Metropolitan City Area Integrated Intelligent Traffic Management System (MIITMS)

Anyone who drives in a major city knows what a frustrating experience it can be, being stuck endlessly in bumper-to-bumper traffic and held up by VIP movements and traffic snarls. Developing a system with an integrated approach to intelligent traffic management in metropolitan city area a) by modeling optimal traffic flows and b) by predicting best possible traffic routes and c) by tweaking time intervals of traffic signal points can ease traffic stress considerably and smooth traffic flows. The system could use live traffic density updates, road capacity, external factors and city road network topology to achieve this.

This system is henceforth referred to as Metropolitan City Area Integrated Intelligent Traffic Management System (MIITMS) in this paper. For MIITMS to work effectively it should ideally be developed and maintained jointly with State/Central Governments using a Public Private Partnership (PPP) model. Naturally, some amount of redesigning of the topology of the city road network will be required, but once developed and adopted the system would greatly reduce modern day traffic problems in almost all cities by taking into account the traffic density and movement as a single unit in a holistic and interdependent fashion rather than in an isolated and discrete way.
About the Authors

Pavan Kumar Pannala

Pavan Kumar Pannala, IT Analyst with TCS has a Masters in Computer Application (2007) from Osmania University, Hyderabad and has over four and a half years of experience in various projects related to GIS, Telecom and Banking domains. Recently, he has been involved in the research and development of Traffic Management, and of Parallel Computing systems in TCS.

Anup Chakraborthy

Anup Chakraborthy, Systems Analyst with a PG diploma in Business Management and Engineering degree in ECE, has over four and a half years of industrial experience. Anup has worked in the Marketing and Telecom domains. He has contributed to the growth of TCS’ Value Added Services and has worked in the Market and Competitive Intelligence unit.. In his present role, in TCS, he carries out business research in the public sector domain. He has also published papers on Big Data in Public Sector and Competitive Intelligence.
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## Abbreviations

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<th>Abbreviation/ Acronym</th>
<th>Expansion</th>
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<tr>
<td>MIITMS</td>
<td>Metropolitan City Area Integrated Intelligent Traffic Management System</td>
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<tr>
<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>TRT</td>
<td>Time taken to right turn</td>
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<tr>
<td>WTTS</td>
<td>Waiting time at traffic signal point</td>
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<tr>
<td>TT</td>
<td>Time taken to travel</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<td>PPP</td>
<td>Public Private Partnership</td>
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<td>BOT</td>
<td>Build Operate Transfer</td>
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Introduction

Anyone who has driven through a major city has experienced the frustration of being stuck in traffic snarls. The experience itself is obviously exhausting. As for the consequences, on the one hand, there is stress and anger, and the loss of leisure and work time to contend with. On the other, there is huge consumption of gas, vast amounts of air pollution leading to various ill effects. All in all, the human and economic costs of this scourge seem to be ever increasing.

Learning from the Ants

Ants, however seem to have cracked the problem that we as humans have not yet been able to. While our cars get hopelessly mired in traffic jams, ants help each other to move around their colony far more efficiently. Understanding how they do this could inspire more effective routing of road traffic.

Collective Intelligence expert, Dirk Helbing, from the Dresden University of Technology in Germany and his team investigated how ants move around their colony. They set up an ant highway with two routes of different widths from the nest to some sugar syrup. Unsurprisingly, the narrower route soon became congested. But when an ant returning along the congested route to the nest collided with another ant just starting out, the returning ant pushed the newcomer onto the other path. However, a returning ant that enjoyed a trouble-free journey, did not redirect a newcomer.

The researchers then went on to create computer models of more complex ant networks with routes of different lengths. The team found that even though rerouted ants sometimes took a longer route, they still got to the food quickly and efficiently.

If automobile drivers travelling in opposite directions could pass on traffic congestion information to each other this way, traffic flows would be far smoother.

The model takes the learning from this experiment and tries to put forward technology to solve the problem.

Using technology to solve traffic woes

The objective is to use technology to model a highly complex, integrated and intelligent system that can automate the process of traffic management in a metropolitan city area. The system would do this by predicting the optimal traffic routes and time intervals for various traffic signal points by factoring in live traffic density updates, road capacity, external factors and city road network topology. This system would take a holistic view of city road network topology by means of live traffic updates and it would be possible to use it as a Decision Support System (DSS) to predict optimal traffic routes and time configuration for traffic signal points in a live/offline scenario. Further, the system would also allow traffic simulation and an IF/THEN analysis for traffic diversion.

For the sake of a trial run, a prototype of the system can be developed in any select city in India for evaluation purposes. The system will be open and subject to change and improvement.

Challenges for the MIITMS

To develop the proposed system the State or Central Governments must participate actively through PPP in the Build-Operate-Transfer (BOT) mode at various levels during project development and implementation. To work effectively, the developed system requires accurate geographical data (Google Maps or others etc.), live traffic density inputs at regular intervals, and other sets of predefined parameters. Further a complex algorithm executed on a high-end-server will provide continually updated traffic and route information.

How the new MIITMS solution works

Traffic police, stationed across the city at various traffic signal points, are provided with hand held devices (low end android tablets) or custom apps on mobile phones that allow them to provide traffic related inputs from each point. This in turn allows the system/server to receive live updates of traffic density. The inputs from various points are then aggregated taking into account other external factors such as road blockage, water works repairs, road capacity, city road network topology and other predefined parameters/rules. A highly complex algorithm then runs on a high end server, which would intelligently predict the best routes for traffic flow and optimal time interval for various traffic points “from a holistic perspective of the metropolitan city area.

For example, Point A connects to Point B and Point C and both of these converge to Point D. Let’s assume there is traffic blockage on Route A-B and Route A-C is relatively free. This proposed System would then automatically increase the time interval of traffic signal point at Route A-C thereby distributing the traffic flow in an optimal fashion.

Redesign for optimal results

For effective working of the system, redesigning in the following areas would be necessary:

- Topology of City Road Network
  - Have the maximum possible number of free left turns and have none or few traffic signal junctions.
  - Avoid or reduce considerably the time taken to right turn (TRT) and the waiting time at traffic signal point (WTTS).
  - Accommodate a right turn or traffic signal junction only if required and if it cannot be eliminated or worked around in the route.
This approach when adopted at City Road Network Topology level can greatly reduce traffic jams as well as the time taken to travel (TT).

- Balanced Traffic Intersection Points
  - Ensure that the number of inputs into a junction (J) is equal to the number of outputs going away from it (J).
  
  This will ensure that there are no bottlenecks created due to uneven traffic flows.

- Time-of-the-Day Traffic Pattern
  - Use time-of-the-day traffic pattern to tweak traffic signal points’ time intervals and enforce a predefined set of routes to reduce TT.

It is possible, for example, that the maximum traffic density and flow towards an industrial area, which is located on the west side of the city, maybe in the morning say between 9AM and 11AM. Likewise, traffic density may increase and flow towards the north side of the city where a residential zone is located in the evening. Tweaking signal time intervals in heavy density points can ease the pressure in these routes during rush hour traffic.

- Constant-Speed Driving Zones
  - Create constant-speed driving zones across the city so that traffic movement is at a given ideal speed.

  This will work only if commuters are educated to comply with recommended speed driving limits within zones as much as possible depending on and subject to real time traffic conditions.

### Outputs of MIITMS

Using the inputs to the MIITMS, a highly complex algorithm will be run at configurable predefined time intervals, say every 15-30 minutes as well as on a need basis. MIITMS will be designed to produce the following outputs:

- Publish set of best possible traffic routes from a holistic perspective of the entire city so as to ensure optimal traffic flow.

- Set time interval automatically for various traffic signal points in line with the objective of optimal traffic flow across the city.

- Provide the ability to carry out IF/THEN analysis of traffic diversion scenario for traffic police on time interval and route level.

### Benefits of MIITMS

- By providing a subscriber model, commuters can get the latest traffic information from MIITMS where users can get customized information at route level. The system will become a go-to tool for all commuters to obtain live traffic density and optimal suggested traffic route information that can be accessed via web/mobile interface.
Emergency services such as ambulances, fire vehicles, etc. can get the best optimal route information. A notification module for emergency services can also be made available where emergency service vehicles can notify traffic police that they will use a particular traffic route with the objective of reducing ‘traffic travel time’. The system can then automatically tweak traffic signal times thereby reducing ‘passage time’ of services vehicles in emergency situations.

The MIITMS system can act as single source to identify traffic bottlenecks and to record and analyze various types of related traffic information such as accidents and traffic violations.

Reports can be generated as and when required on traffic density by date, time of day, etc. so as to understand the increase in traffic density over a period of time. All of this data is stored and maintained in the system and can be retrieved to identify patterns in the increase of traffic density. This can be used to plan rerouting, invest in infrastructure development, or devise strategies to deal with bottlenecks and traffic jams.

For VIP movement, the system can help understand the clearance time of existing traffic or any other information that helps achieve the objective of the ensuring safe and smooth passage of the VIP’s vehicle. By using IF/THEN analysis it also plans alternative traffic routes for general public movement and calculates optimal time intervals for traffic signal points so as to ensure that ordinary commuters do not experience discomfort due to VIP movement.

The GIS component will provide visual representation of live traffic density as well as suggest a set of best possible traffic routes for a given point in time.

Being a DSS for traffic management, traffic department officials can use it and if it is made accessible to the larger public via web/mobile interface via a notification module, the end user/commuter can get relevant information in response to queries about current traffic and route status.
Conclusion

The very premise of MIITMS is a holistic view of traffic flows in a city area. By viewing this as an interconnected problem and weighing factors such as road width, live traffic updates, road repairs, etc., it becomes possible to see how best traffic flows can be regulated.

The system calls for a high level integration of traffic data on top of city road topology (geographical data) along with intelligence that can predict the best possible routes at a given point of time (t). It also considers the approach of logical division of the city along various lines such as zones where high traffic movement is expected between a given time interval or on account of a special occasion. We can also factor in known and expected seasonal traffic patterns across various zones in the city. Over a period of time, with the accumulation of information of traffic patterns we can also do a Root Cause Analysis of the major traffic problems faced in various places of the city and use it as a decision support tool to invest rightly and meaningfully in infrastructure maintenance and development so as to reduce traffic problems.

A possible advantage that the system can provide, if it is fully operational, is to allow for dynamic route manipulation and an If/Then analysis to traffic police. Finally one of the primary intended use of this system is to make this information available to the general public at large in a relevant manner through various communication modes (TV/Web/Mobile/Public Display Systems) and allow commuters to query the system to obtain the required information and plan their travel accordingly.

Another option is to upgrade the system to predict the possible traffic density, say in the next subsequent time intervals in multiples of hours. For instance, what could be the possible traffic flows at 10 AM or 12 AM today, which can be calculated by factoring in historical data by day, season, and time and also by gathering the inputs from users of the system (General Public). To enable this, all users can be registered to notify their plan of travel for the day, so the system can aggregate the data and predict the possible traffic flow.

Clearly this is a complex system that needs to be built over a period of time in a trial run fashion in the PPP mode. The system will be evolving in nature and can be upgraded in phases. This system if employed in any given metropolitan city area would lead to optimized and intelligent traffic management that would greatly reduce the common problems associated with it.

References


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