Approaches for Intelligent Traffic System: A Survey

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Abstract— T**his survey presents various approaches for intelligent traffic systems. The potential research fields in which Intelligent Traffic System emerges as an important application area are highlighted and various issues have been identified which need to be handled while developing such a system for an urban area, where an efficient traffic management has become the need of hour.**

A model is also proposed capable of managing intelligent traffic system using CCTV cameras and WAN. The proposed model will make the traffic signaling dynamic and automatic as well. Besides this, it will generate the dynamic messages for the users on the message boards to avoid congestion, reduce waiting time, pollution control, accident control and vehicle tracking. Further it is possible to extend this model to other related traffic applications.

Keywords-CCTV; GIS; RFID; Traffic load prediction and computation; Vehicle routing and tracking

I. INTRODUCTION

In response to growing traffic congestion on roads, a lot of research is being done ceaselessly to improve traffic conditions and new fields are explored to manage and improve traffic conditions.

This brief survey presents various approaches for intelligent traffic systems. Further a model is also suggested for the real time traffic system based on the use of CCTVs and other technologies.

This study comprises of six sections including the present one, which provide an introduction and objectives of this brief survey. In section II, the various research challenges in Intelligent Traffic System are reviewed. In section III, the research approaches for Intelligent Traffic System are included. In section IV, the various technologies used for developing traffic system are mentioned. Finally, we give a brief overview of the various researches done to improve the traffic system are given in section V. Then a model for traffic control in real time is proposed that relies on the use of GIS and CCTVs is described in section VI.

II. RESEARCH CHALLENGES IN INTELLIGENT TRAFFIC SYSTEM

A. Real Time Signal Control

One way for traffic controlling is to control the signals in real time and operate them automatically according to the demand in traffic. Mirchandani et al. [46] discussed a real time traffic adaptive signal control system called as RHODES.

Dotoli et al. [47] investigated the issue of urban traffic signal control using a real time optimization model. The model was modified to take into account the traffic scenarios, the different types of vehicles in the area, as well as pedestrians. The technique was applied to a real case study also.

B. Traffic Load Prediction and Computation

Many researches focus on improving the traffic by load prediction and forecasting. By these, one can manage the traffic once the correct forecast has been done.

Albers et al. [1] use the real time data in a traffic management system to monitor current traffic flows in a network so that traffic can be directed and managed efficiently. Reliable short-term forecasting and monitoring models of traffic flows are crucial for the success of any traffic management system. The real time data can be provided by the induction loops planted on the road surfaces.

Sheng-Fuu Lin et al. [2] describe an application of computer vision techniques to traffic surveillance. This paper works for improving the efficiency of traffic flow estimation that include pedestrian flow and vehicular flow estimation.

Danko A. Roozemond in [3] states that there are several factors that affect the performance of the conventional traffic control system, e.g. changes in traffic flow, accidents, different behavior and travel demand. This paper has tried to apply autonomous intelligent agents in urban traffic control.

C. Vehicle Tracking

There are many systems that try to process images and track vehicles. All they have to do is process images and track vehicles.

DaHee Hong et al. in [4] studied traffic images and focused on multi-anticipative car following behavior, heterogeneity among individuals and relationship between car-following behavior and road geometry. This

research has tracked individual vehicles on-screen, and aimed at obtaining vehicle trajectories. Then, they applied this manually obtained data to investigate individual heterogeneity of vehicle movement.

Celil Ozkurt et al. in [5] have mentioned three main approaches to detect moving objects in a video viz. temporal difference, optical flow and background subtraction. They stress upon knowing the traffic density for traffic surveillance systems and use a neural network approach for the same.

R. Blake et al. in [6] developed a CCTV camera based application and utilized image processing and pattern recognition methods and functional capabilities of a system to monitor the road, initiate automated vehicle tracking, measure speed and recognize number plates.

Pallavi Choudekar et al. [7] Is also a document for detecting vehicles through images instead of using electronic sensors embedded in the pavement. The authors worked with a camera installed alongside the traffic light, capture image sequences and then image sequences analyzed using digital image processing for vehicle detection, and according to traffic conditions on the road traffic light can be controlled.

Vikramaditya Dangi et al. [8] presented a report at UARJ regarding Image Processing and Traffic Controls.

D. Vehicle Routing

Vehicular ad-hoc networks (VANETs) are a technology that uses moving vehicles as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 metres of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created [29]. So using this created VANET, a system can be developed that will help in managing traffic and pass information from one vehicle to the others.

Vasilis Verroios et al. [30] have proposed a fully distributed approach that uses only the computational resources and communication capabilities of vehicles and requires no fixed infrastructure or centralized servers. This approach bases its operation on wireless ad-hoc communications and offers a protocol for alerting vehicles regarding traffic conditions in areas to be travelled through.

Danny Weyns et al. [31] suggested that the Delegate Multiagent System approach is a promising approach to route vehicles to avoid traffic congestion. The approach mentions some assumptions too in order to apply it on the roads.

Seongmoon Kim et al. [32] have developed decision making process for determining the optimal driver attendance time, optimal departure times, and optimal routing policies under time-varying traffic flows based on a Markov decision process formulation. They present a systematic approach for in the implementation of transportation systems integrated with real time information technology.

LeBrun et al. [45] put forward VGrid. This is an ad-hoc networking and computational grid which can be formed by leveraging inter vehicle and vehicle-to-roadside wireless communications.

E. Route Optimisation

There are some proposed theories that aim for finding the shortest path in any typical traffic condition.

Luca M. Gambardella [9] states that Ant Colony Optimization can be used as a way to find an optimized path. Once we have a transport optimization problem, we can build solutions using the behavior of ants, like ants make any path using pheromone and cost and then awarding the best solutions with new pheromone.

Cyrille Bertelle et al. [10] reported a traffic management approach using the ant behavior. An algorithm for finding the shortest path can be designed on base of an ant algorithm. This work also gives a road traffic management system to avoid jams.

Yongxiang Xia in [11] worked to optimize road network and analyze traffic dynamics by the movement of each car and the statistical property of the whole network.

III. RESEARCH APPROACHES FOR INTELLIGENT TRAFFIC SYSTEM

A variety of approaches are in use to explore and search the field of Intelligent Traffic Management. Some of the prevalent approaches are:

A. Geographical Information Systems

Geographical Information Systems (GIS) are very important and evolving fields of study. They are used in a variety of researches and now we find their use in traffic management systems too.

In [12], Otto Anker Nielson et al. have proposed that one can find a number of applications where ArcInfo and ArcView are used to automate the process of building a traffic network topology.

Hatem F. Halaoui have presented advanced algorithms in his paper [13] and stressed on the use of GIS for traffic solutions.

Harper Ross et al. [14] investigate the potential for developing a raster geographical information system which is capable of analysing crashes on a lane by lane basis on multilane roads. This project uses ArcGIS to combine crash data, road data and traffic characteristics as a raster GIS plot on an aerial photograph. ArcGIS also includes features which enable crash trends displayed, based on the attributes of individual crashes.

Dipo Theophilus Akomolafe et al. [15] site the use of Geospatial Technology for capturing, storing, retrieval, analyzing and displaying data related to positions on the earth and ensure easy location of vehicles and incidents on roads.

Witzmann et al. [16] have developed a tool VeGIS for the synchronization of data between traffic models and GIS.

An advanced Travellers system has been developed and designed using GIS for the Hyderabad city in India by Kumar P. et al. [17]. This system provides complete information for the Hyderabad city like shortest paths between some destinations, bus routes and the complete information about the buses of the city, which demonstrates important usage and application of GIS.

B. Artificial Intelligence

Artificial Intelligence is being applied in a large variety of fields and its application are also cited in managing traffic.

Zhiyong Liu [18] aims to develop a Traffic System that can respond to traffic demand and optimize online timing plans and then implement real time control i.e. be adaptive according to the traffic as demanded. AI methods like Fuzzy logic, neural networks, evolutionary algorithms etc are being developed, which are used in traffic systems too [18].

Clymer J. R. [19] has proposed a Complex Adaptive System (CAS) in which each agent adapts its behavior in order to collaborate with other agents to achieve overall system goals. It is also a way of using AI in traffic system and uses the Fuzzy Classifier System.

Charitha D. et al. [20] develop a tool for estimating the travel time in signalized urban networks, based on probe data. It is a self learning tool and can be applied to basic networks description instead of a detailed modeling of the network structure. In this paper, they use a Bayesian network for forecasting the travel time on a route along an arterial road.

Bartlomiej P. [21] evaluates road traffic control using a fuzzy cellular model.

Regarding traffic congestion problem, W. Wen [22] used an expert system approach to solve the problem of congested roads. The author has proposed a framework for dynamic and automatic light control expert system.

Purohit G.N. et al. [42] provide the use of genetic algorithms to optimize traffic signal timings. They have developed an Emulator for representation of traffic conditions at an isolated intersection with a number of features like GUI developed in JAVA, random generation of vehicles, random vehicular direction, collision avoidance and traffic signals with fixed phase sequence.

Logic programming can also be used to develop a traffic control system [48]. Tan et al. [49] have described the design and implementation of an intelligent traffic lights controller based on fuzzy logic technology.

C. Graph Theory

Graphs are very important in developing the traffic and road networks. The edges and nodes of a graph can be viewed as some or the other component of the traffic system. For example, the nodes represent crossing, bends and ends while the edges may represent the pieces of road of any kind [23], in which various algorithms have been developed to analyze road networks by using approaches like BFS, Dijkstra algorithm etc.

It might be needed to construct road network graphs from geospatial data. [24] aims for finding and exploring the problems in extracting such network graphs. The work has used GPS traces also to develop road geometry.

Eric Galin et al. [25] have proposed an approach based on an original geometric graph generation algorithm based on a non- Euclidean metric combined with a path merging algorithm that creates junctions between the different types of roads. This is also a good work for generating graphs for hierarchical road networks.

Shiuan-Wen Chen et al. [26] have investigated the traffic light setting problem and worked for setting the traffic light, such that the total waiting time of vehicles on roads is minimized. The use of graph model is made to represent the traffic network. This paper is crucial as it has used Ant colony Optimization, Particle Swarm Optimisation and Genetic Algorithms to obtain a near optimal solution.

Larry Head et al. [27] modeled the traffic signal timings using precedence graphs. They argue that precedence graphs can be used to model a series of simple operational treatment at an intersection. The precedence graph approach provides a structured conceptual representation to support the analysis of operational behaviors of controller timing features, such as the added lost time and required fixed time intervals that are induced when certain overlap features are enabled.

[28] provides the process of determining the parts of a network, which are accessible to vehicular traffic and which are not and it too uses the graph algorithms. To determine the connected components of a network it shows the use of the classical connected components graph algorithm. Considering that the road network is represented as a graph as an input and an associated set of barriers, that act as constraints for traveling through the network, the graph algorithm can be built.

D. Real time Systems

Real time traffic control systems collect data in real time and analyze that using some approach to control and monitor traffic.

Bartłomiej P. [33] developed a vision based sensor, that is able to detect the absence or presence of a vehicle based on the images captured, automatically and in real time.

VanDaniker M. [50] described the use of Transportation Incident Management Explorer (TIME) for visualizing real time and archived incident data collected.

Choudekar P. et al. [7] have carried out research on the use of real time systems with image processing.

IV. TECHNOLOGIES USED FOR INTELLIGENT TRAFFIC SYSTEM

Technologies like CCTV, RFID, GPS, and Wireless Sensor Networks can be used to control traffic by monitoring traffic.

A. Wireless Sensor Networks

Khalil M. Y. et al. [34] gave a traffic flow control system that uses Wireless Sensor Networks (WSN) to control the traffic flow sequences. WSN is used as a tool to instrument and control traffic signals, while an intelligent traffic controller is developed to control the operation of the traffic infrastructure supported by the WSN. They have given algorithms too for the controller.

Malik T. et al. [35] in their model have aimed for the real time traffic control using the traffic lights. Wireless sensors are deployed on the lanes and can detect vehicles' number, speed etc and communicate to the nearest control station to forward any information.

Sing Y. C. et al. [36] have worked in the field of traffic surveillance using Wireless Magnetic Sensors. This model is supposed to work with the help of a the Sensor Nodes installed where the vehicles are to be detected and uses GPRS to forward the information further to some control system.

B. RFID

RFIDs are found nearly at every place where traffic is monitored.

Chattaraj A. et al. [51] have given a traffic control system using RFIDs. [52] is a document regarding automatic vehicle identification and managing traffic using RFID.

Bandyopadhyay [53] proposed a way to manage traffic using RFID and wireless technologies.

C. CCTV

Jain V. et al. [54] argued that there are several hotspots in a city that are prone to congestion. They devised a way to solve this congestion problem using CCTV captured images and analyzing them by image processing

Dailey et al. [55] have also considered the use of CCTV cameras to estimate mean traffic speed.

D. GPS

Global Positioning System is a growing as an applicable product, that is used commonly nowadays. Traffic can be managed with the use of GPS too. Owusu et al. [56] have shown the importance of using GPS/GIS systems in monitoring the traffic speed in urban areas.

Tong studied the process of extracting the transportation information using GPS integrated with GIS technologies.

V. SOME PROJECTS

Some projects, in many countries, are currently working for improving the traffic system.
Table 1 shows some projects being carried out.

VI. PROPOSED MODEL

The proposed model of traffic system relies on the extensive use of CCTVs. The real time traffic system also introduces new technology in the field of traffic management like WAN. Fig. 1 shows the different components and the abilities of the proposed model for traffic management.

TABLE I. PROJECTS FOR MAKING THE TRAFFIC SYSTEM INTELLIGENT

Name of Project	Place	Description
ATCS[39]	New Delhi, Pune	Using data from vehicle detectors to optimize traffic signals.
Design and simulation of an intelligent traffic control system.[43]	Nigeria	Fuzzy logic based system for traffic control simulated and tested.
Multiagent architecture for intelligent traffic management system.[44]	Barcelona	Comparision of integrated TRYS and TRYS autonomous agents.
Deployment of a Virtual Sensor System, based on Transit Probes, in an Operational Traffic Management System.[38]	Washington	Deployment of a virtual sensor system in an operational traffic management system.
Analysis of an Integrated Transportation GIS for the City of Guangzhou, China.[40]	Guangzhou, China	Uses GIS for the research and framework proposed for the city.
Towards a GIS based system for roads and transportation planning in Norway.[41]	Norway	Using GIS for road and transport planning.

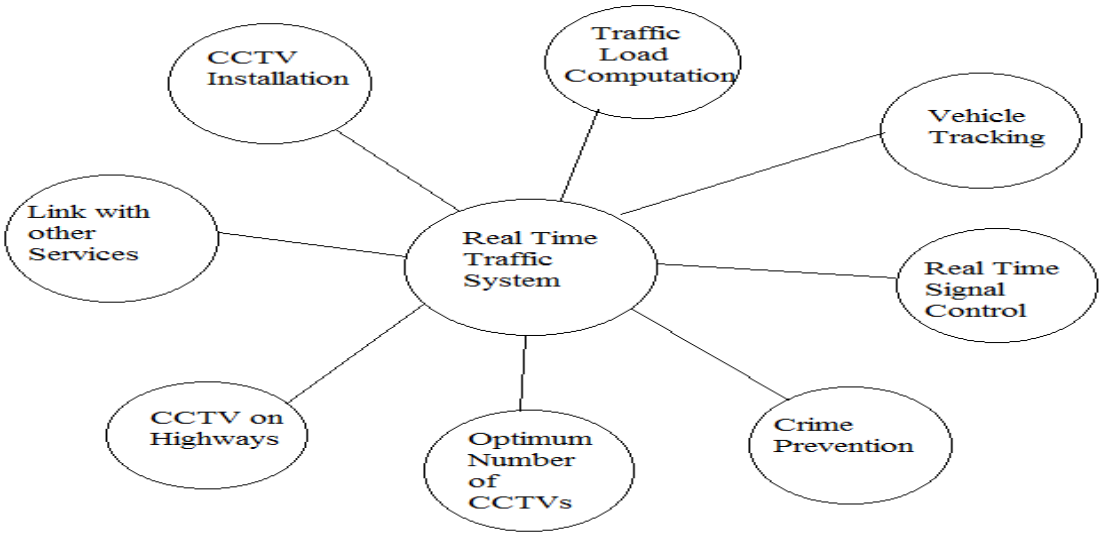

Figure 1. Components of Proposed Model

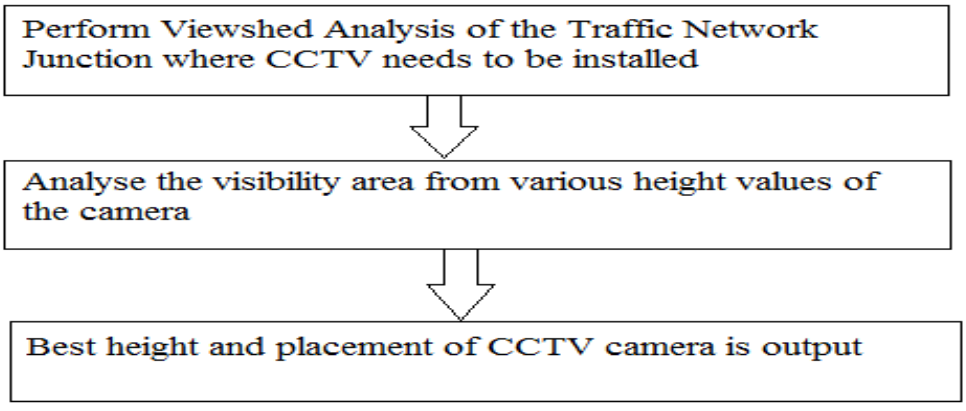

Figure 2. CCTV Installation

The components are briefly described:-

A. CCTV Installtion

CCTV installation is needed in this proposed model. Algorithm for the installation of CCTV is shown in Fig 2.

B. Traffic Load Computation

Traffic load computation is needed for effectively managing the traffic system. By computing the traffic load, green signal timings can be controlled dynamically. Fig. 3 shows the algorithm for Traffic Load Computation.

C. Vehicle Tracking

Vehicle tracking can be of great importance where we want to track some suspected vehicle. Vehicle tracking can be implemented if one can get the number plates of the vehicle under monitoring. For this, the model in Fig. 4 presents the following method to get the number plates of any particular vehicle that detected by the CCTV camera.

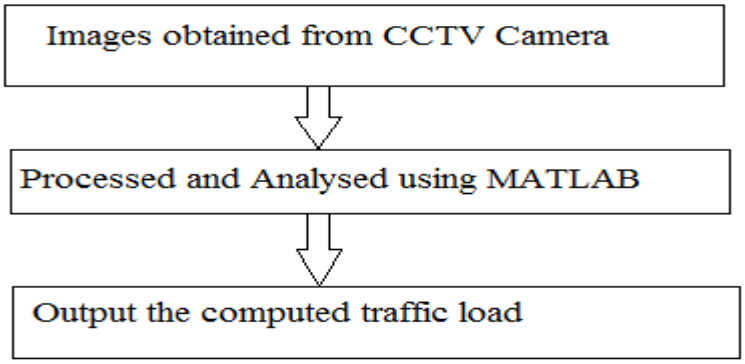

Figure 3. Computing Traffic Load

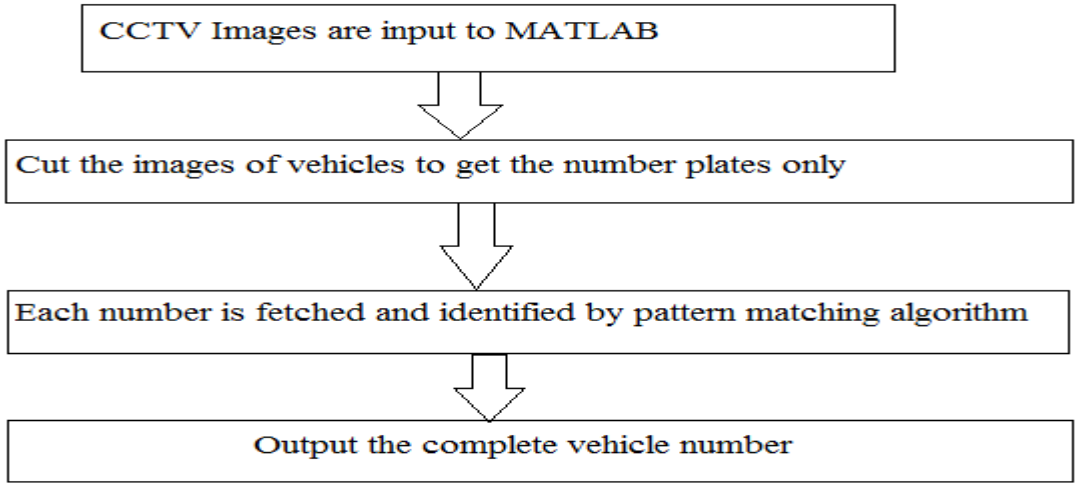

Figure 4. Vehicle Tracking Algorithm

D. Optimum number of CCTVs

It is required to know the number of CCTV cameras to be installed in an urban city. The number should be optimum and within the range of the budget. Optimum number of CCTV cameras can be determined by generating a weighted graph of the network and then finding out the possibilities for installing the CCTVs, as shown in Fig 5.

E. Real time traffic control

The proposed model for traffic control can manage traffic load in real time. Signal timings can be adjusted by calculating the present traffic as shown in Fig 6.

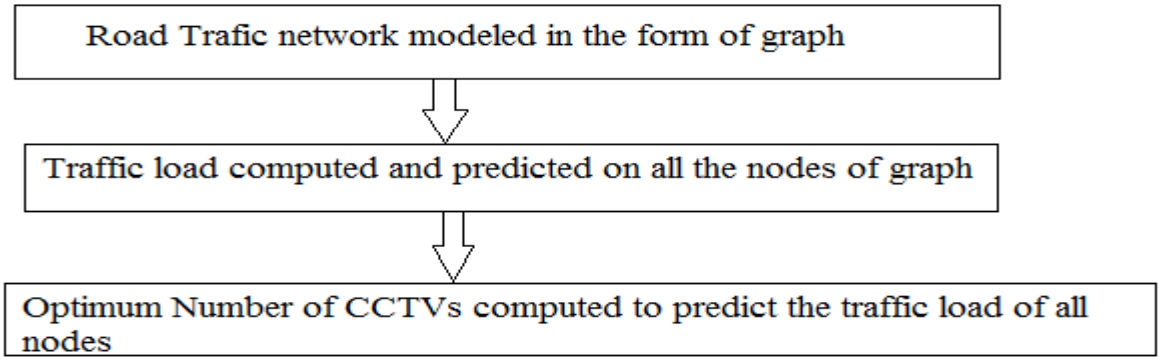

Figure 5. CCTV Computation

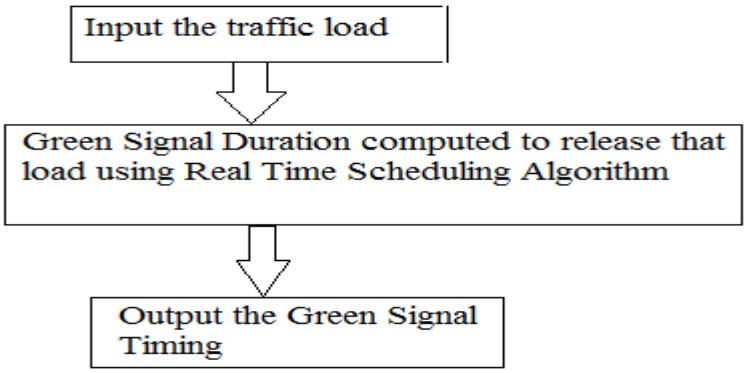

Figure 6. Real Time Traffic Signal Control

F. Crime prevention

Real time monitoring of the traffic helps in collecting the current data and so in preventing crime. A culprit vehicle can be caught by generating proper messages or alarms. This is shown in Fig 7.

G. CCTV on highway

To control accidents on highways too, we can install CCTVs. Points of danger can be determined for this purpose and messages displayed for the vehicles. Fig 8 shows the approach.

H. Linked with other services

Other mobile services like mobile, internet can be helpful to the users for giving the traffic information dynamically and in real time. This can help the mobile users to find emergency services like ambulance etc. from the least crowded and shortest path to the destination(Fig 9).

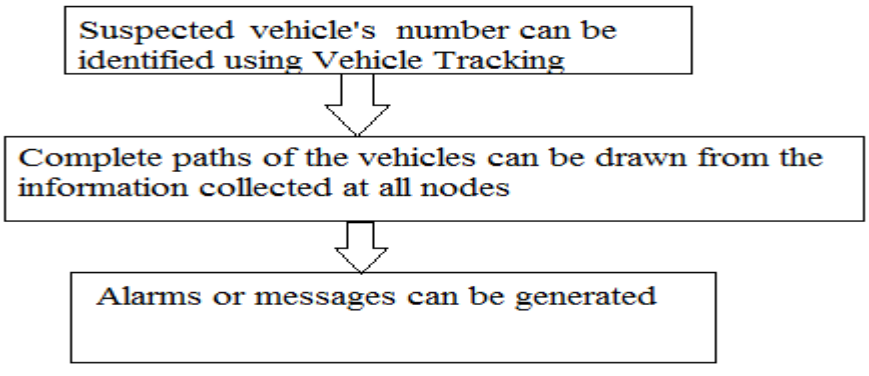

Figure 7. Crime Prevention

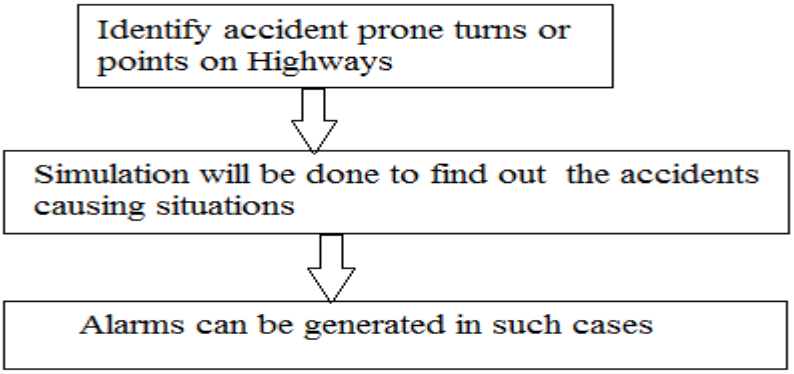

Figure 8. CCTV on Highways

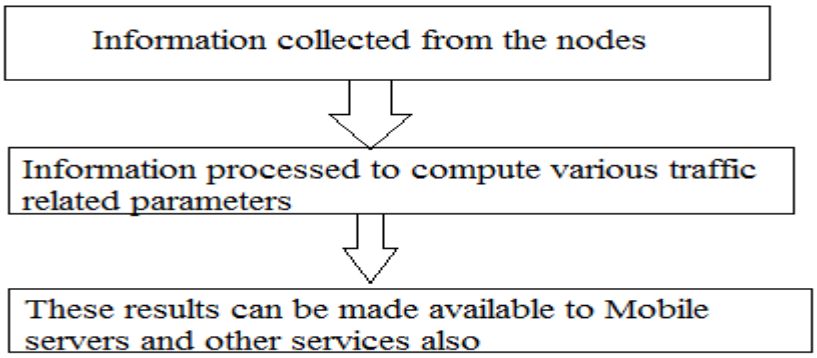

Figure 9. Link to other services

VII. CONCLUSION

Increasing traffic congestion coupled with improved technology, cost constraints, and increasing environmental consciousness has provided an impetus to develop cost effective systems, aimed for improving the efficiency and effectiveness of the traffic system.

The proposed model brings all the issues related to the growing traffic of the urban cities on one platform. Developing such system will indeed be supportive in making the cities smarter in traffic sense.

Whereas intelligent traffic systems will be widely used in many metros and urban cities in near future, the researchers have to continue the daunting search for more efficient approaches and possibilities of the technology. Meanwhile, the academic community have adopted the new field as a playground to apply their ideas to create something completely new. In all, although the widespread deployment of intelligent traffic systems needs some time, the research in this field, being very active and imaginative, will continue for some period.

REFERENCES

[1] Queen, Catriona M and Albers, Casper J (2008) Forecasting traffic flows in road networks: A graphical dynamic model approach.
[2] Lin Sheng-Fuu, Chien Shih-Che, Chiu Kuo-Yu (2009) *Estimating Traffic Flow by Image Processing and the Usage of an Adaptive Traffic Signal Control System.* International Journal of ITS Research, Volume 7, No.2,October 2009.
[3] Roozemond Danko A. Using Intelligent Agents for Urban Traffic Control Systems.
[4] Hong DaHee , Uno Nobuhiro , Kurauchi Fumitaka (2009) *Heterogeneity in multi-anticipative car following behavior by video image data.* . International Journal of ITS Research, Volume 7, No.1,June 2009.
[5] Ozkurt Celil, Camci Fatih, (2009) Automatic Traffic density Estimation and Vehicle Classification for Traffic Surveillance Systems using Neural Network. Mathematics and Computational Applications, Vol 14, No3, pp 187-196,2009.
[6] E. Atko˘ci ¯unas, R. Blake, A. Juozapavi˘cius, M. Kazimianec (2005) *Image Processing in Road Traffic Analysis.*
[7] Choudekar Pallavi, Banarjee Sayanti, Muju M.K. *Real Time Traffic Control* Using *Image Processing.* Indian Journal of Computer Science and Engineering.
[8] Dangi Vikramditya, Parab Amol, pawar Kshitij,Rathod S.S. (2010) *Image Processing based Intelligent Traffic Controller*. Under graduate Academic Research Journal,ISSN: 2278-1129,Volume-1, Issue-1.2012.
[9] Gambardella Luca M. (2003)*Ant colony Optimisation for Ad-Hoc Networks.* The first MICS workshop on routing for Mobile Ad-Hoc Networks, Zurich, February 13,2003.
[10] Bertelle Cyrille, Dutot Antoine, Lerebourg Sylvain and Olivier Damien *Road Traffic Management based on Ant System and Regulation Method*.
[11] Xia Yongxiang (2009) Traffic Control and Optimisation in Road Networks.
[12] Nielson Otto A., Israelsen Thomas, Nielson Erik Rude.GIS based application for establishing the data foundation for traffic models.
[13] Halaoui Hatem F.,(2010) *Intelligent Traffic System : Road Networks with Weighted Time Graphs.* International Journal for Infonomics (IJI), Volume 3, issie 4.

[14] Joshua Aldridge, Ross Harper, Dr Douglas James Wilson, Roger Dunn (2011). *Motorway Crash Analysis Using GIS.* IPENZ Transport Group Conference, Auckland, March 2011.
[15] Akomolafe Dipo Theophilus, Adekayode F.O., Gbadeyan J. A. and Ibiyemi T. S.(2009). *Enhancing Road Monitoring and Safety through the use of Geospatial Technology*. International Journal of Physical Sciences Vol. 4 (5), pp. 343-348, May, 2009.
[16] Witzmann Ursula, Grössl Steve (2010) VeGIS – Tool for the connectivity between traffic models and geographic information systems.
[17] Kumar Praveen, Reddy Dhanunjaya and Singh Varun (2003). *Intelligent Transport System using GIS.* Map India Conference, 2003
[18] Liu Zhiyong (2007). *A survey of Intelligence methods in Urban traffic signal control*. International Journal of Computer Science and Network Security, VOL.7 No.7, July 2007.
[19] Clymer John R. (2003). Simulation of a Vehicle Traffic Control Network using a Fuzzy Classifier System. California State University, 2003.
[20] Dias Charitha, Misca Mark, Kuwahara Masao (2008). *Travel Time Estimation using Probe Data and Bayesian Network Learning.* International Journal of ITS Research, Volume 6, Number 2, December 2008.
[21] Płaczek Bartłomiej (2011). Performance Evaluation of Road Traffic Control using a Fuzzy Cellular Model (2011).
[22] Wen W. (2008). A Dynamic and automatic light control system for solving the road congestion problem. Expert Systems with Applications 34 (2008) 2370–2381.
[23] Wagner Dorothea, Sascha Meinert (2011). *Generating time dependencies in road networks.*
[24] Srivastava Prateek (2010). *Road Network Graph from Partial Sources.* April 2010.
[25] Galin Eric, Peytavie Adrien, Guérin Eric, Beneš Bedˇrich (2011). *Authoring Hierarchical Road Networks.* Pacific Graphics 2011. Volume 30, Number 7.
[26] Chen Shiuan-Wen, Yang Chang-Biau and Peng Yung-Hsing. Algorithms for the Traffic Light Setting Problem on the Graph Model.
[27] Head Larry, Gettman Douglas, Bullock Darcy, Urbanik Thomas () *Modelling Traffic Signal Operations using Precedence Graphs.*
[28] http://proceedings.esri.com/library/userconf/proc97/proc97/to600/pap560/p560.htm.
[29] http://en.wikipedia.org/wiki/Vehicular_ad-hoc_network.
[30] Verroios Vasilis, Kollias Konstantinos, Chrysanthis Panos K., Delis Alex (2008). *Adaptive Navigation of Vehicles in Congested Road Networks.* ICPS 2008.
[31] Weyns Danny, Holvoet Tom and Helleboogh Alexander (2007). *Anticipatory Vehicle Routing using Delegate Multi-Agent Systems.* Intelligent Transport System Conference, 2007.
[32] Seongmoon Kim, Mark E. Lewis, Chelsea C. White III (2004). *Optimal Vehicle Routing with Real-Time Traffic Information.*
[33] Płaczek Bartłomiej. A real-time vehicles detection algorithm for vision-based sensors.
[34] Yousef Khalil M., Al-kariki Jamal N. , Shatnawi Ali M. (2010) .*Intelligent Traffic Light Flow Control System using Wireless Sensor Networks.* Journal of Information Science and Engineering. 26, 753-768.
[35] Tubaishat Malik, Shang Yi, Shi Hongchi (2007). Adaptive Traffic light control with Wireless Sensor Networks.
[36] Cheung Sing Yiu, Ergen Sinem Coleri and Varaiya Pravin. *Traffic Surveillance with Wireless Magnetic Sensors*.
[37] Palau C. E., Esteve M., Martínez J., Molina B., Pérez I. (2005).*URBAN TRAFFIC CONTROL: A STREAMING MULTIMEDIA APPROACH.* IEEE, 0-7803-9332-5/05.
[38] Dailey Daniel J., Cathey Frederick W. (2006).Deployment of a Virtual Sensor System, based on Transit Probes, in an Operational Traffic Management System. U.S Department of Transportation.
[39] Murlidharan V., Ravikumar P. (2005). C-DAC.
[40] Chen Shaopei, Ray Cyril, Tan Jianjun, Claramunt Christophe. Analysis of an Integrated Transportation GIS for the City of Guangzhou, China.
[41] Ness Snorre and Norvik Roar. Towards a GIS based system for roads and transportation planning in Norway. ESRI User conference 2008.
[42] Purohit G.N, Sherry A.M., Saraswat Manish (2011) *Time Optimization for Real Time Traffic control System using Genetic Algorithm.* Global Journal of Enterprise Information System. Volume -3, Issue-IV, October-December 2011.
[43] Chinyere Osigwe Uchenna, Francisca Oladipo Onaolapo, Amano Onibere Emmanuel (2011). *Design and Simulation of Inteeligent Traffic Control System.* International Journal of Advances in Engineering & Technology, Nov 2011.Vol 1, Issue 5, pp. 47-57.
[44] Josefa Z. Hern_andez, Sascha Ossowski, Ana Garc_ıa-Serrano(2002). *Multiagent architectures for intelligent traffic management systems.* Transportation Research Part C 10 (2002) 473–506.
[45] LeBrun Jason, Anda Joey, Chuah Chen-Nee, Zhang Michael, Ghosal Dipak. VGrid: Vehicular AdHoc Networking and Computing Grid for Intelligent Traffic Control.
[46] Mirchandani Pitu, Head Larry. RHODES: A REAL-TIME TRAFFIC SIGNAL CONTROL SYSTEM: ARCHITECTURE, ALGORITHMS, AND ANALYSIS.
[47] Dotoli Mariagrazia, Fanti Maria Pia, Meloni Carlo. Real Time Traffic Signal Control: Application to Coordinated Intersections.
[48] Felici Giovanni, Giovanni Rinaldi, Sforza Antonio, Truemper Klaus. Intelligent Traffic Control: A Logic Programming Approach and a Real Application.
[49] Tan Kok Khiang, Khalid Marzuki and Yusof Rubiyah (1996). INTELLIGENT TRAFFIC LIGHTS CONTROL BY FUZZY LOGIC. Malaysian Journal of Computer Science, Vol. 9 No. 2, December 1996, pp. 29-35.
[50] VanDaniker Michael (2008). Visualizing real time and archived traffic incident data.
[51] Chattaraj Anuran, Bansal Saumya, Chandra Anirudh (2009). *An Intelligent Traffic Control System using RFID.* IEEE
[52] http://www.superrfid.net/english/upload/AVI%20and%20city%20traffic%20management.pdf.
[53] http://www.intranse.in/its1/sites/default/files/7Congestion%20Management-Somprakash.pdf.
[54] Jain Vipin, Sharma Ashlesh, Lakshminarayanan (2012). *Road traffic congestion in developing the world.*ACM 978-1-4503-1262-2/12/03.
[55] Dailey Daniel J., Cathey Frederick W., Pumrin Suree(2001). The use of uncalibrated roadside CCTV camers to estimate mean traffic speed.
[56] Owusu Joseph, Afukaar Francis and Prah B.E.K. (2006). *Urban Traffic Speed Management: The Use of GPS/GIS* .
[57] Tong Daoqin (2005). Traffic Information Deriving Using GPS Probe: Vehicle Data Integrated with GIS.