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ITS in India : Scope and Proposed Solution

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Abstract — Traffic, can be pronounced as "terrific" when concerned as a burning problem across the globe. In Indian road-traffic, problems like congestion, unpredictable travel-time delays and road-accidents, are taking a serious shape. This calls for the vital need of Intelligent Transportation Systems (ITS), which make use of various technologies to alleviate traffic problems. Many such systems exist for developed countries. These countries are using various technologies like Artificial Intelligence, sensing technology and many more. In developing countries, like India, traffic is inherently chaotic and noisy. The ultimate goal behind this paper is to maximize the traffic flow for selected span of Anand city with minimum waiting time. This paper focuses on the use of traffic simulation using SUMO in helping traffic engineers to reduce congestion problem of traffic on road. The focus of Multi Agent System is on accurate modelling of individual agents rather than the design of functions.

Keywords – ITS, Multi Agent Systems, Sensing Technology, Artificial Intelligence, Agent , SUMO

I. INTRODUCTION

Urban transport is an old industry, the first system, a horse-drawn bus, was organized in 1662 in Paris by Blaise Pascal .After that this industry has never looked back. It was growing with a huge success and is still growing at lightning fast speed. As it is grown day and night, it has invited various challenges and problems also. The biggest problem the globe is facing today is global warming and one of the major contributor to global warming is Traffic Jams and congestions. This is the biggest motivation ever for anyone who wants to keep his/her globe pollution free. Also today world has achieved almost a saturation as far as technology is concerned. This leads technocrat to think about using effective technologies to solve issues like traffic congestion. Now a days we have such technologies that if can be used in proper way, can solve issues like traffic congestions.

India's road network has grown at an annual rate of 4% since 1951 but the number of vehicles has increased nearly 11%, choking roads and increasing pollution. [1]. India has the second largest road network in the world with 4.2 million km. Road traffic conditions in India are getting worse day by day. The average number of vehicles in India is growing at the rate 10.16 percent annually, since last five years [2]. Spending hours in traffic jam has become part and parcel of urban life style, leading to health and environmental hazards. The vehicle penetration in metropolitan cities like Mumbai is suffering from about 590 vehicles per Km of road stretch and Bangalore with around 5 million of vehicle ply over a network that extends barely up to 3000kms

There could be two approaches to solve this problem. First and the most obvious solution is to come up with infrastructure involving wider roads, flyovers, bypasses and expressways. But for developing countries like India, money and space are serious concerns. Second approach is to manage existing traffic with same infrastructure, with the use of technology and by involving commuters in the process. This paper is concentrating on the second approach that is Intelligent Transportation System (ITS) which makes use of technology to alleviate road traffic problems. Different ITS techniques aim to provide information like current road congestion level, predicting travel time, predicting traffic congestion. This paper will focus on maximizing the flow of vehicles to achieve minimum waiting time for individual. Commuters can make use of this information to plan their travel better- by choosing less congested road if there is a choice, by adjusting traveling time to avoid peak-traffic hours. In short can prevent congestion from getting worse by better planning and scheduling.

II. INTELLIGENT TRANSPORTATION SYSTEM

Intelligent transportation systems (ITS) are advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.[4]

Over the past two decades, India has established itself as a leader in information technology (IT). However, the subsequent economic boom has also resulted in an exponential increase in motorization, urban traffic congestion and deterioration of air quality in the Indian megacities. With a robust IT and telecom infrastructure in place, India stands to gain from the use of ITS to alleviate many transport related urban issues. Use of such technologies can be either at a vehicular or infrastructural level. Some broad categories of ITS technologies are as follow:

- Automated speed enforcement.

- Incident management.
- Electronic toll collection.
- Traveler information.
- Vehicle control technologies like intelligent cruise control and speed alerts.

2.1 World Wide Leaders of ITS

ITS had been deployed in various developed countries and some of the major countries which are world-wide leaders in the field of Intelligent Transportation System which are as follows:

Japan

Japan leads the world in Intelligent Transportation System based on the importance of acceptance of ITS in Japan, citizens get benefits of deployed ITS applications and maturity of those applications. The goal of ITS is to provide the real time information about the traffic conditions. Real time information can be collected using two techniques. One is to embed fixed sensors in or on the road sides, which was started in 1996 and the second is via mobile probes like taxis or mobile phones, which was started in 2003.

South Korea

The strength of South Korea in the ITS application makes the world leader in Intelligent Transportation System. The strengths include the real time traffic information, advanced public transportation and electronic fare payment. The South Korean's Expressway Management Systems collects the traffic information via Vehicle Detection Systems, which is installed on the roadside at 1km of intervals. Second is Closed Circuit Camera deployed every 2-3 km. and last through probe vehicles. The data is collected and stored at South Korean's National Transport Information Center where the data is disseminated to other users via various communication means.

Singapore

Singapore is a world leader in Intelligent Transportation Systems based on the use of probe vehicles to collect the real time traffic information, road pricing, and deployment of computerized traffic signals national wide and the use of ITS applications. Singapore's ITS will deliver the services like location based and traffic information to the commuters through in-vehicle devices or advances congestion management systems which will target the pedestrian and variable user on the roads.

United States

United States Department of Transportation coordinates the ITS through Research and Innovative Technology Administration (RITA) wing. US-ITS specially focus on Telephonic Data Dissemination, IntelliDrive, Next Generation 9-1-1, Cooperative Intersection Collision Avoidance Systems, Congestion Initiative, Integrated Corridor Management Systems, Clarus Initiative, Emergency Transportation Operations, Mobility Services for All Americans and Electronic Freight Management.

Australia

Australia also leads in the field of Intelligent Transportation System. The main motive of Australian's ITS is to improve the traffic scenarios and enhancing the public safety. The project team of Australian's ITS recommended to adopt FRAME as its architecture basis so that future enhancements and additions can be easily adopted both in Australia and FRAME.

United Kingdom

United Kingdom also leads world in Intelligent Transportation System. United Kingdom used the MIRA Intelligent Transportation System as its base ITS architecture. MIRA uses the military grade self-healing communications networks technologies and topologies, MIRA is able to ensure safe operation of very complex control systems.

III. THEORITICAL TRAFFIC STUDY AND DESIGN APPROACH

ITS is a combination of following technologies and components.

- Wireless Communication
- Computational Intelligence
- Floating Car
- Sensing Technology

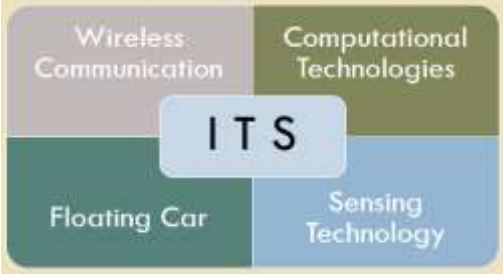

Figure 1. ITS – A bigger picture

Wireless Communication

This section takes care of communication between various traffic signals, traffic control centers and other devices. It accommodates various network protocols like WAN, MANET and others. All the regional traffic control sub systems and authorized central control center can remain connected without any interrupt is the responsibility of this section.

Various forms of wireless communications technologies have been proposed for intelligent transportation systems. Radio modem communication on UHF and VHF frequencies are widely used for short and long range communication within ITS. Short-range communications of 350 m can be accomplished using IEEE 802.11 protocols, specifically WAVE or the Dedicated Short Range Communications standard being promoted by the Intelligent Transportation Society of America and the United States Department of Transportation. Theoretically, the range of these protocols can be extended using Mobile ad hoc networks or Mesh networking.

Longer range communications have been proposed using infrastructure networks such as WiMAX (IEEE 802.16), Global System for Mobile Communications (GSM), or 3G.

Computational Technologies

Computational Technologies is considered as a heart of ITS as it computes the real time data and generates various outputs based on which traffic scheduling can be handled effectively and smartly. Computational Intelligence has emerged day by day and it is growing at lightning pace. If we look back as far as traffic related issues are concerned, computational intelligence, in earlier days were using micro controller based logics which later included Real Time Operating system with it and it transformed to embedded systems. Now a days it's a time for Artificial Intelligence and other computational intelligence. The new embedded system platforms allow for more sophisticated software applications to be implemented, including model-based process control, artificial intelligence, and ubiquitous computing.

Floating Car

"Floating car" or "probe" data collection is a set of relatively low-cost methods for obtaining travel time and speed data for vehicles travelling along streets, highways, motorways (freeways), and other transport routes. Broadly speaking, three methods have been used to obtain the raw data:

Triangular Method: The phones periodically transmit their presence information to the mobile phone network, even when no voice connection is established. In the mid-2000s, attempts were made to use mobile phones as anonymous traffic probes.

Vehicle re-identification: Vehicle re-identification methods require sets of detectors mounted along the road. In this technique, a unique serial number for a device in the vehicle is detected at one location and then detected again (re-identified) further down the road. Travel times and speed are calculated by comparing the time at which a specific device is detected by pairs of sensors.

GPS based methods: An increasing number of vehicles are equipped with in-vehicle satnav/GPS (satellite navigation) systems that have two-way communication with a traffic data provider. Position readings from these vehicles are used to compute vehicle speeds.

Sensing Technologies

This section includes scanning of real time data using various sensors and hardwares and softwares .It also includes effective video tracking of vehicles and bit of image processing. Technological advances in telecommunications and information technology, coupled with ultramodern/state-of-the-art microchip, RFID (Radio Frequency Identification), and inexpensive intelligent beacon sensing technologies, have enhanced the technical capabilities that will facilitate motorist safety benefits for intelligent transportation systems globally. Sensing systems for ITS are vehicle- and infrastructure-based networked systems, i.e., intelligent vehicle technologies. Infrastructure sensors are indestructible (such as in-road reflectors) devices that are installed or embedded in the road or surrounding the road (e.g., on buildings, posts, and signs), as required, and may be manually disseminated during preventive road construction maintenance or by sensor injection machinery for rapid deployment.

This paper focuses on computational technologies in ITS and here in this paper we are proposing a method to achieve flow maximization in urban traffic of Anand city.

3.1 Ford Fulkerson Method

The idea behind the algorithm is as follows:

As long as there is a path from the source (start node) to the sink (end node), with available capacity on all edges in the path, we send flow along one of the paths. Then we find another path, and so on. A path with available capacity is called an augmenting path.

Given a graph which represents a flow network where every edge has a capacity. Also given two vertices source‘s’ and sink ‘t’ in the graph, find the maximum possible flow from s to t with following constraints:

a) Flow on an edge doesn’t exceed the given capacity of the edge.

b) Incoming flow is equal to outgoing flow for every vertex except s and t.

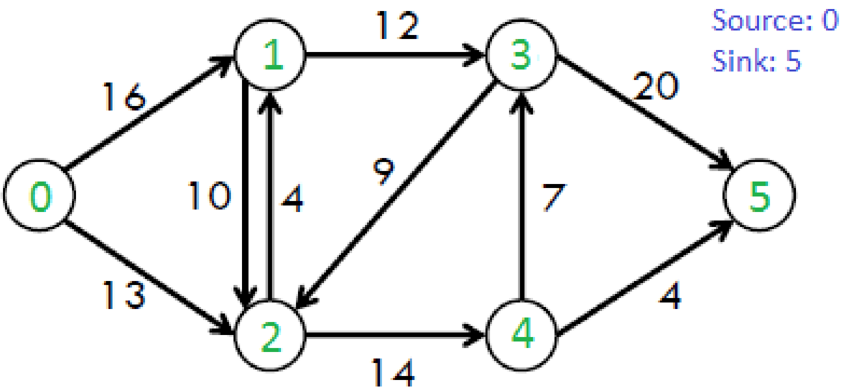

Figure 2. Ford Fulkerson Algorithm for Graph

Residual Graph of a flow network is a graph which indicates additional possible flow. If there is a path from source to sink in residual graph, then it is possible to add flow. Every edge of a residual graph has a value called residual capacity which is equal to original capacity of the edge minus current flow. Residual capacity is basically the current capacity of the edge.

For vehicle set C to travel from s to d, the routing problem can be represented as,

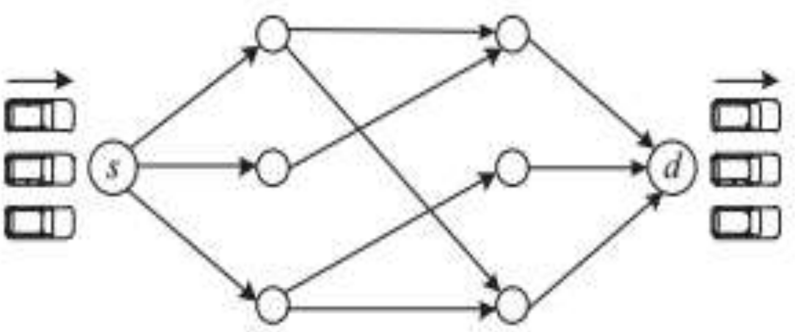

Figure 3. Mapping FF for Vehicular Network

In the minimum-cost maximum-flow problem, there is a directed graph G(V, E) with source $s \in V$ and destination (sink) $d \in V$ .The main idea is that while the original Ford-Fulkerson algorithm is seeking an augmenting path, this solution aims to find the one with the minimum cost instead. Here we are proposing FF algorithm to maximize the flow of vehicles in the vehicular network of any urban city, here we have taken an area of Anand city which is considered as of the most congested routes of city.

Input: routing requests $\langle s_i, d_i \rangle$ for each $c_i \in C$
Output: R_i for c_i
$\forall \langle u, v \rangle \in E$, $f(u, v) = 0$;
$\forall \langle u, v \rangle \in E$, $c(u, v) = (D(u, v) / l) \cdot L(u, v)$
partition set C into C_j , $j = 1, 2, \ldots$, where $c_i \in C_j$ share
the same routing request $\langle s_j, d_j \rangle$
for all C_j **do**
call FF(s_j , d_j , C_j , cost(·)) to update f(·);
end for
For each $c_i \in C$, extracting path R_i from f(·);

Modified FF Algorithm

3.2 FLOW OF PROPOSED SYSTEM

Whole process can be divided into following sections:
1. Scanning and Analysis of Data
2. Computation on Data
3. Simulation Results

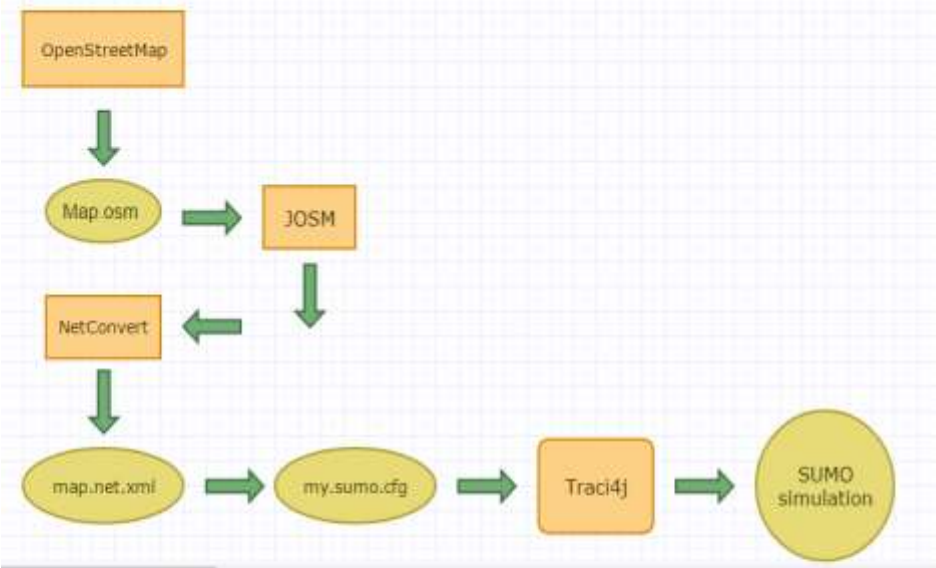

Figure 4. Flow of the Proposed System

Scanning and Analysis of Data

As a span of this work, I have decided the area which is highly useful and one the most congested area of Anand city . It includes Bhaikaka Statue Cross Road – Anand Vidhyanagar Road – Townhall Junction – Grid Junction – Anand New Bus stand – Bhalej OverBridge – Samarkha Chokdi. It is about 6 km of route and it is considered as very busy and congested route for vehicles because it includes Anand Vidhyanagar road – a heart of Anand Vidhyanagar , also includes Bhaikaka circle – which is center place for Vidhayanagar ,an education hub. Also it includes bus stand in between and road to railway station also.

I am very much thankful to Prof. Dr. L.B. Zala (HOD, Civil Engineering Department, BVM Engineering College) and his team for providing guidance and datasets for traffic related matters. He is too supportive and such an experienced personality as far as Anand Transportation systems are concerned.

For data collection the Photographic method and video-camera method is very accurate and best method. In which Time-lapse camera photography has been used successfully to determine the speeds of vehicles accurately in crowded streets. By protecting the film on a screen, the passage of any vehicle can be traced with reference to time. Images by video camera can also be used. Data collection was done by video recording technique on selected stretch for one day at urban mid-block section. For counting the number of vehicles classified volume count was taken from 09.00 am to 18.00 pm.

Table 1. Collected Data Set

SR.NO.	VEHICLE TYPE	MEAN SPEED(KMPH)	STD.DEVIATION (KMPH)	CO-EFF. OF VARIATION	NO. OF OBS.
1	CARS	28.18	4.84	0.172	720
2	LCVs	25.96	4.53	0.174	662
3	TRUCKS	22.14	3.76	0.170	202
4	BUSES	23.3	3.54	0.152	191
5	TWO-WHEELER	28	5.13	0.183	720
6	AUTO	27.06	4.68	0.173	720
7	TRACTOR-TAILOR	15.74	3.23	0.205	78

Computation on data and Simulation Results

“Simulation of Urban Mobility" (SUMO) is an open source, highly portable, microscopic road traffic simulation package designed to handle large road networks. [16]
The simulation platform SUMO offers many features:

- Microscopic simulation - vehicles, pedestrians and public transport are modeled explicitly
- Online interaction – control the simulation with TraCI
- Simulation of multimodal traffic, e.g., vehicles, public transport and pedestrians
- Time schedules of traffic lights can be imported or generated automatically by SUMO
- No artificial limitations in network size and number of simulated vehicles
- Supported import formats: OpenStreetMap, VISUM, VISSIM, NavTeq
- SUMO is implemented in C++ and uses only portable libraries.

Usually SUMO works with XML files, where one has to write xml files for each and every single detail he/she wants to add in simulation. There are various ways in SUMO where we can build our own road network. Writing long and complex xml files for complex types of Road Network is a tedious task to do. Here in my work I have chosen another way to deal with this issue. There is an open source map library called Openstreetmaps.org which can help one to import map in SUMO with less efforts.
Here is the procedure how one can import that map in SUMO.

- Extract map from openstreetmap.org.
- It will be a file with extension *.osm / *.osm.xml
- If any modification needed, one can use tools like JOSM / OSMOSIS which are based on java and will help to edit map as per requirements.
- That generated file is to be given to SUMO where we use NETCONVERT , which will convert osm file into *.net.xml
- Using SUMO –gui we can see that map in simulator.

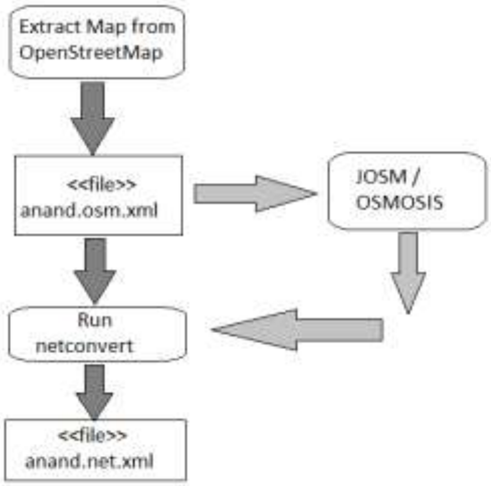

Figure 4. Diagram to import map in SUMO

Here is the screenshot of SUMO Gui where I have generated map of Anand city from openstreetmap.org without any modification.

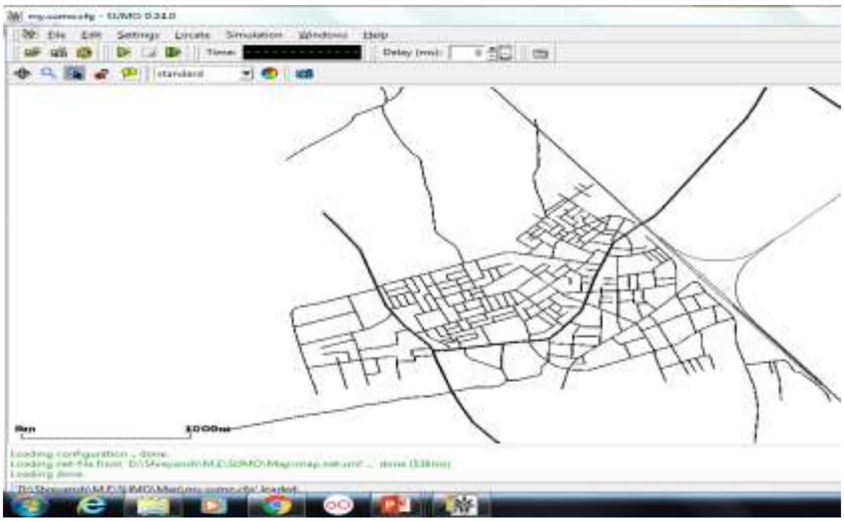

Figure 5. Screenshot of Sumo gui for Anand map

One can edit imported map using JOSM tool which can modify map as per requirements. After importing or creating a map in SUMO, the next task is to create vehicles and their behaviors in network. Again to achieve this task, there are various methods available .The traditional way is to write xml files for vehicle and their characteristics including their behaviors in network.

Generally, SUMO works with xml for UI and for operations and logic work, python is the language which need to be used. We decided to do it in a different way. We will use JAVA language as a front end to handle events in SUMO using one library, known as TraCi4j , which is specially designed to work with SUMO using JAVA .Using TraCi4j , one can handle simulations with java programs on a same machine or from a remote machine.TraCi4j will be edited to implement FF algorithm within it and the whole scenario will be simulated using SUMO.

III. FUTURE WORK

Once the map is fully generated , ford Fulkerson algorithm will be applied to gathered data set using TraCi4j library and appropriate simulation will be generated .Simulation will be examined to check if we are getting maximized flow or not. If it gets success it can be apply to real world to reduce congestion and to increase flow of the vehicles in Anand city. It can be tested for other areas also and overall Intelligent Transport System can be designed.

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