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The effectiveness of the smart sea ports operations within smart cities

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ABSTRACT

Global population growth encourages the coordination between urban city planning and other stakeholders in order to maximize logistics utilization of Technologies 4.0, many researchers investigated the different factors affecting the implementation of smart cities, these factors includes technological and social factors that considerably affect the transformation toward a smart environment, for instance ,smart cities can't run properly without smart logistics solutions, the Implementation of advanced technologies solutions in the smart cities will facilitate the flow of goods and the transportation as well, in this respect, Smart logistics is a necessary condition to efficiently provide mobility to the transportation and flow of goods within smart cities, respectively, sustainable sea ports entails to integrate the business strategies and operations in way that meets the present and projected needs of the port and its stakeholders while safeguarding and protecting the marine environment, this paper aims to present the role of smart sea ports in the transformation of coastal cities in to smart cities.

1. Introduction.

The emergence of the smart city concept has brought a paradigm shift in urban mobility systems. Today, with technologies such as Internet of Things (IOT), Wireless Sensor Networks, Data Analytics, Big Data, etc., the transportation sector is seeing a new scope for significant changes and transformations. Today, the transport sector has become a complex system with services integrated into one platform governed by technology, In this regard, IoT technologies entails to speed up data collection and provision on rural transportation, making it possible for local authorities to provide exhaustive information of the current usage trends in a specific area, which could lead to a more effective action coordination between authorities at different levels. [23]

Accordingly sustainable urban mobility intent to meet the needs of society to move freely, gain extensive access to desired locations, communicate, negotiate and make relationships without sacrificing other values. [21], alternatively, the concept of smart logistics aims to increase the efficiency, safety, and eco-friendliness of the logistics environment.

In this respect, port connectivity entails to secure collaboration between ports and adjacent cities. Ports as a logistical centers facilitate freight and passenger transportation, hence Ports play an important role in international trade and have an impact on adjacent communities by lowering transportation costs for commodities and people.

According to (Uckelmann, 2008), Smart Logistics integrates existing logistic technologies, such as material handling systems, and enable these to react and act in a correspondingly smart manner [28].

2. Smart Logistics.

Smart logistics is a key solution to cope with the challenges in supply chain management, Smart Logistics can be defined as the combination of traffic management structuring and navigating traffic for optimal use of traffic systems and logistics management (organizing, planning, control and execution of the flow goods) by effective usage of data, Respectively, Logistics 4.0 can be defined as networking the whole supply chain through information technologies (IT), where high technologi-

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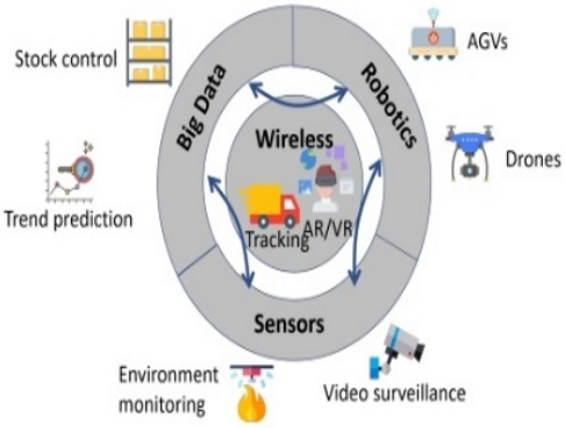
cal sensors and advanced robotics are used in operations Logistics centers in the new industrial era[5].

Figure 1: Depicts the smart logistics supply chain process.



Source: Adopted from Khatib, Emil Jatib, and Raquel Barco (2021).

According to (Kauf, Sabina,2019), the biggest influence of smart logistics for realization smart city concept is visible in area of smart mobility which means huge web of connections, transport and communication with big speed of connecting all of the resources of the city, in this respect, an intelligent systems of transport (ITS) can be defined as a network that maximize the use of existing infrastructure through a range of technological means, such as traffic signals, travel planners, smart ticketing, and cooperative systems [2], accordingly the implementation of the (ITS) is expect to provide the smart cities residence the following benefits;

- Improvement of safety of traffic (decrease of car accidents by 40-80%).
- Decrease time of traveling and use of energy by 45-70%.
- Improvement of convenience of traveling and conditions of traffic of drivers that are traveling by collective transport and pedestrians.
- Reduction of costs of management of traffic supply train.
- Reduction of costs connected to maintenance and renewal of surface.
- Improvement of quality of natural environment (reduction of exhaust fumes by 30-50% increase of economic advantages [15].

3. The implementation of IOT in the logistics sector.

Internet of Things (IOT) includes all machines, devices and services connected via electricity grids and information systems, such as solar panels, weather stations, heating and air conditioning, washing machines, dishwashers' light bulbs, or electric vehicles, furthermore, it can also support the efficiency of public service delivery in a number of ways. For instance, by enabling street objects (street lamps, parking meters) to communicate, which allows a continuous monitoring of their performance and scheduling maintenance only when it is needed – or predict when there is danger of a breakdown, in this regard, the Netherlands adopted IOT technologies to better plan and manage shipping and reduce the ecological footprint of the port of Rotterdam [13].

3.1. Intelligent Transportation Systems (ITSs).

Intelligent Transportation Systems (ITSs) are advanced intermodal transport networks used for smart cities. As one of the key tenets of mobility solutions, ITSs are specialized systems for data collection, storage, and processing and provide expertise in the planning, execution, and assessment of the integrated initiatives and policies of smart mobility [9].

Given the increasing traffic volume, a modern port should ensure high cargo handling performance, reliability, and efficiency, as well as a reduction in vessel waiting time in the port and uninterrupted operation. This necessitates improvements in logistics organization as well as the application of new digital technology.

3.2. Internet of Vehicles (IOV).

Internet of Vehicles (IOV) is an open and integrated network system with high manageability, controllability, operationalization and credibility and is composed of multiple users, multiple vehicles, multiple things and multiple networks. Based on the cooperation between computation and communication [29], IOV is evolving from Vehicular ad hoc Networks (VANETs) to achieve the vision of 'from smartphone to smart car'. The sole aim of conventional VANETs is to enhance traffic safety and efficiency using real time communication among advanced wireless access technology enabled vehicles with or without the help of Road Side Units (RSUs) [18],the backbone of the system rests on a fast, reliable and high-bandwidth connection that is possible only with 5G's speed and performance [15].

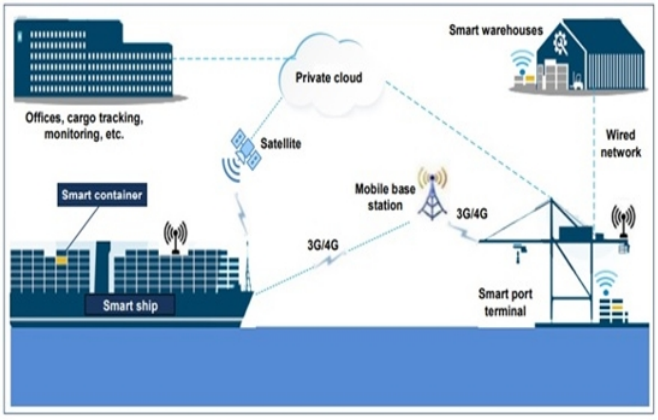
3.3. Block chain technology.

The Block chain technology (BC) acts as a database, whereby the data must be stored permanently and without contradiction along the supply chain (SC). In this way, a complete, cross company data and information flow along the entire SC can be ensured. [4], respectively, IBM and Maersk have announced in 2017 a collaboration agreement to implement Block chain technology in the supply chain, whereby it has been considered as one of the biggest steps to integrate Block chain with IOT in order to transform a global supply chain [22].

In the same essence, the "Internet of Ships (IoS) is the interconnecting of sensing objects like ships, crews, cargoes, onboard equipments, waterway environment, waterway facilities, shore based facilities and other navigation elements, which are embedded with a variety of sensor and heterogeneous network technologies to enable these objects to collect and exchange

data". IoS enables the monitoring of vessels and on-board equipment in real-time. Furthermore, ship owners can perform data analytics on historical and current data to enhance the vessel's efficiency and minimize fuel consumption [1].

Figure 2: Depicts the Internet of ships communication environment at sea.



Source: Adopted from Aslam, S., Michaelides, M. P., & Herodotou, H. (2020). Internet of ships: A survey on architectures, emerging applications, and challenges.

3.4. Radio Frequency Identification (RFID).

RFID is a type of auto ID technology that uses radio waves (as the name Radio Frequency Identification denotes) to identify, monitor and manage individual objects as they move between physical locations, With RFID systems, companies would have increased product visibility, reduce out-of-stock items, trim warehouse costs, eliminate stock errors, reduce theft and shrinkage and allow companies to regularly update their logistics and inventory databases [3]. Respectively (Cho, Gyu-Sung, 2018) proposed the implementation of Warehouse Management System (WMS) in the logistics centers which automatically trigger barcode or RFID information attached to the pallets required for warehouse automation and automates both goods receipt and warehousing in a way that interoperates with shuttle, stacker crane, or satellite.

In that context, (Cimini, et al , 2020) shed light on the utilization of drones to undertake the monitoring tasks required to overview the warehouses security and during picking or inventory auditing, moreover, the research reviewed the use of collaborative robots to assist in the process of pickn'-place, loadn'-unload, inspection, kitting and packing activities of parts and products.[24], in this respect ,Amazon started using robotics in 2012, and currently has 26 of its fulfillment centers worldwide using robotics and people together. [19],Similarly ,DHL smart warehouse deployed a team of autonomous mobile robots (AMRs) in their smart warehouse in the Netherlands, consequently ,the robots can move freely between pickers and packagers, which means people will spend less time on their feet moving around the warehouse and more time performing the more demanding task of picking [13].

Currently, simulation modelling of the port terminal is used at levels associated with ship movement, ship handling on the terminal quay, and container handling. This enables for better utilization of terminal resources and overall performance.

Reducing the time the vessel spends in port, among other things, decreases the environmental impact. Tagging is commonly used in Smart Warehouses, with low-cost identification devices such as RFID. Sensors and actuators, in conjunction with radar or cameras mounted on forklift trucks, can assure the proper operation of self-driving warehouse forklifts [14].

In this respect , (D'Amico, G.,et al , 2021) highlighted the role of the RFID in the port of Hamburg in monitoring the movement of containers, checking the expected delivery and which port processes and infrastructures must be used for correct routes management [8].

4. 5G Logistics.

Connectivity is a key feature of smart mobility, which, together with large data, enables consumers to send all travel data instantaneously while members of the local municipal administrations may perform strategic control simultaneously.

The evolving of fifth generation (5G) networks is becoming more readily available as a major driver of the growth of IOT applications ,Respectively (Liu, Mei.,2021) suggested that 5G technology can be widely used in logistics, mainly because of the close relationship between logistics and the Internet of Things. The massive access characteristics of 5G promote the application of the Internet of Things in the logistics industry and promote the intelligent development of logistics [21], consequently (Khatib, Emil Jatib, and Raquel Barco,2021) proposed a non-standalone (NSA) system mode of 5G centered around the needs of logistics, the research demonstrated that the possibility of outsourcing the communications management (while keeping confidentiality thanks to end-to-end encryption), the displace costs of ownership, communications infrastructure equipment and management, security patches, universal connectivity solution were among the main benefits of 5G implementation on the logistics industry [19].

According to (Chamarajnagar, Ravishankar and Ashwin Ashok, 2019), The 5G-IoT architecture should be able to satisfy the services requirements from following aspects:

- Scalability, cloudification/network function virtualization (NFV).
- Network virtualization capability.
- Sophisticated network management, includes mobility control, access control, and resource efficient network virtualization.
- Smart services provider, the architecture should be able to provide smart services based on big data analysis. [9]

from a different perspective the IOT in a 5G framework mainly comprises of five layered architecture; IOT Sensor Layer, Network Layer, Communication Layer, Architecture Layer, Application Layer which involves the operation of collecting data,

processing, analyzing and sharing the information between the devices and communication network [11].

In this respect, the Hamburg Port uses 5G-based networks to monitor vital infrastructure via enabling virtual reality, while the Seville Port exploits mobile network technology for monitoring goods and traffic in the port in real Time.[16] , accordingly , In May 2020, three Chinese enterprises (Dongfeng Motor Corporation, China Mobile Limited and China COSCO SHIPPING Corporation) jointly launched a project to implement a 5G-based smart port full-scene demonstration application at Yuanhai Terminal in Xiamen, East China's Fujian Province.

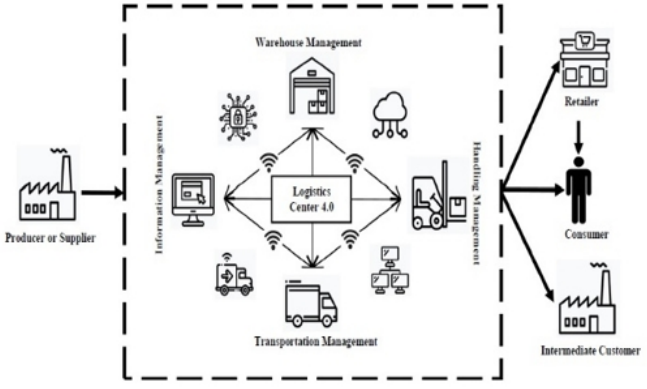
The solution gives a comprehensive way to operate unmanned container trucks, high precision positioning, and multi-sensor fusion based on Beidou Navigation System, plus 5G-based port machinery remote control transformation [7].

5. Smart Logistics Center.

Logistic Center can be defined as a hub of a specific area where all the activities relating to transport, logistics and goods distribution – both for national and international transit – are carried out, on a commercial basis, by various operators [14], The new technological developments of logistics through Industry 4.0 are expected to alter LCs' operations including handling, warehousing, distribution, and transportation, where smarter systems are needed.

In this regard (Yavas, Volkan, and Yesim Deniz Ozkan-Ozen,2020) examined the factors affecting the four main functions (Handling Management ,Information Management ,Transport Management and Warehouse management)of a logistic center 4.0 , the study found that digital information platforms and intelligent transportation systems , along with real time locating system are considered as the main factors affecting the smart logistic center operations ,accordingly (Kostrzewski,et al ,2021) suggested that adoption of modern cargo identification systems and modern warehousing technology will boost the logistic centers operations efficiency [17].

Figure 3: Shows the smart logistics center operations.



Source: Adopted from: Yavas, Volkan and Yesim Deniz Ozkan-Ozen, 2020.

From another perspective, an interregional logistic center entails to carry out integrated logistics (information, storage and transport) services to the inter-regional and international level in the organization of a full cycle of transportation management, respectively, (Gafurov, Ilshat, Michael Panasyuk, and Elena Pudovik,2014) suggested the town of Sviyazhsk to host the Network of inter-regional and international logistics centers (ILCs) in the Russian federation in order to perform the following functions;

- Support of process of planning, organization and implementation of rational delivery of foreign trade goods;
- Providing cargo owners and other parties concerned with information on transport and other operations involving transport of foreign goods to meet consumer demand of users;
- Technological connections with the international logistics system;
- Development of a single scheme of national transport infrastructure complex, etc. [20].

The smart logistics center optimize the performance of the following operations:

(i) Monitoring: governments can observe and record the status and flow of their supply chain;
(ii) Measuring: the supply chain performance can be measured without incurring in additional costs;
(iii) Controlling: governments and states can modify and reevaluate the implementation of their business operations if required;
(iv) Automating: warehousing operations can be initiated or ended even without human intervention;
(v) Optimizing: coordination among people, products, and means can be improved;
(vi) Learning: analytics can be provided that inform managers of Weaknesses and strengths in their supply chain Scientific and technological research article.

5.1. Smart Ports.

According to (ITU-T, recommendation Y.4209 (2020) smart port is expected to provide services that enable the enhancement of the user experience in the port, including passengers, visitors and port employees. A smart port may interoperate with the port area of influence, with one or more smart cities, with other smart elements (e.g., airport, railway stations) and with third parties (e.g., stakeholders, service providers). A smart element is regarded in this Recommendation as a logical or physical entity that is typically part of the smart city ecosystem (e.g., railway stations, airport) but not necessarily (i.e., the smart port is an independent smart element that might not be related to any city), and that interoperates with the city itself or with any of the rest of the smart elements [26].

The UNCTAD report in 1999 classified sea ports in to four generations, the first generation entails to stevedore cargo between land and sea-based means of transport. In this generation

the seaport operates in isolation from transport and the commercial function. The second generation ports, integrate with their surroundings via their transport, industrial, and commercial function. Within the port areas, industrial parks are created to receive imported raw materials delivered by sea , The third generation ports are characterized by higher activity than the previous generations, in connection with searching for cargoes by implementing the strategy of development which fosters the creation of integrated logistics centers and even logistics platforms supporting international trade, The fourth generation ones play a super-regional role creating a hub, where Port authorities are interconnected by a common administration (such as in the case of ports in Copenhagen and Malmo) or a common operator of the container terminal. respectively Kaliszewski, A. (2017) referred to the fifth generation of sea ports as having deep IT integration with various stakeholders, where, port operations enables an undisturbed exchange of cargo between the port and its hinterland, and ensure a high level of security, cost rationality, and generate progressively smaller external effects on the environment [20].

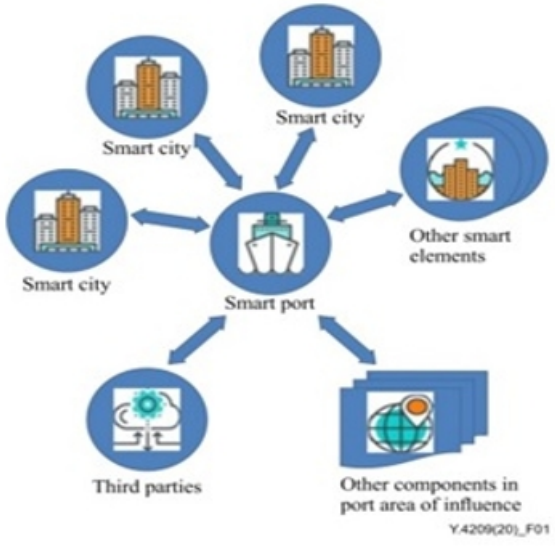
Respectively, (Chen, J., et al, 2019) suggested that the first four generations of ports paid far too little attention to port technology innovation and environmental protection, failed to achieve green and low-carbon development, and neglected issues such as climate change and environmental pollution. Global climate warming is one of the huge challenges facing mankind, and people in all walks of life must endeavor to save energy and reduce emissions. Port pollution greatly affects the climate environment. Most of the pollution comes from port production and transport ships. Approximately 70% of the world's marine emissions occur in the coastal area of the port, whereas 60–90% occurs during the berthing period [6]. In this respect, Piraeus Port Authority (PPA) and the Huawei Technologies SA have signed a mutual agreement in 2018 with the aim of modernizing the Piraeus ports main networks, Moreover to maintain high network services availability, and to increase the internet speed data rates from 20Gbps up to 80Gbps, which will make the port network infrastructure capable of supporting any future need as well as shielding against network threats [14].

Accordingly, port cities engaged in smart and sustainable logistics aim to involve institutions, citizens, start-ups, high tech companies, research centers, universities, freight forwarders, couriers, financial institutions, etc. in activities of planning, design, monitoring, analysis, evaluation and redefinition of logistics strategies that embrace the economic, social, environmental and technological spheres [8].

According to (Giménez, P., ,et al,2021)Typical logistic operations within a port can be enhanced due to interoperability, e.g. parking space availability, container status, availability of unloading/loading capabilities at the container terminals, ETAs (Estimated Time of Arrival), and remaining driving times [11].

As it's demonstrated in figure (3), smart port needs a smart port platform in order to provide the smart ports with smart services and interoperation capabilities, the smart port platform includes computer system or integration of computer systems that, under control of the port, uses information and communication technologies (ICTs) to access data sources and process

Figure 4: Shows the main components of the smart port ecosystem.



Source: Adopted from: ITU-T, recommendation Y.4209 (2020).

them to offer both port operation and services.

According to (Rodrigo González, A, et al, 2020) digitalization can play an important role covers the whole range of port activities. It allows for a substantial potential improvement in the following fields:

- Greater efficiency in operations (which leads to better economic returns);
- Worker safety;
- Active and dynamic communication with the social environment;
- Port management at an institutional level;
- Environmental and energy sustainability [23].

Furthermore, according to (Triska, Y.,et al , 2019) an automated container terminal can save at least 25% more energy and reduce 15% more carbon emissions than the traditional terminal as a result of using power-driven vehicles [27].

5.2. The smart ports effectiveness in the coastal cities .

Sea Ports serve as logistical hubs which facilitates freight and people transportation and hence interconnection between sea ports and cities is more important than ever before. Subsequently, Ports play an important role in international trade and have an impact on adjacent communities by lowering transportation costs for commodities and people.

Seaports has a significant economic and environmental effect in coastal cities more than other cities. The city-port interface zone connects the city to its port directly. The new economic development programs considered the sustainable operations of the sea ports operations as one of the main objectives,

especially with the increasing volume of freight traffic and the growing demand for rapid, efficient, reliable, and environmentally friendly logistics solutions, in this respect, the united nations Sustainable Development Goals (SDG 9) aims to build resilient infrastructure, promote sustainable industrialization and foster innovation.

In this respect, "port city" can be defined as a city with a maritime hub, where the port acts as a junction point between land and sea transport networks. According to this concept, global trade starts from the hinterland, whereas ports are points of arrival and departure. Ports are strengthening the competitiveness of a city and increase the economic prosperity of a region [12].

According to (Yulai Wan , Anming Zhang & Andrew C.L. Yuen ,2013) a 1% increase in road congestion is associated with 0.90–2.48% reduction in the container throughput of the seaport affiliated with that urban area, while implying an increase in the throughput of its rival port by 0.62–1.69% [30].

Efficiency is one of the characteristics of successful logistics. It is critical to deliver items from point A to point B as quickly and smoothly as possible. Fast clearance, as well as an invisible registration process and easy processing operations, such as with customs, are essential. Indeed, new digital platforms have created an electronic "parallel world" that supports genuine commodities delivery, making it speedier and more transparent.

The best collaboration can be achieved by developing an interconnected integrated system of good transport infrastructure for all modes of transportation and cargo owners, as well as a unified information environment of technological interaction between various modes of transportation and transport process participants for a modern distribution network, ensuring the volume and quality of transport services.

In this context, Block chain technology provides security, transparency and decentralization of processes.

Respectively, Logistics centers is a vital component of global logistics networks that provides efficient terminal handling and cost-effective logistics solutions for a variety of transport flows. Logistics centers may have diverse business processes in marketplaces, trade, and industry, or logistics service provider systems. These logistics parts are often formed on a market basis, but cities may also be active in establishing logistics areas and may even initiate campaigns to do so.

Accordingly, Eckhardt, J., & Rantala, J. (2012) investigated the effectiveness of smart logistics center that relies on RFID technology in enhancing the efficiency of logistics operations and also in developing new service models for their customers. Moreover, the smart logistics center promote the tracking and tracing of material flows including effective handling processes ,along with maintaining cost-efficiency throughout the supply chain.

Conclusions

Logistics centers play a key role in ecommerce because they determine where you will store your inventory, how soon you can deliver customer orders, and the different types of shipping options you can offer your customers.

IOT technologies, especially block chain technology and RFID with sensors, can guarantee the safety and quality of goods, particularly perishable products, by collecting, monitoring, and tracking ambient environmental conditions during delivery.

5G can be widely used in logistics, mainly because of the close relationship between logistics and the Internet of Things. The massive access characteristics of 5G promote the application of the Internet of Things in the logistics industry and promote the intelligent development of logistics. The new generation of logistics has a complex structure system.

5G network adoption will have a significant impact on high-end IoT applications such as robots and automation, virtual and augmented reality, and artificial intelligence.

Logistics efficiency is improving as the automation of logistics centers and logistics facilities around the world is progressing. In particular, advanced systems introduced in logistics centers have replaced manpower while carrying out tasks that are difficult for people to do. logistics center based on IoT and ICT, utilize and analyze smart technology such as Big Data, and optimize the storage, transportation, unloading, packaging and delivery of products based on the analyzed knowledge.

Smart ports are intended to operate and manage modern ports by utilizing advanced intelligent technology and procedures. To realize smart and green port operation, the construction and sustainable growth of a smart port should be built on the concepts of cooperative cooperation, technological innovation, environmental protection, energy conservation, and full use of information technology.

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