# A SURVEY ON USING WIRELESS SIGNALS FOR ROAD TRAFFIC DETECTION

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## Abstract

*With the advent of wireless technologies, it has been found that using wireless signals for the purpose of vehicular traffic management is the most cost effective process as wireless signature are available across all terrains and it is ubiquitous. As the road space is not expanding in line with the growth of automobiles, traffic congestion is bound to increase on a regular basis. The only way to avoid vehicular congestion is to have a regulated traffic movement plan in a real time basis. During the last decade, a number of methods were developed to obtain real time data on vehicle movements such as using RFID, Wireless Sensor Networks, VANETs, Mobile Technologies, Infrared signals, Cameras etc. A number of studies have been carried out to find out optimum vehicle traffic management to predict and manage traffic congestion and these studies have its own merits and demerits .Most studies have not been conclusively proved to be effective to address the issues concerned with road traffic management because of implementation difficulties, data inaccuracies, difficulty in real time application and cost. This is causing serious safety concerns in traffic management because of the tremendous growth in the number of vehicles and the non-availability of effective traffic management system. This paper is a comparative study of existing methods for detecting vehicular traffic density by using wireless signals.*

***Keywords:*** *Vehicle Traffic Management Techniques, Wireless Signal Detection*

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## 1. INTRODUCTION

The annual increase of automobile production is about 6% globally. Due to migration of population, urban growth and infrastructural constraints, the road space is not keeping in pace with cumulative automobile increase and thus causing severe traffic congestion everywhere. On account of resource constraints and public resistance, development of new road space either within or outside the city limits is time consuming and costly. Therefore, to ensure seamless movement of vehicles, an effective monitoring and management of traffic movements are essential to overcome the constraints of availability of road space. With the spread of mobile cellular network along the length and breadth of every country and thus the ubiquitous availability of wireless signals, it is possible to make use of the wireless signals for detection and management of traffic cost effectively. In the recent past, a no. of studies has already been carried out by large no. of researchers in this aspect. However, in most of the cases, the studies have been confined to detecting mobiles while on traffic mode. With the present day emphasis on safe driving, mobile conversation is banned while driving, and thus a large no. of mobiles are in idle mode.

Presently there are different techniques using wireless signals to detect traffic density on highways and lateral roads. Each technique has got its inherent merits and demerits. Most methods need modification in infrastructure. Some methods were able to detect vehicular density accurately than others. The major techniques include use of RF-Id tags, Wireless Sensor Networks (WSN), Vehicular Ad-hoc Networks (VANET), Infrared systems, Bluetooth, Zigbee, Multi-Agent Systems, Cameras, Global Positioning Systems (GPS) and use of Mobile Signals including 2G, 3G and LBS systems.

## 2. SURVEY OF DIFFERENT TECHNIQUES

### 2.1 RFID

Radio frequency (RFID) tags are used to detect traffic and this information is passed through wireless or wired means to a distant control centre. These tags are implemented on both sides of the road so that vehicles which pass through their communication range will be detected and this information is passed to the control server. Other methods using RFID tags include tags which are connected near to the number plate of vehicles so that when these vehicles cross the tags attached on road, the traffic count is taken which is shown in Fig.1. A system using RFID and GSM modem is being proposed in [1]. They propose to design a system that will detect the traffic congestion in real time using RFID tags, and subsequently manage it efficiently to ensure smooth traffic flow with the use of RFID devices itself. This system uses low cost RFID tags to detect vehicles at junctions as well as GSM modem to transmit traffic information. There will be two sets of tags at each road from/ to the junction.

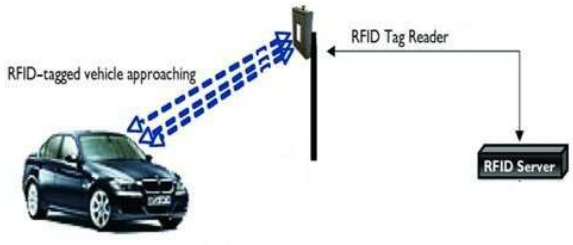


**Fig-1:** Identifying vehicle with RFID [25]

In [2], it is presented a comprehensive system called Traffic Monitor to detect, monitor and measure congestion over a given stretch of lane. The system will use roadside signals from active RFID tags attached to the vehicle which is used as traffic probe. The advantage of this system is it is economical, but to a larger extent, this system is not effective due to the fact that it can detect traffic only at the junctions and also implementing it along longer and wide road network will be involving more infrastructural expenses and the detected traffic is sent via the GSM modem which is less reliable during bad weather. The immediate advantage of using RFID is it is economical, but considering the maximum range of these tags (10m), such systems cannot be used on highways.

## 2.2 Camera & Image Processing

Camera and image processing techniques are used to predict the number of vehicles crossing the junction at a particular instant of time.

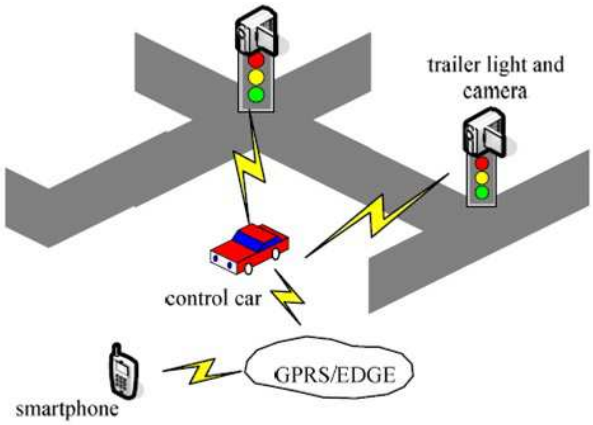


**Fig-2:** Using camera for traffic detection [3]

These systems involve complex image processing software and also cameras need to be implemented at regular intervals along the road length. Implementing cameras along road network is not a cost effective solution for traffic detection. In [3], digital image processing is used. It proposes a traffic control system which uses camera imaging along with conventional traffic routing techniques. The working of the system is such a way that the camera will capture images of vehicles and these images will be used for image processing and this value will be used to calculate traffic load at a particular junction at a particular time as shown in Fig.2. The traffic load is transferred to a server through GSM modem. The advantage of this system is accuracy. Since a camera captures images always, the accuracy will be better as compared to other systems. However the system efficiency reduces during rainy season, in foggy weather due to reduced visibility.

## 2.3 Wireless Sensor Networks (WSN)

Wireless Sensor Networks (WSN) is an efficient technique to detect traffic and remote control management. These systems detect traffic using their dedicated sensor network which includes wireless nodes at sides of roads and this information is passed to central server at the control centre as shown in Fig.3. The major advantage of using wireless sensor networks is that they have their own dedicated network for detection of traffic and transfer of information. So availability of traffic information will be fast as compared to other networks. However, implementing and maintaining such networks would involve considerable amount of efforts and cost. These sensors can communicate through Bluetooth, IR sensors or Zigbee by respective protocols according to network design.

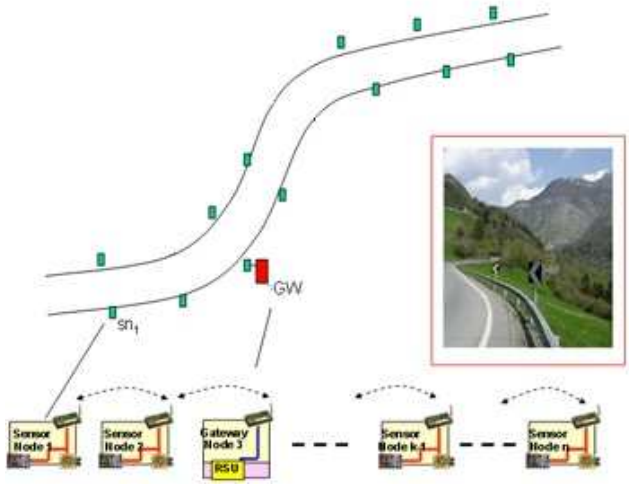


**Fig-3:** Placing sensors in traffic detection using WSN [26]

In [4], it is proposed a traffic management system which uses WSN to detect traffic information on roads. The system consists of two parts: WSN and a control box running control algorithms. The WSN, which consists of a group of traffic sensor nodes (TSNs), is designed to provide the traffic information. This system can detect traffic information using the help of wireless sensor nodes and then control the traffic using algorithms based on traffic load. The advantage of this project is that the acquisition and transmission of traffic

information is very fast due to the sensor network. Since it requires detailed infrastructure at long distances, there is a limitation of deploying this project for traffic management on a large scale.

### 2.4 Multi-Agent Systems (MAS)

Multi-Agent System (MAS) implies a system which uses different devices to capture information and transmit messages. These agents may be either hardware, software or a hybrid of both. MAS contain different types of communication protocols and sensors such as Infrared sensors, Bluetooth, Zigbee, and RFID devices. The advantage of using such devices is that there will not be any frequency clash with each other which makes the communication interference free. A level of hierarchy is maintained in such systems. As in the case of wireless sensor networks, these systems also have their own dedicated network. Use of multiple agents to detect and control traffic is being described in [5]. This project proposes a layer wise architecture for different set of agents. Each intersection in a road network is controlled by an agent whose actions is either chosen autonomously or through other superior agent and is shown in Fig.4. The main objective of such a distributed multi-agent system is to achieve a coordinated signal control to ensure a lesser level of network congestion.

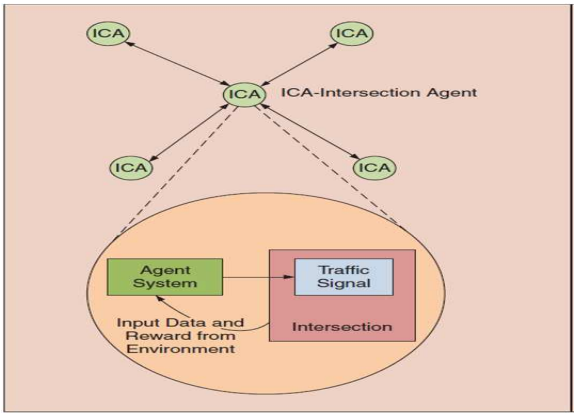


**Fig-4:** MAS as in [5]

The topmost layers will control the overall working of all layers. The agents can be different wireless communication protocols depending on the range of communication and power required to operate them. Since a number of devices are required in this system, the system is not cost efficient and frequent system disruptions can take place.

### 2.5 Vehicular Ad-hoc Networks (VANET)

Using VANET for road traffic detection and control is one of the methods in traffic control. VANET technology involves vehicle to vehicle (V2V) communications and roadside sensors. VANET systems can support any network which is 3G and above compatible as mobiles meant for 3G and above usage have have built in software for detecting traffic information. However, these phones should be within close proximity to each other not more than 100m. As VANET have its own network, there is less amount of congestion as information passage is intelligently controlled and the vehicles already have preloaded software to detect road information and traffic information is transmitted to the network. Working of VANET for traffic management is shown in Fig. 5.

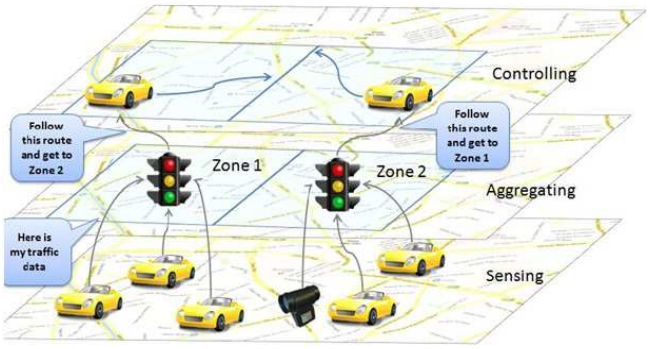


**Fig-5:** Traffic detection and routing using VANET as in [6]

In [6] the authors propose a system for traffic control in large cities. A traffic model is constructed using data collected by sensors along the road and inside the cars. This system averages data from all cars and road sensors into a real-time traffic model. The aggregated data is further sent back towards cars, which in turn can dynamically adjust their travelling routes. An advantage of this is that cars become data sources, and can help better collection of traffic data providing the driver information about possible congestions and enabling him to choose the route. Implementation of this system is cost prohibitive as infrastructure need to be provided all along the road networks.

### 2.6 Mobile Signals-GSM, UMTS

Use of mobile signals is a major breakthrough in road traffic management due to its availability everywhere being ubiquitous. One of the major drawbacks in using mobile signals is that most of the studies have been done in detecting mobiles when they are on active mode. Presently, there are large no. of mobiles which are in idle mode and that information is not picked up. Hence, there is a considerable amount of error in vehicular density prediction. Some researchers have used handover management techniques to find the position of a mobile. The major works in detection of vehicles using mobile signals are connected with double and single handover which is illustrated in Fig.6. In [7] it has been studied to use double-handover (DHO) data to monitor highway traffic conditions. However, handover data is not sufficient to predict the traffic congestion accurately because of signal strength variations due to terrain topography and

fading. At times highways may come under one large cell for long distances, so use of double handover may not be much feasible as most users will not be undergoing a second handover during the journey through the whole area of interest. However, network related data are to be obtained from operators and as such dynamic prediction become an issue.

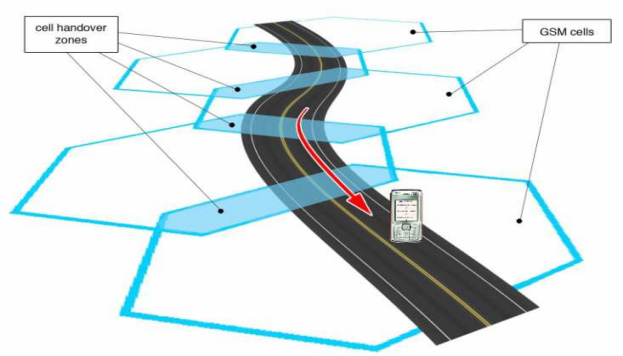


**Fig-6:** Illustration of mobile phone movement [27]

A study in [8] presents the case study based in the metropolitan area of Milan, Italy. With the help of data from base stations, town planners can monitor rapidly changing urban dynamics, which are difficult to capture by traditional surveys. The technique presented here uses cell phone signals in active mode. The resolution according to them is of a few hundred meters. However, they have not accounted for the MSs in idle mode. In [9], the authors use cell phone signals for finding real-time road traffic information. They propose a unified framework that incorporates GSM and GPRS data collection and UMTS, which uses active and idle mode signals from mobile phones.

### 2.7 Global Positioning System (GPS)

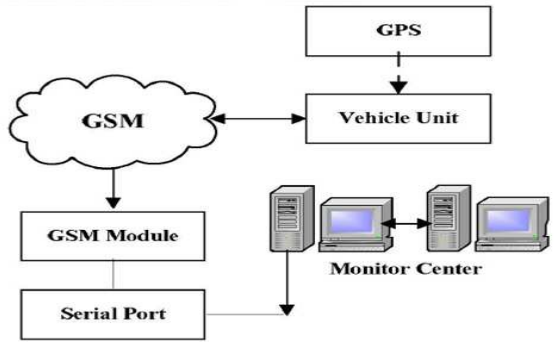


**Fig-7:** Traffic detection system using GPS as in [10]

Global Positioning System (GPS) is also used to detect traffic. GPS is used along with GSM and other technologies as a hybrid system. As the GPS systems are not universally available in all phones and restricted to smartphones only and accurate signal collection will be difficult. Considering the modern automobiles and their speed, GPS processing is likely to bring in delays.

In [10], it is given a system which combines GSM, GPS and other positioning technologies. They propose to implement infrastructure inside vehicles making the vehicles as probes for traffic detection while they are on the move. These vehicles will acquire their position with the help of GPS technology and send this position related data to a traffic monitoring and control centre and is depicted in Fig.7. As it is a hybrid system involving GSM and GPS, the system is not cost effective for implementation.

## 3. IMPLEMENTED TECHNOLOGIES

There are few systems to detect and control traffic which have been implemented in few countries. Most of these systems use hybrid technology for traffic management. The CAPITAL (Cellular APplied to ITS Tracking And Location) [11] project in USA focus on positioning vehicles with cellular phones to measure traffic conditions (speed and incidence detection). The system detects only active mode signaling. STRIP (System for TRaffic Information and Positioning) [12], a subproject of SERTI (Southern European Road Telematic Implementations), manages the traffic from Germany, Switzerland, France, and Spain into Italy during holiday season. The purpose of this project is to find road traffic by collecting and processing the GSM signaling on the Abis/A interfaces. OPTIS [13] project in Sweden, the goal was in developing a method of collecting traffic data in order to create traffic information on road. Vehicles send GPS position to a server via GSM/SMS or GPRS. The server processes this data and estimates road conditions. Cellint Trafficsense project [14] measures traffic data by monitoring the cell phone transmissions. The system is connected to cellular networks and monitors the control channel to obtain traffic information from signaling during active mode. Estimotion CFVDTM-CFVD (Cellular Floating Vehicle Data) [15], developed by Israel, is a system for measuring and predicting real time road traffic information based on mobile phone transmissions .
There are many factors to be considered while considering use of wireless signals for road traffic management. The main factor will be obtaining accurate data in respect of network traffic involving mobiles on active and idle mode. The second factor will be issues connected with data monitoring, collection and database management. The third factor needs the data collection and its cost effectiveness. All the systems discussed earlier have merits and demerits and there is not a single system which is effective in predicting traffic density in a real sense.

## 4. PROPOSED SOLUTION

From the above mentioned studies, it is evident that wireless signals can be used cost effectively in finding out the density of the vehicles along highways and lateral roads. Amongst all

the technologies given above, it is to be noted that use of mobile signals for vehicle traffic detection is cost effective. Although acquiring mobile signals has got its own advantages and disadvantages, it is the most cost efficient way to detect traffic as mobile signals are ubiquitous. As a solution for traffic detection, we can use active mode and idle mode signals effectively for detecting the presence of a mobile and thereby convert the number of mobile phones into number of vehicles.

There is coverage for a mobile phone almost everywhere where there is a BTS. So, even if the vehicle is moving, the mobile phone/phones which are inside it will be attached to the nearest and strongest BTS for paging and call purposes. For mobile network coverage purposes, most of the highways and other roads come under BTS range according to the design. Thus we can gather information about mobile phones which are particularly belonging to cell sites covering the desired road spaces.

### 4.1 Explanation of Proposed Solution

Due to present restrictions in using mobile phones while driving, most of the mobile phones will be in idle mode while on move. The presence of a mobile phone in idle mode can be identified when there is a location update procedure, i.e. while the mobile moves from one location area to another. A mobile phone in traffic mode can be used to detect position in two cases. The first case will be when the mobile will be undergoing a handover procedure. The other case will be when the mobile phone does two different calls in two adjacent cells. In both these cases, the Customer Details Record (CDR) is used to identify movement and position of the mobile phone. From the CDR data, we can identify the present BTS to which the mobile is presently attached. The CDR data and the location update count are acquired from the mobile service providers. We need to tap the MSC of the service provider to obtain the CDR data and the location update data as shown in Fig 8.

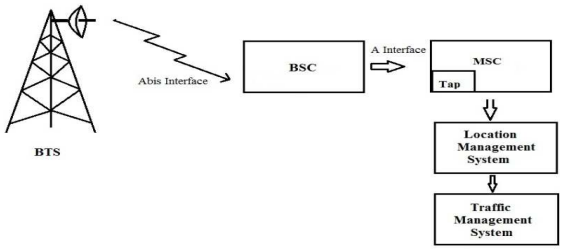


**Fig-8:** Illustration of the proposed solution

In a Location Management system, we convert the number of mobile phones into number of vehicles using equations given in [16]. Then we accumulate the data taken from all network providers in a single Traffic Management System which translates the number of mobile phones into number of vehicles. Thus we get the traffic density at a particular junction, highway or any other road of interest. After getting the traffic density, appropriate traffic management algorithms can be used to control the traffic efficiently. The highlighted techniques in traffic control are using genetic algorithms, ant algorithms, neural networks, fuzzy algorithms and other adaptive techniques [17] according to the traffic conditions of the area.

The advantage of using mobile phones for the purpose of vehicular traffic detection and also in traffic management is that mobile signals are available almost every place of interest. Also, using mobile signals is cost effective as compared to other technologies discussed in previous sections of this paper.

## 5. CONCLUSIONS

In this survey report, efforts were made to carry out a comparative study of different systems and technologies being used for using wireless signals for traffic management. Most of these systems operate in near real-time to detect traffic conditions. However, the selection of appropriate technology is a major factor dictated by the road conditions, network availability and cost. Implementing wireless network systems for traffic control would be a breakthrough for present and future traffic management. To sum up, using mobile signals for the purpose of traffic detection can be regarded as a superior solution comparing to RFID, Wireless Sensor Networks, VANETs, Infrared sensors, Bluetooth, Zigbee, GPS, Camera, Multi-agent systems etc.

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