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A Survey on Role of Cyber Physical Systems in Transportation

S.Kavitha

Department of Computer Science & Engineering,Koneru Lakshmaiah Education Foundation

Green Fileds, Vaddeswaram, A.P. – 522302.

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ABSTRACT

Road accidents and congestion problems are leads worse in these days. Because of growing number of vehicles on, transportation sector is increasingly developed this leads to more accidents. The solutions to address these problems is smart Transportation solutions, which help to avoid traffic problems**.** There is a fast development in the domain of Vehicular Ad-hoc Networks (VANET). One of the major applications of VANET is Intelligent Transportation systems (ITS). The objective of intelligent ITS is to improve various transportation-related aspects, including travel reliability, environmental conservation, traffic resilience, and road safety. An intelligent transportation system (ITS) aims to optimize vehicle operations, manage traffic flow, and enhance driver safety.as well as supply convenient messages for passengers. Cyber-physical systems are proposed to improve the performance of a transportation system. This paper introduces a novel approach based on VANET which provide a basis for transportation processes and requirements for cyber-physical systems to support road transport systems. Moreover, this study primarily centers on Intelligent Transport Systems, exploring their extensive applications, the technologies they utilize, and their deployment across various domains.

Keywords-Intelligent transportation system, VANET's, Cyber Physical systems

1. INTRODUCTION

Intelligent Transportation System (ITS) as shown in figure 1.uses advanced technologies of electronics, communications, computers, control and sensing in order to improve transportation safety, efficiency through transmitting real-time information.

Objectives

1. To improve traffic safety
2. To relieve traffic congestion

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3. To improve transportation efficiency
4. To reduce air pollution
5. To increase the energy efficiency
6. To promote the development of related industries

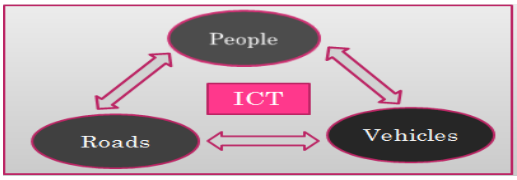

Figure 1: Intelligent Transportation System

The main motive to promote ITS is To Solve Problems on Road transportation. To activate the Economy, To reach an Advanced Information and Tele communication Society, To Co-ordinate different Transport Modes, To reduce Driver's run. The Significance of Promoting ITS is Breakthrough for Solving Road Transport Problems, Creation of New Industries, Leader of an Advanced Information and Telecommunications. VANET is a mainstream to design car-to-car interaction for information dissemination. Among research on traffic data dissemination in VANET, many have proposed on traffic safety driving information such as warning information, anti-collision control for driving vehicles. Few methods have designed on automatic generation and dynamic update of road network traffic information, mainly in terms of the automatic collection, diffusion, and dissemination of traffic information in a large-scale road network. Vehicular Ad Hoc Networks (VANETs) are a part of the mobile networks which establish a wireless interactions between vehicles and devices. These networks are particularly focus by the research in the field of networks because of their advantages. They designed applications that mainly concentrate on road safety and how to make roads more efficient for vehicles, offering comfort and entertainment to passengers to their journey. Vehicular Ad Hoc Networks (VANETs) are constructed by applying the rules of mobile ad hoc networks (MANETs) which are the dynamic creation of a wireless network for data exchange. They are a key component of intelligent transportation systems. VANETs support a wide range of applications from one hop to multi hop information dissemination. Rather than moving at random, vehicles tend to move in some streamline fashion. First, to collect the real-time traffic information, VANETs can provide the communication

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capabilities and real-time traffic information delivery. Both vehicle-to-vehicle and vehicle-to-roadside communications are supported in VANETs to efficiently collect/report traffic updates. As a result, the collected real-time traffic information can be used for traffic-flow management, vehicle path planning, and vehicle localization. Mostly proposed that the incorporated techniques have sufficiently small delivery delay for real-time information. As vehicular ad hoc networks rely on short-range communications, the transmission delay cannot be neglected. Therefore, it becomes compulsory to know how the transmission performance affects the performance of path planning. Cyber-physical system (CPS) having a physical system and its cyber systems that are tightly coupled at every levels. CPS is designed to improve the controllability, efficiency and reliability of a physical system, such as vehicle collision. It hasbecomeahottopic in R&D[7]. In fact, most of physical systems and cyber systems are developed to built and used by human beings in the practical and natural environments. In past several decades, 3Cs (computing, control, and communication) methods has been applied to physical systems, like defence, critical infrastructure, health care, manufacturing and transportation. A CPS consists a physical system and its cyber systems that are tightly coupled at all levels. Cyber systems are embedded in all types of physical systems, and are making the systems more intelligent, e.g., intelligent transportation systems (ITS), industries, and large cities. The CPSs are becoming more important in everyday life and their applications are growing continuously. The benefits of the CPS can be found in several areas: e.g., collision avoidance, robotic surgery and nano-level manufacturing, operation in en-dangerous environments, e.g., fire fighting, and deep-sea navigation, coordination, healthcare monitoring and delivery. To fulfill the demanding reliability and safety criteria of these systems, several GPS-based applications have been introduced. The advent of mobile internet has reshaped the architecture of transportation Cyber-Physical Systems (CPS). An example of such innovation is the development of the 'Mobile Millennium' traffic monitoring system, which gathers traffic data from GPS-equipped mobile phones to assess traffic conditions. However, a significant drawback of this approach is the considerable battery consumption, as it necessitates each mobile phone to have GPS functionality. Proposed information technology-based CPS architecture to improve road safety.

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2. Intelligent Transportation Technologies

(1) Wireless Communications: Dedicated Short-Range Communications (DSRC) enable communication between vehicles and specific roadside locations, such as toll plazas. Applications like Electronic Fee Collection (EFC) are designed to function seamlessly with DSRC technology.*Continuous Air interface Long and Medium range (CALM) :* CALM establishes continuous interaction with a vehicle,roadside devices using a different communication medias. CALM will offer a variety of applications, encompassing vehicle safety, information, and entertainment for both drivers and passengers

(2) Computational Technologies: Computational Transportation will advance technologies that involve sensors, travelers' computers, in-vehicle computing systems, and stationary infrastructure computers. The integration of operational systems and processors into transportation vehicles has also facilitated the installation of software applications and artificial intelligence systems.[4] These systems include internal control of model based processes, ubiquitous computing are integrated into a transportation system.

3) Car Data: Available Floating Car Data Detection Techniques are,

- Non Real-time:–
  - surveys.
  - Video recording
  - data recording
- Real-time:– Automatic Number Plate Recognition
  - GPS trace
  - Radio Signal .
  - Roadside beacon

(4) Sensing Technologies: Intelligent Transportation Systems employ sensing systems, which are networked and based on both vehicles and infrastructure, as depicted in the diagram below. For instance, smart vehicle technologies employ pavement loops to detect vehicle presence at intersections and parking lot entrances. Pressure pads are utilized to sense pedestrians to cross a road as a car passes over an inductive loop Much of this time is spent waiting at traffic signals. Many drivers have had the experience of waiting, waiting for a signal to change to green. Much of this waiting could be avoided if the traffic-signal control system could detect that a driver was present or if the system could accurately count number

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of vehicles were waiting for the signal. Many times, the traffic-signal controller is not aware of the vehicles waiting at the traffic light because the sensor, a simple loop of copper wire embedded in the pavement, has malfunctioned.

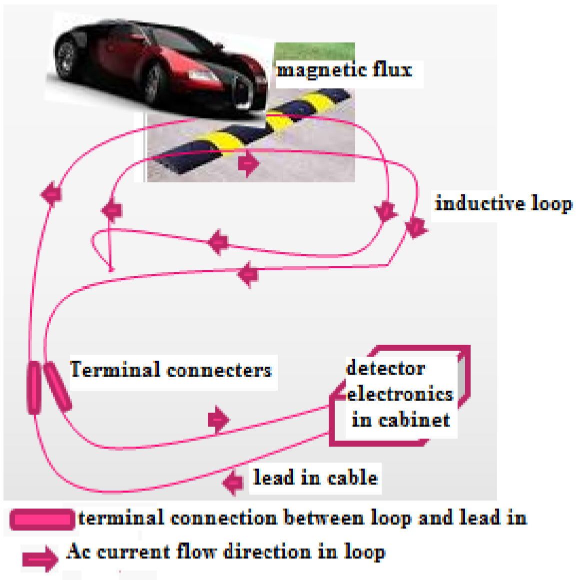

Figure 2: Car passing over inductive loop

acoustic sensors are a used for finding vehicles in the road shown in figure 3. it works on

- radar pulses ,
- The energy is reflected

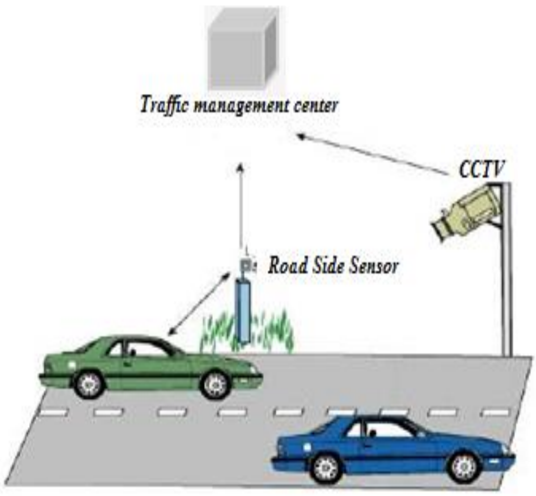

Figure 3 : Road traffic surveillance using roadside sensors

3. Smart Transportation Applications

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(1) Toll Collection: In the present day, the majority of roads are outfitted with an electronic toll-collection system, such as E-ZPass, which effectively processes electronically. E-ZPass operates via a vehicle-mounted transponder, activated by an antenna positioned at a toll lane. Account details are securely stored within the transponder, and the antenna recognizes your transponder to access account information. Subsequently, the toll amount is automatically deducted, granting you passage through the toll booth.

(2) Vehicle notification systems: transportation systems particularly the Car Data design can be used to provide warning to drivers. This system also intimated alternative routes during congestion .

(3) traffic zones: The implementation of an intelligent transportation system enables the enforcement of cordon zones, particularly in areas where larhe transportation systems are accessible, such as the Congestion pricing gantry on North Bridge Road, Singapore. Cordon systems facilitate the collection of fees from vehicles entering densely congested city areas, simultaneously encouraging the utilization of public transit. Road signs demarcate the boundaries of these cordon zones [5]

(4) Automatic Road Enforcement: A traffic enforcement camera system, comprising a camera as monitoring device, is employed to identify and record vehicles that violate speed limits or other legal road requirements. Offenders are automatically issued tickets based on their license plate numbers. These traffic citations are subsequently delivered by mail. For Example:-

- o Speed cameras identify speed limit.
- o Red light cameras detect vehicles that cross a stop line.

(5) Traveller Information Service (TIS):

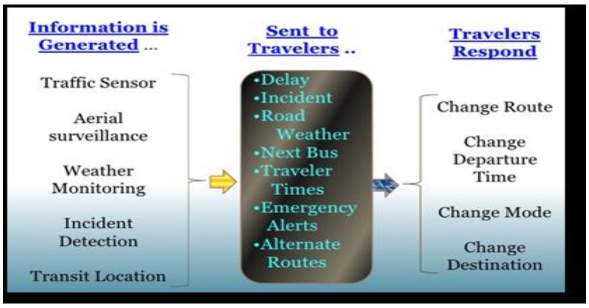

Figure 4: services provided by TIS system

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(6) Emergency Management Services: Traffic control centers play a significant role in augmenting the capabilities of Emergency Management Services by maintaining constant vigilance over road conditions, the closest emergency vehicle is swiftly pinpointed using electronic means and sent to the location. Concurrently, highway management authorities notify other drivers about the incident through dynamic message signs. These services contribute to the reduction of response times, potentially saving lives, and diminishing the likelihood of subsequent incidents

Table 1: Summarized literature review of Intelligent Transportation System

Author	**Title**	**Problem**	**Solution**
Shi Jianjun, Wu XuGuan Jizhen,Chen Yangzhou	The Examination of Cyber-Physical Systems for Traffic Control	Integration of Information and Transportation	Theory and design of CPS will provide a potential solution to a problem of Traffic control
Ankit Mundra Geetanjali	Centric CPS for Querying Transport Information Systems	significant reduction in traffic fatalities and serious injuries on all public roads and highways	Introduces QCPS model
Alexander Smirnov Alexey Kashevnik	Driver Assistant in Automotive Socio-cyber physical System	Vehicle driver assistance	Automotive socio-cyber physical system for assisting a vehicle driver.
Salim Bitam,Abdelhamid Mellouk	Integrating Cloud Computing into Intelligent Systems	Cloud computing to serve drivers and ITS users	ITS-Cloud Transportation Systems is proposed to improve transport outcomes .
MauroDa io, Francesco Biral	Universal Enabling Technology for	Design principles of co-drivers within	Artificial "co-drivers" a technology

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	Future Intelligent Vehicles and Transportation Systems"	general human–robot interactions.	for intelligent transportation systems.
Victoria J. Hodge, Simon O'Keefe	Sensor for for railway Monitoring	monitoring the railway infrastructure	Wireless sensor networks(WSNs) can be used for monitoring the railway infrastructure
Qi Zhang, Hao Zheng, Jinhui Lan,	An Autonomous Data Gathering and Dissemination Model for Extensive Urban Road Networks	Autonomous traffic information systems	vehicular ad hoc network (VANET).
Rodolfo I.Meneguette	A Vehicular Cloud-Based Framework for the Intelligent Transport Management of Big Cities	intelligent transport management of big cities.	VICTiM, a vehicular cloudbased framework for the intelligent transport management of big cities.
Kashif Naseer Qureshi and Abdul Hanan Abdullah	A Survey on Intelligent Transportation Systems	virtual technologies integration in transportation field	to integrate and synthesize some areas and applications, technologies of Intelligent Transportation Systems
HassanAbid, Luong Thi Thu Phuong	V-Cloud: Vehicular Cyber-Physical Systems and Cloud	Solution to driver is not healthy and comfortable enough	novel V-Cloud architecture that combines the concept

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	Computing	to drive.	of VANET, CPS and Cloud Computing to provide safety and comfort for driver, and improve environmental conditions.
Dong Jia, Kie Lu, Jianping Wang	A Survey on Platoon Vehicular Cyber-Physical Systems	Vehicle platooning	platoon-based vehicular cyber-physical systems.
Jiafu Wan, Min Chen	From Machine-to-Machine Communications towards Cyber-Physical Systems	CPS is an evolution of M2M	correlations among machine-to-machine (M2M), wireless sensor networks (WSNs), CPS and internet of things (IoT)
Dietmar P.F. MöllerHamid Vakilzadian	Cyber-Physical Systems in Transportation	prediction of travel times on arterial roads within urban environments.	system processes requirements for cyber-physical systems to transport systems.
GangXiong, Fenghua Zhu, Xiwei Liu,	Cyber-physical-social System in Intelligent Transportation	CPSS-based transportation	Cyber-physical-social system (CPSS), based intelligent transportation system (ITS)
Pallavi A. Targe , Prof. Dr. M. P. Satone	Real–Time Intelligent Transportation	A predictive approach traffic management	android mobile application will help the user to find a path

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			with minimum traffic to their destination.
iruddha Gokhale and Mark P. McDonald	A Cyber Physical Systems Perspective on the Real-time and Reliable Dissemination of Information in Intelligent Transportation Systems	Timely and reliable dissemination of traffic-related information to drivers	vehicle-to-infrastructure communication
Fei-Yue Wang	Parallel Control and Management for Intelligent Transportation Systems: concepts, Architectures, and Applications	artificial transportation systems (ATS)	parallel control and management of complex transportation systems.
Vidhi R. Shah and Sejal V. Maru	Obstacle Detection for Vehicles in an Transportation System	Detecting Road obstacles	spatio-temporal traffic scene, designed for moving object motion detection
Anitha Chepuru , Dr.K.Venugopal Rao	A Survay on IOT applications for ITS	research challenges and opportunities to the development of ITS applications	IoT-based intelligent transport

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4. Architecture and standard of (VANETs)

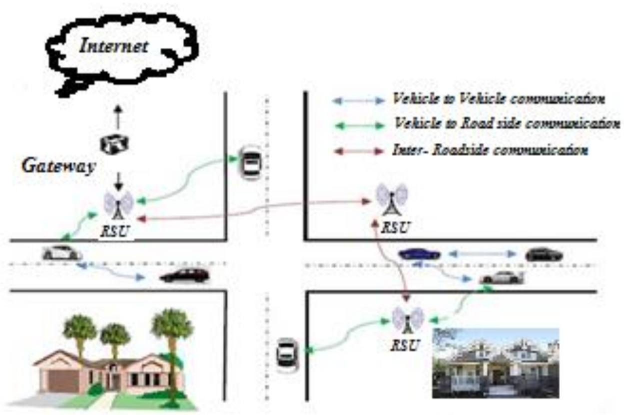

Figure 5: Vanet

Vehicular Ad hoc Network (VANET) comprises of three domains shown in figure 5.such as

- in-vehicle,
- ad hoc, and
- Infrastructure domains.

A. In-Vehicle Domain

The in-vehicle domain is composed with two parts such as on-board unit (OBU) and application units (AUs). The connections between them are wired and sometimes wireless. An OBU is used for giving the vehicle-to-infrastructure and communication. An OBU is fitted with a single network device based on IEEE 802.11p.mainly the device is used for sending, receiving non- safety messages.

B. Ad hoc Domain:

The ad hoc network comprises vehicles with Board Units (OBUs) and static roadside units (RSUs). An OBU be connected to a mobile node, while an RSU is considered a stationary node. RSUs have the capability to establish an internet connection via a gateway. The primary function of RSUs is to facilitate internet connectivity for OBUs[10]. Collectively, On-Board Units (OBUs) create a mobile network that enables vehicle-to-vehicle communication without reliance on centralized devices

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C. Application Units (AUs):

An Applications Units (AUs) is an in-vehicle entity, multiple AUs can be plugged in with a single OBU. An Application Unit (AU) interacts via the On-Board Unit (OBU), which manages all mobility and networking utilities on the Application Unit (AU) . The difference between an Application Unit (AU) and an On-Board Unit (OBU) is only logical.

D. On-Board Units (OBUs): The function of On-Board Unit (OBU) is vehicle to vehicle interaction and communications with vehicle to infrastructure or road side unit. It is also used to deliver communication services to the application units. An On-Board Unit (OBU) is with at least a single network device based on IEEE 802.11p standard.

E. Road-Side Units (RSUs):

A Road-Side Unit (RSU) is a device that is placed at fixed places along roads and highways, or at permanent places such as parking places, shopping complexes, restaurants, industries etc. A Road-Side Unit (RSU) is installed with a network device based on IEEE 802.11p. Internet connectivity to the OBUs is the major function of RSUs.

5. ITS Architecture

With the advancements in the areas of mobile, wireless communications and remote sensing, intelligent transport systems (ITS) have recently becoming a promising technology that will enable the development of applications like road safety, traffic efficiency . This section provides overview of the ITS architecture. The high level architecture of ITS comprises three main domains, that is1) in vehicle domain2) V2X domain and the3) infrastructure domain, as shown in Figure 6.The in-vehicle domain consists of a vehicle fixed with electronic control units (ECUs), wireless technology enabled on-board units (OBUs), a trusted platform module (TPM) and an application unit (AU). ECUs collect data about the vehicle's such as location, speed, position, vehicle size, etc These ECUs exchanging messages with the OBU and AU, and form an in-vehicle network.. The AU is responsible for executing one or multiple applications. Each connected vehicle is also equipped with a TPM to provide secure and efficient communications.

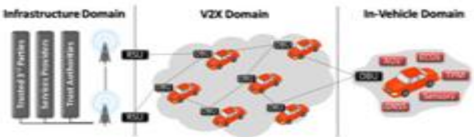

Figure 6. ITS Highlevel architecture

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Finally, a Global Navigation Satellite (GNS) unit is used to get location related data. The V2X domain (or adhocdomain) consists of vehicle OBUs and roadside units (RSUs) which can be placed along the roads. The information gathered at the vehicles OBUs, are exchanged with nearby ITS entities (OBUs, RSUs,) using various vehicular communication technologies, including: (i) vehicle-to-vehicle (V2V) communications using a dedicated short-range communications (DSRC) technology(ii)vehicle-to-infrastructure (V2I) communications (iii) vehicle-to-pedestrian (V2P) communications between the OBUs/RSUs. Infrastructure domain consists of the trusted third parties (TTP), such as vehicles manufacturers, the service providers (SPs) and trust authorities (TA). The static RSUs are generally not fully trusted and subordinated by the TA.

The registration and authentication of these RSUs and OBUs are generalized by TA. The SPs provide applications to the vehicles and are responsible for managing dedicated software updates, billing and deliver value added services. Several applications, such as collision warning, wrong way driving alerts, location of vehicles.

6. Components of ITS

A Traffic management centre (TMC) is a central component of transport administration, where data is collected, and analysed and integrated with other operational concepts to manage transportation system. It is the central point for providing transportation related information to the media and the public, a place where traffic monitoring agencies can coordinate their responses to transportation situations. Typically, several agencies share the administration of transport infrastructure, through a network of traffic operation centres.

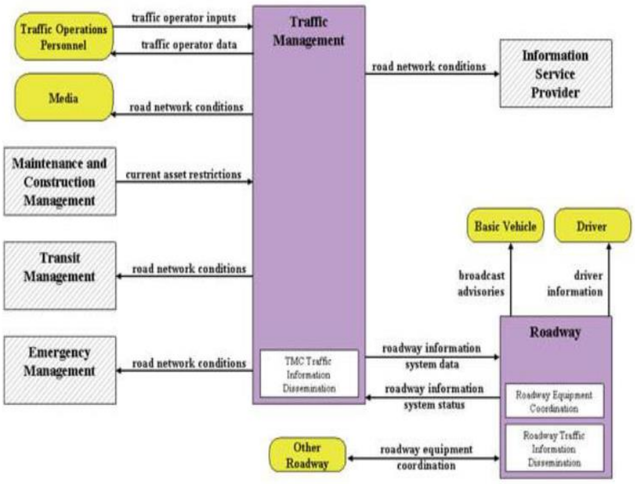

Figure 7. ITS components

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7. Applications of ITS

ITS applications can be categorized into four main classes: (i) infotainment and comfort; (ii) traffic management; (iii) road safety; and (iv) autonomous driving applications these applications are shown in fig 8

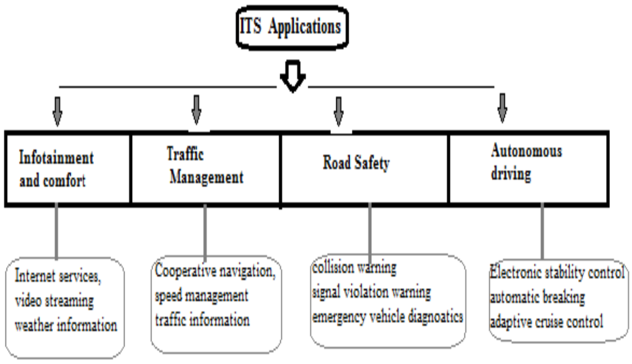

Figure 8: ITS Applications

8. Cyber-Physical Systems in Transportation

Cyber-physical systems that go beyond traditional systems employed in manufacturing industries, such as automation of systems, which needs tight coupling between the subsystems and software engineering concepts.

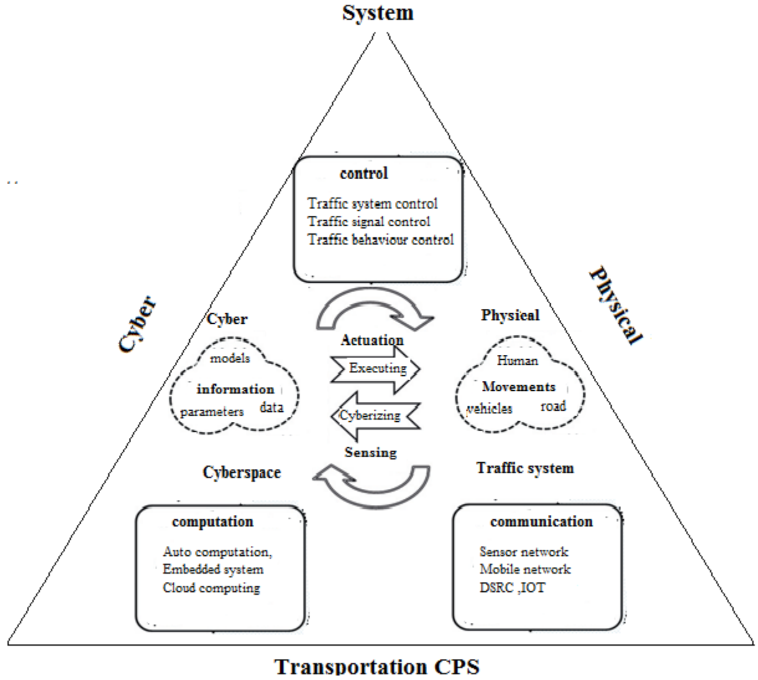

Figure 9. High level Components of CPS In Transportation

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Cyber-physical systems, open network concepts like the Internet, the following features.

- Integration of computational elements controlling the physical entities
- Group of communicating entities with physical inputs and output instead of as standalone devices
- Internet of Things, and Services
- Intersections between physical and virtual world concepts
- Internet-based business models, social networks,
- Systems of systems

Cyber-physical systems go beyond traditional systems requiring a close inter networking with the proper disciplines. The integration of information, communication and transportation processes will result in:

- Information flow
- Control flow
- Behavioural control flow of the traffic system

There is a need in cyber physical systems based traffic control to analyze the:

- Information flow among vast number computer systems
- Traffic signal systems
- Passengers in the traffic control system

9. PROPOSED SYSTEM ACHITECTURE

Integration of information and transportation processes can be generalized by cyber physical traffic control system. As a result, smart transportation systems are focusing on guaranteeing collision avoidance of autonomous cars, effective algorithms for collision avoidance at traffic intersections.

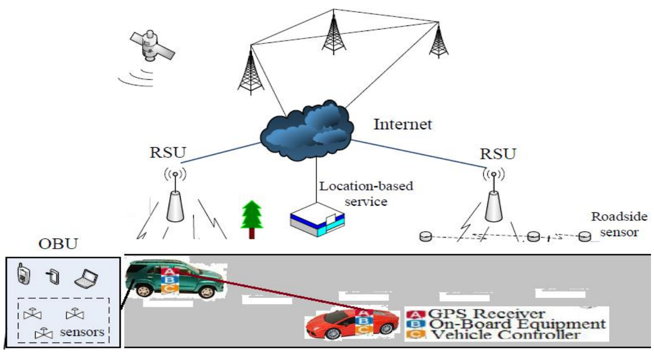

Figure10.CPS to on road transport system

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As shown in the above figure the development of smart cyber-physical transportation controls systems. All information needed to achieve cyber physical transportation control objectives, such as materials, energy, and the ways they are obtained, stored, transmitted, and processed, are important for achieving the objectives [5]. Supporting these applications requires a understanding of the smart transportation systems with regard to its types of communication networks:

- Wireless network among vehicles for vehicle-to-vehicle (V2V) communication
- Wireless network that enabling vehicles to communicate with road-side infrastructure(V2I)

Timely and accurate dissemination of information via vehicle-to-vehicle and road-side infrastructure communication is a typical problem due to multiple challenges, as described in [10].Some challenges are constrained by the laws of physics of the system, including the wireless radio transceiver power, shared nature of the wireless channel, vehicles mobility, and number of the vehicles. Other challenges are from the varieties of the cyber infrastructure, including the protocols like IEEE 802.11 Media Access Layer (MAC), Address Resolution Protocol (ARP), Internet Protocol (IP), and the Transmission Communication Protocol (TCP).

CONCLUSIONS

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. VANET is a promising technology and with the corresponding advancement in wireless technology, vehicles are becoming an important part of whole network. Vehicles can be designed that they have learning capabilities so, to have proper perception of dangers situations and to modify vehicle's behaviour consequently. It can help vehicles to take decisions from it's past experience. In this paper, the features of cyber physical transportations system scenarios were investigated. The transportation system sector and the transportation traffic flow analysis were introduced. Based on the introductory remarks, smart transportation has been discussed in more detail to extract the essential features and constraints for cyber-physical smart transportation systems.

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