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A Composite Remote Sensing and Monitoring Method for Effective Traffic Management

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Abstract: One of the major goals of developing countries is to build smart cities to avoid different kinds of congestions, accidents and many kinds of inordinate delays. The most important consideration is intelligent traffic management system. Many sub-systems are required which include visualisation, bio sensing, image processing, remote sensing, messaging, cognition and a communication system that caters for communication among several sub-systems of traffic management. Out of all these systems, remote sensing and monitoring plays a vital for effective wide area based traffic monitoring and control system. The type of sensing to be used for identifying an object which is met with an accident differs. Sometimes combinations of gadgets are to be used for implementing comprehensive remote sensing and monitoring system. In this paper a composite method is presented which considers all aspects related to communicating with remote objects that have been met with an accident and many other parameters that deal with monitoring and controlling the traffic at remote locations.

Key words: Smart city, traffic management system, eventful routes, accidents, monitorin

INTRODUCTION

An intelligent traffic management system can be conceived through many individual sub-systems which include bio-sensing, imaging, messaging, cognitive, visualization, remote sensing and communication systems. Each of the sub-systems is expected to work independently and also in unison along with other sub-systems. Smart cities is a name that is connected with a huge outlook change of enthusiasm toward proposing and utilizing different imaginative innovations to make urban communities "more brilliant" keeping in mind the end goal to enhance the general population's personal satisfaction. Traffic Management is the association, course of action, direction and control of both stationary and moving traffic, including people on foot, cyclists and a wide range of vehicles. Traffic on the roads is to ensure safety and smooth flow of traffic with no loss of time considering the necessities of road users. A wide range of requirements exists that include alluring levels of security, availability, enhancement and ecological quality in the traffic regions. Traffic at any point in a route is affectedby volume, organization and rate of the traffic either all through the road system or in combination with other types of traffic systems.

Traffic on remoteroutes is one of the main reasons for traffic jamming in local traffic routes and therefore the remote routes have to be screened in fixed time internals and necessary controls are to be exercised when any of the accidents occurs. The data related to local and remote traffic is collected and sent to the vehicle owners giving the information related to traffic congestion, accidents, time duration for clearing the traffic etc. Even the traffic data is sent to the police and traffic managers in case of accidents so that vehicles that met with an accident can be rescued.

Monitoring remote traffic requires use of various technologies which include GSM, CDMA, TDMA, SOS transmission, multiple beam laser radars, rotating camera, RF transmitters and receivers, RFID tags, image processing systems, SOS transmission system, multiple beam laser radar system, camera and image processing system, RF transmitters and receivers, RFID tags etc. The remote monitoring traffic management system helps to avoid the blockage of long stretched traffic routes when an accident occurred at remote areas. Knowledge about the traffic volume, congestions and accidents in the long stretched remote routes is required to mitigate the traffic congestions and carry rescue operations and help the vehicle owners to re-route their commuting through those routes where the flow of the traffic is smooth and clear. If rerouting is not done, the vehicles may be diverted to those eventful roads and get struck which results in blockage of long stretched roads. It will take much time and effort to clear these blocked areas.

One of the most important issues related to traffic management system is the implementation of a composite system that deals with three essential segmentations

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which include Local signal post system, local earth station and a remotely situated monitoring and controlling system. Communication in between these systems is needed for managing the traffic both local and remote routes most effectively and efficiently. Identification of exact location of an object which met with an accident is one of the most important issues that must be considered when it comes to remote monitoring systems. Remote monitoring system should be able to find alternate routes of travel at least one kilometre behind the object, so that if any congestion along one route occurs, the user can take the alternate route and can save his time. Communication with visual display systems and message signal post is very important to provide the alternate routes of travel. Remote monitoring system should be able spot the telephone systems which are in the vicinity of the accident areas so that vehicle drivers can use the telephone services in the emergency situations.

Communicating with mobile phones in the vicinity is important to transfer data related to events on the road, alternate routes etc., efficiently to the vehicle users. There is a need to develop a remote monitoring system which can identify the exact location of an accident and can communicate through local signal post system, local earth station and remote earth station and be able to find alternate routes of travel at least one kilometre behind the object. With the coming of advancements, it has been observed that utilizing wireless signals with the end goal of vehicular traffic management is the savviest procedure as wireless signals are accessible over all landscapes and it is omnipresent. As the road space is not extending in accordance with the development of vehicles, traffic clog will undoubtedly increase all the time. The best way to keep away from vehicular congestion is to have a directed traffic development arrangement in a real time premise. Amid the most recent decade, various techniques were developed to get real time information on vehicle developments, for example, utilizing RFID, wireless sensor networks and mobile technologies, infrared signs, cameras and so forth. Most innovations have not been turned out to be successful to address the issues related to remote monitoring of road traffic because of implementation difficulties, data inaccuracies, difficulty in real time application and expenses. This is bringing about genuine security worries in traffic management in light of the colossal development in the quantity of vehicles and the non-accessibility of viable traffic management system.

A comparative study of all such technologies is required considering every aspect of remote monitoring and controlling and to find the most suitable system that provides a basis for implementing remote monitoring and controlling of traffic in a cognizant way. A composite system of communication which deals with most of the communication methods are also required which caters for length and size of the communication that must be effected.

Literature review: Nishizawa *et al.* (1997) proposed a multiple-beam laser radar system which gives a more wide distinguishing area of object identification, yet has small proximity troubles. It has been shown how two multiple-narrow beam laser radars were used to get a smooth movement of an object in its wide range area.An object represents a real life entity. Vijayendra and Srinivasa (2010) provided a system for monitoring and locating objects using Radio Frequency (RF) transmitters and receivers and updating the location of objects using mobile phones. RF transmitters and receivers are tagged to objects and their respective toll gates. A mobile phone is used to locate an object, the details of which are encapsulated into a message and sent to the target. Abid Khanand Ravi Mishra attempted to design a tracking and controlling system that uses a GPS to determine the precise location of an object, person or any other asset to which a TAG is attached and using GSM modem this information can be transmitted to a remote user. A real time control over the vehicle by tracking it using GPS and controlling it using GSM mode has been presented. Singh *et al.* (2012) stated that traffic management is the critical issue of the roadways all around the nation. They have presented a systemthat provides quality of service to emergency vehicles like ambulance and improves the accuracy of holding the vehicles, violating the traffic rules as well as helps to trace out the stolen vehicles using RFID tags.

Kantawong and Phanprasit (2012) has proposed an intelligent RFID traffic system for vehicle accident detection and identification which avoids problems that arise with vehicle accident. It provides an efficient time management scheme with correct data reporting in which a dynamic time schedule is worked out in real time for the driver or passengers of each accident situations by Rashed *et al.* (2013) proposed a GPS based tracking system which keeps track of the location of a vehicle and its speed based on a mobile phone text messaging system. If any of the parameters are changed, i.e., the vehicle is moved or the vehicle accelerates over certain speed, the owner is alerted using a message. As wireless signals are available across all terrains and it is omnipresent, it is most cost effective process used for the purpose of vehicular traffic management. Mathew and Xavier (2014) stated that only way to avoid vehicular congestion is to have a regulated traffic movement plan in a real time basis. They have presented a comparative study of

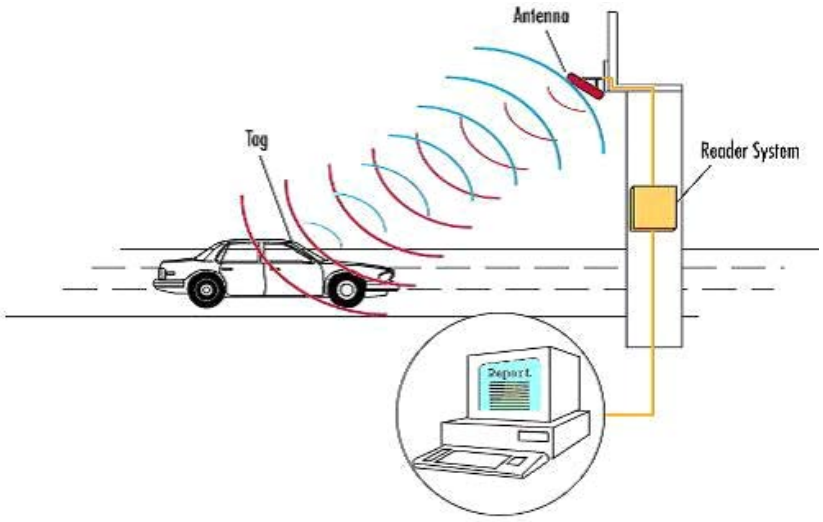

Fig. 1: Electronic toll system

existing methods for detecting vehicular traffic density by using wireless signals. Djahel *et al.* (2015) have presented open challenges that must be met for developing future smart city and proposed a solution to develop strong and cognizant traffic management systems. They have presented a survey of latest technologies which can be used in different parts of traffic management systems. Simaria and Pipalia (2015) presented an implementation of real time detection and tracking of an unknown object in video stream with 360° (azimuth) rotating camera. They have also presented adaption of different object tracking algorithms and their effect on implementation.The algorithms presented by them can be used to detect the object and later trackit.

MATERIALS AND METHODS

An overview of existing remote traffic management related tehcnologies: Radio-Frequency Identification (RFID) is the core technology of many sensors known as transponders. Thetransponders 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. An Electronic Toll gathering (ETC) system which comprises of:a transponder on the vehicle, a label reader radio wire at every court toll path, path controllers that control the path hardware and track vehicles going through, a host PC system as shown in Fig. 1. The majority of the toll court controllers are associated to a central database. When a vehicle goes to the toll corner at a speed, the label reader identifies the transponder and records it's unique ID, the time moment and other record related data. The RFID based sensors are less expensive but considering the maximum range of these tags (10 m) such systems cannot be used on highways. To a larger extent, this sort of a system is not effective due to the fact that it can detect traffic only at the junctions

Cameras and an image processing system are utilized to predict the quantity of vehicles crossing the intersection at a specific moment of time. These frameworks include complex image processing programming and cameras should be run at standard interims along the street length as shown in Fig. 2. Actualizing cameras along street system is not a financially savvy answer for traffic density detection. A traffic control system utilizes camera based imaging alongside customary traffic steering systems. The traffic control system involves the use of cameras for capturing images of the vehicles and the images are processed and used for finding the traffic load at specific intersections and time. The benefit of this system is precision. Since a camera catches pictures dependably, the precision will be better as contrasted with different systems. However the effectiveness of the framework decreases amid stormy season, in foggy climate because of diminished visibility. Global Positioning System (GPS) is additionally used to detecting traffic. GPS is utilized alongside GSM and different innovations as a hybrid system. As the GPS systems are not generally accessible in all telephones and limited to cell phones, precise sign gathering will be troublesome. Considering the modern cars and their velocity, GPS handling is likely to get delays.

Figure 3 shows a system which joins GSM, GPS and other situating advances. These GPS systems are embedded inside vehicles making the vehicles as probes for traffic discovery while they are moving. These vehicles will get their position with the assistance of GPS

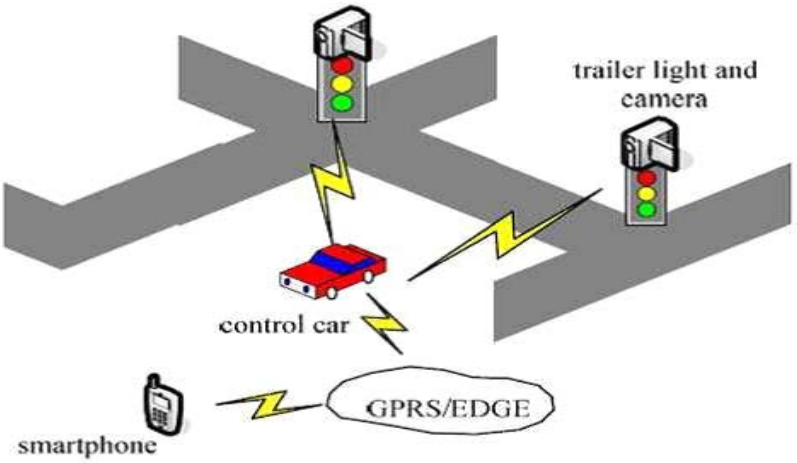

Fig. 2: Cameras and image processing

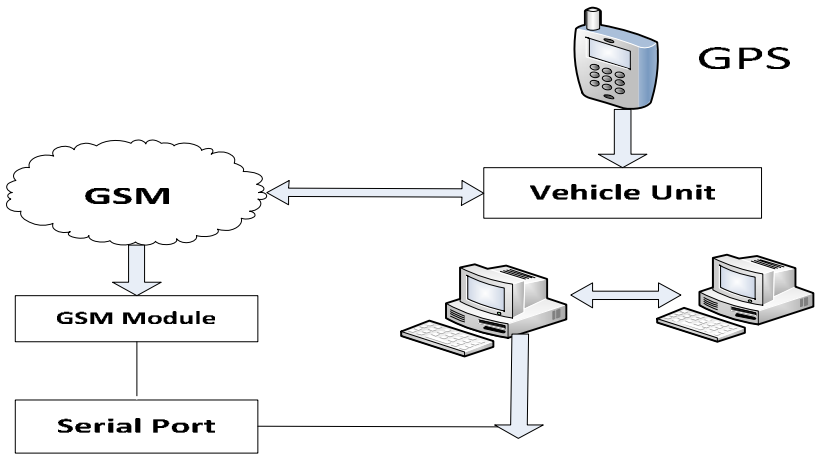

Fig. 3: The GPS system

innovation and send this position related information to a traffic checking and control centre as delineated and presented in Fig. 3. As it is a mixture system including GSM and GPS, the system is most certainly not practical and economical for usage A typical laser radar is used for distinguishing vehicles on parkways has an exceptionally restricted shaft that constrains its capacity to recognize any targets outside its available zone. Multiple-beam laser radar gives a more extensive wider target coverage area as shown in Fig. 4, yet, at the same time experiences short proximity issues. Two multiple-narrow beam laser radar units can be extended to produce a smooth traffic monitoring coverage over a relatively wide frontal area.

A mechanical structure is typically required to reorient the sensor shaft to get multi-directional data since it is hard to produce multiple beams effortlessly gotten from laser radar (lidar) by utilizing optical refraction. The lidar's greatest shortcoming is its vulnerability to dirt aggregation on the surface of the sensor. Thus, lidar is still a suitable decision to use as a traffic checking sensor. Lidar sensors distinguish the taillight reflector of a vehicle. Sensing advances can be achievedthrough transmitters, receivers and a mobile handset that connects to a remote mobile network. Widearea communication empowers the coordination of information from numerous transmitters and support applications with backend administrations, for example, information storage. This system is viably utilized in the area of vital things that are labelled and their area can be questioned by different clients. Utilizing remarkable properties of mobile telephones and the cellular network, one can show a system that observes and finds the objects through use of mobile telephones.

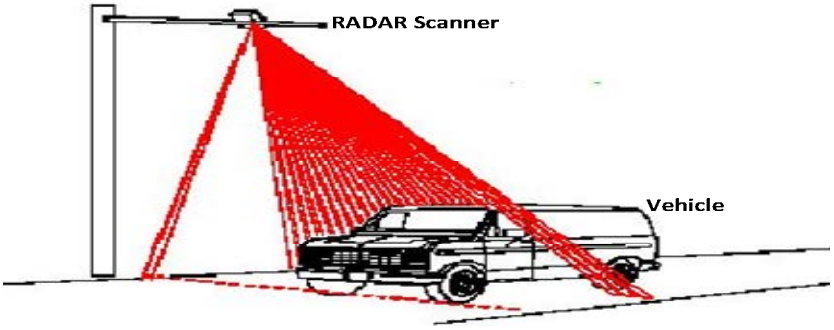

Fig. 4: Lidar system

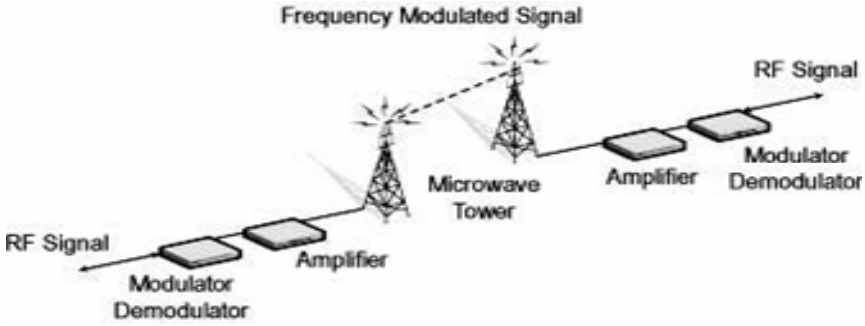

Fig. 5: RF transmitters and receiver

The objects that are tagged with the hardware which are the transmitters in the nearby are detected by the corresponding receivers and the location are queried using a mobile phone by means of a GSM modem. The dual technique employed is: object sensing using the RF transmitters and receivers, user interface provided by the mobile phone aid for sensing and querying the personal items simultaneously. Clear picture of this was given in Fig. 5. It has constraints regarding same frequency working, high performance with high power consumption which makes the researchers to take a step backward to use this technology. A system near to reality is always the best opted all over the world. A black box is a perfect form from hub of such ideas. It is about the size of two decks of playing cards, side-by-side and is installed unobtrusively in the car's cabin or under the hood as shown in Fig. 6. Except for a power connection, the black box isn't attached to any of the car's systems. Inside, the box has enough memory to store the last 10 or 20 sec of driving data. A global-positioning-system device tracks vehicle location and can interpolate speed, acceleration and deceleration by calculating changes in location over time. The unit's brain is a microprocessor that decides when an accident has happened and then sends a distress signal over a standard cellular link.

The box can send more than just a cry for help. Its signal can be packed with helpful data, such as the vehicle's exact longitude and latitude. So if the car was hit on the highway and skidded into oncoming traffic, emergency responders can adjust in advance or it can relay an estimate of the crash's intensity, based on the computer's measurement of how fast the car decelerated or changed direction, so responders will know in advance if an ambulance may be necessary.

RESULTS AND DISCUSSION

Effective communication systems for remote monitoring the controlling of vehicular traffic: Many sub-systems are to be used for effecting an integrated traffic management systems that includes the issue of remote monitoring and controlling. The most essential among them include the signal post system, the base station (Local HOST) and a remote HOST at which most of the traffic related data is stored and the same is used for monitoring and controlling the traffic. There should be effective communication systems that facilities communication among devices, local and remote host. The communication system must be fault tolerant which means that many alternate paths of communication should exists. Failure of one path should not lead to failure of the entire traffic management systems. Figure 7 shows different ways of communication between Local host systems and a remote host. The flow of data across the local and remote host systems can be understood from Fig. 7.

Fig. 6: Black box systems in car

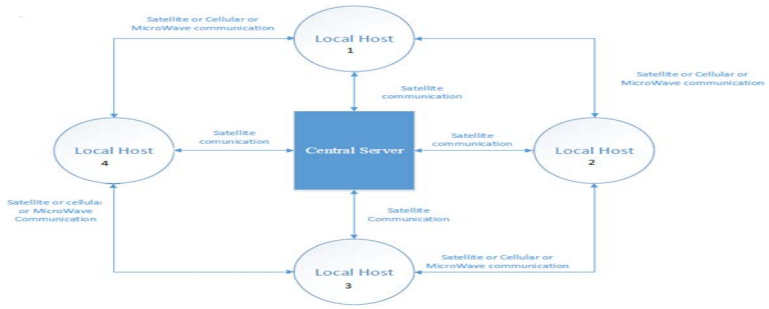

Fig. 7: Communication between the local host systems and the remote host

The hosts and the centralized server are separated by long distance from each other necessitating the use of satellite communication. The hosts are separated from each other at short distance compared to centralized server; therefore, the communication medium chosen between them is satellite communication or cellular communication or Microwave communication. All the local hosts and the centralized server are interconnected with each other. The local hosts communicate with the centralized server using satellite communication and the local hosts communicate with each other using satellite or cellular or microwave communication. If there is data to be sent from local host to centralized server, the data is transmitted using satellite communication. But if there is a problem in satellite communication the data will not be locked near the local host, as the entire host and the centralized server are interconnected, the data from local host to centralized server is sent from any one of the local host. Similarly, if the data is to be sent from centralized server to local host after data processing, the communication follows the same procedure (i.e.,) if there is any problem with the satellite communication, the data is sent in alternate methods through the local hosts. Similarly if the data is to be sent from one local host to other local host and if the straight routeis problematic, alternate route is chosen through other local hoststo be able to reach the target local host. The transfer of data through centralized server is not appreciated because the centralized server is located at a far distance from local hosts but if there is no alternate route the data must be passed form central sever as it must not be locked near the transmitting host.

Communication between the vehicle that meet with an accident at remote locations generally for way from either the Local or remote host is needed to spot out the accident location and take corrective measures to rescue the vehicle and regulate the follow of traffic. Figure 8 shows various means of achieving communication between a remotely situated vehicle and various communicating elements that were made part of traffic management system. Whenever accidents takes place at remote locations, the information of which must be sent to the remote server as fast as possible so that corrective actions can be taken. The information related to the accident is received using wired or cellular communication to the local host and through satellite or microwave communication to the central server. If the distance between the remote location and local host is short compared to the distance between remote location and central server, the message is sent to the local host nearby and then transmitted to the central server. The information passes through the shortest route possible,

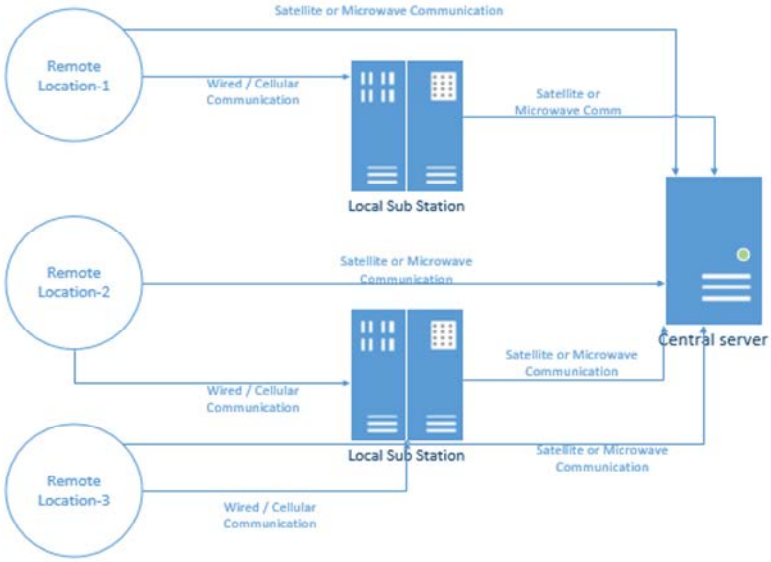

Fig. 8: Communication system for effecting communication between the remote vehicles, local and remote stations

(i.e.,) if the distance between the remote location and the central server is short compared to the distance between remote location and local host, then there is no point in sending information to the central server through the local host, the message can be directly transmitted to central server using satellite communication.

We have devices for various functionalities separately in today's world but in future generation, integrated systems are more valued at the same time more sophisticated too. The remote traffic management system must implement various features that include density check, accident identification, traffic diversion through proper actuation, traffic saturation, location of the objects, vehicle tracking and sending SOS messages. The density of traffic at different strategic points is required to regulate the traffic in alternate paths. Saturation limit could be one of the basis for regulating the traffic. Once the saturation limit is crossed, it either diverts traffic to alternate routes or sends messages to the hosts. This model features the GPS tracking, finding the location of the vehicle and giving the density notifications about the road traffic. This information is travelled over either long distances or short distances, based on the mode of communication that should be used for effecting the communication either through a satellite communication, cellular communication, etc. The most concerned issue all over the globe is road mishaps which can be controlled using accident prone detection using new technology. This model shows immediate notification about accidents, thus diverting the traffic from blocked area to alternate routes and immediately helps the accident victims with hospitalization nearby. We need to finally find appropriate devices to execute all this functionaries in real time.

Comparative analysis of existing remote monitoring and controlling systems: The comparison of various existing remote monitoring systems is shown in Table 1 and 2 which show the mapping between the existing systems and remote monitoring and controlling requirements. From the above comparison and analysis, it is clear that technologies like GPS, RADAR and Black Box are satisfying the application based specifications. While each of these systems meets specific requirements of the application, there is a necessity to integrate them and use the integrated solution in the scope and ambit of traffic management system.

Composite and comprehensive remote traffic monitoring and controlling system: Now days we have multi tasker integrator circuits as we are racing in the world of innovation, The cognizant remote area traffic monitoring system should also have all the features embedded in it. Figure 9 shows a new architecture that has all the components in it to meet with all the functional requirements. As per above comparisons, it could be said that the "black box for cars or vehicles" technology can meet maximum featuresof an application system. Even though it requires its supporting systems, the main area of interest is to save accident victims and reduce the accident cases all over is satisfied by a composite model. Usage of black box in the vehicles has its own advantages and disadvantages. The disadvantages of ablack box are

Table 1: Comparing remote monitoring systems

	Remote monitoring systems				
Technology	RFID	Camera and Image processing	Global Positioning System (GPS)	Multiple-beam laser radar	RF transmitters and receivers
Power consumption	High (for UHF)	16 Watts (approx.)	High	Medium	Low
Size	In mm or cm	High	In cm	Very high	In cm
Range	Up to 100 m	Up to 500 mts	From any position	Hundreds of kilometres	Up to 2 km
Cost	Passive: 1-3$Active: 15-20$	High	100$ (approx.)	Very high	Low cost
Efficiency	Low	High	High	Very high	Low compared to GPS
Reliability	Less	High	High compared to RFID	High	High
Application (to which part)	On any external part of car	On road sides	In the car	At toll gates	Can placed any where
Storage	2 kb	Depends on capacity of memory card	Depends on capacity of memory card	High storage capacity	High storage capacity
Programming	Possible can use JAVA	Algorithms	PossibleCan use python or java	None	Possible can use java
Hardware	RFID tags and readers	Cameras	GPS kit	Radar systems	RF chips
Reusability	Yes	Yes	Yes	Yes	Yes
Weight	25 g (approx.)	215 g (approx.)	More weight	Very high	10 g
Visibility	Yes	Yes	no	No	No
Speed	40 kbps	250 frames per second	Based on distance	Based on distance	22.5 kbps
Life time of the device	About 10 year (approx.)	Durable with respect to usage	All time	About 5 year (approx.)	About 3 year (approx.)

Table 2: Comparing of remote monitoring systems in relation to application requirements

	Remote monitoring systems					
Application requirement	RFID	GPS	RF transmission and Reception	RADAR	Camera and image processing	Black box
Identification of exact location of the object which met with an accident	No	Yes	No	Yes	Yes	Yes
Exactness with which the object is identified	Yes	No	No	Yes	Yes	No
Ability to communicate through local signal post system, local earth station and remote earth station	No	Yes	Yes	No	No	Yes
Ability to find alternate routes of travel at least 1 km behind the object	No	Yes	Yes	Yes	No	No
Ability to communicate with visual display systems, message signal post, giving details about routes, alternate direction etc	No	No	Yes	Yes	No	Yes
Ability to communicate with service providers who attends to the accident management	No	Yes	Yes	No	No	Yes
Ability to spot and display telephone systems	No	Yes	No	Yes	No	No

covered up by using supporting systems like RADAR, GPS etc. Black box is very useful in accident detection when there is a deadly accident and nothing is left over. The black box being a rigid body radiates some signals (SOS) to claim that there is an accident. These gives longitude and latitude of the place. When opened, the black box gives vital information about crucial 20 sec 2 mins of time before the accident took place, to know the real reason behind the accident happened at the location. These black boxes can withstand high temperature desirably happening at accident locations. The other points like message sending, density of traffic, count of traffic are furtherly divided as submodules using different technologies. It is common scenario in metropolitan cities to occur traffic jams, collisions, accidents and moreover density of traffic is increasing day-by-day. The proposed block diagram shown below gives us a complete view of traffic management in remote locations as well as in city scenario using best of the various technologies. In the model shown in Fig. 9, various technologies have been chosen and integrated so that composite system can perform different works. The GPS module inside the car helps us providing the location of the vehicle along with the feature of tracking it. It also provides the density ratio on the route to the central system through satellite communication. The most reliable technology of black box has its appropriate application inside the vehicle for detection of accident along with its location even after a complete crash.

Black box sends signals to nearest available transmitter to give alert signals and also records last few incidents of the accident area. It provides an efficient way to solve major accident cases with ease. It is evenpossible to divert the traffic from that area in an alternate route to avoid any congestion further. All the devices that include black box and the supporting systems are integrated into

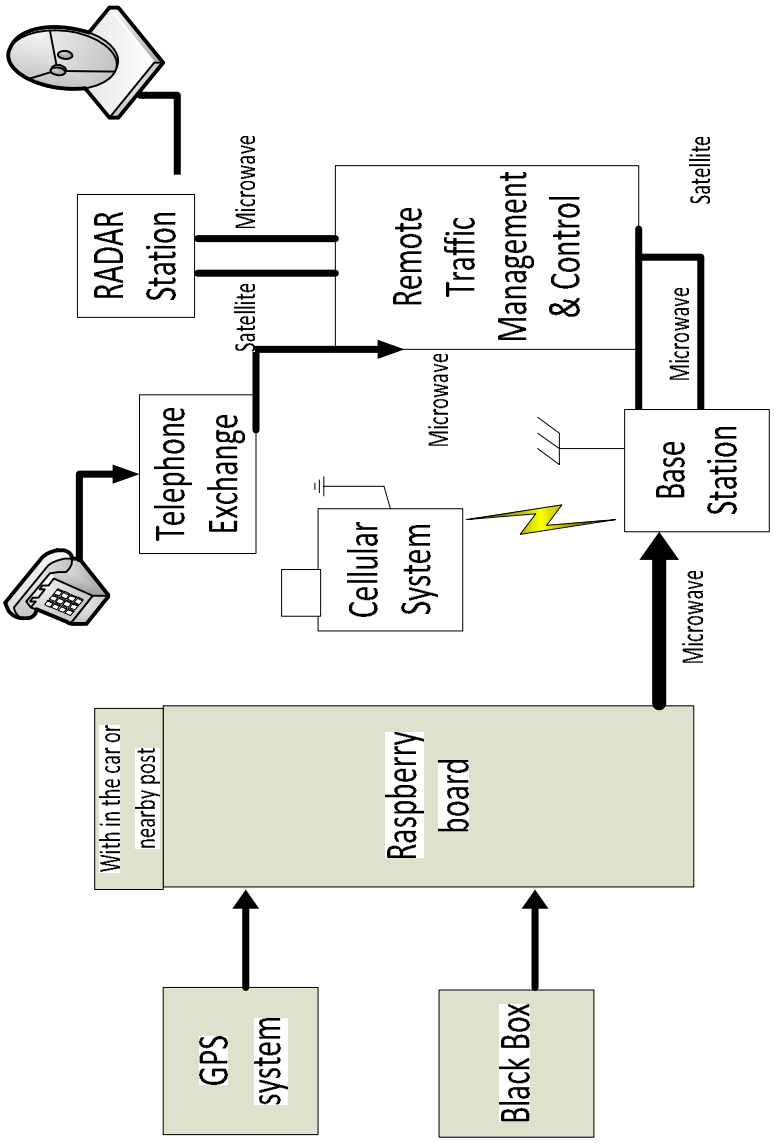

Fig. 9: The composite remote traffic monitoring and controlling system

Raspberry Board, into which GPS and Black Box are embedded over it. All the communication interfaces required to communicate with signal post, base station and the remote server systems are integrated into the board.

Apart from this,the RADAR system has been used to identify various objects and monitor accident prone areas regularly. It provides information regarding the traffic around 1km radius of its radiation region, such that the host receives the information about its current location and the host's next destination to be reached in a convenient way. These signals are fed to remote traffic monitoring and control block via satellite or microwave communication. These signals are further processed and then sent to base station. Use of a telephone network all along the highway or lateral road has also been integrated into the system. This network helps in providing the required aid at required time along with answering the queries of the travellers. The whole information from base station is transmitted and received using cellular transmitters and receivers playing a vital role in long distance communication using wireless network with low loss of data, high reliability and efficiency. Thus, this proposed model covers best of the features which a remote monitoring traffic management system can have and efficiently execute it.

CONCLUSION

The study and comparison of various systems reveal that a composite and comprehensive system is needed for achieving effective remote traffic monitoring and control system. Alternative means of communication is necessary and the same is to be effected considering different kinds of communication technologies and different communicating stations which are distantly located.The addition of black box system for vehicles to monitor the remote locations and respective traffic management can be enhanced as a superior solution along with RADARs, Cellular networks, GPS, additional sensors, etc. The implementation of traffic network system for remote monitoring of traffic would work wonders for present and future traffic management.

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