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Maritime Blockchain Prospects and Concerns

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ABSTRACT

This paper gives an overview of blockchain in maritime, with emphasis on (1) TradeLens blockchain-based maritime ecosystem, which was in operation from 2018 since 2023, and (2) Blockshipping decentralized platform for containers' smart booking and releasing. More precisely, a conceptual framework of blockchain in maritime is presented, including its benefits, concerns, key players, events, and documents in shipping and port management. Principles of smart contracts and crypto-currency payment mechanisms are described at a rather high level of abstraction regarding their complexity. Furthermore, Blockshipping global shared container platform and associated crypto-currency payment mechanisms are presented, along with the potential for increasing efficiency, reducing costs, and environmental impacts through enhancing rational containers' shipments.

1. Introduction.

The shipping industry is a key driver of the global supply chain. Everybody in the world needs shipping, but they are not always aware of this. The shipping industry is connected to suppliers, sellers, and buyers; to the oceans, the land, and the air. We cannot speak about global commerce without considering the logistics and operations that empower it [1].

A lot of products today, when the buyer orders them or goes to the local retailers are actually delayed because of the difficulties that the supply chain has to deal with. New dimensions, regionalization, trade tensions, and the like, make supply chains more complex.

While moving a container from one country to another, we have to go through customs, to the ports, to the terminals, and to the customer and everyone needs access to information and to provide this to others along the journey. So, the shipping industry needs to be better connected.

"We are all connected, only not to each other. I thought, in the beginning, it was funny, but actually, it is the case. We think we are connected, and we somehow are, but often what happens in shipping today, is that people are connected by fax, email, EDI, and all types of communication, that are really not up to speed with what is required today, which is real-time information. The value proposition at the beginning [of the TradeLens project] was simply to take out the function, and remove the friction from the communication that goes on between the different parties in the supply chain, because it is a chain, so no actor can act independently anyway."

A senior Maersk executive [2].

A typical transaction has 30 to 40 stakeholders, parties or actors worldwide, who have to follow different processes including data in different formats, fields, and timelines. As a result, the whole workflow suffers from inefficiencies and these unfortunately get passed to the customers at the end of the chain. From a digital standpoint, there are thousands and thousands of data connections between carriers, customers, and vendors, and if we want them to work together and 'speak the same language', it would be very difficult to achieve this without predefined rules. Consequently, standardization is the only way to bring that foundation. All players in the maritime industry have to do this together. There is a need for a tide to lift all boats. And that is why Maersk, a lot of shipping lines, and IBM (International Business Machines Corporation) operating in over 171 countries, have joined forces to create a platform called Trade-

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Lens, which was in operation from 2018 since January 2023. This blockchain-based platform was conceived to solve numerous problems that have been plaguing the global supply chain for a long time.

TradeLens was a platform open to the entire ecosystem that participates in the global supply chain and allows all participants to collaborate more efficiently, but also to share data and build a level of insight across what is happening in the supply chain. TradeLens used to provide the information that all actors in the shipping industry need on the common platform. It enabled the industry to operate more effectively on a global scale. It used to enhance customer satisfaction, lower operations' costs, and increase services to cargo owners everywhere.

"The benefit of TradeLens is that we only need to connect to the platform, and all the shippers need to connect to the platform versus us connecting to each of the 15 shippers directly, which costs a lot of money, takes a lot of time, and does not create a lot of value."

The president and CEO of Global Container Terminals [2].

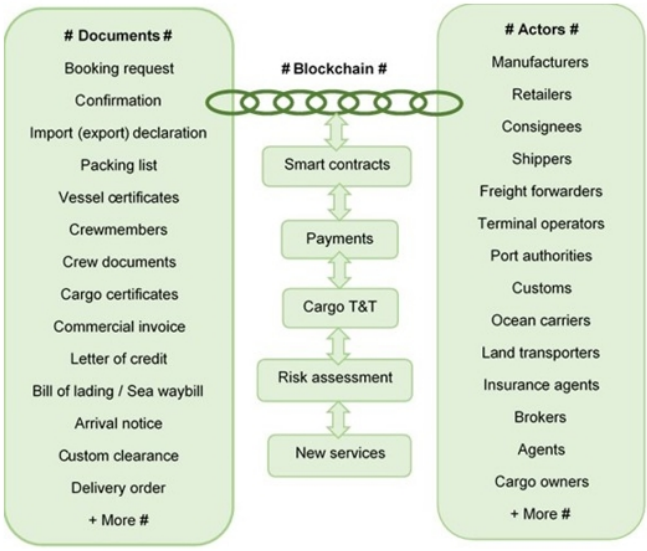
Having in mind all foretasted, the rest of the paper is organized in the following manner: Section 2 gives a maritime blockchain conceptual framework based on the former TradeLens concept; Section 3 highlights some impediments regarding blockchain faster adoption; Section 4 deals with the smart contracts concept, including electronic bill of lading; Section 5 considers crypto-currency payment mechanism, along with an example of its successful implementation in maritime; Section 6 presents Blockshipping platform for optimal deployment of empty containers, including revenue scheduling model and processes flow; the last Section 7 gives some conclusion remarks on further actions towards rational adoption of blockchain as a disruptive technology across the maritime sector.

2. Conceptual framework.

Blockchain in the maritime industry enhances supply chain management that encompasses designing, engineering, manufacturing, and distributing products or services from manufacturers to consumers [3]. In the blockchain-based maritime supply chain system, the blockchain itself brings together a wide range of logistics actors. These include, but are not limited to manufacturers, retailers, consignees, shippers, freight forwarders, terminal operators, port authorities, customs, ocean carriers, or shipping lines, land transporters, insurance agencies, brokers, agents, beneficiary cargo owners, and the like, enabling tracking and tracing cargo thoroughly and providing access to information relating to shipments delivery timeframes [4;5]. The actors are usually from different departments, and countries, with different regulations, business practices, and cultures. In order to reduce paperwork, inefficiency, and limited data captured capacities, maritime blockchain arises. Essentially, blockchain is a distributed ledger supported by complex asymmetric (de)encryption algorithms, time-stamps, hashes, mathematical puzzles, difficulty targets, and consensus mechanisms entitled to ensure maritime data exchange in close to real-time with a high level of traceability, transparency, verifiability, audibility, and immutability. The key benefit behind the blockchain in maritime is that it can systematically store big data and make it visible to the stakeholders in the global trade chains. This has significant advantages in comparison to time-consuming and error-prone manual work, which is still dominant in maritime. However, we should be aware that the maritime industry involves a lot of players, who are mostly conservative and prefer to rely on legacy systems than on innovative digital solutions. More regulations, knowledge, organizational culture, and trust would be needed to make a real change in maritime business operations.

Blockchain in maritime should enhance service efficiency through smart contracts, cryptocurrency-based payment mechanisms, tracking and tracing the status of cargo via Radio Frequency Identification (RFID), Global Positioning System (GPS), and Internet of Things (IoT), empty containers placement, and early risk assessment, including opportunities for new value-added services development on the open platforms (see Figure 1).

Figure 1: Maritime blockchain key constituents.



Source: Authors.

There are a plenty of projects and initiatives to deploy blockchain technology in shipping and port logistics. One of the market leaders was the TradeLens solution developed as a result of collaboration between Maersk and IBM in 2018 [6]. Besides TradeLens, which was operational since recently, there are a lot of similar high-tech initiatives in maritime. Danish Maritime Authority started to work on implementing blockchain in custom clearance. The IT Company Ideanomics works with Asia-Pacific Model Electronic Port Network on blockchain for the biggest Chinese ports like the Port of Shanghai and the Port of Guangdong. The Port of Rotterdam started to investigate blockchain implementation in reducing the turnaround time of vessels. Maritime Blockchain Labs developed a prototype of blockchain to address the declaration, tracking and tracing, online auditing, and processing of dangerous goods to increase

visibility and reduce risks. Cargosmart and IBM are working together on improving customs clearance, logistics trusts and transparency, etc. [7]. CargoLedger, which is Rotterdam Port Authority and Dutch blockchain start-up, works on ship tracking [8]. Furthermore, CargoX provides services related to the first smart bill of lading and other maritime document transactions [9] (Table 1). Regarding safety, semi-private blockchains are common. The consortium companies' reputation is commonly in direct correlation with the safety of this disruptive technology and accompanied new business models.

Namely, maritime blockchain is a complex, distributed relational ledger of digital transactions, which enables participants' easy communication and information share in near-real time. It allows cargo tracking and tracing along the entire supply chain in close to real time. It is a base for smart contracts like letters of credit and bills of lading. Maritime blockchain incorporates smart payment mechanisms based on cryptocurrency as 300Cubits, ShipChain, and Prime Shipping Foundation [10]. It enables early risk assessment and efficient interventions across the supply chain when planned activities unexpectedly turned into unplanned ones. Since it is dominantly based on an open platform, new added-value services can be developed on it, as well.

3. Concerns.

Maritime as a conservative business assesses and recognizes the quality of operation in long run. In other words, stakeholders in maritime are not early adopters. Trust between network players is a bigger problem than safety. Blockchain in maritime as an unorthodox technology, which includes cryptocurrencies, is still highly volatile. In such a setting, maritime stakeholders do not like to disclose essential business information about customers, suppliers, and cargo. Many freight forwarders and intermediaries earn their profit thanks to information asymmetry. Interoperability will be a smaller problem in terms of technology, since standards have been intensively developing, in comparison to the processes' flows at the inter-organizational level [12]. Additionally, positional data might be used to track vessels by identifying port locations, fueling points, and routes. This is the case, in particular, with tracking dangerous and hazardous goods, pharmaceuticals, or food. The use of maritime blockchain does not guarantee that the information recorded in the ledger is correct and does not prevent tampering with data prior to entering it into the blockchain. The data on the content of a container, fuel production, testing, or combustion, and the like, might be wrong. Due to the huge amount of data and traffic, including data storage, blockchain requires a wideband channel like 5G or 6G, while the internet speed can be low when the working stage is offshore. Further, maritime blockchain causes high-energy consumption.

It is important to mention that blockchain started with a step-by-step introduction in the maritime shipping supply chain in the past decade. Its purpose is to improve the efficiency of end-to-end logistics chains providing faster digitalization of all maritime services. The emphasis is on the digitalization of maritime shipping records, including keeping real-time track of the status of cargo; improving visibility; and reducing consumers' clearance time, costs, and risks. It is evident that blockchain is capable to support various applications in maritime clusters, especially for container tracking and tracing and near-instant logistics adjustments. Also, blockchain provides features for automated risk management, insurance purposes, and secure payments, which is overall based on Hyperledger as a background platform.

According to the results of recent investigations, many IT experts recognize the importance of blockchain adoption for increasing benefits in terms of easier payments among supply chain players, management of passengers and cargo flows, and market analysis, Thus, the blockchain represents a unique place for gathering the crucial data and information on the platform as the modern IT solution for connecting the inputs from providers, ports, agents, freight forwarders, insurance companies, and other stakeholders. Using an advanced Application Programming Interface (API) model, the platforms for Blockchain provide and display relevant data for each component in transportation flow including equipment number, bill of lading number, cargo manifest number, booking number, and all-important information related to the container shipment [13].

Blockchain in maritime indicates the potential to reduce transaction costs, including reducing the need for intermediaries such as brokers and courier services. But, previously stated does not consider the comparable costs of the overall investment and expenses associated with blockchain implementation and adoption, especially in developing environments. The present level of awareness, knowledge, and expertise about blockchain is scarce among the stakeholders. Therefore, educational, training, or human capacity-building programs are necessary at regulatory, administrative, and operational levels. A higher level of standardization across the global supply chain is still necessary. The Digital Container Shipping Association conducts efforts in this regard, but further actions are necessary.

In general, there is hesitation by stakeholders to invest in blockchain in terms of technological integration, regulatory, organizational, and educational costs, since the maritime sector traditionally relies on its legacy. There appears to be a gap between what practitioners in the blockchain area suggest and what has been a range of state-of-the-art approaches in software engineering and information security research and practice.

Besides, the major liner shipping companies are the most likely parties to benefit from blockchain due to the complexity of their blockchains, and a huge requirement for financial resources. This can put other potential actors in the global supply chain in a disadvantageous position.

Last but not the least, the basic attitude should be that technology, in this case, blockchain, which is at the top of the global supply chain should improve the human condition, but not replace humans [14]. Therefore, human and ethical dimensions of blockchain technological development should not be neglected as well.

Something that cannot be skipped in this context is the recent announcement that TradeLens will be shut down in early 2023 since competitors are not wanting to share business-sensitive data on the common digital platform [15;16]. The other source

Table 1: Some maritime blockchain applications.

No.	Maritime blockchain applications		
	Consortium	Platform	Ledger
1.	Port of Koper, Slovenia	CargoX	Public
2.	Malaysia's West Port & LPR - Brazilian textile importer	300cubits	Public
3.	Abu Dhabi Ports and Port of Antwerp	Silsal	Consortium (permissioned)
4.	EY & Guardtime	Marine Insurance Blockchain	Public
5.	PIL, PSA & IBM	Proof of Concept (POC)	Consortium (permissioned)
6.	Port of Antwerp with Belfruco, Enzafruit, PortApp, 1-Stop and T&G Global	Smart Contracts	Consortium (permissioned)
7.	2021.AI Den Danske Maritime Fond, EUDP, INVICTA	Blockshipping	Public
8.	Port of Malmo & Port of Copenhagen	PortChain	Consortium (permissioned)
9.	AAT, FileVersion Health, CROP	CargoChain	Consortium, (permissioned)
[...]	[...]	[...]	[...]

Source: [10;11].

reported that Australian Securities Exchange (ASX) cancels the blockchain-based clearing system at a $168M cost. The ASX said the decision has been taken in light of the solution uncertainty [17].

"TradeLens was founded on the bold vision to make a leap in global supply chain digitization as an open and neutral industry platform. Unfortunately, while we successfully developed a viable platform, the need for full global industry collaboration has not been achieved. As a result, TradeLens has not reached the level of commercial viability necessary to continue work and meet the financial expectations as an independent business."

Head of Business Platforms at Maersk [17]

Also, when it comes to TradeLens technical and operational capacity, it can be noted that enterprise blockchain overall as a technology worked properly with expected outcomes and efficiency, but the limited deployment vision and commercial aspects were the key reasons for terminating this platform. It is evident that Maersk partners are not interested to invest in such a network for improving supply chain effectiveness. Though IBM, as a strong cooperation partner, has great marketing of supply chain solutions, it turned out that its efforts and vision for further excellence in the deployment of blockchain do not fit the Maersk company's commitment to investing in the creation of next-generation solutions. Overall, it is expected that the failure of TradeLens is a short-lasting interruption, since it laid on close vision and was focused just on short-term returns.

Regardless of this unexpected upheaval, the paper provides an overview of the solutions offered by TradeLens technology, since they are indeed advanced and will most likely be used in the future; if not as TradeLens, then as some other similar platform(s). We believe that the issue is not the quality of the technology, but its adoption. If some commercial, organizational and implementation issues exist, these should be overcome, since it would not be rational to leave this huge leap in technology development unemployed in the future.

"... business capabilities must catch up to technological capabilities. Business processes must be redesigned to take advantage of the many benefits the technology can provide." [18]

4. Smart contracts.

Smart contracts are programs stored on a blockchain that run when predetermined conditions are met. They are used to automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary's involvement or time loss. They can also automate a workflow, triggering the next action when conditions are met [19]. Smart contracts work by following simple "if/when... then..." statements that are written into code on a blockchain. In other words, a smart contract presents the lines of code that are stored on a blockchain and automatically execute when predetermined terms and conditions are fulfilled [20]. A network of computers executes the actions when predetermined conditions have been met and verified. These actions could include releasing goods, funds, or confirmations in maritime trade. The blockchain is updated when the transaction is completed. This means the transaction cannot be changed, and only parties who have been granted permission can see the results. The network controls

access. Within a smart contract, there can be as many stipulations as needed to satisfy the participants' needs, so that the task will be completed correctly. To establish the terms, participants must determine how transactions and their data are represented on the blockchain, agree on the "if/when...then..." rules that govern those transactions, explore all possible exceptions, and define a framework for resolving disputes. A smart contract can be programmed by a developer, although organizations that use blockchain for business, provide templates, web interfaces, and other online tools to simplify structuring smart contracts.

The key benefits of smart contracts are speed, efficiency, accuracy, trust, transparency, and security. Blockchain transaction records are encrypted, which makes them very hard to hack; plus, each record is connected to the previous and subsequent records on a distributed ledger, and hackers would have to alter the entire chain to change a single record.

In the maritime supply chain, a sea waybill or bill of lading can be converted into a smart contract, while it requires an agreement between the shipper and carrier, and/or any other relevant and permissioned party to view the consignment, transport equipment, and documents as permissions allow [21]. The benefits of smart contracts include simplified transmission of shipping instructions, management of document status and versioning, faster submission of shipping instructions for the creation of final bill of lading, quick sharing of documents with all permissioned parties, including immutability, traceability, and auditability of the documents involved [22].

4.1. E-Bill of Lading (eBL).

An original bill of lading is used on an estimated five trillion US dollar worth of containerized freight shipments every year [23]. It serves as a receipt of cargo, evidence of a contract of carriage, and title. But this paper document requires transport and handling that is time-consuming and costly for shippers, carriers, consignees, and their agents throughout the supply chain.

Bringing together major ocean carriers worldwide TradeLens has created the electronic bill of lading (eBL) that turns the issuance, transfer, and surrender of an original bill of lading into a streamlined and secure digital process. Using TradeLens, carriers used to issue eBL for a shipper as a digitally structured document. The issuance is recorded and a hash of the document used to be sent to the TradeLens blockchain. Then, the shipper could view the issued eBL in the platform and when ready instantly and securely transfer it to the consignee with the click of a button. When the container shipment was ready to be received, the consignee could simply click the "surrenders" button and eBL should return to the carrier for cargo release with many of the world's biggest carriers participating. In such a way, TradeLens used to provide shippers, cargo owners, and freight forwarders with a reliable blockchain as a secured fully digitalized standard for exchanging eBLs.

However, regardless of all the above-mentioned benefits, there is some impediment to eBL deployment worldwide. Several customs authorities around the globe still require original paper documentation, including stamps and signatures. Fully realizing the benefits of eBL will, therefore, require some changes in platform regulations and developing bylaws. Adopting an industry-wide platform is largely a political decision because many governments are skeptical of sharing data through a global platform.

"So, bylaws could help interoperability, but it's not only for interoperability. Let's imagine for a second a world in which interoperability never happens in terms of eBL solution providers; to us, it still makes sense [to create standard bylaws]."

DSCA-Digital Container Shipping Association program director [2].

5. Payment principles.

Maritime blockchain, like any blockchain, has the potential for solving issues with the banking system. Namely, banking channels usually include high transaction fees and these are prone to fraud. Blockchain reduces the costs of transactions since no third party is needed to govern the system. Cryptocurrencies, e.g. bitcoin, which run on blockchain follow the decentralized system, where no third parties like governments, banks, or any other financial intermediary are involved during the transaction between sender and receiver. Costs of money transfer are lower, but we should be aware of the lack of regulations compared to regular currencies. Double spending is avoided through the basic structure of blockchain, which involves the verification of transactions. In a blockchain, each block is linked to its previous block. The transactions become invalid for a specific bitcoin, which has already been spent [24].

A public ledger records all bitcoin transactions. Once a user joins the blockchain network, (s)he gets a copy of the blockchain, i.e. all transactions. Through the public ledger, only the user's address and transaction detail are available to the users of the network. By looking at the address, one cannot figure out to whom this address belongs. The identity is secured. This keeps blockchain safe from data tempering. The private key is known only to the sender. It is used to confirm if the origin of the transaction is legitimate. The public key is used to uniquely identify the user.

A transaction has to be registered on the blockchain, then a block has to be approved by all nodes in the network, and verified by the miners of the public ledger. In the end, it has to be added to the main blockchain. A block contains aggregated transactions, which a minor has to validate, and lien of that it gets a reward. Miners in the Bitcoin network have dedicated nodes of the network, which compete in resolving a complex mathematical puzzle and reaching a difficulty target that is known to all miners. The whole process is called mining. Transaction verification is a complex process. Let's go back and try to explain it shortly as a concept. Message or intended transaction has to pass through hash function algorithm. For this purpose, one uses SHA (Secure Hash Algorithm) 256. More precisely, the bitcoin network uses the SHA-256 hashing algorithm to generate a 256-bit length hash. It looks like a hexadecimal value. In fact, blockchain eliminates unauthorized access by using the cryptographic algorithm (SHA-256) to ensure the

blocks are kept secure. Later, the hash value passes through the signature algorithm, and with a private key a digitally signed document is created.

Each block in the chain of blocks of transactions has a header, which contains a timestamp, block number, and Merkle's root of transactions, which is like a fingerprint of all the transactions in the block. It contains the hash of the previous block. For a block to be valid, this information cannot be changed. But, in each block header, there is a 32-bit part reserved for the nonce. What is the nonce? - It is a space in the block header into which miners plug in the numbers randomly in attempts to resolve (match) the difficulty target. Randomly chosen nonce and a hash of the block have to match together the difficulty target. The miner that resolved the complex mathematical puzzle first, wins the reward, i.e., a bitcoin. When the miner winner resolves the puzzle and verifies the block, by generating its unique fingerprint, then all other miners have to confirm this, add the right nonce to the block header, and then the block becomes part of the blockchain. For resolving the puzzle, the miner gets a reward for proof of work. Proof of work is the process of transaction verification done in the blockchain. However, it takes time to find the nonce that matches the difficulty target and this can last up to 10 min for the transaction to be verified and added to the blockchain [25].

In the context of maritime blockchain, TradeLens has succeeded to complete the first end-to-end paperless trade finance transaction. The deal, which involved the shipment of agrichemicals from South Korea to Bangladesh by Syngenta, was financed with a letter of credit from HSBC (financial service company) [26]. All associated documentation was shared among the parties via the TradeLens platform. Digitized documents included the eBL directly from the ocean carrier Sealand, the commercial invoice, the packing list, the certificate of origin, and the certificate of analysis, as well as the bank collection documents - all underpinned by blockchain and visible to permissioned parties as soon as they were uploaded to the platform.

"This process knocked ten days off the usual document processing lead time for Syngenta, and helped avoid extra costs due to delayed paperwork, such as potential destination detention and demurrage costs."

TradeLens [26]

6. Blockshipping.

Nowadays the container shipping industry accounts for around 60% of the world's seaborne trade [27]. This valuable industry has been troubled for years by challenges like overcapacity, low freight rates, security threats, and increasing environmental regulations. It is well-known fact in the industry that global shipping needs increased efficiency, improved processes, and fundamental digital transformation to enhance profitability in the future and to comply with environmental regulations.

Currently, there are about 27 million containers in the world, which are moved from one destination to another on trucks, container cars, ships, rail, or waiting in the port, container yard, railway station, and the like. About 5 million containers are uncontrolled and nobody knows their precise locations; if they are currently in transit or waiting for collection. Consequently, no one knows if they are empty or loaded, which means that no one knows if a truck or a train is wasting time and energy carrying an empty "metal box" instead of carrying goods. This is a huge waste of energy; it produces additional costs and negatively affects the environment [27].

Therefore, the global shared container platform (GSCP) is currently under development. As the world's first blockchain-based container registry, it will allow the industry to help real-time track all containers worldwide. The platform will enable the industry players to manage efficiently all kinds of transactions related to container handling. The GSCP has several user groups like shipping lines, leasing companies, banks, financial institutions, blockchain container investment syndicates, transport service providers, beneficiary cargo owners (BCO), container terminals, container depots, repair shops, etc.

Through a secure login, each user group will have a unique set of functionalities that matches their exact needs. For example, if you are a shipping line export user, you can use the GSCP platform to find street turn matching opportunities for ensuring that empty containers meet export demands. You will see an inventory list of all export bookings, which require an empty container to the customer location for stuffing, rather than transporting an empty container from the port or the depo. For convenience, the platform enables users to switch between list and map view. The user can apply one or more filters and inventory will update accordingly, for instance, only showing FEUs (40-feet units). Any set of applied filters can be saved in the user's filter presets. This way they are quickly accessible whenever the user needs them. Matching export containers with import containers is easy and swift. This enables both importer and exporter to save an empty container haulage trip, plus gate-in and gate-out fees at the terminals. The system identifies possible matches based on container size, type, boarding date, previous commodities carried, and availability. The platform also enables sending a request to the involved shipping line with the comment. The GSCP provides various ways to import booking and container data. The user can use EDI and API connection with the in-house booking or order platforms [28].

Blockshipping is a shared pool of containers, which enables a "just in time containers" situation. Today more than 40% of all containers in transport are empty. Therefore, resources are wasted and costs are increased. With blockshipping saving potential for the shipping industry might be at least 5.7 billion US dollars and the reduction of CO_2 emission can be 4.6 million tons yearly [28]. The blockshipping platform is a part of the so-called programmable economy. In such an economy, the interactions among different parties will not occur through mediation of a third trusted party, but automatically through autonomous intelligent software agents (AISA). These are also called dApps (distributed Apps) that run on blockchain and are authorized and instructed by the parties involved in maritime Blockshipping to negotiate autonomously on their behalf.

Key components of Blockshipping are:

- *Global Shipping Container Registry (GSCR)* that holds

real-time information about every container available through Blockshipping;

- *Empty Container Repository Engine (ECRE)* that continuously calculates the next best-laden transport for each container. The engine also 'understands' the position of every truck available to transport the empty container;
- *Autonomous Intelligent Software Agents (AISA)* that run on blockchain and negotiate all agreements; and
- *Smart Contracts (SC)* that can be treated as rental contracts established through autonomous negotiations, which persist on the blockchain and govern the rental through binding self-enforcing rental agreements.

6.1. Revenue scheduling model.

Blockshipping has been developed a unique revenue-sharing model, whilst issuing two types of tokens:

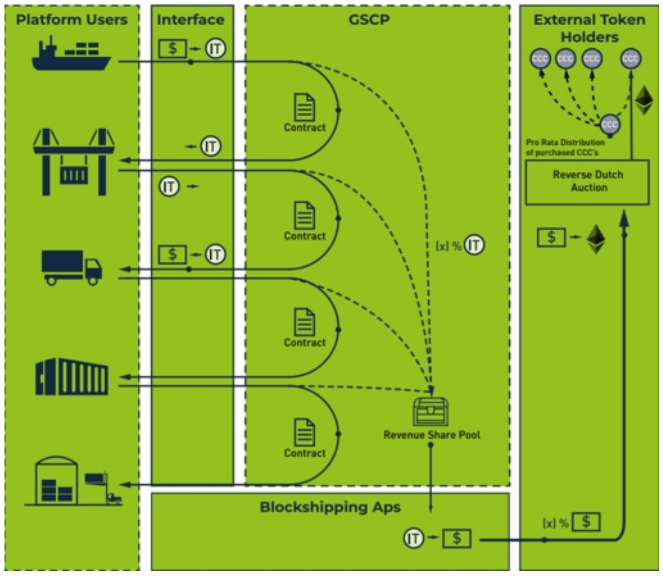
- *Internal utility token or Container Platform Token (CPT)*; and
- *External revenue share coin or Container Crypto Coin (CCC).*

The CPT is used for clearing and settlement of transactions between the users of the platform. These transactions will relate to many different services and fees. A percentage of the revenue goes to a revenue share pool and is passed on to the owners of CCC tokens. Blockshipping exchanges the CPTs in the revenue share pool to Ether via USD. Then, Blockshipping uses smart contracts to convert revenue Dutch auction on the Ethereum blockchain in which Blockshipping offers the owners of the CCC tokens price for their tokens. The offered price will increase until all available Ethers are spent. After the auction, Blockshipping distributes the acquired CCC tokens to all the owners of CCC tokens on a pro-rata basis. In this way, token owners are rewarded regardless of their decision to sell or keep their CCC tokens (Figure 2).

6.2. Processes flow.

The processes flow within Blockshipping is based on several simple and fully automated steps that will be explained shortly. The easiest way to make an explanation is to follow an example. Let us assume that the shipping line needs to rent a container to transport goods from Nairobi (Kenya) to Rotterdam (Netherlands). Blockshipping empty container repository engine identifies the best-positioned empty container in Nairobi and informs the shipping line about the options. The shipping line informs its autonomous intelligent software agents (AISAs) about the containers. The rental negotiations then happen unsupervised between the shipping line and the container owner through their autonomous agents. The agreements established by AISAs are persisted on blockchain in smart contracts that govern the rental in binding self-enforcing rental agreements. Blockshipping container platform tokens CPT are used

Figure 2: Blockshipping conceptual scheme.



Source: [26].

to pay rental fees, while the fees are transferred from the shipping line wallet, in accordance with the smart contract and reserved payment. The smart contracts can be changed if conditions change. For example, if the rental period is extended when the container reaches its final destination in Rotterdam. Then, the smart Oracle blockchain enforces the smart contract. The rental ends and releases CPTs to the container owner's wallet [30].

6.3. Blockchain for containers transport management: ePIcenter project approach.

One of the current research and innovation action projects in the European Union (EU) related to digital transformation and the introduction of new advance information technologies in transport systems design is ePIcenter, concerning enhanced physical internet-compatible earth-friendly freight transportation answers [31]. Disruptive technologies such as blockchain and artificial intelligence (AI) are used in ePIcenter to not only facilitate digitalization and visibility in the logistics chain, but also to exploit this new technology for real-time optimization. Therefore, the ePIcenter covers many emerging technologies including AI modules for transport, "chatbots", 5G networks introduction, blockchain analysis, related visibility and cybersecurity algorithms.

In particular, the work on innovative new technology such as blockchain, container modularization, and big data techniques for navigation are likely to advance beyond the scope of current standards and new ones may be suggested. In that context, one of the project tasks is the research and design of necessary extensions for modular containers, e.g. 40ft containers that can be converted into two 20ft containers while in transit, using distributed ledger technology such as blockchain. Also, blockchain or hashgraph, combined with AI, is used to detect usage abnormalities to increase cybersecurity in demonstration

trials. The ePIcenter contemplates the toolsets and innovations to be tested in trial related to freight flows between North America and Europe, China, and Europe (via Silk Road) and intra-Europe movements, the TEN-T network as well as the integration with international waterways. For this purpose, the blockchain-enabled information flows between ports, synchromodal planning along the Silk Road routes, and integrated optimization of intra-Europe multimodal shipments, with reference to findings from International research partners regarding Silk Road railway strategies.

Generally, applying emerging technology of blockchain and logistics concepts like synchromodality and the Physical Internet (PI) on major international and intra-European routes strives towards a deeper understanding of their impact and potential benefit for all international users in terms of improved exploitation of blockchain capabilities and infrastructure.

Following the concerns on empty container identification, management, and handling, within the ePIcenter project, the research has been carried out the modularity concept and its development possibilities [32;33]. The proposed solutions within this project open up many possibilities for disruptive technologies implementation including the blockchain, IoT, tracking and tracing, and new sealing systems for container transport management. In this context, the blockchain's technical advantages could be used by various stakeholders, including customs. For instance, technological advances in blockchain communication together with other IoT ones (including QR displays and GPS to control the positioning), could be complemented with the requirements that customs may have, which would help them to be informed about the potential risk of the containers without the need for a physical inspection.

Conclusions.

Information sharing between multiple actors in the maritime is a challenge, while trust and transparency are crucial. Blockchain, as an alternative to traditional centralized information systems, offers the potential to redefine maritime business processes through immutable and safe records that can be shared between multiple parties. It allows actors to keep cryptographically protected ledgers that can be shared trustfully among selected actors.

Since the maritime cluster is mostly driven by costs and gains to adopt technological advancements, blockchain adoption is still relatively slow. This can be caused also by the lack of knowledge of the opportunities that this technology can bring into the sector.

However, there are impediments to adopting this advanced technology when it comes to smaller companies, which operate in transitional or developing environments and chronically suffer the lack of knowledge and resources for making the transition to the new system of operation. Implementation of by-laws, which will regulate maritime blockchain applications at the global scale is an additional issue. Asymmetric information sharing up and downstream supply chains, it should be taken into consideration as well. So, all these are the concerns that worry some big players, but even more, smaller ones, lower positioned in the supply chain. Having in mind all the aforementioned, the worldwide adoption of maritime blockchain will not happen overnight. This requires time, a higher level of maritime education, business, and organizational culture, and joint efforts of all relevant stakeholders.

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