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Research Article

Modelling a Blockchain ready Ports and Shipping Supply Chain in West Africa - A case of Ghana.

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Abstract

In recent decades, Blockchain (BC) has emerged as one of the most disruptive technologies, gaining considerable attention from industry and academia. BC is currently being used in a range of disciplines for study in academia and industry throughout the world [1]. Initially established in 2008 as part of Bitcoin's basic infrastructure [2], the topic of whether BC adoption would result in the replacement of existing technologies is still up for contention.

MODELLING A BLOCKCHAIN READY PORTS AND SHIPPING SUPPLY CHAIN IN WEST AFRICA - A CASE OF GHANA

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INTRODUCTION

In recent decades, Blockchain (BC) has emerged as one of the most disruptive technologies, gaining considerable attention from industry and academia. BC is currently being used in a range of disciplines for study in academia and industry throughout the world [1]. Initially established in 2008 as part of Bitcoin's basic infrastructure [2], the topic of whether BC adoption would result in the replacement of existing technologies is still up for contention. BC has been successfully deployed in non-monetary systems, including online voting, decentralized messaging, distributed cloud storage systems, proof-of-location, and healthcare, among others [3]. In addition, supply chain and logistics, social governance, gaming, e-commerce, global payments, digital rights, crowdfunding, and intellectual property are all in varying adoption stages. The BC technology is still in its infancy, with the purpose of, among other things, decreasing rising transaction settlement speed, fraud risk, and enhancing transaction auditability [4-7]. Countries such as Sweden, Estonia, India, Singapore, and Dubai are building the essential infrastructure for British Columbia in order to improve governance and mitigate the negative effects of urbanization [8]

In the past and more recently, there have been several complaints regarding the excessive delays at the clearance of goods in the majority of West African seaports [9,10]. Lack of integrated systems has led to excessive bureaucracy in the port supply chain network, which accounts for a portion of these delays. Studies in relevant sectors of the port business have emphasized the need to increase port system efficiency through port information management. For instance, [11] and [12] highlighted the effects of port congestion on the logistics and supply chain network in Africa due to delays.

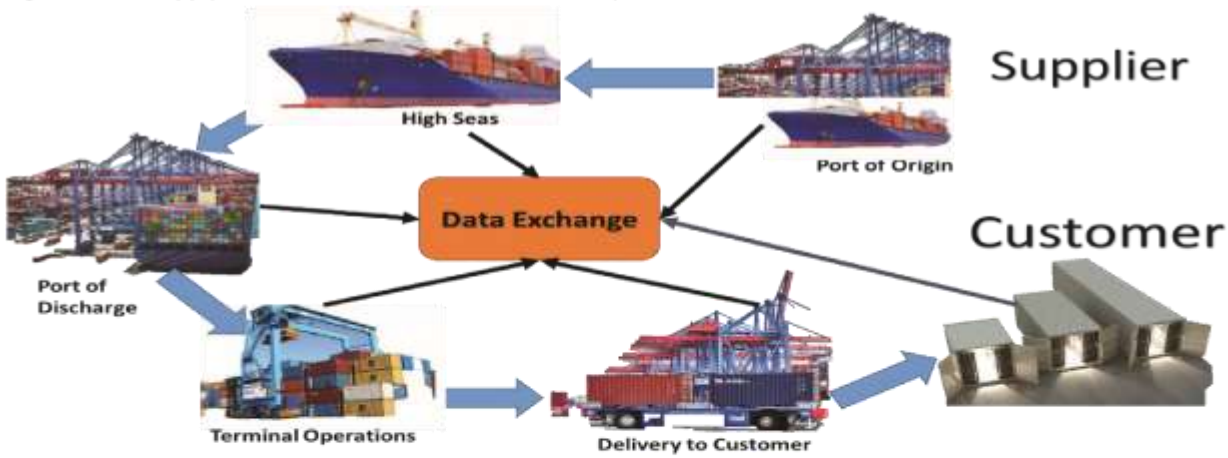

Figure 1: Seaport Supply Chain Network; Source: Boison and Antwi-Boampong (2020)

Figure 1. illustrates a typical port supply chain network system where a supplier at the port of origin (shipper) moves cargo to a customer (consignee)\sat the port of discharge. To facilitate this movement of cargo, certain required documents (Manifest, Bill of Lading, Bill of Entry, Commercial Invoice etc) (Manifest, Bill of Lading, Bill of Entry, Commercial Invoice etc.) must be exchanged via systems (mostly Electronic Data Exchange) by actors or stakeholders (Customs, Port Authorities, Freight Forwarders, Regulatory Agencies etc.) in supply chain to play their mandated roles to complete the transaction. The various challenges identified by [13] and

[14] among others give rise to the need to explore the potential of adopting BC technology to the port supply chain ecosystem using the importation of vehicles to ports in West Africa sub-region as a scenario case. The purpose of this paper is to propose a BC ready port supply chain for ports in West Africa. Specifically, this paper explores the need for transparency and traceability in port supply chain, the current state of the BC technology and the potential growth in other areas and finally propose a BC ready port supply chain concept using west Africa seaports as a case study. Port Supply Chain Transparency and Traceability Using BC Technology.

The supply chain in the port and maritime industry is a network of businesses, organizations, and individuals who work together to transport goods from the point of origin (the loading port) to the point of destination (the discharging port). When dealing with a complex supply chain system, it might be difficult to see the big picture of all the transactions happening within the chains [15]. Typically, some system operators or stakeholders have access to this data, which is stored in numerous locations. The end consumer or network stakeholder (the consignee) typically has only limited access to all data in such systems [16]. Information can be treated as a commodity for a shipping line (the supplier of the carrier service) in some instances. However, due to the limited visibility, trust is assumed exclusively among the participants in the system to guarantee the tractability of transactions. Transparency and traceability in the port supply chain may be improved by implementing BC technology. This would be possible through the immutable record of data, restricted user access, and distributed storage. All the way through the service lifecycle, the technology can provide a decentralized distributed system to gather, store, and manage crucial service information for each individual service.

APPROACH

Ports in West Africa served as a case study for the qualitative method's use. The region was selected because of its customs procedures, which are very comparable to those used in other sub regions. Extensive literature reviews were undertaken of BC technology in both established and emerging fields to identify potential application areas. Issues like the birth and death registries, customs classification, port supply chain applications, and asset monitoring are examples of recent and contentious problems in rapidly expanding areas of British Columbia. A design for a BC ready port supply chain was suggested after considering these studies, and its advantages and disadvantages were highlighted.

BC READY PORT SUPPLY CHAIN

Figure 2 depicts the intended implementation of BC within port supply chain systems. The proposed method includes a BC system that employs a decentralized, distributed technology to collect, store, and manage important cargo information for each cargo during its entire life cycle. This generates a safe and shareable record of exchange for each cargo, together with cargo-specific details. As cargo moves through its service life cycle (movement of cargo from port of loading to port of discharge and delivery to consignee), it is owned by a variety of parties including the shipper, shipping line (owners or agents of ships or vessels), customs, port authorities, terminal operators, regulatory authorities (such as the Food and Drugs Authority, Environmental Protection Agency, and Standards Authority), freight forwarders, and the final consignee (customer). Each of these stakeholders or individuals plays a crucial role in this system, recording of important data.

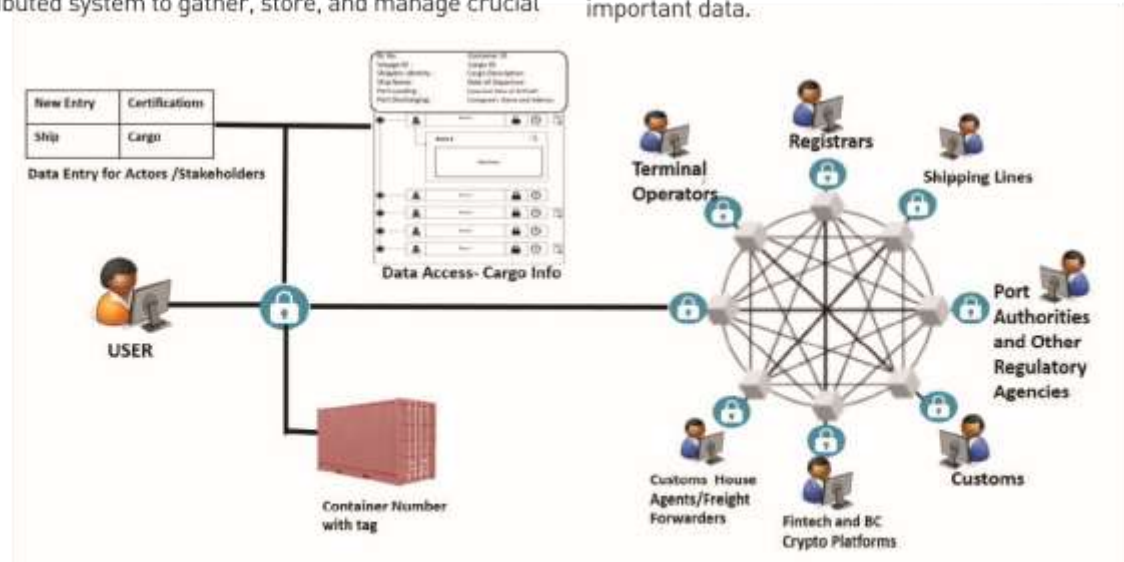

Figure 2 Overview of the proposed port BC concept.

On the BC network, information regarding the cargo and its current status (current location of the cargo, whether on terminal or ship) is uploaded. Each cargo posted on the BL would have a unique digital profile comprising all pertinent data, which would be populated at various phases of the cargo's transit. This scenario is based on the whole port logistics and transport supply chain, from the port of loading to the port of discharge, including all processes necessary to ensure cargo delivery to the consignee. Each voyage (movement of a ship from a port of loading to a port of destination) would have a unique transaction code (voyage ID), representing a unique digital cryptographic identifier that links a voyage made by a ship carrying particular cargoes to its identity on the network. In the scenario described above, it is useful to notice that containers are employed as enclosures for cargo on board a ship. These containers would also be equipped with the same digital cryptographic identity (RFIDs, barcodes, etc.) that ties the container (depending on its type: 20 or 40 feet) to its payload. It is assumed that each type of cargo in a container with a BL number has its own information tag with a manufacturer-issued unique digital cryptographic identification (RFID, barcode, or QR Code).

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Upon registering with the system, stakeholders or actors can also keep their own digital profile on the network.

This profile displays the cargo ID, cargo description, BL No., container ID, shipper's identity, ship's name, port of loading, port of discharging, date of departure, projected date of arrival, and certifications (Regulatory authorities) related to the cargo. A cargo profile that has been signed or handled by an actor (shipper, customs, regulatory agencies, etc.) will have a link to the actor's profile. The technology enables actors to modify their profile's privacy settings for different types of actors. Actors are registered on the system via a registrar with information describing their involvement in the service cycle. To build trust in the system, actors who wish to remain anonymous must, nevertheless, be confirmed by a recognized certifier or auditor. Through registration on the network by a registrar, the system provides accreditation services and a unique identifier to system participants.

Upon registration, a public and private cryptographic key pair is established for each actor. The public key is used to identify an actor within the network, whereas the private key authenticates the actor's transactions within the system. Actors can execute transactions with the network by cryptographically authenticating themselves with their private unique keys. This enables each cargo and its journey to be digitally signed by the players while being transferred from one port to another or added to the port supply chain further down the line. The categories of actors/shareholders and their assigned roles in the proposed system. This system offers each actor with a user interface to access a specific BC network. The application software can configure a specific digital profile of a cargo utilized by an actor. The system software is developed by trusted parties in the port supply chain network (such as port authorities, customs, etc.) and made available for registered organizations and stakeholders to download and run on their systems. Customized versions of the user interface would be available for consignees and customs agents to access information about a shipment with which they are linked.

The system software provides access to both existing and newly entered data. The system runs on a BC that delivers executable programmable code, such as Ethereum[17] BC. All data saved on the BC network is

accessible to anyone using the system software with the proper authorization. Nevertheless, actors' access to data would be contingent on the validity of the data. As long as these rules are written and saved on the BC system, they cannot be modified without notifying all nodes and receiving approval from relevant actors. Fairtrade or FSC, which are certification and standardization programs, may be deployed on the system. Certifiers and auditors within the network will inspect the ports and terminals for compliance with standard program regulations. Once validated by the certifiers, the certifiers and standards organization can digitally sign the actor's profile and its cargo to demonstrate their certification. The certifiers evaluate all actors to confirm their identities. The certifiers must reveal the identities of all actors to the network via a registrar.

The objective is to increase the visibility of system components while preserving the security and integrity of data kinds and places inside the port supply chain network. These rules specify how actors are to communicate, do business, and share data on the network with the system (type and position). Actors cannot alter these norms, which guarantee data integrity and are a prerequisite for data validity. As long as these rules are written and saved on the BC system, they cannot be modified without notifying all nodes and receiving approval from relevant actors. Fairtrade or FSC, which are certification and standardization programs, may be deployed on the system [18, 19]. Certifiers and auditors within the network will inspect the ports and terminals for compliance with standard program regulations. Once validated by the certifiers, the certifiers and standards organization can digitally sign the actor's profile and its cargo to demonstrate their certification.

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APPLICATION SCENARIO (WEST AFRICA SEAPORT PROCESS)

In this chapter, we illustrate and clarify the capabilities of the suggested concept through the use of an application scenario example. The BC ready port supply chain is considered for the shipment of a containerized vehicle from a port of loading to a port of destination (port of discharging). Involved in the transportation of cargo on the high seas are a number of parties. The application of BC in this instance may be extended to various transportation supply chain networks for additional items. The scenario focuses on a segment of the port supply chain (seaport) that involves the movement of containerized cargo (vehicle) from a port of loading to a port of destination, as represented in Figure 4. Through the BC system, all of the actors in this scenario have registered with a registrar service and have been assigned a unique identity on the network, including an actor profile. The system software developed for industry participants provides an interface for them to communicate with one another. The following business processes would be involved in a containerized freight scenario that is BC-ready:

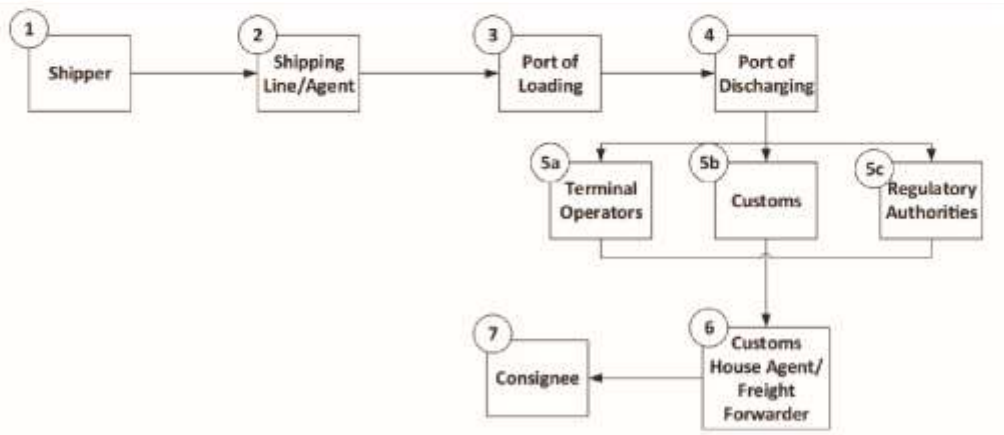

Figure 4 Port supply chain of movement of containerized vehicle from port of loading to port of discharging.

1. SHIPPER: Specific information about the vehicle being exported is entered by the shipper (type of vehicle, make, year of make, engine capacity, weight, consignee name, address and port of destination, etc.). After signing a digital contract recorded on the BC, a new trade is established between the shipper and the consignee in which cargo is swapped (data entry could be through a handheld device or a desktop computer). The registrar appoints certifiers to conduct physical checks to ensure compliance with regulations as shown on the system. The certificate is then shown alongside the digital signatures of both the certifiers and the standard bodies on the shipper's profile (regulatory authorities).

2. SHIPPING LINE/AGENT: After cargo has been transported to the terminal of the shipping line, the shipper picks a shipping line from the system and executes a digital contract with the shipper. After signing a digital contract with the port authority to undertake cargo activities, the shipping line enters more details about the cargo by specifying ship specifics, details of the container (Container Number, Weight, Size, etc.) and moves cargo to the port for loading/destination. This information is also presented on the system profiles of the port authority and shipping line.

3. PORT OF LOADING: The port assigns a specific berth and terminal(yard) to the shipping line for ship berthing and cargo stacking prior to the commencement of loading operations, respectively. This transaction is made possible after the shipping company and port authority sign a digital contract. When duties and taxes must be paid on exported cargo, the cargo is stopped in the system until payment is made and a customs officer physically verifies that the actual cargo at the yard matches the features provided, with the officer's digital signature added to the shipper's profile.

When cargo is loaded onto a ship, port tally clerks record the transfer of the goods from the yard to the ship at each stage to indicate whose equipment handled the cargo prior to its stacking. This provides time-stamped logs of all port activities. If a ship departs on time, the shipping line displays that on the system; however, if there are delays, the shipping line indicates a revised projected time of departure, and all system actors are told appropriately.

4. PORT OF DISCHARGING: Prior to a ship's arrival at the destination port, the system provides all actors with GPS capabilities with a platform to examine the ship's location and the status of each cargo on board. The destination port (port of discharging) assigns berth and yard space for the ship prior to its arrival, and the officer at the port of discharging enters this information into the cargo profile. Based on the permit level, the appointed officer records all cargo activities using a handheld device.

A. TERMINAL OPERATORS: Typically, cargo at the berth of the destination port is transferred to an off-dock terminal, where the delivery processes are carried out. Certain ports function as terminal operators. After a customs officer displays the container movement report on the cargo profile on the BC system, showing that the location of cargo has changed, cargo is moved from the destination port to a terminal yard.

The data is added to the cargo profile. Customs and Regulatory Agencies: Before the cargo may be delivered to the consignee, duties and taxes must be paid at the port of destination or the off-dock terminal. To gain a cargo release on behalf of the consignee, the customs agent performs physical actions. A built-in algorithm on the BC platform classifies goods based on the WCO classification nomenclature, and duties and taxes are automatically calculated after the shipper makes the initial entry into the system.

Similarly, taxes and other levies (penalties) to be paid by a consignee in order to comply with the required requirements are calculated using the same methods as those used for calculating duties. Certifiers validate that all standards have been met in the terminal and display a digital certificate on the profile of the cargo. These statistics also comprise the shipper's and receiver's cargo risk profile.

The approach classifies these dangers into three categories (Red-Poor, Yellow-Fair, and Green-Excellent) based on their severity. It is instructive to remember that cargo cannot be released on the system unless customs and regulatory obligations are satisfied.

B. CUSTOMS HOUSE AGENTS/FREIGHT FORWARDERS: A customs house agent or freight for warder facilitates the flow of cargo from the location of the shipper to the terminal (port of loading or port of discharging). Similarly, the customs house agent or the freight forwarder facilitates the delivery of cargo from the discharging port to the consignee. These practices, in which agents facilitate import and export processes for consignees, are widespread in the majority of African seaports and are typically codified in the customs legislation.

In this manner, a customs house agent utilizes a private key to enter the system once the consignee and the customs house agent have signed a digital contract. This contract grants the customs agent the authority to facilitate all import and export processes for cargo. In ports where customs house agents are not involved in the supply chain network, the consignee conducts these transactions directly with the shipping lines, customs, regulatory authorities, and terminal operators.

C. CONSIGNEE: The consignee can visit the platform at any time to determine the status of cargo transactions. For example, the number of releases made, pending releases, duties and taxes paid, port handling fees, cargo turnaround time, and all cargo-specific historical data. The consignee receives shipment from the customs house agent and marks shipment receipt by updating the shipment's profile in the system. A built-in Fintech and crypto BC platform will enable the execution of financial transactions without the need for intermediaries.

CONCLUSIONS AND RECOMMENDATIONS

The suggested system will permit the collection of voluminous data regarding cargo and its participants in the port supply chain network, which can prove advantageous to a variety of stakeholders (government, organizations, investors, producers, retailers, shipping lines, consignees etc.) This enables consignees (consumers) to immediately access precise data relevant to any cargo that has been transported via a BC-enabled port supply chain, enabling them to make more informed shipment decisions. Companies engaged in design, production, and manufacturing can have a better understanding of how their products are bundled and transported around the seaport supply chain.

This level of input can be utilized to enhance the company's production, marketing, and technological strategy. Large ports and maritime originations would be required to advocate for the potential benefits of the proposed port supply chain systems. Some may be initially resistant to characteristics such as cargo lead times, transparency, and automated payments (digital currencies), as these are occasionally exploited as corporate leverage. However, the experience with digital currencies and large financial institutions demonstrates that large industrial and political entities will recognize the technology's potential and strive to remain neutral towards it

DID YOU KNOW?

- Did you know that Ghana once owned a national shipping line, the Black star line, which had about 18 ships with names such as the Volta River, Keta, Tano and Sissili?
- Did you know without shipping half of the world's population would starve to death whilst the other half freezes to death?
- Did you know the minimum age at which a Ghanaian can be employed on a ship is 16 years?
- Did you know the largest container ships are 400 meters long *(the length of 4 standard football pitches joined together)* and can carry up to 20,000 containers?
- Did you know that with the completion of phase 1 of the MPS Terminal, the Tema Port is currently the biggest port, in terms of capacity, in West and Central Africa?

Source: Ghana Maritime Bulletin '20