THE SEA-FREIGHT AUTOMATION FRAMEWORK (SAF)

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Current supply chain operations sit in an information technology paradigm that can be characterized as follows: human controlled supply chain processes and manual user tasks, large monolithic platforms, process 'silos', incommensurable user interfaces, and no industry wide APIs and communication protocols. The combined result of all these factors is a low automation level and high software initial, as well as extensive maintenance costs.

The sea-freight automation framework (SAF) is an open source initiative created to introduce an automation structure (a set of APIs for supply chain operations and communications) to the industry. Its objective is to unify and further automate business processes as per the table below:

CONCEPT OF ENGAGEMENT

The SAF engagement concept is derived from the smart contracts model used in blockchain. 'Engagement' simply means a set of promises by actors within shipping processes to handle a particular asset (i.e. a shipping container, a conventional consignment, export declaration, a marine

Current Paradigm	SAF
Human control supply chain processes and manual user tasks	Machine controlled supply chain with process flow automation spanning over all supply chain participants with less dependency on human availability and efficiency
Large monolithic platforms	Individual well defined granular services integrated with traditional operating systems when required
Process 'silos'	Full integration between processes
Incommensurable user interfaces for online services	Unified user interfaces for all online services
No industry wide standard APIs	Standard engagement APIs: Message data structures and service definitions written using interface description language (IDL).
No industry wide standard protocol	gRPC Protocol: Modern, cross-platform, open source remote procedure call protocol (initially developed by Google)

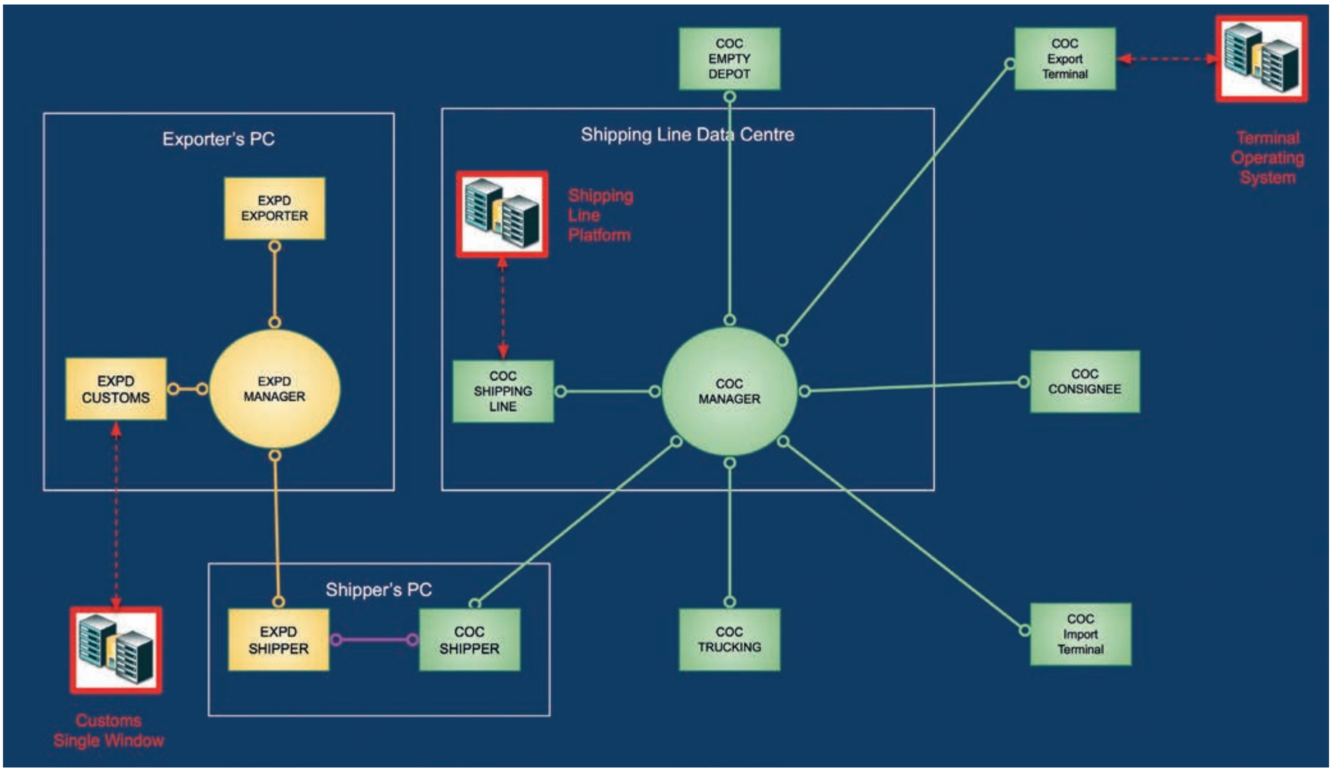

Figure 1: Export Declaration (EXPD) and Contract Of Carriage (COC) chains

vessel). Realization of the promises leads to achieving a certain target milestone event, such as "export declaration is accepted", "container arrived" or "vessel departed".

SAF presumes that all physical shipping tasks such as container stuffing, road transportation, and vessel discharge, as well as all non-physical tasks such as preparation of the contracts and documents, data input, data exchange, and payment processing, are performed to fulfill a certain promise pledged by an actor. SAF also identifies the types of repetitive sea-freight engagements requiring communication between actors.

CONTRACT OF CARRIAGE ENGAGEMENT (FCL SHIPPING)

Full container load (FCL) shipping is a door-to-door sea-freight concept. Containers are sealed at the origin and opened at the destination. Therefore, the target milestone for this engagement is a full container arrived at the destination. The main actors in the engagement are the shipper, shipping line, the trucking company, rail company (if applicable) and consignee. Their promises are stated in the terms of conditions of the 'contract of carriage' governed by the bill of lading (BOL).

For this BOL type, shippers are bound to:

- Transport empty containers from empty depots to exporter premises
- Load cargo inside containers
- Provide verified gross container weights to shipping lines
- Transport containers to export marine terminal
- Send shipping instruction to shipping lines

ENGAGEMENT CHAIN PATTERN

The SAF network consists of two types of service:

1. Manager Service: Fully automated application (no user tasks) which tracks and controls execution of the engagement processes
2. Actor Service: Semi-automated application (some user tasks). The application supports human-machine interfacing and automates the execution of an engagement process on behalf of an actor

An engagement chain is a temporary group of services participating in an engagement process. It consists of a manager and multiple actor services. A chain is established dynamically every time a new engagement process is created. The chain gets depreciated whenever the engagement process terminates.

MANAGER/ACTOR SERVICE RESPONSIBILITIES

An SAF network of independent services should be in constant evolution. Services will startup and shutdown, and the service network location (IP address and port) will be changing due to upgrades. However, SAF services will able to find each other and form engagement chains. To accomplish this, SAF needs a centralized service registry (SAF SR) – a database containing the network location of active service.

The engagement manager and actor services perform automatic tasks on behalf of the participating actors. It replaces 'user' tasks, performed by human users. The Manager Service records the creation of the engagement process and assigns a unique process identifier. This ID is used in all further communications between actors and manager services. The process gets created when parties agree to cooperate to execute the engagement.

The execution of engagement processes are governed by the terms and conditions of the contracts between participating actors. The Manager Service maintains data objects containing parameters of the contracts and the type of messages exchanged during the execution.

Upon receiving certain milestones in the engagement process, The Manager Service automatically generates and sends an invoice to the 'payer' Actor Service. It follows a predefined control process if notification of payment has not been received after the due time.

Actor services perform as a facade for traditional operating systems such as the customs single window, shipping line platform, or terminal operating system (TOS). Engagement chains exchange data amongst themselves. This is done by communication between services representing the same actor.

SAF APIS

APIs are an agreement between the services and the clients. It defines the requests the service will receive and the expected responses. SAF defines one API for each service. Thus, SAF services play

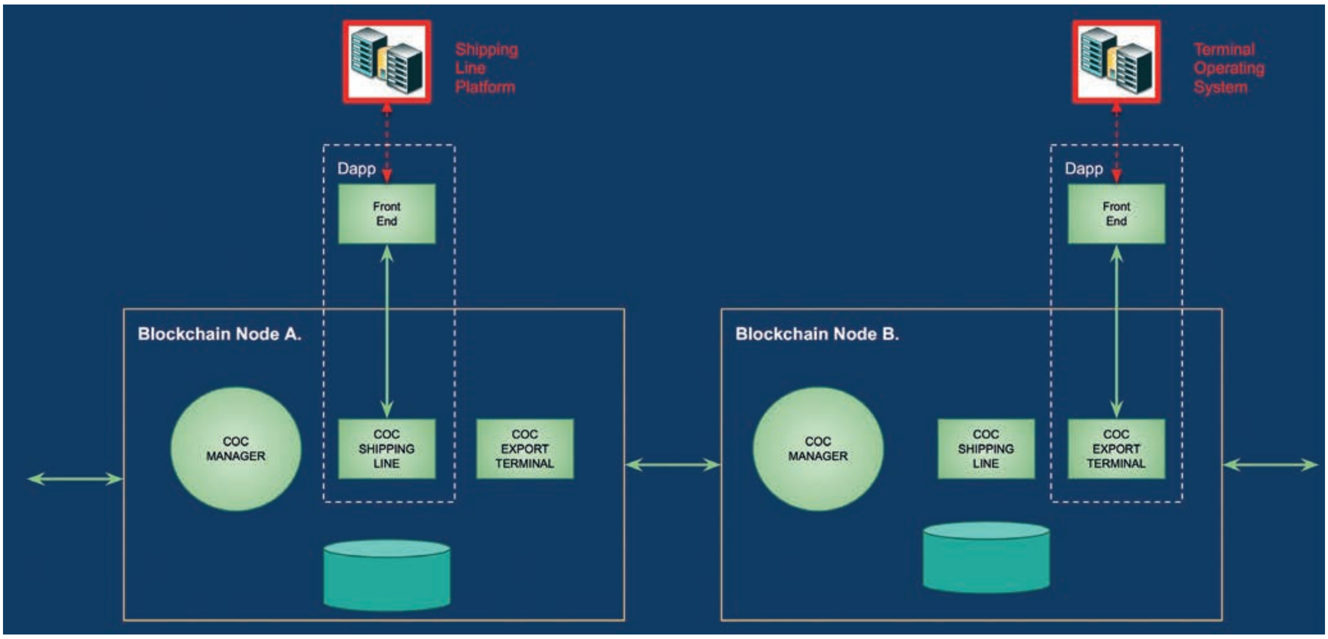

Figure 2: SAF Services Implemented as Blockchain Dapp

both the client and server role.

SAF APIs use Protocol Buffers (Google's open source data interchange format) version 3 (Proto 3) as their interface definition language (IDL) to define the API interface and the structure of the payload messages. The APIs precisely define methods that clients can call, as well as parameter and return messages for the methods.

Proto 3 is also used to describe complex multilayer and extendable data structures of messages. In the message definition, each field has a name, type, and unique numbered tag. The tag should not be changed during the use of the message, however, new fields can be added if required.

SAF uses gRPC, an open source remote procedure called (RPC) protocol. The protocol and software library were initially developed at Google, which connect SAF services in and across data centers and connect devices, mobile applications and browsers to SAF services. The gRPC protocol can also be used to communicate with blockchain network nodes including Ethereum Project and Hyperledger Fabric.

Most importantly, gRPC generates idiomatic client and server stubs for services using Proto 3 API as a source. Thus, SAF API will be automatically converted to fully functional programmes simplifying the network programming and eliminating the need for parsing the messages defined in SAF API.

IMPLEMENTATION

SAF doesn't prescribe how engagement services are implemented. The SAF framework can accommodate services created by various technologies. Any 'cloud-based' or 'on- premises' application which supports SAF API is a legitimate SAF service. The following scenarios describe typical implementation of SAF Services:

SCENARIO 1: MICROSERVICES

Both Actor and Manager Services can be implemented as a 'microservice'. Microservices are an approach to distributed systems that promote the use of finely grained services with their own life cycles which collaborate together. Microservices with their own communication layer, business logic and databases match the requirements of SAF very well.

There are many models for the deployment of SAF microservices: On premises, public cloud, private cloud, and software as a service. Figure 1 presents a model where all SAF services are deployed on premise.

SCENARIO 2: BLOCKCHAINS

Both Actor and Manager Services can be implemented as a Blockchain Decentralized Application (Dapp) which consists of 'smart contracts'. Smart contracts are special programmes which run on top of a blockchain database and frontend, which is a channel that connects blockchain with the outside world.

If services are implemented in the same blockchain, their 'smart contracts' will communicate directly by calling each other. For example, COC Manager smart contract will calls methods on COC Shipping Line smart contracts and vice versa. Semantics of the messages exchanged between the smart contracts shall adhere to SAF API.

Actor Services will perform as a facade for the operating systems using Dapp frontend as a communication channel. For example, COC Export Terminal service will perform as facade for a TOS. The service will use the front end as a channel for communication with the TOS.

SCENARIO 3: MICROSERVICE/BLOCKCHAIN HYBRID

The SAF API framework can be used to integrate multiple blockchain networks and microservices utilizing the advantages of both technologies. For example, SAF microservices can utilize a centralized service registry and payment processing blockchain applications.

CONCLUSION

SAF is an initiative to create an automation framework and shift from current human control to machine control operation. If adopted by industry it should drastically increase the level of automation and reduce IT costs.

ABOUT THE AUTHOR

Alex Goussiatiner, PEng, is a Senior Port Consultant specializing in port management, engineering, port automation and industrial AI. During his carrier, Alex has worked with several scientific research institutions, leading engineering companies (Ausenco and AECOM) and with marine terminal operators including Global Ports PLC as COO of the group.

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