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PAPER

Implementation of AI in Smart Logistics Based on Mobile Technologies

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ABSTRACT

These days, transport and logistics are undergoing a major transition due to the introduction of smart technologies (STs). STs use data science and artificial intelligence (AI) technologies, like big data and machine learning, to develop cognitive awareness of an object with the help of IoT and blockchain-based information and communication technologies. Currently, several ST applications have shown promise in raising the efficacy and efficiency of diverse transport and logistical systems. Furthermore, the modeling challenges posed by these new, cutting-edge technologies to conventional optimization techniques provide a wealth of fresh research opportunities for the development of novel optimization procedures in the field of logistics and transportation studies. The most effective system was discovered to be the human-AI one. The ultimate objective is to empower users with more knowledge and encourage safer, more organized, and "smarter" usage of transportation networks on mobile technologies. The Internet of Things (IoT) offers countless prospects for improved transportation management and new services related to logistics and data integration.

KEYWORDS

transport, human-AI group, Internet of Things (IoT), mobile technologies, smart logistics

1 INTRODUCTION

The logistics industry is undergoing significant change at the moment due to technological advances, new competitors entering the market, new business models, and elevated customer expectations. This shift presents both opportunities and risks. Modern technologies that dramatically simplify and enhance the efficiency of logistics include big data, blockchain technology, cloud computing, and the Internet of Things (IoT). With innovative business models built on cutting-edge technology, new competitors steal market share from established players. For instance, it uses its app and platform to create an on-demand logistics network and match carriers with the best cargoes available; this has had a detrimental effect on the US freight sector [1]. Consumers anticipate receiving their purchases in a quicker, safer, and

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more flexible manner with little or no delivery fees. The aforementioned innovations boost productivity and enhance customer happiness, but they also intensify competition. Failing to develop the present logistics systems could result in the closure of some logistics companies. Building intelligent logistics on top of emerging technology is a practical way to stay on top of developments.

Figure 1 illustrates how cooperative application of IoT, massive amounts of data, cloud computing, artificial intelligence (AI), and advanced management can become information sharing, rapid response, and resource integration in logistics procedures, i.e., freight transportation, warehousing, and delivery, in smart logistics. Intelligent logistics becomes a collaborative and integrated system through collaborative development. Moreover, compared to the conventional approach, it increases the intelligence of logistics operations. In summary, smart logistics leverages advanced information and communication technologies (ICTs) to make the logistics system more intelligent, collaborative, and integrated. It also facilitates resource integration, fast response times, and information sharing within the logistics process. From a customer standpoint, smart logistics offers safer, more accurate, flexible, and efficient logistical services.

The term "smart technologies" describes the use of data science and AI methods, such as machine learning and big data, in conjunction with technology for communication and information, such as the IoT and blockchain, to develop cognitive perception of an object (such as a system) [2]. Making the item autonomous is the goal. STs have been implemented in various fields, giving rise to an array of novel and captivating study subjects, such as smart manufacturing, smart cities, smart houses, smart farming, smart the hospitality industry, and clever shopping, among others. They have shown how important it is and how it may save expenses while also improving operational efficiency. Smart manufacturing, according to CNBC, is predicted to boost the manufacturing sector's GDP by up to US$1.5 trillion by allowing firms to operate more efficiently and at a cheaper cost. One New subjects are also emerging in the logistics industry, and in recent years, intelligent warehouses and innovative logistics have gained a lot of attention.

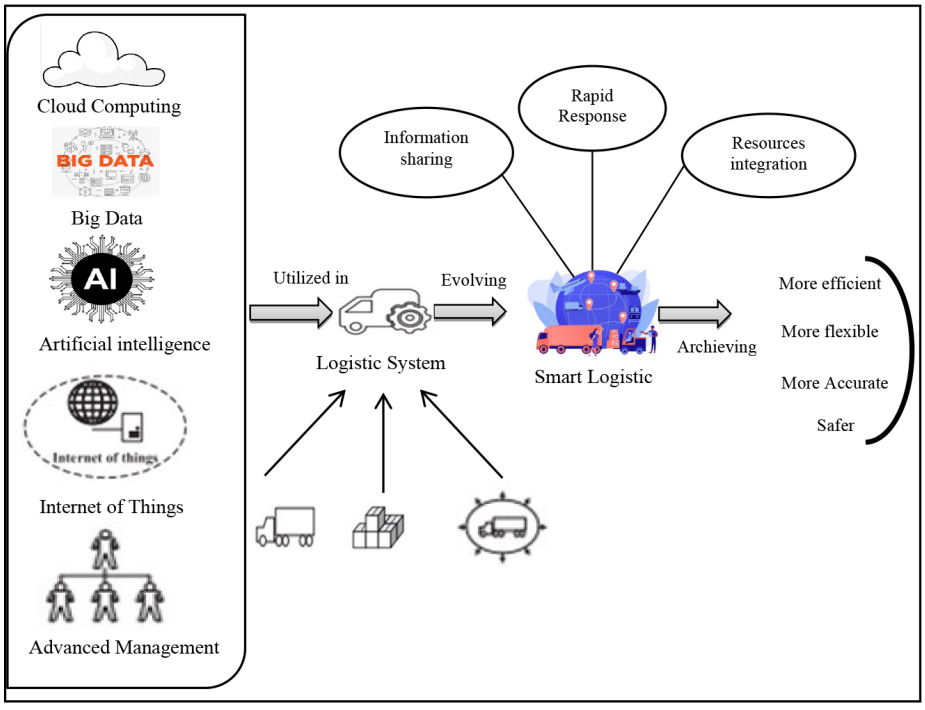

Fig. 1. Diagrammatic representations of smart logistics

These days, STs are drastically changing transport networks and the logistics sector. By referencing the ideas of interconnection, digitization, and robotics, the fourth industrial revolution (Industry 4.0) consists of a collection of concepts and technologies that should be employed to increase the competitiveness of industrial organizations. The effective deployment of smart and efficient supply chains built on flexible and cooperative networks and interconnected organizations is the goal of smart logistics in this context. Moreover, networked data actors, detectors, automated identification, and materials tracking technologies are used to establish information exchange in current ICT [3]. Furthermore, partially or fully autonomous system control should be made possible by autonomous transport, change, and storage systems that are backed by autonomous transport vehicles.

The structure for the paper is as follows: Section 2 provides the review process and bibliometric analysis. Section 3 examines and evaluates IoT research and applications related to delivery, warehousing, and freight transportation. Section 4 lists the obstacles to IoT-based smart logistics. The needs for research in creating smart logistics are outlined in Section 5.

2 RELATED WORKS

The future of multimodal logistics could be shaped by advancements in the field of intelligent transportation systems (ITSs), particularly in the areas of short-range dedicated communication protocols (DSRC), cooperative systems that link infrastructure-based systems with transport modes, and all the technologies utilized over automated control, situational awareness, and state estimation [4]. Concepts like synchro modality, cross-chain control centers, driverless transport vehicles, and other highly computerized transportation networks that will eventually lead to self-organizing logistics make up this future landscape. Advanced information systems are necessary for adjusting control in complicated settings, and all these principles call for them.

Specifically, Logistics 4.0 depends on digital technologies like cyber-physical systems, online systems, the IoT, and big data-based systems to effectively meet the exacting demands of customers regarding lead times and delivery dates. The use of autonomous systems and robotics for carrying goods, the implementation of solutions for identification and traceability, and the deployment of decision-support technologies to improve logistics management overall are the major uses of Logistics 4.0 [5]. To facilitate incoming and outward Logistics 4.0 activities, highly dependable Internet connections must be set up both inside and outside the manufacturing facilities.

When a catastrophic occurrence is imminent, the world considers its moral obligations and acts to halt extreme weather phenomena such as violent storms, intense rain, hurricanes, catastrophic droughts and the fires they cause, black ice storms, severe thunderstorms, sea level rise, and acidification of the seafloor. The globe is facing devastation due to factors including hunger, a rise in diseases and deaths among the population, a decline in biodiversity, financial losses in fisheries and agriculture, and an imbalance in the potable water supply [6]. The Earth's ecosystems and human well-being are at risk due to the current climate change, which might have catastrophic effects on society, the economy, and health outcomes. Humanity is to blame for the current state of climate change, and it is also to blame for the possibility of recovery.

Threats to ecosystems and human well-being on Earth emerge from the current climate change, which might have disastrous economic, social, and health effects. Man is the one who brought about the current climate change and the one who can enable a recovery [7]. With the speed at which technological advances are advancing industrial paradigms and the enormous socio-economic effects they have, it is critical to assess the current state of the literature and forecast how smart logistics will develop in Industry 5.0. This paper offers a comprehensive understanding of the key elements of smart logistics in Industry 5.0 through a systematic literature review (SLR).

The effective use of the limited computational resources at the edge has been the focus of recent research efforts in the field of machine learning techniques for anomaly detection at the edge of IoT devices. It is commonly known that the majority of deep learning-based AI models require a significant amount of hardware throughout their training process [8]. Another area of research has looked into resource-aware edge AI model architectures. The models were customized to meet the hardware resource requirements of network servers and the underlying edge devices. Significant advancements in the field of targeted design of deep learning architectures for devices with limited resources have also been accomplished.

Urban mobility encompasses the transportation of both people and goods. The former takes into account the mobility of automobiles (such as trucks and vans), whose main function is to transport cargo into, out of, and within metropolitan areas. The latter ought to be divided between private and public transportation. When it comes to personal transportation, the route is determined by the traveler; the most popular options are automobiles, motorcycles, bicycles, and strolling [9]. On the other hand, the goal of communal transportation is to link particular areas of the city through public transportation. Reaching economies of scale and moving a lot of people are the foundations of its effectiveness. Transportation modes such as trams, buses, trains, subways, and ferryboats are included. Cargo owners and transportation service providers arrange the routes for collective transportation. The majority of the literature currently in publication analyzes goods and people transportation separately.

There are two research goals for this study. First off, incorporating IoT into logistics solutions is a fascinating subject in and of itself [10]. Since logistics is by its very nature a networked industry, any changes made to this network ought to be carefully considered in order to see the big picture before industries begin to consolidate. As was previously said, there have been a few prior studies that concentrated on offering evaluations of IoT in logistics and/or SCM. Therefore, it is crucial and worthwhile to look into the significance of establishing IoT-based logistics services. Finding out how IoT technologies are evolving and adding value to logistics services is the second part of the study objectives.

3 METHODS AND MATERIALS

The field of smart logistics is gaining traction in both academia and industry as a necessary trend in the growth of modern logistics. This Section provides a quick overview of smart logistics, covering its concept, evolution [11], fundamental uses, and solutions.

3.1 Idea

Since "smart logistics" has been introduced, the concept of smart products and smart services has not been widely accepted in academics. This implies that humans can assign some of their management activities to these products and services. Uckelmann defines smart logistics in terms of smart products and smart services.

Uckelmann goes into detail about the traits of smart logistics, which are utilized to characterize smart logistics according to the specified standards.

Cullity explained that the integrated planning, control, realization, and monitoring of all material, part, and product flows both inside and throughout the network constitutes the entire value-added chain. The concept of smart logistics has evolved in tandem with the advancement of modern technologies, as the performance of logistics is increasingly reliant on technological innovation. As previously indicated, the term "smart logistics" is frequently used to describe a variety of logistical operations (such as order management, transportation, inventory, and so on) that are organized, regulated, or managed more intelligently than they are using traditional methods.

Nevertheless, regardless of how scholars define the term "smart logistics [12]," we can discover that they all agree that it is a concept that integrates cutting-edge communication and information technologies with the ability to integrate and optimize the logistics system through thorough analysis, prompt manufacturing, and self-adaptation to make the system more intelligent.

3.2 Evolution

Technology advancement and logistical development are strongly intertwined. We provide an overview of the growth of logistics from the standpoint of technical advancement.

Logistics' evolution is depicted in Figure 2. The four phases of modern logistics development are logistics robotics, logistics integration, logistics mechanization, and logistics intelligence. Logistics mechanization dates back to the 1920s, when the CLARK Equipment Corporation produced the first truck tractor in 1917, which was used to transport merchandise. Initially, mechanical equipment replaces labor in logistics tasks due to advancements in internal combustion engines, mechanical manufacturing, etc.

Since the 1960s, contemporary logistics have gradually moved from mechanization to automation due to the development of sensors, bar codes, RFID tags, and other technologies. It devised a heuristic method to address the issue of the AS/RS's inability to hold all items in storage. With the development of RFID, networks, and communication technologies between the 1990s and 2000s, logistics transitioned from automated to synergies. A framework for an e-commerce community network was presented by the connection between information, organizational framework, and the effective implementation of the incorporated distribution concept. This community network expands conventional business-to-business e-commerce to industry-level e-commerce and achieves the online integrating business transactions. The rapid advancement of technology in the twenty-first century, such as big data, artificial intelligence, and the IoT [13], has aided in the growth of smart logistics.

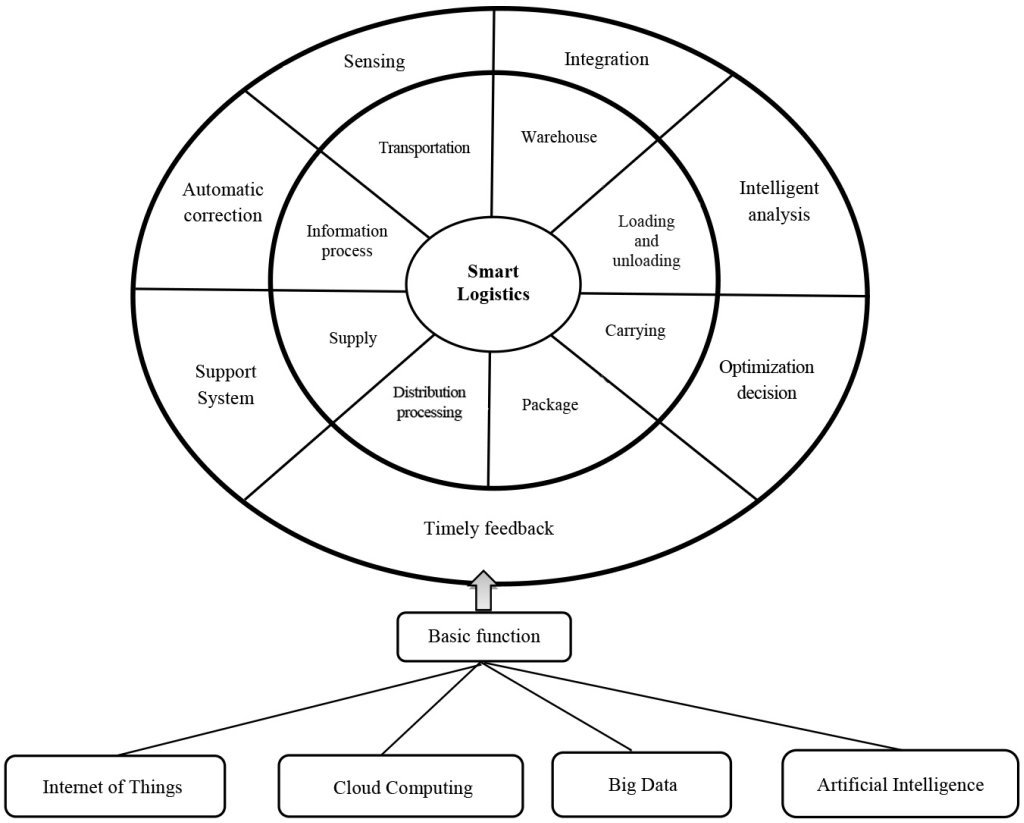

Fig. 2. The growth of smart logistics is illustrated

It incorporates computing and IoT infrastructures to provide an intelligent production transportation control mechanism with multilevel dynamic adaptability. This dynamic production logistics synchronization system is being investigated the outlined a framework for implementing intelligent modelling of critical manufacturing assets and researching autonomous configuration methods in smart production-logistics networks. The investigation centers on the smart connected logistic system, utilizing cutting-edge principles including mobile robotic systems (MRSs), mobile device automated platforms, multivalent cloud-based control, and different IoT ideas. The system proposes a robot control mechanism that can automatically sort parcels and generate data to regulate the motion of a robot in a context-aware manner [14]. By merging the capabilities of numerous tracking systems, the study creates an effective target-oriented smart integrative tracking system that looks up item location in real-time and ensures the accuracy and dependability of logistical placement and resources management.

Scenes and fundamental operations. Figure 2 depicts logistics situations as well as the fundamental operations of smart logistics. Logistics transportation, warehousing, load/unloading, hauling, packing, redistribution manufacturing, shipping, and data processing are the eight scenarios that make up smart logistics.

- **Transport:** Logistics transport is the use of facilities and equipment to move goods from one location to another. Of all the elements that make up logistics systems, this is the most significant business activity.
- **Storage:** One important, dynamic component of the logistics supply chain is inventory, which is controlled, categorized, and managed through the activities of logistics warehouses.

- **Filling or removing:** It entails using technological or human methods to load or unload goods at the specified place.
- **Taking up:** It is the primary logistical process for transporting goods vertically in one location.
- **Packaging:** Its purpose is to ease storage and transportation while safeguarding goods throughout delivery. It is among the most crucial facets of logistics.
- **Distribution handling:** It refers to straightforward procedures like labelling, packing, dividing, metering, and sorting, and so on, in accordance with the requirements from the creation location to the usage location.
- **Circulation:** It is a logistical technique that fulfills the consignee's order requirements from customs while delivering the products. A thorough and ideal logistics distribution solution is now a significant component influencing the cost of logistics.
- **Data processing:** Logistics-related plans and projections are created by gathering and processing dynamic data on production, markets, costs, and other factors. This makes logistics operations run more effectively and smoothly.

Sensing, integrating, intelligent analysis, optimization decision-making, system support, and rapid feedback for every logistical situation are the fundamental components of smart logistics.

- **Perception:** It is applied to achieve astute perception. It gathers a lot of precise data on the loading and unloading of information services, logistics, storage, and other topics using a range of cutting-edge technology.
- **Combination:** By standardizing data and procedures, data connectedness, transparency, and dynamism are to be achieved. The network is used to send the gathered data to the data center, where it is archived to create a strong database.
- **Astute evaluation:** It involves applying sophisticated simulation algorithms and models to the analysis of logistics issues. The logistics system can access the initial experience data to do analysis while the activity is underway. Finding gaps or weak points in the logistical operations is then accomplished by merging the recently acquired data.
- **Making an optimization choice:** This function makes intelligent decisions. By using predictive analysis, the most intelligent logistics system may provide the most logical and practical alternatives. Subsequently, it renders more precise and empirical decisions based on various scenarios.
- **System assistance:** Effective logistics depends on every situation. With the ability to exchange data and optimize resource allocation, every logistical scenario may be linked to another, offering the most robust system support possible for all possible scenarios.
- **Auto-correction:** The smart logistics system can function by choosing the best course of action based on its prior functions. When issues are discovered, they are automatically resolved.
- **Quick response:** Real-time updates are provided by the smart logistics system. In order to apply system improvement and correction and to strongly ensure that system issues are resolved on schedule, feedback is a crucial component.

3.3 Resolutions

Many researchers explore smart logistics options from the viewpoint of technological development. For instance, Hoffman and Rüsch examined Industry 4.0's

potential in relation to logistics management. They present a logistics-oriented Industry 4.0 implementation model as well as the basic elements of Industry 4.0 and illustrate the potential ramifications of Industry 4.0 on diverse logistics scenarios. It talks about some "smart" supply chain and logistics solutions based on the IoT, massive data sets, and Industry 4.0. It also shows how to apply these cutting-edge technologies to smart logistics in the Industry 4.0 era from the perspectives of information security, smart transportation, and storage, outlines a few uses for decision support and large-scale information systems that can improve the planning and assessment of city logistics systems.

A few scholars examine how consumer behavior affects smart logistics systems and suggest ways to combine technological advancement with innovative solutions. For instance, it suggested a theoretical framework for customer focus in intelligent logistics and enhanced the significance of the client in the logistics process. It looked at how customers affect the logistics system's ability to operate efficiently and proposed models that let you figure out how the consumer and the supply chain interact.

3.4 Considerations for smart logistics

By combining the current definitions and the research done in this area, we aim to streamline the public knowledge of smart logistics. We achieve this by focusing on four key areas that are discussed in this Section.

Effects of transportation. It is crucial to keep an eye on and oversee things during the shipment process when moving goods. Special sensors that can be affixed to goods, parcels, containers, transit vehicles, or even infrastructure can be used to accomplish this. These sensors gather data and send it to computer systems in real time. These systems then evaluate the information to make decisions. Lastly, the data is stored to serve as a foundation for learning algorithms that will enable ongoing itinerary planning improvement.

In fact, technological advancements have turned transportation networks' cars into the model of the Internet of cars. The Internet of Vehicles involves outfitting automobiles with sensors, processing power, and a network connection. Transportation cars and objects in their surroundings, or specifically the transportation infrastructure, which needs to be sensor-equipped and networked in turn, can exchange data thanks to connection. The major objectives of employing smart transportation models are to guarantee effective delivery administration, lower operating expenses, motion accountability, and enhanced consumer satisfaction through better service.

The value of warehousing in intelligent logistics. Both inbound and outgoing tasks including receiving, storing, quality assurance, order picking, and shipping are included in warehouse operations. The warehouse management system (WMS) must, however, overcome a number of management and control obstacles, including tracking inventory, streamlining space management, and processing orders quickly. Numerous elements may impact the development of the above listed difficulties.

The expansion and diversity of personalized customer orders came first, followed by a rise in the availability of customer delivery services and the boom of e-commerce. It becomes imperative to strengthen management practices and procedures in order to meet these problems. Indeed, the integration of administrative and technological innovations is necessary for the evolution of the conventional WMS systems towards the CPS-WMS system. These include the optimal choice of CPS methods, environmental information, prompt data flow, and speed.

Characteristics of smart logistics management. The administration of every activity that makes up a supply chain's operations is known as supply chain management. Indeed, the goals of supply chain management (SCM) are to manage both the business's and the natural world's problems. Otherwise, SCM enables the management of devices, methods, implies and assets. The volume of released studies on logistics indicates the evolution of supply chain management in the past ten years. Effective purchasing and distribution strategies are critical to achieving higher performance, which is why controlling a supply chain is important. In actuality, in addition to the necessity of implementing cutting-edge technology in a number of operations, the enormous connectivity of equipment fosters the development of fresh ideas and new viewpoints for SL administration.

As an example, consider the intelligent contract that collects the parameters that both parties can define. It offers transparency at every stage of the supply chain and guarantees trust throughout the contract's implementation. When an item is moved from the shop to the shops, IoT devices have the ability to update a smart contract. This gives a company's complete supply chain immediate visibility.

Furthermore, to enhance client orientation, the preceding procedures must be reorganized with an assurance of delivery revenue, resistance to problems, and the flexibility to swiftly switch logistical priorities. This can enhance the capacity to foresee shifting customer preferences and requirements. As a result, new difficulties appear, and the logistics industry is restructuring.

Solutions for sustainability. The word "sustainable" refers to a normative idea. It looks at how businesses and society should behave while keeping in mind the environment, relationships between people, and communication with future generations. Sustainable practices are becoming increasingly important due to rising consumer demand and economic advancement.

Because of pollution and environmental damage brought on by industrial waste, this idea is growing in importance in the industrialized world. Therefore, it is critical to manage garbage in an eco-friendly manner while keeping the business's and humanity's longevity in mind. Thus, raising the standard of living without compromising that of future generations is the fundamental challenge of sustainability. The process of reverse logistics seeks to do this by enhancing the industry's viability through the reuse and recycling, refurbishment, fixing, and secure disposal of goods and parts. Reverse logistics also includes packaging management and end-of-life product management. Instead of throwing away material in a garbage dumps, it is feasible to get additional value out of goods and their packaging that customers return.

4 IMPLEMENTATION AND EXPERIMENTAL RESULTS

Three basic and highly permeability viewpoints can be used to analyze the goals and tasks of SL: policy (financial and societal), the entrepreneur, and the customer. When identifying a policy in the operational area of logistics from an economic standpoint, such as the state, it is important to highlight its formal and legal relationship with government institutions and human beings. These entities distinguish a portion of their logistics operations, such as shipping, storing, and communications infrastructure, from those of defense.

The policy addresses social issues by providing goods and services that are needed by society in compliance with the 7W rule (the appropriate product, appropriate quantity, appropriate condition, appropriate place, appropriate time, appropriate

client, and appropriate cost (price)) and by "using" logistics in an objective manner. Considering the aforementioned, it can be concluded that government agencies and institutions intentionally, both directly and indirectly, influence the development of logistics policies that enhance the efficacy and efficiency of product flow procedures and the data that flows between suppliers.

It must be noted that the concept of logistic policy is not superior to other strategies; rather, it is complimentary to some (such as security and transportation policies) and collaborative to others (such as industrial and maritime policies). It is crucial that it not be "closed" in the context of a state but rather considered and recognized in every aspect of its operation, including economic and comprehensive policies. This is closely related to the processes of globalization and aims to establish a logistics relationship with "no barriers" across countries, regions, and continents. In this instance, the logistics policy—for example, the standardization policy—creates a link that essentially unites the several domains of the operation of the regional, state, and, ultimately, global economies.

Identifying the decision-making hub in charge of creating a state's logistic policy or the worldwide logistic strategy is a different issue that hasn't been resolved yet.

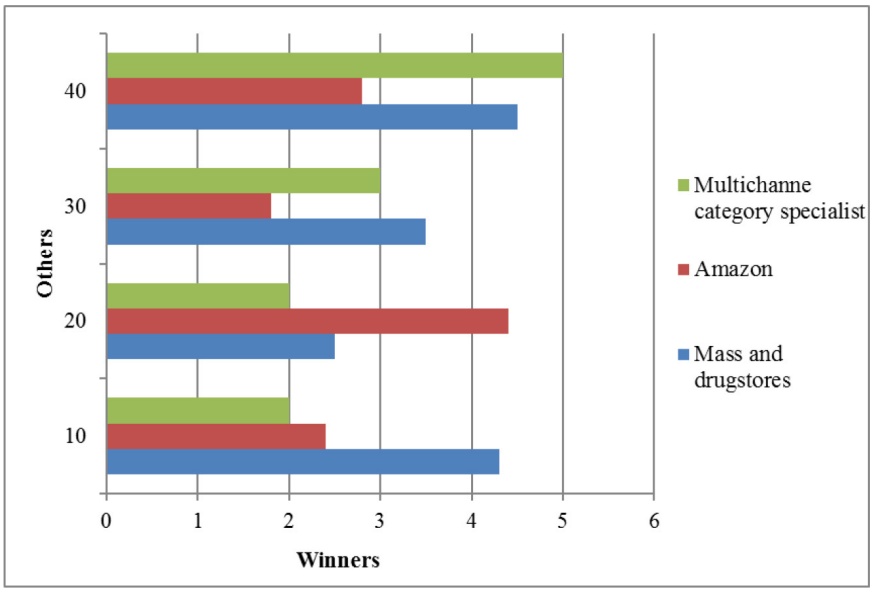

Fig. 3. Relationship between government policies and logistical policy

It can be believed that the various types of logistics, such as worldwide, the euro, marketplace, vital, and supply chain logistics, are emanations of each of the main and comprehensive policies that serve as the foundation for actual systems and processes. This assumption is based on an analysis of the scientific literature, primary information, and actual logistics practices in Figure 3. The definition of these logistics, which includes SL, allows for the determination of both the areas of their appropriate policy as well as the characteristics attached to them.

By utilizing SL solutions, businesses can take advantage of opportunities related to productivity growth, production optimization, inventory reduction, stoppage reduction, improved resource allocation and product quality, and the development of new, highly valuable products. Furthermore, because they may customize items to fit specific orders and shorter manufacturing runs, companies can accurately meet customer requests. Meanwhile, fresh players can enter the market as a result of the emergence of new industries and modifications to established company structures.

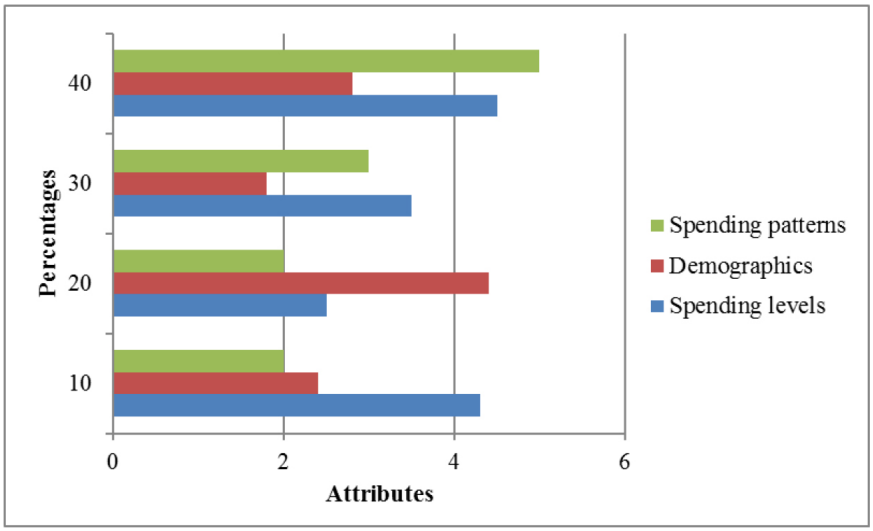

Fig. 4. The percentage of respondents who analyze the attributes of shoppers

The proper preparedness of entrepreneurs to use the data provided by SL channels is shown in Figure 4. The actions of the leading e-commerce branches are depicted in this figure in relation to the other market participants in the data analysis space. When examining the goals and tasks of Second Life from the viewpoint of the consumer, consideration should be given to the financial paradigm, which is unmistakably moving towards the shared economy and creating an economy that can adapt to changing demands.

The IoT, mobile technology, and social communication are all influencing this paradigm shift. This is related to meeting the requirements of each individual customer individually, providing possibilities to work more efficiently and earn more money, opening up new career paths and employment opportunities based on interests and skills, and providing opportunities to further your education and develop new skills.

5 CONCLUSION

The IoT technologies currently being used in smart logistics were surveyed in this paper. We started off our conversation by going over some relevant papers and some basic understanding of smart logistics. Next, our attention was directed towards IoT enabling technologies in smart logistics. Also covered in-depth were the ways in which IoT technologies are used in the field of smart logistics, as seen from the viewpoints of information processing, distributing processing, lugging around, storage, loading/unloading, and transport. In addition, we talked about some important research obstacles and potential lines of inquiry for IoT-based smart logistics.

Our primary contribution is the presentation of extensive and in-depth work. First, we talked about the latest developments in smart logistics and the scientific studies conducted in this field. Second, we discussed the concepts and technologies that need to be implemented in order to ensure a successful rollout. Lastly, we annotated the smart logistics paradigm's application. In addition to discussing open research possibilities for future works this survey covers recent research efforts to address important difficulties in several fields of smart logistics research.

Even with all of the scientific advancements in our field of study, there are still a number of gaps in the actual application of AI in the field of smart logistics, namely. One of the primary future paths that will guarantee more effective operation leadership, value for money, and enhanced performance is still smart logistics.

Additionally, a key area of focus for future research is the implementation of the theories and concepts that have been brought up most frequently in the examined samples. Our future works will present our smartly developed prototypes, taking into consideration all the concepts, paradigms, and technologies studied in this contribution. Most notably, we will apply machine learning algorithms to transport to increase efficiency and reduce costs.

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