E-ISSN: 2583-9667
Indexed Journal
Peer Reviewed Journal
https://multiresearchjournal.theviews.in

Received: 03-07-2023
Accepted: 10-08-2023

INTERNATIONAL JOURNAL OF ADVANCE RESEARCH IN MULTIDISCIPLINARY

Volume 1; Issue 1; 2023; Page No. 210-215

Design and implementation of intelligent transportation system to improve safety and security

[1]Satnam Singh and [2]Dr. Inderpal Singh Oberoi

[1]Research Scholar, Department of Computer Application, Maharaja Agrasen Himalayan Garhwal University, Uttarakhand, India
[2]Assistant Professor, Department of Computer Application, Maharaja Agrasen Himalayan Garhwal University, Uttarakhand, India

Corresponding Author: Satnam Singh

Abstract

The rapid urbanization and increasing population density in modern cities have led to a growing demand for efficient and sustainable public transportation systems. To address this challenge, the integration of wireless sensor networks (WSNs) with public transportation infrastructure has emerged as a promising solution. This paper presents an introductory design for a Wireless Sensor Network-Based Intelligent Public Transportation System (WSN-IPTS), which aims to enhance the overall quality, safety, and reliability of public transportation services.

Keywords: Design, wireless sensor network, intelligent, public transportation system

Introduction

Modern urban areas face the dual challenge of providing efficient transportation services while minimizing environmental impact. Conventional public transportation systems often struggle to meet the demands of a rapidly growing population, resulting in issues such as congestion, delays, and inadequate service quality. The convergence of wireless sensor network technology with public transportation offers an innovative approach to address these challenges.

The design of a WSN-based ITS typically involves the following steps

1. **Sensor selection:** The type and number of sensors to be used in the WSN depends on the specific application. For example, a WSN for tracking buses may need to include sensors to measure the bus's location, speed, and direction.
2. **Network topology:** The network topology refers to the way the sensors are connected to each other. The most common network topologies for WSNs are star, mesh, and tree.
3. **Routing protocol**: The routing protocol is used to determine the path that data takes through the network. The most common routing protocols for WSNs are flooding, hierarchical routing, and ad hoc routing.
4. **Data fusion:** Data fusion is often used in WSN-based ITS to track the movement of vehicles or to monitor traffic conditions.
5. **Security:** WSNs are vulnerable to security attacks, such as data tampering and denial-of-service attacks. It is important to implement security measures to protect the WSN from these attacks.

The design of a WSN-based ITS is a complex task that requires careful consideration of the specific application. However, WSNs offer a number of advantages over traditional ITS technologies, such as their scalability, flexibility, and low cost.

Existing ITS System

There are many existing ITS systems in use around the world. Here are some examples.

Advanced traffic management systems (ATMS)

ATMS employ sensors, cameras, and various technologies to oversee traffic conditions and enhance traffic flow. This entails tasks such as adapting traffic signals, furnishing drivers with real-time traffic updates, and coordinating responses to incidents.

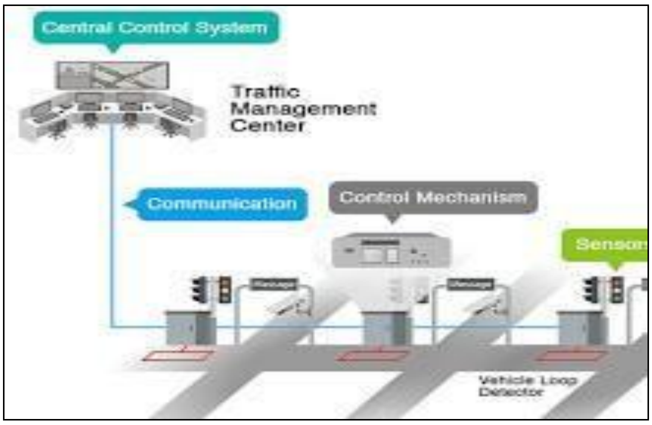

Fig 1: Advanced traffic management systems (ATMS) ITS system

Intelligent transportation systems (ITS): ITS is a broader term that encompasses a variety of technologies that can be used to improve the efficiency, safety, and sustainability of transportation. This can include things like electronic toll collection, bus tracking, and parking guidance systems.

Fig 2: Intelligent transportation systems (ITS) ITS system

Automatic vehicle location (AVL) systems: AVL systems use GPS or other technologies to track the location of vehicles in real time. This information can be used for a variety of purposes, such as monitoring fleet operations, providing real-time passenger information, and optimizing traffic signals.

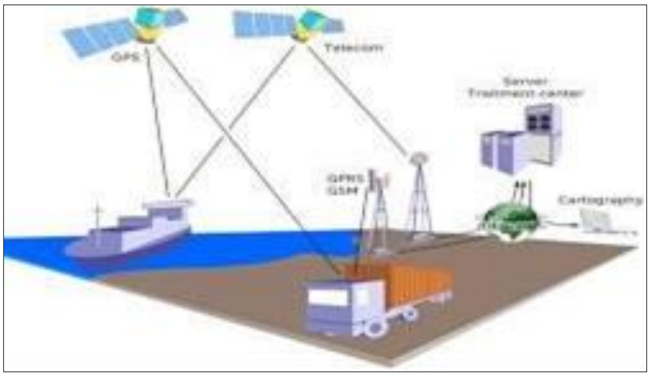

Fig 3: Automatic vehicle location (AVL) systems ITS system

Electronic road pricing (ERP) systems: ERP systems charge drivers a fee to use certain roads or at certain times. **This can be used to reduce congestion and pollution**

Fig 4: Electronic road pricing (ERP) systems ITS system

Intelligent speed adaptation (ISA) systems: ISA systems use sensors to monitor a vehicle's speed and provide feedback to the driver to encourage them to drive at a safe speed.

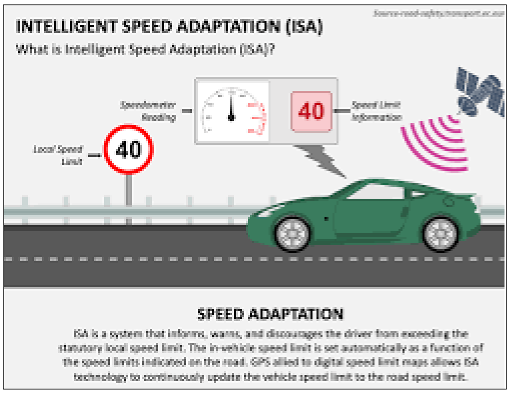

Fig 5: Intelligent speed adaptation

These are just a few examples of the many existing ITS systems. As technology continues to develop, we can expect to see even more innovative ITS solutions being implemented in the future.

Future of ITS systems

The future of ITS systems is bright. As technology continues to develop, we can expect to see even more innovative ITS solutions being implemented in the future. Here are some of the trends that are expected to shape the future of ITS systems:

- The rise of connected and autonomous vehicles: The term "connected vehicles" refers to vehicles equipped with sensors and communication devices that enable them to exchange data with each other and with infrastructure. "Autonomous vehicles," on the other hand, are vehicles capable of operating without human intervention. When combined, these technologies have the potential to significantly enhance transportation by improving safety, efficiency, and sustainability.
- The use of artificial intelligence (AI) and machine learning: Implementing artificial intelligence (AI) and machine learning in Intelligent Transportation Systems (ITS) facilitates the development of innovative applications. These technologies aid in enhancing traffic flow, preventing accidents, and optimizing fleet

operations. For instance, AI can analyze traffic data to pinpoint potential congestion areas and forecast traffic patterns, while machine learning can enable the creation of algorithms for automatic detection and response to traffic incidents.

- The development of new infrastructure: New infrastructure, such as smart roads and traffic signals, is being developed to support the deployment of ITS systems. Smart roads are roads that are equipped with sensors and communication devices that can collect data about traffic conditions and infrastructure. Traffic signals can be equipped with sensors that can detect the presence of vehicles and adjust the signal timing accordingly.
- The growth of the sharing economy: The sharing economy is a trend where people share goods and services, such as cars, bikes, and homes. The sharing economy has the potential to reduce traffic congestion and emissions by providing people with more transportation options.
- The increasing focus on sustainability: There is a growing focus on sustainability in transportation. ITS systems can be used to promote sustainability by encouraging people to adopt more fuel-efficient driving habits and by providing information about public transportation options.
- These trends merely scratch the surface of what lies ahead for ITS systems. With ongoing technological advancements, we anticipate a proliferation of innovative ITS solutions in the future. These solutions are poised to enhance transportation by bolstering safety, efficiency, and sustainability.

Impact on Road User: The impact of ITS on road users can be both positive and negative.

Positive impacts

- **Improved traffic flow**: ITS systems can help to improve traffic flow by optimizing the use of road space and reducing congestion. This can lead to shorter travel times and less fuel consumption.
- **Increased safety:** ITS systems can help to increase safety by providing real-time information to drivers and by monitoring the performance of vehicles and infrastructure. This can help to prevent accidents and reduce the severity of accidents that do occur.
- **Reduced emissions**: ITS systems can help to reduce emissions by optimizing traffic flow and by encouraging drivers to adopt more fuel-efficient driving habits. This can help to improve air quality and reduce greenhouse gas emissions.
- **Improved accessibility:** ITS systems can help to improve accessibility by providing real-time information to people with disabilities and by providing transportation options that are more convenient and affordable. This can make it easier for people with disabilities to get around and can help to reduce social isolation.

Negative impacts

- **Cost:** ITS systems can be expensive to implement and maintain. This can be a barrier to adoption, especially in developing countries.
- **Privacy:** ITS systems collect a lot of data about drivers and vehicles, which raises privacy concerns. Drivers may be reluctant to use ITS systems if they are concerned about their privacy.
- **Complexity:** ITS systems are complex and can be difficult to manage. This can lead to problems such as system outages and data errors.
- **Acceptance:** ITS systems need to be accepted by drivers and the public in order to be successful. If drivers and the public do not trust or understand ITS systems, they may not use them.

Overall, the impact of ITS on road users is likely to be positive. However, there are some potential negative impacts that need to be considered. It is important to carefully evaluate the potential benefits and risks of ITS systems before they are implemented.

Here are some specific examples of how ITS can impact road users

- **Real-time traffic information:** ITS can provide real-time traffic information to drivers, such as the location of traffic congestion and accidents. This information can help drivers to make better decisions about their routes and to avoid traffic congestion.
- **Intelligent speed adaptation (ISA) systems:** ISA systems use sensors to monitor a vehicle's speed and provide feedback to the driver to encourage them to drive at a safe speed. This can help to reduce speeding and accidents.
- **Automatic emergency braking (AEB) systems:** AEB systems use sensors to detect obstacles in front of a vehicle and automatically apply the brakes if the driver does not react in time. This can help to prevent or reduce the severity of rear-end collisions.
- **Connected vehicles:** Connected vehicles are vehicles that are equipped with sensors and communication devices that allow them to share information with each other and with infrastructure. This information can be used to improve traffic flow, prevent accidents, and optimize fleet operations.

These examples offer a glimpse into the profound impact ITS can have on road users. With the relentless advancement of technology, we anticipate a proliferation of innovative ITS solutions in the coming years. These advancements hold the promise of transforming transportation, enhancing safety, efficiency, and sustainability alike.

Reducing traffic accidents

Intelligent transportation systems (ITS) can be used to reduce traffic accidents in a number of ways. Here are some examples:

- **Real-time traffic information:** ITS can provide real-time traffic information to drivers, such as the location of traffic congestion and accidents. This information can help drivers to make better decisions about their routes and to avoid traffic congestion. This can help to reduce speeding and accidents.
- **Intelligent speed adaptation (ISA) systems:** ISA

systems use sensors to monitor a vehicle's speed and provide feedback to the driver to encourage them to drive at a safe speed. This can help to reduce speeding and accidents.
- **Automatic emergency braking (AEB) systems:** AEB systems use sensors to detect obstacles in front of a vehicle and automatically apply the brakes if the driver does not react in time.

This can help to prevent or reduce the severity of rear-end collisions
- **Collision warning systems:** Collision warning systems use sensors to detect potential collisions and warn the driver. This can help drivers to take corrective action and avoid collisions.
- **Lane departure warning systems:** Lane departure warning systems use sensors to detect when a vehicle is about to drift out of its lane. This can help drivers to stay in their lane and avoid accidents.
- **Blind spot monitoring systems:** Blind spot monitoring systems use sensors to detect vehicles in the driver's blind spots. This can help drivers to avoid accidents when changing lanes or merging.
- **Connected vehicles:** Connected vehicles are vehicles that are equipped with sensors and communication devices that allow them to share information with each other and with infrastructure. This information can be used to improve traffic flow, prevent accidents, and optimize fleet operations.

These represent merely a fraction of how ITS contributes to the mitigation of traffic accidents. With the continuous evolution of technology, we foresee a plethora of innovative ITS solutions being integrated in the years to come. These advancements are poised to not only enhance safety but also elevate the efficiency and sustainability of transportation systems.

Here are some specific examples of how ITS has been used to reduce traffic accidents
- In the United States, a study by the National Highway Traffic Safety Administration (NHTSA) found that AEB systems can reduce rear-end collisions by up to 50%.
- In Sweden, a study by the Swedish Transport Agency found that ISA systems can reduce speeding by up to 20%.
- In the Netherlands, a study by the Dutch Ministry of Infrastructure and Water Management found that connected vehicles can reduce traffic accidents by up to 80%.

These studies show that ITS has the potential to significantly reduce traffic accidents. However, more research is needed to fully understand the impact of ITS on road safety.

In addition to the technical solutions mentioned above, there are also a number of non-technical measures that can be taken to reduce traffic accidents. These measures include
- **Improving driver education:** Driver education programs can teach drivers about the importance of safe driving practices, such as following the speed limit, avoiding distractions, and using turn signals.
- **Enforcing traffic laws:** Traffic laws should be enforced consistently and fairly to deter drivers from breaking the law.
- **Making roads safer:** Roads can be made safer by installing safety features such as traffic calming devices, guardrails, and wider shoulders.
- **Addressing the underlying causes of accidents:** The underlying causes of accidents, such as drunk driving and distracted driving, need to be addressed to reduce the number of accidents.

Through a comprehensive approach to traffic safety, we can decrease accidents, ensuring safer roads for all.

Minimize Secondary Impacts of ITS

The secondary impacts of ITS can be minimized by carefully considering the potential impacts of ITS systems before they are implemented. Here are some specific examples of how to minimize the secondary impacts of ITS:
- **Privacy:** ITS systems collect a lot of data about drivers and vehicles, which raises privacy concerns. To minimize privacy concerns, ITS systems should be designed to protect the privacy of drivers and vehicles. This can be done by using anonymized data or by encrypting data.
- **Complexity:** ITS systems are complex and can be difficult to manage. To minimize complexity, ITS systems should be designed to be as simple as possible. This can be done by using standardized protocols and by using off-the-shelf components.
- **Acceptance:** ITS systems need to be accepted by drivers and the public in order to be successful. To increase acceptance, ITS systems should be designed to be user-friendly and to provide clear benefits to drivers and the public.
- **Security:** ITS systems are vulnerable to security attacks. To minimize security risks, ITS systems should be designed to be secure. This can be done by using encryption, authentication, and authorization mechanisms.
- **Environmental impacts:** ITS systems can have environmental impacts, such as the production of electronic waste. To minimize environmental impacts, ITS systems should be designed to be environmentally friendly. This can be done by using sustainable materials and by using energy-efficient technologies.

By carefully considering the potential impacts of ITS systems, we can minimize the secondary impacts of ITS and make ITS systems more beneficial to society.

Here are some additional tips for minimizing the secondary impacts of ITS
- **Involve stakeholders:** Stakeholders, such as drivers, transportation agencies, and privacy advocates, should be involved in the design and implementation of ITS systems. This will help to ensure that the systems are designed to meet the needs of all stakeholders and that the potential impacts are minimized.

- **Conduct research:** Research should be conducted to understand the potential impacts of ITS systems. This research can help to identify potential risks and to develop mitigation strategies.
- **Monitor and evaluate:** ITS systems should be monitored and evaluated to assess their impacts. This will help to identify any unintended consequences and to make adjustments to the systems as needed.

By following these tips, we can minimize the secondary impacts of ITS and make ITS systems a force for good in society.

Existing Versus future system

Table 1 compares the approximate number of ITS systems that are now deployed around the nation with the number of systems that are planned for the future. The current figures are approximations because construction causes them to fluctuate. Since the bulk of ITS designs are either incomplete or inaccessible, exact quantities of ITS devices could not be calculated for all systems. However, Table 1 gives a general notion of how the systems (Expressways, Arteries, etc.) are deployed and positioned.

Table 1: Khaled Shaaban *et al*. Transportaion research procsidia 55 (2021) 1373-1380

ITS System	Existing*	Future
Traffic Signal Systems	≈ 30 intersections	Every intersection on arterial and major collector roads
CCTV Cameras	≈ 140 Cameras	Deployment plans are to cover the roadway network (all intersections and roads. Exact numbers are not available.
Dynamic Message Signs	≈ 40 signs	Deployment plans are to cover all major decision points on expressways and arterial roads. Exact numbers are not available.
Lane Control Signs	≈ 30 Sets	Deployment plans are to cover all major decision points on expressways and arterial roads. Exact numbers are not available.
Weigh-in-Motion	6 WIM systems	70 WIM systems
Over-height Vehicle Detection	25 OVDS systems	65 OVDS systems
Road Weather Information System	None	21 Systems

Future work

The future work on ITS is vast and exciting. Here are some of the areas that are being explored:

- **Connected vehicles:** Connected vehicles are vehicles that are equipped with sensors and communication devices that allow them to share information with each other and with infrastructure. This information can be used to improve traffic flow, prevent accidents, and optimize fleet operations.
- **Autonomous vehicles:** Autonomous vehicles are vehicles that can operate without human input. The combination of connected and autonomous vehicles has the potential to revolutionize transportation by making it safer, more efficient, and more sustainable.
- **Artificial intelligence (AI) and machine learning:** AI and machine learning are being used to develop new ITS applications that can improve traffic flow, prevent accidents, and optimize fleet operations. For example, AI can be used to analyze traffic data to identify potential congestion hotspots and to predict traffic patterns. Machine learning can be used to develop algorithms that can automatically detect and respond to traffic incidents.
- **Big data analytics:** Big data analytics can be used to analyze large amounts of data collected from ITS systems to identify trends and patterns that can be used to improve transportation. For example, big data analytics can be used to identify areas where traffic congestion is likely to occur and to develop strategies to mitigate it.
- **5G and beyond:** 5G and beyond wireless technologies will provide the high-speed, low-latency connectivity that is needed to support the development of connected and autonomous vehicles.
- **Public-private partnerships:** Public-private partnerships can be used to finance and implement ITS projects. These partnerships can bring together the resources and expertise of both the public and private sectors to accelerate the development and deployment of ITS solutions.

These are just a few of the areas that are being explored for future work on ITS. As technology continues to develop, we can expect to see even more innovative ITS solutions being developed and implemented in the future. These solutions will help to make transportation safer, more efficient, and more sustainable.

Here are some specific examples of future work on ITS

- **Developing new algorithms for traffic flow optimization:** Researchers are working on developing new algorithms that can be used to optimize traffic flow. These algorithms will take into account the real-time data collected from connected vehicles and infrastructure to make better decisions about traffic signal timing and other traffic management measures.
- **Improving the safety of autonomous vehicles:** Researchers are working on improving the safety of autonomous vehicles. This includes developing new sensors and algorithms that can detect and avoid obstacles, as well as developing new ways to ensure that autonomous vehicles behave safely in all situations.
- **Using big data analytics to improve transportation:** Researchers are using big data analytics to improve transportation. This includes using big data to identify traffic patterns, predict congestion, and optimize fleet operations.

Developing new wireless technologies for ITS: Researchers are developing new wireless technologies that can be used to support ITS applications. This includes developing 5G and beyond wireless technologies that can provide the high-speed, low-latency connectivity that is needed for connected and autonomous vehicles.

Building public-private partnerships for ITS

Researchers are working on building public-private partnerships for ITS. These partnerships can bring together the resources and expertise of both the public and private sectors to accelerate the development and deployment of ITS solutions.

These are just a few of the areas that are being explored for future work on ITS. As technology continues to develop, we can expect to see even more innovative ITS solutions being developed and implemented in the future. These solutions will help to make transportation safer, more efficient, and more sustainable.

Conclusion

Intelligent Transportation Systems (ITS) represent a diverse range of technologies aimed at enhancing transportation efficiency, safety, and sustainability. Current ITS infrastructure includes advanced traffic management systems (ATMS), automatic vehicle location (AVL) systems, and electronic road pricing (ERP) systems. Looking ahead, the evolution of ITS is poised to leverage emerging technologies such as connected vehicles, autonomous vehicles, artificial intelligence (AI), and machine learning.

The ongoing advancements in ITS are driving extensive research efforts towards optimizing traffic flow algorithms, enhancing autonomous vehicle safety, leveraging big data analytics for transportation improvement, and developing innovative wireless technologies. Moreover, fostering collaborative public-private partnerships is crucial in realizing the full potential of ITS initiatives.

As technology continues to progress, we anticipate the emergence of even more groundbreaking ITS solutions. These innovations hold the promise of not only enhancing transportation safety and efficiency but also fostering sustainability. By embracing these advancements, we can envision a future where transportation systems are safer, more efficient, and environmentally friendly, ultimately improving the quality of life for all.

References

1. Feng Z, Liudong L, Yang Y. The transportation accessibility evaluation of China: from Province to Prefecture. Geographic Research. 2009;28(2):419-429.
2. Liu B, Tao H, Liu S, Shi Z, Guo S. The Transportation Accessibility of Measuring Model and Cases Study in Mountainous Areas. Geographic Development. 2011;30(6):733-738.
3. Zhang H, Zhang J, Cao J, Liu C, Wang L. The Tourism Developing Potential in Jiangsu Province Based on Transportation Accessibility and Tourism Resources. Journal of Nanjing University; page range.
4. Song Q, Liu W, Qiao J, Xiao Y. The Regional Transportation Accessibility Model Research and Study based on GIS. Journal of Jilin University. 2006;36:182-184.
5. Bai Y, Wu C, Chen B. The Transportation Accessibility Model and Analysis in Areas of Complex Terrain taking the example of economic belt of Tianshan Beipo. Geography and Geographic Information Science. 2013;29(1):74-79.
6. Chen S, Zhang H, Mu G. The Tourism Transportation Network Analysis of the Six Capital Cities of Six Provinces Which Have Tourism Cooperation in the Middle Areal. Journal of Henan University (Natural Science Publication). 2009;39(3):275-279.
7. Li E, Sun H, Li G, Bao F. Tourism Roads Development Methods and Study in Underdeveloped Areas---taking the example of tourism roads analysis in loess plateau of Northern Shanxi province. Tourism. 2005;19(4):6-10.
8. Wei L, Cong Y. The Mechanism Analysis of the Influences on Transportation Space and Pattern by High-speed Rails in Big Cities taking the example in big cities of Beijing, Tianjing and Tangshan. Geographic Economy. 2004;24(6):384-387.
9. Cao X, Xue D, Yan X. City Accessibility of Main Road Lines Net in China. Journal of Geography. 2005;60(6):903-910.
10. Jin F, Wang J. The Expansion and Special Accessibility of Railways in China of the 20th Century. Geographic Journal. 2004;59(2):293-302.
11. Sun L. The Influence Study of Highway on the Transportation Accessibility of Capital City. Economic Observation.
12. Zhang L, Lu Y. Regional Accessibility Evaluation Based on Continental Transportation Network----taking the example of Yangtze River Delta. Geographic Journal; page range.
13. Ding P, Zhang J, Wei J. Special Structure Study of Tourism Resources in Wuhu city. Journal of Xuchang College. 2013;32(5):125-130.
14. Li Y. The Comprehensive Evaluation and Study of Traffic Advantages in Liaoning Province. [Master’s thesis, Liaoning Normal University].
15. O. Sullivan D, Morrison A, Shearer J. Using desktop GIS for the Investigation of Causality by Public Transport: an isochrones Approach. International Journal of. 2000(1):85-94.