CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Road traffic management has long been a composite predicament and it is ever likely to remain so in the near future. Road traffic decrees and policies depend upon a sizeable integer of attributes. Making a truthful pronouncement for traffic management can be easier said than done because decision makers need to investigate and grasp a large measure of information. This information can be imprecise and sometimes even incompatible in nature. Hence there arises a need to have superior command and an unswerving and coherent system which helps in simplifying the traffic decision making process by Almejallli et al.

1.2 TRANSPORTATION

Transportation in developing countries is of great implication because of its contribution to national, regional, economic, industrial, social and cultural evolution. However, most developing countries confront inconveniences relating to traffic and transportation. Ineffectual transportation facilities hinder the process of socio economic development in a country. The management of different aspects of transportation is a difficult task, especially in a developing country like India with a heavy population. The most serious problem that confronts the professionals involved in transportation is safety. This is immediately followed by pollution of different hues – noise and air.

1.3 TRANSPORT IN INDIA
Transport in the Republic of India is a crucial facet of India’s economy. India’s transport sector is large and diverse: it caters to the need of 1.1 billion people. In 2007, the sector contributed about 5.5 percent to the nation’s Gross Domestic Product, with road transportation contributing the lion’s share. Since the early 1990s, India’s growing economy has witnessed a rise in demand for transport infrastructure and services. This resulted in a boom in infrastructure development in tandem with economic liberalization of the 1990s and the rapid pace of progress is seen in various modes of transport on land, water and air.

Public transport, by far, remains the principal means of transport of the majority of population and in comparison, the most heavily used mode of travel. For instance, India’s rail network is the fourth longest in the world transporting 8224 million passengers and 969 million tons of freight annually as of 2012 (Indian Railways 2012). There is a current rapid growth of vehicle population of over 4.6 million and there is an expectation of faster expansion in the population of vehicles in the years to come. The transport sector is unable to cope with the ever annual average increase of ten percent demand for development in transport infrastructure and services (World Bank 2011).

Traffic in Indian cities is generally dead slow with traffic snarls, traffic jams and accidents not so infrequent. India’s record on road safety is very dismal – around 90,000 people die every year in road accidents. A Reader’s Digest survey of traffic congestion in Asian cities presented a depressing account ranking many Indian cities within the top ten positions in the list (Moore 2007).
1.3.1 Roads

The network of roadways in a country resembles the arterial network in human body. They facilitate advancement in transportation and communication. In surface transport, railways and roadways play interdependent roles. Potentially defined, roads form the backbone of the nation with rich contributions towards industrialization and agricultural economy.

Roads in India account for 90 percent of the country’s passenger traffic and 65 percent of its freight traffic. The density of India’s highways network –0.66 km of highway per square km of land- is similar to that of United States of America (0.65) and much greater than that of China (0.16) or Brazil (0.20). As per the estimates in the year 2013, the total length of roads in India is 4,689,842 km (2,914,133 miles) (World Bank 2011). Table 1.1 illustrates the types and approximate lengths of roads in Indian subcontinent.

Table 1.1 Types of Roads

<table>
<thead>
<tr>
<th>Type of Road</th>
<th>Total Length</th>
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<tbody>
<tr>
<td>1. Expressways</td>
<td>1,208 km (751 miles)</td>
</tr>
<tr>
<td>2. National Highways</td>
<td>79,116 km (49,160 miles)</td>
</tr>
<tr>
<td>3. State Highways</td>
<td>1,55,716 km (96,757 miles)</td>
</tr>
<tr>
<td>4. Rural and other roads</td>
<td>44,55,010 km (27,68,210 miles)</td>
</tr>
<tr>
<td>5. Total Length</td>
<td>46,89,842 km (29,14,133 miles)</td>
</tr>
</tbody>
</table>
In recent years, efforts are afoot in the construction of a nationwide system of multilane highways (many are complete and under active use) that include Golden Quadrilateral and North-South and East-West corridors which link scores of cities in India.

1.3.2 Initiatives for Road Development

Some of the initiatives undertaken by the administrators which have paid selected dividends are:

- Accelerated Road Development Program for the North East Region to provide road connectivity to all state capitals and district headquarters in the region
- Creation of Central Road Fund (CRF) through an earmarked tax on diesel and petrol for financing the development and maintenance of roads
- Operationalizing the National Highways Authority of India (NHAI) to act as an infrastructure procurer and not provider
- Improving rural access by launching the PradhanMantri Gram SadakYojana (Prime Minister’s Rural Roads Program)
- Improving urban transport under Jawaharlal Nehru National Urban Renewal Mission (JNNURM)
- Enhancing sector capacity and improving efficiencies through clear policy directive for greater private sector participation – large number of projects of National Highways Development Project (NHDP) and National Metropolitan Development Project (NMDP) are to be executed through public private partnerships (PPP)
1.3.3 Roads – Challenges

The major challenges facing the road sector in India can be put in a nutshell.

- India’s roads are not weather-proof. Soon after a heavy downpour of rain or after a rainy season, they become full of potholes.

- Such a poor quality of roads leads to a number of different kinds of accidents, causing untold sufferings and loss of lives and property damage.

- Many urban roads are also highly congested and it is a nightmare to traverse on these roads during peak hours, resulting in great loss of time, energy, resources and causing tedium and boredom.

- Lane capacity of roads is also very low even on many major national highways – only two lanes in many of them.

- Maintenance of roads is also very mediocre, the less said the better. The deficient funding for the maintenance of roads – only one third of the needs are met – leads to quick deterioration of the roads and high transport cost for the users.

1.3.4 Indian Road Congress

India is a large economy with more than 1.2 billion population. There is a mismatch or imbalance between population and production. In order to wipe out this, either the population explosion should be contained or production should be increased or both should be done concurrently. Increase in production could be achieved through effective use of the productive resources (i.e. land, labor and energy) or economic and efficient use of the
resources or simultaneous application of both approaches. Hence, to achieve higher production and greater production efficiency in an economy which is as geographically large, as densely populated and as resource constrained as India, a well-organized transportation is absolutely compulsory.

In this context, it benefits to remember the relevant resolution passed in 73rd Annual Session of the Indian Roads Congress (IRC) held at Coimbatore: “Roads should be considered as active infrastructure facility for people, for safety and services, besides a catalyst in the development of the economy in place of passive approach of exclusivity. The IRC will evolve itself through synchronization and synergization with other sectors of economy based on interdependent model, wherein the safety of all stakeholders of highway sector is fulfilled through inclusive approach. Accordingly, the IRC is to adopt multi-modal transport concept while developing the guidelines and codal practices” (Indian Road Congress 2013).

1.3.5 Boulevard Network

For instance, an area identified as Boulevard Network (BN), is a large road network without a central administrative control to cope with the unanticipated turmoil. The computational exertion multiplies as the network magnitude becomes substantial, making it inappropriate for real-time routing. The conundrum with a boulevard network is that it would entail massive measure of storage space and pre-computation in network. Hence an attempt is made towards reducing the huge quantity of hold room and pre-computation by harnessing hierarchical based community.
1.3.6 National Highways Authority of India

The design of the thesis touches upon a pragmatic approach for application in the transportation of people from one location to another through an optimal route in a BN. BN in this research does take into contemplation the National Highway System (NHS). National Highway Authority of India (NHAI) was constituted by an Act of Parliament, namely, the NHAI Act, 1988, to develop, maintain and manage the National Highways vested or entrusted to it by the Central Government. It became operational in February, 1995. NHAI is a network of strategic highways including the interstate highway system and other roads, serving major airports, rail or truck terminals and railway stations. The interstate highways also connect other roads that form a portion of tactical highway network. Individual states are convinced to target central resources on upgrading the robustness and buttressing of this network.

NHAI has launched a web-based integrated Road Information System (RIS) (Zeiss 2012). This web is the primary channel through which road condition is monitored. This web-based geospatially-facilitated configuration amalgamates a linear referencing system in the tracking of the condition of pavement, geospatial data and investigation. Within the parameters of RIS, the customers could demand and acquire customized and defined data and information using discrete subsystems pertaining to geographical location type or condition of a road and also details of pavement, traffic and many other related aspects, tolls and toll plazas on the way, accident-prone zones and highly sensitive sectors. Despite all these salient features, this RIS system is flawed since it does not identify the demand in identifying the optimal and safe route from source to destination.

RIS system does not sort out hazards or various factors of insecurity effectively, especially with reference to major
transportation movement and hence entails operation of a designed, ingenious risk management plan. The use of this RIS system does not guarantee the elimination of risks altogether nor does it assure any detail on safety in the selection of optimal route from source to destination. Only when RIS is extended to offer aspects aiding multi-modal transport, it can be rest assured that a complete tool is evolved in optimal routing.

Such an outsized problem faced by the passenger and the driver community as well has given the spark and flash igniting the thoughts in the pursuit of this research. The basic tenet of this research lies in an endeavor to expound a Fuzzy Knowledge Based Pragmatic Approach system for the use of every stakeholderto compute the best optimal route from end to end in a perilous and menacing boulevard network.

1.4 OPTIMAL ROUTES

Optimal route crisis in the network will be one of the factors to inhibit the customer satisfaction of both developing and developed countries because optimal route plays a key role in the overall Computer Network, Mobile Communication Network, Road transport Network and social well being of the other networks. The transport sector is an important component of the economy influencing the development and welfare of populations.

The nature of routing application demands that one needs efficient and flexible shortest paths from source to destination taking into account traffic congestions, fuel consumption, overlay of roads, inconvenience in driving and pollution of multiple types. Unfortunately, prior research (Bellman 1958), (Dijkstra 1959), (Dreyfus 1969) does not provide a flexible shortest path and concentrates only in finding the path with minimum distance, time or cost from source to destination. Since no “best” algorithm currently exists for
every kind of transportation problem, research in this domain has recently shifted to the design and implementation of “heuristic” shortest path procedures.

1.5 BASIS OF THE THESIS

Optimal routing is an essential and inherent prerequisite in everyday life of every one. Otherwise, the hazards like traffic congestion drain our money by way of exceptionally excessive concession of fuel, much longer durations of travel time, in addition to debilitating effects of movement of vehicles at snail’s pace, leading to inconvenience and world-weariness in driving and contributing freely to the pollution of every kind.

The optimal routing that is currently in trend has a major downside since it does not deliberate on the existing predicaments of the boulevard but rather weighs up factors like distance, time, and cost, elements which play a role in an increase in air pollution, fuel consumption and accidents. So the situation turns all the more murky with a swift variation in the configuration of boulevard network. The very conceptual framework of this research incorporates ideas like non frequent, frequent and stagnant constraints in identifying the optimal route and thus becomes viable and pragmatic in implementation and approach in the boulevard network.

This convenient attitude does envisage a model in advancing a fuzzy optimal route system with a code based community and Fuzzy Knowledge based technique in arriving at a solution in finding out of an OR in hazards ridden BN. It is a sizeable and unrestrained road network without any whatsoever directorial monitoring in managing the unforeseen disturbance. It is also near impossible to predict or prevent the dimension and magnitude of the obstacle or interruption. Hence, it becomes imperative to
develop and implant code-based hierarchical community graph model by defining the important cities and edges by Liu (1997) and thereby setting a mode of road control mechanism in predicting the unexpected alterations that may occur on roads. The risky elements that are issues of a road network such as frequent and non-frequent strictures are uncertain in nature. To encounter this difficulty, the Fuzzy Set Theory (FST) is brought into play to resolve such of these risk factors with uncertain information into quantitative form.

The system developed in this research serves a road user by assisting him in optimal route planning through managing the risk of uncertainty of road networks described by Salehinejad & Talebi (2010). This basic decision making process is at the heart of risk management. Risks do arise in transport route construction and there is every chance that the road user may face risks logically dovetailed to road environment, road quality, road safety rules and other safety factors. An unrealistic assessment of risk, for example, could lead to overly optimistic estimates, resulting in unachievable goals and unmet expectations.

Since this research is founded on realistic estimates taking into deliberation most real time analytic issues, this research work could serve as a guiding factor in a boulevard network, with highly distributed systems that operate in an unbounded network environment. Fuzzy set theory helps readily in shaping and resolving uncertain information concerning boulevard risk factors such as the pavement condition, road inventory, traffic analysis and pothole-filled roads, with inputs from highway authority or traffic police. This approach makes the system robust since factors like the user satisfaction, quality of service, speed of transfer and non-toxic route are incorporated in the fruition of the optimal route in optimum time.
1.6 HISTORICAL PERSPECTIVE

Modeling studies in road network or supply system planning falls into assorted classes. The major and significant kinds that form the basic modes are listed.

- Evaluation based planning
- Relational Analysis based planning
- Orientation or Structure based planning with geographical considerations
- Activity based planning
- Route based planning with route guidance systems
- Accessibility based planning
- Land use based planning
- Simulation based planning
- Network equilibrium based planning
- Conceptual planning

These different analyses are evolved by multiple authors with slight deviations in their approaches suited to their approaches. These approaches are presented in a nutshell in Table1.2.
### Table 1.2 Modeling studies in road network

<table>
<thead>
<tr>
<th>Analysis category</th>
<th>Approaches</th>
<th>Author</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Transportation Cost</td>
<td>Farbey &amp; Murchand (1967)</td>
</tr>
<tr>
<td></td>
<td>Activity Based Planning - Travel Behaviour and Activity Characteristics, Land Use</td>
<td>Xuedon Lu &amp; Eric I. Pas (1999), Kara Maria Kockelman (1996)</td>
</tr>
<tr>
<td>Accessibility Based Planning</td>
<td>Graphical Methods</td>
<td>Khaled Al Sahili &amp; Mohammad Abould Ella (1992)</td>
</tr>
<tr>
<td>Simulation Based Planning</td>
<td>Cellular Automata</td>
<td>Clarke K. C. et al 1997</td>
</tr>
<tr>
<td>Network Equilibrium Based Planning</td>
<td>Optimisation Theory</td>
<td>Reggiani (1997)</td>
</tr>
<tr>
<td>Conceptual Planning</td>
<td>Road user Concept</td>
<td>Daniel B. Staffer (1977)</td>
</tr>
<tr>
<td></td>
<td>Scenario Planning</td>
<td>John M. Courtney</td>
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</tbody>
</table>
1.7 RATIONALE OF THE THESIS

Early approaches, as enunciated earlier, for shortest path system primarily focus on basic factors in road use such as distance, time, cost and similar other elements. In general, these approaches are operated by NHAI’s road information system; thus, there is almost no optimal route pedestal on road inventory issues relating to this approach. This research work reviews the requirements and objectives for optimal route from source to destination on the following counts.

The following form the objectives of the research.

- To improve the computational efficiency and response time with the use of community to fence off the unbounded boulevard network to bounded network.
- To link the road information system that collects and maintains pavement condition, road inventory, traffic analysis and condition and shape of roads to a centralized system providing optimal route guidance to the user.
- To convert uncertain information relating to frequent changing, non-frequent changing and static factors into quantitative form.
- To convert fuzzy parameters like one way or two way of road, U-turn, left turn, right turn, the diameter of the road and the number of pedestrian crossings that are non-frequent or changeable parameters based on the position of the road.
- To reduce the problems caused by traffic congestion by using a selection of next best optimal routes.
- To satisfy the user needs and requirements of the road.
To satisfy all the road parameters in order to obtain safe routing, user pleasure route, speed up the arrival time, low depreciation of vehicles and healthy driving.

1.8 METHODOLOGY

To fulfill the above objectives, the following methodology has been adopted. The proposed system consists of hierarchical topologies of road network which casts a road network into a hierarchical representation according to the criteria such as road categories, road lengths, speed limits, number of lanes etc. Taking Pin-Code criterion as an example, Liu (1997) suggested that major roads and express ways themselves form a higher level network; the higher level network partitions the whole network into sub networks. In this approach, each hierarchy forms a connected network based Pin-Code. This implies that adjacent sub networks are overlapping, and they share some common cities and roads. Assistance of human approach is generally needed to select the best route from source to destination. It consists of hierarchical topologies of road network and knowledge acquisition methodologies and the most important methods used in this research include the following.

- Code based community network
- Knowledge acquisition process
- Risk factor analysis
- Fuzzy optimal route

1.9 CONCLUSION

Optimal route selection in road network remains a persistent and perennial predicament of road users. Ever so many methods and algorithms
have been developed to solve the issues and challenges in this sector. The problems confronted are compounded by the interplay of multiple factors – human, machine and nature. To identify all the relevant and related elements and bring them into play in the amelioration of all the problems concerning route selection in road network is near impossible.

Hence a pragmatic and user-friendly stance is attempted in the thesis in a progressive manner.

In Chapter 1 of the thesis, which forms the introduction, initiation of the discussion is taken up with the securing of background information. The bad shape of transportation in India, types of roads in India, the need for optimal route selection, historical perspective in the development of modeling studies by earlier researchers, objectives and methodology of the current study with an outline of the entire process are the significant aspects of this chapter.

Chapters 2, 3 and 4 form the knowledge building blocks for the entire study as they provide the necessary basic knowledge for a clearer perspective of the study.

Chapter 2 is an elaboration of a community in road network and a brief note on the definitions of community and basic concepts of community detection. Of all the algorithms relating to community detection, fuzzy algorithm is treated elaborately as its application is widespread in this study.

Chapter 3 is a meticulous attempt in outlining the fuzzy logic algorithm. Fuzzy logic algorithm and other control systems, advantages of fuzzy logic, applications, truth values, If-Then rules, propositional fuzzy logic, fuzzy logic and probability are the major areas of concern in this chapter.
Chapter 4 is the knowledge acquisition process of risk factors associated with road network. The risk factors are obtained through two procedures – literature survey and domain experts’ knowledge engineering. The data obtained from them are synthesized.

Chapters 5, 6 and 7 form the actual progression in processes in achieving the goal of optimal route selection in road network each having an individualistic facet of approach.

Chapter 5 deals with hierarchical community mining – fuzzy ant dynamic routing on large road networks. Hierarchical community structure, fuzzy logic and ant colony system are applied in the study of the problem of route selection.

Chapter 6 endeavors an approach in the use of Dijkstra’s fuzzy algorithm in the location of shortest path in large road networks using fuzzy parameters.

Chapter 7 has a different perspective in route selection with the course of action modeled on code based community network. The community network is systematized through postal index numbers and then fuzzy logic algorithm is implemented to accomplish the target.

Chapter 8 is the conclusion that is the summation of all the ideas dealt with in earlier chapters. The study ends with a brief suggestive note of the scope for future developments in this study.

The succeeding chapter is a background resource mining one with the analysis of community structure and community detection algorithms with special reference to fuzzy logic algorithm.