CONTAINER STREAMS

AN INTEROPERABLE BLOCKCHAIN-ENABLED, DLT-BASED SYSTEM FOR THE SHIPPING INDUSTRY

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The maritime industry has historically been wary of technology and its implementation. However, in recent years its stance has changed, as major players understand the significant potential of digitalisation in helping overcome the challenges many face, whether it be fluctuating fuel costs or decreasing cargo rates.

While there may be a growing acceptance that shipping needs to 'go digital', new arguments have arisen as to the best way to achieve this. From cloud computing to Big Data, software-as-a-service to the Internet of Things, new trends and hype appear as potential silver bullets, before the hype settles back down. Arguably the latest of these trends to capture the imagination is blockchain, which Fortune defined as 'a way to structure data, and the foundation of cryptocurrencies like Bitcoin…[It] consists of concatenated blocks of transactions…to share a digital ledger across a network of computers without the need for a central authority.'

Numerous pilots and announcements over the past year have been making waves in the media, all allegedly ushering in a new blockchain-enabled era for the maritime industry. While these initiatives home in on specific use-cases within the industry, they generally all aim to replace current processes and systems with a new and improved blockchain-based, or distributed ledger technology-based solution.

In this paper, Karim Jabbar of the University of Copenhagen and Deanna MacDonald of Blockchain Labs for Open Collaboration (BLOC) consider another approach, one that aims to link the underlying distributed ledger with existing legacy systems, other blockchains, shipping portals, weighbridges and messaging services such as EDIFACT, e-mail or API. What does this mean? Barriers to entry are lowered so that all parties involved, no matter what size, can connect easily. The digital reach of existing systems expands beyond just those using that software leading to faster and more transparent connections between all parties. All critical components of logistics in the 21st century.

In order to prove the soundness of the technology enabling this interoperability, and the data adapters in particular, MTI has launched a proof of concept which has resulted in the findings in this paper.

– Jody Cleworth MTI

BACKGROUND: SOLAS VGM ADAPTER AND THE CONTAINER STREAMS ECOSYSTEM

The International Maritime Organization (IMO) implemented new regulations to improve safety aboard container ships in 2016. It did this by putting in place

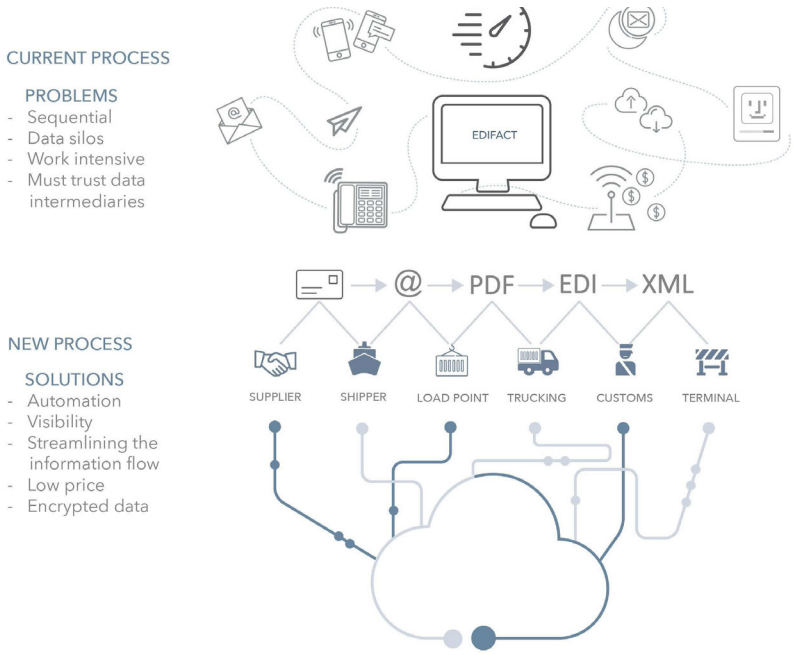

Figure 1

reporting requirements that would ensure a proper weight balancing of containers as they are being loaded onto vessels. The intention behind this was to prevent accidents due to improper loading, and to avoid the loss of lives at sea. Practically speaking, this new regulation, called Safety of Lives at Sea - Verified Gross Mass (SOLAS VGM), requires an EDI data transmission of the weight of each container to the shipping line prior to the container's arrival to the loading port.

This will ensure that the port can plan the loading sequence of containers in advance and be certain that the overall load balance of the vessel is within a tolerable safety range. Given the amount of data the regulation necessitated collecting, MTI saw the need to build a DLT-based application as a solution for digital weight reporting. This may ultimately result in a fundamental re-design of the reporting flow in the maritime industry.

The MTI solution, named SOLAS VGM to reflect the specific need it addresses, aims at leveraging the new legal requirements to extend the reach of the shipping infrastructure into the landside operations, and to connect previously disconnected actors into the shipping systems infrastructure. SOLAS VGM allows for all actors to interact with a common system via seamless integration of their legacy systems with a distributed ledger via an "Adapter API" which in turn transmits this data as a message to the appropriate shipping lines in any format required. This creates a streamlined, visible and verified data flow between all actors required to report and send this data.

FROM SOLAS VGM ADAPTER TO A COMPLETE CONTAINER STREAMS ECOSYSTEM

While the immediate value proposition lies within this 'one stop shop' communications platform allowing for the capture, storage, and transmission of VGM data to all relevant stakeholders in the supply chain, the additional data being collected and stored on the distributed ledger will become the foundation for creating significant value and digital innovation for the maritime industry.

Collecting data from weighbridges and mandatory weighing has been used as an opportunity to record more than 44 different data points that are relevant for the ongoing journey of the container. These data points include, but are not limited to, container size, type, number, shipping line, hauler, commodity and description. In addition, all associated paperwork, including any regulatory and customs clearance documentation, can be captured.

PARAMETERS OF SOLAS VGM PILOT

While there are several directions in which the Container Streams solution will be developed in the future, development thus far has been focused on connecting the first set of actors in the transport and logistics supply chain with those directly affected by the VGM regulation.

These actors are the shipper, freight forwarder, load point, shipping lines, and trucking companies. The first pilot case for Container Streams has been focused on creating interoperability and standardisation for the retrieval, storage and exchange of data.

This interoperability was achieved by building an adapter system that acts as a bridge between the distributed ledger storing the data and the various legacy systems and formats of the clients.

The core purpose of the pilot is to demonstrate:

- How the adapter allows for interoperability of the container data, the underlying distributed ledger, and a number of existing legacy systems.
- How this is done through conventional APIs as wells as by means of standardized protocols such as EDIFACT sent over SFTP to a remote server.

More specifically, in order to demonstrate the solution, MTI has set up a collaboration with Increase Computers, which is a major, an UK-based ERP solutions provider for the export industry.

Through the Increase Computers software module named FRED (Fast Remote Entry of Data) these weighbridges have been collecting data for the SOLAS VGM application over three months in 2017.

For the purpose of this paper, we have assessed live data from Parry & Evans (Load Point) that was recorded on the distributed ledger on July 31, 2017.

This was done through Container Streams' browser-based application called

LOAD POINTS	
PARRY & EVANS	Extendable to all Increase Computer Ltd enabled load points and all shippers from these load points

DATA POINTS COLLECTED	
Booking Number	Weighbridge (GROSS Weight) calibration Contact Name
Purchase Order Number	Weighbridge (GROSS Weight) calibration Due Date
Load Reference	Weighbridge (GROSS Weight) calibration Contact Phone Number
Container Number	Loadpoint Company
Container Type (e.g. 40 Ft High, 20 Ft Dry)	Shipper Details
SEAL #	Trucking Company
TARE Weight - FRED (Empty vehicle + Container)	Product Description
GROSS Weight - FRED (Loaded vehicle + container)	Product Commodity Code
NETT Weight - FRED (GROSS - TARE)	Product Customer Code
Container TARE Weight - FRED	Product Group Description
Weigh (Tare Head) Datetime - FRED (Incoming / Arrival)	European Waste Code (EWC)
Weigh (Gross Head) Datetime - FRED (Outgoing / Departure)	Bales / Package Count
Weighbridge (TARE Weight) serial number	Weighbridge Ticket: Ticket Number
Weighbridge (TARE Weight) calibration certificate number	Weighbridge Ticket: Document Date
Weighbridge (TARE Weight) calibration Contact Name	Weighbridge Ticket: Created By (Weighed by User)
Weighbridge (TARE Weight) calibration Due Date	Weighbridge Ticket: Signed By (Weighed by User)
Weighbridge (TARE Weight) calibration Contact Phone Number	Weighbridge Ticket: Signature (Weighed by User)
Weighbridge (GROSS Weight) serial number	Weighbridge Ticket: Trucker Signature
Weighbridge (GROSS Weight) calibration certificate number	Weighbridge Ticket: Trucker Name

ATTACHMENTS	
Photos	Already in FRED
Packing list	Not Available
Annex VII	Not Available
Weighbridge Ticket	Already in FRED
Weighbridge certificate	Not Available
Any others collected	Any attachments

Figure 2

"Event Viewer", as well as by direct access to the Terminal windows and log feeds displaying the transactions taking place on the network.

The data recorded on the ERP system was successfully captured through API by the SOLAS VGM application, recorded on the MAS distributed ledger, and given a unique ID, a so-called stream ID.

Furthermore, it was instantly confirmed back to the load point, and validated for provenance, which means tying the data input to the geographical location of the weighbridge.

Finally, a data (VERMAS) message was submitted using the EDIFACT format over SFTP to the shipping portal INTTRA for further relaying to the shipping lines. Figure 2 lists the complete data captured at the loadpoint. Figure 1 is an illustration of the data flow and how the new process enabled by the MTI solution differs from the current process.

The result of an adapter on top of a distributed ledger is an application that allows for entities to automatically report their weighbridge data to a secured storage solution, receive a 'container stream ID number', and then use this ID as a means of tracking the container through the supply chain.

The advantages of an interoperable system of this kind is that not only does this automate compliance with regulations for the reporting of VGM data and streamline documentation and customs processes, but that in doing so it also creates trust, transparency using verifiable provenance for containers being shipped throughout the world.

MAS DLT SPECIFICATIONS

It is important to understand the underlying digital infrastructure upon which Container Streams is built. MAS Protocol developed by Agility Sciences and the infrastructure supporting it provides the distributed database in which the data, documentation and messages are stored and which interacts with the SOLAS VGM Adapter and Container Streams Applications.

The network is operated by permissioned nodes that process messages, and guard the common ledger. The nodes all perform the duplicated task of cross-referencing new messages to

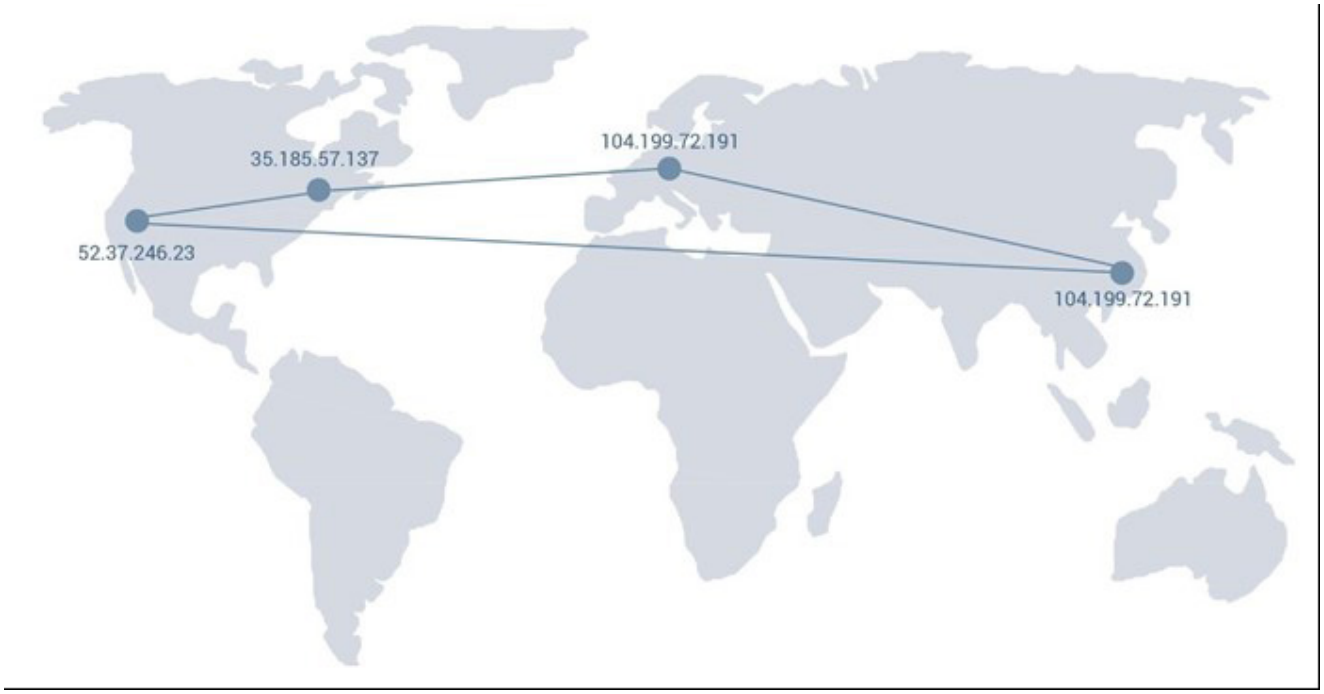

Figure 3

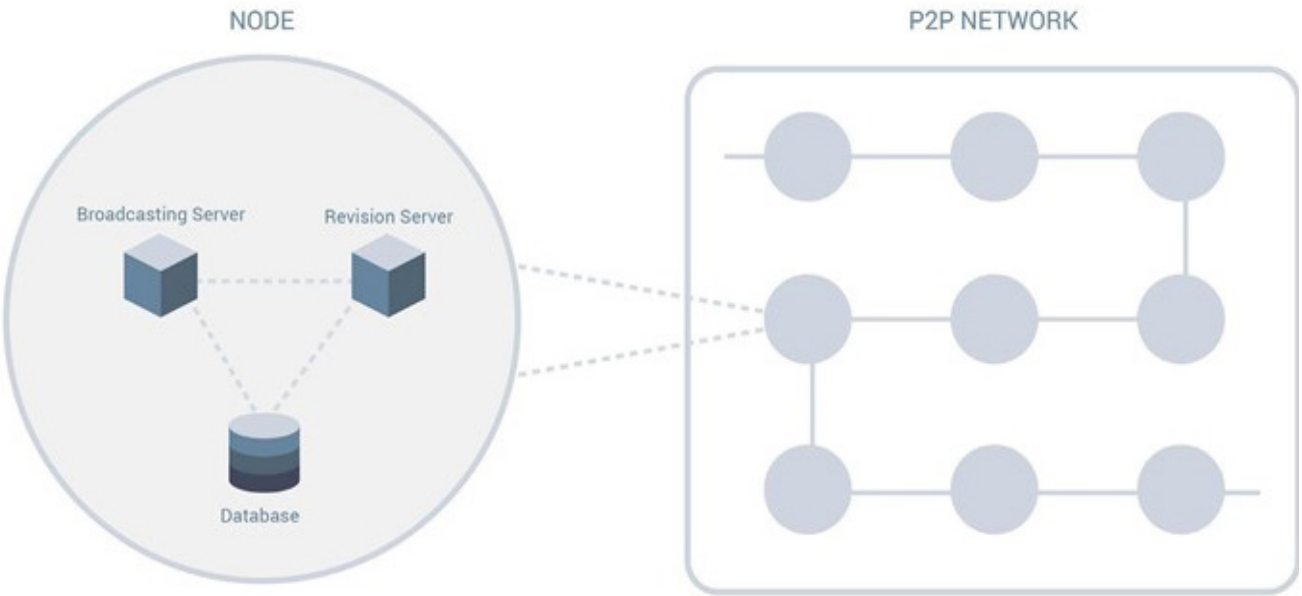

Figure 4

their existing database to see if it links up properly to prior entries.

The identity of all nodes has been checked and is publicly available for greater trust. External clients of the ledger can submit their messages to the ledger by sending it to any node for processing (see figure 3 for distributed server details of the MTI Proof of concept).

MAS distributed ledger (MAS DL) primarily consists of three foundational components:

- Database (CouchDB, java)
- Transmission-layer (P2P network, http)
- Security and data privacy (Cryptography, PKI, hashing).

Each node does the processing on two different servers: one for immediate verification, which allows quickly passing on the message to its neighbours, and the other for final clearing and alignment with the network's common decentralized database. This distinction from other distributed ledgers is what paves the way for substantial performance improvement (see figure 4).

ROLES AND SPECIFICATIONS OF THE SOLAS VGM ADAPTER:

PROVENANCE AND IMMUTABILITY

Given the various types of data sources, in this case ERP systems and weighbridges, there is a need for the sorting, formatting and delivery of this data to the DL. Therefore, the adapter is a software

Figure 5

4.5 Adapter Interface

The following images show the admin interface of the MAS adapters and serve as an example of how the adapter is configured.

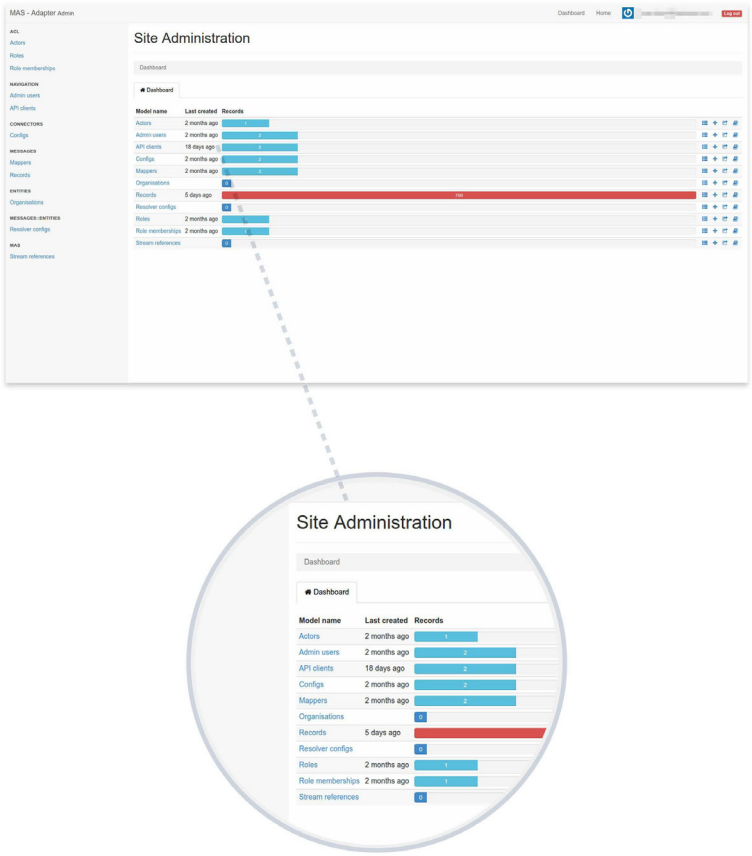

Figure 6

solution created by MTI to facilitate the mapping of disparate data sources to any data destination, in this case MAS DL.

The adapter database is set up with configuration data to operate using mapper definitions. The mapper definitions are used to provide endpoints to incoming traffic and connect to an onward destination endpoint or queue, all without any manual intervention.

The result is an automated process of collecting data from its various sources and mapping it to its shared destination.

After having mapped and sent this data to the DL, this event is mapped and tagged by the adapter and in turn becomes a data source itself. In essence, the data is posted to the DL along with an event tag (stream ID) and the event tag becomes the base destination to map all other associated data to.

The event tagging mechanism is what forms the basis of traceability and provenance of this data (a blockchain). The stream IDs having been pushed back to the originators of messages provide an extension of the provenance from within those third-party systems and into receivers of the events broadcast by the network.

In the context of this proof of concept, the adapter retrieves the full data set from the ERP systems and weighbridge collection points and then tags the data as a “stream ID”. The MAS protocol provides for all kinds of encrypted data to be stored on the network and referenced by its applicable stream ID, which is a unique identifier to a data event which can in turn point to prior event streams. At various stages the stream IDs of previous activities associated with the container are referenced in onward DL entries forming links and thus provenance blockchains. As part of the proof of concept, PDF documents and various formats of images were used in the data associated with the weighin-weighout message of a container.

SECURITY

To ensure that this data is tamper-proof and secure and thereby a source of verifiable and validated truth, another role of the adapter is to augment the data with additional intended actor information, which the MAS broker uses for encryption and access control on the onward messages.

In this way, only actors identified and configured within the adapter will be able to access the encrypted data on the MAS Distributed Ledger. Data received from third party applications via the adapter is processed by a smart contract interacting with the distributed ledger that validates the cryptographically secured information.

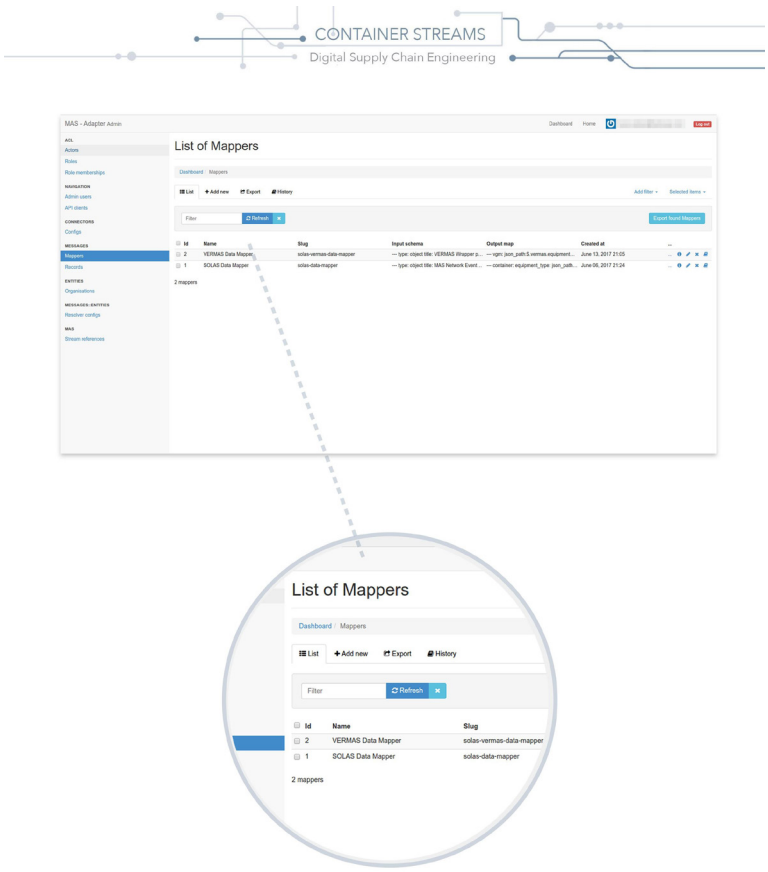

Figure 7

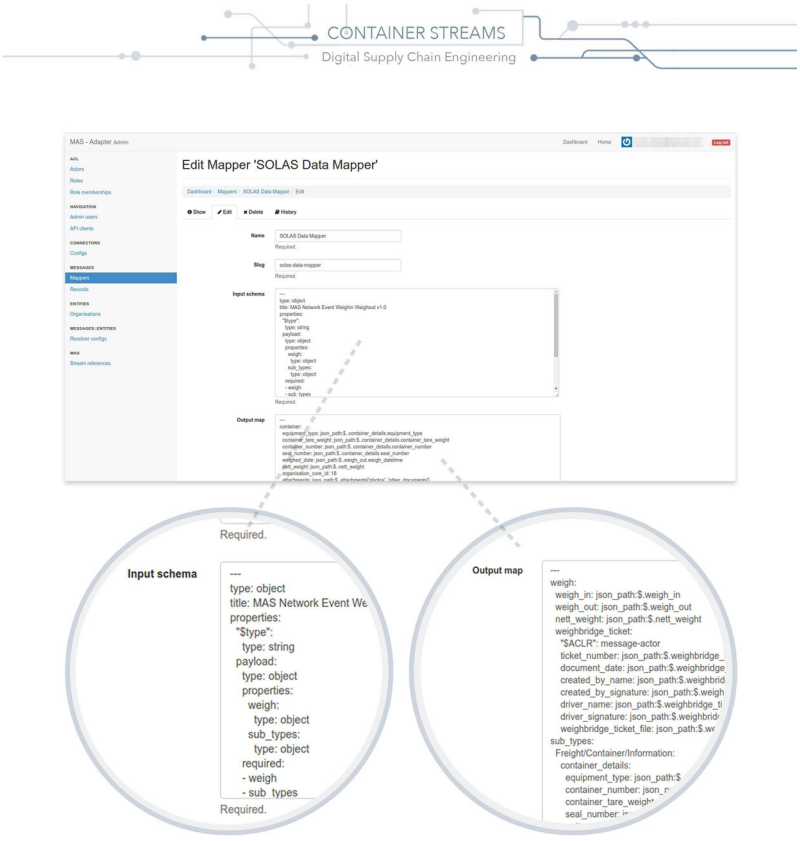

Figure 8

NETWORK PARTICIPANTS PRIVACY

Given that the solution as presented in this paper, is intended as an industry-wide peer to peer public distributed ledger where the participants would not want their information to be known to any parties other than the intended recipients, the core of the solution features a cryptographic recipient addressing mechanism.

This essentially means that the DL nodes only have access to the encrypted versions of participant data and the public keys of the intended recipients.

All consensus formed on the network is done using the encrypted form of the data and not on the actual data transmitted. Furthermore, the data is encrypted in logical role based chunks such that different encryption is applied to different role players enabling partial and wholesale decryption of the data messages as required where multiple actors may be party to the message.

When events are received from the network, if a recipient finds their public key in the address headers, they are able to decrypt the data that has been placed in their respective roles' sections. In order to achieve this, the adapters are configured with the public keys of the intended recipients.

The data, once sent to the broker with the intended recipients in the message header, is then encrypted before onward distribution to the MAS network.

In the envisaged case, the owner of the data would administer both the adapter layer and the broker layer ensuring that encryption happens within their own private network.

INTEROPERABILITY

To summarize, the role of an adapter is to act as;

- An interface that collects data from various data sources
- A data format mapper
- A cryptographic addressing provider (the addressing is configured in the adapter)
- An API connecting to a distributed ledger.

In essence, the adapter is an asynchronous network communication system between various componfiguents.

As such it is the foundation for interoperability between various data sources and distributed ledger technology. In this context, MTI's adapter creates a bridge between the terminal, trucking companies, weighbridges, freight forwarders and shipping lines and a trusted, immutable, traceable and secure blockchain database (see Figure 6).

Interoperability is a crucial feature

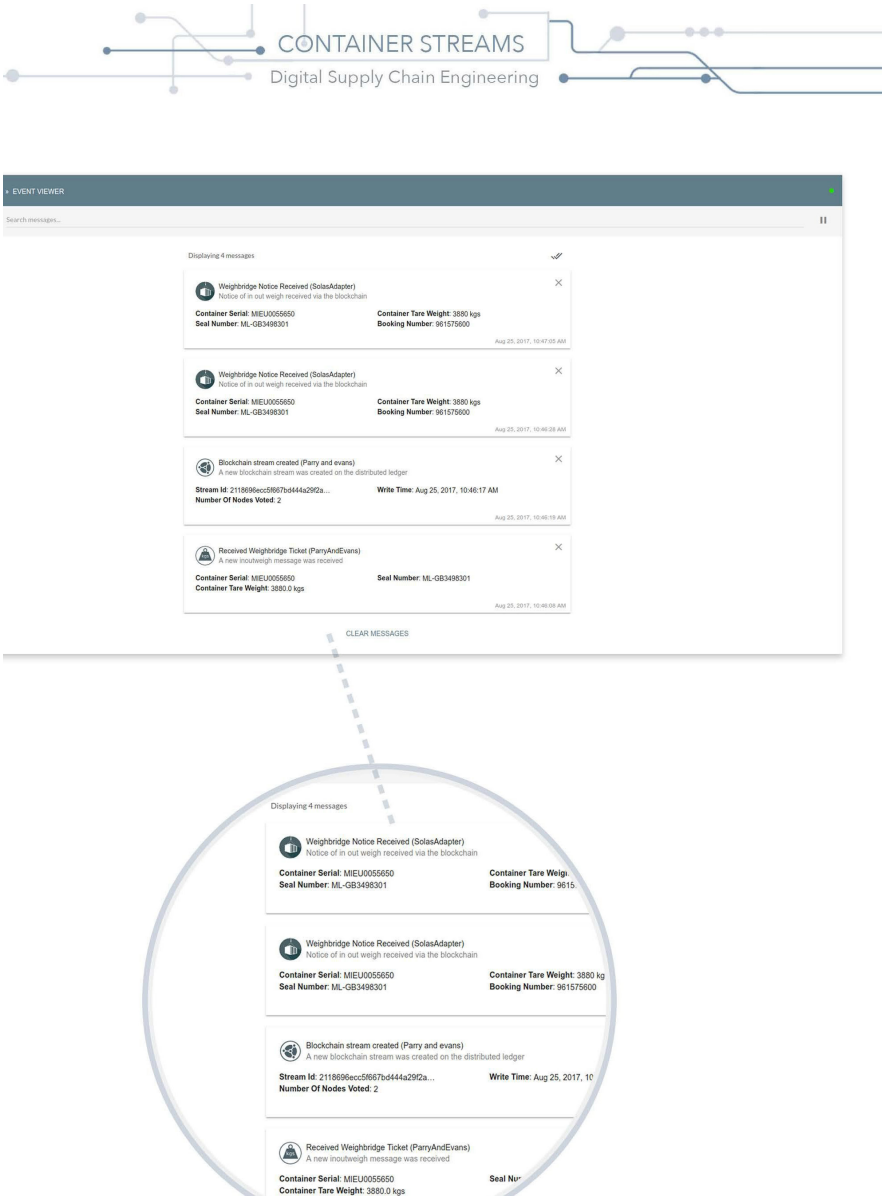

Figure 9

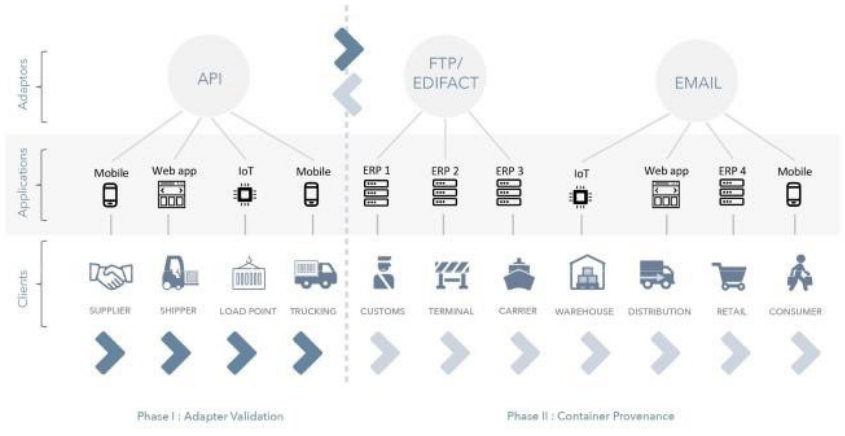

Figure 10

when it comes to market adoption of Distributed Ledger Technology. Whereas, other blockchain and DLT-based applications for the shipping industry have been aimed at replacing the current EDI (Electronic Data Interchange) system with a new solution, the interoperability built into the Container Streams platform and its underlying DLT will most likely allow for a more organic piecewise transition providing for more rapid market adoption.

Issues related to switching costs and considerations of critical mass are less important when the immediate value proposition is an enhancement of the existing system through fast, secure and transparent sharing of data at very little upfront cost and low risk.

ADAPTER INTERFACE

Figures 6, 7, and 8 show the admin interface of the MAS adapters, and serve as an example of how the adapter is configured.

EVENT VIEWER

Once a message containing the requested load point data enters the system, a weighbridge ticket is relayed to the DLT and the resulting stream ID sent back to the load point service provider in the response message.

The stream ID is used as the unique identifier of the message sent pertaining to this activity.

As the SOLAS VGM platform is set as an actor in the Proof of concept scenario, another adapter picks up the message from the ledger and imports the data into the appropriate user profile within SOLAS VGM.

The user checks and verifies the data resulting in the generation of a VERMAS (Verified Gross Mass) message, which is also relayed via adapter back onto the MAS network using the original stream ID as an onward reference.

The verified mass message along with the stream ID is then picked up by a third adapter (actor) which is configured to send an EDI message to INTTRA adapter as per the traditional process. For future use, this ID will be matched against the records obtained and passed along the supply chain to ensure provenance, tracking and monitoring of the freight.

A live view of the messages as they traverse the various adapters, DL and SOLAS VGM is provided using the Containers Streams Event Viewer. This digital message viewer can be easily accessed and viewed from any web browser at http://event-viewer.containerstreams.com/ (See Figure 9 for a screenshort).

It should be noted that the information

in the event viewer is unencrypted for the purposes of the proof of concept to demonstrate the interoperability of the system as a whole. Ordinarily the information shown will be segregated and access controlled by the parties taking part.

VALIDATED OUTCOMES OF THE PROOF OF CONCEPT

The main validated outcomes of this proof of concept are that MTI has succeeded in building a distributed-ledger-based system for data sharing in the shipping supply chain based on configurable adapters. This system allows for automation of messaging while simultaneously providing privacy, transparency, security, and interoperability with existing legacy systems. The proof of concept showcased the functionality of the SOLAS VGM adapters by setting up three different adapters on separate servers.

Each of these adapters performed the following functions:

- Accept, process and forward in MAS protocol all messages from the load point ERP system
- Accept incoming distributed ledger events pertaining to the weighin-weighout documents and push them into the SOLAS VGM application for user verification
- Accept and process user-verified documents back onto the ledger using the original stream ID as a reference
- Accept verified (VERMAS) documents from the distributed ledger, process them into EDI format and upload to an SFTP server to be picked up by INTTRA
- Poll the SFTP server to push carrier responses back onto the distributed ledger
- Accept carrier response events from the distributed ledger and notify SOLAS VGM users once the response was received

NEXT STEPS

The validated outcomes of this proof of concept have primarily been linked to the demonstration of the ability of the SOLAS VGM adapters to connect and exchange data with a legacy ERP system, a container load point, and to relay this data two-way via SFTP server to INTTRA (See Phase 1 in Figure 10).

For this to become a fully functional out-of-the-box system to which all actors in the shipping supply chain can connect, Phase 2 will need to be finalized to expand the connectivity of the Adapter to include communication to customs, port terminals, and direct to carriers through EDIFACT.

Phase 1 has demonstrated that it is possible for the SOLAS VGM Adapter to communicate with INTTRA via EDIFACT, thus finalizing connectivity to the above-mentioned systems will be achievable in the short term. Furthermore, to truly have an end-to-end system, communication via e-mail to consumers and retailers on the distribution side is also needed, which is likely only a matter of programming hours. Our assessment of the proof of concept is that the bulk of the work has been done, and that the core features of the system have been validated. What is needed now is to get more users on the system at all stages of the supply chain, so that the last connections can be finalized and the final product launched. It is our estimate that depending on available resources, this can be done within a month or two.

FUTURE IMPLICATIONS

Container Streams and its first application, SOLAS VGM, is addressing the need for legally required transmission of VGM information while also providing the platform for connecting the various upstream actors in the shipping and logistics value chain to share data and information.

This is a significant step forward in the digitialization of the maritime industry, wherein data, business processes and transactions that have historically been interacting within silos, disconnected due to the multitude of individualized systems used to manage various small-scale operations.

The implications of an interoperable data sharing platform for the maritime industry are immense, including creating efficient and streamlined processes, reducing complexities in the logistics supply chain and levelling the playing field by creating an accessible and interoperable platform for all shipping and logistics providers, regardless of scale.

A natural extension of the SOLAS VGM application, once connections between the adapters and the remaining supply chain actors are established and the application starts gathering large amounts of data into the underlying Distributed Ledger, would be to extend the application's functionality into the area of operations management, including functionality such as supply chain finance. More specifically, it is these very elements that will be included in the next application currently in development by MTI on the Container Streams platform COMSHIP.

In this next application, the interoperability achieved by the adaptions in connection with SOLAS VGM will be further leveraged at the operations level, creating an actual seamless booking portal whereby data from load points and various other supply chain actors can be streamed, allowing users of the COMSHIP application to have complete transparency over their data.

In summary, we conclude that this proof of concept has validated what it set out to do, and that we believe that the MTI solution, based on the MAS distributed Ledger, is a fundamentally new way to address the transition from a traditional patchwork of silo legacy systems, to a global digital "commons" for the shipping supply chain, on which a whole range of innovative applications can be built, thus fostering more transparency, efficiency and security in the digital infrastructure supporting global trade.

ABOUT THE AUTHOR

Deanna MacDonald has spent over a decade developing and applying technology to benefit society and the environment, in industries such as renewable energy, biotechnology, medical technology and artificial intelligence. As CEO of BLOC, she is focused on providing the platform for blockchain solutions that enable a frictionless, peer-to-peer trading economy.

Karim Jabbar focuses on emerging technologies, the entrepreneurial practices that bring them about, and their strategic uses in corporate settings. His specialisms include blockchain, open hardware and the Internet of Things. Prior to moving into academia, he was the MD of a travel company with a turnover of USD $12 million.

ABOUT THE ORGANISATION

MTI brings technology and logistics together, keeping customers in control through high performing, low cost software products. With access to over 30 years of technology and logistics experience, MTI ensures clients get the best products available in the market, whilst making cost savings in their supply chain.

ENQUIRIES

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