**CHAPTER 1. INTRODUCTION TO BIG DATA AND TRANSPORT**

**1.1 What is Transport?**

Transport (in British English), or transportation (in American English), is the movement of humans, animals, and goods from one location to another. A transport action is defined as a specific movement of an organism or thing from point A (a location in space) to point B [1].

Space, air, land (rail and road), cable, pipeline, and water are all modes of transportation (Figure 1.1). The field is divided into vehicles, infrastructure, and operations. Transportation allows people to trade with one another, which is necessary for developing civilisations.

Transportation infrastructure consists of fixed facilities including, railways, roads, airways, canals and pipelines, waterways, and terminals, such as airports, warehouses, railway stations, bus stations, truck terminals, and fuel refuelling depots, fuel (including refuelling docks and fuel stations), and seaports. Terminals can be used for both passenger and cargo exchange and at the same time for maintenance.

Means of transport are any different types of transport used to transport people or cargo. They can include vehicles, riding animals, and pack animals. Vehicles can include railcars, automobiles, bicycles, buses, trains, trucks, helicopters, ships, spacecraft, and aircraft.

**1.2 Transportation Industry Challenges & Opportunities**

New technologies are altering how we plan, design, construct and operate transportation systems. Transportation agencies use them to count traffic, detect accidents, collect tolls and fares, and manage transit operations and traffic signal systems. Travellers rely on traffic reports, electronic maps, onboard vehicle performance monitors, real-time transit arrival information, and various other services that were not available a generation ago. Some of us are already driving hybrid cars or taking buses that run on hydrogen or biofuels.

It was Elizabeth Deakin, Professor in the Department of City and Regional Planning at the University of California, Berkeley [2], who said that we all rely on further advancements in transportation technology in the future, not only to get us where we want to go, but also to cut greenhouse gas emissions, enhance air quality, and support economic development explains.

As these examples show, transportation technologies frequently involve using new materials or tools, such as emission control devices or long-lasting pavements. These physical artefacts are the focus of many research and development efforts. In addition, however, technology encompasses various methods, procedures, and organisational arrangements for providing transportation facilities and services and the user applications that a new device or method may find in the market. These "soft" elements are frequently critical to success or failure.

For example, if several technologies compete for a market, it is critical to understand whether the market is large enough to share or so small and specialised that only a few providers (if any) can succeed. In addition, design standards and product specifications and rules governing competitive bidding and product liability can enable or obstruct technologies. Furthermore, the political acceptability of a new technology's impacts, including its social and environmental consequences, may be as significant as - or even more important than the technology's effects on mobility or cost-effectiveness.

Planners and engineers must understand the potential of new technology and its limitations to incorporate it into new project proposals effectively. Decision-makers need evidence of benefits and costs, including social, economic, and environmental effects, to decide whether to invest in new technology or stick with traditional approaches. In addition, because new technologies have the potential to disrupt established ways of doing things, technological development may need to be supplemented by institutional analyses that enable leaders to remove barriers and support innovation. Research on a wide range of issues can help to inform these decision-making processes while also advancing the technologies themselves.

The evolution and development of technology have resulted in significant improvements in the various stages of the delivery process for transportation companies [3]. Logistics, a critical component for transportation companies, has evolved due to technological advancements. The use of computers and more powerful software and technology has allowed for a better transportation company organisation. Trucks are even outfitted with electronics to improve communication between drivers and the logistics centre. It is now more straightforward for a business to manage the transportation of truck fleets and their personnel. These enhancements enable businesses to comply with prescribed standards, knowledge of pricing, inventory, and procurement, allocating commands between different trucks to optimise deliveries and establishing shorter routes to improve drivers' daily lives, among other things. In other words, technological advancements in transportation services have resulted in numerous logistical benefits, advantageous in providing competitive services.

Technology has also had an impact on automobiles. This impact has resulted in more excellent dependability for businesses in terms of their truck fleets. In addition, onboard electronics provide mechanics and engineers with a wealth of information about the health and status of their vehicles, reducing the risk of failure or breakdowns significantly. These new improvements mean increased safety for truck drivers on each of their deliveries. The contribution of technology in the field of transportation has also benefited ecology. The introduction of technology such as hybrid engines and the ability to turn engines off when the vehicle is stationary are two examples of technological advancements. As a result, trucks can make more secure deliveries thanks to new technology developed daily, using fewer natural resources on our planet. In addition, we have seen a significant improvement in logistics due to the numerous changes brought about by new technology [4].

Logistics is managing the flow of assets or goods from the point of origin to the endpoint of consumption. The future of logistics [5] and transportation lies in technology and innovation.

**1.3 The Impact of the Internet of Things, Big Data and Artificial Intelligence**

In the current situation, humans are developing numerous technologies to understand our daily activities better to improve our lifestyles by improving our operations. Table 1.2(List of emerging technologies in Transport [7]) shows many of the technologies developed in this area of expertise. AI, IoT, and Big Data have all contributed to some exciting and intriguing advancements in the transportation business. By this time, cutting-edge technologies and apps like Taxi Dispatch Solutions have transformed practically every business.

The Internet of Things (IoT), Big Data, and Artificial intelligence (AI) revolutionise how the world functions. The following technologies are causing waves in industries ranging from transportation to our houses. Moreover, incorporating these technologies into new mobile app development is critical for generating cash. As a result, its benefits and prospects appear limitless.

The Internet of Things (IoT) is a network of interconnected physical things that anybody can access via the internet. IoT is a fundamental concept that connects all objects in a person's environment to the internet. For example, an IoT 'thing' could be a human wearing a heart monitor or a car with built-in sensors, i.e., things with an IP address and the ability to transport data over a network without manual intervention.

The transportation industry's adoption of IoT has resulted in the incorporation of a variety of tools and services that help with better transportation management, including:

* Traffic congestion control systems
* Automotive telematics
* Reservation systems
* Toll & ticketing systems
* Security and surveillance systems
* Remote observance and others.

Let us have a look at some statistics that support the influence of IoT on the transportation industry (Figure 1.3.1):

* According to the report, the global IoT market in transportation was worth $135.35 billion in 2016 and is predicted to grow to $328.76 billion by 2023.
* North America had the most revenue in 2016, at $46.75 billion.
* From 2017 to 2023, IoT in the transportation sector is expected to increase at a CAGR of 13.1%.

Artificial intelligence (AI) refers to the ability of a computer program or machine to think and learn. The AI concept is predicated on creating robots that can think, act, and learn in the same way that people can.

Artificial intelligence is a human invention designed to make life easier and more comfortable. Artificial Intelligence in the Transportation Segment cab is worth 10.30 billion USD by 2030. AI applications in the transportation industry drive the evolution of the next generation of Intelligent Transportation Systems. Meanwhile, some of the most prevalent aspects of transportation that we employ are (Figure 1.3.2):

* Traffic Management Solutions
* Smartphone Apps
* Passenger Transportation
* Law Enforcement

AI has made everything from road safety issues to fleet management system monitoring possible in the transportation business. Nevertheless, Artificial Intelligence (AI) has served as a one-stop shop for various problems.

Stats to prove the impact of Artificial Intelligence on the transportation and logistics industry (Figure 1.3.3):

* The report estimates that the worldwide AI in the transportation market is worth USD 1.21 billion in 2017 and will grow to USD 10.30 billion by 2030.
* Indeed, from 2017 to 2030, it will rise at a CAGR of 17.87 per cent.

**Big Data in Transportation Industry**

To begin, Big Data is a word that refers to a massive collection of data that is extremely large. It is still increasing at an exponential rate. Second, it comes in three different varieties:

* Structured
* Unstructured
* Semi-structured

As a result, big data can extract information from that data and use it in various sophisticated analytics applications. Big data has changed everything in the last few years. Even the transportation business is helping to make regular commutes easier. On the other hand, Big Data is a rapidly expanding paradigm that has piqued everyone's curiosity worldwide. Particularly in the transportation sector, such as airlines, trains, hospitality, and other travel and transportation industry aspects. They have used big data analytics in their iPhone or Android app development to manage:

* Customer records
* Transaction history
* Pricing data for better customer feedback
* Enable optimised route planning
* Detection of networks with weak infrastructure
* Calculation of travel delay

Some statistics that indicate Big Data's rise in the market

* Revenues from the Big Data market are expected to rise from $42 billion in 2018 to $103 billion in 2027.
* Furthermore, the entire global software market is worth $628B in revenue.

**1.4 The Importance of Big Data Analytics in Transportation and Logistics**

<https://bigdatapath.wordpress.com/2021/10/11/the-distinct-impact-of-big-data-analytics-in-transport-logistics/>

<https://www.globaltranz.com/big-data-in-supply-chain/>

<https://www.globaltranz.com/big-data-in-the-transportation/>

Big Data is everything. It is a new term but an established concept. It collects, stores and then mines (analysing for patterns) a massive amount of data for competitive advantage. It can be very revealing, and the trail has been blazed by retail giants over the last 20 years. Got a loyalty card anywhere? They are collecting your purchasing data. When you look at massive amounts of it, it throws out some interesting information that can be used to sell more products. These processes are the same in every field. However, looking at the transport sector, we can find some new or odd patterns among the information we collect. For example, we can analyse accidents happening during a specific day, such as during rush hours on 1 of the major roads. With this information at hand, we can change or alter the roads or make them safer for driving. It would help if you had tons and tons of data before these patterns become apparent, and it is now straightforward (from a technical standpoint) to collect and farm this amount of stuff, hence the Big Data trend. In the recent past, you would have needed lots of costly hardware and intelligent people to run it, so it would only be available to the giants like Walmart.

Data capture all of the seemingly trivial facts of modern life. With each passing day, data evolves and expands, from studying your bank account spending habits to more extensive, more complex processing capabilities. Considering how intimately people engage with their digital selves, you could easily mistake humankind for a hybrid of digital and biological stuff. This is not a fantasy discussion, either. It is accurate, and the amount of data produced every 48 hours rivals the total amount of data and information accumulated over thousands of years of human history, as Bernard Marr explains [8]. Big data in the supply chain has become associated with more excellent business, supply chain efficiency, continuous improvement, and innovation.

**What is it about Big Data that has piqued everyone's interest?**

Big data has been trending during the last few decades because it is accessible with cheap technology. Unlike mid-nineteenth-century computer systems, modern data processing is more cost-effective than calculating data on paper. Furthermore, keeping data digitally is less expensive than storing physical copies of data, especially when climate control, security, and accessibility are considered. According to Forbes magazine's Lisa Arthur, big data can take numerous forms, including unstructured and multi-structured data. These many forms significantly impact what and who creates and uses big data.

Big data will be a defining force in logistics, but its advantages are already being realised in the future. However, before you consider future possibilities, you must first comprehend how it is currently utilised. As a result, supply chain organisations will be able to reduce total operational expenses, develop and test new business models, build and sustain a higher level of customer service, and reach unrivalled efficiency, according to Katrin Zeiler [10]. Figure 1.4.1 depicts the full spectrum of big data's impact on the transportation, supply chain, and logistics industries [11].

According to DHL Customer Solutions & Innovation, nearly all of these processes revolve around a few fundamental variables, and you need to know what they signify for the supply chain and transportation industries. The following can occur if the entire organisation is involved:

1. **Real-time route optimisation:** based on delivery sequence, traffic conditions, and recipient status, delivery routes are dynamically computed.
2. **Operational Capacity Planning:** short- and medium-term capacity planning enables practical resource usage and growth.
3. **Strategic Network Planning:** Long-term demand predictions for transportation capacity are developed to support strategic network investments.
4. **Crowd-sourced pickup and delivery:** Many sporadic carriers pick up or deliver packages along routes they typically take.
5. Product Innovation and Service Improvement: A comprehensive perspective of consumer requirements and service quality is applied to improve the product portfolio.
6. **Consumer Loyalty Management:** To predict attrition and take countermeasures, public customer information is mapped against business characteristics.
7. **Financial Demand and Supply Chain Analytics:** a microeconomic picture of global supply chain data is created to help financial institutions improve their credit ratings and investment decisions.
8. **Risk Assessment and Resilience Planning:** The resilience of transportation services is improved by tracking and predicting events that contribute to supply chain interruptions.
9. **Environmental Intelligence:** Sensors on delivery vehicles generate fine-grained statistics on pollution, traffic density, noise, and parking spot utilisation, among other things.
10. **Address Verification:** Fleet personnel double-checks the recipient address verification used by retailers and marketing agencies.
11. **SME Market Intelligence:** Data from supply chain monitoring is utilised to develop market intelligence reports for small and mid-sized businesses.

In the transportation industry, big data decreases delivery and pickup errors. Industry professionals agree that courier service firms are often major operational organisations dealing with enormous cargo volumes, hub terminals, general information systems, and various vehicles. In addition, they are made up of a complex network of personnel and equipment. This means that there will be many transactions to complete, from deliveries to product pickup. Errors in deliveries, pickups, and shipping operations, on the other hand, can result in increased costs for the organisation. While these costs may seem modest, consider how much money is lost every day if a single error occurs. This could cost more than it should, and customers may demand replacements or refunds, ruining the company's reputation. However, delivery and pickup errors can be eliminated with big data. Therefore, sensors are integrated into all delivery vehicles used by logistics companies, with GPS-enabled cellphones filling up the gaps.

When logistics businesses are competing for new contracts, the dependability and timeliness data from these sensors is used by a third party to check them for correctness. So instead of causing a corporation to lose money due to errors, big data may assist the organisation in increasing profitability.

The use of big data will boost operational efficiency. One of the first and most essential benefits of using Big Data in transportation and logistics is to improve operational efficiency. In most cases, automated data processing enhances decision-making capabilities, process quality and performance, and resource consumption. The advantages can be extended in the following ways.

* Better visibility for future orders and demand forecasts.
* Ability to track and forecast low-in-stock items ahead of time
* Reduce the impact of late and partial shipments significantly.
* Examine the potential for a variety of events to emerge.
* Forecast how much inventory you will need for promotions and when the optimum times are to ship it.
* Where no historical data is available, give retailers the flexibility to suggest pricing and allocation strategies.

In reality, big data can improve forecasting, demand planning, sourcing, transportation, and distribution processes while also providing real-time visibility across the supply chain. For that reason, companies will be able to model supply chain data more precisely, make real-time choices, and use predictive and prescriptive analytics to prevent problems. Big data enables improved shipping alternatives with higher product quality. However, when it comes to shipping sensitive items, the best route must be chosen first to avoid late delivery and ensure that the goods remain in good condition when they arrive at the consumer. Shippers must use big data to evaluate several models, ranging from rail to truck, and then go even further by determining the most cost-effective approach to get the right product to the right consumer at the right time and the correct rate.

Indeed, big data combined with the Internet of Things might provide delivery drivers and managers with a much better understanding of how to avoid expenditures associated with perished items. A truck is transporting a shipment of fruits and vegetables, for example. You may install a temperature sensor inside the truck to check the condition of the items inside and send the data to a central routing computer along with traffic and roadwork data. The computer might then warn the driver if the driver's intended path would harm the fruit and vegetable and recommend different routes instead. When you consider these advantages, you will realise that they derive from three main areas in the transportation business that are touched by big data, as shown in Figure 1.4.2.

Big data can significantly impact the supply chain and transportation industries and define new options and courses to follow. Big data in the transportation business is on the verge of making the impossible possible, rather than isolating a corporation to known variables and possibilities. However, as big data's benefits converge into a single, pleasant, mutually advantageous connection with customers, the most significant advances are likely to focus on customer service.