JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Intelligent Transport Solutions for Smart Cities

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Abstract. Intelligent Transportation Systems (ITS) combine management strategies with computers, electronics, and communication technologies to improve road transportation systems' safety and effectiveness by giving travellers information. To enhance the safety and efficiency of road systems, these systems connect to complex infrastructure systems and involve vehicles, drivers, passengers, road operators, and management engaging with the environment and each other. The primary topics covered in this paper are ITS architecture, ITS planning, and ITS user services. A standard framework for organising, specifying, and integrating intelligent transportation systems is provided by the ITS architecture, which emphasises both logical and physical design. According to the World Health Organisation Report (1999), traffic accidents were the tenth leading cause of death or disability in 1990. It was shown in the systems.

Keywords: ITS Structures, ITS architecture. ITS planning.

I.Introduction

ITS

Computer, electronics, and communication technology are all harmoniously integrated with management techniques in Intelligent Transportation Systems (ITS). Together, these components provide travellers with useful information, which eventually improves the effectiveness and safety of road transportation networks. ITS improves mobility and safety in transportation while increasing productivity and global connection. Advanced communication technologies are integrated into automobiles and the transportation infrastructure to achieve this. To efficiently manage traffic flow and maximize the utilization of existing transportation infrastructure, intelligent transportation systems comprise a large range of information and electronics technologies based on wireline and wireless communication. In addition to reducing transportation risks, easing traffic congestion, increasing transportation efficiency, and minimising pollution, it also improves the driving experience, road system capacity, and safety.

II.Literature Review

Several foundational and contemporary studies reinforce the significance of these advancements:
T. Khalid et al. (2018) proposed a fog-based security framework for intelligent traffic light control.
C.T. Barba et al. (2013) demonstrated the application of smart cities for VANETs, integrating traffic statistics and warning messages.
H. Noori (2013) evaluated VANET-enabled traffic light control on emergency response times.
L.M. Ang et al. discussed the challenges and architecture of IoT deployment in smart cities (IEEE Access).
M. Soyturk et al. (2023) examined vehicular networks transitioning to vehicular clouds.
Xiao Zhende et al. proposed an intelligent traffic light approach aimed at CO2 emission reduction.
These works collectively highlight the evolution and transformative potential of ITS when coupled with cutting-edge technologies and smart urban planning.

ITS services

A framework outlining the many services that users can access has been developed to construct an Intelligent Transportation System. Eight groups comprise all of the previously listed services. The organization's perspective and the sharing of common technical functions dictate how these services are distributed.

ITS Services

III. Traffic management

This service group's main objective is to reduce the adverse environmental consequences of the transportation system while also improving its efficiency and productivity by using real-time information about its state.

3.1 Information Before Trip

Before starting their journeys, tourists can utilize this user service to learn more about the transportation system. This allows individuals to make educated choices about when to travel, what kind of transportation to use, and the best path to take to get to their destinations. This information is readily available to travellers via telephone or computer systems at home, at work, and in public areas.

3.2 Driver Information

Once travellers have started their journeys, this user service provides them with travel-related information. Portable communication devices, automobile radios, and variable message signs (VMS) are all used to transmit information. By modifying routes, etc., to avoid congestion, travellers can make the most of the current capacity.

3.3 Guidance

This program provides travellers with direction by laying out a suggested path to their intended location. Additionally, it gives precise directions for impending curves and maneuvers. This feature provides real-time information about the transportation system, including traffic conditions, road closures, and the status and schedule of transit systems, for all kinds of travelers.

3.4 Travelers Information

This site provides a thorough company directory providing details on a variety of travel-related amenities and services, including location, business hours, and the accessibility of services like dining options, lodging, parking, auto repairs, hospitals, petrol stations, and police stations. For many of these travellers, booking services are also included. To help with travel planning, the travelers' service information is available at home, at offices, and in other public places. On the way, these services are also offered.

3.5 Density Control

To determine the optimal right-of-way distribution for cars and pedestrians, This service gathers data in real-time from the transportation system, converts it into useful information, and then uses it. Improving traffic flow can be achieved by prioritizing transit and high-occupancy vehicles or by modifying signal timing to suit the existing traffic conditions. The data gathered by the Traffic Control service is shared by some distinct user services.

3.6 Incident Management

Enhancing the response and incident management abilities of transportation and public safety officials, the towing and recovery industry, and other incident response staff is the aim of this service. Closed-circuit television cameras, data processors, and communication technologies are examples of advanced sensors that are used to quickly and accurately identify events. Implementing solutions that lessen traffic jams and lessen the effects on the environment, as well as on the movement of people and commodities, is made easier by this.

3.7 Demand Management

To reduce the number of single-occupancy automobiles, this user service develops and implements initiatives. Additionally, it encourages the adoption of more environmentally friendly modes of transportation and the use of high-occupancy cars.

3.8 Mitigation of Emissions

This service's main objective is to use sophisticated sensors to monitor and put plans into place to control access to or divert traffic from regions with sensitive air quality. This is also used to detect cars that are releasing more pollutants than allowed and to alert drivers so they may take the appropriate corrective action. This makes it easier for authorities to implement and assess different pollution control methods.

3.9 Addressing Global Challenges through ITS

Intelligent Transportation Systems (ITS) are at the forefront of addressing critical global urban challenges such as traffic congestion, environmental pollution, and mobility equity. As discussed in the paper, ITS facilitates the efficient use of transportation infrastructure, thereby mitigating congestion and enhancing the mobility experience for all users. Emission control services directly contribute to environmental preservation by identifying high-emission vehicles and controlling access to areas with sensitive air quality. Additionally, demand management strategies promote the use of environmentally friendly and high-occupancy vehicles, aligning with global sustainability goals.

3.10 ITS Architecture: Structured and Scalable Design

The ITS architecture presented in the paper serves as a standard and unified framework for organizing, integrating, and specifying intelligent transport components. It incorporates both logical and physical system designs and ensures interoperability between different regions and agencies. Key elements include:
Seamless communication and data sharing among stakeholders.
Allocation of responsibilities to relevant authorities.

Adoption of standardized communication infrastructures, including private sector-built communication towers.
This structured approach enables ITS scalability and adaptability to future expansions and technological advancements.

IV.Operations of Public Transit

The four services that make up this category are described below:

4.1 Public Transit Management

To improve vehicle and facility operations and automate the public transit planning and administration procedures. networks, this user service makes use of cutting-edge communication and information systems.

Figure 1: Vehicle communication in Smart cities

4.2 En-Route Transportation Data

When travelers start their excursions using public transportation, this service seeks to provide them with information on expected vehicle arrival times, as well as information on connections and transfers. To help passengers make decisions and modify their journeys in progress, this also provides accurate and up-to-date transit service information at bus stops, transit stations, and within the vehicle.

4.3 Customized Public Transportation

Through the rerouting of transit vehicles with flexible routes and the on-demand assignment of privately run vehicles, such as minibuses, taxis, or other small vehicles, this service aims to give travellers options for transportation. At the service station, travellers exchange information regarding the start and finish points of their excursion.

4.4 Security for Public Travel

For public transportation operators and support personnel, this user service creates a secure environment. It keeps an eye on the conditions within transportation buildings, stations, parking lots, bus stops, and inside moving cars. When necessary, either manually or automatically, alarms are set off. Moreover, it provides security for the systems that manage vital transit infrastructure.

4.5 Comprehensive ITS Services

The document elaborates on several critical ITS user services categorized across domains such as traffic management, traveller information, public transit, commercial vehicle operations, emergency handling, and maintenance. Highlights include:

Real-Time Traffic Information: Provided through Driver Information, Guidance, and En-Route Transportation Data services.
Incident Management: Rapid identification and resolution of traffic incidents using CCTV and sensor-based detection.
Emission Control: Monitoring and mitigating vehicle emissions using advanced sensors and feedback systems.
Smart Public Transit: Includes Public Transit Management, Customized Transportation, and Security services to improve transit efficiency and safety.
These services collectively enhance urban mobility, reduce travel time, and contribute to sustainable transportation ecosystems.

V. Payment via electronic means

Using a universal electronic payment method that supports a variety of transportation modes and functions, this user service makes it easy for travelers to pay for transportation services. Through a multifaceted computerized system, Parking fees, transit fare payments, and toll collecting are all connected. An integrated payment system would allow users to conveniently pay for tolls, parking fees, and transit expenses using a single electronic device when on a toll road or in a parking lot.

VI. C V Operations

Improving the effectiveness and security of commercial vehicle operations is the aim. This includes the services listed below:

6.1 Electronic Clearance for Commercial Vehicles

Before commercial trucks arrive at an inspection station, this service allows law enforcement to electronically confirm the vehicle credentials, safety status, and size and weight information. Bypassing safe and authorized carriers, the authorities send vehicles that are illegal or potentially dangerous for inspection, allowing them to go without pausing for compliance checks at inspection points.

6.2 Roadside Safety Inspection Automated

Automated inspection capabilities at the inspection station allow for the quick and precise verification of safety criteria. Modern tools are used to evaluate the driver's attentiveness and suitability for duty, as well as the operation of the brakes, steering, and suspension.

6.3 Safety Monitoring

If any dangerous circumstances arise while the vehicle is in motion, this service notifies the driver, carrier, and law enforcement. It also monitors the driver, vehicle, and cargo. Additionally, this user service protects the integrity of commercial vehicles, freight containers, and trailers by keeping an eye on onboard sensors for any breaches or instances of tampering.

6.4 Response to Hazardous Materials Incidents

Emergency workers at the scene of the incident can quickly learn about the kinds and amounts of hazardous compounds present thanks to this user service. This facilitates a prompt and efficient reaction. To guarantee a timely reaction in the event of an accident, emergency professionals are informed when sensitive hazardous materials are being transported.

6.5 Mobility of Freight

For drivers, dispatchers, and intermodal transportation providers, this service provides useful information. By giving real-time traffic information, vehicle positions, and cargo details, it assists carriers in maximizing productivity.

VII. Advanced vehicle control and safety systems

Figure 2: A caution to the vehicle and pedestrians

By assisting drivers in maintaining awareness and control over their vehicles and enhancing their ability to prevent collisions, the goal of this user service is to make the transportation system safer.

The following user services are included in the group:

- Avoiding Longitudinal Collisions
- Avoiding Lateral Collisions
- Avoiding Collisions at Intersections
- Improved Vision for Preventing Collisions
- Vision Improvement to Prevent Collisions
- AVO stands for Automated Vehicle Operations
- Preparadness for Safety

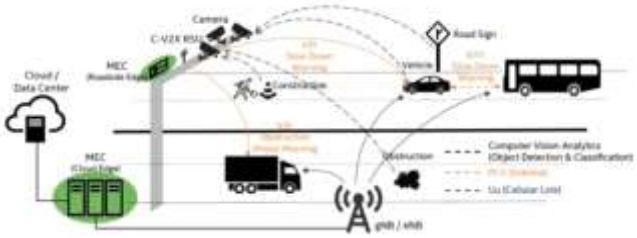

Figure 3: Vehicle to Roadside Units (V2R)

VIII. Handling emergencies

Notification of emergencies and personal safety - When assistance is needed for either emergency or non-emergency situations, travellers can use this function to alert the appropriate emergency response professionals. In the case of an accident, this can be done automatically from the car or manually.

Management of emergency vehicles - To lessen the severity of accident injuries, this service attempts to shorten the time between receiving an emergency notification and emergency vehicles arriving at the scene.

IX.Management of information

Offering the capabilities needed to store and archive the massive volumes of data that are constantly being gathered by various IT systems is the aim of this service.

9.1 Technological Enhancements: AI, IoT, 5G, and V2X

Modern technologies significantly augment the effectiveness of ITS. The paper concludes with a strong emphasis on the role of:

Artificial Intelligence (AI) and Machine Learning for predictive traffic analysis and adaptive system control.

Internet of Things (IoT) for real-time data collection through sensors and networked devices.

5G Connectivity for high-speed, low-latency communication is essential for real-time traffic control and vehicle-to-everything (V2X) systems.

V2X Communication enables dynamic interaction between vehicles and roadside infrastructure to ensure safety and efficiency.
The integration of these technologies allows for the deployment of Intelligent and Vehicular Traffic Lights (ITL and VTL), enhancing coordination, reducing delays, and cutting down carbon emissions.

X.Management of Construction and Maintenance

The functions required for managing fleets of maintenance vehicles, supervising the building and upkeep of roads, and guaranteeing safe road operations are all included in this user service.

XI.The Architecture of ITS

A unified framework for intelligent transportation system integration, specification, and organization is provided by the ITS Architecture. It outlines how different ITS components work together to address transportation-related concerns. It gives transportation workers a variety of options to suit their requirements. It lists and explains a number of ITS functions and allocates duties to relevant stakeholders. To efficiently handle numerous difficulties and interact with various authorities throughout the state or region, the ITS architecture should be consistent and adhere to specific standards.

1. Multiple agencies in various states and regions must be able to use the data collected, operations performed, or equipment installed thanks to the ITS architecture. The smooth collaboration and communication between the various parties involved depend on this interoperability.
2. Able to communicate and share information: Emergency services may find use for the information that traffic operations provide.
3. ITS operations need the use of regional communication towers built by several private agencies.

XII.ITS Scheduling

A comprehensive transportation infrastructure that can accommodate future needs is developed in part through transportation planning. The process of transportation planning is a multi-step one that includes problem identification, solution generation, analysis, evaluation, and implementation. Through the use of computers, software, and communication systems, this system can be effortlessly integrated with Intelligent Transportation Systems.

It is essential to upgrade the ITS facilities regularly while preparing for the long term. Making sure that the technologies and equipment are compatible with upcoming advancements and expansions is crucial.

The conventional method and the ITS transportation planning procedure are not the same. By utilising communication and control systems, ITS has the incredible ability to seamlessly combine multiple forms of transportation, including public transportation, and infrastructure components. Planning across several modes is made possible by the possibility of multi-modal integration.

XIII.Challenges

The primary hurdles in integrating ITS into the daily activities of transportation agencies include:

1- Institutional coordination and collaboration to facilitate information and data sharing
2- Ensuring that various ITS projects are technically compatible
3- Attending to training and human resource needs 4. Overcoming budgetary constraints and investigating private sector participation.

Conclusion

Commented [1]:

To improve mobility, lessen traffic, regulate traffic flow, and solve environmental issues, ITS must be integrated into smart city infrastructures. New technologies like ITL and VTL have been made easier to deploy thanks to recent developments in IoT, V2X communication, and 5 G networks. In conjunction with ITL systems, Traffic flow may be optimized, and CO2 emissions can be decreased by utilizing real-time communication enabled by 5G networks and a variety of sensor technologies, such as AI cameras, RSUs, and OBUs. Advanced technologies like artificial intelligence, machine learning, the Internet of Things, and 5G connectivity will be extensively included in future ITS. Improved traffic management, dynamic decision-making, and real-time data collection will all be made easier by the developments.

References

[1] Ajayi, O. O., Bagula, A. B., Maluleke, H. C., & Odun-Ayo, I. A. (2021). Transport inequalities and adopting intelligent transportation systems in Africa: A research landscape. *Sustainability, 13*(22). https://doi.org/10.3390/su132212650

[2] Ang, L. M., Seng, K. P., Ijemaru, G. K., & Zungeru, A. M. (n.d.). Deployment of IoT for smart cities: Applications, architecture, and challenges. *IEEE Access*. https://ieeexplore.ieee.org

[3] Barba, C. T., Mateos, M. Á., Soto, P. R., Mezher, A. M., & Igartua, M. Á. (2013). Smart city for VANETs using warning messages, traffic statistics and intelligent traffic lights. *IEEE Xplore*. https://ieeexplore.ieee.org

[4] Box, G. E. P., Jenkins, G. M., & Reinsel, G. C. (1994). *Time series analysis: Forecasting and control* (3rd ed.). Prentice Hall.

[5] Brincat, A. A., Pacifici, F., Martinaglia, S., & Mazzola, F. (2019). The Internet of Things for intelligent transportation systems in real smart cities scenarios. In *Proceedings of the 2019 IEEE 5th World Forum on Internet of Things (WF-IoT)*. https://ieeexplore.ieee.org

[6] Cheng, J., Lei, M., & Jiang, R. (n.d.). JHCTECH® MEC equipment based on Intel® architecture accelerate V2X commercial deployment solution. *Business Contacts: Content Overview*.

[7] IEEE Xplore. (n.d.). A destination and mobility path prediction scheme for mobile networks. https://ieeexplore.ieee.org

[8] IEEE Xplore. (n.d.). Exploring trajectory prediction through machine learning methods. https://ieeexplore.ieee.org

[9] IEEE Xplore. (n.d.). Mobility-aware pre-caching based on an unsupervised deep generative model for small cell networks. https://ieeexplore.ieee.org

[10] IEEE Xplore. (n.d.). Mobility-aware proactive edge caching for connected vehicles using federated learning. https://ieeexplore.ieee.org

[11] Jamil, M. S., Jamil, M. A., Mazhar, A., Ikram, A., Ahmed, A., & Munawar, U. (2015). Smart environment monitoring system employs wireless sensor networks on vehicles for pollution-free smart cities. *Procedia Engineering, 107*, 480–488.

[12] Javed, M., Ben Hamida, E., & Zaidi, W. (2016). Security in intelligent transport systems for smart cities: From theory to practice. *Sensors, 16*(6). https://doi.org/10.3390/s16060879

[13] Jeung, H., Yiu, M. L., Zhou, X., & Jensen, C. S. (2010). Path prediction and predictive range querying in road network databases. *VLDB Journal, 19*(4), 585–602.

[14] Khalid, T., Khan, A. N., Ali, M., Adeel, A., Khan, A. U. R., & Shuja, J. (2018). A fog-based security framework for an intelligent traffic light control system. *Multimedia Tools and Applications, 78*(17).

[15] Khodaparastan, M., Mohamed, A. A., & Brandauer, W. (2019). Recuperation of regenerative braking energy in electric rail transit systems. *IEEE Transactions on Intelligent Transportation Systems, 20*(8), 3006–3014.

[16] Mateos, M. Á., Barba, C. T., Soto, P. R., Mezher, A. M., & Igartua, M. Á. (2013). Smart city for VANETS using warning messages, traffic statistics and intelligent traffic lights. *IEEE Xplore*. https://ieeexplore.ieee.org

[17] Noori, H. (2013). Modelling the impact of VANET-enabled traffic light control on the response time of emergency vehicles in a realistic, large-scale urban area. In *2013 IEEE International Conference on Communications Workshops (ICC)*.

[18] Sahu, K., & Srivastava, R. K. (2021). Predicting software bugs of new and large datasets through a unified neuro-fuzzy approach: Reliability perspective. *Advances in Mathematics: Scientific Journal, 10*(1), 543–555.

[19] Sahu, K., Srivastava, R. K., Kumar, S., Saxena, M., Gupta, B. K., & Verma, R. (2023). Integrated hesitant fuzzy-based decision-making framework for evaluating sustainable and renewable energy. *International Journal of Data Science and Analytics, 16*(3), 233–245.

[20] Singh, P. K., Nandi, S. K., & Nandi, S. A. (2019). Survey on vehicular communication: State of the art and future research directions. *Vehicular Communications, 18*. https://doi.org/10.1016/j.vehcom.2019.100164

[21] Soyturk, M., Muhammad, K. N., Avcil, M. N., Kantarci, B., & Matthews, J. (2023). From vehicular networks to vehicular clouds in smart cities. In *Smart Cities and Vehicular Technologies* (Ch. 8). *ScienceDirect*.

[22] Utilities One. (2024). Telecommunications and smart traffic management systems. https://utilitiesone.com/telecommunications-and-smart-traffic-management-systems#

[23] Vani, R., Thendral, N., Kavitha, J. C., & Bhavani, N. P. G. (2018). Intelligent traffic control system with priority to emergency vehicles. *IOP Conference Series: Materials Science and Engineering, 455*, 012034.

[24] Zhang, C., & Patras, P. (2018). Long-term mobile traffic forecasting using deep spatiotemporal neural networks.