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Intelligent Transport System: A Progressive Review

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Abstract

Objectives: Increase in traffic density in the world results in more and more congestion, air pollution and accidents. Hence Intelligent Transport System (ITS) has been emerged as a solution to various transport related issues. The aim of this research paper is to conduct systematic analysis on ITS. **Methods/Statistical Analysis:** ITS is defined as the set of applications which are advance and aim to apply intelligent information and communication technologies in order to provide services for transport and traffic management. ITS have combined various technologies such as Data collection, Communication, Data Mining, Machine Learning, Artificial Intelligence and Database Management. By combining these information technologies ITS have provided various applications such as Traffic control, Fault detection systems, In-vehicle information and navigation systems and driver assistance systems. **Findings:** We have considered the most relevant published work from 2008 onward relative to our objective from different popular digital libraries. We have summarized this work into issues in ITS and techniques used to solve them. **Application/Improvements:** It has been found that by combining various new technologies such as agent based computing, cloud computing, VANETS etc. ITS have become very efficient to solving transport related issues in smart cities.

Keywords: Agent Based Computing, Intelligent Transport System, Parallel Transportation and Management System, Vehicular Ad-hoc Networks, Vehicular Cloud Computing

1. Introduction to Intelligent Transport System (ITS)

Transport is the fundamental for the everyday functioning of economy and the society. Over the last few decades there is seen the initiation, development, deployment and huge growth in transport system and significant effect of these developments in our society and life. Hence we can redefine transport system as ITS. Now a day's not only civil and mechanical engineering areas deal with research and development of transportation. Rather the computer science engineering concepts such as Artificial Intelligence (AI), machine learning, communication, internet and many other emerging engineering and information sciences areas become the core of ITS. Therefore, ITS is defined as the set of applications which are advance and aim to apply intelligent information and communication technologies in order to provide services for transport and traffic management. ITS plays a crucial part in reducing many problems like air pollution, long travel time, fuel consumption, traffic congestion and accidents, which have been increased due to growth in population. ITS organizations are doing countless efforts in order to find solutions for these critical issues by developing traffic communication and vehicular networking[1,2]. Traffic control and management paradigm is divided into 5 distinct phases[3]. In the initial phase computers are large in size and expensive. Therefore whole traffic management is done using centralized model. In the second phase microcomputers are introduced which also lead to the introduction of Traffic Signal Controller (TSC). Each TSC consists of storage capacity and computing power to handle one intersection. In the third phase introduction of Ethernet (LAN) and wireless networks enables resource and information sharing. In this internet era, retrieving lots of data from remote sites and processing it requires lots of network bandwidth. To solve this problem mobile agents and agent based computing is introduced

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in fourth phase. Mobile agents require only runtime and run computations near data which reduces the communication cost and time. But this agent based computing require large computational resources. Moreover there are continuous improvements in On-Board Equipments (OBE) and Global Positioning Systems (GPS) in transport infrastructure. Now the IT industry has been revolutionized by cloud computing. It is a paradigm that provides on-demand computing resources to users on pay-per use basis. In recent years Parallel transportation and Management System (PtMSs) become the hot spot in traffic management systems. PtMSs use Artificial Transport System (ATS) which incorporate artificial systems, parallel execution and computational experiments. ATS helps to evaluate and optimize various traffic control strategies[3]. ATS can make use of cloud computing concepts to very well coordinate the resources and also keep a check on the work of strategies to enhance the performance of traffic systems and minimize hardware requirements.

1.1 Technologies used in ITS

The area of ITS is supported by three technologies: Data collection technologies, communication technologies and common database system. Further advance techniques are also included in ITS which are discussed in literature review. The description of basic technologies is given:

- **Data collection technologies:** The prime requirement of ITS is accurate and comprehensive data. In recent years distinct techniques have been proposed and implemented for the improvement of data collecting methods. The data collection technologies are mainly divided into two categories: infrastructure-based technology (Inductive loops, sensors, CCTVs) and vehicle-based technology (GPS, cell based and floating car technologies).
- **Communication technologies:** There are numerous communication technologies that are available to be used in ITS. The methods differ with respect to capacity, price and working strategy. These technologies vary from telephone lines to advance technology such as General Packet Radio Service (GPRS) and finally various Adhoc wireless communication and wireless broadband technologies. Vehicular Ad hoc NETworks (VANETs) have become popular in wireless communications for intelligent inter-vehicle communication[4,5].
- **Database management:** ITS also makes use of databases for managing the information related to traffic as well as to get a overview of the network based on information received.

1.2 ITS Applications

The various ITS applications are described as follows:

- **Traffic Control:** It focuses mainly on prioritizing the modes of transport such as buses, cyclist, pedestrians and other emergency vehicles in order to evaluate the performance and study the reasons for traffic emissions and congestion.
- **Disaster management systems:** Various technologies are used for this purpose in order to smooth the traffic flow and to provide medical and other related help in such cases.
- **Vehicle information and navigation systems:** In-vehicle information system warns drivers about adverse climate conditions, road surface conditions, traffic jams and hazards including accidents. Navigation systems provide vehicle location information in real time and route guidance for driver to take optimum route.
- **Driver assistance systems:** In order to save the driver from accidents these systems have replaced some human driver decisions with machine decisions which also help to achieve smoother vehicle control.
- **Air pollution control:** Road transport is the major source of air pollution which has caused impact on human health and environment quality. Various models and protocols are used in ITS to control air pollution[6,7].

2. Literature Review

In order to conduct progressive review on ITS, we have searched various digital libraries which include IEEE, ACM, Springer, Elsevier and Google scholar database. We found 28000 results based on the search string for this review. We have downloaded the research papers from the searched results and based on manual screening (we have read their title, Abstract and conclusion part to assess them) found 25 most rel-

evant papers. Some of the papers which were found to be weak in context to our review were also dropped from selected list. Review of all 25 papers is presented.

Shandiz et al.[8] proposed a method for controlling traffic lights to have maximum flow in route and which results in moving traffic. This algorithm uses real situations. The sensors send the traffic flow information on a computer, and then based on Genetic Algorithm (GA) timing of green light is adjusted. Simulation result shows the full capacity of cross and road is reached based on real data. In aims to view the relationship between transport emissions and air quality concentrations and also to allow them to communicate. Air Quality Stations send air data to Data center then based on that data the Data center Request restriction from traffic management. After restricting vehicles Traffic monitoring centers activate monitoring traffic and then datacenter requests extra buses from public transport management. Simulation results show that the system can automate the air pollution assessment. In[9] reported project SMARTY for viable transport and mobility in smart cities. All its services mainly rely on the collected data by social and environmental sensors. It consists of social sensing module that senses data from social networks, tweets etc. and urban sensing module. Data is further processed using some mining techniques to find important information like traffic flow and accidents. All of this information helps user to take optimal routes. In[10] proposed a new Parallel Transportation Management Systems (PTMS). It is basically deals with analyzing models and making decisions for those. PTMS consist of components such as Operator Training System for Transportation (OTST), Dyna CAS (Testing and evaluation component), Agent based Distributed and Adaptive Platforms for Transportation Systems (ADAPTS) and ITOP (Actual control and management component of traffic equipment and system). In[11] described Intelligent Sensor Information System (ISIS). In order to reduce crime and antisocial behavior on public transport systems, an active CCTV approach ISIS can be used. Event composition component is used to directly detect small events and combine them to deduce events with linguistic meaning. In the overall system architecture, to generate alert in real-time over a wireless network On-board event recognition is combined with control room software. Alazawi et al.[4] proposed an emergency response system for disasters and specially focused on transport system. In this paper, technologies such asVANETs, disaster management system is proposed by integrating mobile and cloud computing technologies. The proposed system is evaluated on the basis of the brunt of disaster on the transport system and comparing it with traditional disaster management system. In proposed a scheme which consist of smart city framework that share traffic condition related information to help drivers in taking appropriate decisions. The communication between the vehicles and road side units is provided by Vehicular and Adhoc NETwork (VANET). The smart city framework has warning message module which consists of Intelligent Traffic Lights (ITLs). This module traffic information, make decision about routes and inform driver about current traffic conditions. In[12] gave a new scheme to provide accurate GPS information for land vehicle monitoring systems. In the proposed technique GPS integrity check is provided at each level to check the quality of output of GPS positioning. GPS Doppler information checks integrity of vehicle's velocity which improves the results of map matching process. The final step confirms the correctness of the algorithm for map matching. In[13] focused on improving the tools for making decisions while natural disasters. It has described development and use of Intelligent Disaster Decision Support System (IDDSS) and its capabilities to respond and plan in floods. Therefore using IDDSS, the concept of risk, susceptibility and resiliency for disaster management can be improved. In[14] proposed an intelligent traffic control system. In the proposed system each vehicle is equipped with Radio Frequency IDentification (RFID) tag which is impossible to remove and they can only be read by RFID readers. RFID reader also counts no of vehicles during specific duration to determine network congestion and based on that the duration of green light for that path. It also helps in determining stolen vehicle. Zig bee module CC2500 is used to provide a wireless communication between emergency vehicles (e.g. ambulance) and traffic controller. The prototype of system is tested for different combination of input and experimental results are found good.

In[15] described the role of telematics in transport system. Telematics can strengthen characteristics of transport while reducing its bad impacts. It helps to reduce various transport system issues such as air pollution, energy use, congestionwithout any extra contribution. In[16] described how vehicles evolved from some sensors to network of autonomous vehicles. Like IOT, these autonomous vehicles are intelligent, have storage and also learning tendency to interact with users. The cars have sensors which

receive information from outside and assist the drivers and software to help in navigation, controlling pollution and traffic management. Concept behind all this transition is vehicular cloud. In[17] proposed a solution to improve performance of Intelligent Transport System (ITS) for applications that require proper dissemination of event driven warning messages. The solution has three parts. In the initial phase priority is assigned to transmitted or forwarded messages. In the second phase the congestion is detected and in the last phase transmit power rate and beacon transmission rate are adjusted so that emergency messages spread within VANETs. Simulation results show that this scheme outperforms existing because it does not alter the ITS applications running until and unless it detects VANET congestion rate.

In[18] introduced a new strategy named Weighted Congestion Coefficient Feedback Strategy (WCCFS). Through this technique any dynamic information can be produced and shown to guide the users on road. The simulation results are compared with three existing technologies. The results demonstrate that WCCFS is better than other technologies. WCCFS can very well improve the conditions on road and also ease the effects of congestion caused by traffic jam. To relief the government, in[19] plan to develop Artificial Emergency Planning System (AELPS). AELPS describes the characteristics of elements in emergency system by using artificial society theory based on agent based modeling. AELPS generates results that can be used in emergency planning. AELPS framework assembles various components such as Pollution, Medical and rescue subsystem, Geology subsystem, Weather subsystem, Epidemiology subsystem and Transportation subsystem to provide disaster relief. Alsabaan et al.[7] focused on creating an Economical and Environment Friendly Geo cast (EEFG) protocols to minimize fuel consumptions and emissions. They proposed the method to integrate vehicular networks with fuel models. These models are Comprehensive Modal Emissions Model (CMEM) and Virginia Tech Microscopic model (VT-Micro) and Geo cast protocols. The basic idea is to send Traffic Light Signal (TLS) related information to vehicles to reduce emissions and fuel consumption. Geo cast protocols with TLS play a key role in this model. VT-Microscopic model is used to measure fuel consumptions and CO_2 emissions. Vehicles calculate environment friendly speeds after getting TLS information. Simulation results show that EEFG protocols can reduce CO2 emissions and fuel consumptions. Li et al.[3] introduced a prototype for traffic management. He aimed to combine Agent-based traffic management with cloud computing. Traffic management based on agents use adaptability and mobility of mobile agents to deal with transport issues. Intelligent transportation cloud can help these systems to provide large amount of storage, computing resources, decision support and environment for traffic management strategies. More use of mobile agents also requires computing and power resources which can be provided through cloud computing. In[20] promoted the vision of Vehicular Clouds (VCs) and various security challenges in vehicular clouds. In VC, vehicular resources which are less utilized such as power, Internet connectivity and storage are rented out or shared between customers. Hence the adoption of VC concept has various privacy and security issues which are need to be addressed. The security challenges specific to VCs are authentication of vehicles, tangled locations and identities, building trust relationships etc. A directional security scheme is provided in this paper to handle these security challenges. In[21] presented rule based iterative Artificial Transportation System (ATS) design process. In ATS traffic simulations are done in synthetic way to deal with traffic issues from complex system point of view. The simulation results are conducted on prototype that consists of multi agent platform. The prototype is able to generate traffic behaviors such as congestion and helps in evaluating traffic rules. In[22] proposed universal framework based on evaluated hybrid Assisted GPS (A-GPS) and Uplink Time Difference Of Arrival (U-TDOA). The framework is designed for real time road transport data collection system. The framework based on ANN integrates several technologies for traffic data collection, state analysis, processing analysis, presentation of traffic flow information and optimization. A new approach 'Pinpoint-Temporal' sampling frequency method is presented in Data analysis component. In[23] proposed a service based Intelligent Transportation System Framework (s-ITSF) to provide efficient accident management. It provides various services such as before/after accident management and traffic information data through Vehicular Cloud Computing (VCC). The proposed framework provides Accident Management Center (AMC) to identify level of damage and Accident Management Organization (AMO) is used to provide facilitiesin accident area. Transportation and Accident Database Center (TADC) is used to provide information for prevention of accidentsby collecting and managing traffic information. In[24] proposed a prototype

Table 1. Summary of various transport issues covered in literature survey

Sl. No.	Ref. No.	Transport Related Issues						
		Traffic Control	Air Pollution	Crime control	Efficient navigation	Congestion control	Resource management	Disaster Management
1	.8	×						
2	6		×					
3	9	×						×
4	10	×						
5	11			×				
6	4							×
7	5	×						
8	12				×			
9	13							×
10	14	×				×		
11	15	×	×			×		
12	16	×	×		×		×	
13	17					×		
14	18					×		
15	19							×
16	7		×					
17	3	×					×	
18	21	×				×		
19	22				×			
20	23							×
21	24					×		
22	25						×	
23	26				×			
24	27					×		×

Table 2. Summary of techniques and technologies used to solve transport related issues

Sl. No.	Author's Name	Techniques and Technologies						
		Sensors	Agent based computing	Vehicular cloud computing	VANET/ VSS	RFID readers	Advance GPS	Smart traffic lights
1	8	×						
2	9	×						
3	10		×					
4	11	×						
5	4			×	×			
6	5				×			×
7	12						×	

8	14					×		
9	16	×		×				
10	17				×			
11	19		×					
12	3		×	×				
13	20			×				
14	21		×					
15	22						×	
16	23			×				
17	24					×		×
18	25			×				
19	26						×	
20	27				×			

for automatic traffic light control expert system.Its simulation model consists of various sub models. The model simulates the arriving and leaving number of vehicles on roads by using inter-arrival and inter-departure time. In this model each sub model represent road with three intersections. Simulation results show that waiting time for car at various intersections is decreased when durations of red light and green light are kept fixed to some value. The performance of simulation model is best when inter-departure time at three intersections of road is 0.6s. In[25] proposed a model to integrate cloud computing and vehicular networks to share computational resources. The proposed architecture consists of central, vehicular and roadside cloud. The cloud resources are allocated through game theoretical approach. Resource reservation method is used for migration of virtual machines. Experimental results show significant reduction of service dropping rate. In[26] proposed within CAPLOC project (2010-2013) way to combine signal propagation and image processing techniques. Global Navigation Satellite Systems (GNSS) combined with GPS offers global positioning solution in lower costs. However these systems sometimes give wrong results because of signal processing conditions. A laboratory vehicle equipped with two GNSS receivers and a fisheye camera is used. Images of sky are captured using camera located on roof of vehicles.Positions of vehicle and reference trajectory is obtained using GNSS receivers. NLOS signals can be used effectively by using knowledge from image to evaluate various errors originated from obstacles. In[27] proposed a Vehicular SMS System (VSS) in order to problems such as traffic jams and road accidents. The proposed VSS uses the concept of cellular network by using SMS systems in order to provide VANET services. In comparison to VANETs, VSS are less costly. However it requires more research to solve privacy and trust issues.

3. Analysis

Analysis of review work can be classified into two aspects of Intelligent Transport System (ITS): Transport related issues and Techniques involved in solving these issues.

3.1 Transport Issues

Increase in traffic due to population growth has raised various issues such as traffic control, air pollution, crime control, disaster management, congestion control and proper navigation systems. Table 1 summarizes various issues which have been focused in literature review. Based on the Table 1, it can be concluded that the major challenges in most of the work related to ITS are Traffic control, congestion control and disaster management. However air pollution, crime control, Efficient navigation and resource management are less focused by researchers.

3.2 Techniques for Solving Transport Issues

Various issues reported in the Table 1 require real time information to solve them. Therefore various technologies and techniques are proposed by various researchers in order to solve them. Various active CCTV cameras and sensors are used to provide real time information. GPS technology is combined with different image processing techniques to have more advance navigation systems. In addition to this several advance technologies such as VANETs, cloud computing, agent based computing have been introduced to make transport system more efficient and intelligent. Table 2 summarizes the techniques used by various researchers to solve transport issues. Researchers are exploring number of techniques to solve transport related issues. However till date Sensors, VANETs, Vehicular cloud computing and Agent based techniques are found to be the best solution in current scenario. For the further improvements due to technological advancements other techniques might be effective in future using Advance GPS, Smart Traffic lights, RFID readers etc.

4. Conclusion

Explosive growth in traffic density and population has raised various issues such as air pollution, congestion and accidents thathave become the area of research. Hence Intelligent Transport System (ITS) is used to solve these transport related issues. ITS combines various technologies such as data collection, communication, machine learning and data mining to provide transport related services. These services include Traffic control, navigation systems, driver assistance systems and Fault detection systems. In addition to this ITS also solves transport related issues such as disaster management, congestion control and air pollution. Further enhancement in ITS include addition of new techniques such as internet of vehicles, vehicular cloud computing, Agent based computing which includes the introduction of Artificial Transport System. By combining these techniques the ITS can be made more efficient in solving transport related problems.

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