DEVELOPMENT OF A MULTI AGENT COGNITIVE NETWORK FOR URBAN TRAFFIC SYSTEM (MACNUTS)

A Thesis Submitted to
Babu Banarasi Das University
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in

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by

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Certificate of the Supervisor

This is to certify that the thesis entitled "**Development of a Multi Agent Cognitive Network for Urban Traffic System (MACNUTS)**" submitted by **Mr. Shailendra Tahilyani** for the award of **Degree of Doctor of Philosophy** in Electronics & Communication Engineering from Babu Banarasi Das University, Lucknow (Uttar Pradesh), is a record of authenticate work carried out by him under my supervision. To the best of my knowledge, the matter embodied in this thesis is the original work of the candidate and has not been submitted elsewhere for the award of any other degree or diploma.

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DECLARATION

I, hereby, declare that the work presented in this thesis entitled "**Development of a Multi Agent Cognitive Network for Urban Traffic System (MACNUTS)**" in fulfillment of the requirements for the Degree of Doctor of Philosophy, Department of Electronics & Communication Engineering, Babu Banarasi Das University, Lucknow is an authentic record of my own research work carried out under the supervision of Dr. Manuj Darbari.

I also declare the work embodied in the present thesis is my original work and has not been submitted by me for any other degree or diploma of any university or institution.

(Shailendra Tahilyani)

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SHAILENDRA TAHILYANI

PREFACE

The limited road infrastructure and exponentially increasing number of vehicles are major reasons for traffic congestion in urban cities. With these unavoidable limitations, the Artificial Intelligence approaches are being applied to deal with this problem. A new lane-by-pass approach has been investigated to deal with the problem of traffic congestion using cognitive radio in a multi-agent environment. Genetic Algorithms are utilized for optimization of various parameters used in traffic routing mechanism.

Ass mechanism involves generation of minor sublane and dynamic route information focusing on three basic aspects:

i) Velocity of information and

ii) Quality of information

iii) Dynamicity of the information

Besides these it has got various factors like signal control from control centre, these are controlled using the concept of Multi Objective Optimisation. Before applying this three major activities are to be performed:

a) Identification of Route Network in the city, showing the relationship between al the roads (routes).

b) Identification of Traffic Jams and then identification of alternative minor sub lane route information.

c) Coordination among all the decision (alternative traffic routes) to ensure the smooth traffic flow from source to destination.

In an MOO problem space, a set of solutions optimizes the overall system, if there is no one solution that exhibits a best performance in all dimensions. This set, the set of non-dominated solutions, lies on the Pareto-optimal front (hereafter called the Pareto front). All other solutions not on the Pareto front are considered dominated, suboptimal, or locally optimal. Solutions are non-dominated when improvement in any objective comes only at the expense of at least one other objective.

Our work proposes to generate various sets of subroutine program using Software Defined Radio using XML. Cognitive radios need to be able to tell other cognitive radios what they are observing that may affect the performance of the radio communication channel. The receiver can measure signal properties and can even estimate what the transmitter meant to send, but it also needs to be able to tell the transmitter how to change its waveform in ways that will suppress interference. In other words, the cognitive radio receiver needs to convert this information into a transmitted message to send back to the transmitter.

In Radio XML, <Radio/> defines "the domain of natural and artificial knowledge and skill having to do with the creation, propagation, and reception of radio signals from sources natural and artificial." That's pretty much how RXML, defined in terms of the use of XML <Tag/>s as schema-schema, was envisioned, within an open framework for general world knowledge needed for AACR. RXML recognizes critical features of micro-world not openly addressed in any of the e-Business or semantic web languages yet:

1. Knowledge often is procedural.
2. Knowledge has a source that often establishes whether it is authoritative or not, or its degree of attributed voracity.
3. Knowledge takes computational resources to store, retrieve, and process.
4. A chunk of knowledge fits somewhere in the set of all knowledge and knowing more or less where that knowledge fits can help an algorithm reason about how to use it.

Major findings of the proposed research work are as follows:

1. A new lane-by-pass approach has been investigated to deal with the problem of traffic congestion using cognitive radio with XML Macros in a multi-agent environment.
2. Genetic Algorithms are utilized for optimization of various parameters used in traffic routing mechanism.

List of Publications:

1. A New Multi Agent Cognitive Network Model for Lane-By-Pass Approach in Urban Traffic Control System, S Tahilyani, M Darbari, PK Shukla, International Review on Computers and Software 7 (5), 2012.

2. A New Genetic Algorithm Based Lane-By-Pass Approach for Smooth Traffic Flow on Road Networks, Shailendra Tahilyani, Manuj Darbari, International Journal of Advanced Research in Artificial Intelligence 1 (3), 2012, (with Manuj Darbari).

3. Soft Computing Approaches in Traffic Control Systems: A Review, Shailendra Tahilyani, Manuj Darbari, AASRI Procedia 4, pp 206-211, 2013, (with Manuj Darbari).

4. Cognitive Framework for Intelligent Traffic Routing in a Multiagent Environment, Shailendra Tahilyani, Manuj Darbari, Software Engineering in Intelligent Systems, Springer International Publishing, pp 67-76, 2015, (with Manuj Darbari).

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

With ever increasing travel needs of people it is not surprising in least to say that traffic congestion is among the foremost problems being faced by cities in developed as well as developing countries. As per the 2003 Urban Traffic mobility survey (Urban Statistics , CPCB, New Delhi 2003) published in Transportation Research India, traffic congestion in 2003 resulted in loss of 3.5 million hours of productivity valued at 34000 crores. While congestion cannot be eliminated completely, measures can be adapted to alleviate the traffic conditions. The previous models that were developed for the study of vehicles consider only limited macro mobility which involves limited vehicle movements. On the other hand, no attention is paid to the micro mobility and its communication with macro mobility counterpart. The research society could not provide the realistic environment for modeling urban traffic which could provide a clear picture about traffic movements and its implications. We have developed a model using the concept of Cognitive Radios with multi-objective optimization for effectively managing the congestion problem. The main thought of the thesis is to compare the previous models.

1.2 BACKGROUND

The thesis examines the nature of the workflow system and its modeling with specific reference to the issues of urban traffic modeling (Ghaffar, 2002; Godratt, 1992). Over the past years there have been many incidents of traffic related problems, which has now become a serious threat to the developing cities like Lucknow. We outline the deficiencies in the existing traffic modeling tools and techniques and highlight the areas where it can be improved.

Our work demonstrates step by step refinement of Urban traffic systems using process algebra, queuing theory and continuous petrinets. We extend petrinet modeling of urban traffic systems using a notational language PENTRAL. It helps in simulating the urban traffic movements focusing on interaction of four major parameters: objective, mobility, constraints and assimilations. The language treats every entity as an individual and can simulate the behavioral aspect of traffic reacting with the environment; allowing the users to study wide range of traffic dynamics.

We have also verified our model using fuzzy petrinets (Zhao, 2008), which helps in modeling an unpredictable situation of urban traffic system as it is not always possible to simulate by assuming certain conditions that are considered as "Ideal".

1.2.1 Design issues of Intelligent Traffic System-ITS

ITS consists of many technologies like efficiency, safety, pollution and quality. There are various approaches for Urban Traffic modeling but UMTS programme by British government is very popular the job of this project is to provide ease of traffic movement. It focuses on Open system design specification for Network management focusing on the areas which includes:

Traffic calming

Managing efficiency of the systems

Coordination between road demand and vehicle usage at various interval of time.

Improving a mix of public and private transit system

There are various traffic systems being developed to coordinate network management like SCOOT, SPOT and MOTION. They use adaptive control system with efficiency of only 10% to 40% while SPOT and MOTION uses inductive loop to control the traffic. These models use response agent system to control network traffic.

The problem with these models was that they provide only localized view of the problem, ie only to particular area, secondly driver information and guidance is not supported in these models. Our model provides a cooperative Advanced Urban traffic System using the criteria of optimization of the two crossings ahead and back of the event occurrence scenario. This is achieved by Multi-Agent framework of Cooperative

Cognitive Radio network well connected through control centre using certain set of protocols, thus managing the traffic much more efficiently.

1.3 PROBLEM STATEMENT

The objective can be summarized in the following steps:

- The first step covers the identification of issues relating to traffic management.
- The second step is to analyze the traffic situation of Lucknow within various time frame at different locations.
- The third step covers the interpretation of the survey relating to flow & traffic jams.
- Fourth step involves identification of cognitive radio functionalities which can be used to monitor the traffic.
- The fifth step involves the extension of Cognitive Radio with Evolutionary computing to analyze the optimized solution for traffic flow.
- The last step provides formal verification of the entire framework using simulation through Optimization tool of MATLAB and secondly testing the model for hypothesis.

1.4 RESEARCH OBJECTIVE AND MAIN CONTRIBUTION

Traffic simulators are required to not only evaluate the benefits of ITS (Intelligent Transport System) in the initial mode, instead they are also used to create scenarios, optimize control, and forecast the behavior of the network at the operational level. ITS can provide the traffic engineer with an overall picture of the traffic and it has the capability to assess the current problems and determine the possible solutions instantly. Novel techniques can be tried and tested without causing any commotion to traffic in the real network. Traffic projects some of the characteristics of a complex system like the stable and unstable states, the deterministic, chaotic or even the stochastic behavior with phase transitions. Simulation can be considered as a good tool for handling such complex systems.

The traffic simulation models can be divided as: microscopic, mesocopic, or macroscopic. Microscopic models are those models that will continuously predict the state of the individual vehicles. For example: the speed of the independent vehicle and its location. On the other hand, the macroscopic models amass the descriptions of the traffic flow. Such measures of effectiveness include the speed, flow and density. Mesoscopic models are those models that have both the aspects of macro as well as the aspects of microscopic models. Simulation models are classified by their functionality i.e. signal, freeway, or integrated.

1.4.1 Functions of Traffic Simulation Models

Four major have been identified for Urban Simulation model:

- **The simulating networks** include interaction between the vehicles and new responsive control and information systems. The main purpose of the simulation model is to review a collection of transportation control options off-line. Because of the instantaneous variation in traffic, the on street evaluation is very difficult as it is very tedious to gather statistical data to produce significant conclusions. Hence, simulation models have been formed in order to allow for complete control over the network.

- **Short term forecasting:** Simulating models can also be used when immediate results are required after analysis. For example: real-time evaluation of a set of possible responses following an incident on a roadway, or to predict emissions so that plans, which restrict CARS entering the city center, can be implemented if the predicted emissions rise above a certain level.
- **Enhancing assignment models:** These models are used to estimate changes in traffic flow when changes are made to the road network.

1.4.2 Limitations of Traffic Simulation

Some limitations have been highlighted as follows:

Modeling congestion:

Most of the simulation models make use of simple car following and lane changing algorithms to determine the movement of the vehicles. The behavior of the driver is not realistically reflected in conditions of congestion.

Environmental modeling:

A considerable amount of effort is being used for the production of emission models for incorporating them into simulation models. It is straightforward for some emissions but for other emissions complex chemical reactions are taking place.

Integrated environments and common data:

Simulation models are often used in conjunction with other models such as the assignment models. The common inputs that are required by all these model are data about origin and destination, network topology, and the bus route definitions. However, each model requires data in different formats so the effort is not shattered in re-entering of the data or writing of conversing programs.

Safety evaluation:

Safety is a very multifarious issue. Most of the safety prediction models are crude and are based on the vehicle flows on given roadways or on lane changes in mean vehicle speeds. Such models totally ignore susceptible road users such as cyclists or pedestrians.

Standard procedures and indicators for evaluation:

The traffic simulation has to produce outputs in order to rank the alternatives realistically. Alternative rankings are a function of the chosen performance indicators and the weights used. Standard sets of performance indicators and procedures that are to be applied need to be produced.

Although there is a need for the development of traffic simulation models which will support ITS, but there is also a need to evaluate the existing models in order to define their specific functions and features. The research work is an attempt to contribute to the ongoing effort to establish standards and criteria for traffic simulation models in order to integrate them into the framework of ITS benefits assessments.

Table 1-1: Summary of Models

	MODEL NAME								
	AIMSUN2	**CONTRAM**	**CORFLO**	**CORSIM**	**FLEXYT II**	**HUTSM**	**INTEGRATI**	**PARAMICS**	**VISSIM**
ITS Features Modeled									
Traffic devices	X						X	X	
Traffic device functions	X						X	X	
Traffic calming							X	X	X
Driver behavior	X						X	X	
Vehicle interaction	X						X	X	
Congestion pricing						X		X	
Incident	X		X	X	X	X	X	X	X
Queue spillback	X			X	X	X	X	X	X
Ramp metering	X			X	X	X	X	X	X
Coordinated traffic signals	X	X		X	X	X	X	X	X
Adaptive traffic signals	X	X							
Interface w/other ITS algorithms	X								
Network conditions	X					X		X	
Network flow pattern predictions					X	X	X	X	X
Route guidance									
Integrated simulation	X	X		X		X	X	X	X
Other Properties									
Runs on a PC	X	X		X	X	X	X	X	X
Graphical Network Builder	X	X			X	X			X
Graphical Presentation of Results	X	X		X	X	X	X	X	X
Well Documented	X	X	X	X	X	X	X	X	X

1.5 STRENGTHS AND WEAKNESS OF THE MODELS

The traditional traffic simulation models often consider traffic as homogenous platoons that obey simple speed and flow relationships. Hence such models often find it difficult to evaluate the effectiveness of ITS which often requires, among other things, interaction between individual vehicles and the new system (systems under information) to be modeled.

1.6 THESIS ORGANIZATION

The thesis has been organized into six chapters.

Chapter 1: It is an introduction of the proposed work that includes the basics of Intelligent Transportation system, Cognitive Radios and their extensions with evolutionary algorithms. This includes the research objectives and major contribution and thesis organization.

Chapter 2: It is the critical review of the proposed work which includes issues relating to Intelligent Transportation system, Evolutionary Algorithm and its application in optimized solution for multi agent cognitive radio network.

Chapter 3: It introduces the basic concepts of Multi agent cognitive network and its application in designing the traffic network control. Secondly introduction of evolutionary algorithm and how it is useful in designing Intelligent control system.

Chapter 4: Chapter 4 deals with the development of Multi-Agent Cognitive network model for lane by pass using self-cognition approach in multi-agent architecture, a grid of multi-agents are coordinated at various levels of junction to provide real time traffic information is communicated. The second part of the chapter adds the feature of evolutionary algorithms in optimizing the signaling.

Chapter 5: This chapter focuses on verification of the model using cognitive radio by applying evolutionary algorithm to generate non-dominated set of output. We have compared it with other models to find out the efficiency of ITS control models. Second part of the chapter deals with the hypothesis testing of the MACNUTS framework.

Chapter 6: Chapter 6 brings the thesis to conclusion by discussing various aspects of MACNUTS and its advantage, its superiority over other ITS methodologies. It discusses the innovative idea by summarizing the technologies developed for UTS.

CHAPTER 2

LITERATURE SURVEY

A critical research issue is the development of control systems that deal with the congestion for the smooth flow of traffic in urban areas. Although, several traditional methods Arnott, Rave and Schöb (2005), Papageorgiou et al. (2003) have been applied to reduce this problem of traffic congestion. Some of these include price of the road, supporting of the green traffic, enforcement of parking, fuel levies, expanding the existing road network and many others. Due to the non-linearity and unpredictability of the traffic movement and the high cost associated with expanding the existing infrastructure of road network and other related problems, the Conventional methods are not very suitable.

In between this time, integration of technology has been done to develop intelligent control systems that deal with the traffic congestion issues, specifically in urban areas.

The different approaches that have been integrated to model and simulate the real time traffic control system include activity theory, neural network, fuzzy logic, Petri Nets, genetic algorithms and their hybrid approaches.

The first phase highlights the issues regarding traffic problems in Lucknow. It focus on an empirical study in three major factors : congestion, pollution and infrastructure problems. In order to start with the first phase we were motivated by the work of Ghaffar (2004) which identifies the road injuries caused due to traffic in developing countries. This paper focuses various discrepancies in existing road network of Pakistan and the factors that are responsible for the accidents. We have also used the concept of econometric analysis from the work done by Kahneman (1979) which highlights the methodology for sample design. The paper states how the experimental hypothesis is correlated with sampling frame. It discusses the survey plan with various stages like site visit, field test, conducting a pilot interview and finally the analysis. The paper by Katsikopoulous (2002) also highlights the human factors that are involved in drivers route option when array of the travel time is provided. It suggests a methodology to calculate the travel facilities. We have used the concept of inter-zonal travel demand in designing our questionnaire.

Straub (1995) on control property of business process models explains the general framework of workflow methodology applied to any business processes. We have extended the concept of the constraint modeling, which is applied while modeling urban traffic system.

Moving on to impact of various workflow techniques for effective urban Traffic management. We have used the concept of producer consumer theory determined from the paper by Rao and Teran (2004), the paper illustrates the dynamics of information flow in health care sector using producer consumer theory. Paper by A'alast (2000) helped us in categorizing the urban Traffic movement into mesoscopic and microscopic categories.

We are inspired by the work of Hilstors (1997) on compositional approach to performed modeling which describes about generation of process algebra models by developing a notational language supporting sequence of information and activity flow with buffer in between facilitating the asynchronous communication between the process.

We are inspired by the work of Ellis (1995) describes dynamic changes within workflow systems. The paper on "Evaluation of Generic process design patterns" by Zapf (2000) describes the use of queuing theory applied for business process modeling. We are inspired by the work of Zapf (2009) on queuing workflow representation and have extended his work to develop a software "Q-Modeler", which could find optimum solution for the movement of traffic. In the conversion process of queue model to workflow representation we have also taken help of Technical report published by WFMC (1996).

The implementation of Petrinet in workflow is being achieved by the help of paper "The application of Petrinets to workflow management" by Aalst (1999). In this paper he has highlighted the issue relating to application of Petrinets in workflow design.

The unpredictable nature of Urban Traffic movement is represented by Stochastic Petrinets. Wang and Deng has described about conversion of Petrinets into Stochastic Petrinets which is specifically suitable for unpredictable behaviour of traffic system. The paper describes the two-way and four-way intersection patter with dedicated workflow for control section. It is directly linked with Main section with separate representation of traffic flow and control section. We have enhanced their model using orthogonal extension of workflow patterns.

Tari and Zahir (2000) have beautifully described about object oriented about object oriented data modeling regarding travel choice. This paper helped us in generating number of test cases which are specifically designed for variable situations.

The work by Desel (1990) & (1995) have also guided us in developing a mathematical form of Petrinet representation Rank Theorem also helped in developing a readable textual notations as graphical models which are hard to visualized. We are able to develop a simplified version from the paper by Gilmore which advocates a two layered structure with traffic flow representation in the first layer and control section representation in the second layer.

The work by Knybel (2005) and Novak (2000) also helped us in developing a fuzzy If- Then rules for Urban traffic petrinets represented by MACNUTS. We have extended his algorithm to suite our conditions of fuzzy traffic control.

Cognitive radio plays a major role, we are motivated by the work of Mitola who defined the cognitive radio as “It is a radio which inhibits model-based reasoning to attain a particular level of proficiency in radio-related domains”. Later on a modified definition was given by Haykin highlighting the concept of Adaptive nature of wireless communication system based on stimulus.

In our model we have used the concept of RKRL (radio Knowledge representation Language) we have customized this language for writing macros of urban traffic systems based on Vehicle to Vehicle(V2V) and Vehicle to Infrastructure(V2I). RKRL can be further improved as mix of cognitive process consisting of statement of language which can model in time and space defined through initial representation of sets, definition and conceptual models.

Since the cognitive radio fits very well in the definition of intelligent systems design a new terminology known as Co-operative Distributed Problem Solving (CDPS) also known as coherent group modelling.

"Cognition" proposed Sifalakis define the term as a layer of cognition to be applied over any active network to make it intelligent, while Boseovic defines that if the topology of the network can be adjusted according to the percept then overall performance of the network can be optimized. Later on Ramming presented a new state of networks in which network manages itself according to the situation is known as Cognitive technology.

The era of cognitive radio started way back in 1991 when Soft ware Defined radio (SDR) was introduced. The main advantage of SDRs was that it can work on any frequency. Joseph Mitola changed the name of software defined radio to cognitive radio; he defined it as intersection of "personal wireless technology and computational intelligence".

Ewing and Dumbaugh (2009), reaches two conclusions counter to accepted transportation engineering theory. First, the traffic environments of dense urban areas appear to be safer than the lower-volume environments of the suburbs. Second, at least in dense urban areas, less-"forgiving" design treatments—such as narrow lanes, traffic-calming measures, and street trees close to the roadway—appear to enhance a roadway's safety performance when compared to more conventional roadway designs. The increase in transportation demand can be met by providing additional capacity. However, this may no longer be economically or socially attainable or feasible. Thus, the emphasis has shifted to improving the existing infrastructure without increasing the overall nominal capacity, by means of an optimal utilization of the available capacity. Two complementary measures can be taken: improving the management systems by use of recent developments in the areas of communication and information technology, and improving the management via control techniques. The set of all these measures is framed as Intelligent Transportation Systems (ITS).Artificial intelligence and multi-agent techniques have been used in many stages of these processes.

During the last decade, there has been a tremendous progress in traffic engineering based on agent technology. The approaches can be classified into three levels: integration of heterogeneous traffic management systems, traffic guidance, and traffic flow control.

The first of these levels is discussed in several papers, for example the platform called Multi-Agent Environment for Constructing Cooperative Applications - MECCA/UTS – (Haugeneder and Steiner, 1993), as well as in Ossowski et al. (2005), in

Rossetti and Liu (2005), and in van Katwijk et. al. (2005). Regarding traffic guidance, it is generally believed that information-based ITS strategies are among the most cost-effective investments that a transportation agency can make. These strategies, also called Advanced Traveler Information Systems (ATIS), include highway information, broadcast via radio, variable message systems, telephone information services, Web/Internet sites, kiosks with traveler information, and personal data assistant and in-vehicle devices. Many other new technologies are available

In order to assist people with their travel decisions Multi-agent techniques have been used for modeling and simulation of the effects of the use of these technologies, as well as the modeling of behavioural aspects of the drivers and their reaction to information. Details can be found in Balmer, Cetin, Nagel & Raney (2004), Bazzan and Klügl (2005), Bazzan, Wahle and Klügl (1999), Burmeister, Doormann & Matylis (1997), Elhadouaj et al. (2000), Klügl and Bazzan (2004), Klügl et al. (2003), Paruchuri et al. (2002), Rigolli and Brady (2005), Rossetti et al.(2002), Tumer et al. (2008), and Wahle et al. (2002).

Regarding the third level mentioned above – traffic control – a traffic control loop was proposed by Papageorgiou (2003). It applies to any kind of traffic network if one is able to measure traffic as the number of vehicles passing on a link in a given period of time. With the current developments in communication and hardware, computer-based control is now a reality. The main goals of Advanced Transportation Management Systems (ATMS) are: to maximize the overall capacity of the network; to maximize the capacity of critical routes and intersections which represent the bottlenecks; to minimize the negative impacts of traffic on the environment and on energy consumption; to minimize travel times and to increase traffic safety. In order to achieve these goals, devices to control the flow of vehicles (e.g. traffic lights) can be used. However other forms of control are also possible. For classical approaches please see: TRANSYT (Robertson, 1969; TRANSYT-7F, 1988), SCOOT (Split Cycle and Offset Optimization Technique) (Hunt et al., 1981), SCATS (Sydney Coordinated Adaptive Traffic System) (Lowrie,1982), and TUC (Traffic-responsive Urban Traffic Control) (Diakaki et al., 2002).

The paper by Balmer, M., Cetin, N., Nagel, K., & Raney, B. (2004)on agent-based traffic and mobility simulations describes about agent based collaboration in mobility and traffic system. It helps us in extending our model for coordinated Cognitive radios and urban mobility.

The paper "Adapt or not to adapt – consequences of adapting driver and traffic light agents" by Bazzan, de Oliveira, Klügl, and Nagel (2008) and paper by Dresner and Stone (2004) on adaptive multi agent in Urban Traffic systems describes coherency between traffic signaling and urban traffic movement.

Elhadouaj, Drogoul and Espié (2000) also describes conflicts resolution in a simulated road traffic environment (France and Ghorbani, 2003). A multi-agent system for optimizing urban traffic In Proceedings of the IEEE/WIC International Conference on Intelligent Agent Technology, (pp. 411–414), Washington, also motivated us in application of EMO algorithms in Urban traffic systems.

Haugeneder and Steiner (1993) in his paper also supports very well about MECCA/UTS: A multi-agent scenario for cooperation in urban traffic.

2.1 APPROACHES BASED ON FUZZY TECHNIQUES

Traffic signal control system is not efficient controlling congestion in urban areas. A model based multi agent fuzzy system with three levels of control is proposed in Balmer, Cetin, Nagel and Raney (2004). To control traffic at an intersection; parameters used are intensity of traffic, recommendations from near about intersections and a knowledge repository which gives information about data at any particular time. A traffic observer is used to deliver data to data management component according to which the decision making layer makes the decision. A two stage fuzzy clustering algorithm can be used by the prediction module to predict the effect of most intersections on a specific intersection as shown in Bazzan, de Oliveira, Klügl & Nagel (2008). Type 2 fuzzy logic based multi-agent integrated architecture having distributed type nature has been proposed in Dresner and Stone (2004) for reducing the traffic congestion in urban areas PARAMICS simulator has been used.

Dynamic nature of the traffic in urban areas has caused heavy congestion in urban areas. A signal control system using multi agents is proposed in Katsikopoulos, Fisher, Duse-Anthony and Duffy (2002) with an aim to reduce the congestion. Urban traffic is difficult to control because of its dynamic nature with vehicle types, speeds, length, flow rates etc. An Adaptive fuzzy algorithm is proposed which is integrated with multi agent approach as shown in Elhadouaj, Drogoul, and Espié (2000). Geometric fuzzy system is proposed in France by Ghorbani (2003) GFMAS efficiently handles dynamicity and outperforms other traffic control algorithms such as GLIDE and HMS.

A fuzzy neural network based traffic control system is designed in Haugeneder and Steiner (1993) wherein a coordination system is used where each junction and coordination is treated as agents. Particle swarm optimization is used to optimize the queue length. To handle congestion in urban traffic an Intersection Agent (AI) hardware platform is developed by Ellis, Keddara and Rozenberg (1995) where an intersection agent is designed for coordination using fuzzy control strategies we have used their concept in developing a multi agent coordination algorithm .

2.2 SIMULATION BASED APPROACHES

Computer traffic simulation can be used to understand traffic flow and develop traffic control strategies.

In Bonasso, Gat, Miller and Slack (1997) traffic simulation with microscopic vision is designed which follows the concept of multi-agent systems. The whole concept is implemented in MS C++. A multi agent based simulation approach is proposed in Castelfranchi(1998). This approach uses Object- Z and state chart formal languages. Past historical real world data and dynamic simulated data can be used to forecast traffic. Based on this an online simulation framework is proposed in Chmura, Pitz, Möhring, and Troitzsch (2005) which integrates real traffic data along with multi-agent approach.

To control simulated vehicles, reactive agents can be used. Using microscopic traffic simulator, an approach is developed in Gilbert and Troitzsch (2005) wherein vehicles are controlled by driving agents with different behavior settings.

In Harel (1987) a multi agent based simulation tool is developed which includes the factors, such as opportunistic behavior of an individual causing norm violations and anticipation of critical situations by individuals. An approach named HUTSIG is derived from a microscopic traffic simulator HUTSIM in Helbing and Johansson (2007). It is based Queue models can be used for simulating traffic agents such as travelers and traffic signals as proposed in Balmer, Cetin, Nagel and Raney(2004). Traffic signal control can be made efficient by utilizing the signal phase transition time. In Bazzan (2005) a multi-agent based simulation model is designed using Repast S on java platform, it is used to enhance the system capacity at the intersections. Simulating driver's behaviour is difficult because of its uncertainty. A simulation model named DRACULA is proposed in Bazzan, de Oliveira, Klügl and Nagel (2008) which integrates reasoning capabilities with multi agent based approaches to simulate the driver's behaviour on fuzzy inferences using multi agents and simulating real traffic data.

2.3 COGNITIVE/LEARNING BASED APPROACHES

For minimizing the waiting time of the commuters in the queues, signals of the adjacent intersections are coordinated. In Bazzan, and Klügl (2005) multi agent coordination is done using RMM (recursive modeling method). To update the knowledge base and selecting the correct model for other agents, Bayesian learning is used. For adapting the changing network conditions an urban traffic control system is designed in Bazzan, Wahle and Klügl (1999). Multi-agent based approach integrated with fusion technology is proposed. Reinforcement learning is used for coordination of traffic signal control network.

Pre-timed controllers cannot adapt to the dynamic changes in traffic flow. Agents need to communicate directly to learn the system behaviour. Machine learning algorithms can be used by agents to learn the traffic control policy as proposed in Burmeister, Doormann and Matylis (1997).

A multi agent traffic handling method, which is based on reinforcement learning, is proposed in Camponogara, and Kraus Jr. (2003) to adapt the dynamicity of traffic flow.

In Diakaki, Papageorgiou and Aboudolas (2002) traffic signal control problem is solved by designing a hierarchical multi agent system where multi-stage online learning process is implemented. Agent learning is based on reinforcement learning, learning rate and weight adjustment and fuzzy relation updates.

A decentralized strategy is proposed in Dresner and Stone (2004) wherein individual agents are responsible for each intersection. Sensors are placed at each intersection to gather information and decisions are influenced by opinions of other agents.

Urban areas require their traffic signal controllers to adapt according to the traffic situations. In Elhadouaj Drogoul and Espié (2000) a Q-Learning based approach is proposed wherein the average queue length is used as estimation parameter by the controller agents. Results show better performance as compared to fixed time controllers.

An approach supporting coordination between neighbouring intersections and supporting Q- Learning is proposed in France and Ghorbani (2003). This approach gives an optimal control policy for multi-intersections environment and also reduces the average delay time.

A distributed control approach for controlling traffic is used where for every intersection a local agent acts as the traffic signal controller. Based on this two models are proposed in Haugeneder and Steiner (1993). In first model, agents update their knowledge using multistage online learning process and accordingly take decisions. Second model uses perturbation stochastic approximation theorem with fuzzy neural networks. PARAMICS simulation program is used proving the efficiency of proposed models.

Online reinforcement learning can be used by multi agents for computing the green time. In Hunt, Robertson, Bretherton and Winton (1981) sensors are used at each intersection to compute green time on the basis of historic traffic patterns and information from agents of adjacent intersections. Proposed approach results in reduced mean time delay. In Klügl and Bazzan (2004) Green Light District (GLD) vehicle traffic simulator is used adding reinforcement learning like cooperation among the adjacent agent controllers. This results in minimized time, reduced rate of accidents and maintaining threshold speed for lowest fuel consumption.

2.4 OTHER APPROACHES

To solve the congestion problem, coordination among the control strategies is required. An approach named Intelligent Traffic Control System (ITCS) is proposed in Klügl, Bazzan and Wahle (2003). It is based on coordinated-agents that help managing the current traffic flow. Upon occurrence of any incident, each affected agent interacts with each other to take an optimal control action.

Urban Traffic Control (UTC) system can be made effective by use of autonomous intelligent agents. In Kosonen (2003) a UTC system is designed and it has signal and authority agent making it adaptable to real time traffic conditions. For the overall network performance improvement, global information about whole network is required. For this a higher level agent is appointed as shown in Lowrie (1982) which communicates with the decentralized traffic light controlling agents.

Traffic operators need to take the best control measure corresponding to the prevailing traffic situation. For this, they need to predict the possible outcomes of these control measures. A multi agent based simulation approach is proposed in Morgan and Little (1964) which allows on line, real time evaluation of the traffic situation.

To resolve the disturbances in the transportation system, a multi agent based regulation process is proposed in Nunes and Oliveira (2004). It also uses evolutionary algorithms to optimize this regulation process. 802.11p is standard for wireless access tin vehicular environments (WAVE) which allows communication among cars and other roadside systems. An agent based simulator is proposed in Oliveira, Bazzan and Lesser (2005) that can simulate communication between cars.

In Tumer, Welch and Agogino (2008) a multi agent based system is proposed for urban traffic management. It consists of following types of agents: segment, crossing, section and central decision agent which share information for a group decision to make an efficient traffic management system.

As per the demands of the traffic environment mobile agent technology can be used, Van Katwijk, van Koningsbruggen,, Schutter and Hellendoorn (2005)shows how these mobile agents can be reconfigured according to required traffic conditions. In Wahle, Bazzan and Kluegl (2002) multi agent technology is used along with genetic algorithms to improve the urban traffic control system. It involves optimization of the timing schemes at traffic intersections. A hierarchical multi-agent architecture is proposed in Wiering (2000) where each agent is responsible for any one task such as collection of data, pre-processing of data and decision making. A policy based management model is proposed to develop an intelligent algorithm for coordination among the agents. It aims at reducing the average size of the queue, average waiting time and travelling time.

“Microscopic Traffic Simulation Model with the Fuzzy Logic technique” the paper by Errampalli, Okushima and Akiyama (2013) describes microscopic traffic simulation (MTS) and individual vehicle/driver behavior more precisely and realistically than other methods. MTS is nothing but a series of human decisions under various traffic situations. In order to analyse the driver’s behaviour fuzzy logic technique appropriately is used to model the drivers’ decisions. We have used his work in integrating jam condition with VMS.

Paper by Jesus Felez, Maroto, Cabanellas and Mera (2013) on “A full-scale simulation model to reproduce urban traffic in real conditions in driving simulators”, describes a model capable of simulating large-scale traffic in an urban environment. It provides the detail behaviour of the driver using various types of simulators we are inspired

Secondly, the behavior of the drivers is simulated using three basic categories passive, moderate, lastly traffic light regulation model and the complete signposting of the urban environment are also included.

Navigation Styles of Social Agents in Urban Traffic by Toiskallio (2002) describes the framework for Simmelian Urbanism: positive meanings of impersonality that resonate with the late Chicago School.

Implementation of a fuzzy-inference based, low-speed, close-range collision warning system by Kim, Lee and Lee (2012) also motivated us in building MACNUT simulation environment as it highlights a low-speed, close-range collision-warning algorithm for urban areas using fuzzy inference.

A microscopic model of urban traffic for implementation in driving simulators by Maroto, Delso, Cabanellas and Félez (2006) highlights traffic simulation of an urban environment.

Its main application is for implementation in driving simulators as it focuses on real-time applications, which consists of realism and the computation speed obtained. He has divided the entire city into segments of road, junctions, and sectors that minimize the interaction between the cars involved in the traffic simulation, with the traffic simulation being considered only in a control zone centered on the driven vehicle.

Lastly, a review of current sensor technologies and applications in automotive and traffic control systems by Turner and Austin (2000) focuses on current sensing technologies for automotive control network by embedding the sensors and to deactivate the acceleration in case of exceeding the limit of that region.

CHAPTER 3

In this chapter, we provide with the literature material in order to understand the subsequent lessons. The chapter is classified into two parts: the former part deals with multi optimization techniques and the second part of the chapter deals with the brief overview of Cognitive Radio and its applications.

INTRODUCTION TO OPTIMIZATION AND MULTI OBJECTIVE OPTIMIZATION

Optimization is a mathematical discipline that concerns finding alternative solutions with most cost efficient and highest achievable performance under certain constraints by maximizing the desired criteria and minimizing the undesired criteria. Maximization implies an attempt to attain the maximum result or outcome irrespective of cost or expense. Optimization comprises a wide variety of techniques from artificial intelligence and is used to improve business processes in practically all industries

3.1 MULTIOBJECTIVE OPTIMIZATION

The multi objective optimization problem states that there is no single solution and it should be best when measured on all objectives/ solution. It minimizes the n components f_k, for k = 1, n, of a non-linear vector function f of a decision variable x in the universe U simultaneously where

$f(x) = (f_1(x), \ldots, f_n(x))$

If there exists no, perfect, feasible, unique solution but a set of non dominated alternate solution called Pareto Optimal Set. Let the dominance of the minimization problem be defined as: Definition 3.1 (Pareto Dominance) *A vector* $u = (u_1, \ldots, u_n)$ *is said to dominate* $v = (v_1, \ldots, v_n)$ *if and only if u is partially less than v (u p< v), i.e.,*

$\forall I \in \{1,...,n\}, u_i \leq v_i \; \exists i \in \{1,...,n\}: u_i < v_i$.

Definition 3.2 (Pareto optimality) *A solution* $x_u : U$ *is said to be Pareto optimal if and only if there is no* $x_v \in U$ *for which* $v = f(x_v) = (v_1, \ldots, v_n)$ *dominates* $u = f(x_u) = (u_1, \ldots, u_n)$

The trade off surfaces can neither be convex nor concave. Hence, the regions of local convexity and concavity can be identified in such trade off surfaces.

The way in which the objectives are scaled determines the convexity . So, the search for an optimal solution is rejected from what we see in case of single objective problem. The task of solving Multi Objective Problem's is called Multi Objective Optimization. Usually we need only one solution from the set of optimal solutions. Solving the Multi Objective Problems can be seen by searching and decision making. The first step towards solving a Multi Objective Problem is the Pareto Optimality. In order to support searching and decision making, four approaches are identified.

3.1.1 Priori Articulation of Preferences

To incorporated the use of preference before the optimization process and hence it will result in only one solution at the end. In this approach, the bias is imposed all the time.

Methods Involved in Apriori Articulation of Preferences

Such methods allow the user to specify his preferences that can be articulated on the basis of goals or by the importance of diverse objectives. A large number of these methods make use of parameters that are coefficients, exponents, limits, etc. If we consider more than one objective function in an optimization problem it introduces an additional degree of freedom. Preferences specified by the decision-maker improvise the constraints. One approach to impose such constraints is by developing a utility function.

Physical programming

Though it was originally developed for apriori articulation of preferences, we can use it in providing Pareto optimal points which will correctly depict the complete Pareto optimal set, even in conditions when the Pareto optimal surface is non-convex. These ranges are associated with different degrees of preference (undesirable, tolerable, desirable, etc). This task is done for every metric, which results in a unique utility function.

Posteriori Articulation of Preferences

To find all possible solution of the non dominated set to then use the user preference to determine the most suitable are called decision making after search or posterior.

There are a number of techniques which enables to search solution space for a set of Pareto optimal solutions and then present to the decision-maker. The big advantages with these types of methods are that the solution is independent of the Decision Maker's preferences. The analysis has only to be performed ones, as the Pareto set would not change as long as the problem description are unchanged. However, some of these methods suffer from a large computational burden. Another disadvantage might be that the Decision Maker has too many solutions to choose from. There is however methods that supports in screening the Pareto set in order to cluster optimal solutions.

Preference Function.

A preference function is an abstract function (of points in the criterion space) in the mind of the decision-maker, which perfectly incorporates his/her preferences.

Utility Function:

In the context of economics, utility, which is modeled with a utility function, represents an individual's or group's degree of contentment. In terms of multi objective optimization, an individual utility function is defined for each objective and represents the relative importance of the objective. The utility function U is an amalgamation of the individual utility functions and is a mathematical expression that attempts to model the decision maker's preferences.

Global Criterion:

A global criterion is a scalar function that mathematically combines multiple objective functions; it does not necessarily involve utility or preference.

PROGRESSIVE ARTICULATION OF PREFERENCES

In this preference at each step, partial preference information is supplied to the optimizer by the decision maker, the decision making and optimization occur at interleaved steps, so it received information and generates better alternatives. Progressive articulation of preferences, in which the decision-maker is not continually providing input during the running of the algorithm. In which Decision Maker and search inter-wined, with the Decision Maker using progressive solutions to inform the decision making process and the final choice of pay-off.

3.2 PREFERENCE CONSTRAINTS

It imposes further restriction on the solution of the problem according to knowledge at a higher level. A given stability margin, for example, expresses a (subjective) preference of the designer.

Constraints can usually be expressed in terms of function inequalities of the type.

$f(x) \leq g$

Where f is a real valued function of a variable x and g is again a constant value. The inequality may also be strict (< instead of ≤). Equality constraints of the type

$f(x) = g$

Can be formulated as particular cases of inequality constraints e.g.

g - δ1 ≤ f(x) ≤ g + δ2

for arbitrarily small, non – negative δ1 and δ2.

Without loss of generality, the constrained optimization problem is that of minimizing a multiobjective function (f1,…….,fk) of some generic decision variable x in a universe U , subject to a positive number

n – k of conditions involving x and eventually expressed as a functional vector inequality of the type

(f k+1 (x),………, fn (x)) ≤ (g k+1,……..g n),

where the inequality is component based.

3.3 VISUALIZATION AND PERFORMANCE ASSESSMENT ISSUES

This is concerned with the graphical visualization of trade-off data, i.e. if one or more sets of relatively non-dominated solutions produced by as many runs of a general multi-objective optimizer.

The aim is to convey to the human decision maker information concerning the best trade-of overall non-dominated solutions. Two graphical representation methods commonly used for this purpose will be described in fig, one for two objectives and another for three or more objectives.

On the other hand, in order to gain insight into how well an optimizer can be expected to perform on a given problem, data from multiple optimization runs must be considered in its entirety, i.e. it is not sufficient to consider only the overall non-dominated solutions. For this reason, a method for the visualization is used, Visualization of trade-off data from a single run methods for progressive and a posteriori articulation of preferences require that trade-off information be communicated to the decision maker in a form which can be easily comprehended. When there are only two objectives, non-dominated solutions (the data) can be represented in objective space by plotting the first objective component against the second.

When assessing an optimizer, one is usually concerned with the quality of the solutions it is able to produce, and with the amount of computation effort it requires. In addition, it is important to assess how likely a single run is to produce good results.

When there are multiple objectives, however, runs will generally produce not one, but a variable number of approximate non-dominated solutions. The quality of the trade-off description produced by each runs both on how close to the real trade-off surface the non-dominated points found and on how well they cover it. Simply superimposing non-dominated points obtained from various runs does give an idea of how good individual points found in each run tend to be, but information on how they tend to be distributed along the trade-off surface is lost.

3.4 MULTIOBJECTIVE GENETIC ALGORITHMS

Multiple individuals should be able to search for multiple solutions in parallel, while taking advantage of any similarities available in the family of possible solutions to the problem. The ability to handle complex problems, involving features such as discontinuities, multimodality, disjoint feasible spaces and noisy function evaluations reinforces the potential effectiveness of GAs, and of other evolutionary algorithms, in multiobjective search and optimization. However, contributions in the area have remained scarce.

Fitness, as a measure of the expected reproductive success (or number of off-spring) of an individual, is inherently a non-negative scalar. When a problem is characterized by a scalar measure of quality or cost, i.e., a single objective, the mapping from such a measure to fitness simply involves a monotonic transformation, such as scaling or ranking.

3.5 COGNITIVE NETWORK

3.5.1 What is a Cognitive Network?

The concept of CNs has been bouncing around the collective psyche of the wireless and networking researching world for a while. Mitola makes brief mention of how his cognitive radios (CRs) could interact within the system-level scope of a CN. Saracco refers to CNs in his investigation into the future of information technology. He postulates that the movement of network intelligence from controlling resources to understanding user needs will help “flatten” the network by moving network intelligence further out towards the edges of the network.

3.5.2 History and Background Leading to Cognitive Radio

The sophistication possible in a software-defined radio (SDR) has now reached the level where each radio can conceivably perform beneficial tasks that help the user, help the network, and help minimize spectral congestion. Radios are already demonstrating one or more of these capabilities in limited ways. A simple example is the adaptive Digital European Cordless Telephone (DECT) wireless phone, which finds and uses a frequency within its allowed plan with the least noise and interference on that channel and time slot. Of these capabilities, conservation of spectrum is already a national priority in international regulatory planning. This leads us through the technologies and regulatory considerations to support three major applications that raise an SDR's capabilities and make it a cognitive radio:

- Spectrum management and optimizations.
- Interface with a wide variety of networks and optimization of network resources.
- Interface with a human and providing electromagnetic resources to aid the human in his or her activities.

Many technologies have come together to result in the spectrum efficiency and cognitive radio technologies that are described in this thesis. This chapter gives the reader the background context of the remaining chapters of this thesis. These technologies represent a wide swath of contributions upon which cognitive technologies may be considered as an application on top of a basic SDR platform.

To truly recognize how many technologies have come together to drive cognitive radio techniques, we begin with a few of the major contributions that have led up to today's cognitive radio developments. The development of digital signal processing (DSP) techniques arose due to the efforts of such leaders as Alan Oppenheim , Lawrence Rabinera , Ronald Schaefer , Ben Gold, Thomas Parks , James McClellen , James Flanagan, Fred Harris , and James Kaiser. These pioneers recognized the potential for digital filtering and DSP, and prepared the seminal textbooks, innovative papers, and breakthrough signal processing techniques to teach an entire industry how to convert analog signal processes to digital processes. They guided the industry in implementing new processes that were entirely impractical in analog signal processing.

Somewhat independently, Cleve Moler, Jack Little, John Markel, Augustine Gray, and others began to develop software tools that would eventually converge with the DSP industry to enable efficient representation of the DSP techniques, and would provide rapid and efficient modeling of these complex algorithms .

Meanwhile, the semiconductor industry, continuing to follow Moore's law, evolved to the point where the computational performance required to implement digital signal processes used in radio modulation and demodulation were not only practical, but resulted in improved radio communication performance, reliability, flexibility, and increased value to the customer. This meant that analog functions implemented with large discrete components were replaced with digital functions implemented in silicon, and consequently were more producible, less expensive, more reliable, smaller, and of lower power.

3.6 BASIC SDR

3.6.1 The Hardware Architecture of an SDR

SDR includes the front-end as radio, the modem, the security function, and the application function. In addition, some of the radios also take the support of network devices that are connected to the plain text side or the modem side of the radio, allowing the radio to provide network services and to be remotely controlled over the local Ethernet.

Some radios will also provide for control of external radio frequency (RF) analog functions such as antenna management, coax switches, power amplifiers, or special-purpose filters. The hardware and software architectures should allow RF external features to be added if or when required for a particular installation or customer requirement.

The RF front-end (RFFE) consists of the following functions to support the receive mode: antenna-matching unit, low-noise amplifier, filters, local oscillators, and analog-to-digital (A/D) converters (ADCs) to capture the desired signal and suppress undesired signals to a practical extent. This maximizes the dynamic range of the ADC available to capture the desired signal. To support the transmit mode, the RFFE will include digital-to-analog (D/A) converters (DACs), local oscillators, filters, power amplifiers, and antenna-matching circuits. In transmit mode, the important property of these circuits is to synthesize the RF signal without introducing noise and spurious emissions at any other frequencies that might interfere with other users in the spectrum.

It defines, develops, classifies, implements and analyzes the CN concept. We promote an approach to achieving, in a distributed manner, end-to-end network objectives in the context of complex, dynamic networks. In particular, this work formally defines the term cognitive network, differentiating it from other adaptive communication technologies and providing a context and purpose for the concept. In order to further develop this definition, a reference framework that shows the components, interactions and roles of the CN is designed. This framework is inclusive enough to incorporate different objectives, network architectures, hardware, protocol stacks, and cognitive processes. In this manner we design a structural, rather than functional, framework.

Size of the system is a commonly cited distinguishing feature. Interaction-based systems (as opposed to algorithm-based systems) are given as another characteristic. The interactions are a more powerful paradigm than algorithms, since algorithms cannot take into account time or the interaction events that occur during computation. For this reason, he claims that interaction-machine behavior cannot be reduced to Turing Machine behavior. Whether or not his postulate is correct, the idea of interaction is a critical aspect to differentiating a complex system.

Another idea used to describe complexity is that complexity is a mix of order and disorder]. Rather than being called complex, completely predictable systems are better described as being ordered; completely random systems are better described as chaotic.

While complexity can be observed in many different systems, it is certainly present and an issue in networking technology. There are a multitude of possible interactions in a communications network, and yet the only interactions that are typically well-understood and examined are those interactions that are designed and intended. The actual behavior of a network is rarely analytically tractable, meaning that simulation and direct observation are often required to determine system behavior. For instance, interactions between the routing protocol in the network layer and Medium Access

Control (MAC) layer require a tremendous amount of statistical analysis and a number of simplifying assumptions to characterize.

3.7 OPEN ARCHITECTURE FRAMES COLLABORATION

Evolution from AAR toward iCR may be accelerated by industry agreement on an open cognitive radio architecture (CRA), a minimal set of AACR functions, components, and interfaces. The use of standard functions relates both use cases and product components. The evolution of RF function has (1) perception of user through speech, vision, etc; (2) computational semantics; (3) space and time planning; and (4) open architecture framework AML.

3.7.1 THE iCR HAS SEVEN CAPABILITIES

An ideal cognitive radio (iCR) may be defined as a wireless system with the following capabilities, each of which is necessary in evolving AACR toward iCR:

- Sensing: RF, audio, video, temperature, acceleration, location, and others.
- Perception: Determining what is in the "scene" conveyed by the sensor domains.
- Orienting: Assessing the situation—determining if it is familiar
- Planning: Identifying the alternative actions to take on a deliberative time line.
- Making Decisions: Deciding among the candidate actions, choosing the best action.

- Taking Action: Exerting effects in the environment, including RF, human–machine, and machine–machine communications.
- Learning Autonomously: From experience gained.

3.7.2 SENSING AND PERCEPTION: WHAT AND WHOM TO PERCEIVE

The iCR perceives three distinct information spaces: the iCR itself (the <Self>), the <RF/> environment, and the <User/> in its environment.

Legacy Control Does Not Require Machine Perception

The AACR evolution begins with today's mix of legacy hardware-defined radios (like push-to-talk sports and military radios) and emerging SDR devices like cell phones. Control of such traditional radios includes user oriented (input and output interfaces) and radio-oriented aspects (RF reception and transmission). The radio-oriented aspects are controlled via radio-engineering parameters: layers of the International Standards Organization (ISO) Open Systems Interconnect (OSI) protocol stack from physical (PHY), including media access control (MAC) if any, to applications. A single-band single-mode radio like VHF push-to-talk has null middle layers of the ISO stack with simple band and mode control parameters like on/off, audio volume control, squelch, and channel selection. User controls employ human–machine interface (HMI) principles, traditionally limited to microphone/speaker, dials, buttons, and displays.

Commercial multiband multimode radios (MBMMRs) like most vintage 2005 cell phones perceive RF but hide band and mode from the user except for status such as

“Extended” or an icon for digital or analog mode. Military MBMMRs typically use a softcopy HMI display, which may be part of the radio or may be remote (e.g., in the cockpit for airborne radios). User control may include band, mode (e.g., air interface), and related parameters (data rate, voice versus data, etc.). In commercial MBMMRs like triband cell phones, the network sets the parameters for the user, while in military MBMMRs users set many of the parameters.

Contemporary radios may blindly attempt the best communications possible such as 50 W radiated power even if not needed (e.g., between vehicles 20 meters apart). The knowledge of which bands and modes, powers, frequencies, call signs, telephone numbers, and so on yield what kinds of connectivity is not in the radio but in the mind of the user. If an attempt to communicate fails, the process of establishing alternate communications can be labor intensive. The user may give up on the military radio or cell phone, turning to land line, or just wait until later. Such primitive RF control and simple HMI sufficed for inflexible hardware-defined legacy radios. Moore’s Law has both increased radio complexity and created technologies for coping with complexity.

3.7.3 From Provider-Driven to Perceived-User Responsive

A radio following FCC spectrum-use rules can identify new opportunities for ad hoc networking in <RF> <TV-bands/> </RF> implemented as yet another preprogrammed MAC layer. This is an aggressive regulatory step, enabling user-oriented <TVband> behavior but not needing the radio to perceive <Self/> or <User/> per se. Similarly, in the GSM–DECT badges at KTH the initial personalities typically stayed in

GSM mode inside buildings because GSM penetrates buildings, generating revenue for Telia. With SDR technology, KTH programmed those badges to regularly check the DECT RSSI, switching to DECT whenever available, a pro-KTH behavior.

3.7.4 Self Perception

Additional wireless badge flexibility could be achieved via a <Self/>, a software object in each badge. Self-awareness data structures would include objects with relationships to the <Self/>, like <Telia/>, <KTH/>, and the <User/>, each noted in the format of a closed XML tag <. . ./> indicating that the name of the data structure defines the ontological primitive

<Name >Badge-001 </Name >

<Owner> KTH </Owner>

<User> Chip </User>

<Optimization> <Lowest-cost/> </ Optimization>

</Self>

This badge's <Self/> behavior is defined not by the preprogrammed pro-Telia nor by the reprogrammed pro-KTH behavior, but by the more general <Optimization/> objective best supporting the <User/> <Optimization/> value system. Normally, the <User/> might assert <Lowest-cost/>, resulting in the pro-KTH behavior. Alternatively, the <User/> might <Optimize/> for <Minimum-handover/> during an experiment that handover would disrupt, and for which the cost of GSM is warranted. Such situation-dependent objectives are realized by situation-dependent choice among the fixed pro-

Telia and pro-KTH behaviors. Thus, the association of behaviors with relationships among <Self/> and <User/> in a <Scene/> enables greater flexibility than either preprogrammed AAR. The AACR with <Self/> and <User/> data structures can respond to discovered objectives like <Lowest-cost/>.

3.7.4.1 The Autonomous Self

Radio control thus may migrate toward the autonomous iCR <Self/> using distributed RF control that optimizes situation-dependent <User/> goals. To stretch computational awareness to such an autonomous iCR, the following should be known to the <Self/>:

Expression: Data Structures for the Autonomous Self

<Universe>

<Self> . . . data structures . . .

<Autonomous-control> . . . methods. . .</Autonomous-control>

</Self>

<User> . . . data structures . . . </User>

<Environment> <Users/> <RF/> <Self/> <Others/> </Environment>

</Universe>

This data structure asserts that the <Self/> has <Autonomous-control/> in a <Universe/> shared with </Users>. Initially, <Environment/> of AAR may be limited to the RF bands and modes of a service provider. The <Self/> shares this <Environment/> with <Users/>,<RF/>, and unspecified <Others/>.

Pro-provider <Autonomous-control/> could enable the AAR to be always best connected (ABC, a European Framework objective) with respect to the provider's radio resources. The <Self/> that is autonomously controlled by iCR for the <User/> achieves new ideas like autonomous spectrum rental and open optimization of band/mode alternatives, optimizing ABC across multiple service providers and free access bands like ISM, unused TV, possibly the U.S. Citizens Band for ad hoc voice networking, and so on. Pro-user <Autonomous-control/> could choose a private rental of IEEE 802.11 or DECT air time instead of a conventional service provider.

Quality of Information (QoI) The <User/> data structure must accurately model the user's specific and context-sensitive information value system, QoI. Like QoS and GoS, QoI can be defined. Unlike those metrics, QoI must be defined in user-centric terms. QoI is the degree to which available information meets the specific user's specific needs at a specific time, place, and situation. A mathematical framework for QoI is defined as:

*QoI = Availability * Quantity * Relevance * Timelines * Validity * Accuracy * Detail * Need*

Specifically, the ontological primitive <User/> refers to the person using the system. Thus, the intersections refer to a subset of physical space and ordinary time along with the person being served. In a programming language, plus in "A + B" operates on memory locations, not on the literals A and B. So too, <User/> refers to the "memory location" out there in the real world, everything inside the skin of that person, including his/her thoughts, eruptions, prejudices, and specifically information needs.

Ontological statements in this book express the open set existential potentiality of the real world, not the closed set existential and universals of symbolic logic.

3.8 GROUNDING

The process of firmly linking syntactic ("formal") expressions such as the <Self/>, <Owner/>, and <User/> data structures to real-world entities is called grounding. Grounding is fundamental to perception. In logic, grounding is the process of establishing a valid interpretation of the statements of a (formal logic) language with respect to a "model" of those statements in some domain, typically the real world.

3.8.1 Implicit Grounding

Legacy radio control includes physical buttons and computer commands, the syntactic expression of the user's intent. Grounding the formal term <Authorized-user/> to people in the real world is informative. Legacy radio systems allow control by an <Authorized-user/>. If the radio has no user authentication system, then any user is an <Authorized-user/>. This type of default grounding allows whoever possesses the radio to control it, no questions asked:

<Authorized-user/> ≡ <Current-user/>

Commercial GSM cell phones with built-in SIM cards (not removable ones) employ this kind of implicit grounding of control authority, as do most sports, public service, and amateur radios. <Authorized-user> is the simplest of symbols to ground. <Daughter/>, <Vacation/>, and <Car/> are much more difficult to ground.

3.8.2 Explicit Grounding

Explicit grounding of <Authorized-user/> may be based on authentication. Military radios historically have used physical cryptographic keys to limit access to the radio. More familiar to nonmilitary users is the grounding of <Authorized-user/> via a password.

In this case:

<Token-correct/> ⇒ *<Authorized-user/>*

If the crypto-key <Token/> is correct, then the radio behaves as if the <Current-user/> is the <Authorized-user/> even if the person who inserted the key stole the key. The GSM cell phone with removable SIM card has this degree of trust. Explicit grounding is more secure than implicit grounding, but still cannot ground <Daughter/>.

3.9 IDEAL COGNITIVE RADIO (ICR) PLATFORM EVOLUTION

An evolutionary AACR strategy realizes the seven core iCR capabilities with incrementally evolving functionality for a sequence of use cases. The hardware–software platform evolves sensors, perception subsystems, and information architecture to ground those critical entities <Self/>, <RF/>, and <User/> with sufficient accuracy to reliably enhance wireless QoI per use case. Platform evolution may be driven by scene perception, RF, or user interface.

Platforms Driven by Scene Perception

A sensor-rich hardware–software scene perception platform perceives the world to ground the <Self/>, <User/>, and other objects in <Scenes/> in two primary domains of discourse: (1) the wireless communications environment and (2) the user's social environment. With this strategy, a communications context consists of a <Scene/> with perception–action linkages for communications services tailored to entities perceived in the <Scene/> given the opportunities and constraints of the <RF/> <Scene/>. More formally, a scene includes the wireless and user aspects:

<Scene/> :: = <RF-environment/> ∪ *<User-situation/>*

<Scene> <RF-environment/> <User-situation/> </Scene>

<Scene/> is an open-set construct expressed in RXML <Scene/> unites two quasi-orthogonal sets, one primarily physical <RF/> and the other the abstract reality of <User/> perception. The <User-situation/> defines perceived <Scene/> boundaries. Thus, <Home/>, <Commuting/>, and <Work/> could be the major scenes of a <Work-day/>, defined not in terms of home WLAN or cell phone coverage but by <User/> perception and associated terminology and visual of such <Scenes/>.

In a given <Scene/> the constituent subsets usually are not completely orthogonal. If the iCR is planning future connectivity, the current <RF environment/> is not the <Location/> of the future <Scene/>, so the intersection is empty ("null"). A <Primal-sketch/> locates a <Scene/> in space–time, placing entities in the scene and enabling the iCR to assist the user in planning.

Thus <Scenes/> include the space–time coordinates of every experience, plan, action, and response from the environment. A corresponding CWPDA platform (sensors and perception subsystems) continuously locates the position of the radio.

3.9.1 iCR Objective Platform

Scene perception, RF, and user interface evolution each lead to the iCR objective platform with the capabilities to sense <RF-environment/> and <Usersituation/> as outlined above.

Over time, iCR will evolve to a wireless fashion statement, an intelligent wearable information appliance that dramatically enhances its user's capabilities, a RF information prosthetic. The CWPDA personal area network (PAN) interconnects the CWPDA ensemble of glasses and a belt-pack integrating fourth generation (4G) and beyond wireless with the wireless Web.

With iCR built on a PAN and designed as a fashion statement, readout could be in your sunglasses, the core module worn in the small of your back, powered via micro-power generators in your shoes, mouse-like control via movement of your wrist, and typing by just placing your fingers on some convenient surface and then typing away while sensors in wristbands read out your keystrokes.

3.9.2 Policy Challenges for Cognitive Radios

The capacity to sense, learn, and adapt to the radio environment provides new opportunities for spectrum users. However, the same sensing and adaptation also creates challenges for policy-makers. The primary concern is with the potential to have nondeterministic behaviors. Nondeterministic behaviors can be created by a variety of conditions:

- The allowance of self-learning mechanisms will create a condition in which the response to a set of inputs will be changing and thus unknown.
- The allowance of software changes will create conditions either from errors within the software or from rogue software, which can cause the device to not conform to the transmission rules.
- The allowance of frequency and waveform agility will create conditions in which devices that conform to transmission rules may cause interference due to mismatch between out-of-band receivers and the in-band transmitter waveforms.

In addition to nondeterministic behaviors, another primary concern is the impact of horizontal versus vertical service structure. Vertically integrated services, such as cellular telephony, clearly delineate responsibility for spectrum management to the service provider.

However or horizontally integrated service, which includes device-centric systems that may be the initial focus for cognitive radio technology, there isn't a single point of responsibility for interference and other problems. One example has been the issue with secondary spectrum markets. The formal responsibility of a device creating interference is the primary licensee. The rules had to be modified to allow that responsibility to follow the usage to the secondary licensee when appropriate. The extrapolation of this approach is problematic when applied to cognitive radios, as each device is, in essence, a licensee. This is a serious problem for the policy-makers that can be addressed by rules, technology, or a combination of both.

CHAPTER 4

A NOVEL MULTI AGENT COGNITIVE NETWORK MODEL FOR THE LANE-BY-PASS APPROACH IN THE URBAN TRAFFIC CONTROL SYSTEM

4.1 INTRODUCTION OF THE LANE BY PASS USING COGNITION

The matter of traffic jam in the various urban cities is a critical topic. It leads to loss of productivity and degrades the living standard of the human beings. The factors like inadequate road infrastructure and escalating number of vehicles are main problems while dealing with traffic congestion. To deal with this problem, various approaches of Artificial Intelligence have been invented to simulate and model the situation. These approaches are neural network (Carrillo, Harkin, McDaid, Pande, Cawley and Morgan, 2011, Nagare and Bhatia, 2012, Carrillo et al., 2012), fuzzy logic (Mehan and Sharma, 2011, Vijayan and Paul, 2010), Petri-nets (List and Setin, 2004, Wang, 1992), genetic algorithms (Sánchez-Medina, Galán-Moreno and Rubio-Royo, 2010) and their amalgam approaches.

In any urban city, we may consider the net of major and minor roads. It is implemented using a n-dimensional grid network for the whole situation. This network consists of nodes, representing X- Junction (Fig. 1) and T-Junction.

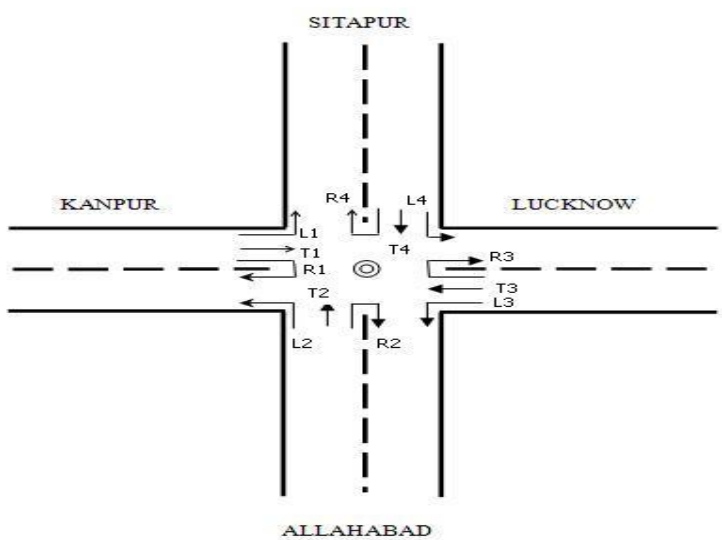


Figure 4-1: Junction representation

Movement and phase are the two terms that are very important in traffic signal control theory. A movement is defined as a specific traffic flow that occurs at the intersection. Phases are the paired combinations of the movements.

This chapter proposes two schemes relating to “Lane by Pass” methodology that is used in Traffic Control Systems. The first approach deals with the problem of traffic congestion, based on n-dimensional road network. For the traffic information communication, cognitive radio systems are utilized and for effectively implementing the decision making process the multi-agent systems are used.

4.2 OVERVIEW OF PROPOSED SYSTEM

A lane-by-pass approach in a n-dimensional road network of an urban city has been carried out in Darbari, 2009. This approach has been extended using Multi-Agent Systems (MAS) and Cognitive Radio Systems (CRS).

The Multi Agent System (MAS) consist of variations on systems consist of various software agents. The Multi Agent Systems are derived from Distributed Artificial Intelligence (DAI), which concentrate on questions like coordination, task allotment cooperation and communication languages among the agents. The multi agent systems are the next generation of technology in the development of software systems. This provides the new approach of conceptual modeling, designing and implementing the software systems. Modularity and abstraction are the powerful tools provided by the MAS to deal with the software complexity. The software agents are intelligent also which makes them to inference the conclusion. Several aspects in the MAS are still under research like, effective framework of agents for communications, efficient communication methodologies, reasoning by individual agent, designating the responsibility of the agents, identification of conflicts and their resolving approaches.

MAS are highly are highly applicable during the design of Urban Traffic Control Systems. A review on this issue has been carried out in Chen and Cheng (2010).

A distributed MAS technology has been used in Oliveria and Camponogara (2010) for solving the problem in urban traffic control system. It utilizes multi agent control for linear dynamic systems.

Apart from MAS, CRS are also integrated in this approach for reliable traffic information flow in the road network. CRS (Haykin, 2005) is similar to radio defined by software that is functioning as the intelligent wireless communication system. This system is familiar with its surroundings as well as utilizes the approach understanding through building to learn from the surroundings and adjust the changes. By using CRS, a highly reliable communication can be established. Several variations of CRS has been proposed and implemented, like Multi-Antenna based Cognitive Radio System (Gao, Zhang, Liang and Wang, 2010).

Also, the cognitive radio systems are applicable in various fields like, smart grid (Qiu et al. 2012), short range CRS for WLANs (Hao and Yoo, 2011) etc.

The above two technologies, MAS and CRS are integrated with each other to implement an efficient urban road traffic control system.

4.3 PROPOSED SYSTEM

A n-dimensional road network is considered as a graph G=(V,E) where V is identified as X or T junction and E is the set of roads connecting the junctions identified as V. This network is given in Figure 4.2.

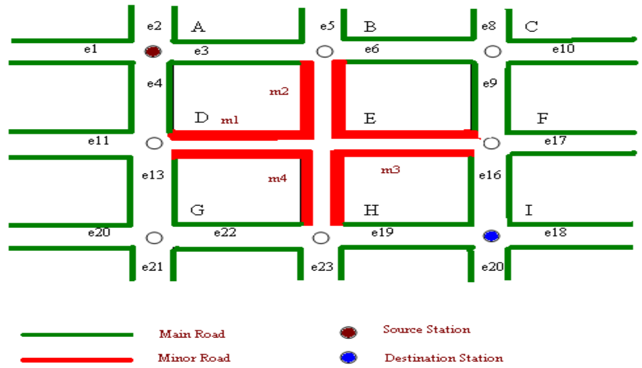


Figure 4-2: N-dimensional road network in urban city

The goal of the problem is to ensure the smooth traffic flow in the road network. The architecture has been divided into following components:

- Cognitive radio network utilized for the traffic information communication
- Implementation of multi-agent system on each X or T junction in the whole road network
- Establishment of communication system among all the agents
- Self cognition process in the multi agent architecture

The multi-agent route diversion algorithm is as follows:

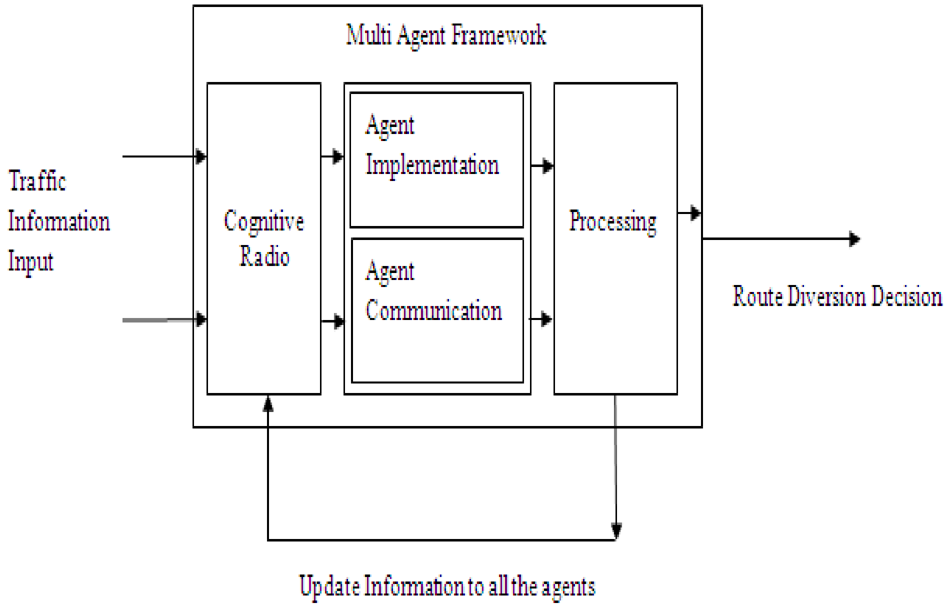


Fig. 4.3 An integrated model of multi agent system and cognitive radio system for road network traffic flow

According to above framework, at each T or X junction, a software agent has been implemented. The number of agents will be equal to the number of X or T junctions in the whole road network. The sensing device for inputting the traffic information to the agents is RFID through CRS. The reliable communication among all the agents has been carried out by CRS.

The traffic information upon which the system is based are traffic queue at particular junction, mean velocity (depending on time) and traffic density. The agent is taking the decision of route diversion based on Rule Base defined in it.

Table 4-1: MA-ROUTE-DIVERSION

```
MA-ROUTE-DIVERSION ( )
{
        Initialize all the paths (e1,e2,…….en)
        Acquiring the initial information by cognitive radio systems
        Transmit it to all agents
        Set to node i
        Update traffic information to cognitive radio systems
        Processing by Agent
        Inspect the Rule Base
        Fire the Rule
        Conclude the decision
        Outcome of the signal (route diversion)
        Communication of the update to all the agents
        Repeat step 4 to 8 till the destination reach
}
```

Three major activities have been identified in this approach.

- Identification of traffic jams and after the recognition of substitute minor sub lane route information.

- Identification of the Network of Route in the city, demonstrating the association among every roads (routes).
- The Coordination between all the decisions (substitute routes of traffic) to confirm the even traffic flow from the starting place to destination.

4.4 RESULT ANALYSIS & DISCUSSION

The system developed and simulated is implemented on the real time network wide signal control system. The system has been studied at Lucknow, the capital city of Uttar Pradesh, India, for the road network. The proposed system has been analyzed with traffic flow and mean velocity at different time and improvement has been carried out.

Table -4-2: TRAFFIC FLOW AND MEAN VELOCITY AT DIFFERENT INTERVAL OF TIME

Time	Traffic Flow	MeanVelocity (km/h)
7:00 AM	20	80
9:00 AM	200	40
11:00 AM	160	50
1:00 PM	140	55
3:00 PM	135	60
5:00 PM	196	45
7:00 PM	215	40

9:00 PM	170	70
11:00 PM	96	55
1:00 AM	10	80

Overall, the proposed system constituted by both phases is found satisfactory for developing the traffic control system for real applications.

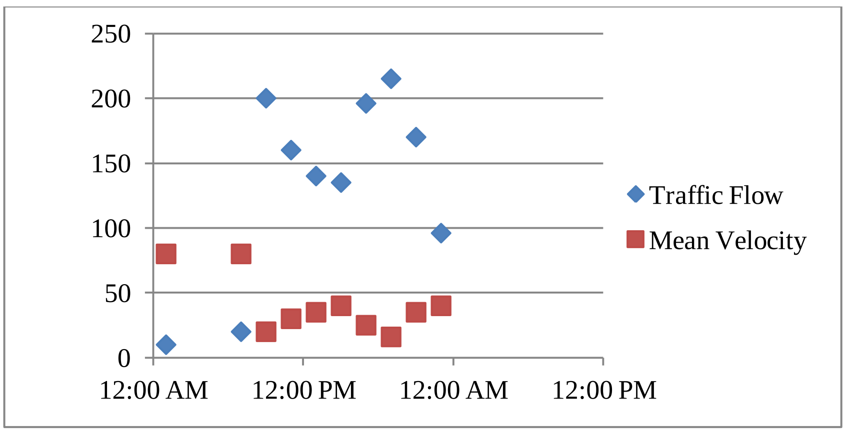


Figure 4-3: Traffic and Mean Velocity at dissimilar interval of time

The mean velocity and traffic flow graph is generated and is as follows:

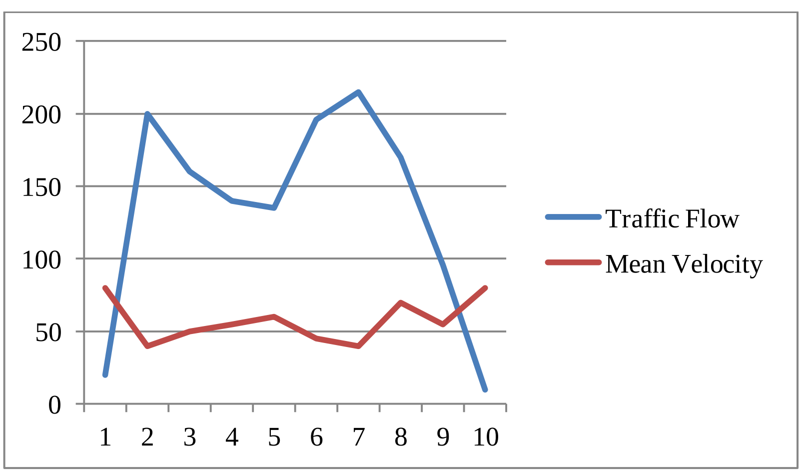


Figure 4-4: Traffic Flow and Mean Velocity relation

4.5 OUTCOME OF THE MODEL

This work is an effort of using Multi Agent System and Cognitive Radio Network for modeling an urban traffic problem in the form of lane-by-pass approach. The results were satisfactory as well as competitive.

The authors would be interested to simulate and model the problem for Intelligent Highway Vehicle Routing System using Cognitive Radio and Multi Agent Systems with the help of Global Positioning System in future.

4.6 INTRODUCTION TO LANE BYPASS USING GENETIC ALGORITHM

Second problem starts with a new lane by pass algorithm using Genetic Algorithm in metropolitan congestion of Road Traffic (Singh, 2005) is a scenario that is characterized by large number of vehicles of various types on the road that ends up into longer time taken for a journey as well as low speed. The growth in population as well as the rapid expansion in the figure of vehicles has amplified the crisis of jamming on the freeways and highways of the country. The traffic jamming can be divided into two categories, in which the first is recurring and the other is non recurring (Bell, 2006). The recurring congestion is dependent on the expected delays in time that result due to the large number of motor vehicles in the same period of time and on the same place. The second one is the Non-recurring congestion, which is related to the changeable delays in the time period that are shaped by impulsive traffic jam situations for example accidents.

The development of the control systems to treat with the jamming for smooth flow of the traffic in cities is a critical issue of research. Quite a few conservative methods (Arnott et al., 2005, Papageorgiou et al., 2003, Chiou et al., 2010, Hearn et al. 1998, Bai et al., 2006, Hearn et al., 2001, Blyth et al., 1991, Ericsson et al., 2006) have been deployed to trim down the hitch of traffic jamming such as elimination of roundabout, road pricing, focusing on the green traffic, enforcement of parking, expansion of existing road network, fuel levies and so on. However because of unpredictable and non-linear character of the movement of traffic and the elevated cost coupled with the extension of on hand infrastructure of network of roads, the conservative ways are not found very appropriate. In meantime, the expertise is incorporated to build up several control systems to deal with the traffic jam issues, particularly in the urban areas. Several approaches are incorporated in order to simulate and model the real time traffic control system such as neural network in Carrillo et al. (2011), Nagare et al. (2012), Carrillo et al. (2012), activity theory in Engestrot et al. (1990), Chin et al. (2011), Lin et al. (2009), fuzzy logic in Mehan et al. (2011), Vijayan et al. (2010), genetic algorithms in Sanchez-Medina (2010), Petri nets in List et al. (2004), Wang et al. (1992) and their blend of approaches.

4.6.1 The Fundamental Concepts of Proposed System

The road network in the urban areas can be measured in the form of a graph in which the edges can be categorized into two parts:

- The Major Lanes,

- The Minor Sub-lanes.

Through the peak hours of the movement of traffic, the minor Sub-lanes that are present can be utilized to conquer the condition of the traffic jam on the major roads of the road network. The forecast of the traffic jam as well as this information is done by the novel algorithm which is proposed. The information sharing and appearance are carried out by the help of VMS (Variable Message Sign Board).

The main actions in the proposed algorithm are acknowledged as:

- The recognition of the Network of route of the city, representing association among all the roads.
- The Identification of the Traffic jamming and then detection of the information about substitute minor sub lane route.
- The synchronization between all the decisions (substitute routes of traffic) to make sure the smooth traffic flow from the starting place to the end.

A sample of the road network in Lucknow City is given in the Fig. 4-5.

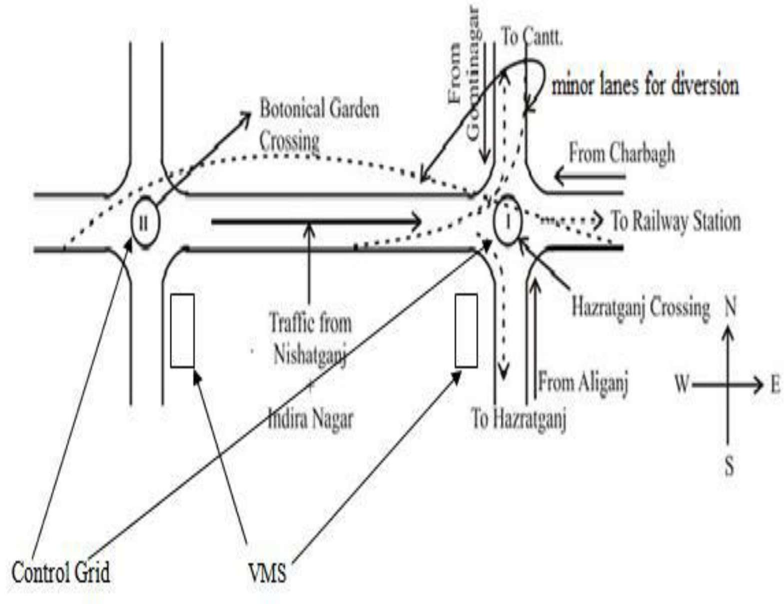


Figure 4-5: A Sample Road Network in the Lucknow City

The network of road is presented with the help of a graph having links $z \in Z$ as well as junctions j $\in J$. For any signalized junction j, we can declare incoming Ij sets as well as outgoing Oj links. The dependence of the signal control map of the junction j is on the set of the number of stages that fit in the set, v2 denotes a set of stages where as the link 2 has right of way. Lastly, saturation flow S2 of the link $z \in Z$ and revolving movement rates tx, y, where $x \in I_i$ along with $y \in O\, j$, are understood to be identified and constant.

As per the definition, the constraint

$\sum_{i \in F_n} g_{n,m} + L_n = C$ hold at junction n, where n, g and m are the green time of state m at the junction n. Ln is the entire lost time at the nth junction. It follows the constraints, $g_{m,m} \geq g_{n,m,min}$ $m \in F_n$

Let's take the subsequent N Dimensional network of roads for the analysis of outcomes.

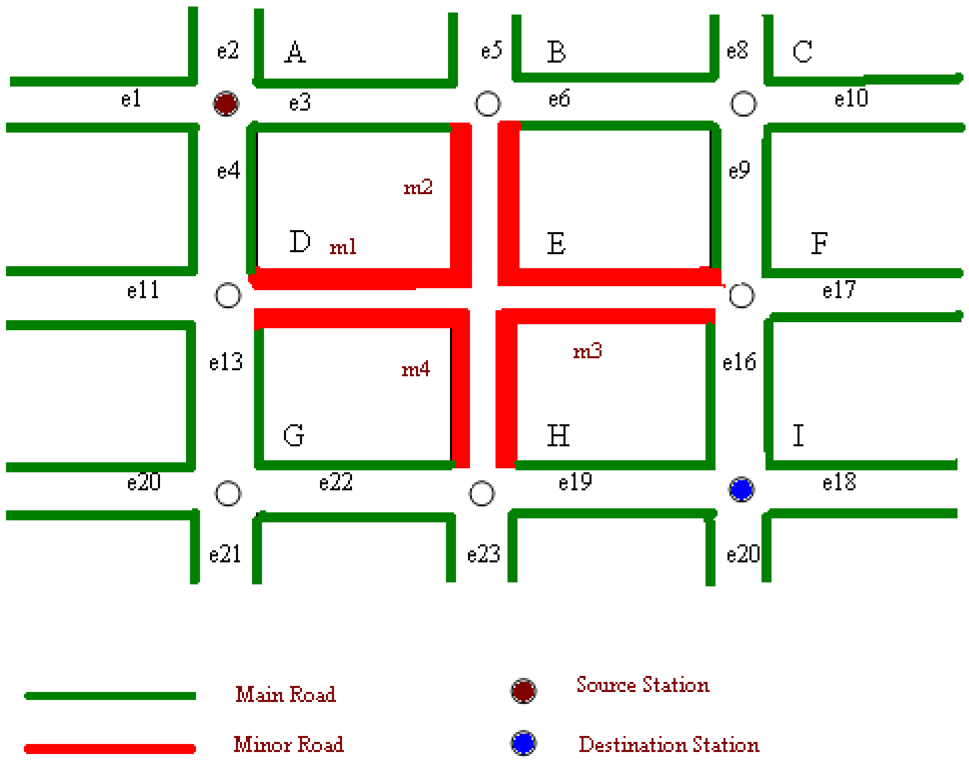


Figure 4-6: The N Dimensional Network of Road

As described in the above diagram A, B, C……., I are junctions at the traffic road network connected by the road connectives. The movements and phases are carried out in the same way.

The approach for the route change and selection is based completely on the Genetic Algorithm, which is an evolutionary approach for optimization in complex and poorly defined search spaces. Genetic Algorithms are common and accepted search and optimization techniques which are based on the Natural Selection. The fundamental thought following the natural selection is the “choose the best and reject the rest”. The Genetic algorithm’ optimization techniques are deployed by simulating progress and evolution of the species by the process of natural selection.

The Genetic Algorithm’s basic technique consist the following steps:

a. The assessment of the individual strength or its fitness,

b. The structure of the gene pool, and the last

c. The Recombination by the alteration and intersect or cross operators.

The operation of the Genetic Algorithm can be diagrammatically represented by the following DFD, evidently as in Figure 4-7.

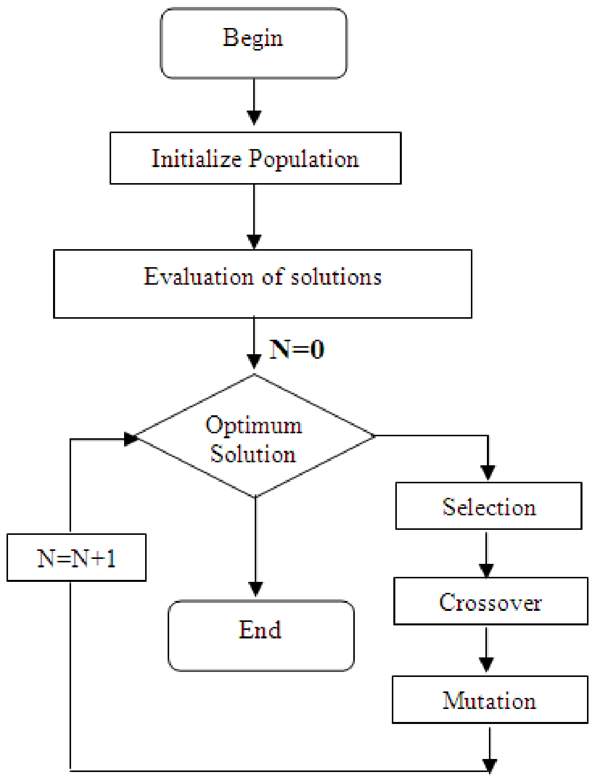


Figure 4-7: Working of Genetic Algorithms

4.7 THE PROPOSED SYSTEM

The problem is acknowledged and this problem's mathematical representation is as follows:

Set of junctions J = (A, B, C, D, E, F, G, H, I)

Set of connectives E = (e1, e2, e3 ……….e23)

Set of Minor Sub lanes M= (m1, m2, m3, m4)

The traffic flow is determined by the set of the connectives commencing source to the destination. A small amount of the connectives are the bypass connectives that are utilized by the transfer office by pass when the major connectives are jam-packed with traffic.

The traffic flow will be determined by the set of the connectives from source to destination. Few of the connectives are the bypass connectives which are used by the transfer office by pass in case the major connectives are completely occupied with traffic jam.

To handle this trouble, the sensors will be positioned at all junctions for intimating the traffic jam to the earlier junction by the VMS.

Let the traveller be travelling from station A to station I. Consider the situation in which the traveler identifies a traffic jam at the junction G through VMS where he or she is on the e4 route at junction D. In order to cope up with this situation the control system will produce the signal for the diversion of the route by using the minor lane by pass and the traveller would attain the signal to decide the route m1 and m4 to arrive at the destination.

The process of the route diversion is incorporated with the traffic phase and movement decision approaches.

4.7.1 PROPOSED ALGORITHM OF ROUTE DIVERSION THROUGH MINOR SUB-LANE

The algorithm is as follows:

ROUTE DIVERSION (αVMS, αMVMS)

Start

Generate αVMS for each junction at the different intervals of time.

αVMS = Traffic Flow / Mean Velocity

The value of the traffic flow will be calculated by the Sensors and the Mean Velocity is calculated at dissimilar intervals of time.

Repeat steps 3 to 5 until the desired destination is reached.

Gather the values of αVMS and update them on the time intervals for every junction in different path from a particular source to a particular destination, at the control centre.

Produce the utmost value of αVMS from which the traffic congestion will start and it is represented by αMVMS.

Apply minimization function Fmin on the values of αVMS to get the next node, *iteratively.*

If Fmin (αVMS, αMVMS)≥ αVMS

then

Send the signal to preceding junction's VMS for the route diversion, if the chosen junction is dissimilar from the regular path,

otherwise

Follow the main route decided formerly.

End.

4.7.2 GENETIC ALGORITHM ROUTE DIVERSION ALGORITHM

This diversion procedure of route can be viewed as an optimization crisis and its comprehensive version can be shaped through the genetic algorithm. This proposal can be given as:

GA- ROUTE DIVERSION (α_{VMS}, α_{MVMS})

{

Initialize all the paths as the initial population

(e1, e2, ……………., en)

Evaluate the fitness of the each path as per the function

Fmin (αVMS, αMVMS)

Set the termination criteria

Fmin (αVMS, αMVMS)≥ αVMS

while the termination criteria is satisfied

```
{
Select the most optimized path
Crossover (Various combinations of paths)
Mutation (Change a particular path in the route)
Evaluate the new population
}
}
```

4.8 RESULT ANALYSIS

The two cases are taken here for the result analysis. Let the source station is A, and the destination station is I.

The chosen route by traveler is (A, B, C, F, I). At this moment, as per to the space capacity of the junction, α_{MVMS} =9.5 (for junction C). Here, TABLE 4-3 represents the mean velocity, calculated values of αVMS and traffic flow at various time intervals in a day.

Table 4-3: TRAFFIC FLOW & MEAN VELOCITY [JUNCTION C]

TTime	**Traffic Flow**	**Mean velocity (km/h)**	**αVMS**
7:00 AM	10	60	0.16
7:30 AM	20	40	0.50
8:00 AM	40	30	1.33
8:30 AM	60	25	2.40

9:00 AM	100	20	5.00
9:30 AM	150	15	10.00
10:00 AM	200	10	20.00
10:30 AM	250	5	50.00

4.8.1 Case 1

At time 9:00 AM,

$$F_{min}(\alpha_{VMS}, \alpha M_{VMS}) = F_{min}(5{,}9.5) < \alpha_{VMS}$$

Therefore as per the algorithm, no diversion is necessary by the minor sub lane by- pass. This case is exposed in Figure 4-8.

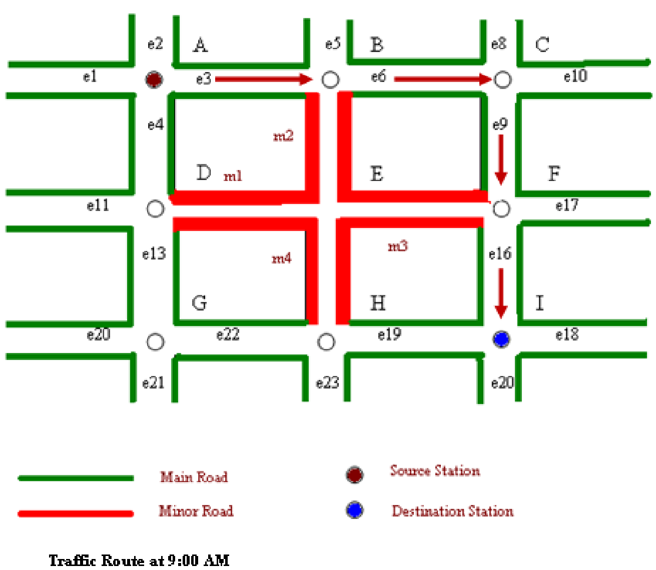


Figure 4-8: Case 1

4.8.2 Case 2

At time 9:30 AM,

$$F_{min}(\alpha_{VMS}, \alpha M_{VMS}) = F_{min}(10{,}9.5) > \alpha_{VMS}$$

Therefore as per the algorithm, the minor lane by pass would be generated and the traveler will obtain the signal to redirect the route at minor lane m2. This case is exposed in Figure 4-9.

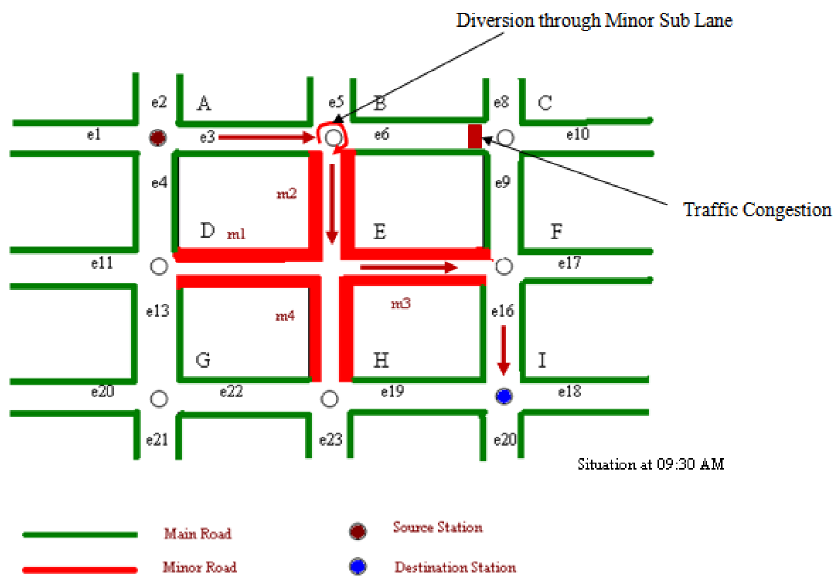


Figure 4-9: Case 2

The variations of α_{VMS} are represented as follows at both the junctions,

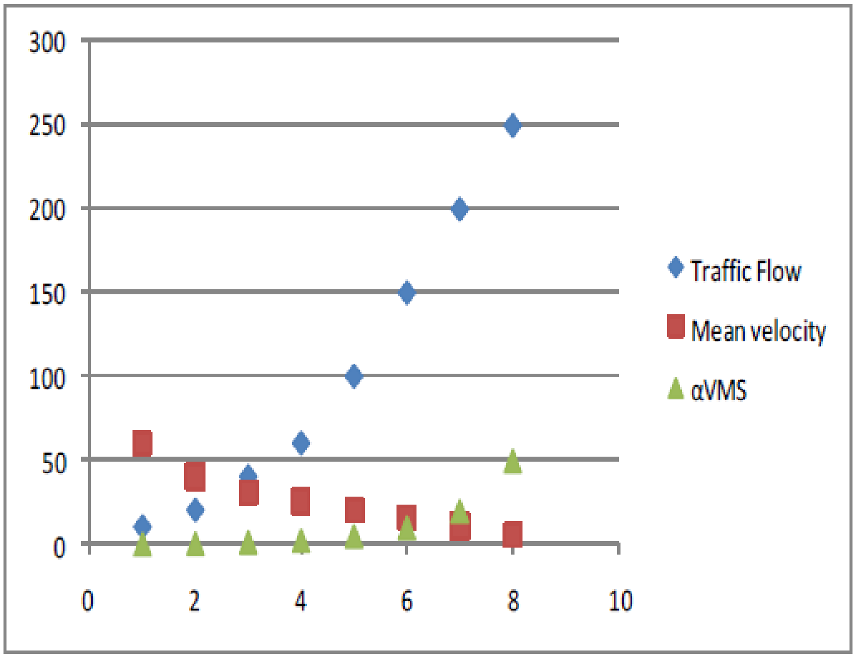


Figure 4-10: Mean Velocity, Traffic Flow and αVMS at Junction C

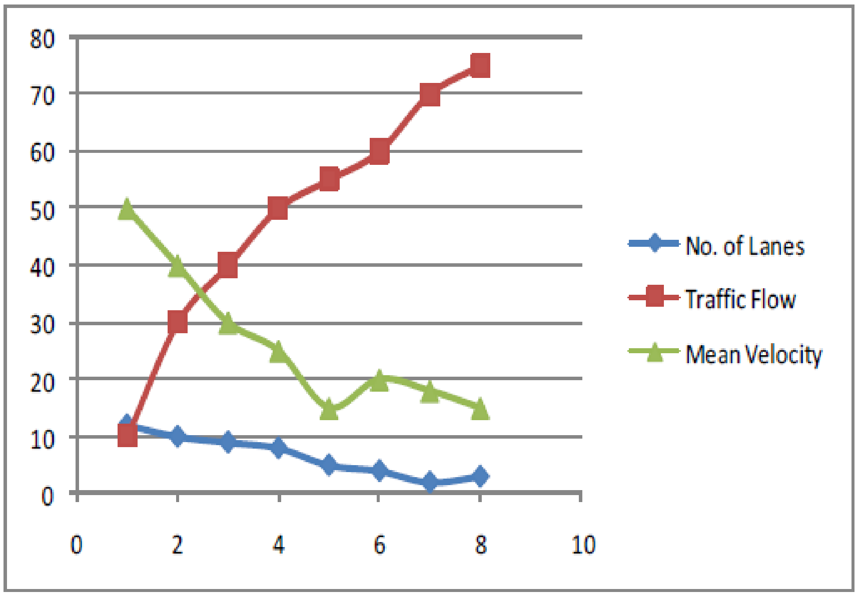


Figure 4-11: Simulation result (Showing importance of Minor Role)

The obtained outcomes are given in the Figure 4-10 and 4-11 and point out that the shutting of minor lanes could recover the time of travel. The assessment of the routing is generally done by computing the feedback costs allied with each of the link network-wide for all pre-specified interval of time (5 min in this case). This result the vehicles to go for the major links, so obtaining improved optimization and smaller delay in the travel time. On the other hand, when several lanes were blocked, a slight deprivation is seen throughout the initial peak traffic period, which then settles down in the afterward peak traffic periods to a little elevated delay value than in the normal operation.

4.9 CONCLUSION AND FUTURE SCOPE

This particular chapter gives an introduction of a novel approach to handle the congestion of traffic on various networks of roads. A novel lane by pass based approach has been presented by means of the genetic algorithms. The results that are generated are acceptable and suitable.

The authors would like to develop the approach for the IVHS (Intelligent Vehicle Highway System) by using the Multi Agent Systems in future.

CHAPTER 5

VERIFICATION AND VALIDATION

5.1 INTRODUCTION

This chapter highlights the verification of the model using Cognitive Radios by applying EMO with no-elists and non-dominated genetic algorithm. Traffic management using Multi-Agent system has grown significantly. Autonomous agent provides excellent coordination capabilities while we are designing cooperative Multiagent.

Due to advancement in Urban Traffic there is an urgent need of developing a complex control system which can manage traffic efficiently. We focus on all the design aspect of Information Model which is divided into two parts namely Urban Decision Subsystem and Urban Physical Subsystem.

The focus is on hierarchical structure for urban traffic control and management. The rapid growth of UTS application in recent years is generating an increasing need for tools to help in system design and assessment. Traffic simulation models have proven to be one of the main cost-effective tools to reach these objectives. Tools are needed to improve the increasing complexity and rapidly deteriorating transportation systems of today. The ability of traffic simulation models to quantify the urban transportation system is still missing even today. Currently there are 80 simulation models available out of them CORSIM and ITEGRATION appear to have the highest probability of success in real world applications. But both of them suffer from the disadvantage of high complexity of the system, which makes them difficult to be enhanced or customized according to specified user's requirements.

The main goal of this chapter is to incorporate the unified architecture which allows to Couple Transportation Systems and Cognitive extension in addition to its potential application to the real world. The whole framework serves as an important tool to assess and validate innovative approaches to deploy sustainable transportation solutions. However, some challenges like coordination amongst agents and validation of behavioral models is an actual issue which we have also incorporated in our work. Coupling multi-agent systems with intelligent transportation solutions have boosted our efforts to promote the quite recent area of Artificial Transportation Systems as one important instrument to better analyze sustainable transportation.

The limited road infrastructure and exponential increase in the number of vehicles are the major reasons congestion in traffic in urban cities. With these unavoidable limitations, the Artificial Intelligence approaches are being applied to deal with this problem. In order to deal with the problem of traffic congestion using cognitive radio in a multi-agent environment a new lane-by-pass approach has been investigated.

Genetic Algorithms are utilized for optimization of various parameters used in traffic routing mechanism.

As mechanism involves generation of minor sublane and dynamic route information focusing on three basic aspects:

- *a) Velocity of information and*
- *b) Quality of information*
- *c) Dynamicity of the information*

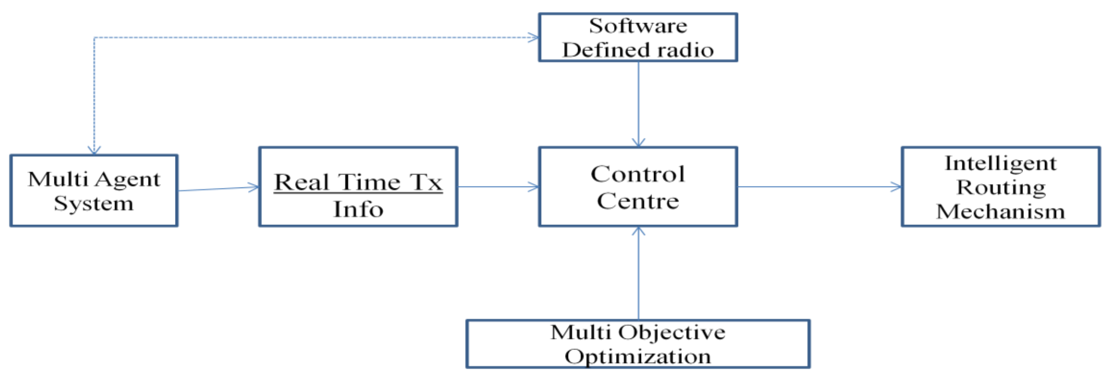


Figure 5-1: MACNUTS

Model starts with receiving of signals from Software defined radios which are controlled by short macros written in XML working as software agents. These Multi-agent systems also provide a feedback to the Control Centre(figure 5.1). The Control Centre acts as Decision centre where all the possibilities are analyzed using the concept of Multi objective optimisation where the non-dominated sets of possible combinations of action-situation are stored, in our case we have used NSGA-II as the basic algorithm to generate non-dominated sets. Finally the signals are given for intelligent routing using dynamic change in VMS messages and signal timings. Besides these it has got various factors like signal control from control centre, these are controlled using the concept of Multi Objective optimization it performs three basic functionalities:

- Identify the Route Network in the city, to depict the relation between all the roads (routes).
- Identify the traffic Jam and then identify the alternative minor sub lane route information.
- Coordinate among all the decisions (alternative traffic routes) to ensure the smooth flow of traffic from source to destination.

In an MOO problem space, a set of solutions optimizes the overall system, if there is no one solution that exhibits a best performance in all dimensions. This set of non-dominated solutions, lies on the Pareto-optimal front (hereafter called the Pareto front). All other solutions not on the Pareto front are considered dominated, suboptimal, or locally optimal. Solutions are non-dominated when improvement in any objective comes only at the expense of at least one and other objective.

5.2 MACNUTS (MULTI AGENT COGNITIVE RADIO NETWORK FOR URBAN TRAFFIC SYSTEM) A FRAMEWORK TO MODEL UTS INTELLIGENTLY

Our work proposes to generate various sets of subroutine program using Software Defined Radio using XML. Cognitive radios should be able to inform other cognitive radios of their observation that can affect the performance of the radio communication channel. The signal properties are measured by the receiver. Apart from this it should also be able to find an estimate of what the transmitter intended to send, and how it must transform its waveform in a manner that will suppress interference. In other words, the cognitive radio receiver must convert this information into a transmitted message that must be sent back to the transmitter.

In Radio XML, <Radio/> defines "the domain of natural and artificial knowledge and skill having to do with the creation, propagation, and reception of radio signals from sources natural and artificial." That's pretty much how RXML, defined in terms of the use of XML <Tag/>s as schema-schema, was envisioned, within an open framework for general world knowledge needed for AACR. RXML recognizes critical features of micro-world not openly addressed in any of the e-Business or semantic web languages yet:

- Knowledge often is procedural.
- Knowledge has a source that often establishes whether it is authoritative or not, or its degree of attributed voracity.
- Knowledge takes computational resources to store, retrieve, and process.
- A chunk of knowledge fits somewhere in the set of all knowledge and knowing more or less where that knowledge fits can help an algorithm reason about how to use it.

5.2.1 Lane Division Scenario

With this basic understanding, semantics for a language L can be considered to be the basis of a theory of meaning: given any syntactically well-formed expression E of L, a semantics for L can be used to describe, characterize and reason about the meaning of E in a principled fashion.

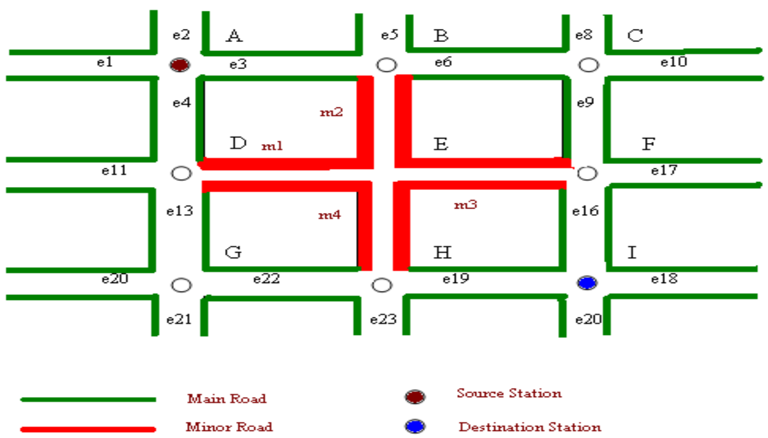


Figure 5-2: Multi lane Diagram showing Lane bypass

Consider a situation of a traffic movement scenario with Road network defined mathematically as:

Junctions set J = {A, B, C, D, E, F, G, H, I}

Connectives set E = {e1, e2, e3 ……….e23}

Minor Sublanes set M= {m1, m2, m3, m4}

The flow of traffic is decided by the set of connectives from source to destination. Some of the connectives are called as the bypass connectives that will be used by transfer office by pass when the major connectives are filled with traffic jam.

We use the VMS (Variable Message Signboard) technology for this approach. The commuters will determine the signal for diverting the route before one crossing through minor sub lane generation in case there is any traffic jam at the next crossing. The path from source to destination should be as minimum as possible.

In order to deal with the above mentioned problem, we place sensors at each junction for informing the traffic jam to the previous junction through VMS. It finds the traffic congestion at a junction J through VMS when it is on the route at e4 junction. To deal with this situation the control system must produce the signal for diverting the route through minor lane by pass. The commuter would get the signal to choose the route m1 and m4 to reach its destination. The procedure for route diversion should be integrated with the traffic phase and movement decision approach. The OWL for the above situation can be modeled as:

```
<owl:Class rdf:ID='Sub_lane'>
<rdfs:subClassOf>
<owl:Class rdf:ID='Main_Road'/>
</rdfs:subClassOf>
</owl:Class>
```

Knowledge representation and semantics can provide such a cognitive radio community architecture with a shared base of constructs that can enable a more flexible and dynamic environment.

According to the IEEE 802.11 specification, in order for a station (STA) to use the medium it must first associate with an access point (AP), i.e., STA must transmit a message with certain information to the AP. In particular, the type of the message must be management and its subtype must be association request. (The message must also include address identifiers for the STA and AP, but those are ignored here.) We use Message(x) to encode ‘x is an IEEE 802.11 protocol message,’ msgTypeIs(x, y) to encode ‘the type of message x is y,’ and msgSubTypeIs(x, y) to encode ‘the subtype of message x is y.’ The following written axiom encodes this information more compactly:

If

Message(x) & msgTypeIs(x, MANAGEMENT) &

msgSubTypeIs(x, ASSOCIATION REQUEST)

Then

AssociationRequestMessage(x)

where ‘MANAGEMENT’ and ‘ASSOCIATION REQUEST’ are individual con-stants that denote the IEEE 802.11 message parameters. In terms of an OWL ontology, it states that if an individual is an instance of the class of IEEE 802.11.

Let the predicate Cognitive Sensor(x) encode ‘x is a sensor,’ let SensorInUse(x, t) encode ‘sensor x is in use at time t,’ let ControlCentreCheckedAtTime(x, t) encode ‘a ControlCentre check of channel x occurs at time t,’ let TimeDifference(t1, t2) be a function that returns the time difference in seconds between the time values of instants t1 and t2, let CONTROLCENTRE CHECK TIME THRESHOLD be an individual constant with the value difference between t1-t2, and finally let RequireControlCentre Check(x,t) encode ‘a ControlCemtre check on sensor x is required at time t.’ Then consider the following rule:

If

Sensor(x) &

Instant(t1) & SensorInUse(x, t1) &

Instant(t2) & ControlCentreCheckedAtTime(x, t2) &

TimeDifference(t1, t2) ≥ CONTROLCENTRE CHECK TIME THRESHOLD

Then

RequireControlCentreCheck(x,t1).

The above method shows the semantics between Control Centre and the Cognitive radio network. Depending on the velocity of information (Complexity) we have enhanced our software network and written all the possible sub-routines for software defined radio network for traffic modeling.

5.2.2 Applying EMO algorithm using NSGA-II with elist non-dominated genetic algorithm

Let MACNUTS be defined as $M_{C\ ;}$ representing the entire control situation consisting of various variables like: Multi agent based Coginitive radio subroutines, Multiagent percepts Ontology Rule base(Traffic Domain).

Step1: MC:= Initialize (MC)

Step2 : while termination condition is not satisfied, do

Step 3: MC':= Selection (MC)

Step 4: MC" := Genetic Operations(MC')

Step 5: MC := Replace (MC U MC")

Step 6: end while

Step 7: return (non dominated solutions (MC))

The entire set of Cognitive radio readings are adjusted according to the non-dominated sorting and crowding distance. The XML program which is going to be executed will be dependent on Pareto dominance relation based on the rank of the current population.

Two objectives of the Multiobjective Optimization are as:

- Objective-1 Maximize Traffic Density
- Objective-2 Maximize Traffic Flow

Traffic density and Traffic Flow are formulated ass given in L.H. Immers, S. Loggle, Traffic Flow Theory, Digital library, University of Katholieke, 2002.

$$Traffic\ Flow = \frac{Speed\ Difference}{Space\ Interval} = \frac{\Delta v_{\alpha(t)}}{SI}$$

$$TF = \frac{v_{\alpha+1(t)} - v_{\alpha(t)}}{SI}$$

$$Traffic\ Flow = \frac{1}{SI}\left(\frac{d_{\alpha+1}}{t_{\alpha+1}} - \frac{d_{\alpha}}{t_{\alpha}}\right)$$

But

$$d_{\alpha+1} = d_{\alpha}$$

Hence

$$TF = \frac{d_{\alpha}}{SI}\left(\frac{1}{t_{\alpha+1}} - \frac{1}{t_{\alpha}}\right)$$

$$TF = \frac{d_\alpha}{SI}\left(\frac{t_\alpha - t_{\alpha+1}}{t_{\alpha+1} * t_\alpha}\right)$$

$$Traffic\ Density\ (TD) = \frac{Space\ Interval}{Traffic\ Time\ Interval} * distance$$

$$TD = \frac{SI}{t_{\alpha+1} - t_\alpha} * d_\alpha$$

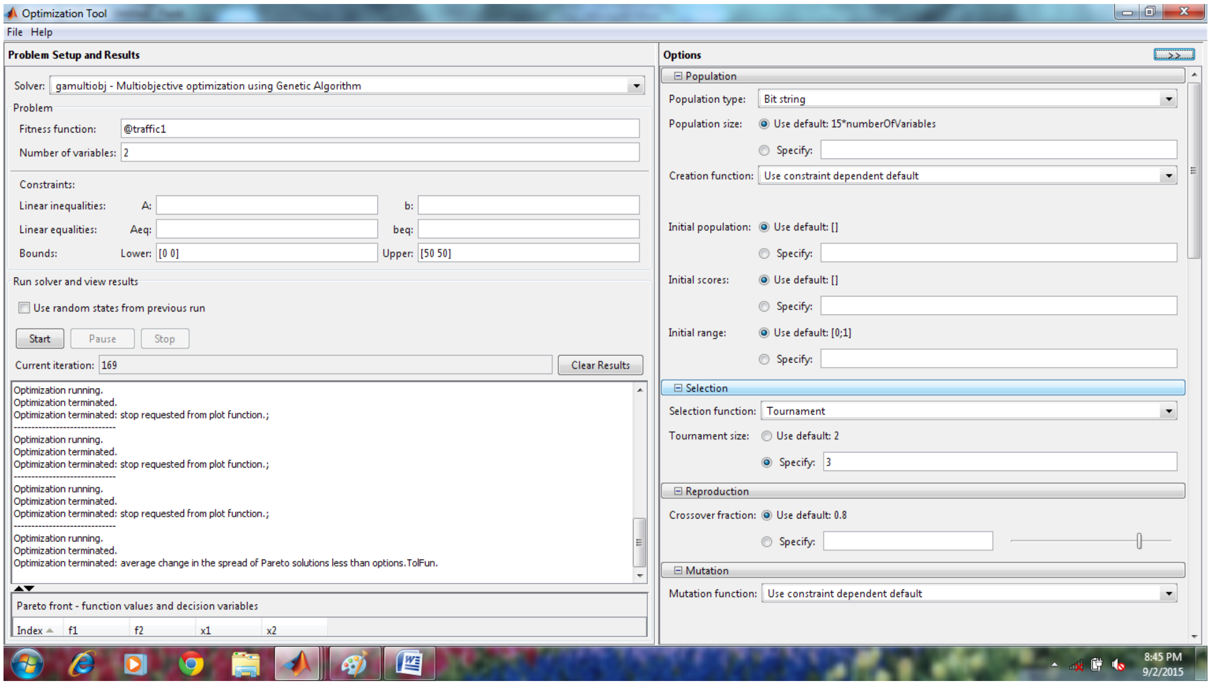
$$TD = \frac{d_\alpha * SI}{(t_{\alpha+1} - t_\alpha)}$$

Hence this is maximization function, but for similarity

$$TD = Maximize\ \frac{t_{\alpha+1} - t_\alpha}{d_\alpha * SI}$$

<u>Experimental Setup:</u>

Population Type	:	Bit String
Number of Population	:	0 to 400
Selection Function	:	Tournament
Tournament Size	:	3
Crossover Fraction	:	0.8
Mutation	:	Uniform Crossover
Function	:	Scattered



Solutions in the current population are sorted to assign a rank to each solution. The outcome is formulated using crowding distance which is the sum of the calculated distance over all the objectives. On plotting this for two objective (variables) we got large number of non-dominated solution for multi objective optimization at the value of 67, 136 and 144 iterations (figure 5.3,5.4 & 5.5).

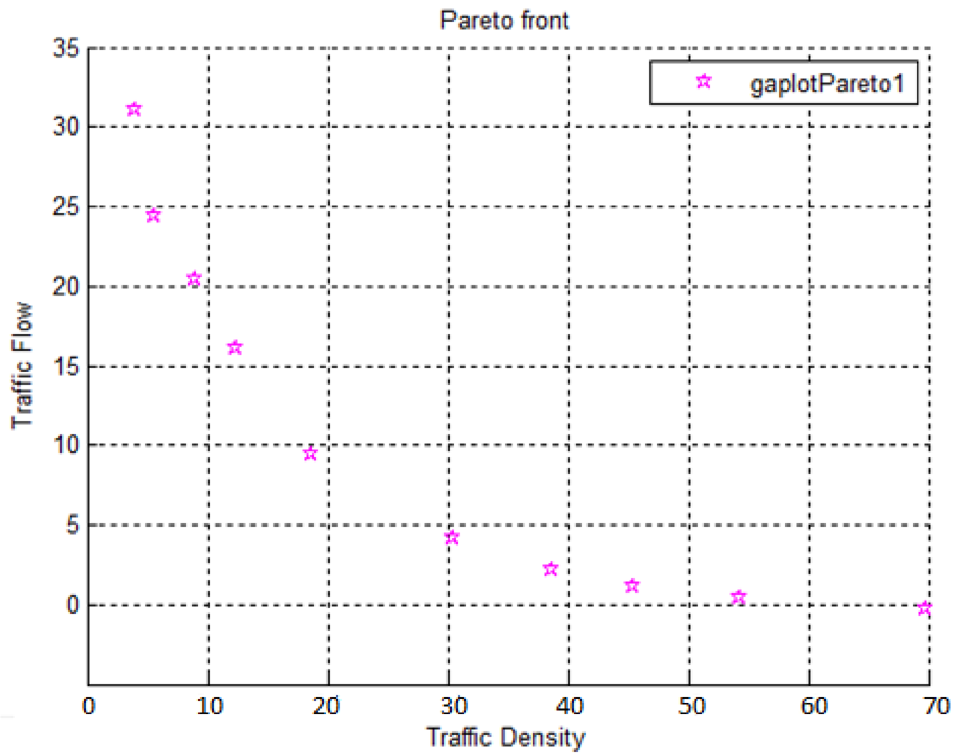


Figure 5-3: Pareto Front 1

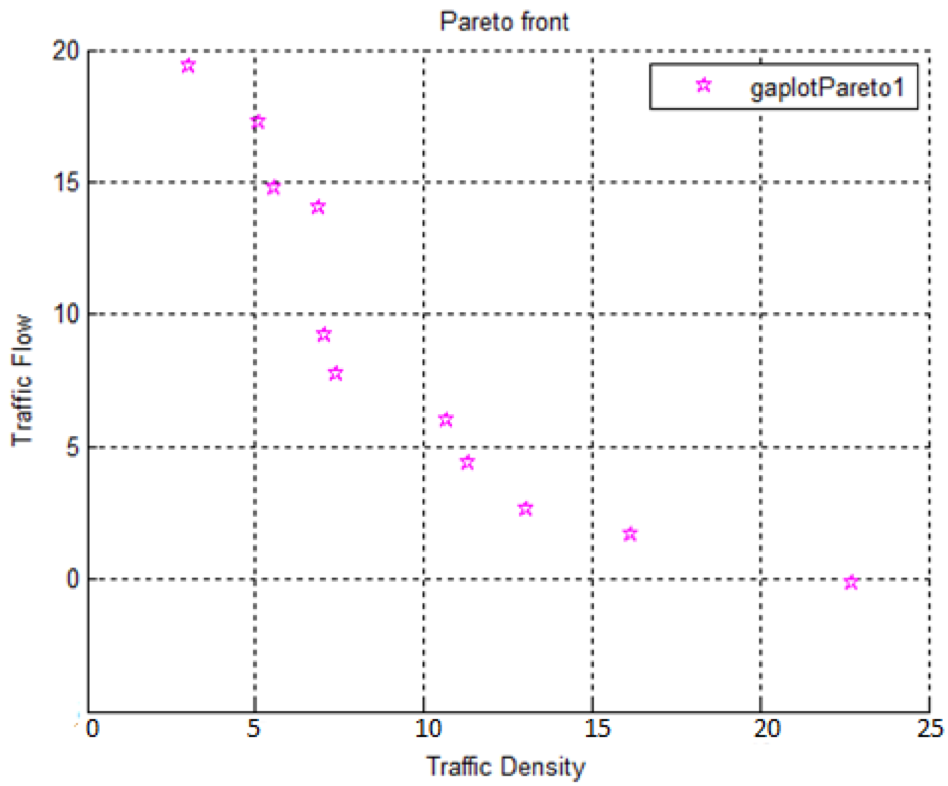


Figure 5-4: Pareto Front 2

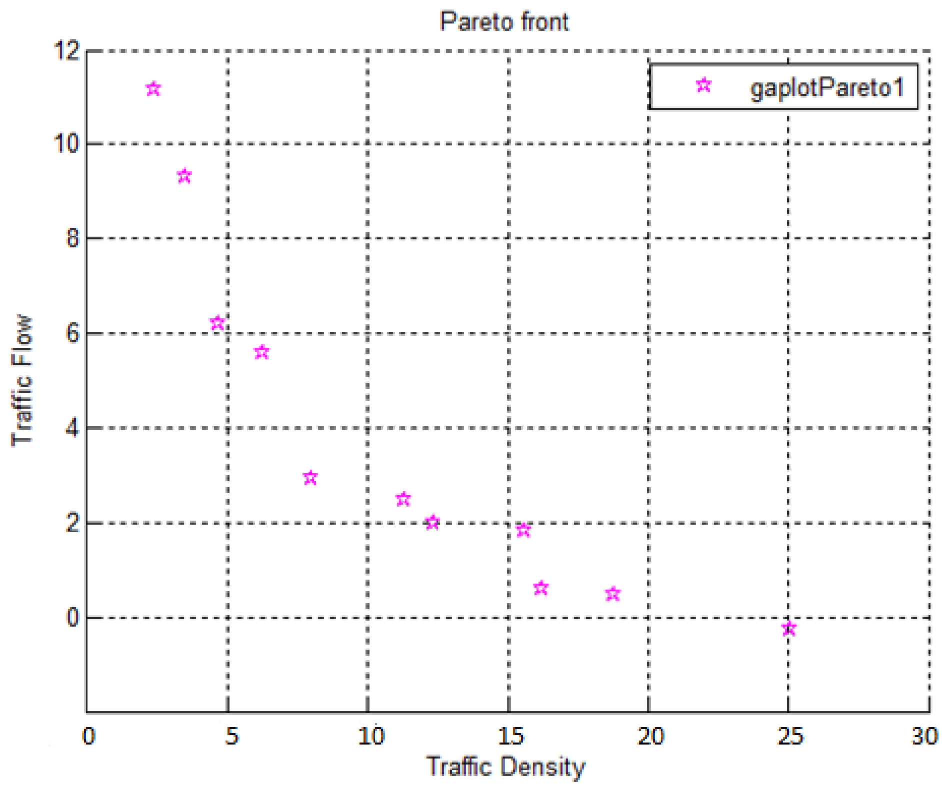


Figure 5-5: Pareto Front 3

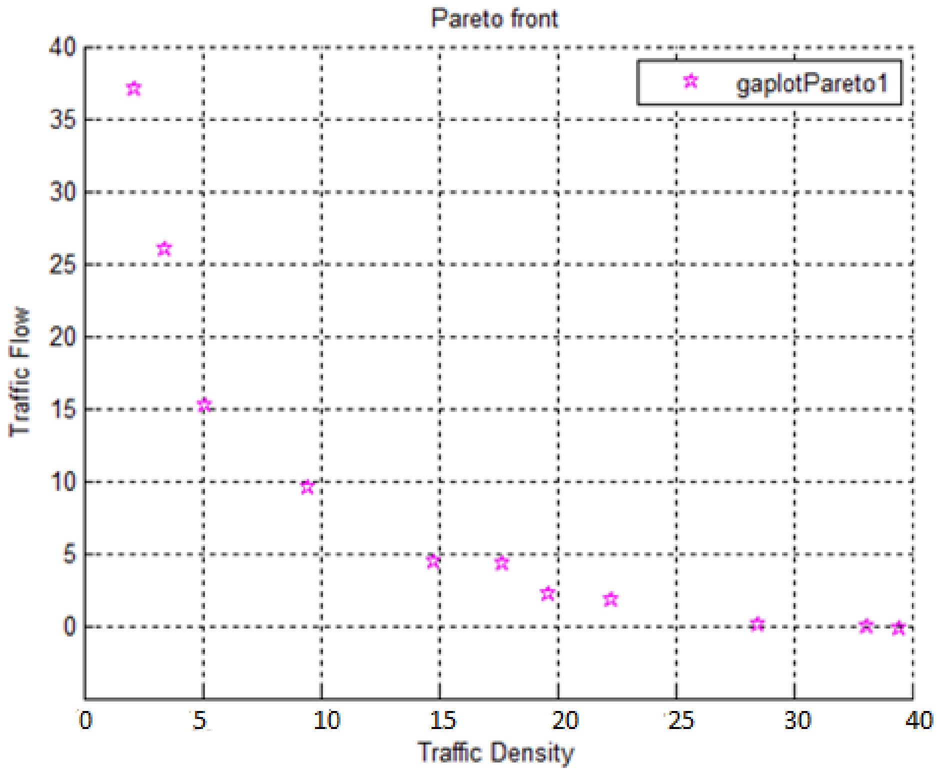


Figure 5-6: Pareto Front 4

From figure 5.4, 5.5 and 5.6 we are able to compare two other proposed models using multi objective optimization, we found that out of the two our model optimized with perfect non dominated set of variables. As we increase the cognitive radio sensors the accuracy of the model increases leading it high complexity(number of rules set) of the model, these are the factors in which we have used EMO to maximize.

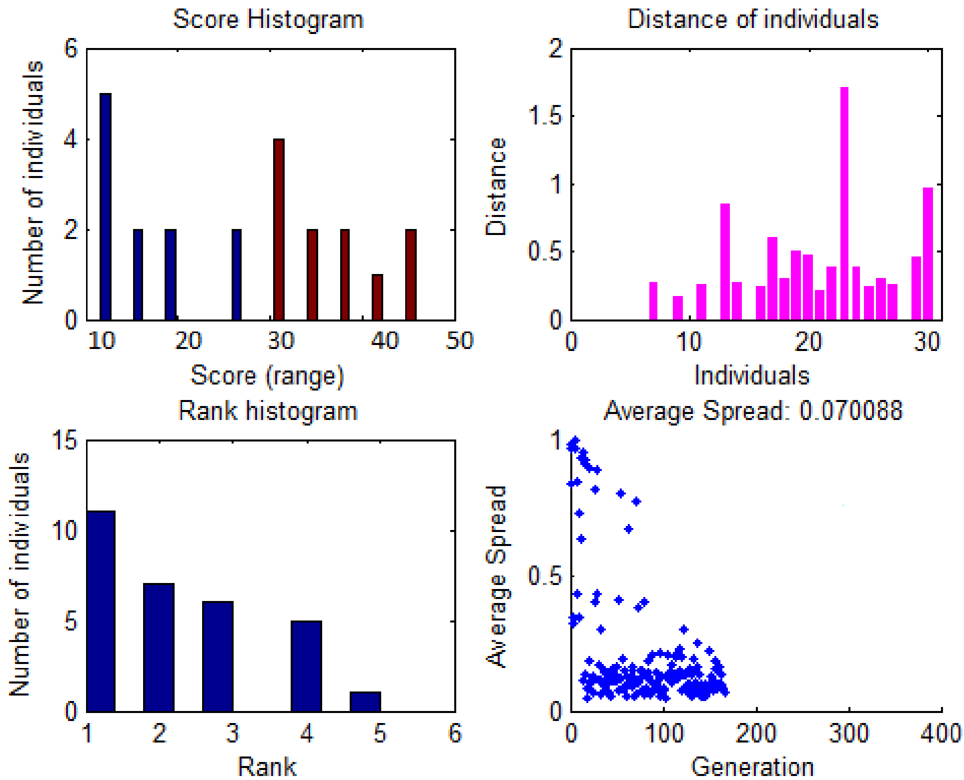


Figure 5-7 Accumulated Results

As we have seen, cognitive radio, as an engineering endeavor, bridges community and device architectures. We have tried to bridge linguistic styles of both declarative and imperative semantics using radio device technology, software defined radio (SDR) and finally extending it to object-oriented programming, the semantics of which is essentially imperative in nature.

5.3 STATISTICAL VERIFICATION

The second part of the chapter deals with statistical verification of the model. After analyzing our model under various cognitive radio signals are in rough form hence need to analysed, which leads us to use the operations like editing and classification. The basic categories in which we have classified our data set are: Vehicle-to-vehicle (V2V) , Vehicle -to-Infrastructure (V2I) and Infrastructure to Vehicle (I2V).

After performing the processing operation we tested our framework using Hypothesis testing.

5.3.1 Introduction to Hypothesis Testing

Hypothesis testing is a process of making a choice between several competing hypotheses about probability distribution on the basis of the observed data distribution. Hypothesis Testing is a very prominently used method of verification that is used in statistics. In statistical hypothesis testing we make a statistical inference based on the data that has been gathered from a research or survey carried out. If the occurrence of the result is predicted as unlikely according to the pre-calculated threshold probability also referred to the significance level, then the result is called as statistically significant in statistics. Ronald Fisher (1929) was the person who initiated the concept of "test of significance". The tests of significance are used to determine that which outcomes of a research will direct to a denial for a pre-specified significance level of the null hypothesis. This provides contribution in deciding whether the results contain sufficient information or not in order to cast disbelief on predictable insight, to establish the null hypothesis, considering the fact that the usual perception has been applied. The critical region of the hypothesis test is defined to be the collection of all the outcomes that will cause the null hypothesis to be redundant in comparison to the alternative hypothesis.

Hypothesis testing is referred to as statistical or confirmatory data analysis as it has pre-defined hypotheses, in disparity to the exploratory method of data analysis that might not have pre-specified hypotheses. One of the vital part of the statistical inference is the setting up of the hypothesis and then testing the hypothesis. For formulating, some theory has to be put ahead and that theory may be supposed to be accurate or it can be used as a source for the argument and then proved later. For example, claiming that a particular medicine for a particular ailment is better than the existing one.

5.3.2 Steps Of Hypothesis Testing

Hypothesis testing is carried out in following steps [144,145]:

Step 1: Identify the hypothesis or claim that needs to be proved. For instance, we want to determine that majority of students prefer e-Learning in comparison to traditional learning.

Step 2: Decide upon the criterion on the basis of which we will decide whether the hypothesis being claimed upon is true or false. In a way, it can be said that in this step we define the threshold value for deciding the truth or falsity of the hypothesis.

Step 3: The third step involves selecting a sample population and measuring the sample mean.

Step 4: In the last step, we compare the sample mean obtained in Step 3 above with the expected threshold that has been defined in Step 2. If there is a small difference jammed between the two means: the sample mean and the population mean, then the hypothesis is true else it is false.

For every problem under the consideration, we decide upon an issue that is of interest to us. Then there are two distinguishing claims that can be made about the issue that we term as the hypothesis: one of them is the Null Hypothesis denoted by H0 and the other one is the alternative or the substitute hypothesis denoted by H1. The above said hypothesis a not observed on an like basis, we give special consideration to the Null Hypothesis.

There are two situations:

1. The experiment is performed in order to invalidate or nullify the null hypothesis. The Null Hypothesis cannot be discarded until the confirmation in opposition to it is adequately strong. For example,

   H0: Suppose that there is no distinction in flavor of Pepsi and Diet Pepsi against

   H1: Distinction between the two exists.

2. If either of the two hypotheses stated above is simple enough, we give it more preference in comparison to the other complicated one so that the latter one is not adopted until and unless there exists adequate amount of confirmation in support of the alternate hypothesis. For instance, it is more simple to state that no variation in flavor exists between Pepsi and Diet Pepsi instead of saying that there exists a variation.

The assumptions or hypotheses are the statements that are very prominently used regarding the population parameters such as variance, expected value etc.

The outcome of a hypothesis test is "Reject H0 in favour of H1" or "Do not refuse H0".

In order to evaluate the behavior of a population that is too large or inaccessible, we can use inference statistics to study the behavior in a sample of population as it allows us to do a more accurate study. Samples are used for evaluation as they are linked to the attributes of the population. Sample means can used to make an estimate of the population mean. The standard value of the sample mean will be approximately equal to the value of the population mean, if an arbitrary sample is selected from a population. The method in which we make a decision about samples to study about attributes of a particular population is known as Hypothesis Testing. Hypothesis Testing is a regular approach to verify the claims or facts regarding an assembly or population.

5.4 HYPOTHESIS TESTING

In order to confirm our representation Hypothesis Testing was performed of our framework on a total of 100 Test samples(n=100). We deliberate the level of satisfaction and establish that mean to be equivalent to 70% (M=70) (70+10) i.e., μ =10. After calculating one independent sample Z-test we will preserve the Null Hypothesis

(M=70%) at a 0.05 significance level (α=0.05). We trace the sample mean as 90% (M=90).

5.4.1 Step I: State the Hypothesis

We begin with defining the population mean's value in a Null Hypothesis, which is considered as true. The Null Hypothesis H0 is a statement relative to a population parameter, like the population mean, that is hypothetical to be true. It is the preliminary assumption. Next, it will be checked whether the value stated in the Null Hypothesis is expected to be true. The value of the population mean is 70%.

5.4.2 Step II: Lay Down the Criteria Of Decision

In order to set a criteria for a decision, we declare the level of impact for the test. During hypothesis testing, we collect data to exemplify that the null hypothesis is false, depending upon the probability of choosing a sample mean from the population (the criterion is the likelihood). In behavioral research analysis, the significance level is usually fixed at 5% in. If the probability of achieving the sample mean is not as much as 5% and if the null hypothesis is true, then the sample we selected is unlikely and so the null hypothesis is turned down. The level of significance or the significance level, refers to a standard upon which a decision is to be made with regards to the value settled in a Null Hypothesis. The criterion depends upon on the possibility of getting a statistic calculated in a sample if the settled value in the null hypothesis is true.

The level of significance is 0.05, which makes α=0.05. Now, in order to uncover the chance of a sample mean from a given population, we have taken the method of standard normal distribution by placing standard normal distribution of Z-scores that are frequently cut offs or defined as critical values for the sample mean values lower than 5% probability of occurrence. We split the alpha value in half in a non-conditional two tailed, so that an identical proportion of area is placed in lower and upper tails.

Dividing α in half : $\alpha/2=0.05/2=0.0250$ in each tail.

The region ahead of the critical value of the hypothesis is the rejection region.

5.4.3 Step III: Calculate the Test Statistic

A test statistic helps us to determine the number of standard deviations or the distance between the sample mean and the population mean. The larger is the value of the test statistic, the more the distance, or the figure of the standard deviation. We can determine a sample mean from the population mean in the null hypothesis. The test statistics value is considered to construct a decision in Step 4. In this stage we judge the generated value to the critical values.

Z statistics: Z obtained = $M-\mu/\sigma M$ where $\sigma M=\sigma/\sqrt{n}$

where Zstatistics is inference statistics that is applied to resolve on the amount of standard deviations in the standard normal distribution.

The value of the test statistics is the resultant value. To formulate a decision, the value of resultant statistics is compared with the critical values.

$\sigma M=\sigma/\sqrt{n}=10/\sqrt{100} = 1$

Z obtained = $90-80/10 = 1$

5.4.4 Step IV: Compose a Decision

The computed value of the test statistic is used to compose a decision regarding the null hypothesis. The result depends upon the possibility of getting a sample mean, taking into consideration that the value known in the null hypothesis is true. The value of the Null Hypothesis is true if the value obtained in the sample mean is lower than 5% and then we come up with the decision of discarding the null hypothesis. However, if the probability of getting a sample mean is more than 5% while the null hypothesis is assumed to be true, then we come up with the decision to maintain the Null Hypothesis. Apart from these, the following two decisions could be taken by the analyst:

- *Denial of the Null Hypothesis. In this case the sample mean is related with a low likelihood of occurrence when the null hypothesis is correct.*

- *Retention of the Null Hypothesis. In this case the sample mean is related with a high likelihood of occurrence when the null hypothesis is correct.*

The probability of obtaining a sample mean, taking into account that the value defined in the null hypothesis is true, is settled by the probability value p. The value of p ranges from 0 to 1 and can never be negative. In the next step, we settle the probability of generating a sample mean and at that point we will make a decision to discard the value defined in the null hypothesis, which is settled down at 5% in behavioral research.

In order to derive a conclusion, we place the value of p side by side to the criterion that has been set in Step 2. The probability of obtaining a sample result is p, in view of the fact that the value defined in the Null Hypothesis is true. The p-value obtained for generating a sample result is compared to the significance level.

A decision made related to a value defined in null hypothesis is explained using statistical significance. When the null hypothesis is discarded, we arrive at the significance and when the null hypothesis is retained, we will not be successful in attaining the significance.

Null hypothesis is discarded when the p value is lower than 5% ($p < .05$). Also, when the value of $p = .05$, the conclusion is still to discard the null hypothesis. However, in the case when the value of p is larger than 5% ($p > .05$), then we decide to retain the null hypothesis. Significance is mainly the decision of discarding or retaining the Null Hypothesis. When the value of p is lower than .05, we arrive at significance and the decision is to reject the null hypothesis. When the value of p is greater than .05, we do not succeed to get to significance and the decision is to keep hold of this stage to compose a decision by comparing it with the critical value. The Null Hypothesis is refused if the generated value exceeds a critical value.

Table 5-1: Four Outcomes to make a Decision

	Decision	
Truth in the population Truth	Retain the Null	Reject the Null
	Correct (1-α)	Type I Error-α
Falsity	Type II Error-β	Correct (1-β)

In Step 4, we come to a decision whether to keep hold of or discard the null hypothesis. As we are evaluating a sample and not the total population, it is likely that the conclusion may be incorrect. Table 5.1 above shows that there are four decision options regarding the falsity and truth of the decision that we construct concerning a null hypothesis:

- *The decision regarding retaining of the null hypothesis might be right.*
- *The decision regarding retaining of the null hypothesis might be incorrect.*
- *The decision regarding discarding of the null hypothesis might be right.*
- *The decision regarding discarding of the null hypothesis might be incorrect.*

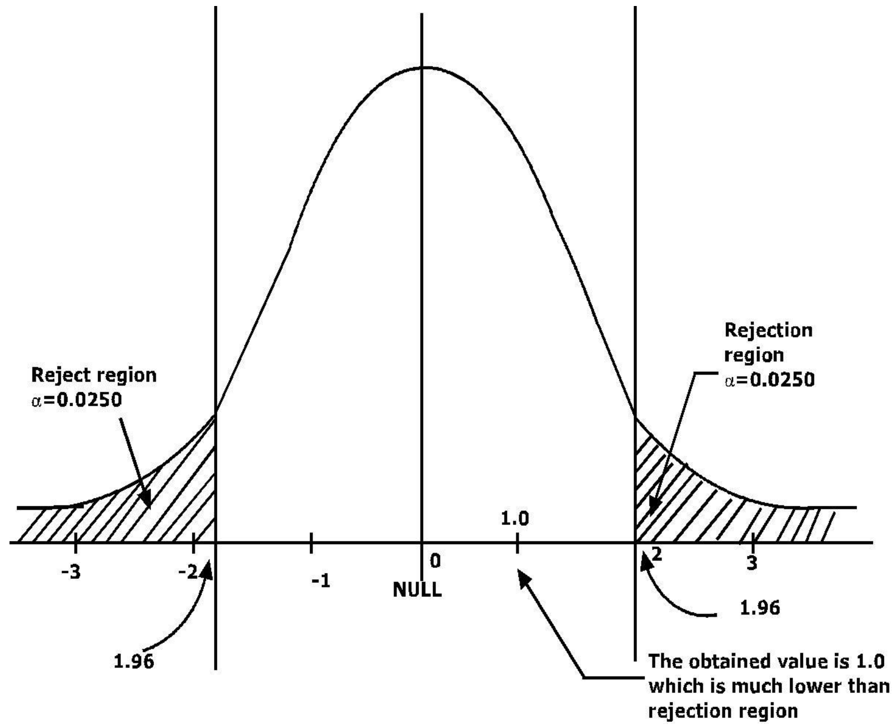


Figure 5-8: Acceptance of the Hypothesis

From Figure 5-8 we bring to a close that our framework has a reception of 70% supporting the Null Hypothesis.

5.5 CONCLUSION

We can conclude our work by verifying our framework using EMO and Hypothesis testing The above method shows the semantics between Control Centre and the Cognitive radio network. Depending on the velocity of information (Complexity) we have enhanced our software network and written all the possible subroutines for software defined radio network for traffic modeling.

As we have seen, cognitive radio, as an engineering endeavor, bridges community and device architectures.

We have tried to bridge linguistic styles of both declarative and imperative semantics using radio device technology, software defined radio (SDR) and finally extending it to object-oriented programming, the semantics of which is essentially imperative in nature.

The second phase of the thesis involves verification of our model using Hypothesis testing, since it lies within the acceptance region so we can assume that whatever modeling variables we have used is correct.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

We would like to summarize our work by highlighting various features of MACNUTS framework. The framework describes how the information model can be derived from real time problems. It also discusses the concept of cognitive radio agents which can provide a new dimension for modeling the Urban Traffic System. It has presented an approach to reify high-end interaction abstractions of XML components forming a refinement process that transforms it into cognitive grid.

The framework indicates how a structure in a source language can be represented by a cognitive radio is mapped with Evolutionary computing to optimize the entire control process. This MACNUT framework is rich enough to support most intentional and social concepts presented in agent-oriented modeling language. The main advantages of the proposed integration architecture are:

- It is independent of any agent-oriented methodology;
- The pattern matching process gives simple explanations about the correspondences applied in the translation;

- The addition of new methodologies just requires the specification of their mappings;
- Mappings with evolutionary computing provide a suitable resource to discover and analyze missing features in agent-oriented languages;
- The architecture provides necessary automation tools to support Unified framework.

The thesis has a chapter which proposes two schemes relating to "Lane-by Pass" approach in Urban Traffic Control Systems. The first approach deals with the problem of traffic congestion, based on n-dimensional road network. For the traffic information communication, cognitive radio systems are utilized and for effectively implementing the decision making process the multi-agent systems are used. A lane-by-pass approach in a n-dimensional road network of an urban city which extends use of Multi-Agent Systems (MAS) and Cognitive Radio System.

The system developed and simulated is implemented on the real time network wide signal control system. The system has been studied at Lucknow, the capital city of Uttar Pradesh, India, for the road network. The proposed system has been analyzed with traffic flow and mean velocity at different time and improvement has been carried out.

Second problem starts with a new lane by pass algorithm called as Genetic Algorithm Urban Road traffic congestion in which each circumstance is described by heavy amount of vehicles on a street that leads to slow down speed and increase in the time taken for a drive. The growth in population as well as the exponential growth in number of vehicles has raised the disaster of traffic congestion on the highways and freeways of the country.

The assessment of the routing is typically done by analyzing the costs of feedback that is connected with every link in the network for each allotted time gap (assumed 5 minutes). This results in the vehicles to select for the foremost links, in order to achieve improved optimization and reduced delay in the travel time. Although, when several lanes are blocked, a slight deficiency is found at some stage during the original peak traffic time, which then becomes constant in the afterward peak periods to a little higher delay value than in the usual operation.

Lastly, the Chapter on “verification and validation” highlights the verification of the model using Cognitive Radios by applying EMO with non-enlists and non-dominated genetic algorithm. The major objective of this chapter is to incorporate the unified architecture which allows to Couple Transportation Systems and Cognitive extension in addition to its potential application to the real world.

The whole framework serves as an important tool to assess and validate innovative approaches to deploy sustainable transportation solutions. However, some challenges like coordination amongst agents and validation of behavioral models is an actual issue which we have also incorporated in our work.

Coupling multi-agent systems with intelligent transportation solutions have boosted our efforts to promote the quite recent area of Artificial Transportation Systems as one important instrument to better analyze sustainable transportation.

The second part of the chapter verifies the model using hypothesis testing, the framework is found to be well within the acceptance region.

In future a new lane-by-pass approach can been investigated to deal with the problem of traffic congestion using advanced cognitive radio with XML Macros in an new multi-agent environment. Advanced Genetic Algorithms can be utilized in future for the optimization of various parameters used in traffic routing mechanism.

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