SAFE Backbone:
A centralised coordinator of supply chain data for blockchain applications.

SAFE Responsible Supply Chain Solutions
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Abstract: A system of bespoke, client facing applications which access the SAFE Backbone, a centralised coordinator and blockchain integrator of supply chain data, would enable physical supply chain actors to move away from predominantly paper-based, manual supply chain data management to digital data capture, storage and sharing. A digital transformation of this nature in a physical supply chain would greatly reduce the risk of error and fraud, greatly reduce the amount of effort required to operate the supply chain, greatly improve actors control over their data and privacy, and greatly improve stakeholder trust in the supply chain system.

1. Introduction

Commodity supply chains have evolved over thousands of years to rely on paper-based processes. This manual approach to the capture, organisation, storage, and sharing of supply chain data causes the system to suffer from lack of transparency, vulnerability to fraud, loss of productivity and obstacles to accessing efficient third-party services, such as finance and insurance.

The emergence of new technologies, during a time of great change in supply chains caused by the demands of increasingly important mega-trends, present an opportunity for supply chains to undergo an important digitalisation. These mega-trends such as Environmental, Social and Governance (ESG), Decarbonisation, Provenance & Sustainability, Trade Finance Liquidity, and Digitalisation are transforming the demands that corporations, financiers, regulators and consumers make on supply chains. Awareness of information in supply chains is now a top priority across all industries world-wide and is one of the key determining factors in accessing financial markets, achieving compliance and attracting customers. Supply chain visibility is now directly impacting the bottom line.

Emerging technologies, such as Blockchain, Cloud, Mobile Internet, Internet of Things, and Machine Learning & Artificial Intelligence offer new approaches to managing data in supply chains in more secure, accurate, efficient and trusted systems. Convergence of these technologies, codifying them to work together in a unified system, enables these new systems to tackle the complexities of physical supply chains in ways that were not previously possible using earlier technologies. Emerging technologies unlock previously unavailable solutions to the inherent problems faced in physical supply chains.

This white paper outlines the technical design of the SAFE system of bespoke client-facing apps that leverage the SAFE Backbone blockchain solution by considering a hypothetical Demo supply chain with only two actors in it – a Seller and a Buyer.

2. Operation of a Typical Supply Chain

In Figure 1 is an example of how a typical physical supply chain operates, and the document flow for a single shipment in the absence of any SAFE components. The flow is complex and it can be seen that;

a) Multiple parties share data
b) Multiple parties update data
c) There is a requirement for 3rd party verification
d) There are intermediaries and complexity
e) Interactions are time sensitive
f) There are dependencies between separate transactions

This complexity and lack of resilience in the management of data in the operation of a supply chain is what can be simplified through the application of a blockchain technology system.

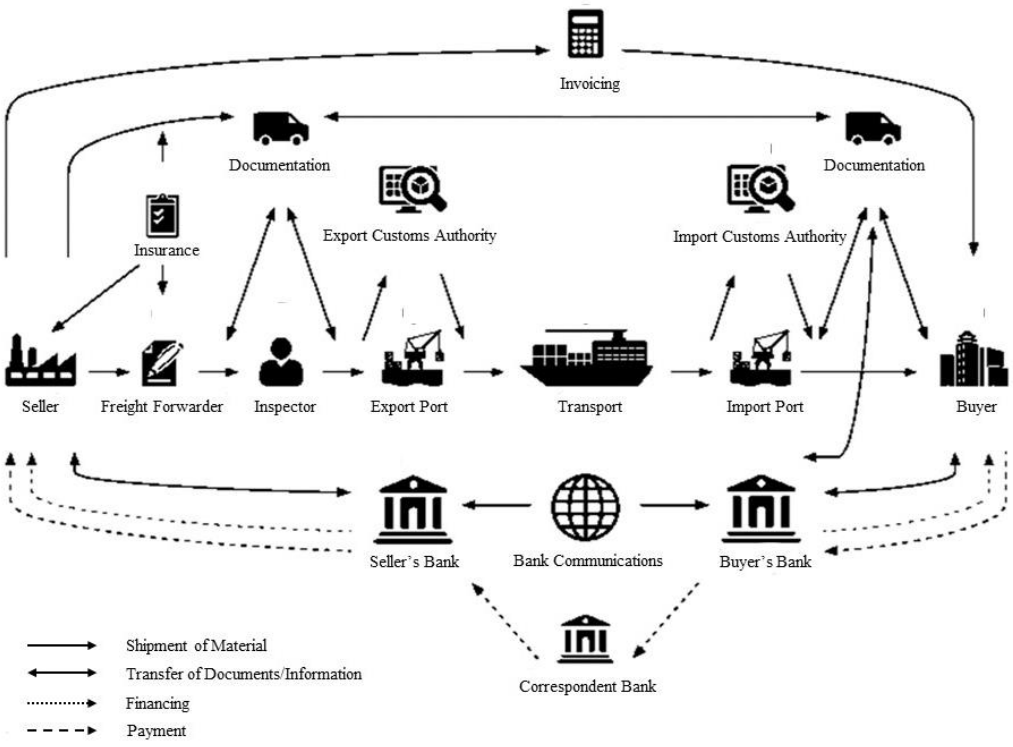

Figure 1: Example of the data and document flows in a typical supply chain

a) Seller and Buyer interact and negotiate by way of communication of data and physical or electronic documents, for example Request For Quotation (RFQ), over various communications channels, such as face-to-face, email, telephone, social media chat.
b) Seller and buyer agree commercial terms for the exchange of goods or materials and consummate these terms under a signed purchase and sale contract.

c) The purchase and sale contract is shared over email and postal services in original or copy form with multiple stakeholders, both internal and external to the counterparts of the contract.
d) The goods or material are then delivered from Seller to Buyer. Various methods of transport and logistics may be used, any of which will include multiple actors who generate and share data and documents that facilitate proper operations in the supply chain in order to successfully transport, finance, insure and risk manage the goods or material in transit from one location to the other. During this process multiple actors create, share, update, verify or require access to, existing or new data or documents produced during the supply chain operations.
e) The Seller will generate an invoice for the goods or material, alongside other required commercial or transport documentation, and send to the Buyer, and any other relevant stakeholders, over various communications channels, such as face-to-face, email, post, social media chat.
f) The Buyer checks the invoice against the relevant data and documents produced during the supply chain operations and effects payment via the Buyers bank to the Sellers bank, conditional upon presentation of the required data and documents from the supply chain being made available.

In practice this process is paper-based and manual. Data is captured, stored, manipulated, and shared via various methods ranging from hand-written or emailed communications and forms, pdf's, scans and excel files which are often taken by actors in the supply chain and used "as is" or converted by manual process into another format or system before further use or sharing. This paper-based, manual process of handling supply chain data creates risk of fraud or error, high levels of manual effort, discontinuous data around the same activity amongst different actors and poor visibility into the supply chain.

3. The SAFE Solution for the Demo Supply Chain

The SAFE System of client-facing apps and the SAFE Backbone solution is generic enough to accommodate a supply chain of any size and complexity but to demonstrate its core functioning we use the same example of two actors, a Seller and a Buyer.

In the presence of SAFE components, the data and documentation flow for the single transaction or shipment is greatly simplified.

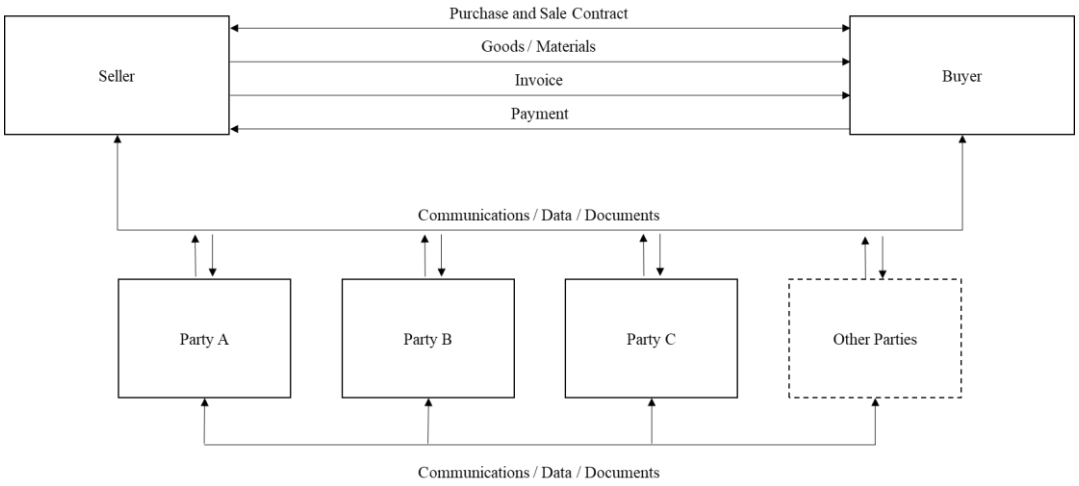

Figure 2: Simplification of the flows of documents and data using the SAFE blockchain system

The SAFE solution in this Demo supply chain is split into three systems – bespoke digital solutions for the Seller and the Buyer as well as the SAFE Backbone which acts as a centralized coordinator of the progress of shipments.

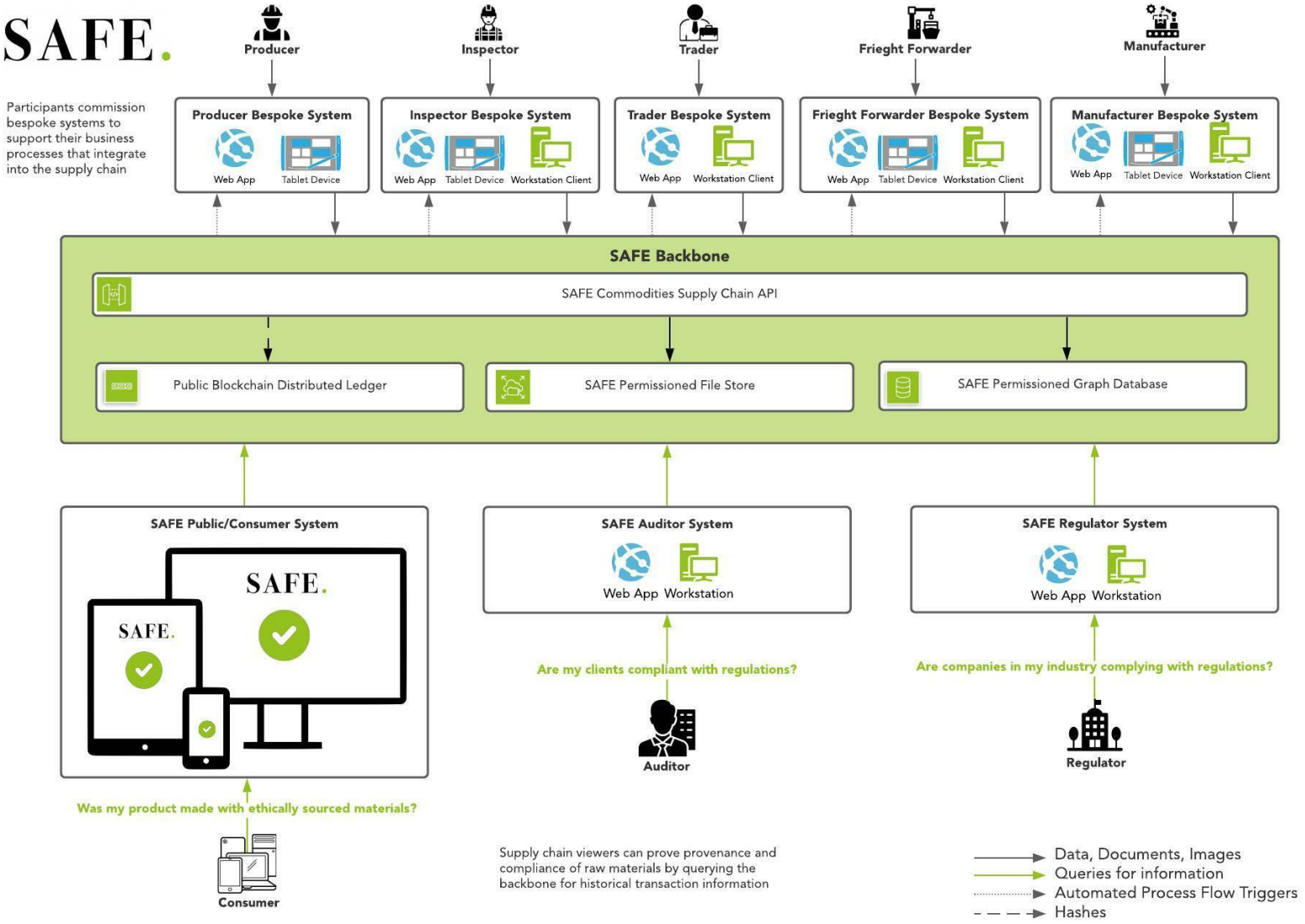

Figure 2: Simplification of the flows of documents and data using the SAFE blockchain system

At each step of the process outlined above the bespoke digital solution of the actor that is generating the document or data sends a hash of the document to the SAFE Backbone. The SAFE Backbone notifies the bespoke digital solution of the other actor that a new document relevant to the shipment has been posted. At the same time, the SAFE Backbone generates a "manifest" in JSON format (which is both human and machine-readable) capturing metadata about the document that changed hands. For example, the RFQ which is the first step of the transaction would have the following manifest:

```
{
        "supplyChain": "Demo",
                "type" : "RFQ",
                "shipmentId" : "1234",
                "hash" : "1234abcd...",
}
```

This manifest is stored inside the SAFE Backbone system and a hash of its text representation is inserted into the Ethereum blockchain as a smart contract without any executable logic other than to store the hash value. Ethereum generates an address for that smart contract, as an example; "addressOfRFQ".

The SAFE Backbone makes public the document manifests (via their hash values) into the Ethereum blockchain, which amongst other things serves as an immutable distributed ledger. Tens of thousands of computers around the world, who are under the control of different parties ensure the consistency of this ledger, which renders it practically incorruptible. SAFE uses this property to ensure that the documents processed by the system cannot be tampered with after the fact, and to ensure immediate detection if anyone attempts to make any changes. The public nature of Ethereum also enables audits by third parties, (see 4. Audit by Third Parties).

The next transmission of documents between the actors is of a Quote from the Seller to the Buyer. The bespoke digital solution of the Seller sends a hash of the quote document to the SAFE Backbone, which in turn notifies the Buyer that there has been progress on the transaction. It then proceeds to generate a manifest for the Quote document, which is almost identical to the RFQ manifest except for an extra field "Dependency":

```
{
        "supplyChain" : "Demo",
        "type": "Quote",
        "shipmentId" : "1234",
                hash: "2345bcde...",
        "Dependency": "addressOfRFQ"
}
```

The SAFE Backbone then publishes the hash of the manifest to the Ethereum blockchain.

4. Audit by Third Parties

The SAFE Backbone exposes an API which allows authorized third parties to request the JSON manifests based on their hash. The bespoke digital solutions of each actor exposes an API which allows authorized third parties to request the original documents from their hash.

An example auditor of the Demo supply chain can begin their audit with an offline analysis of the Ethereum blockchain or by requesting the Ethereum addresses of the latest entries for a given supply chain from the SAFE Backbone API.

a. The auditor requests the manifests from the hash contained in the Ethereum contract. Manifests contain only public data.
b. Going backwards via the Dependency field of the manifest they can reconstruct the full sequence of events down to the initiating RFQ.
c. Using the value of the hash field of each manifest they can request the original document from the APIs of the actor bespoke systems. Anyone can request a document, but the owners are free to restrict access based on permissions.

This example uses only 2 actors in the system, the Seller and Buyer. The SAFE System is capable of managing all possible activities carried out on a supply chain by the full range of potential actors, captured in this manner. Thus providing visibility and awareness of information in any supply chain across all actors in a permissioned manner.

5. Inherent Features of the SAFE Backbone System

a) Flexibility
Supply chains of arbitrary complexity and size can be represented.

b) Adaptability
The SAFE Backbone system adapts to the existing real-world supply chains and does not require any changes in existing processes.

c) Simplicity:
Only hashes of manifests are stored on Ethereum, there is no executable logic.

d) Immutability:
Ethereum is immutable which provides assurance to auditors they are getting the genuine documents.

6. Privacy & Data

The actual documents and data that participate in the supply chain transaction are never transmitted through the SAFE Backbone; only digital fingerprints ("hashes") of those documents reach the SAFE Backbone. The documents, data and any other information is only ever shared with the SAFE Backbone as a hash. Therefore all company data remains hosted entirely on the company's own infrastructure, in a location of their choice and never leaves the control of the company. The hash alone is not enough to reconstruct any part of the original document. The participants remain in full control of how the documents will be stored (i.e. cloud or on-premises) and they retain control of who can see the documents. In the example of an RFQ or

proposal changing hands, the SAFE Backbone serves only to notify the Buyer that the Seller has an RFQ waiting for them (with a specific hash). It is up to the Buyer to fetch the actual RFQ, and while the bespoke SAFE components can automate that process both sides can continue to use legacy methods, like email, if they so prefer. This structure ensures companies a higher level of sovereignty over their data that under the current paper-based processes alongside a higher level of security and permanence over that same data.

7. Conclusion

We have proposed a system to digitise data and documentation in physical supply chains. Existing capture, storage, management and sharing of data and documents in physical supply chains is inefficient and insecure. This results in a low level of stakeholder trust in supply chain data, a high level of error and fraud, and a high level of effort employed by stakeholders to mitigate risks in a paper-based, manual system. Supply chains are complex and diversified. To solve this problem set, we propose a combination of bespoke, client facing solutions, designed to fit the clients supply chain use case and utilising combinations of emerging technologies as the use case deems necessary. These client-facing digital solutions leverage the SAFE Backbone which acts as a structured and centralised coordinator of supply chain data, enabling separate client systems to interact with each other while enabling the benefits of integration with the Ethereum blockchain.

8. References

[1.1] Hashing https://en.wikipedia.org/wiki/Hash_function
[1.2] Ethereum https://ethereum.org/en/whitepaper/