, Michael, and Michael (2010) explain that LBSN is the composite of LBS and OSN and therefore the literature on each of these technologies provides insight into core concepts related to location based social networking. One attribute of locative mobile social networks is that it permits users to view each other's location on a map on a mobile phone screen and connect with one another based on their distance in physical space. De Souza E Silva and Frith (2010) state that LBSs represent an attempt to commercialize location awareness-LBSs are typically commercial applications that are funded either through location aware advertisements, subscription fees or venture capital. Locative mobile social networking applications symbolize a particular type of LBS.

A significant mode of sharing information amongst Internet users is through online social networks. Within the past years, online social networks have developed into essential social happenings on the Internet. Li and Chen (2010) state that Facebook has more than 400 million active users and more than 25 billion pieces of content (web links, news stories, blog posts, notes, photo albums, etc.) shared each month. Sharing and networking around material is a key online social network feature, while recently various online social networks have presented open methods to permit their users to disclose location information.

Facebook has doubled its user base from January 2009 to January 2010, from 150 million to 350 million. As smartphones numbers grow, the integrated client software increases. The Blackberry Facebook client and the iPhone Facebook application are two examples of client software. Scipioni, Paolo, and Langheinrich (2010) state that several models already allow users to integrate their contacts from multiple SNSs (social networking sites) into a single phone book, linking not only their numbers, pictures, and birthdates; but also displaying people's status updates almost in real time. Considering the great quantity of sensors in mobile phones today really simplifies *fully automated* status updates, in which the phone separately publishes updates on the owner's activities. LinkedIn, MySpace, and Facebook are social computing applications that increase social connections through partnership and synchronization by allowing forceful and efficient online social relations. These functions guide a change from physical societies to virtual societies. Gupta, Kalra, Boston, and Borcea (2008) state that mobile social computing applications can take advantage of mobile computing algorithms, wireless technologies, and real-time location systems to help people re-connect with their physical communities and surroundings.

With location sharing applications, we currently see a change in location sharing to current methods of sharing with numerous people at a time. Twitter and Facebook propel for information sharing techniques. There are two types of location sharing analyzed: *purpose-driven* and *social-driven*. Tang, Lin, Hong, Siewiorek, and Sadeh (2010) observe that social-driven and purpose-driven sharing favored semantic location names, blurring of location information, and using location information to attract attention and boost self-presentation. Location sharing applications have been grouped into four categories: users who primarily support sharing location with one person, with a small group of people, with a large group of people, or with everyone.

The vision of Location-based Services 2.0 allows users to create important location-based material and consequential location-aware communication with the system and users. Mokbel, Bao, Eldawy, Levandoski, and Sarwat (2011) state that there are two ways to look at LBS 2.0, either as embedding location-awareness into existing Web 2.0 infrastructures, or embedding Web 2.0 functionality inside the core of existing location-based services. The location-based 2.0 takes the method of making use of the existing Web 2.0, therefore forming an already-flourishing infrastructure. The three aspects are: personalization- more personalized inquiries to evaluate location-based queries; socialization- incorporating location-awareness into the social network functionality, and recommendations-embracing existing recommendation methods to consider the spatial aspects.

Li and Chen (2010) states that these location-based OSNs (LSNs) enable users to see where their friends are, to generate or search location-tagged content within their social network, and to meet others nearby who may have the same interests.. Actually, various online social networks deliver methods to enable sharing of users' locations, which has excelled in reputation due to the development of smartphones with GPS capabilities. Li and Chen (2010) also states that a recent study shows that the social network sites are among the top mobile Web destinations, and it is expected that LSN services will attract 82 million subscribers and reach $3.3 billion revenues by 2013.

A few location-based social networks are Dodgeball, Brightkite, Loopt, Foursquare. Gowalla, and Google Latitude. Dodgeball was founded in 2002 by Dennies Crowley and Alex Rainert, and happens to be one of the first location-based social networks. Dodgeball functioned by depending on short message service to permit users to “check in” at locations within cities, revealing their exact location. Bridgekite started in 2005 and allowed users to publicize and share updates via text (restricted up to 140 characters), through a picture or broadcasting their location. Loopt was also founded in 2005 and supplied a map view of the user’s existing locale and proximate friends, events, or places, symbolized by pins on the map. Foursquare, founded in 2009 by the Dodgeball founders, allowed users to make check-ins at locations, where they could score points and “badges.” Gowalla, launched in 2009, also allowed a user to check-in to disclose their location and have the chance to receive virtual items and also earn points. Lastly, Google Latitude, launched in 2009, provided simple functions where the Latitude automatically depicted the user’s location and discloses it among friends. Barkhuus et al. (2008) states ‘Connecto’ is an always on, location tagging and sharing application that allows groups of friends to ‘tag’ locations using a standard Windows Mobile phone Connecto records every user’s status and location to a group while increasing the standard contact view. By doing this, Connecto maintains the sharing and location in an understated way by automatically connecting location and status with no user interaction.

Gowalla, Facebook Places, and Foursquare are all location sharing services that support millions of user-driven footprints such as “checkins”. Cheng, Caverlee, Lee, and Sui (2011) state that those global-scale footprints provide a unique opportunity to study the social and temporal characteristics of how people use these services and to model patterns of human mobility, which are significant factors for the design of future mobile + location-based services, traffic forecasting, urban planning, as well as epidemiological models of disease spread. The responsibility of environmental and locale in online social networks has lately invited more attention.

Foursquare is utilized as a paradigm to examine the exposure in location-based social networking. The objective is to increase recognition of location cheating and recommend potential resolutions to propel the achievements of the business prototype amongst users, service providers, and registered locations. Location cheating is when a user states that he or she is existence in a particular location which is many miles away from the authentic locale, thus misleading the service provider on location information. He, Liu, and Ren (2011) states that even if defending mechanisms like cheater code are deployed, the loosely regulated anti-cheating rules still leave space for location cheaters.

Li and Chen (2009) explain that Location-based Social Networks (LSNs) have also emerged to allow users to see where their friends are, to search location-tagged content within their social graph, and to meet others nearby. Sharing ideas, events, pictures and other information with acquaintances to boost their connections is permitted by the user of online social networks. This is often referred to as status updates. He, Lui, and Ren (2011) state that the service providers offer virtual or real-world rewards to a user if he or she checks in at a certain *venue* (i.e., places like coffee shops, restaurants, shopping malls) as a way to encourage the use of location-based social network services. Li and Chen (2009) state that LSNs take a step further to allow users to share her location, which can be broadcast to her friends or be used to tag her other shared content.

It seems as if mobile users rarely call people anymore because text messaging is so popular in society today. Two of the most common text messages sent are “where are you?” and “what are you doing?” GPS, microphones, and cameras help in answering these questions as well. Mobile phones are able to create mobile sensor networks that have the ability to sense information such as where a person is or exactly what they are doing. People sensing is propelling a new application area that focuses on people conveying sensing devices. Miluzzo et al. (2008) state that the sensing of people is driving a new application domain that goes beyond the sensor networks community's existing focus on environmental and infrastructure monitoring, where people are now the carriers of sensing devices, and the sources and consumers of sensed events.

3.2 Social-Media Based

Social web sites are defined as Web sites that allow people to create online communities, and share user-created contents (UCCs). The people may consist of open Internet users, the community could be a network of acquaintances, and the UCC may consist of pictures, videos, user profiles, etc. There are four aspects of social web sites believed to serve as a framework for comprehending the status and future of social Web sites. Kim, Jeong, and Lee (2010) state that the four aspects are taxonomy of social Web sites, taxonomy of their essential features, taxonomy of the uses and benefits of social Web sites, taxonomy of the issues and challenges facing the sites, and a prognosis of how the sites are likely to evolve in the near future.

Marcia and Monne (2009) state a social network provides a variety of mechanisms for users to share date with other users Mobile social networking references to transmitting the existing trends in social networking to mobile devices, while including new characteristics. Some features of the mobile social networking are positioning, friend locator, update personal status, and advertising. The personal status update feature allows a user to give status updates, such as their location, what music they are listening to, etc.).

Social network sites (SNSs) have the ability to profoundly modify the originality of our social lives, both on a personal and a community level. The extreme users of social networking sites are young people, where there are modifications in relation patterns and social connections.

Pre-social network site times, people depended on communication techniques like personal gossip and newsletters to keep abreast of the latest happenings, friends, distant relatives, and even former co-workers. Ellison, Lampe, and Steinfield (2009) state that through status updates and feeds, SNSs enable individuals to broadcast both major life changes and ephemeral activities to their broad network, allowing others to engage in lightweight social surveillance.

An innovative foundation of social network data is produced as businesses and establishments embrace social media tools like video sharing, blogs, photo sharing, message boards, wikis, and friend networks. These social media tools function as thorough accounts of social networks, providing plans of the structure of social relations within an establishment. Smith, Hansen, and Gleave (2009) state that while social networks have always existed in human institutions, only recently have such richly detailed networks been made available in machine readable format as a natural byproduct of interaction between people and their artifacts. Removing, administering, and evaluating these networks can disclose significant outlines in the structure and changing aspects of the organizations that accept these tools. Smith et al. (2009) state that network analysis is a set of methods for calculating measures that describe a population of “nodes” (representing people and other entities) and their “edges” or relationships to one another. These metrics can define the general shape, size, location, and relationship outline of each connection in the network.

The collective innovations of open mobile platforms and online social networking applications (SNAs) are propelling ubiquitous computing to the actual users, as the mobile social networking applications are presumed to transform wireless application industry. Even though sharing location by the means of social networking applications is effective for data access and user relations, privacy concerns must be tackled at the design point of mobile social networking applications. The recent developments on mobile devices and social networking applications are constantly and rapidly uniting, fast-tracking the transformation of credible computing from imagination to actuality. Chen and Rahman (2008) state that the open mobile platforms, particularly Apple iPhone and Google Android, make it much easier than before for developers to build third-party applications that may potentially be used by millions of people on their always-on always-carried mobile devices.

There are plenty of online social network users who are content with utilizing the advantages and fun of these networks, but may want to restrain access to their sensitive and personal information not just from other unknown individuals, but also from "big brothers." This alienated community is presumed to be the embracers of social networks which depend on a peer-to-peer infrastructure and encryption.

The prospect of Internet usage has diverged tremendously in the latest years, by the means of computer network connection interactions as well as the end-users interaction with computers consisting of the Internet with each other. Buchegger and Datta (2009) explain that on the networking layer, infused by the (somewhat infamous) success of P2P file-swapping software, the last decade has witnessed an increased emphasis of using resources available at the edge to perform tasks which would otherwise have heavily burdened any centralized infrastructure. Therefore, there happens to be increased expansions of peer-to-peer methods to displace or enrich the clients-server paradigm. Buchegger and Datta (2009) state that on the application layer, with the advent of Web 2.0 and social networks, we witness end users participating not only as passive consumers of content provided by the web-sites (client/server), but also as a contributor creating content collaboratively with fellow users. Although, contradictory speaking, the recent Web 2.0 applications depend on a primitive infrastructure derived from the conventional client-server model.

Tsai, Han, Xu, Chua (2009) states a P2P configuration refers to a network of peers using proper information and communication systems, in which two or more individuals are able to spontaneously communicate without any central coordination. As an outcome, a P2P network depends on computing control instead of the actual network. A P2P infrastructure proposed conditions that a client-server does not. An advantage of a peer-to-peer infrastructure is that it is not centralized. The central storage of sensitive information and proprietorship by a business increases privacy issues that could be approached by a peer-to-peer method, with encryption and proper administration. MAgNet is a middleware based on software agent technology that allows social networking services for users in the mobile network domain. (Basuga et al. (2009) state that due to the nature of mobile phones, their status as one of the most personal items user can have, they present an ideal platform for implementation and development of SNSs. MAgNet middleware services can be split into two groups: developing and administering user groups and planning group events.

Smith, Hansen, and Gleave (2009) state that the ability to identify individuals within an organization with particular network properties can be applied to improve enterprise search applications, provide better reporting and ranking services, and can be used to guide management by producing reports on the rates of internal connection within and across groups in an organization. Social network analysis has a historical background and relations to business and establishment studies. Primitive social network information was developed on physical gatherings and managed data regarding social bonds. Researchers would usually examine or assess business members asking for a deviation of responsibilities and purposes. Smith, Hansen, and Gleave (2009) state the prohibitive cost of this approach was a major limiting factor in the widespread application of social network analysis in enterprises and organizations.

The connection amongst location based services, online social networking, and location-based social networking reveals a highly researched area mainly because of its freshness to the information and communication technology field. Zheng, Chen, Xie, Ma (2009) explain that the increasing popularity of location-acquisition technologies, such as GPS and GSM networks enable people to conveniently log the location histories they have visited with spatial-temporal data. These real-time histories entail user's interests and bring chances to grasp the connection between users and locations. In searching a user's location history, then the system is able to help people automatically find potential acquaintances in a GIS community. The framework, HGSM, hierarchical-graph-based similarity measurement is recommended to consistently form each user's location history. There are three factors considered in this framework: the chronological order of people's movement behaviors, the most common geospatial regions, and the chain of command of geographic spaces. An overview of the architecture of the potential system consists of the location history depiction, similar user journeys, and location suggestions.

It is projected that location-based social networking will create $3.4 billion by 2013. Usually there are two forms of usage patterns for social networks; one is to permit users to increase their relations with current friends (i.e. sharing their activities) via status updates. As far as the location-based mobile social networking users, they are able to share their existing statuses with the mobile device's localization capability. Li and Chen (2009) state that location-based MSNs make it possible to select potential new friends based on geographic proximity, so it is more likely that they can meet in person.

Iachello, Smith, Consolvo, Chen, and Abowd (2005) state that there has been an interest in proposing mobile Information Technology applications to simplify daily social communications. These social mobile applications would contain accessible managers, people locaters, and text messaging services. These types of applications are extensively reflected to consume a compelling commercial ability, particularly with young age groups. A few motives for the hesitant embracing of the acceptance of social location disclosure applications are privacy issues, controlling hindrances, and technical problems. When accessing adoption patterns of application evaluations, there are numerous interconnected social implications to take into consideration. There has been research conducted to fabricate parameters for improving security and privacy in mobile computing, based around different executions of the Fair Information Practices (FIPS). There have been surveys performed to determine the basis and motive of users disclosing their information considering privacy issues at hand. Research has also been conducted regarding environmental privacy in connection to mobile phones and usage frameworks.

Researchers are continuing to study the attributes and growth of online social networks, as well as how online social network users disclose personal information using application and advertisers. Research is also being performed to depict privacy issues with online social networks.

3.3 Privacy Issues/Concerns

With the growing number of users of online social networks (OSNs), there are new and substantial increased privacy disclosure concerns. Most online social network users are able to convey a large portion of their actions on online social networks while considerably decreasing the volume of private data that is accessible to others. Various works has been performed regarding the privacy and unknown field on conventional Web sites related problems. In OSNs, it is easier to obtain different pieces of information that can be collaborated with outside information to identify a person. Considering the current extensive endeavors to have medical records online, such matters are definitely influenced (Krishnamurthy and Willis, 2008).

Privacy concerns are raised when it comes to sharing user information in online social networks. Chen and Rahman (2008) state that location-sharing is the key to enable many interesting LSN features, while its privacy implication is significant. The majority of location-based social networks supply user with controls to shield their location updates, such as immobilizing live tracking and signing-in at the user’s discretion. Barkhuus et al. (2008) observed motives as to why individuals would want to wear location-tracking devices. Two of his studies specified users’ privacy disputes decreasing when using location-based services. Iachello et al. (2005) evaluates which elements are most essential for a user to be inclined to reveal their location. Chen and Rahman (2008) state that developers have designed and evaluated privacy mechanisms for an instant messaging application that allows users to share their location and other contextual information.

Safeguarding privacy in ubiquitous computing is a significant topic and has been studied meticulously. Chen and Rahman (2008) insist that researchers most commonly performed two categories of privacy analyses: one is to create probability paradigms and offer standards on noble privacy designs, and the other is to perform user analyses with actual applications. The first privacy wizard is anticipated for social networking sites. Fang and LeFevre (2010) explain that the goal of a privacy wizard is to automatically configure a user’s privacy settings using only a small amount of effort from the user. The execution and design of an appropriate wizard poses numerous complex challenges. Fang and LeFevre (2010) state that the privacy wizard should gratify these obligations: perceptible data, low effort, and elevated precision, graceful degradation, and augmentations. The sample wizard is centered on an active learning concept.

The location-based social network manager process consists of execution on a server computer joined to a multitude of mobile communication devices over a wireless network. Various mobile devices are location-aware mobile communication gadgets. Altman, Sivo, Tana, Knapp (2008) state the process determines the geographic location of a mobile communication device operated by a user within an area, displays a map representation of the area around the mobile communication device on a graphical user interface of the mobile communication device, and superimposes on the map the respective locations of one or more other users of mobile communication devices coupled to the mobile communication device over the network. Considering the convenience of open mobile platforms, it is to be anticipated that people will progressively use social networking applications on their mobile phones. While locations are capable of discovering and networking with proximate happenings, businesses, and acquaintances, privacy disputes continue as a substantial design encounter for mobile social networking applications. The privacy designs for 31 mobile social networking applications registered in the Apple App Store were examined. For this particular study, Bellotti and Sellen's *feedback* and *control* framework was used. Chen and Rahman (2008) state that they have detected that privacy designs for information constructions and accessibility are particularly weak for many mobile SNAs, and we identified two unexpected privacy violations and suggest three misuse scenarios.

The framework reflects four elements concerning data flow: capture, construction, accessibility, and purpose. Most surveyed iPhones inquired permission to obtain current locality. This type of feedback method informs users of when their locale is depicted. Chen and Rahman

(2008) explain that Loopt, Graffitio, and Twinkle seem to automatically acquire location at startup with a short message showing on the status bar. As far as the construction, what happens to the users' data once it has been gathered is dependent upon separate applications. As more social networking applications are smashed together, data flow becomes more complex and refined. Regarding applications that share content, accessibility becomes problematic to track as user's statuses proliferate through different social networking application sites, on which a user may exhibit various friends and hence various access guidelines. Chen and Rahman (2008) state that existing mobile SNAs have various feedback and control mechanisms over capturing user location, although most locations acquisitions policies are quite simple. In regards to purpose, users are only able to implement social restraints to confine immoral and prohibited handling of their personal information.

Flick has been studied to determine how locale information of a user is revealed through the user's photographs. Baden, Bender, Spring, Bhattacharjee, and Starin (2009) explain that Persona resolves these issues by allowing users to precisely express the policies under which their data, including friend information, is encrypted and stored. A few research proposals to provide solutions in privacy issues of online social networks are NOYB and flyByNight. Baden et al. (2009) explain that the NOYB hides an online social network user's personal data by swapping it with data "atoms" of other online social network users. FlyByNight expedites protected messages between users.

There are a number of mobile applications that have surfaced that allows user to find one another. On the other hand people have voiced concerns regarding privacy allusions dealing with this type of software, recommending that wide spread acceptances may occur when these issues are properly focused on. Sadeh et al. (2008) state that the objective of our work has been to better understand people's attitudes and behaviors towards privacy as they interact with such an application, and to explore technologies that empower users to more effectively and efficiently specify their privacy preferences (or "policies").

Voong and Beale (2008) explain that controlling location disclosure is a salient issue in these systems as they reach out to more than just close friends; people become more self-conscious of how their location is perceived by the systems and others. Location sharing brings about privacy issues as information conveys between service providers and users. Representing location is trying to imagine personal signals to decrease privacy concerns by considering existing social activities of location sharing into designs.

There has been research conducted to fabricate parameters for improving security and privacy in mobile computing, based around different executions of the Fair Information Practices (FIPS). There have been surveys performed to determine the basis and motive of users disclosing their information considering privacy issues at hand. Research has also been conducted regarding environmental privacy in connection to mobile phones and usage frameworks. Cheating on location disclosure comes as no surprise in location sharing and reveals that online social network users are receptive to disclosing their location, while also being misleading.

Examining mobile privacy obliges an open mind and a differentiated method which should incorporate users' activities, instinctive behavior, and communication processes as they are occurring. In the case of evaluating privacy, there are numerous impediments to examine. Mancini et al. (2009) state that if participants perceive the presence of the observing agent, they are very likely to react to what effectively constitutes an intrusion of privacy by altering their behavior.

3.4 Path Optimization

Simple path optimization is a technique for optimizing limit functions transpiring in stochastic modeling problems. Simple path optimization is associated with reflective optimization methods and to M-estimation. A technique is analyzed for reducing a function X_∞ that is an almost guaranteed limit of a calculable arrangement of random functions X_n. A normal case of the type of problem is reduction of a steady-state (limit) function in mockup. In this case the X_n could be outputs of a mockup run reduced at numerous lengths n; from examining these, and making appropriate calculations with them, the outcome is to estimate an optimizer of X_∞. The technique in sample-path optimization is to enhance, for a fixed ω and a fixed n, the defined function $X_n(\omega, .)$. One of the forces of sample-path optimization is when working with the defined function $X_n(\omega, .)$, it can be produced to bear the huge and potent assortment of defined optimization techniques that have been created in the last half-era. Specifically, problems concerning parameters could be dependent on complex restrictions, and therefore wherein gradient-step techniques like stochastic approximation may have complications (Robinson, 1996).

The technique of proposing optimizing convex performance functions in stochastic systems has also been examined. The functions can consist of anticipated execution in static systems and steady-state performance in separate-event active systems. This technique is closely connected to reflective simulation optimization, in the case that it seems to overpower some restrictions of stochastic estimation. This technique was proposed with the intentions of optimizing curved, rough performance functions in specific stochastic systems. The condition to be optimized can be an anticipated value in a static system, or a constant-state performance in an active system, wherein normal performance along a sample course of the system will join with likelihood one. Systems in which such functions occur and follow specific limitations are considered. It is common in various stochastic systems in which their execution functions are unable to be expressed diagnostically. In this case, people utilize Monte Carlo mockup to assess them. A major setback to the standard stochastic estimation technique is inequality restrictions. These restrictions bestow complications considering the essential gradient incline method has to then be altered in some impromptu style so that the order of parameter values continue to be likely. These complications do not occur with linear equation restrictions considering one can lessen such a challenge to an unrestricted challenge in lesser parameters by a suitable conversion. The proposed technique of sample path optimization seems to elude these complications. Sample path optimization makes use of the function that is desired to optimize is actually the limit, amongst nearly every sample course of an order of estimating functions (yielding mockup runs of expanding lengths, all utilizing the equivalent random number course (s). Plambeck, Fu, Robinson, and Suri (1996) state that the simple concept is to go out far enough along the sample path to have a sufficient approximation of the limit function, and then to optimize the following deterministic function by the best effective technique available, taking the outcome as a guesstimate of the limit function.

Previous research shows that chemical processes formed by constant-state simulators could be optimized without having to reprise the process simulation. As an alternative, optimization and replication of the flow sheet can be executed at the same time, along a viable path, consequently leading to more effective performance. Considering recycle convergence and optimization transpires together, the results of algorithmic malfunction can be critical, while there is a small amount of beneficial information to be retrieved. At this point, the expansion of various elements that could influence the effectiveness and strength of the continual quadratic programming optimization algorithm are taken into consideration. The key consideration is the computation of the goal and restriction along with their gradients from the segments in the process flow sheet. Lang and Biegler (1987) explain that the optimization algorithm has to be effective and strong in order to keep information.

Another approach has been taken regarding path optimization, probabilistic roadmap construction for path planning. The innovative element of the planner was that it utilized a strong local planner to create joined roadmaps and path optimization to sustain the swift query processing by means of a quick local operator. Even though preceding methods obtained suitable roadmaps by improved testing methods, the existing method focused on the technique used to gather the samples. Experimental findings revealed that the new technique overtakes the more conventional approach of using quick local planners who are capable of yielding roadmaps with only limited joined elements. Statistical assessment is utilized to recognize characteristics fundamental for the effectiveness of the local planners. The calculation of a crash-free path for a set or connected object amid complications is a significant, yet a difficult computational problem. Some engineering applications, such as spot welding and riveting demand a huge amount of courses in a constant or slowly changing environment.

The probabilistic roadmap (PRM) is a two stage path planning method. The initial stage creates a probabilistic estimation of the joining of the crash-free formation space in the form of a graph. After the graph is formed, queries can respond by joining the beginning and goal configurations to the roadmap graph and examining the roadmap for an answer. In the case of queries not being compelled to pass through confined passages, there have been hypothetical examinations and tests to show that the PRM method can be effective. The outcome signifies that utilizing strong local planners should contribute to solving the confined passage problem (Isto, 2002).

CHAPTER 4

Proposed Mathematical Model to Rank Emergency Hospitals and Identify Associations between Parameters

4.1 Mathematical Model to Calculate Ranking

We propose a mathematical model, which can be used to analyze the optimization travel time to an emergency facility. As said earlier in this thesis, the travel time to an emergency facility along with the wait times and average treatment times is not promising to the patient. It is also not a concept that is very well understood to patients and non-patients, for that matter. It may be better to understand if one can devise a score based on different parameters of the optimization travel time. We suggest the following mathematical model to evaluate the optimization travel time, and provide a low score.

The model can be used to acquire a tool for individual users to identify the optimization travel time to an emergency facility according to patient wait time, service time, time to reach the hospital, review rating, and patient perception. The optimization travel time may have various effects on different users depending on the urgency of the treatment needed. A traffic delay is a major notable problem in transportation networks and constantly needs reassessing and revamping. In the technology ruling world today, traffic methods to alleviate congestions are typically based upon the idea of utilizing the present communication with information technology developments, something similar to intelligent transportation systems. Panahi and Delavar (2008) state that traffic delays and jams are major explanations that influences the travel time of emergency vehicles.

A way for road users and emergency vehicles to mollify this problem is to commence to active direction-finding to reach their emergency facility destination. The quickest path issue will be locating the path with the least distance or time from one place to the destination, which happens to be an essential problem in system models.

We propose a mathematical model, which can be used to determine the final ranking of emergency facilities by assigning weights to different parameters. We need to design a score based upon various characteristics of the emergency facilities. We propose the following mathematical model to analyze the hospital ranking and provide a result in the scope of 1 to 10. Higher numerical results will give the suggestion of an ineffective hospital ranking.

Let us presume that there n types ($v_1, v_2, \ldots v_n$), which are significant to be incorporated in determining the hospital rank. Each type has to be assigned a proper weight. In our paradigm, we take into account that the types are independent; however it is probable that more than one type may have some type of intrinsic connection with each other. For that reason, it is imperative that this connection be depicted while recognizing various types in the hospital ranking. In the present paradigm, the detection of the connection amid different types has not been considered.

The hospital ranking then can be depicted using the following equation:

$$Hr(v_1 v_2, \ldots vn) = w_1 * hr(v_1) + w_2 * hr(v_2) + \ldots . w_n * hr(v_n)$$

where $hr(v_i)$ is a function of a certain parameter v_i and w_i is the weight assigned to *i*th parameter. In an easy scenario, $hr(v_i)$, can have the value 1 and w_i is assigned a weight factor contingent upon the significance of the parameter in the perspective of the hospital ranking. The total of all the weights cannot surpass the value 1.0.

4.2 Identifying Correlations between Parameters

Correlation is a statistical method that is used to compute and describe the intensity and direction of the relationship amongst two parameters. The parameters were assessed to determine if there was any or significant correlations amid any two given parameters. In determining the best quality health care, the correlations amongst the five parameters have to be evaluated to further ensure quality treatment and care. The purpose of the quantitative, correlational assessments was to determine a relationship between health care ratings and time measurements associated with the visit (wait time, service time, and time to reach the hospital). The technique for the study was appropriate considering it recognized a relationship between two parameters; even though five parameters were evaluated interchangeably.

The Pearson correlation coefficient is a computation of the strength of a linear connection between two parameters and is symbolized by r. Typically, a Pearson product-moment correlation makes an effort to draw a line of best fit through the data of two parameters, and the Pearson correlation coefficient, r, implies how far away all these data points are to this line of best fit.

The Pearson correlation coefficient, r, can fluctuate from values of +1 to -1. A value of 0 denotes that there is no connection between the two parameters. A value greater than 0 denotes that there is no positive connection considering the value of one parameter increases, just as the value of the other parameter. A negative connection is denoted by a value of less than 0. In this case, as one parameter's value increases, the other parameter's value decreases. We estimated the correlation between two parameters, such as wait time and review rating by using the correlation coefficient formula: $\boldsymbol{r} = \frac{\boldsymbol{cov}\,(\boldsymbol{y},\boldsymbol{x})}{\overline{\boldsymbol{var}\ \ \boldsymbol{y}\ *\boldsymbol{var}\ \ \boldsymbol{x}}}$

cov (y,x) = the covariance of y and x

var (x) = the variance of x

var (y) = the variance of y

CHAPTER 5

Mathematical Analysis and Explanation of Scoring Model and Association between Parameters

5.1 Data Used

In this chapter, we provide mathematical analysis of the proposed scoring model as described in chapter four. We also establish the association between different parameters which are used to calculate the scores of emergency hospitals. We compare twelve hospitals in North Carolina within a thirty mile radius of each other. We used the following data to conduct mathematical analysis.

- Greenville: six hospitals within a thirty mile radius of each other
- Raleigh: three hospitals within a thirty mile radius of each other
- Greensboro: three hospitals within a thirty mile radius of each other

Public data was used to calculate rankings wherever possible for all three hospitals. The following parameters are used to calculate the ranking:

- **Wait time (v_1):** how long the patient waits to be seen by a physician (in minutes).
- **Service time (v_2):** average time that it takes for a patient to be treated by a physician until the patient is discharged (in minutes).
- **Time to reach the hospital (v_3):** the distance to the hospital from the patient's location (in miles). A specific address of a fictional patient was used to measure this value.
- **Patient reviews (v_4):** patients' shared experiences and opinions of their hospital visit at (on a scale of 1 to 10, where 1 being the best and 10 being the worst).

- **Patient perception (v_5):** overall results regarding how the patient feels after the visit (on a scale of 1 to 10, where 1 being the best and 10 being the worst).

A balanced scorecard approach was used, based on public data downloaded from various centers and websites, such as Healthgrades. Hospitals willingly report their data, and in some cases hospitals do not provide data for some topics or measures. The hospital scores from the patient's perceptions have been converted from the Healthgrades percentages. With the hospitals in comparison, the hospitals are ranked according to the performance parameters independently, in relation to other hospitals in the surrounding geographical area. Each parameter is assigned a weight for use in overall ranking. Each hospital's parameter is computed to reach a total score for the hospitals. The hospitals are ranked according to their final calculated scores.

To calculate the hospital ranking amount, the specific weight of each individual hospital is multiplied by the parameter of each of the six hospitals mean summed together and then divided by the standard deviation of the specific parameter. In table 1, we take each parameter of the given hospital and subtract it from the mean of the total of that parameter for all six hospitals, and divide it by the standard deviation of that parameter. In table 2, we take the weight of each specific parameter and multiply the parameter's total amount and then we add the next parameter's total amount of that next parameter and so forth for that particular hospital until all parameters of that parameter have been totaled to obtain the ranking for each hospital. Afterwards, the score of all the hospitals are ranked from low to high. Low score represent high ranking, whereas higher score represent low ranking.

5.2 Mathematical Analysis

We provide the calculations using the data of the hospitals.

5.2.1 Ranking emergency hospital.

Greenville, NC Hospitals

Table 1

Greenville, NC data

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1
Hospital 1	30	30	0.9	5	2.2
Hospital 2	20	10	24.9	2	3.6
Hospital 3	40	20	23.7	1	4.2
Hospital 4	50	15	22.8	1	2.1
Hospital 5	25	15	36.6	4	1.7
Hospital 6	10	40	20.5	8	10

Table 2

Greenville, NC ranking

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1
Hospital 1	0.058321	0.740436	-1.78342	0.547723	-0.56822
Hospital 2	-0.64153	-1.03661	0.287649	-0.54772	-0.11793
Hospital 3	0.758175	-0.14809	0.184095	-0.91287	0.075048
Hospital 4	1.45803	-0.59235	0.10643	-0.91287	-0.60038
Hospital 5	-0.29161	-0.59235	1.297295	0.182574	-0.72904

Table 2

(cont.)

Hospital 6	-1.34139	1.628959	-0.09205	1.643168	1.940524	
Hospital ranking	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5	Hospital 6
	1-Best	2	4	3	5	6-Worst

In Table 1, there are five parameters which consist of the parameters of wait time at the hospital (v_1), average service time for a patient (v_2), time to reach the hospital (v_3), review rating of hospital on a scale from 1 to 10 (v_4), and patient perception on a scale from 1 to 10 (v_5). For instance, hospital 1 has a thirty minute wait time at the hospital (v_1), thirty minute average service time for a patient (v_2), while its 0.9 miles away to reach this hospital (v_3), with a review rating of five (v_4), and a patient perception of 2.2 on a scale of 1 to 10 (v_5). All of the five parameters have equal value or weight. The sum of all weights should equal 1. Each parameter has been assigned a value or weight. In table 1, the time to reach the hospital (v_3) is more important than the average service time for a patient (v_2). The time to reach the hospital (v_3) is shown with a weight of 0.4, whereas average service time for a patient (v_2) holds a weight of 0.3. While table 1 does not contain normalized data, table 2 on the other hand, does contain normalized data. Normalized data is created by using the following equation:

Standard score = (data value – mean) / standard deviation.

Using our data in tables 1 and 2, we can calculate the ranking for all of the six hospitals.

Ranking (H1) =0.1* 0.058321 + 0.3*0.740436 + 0.4*-1.78342 + 0.1*0.547723 +0.1*-0.56822 is -0.48746

Ranking (H2) = 0.1*0.058321 + 0.3*0.740436 + 0.4*-1.78342 + 0.1*0.547723 + 0.1*-0.56822 is -0.32664.

Ranking (H3) = 0.1*-0.64153 + 0.3*-0.14809 + 0.4*0.184095 + 0.1*-0.91287 + 0.1*0.075048 is 0.021247.

Ranking (H4) = 0.1*1.45803 + 0.3*-0.59235 + 0.4*0.10643 + 0.1*-0.91287 + 0.1*-0.60038 is -0.14066.

Ranking (H5) =0.1*-0.29161 + 0.3*-0.59235 + 0.4*1.297295 + 0.1*0.182574 + 0.1*-0.72904 is 0.257407.

Ranking (H6) = 0.1*-1.34139 + 0.3*1.628959 + 0.4*-0.09205 + 0.1*1.643168 + 0.1*1.940524 is 0.676099.

According to the data above, we can say that hospital 1 is the best hospital to go to in case of an emergency for the hospitals in Greenville, North Carolina and surrounding areas. The next hospital in line would be hospital 2, hospital 4, hospital 3, hospital 5, and hospital 6 would be the least hospital to choose in an emergency. Hospital 1 has a 30 minute wait time (v_1), 30 minute average service time (v_2), located 0.9 miles from Greenville, NC (v_3), with a review rating of 5 on a scale from 1 to 10 (v_4), and patient perception of 2.2 on a scale from 1 to 10 (v_5). In comparison to hospital 1, hospital 6 has a 10 minute wait time (v_1), 40 minute average service time (v_2), and located 20.5 miles from Greenville, North Carolina (v_3), with a review rating of 8 (v_4), and patient perception of 10 on a scale from 1 to 10 (v_5). The estimated mileage to reach the hospital (v_3) and the patient perception (v_5) is real data. Synthetic data is used when real data was not applicable from these hospitals located within a thirty mile radius of Greenville, North Carolina.

Table 3

Raleigh, NC hospitals

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1
Hospital 1	30	25	9.4	5	2.7
Hospital 2	20	15	4.3	2	2.8

Table 3

(cont.)

Hospital 3	26	35	4	1	2.8

Table 4

Raleigh, NC ranking

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1
Hospital 1	0.927173	0	1.153289	-1.1547	0.550653
Hospital 2	-1.05963	-1	-0.52722	0.57735	-0.59114
Hospital 3	0.132453	1	-0.62607	-0.80064	0.57735
Hospital rank	Hospital 1	Hospital 2	Hospital 3		
	3-Worst	1-Best	2		

In table 3, there are five parameters which consist of the parameters of wait time at the hospital (v_1), average service time for a patient (v_2), time to reach the hospital (v_3), review rating of hospital on a scale from 1 to 10 (v_4), and patient perception (v_5) on a scale from 1 to 10 for three hospitals within a thirty mile radius of Raleigh, North Carolina. For instance, hospital 1 has a thirty minute wait time at the hospital (v_1), twenty-five minute average service time (v_2), while its 9.4 miles away to reach this hospital (v_3), with a review rating of five (v_4), and a patient perception of 2.7 on a scale of 1-10 (v_5). All of the five parameters have equal value or weight. The sum of all weights should equal 1. Each parameter has been assigned a value or weight. In Table three, the time to reach the hospital(v_3) is more important than the average service time for a patient (v_2). This is shown considering the time to reach the hospital (v_3) is shown with a weight of 0.4, whereas average service time for a patient holds a weight of 0.3.

Ranking (H1) =0.1* 0.927173 + 0.3*0 + 0.4*1.153289 + 0.1*1.120897 +0.1*-1.1547 is 0.550653.

Ranking (H2) = 0.1*-1.05963 + 0.3*-1 + 0.4*-0.52722 + 0.1*-0.32026 + 0.1*0.57735 is 0.59114.

Ranking (H3) = 0.1*0.132453 + 0.3*1 + 0.4*-0.62607 + 0.1*-0.80064 + 0.1*0.57735 is 0.040488.

Judging from the data, we can say that hospital 3 is the best hospital to go to in case of an emergency for the hospitals in Raleigh, North Carolina. The next hospital in line would be hospital 1, and hospital 2 would be the least hospital to choose in an emergency. Hospital 3 has a 26 minute wait time (w_1), 35 minute average service time (v_2), located 4 miles from Raleigh, NC (v_3), with a review rating of 1 on a scale from 1 to 10 (v_4), and patient perception of 2.8 on a scale from 1 to 10 (v_5). In comparison to hospital 3, hospital 2 has a 20 minute wait time (v_1), 15 minute average service time (v_2), and a 4.3 mile travel time from Raleigh, NC (v_3), with a review rating of 2 (v_4), and patient perception of 2.8 on a scale from 1 to 10 (v_5). Hospital 1 wait time (v_1) is real data. The estimated mileage to reach the hospital (v_3) and the patient perception (v_5) is real data. Synthetic data is used when real data was not applicable from these hospitals located within a thirty mile radius of Raleigh, North Carolina.

Table 5

Greensboro, NC hospitals

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1

Table 5

(cont.)

Hospital 1	30	17	5	9	3
Hospital 2	20	15	22.5	10	2.7
Hospital 3	25	15	13	9	2.8

Table 6

Greensboro, NC ranking

Parameter	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5
Weight	0.1	0.3	0.4	0.1	0.1
Hospital 1	1	-0.37796	-0.97024	-0.57735	1.091089
Hospital 2	-1	-0.75593	1.027314	1.154701	-0.87287
Hospital 3	0	1.133893	-0.05707	-0.57735	-0.21822
Hospital rank	Hospital 1	Hospital 2	Hospital 3		
	1-Best	2	3-Worst		

In table 5, there are five parameters which consist of the parameters of wait time at the hospital (v_1), average service time for a patient (v_2), time to reach the hospital (v_3), review rating of hospital on a scale from 1 to 10 (v_4), and patient perception (v_5) on a scale from 1 to 10 for three hospitals within a thirty mile radius of Greensboro, North Carolina. For instance, hospital 1 has a thirty minute wait time at the hospital (v_1), seventeen minute average service time (v2), while it is 5 miles away to reach this hospital (v_3), with a review rating of nine (v_4), and a patient perception of 3.0 on a scale of 1 to 10 (v_5). All of the five parameters have equal value or weight.

The sum of all weights should equal 1. Each parameter has been assigned a value or weight. In Table 5, the time to reach the hospital (v_3) is more important than the average service time for a patient (v_2). This is shown considering the time to reach the hospital (v_3) is shown with a weight of 0.4, whereas average service time for a patient holds a weight of 0.3 (v_2).

Ranking (H1) =0.1*1 + 0.3*-0.37796 + 0.4*-0.97024 + 0.1*-0.57735 +0.1*1.091089 is
- 0.35011.

Ranking (H2) = 0.1*-1 + 0.3*-0.75593 + 0.4*1.027314 + 0.1*1.154701+ 0.1*-0.87287 is
0.11233.

Ranking (H3) = 0.1*0 + 0.3*1.133893 + 0.4*-0.05707 + 0.1*-0.57735 + 0.1*-0.21822 is
0.237782.

From the data, we can say that hospital 1 is the best hospital to go to in case of an emergency for the Greensboro, North Carolina and surrounding areas. The next hospital in line would be hospital 2, and hospital 3 would be the least hospital to choose in an emergency. Hospital 1 has a 30 minute wait time (v_1), 17 minute average service time (v_2), located 5 miles from Greensboro, NC (v_3), with a review rating of 9 on a scale from 1 to 10 (v_4), and patient perception of 3.0 on a scale from 1 to 10 (v_5). In comparison to hospital 3, hospital 1 has a 25 minute wait time (v_1), 25 minute average service time (v_2), and a 13 mile travel time from Greensboro, NC (v_3), with a review rating of 9 (v_4), and patient perception of 2.8 on a scale from 1 to 10 (v_5). The wait times (v_1) are synthetic data. The estimated mileage to reach the hospital (v_3) and the patient perception is real data (v_5). Synthetic data is used when real data was not applicable from these hospitals located within a thirty mile radius of Greensboro, North Carolina.

5.2.2 Correlation between parameters. In this section, we calculate and discuss the relationship between parameters used to calculate the hospital ranking.

Table 7

Correlation values

Table 7

(cont.)

Between v_1 and v_2		Between v_1 and v_3		Between v_1 and v_4		Between v_1 and v_5	
30	30	30	0.9	30	5	30	2.2
20	10	20	24.9	20	2	20	3.6
40	20	40	23.7	40	1	40	4.2
50	15	50	22.8	50	1	50	2.1
25	15	25	36.6	25	4	25	1.7
10	40	10	20.5	10	8	10	10
correlation	**-0.46**		**-0.05**		**-0.78**		**-0.63**

In table 7, we can see a small correlation between wait time (v_1) and the time to reach the hospital (v_3). We want to see the correlation between wait time (v_1) and the review rating (v_4) to see if the wait time (v_1) is correlated to the review rating of the hospital (v_4). The correlation ($r = -0.05$) between the time to reach the hospital (v_3) and the wait time (v_1) of hospital has some relationship. The correlation ($r = -0.78$) between the wait time (v_1) and the review rating (v_4) does not appear to have a definite association, same as wait time and service time and the relationship between wait time and patient perception.

Table 8

Correlation values

Between v_2 and v_3		Between v_2 and v_4		Between v_2 and v_5	
30	0.9	30	5	30	2.2
10	24.9	10	2	10	3.6
20	23.7	20	1	20	4.2
15	22.8	15	1	15	2.1
15	36.6	15	4	15	1.7

Table 8

(cont.)

40	20.5	40	8	40	10
correlation	**-0.53**		**0.84**		**0.73**

In table 8, we can see a negative correlation between the average service time (v_2) and the time to reach the hospital (v_3). According to Pearson's correlation rules, the correlation (r = -0.53) is considered negative, with a large strength of association. We recognize a positive correlation between average service time (v_2) and the review rating (v_4). The correlation (r = 0.84) is considered positive, with a large strength of association. There is a large strength of association between average service time (v_2) and patient perception of the hospital (v_5), the correlation is positive (r = 0.73).

Table 9

Correlation values

Between v_3 and v_4		Between v_3 and v_5	
0.9	5	0.9	2.2
24.9	2	24.9	3.6
23.7	1	23.7	4.2
22.8	1	22.8	2.1
36.6	4	36.6	1.7
20.5	8	20.5	10
Correlation	**-0.26**		**-0.04**

In table 9, we can see a negative association between the time to reach the hospital (v_3) and review rating (v_4). The correlation (r = -0.26) is negative, with a small strength of association. We establish a negative association between the time to reach the hospital (v_3) and patient perception (v_5). The correlation (r = -0.04) between the time to reach the hospital (v_3) and patient perception (v_5) do not have an association.

Table 10

Correlation values

Between v_4 and v_5	
5	2.2
2	3.6
1	4.2
1	2.1
4	1.7
8	10
Correlation	**0.66**

In table 10, we see a positive association between the review rating (v_4) and patient perception (v_5). The correlation (r = 0.66) is positive, with a large strength of association. We see that the values of the review rating fluctuate from a range of 1 to 8 on a scale of 1 to 10. We also see the values of the patient perception fluctuate from a range of 1 to 10 on a scale of 1 to 10. We establish a distinct, large strength of association between the review rating of the hospital and the patient perception of the hospital.

CHAPTER 6

Conclusions and Future Research

In this thesis, we proposed a smart phone based service to optimize travel time to a medical facility utilizing patient wait time, service time, time to reach the hospital, patient reviews, and patient perception of the facility and Global Positioning System (GPS) data. We compared various hospitals' rankings in accordance to individual parameters relative to other hospitals in neighboring counties and cities. Each constraint was assigned a weight to be used in the overall ranking of the hospital. Each emergency facility's parameter was calculated to reach a total score for the facilities. The hospitals were classified according to their scores. The emergency facilities with the best overall rankings were measured on a numbered scale from the best to the worst. Using these parameters, ranking of all nearby hospitals was calculated to determine the best hospital to go to in the event of an emergency. We used Pearson correlation to calculate and establish the correlation between parameters.

With technology's advancement and innovative adventures, healthcare facilities are constantly trying to abreast of the new technologies. Current medical applications exist that measure patient wait time in emergency facilities. These applications assist patients in their choices of care and treatment, but not all applications focus on other major concerns of the patient. In the future, we propose to design a better mobile application to incorporate more number of values and other approaches to provide better hospital ranking. The integration of individuals' digital well-being through smartphones, with the help of optimization, will definitely flourish more implementation of mobile healthcare in forthcoming years.

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