Central Traffic Management Platform

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1. Introduction

Traffic congestion, a major problem faced by all cities, is one of the major factors contributing to countries health and economic development. Good roads and smooth flowing traffic makes the environment pollution-free, noise-free and invites lots of business opportunities.

The world’s first traffic signal was installed over a hundred years ago, in 1868 in London to control the ever increasing horse drawn traffic. It was conceived as a means to provide a safe crossing for pedestrians. Over time, this system was adopted by America and the rest of the world. The first electric traffic signal was installed in Cleveland. Other countries soon followed suit and installed traffic signals of their own. The world has since moved on from horse-driven carriages and the first cars. Ever increasing vehicle traffic on the roads calls for a more sophisticated traffic control system which can incorporate the latest technological solutions. There are many solutions that can be used to control the traffic menace.

In this article we will discuss effects of traffic on the environment, walk through a few existing solutions to control traffic and also present the design of a centralized traffic management platform that can address different traffic issues.

1. Effects of traffic congestion

Increase in the number of vehicles and concentrated population in urban areas has resulted in heavy traffic on roads. Traffic affects the environment as fossil fuels burnt by the vehicles leads to air pollution which in turn causes medical issues to people.

Bad traffic management leads to vehicle wear and tear which results in breakdowns and accidents, incurring health care costs. Emergency vehicles are most affected in today’s traffic. There are many examples where ambulances or fire engines get stuck in traffic and are not able to reach the destination on time. Good business opportunities are lost when a city is affected with snarled traffic. This has a long term impact on a city’s economy and growth.
Road traffic management is a huge challenge in current society. This article discusses various existing solutions and our approach to create a smart Centralized Traffic Management Platform (CTMP) by combining existing and new technology.

There are many factors to consider when designing an effective traffic management solution. Traffic management comprises:

- Obtaining traffic information for re-routing traffic
- Automated traffic management instead of manual
- Incident management
- Driver support and monitoring
- Parking Management
- Emission Control
- Green Corridor Creation

2. Existing Technologies in Traffic Management

A few existing solutions that address some of the traffic problems:

- Emergency Vehicle pre-emption – This technology is used to create green corridor for emergency vehicles. When emergency vehicles are close to a signal the system sends a preemption signal to the receiver and gets a green light. The emergency vehicle should get somewhere close to the traffic signals to preempt. However, this might be challenging when traffic volume is very high.

- Information about the traffic - There are several applications that integrate with GPS and provide traffic status on any given route.

- Intelligent traffic signals – In a few places intelligent traffic signals are installed which read the volume of traffic [1] on each side and open the signal accordingly. But this is not of much use when all 4 directions have the same volume of traffic.

Let us discuss a few technologies in detail.

2.1 Emergency Traffic Signal Preemption system

Traffic Signal Preemption [2] is a system that preempts traffic signals and changes their normal operation. Most common use of this system is to preempt traffic signals in the path of emergency vehicles, manipulate the signal, halt the conflicting traffic and give way for emergency vehicles.

Traffic Preemption devices should be installed on vehicles. They can be switched on and off based on the requirement. Once switched on, the traffic preemption device will clear signals in the path of vehicle to grant way in the desired direction.

2.1.1 Types of Traffic Signal Preemption system

*Acoustic*

Sound sensors linked to the preemption system are used to activate a green signal. These systems override the signal when a specific pattern from the vehicle’s siren is detected. Major
disadvantage is that sound waves can be reflected by buildings or huge vehicles preempts signal in wrong direction.

**Infrared**

Vehicles with preemption system emit infra-red signals to the traffic signals on its way. The receivers installed at the signals receive and clear the route for the emergency vehicle. Drawbacks are obstruction and atmospheric conditions.

**Global Positioning System**

GPS-based traffic preemption system was introduced integrating with GPS. These systems require software and communication platform to determine the location, direction and speed of the vehicle. Based on these parameters, the central application should activate the desired traffic lights in its route.

**Radio Signals**

Radio-based traffic preemption system is considered more effective than the other systems. Here, a radio-based signal is transmitted from emitter to receiver. It is not blocked by visual obstructions as it is radio based. However, there are chances of interfering with other signals on the same frequency.

**Opticom**

This is a robust and secure emergency preemption system. Opticom uses GPS technology and highly secure radio communication power.

Opticom [3] should be installed in both traffic signals and the ambulances. There will be an embedded GPS receiver on the Opticom GPS vehicle unit which determines vehicle location, direction, speed and other parameters. This is transmitted over Opticom radio once every second. There will be a radio receiver at the signal intersection which is being approached by the emergency vehicle. The radio receiver detects the vehicle signal and passes the signal to a phase selector. The phase selector process the signals based on pre-provisioned settings and notifies the controller to open up the signals based on priority.

The workflow of Opticom is as follows:

a. Opticom vehicle transmits location, speed and direction to GPS intersection equipment installed at signal.

b. When vehicle enters radio range GPS intersection equipment transmits request to phase selector.

c. Phase selector validates request and alerts the traffic control system to trigger green signal.

d. Signal reverts to red once the emergency vehicle crosses the signal.
2. Workflow of Opticom

2.2 Intelligent Traffic Signals
Intelligent Traffic Signals [4] are installed at certain places to control traffic. Traffic signals that can communicate with each other can control the signal timing based on traffic density.

A camera with digital controller is mounted on the traffic signals. This prioritizes the movement of vehicles based on density of traffic.

This system has reached saturation because most of the time there is maximum density in all four directions. This kind of system works effectively only when there is lower traffic volume.

This type of solution is implemented at an intersection level. However, a solution is needed that can study the traffic on all sides in a given area. This will be an area control mechanism which will overcome the problems faced when controlled only at intersections.

Currently, Dubai uses SCOOT [5], a traffic control system equipped with sensors. This helps detect traffic volume on roads and hence aligns the movement based on traffic volume. SCOOT has a series of detectors buried underground. These communicate with a central computer to share data on traffic volume. This data is then used to control timing of signals.

2.3 Global Positioning System (GPS) Applications
GPS applications are best used for navigation and tracking. There are a number of GPS tracking apps which can be launched on a hand-held mobile device. This helps to track assets on the move.

A satellite-based technology, GPS helps get the location details of vehicles, person or any other asset. This information is sent to a central server where further computation is done.

Well-known applications are Google Maps, Mapquest, Waze, and more.

GPS application can provide the following details:
• Volume of traffic - This information is provided based on vehicles location coordinates.
• Route - GPS application provides various routes between source and destination.
• Navigation on the move - GPS application provides route instruction to guide users on the move.
• Nearby landmarks - GPS application provides information on nearby landmarks, i.e. hotels, hospitals and schools.
• Emergency vehicle availability
• Nearest availability of Uber-like services
• School bus tracking

**GPS with Radio Frequency Identification (RFID)**

GPS embedded with RFID [6] enables asset tracking. GPS application collects information such as location, speed, altitude, etc. which is then sent to a central server for further computation.

Wide-spread uses include RFIDs embedded on Student ID cards. For example, students swipe this card while entering and exiting the bus. RFID tracker is also installed on vehicle to track the vehicle, enabling the following information to be sent to parents via GPS connection.

• Boarding status of student
• Status of vehicle (Started or not)
• Current location of vehicle
• Distance between vehicle and the bus stop
• Exiting status of student

Along with navigation and providing traffic information, GPS embedded with RFID is efficient for tracking and thus used in security applications. Applications like FALCON use this technology and are used for tracking school bus and boarding status of the child. Similar technology is used for electronic toll management.

### 2.4 Electronic Toll Management

Vehicles slowing down at toll plazas are a major reason for slow traffic in highways. This can be overcome by implementing electronic toll.

GPS embedded with RFID [7] is used at toll gates to implement electronic toll collection.

• RFID tag is mounted on vehicle’s windscreen.
• Every vehicle’s tag will have a unique identification number.
• As the vehicle approaches toll plaza this unique number will be read by the RFID reader installed at toll plaza.
• Toll amount is deducted from the prepaid account that is linked to the tag.
Advantages
- Online toll fee collection
- Vehicles do not stop at toll plaza
- Avoids traffic congestion
- Easy recharge

2.5 Parking Management
Parking management is another challenge caused by growing traffic. People looking for parking spaces in residential areas, shopping centers, hospitals and other public places also contribute to the slowdown of traffic on main roads and busy junctions. Various integrated parking management solutions have tried to mitigate the parking issues.

Advantages of various parking address management systems
- Parking Management software is simple and easy to handle by the parking staff.
- They are cost effective.
- Reduces vehicle slow down and traffic can be controlled efficiently near parking lots.
- Reduces search time.

Parking management applications such as Omnitec [8] and CPS make use of best technologies to provide hassle-free parking services.
3. Centralized Traffic Management Platform Architecture and Design

Centralized Traffic Management Platform (CTMP) is a platform where different applications such as emergency vehicles, traffic signals, traffic monitoring apps, vehicle tracking apps and other IoT-related applications can plug in. It can also be used as a platform where existing applications like OLA, Uber, TaxiForSure, and so on can be operated. This platform can also be integrated with Google Maps APIs to provide directions to different locations, handle traffic signals using IoT, management of public transport, and so on. The real life use cases which can be handled by this platform are enormous.

If existing applications need to be integrated, the applications should expose open APIs which can be used by CTMP to perform necessary operations. If not, the application should provide the option to deep link from CTMP.

For example, OLA and Uber provide open APIs [9][10] which can be used to handle ride availability, ride estimates, ride booking and ride tracking. OLA also provides an option to use deep linking to direct users to use the OLA app.

4. CTMP workflow

3.1 Application for better traffic management

We will now address two important problems.

- Green corridor for emergency vehicles
- Public transport management

3.1.1 Green corridor for emergency vehicles

Emergency Vehicles are most affected in today’s traffic. Too often, ambulances get stuck in traffic and do not reach the hospital in time. This module establishes communication between
traffic signals and ambulance so that traffic signal will respond to the arrival of the ambulance and change to clear the traffic in front of the ambulance so that it will move without any blocks.

**High Level Architecture**

The system is designed to control the traffic signal in the route of the ambulance. This is achieved remotely from CTMP server which communicates with emergency vehicle and traffic signal. Proposed method uses GPS technology and IoT. Main components will be emergency vehicle, traffic signal and CTMP server. CMTP server will get periodic updates from emergency vehicle and will decide whether to trigger green for next approaching signal based on distance. GPS tracking applications like Falcon and Opticom can be used for tracking emergency vehicle.

The initial step to implement this is to configure and manage the traffic signaling systems at every key city. To make the traffic signaling system more predictive and adaptive, sensors should be installed on the roads to determine the traffic flow. Traffic signaling systems like SCOOT which is presently used for traffic management in Dubai has options to remotely manage the signals.

The next step requires installing GPS tracking application on the emergency vehicles. There are two ways to implement this feature. One is to integrate with the existing GPS tracking applications like Falcon, Opticom, etc. Another method is to write a new application with the help of Google Map APIs to identify the existing location, to understand the traffic congestion and to identify the best possible route from source to destination.

The final step is to integrate the traffic signaling system and GPS application on emergency vehicles to the CTMP to seamlessly manage the movement of emergency vehicles.

Here is the pictorial representation of the workflow. This workflow assumes that the traffic signaling system and GPS application is integrated with the CTMP platform.

- GPS-enabled Android application will be running on the ambulance. Driver should input destination to get shortest congestion-free route.
- Emergency vehicle should register with CTMP server. Once registered, CTMP server will get the map of the ambulance route and all the signals in the specified route.
- CTMP server will get real-time updates on location and speed from ambulance.
- CTMP server will decide whether to trigger green for next approaching signal based on distance between ambulance and signal. If there is an ambulance within 1km distance of the traffic signal CTMP server communicates with sensor installed at signal to change the signal to green. It will stay green until the ambulance crosses the signal. If there are two or more ambulances coming the same way, the closest to the signal will be given priority.
6. Workflow of tracking emergency vehicles

3.1.2 Public Transport Management
One of the best ways to reduce traffic is to encourage people to take public transport. But the challenge is unpredictable bus schedule and flexibility. Since Google Maps integration is vital for all CTMP use cases, public transport management can also be implemented with ease.

This would require a system which provides information on different public transport options and schedules which will encourage people to use public transport.

A major building block for this design is to install the GPS tracking application in public transport vehicles. As discussed earlier, there are two ways to implement this feature. One is to integrate with the existing GPS tracking applications like Falcon, Opticom, etc. Another method is to write a new application with the help of Google Map APIs.

The next-most important step is to build a database with all the transport routes and the tentative schedules. Client applications (like mobile apps) can be used to retrieve the approximate time of buses via the said route. The statistics can help authorities balance the schedules for certain routes and also introduce fresh vehicles via certain routes.
6. Public transport management

4. Benefits
“Organizing is something you do before you do something, so that when you do it, it is not all mixed up.” – A.A.Milne

CTMP is a method to better organize vehicular traffic to avoid chaos. This is a platform where technology, people, government and private organizations come together to improve the quality of life of everyone. This solution can be adopted to develop smart cities. It can also help reduce carbon foot print of highly populated and polluted cities.

5. Technology overview
Below are a few technologies that we will adapt into CTMP project.

5.1 IoT
Internet of things is a network of interconnected devices which are equipped with sensors, hardware and the required software, along with required connectivity that enable them to communicate with the computers. IoT establishes an architectural framework which enables the devices to become responsive and exchange data over the existing network infrastructure.

As the Internet becomes more efficient and extensive, its availability is increasing. Also the technology in the sensors are becoming increasingly economical, setting a platform for IoT-
enabled devices and the required infrastructure. These days there are sensors available with a WiFi-chip which can transmit information collected to a cloud database or a central server in the cloud.

Traffic management can be handled efficiently if the traffic signals, roads, and vehicles are equipped with sensors that can be used to communicate with a central server.

Sensors installed on the traffic signal can be used to send information about the number of vehicles at the signal to the central server.

Vehicles connected to the server can get live traffic updates and dynamically change the route depending on the number of vehicles at a particular junction.

Ambulances equipped with IoT can dynamically find the most traffic-free routes. And if there is an ambulance on the road, traffic signals can modified to provide priority to the ambulance.

5.2 Cloud Technologies
Cloud Computing is a type of Internet-based computing which has the ability to provide shared resources to servers and devices on demand. In the case of traffic monitoring, a number of technologies based on cloud can be utilized.

5.2.1 Cloud Computing Database
Data from the sensors can be dumped periodically to a database which is hosted on the cloud. A number of databases such as Thinkspeak are available which can be used to dump the information collected from the sensors. Thinkspeak enables devices and websites to store data in one of its channels. There is also a provision to analyze and visualize the data collected. It can also be used to interact with social media.

5.2.2 Google App Engine
A cloud computing platform to host applications, Google App Engine enables a web or mobile application to scale automatically depending on the traffic. This is achieved by allocating the resources as per the request received by each application. The database can be exported to Google App Engine to facilitate multiple clients to communicate with the server simultaneously.

5.3 RFID
Radio frequency Identification uses electromagnetic fields to track objects. The objects are tracked with the help of a tag which contains electronically stored information. One significant feature of the tag is that it need not be in the line of sight of the reader.

Tags are labels containing information attached to the objects. The readers send a signal to the tag and receive a response from it. RFID tags can be of two types

5.3.1 Active Tags
Active Tags are fitted with a battery which will transmit the signal back automatically.
5.3.2 Passive Tag
Passive Tag does not have a battery; instead it collects energy from the radio waves transmitted by the reader.

Each Tag consists of a microchip, antenna and/or a battery. Basically, here is how RFID works:

1. Data is stored in the RFID chip (Up to 2 kb)
2. Reader will send electromagnetic energy which can be received by the RFID tag antenna.
3. RFID tag sends data back to the reader.
4. Reader interprets the frequencies to construct meaningful data.

There are three types of data storage possible on RFID tags. Read-write, read-only and WORM (write once, read many). Read-write tags can have data written to and read from them. Read only tags cannot be overwritten. WORM tags can be used to write additional data only once.

These tags can be produced very economically and can be made small enough to fit into any product.

RFIDs can be established as a network and the readers can communicate with the Internet providing a number of use cases to resolve real world problems

5.4 REST API Interface
REpresentational State Transfer (REST) is a standard that uses HTTP for data communication. The REST API can be used to Get, Put, Delete or Post data. Among the technologies available for data communication, REST is preferred due to its low bandwidth usage.

REST is the most preferred form of communication in the cloud applications. Some major reasons why are:

- REST calls are stateless. Stateless calls are scalable depending on the application load and can be redeployed easily.
- Uniform and user friendly interface.
- Supports both JSON and XML formats.
- Cacheable
- Layered system

6. What next?
This requires integration of all existing applications like OLA, Uber, Opticom, etc. with the CTMP platform. Integration is possible if open APIs are available or if deep linking of the applications are possible. This will also require discussions with the vendors to expose APIs for seamless integration.

As discussed earlier, there are several creative ways to use CTMP:

- Get doctors available on the given route to help treat emergency patients
• Monitor and constantly re-route vehicles to avoid congestion of vehicles along the same road.
• Alert traffic information to school authorities and parents in case a child fails to reach home/school on time.

7. References


[10] https://developers.olacabs.com/docs/deep-linking

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