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# Internet of Things (IoT) in Intelligent Transportation Systems: Benefits and Challenges of Implementation

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**Abstract**: This study examines intelligent transportation systems and evaluates the applications of the Internet of Things technology in intelligent transportation systems. Moreover, this study discusses the many challenges and benefits of the functionalization of the Internet of Things (IoT) in intelligent transportation systems. Based on the increasing demands of transportation development, the concept of an intelligent transportation system and Internet of Things technology has received increasing attention both in the academic and transportation industries. The increase in traffic accidents in transportation and the lengthening of travel times have led to the emergence of the need for IoT. Developing a sustainable intelligent transportation system requires seamless integration and interoperability with emerging technologies such as connected IoT and vehicles. IoT in intelligent transportation systems decreases the number of vehicles in traffic and reduces harmful gas emissions. Intelligent transportation systems play a key role in increasing traffic safety, optimizing existing road capacity, and reducing delay times. In addition, it contributes to the country's economy and the environment by reducing the inefficient use of time and energy. The IoT in intelligent transportation systems will be one of the most important competitive elements for all countries. This study sheds light on IoT technology in intelligent transportation systems and points out possible future research directions.

**Keywords:** Internet of Things, Intelligent transportation systems, Benefits, Challenges.

## Introduction

Nowadays, IoT technologies are assumed to be one of the key pillars of the fourth industrial revolution because of their significant potential for innovation and useful benefits for the population. Intelligent transportation systems are a rapidly developing concept within the framework of sustainability and IoT worldwide, especially in countries such as the United States, Netherlands, Sweden, Japan, Canada, Singapore, Germany, United Kingdom, Australia, France, and South Korea. New-generation technology in transportation facilitates a range of revolutionary implementations. This technology is designed to solve operating problems on highways and improve service quality. It has been enriched with different transportation modes, such as airports, ports, and subways, over time. With the rapid development of the Intelligent Transportation System, transportation infrastructure has significant potential, and due to the widespread demand for services associated with transportation cheaper, sustainable, efficient, and safer (Camacho et al., 2018).

IoT can modify the business processes, strategies, and competencies across the transportation sector through a new computing paradigm. Through the adoption of IoT, objects, and machines may correspond with each other, locate, sense, and control via the global platform (De Vass et al., 2018). The Internet of Things (IoT) brings a new era to transportation systems. Nowadays smart devices collect and enhance important data over the Internet and also connect the devices to intelligent transportation (Muthuramalingam et al., 2019). Recently, transportation modes have changed greatly, and the concept of the internet of vehicles has come to the fore. Thus, transportation infrastructures must be developed to adapt to certain vehicle technologies. Smart vehicles are a concept that is integrated into the Internet of Things technology and focuses on optimization (Shen et al., 2020). Using the IoT will increase driving comfort and safety. In addition, this technology will collect data on

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the vehicle and provide information in areas such as fuel filling, early detection of possible malfunctions, and regular maintenance indicators. IoT prevents collisions with autonomous vehicles and greatly reduces transportation problems (Nižetić et al. 2020). It has helped reduce accidents, especially by simultaneously monitoring the location and directions of autonomous vehicles from security systems (Bylykbashi et al., 2020).

The motive of our research is to define the breadth, depth, and diversity of present research IoT in intelligent transportation. As a result, an enormous number of research publications in journals and conferences are based on IoT in intelligent transportation. This paper presents an overview of IoT in intelligent transportation applications and explores its benefits and challenges. It is organized to give a big picture of IoT applications in intelligent transportation.

## Literature Reviews

### Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) is an emerging transportation construction that incorporates real-time information and corresponds between passengers, roads, and vehicles. The fundamental goals of ITS have been focused firstly on these applications presenting a large amount of information while increasing safety and improving mobility and efficiency. In addition, it is now well-known that ITS can be used to decrease transportation-related environmental impacts. Intelligent transportation is a framework that enhances sustainability and public transportation and optimizes modes of transportation (Papadimitratos et al., 2009).

The concept of ITS has witnessed remarkably enhanced applications in recent years, with traffic information systems, driver control systems, intelligent vehicle parking systems, traffic monitoring systems, longitudinal assistance systems, and lateral assistance systems (Barth et al., 2015). This technology is combined with advancement utilizing equipment, PCs, communications, and impelled sensors. ITS has been designed and implemented in many countries such as the U.S., Japan, and Europe (Camacho et al., 2018).

Japan is the first country Which conducts intelligent transportation system applications in the world. This country has developed intelligent transportation systems that focus on reducing traffic congestion and increasing traffic safety and fuel efficiency (Suryadithia et al. 2021). Intelligent transportation systems in the U.S. were first established between 1960 and 1970 to ensure effective communication between vehicles and roads. It developed in the 1980s with the cooperation of the public and private sectors. Intelligent transportation systems in the U.S. vary by state, and no integration covers the entire country. The most important element is that intelligent transportation systems should not be seen as a national strategy. Canada has broken new ground in intelligent transportation system technology. The first computer-controlled traffic signal system in the world was implemented in 1959. The full electronic toll system was applied worldwide in Canada in 1999 (Al-Dweik et al., 2017).

Table 1. Benefits of ıntelligent transportation systems

| **Benefits** | **References** |
|---|---|
| Improving safety<br>Increasing traffic accidents<br>Reducing environmental impacts<br>Enhancing mobility<br>Improving transportation efficiency<br>Decreasing energy consumption<br>Real-time information<br>Selecting the optimal routes in the roadway network<br>Spreading out the peak traffic volume<br>Reducing greenhouse gas emissions<br>Managing travel demand<br>Estimating traffic flow<br>Promoting and increasing the use of public transportation | Barth et al. (2015), Ran et al. (2012), Camacho et al. (2017), Haynes et al. (2000), Shaaban et al., (2021) and Cheng et al.(2020). |

The history of intelligent transportation system applications in Australia dates back to the 1970s. Australia has focused on road transportation and is expected to gain economic benefits by increasing investments in intelligent transportation systems because of geographical factors to ensure efficiency (Chowdhury et al., 2020). Today, route guidance and communication systems called navigation have been implemented as the Electronic

Route Guidance System in the USA (1969), the Comprehensive Automobile Control System in Japan (1973), and the Driver Radio Broadcast Information System in Germany (1974). The transition to intelligent transportation systems in Turkey began in 1992 with the implementation of automatic toll payment systems on highways (Bıyık & Yigitcanlar, 2020).

The International Intelligent Transportation Systems Congress held in Paris in 1994 is recorded in history as an example of the first steps in the formation of worldwide standards. Singapore is among the leading cities in traffic congestion. The average vehicle speed in Singapore was measured at 27 km/h, compared to an average speed of 16 km/h in London and 11 km/h in Tokyo. This country proposes to reduce traffic congestion by utilizing an Electronic Road Pricing system, where tolls vary according to traffic flow, The Highway Monitoring and Advisory System warns drivers of traffic accidents on main roads (Muthuramalingam et al., 2019).

**Internet of Things (IoT)**

IoT is a dynamic network structure that proposes to confederate the physical and the virtual fields by utilizing the internet as the medium for communication and transmission of data (Balaji et al., 2019). The concept of the "Internet of Things" was first founded by Ashton (1999). Since then this technology began to be used effectively in the medicine, industry, agriculture, and defense sectors and paved its way into our day-to-day lives. IoT applications software authorizes interaction between devices, and human-to-device communications modes are reliable and decisive (Lee et al., 2022). This application is a combination of managing sensor data calculating data analytics and arranging the traffic system effectively (Muthuramalingam et al., 2019).

Table 2. Benefits of IoT Applications

| **Benefits** | **References** |
|---|---|
| Providing competitive advantage<br>Increasing proactivity<br>Ensuring a good planning strategy<br>Decreasing the costs<br>Having more control over operations<br>Synchronizing information flow with physical flow<br>Boosting the ability to supply chain integration<br>Rising transparency and visibility of data<br>Improving life quality<br>Enhancing customer satisfaction | Nižetić et al. (2020), Selvaraj and Sundaravaradhan (2020), Reyna et al. (2018), Narasimha Swam (2016), Zikria et al. (2021), Yao et al. (2021), Nayak et al. (2016), Balaji et al. (2019), Porkodi and Bhuvaneswari (2014) and Lee et al. (2022). |

Shaaban et al. (2021) identified the challenges of IoT applications such as the cultural structures of countries, stakeholder coordination, and integrating existing systems. On the other hand, Camacho et al. (2018) categorized the challenges in IoT applications as strategic challenges, system capabilities challenges, legal challenges, organizational challenges, and standardization challenges. One of the IoT challenges is the development of different tools for monitoring network operations. (Kakkavas et al. 2020). Additionally, several IoT problems exist, such as security issues related to IoT networks, software errors, and maintenance demands of IoT networks (Almusaylim et al., 2020).

The slowest Wi-Fi speeds are found in Latin America, the Middle East, and Africa, which also prevents the effective use of IoT. Moreover, another challenge in IoT is data privacy. Since all data transferred from source to destination is transported on the internet, it is very difficult to ensure data security. There is a lack of a standard in the field of IoT. Connecting devices to the internet via IoT is expected to increase in the next years. Managing large numbers of devices over various networks will become harsher. Also, IoT infrastructure is significantly crucial in that when new devices are added to the system, current devices running on the existing infrastructure should not be affected (Lee & Lee, 2015).

**Internet of Things Technology (IoT) in Intelligent Transportation Systems**

ITS' purpose is to recompose the transaction of vehicles, administrate vehicle traffic, and assist drivers with security. The development of IoT in intelligent transportation systems depends on the interaction between objects, vehicles, machines, and infrastructure (Martínez-Torres et al., 2013).

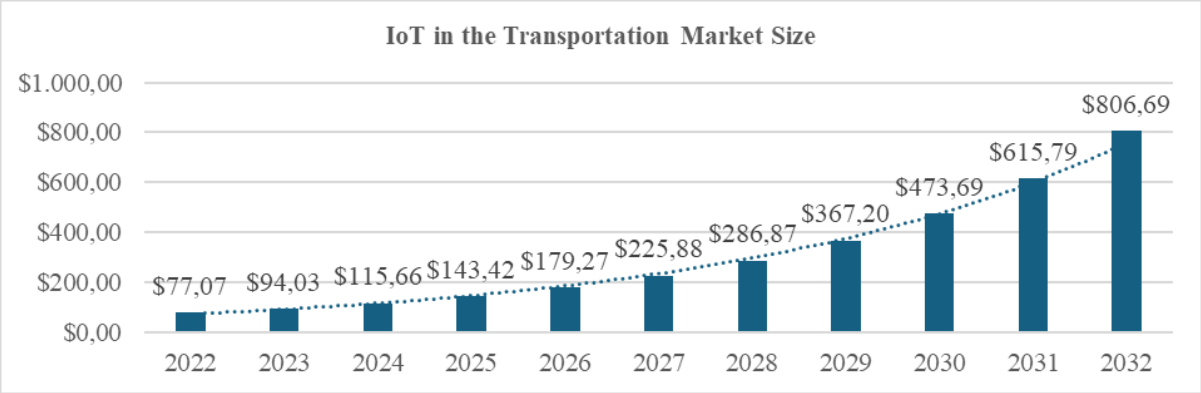


Figure 1. IoT in the transportation market size

According to Figure 1, it is predicted that IoT applications will gradually increase between 2022-2032. IoT in transportation market size is expected to increase by approximately 10.5 times from $77.07 in 2022 to $806.69 in 2032 (Precedence Statistics, 2024).

Table 3. IoT applications in ıntelligent transportation systems literature reviews

| **References** | **Results** |
|---|---|
| Kaluvan et al. (2021) | IoT-based techniques provide the traffic flow data using machine learning algorithms. These data help to calculate travel time estimation, optimum route planning, and traffic forecasting. |
| Guevara and Auat Cheein (2020) | IoT will be characterized by the widespread in intelligent transportation services: anywhere, anytime, via any device. 5G technology is projected to enable brand-new classes. |
| Srinivas et al. (2020) | The data collected in the IoT-based ITS environment has a colossal volume. These data are analyzed to provide information flow to passengers and lead to an increase in the safety, capability, and security of the transportation system. |
| Luo et al. (2019) | IoT in intelligent transport systems assists a new framework for public transport for consubstantiating the scheduling problems of subway, bus, and shared taxi. |
| Muthuramalingam et al. (2019) | IoT-based Intelligent transportation system helps automate railway, road, air, and sea transportation which increases customer experience. |
| Salazar-Cabrera et al. (2019) | IoT applications in Intelligent Transportation Systems can solve mobility issues in cities, decrease traffic accidents, and improve tracking systems for public transport vehicles. |
| Chand and Karthikeyan(2018) | The IoT device collects, stores, and processes faster way of traffic information, which solves optimizing traffic problems. IoT improves the performance of intelligent transportation management. |
| Dubey et al. (2017) | The IoT data acquired from different lanes are examined and inspected by the Traffic Control Office from one place in the Intelligent Transport System. Thus, it reduces waiting times and pollution in traffic and increases traffic efficiency. |

## Results and Discussion

IoT technology and intelligent transportation systems integration provide detailed information to both passengers and drivers about the current empty-full or free-paid status in vehicle parks (Muthuramalingam et al., 2019). Route Guidance Systems considerably developed in a diversity of forms involving on-board, off-board,

and smartphone-based systems. It can cut back on redundant travel that emerges when a driver gets lost or selects along. Moreover, IoT technology and intelligent transportation systems integration utilize geographic and real-time traffic information and can elect optimal routes in a roadway network between destinations (Srinivas et al., 2020).

Computer vision technology and other sensors coupled with wireless communications in IoT-based intelligent transport systems are utilized to ensure lane departure warnings and alert drivers of pending lateral collisions. IoT based on intelligent transport systems is an effective technology for early detection in returning traffic operations to normal as quickly as possible after traffic accidents occur (Kumar et al., 2020). Furthermore, Electronic Payment Systems are becoming more widespread day by day in many countries. It allows the driver to pay tolls without stopping the vehicle. These systems aim to reduce travel time, travel distance, and GHG emissions. Moreover, they play a key role in reducing traffic accidents and traffic congestion (Barth et al., 2015).

The geographical location of the vehicle, parking availability, pre-reservation information, parking lot location, details about the vehicle, and current traffic information is collected in real-time through sensors used in the intelligent vehicle parking system (Vaidya et al., 2021). Geo-location systems are integrated with route guidance systems to convince drivers to find specific destinations, cutting down on extravagant driving (Srinivas et al., 2020). The Microwave radar delivers signals in the recognition district and receives the reflected signals from public transportation. This signal is conducted to determine the speed and direction of the vehicles (Peng et al., 2016).

Sensors in Longitudinal Assistance Systems are used to monitor headways between vehicles and provide feedback to the vehicle's braking system. These systems not only allow the driver to choose the desired speed but also empower them to adjust the following distance and encumber front and rear collisions (Ouallane et al., 2022). Lateral Assistance Systems are deliberated to develop the performance of vehicles during lane changes, merges, or any type of turning movement. By placing temperature and humidity sensors in public transportation, after a specific threshold it may automatically shift the air conditioner on through a relay cycle or it can point out the driver to switch on the air conditioner because of the intense temperature in the vehicle (Bojan et al., 2014).

The smart station contains appliances agglomerating the dynamic road traffic status and passenger flow around the vehicles. When a smart station defines the approach of a vehicle, it is acquainted with the Radio Frequency Identification (RFID) tags on the bus, train, vessel, and airplane that correspond with them, and admit data from the vehicle. Passengers can learn all schedules in the system via wireless stations like smartphones, which can present geographical location data. Shared taxis utilize smart tools to get the signal from the satellite and engage the control and scheduling center (Luo et al., 2019).

Some sub-system of transportation based on IoT has the capability of self-coordination and self-autonomy, which may diminish the amount of data transmission. For instance, an intelligent traffic light controller comprehends the approaches of vehicles at a crossroads and adjusts the times of traffic signal stages. An automatic passenger counter on vehicles senses the existence of passengers, calculates the number of passengers by using its set identification algorithm, and forwards the evaluating results to the terminal box of the vehicles. Therefore, IoT will advance the quality of public transportation (Wang et al., 2020). Travel Demand Management is another essential element of IoT in intelligent transportation that improves traffic flow by identifying the locations with the highest traffic volume and then spreading the density to other points. Moreover, this technology can provide better design, faster, and better quality, at a low cost that authorizes ecological sustainability in transportation (Camacho et al., 2018).

## Conclusion

Traffic congestion, traffic accidents, and environmental pollution have become a major phenomenon in metropolises in developing countries. For example, in Beijing, the capital of China, people have to spend 3 hours in traffic every day (Luo et al., 2019). The high rate of traffic accidents worldwide causes loss of property and life. Approximately 1.19 million people die in traffic accidents and as a result of this situation, 500 billion dollars of economic loss occurs every year (World Health Organization, 2024). Traffic congestion in urban areas reduces the performance of transportation systems and therefore, postpones economic growth. The most effective way to solve traffic congestion and decrease traffic accidents in developing countries is IoT in Intelligent transportation systems.

The main outcomes of the review contributed to a better understanding of IoT applications in intelligent transportation systems and the explained benefits and challenges. IoT based on intelligent transport systems has several benefits for decreasing the uncertainty of the transportation network and enhancing the ability of rapid response and can assist in administrating efficiently the public transportation system. These systems significantly provide alternative routes to drivers and passengers with real-time traffic information and minimize human errors, shorten travel times, increase traffic safety. IoT in intelligent transportation ensures drivers and passengers new data processing techniques are advanced to forecast traffic density and speed which ensures public transportation is more convenient and reliable. IoT may bring considerable business advantages in intelligent transportation providing a potential for enhancing the accuracy of the traffic flow, and operational processes. In addition, it enables the optimum use of existing road capacities, increases energy efficiency, and reduces environmental damage, costs, and risks.

IoT based on intelligent transport systems has great challenges in terms of coverage availability and less complexity. Many technical challenges are likely to be encountered such as high mobility of vehicles, a major span of relative speeds between knots, the real-time nature of implementations, and a plurality of system and implementation-related requirements. The integration of IoT and intelligent transportation technologies should be planned to take into account the challenges identified such as the slow Wi-Fi speeds, security issues, and maintenance demands of IoT networks. Moreover, standardization and legal regulations will be expected to play a key role in the adoption of IoT in intelligent transportation. For future studies, it would be interesting to analyze the impact of IoT-Blockchain integration on intelligent transportation.

## Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the author.

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