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A Survey on Intelligent Transportation Systems

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Abstract: Transportation or transport sector is a legal source to take or carry things from one place to another. With the passage of time, transportation faces many issues like high accidents rate, traffic congestion, traffic & carbon emissions air pollution, etc. In some cases, transportation sector faced alleviating the brutality of crash related injuries in accident. Due to such complexity, researchers integrate virtual technologies with transportation which known as Intelligent Transport System. The idea of virtual technologies integration is a novel in transportation field and it plays a vital part to overcome the issues in global world. This paper tackles the great variety of Intelligent Transport System applications, technologies and its different areas. The objective of this literature review is to integrate and synthesize some areas and applications, technologies discuss with all prospects. Furthermore, this research focuses on a wide field named Intelligent Transport Systems, discussed its wide applications, used technologies and its usage in different areas respectively.

Key words: Intelligent transportation system · Transportation · Technologies · Applications · Transport management

INTRODUCTION

Intelligent Transportation system (ITS) takes a vital part in global world. Intelligent Transportation System (ITS) is the conventional of the development of next-generation technologies. It is a novel field that interoperates in different fields of transportation system, such as transportation management, control, infrastructure, operations, policies and control methods, etc. There is a wide range of reimbursement that obtained from ITS deployments. Intelligent Transportation System (ITS) can play a major role in reducing risks, high accidents rate, traffic congestion, carbon emissions, air pollution and on the other hand increasing safety and reliability, travel speeds, traffic flow and satisfied travelers for all modes.

A glance at the state of transportation system is totally change because of development in various areas and adopted the new technologies like computing hardware, positioning system, sensor technologies, telecommunication, data processing, Virtual operation and planning techniques. Intelligent Transportation System provides solutions for cooperation and reliable platform for transport. Major areas of ITS in Metropolitan deployments are Arterial and Freeway Management, Freight Management, Transit Management Systems (TMS), Incident and Emergency Management Systems, Regional Multimodal and Traveler Information Systems, Information Management (IM) Systems. Many applications in ITS sector are plays a significant role some of them are Electronic Toll Collection (ETC), Highway Data Collection (HDC) ,Traffic Management Systems (TMS), Vehicle Data Collection (VDC),Transit Signal Priority (TSP) ,Emergency Vehicle Preemption (EVP) etc. In these applications, different type of transmission works some applications works on long-distance transmission and some are works with short-distance communication and some systems works on Radio modem transmission for collection of computerized information for analyzing and reporting.

ITS is not limited for highway traffic, it is also provide services and implement in navigation system, air transport system, water transport system and rail systems. Day to day popularity of Intelligent Transportation System and

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Table 1: Generations of Intelligent Transportation System (ITS)[1]

	Generation	Period	Technology
1	First Generation (ITS1.0)	2000	One way infrastructure based
2	Second Generation (ITS2.0)	2000-2003	Two way communication technology
3	Third Generation (ITS3.0)	2004-2005	Automated vehicle operations and automated, interactive system operations and system management
4	ITS (ITS 4.0)	2006-2011	Multi-modal Incorporating personal mobile devices, vehicles, infrastructure and information networks for system operations as well as personal contextual mobility solutions

increasing the demands and development in transportation systems intelligent transportation system divided into generations. Table 1 shows the generation of Intelligent Transportation System with period.

Areas of Its: This literature review also includes a brief discussion of the following areas of ITS Metropolitan deployments:

- Arterial and Freeway Management Systems
- Freight Management Systems
- Transit Management Systems (TMS)
- Incident Management Systems
- Emergency Management Systems
- Regional Multimodal and Traveler Information Systems/ Information Management (IM)

Arterial and Freeway Management Systems: Traffic jamming becoming is more serious problem throughout the world. Many causes behind it like population, poor infrastructure and worse traffic system. To solve this problem, Arterial and freeway Management System used in many developed countries. The system install and use in South Nevada (RTS) for controlling and monitoring the Las Vegas transport [2]. Another example of this system is California freeway management system. In this system 2 Gb/day data processes in real time [3]. In these systems, millions of unprocessed data collect and store, the data have speed record, traffic flow, etc. The system works with the help of different emerging technologies and hardware like Variable message Sign (VMS), ramp meter, circuit television (CCTV) and traffic signal control system. Table 2 shows some new research and proposed solution in the field of Arterial and Freeway Management System.

Various studies have attempted the arterial and freeway system. Some of studies we discuss here. Freeway system provides the navigation services, traditionally freeway system use fixed sensor such as loop detectors and television cameras but there are many problems in these systems such as high cost, maintenance and limited coverage. In the recent years, mobile sensors and GPS (Global Positioning System), mobile phones are increasingly applied. The studies show the comparison of mobile-based sensors with GPS based sensor. The mobile-based sensors are more efficient due to ready-to-use infrastructure and the wide coverage [4]. Bluetooth traffic monitoring system suggested with the replacement of loop detectors and measures their accuracies [5]. Development in the field of arterial incident detection problem [6].

Freight Management Systems: Freight Management system is using for logistic and cargo shipments and delivery through transportation that includes sea, land, air, tug and barge and rail services. Freight Management System is significant factor towards the commencement and exploitation in policies of urban freight management. The development of Intelligent Transportation System the freight management system takes a turn with the help of technologies. Freight system raises the mobility and enhances customer value. The significant role of freight system is reducing congestion, pollution and noise, energy concerns. According to the research transportation sector is accountable of a significant amount of greenhouse gas emissions: 13% and 23% emissions of world and responsible of CO2 emissions from fossil fuel combustion (ITF 2007). The growth of Internet-based electronic business is also powerfully contributing to the transformation of the freight transportation industry, decision technologies, two-way communication, tracking devices, higher planning and operation decision-support systems and transportation cost, distribution cost and delivery time etc [7].

The Freight Management System classified into two wide classes Commercial Vehicle Operations (CVO) and advanced fleet management System (AFMS) [7]. Advanced systems designed for simplifying and automating freight transportation operations. Commercial Vehicle Operations are for safety information exchanges, electronic certificate management and wayside electronic screening. Advanced systems designed for simplifying and computerized freight and fleet management operations at the carrier or business-to-business level. Present transportation system is to reach a more timely operation, competent provision and consumption of the fleet.

Table 2: Summarized literature of Arterial and Freeway Management System

Author (s)	Title	Problem	Solution
GAO2013	Estimating freeway traffic measures from mobile phone location data.	High cost in Installation, Maintenance, Limited coverage problems in GPS based sensors.	Proposed a relatively simplistic clustering technique in mobile phone for vehicle count, density, speed
Hussein Dia,2011	Development and evaluation of arterial incident detection models using fusion of simulated probe vehicle and loop detector data	Performance of various data fusion neural network architectures and probe vehicle penetration rates and loop detector configurations	Automatic incident detection on arterial roads
Bachman 2012	Fusing a Bluetooth Traffic Monitoring System with Loop Detector Data for Improved Freeway Traffic Speed Estimation	Comparison loop detector data and compared against GPS collected probe vehicle data with Bluetooth Monitoring system	Improve the accuracy of traffic speed estimation
Bachman 2013	A comparative assessment of multi-sensor data fusion techniques for freeway traffic speed estimation using micro simulation modeling	Real-time traffic speed estimation	Seven multi-sensor data fusion-based estimation techniques are investigated

Table 3: Summarized literature of Freight Management System, Commercial Vehicle Operations (CVO) and advanced fleet management

Author(s)	Title	Problem	Solution
Poon, T.C.May 2009	A RFID case-based logistics resource management system for managing order-picking operations in warehouses	Difficult and lengthy process of Collecting the real time data with bar-code-based or manual-based	RFID technology for order-picking operations
Crainic, December 2009	Intelligent freight-transportation systems: Assessment and the contribution of operations research	Worse performance in Logistics and electronic business for operation and fleet management	Research-based decision-support software suggest for ultimate performance of Freight ITS.
John Zumerchik	Automated Transfer Management Systems and the Intermodal Performance of North American Freight Distribution	High embedded costs in freight transportation	Automated transfer management system (ATMS) at terminals and distribution centers
Jeffrey SMay 2011	Use of a video monitoring approach to reduce at-risk driving behaviors in commercial vehicle operations	Risk for a vehicle crash and/or serious injuries	Onboard safety monitoring (OBSM) system
K. Bouvard June 2011	Condition-based dynamic maintenance operations planning & grouping. Application to commercial heavy vehicles	Deficiency in Maintenance planning in commercial heavy vehicle	Static or Dynamic methods are used for efficiency
Miguel Andres Figliozzi, July 2010	The impacts of congestion on commercial vehicle tour characteristics and costs	Increased travel times and the uncertainty brought about by congestion impacts the efficiency of logistics operations.	Tour model
Lee, J.B.May 2013	Commercial vehicle pre-clearance programs: Current issues and recommendations for potential implementation	Inefficient weigh stations	Vehicle pre-clearance programs

Research examining the new technologies adds in the field of Freight Management System for its applications and operations. A new technology RFID (Radio Frequency Identity Chip) is use for order-picking operations and for tracking the logistics [8]. Different types of software use for betterment in Freight and commercial vehicle operations, several studies have shown many types of software such as Decision support software, automated transfer system, onboard safety monitoring and vehicle clearance program [7, 9-11].

Transit Management Systems (TMS): Transit Management System is providing accurate information about position and satisfaction safety and security of traveler. Transit Management System increases ridership, enhances operating efficiency, service reliability, response to service disruptions. The passenger or user may right to use the information at home, work, a transportation center, wayside stops, on board the vehicle, or through various technologies while traveling. This information has General information, maps,

Table 4: Summarized literature of Transit Management System,

Author (s)	Title	Problem	Solution
Yan, Y.March 2012	Bus transit travel time reliability evaluation based on automatic vehicle location data	Deficiency and instability of bus operations	Evaluation index system
Diab, E.I,March 2012	Understanding the impacts of a combination of service improvement strategies on bus running time and passenger's perception	Decreasing the regular route running time	Automatic vehicle location (AVL) and Automatic passenger count (APC) systems
Wu, H,2013	Evaluation methodology of bus rapid transit (BRT) operation	Infrastructure, transport capacity, service level, economic results, safety and emergency management, and energy saving & emission	Bus Rapid Transit (BRT)
Barbeau, S.JMarch 2012	Travel assistance device: utilizing global positioning system-enabled mobile phones to aid transit riders with special needs	Required improvement in real-time location-based services	Travel assistance device (TAD)

Schedule Information, Operational Information. In the case of a transit agency, the customers may obtain information about arrival/departure times. An example of Transit Management system is an Automatic Vehicle Location (AVL) technology gives the foundation for vehicle tracking. AVL provides information concerning the real-time position of a vehicle that used to check schedule devotion and provide travelers with information relating to the location of transit vehicles. In the US transit, ridership has been rising as tax-supported funds to cover its operating expense have been declining [6].

At the operational level, several studies have shown deficiency and instability in different operation of transit management system and proposed suggested programs. In Transit management sector various software like AVL (Automatic vehicle location), BRT (Bus Rapid Transit), TAD (Travel assistant device) works for betterment in location and transit time and for safety operations [12-14].

Incident Management Systems: Incident Management System is a very significant area in intelligent transportation system. It is constructive when different types of incidents happen, such as SARS epidemic, 2008 Sichuan earthquake, September 11 attack, these emergencies and in road accidents transportation play a major role. Fire vehicles and ambulances are track the safe passage to reach our destination is a main objective in these situations. According to World Health Organization data, injuries and accidents are a major public health issue in Europe and death rate is about 31 thousand per year 4. Over 1.2 million citizens die on the world roads, further WHO forecast the transportation injuries will go up to become the fifth foremost reason of death by 2030. [15]. Technological expansion in Incident management areas such as data gathering, storage, calculation and prototype recognition have enabled more efficient for incident information collection, processing and exploration [16].Incident management system have many sub systems such as roadway incident management, emergency response management, incident detection, traffic management.

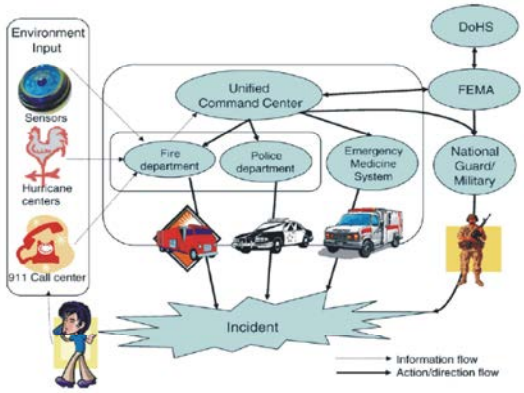

Fig 1: Information and Action flow of the CIMS System (KIM 2007)

Studies show the different models and systems proposed and evaluate for incident management system. The systems are CIMS (critical incident management system), CPs (cyber physical system), decision support systems and many programs for real time data collection and traffic management in incidents. Fig 1 shows the flow chart of CIMS system how its works and related with each other [17-20].

Table 5: Summarized literature of Incident Management System

Author (s)	Title	Problem	Solution
Jin Ki Kim November 2007	Efficiency of critical incident management systems: Instrument development and validation	A poor assessment of CIMS efficiency	CIMS efficiency model
Yaodong Wang November 2012	Perceptual control architecture for cyber-physical systems in traffic incident management	Problem of unified modeling for incompatible approaches of Cyber-Physical Systems (CPSs)	Perceptual Control Architecture of CPSs
S. Akhtar Ali ShahJune 2008	System architecture of a decision support system for freeway incident management in Republic of Korea	Inefficient freeway network in the post-incident scenario	FIAS - Freeway Incident Analysis System
Choi, E.H.C. March 2007	Multimodal user interface for traffic incident management in control room	Collection of critical data	Advanced MMUI systems for emergency management

Table 6: Summarized literature of Emergency Management System,

Author (s)	Title	Problem	Solution
James H. Lamberta January 2013	Understanding and managing disaster evacuation on a transportation network	Harmful performance of the region's transportation system	Analyze transportation system demand and system and its performance for emergency management
Eren Erman Ozguven April 2013	A secure and efficient inventory management system for disasters	Inefficient usage and distribution of emergency supplies	Multi-commodity stochastic humanitarian inventory management model (MC-SHIC)
S.W. Yoona, December 2008	Transportation security decision support system for emergency response: A training prototype	Challenging Task of decision making in emergencies	The emergency training prototype
Deng Chunlin 2012	Sample Average Approximation Method for Chance Constrained Stochastic Programming in Transportation Model of Emergency Management	Problem of the chance constrained stochastic programming	Optimal model for the transportation of emergency resource

Emergency Management Systems: The simple definition of Emergency Management System is "a discipline that deals with risk and risk avoidance" [21]. This system contract with natural hazards are those that be in the natural surroundings as a result of hydrological, meteorological, seismic, geological, volcanic, mass-movement or other natural processes and that pretense a danger to human populations and communities. The emergency management information systems (EMIS) provide the environment to monitor and computation the information and decision-support systems that make possible for decision making in crises for transportation system. In the emergencies, it is imperative to monitor the transportation system and services, supply, or transfer the human for safe destination is a priority.

Research shows the different models and analyzing techniques changed with the passage of time in emergency management system. Many inventory management systems were proposed such as MC-SHIC (Multi-commodity stochastic humanitarian inventory management model), prototypes and optimal models etc use for security, decision support and for efficiency [22-25].

Regional Multimodal and Traveler Information Systems/ Information Management (IM): Regional Multimodal and Traveler Information System is the central focal point for data collection of road and transit data. This system consist all types of freeways and arterials, road, transit and covering all areas like neighboring cities and countries. The system is improving the overall quality of real time data collection and information and accessibility for travelers. It is also use in trip planning, real time transit, schedules of transits and traffic, parking. In Regional Multimodal and Traveler Information System makes easy and beneficiary for travelers to get the information from single platform in real time mode [26]. Regional Multimodal and Traveler Information System work with the integration of wireless and web

Table 7: Summarized literature of Regional Multimodal and Traveler Information Systems/ Information Management system

Author (s)	Title	Problem	Solution
Natvig, M.K. December 2010	Flexible organization of multimodal travel information services	Inefficient and flexible establishment and provision of new and improved travel information services	Generic and multimodal ITS framework
Jianwei Zhang 2011	A multimodal transport network model for advanced traveler information systems	Delay time for data reading and compiling	Generic multimodal transport network model for ATIS applications
Zhong-Ren Peng September 1997	A methodology for design of a GIS-based automatic transit traveler information system	Inefficient system of trip planning for transit customers	GIS)-based automatic transit traveler information system (ATTIS)
Gerhard Schilka 2012	Use of ITS Technologies for Multimodal Transport Operations - River Information Services (RIS) Transport Logistics Services	Deficiency in transport planning and management processes	Next generation of multimodal transport management and information systems

Table 8: Vehicular Communication application and characteristics [35].

No	Application Name	Communication	Messaging Type	Message period	Latency	Other Requirements
1	Emergency Electronic Break Lights	Ad hoc V2V	Event-triggered, time-limited broadcast	100 ms	100 ms	Range:300 m, high priority
2	Intersection Collision Warning	Ad hoc, infrastructure V2V,V2I	Periodic permanent broadcast	100 ms	100 ms	Accurate positioning on a digital map, high priority
3	Intersection Collision warning	Ad hoc, infrastructure V2V,V2I	Event-Triggered time-limited Geo Cast	100 ms	100 ms	High priority
4	Hazardous Location warning	Ad hoc, infrastructure I2V.V2V	Event-Triggered time-limited Geo Cast	100 ms	100 ms	High priority
5	Traffic Signal Violation warning	Ad hoc, infrastructure I2V	Event-Triggered time-limited broadcast	100 ms	100 ms	Range:250 m, High priority
6	Pre-Crash Sensing	Ad hoc V2V	Periodic broadcast, unicast	100 ms	50 ms	Range: 50 m, high/mid priority for beaconing/unicast
7	Lane Change Warning	Ad hoc V2V	Periodic broadcast	100 ms	100 ms	Relative positioning accuracy: < 2 m; range :150 m
8	Cooperative forward collision warning	Ad Hoc V2V	Periodic, event-triggered broadcast, unicast	100 ms	100 ms	Relativepositioningaccuracy:<1m; range:150 m
9	Intersection Management	Infrastructure, ad hoc V2I,V2V	Periodic broadcast, unicast	1000 ms	500 ms	Positioning accuracy: < 5 m
10	Limited Access and Detour Warning	Infrastructure,I2V,other broadcast network	Periodic Broadcast	100 ms	500 ms	Mid/Low priority
11	Cooperative Adaptive cruise control	Ad hoc V2V	Unicast Broadcast	500 ms	100 m	Mid priority
12	Electronic Toll Collect	Infrastructure, ad hoc V2I, Cellular	Periodic broadcast,unicast	1000 ms	200 ms	CEN DSRC
13	Remote Diagnosis/ JIT Repair Warning	Infrastructure, ad hoc V2I,V2V, Cellular	Unicast, broadcast, event-triggered	N/A	500 ms	Internet access Service availability
14	Media Download	Infrastructure; cellular, other broadcast network	Unicast, broadcast, on -demand	N/A	500 ms	Internet access Digital rights management
15	Map Download/update	Infrastructure, ad hoc V2I,V2V, cellular, other broadcast network	Unicast, broadcast, on -demand	1000 ms	500 ms	Internet access Digital rights management Services availability
16	Ecological Drive assistance	Infrastructure, ad hoc V2I,V2V, cellular	Unicast, broadcast, on-demand	1000 ms	500 ms	Internet access service availability

technologies. The examples of this system is ENOSIS (Greek: Ἐνωσσις, meaning "union") in Greece, it is a pilot project and the results and performance of this system is cost effective [27].

Information Management or Management information system (MIS) in intelligent transportation system plays a vital role in the world [28]. The system works on current and previous information in appropriate period to assist the decision makers. It is also use for operational and strategic purposes. The definition of MIS is "an organizational method of providing past, present and projected information related to internal operations and external intelligence. It supports the planning, control and operation functions of an organization by furnishing uniform information in the proper time frame to assist the decision makers" [29]. Information Management System provides efficiency in transportation planning and design, modeling, analysis, management and prevents the delays problems. The example of the system is container freight transshipment at container centers, the system collect significant related data and process it for transshipment work of multimodal freight [30].

Development of regional multimodal and information management system is possible for adoption with different model for information systems. Different Technologies are working in travel information service and logistics, such as GIS (Geographical information system), sensors, etc [31-34].

Applications of ITS: Applications of Intelligent Transportation System use for transportation safety, efficiency and user services.

In table, we provide a list of applications used in different projects.

Intelligent Transportation have many applications but we discuss here some of them which studied over the period of 1999 and 2007.

- Electronic Toll Collection (ETC)
- Highway Data Collection (HDC)
- Traffic Management Systems (TMS)
- Vehicle Data Collection (VDC)
- Transit Signal Priority (TSP)
- Emergency Vehicle Preemption (EVP)

Electronic Toll Collection (ETC): Electronic toll collection is a one of the most popular application of intelligent transportation system, which eliminates the delay and enhances the mechanism of collecting toll electronically in transportation sector. Electronic Toll Collection concept such as safety of travelers, increasing the performance of toll stations, safe time of travelers and also help in environmental problems and fuel consumption.

ETS system classified as DSRC (dedicated short-range communication), in this system on board unit (OBU) in places in the vehicle and on other side, RSU (Roadside unit) installs on the road and they communicate with each other in the range of 30 meter. The systems works in ETC technology like MLFF (Multilane free flow), VPS (Vehicle positioning system) technology, based on positioning and mobile communication technologies [36].Electronic toll Collections applications move to standardize ETC protocols by the Intelligent Transportation Society of America, ERTICO and ITS Japan [37].

Highway Data Collection (HDC): Highway Data Collection technology provides acquisition of road traffic data in intelligent transportation system. Positioning and communication systems (GPS, GSM and GPRS) work with the help of sensors on the road network provide basic data to the traffic control center for the purpose of

Fig. 2: Electronic toll collection at Costanera Norte Freeway [18]

Fig. 3: Traffic Management System

calculating, analyzing and identifying traffic congestion, travel time [38]. Another major role of Highway Data Collection applications are collection of wind velocity data, inclement weather, complex terrain, from weather stations for reliable safety of vehicles [39].

Traffic Management Systems (TMS): Traffic Management System plays a central role in Transportation System, It increases the overall transportation efficiency such as flow, Improve safety, better mobility, economic productivity and crucial in environment for an ITS market. Traffic Management System collects the real-time information from different hardware components like cameras, speed sensors etc and flows into Transportation Management Center (TMC) where it is processed and analyzed. Traffic Management system is use in railway traffic, road traffic, air traffic Management [40].

Many systems exists in TMS:

- Event Management System (EMS)
- Traffic Control System (TCS) brochure
- Traveler Information System (TIS)
- Video Control System (VCS)

Vehicle Data Collection: Vehicle Data Collection Systems collects the data of vehicles related to the performance and quality of vehicles for analyzing, processing and remote monitoring. The system bases on vehicle gateway, server software framework, databases and web based interfaces. Application of the system provides support to the Military, Engineering, Ground durability testing, vehicle tracking and predictive maintenance. The example of this system is Georgia Tech Trip Data Collector (GT-TDC) in DRIVE Atlanta Laboratory (DriveLab) in Geogia.The system works on the second-by second vehicle record, position and speed through GPS [41].

Transit Signal Priority (TSP): Transit Signal Priority system makes transit services faster, reliable, cost effective and inexpensive. Main objective of the system includes efficient schedule adherence, travel time and traffic movement through controlling traffic signal intersections. The measured benefits records in different countries below in table

Emergency Vehicle Preemption: Emergency Vehicle Preemption System designed for emergency transportation movement for safe passage for lifesavings and scene stabilization. Emergency transportation like ambulances and fire fighters are required to reach in time and avoid congested traffic conditions [43].Emergency Vehicle Preemption reduces the crash rate, promote mutual aid strategies, minimizing response time and maximizing safety. This system works with the help of GPS technologies, infrared systems and radio communication to deliver safe, proficient results.

Technologies in Its: Firstly we look the summary of enabling technologies in Intelligent Transportation System after that we discuss the enabling technologies areas in ITS.

Intelligent Transportation System integrates current and growing communication technologies. Due to emergence of many technologies, the transportation system is able to improve transportation conditions, safety and services.

- Wireless communications
- Computational technologies
- Floating car data/floating cellular data
- Sensing technologies
- Inductive loop detection
- Video vehicle detection
- Bluetooth detection

Fig. 4: GT trip data collector and wires [22]

Fig. 5: TSP System in Boston, MA: Huntington Avenue

Fig. 6: Monrovia, California fire trucks equipped with emergency vehicle preemption and visual warning system.

Table 9: Measure benefit record [42].

S/No	Country/City	Benefits
1	USA, Washington	Decrease transit signal delay
2	TriMet, Portland, Oregon	10 % improvement in travel time 19% reduction in travel time variabilityReduce scheduled recovery time
3	Chicago	15% reduction Efficient run cutting
4	Los Angeles	25% reduction travel time

Wireless communications: The wireless communication has become an immense area. Wireless networks connect the devices, transmit the data through signals and use medium (radio wave, microwave) for transferring and sharing the data between nodes. Wireless communication have a various sub domains such as ad hoc networks, sensor networks, mesh networks, cellular networks,

Table 10: Enabling Technologies in ITS

No	Technologies	Systems
1	Communication	Wireless (Cellular or Wide Area)Wire line (Coaxial or Fiber Optic)
2	Data Storage and Processing	Compact Disc, Magnetic storage, Media Magnetic stripe cards, hard disks and data cartridges, smart cards.
3	Database Management Systems	Data Warehousing, Expert Systems,
4	Information Display	Cathode ray Tubes (CRTS), LCDs, Variable message sign.
5	Location	Dead reckoning, Map matching, GPS, Beacon based Vehicle Location
6	Sensors	Inductive Loops, Infrared Beams, Microwave (RADAR), LIDAR, Vision-based Sensors, Acoustic scanning Laser
7	Actuator	Gates and Displays

which are different in nature in terms of packet types, resources and infrastructure. We discuss some technologies of wireless communication.

Radio Modem Communications: Radio Modem Communication and modems are use to send data between two locations, typically the distance of modems 10-40 mile range. The frequencies of Radio modems are UHF (Ultra High Frequency) and VHF (Very High Frequency) frequencies. In this type of communication the information broadcast in traffic congestion and in emergencies via FM radio band, through the system warn drivers about weather changing etc [35].

Typically Radio Modem Communication Users Are:

- Fleet Management
- Automated Meter Reading (AMR)
- Telemetry Applications
- SCADA (supervisory control and data acquisition) Applications
- Land Survey

Short Range Communications: Intelligent Transportation Society of America and the US Department of Transportation promoted the standards of short-range communication, specifically WAVE (Wireless Access for Vehicular Environment) or the DSRC (Dedicated Short Range Communication) using IEEE 802.11 protocols, the range of IEEE 802.11 protocols extended using Mesh and ad-hoc networks. Dedicated Short Range Communication allocated 75MHz of spectrum at 5.9 GHz to be use entirely for Vehicle-to-Vehicle and infrastructure-to -vehicle communication. The goal of Dedicated Short Range Communication improves traffic flow and save lives [44]. DSRC communication protocol stack have many protocols and standard which are use in different layers, IEEE 802.11p work on PHY and MAC layer in WAVE (Wireless access for vehicular environment), IEEE 802.11 is Wi-Fi standard, 1609.4 for channel Switching, 1609.3 for Network Services, 1609.2 for security, Internet Protocol version 6 (IPv6), UDP and TCP, WAVE short message protocol VWSMP etc [45]. Dedicated Short Range Communication features are fast network acquisition, Low latency, high reliability, priority, interoperability, security and for privacy in transportation system [46]. Fig below illustrates the protocol stack in DSRC communication.

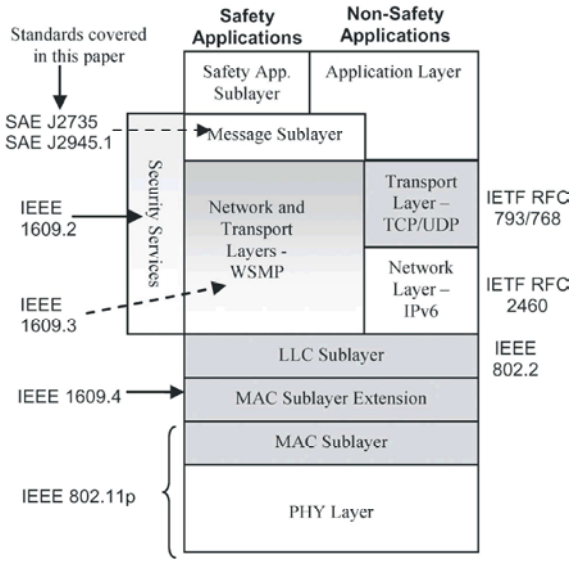

Fig. 7: Layered Architecture for DSRC Communication in USA [45]

Long Range Communications: Long Range Communication using different networks like WiMAX (Worldwide Interoperability for Microwave Access) (IEEE 802.16), 3 G, GSM (Global System for Mobile Communication) meant at providing wireless access over long distance [47]. The WiMAX (IEEE 802.16) comprises two sets of standards; 802.16-2004 (802.16d) fixed WiMAX and 802.16-2005 (802.16e) for mobile WiMAX. The WiMAX range up to 30 miles (50 kms) and data rate of up to 70 Mbps [48]. GSM (Global System for Mobile

Communication) and 3G (Third Generation) telecommunication networks use for long-range communication in transportation sector.

Computational Technologies: With the development of technologies, computational science is use in different fields. In intelligent transportation system the computational technologies provides a platform and development in architecture and software for real-time applications. This type of platform includes model-based process control, ubiquities computing and artificial intelligence [37]. Application of ITS has many real time operating systems, rich microprocessors, memories and hardware installed in vehicles.

Computation technology is making up with four parts, Quantitative, Operational, Languages, tools for automatic running [49]. Many algorithms and computational programs resolve different problems in transportation sector. With the help of computational technology, we have obtained the chance to understand and control difficult systems. Example of this system is Advance driver assistance System (ADAS) solve the safety problem in transportation [50].

Floating Car Data/Floating Cellular Data: Floating car data (FCD) in transportation system determines the transportation speed on the track. FCD works on various data types for instants speed, travel direction, time and localization data from mobile phones and the mobile acts as a sensor. Floating data or cellular data works on different networks like (CDMA, GPRS, UMTS, GSM). Flatting card data is an embedded system and data being collected through position of vehicles at constant time intervals [38]. The predicted data come from loop detector and automatic vehicle recognition further in some conditions data come from vehicle-based measurement [51].

Sensing Technologies: Sensing Technology in transportation system is an unprecedented technology. In a technology the embedded sensors works, wireless sensor nodes are normally low-cost and low power, data processing and wireless communication capabilities examples are microchip, RFID etc. The WSNs (Wireless sensor networks) have a large number of sensor nodes represent a significant efficiency over traditional sensors [52]. Sensor technologies designs for dissimilar scenarios in intelligent transportation systems applications for instants car communication with each other traffic condition monitoring. These applications run on real time; therefore, end-to-end delay and synchronization is critical for such systems [53]. In WSN the sensors or nodes, which are deployed for data gathering and one or more sink nodes connected through different long range connections i.e. satellite , WiFi, WiMAX, etc [54].

Sensor networks may exist in variant types such as seismic, thermal, infrared, acoustic, low sampling rate magnetic. These sensors are capable to monitor the different conditions like monitor the temperature, humidity, movement of vehicle, pressure, noise, speed, direction etc. A sensor node is consist main four components, Power Unit, transceiver, Sensing and processing unit. Sensor node has a additional unit for application called location finding system and a power generator, mobilizer. Further sensing unit is dividing into sensors and analog to digital converters (ADCs). The sensors are very small like a matchbox. Below table shows the functions of all components of sensor [55] .

Inductive Loop Detection: An inductive loop vehicle detector is a detection system, which uses the magnet to induce an electrical current in a wire. Inductive loops are use for communication and reception of signals like vehicle detector, vehicle passage, presence, count and occupancy. Inductive loop vehicle detection is still the most consistent and cost-effective technique of vehicle detection in today's traffic and parking applications.

The System Are Consist with Three Components:

- A loop
- Loop Extension Cable
- Detector

VSN240 vehicle sensor node is one example of inductive loop detection, the node measuring the earth's magnetic field [57].

Video Vehicle Detection: Video vehicle detection is a dominant form of detection in intelligent transportation system.

VVD system is popular method and changes the traditional loop detector system. The system components are video image acquisition, appropriate cabling, video image processing unit, vision-processing software. The features of this system are reduce costs for the data collection, better analysis, accuracy, useful information, enhance the driver ability, safety etc [58].

Table 11: Sensor components with functions

No	Components	Functions
1	Power Unit	It has a solar cells for power
2	ADC(Analog to Digital Converters)	It converts the analog signal into digital signal and fed into the processing unit
3	Processing Unit	It is a small storage unit, manage the procedures for collaborate with nodes
4	Transceiver	For Networking
5	Other sub units	Application dependent

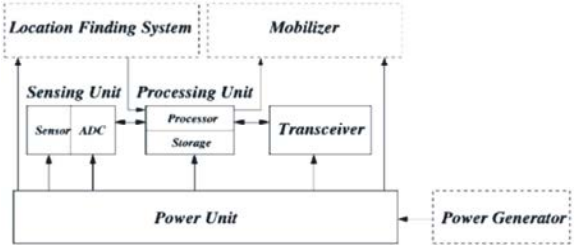

Fig. 8: Sensor Node with Components

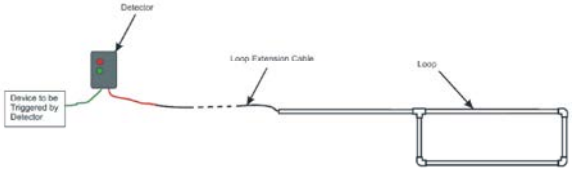

Fig. 9: (MARSH 2010)[56]

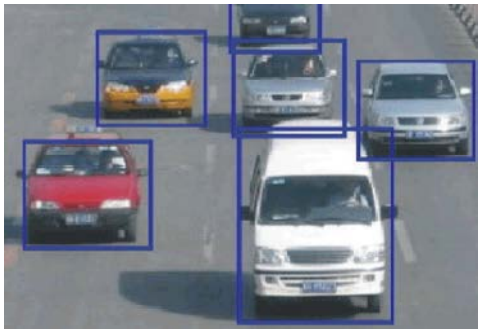

Fig. 10: Vehicle Detection through Video

Inductive Loop Detection: An inductive loop vehicle detector is a detection system, which uses the magnet to induce an electrical current in a wire. Inductive loops are use for communication and reception of signals like vehicle detector, vehicle passage, presence, count and occupancy. Inductive loop vehicle detection is still the most consistent and cost-effective technique of vehicle detection in today's traffic and parking applications.

The System Are Consist with Three Components:

- A loop
- Loop Extension Cable
- Detector

VSN240 vehicle sensor node is one example of inductive loop detection, the node measuring the earth's magnetic field [57].

Video Vehicle Detection: Video vehicle detection is a dominant form of detection in intelligent transportation system.

VVD system is popular method and changes the traditional loop detector system. The system components are video image acquisition, appropriate cabling, video image processing unit, vision-processing software. The features of this system are reduce costs for the data collection, better analysis, accuracy, useful information, enhance the driver ability, safety etc [58].

Bluetooth Detection: Bluetooth developed by Special Interests Group (SIG) for a short-range communication.

Now a day's most electronic gadgets use Bluetooth protocol for instant laptops, computers, headsets, cell phones etc. The Bluetooth technology in intelligent transportation system is use for capturing travel time, license plate recognition (ALPR) systems and different methods of data collection. The Bluetooth protocol itself broadcasting a 48-bit Media Access Control (MAC) address to gadgets within range [59].

Conclusion and Summary: The results of this literature review have shown that Intelligent Transportation System is a broad field which covers many technologies and they plays a significant role in the technology era. ITS deployments have the possible to offer the following benefits: improved safety, efficiency, mobility, accessibility, intermodal connections.

Through the Intelligent transportation system, many areas take advantages. The beneficiaries' areas are arterial, freeway, freight, transit, incident, emergency, data collection, toll collection, environmental issue, traveler information and archived information management. This paper presents a wide-ranging area of intelligent transportation system and its applications and range of technologies. This paper enables researchers to understanding of Intelligent Transportation system overview and provides researchers with information on ITS areas in which further study may be needed.

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