SMART TRANSPORTATION SYSTEMS AND TECHNOLOGIES

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ABSTRACT

Transportation has become a significant factor in the rapidly growing urbanisation and traffic congestion of every city in the world. Smart Transportation System (STS) is the critical enabling technology in which various transport mechanisms and technologies are cooperated to enhance the quality of life by reducing fuel and electricity usage, decreasing congestion, and decreasing travel time. STS establishes a broader range, fully efficient, real-time and accurate information management system and it has been proposed as an innovative solution for the next-generation transport networks in developed cities to provide effective, low cost and energy-efficient transport services. The objective of this study is to present modern transportation technologies are being developed and implemented in STS such as Sensing technologies, Wireless communication, Computational technologies with examples of systems which are implemented using above technologies in many industries of developed cities in order to provide an efficient transportation system for people of the city.

Keywords: variable message signs, global positioning system, on-board units, light detection and ranging, radio detection and ranging

1. INTRODUCTION

The main considerations that need to be paid for when developing a smart city are multimodal Smart Transportation System (STS), public safety, electric vehicle infrastructure, e-services, environment-friendly design buildings, emergency and disaster management, smart houses and so on. STS is one aspect of the smart city and an integral part to roadway safeness and home environment security in developed cities of the world which uses modern technologies to provide intelligent response to the need of the city and includes not only smart transportation as well as smart environment, smart economy, smart people, smart living, smart government. Because of low efficiency of the Transportation System Management, the transportation has become the second largest factor of carbon emissions which affect the environment. Therefore integration and features of modern technologies is very important to be add on existing STS to improve the efficiency of transportation of the city. Technologies which are used in smart transportation of cities, mainly focus on reduce the above problems, improved connectivity of transportation, support to city governance and meaningful benefits to citizens.

Therefore, Smart Transportations Technologies (STT) apply for advanced techniques such as electronics, computers, communications, control and sensing and tracking at transportation system. STT provide a promise to

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improve roadway congestion level, well-structured transport infrastructure, lead to develop and improve safety of transportation, efficient usage of resources and traffic network flow in the cities and also reduce the disappointments and stress of driving over the heavy traffic jam could be reduced as well as the occurrence of an accident can be completely eliminated.

1.1. Background

Recent developments in Transportation Systems and Technologies have made our daily tasks easier. However, STS is a new application for our cultural transportation society when there have been difficult to describing STS and introducing it in our tradition. STS has been focused almost on improving efficient and effective paths of spilling concrete to construct and manage durable highways and roads. The necessary vouch of STS has produced a new mechanism for a surface transportation society and also is participating to enhance transport functions and underlying systems.

There were wider collection of applications and policies in transportation that have various paths of influencing energy usage and emissions of carbon dioxide, and thus cannot be designed between a common frameworks and examples. STT can help to reducing the emissions of carbon dioxide in several of ways and can decrease transportation energy sustain. Smart technologies have become cheaper and executable options. Solar power and wind power are good examples of green or renewable energy resources of smart technology which is helpful in reducing greenhouse emissions that have a negative impact on global warming. With the development of the information technology, big data is one of the technology which has a rather subversive progress following the cloud technology and internet technology of things, it can provide key technical support for the construction of Smart Transportation Systems.

STS Techniques are providing better communication with drivers and passengers on a busy cities between government's highways, well-travelled roads to build the exactness for the required traffic network processed data and the least-term traffic network future prediction. What interested me into doing my research on this were basically the benefits that people can be achieved using this systems and technologies of the modern transportation. This has become a major research area because it will help the people in many ways.

2. LITERATURE SURVEY

Lack of quality and safe public transportation, inadequate capacity of public transportation, road safety concerns, overcrowded road network, existing poor traffic management, parking issues, theft, poor road conditions, lack of modal options remain the key issues in most of the cities. Most cities lack the integrated transportation plans leading to poor transportation network. . Efficiency of smart cities largely depends upon the effectiveness of its transport systems, that is, people and goods are moved throughout the city. Poor transport systems restrain economic growth and development. Public transport systems in cities have not been able to keep pace with the rapid and substantial increases in demand over the past few years. STS can provide the solution for efficient traffic flow and improve reliability of public transportation network by providing visibility on arrivals, departures and route information for travelers for journey without any complications. STS needs to be implemented if public transport is to play a significant role in the life of a smart city. Measures need to be taken to enhance the quality as well as quantity of public transport services and to impose constraints on the use of private vehicles. Multi modal integration of sensors, wireless and computational systems can help citizens to use multiple modal innovative systems

3. METHODOLOGY

3.1 SMART TRANSPORTATION TECHNOLOGIES

Smart technology is key for the design, implementation and operation of smart cities. A different types of selected technologies used in smart cities are Sustainable Transportation, Communication Infrastructure, Global ICT Infrastructure, Social Network and CPS etc. STS technologies are changing in different applications from basic management systems such as traffic signal control systems, variable message signs, automatic number plate recognition or speed cameras to monitoring applications such as security CCTV systems to more enhanced applications that combine live data and feedback from other sources, such as parking guidance, information systems, weather information and bridge de-icing systems.

Technologies like Radio Frequency Identification (RFID), Bluetooth, Global positioning System (GPS) and image processing are used to measure vehicles counter, average velocities of vehicles and destination matrices among vehicles which are help to establish the possible behaviours of vehicles on the road. Additionally, predictive techniques are being

developed in order to allow advanced modelling and comparison with historical baseline data. Smart Communication Technology and ICT are including fibre optics to homes, citywide Wi-Fi, near-field communication (NFC), and Bluetooth. Citywide Wi-Fi can be used to basic services such as calling a taxi, easier. NFC remodels the way that credit cards are used. The day may come where we will have a cashless society. Social networks and short message services makes communications mechanisms as more efficient in smart cities. Technologies such as Wi-Fi and NFC can be considered as part of this trend. Also a network of secure digital cameras can be an effective solution for secure image or video communication in the smart transportation.

The main aspects of some innovative system technologies commonly can be implemented in Smart Transportation Systems under following classified sections.

Sensing Technology.

Wireless Technology.

Computational Technology.

1.1.1 Sensing Technology

a. Sensors

One of the main source for data generation are sensors. The sensor is a physical device that is able to sense and get a specific type of input such as light, heat, motion, pressure or noise from the physical layer. The input can be transformed to human-readable display at the sensor location or transmitted electronically through the network for future work. There are many different types of sensors for instance, acoustic and sound sensors (e.g. Microphone), automotive sensors (e.g. Speedometer), chemical sensors (e.g. PH sensor), electric and magnetic sensors (e.g. Metal detector), environmental sensors (e.g. Rain gauge), optical sensors (e.g. Wave front sensor), mechanical sensors (e.g. Strain gauge), thermal and temperature sensors (e.g. Calorimeter), proximity or presences sensor (e.g. Doppler radar), and so on. There are some important challenges for selecting and installing the appropriate sensors in a given context such as accuracy, environmental condition, range, calibration, resolution, cost and repeatability.

b. *Sensor Based Technologies in Transportation*

Technological advances in telecommunications and information technology coupled with state-of-the-art microchip, radio frequency identification (RFID) and inexpensive intelligent beacon sensing technologies have enhanced the technical capabilities that will help traveller safety benefits for STS globally. Sensing systems for STS are vehicle and infrastructure based networked systems. Infrastructure sensors are durable such as in-road reflectors devices that are installed or embedded on the road or surrounding the road (buildings, posts, and signs for example) as required and may be manually announce during precautionary road construction maintenance or by sensor injection machinery for rapid deployment of the embedded radio frequency powered in-ground road sensors. Vehicle-sensing systems include categorization of infrastructure-to-vehicle and vehicle-to-infrastructure electronic beacons for identification communications and may also provide benefits of CCTV automatic number plate recognition technology at required intervals in order to increase continues monitoring of suspect vehicles operation in critical zones.
Sensor devices are a promising technology for monitoring possible obstacles to traffic. Sensor networks can be considered as one of the building block in technologies of smart transportation.

c. *Roadway its Technology*

The roadway and vehicle infrastructure has to be installed to collect and communicate accurate and trustworthy information about traffic flow and road conditions for effective understanding of the STS services. The sensor, communication and traffic control the technologies which are included by the system. Vehicle detection technology is providing speed monitoring, traffic counting, presence detection, headway identification, vehicle classification and weight-in motion data collection. Following roadway infrastructure technologies are currently available.

a. In-roadway sensor technologies:

An in-roadway sensor is fixed in the path of the roadway or enclosed to the surface of the roadway. Followings are some examples of in-roadway sensors:

Pneumatic road tube sensor:

It sends an eruption of air pressure along a rubber tube while a vehicle's tires pass over the tube. The pressure pulses close electrical switch, which is detected by a counter. The road tube, installed perpendicular to traffic flow direction, is commonly used for short term traffic counting, traffic classification by axel count and spacing, for the purpose of planning and research studies [7]. The vehicle gaps, intersection stop delay, stop sign delay and saturation flow rate can be calculated by using the data gathered from the sensor.

Inductive loop detector (ILD):

The ILD is the most common sensor in traffic management applications which senses the existence of a conductive metal object by persuading current in the object. The vehicle passage, presence, count and occupancy are included in the data which is obtained from standard ILD.

Magnetic sensor:

These sensors are inactive devices which indicate the existence of a metallic object by detecting the perturbation created by the object in the Earth's magnetic field. Followings are two types of magnetic sensors used for traffic flow management.

Two- and three-axis fluxgate magnetometers.

These sensors identify stopped and moving vehicles which can be detect changes in the vertical and horizontal components of the Earth's magnetic field produced by a ferrous metal vehicle.

Induction or search coil magnetometer.

It normally finds moving vehicles by measuring the movements in the magnetic lines of flux which is caused by a moving ferrous metal vehicles.

b. Over-roadway sensor technologies:

These sensors are not directly being installed on the road surface which are attached over the centre of the roadway or to the side of the roadway. Followings are some examples of over-roadway sensors

Video image processor (VIP):

It usually includes one or more cameras, a microprocessor-based unit for digitizing and processing the imagery and software for interpreting the images and converting them into traffic flow data and also VIP can replace various in-roadway inductive loops which detect number of vehicles across several lanes, lower the maintenance costs and categorize vehicles by their length and report vehicle presence, flow rate and occupancy.

Microwave radar:

Radar stands for *ra*dio *d*etection *a*nd *r*anging, detects the object and measures the distance and speed by using radio waves in the microwave frequency spectrum (1 GHz to 30 GHz). The microwave radar sensors which are attached in the roadside, transmit radio waves on the direction of an area of the roadway from an overhead antenna. When a vehicle passes through the antenna beam, a portion of the transmitted energy is reflected back towards the antenna [7]. The receiver consists of detection system which can be calculated the data of vehicle such as volume, speed, occupancy, length, etc. Followings are two types of microwave radar sensors which are used in traffic management applications,

Continuous wave (CW) Doppler radar.

It can be used to detect moving vehicles and to determine their speed however they are not capable of detecting stationary objects.

Frequency modulated continuous wave (FMCW) radar.

It can be used to detect motionless objects.

Infrared sensors:

There are Active and Passive infrared (IR) sensors available for traffic monitoring applications.

Active infrared sensor:

The active infrared sensors are able to provide data on vehicle presence at traffic signals, volume, speed, length, and queue measurement and they are illuminating detection zones with low power infrared energy supplied by laser diodes operating

in near infrared spectrum at 0.85 µm. The energy reflected from passing vehicles is focused by an optical system onto an IR-sensitive receiver unit [7].

Passive infrared sensors:

They are able to measure vehicle counting, volume, lane occupancy detection and queue detection. Passive IR sensors are detecting the energy emitted from vehicles, road surfaces, objects in the field of view and from the atmosphere, however without transmitting energy of their own.

Ultrasonic sensors:

They transmit sound energy at frequencies above the human audible range between 25 KHz and 50 KHz. Most ultrasonic sensors performing their operations using pulse waveforms to calculate distance to the road surface and vehicles by detecting the arrival time of reflected waves coming towards the sensor from an area defined by the transmitter's beam width [7]. The Doppler principle which is more expensive than the pulse models used by ultrasonic sensors to measure speed.

d. RFID sensor technologies for optimization of transportation system

The RFID technology and variable message signs (VMS) can be used along to reduce the problems faced by commuters and transport operators. The RFID evidently is not a new technology and its origin dates back to World War II. It is a programmed identification technology that allows for non-contact reading of data, thereby making it attractive in vehicles. Currently most of the developed countries are making use of RFID in transportation area to ease traffic congestion and keeping track of the buses when they leave bus stations in order to ensure safety of the passengers and identification of the mechanical problems that might occur with the buses.

Practically, RFID cargo tags can be placed on all the buses, while the RFID readers can be put on the bus stops. This would allow bus operators to know which buses in relation to their own are with the integrated wireless local area network (WLAN) radios, resulting in smooth flow of traffic along the route. The commuters also would be informed the time of arriving at the certain stops of buses. If a bus

is behind schedule or on time or having mechanical problems could be confirmed as well by the VMS and the information technology personnel would know where a particular bus is at any given time. Transmit sound energy at frequencies above the human audible range between 25 KHz and 50 KHz. Most ultrasonic sensors performing their operations using pulse waveforms to calculate distance to the road surface and vehicles by detecting the arrival time of reflected waves coming towards the sensor from an area defined by the transmitter's beam width [7]. The Doppler principle which is more expensive than the pulse models used by ultrasonic sensors to measure speed.

1.1.2 Wireless Communications Technology

Many forms of wireless communications technologies have been implemented for STS. Short-range communications can be achieved using IEEE 802.11 protocols. Theoretically, the range of these protocols can be expanded using Mobile ad-hoc networks or Mesh networking. Longer range communications have been proposed using infrastructure networks such as WiMAX (IEEE 802.16), Global System for Mobile Communications (GSM) or 3G. Long-range communications using these methods are well authorized but unlike the short-range protocols, these methods require vast and very expensive infrastructure deployment.

a. Message Authentication in Driverless Cars using Vehicular Ad Hoc Network (VANET)

Driverless cars and driver-assisted vehicles are becoming common in STS. Modern vehicles which are equipped with sophisticated navigation devices, complex driver-assisted systems and a whole lot of safety features, bring large impacts to our quality of life. Instant safety messages such as pre-collision warnings, blind-spot detection are significantly improving the safety of drivers, passengers, and pedestrians. As a result, vehicles would be able to travel closely and safely together without resulting a traffic congestion and fuel consumption. Driverless cars also have non-safety-related applications which are used to improve traffic management.

Vehicular Ad hoc Network (VANET) is the wireless communication technology, enabling driverless cars features not only dynamic topology but also high mobility. Nowadays VANET technology is promising much. This type of network enables inter vehicular communication as well as communication between vehicles and different road side units (RUS).

VANETs could be given not only by autonomous but also by normal vehicles. A normal vehicle need only be furnished with an on board equipment that gives the necessary communication behaviors to make it a networked car. VANETs make able the interchanging of information among vehicles or between vehicles and RSU is enhancing the common driving experience. VANETs include of roadside infrastructures and vehicles that are furnished with wireless communication devices. A VANET is a dynamic collection of networked vehicles that communicate with each other and nearby RSUs are using a consecrated short-range communications technique. Wireless on-board units (OBUs) are fixed in these vehicles to execute the process of communication.

The rapid movements of vehicle nodes on highways also depend on but not limited to road traffic, speed limits, and movements of nearby vehicles. The massive amount of messages are exchanged among driverless cars. The command to the cars' movements at high speeds and in close distances can cause any spiteful alternation. It could be led to disastrous accidents.

Message authentication to ensure data integrity is overriding to attack preparation. A novel message authentication scheme protects cars from bogus messages and forms VANET resilient to Denial-of Service (DoS) attacks. Here a simulation framework is integrates vehicle and data traffic models to validate the effectiveness of the proposed message authentication scheme. In order to form a network, vehicle nodes must be within wireless communication range from each other. If a node moves beyond this limit of range, it will be forced to disconnect.

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1.1.3 Computational Technology

The recent advancement in vehicle electronics is consisting more capable computer processors on a vehicle. In early period, vehicle would have less than 100 individual networked microcontroller or programmable logic controller modules with no real-Time operating systems. However, the current trend is toward more costly microprocessor modules with hardware memory management and Real-Time operating systems which are the new securely surrounded systems allow for more advanced software applications to be implemented, including model based process control, artificial intelligence and universal computing.

a. *Implementation of Microcontrollers in Railway Automatic Traffic Control Systems*

The railway administrations are using unified microprocessor schemes and structural modules in the railway automatic devices in order to reduce the material consumption and operational costs. The systems which are implemented by railway administration, qualified based on the lack of electromagnetic relays and other electromagnetic units and permit introducing distance control, distance change and equipment diagnostics.

The microcontrollers can be used as structural modules of microprocessor receiving and transmitting devices and for protecting the signalling information systems in the electrified railway sections. There are ways of developing and implementing microcontrollers with the control on the decentralized units of the automatic traffic control. This system presents use of microcontrollers as part of an interlocking system for control on traffic lights, the serviceability of the railroad, counters of axles. This new innovative technology will increase the reliability of safety systems in railway transport. To increase the efficiency of operation and provide the traffic safety, modern railway transport employs automation of the train traffic control processes more and more widely. The microcontrollers are the main element of these systems.

2. DISCUSSION AND RESULTS

2.1 DISCUSSION

The “smartness” of a city describes its ability to bring together all its resources and to effectively operate with maximum possible efficiency to fulfill the purposes it has set for itself. For a city to prosper, all of the key systems technologies fall under,

Sensing Technology,

Wireless Technology,

Computational Technology

Which are need to work together by utilizing all of their resources to overcome the challenges the city faces. Smart cities with minimal implementation and operations cost are the keys for long-term sustainability. The need for smart technologies in smart cities is increasing day by day with the growth in population and as earthly resources become limited.

2.2 RESULTS

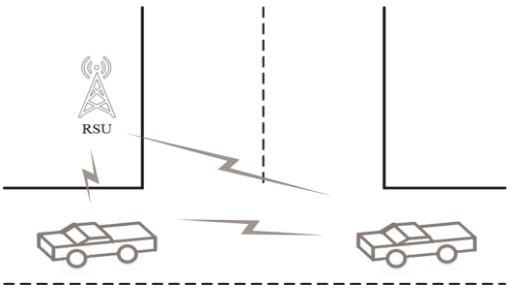

Fig. 1. Vehicular Ad hoc Network (VANET).

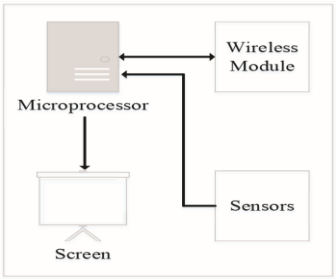

Fig. 2. On-Board Unit

Figure 1 shows a simple Vehicular Ad hoc Network including of one RSU and two vehicles each with its own OBU. VANETs could consist of dozens or even hundreds of vehicles and roadside units.

Figure 2 shows the high level components of a vehicle's OBU. OBU includes a microprocessor where the makes up of external sensors occurs. It deploys Light Detection and Ranging (LIDAR) as well as Radio Detection and Ranging (RADAR) for collision warning, blind spot detection, and proximity detection. RSU has components similar to OBU.

3. CONCLUSION

The analysed studies on Smart Transportation Systems and Technologies, advance Smart Transportation of many developed cities of the world and can present solution in aiding to ease traffic congestion and other modern transportation issues in present and future. The sensor technology, wireless communication technology, and the computational technology can be the suitable key enabling technologies which can be implemented by developing cities in STS development. The paper presents the different examples of those technologies. Further, this research will be continued by exploring implementation of new systems in STS, how it implemented with the use of new technologies, how it reduce the transportation issues and the major advantages and disadvantages of new technologies in STS.

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