Decentralized Enterprise Resource Planning (ERP): End-to-End Supply Chain Analytics on the Blockchain

Proposal by D-ERP INC.

Sundar, Ramamurthy

University of the Cumberlands

ITS 631 - Blockchain Implementation

Prof./Dr. Ying Lin

April 27, 2023

Organizational Overview

We get it, data is difficult to work with. From collecting it, to storing it, to reporting on it, to analyzing it in business intelligence applications, to creating predictive models. People say data is the new oil, but it's such a shame that end-to-end analytics (from data collection to predictive modeling) is so expensive to accomplish. From the days of expensive, silo-ed, on-prem analytics solutions like OracleDB to the more trendy approaches like Azure or AWS cloud solutions in the mid 2010s, a major problem remains - why is it so darn hard for apps to communicate data with one another? Getting a team of migration specialists or data engineers is no cheap task and many times even talented developers are unable to extract much meaning from the awful SaaS products that flood the IT market. It's time to change things up. The client-server model has had its time and the benefits of the peer-to-peer server model through blockchain technology is too hard to pass up.

The ability to both process transactions from end-users (i.e. collect user data) as well as analyze them for business intelligence purposes in one virtual environment is usually no easy task. Traditionally, apps that involve end-users to perform a great amount of CRUD operations (CREATE, READ, UPDATE, DELETE) would involve some kind of OLTP (online transaction processing) schema design. These highly normalized database designs are good for two reasons. Firstly, they reduce redundancies in data by reducing the size of larger datasets, since repeated data is stored in a separate table and joined to another table through a modality and cardinality mapping. Secondly, normalization can provide a security redundancy, wherein a hacker has to obtain an additional key in order to join, for example, the personal information table containing

SSN and names to the rest of the operational data. The problem, though, is that these systems are usually not easy to write analytics queries, or SELECT statements, from. Junction tables can be a mess to trace, so analytics queries have usually been done from OLAP schema models stored in entirely different apps. These OLAP models usually consolidate multiple data models from a few systems, including OLTP databases.

This is where blockchain and our company, Decentralized ERP Inc. (D-ERP Inc.), come in. Our vision is to leverage blockchain technology to expose database architectures like entity relationship diagrams for transparency, auditability, and contextualization. Gone are the days where people would haphazardly create a database within the org and fail to document their design. In many use-cases, like supply chain management, databases really do not need to be so different from one another. Most companies in the supply chain space face similar problems and challenges, so why can't more people share server architectures, data, and software logic? With blockchain technology, this efficient sharing might actually be possible and secure. We all trade with one another in this world, whether as a dispatcher, farmer, retail employee, or customer in a retail store. It's time for us all to transact as one!

Blockchain Environment Overview

The technology our company is using as our backbone is the Hyperledger fabric. There are a number of reasons our company is going for a private/consortium blockchain as opposed to a public blockchain like Ethereum. Firstly, the commitment to various technology characteristics like high transaction speeds and transaction costs is very important for an optimal user experience. Permissionless blockchains do not provide this kind of speed and energy savings. Also, including regulators into the equation is a must. Regulators usually want KYC (know your

customer) policies in place, so major transacting parties will require identification in order to transact in the digital trade economy.

To make up for the shortcoming of a single point of failure our company will promise to work towards being as transparent as possible when it comes to our level of security and operations. Cybersecurity and encryption of personal information is of utmost importance to us. Also, the whole point of blockchain technology is for integrity in the system. Our company believes in consensus technology and that one day it can be efficient enough to work well, but for now it is just not economical. Our app development methodology is described below.

Project Overview

The application we are developing within the Hyperledger Fabric is essentially an enterprise resource planning dApp. Apps like Oracle and Microsoft Dynamics NAV are popular ERP systems, but they can leave a little to be desired. Regardless of whether you go on-prem or in the cloud, the hardware these servers run on are simply not meant to be interoperable. Data exchange between businesses (B2B) is difficult to make secure with existing methodologies, but smart contracts and blockchain data storage is capable of changing all of that. If an ERP system were to be developed within a decentralized server environment, the ability for multiple businesses to perform the same operational transactions and analytic queries on the same server could lead to a new world for supply chain management.

Project Charter

The frictions caused by information asymmetry in the supply chain management world are sometimes insurmountable. It's highly risky to move large quantities of items from one place to another, given how many businesses and people need to interact with the item in question.

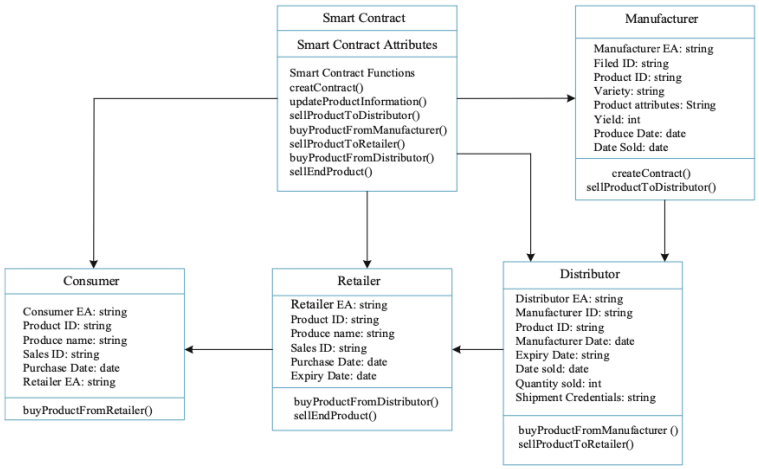
Instead of forcing individual companies to manage their own data and act as silo-ed parties, it would make more sense for all parties to transact on the same database and work together in a federated and controlled manner. Instead of having an engineer try to combine all of the data from these parties after the fact, it would make more sense to try and capture the flow of data within the original server to begin with.

The objective of this project is to build an ERP system that would enable peer-to-peer or business-to-business data exchange in such a way that both the reportability and analysis are enhanced.

Our team is currently a little small for our liking and does not have the time or resources to flesh out the underlying blockchain network. We would like for a robust and powerful consensus mechanism to ensure integrity for network members as well as hold D-ERP more accountable.

Stakeholders in our project are many of the typical transacting entities in a supply chain. An entity relationship diagram is shown below:

Image 1: Stakeholders in blockchain economy joined via the smart contract.



Note: From Huang, H., Zhou, X., & Liu, J. (2019). Food supply chain traceability scheme based on Blockchain and EPC Technology. *Smart Blockchain*, 32–42.https://doi.org/10.1007/978-3-030-34083-4_4

The stakeholders are consumers, manufacturers, retailers, and distributors, in our multi-stakeholder governance model.

While ERP systems have been built before, venturing to build these systems as a blockchain app could prove to be challenging. ERP systems are known for their customizability and since supply chain is a fairly vast industry, it could be tough to make a single supply chain dApp that solves problems for all companies. This is why our org is limiting our scope to a subset, which includes food (re)distribution for now.

Moving onto risks, since we are currently working on a permissioned chain, scalability will not be an issue. Incorporating a robust consensus mechanism is definitely due sometime in the near future, but for now we are working with a mostly centralized validation protocol. In order to mitigate risks of single point of failure, however, we would like to enroll some more business entities to take on the responsibility of ordering nodes and validating transactions for a greater stake of equity. As for compliance, we are already working with the USDA as a regulatory body. Since D-ERP Inc. takes multistakeholder governance seriously, we have been including the USDA in our conversations since day one for privileged audit access.

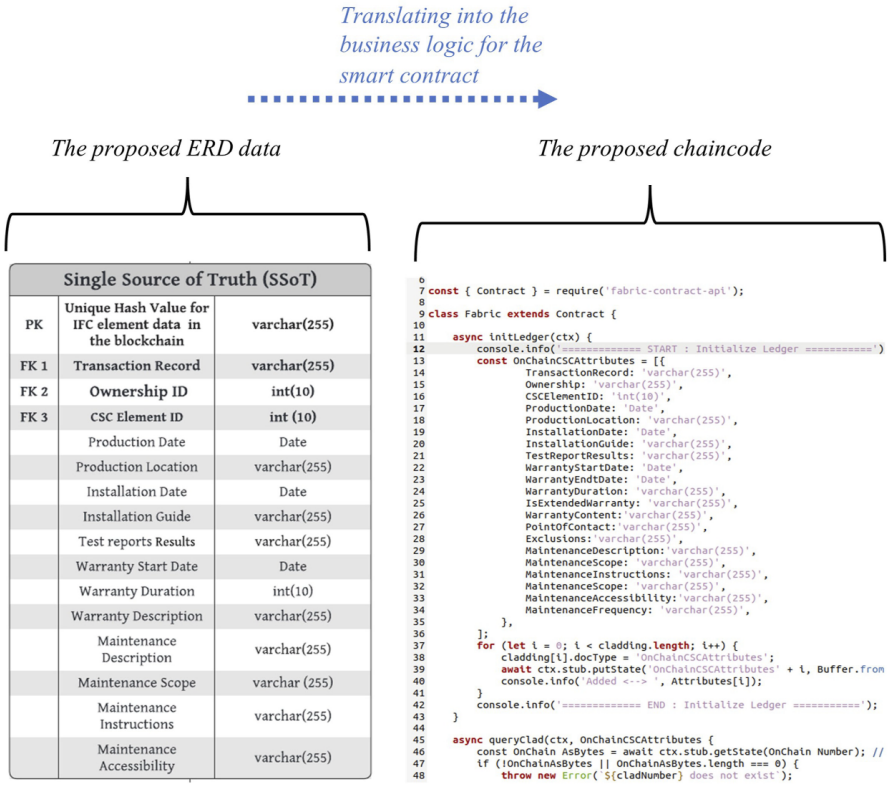
We hope that this app will help decrease the loss of funds many supply chain companies face due to information asymmetry and a lack of tactical data for decision making. We expect stakeholders to do quite a bit off-chain, so while we are able to keep costs down for using our software, at just 5% of your company's total profit, there are certain expectations and

requirements on the individual level to be able to transact in this private economy. Off-chain collateral is a must!

Deliverables

D-ERP Inc. is working primarily with the Golang programming language when it comes to smart contract development. While we are designing many taxonomies and entity relationship diagrams, since our goal is to encode these models into the smart contracts, our deliverables will mostly include Go scripts like the following:

Image 2: Representation of entity relationship diagram as chaincode



Single Source of Truth (SSoT)		
PK	Unique Hash Value for IFC element data in the blockchain	varchar(255)
FK 1	Transaction Record	varchar(255)
FK 2	Ownership ID	int(10)
FK 3	CSC Element ID	int (10)
	Production Date	Date
	Production Location	varchar(255)
	Installation Date	Date
	Installation Guide	varchar(255)
	Test reports Results	varchar(255)
	Warranty Start Date	Date
	Warranty Duration	int(10)
	Warranty Description	varchar(255)
	Maintenance Description	varchar(255)
	Maintenance Scope	varchar (255)
	Maintenance Instructions	varchar(255)
	Maintenance Accessibility	varchar(255)

```
const { Contract } = require('fabric-contract-api');

class Fabric extends Contract {

    async initLedger(ctx) {
        console.info('============= START : Initialize Ledger ===========')
        const OnChainCSCAttributes = [{
                TransactionRecord: 'varchar(255)',
                Ownership: 'varchar(255)',
                CSCElementID: 'int(10)',
                ProductionDate: 'Date',
                ProductionLocation: 'varchar(255)',
                InstallationDate: 'Date',
                InstallationGuide: 'varchar(255)',
                TestReportResults: 'varchar(255)',
                WarrantyStartDate: 'Date',
                WarrantyEndtDate: 'Date',
                WarrantyDuration: 'varchar(255)',
                IsExtendedWarranty: 'varchar(255)',
                WarrantyContent:'varchar(255)',
                PointOfContact:'varchar(255)',
                Exclusions:'varchar(255)',
                MaintenanceDescription:'varchar(255)',
                MaintenanceScope: 'varchar(255)',
                MaintenanceInstructions: 'varchar(255)',
                MaintenanceScope: 'varchar(255)',
                MaintenanceAccessibility:'varchar(255)',
                MaintenanceFrequency: 'varchar(255)',
            },
        ];
        for (let i = 0; i < cladding.length; i++) {
            cladding[i].docType = 'OnChainCSCAttributes';
            await ctx.stub.putState('OnChainCSCAttributes' + i, Buffer.from
            console.info('Added <--> ', Attributes[i]);
        }
        console.info('============= END : Initialize Ledger ==========');
    }

    async queryClad(ctx, OnChainCSCAttributes {
        const OnChain AsBytes = await ctx.stub.getState(OnChain Number); //
        if (!OnChainAsBytes || OnChainAsBytes.length === 0) {
            throw new Error(`${cladNumber} does not exist`);
```

Note: From Hijazi A.A., Perera, S., Calheiros, R.N., & Alashwal A. (2022). A data model for integrating BIM and blockchain to enable a single source of truth for the construction supply chain data delivery. *Emerald Publishing Limited.*

Critical Success Factors

A common data model is of no use if it cannot be used for good reporting or ethical AI. We hope that the stakeholders involved, or even new analysts, can take the data models present in our dApp environment and leverage them to create powerful AI visualizations within business intelligence visualization software. If the data models do not contain useful data or are difficult to create visualizations with, then the project can be considered a failure.

Work Breakdown Structure

The work for an ERP system such as ours is no joke. Our team takes version control seriously, and there are working CI/CD pipelines in place to allow our team of developers to work around the clock to improve our product. Version control with Git is also in place to make sure updates are hassle-free and rollbacks or hardforks can be easily performed. Not only are OLTP transaction databases represented within the environment as Golang code, but ETL scripts in Golang that transform the OLTP databases into a more easily querry-able OLAP database (STAR schema) will also be present. All software will be packaged and deployed as a Docker container. Finally, the basic consensus mechanism is Proof of Elapsed Time for now.

Quality Plan

Right now, the quality of the product is based on how good the taxonomy is for both the transaction processing and analytics processing schemas. In this kind of product, standards, practices, and specifications must be paid particular attention to. Proper documentation is of course necessary, but discovering the right taxonomy is never an easy task. It could take working with domain experts across various fields in order to design a data model that serves well for custom measure or index creation.

As stated previously, a good data model is one that allows for easy and powerful reporting, but what really makes a report is the semantic layer of the report. If custom measures, like a food insecurity index or other socio-economic measure, were to take off, major problems around the world could be solved in a heartbeat. It is important for a good data model to enable a rich set of measures to be described in the semantic layer for global economic analysis.

Operationalization Plan

Once the product is handed off to customers, it will be important to get feedback from said customers. Changes to schemas and taxonomies will likely be a regular occurrence, but as outlined in the previous sections, we have systems in place for smooth updates and rollbacks. We will be working on rolling out a robust voting system so that members of the consortium can give valuable feedback to everyone in the network. Being able to combine information resources to create a better trade economy requires constant communication and improvement, but I imagine the kinds of trade problems that could potentially be solved as a result of collaboration and empowerment at scale would be worth the risks and challenges.

References

Hijazi A.A., Perera, S., Calheiros, R.N., & Alashwal A. (2022). A data model for integrating BIM and blockchain to enable a single source of truth for the construction supply chain data delivery. *Emerald Publishing Limited.* *https://www.emerald.com/insight/content/doi/10.1108/ECAM-03-2022-0209/full/html*

Huang, H., Zhou, X., & Liu, J. (2019). Food supply chain traceability scheme based on Blockchain and EPC Technology. *Smart Blockchain*, 32–42. https://doi.org/10.1007/978-3-030-34083-4_4