Project Proposal for Analysing Blockchain Implementation in Agriculture

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***Abstract*— In recent years, many case studies and implementations have been done by Walmart-IBM, Skuchain, Oregon, LDC, etc., on implementing blockchain for agriculture mainly in the domains of food traceability and supply chain management using Hyperledger fabric, Popcodes, Sawtooth, Ethereum, Quorum[21,22] to create Agri-Based Decentralized systems. In this project proposal, we have analyzed various white papers and practical implementations in different organizations, the technologies, and protocols they use and investigated on the challenges and limitations of these implementations. In this project, we aim to extend blockchain architecture to make product details accessible to consumers, which many of the current papers/organizations haven't taken into consideration and the challenges involved in the same. We have also specified the road map and goals for the project[25].**

Keywords—agriculture, Blockchain, project, proposal, roadmap, challenges, limitations, food, traceability, P2P, supply chain management, consumers, Hyperledger fabric, Sawtooth

I. Introduction

In July 2017, papayas in the US market were linked to a multi-state outbreak of Salmonella. It took almost three weeks to track the origin back to a single farm in Mexico. With introducing blockchain to agriculture, this time can be reduced to as far as 7.7sec[2]. This has been one of the main reasons for many companies like Walmart-IBM[6], Skuchain, Maersk, LDC, Cargill, Bungee, Provenance etc., on implementing blockchain for agriculture mainly in the domains of food traceability and supply chain management. Their main focus has been to aid the industries and organizations involved in the food industry. Our focus for this project deals with bringing this technology to the consumer, designing an architecture and identifying various challenges and limitations involved in this process.

II. Motivation for the project

Food fraud is estimated to cost the global food industry $40 billion a year. In 2011, China witnessed a massive pork mislabeling debacle, along with a contamination hoax in which donkey meat products were recalled because they were found to include fox meat (Bradsher, 2011; Clemons,2014)[2,7]. All the agri-food industries that are implementing blockchain are using it as an efficient solution for their business problems and management and is visible and accessible to a closed network[3]. This network includes farmers, distributors, processors and others involved in the production till the retailers.

With increasing trust issues in customers and scale of fraud involved. It is important to provide product details to consumers through trusted infrastructure. Motivation of our project is to make every detail of the product visible to consumers. For this, we are using data of products stored in blockchain and presenting them through an interface to customers for transparency.

III. Related work

In blockchain implementation, Information related to a product is obtained by incorporating IoT devices in each stage of farming, distribution, processing, marketing and retailing[4,8]. Even the quality of the product can be tracked using soil and water level sensors in the farming stage and storage conditions in warehouse can also be tracked through temperature sensors. Location based sensors like GPS are used in real time implementation for updating smart contracts of the blocks[12]. All these details are transferred through gateway software and smart contracts to blocks and consensus algorithms used in various blockchain models discussed below are different[24]. Business logic for updating the status and other event based triggers can be programmed in application level and induced to smart contracts. Like updating data when a product reaches the distributor from farmer. Once data is stored in block it is immutable and untamperable and accessibility to it depends on the permissions of the blockchain model. Above discussed model is used in companies like Walmart, Oregon etc.,[20]

IV. Case Studies

1. HyperLedger Fabric

Walmart, Nestle, and Golden state foods have used HyperLedger Fabric to develop blockchain applications for Agri based supply management[1,14]. HyperLedger Fabric is a modular extensible open-source system for deploying and operating permissioned blockchains. The most attractive feature of HyperLedger fabric which makes it the most selected platform for building Agri based is due to its openness towards the choice of programming language. It allows the creation of Distributed Ledger systems using general programming languages such as Go, Java, and NodeJs. HyperLedger also allows integration to industry-standard identity management systems for the creation of distributed applications.

Walmart, Nestle and Golden state use blockchain for internal tracking of their food products and for detecting fraud at any point. HyperLedger being a permissioned blockchain allows this[14,15,17,18]. The food suppliers, processors and retailers make up for the entities on the blockchain. No outside entity is allowed to access the blockchain network. Having a permissioned blockchain helps secure the blockchain network from attacks and also hides business trade from the public.

HyperLedger believes that there is no one-size-fits-all solution to BFT[9]. Hence, it provides flexibility in the consensus model and trust model. HyperLedger uses an Execute-Order-Validate Model which is different from other blockchain platforms that have order-execute architecture.

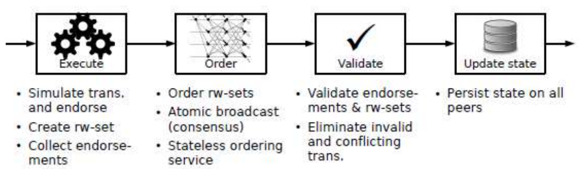


Fig - 1.a

a. HyperLedger Fabric Architecture:

Fabric Architecture uses the Execute-Order-Validate Model. The transaction made by any supplier is executed by a subset of the trusted node, which can even handle non-deterministic cases. The trusted nodes endorse the transaction by simulating it. After getting endorsements from the trusted peers the node is broadcasted to all the nodes by Ordering Service. Each node validates the endorsements and adds the node to their local ledger.

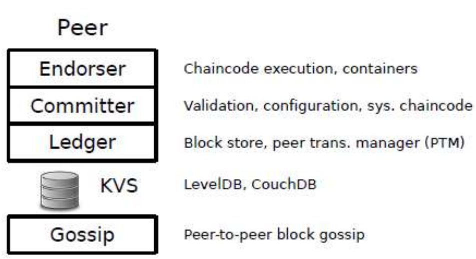


Fig - 1.b

b. HyperLedger Fabric Node Components:

Each peer/node has the following Component - Endorser, Committer, Ledger, KVS and Gossip Protocol (fig-1.b). The Endorser defines the execution policy for the transaction. The Committer component defines the protocol for validation of the transaction. Ledger is the local blockchain of the node. KVS is a database that gives a snapshot of the transaction in a key-value structure.

2. HyperLedger Sawtooth:

Intel and Oregon State University collaborated on a food traceability project for blueberries of Oregon brand using HyperLedger sawtooth. Their main focus was to collect data regarding the temperatures of berries as they are very sensitive to heat and it affects their quality and to eliminate manual tracking of farming practices and supply chain conditions. To enable pallet-level control and monitoring of goods for inspection of shipped goods[1].

a. HyperLedger Sawtooth architecture:

This is an enterprise blockchain platform that supports hyperledger applications. Business logic that consists of conditions for data creation, modification. Transaction processing can be specified in the application layer using Python, JavaScript, Go, C++, Java or Rust. This dynamic environment allows us to customize transaction rules, consensus algorithms and permissions[5].

Multiple application types are allowed in the same instance and design of smart contract, business logic is done in transaction processing layer. We can use either permissioned or permissionless blockchain.

Parallel transaction execution is a valued feature of sawtooth. It isolates the execution of transactions from one another while maintaining contextual changes. As parallel scheduling provides a substantial potential increase in performance over serial execution. It allows applications to subscribe to specific events defined in the smart contract and transaction processes.

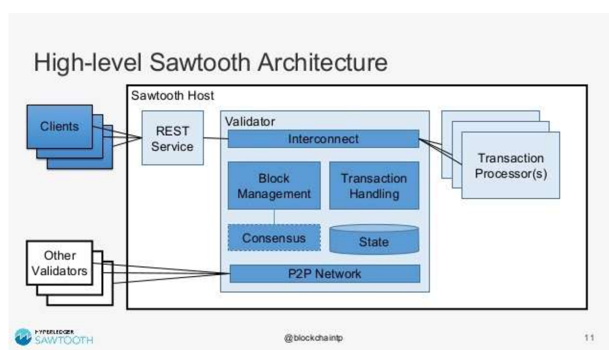
The consensus algorithm used in this model is PoET(Proof of Elapsed Time)[10,11]. PoET is a modification of PoW (Proof of Work) that allows scalability as it works on secure instruction execution and cuts down the power consumption compared to PoW.

It also interoperates with Ethereum through an integration project. which enables smart contracts in Ethereum virtual machines to be deployed in sawtooth.

Live tracking of products using GPS sensors was implemented by intel with Intel connected logistics platform[19]. Companies like Curry & Co. have decent supply chain monitoring and in such cases they require a model that does not interfere with existing workflow and so sawtooth is opt choice as they are pluggable frameworks that do not interfere with the present flow.

The key difference between Fabric and Sawtooth is that fabric uses only permissioned network while sawtooth can use either of it as per requirement.

Fig - 2.a



V. ROAD MAP & MILESTONES FOR THE PROJECT

1) *Detailed study of blockchain architectures:*

First step in the roadmap is to study and analyse the different type of architectures that can be used for blockchain in agriculture like Hyperledger Fabric, Ethereum, Sawtooth, Quorum, Hypergrid, etc.,

2) *Analysis of case studies & real-time implementations:*

Different approaches have been taken forward by different organizations like Walmart-IBM, Skuchain, Oregon, Covantis, LDC, Nestle, Bungee, etc., in food traceability and supply chain management. An in-depth analysis of these different implementations, architectures and protocols that are being used have to be done. We have identified that all these are beneficial towards the entities involved in selling and identified that our focus will be towards the consumer.

3) *Projection of system architecture*

As mentioned in (b), the main focus is proposing an architecture that makes the consumers trace the product in the food chain. This is the aspect where there was no proper if at all research done. We plan to base our project in this area as most of the proposed ideas deal with a private blockchain network whereas with consumer introduction, it might become a public or a privileged open private blockchain network.

4) *Outline of challenges and limitations*

Coming up with challenges faced in the system architecture proposed and the study of limitations involved in the proposed design.

5) *In-depth component, architecture and protocol design*

Studying further on the components involved in the architecture, and doing an in-depth analysis on the system design at the consumer end and proposing a concrete application design

6) *Identifying the vulnerabilities in the proposed architecture*

Checking for security vulnerabilities, endpoint vulnerabilities. Feasibility study of the proposed implementation of the architecture in real time.

7) *Ideas to curb the vulnerabilities*

coming up with ideas to overcome the challenges faced in the design proposal.

8) *Final report*

Composing the final report and submission.

VI. MILESTONES

Milestone 1: PROJECT PROPOSAL

i. Detailed study on existing works and coming up with challenges and limitations in the existing approaches
Roadmap sections: a, b, d

ii. **System Architecture Overview**
Coming up with the system architecture overview with involving the consumer. This is discussed more in detail in section VI of this paper.
Roadmap section: c

iii. **Milestone 3: MID-TERM**
In-depth component, architecture and protocol end-to-end design of the application
Roadmap section: e

iv. **Milestone 4: FINAL**
Identifying vulnerabilities, ideas to curb them, feasibility of the proposed design in real time and composing a final report on the entire findings that were done.
Roadmap section: f, g, h

VII. SYSTEM ARCHITECTURE

At this stage we are analyzing the technologies available at each step of architecture to utilize and the best suited features to the model. Outline of the model consists of IoT devices that act as source of the data (details of product) at one end. They communicate to a blockchain system that has customized transaction processing as per the requirements of the application and here the data values from sensors are written into the ledger and this is done for each stage of supply chain[23].

Record stored in ledger comprises information like category code of product, identification number, manufacturers, soil quality, fertilizer info, temperatures and other environmental parameters as required and timestamp of updated supply chain status.

Snapshot of data collected is processed to an user interface and allows customers to lookup their product of interest using the identification number or QR code associated with the product from the beginning stage of supply chain.

For the Hyperledger model we are comparing HyperLedger Fabric, Sawtooth and Ethereum (Quorum)[13],[16],[21] to choose and for web interface we are looking into the programming languages and interfaces that is most compatible with core level and application level logic of blockchain model that is to be chosen. Concrete approach on processing data from blockchain is under analysis at this stage.

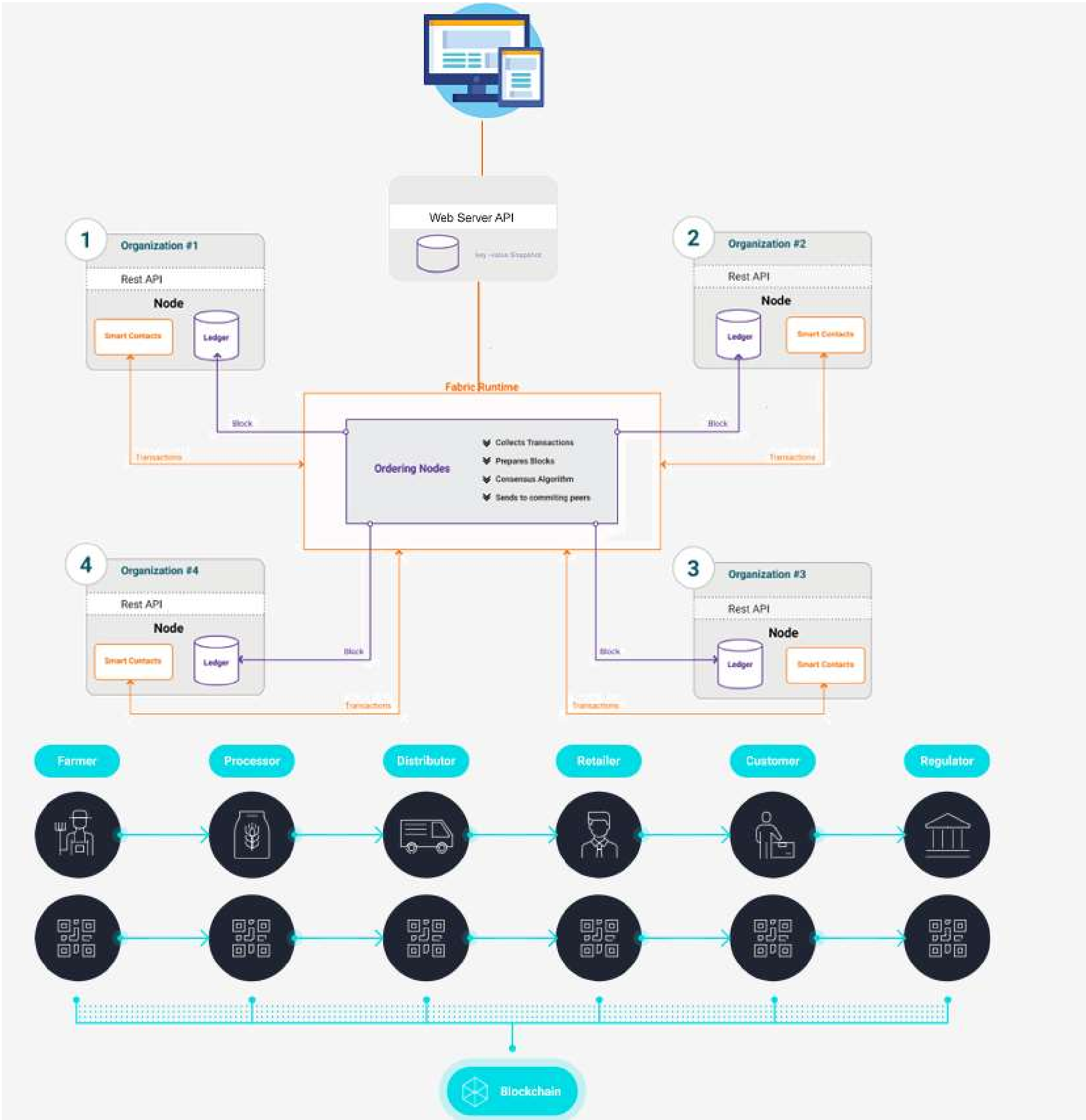


FIG. 7.A SYSTEM ARCHITECTURE OVERVIEW

VIII. CHALLENGES & LIMITATIONS

1. *List of issues to be addressed:*

a) Since we are adding an entity for consumer accessibility, it should be taken care that this inclusion does not conflict with the decentralizing property of the blockchain.

b) Allowing customers to view the snapshot of the blockchain without affecting the security of the network.

c) Implement a mechanism so that there is a secure channel from blockchain to the front end/customer view.

d) Selecting a mechanism that also takes into consideration the business needs of companies like Walmarts, Nestle and Covanta.

e) All the blockchain platforms like hyperLedger fabric, sawtooth, quorum are at the initial stage, so it is difficult to find enough real-time data that is being used. The usage data of companies like Walmart are also not publicly available.

2. *Outline of the approaches for the limitations:*

Approaches listed in the order of challenges

a) Avoiding centralized database usage in the process of querying and displaying data.

b) Customized abstraction levels of ledger data as required before processing it to customer view API.

c) Strict protocol permissions to avoid any network attacks for protecting the data once it is taken from blockchain.

d) This can be achieved by giving the outline information that is required for the user to get the high level idea in normal terms. Whereas, when it is for investigation purposes all the details can be queried from blockchain.

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