

Smart Transportation: The Role of Big Data and Internet of Things

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Abstract— Industrial revolution 4.0 has brought the world to a new trend called "smart trend". Countries have been building smart cities, which is also the orientation of the Vietnamese government. There are many factors that make up a smart city, in which the most important component is the smart transportation. This paper provides the basics of smart transportation, and the role of Big Data and Internet of Things in improving transportation system to become smarter.

Keywords— Big Data; Internet of Things (IoT); Smart Transportation; Smart City

I. Introduction

The history of transportation development is closely related to the history of human development from the earliest days, when humans used labor and animals as the main means of transport. It plays an important role in the economy, society and politics of a country. As transportation demand has been increasing leads to challenges such as the land uses, traffic accidents or environmental pollution. That requires countries to find a solution, and smart transportation seems to be the best solution in the context of the Fourth industrial revolution. The paper answer following question:

1. What is smart transportation
2. What makes smart transportation?
3. What are the benefits of smart transportation?
4. What is the role of Big Data and Internet of Things (IoT) in application smart transportation?

II. Smart Transportation

“Smart transportation (and its cousin, intelligent transportation system) offers a means of providing innovative services on different modes of transportation and traffic management. It is an important area in the smart grid and an extension of smart cities. Its components include infrastructure, vehicles, and users.” (Sadiku et al., 2017).

Intelligent transportation system (ITS) or smart transportation optimises existing infrastructure to make transport more efficient, and helps improve transportation in many ways, as belowing:

- Health, safety and environmental benefits: Reducing accidents
- Public transport benefits: Reducing congestion, optimising route of bus
- Driver and traffic management benefits: Traffic control, gathering traffic data, parking management

- Economic benefits: Reducing infrastructure damage.

The elements of smart transportation are shown in Figure 1. Smart transportation system is the integration of many systems such as Automated Vehicle Location System, Real-Time Traffic Information System, Automated Fare Collection System, Car Sharing Cycle Sharing Systems, Intelligent Signaling System, Real-time Monitoring System, Parking Information System, ... Technology is the best tool to connect all above systems effectively, including Big data and IoT which are mentioned in the next section of the article.

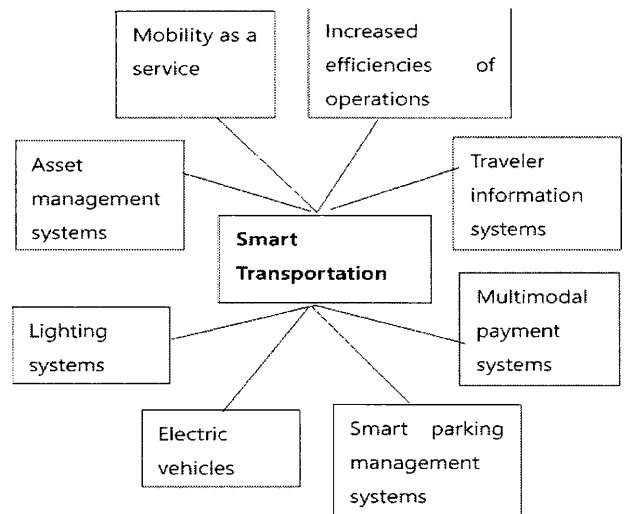


Fig 1. Elements of Smart Transportation in Smart city (Source: Author's work based on Neil Pedersen, 2017)

III. Big Data and Internet of Things in Smart Transportation

After the invention of the Internet, the Internet of Things (IoT) is a technology that has created maximum impact in the way businesses and corporates function. IoT can be defined as the network of interconnected computer devices embedded in various objects, ranging from mobile devices and household appliances to vehicles and even structures. The IoT has already had a huge positive impact on all industries such as healthcare, agriculture, etc ... and transportation is not an exception. Smart transportation includes the use of IoT in transportation systems.

IoT applications in transportation deliver not only the following benefits:

- Cost-savings: Operating data and diagnostics drive preventive maintenance to decrease costs and improve

warranty as well as service processes

- Operational and supply chain efficiencies
- Increased driver safety and job satisfaction.

Figure 2 is an example of benefit from application IoT in transportation. Drivers are alerted to hazardous conditions in real-time to avoid crashes and traffic congestion. Fuel consumption can be monitored and evaluated for efficiencies. Trucks can be monitored for wear and tear so that potential problems can be addressed before a vehicle breaks down. This helps reduce repair costs. Freight conditions can be tracked and monitored throughout the driver’s journey. Drivers can be alerted about the change of cargo environmental to resolve immediately. Drivers can be monitored for physical condition and performance. Every abnormal and unsafe expression like speeding, getting drowsy will be sent to managers, who can take the appropriate action. This enables crash avoidance safety applications. Transport managers can track their fleet status such as location, delivery status, schedules, ...via positioning and sensing systems, in conjunction with the navigation system determines the optimal route based on weather and traffic conditions so that drivers can be rerouted in real time (if necessary).

TABLE I. Traffic Management Data Matrix

Data Domain	Type of Data		
	Fixed	Historical	Real-time
Traffic Operation	Map Route Regulation	Rush hour Traffic jam	Vehicle flow Axle load Traffic density
Traffic Incident	Congestion Accident	Regular place Causation factors	Date/ time Location Type of impact
Vehicle	Amount Age Specification (length, weight, height, ...)	Emissions Fuel consumption	Position Speed Route
Infrastructure	Map fixed data layers (width of road, amount of bridge, ...)	Traffic history	Pavement occupancy Road maintenance Tides
Weather Condition	Sunny season Rainy season	Weather condition at the same period years before	Wind speed Temperature

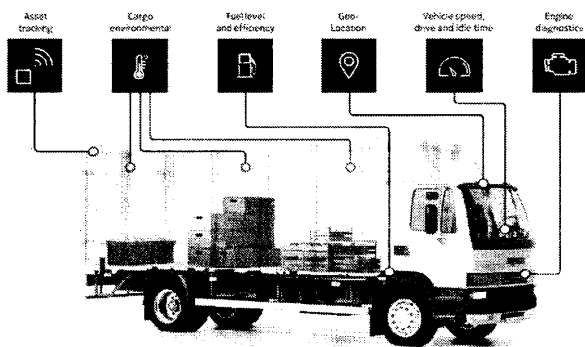


Fig 2. Application of IoT in Transportation (Source: <https://data-flair.training/blogs>)

In the digital age, the amount of data increases with the multiplier. In smart transportation, the need of data collection and data analytics is priority to answer the questions: Where do the traffic streams go? Where is the danger? What is the status of cargo in real time? etc ... Data sets can be so large and complex that they become difficult to process using traditional data processing applications and existing data management tools. This huge data is so-called Big data. Table 1 is an example for traffic management in Hochiminh City. It points out that the transport managers must collect at least five belowing data domains: Traffic operation, Traffic incident, Vehicle, Infrastructure, Weather condition. It also includes data of driver status, passenger information and their behavior, etc..

All parties of transportation industry like airlines, airports, freight logistics, transportation agencies, and others are enjoying the benefits of Big Data. The benefits of Big Data and analytics help the transportation managers to precisely enhance the model capacity, demand, revenue, pricing, customer sentiments, cost and urban or public transportation.

In many countries, the implementation of Big Data in Transportation is one of the leading solutions for smart transportation. Better data can help transport managers understand the behavior of traffic participants, provide information and identify policy interventions. In fact, the biggest benefit from using Big Data can come from changing user behavior. For example, in Singapore, use real-time local traffic data to determine toll rates. This encourages the driver to avoid driving in the most congested time and optimizes the use of the road network.

Table 2 points of the benefits from IoT and Big Data application in some countries.

IV. Applications of Big Data and Internet of Things in Transportation

Application of IoT and Big Data extends to all aspects of transportation systems. Big Data is used not only in traffic management, but also in informing travelers, public authorities and transport industry, developing automated vehicles, etc ... On the other hand, Big Data is useful for all transportation industry parties. Governments are using big data for traffic controlling, transport planning and modeling, route planning, congestion management, and Intelligent Transport Systems. The private sector like travel industry, logistics and supply chain management also gets benefit from Big Data. Individuals can save their time and money by using Big Data because of increasing fuel-efficiency or easily travel planning.

The IoT and Big Data application is dramatically accelerating the pace of innovation and transforming the way of operations in transportation and infrastructure. Some of the key applications of IoT in transport can be listed as below:

- Fleet Management
- Optimal Asset Utilization
- Smart Toll Collection
- Smart Parking
- Vehicle manufacturing.

TABLE II. The benefits of IoT and Big Data Implementation in Transportation

<i>(Bus)</i>	<i>Passenger comfort</i>	Infotainment, Wi-Fi, LED lighting and signage, charging
	<i>Electrical system</i>	Power distribution, computers, sensors, micro chargers
	<i>Processing</i>	Engine control, energy optimisation, driving behavior, safety monitoring
	<i>Steering</i>	Driving assistance, cruise control, radio/ phone

Countries	Problems (before the implementation of IoT and Big data)	Results (after the implementation of IoT and Big data)
<i>Portugal</i>	Recurring cases of fatal accidents due to non-compliance with speed limits	Behavioral change in the drivers' ecodriving, then drastic reduction in the cases of fatal car accidents
<i>Germany</i>	Road safety concern, traffic congestion, and pollution.	Eco-friendliness, and hitch-free traffic flow
<i>England</i>	Operational waste and workers' safety	Operational waste reduction and safe working environment
<i>Singapore</i>	Unpleasant passenger's booking experience	Better passenger's booking experience

(Source: Hussein et al, 2017)

We can see that IoT applications are large and complex. The following are common IoT application areas for smart transportation:

- Smart Driver Advisory Systems: IoT can play a proactive role in helping drivers to stay on track of safe driving habits
- Smart Car Technology: Connected and Autonomous Vehicles
- Smart Traffic Management
- Smart Infrastructure Maintenance: IoT sensors can monitor and detect the structural status of roads and bridges under dynamic conditions and alert government about deficiencies for fixing them before they become less safe and more expensive to repair.

Table 3 is an example of Big Data and IoT application in freight transportation and public transportation.

TABLE III. Application of IoT and Big Data in Transportation

Type of transport	Application areas	Detail
<i>Freight Transport</i>	<i>Inventory management</i>	Real-time capacity availability
	<i>Human resources</i>	Reduction in driver turnover, driver assignment, using sentiment data analysis
	<i>Transport management</i>	Optimal routing, weather conditions, traffic congestion, and driver characteristics
	<i>Forecasting</i>	Time of delivery, factoring in weather, driver characteristics, time of day and date
<i>Public Transport</i>	<i>Fleet management</i>	Bus location, technical diagnostic, fuel monitoring, route optimisation

V. Conclusion

The article presents an overview of the role of IoT and Big Data in smart transportation. The government of Vietnam has realized the benefits of using Big Data and IoT to solve traffic problems. A €37 million-project in collaboration with IBM to set up a Traffic Management System has begun in 2013 in Danang City to solve the problem of traffic congestion throughout the city with a fast-growing population. However, there are challenges for application of IoT and Big Data in transportation which are listed as below: lack of appropriate skills and common standards in collecting and connecting data, software complexity, financial capability, security and privacy, data sources and characteristics, data quality, etc ... This requires that countries (including Vietnam) should have suitable policies and criteria to select the transportation aspect which is appropriate to their available conditions to apply Big Data and IoT.

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