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THE EFFECTS OF DEVELOPMENTS IN DIGITAL TECHNOLOGIES ON THE ACTIVITIES OF MARITIME BUSINESSES AND SHIPS

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Abstract: In the era of digitalization, record-breaking leaps in information and communication technologies (ICT) are revolutionizing industries worldwide, including the maritime transport sector. The theme of this research is to examine the effects of digitalization on maritime business models and ships. Utilizing a qualitative, explanatory, and applied research design, the study reviews secondary data and literature to explain how digital technologies such as broadband systems, wireless networks, and Internet of Things (IoT) are transforming maritime communication, navigation, and ship management systems. Results show that digitalization powerfully enhances operational efficiency, reduces manpower requirements, and introduces new economics paradigms like the use of cryptocurrencies. However, it also has its downsides in the shape of heightened cyber threats, particularly with the introduction of autonomous ships. The discussion stresses the need for updated training, robust cybersecurity measures, and the adoption of next-generation satellite communication technologies (like Starlink, Iridium) to preserve the industry's flexibility and security. The report finds that adjusting digital means and policies is paramount to the competitiveness, efficiency, and security of maritime players with a more data-focused world economy.

Keywords: Information and communication technologies, Digital technologies, Maritime business, Maritime communication, Ship management

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1. Introduction

In today's world where oil pipelines are turning into fiber cables and oil into data, the IT sector is increasing its influence in both individual and corporate areas. Presently, the IT sector and digitalization are advancing at such a rapid pace that numerous individuals and organizations are struggling to keep pace. Today, there is no area left where the IT sector has not had an impact, both individually and institutionally. Because all technological developments in this sector also affect other sectors affected by IT to varying degrees (Tekin et al., 2006). The primary catalyst for recent developments in this sector is digitalization. Digitalization signifies real-time sophistication, and consequently, it has become the focal point of data-driven ecosystems due to new technological advancements and the resultant changes in business models. In the information technology sector, numerous definitions have been proposed regarding this subject; however, the most widely accepted definition pertains to technology utilizing binary number systems. The decimal system, characterized by ten digits, remains prevalent in everyday life, encompassing numbers from 0 to 9. This system facilitates the expression of various measurements, such as length, weight, distance, and time, using ten digits. Conversely, computer systems employ a binary number system, consisting of two digits, known as "bits," which are represented by "0" and "1." In other words, everything is very clear in the 2-digit number system. Something either exists or it doesn't. It is either black or white. In this way, uncertainty is eliminated in digital systems, and everything is defined very clearly (Acarer, 2017). The 2-digit number system, also defined as the "binary system", forms the basis of digital technology. All devices produced in this system are considered digital technology and carry the advantages of the binary number system.

Progress in digitalization has substantially advanced the IT sector, and the profound transformation within this sector impacts all industries to varying extents. Digital technology facilitates the recording of diverse system data, compression (zipping) to conserve space, data transfer, enhancement, and optional modification. The binary number system further enables device miniaturization, accelerates data communication, and enhances system capabilities. A notable manifestation of digitalization is the reduced demand for human resources in the production of these systems.

Maritime transportation is the backbone of the global

trade. Today, about 80% of global trade by volume is carried via sea (Kodak and İstikbal, 2021). A notable manifestation of digitalization in recent years has been observed in the maritime sector. This transformation is evident across various domains, including ship structures, marine communication systems, ship equipment, and maritime transportation. This evolution is encapsulated in concepts such as next-generation ships, electronic commerce, unmanned ships, and Maritime Trade 4.0. Although these concepts encompass diverse expressions, they all fundamentally stem from the differentiation introduced by digitalization in maritime contexts.

The reliance on manual or semi-automatic systems has diminished with digitalization, as exemplified in the maritime sector, where ship management has evolved. Historically, smaller tonnage ships required 35 to 40 crew members, whereas contemporary large tonnage vessels can be operated with 15 to 20 personnel. This transition has resulted in substantial savings, particularly in ship operating costs. Additionally, significant changes have occurred in ship loads and loading areas, accompanied by notable reductions in fuel expenses.

Today, technological and digital innovations frequently alter the competitive landscape, providing strategic implications and new market dynamics for companies (Saygılı, 2021). Digital technology exerts a profound influence across various sectors, significantly impacting the economy. The advancement of digital technology has led to a decline in the traditional economy. The transition between the traditional and digital economy over the 20-year period from 2005 to 2025 is illustrated graphically in Figure 1. The digital economy, whose share of global GDP has increased from 11% to 15% over the last 10 years, is expected to account for 24% of global GDP by 2025 (Huawei and Oxford Economics, 2017).

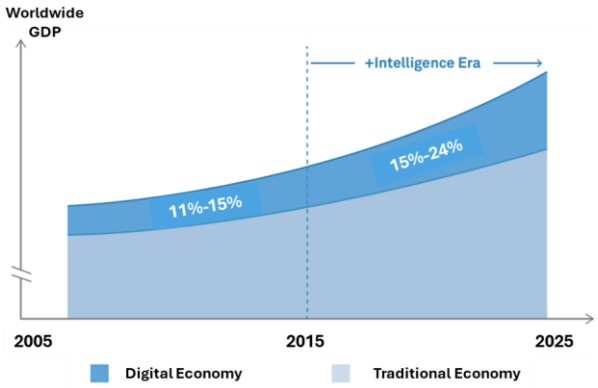

Figure 1. Projected growth in global digital economy (Huawei and Oxford Economics, 2017).

The rapid evolution of electronic commerce continues unabated. Both corporate and individual trade are increasingly transitioning to electronic platforms, significantly altering the nature of commerce. A primary driver of this transformation is the pervasive integration of mobile devices into daily life. These devices facilitate a wide range of functions, from photography to internet access, effectively becoming indispensable tools. Consequently, mobile phones have emerged as essential items in daily life (Acarer, 2020). Beyond voice communication, mobile phones now serve as critical instruments for data exchange, functioning akin to portable computers. Many individuals and organizations utilize mobile phones for mobile payments in commercial transactions, a trend that is gaining momentum. Currently, 73% of consumers are capable of making payments across various domains using their smartphones (Türkiye Bankalar Birliği, 2020). Concurrently, the increased utilization of technology, juxtaposed with a rapid decline in trust in technology, brings cryptology to the forefront. The advent of virtual currencies, which are increasingly recognized as digital money, is propelling digital economies forward. Although Bitcoin, a prominent digital currency, is a relatively recent innovation, it addresses age-old economic challenges (Koçoğlu, 2016). Over time, numerous cryptocurrencies have emerged (Tasca, 2015). Cryptocurrencies other than Bitcoin are commonly referred to as altcoins, a term derived from "alternative" and "coin" (Lee, 2015). Presently, the majority of payments and money transfers occur online, a preference that is strengthening globally due to the acceleration of digitalization and the proliferation of social networks and digital enterprises. Similar advancements are evident in the maritime sector, which demands expedited decision-making and transaction processes. The maritime industry capitalizes on digital systems to enhance its competitive edge. The adoption of digital currencies facilitates the development of payment systems and fosters faster, more secure commercial interactions. Over 2.8 billion people worldwide use mobile payment services on a regular basis as of 2024, which backs the shift towards a fully digitized economy (Statista, 2024). The annual global mobile payment transaction volume has increased over the years in parallel with the number of users. The protection of information has been a persistent challenge since antiquity, with numerous solutions devised for its safeguarding. Cryptology has emerged as the most widely accepted solution to date, effectively preventing unauthorized access to information (Yılmaz, 2007).

Currently, the United Nations estimates an economic volume of 10 trillion dollars globally. The proliferation of internet tools and the development of new payment methods significantly contribute to this figure. According to research commissioned by Google from the Boston Consulting Group (BCG), a substantial portion of this increase is attributed to the more widespread use of mobile devices and mobile phones in recent years. Because mobile equipment is one of the devices we use most frequently in our daily lives (Aktan, 2018).

In contemporary times, the most significant advancements in communication infrastructures are observed in wireless systems. Progress in 3G (Third Generation) and 4G (Fourth Generation) infrastructures continues to enhance this process. Notably, recent technological advancements have precipitated a rapid

increase in broadband data communication. Consequently, many forms of communication that were previously unattainable are now readily achievable. Figure 2 illustrates the advancements in wireless communication systems in recent years. The share of mobile connections on 4G reached its highest level in 2023, approaching 60%, but then this share began to gradually decrease as 5G became more widespread.

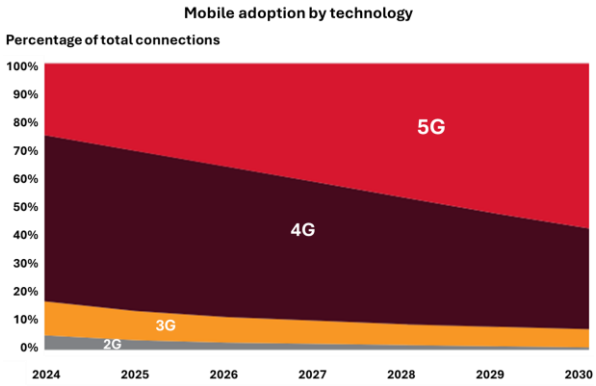

Figure 2. Development of technology investments (GSMA, 2025).

As of December 2024, 305 operators in 121 markets have launched commercial 5G mobile services, with 5G's share reaching 25%. 5G adoption is projected to catch up with 4G adoption in 2028 and approach 60% by 2030. Specifically, developments in mobile communication systems are increasingly facilitating communication from any location at any time. This has also contributed to the development and simplification of maritime trade in recent years. Today, advancements in wireless systems are not confined to mobile networks but extend to short-range systems such as Bluetooth, RFID, and NFC. This has facilitated faster and more efficient communication. Furthermore, the types and coverage areas of various wireless communication systems are comparatively depicted in Figure 3.

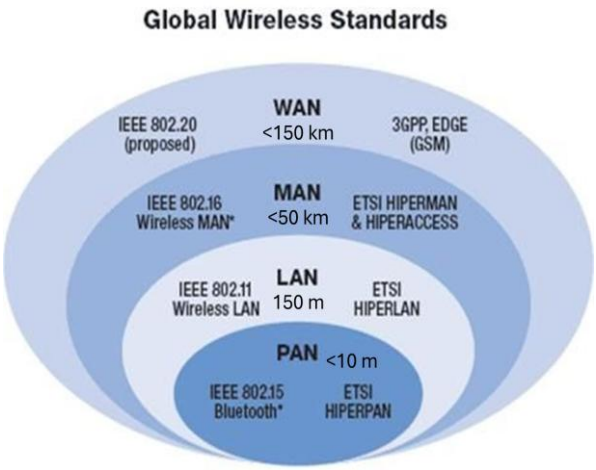

Figure 3. Wireless Networks (Cisco, 2014).

Data speed in wireless systems is increasing with each successive generation. The data speed, which reached 168 Mbps in 3G, was elevated to 300 Mbps in the initial phase with the LTE standard of 4G, and further to 1 Gbps with LTE-A (LTE - Advanced). A new era in mobile communication was inaugurated by establishing a fully IP (Internet Protocol) based communication infrastructure with 4G (Acarer, 2017).

The aim of this study is to examine the effects of developments in digital technologies on the operational frameworks, efficiency, and strategic management of maritime businesses and ships and propose conceptual, system-based solutions to problems resulting from this transformation.

2. Problems and Study Areas

2.1. The Effects of Digital Technology on Maritime

Recent technological advancements have significantly impacted various sectors, including the maritime industry, facilitating substantial changes and developments. The influence of these technological advancements on maritime operations is evident in three primary areas:

- Changes in the systems used on ships,
- Changes in ship communication systems,
- Differences in communication between maritime businesses, agencies, cargo authorities and public institutions related to maritime.

2.2. Systems Used on Ships

The reflections of technological developments on ships are mostly seen in navigation systems. Automation and especially remote-control possibilities in these systems, which are of great importance in terms of the dispatch and management of ships, have led to significant changes in the quality and quantity of personnel required on ships. In recent years, notable advancements have been made in radar systems, Ecdis, and other navigation devices, as well as ship machinery systems. These developments have introduced significant changes and conveniences in the dispatch and management of ships.

In recent years, the information technology sector has increasingly focused on the opportunities afforded by digital technology's most significant feature, the “binary system”. This includes data storage, processing, seamless sharing with other systems, and the interpretation of large datasets. Consequently, effective data communication is now feasible among interconnected devices on ships, such as Autopilot, Ecdis, AIS, and Log systems. These advancements are progressively enhancing ship dispatch and management.

The evolution of ship navigation systems is ongoing, with the ultimate goal being the development of Autonomous Ships. Another domain where technological advancements are markedly impacting ship systems is machinery systems. Innovations in ship machinery systems not only enhance their efficiency but also enable substantial labor savings. As a result, the number of machinery personnel on ships is decreasing, and

significant progress is being made in ship automation. This automation allows for remote operation of ship machinery, monitoring of malfunctions, and status observation without the need to enter the engine room. Today, it has become possible to operate and control the machinery systems of new generation ships from the bridge or other locations, to monitor system alarms from different locations and to troubleshoot problems other than mechanical malfunctions via remote control (Acarer, 2023a). The positive impacts of technological advancements in ship machinery systems continue, and further significant developments are anticipated in the near future.

2.2.1. Changes in Ship Communication Systems

Ship communication systems can be categorized into ship-internal and ship/land, ship/ship communication systems (Ekinalan, 2020). In shipboard communication systems, numerous conveniences have been introduced, particularly with the advancement of wireless communication systems. These developments have gained importance as ship sizes increase. Consequently, each extended cable offers significant maintenance and repair convenience rather than cost, as each additional cable represents a potential failure point. As the volume of information from various devices and systems on ships increases, so does the amount of cabling required to connect these devices to the central evaluation unit, typically an advanced computer system or server. With the growing prevalence of automatic systems on ships, data from sensors, detectors, and various systems is also increasing. If cables are used to transmit this data, a substantial amount of cabling becomes inevitable.

Wireless communication systems offer effective solutions to these challenges. They are particularly cost-effective for data transfer within ships and provide significant advantages in fault detection and maintenance. However, one persistent issue with wireless systems is the propagation of electromagnetic waves in enclosed metal areas, as described by the "Faraday cage" principle. To address this, relay systems are currently employed.

In recent years, numerous systems have been developed, particularly in the realm of maritime communication between ships and with terrestrial stations. Significant advancements have been achieved in wide-band data communication through these systems, which are entirely digital in nature. Currently, maritime communication is conducted via two primary platforms: satellite and terrestrial communication systems (Acarer, 2023b). Terrestrial systems include VHF and HF, while satellite systems encompass Inmarsat, Cospas Sarsat, and Iridium, among others.

A crucial component of the satellite systems currently employed on ships is the Inmarsat devices. Devices such as Inmarsat C and Inmarsat F77 are optionally available on ships undertaking long-distance voyages due to GMDSS obligations (Yılmaz and Acarer, 2014). The widespread adoption of digital technology within these systems has facilitated significant communication opportunities. Recent digital enhancements by the Inmarsat organization (International Mobile Satellite Organization – IMSO) have led to substantial reductions in communication costs and notable increases in data transmission speeds. These developments offer considerable opportunities for communication between ships and with terrestrial stations.

In the short term, the most significant changes in ship-to-ship and ship-to-land communication are anticipated with the deployment of Starlink satellites. The widespread adoption of this system, currently utilized by some large-tonnage ships and yachts, is expected to bring about substantial opportunities and transformations in maritime communication. The low installation costs and affordable communication fees associated with the Starlink satellite system are pivotal factors in its anticipated widespread adoption. Furthermore, the system's capability to facilitate wideband data communication is expected to drive its rapid adoption in marine vessels in the near future.

2.2.2. Changes in Ship Navigation Systems

It is possible to collect the navigation devices that are required to be installed on ships under the following headings.

- Radar,
- Arpa Radar
- Electronic Map (Ecdis),
- AIS
- Auto Pilot,
- Eco Sounder,
- GPS, etc.

Regarding changes in ship navigation systems, radars remain the most critical navigation devices on ships, playing a vital role in ensuring the safe navigation of vessels of all sizes. Other navigation devices serve distinct functions to ensure safe navigation.

Recent technological advancements have led to significant changes and enhancements in both the technical features and navigation-related functions of these devices. Notably, the capabilities of devices such as AIS and Ecdis, which are among the new navigational aid equipment, play a crucial role in advancing ships towards an autonomous structure. The digitalization of navigation-related data now allows for the efficient processing, analysis, interpretation, and sharing of big data with other relevant navigation systems. As a consequence of digitalization, significant advancements have been made in the development of unmanned ships in recent years. Although still in its nascent stages, the production of small-sized and low-tonnage autonomous marine vehicles has commenced. With the advent of new opportunities afforded by digitalization in navigation and communication technologies over the next decade, the proliferation of autonomous ships appears inevitable. Furthermore, recent years have witnessed substantial improvements in the remote monitoring, dispatch, and management of ships, as well as in communication between land units and ship officers. As technological advancements persist, it is

anticipated that the evolution and development of navigation systems, dispatch, and management of ships will continue.

2.2.3. The Impact of Digitalization on Ship Machinery Systems

In recent years, there have been profound changes in the machinery systems utilized on ships. Initially, steam turbine engines were employed; however, contemporary ship engines have evolved significantly in both size and functionality, becoming more technologically advanced. Recently, the machinery installed on ships is predominantly operated via remote control, with many functions being monitored remotely. Indeed, certain malfunctions can be rectified through remote intervention in these systems. Computer systems facilitate remote access to ship machinery systems, and the capabilities provided by these systems have rendered the maintenance and repair of ship engines more efficient and expedient than previously possible. Despite the substantial conveniences afforded in the operation and maintenance/repair functions of ships, which result in significant savings in personnel and time, they also pose considerable risks. This is because the structure of ships is vulnerable to cyber-attacks that could potentially render all machinery systems uncontrollable. Consequently, it is imperative to safeguard remote control systems with security measures against potential cyber threats, both internal and external.

2.3. Changes in Ship Types and Cargo Carried

One of the most significant manifestations of developments in the IT sector in recent years is the widespread use of the internet and broadband data communication. Today, the pervasive use of the internet has transformed the world into a global market.

Consequently, organizations situated in disparate locations can now communicate effortlessly, irrespective of location and time. Concurrently, there have been substantial changes in cargo transportation methods. Container transportation has been on the rise, particularly to expedite the handling of diverse cargo and minimize the risk of spoilage. The widespread adoption of this transportation method has led to significant changes in ship design, capacity enlargement, port handling times, and the structure and characteristics of ports in recent years.

In contemporary container transportation, a critical issue is the requirement for seamless and rapid internet communication among carriers, shippers, cargo authorities, and port authorities. While the duration of loading and unloading operations in container transportation has decreased, it remains essential to ensure the efficient logistics of both the containers and the cargo they carry. Specifically, the appropriate storage of containers, whether empty or full, at ports is a fundamental aspect of this transportation mode. This function necessitates a robust technological infrastructure and uninterrupted internet connectivity.

2.4. The Importance of Digitalization in the Activities of Maritime Companies

When time is not a constraint, maritime transport offers the lowest unit transportation cost among mass transportation methods (Kodak and Acarer, 2021). Currently, 85% of cargo in global trade and 97% of energy transportation are conducted via sea routes. Consequently, approximately 75% of the global population resides in coastal or near-coastal areas (Usluer, 2015).

Digitalization presents numerous opportunities to enhance the productivity, efficiency, and sustainability of the maritime industry (Heilig et al., 2017). Beyond its positive impact on ship operations, digitalization also fosters improvements in the interactions among organizations involved in maritime trade. Numerous businesses participate in the process from the initial transportation order to the final delivery to the recipient. Indeed, the transportation of cargo to ships often involves multiple transportation systems, such as railways and roads, in a combined transportation approach.

Additionally, support services, including insurance, logistics, and agency services, are utilized during cargo transportation. Coordination with various relevant organizations, particularly port authorities, is required from the point of cargo arrival at the ship to its delivery to the intended recipient. Minimizing disruptions in these processes is crucial to ensuring timely transportation activities. Therefore, establishing a fast and reliable communication network among carriers, shippers, and logistics companies is of paramount importance in contemporary maritime activities. As previously mentioned, the IT sector, a domain characterized by rapid technological advancements, has recently provided significant opportunities and conveniences. This progress continues to facilitate the establishment of communication networks with the desired features among relevant maritime organizations. In the context of technological advancements, the ability to communicate with all cargo-related organizations from any location and at any time is becoming increasingly crucial for the operations of these entities. It is anticipated that enhancements in this area will continue to grow in the foreseeable future. Consequently, it can be asserted that technological developments significantly contribute to the efficiency of maritime transportation and trade, thereby fostering the growth of maritime commerce.

2.5. Cyber Attacks on Shipping Companies

The recent wave of digitalization has impacted all sectors, including the maritime industry, leading to substantial changes and differentiations. These transformations are evident not only in the operations of maritime businesses but also in various aspects, ranging from cargo handling to navigation and machinery equipment on ships. Furthermore, new systems are emerging in ship-to-land communication, with automatic and broadband data communication becoming increasingly prevalent. These advancements, while enhancing the quality and quantity

of ship personnel, also expose unprecedented risks of cyber-attacks. Such attacks target not only land-based maritime businesses, cargo operators, agencies, and port authorities but also ships, particularly in recent years. This situation presents a heightened risk in the current era, where ships are becoming more automated and the production of autonomous ships is under consideration.

According to Pawelski (2023), cyber-attacks on the maritime transportation sector increased tenfold between 2017 and 2020. Successful cyberattacks on the maritime industry could have catastrophic consequences (Ahmed and Gkioulos, 2022). Autonomous ships are more vulnerable to cyber threats than conventional ships (Yousaf et al., 2024) and necessitate robust countermeasures (Symes et al., 2024).

Presently, cyber-attacks pose significant threats to both ships and land-based maritime organizations. Therefore, it is imperative to address this issue separately and draw the attention of all stakeholders involved in maritime activities.

3. Materials and Methods

This study adopts a design science research (DSR) approach, which is directed towards identifying real-world problems and developing novel, system-based solutions. The research process includes four phases:

(1) Conceptual Foundation: Literature review of the phenomenon of digitalization, its grounding in binary logic, and its implications for maritime information systems.

(2) Sectoral Impact Analysis: Examination of the effects of digital technologies on labor composition, cost-effectiveness, and operational patterns in maritime logistics.

(3) Technology Mapping: Identification and assessment of key ICT innovations, including wireless networks, mobile generations, broadband infrastructure, and IoT, and their relevance to maritime transformation.

(4) Problem–Solution Synthesis: Recognition of communication gaps, cybersecurity threats, and coordination problems, followed by conceptual solutions such as satellite internet systems and blockchain-enabled authentication.

The section of "Problems and Study Areas" maps out the findings to identify key challenges and trouble areas in ship operation and maritime enterprise. This section indicates the effects of digitalization on the maritime sector, the opportunities it provides in ship equipment, and new opportunities in the activities of maritime businesses and their communications with their ships. In the meantime, attention is drawn to the increasing Cyber Attacks in recent years, and the importance of this issue for businesses and ships is explained.

The "Results and Discussion" section evaluates the feasibility and relevance of the envisaged systems within the framework of the shipping industry and includes topics that can provide solutions to the problems experienced in response to the many opportunities provided by digitalization. This section also draws attention to the positive developments that digitalization has caused in the activities of maritime businesses, as well as the risks experienced, and compares them with examples.

The study uses secondary data sources, including academic literature, industry reports, and technology roadmaps, to create a contextual backdrop of digitalization of maritime operations. In this study, various conceptual solutions have been proposed for the problems addressed.

4. Results and Discussion

The Information Technology sector, internationally recognized as Information and Communication Technology (ICT), comprises two fundamental components: communication and content (Acarer, 2017). Although distinct, these components are interdependent; as communication advances, content becomes richer, necessitating further communication development. Communication, a sub-element of informatics, is categorized into fixed and wireless sub-structures (Acarer, 2021). Additionally, satellite infrastructure is identified as a separate element, constituting the wireless communication framework.

The advancements in wireless communication systems have significantly enhanced maritime communication systems and, consequently, communication between ships and land. Additionally, communication between ship operators, cargo operators, agencies, and official authorities in maritime trade has become more rapid and reliable. As a result, there has been a marked increase in international maritime trade in recent years. In the digitalized maritime sector, relevant institutions are in much greater communication with each other, allowing for the development of commercial relations at every opportunity.

4.1. Developments in Broadband Data Systems

The most tangible outcomes of advancements in information systems are evident in broadband data communication. This is because developments in data communication lead to greater differentiation in other sectors compared to other communication modes. Furthermore, significant differentiation and opportunities are provided in voice over data (Voice over Internet Protocol - VoIP), image, and media communication. Another common feature of mobile communication systems is the increasing demand for higher data communication speeds by both individual and corporate customers. To meet this demand, bandwidth must be progressively increased. Technically, achieving higher speeds in data communication necessitates more bandwidth. Consequently, having more bandwidth has become a technical imperative in every new mobile communication system. This era is characterized by the processing and interpretation of data. Figure 4 shows the increase in data traffic over the years. The increase in total data usage started with the use of LTE Advance (4.5G)

systems and then continued at an increasing rate. However, it is estimated that the real increase in data usage will come with the start of the use of 5G systems. Because the bandwidth and therefore the speed of 5G systems will be much higher than other mobile systems. International Data Corporation (IDC) forecasts the Global Datasphere to grow to 163 zettabytes by 2025.

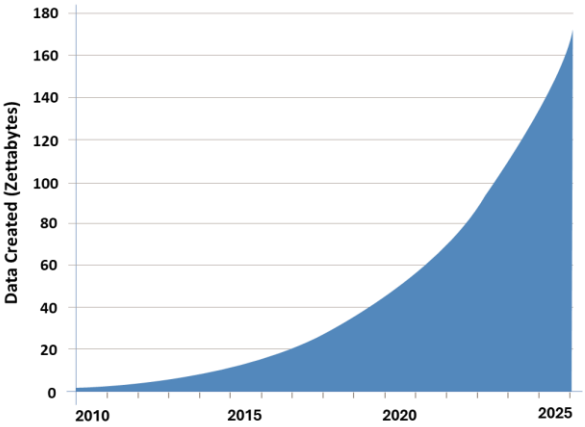

Figure 4. Annual size of the global datasphere (IDC, 2018).

The primary factor in the advancement of broadband data communication is the expansion of data communication channels, with a concurrent aim to progressively reduce latency. Consequently, the latency of 5G systems is anticipated to be lower than that of 4G, while data capacity and connection density are expected to be higher (Bass et al., 2017). As the bandwidth expands, data speed increases, resulting in a proportional increase in the amount of data transmitted per unit of time. Given the substantial data speeds achieved today, the delay in transmitting data generated by sensors and objects to central processing units has been reduced to milliseconds (Acarer, 2021).

The aggregation of data from sensors, the Internet of Things, websites, social media, mobile platforms, and organizational data has led to the emergence of the concept of "big data" (Goes, 2014). Big data analytics is employed to analyze large datasets to extract information that informs decision-making (Gandomi and Haider, 2015). The expansion of bandwidth has facilitated the emergence of various forms of communication that were previously unfeasible with narrowband, thereby providing new communication opportunities for businesses and individuals.

4.2. Developments in the Internet of Things

With the increasing developments in the software and hardware sector, there is a great increase in the amount of addressable objects and devices, and this process continues in the same way (Çavdar and Öztürk, 2018). Developments in the Internet of Things (IoT) have become increasingly prevalent in recent years. IoT, defined as communication between objects, primarily operates on wireless network technologies (Li et al., 2015). It encompasses a global network that connects physical and virtual objects, enabling dynamic communication among them (Sullivan et al., 2020). IoT facilitates the remote monitoring of equipment status (Ichimura et al., 2022). The proliferation of IoT has been further augmented by advancements in mobile access generations (IDC, 2018). Notably, in 4th generation mobile communication systems, it is possible to connect to 50 users and, consequently, 50 objects simultaneously, with download speeds of up to 1 Gbps, upload speeds of 400 Mbps, and capacity values of 100 GByte. This development has presented significant opportunities for mobile access (Acarer, 2020).

4.3. Use of Communication Systems Capable of New Generation Wideband Data Communication in Maritime Communication

To fully capitalize on the opportunities presented by digitalization within the maritime sector, the implementation of next-generation systems is paramount. These systems, characterized by the binary number system and commonly referred to as the binary system in the information technology sector, offer substantial labor and time efficiencies. They also significantly enhance the dispatch and management of ships. As digitalization advances, ship navigation systems have become increasingly technological, simplifying ship operations. In contemporary settings, particularly with the digitalization of new vessels, it is feasible to operate numerous systems, notably machinery systems, via remote control. To maximize the benefits of digitalization for maritime enterprises and vessels, it is essential to employ systems that facilitate broadband data communication between ships and land. As elucidated in section 4.1, modern communication predominantly occurs in the form of data. With broadband data communication, the transfer of substantial information volumes can occur with minimal delay, enabling many ship functions to be executed remotely. Furthermore, numerous functions related to ship activities and system operations can be easily monitored. Additionally, it is imperative to utilize fixed and mobile communication systems with broadband capabilities for communications among businesses, agencies, cargo operators, and port operators on the land side of maritime operations. It is particularly crucial for maritime organizations to optimize the use of mobile communication systems with increasingly advanced broadband features. Based on these assessments, the systems identified for use between ships and land to facilitate broadband maritime communication include the Iridium satellite system, Starlink satellite system, and Inmarsat F77 system. Moreover, satellite systems such as Global Star and Amazon are anticipated to be employed on ships in the near future, enabling broadband data communication through these systems.

4.4. Enhancing Cybersecurity Awareness Among Maritime Personnel and Organizations

Cybersecurity represents a highly specialized domain, necessitating targeted awareness training for employees. It is imperative to deliver cybersecurity training to cargo officers and port personnel within maritime enterprises,

agencies, and liaison offices, focusing on the systems they utilize. Furthermore, integrating information security courses and practices into the training programs for ship personnel, particularly officers, has become essential. This topic should be urgently incorporated into the training curriculum, with current officers receiving relevant information and orientation sessions.

Safeguarding communication systems on ships from external cyber threats is another critical concern. Attention should be directed towards implementing diverse protective measures for communication systems, including mandatory deployment of systems such as firewalls across all communication platforms. This requirement extends to both shipboard systems and land-based entities such as companies and agencies. Establishing cybersecurity laboratories within universities or related institutions is another significant measure to protect ship communication and navigation systems from cyber threats. These laboratories will facilitate security testing of systems intended for ship use. Employing personnel with expertise in both ship communication and navigation systems and cybersecurity will enable comprehensive security assessments. Consequently, expert personnel will be able to evaluate the resilience of navigation and communication systems on existing ships and those planned for new installations against cyber threats.

4.5. Use of Cryptocurrency in Different Payments of Maritime Businesses

While businesses derive substantial benefits from technological advancements, it is crucial to implement stringent safeguards against individuals and organizations that may exploit these technological opportunities for malicious purposes. In recent years, numerous organizations have adopted cryptocurrencies in payment systems that entail monetary risks. Cryptocurrencies represent an increasingly prevalent system, distinguished by the enhanced security of their transmission and accounts compared to conventional monetary systems. For an asset to be classified as money, it must be portable, durable, divisible, universally accepted, and finite in supply. Cryptocurrencies, derived from the combination of the words "crypto" and "currency" (Turan, 2018), represent encrypted money. This form of currency is a novel type of currency pair that is internet-based and decentralized (Yaktıyol, 2018). In essence, cryptocurrency is defined as "digital values that facilitate secure transactions and additional virtual money supply in an encrypted manner." Consequently, cryptocurrency serves as a novel alternative currency designed as an alternative medium of exchange (Chohan, 2022). It is both digital and virtual (Schueffel, 2017) and operates independently of the traditional banking system. Cryptocurrency (crypto asset) employs cryptography to secure transactions (Zohuri et al., 2022), which are conducted on a system known as blockchain. Cryptocurrencies should be distinctly separated from currencies not produced by governments or companies and, therefore, not issued by central banks (Çarkacıoğlu, 2016). Thus, crypto assets are entirely decentralized, in contrast to centralized banking systems (Allison, 2015). Given the mechanisms, algorithms, computer software, and hardware they utilize, cryptocurrencies are pertinent to the fields of mathematics and information technologies (Gültekin and Bulut, 2016). The proliferation of cryptocurrencies has been increasing in recent years, paralleling advancements in these scientific domains. Presently, the supply of most cryptocurrencies increases at a predetermined rate, immune to alteration by any central authority. Generally, the majority of research on cryptocurrencies has focused specifically on Bitcoin. Bitcoin and alternative cryptocurrencies have profoundly impacted various markets, particularly financial markets. They offer significant advantages, such as 24/7 trading capability, low commission fees, and high transaction speed. These features confer an advantage over traditional intermediary institutions and compel businesses engaged in trading with existing financial instruments to modify their business models (Karaoğlan, 2018). Recent developments in the Internet, notably the ability to access it ubiquitously via mobile devices, have diminished the significance of borders in trade. Cryptocurrencies are a product of this development and exemplify how technological advancements transform the financial system (Çağlar, 2007). Consequently, it is inevitable that the Internet will emerge as a formidable force diminishing the role of governments in the near future, and digital currencies will proliferate globally (Wegdell and Andersson, 2014).

The features in question regarding cryptocurrencies ensure that they are an extremely secure payment system for maritime businesses, whose activities generally involve international relations. In this way, maritime businesses can benefit from the developments in the internet and technology to the maximum extent and can also use a very secure payment system.

With the advent of the Internet, the process of accessing information has accelerated and evolved significantly. In the current Fourth Industrial Revolution, data and data-driven ecosystems are increasingly gaining prominence. Recent years have witnessed substantial growth in both the speed and capacity demands of the Internet, particularly in the realm of mobile Internet (Acarer, 2017). In the contemporary business landscape, where enterprises are progressively transitioning to online platforms, advancements in internet technology are positively influencing the structure of commerce. The Internet and various digital platforms afford businesses the capability to provide real-time feedback, facilitating seamless two-way communication between customers and enterprises (Akadal, 2019). Presently, the majority of payments and money transfers are conducted online, a trend driven by the speed and connectivity afforded by digitalization. This phenomenon enables digital enterprises to expand and strengthen their global presence. Consequently, the emerging ecosystem of

cryptocurrencies warrants attention in the field studies of economic and administrative sciences. In alignment with the opportunities presented by information systems, cryptocurrencies utilized via the Internet have emerged as a digital cash system (Nair and Motwani, 2018). This development offers significant advantages for organizations, such as maritime businesses, that require rapid and secure financial transactions.

5. Conclusion

The proliferation of digitalization is inducing profound transformations across various sectors, including maritime. Beyond the core components of the maritime sector, such as carriers, shippers, and cargo, numerous ancillary entities provide logistical support to these transportation activities. Therefore, ensuring seamless information exchange among relevant organizations is crucial for profitable and successful maritime transportation operations. Despite the acceleration of ship dispatch and management through technological advancements, numerous challenges persist. To fully leverage developing technology, it is imperative to enhance user qualifications progressively. Consequently, the number of certifications required from seafarers for ship operations is increasing, with many of these training programs necessitating periodic renewal. Digitalization is also driving significant changes in ship equipment, a process that remains ongoing. As a result, the size of ship equipment is gradually decreasing, while their interconnectivity is increasing, allowing ships to operate with reduced personnel.

One of the ultimate advancements in the digitalization of maritime vessels is the development of autonomous ships. In the operation of these autonomous, or unmanned, ships, data is collected not only from numerous sensors, detectors, and internal components but also from external sources such as positional information, weather conditions, and environmental data. This comprehensive data is processed by an advanced onboard computer system, thereby enabling the technical feasibility of unmanned ship navigation. Furthermore, various communication platforms are employed for the remote monitoring, control, and dispatch of these vessels, with satellite systems being paramount. To date, different Inmarsat terminal satellites have been utilized for this purpose. However, the use of Starlink and similar low Earth orbit satellite systems, which have rapidly advanced in recent years, is becoming increasingly prevalent in land-to-ship communications. Notably, recent amendments to the GMDSS regulations by the International Maritime Organization (IMO) have necessitated the inclusion of Iridium satellite terminals among the essential systems for ships. As digitalization in maritime operations progresses, the emergence of cyber-attacks as a novel challenge is inevitable. Although the concept of cyber-attacks is not entirely new, having been a significant issue in the IT sector for approximately 25 years, it is increasingly manifesting within the maritime industry. These attacks, which have been observed in land-based maritime entities such as shipping companies, agencies, and port authorities, particularly over the past five years, pose a substantial risk to ships as they become more automated and autonomous. Consequently, it is imperative that both the terrestrial components of the maritime sector and the ships themselves, which are among the primary beneficiaries of digital technology, prepare for potential cyber threats. Therefore, the issue of cyber-attacks warrants serious consideration and should be regarded as a distinct area of study. As in many other domains, the IT sector offers significant advancements and benefits to individuals and businesses through cryptocurrencies. In an era where time is increasingly valuable and speed is a critical factor in business competition; it is essential to rigorously evaluate the positive developments that cryptocurrencies bring to payment systems across all management frameworks. Thus, it is advantageous for maritime enterprises to consider the integration of cryptocurrencies into their commercial activities. Recent innovations in payment systems and methods can substantially enhance business opportunities. Accordingly, it is crucial for businesses to monitor the impact of IT sector developments on payment systems and cryptocurrency processes sensitively.

Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript

	M.S.	T.A.
C	40	60
D	40	60
S	60	40
DCP	40	60
DAI	50	50
L	50	50
W	40	60
CR	60	40
SR	60	40
PM	60	40
FA	50	50

C=Concept, D=design, S=supervision, DCP=data collection and/or processing, DAI=data analysis and/or interpretation, L=literature search, W=writing, CR=critical review, SR=submission and revision, PM=project management, FA=funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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