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***Abstract* - Blockchain technology offers potential solutions to tackle issues related to paper documents flow and outdated manual business administrative procedures in maritime industry. While the Blockchain is still a relatively novel technology, mainly used in cryptocurrency applications, it is slowly gaining traction and attention within the maritime industry. This paper presents the possibilities of blockchain implementation in order to solve some of the challenges that the companies operating within the maritime industry are facing: administrative costs, traceability, quality control, transparency, payments management, and dispute resolutions, while highlighting key areas for blockchain application, and main challenges related to blockchain technology and its adoption in the maritime industry.**

Keywords - Blockchain technology; Maritime industry; Blockchain perspectives; Blockchain challenges

I. INTRODUCTION

Blockchain (BC) is a decentralized, distributed, permanent and immutable record, which holds information of all previous transactions that took place. According to IBM [1], more than $4 trillion in goods, and around 80% of all consumer goods are transported by ships each year. The ever-growing volumes of industrial production and population in the world cause the increase in greenhouse emissions which lead to the pollution of environment. These issues are the topic of policymakers, scholars, and practitioners around the globe [2]. Most of logistics activities such as shipment and delivery tracking, estimation of the delivery time, and customs officers' notifications are all manual paper processes [3], which doesn't help with the reduction of environmental pollution. Most stakeholders in the shipping industry operate with extensive handling of paper-based documents, including the Bill of Lading (B/L), Customs declarations, and the Certificate of Origin [4].

With the emerging challenges and uncertainties such as new environmental regulations and the recent outbreak of COVID-19 pandemic, the maritime industry needs to adopt technological solutions and keep abreast of the most recent advances in the field in order to solve some of the challenges. The manifestation of the pandemic has proven that first movers in terms of technological uptake have been able to control the consequences of these sudden changes (for example, online platforms using blockchain solutions and information technology enabled third-party logistics companies) [5].

BC technology [6, 7], could potentially change and improve the maritime industry. There is a growing interest in BC among the researchers and practitioners. However, there is still limited research on the application of the BC technology in the maritime sector [2].

The stakeholders and enterprises in maritime industry struggle with the lack of awareness, collaboration, and commitment for a successful BC implementation [8]. This research aims at presenting the potential of BC technology usage for document digitization and business process digitalization, and how it can help to solve some of the challenges that the maritime industry is facing. The goal of this paper is to highlight the key areas where BC technology could be applied to update maritime industry business processes, and improve efficacy of the system.

II. BLOCKCHAIN OVERVIEW

Emerging new technologies, such as Cloud Computing, Big Data, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Quantum Computing, etc. are slowly becoming standard drivers of economic growth in the near future; and BC is going to be an integral part of all technologies [9]. The integrity of the BC is secured by trustless consensus algorithms and guarded by complex cryptography making it almost impossible to illegally append or modify historical data [10].

Although BC is commonly connected with Bitcoin and other similar cryptocurrencies, which serve mostly as a means of monetary asset transfer; application possibilities of the BC are not limited to monetary assets only [11]. There are functions such as data storage and data sharing, not exclusive for monetary assets. Smart contracts are not new, and they existed even before the invention of BC [12], but only with BC technology, such as Ethereum, they became usable enough to justify the transfer from paper contracts to digital, "smart" contracts. This type of digital technology could change the way the stakeholders involved in the maritime industry communicate and transfer important data, information and documents.

III. SMART CONTRACTS

Business have turned from the traditional ways of conducting business and have adopted novel, more reliable, and cost-efficient systems; smart contracts are one of these systems [13]. Fig. 1 [14] on the following page describes how smart contracts work, and their main processes.

Figure 1: How smart contracts work

A smart contract is a self-executing code that runs on the BC to facilitate, execute, and enforce the terms of an agreement between the participating actors. It is a system that issues digital assets to all or some of the involved actors once the pre-defined set of rules have been met. Some of the main advantages of using smart contracts are:

Accuracy

Since smart contracts are automated, in a sense that they execute automatically upon the completion of terms that have been agreed upon beforehand; application of smart contracts could help reduce issues like contract infractions, delays in signing the contracts and disputes even in the courts of law [15].

Clear Communication and Transparency

Once the contract is established, its terms and conditions are revealed to the different network participants of the specific BC. As the BC is immutable, no changes can be made afterwards, and every attempt by a party to do so is rejected. As a result, transparency is increased, and attempts of fraud are eliminated [15].

Speed and Efficiency

Third party mediation is not necessary in smart contracts, and their implementation is controlled and overseen by other nodes in the BC network. Once the rules of the contract are realized, contract is triggered and the scripted contract self-executes [15]. Verification that the item that was previously agreed upon in the contract has been given to the appropriate party is determined by the nodes in the BC network [16], which results in quick, resilient, and robust way of contract execution [17].

Security

As a consequence of implementing smart contracts in BC and the usage of non-trusting parties in the decentralized network, smart contracts have one of the highest security levels. Parties in the network are non-trusting, which makes them keep check of one another, in order to establish that each transaction is carried out, and that there is a uniform global view of the status of all the transactions [18].

Cost Reduction

The application of smart contracts cuts the need for a mediator, which consequently aids in reduction of the overall organizational costs and magnifies the profit margins by an organization [19]. Essentially, with a smart contract, the user can encode its information assets (such as the B/L or similar document) into the BC, which, upon the completion of certain conditions, or a set of rules, could be instantly transferred to the beneficiary.

IV. Key maritime Industry Areas for Blockchain Implementation

The usage and implementation of BC technology within the scope of the maritime transport and port logistics bears the potential to facilitate the transition from a paper documented process management to a digitalized and more secured one by validating and storing each action or transaction, respectively, in the chain of blocks [20]. It can offer a mechanism of verifiability, traceability, and immutability, which ultimately leads to increased trust between various actors in maritime transport. This complex ecosystem could greatly benefit from a robust digital platform to exchange data in the real time. Some of the key maritime industry areas that BC could improve are:

Transportation payment and dispute resolution

Payment automation resulting from using the smart contract reduces payment delays and disputes. By using smart contracts, the automated check of actions and transaction is realized, which leads to a stronger integration of financial service providers into the supply chain. In addition, the payment approval of transactions can be automatically triggered in case of fulfilment of the pre-defined actions. This results in improvement of the financial flow in the supply chain [21].

Administrative costs

Numerous containers being transported between the ports around the world cannot complete their journey without documents such as the Bills of Lading, packing lists, letters of credit, invoices, sanitary certificates, insurance policies, etc. This is associated with a large number of paper-based documents [22]. The cost of paper document processing and administration reaches 20% of the overall costs of transportation according to Maersk and IBM [23].

Cargo tracking and quality control

One of the main challenges in logistics is to control and oversee the quality of the goods and track their physical movements until end-users are reached [24]. Current systems are not able to provide real-time shipment tracking during the transportation phase [25], which leaves the system vulnerable to fraud and manipulation, which in turn can inflict serious financial losses to involved subjects [26]. Improvements of the tracking system in supply chains could be made with BC implementation, which enables keeping of a distributed ledger, where actors could track product movements from origin to destination on a real-time basis. Each commodity or a product would be tagged with a unique ID and scanned at each transportation phase. Actors involved in an agreement of trade would be able to read scanned data that is recorded in a distributed ledger. It is possible to add data such as product temperature and empty container status. Thus, BC serves as an instrument to check the genuineness of the goods, hamper the risks of counterfeiting, and monitor the product quality along the transportation route [27].

Transparency and trust

Bills of Lading, insurance policies and invoices are particularly vital documents, which are used in international

trade to ensure buyers receive payments [22], but because the documents that are used are still widely found in paper form, they are susceptible to manipulation - counterfeit Bills of Lading, invoices, etc. are a real problem in maritime transport. Furthermore, traditional maritime companies are vulnerable to a wide range of cyber risks. Since BC is based on shared consensus among different parties, the information on the BC is reliable. It is important that companies in the chain can trust each other to share information and increase efficiency in shared processes [28].

Maritime insurance

The potential benefits of BC technology for the maritime insurance industry include both claims handling and underwriting/risk assessment [33]. BC and smart contracts could be used in order to reduce the costs and mistakes related to the manual processing of claims, and to boost the speed of claim processing, A smart contract could encode the rules for enabling the transfer of refund from the company to the insured. Moreover, the expense related to manual data entry and verification of new customers could be decreased [13, 27].

Risk assessment/frauds prevention using BC allows multiple certified intermediaries (e.g., insurance companies) to record information related to an individual person. BC could address the problem of fraud due to its property which enables it to provide cryptographic authentication and data transparency. With BC, insurers could determine double claims, detect patterns of fraudulent behavior, and collaboratively diminish fraud [29, 30].

V. Blockchain Technology Examples in the Maritime Industry

The maritime industry is slow in bringing operations procedures and logistics up to date. One of the most promising areas of the maritime innovations is related to digitalization and digitization of documents and business processes. Although the maritime industry is technologically advanced, innovations in the maritime industry have been mostly limited to engineering-based innovations [31]. However, the maritime industry has seen development and rise of new BC-based initiatives. The following examples clearly show the BC positively affecting the maritime industry.

CargoX

CargoX offers public-BC-based solutions for logistics, seeking to enhance document processing in the current global supply chain industry. One of the first projects they worked on focused on replacing paper-based B/L with a digital B/L, known as Smart B/L, which is the industry's first BC based B/L. A Smart B/L can be uploaded in the form of a PDF document and it can also be created as a structured data document which can be transferred to the platform [32].

CargoX aims to connect all relevant parties that are regularly involved in transport process in a balanced system based on trust and interaction. The CargoX's goal is to eliminate the need for a middleman or a mediator by providing an instrument and platform for secure document sharing, which drastically reduces costs and time of delivery by offering a high level of security and transparency [30]. This platform offers several types of Smart B/L such as: Negotiable B/L, Straight B/L, and SWB (Sea Waybill). Other documents that CargoX offers are bills of materials, cargo damage reports, certificates of analysis, fumigation, inspection, claims notifications, container arrival notices, contracts, cover letters, debit credit advice documents etc. Some of the benefits of the Smart B/L are listed below [33]:

Security

Decentralization means that there is no single point of failure, since there is no central storage to be targeted by the hackers. Most important documents related to the trade and transport of goods are encrypted and stored securely on the BC, accessible only through the owner's' private keys, therefore it can never be lost or stolen.

Speed

A Smart B/L can be released instantly and can be immediately transferred to the legal owner of the goods, with no middlemen or couriers.

No physical documents

The need to print, pack and store paper can be mitigated, which saves time and money.

Cost saving

The average cost for sending a B/L three times is around USD 100, and it takes up to 10 days to reach its destination, mainly because multiple middlemen and couriers make the process excessively expensive and slow.

Auditable and fraud proof

CargoX Smart B/L records each action on the BC together with a timestamp. This offers a more secure and transparent way of handling cargo ownership transfers and prevents cargo release prior to release of Smart B/L ownership to the cargo release agent.

TradeLens

TradeLens is a company which uses BC in order to promote information sharing and collaboration across different supply chains, which results in reduction of issues related to trade, which ultimately benefits trade globalization. The TradeLens platform has been developed by IBM and GTD Solution Inc. They worked together to ensure the product and business model are aligned to meet the needs of the shippers and supply chain operators around the world. Main TradeLens objectives are [34]:

Connecting the ecosystem

TradeLens focuses on bringing together all parties in the supply chain such as traders, freight forwarders, ocean carriers, customs, etc. - onto secure data-sharing and collaboration platform.

Fostering collaboration and trust

Digitalization and automation of business processes which are integral to the global trade ensures that all vital documents and data are secure and auditable inside BC environment.

Dividing true information sharing

Providing for the seamless, secure sharing of real-time, actionable supply chain information across all parties - encompassing shipping milestones, cargo details, trade documents, customs filings, sensor readings and more.

Spurring innovation

Laying the foundation for ongoing improvement and innovation through an open API environment, the use of standards and promotion of interoperability, and the launch of the applications marketplace that allows third parties to design, build and deploy applications on the TradeLens platform.

CargoSmart

CargoSmart's BC solution addresses the issue of an overly complex shipping documentation process, at the same time simplifies it, increases trust, and boosts overall efficiency. The shipping ecosystem is connected through a BC documentation platform, which can diminish disputes, bypass late penalties from customs agencies, accelerate documentation turnaround times with carriers, and reduce detention and demurrage costs once containers arrive at the destination ports [35].

Blockshipping - Global Shared Container Platform

The Global Shared Container Platform uses BC technology, cloud services, and the Internet-of-Things to enable a better utilization of containers through the efficient sharing of containers between carriers. Blockshipping product portfolio offering consists of:

AI-Import Dwell Time Prediction

Enabling prediction of when an imported container will be picked up from the terminal by applying artificial intelligence from Blockshipping, which results in reduction of unnecessary container handling equipment utilization, gaining immediate efficiency improvements.

AI-Terminal Truck Exchange

The Terminal Truck Exchange utilizes real-time information to create a match between import and export moves both at the terminal and the hinterland.

AI-Container Flow Optimizer

The AI-Container Flow Optimizer helps in optimizing container inventory management. Analysis of the existing data and application of the artificial intelligence to predict when a container will be returned empty from an importer improves forecasting ability for the flow of containers and saves valuable resources.

Blockchain Container Asset Register

BC Container Asset Register serves as the first BC-based container register in the world. Using the BC enables tokenization of containers and provides undisputable title and proof-of-ownership for containers. Processes such as buying, selling, and leasing the containers will be improved significantly [36].

VI. Blockchain Challenges And Practical Implications

Several weaknesses and threats related to BC technology can be identified, and will be elaborated in this chapter. BC technology suffers from scalability and performance issues [37]. However, there are challenges that must be taken into consideration, related to the lack of awareness and understanding, lack of cooperation, security and privacy challenges, and lack of regulatory clarity and governance.

Lack of awareness and understanding

One of the major challenges for companies associated with BC, and especially for small and medium enterprises, is the lack of awareness of the benefits of the BC technology, and a widespread lack of understanding of how BC works. Numerous companies do not fully understand what BC is or what benefits it can offer. This has a lot to do with the dominance of "technical" staff in the BC area and their overly technological approach, which managers find hard to understand. In order to raise the awareness regarding the BC, managers should educate themselves on the topic before implementing BC in their business structure. The key questions that managers should ask themselves before adopting a BC solution are related to the application of BC and how it would change the organization and the culture within, how to increase the level of understanding the technology at all levels, and how would it change the way that organization interacts and collaborates with others [38].

Lack of cooperation

The problem with many current approaches, is that organizations are developing their own BCs and applications to run on top of them, which currently, have no means of connecting to other BC ecosystems. In various industries, contrasting chains are being developed by diverse organizations adhering to different standards, which defeats the purpose of distributed ledgers, fails to harness network effects and can be less efficient than legacy approaches.

To increase the level of cooperation among the organizations, a consortium of companies could be a solution. A consortium is a grouping of companies that cooperate for the development and operation of basic BC infrastructure and services, which are then used by the participants to develop their own range of services [31]. One example of such blockchain consortium in the maritime industry is Global Shipping Business Network (GBSN). It includes some of the largest corporations involved in maritime transport such as: CMA CGM, COSCO, Hapag-Lloyd and OOCL [39].

Security and privacy challenges

Many applications that are based on BC require smart transactions and contracts to be indisputably linked to known identities, which raises critical questions about privacy and security of the data stored and accessible on the shared ledger. While BCs offer higher security than conventional computer systems, with some effort, hackers can still breach applications, systems, and businesses built on BCs.

The key to solving this issue is not just government regulated protection of privacy. Enabling actors on BC to capture and control their own data could help in the security

challenges. While there is a lot of work being done on several privacy protocols such as proof of zero knowledge, to overcome these obstacles, significant effort must be made to establish a new identity framework [40].

Lack of regulatory clarity and good governance

Lack of regulatory clarity regarding the underlying BC technology definitely exists, which is a significant obstacle for the mass adoption of the BC technology. Many organizations are using BC as a platform through which transactions can be made, but even though it is the most popular use-case for BC, clear legal regulations still do not exist. There are also other areas that require regulatory support, such as smart contracts. The consequence of not covering smart contracts with legal regulations could lead to inhibition of the BC adoption as well as further investments in the BC industry.

To overcome this challenge, governments and heavily regulated sectors (such as the maritime industry and transport sector) may need to create regulations which could provide means of BC environment control to increase the levels of security and governance, which means that regulators in various countries and industries have to understand what the BC technology is and its impact on the businesses and customers in their sector [40].

VII. Conclusion

This research was conducted by collecting and processing various available sources related to the BC, its usage cases, and its potential of implementation in maritime industry. BC technology and smart contracts could transform the industry in a way that saves time and money, and increases efficiency. One of the main features of BC that can be used in maritime industry are smart contracts. Compared to conventional contracts, smart contracts do not need a trusted mediator to operate, which leads to low transaction costs. Implementing Smart Contracts could help achieve higher accuracy, clearer communication and transparency, more speed and efficiency, increased security, and cost reduction.

Available research and literature related to BC usage in the context of maritime industry is still limited, since the adoption is slow, and the awareness about BC is at a low level. However, the authors have isolated relevant research and studies and deducted information about the potentials of BC technology. By combining some of the most important aspects of BC, this paper offers a brief summary of BC characteristics and perspectives in maritime industry.

The impact that BC could have on the maritime industry is mainly positive, especially in areas of transportation payment and dispute resolution, administrative costs decrease, cargo tracking, quality control transparency and trust, and marine insurance - offering fraud prevention and automatically resolving disputes. Digitalization of documents involved in maritime transport can save money and time by eliminating the need for paper documents and intermediaries. This paper is only a preliminary literature review, and future research will be directed towards thorough analysis of available papers in all relevant databases, with the goal of further exploration of BC usage perspectives in the maritime industry.

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