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A MULTI-AGENT SYSTEM WITH BLOCKCHAIN FOR CONTAINER STACKING AND DISPATCHING.

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ABSTRACT
Port Logistical Supply chains play a very important role in society. Their complex and adaptive behaviours promote the suggested applications of combining a multiagent system with blockchain for solving complex problems. Several technologies have been proven positively to work in logistics, however the concept of combining converging technologies such as blockchain with deep reinforcement multi agent is viewed as a novel approach to solving the complexity that is associated with many facets of logistics. A simulator was developed and tested for the problem of container stacking. The simulation results indicate a more robust approach to currently used tools and methods.

Keywords: Multi Agent, Blockchain, Multi-agent Simulation, Container Stacking Management

1. INTRODUCTION

Papers that don't adhere to the guidelines provided in this Coupled with the growth of global trade and containerisation is the emergence of new technology paradigms, such as Cloud Computing, BigData, A.I. (Artificial Intelligence), Machine Learning and IoT (Internet of Things), which leads to questions on how to develop and operate automated or autonomous systems that can be applied to logistics systems, such as those found in container terminals and port logistics.

Ports and terminals as nodes in a supply chain occupy a very important position in global trade (Stahlbock and Voß, 2007). Their complexity promotes the suggested use of applications that are drawn from distributed artificial intelligence, such as a multi agent systems and deep reinforcement learning for efficiency (Henesey, 2006). Several technologies have been proven positively to work in logistics - individually, however the concept of combining converging technologies such as blockchain with deep reinforcement and multi agent systems is viewed as a novel approach to solving the complexity that is often associated with many facets of port logistical operations. Furthermore, the use of Blockchain in ports is still deemed a novel solution as very little research is published on this subject as it was identified from a literature survey performed by Mahwish et al (2019). et. al. (20019)

In this paper a simulator is developed and tested. One of the port logistical operations tested is the stacking of containers in a container yard. The simulation results indicate a more robust approach to currently used tools and methods is achieved. The port maximises throughput, while still maximising contract-price. In combining the port's objectives with the customers' objective functions into a Multiple Objective Optimization Problem (MOOP) system provides a Pareto set of solutions for the port with regards to a container picklist.

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2. BACKGROUND

Since port, seaport, terminal and container terminal are terms often used interchangeably in research papers and discussions, an attempt is made to clarify the terminology. A *port* can be seen at first hand as a place to or from where goods may be shipped. The use of ports has long been associated with maritime trade and the use of ships to carry cargo. The advent of rail roads, automobiles, and airplanes associates the mode of transport using the port, i.e. airport, seaport. A *terminal* is a specialized part of the port that handles a particular type of goods, e.g. cars, containers, wood, people, etc. The situation today must reflect the change in institutional structures where port authorities are granting concessions to stevedoring companies to operate terminals (e.g. container terminals: CTs) independently and competitively within the port area.

The primary aim of port and terminal managers is to develop strategies that improve customer satisfaction and the terminal's competitive position. The main functions of the terminal management are the *planning* and *controlling* of operations. Terminal management is often driven by tradition rather than theory, thus being conservative with respect to adopting new ideas or technologies. The management of a terminal can affect the choice of ship lines to use a particular terminal. Thus, it is imperative that the terminal management is able to satisfy its customers, such as minimizing the time that a ship spends berthed at a terminal. To shorten this time, terminal managers spend special effort in increasing the productivity in terms of container crane moves per hour, which is regarded to be one measure of CT performance.

The increasing complexity of terminal operations requires management to decide allocation of resources but also the sequence and timing of operations. Due to tradition and outdated practices, the management of a CT or port is often fragmented, with differing organizations handling specific tasks within the terminal. Through interviews and port visits we observed that many terminal managers are often faced with these types of problems, which are further supported in research articles, e.g., Rebollo et al. [5], Gambardella et al. [6], and Frankel [7]:

- lack of planning
- not enough delegation
- ad hoc planning
- little insight in terminal operations
- lack of unity of control

The choice of organizational structure has been observed by Cullinane et al. [8] to affect the efficiency and ultimately performance of a terminal. The most common structure in port and terminal management is a 'unity of command', where key decisions are made by a single manager or group of terminal managers [9]. The development of specific departments leads to specialists in planning, e.g., ship planners, yard planners, and resource planners. The decisions made by port and terminal management demands an understanding of customer service requirements, such as:

- *Performance* – fast ship service ('turn-around') time,
- *Reliability* – predictable performance,
- *Cost* – desired to be competitive and predictable,
- *Quality* – no waste or damage during operations, and
- *Adaptability* – capacity of CT operators to implement solutions, i.e., changes to shipping line schedules and fulfil other customer requirements.

Additionally, terminal managers must understand their resource availabilities, operating costs, and other constraints, such as schedules, budgets, regulations, and the objectives of the terminal [7]. The main objective for many terminals is cost leadership and terminal competitiveness. Through improving productivity, many terminals seek to gain cost leadership, since terminal costs according to Persyn [10], are significant to the total costs of shipping goods. According to Frankel [7], port costs can be in excess of 50 percent of the total costs and where 55 percent of these port related costs are the result of poor ship turn-around times and low cargo handling speeds, which are strong determinants for consideration on using Blockchain solutions. In this study, the following types of ports are studied: Container, Bulk/ Liquid Bulk, Multipurpose, RoRo and Ferry.

With the increasing cargo shipments every year, the container terminals have had to keep up with the demands. The container terminal is viewed not as a passive point of interface between sea and land transport but as the natural point of intermodal interchange. They have become logistic centres acting as 'nodal points' in a global transport system. This means efficient container terminal logistic operations and processes are a need for every container terminal to maintain the business (Voss et al., 2004). Ports such as Antwerp, Rotterdam, and Hamburg are expanding their terminals or creating new terminals to accommodate the projected rise in number of containers. Due to increases in speed and volume, the operations of a container terminal require a better regulating systems approach. Research results in AI, Blockchain and IoT, could answer some of the container terminal challenges, enabling a sustainable improvement of the terminal's capacity and performance, e.g. increasing the performance without large investments for terminal expansion and new equipment.

Congestion and increasing cargo dwell times is a common scene in many of the world's ports. Government authorities such as customs and health may delay containers from reaching their destinations due to inspections. Shipping lines are unconcerned if there is a poor terminal productivity, as long as their vessel sails on time. Terminal operators are trying to reduce or stabilize the cost per TEU (twenty-foot equivalent unit: container) handled and thus maximize profit. Complications in container terminal systems arise in having the various computer systems work together, ad hoc planning, ill-defined data and poor information. Currently, ports are seeking better ways in improving their productivity and offering logistical solutions to shippers of cargo. No longer are ports handling just cargo, but more and more they are becoming "*information handlers*", (Henesey, 2002).

2.1. Container Terminal

In viewing a container terminal as a system, the following operations exist and are illustrated according to their location in Figure 1; Vessel; Berth, Intralogistics, Yard, and Gate. For a more detailed Account of container terminal operations research, c.f. (Stahlbock and Voß, 2007) and (Henesey, 2006).

Container Terminal Operations. A description of the following operations that exist in the movement of containers in and out of the container port is given as follows:

Vessel: Synonymously used as the maritime interface where cranes handle vessels. Terminal operators experience problems in reducing the unproductive and expensive container moves. The number of cranes used to perform the operation varies depending on the size of the containership and the volume of containers to be handled. The vessel planning is typically executed 24 hours before a vessel call by the ship line. The plan includes a manifest, list of containers to be loaded or discharged.

Berth: Each containership that arrives at a terminal will be assigned a berth and a location where a vessel can dock. The characteristics of a container berth are the length, depth, equipment (i.e. cranes), handling capacity, and service facilities.

Intralogistics: Containers are moved from berth to the yard to be stacked or placed in an area for dispatch, or containers from the stack are delivered to the gantry crane at the berth to be loaded on a vessel. The import container information such as its number, weight, seal number, and other information are recorded along with the location identification to a central database, such as a yard system in the terminal. Depending on the operations, either yard tractors, front loaders, or straddle carriers are employed as transport in this operation. The export containers are transferred from a location in a stack, thus notifying a yard system that the location is free and will be given to a gantry crane to be loaded on a vessel.

Yard: There exist three main types of storage systems: short term, long term, and specialized. Specialized storage is reserved for refrigerated, empty, liquid bulk, hazardous materials. The container storage system uses stacking algorithms in assigning a space for the container till it is loaded or dispatched.

Gate: The interface to other modes of transport lies in this system. The managing of the gate is to obtain information of containers coming into the terminal so as to be properly physically handled before ship arrival and to release import containers before the arrival of trucks or rail. Controlling this access to the terminal is important in that it affects other parts of the container terminal system. The data collected for example are; container number, weight, port of destination, IMO number if hazardous, reefer, shipper, ship line, and seal number are used in deciding where to place containers for storage and later for loading.

2.2. Container Processes

In the operations of ports there exist many processes that are required in the execution of operations. The major processes that are identified to be important for the efficient handling of containers are the following:

Documentation. During freight transport verification and validation of the status of the shipments, handover of responsibility, custom documents etc. are exchanged.

Tracking and Tracking. The location and identification of assets is equally important to the location of cargo itself. Improved visibility of assets, such as the equipment to handle the cargo/containers and people leads to higher productivity when such information is considered in moving containers

Sorting and Processing. As a system, the ports and terminals are constantly sorting incoming and outgoing containers and cargo based on defined criteria and rules. To enable the port and terminal management to efficient control the various operations, a number of processing tasks are required that demand expert knowledge and/or the use of computer systems in executing desired decisions.

Resource Management. Various specialized equipment types are used to handle containers and cargo. For many operators the objective is the efficient of use of equipment, number of workers and other resources in order to minimize costs whilst obtaining high performance.

Scheduling. It is an ongoing process in ports affected by many variables that are often not controllable, such as weather, strikes, congestion or traffic. For instance, the scheduling of arriving cargos with vessel calling requires coordination with the schedule of related yard operations and availability of the labour for moving cargo and containers.

Integration of Process Optimization. Often viewed by port and terminal as a “holy-grail” is the decision making that takes into account the multitude of actions and processes to decide on the physical movement of a cargo by a PHE from one location to another with minimal costs. Various IT systems are deployed in assisting port and terminal management in trying to integrate the processes with the operations.

The described operations and processes often characterize the activities existing in major container terminals and ports worldwide. As a result, many major ports and container terminals often have dedicated IT staff or departments, this provides advantages in terms of being more competitive than smaller ports. In the distribution of digital technologies for transport, such as Blockchain and IoT, small and medium ports and their service portfolios are argued to be very limited, not shared and not integrated on the cross-border level. A recent European Union financed study that was conducted, the Connect2SmallPorts project, generated results that concluded very differing levels and meanings of digitalization in ports, e.g. ports of Wismar - Germany, Karlskrona - Sweden and Klaipeda- Lithuania. Most of the small and medium ports still pursue the classical infrastructural path without any clear vision and digitalization strategy. The development for future port and container transportation is a big challenge for such small and medium size ports.

3. WHAT IS BLOCKCHAIN

Since its inception by a person or perhaps a group of people by the name of Satoshi Nakamoto in 2008, the use of Block and Chain have been popularized as Blockchain. Satoshi Nakamoto improved the design of Blockchain by introducing technological solutions, such as a *hashcash*-like method in which Blocks could be added to a Chain without requiring them to be signed by a trusted party. A very well – known example of Blockchain is the cryptocurrency known as Bitcoin, which possess a public ledger for all transactions in the network

The current literature does not provide any clear definition of Blockchain, since the technology is presented in several variances and applications. A Blockchain solution can be public and private, anonymous or based on user's reputation with a validation mechanism that can be centralized or decentralized. These are just few examples that show the broad spectrum of different technologies identified with the word "Blockchain". This confusion on the technology definition generates lack of understanding on the potential uses of Blockchain in port logistics as well as its real benefits. The first scientific problem in the field of the research is the evaluation of the fundamental Blockchain's properties that can be turned into applications in the field of logistics. The idea at the base of the technology is the concept of "distributed transactional database" spread into different nodes of the network (Morabito, 2017). These nodes, which identifies different users, work together in the creation and storage of an encrypted sequence of transactional records, which is defined as "block" (Lemieux, 2016). The technology is expected to bring a substantial transformation in the logistic sector, based on the following characteristics:

Transparency: Blockchain may prevent the creation of organizational silos within existing parties of the supply chain, enabling the different actors involved in the process to access the information. This feature leads to univocal, shared and real-time accessible pieces of information. Instead of having data buried in legacy silos, ERP or TMS, data are accessible in a distributed and decentralized way to supply chain members;

Traceability: Blockchain is able to keep track of the different processes so that every supply chain member is able to produce or collect information about the product's lifecycle (supplier information, the manufacturing process information, logistics information and others). This not only provides a guarantee over the product's origins, but it also offers information about the requirement for the product's handling, transportation and storage. Finally, this feature enables an easier traceability of the causes and responsibilities for problems occurred in the process;

Security: The information is stored in a ledger, which is a distributed data structure where transactions are organized in blocks (Kiayias et al., 2016). Each block is secure by encryption based on a hash mechanism so that the ledger becomes a proof-of-work puzzle. The access to information is based on a key system. Therefore, every member of the Blockchain, the so-called "node", is provided with a private key and a public key, which enable him to access the private information and the Blockchain respectively;

Built-in-trust: The feature of encryption on which Blockchain is based represents the guarantee of trust towards the system. This enables the members of the Blockchain to bypass the third parties that serves as a guarantee of financial, physical and information transaction in today's supply chain. In logistics, this leads to the elimination of documents such as Bill-of-Landings, Letter-of credits and middlemen such as Freight forwarder and banks.

Real-time accessibility: Blockchain provides to every user with authorization a real-time access to the information. This faster and broader access to information leads to speed-up the logistic processes and avoid bottle-necks. Benefits are not only related to the information flow, but also to the financial flow.

The implementation of Blockchain on port logistics opens the discussions on the efficiency and efficacy of the current port inter-organizational information systems. The implementation of Blockchain implies a change in the architecture from centralized to a distributed type. By using a decentralized approach, which modifies the current processes, proposes a new set of possibilities and business opportunities (Subramani, 2004).

In work by Mattia Francisconi (2018), he states that "Blockchain is a relatively new technology and there is still misunderstanding on the potential applications and impact in the field. In this study, we adopt the concept of Business Model (BM) and Business Model Innovation to evaluate small ports in the South Baltic region on impact of technology, such as Blockchain. These concepts assist in evaluating ports by analysis of a Business Model Stress Testing, which is a tool to evaluate the robustness of a company's BM to external factors. This tool was introduced for the first time by De Vos (2012) as a tool to evaluate the robustness of a company's BM by evaluating the impact of a collection of alternative environments

4. METHODOLOGY

Literature survey was performed to pinpoint areas of interest in which Blockchain could be applied and to identify any gaps in research. The data used was obtained from a small terminal in west coast US and the methodology employed is known as simulation method. A prototype that was initially developed in NetLogo® is further developed and written in Python language so that it is supported by Ethereum® for the testing and evaluation on the concept of crypto-currency in coordination and control of container stacking operations. At this time, the incorporation of ML – Machine Learning algorithms is considered but not yet implemented for further development so as to build "deep learning" Multi Agent systems.

4.1. Literature survey on Digitalisation on Ports

A comprehensive survey was conducted by Mahwish et al, (2019) and by (Heilig et al., 2017b) in which both identified areas for growth for digitalisation, such as AI, IoT, and Cloud Computing. However, there is a lack of papers on the subject of Blockchain with ports and container terminals, with Mahwish et al (2019) pointing to that only 3 papers were published.

4.2. Artificial Intelligence

Though, the reception of digital technologies, such as those highlighted in this study, in the container port domain, has been slow, but it has been steady and evolving. In the end of 1990s, the researchers cantered their work on different issues faced by the planners and managers of the container port using different approaches. For example, for the issue of container stacking (Itmi et al., 1995) advocated the concept of a society of agents that are essentially entities or processes with goals. The authors suggest a cooperative mechanism whereby; the agents achieve container stacking via N-puzzle game. (Gambardella et al., 1998) dealt with the allocation of yard and cranes to the container by proposing a decision support tool for planning purposes. The authors used simulation to test the decision policies and compared with actual experiences. (Lee, 1999) contributed with a successfully implemented automatic character recognition system for identification of vehicle and container numbers.

4.3. Internet of Thing and Cloud Computing

With the progress from barcode and magnetic strip, now the radio-frequency identification (RFID) tag is used at container terminal gate to Check-in the truck and container (Yoo et al., 2009) (Lee et al., 2011). The RFID tag refers to the digital encoded label, which is linked with a software system that records the data. In the survey, papers are classified in the context of AI and IoT, as it lays foundation for Internet of things and enables automation. (Lee et al., 2011) refer to the use of smart RFID labels to track container journey in the terminal and suggest it being linked to the overall information workflow to assist in the documentation.

When it comes to use pervasive technologies like IoT and Cloud computing in container terminal, very few research work has been proposed in literature, e.g. (Lee et al., 2011), (Ngai et al., 2011), (Shi et al., 2011), (Chen et al., 2013), (Choe et al., 2016), (Huang and Zheng, 2016), (Tsertou et al., 2016), (Li et al., 2018), (Heilig et al., 2017b) and (Ndraha et al., 2018). All of the studies are theoretical, such as reviews on potential application of IoT in Port (Shi et al., 2011), (Lee et al., 2011) or in cold food chain shipment (Ndraha et al., 2018).

During the investigation, Cloud technology was found to be discussed more of an enabler for IoT and Blockchain. (Tsertou et al., 2016) emphasized for a cloud-based information portal for the stakeholders linked with IoT sensors for real-time information analytics. (Heilig et al., 2017c) shares an idea of having an integrative mobile cloud platform for real-time inter-terminal truck routing. (Costa et al., 2007; Heilig et al., 2017b; Heilig and Voß, 2014; Ndraha et al., 2018) relay the same concept of real-time information access from people to people and machine to people.

4.4. Blockchain

Three articles were located, all from 2018 that touched upon the concept of distributed ledger, Blockchain technology. One of them (Kearney et al., 2018) attempts to set up the framework for seaport stakeholders and policymakers for to enable innovation, such as by Blockchain, in the seaport sector. Also observed, is research in the cold food chain direction where use of Blockchain could help with temperature monitoring (Ndraha et al., 2018) of containers carrying fruits or vegetables. The authors bring into the limelight the demand of having centralized information platform for communication between people and containers and refer to the Blockchain technology to fulfil the requisite whereby making the information exchange between all objects (human and machines) more secure, fast and transparent. It is worth mentioning to point out the recent academic work (Sturmanis et al., 2018) around the challenges faced by the logistic community by the implementation of Blockchain technology.

5. SIMULATION EXPERIMENT

Port logistics chains occupy a very important position in global trade. Their complexity promotes the suggested use of applications that are drawn from distributed artificial intelligence, such as a multi agent systems and deep reinforcement learning for efficiency. Several technologies have been proven positively to work in logistics - individually, however the concept of combining converging technologies such as blockchain with deep reinforcement and multi agent systems is viewed as a novel approach to solving the complexity that is often associated with many facets of port logistical operations. In this paper a simulator is developed and tested.

One of the port logistical operations tested is the stacking of containers in a container yard. The simulation results indicate a more robust approach to currently used tools and methods is achieved. The port maximises throughput, while still maximising contract-price. In combining the port's objectives with the customers' objective functions into a Multiple Objective

Optimization Problem (MOOP) system provides a Pareto set of solutions for the port with regards to a container picklist. In Figure 1 is an example of containers stacked, but are identified by owner (e.g. Amazon, Walmart)

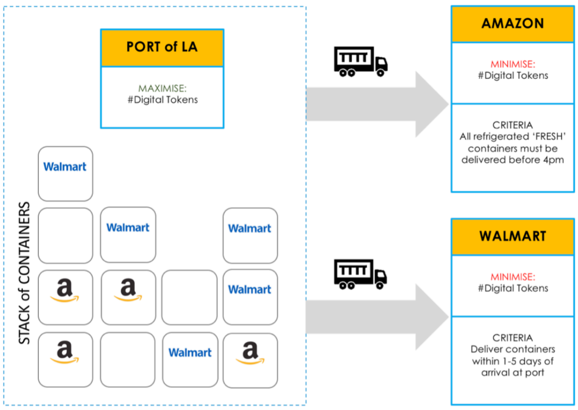


Figure 1. Container Stacking Example

The scenario evaluated in the simulation model is that of a port with a container stack consisting of 400 containers arranged in a 10x10x5. In a typical day, the crane operating on this stack can move 100 containers – a single move is defined as either moving a container within the stack to another coordinate or removing a container from the stack and delivering it to the port's customers (via a 3rd party carrier, who has a truck at the port). Each container belongs to a specific carrier, and each carrier has their own set of delivery goals related to the number, type and importance of the containers they own. Various rules concerning the container stack have been included and are obtained from experts. Rules for the container stack includes: Each container resides within a specific x,y,z coordinate; The maximum x coordinate that containers can be placed in is 10, the maximum y coordinate is 10 and the maximum z coordinate is 5; In any given column, the container with the highest z coordinate is the only container that can be moved; Containers can't 'float' in the air, e.g. a container can only be placed on (5,2,5) if a container is already placed on (5,2,4).

Every container in the stack has been assigned a *contract price* between 1 and 50, reflecting the amount of money that the customer has contracted the port for delivery of this container. The port has a single objective function; maximize the total contract price of containers delivered in a day. The output from simulation considers the Pareto Front and provides a set of moves that maximizes the total contract-price achieved by the port and the number of containers delivered, by splitting the allocation of extra moves across a number of customers.

5.1. Objective of the model

In the context of port logistics systems, how can combining blockchain with crypto currency be used as a standard transactional mechanism is modeled in to Multi-Agent system for faster means of enabling transactions amongst interested actors. The simulation results of the modeled container stacking management yield a number of solutions that satisfies all actors. The blockchain smart contracts enable elements in the process, such as containers and trucks, or applications like the port scheduling system to swiftly define and execute secure transactions between each other.

5.2. Simulation Model

The simulation model presents a means of evaluating various actor's criteria and objectives by automating the decisions, based on auctions, for the picking process for the port, choosing when to rearrange stacked containers, and when to deliver them to transportation. The actors' decisions on the optimal cryptocurrency price to set in order to achieve their goals and satisfy their constraints. In addition, the simulation model shows how the multi agents continually adapts to the changing conditions, and dynamically determines the Pareto frontier, to give the highest benefits to each participant, even as the system is being disrupted or as participants alter their goals. Finally, it is suggested that multi-agent solution helps in efficient use of cryptocurrency in to minimize costs and maximize earnings for each participant, by automatically balancing conflicting priorities. In Figure 2 we present a diagram of the containers stacked in. which an English Auction was conducted for the container customers coupled with a Dutch Auction for crane allocation.

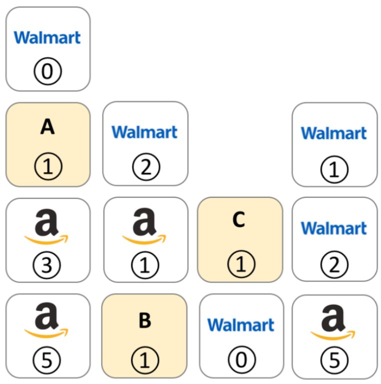


Figure 2. Containers stacked by customer

The prototype was written in NetLogo® a programming language that is supported by JAVA. Test and evaluate the concept of crypto-currency in coordination and control of a container terminal operations (explained in paper 2). At this time, the incorporation of ML – Machine Learning algorithms is not expected but is considered for further development so as to build "deep learning" Multi Agent systems. Simulation of Multi Agents Systems (MAS) in a Container Terminal. Coordination via cryptocurrency platform (e.g. Ethereum: https://www.ethereum.org) provides a new approach that is novel (1). Ideally, the prototype will seek to test and evaluate the work described. Development and test of MAS coordination was performed. Testing of Auction or other "market driven" approaches for control was conducted in the prototype.

6. SIMULATION RESULTS

The agents were bidding in the simulated model programmed in. NetLogo®, a screen shot is provided in Figure 3 that shows the construction of the simulation model.

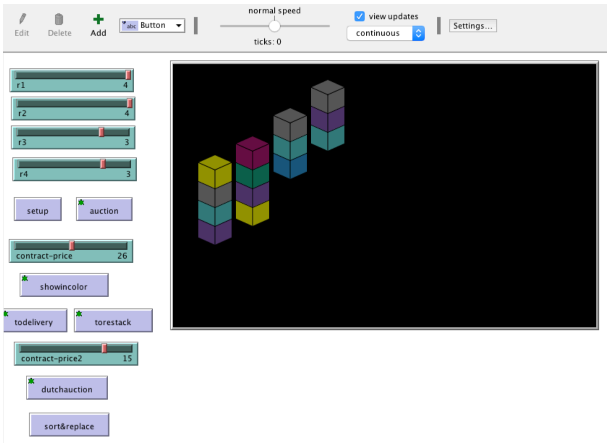
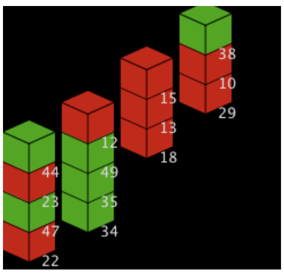


Figure 3 Simulation Model programmed in NetLogo®

From the assignment of containers to customers, the customers will begin bidding on when they would like to have their containers delivered, which will influence stacking in the container terminal. The following steps will be performed within the simulation

1. Summarize the contract price of all the containers.
2. Divide this number by the quantity of containers in the port.
3. Divide that number (2) by the total number of moves that we have (that we call move worth).
4. Multiply move worth with number of moves required to pick up the container
5. Sort and pick bigger containers without considering their positions.



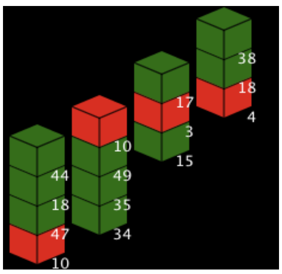
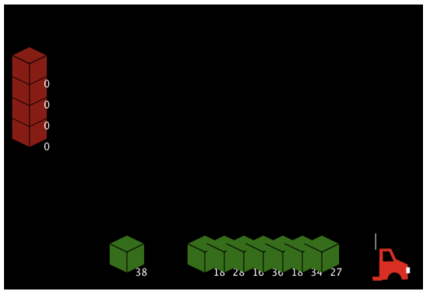


Figure 4. Stacking Figure 5. Crane Assignment

In Figures 4 and 5, the stacking of containers is generated, based on the bidding performed by the agents yielding to a plan on how the containers ought to be stacked. In Figure 5, the containers are organised based on crane assignment. The following figure, Figure 6 shows the containers being dispatched to be delivered to their owners.

Figure 6. Containers being delivered

The results highlight a novel approach in which container customers can bid via a Blockchain to stack and deliver



containers. For example:
We have these containers in three stacks:

5	10	1
15	55	5
5	2	100

1. Total price = 193
2. 193 / 9 = 21,4
3. 21,4 / 4 = 5,3

-0,3	4,7	-4,3
4,4	44,4	-5,6
- 10,9	- 13,3	84,1

Thus, in this case, with 4 moves, we will pick the containers with updated prices: 4,1 -5,6 -4,3 4 ,7

We start by picking 84,1 and the containers on top of it: -4,3 and -5,6. And then we pick 4,7. This performed by using a list that contains the containers in sorted order based on the updated price.

7. CONCLUSION AND FUTURE WORK

In this paper is on how complex systems, such as those found in supply chains and logistics would be more efficient and operational process improved. The solution that we have defined and developed is based on a multi agent systems tool encompassing elements of crypto-currency for conducting transactions in a digitalized supply chain would improve the performances of. The concept of digitalized supply chains is considered partially as a result of the digital transformation of physical global supply chains in which technologies, such as blockchain, cloud computing, machine-learning and deployment of IoT (Internet of Things) are causing disruption on many facets of transportation and trade. According to a report by Gartner, the estimate market for Supply Chain Management is to exceed by $19 billion by 2021(reference). Obviously, this is a large amount of investment on IT systems that are helping with decision making on many levels of transportation, logistics and supply chain itself.

Unfortunately, the supply chains and their management systems are viewed in this research to be inefficient due to the objectives that these solutions are often developed, which are to optimize a particular part or process of the supply chain. These inefficiencies are manifested by sub-optimal performance in specific functions, i.e., container terminal management or observed in the holistic flow of cargo goods through the entire chain. Currently, over 450 million TEU globally yearly, which has been identified in many research papers as to be complex.

The suggested solution proposed in this paper and. Partially simulated by a multi-agent system approach using. NetLogo® is specifically designed to optimize complex processes, such as the example of stacking containers to deliver a higher performance than current solutions. Due to its inherent characteristics, a multi-agent system is by its nature to be distributed, leading to synergies with blockchain, and utilization of cryptocurrency to provide a robust mechanism that is standardized for the exchange of value throughout a post logistics system. This allows the port logistics to run at an extremely high level of efficiency and gives each actor in the port logistics chain the ability to optimize their own function(s), yet still maintain a holistic balance. Multi-agents are programmed to run in a virtual, edge-based, or hybrid environment and are used to simplify deployment through a supply chain. By using cryptocurrency, such as Ethereum® it assists in establishing a standard transactional language across the port logistics chain, the suggested solution solves the multi-objective optimization problems, e.g. container stacking management by modelling a dynamic pareto frontier that maximizes value for each actor.

Future work would be to further improve the model and consider using Python in order to work with many libraries and APIs found in Ethereum organization.

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