Blockchain in Agriculture

Royse Law Firm, PC

Contents

I. Intro: Blockchain, Cryptocurrencies, and Smart Contracts

A. What is Blockchain?
B. Distributed/Decentralized ledger: Permanent and Immutable, Secure, Anonymous, Low cost
C. Cryptocurrencies: Blocks of data, Miners, the Double Spend Problem, the Last Mile Problem
D. Smart Contracts

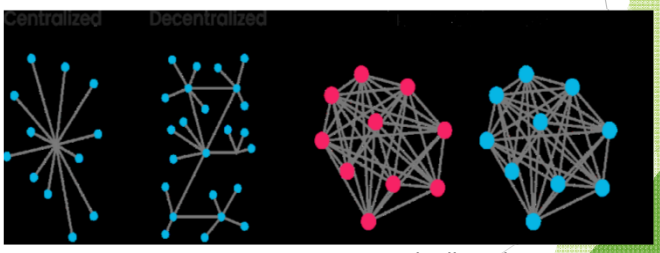
What is Blockchain?

- Blockchain is a technology that allows users to transfer value or assets between each other without the need for a trusted intermediary
  - Analogous to triple entry accounting
  - Reduced cost of verification by eliminating the trusted intermediary
  - Reduced cost of networking by being accessible peer to peer

Distributed or Decentralized ledger: permanent, immutable, secure

- Blockchain creates a permanent, immutable history of events that is replicated and stored on each participating node
  - Immutable: hard to change the history, since there is no central authority or control for the network
- Shared, distributed ledgers
  - Pseudonymous
  - Transparent view for users
- Secure
  - Very difficult to hack

Source: Everys



Source: an image from Everys website where they describe different types of ledgers

Peer to Peer

Centralized servers – information flowed from server to client

P2P networks- each participant (peer or "node") can send and receive information

Nodes are both suppliers and consumers of information

Consensus verification

Consensus Algorithms

- Verified by miners: Proof of work vs. Proof of State

Proof of work

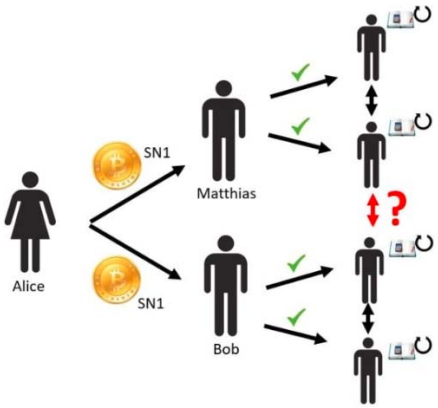
- The most utilized consensus algorithm for a blockchain
- Every computer (node) competes to solve a mathematical puzzle
- Winning node earns the right to write the next block and receives an incentive for that work
- Energy and cost: requires a large amount of computing power

Proof of Stake

- An alternative consensus algorithm for a blockchain yield
- Instead of mathematical contest, miners put up a stake in return for the right to validate the network
- Stake as a non-revocable security deposit against fraud or innacuracy

ROYSE LAW

The Double Spend Problem



Source: an image from Steemit website where they describe the double spend problem

The double spend problem: Preventing someone making a purchase with digital cash from reusing the same token to purchase again

The Last Mile Problem

- The last mile problem is the disconnect between online and offline activities
  - The last mile is a phrase widely used in the telecommunication industry to refer to the final leg of the networks that deliver services to retail end-users
  - Typically the speed bottleneck in networks: its bandwidth limits the bandwidth of data that can be delivered to the customer
  - The most expensive part of the system and the most difficult to upgrade to new technology
- Solving the last mile problem means connecting offline events to a digital recording of those events during the verification of a transaction

Source: Wikipedia website describing the last mile problem

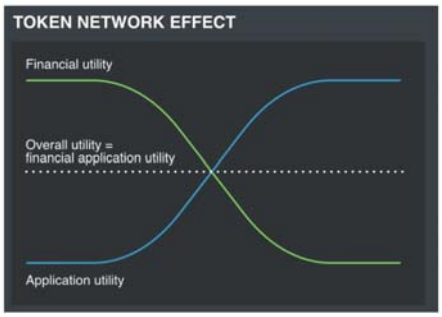
Smart Contract

- Smart Contract/Ethereum allows the users to codify significant parts of a workflow process, agreement, or task
- In smart contract, when a transaction occurs, the software automatically executes an action according to the specification

Source: a chart from Sathguru website where they describe supply chains in agriculture

Network Effects and Cryptoeconomics

- Applications combine cryptography with economic incentives.
- Different participants such as users, resource providers, and application developers may help fund, design, develop, facilitate the operations, and encourage the adoption of digital assets.
- Early adopters can be incentivized to use the platforms



Source: a chart from Medium website where they describe how token network provides financial utility, in the form of tokens, to early users when there is no application utility that usually arises from scale-up

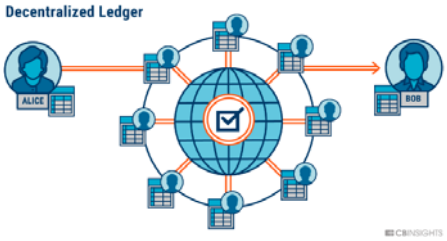
Tokenization

- Is there a business problem that can be solved with blockchain
  - For example, tokens may evidence ownership or transact settlements
- How are tokens used and transferred in the marketplace
- Regulation: securities laws, currency laws, commodity, FTC, etc.

Source: a chart from McKinsey where they describe impact of blockchain by industry

II. Technology Basics: Bob and Alice Example

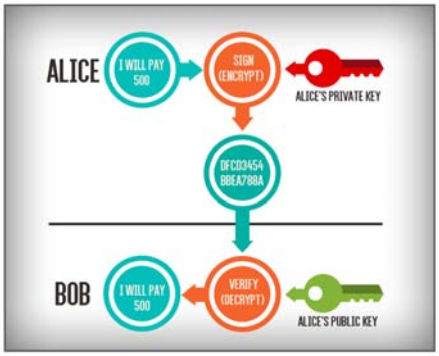
- Example: Alice transfers a digital coin to Bob.
  - A. A shared public ledger keeps a complete record of which coins belong to which persons.
  - B. The transaction between Alice and Bob is recorded on the public ledger
    - a. Alice has a public key that is associated with the transfer
    - b. Transaction is "signed" by Alice with her private key



Source: a chart from CB Insight website where they describe decentralized ledger

Public-private key cryptography

- Public-private (or paired) key cryptography, also known as asymmetric cryptography, refers to a cryptographic algorithm which requires two separate keys
  - Public key: encrypt plaintext or to verify a digital signature
  - Private/secret key: decrypt ciphertext or to create a digital signature
- Two parts of key pair are mathematically linked



Source: a chart from Aaxix Commerce website where they describe public-key cryptography

The network verifies the transaction

Proof of work makes it costly to verify and rewards verification

(1) Verifier must solve a mathematical puzzle

(2) In bitcoin, miners validate by solving math puzzles

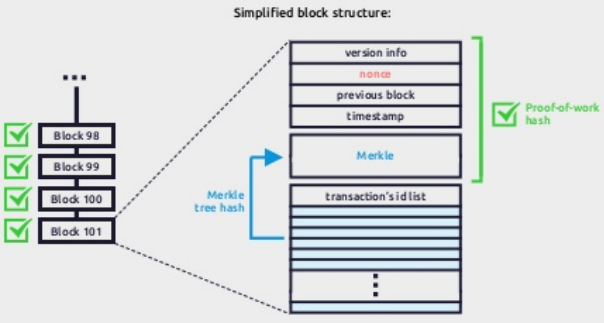
(3) Nonces: arbitrary numbers that can be used once

Proof of stake penalizes false answers

Delegated proof of stake

Block chain

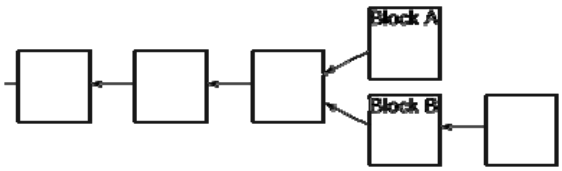
What does a block look like?



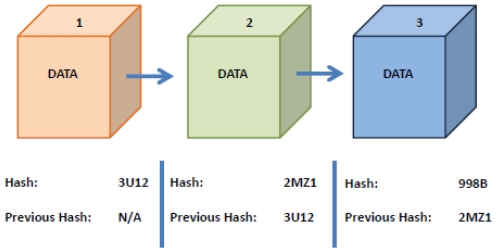
Header - Contains service information (version info, nonce, previous block id ,and timestamp).
Merkle - A summary built from the block's transaction identifiers.
Transaction's id list - list of transaction's identification hashes, that was included into the block's merkle tree

- The Mem Pool
- Bundling into blocks
- Block is hashed
- Blocks contain
  - Hash of the last block
  - Timestamp
  - New hash
  - Merkle tree

D. If two miners validate a block of transactions at the same time. Miners only work on the longer fork



E. Transactions are identified by an automatic "hash" that is assigned by an algorithm

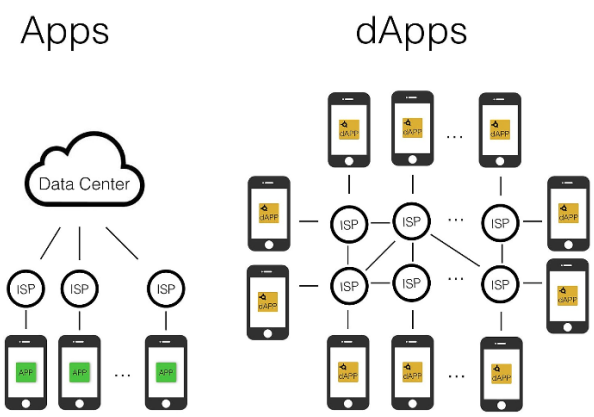


Source: an image from MIT Sloan School of Business where they describe block construction in blockchain

Ethereum

- Free and open source, peer to peer
- Native digital currency is Ether
  - Uses Proof of Work
- Richer functionality
- Solidity, a Turing complete programming language
  - Allows anyone to write a smart contract and deploy a DApp
- Faster (12 seconds vs 10 minutes)
- Can run smart contracts
- Can support Dapps
- Likecode for a website on a server, or NFC instead of QR

Dapps



Source: Coinweez website where they describe decentralized applications

Smart Contracts

- Smart Contract/Ethereum allows the users to codify significant parts of a workflow process, agreement, or task
- In smart contract, when a transaction occurs, the software automatically executes an action according to the specification

Ethereum – 2 accounts

- Externally owned account
  - Public private keys
  - Can send Ether
- Contract Account
  - Public address, no private key
  - Stores data and runs smart contracts
  - Collects Ether
- Ethereum, Virtual Machine (EVM)
  - Runs smart contracts
  - Charge a fee (“gas”) for each computational step

Permissioned and Permissionless networks

Permissioned	**Permissionless**
Faster	Slower
Managed upkeep	Public Ownership
Private Membership	Open & Transparent
Trusted	Trust-free
Legal	Allegal

23

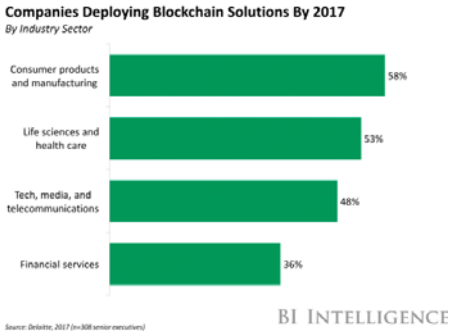
Source: Blockchainhub website where they describe blockchain & distributed ledger technologies

III. Problems in Agriculture

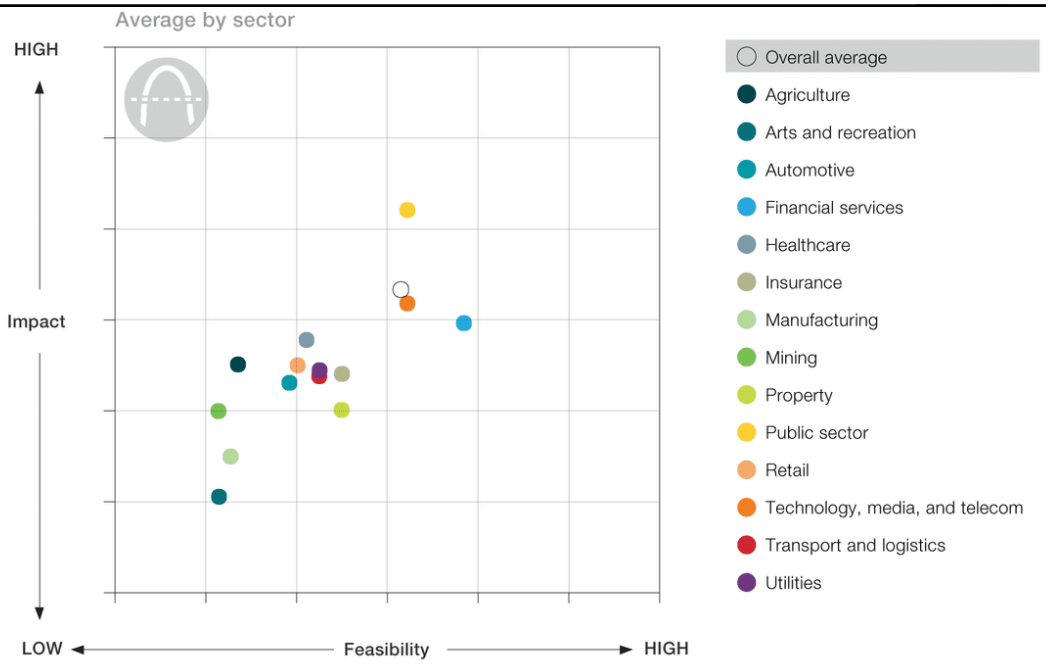
A. Why agriculture?
B. Problems in the agricultural supply chain
   a. Disconnect between supplier and retailer
   b. Limited financing resources
   c. Lack of transparency in food production and distribution
   d. Costly middlemen
C. Blockchain can provide a solution

Why agriculture?

- With 40% of the global workforce, agriculture is one of the leading job providers worldwide
- Huge, important, industrialized, but very complex industry
- Heavily regulated, highly subsidized and complicated
- Many blockchain agricultural solutions are emerging – maybe the last frontier



Source: a chart from BI Intelligence where they elaborate companies deploying blockchain solutions by 2017



Source: a chart from McKinsey where they describe impact of blockchain by industry

Problems in Agricultural Supply Chain

- A disconnect between supplier and retailer
- Lack of transparency in product origin
- Limited financing sources for farmers in industrialized and developing countries
- Costly middlemen

Blockchain technologies can provide solutions

- Greater need for supply chain transparency and data integration: Many potential distributed ledger agricultural solutions are emerging
- Commercially reasonable: Public is increasingly embracing the need for transparency in food products and farming techniques
- Retailers want high quality agricultural products as well as sustainable product, authenticity and informed product process

IV. How can Blockchain solve the problems?

1. Improve transparency in the supply chain
2. Traceability for consumers
3. Expand financial options for farmers
4. Provide immediate payment on delivery
5. Provide farmers with direct access to suppliers and transparent transaction information

1. Improve transparency in the supply chain

- Consumers demand for "clean" food including organic
- Current verification/labeling system is complex, costly, and easy to manipulate
- Consumers are willing to pay for the information: augmenting trust and visibility into the flow of goods

Source: an image from Provenance website where they describe blockchain technology in food tracing

Tracing food from source to table

- Blockchain can provide certification and regulations for clean food
- Open and shared ledger system will trace product origin with immutable provenance data from farm to table
- Retails can verify easily that the product they are receiving is exactly what they paid for

Source: a chart from Sathguru website where they describe blockchain technology in agricultural supply chain

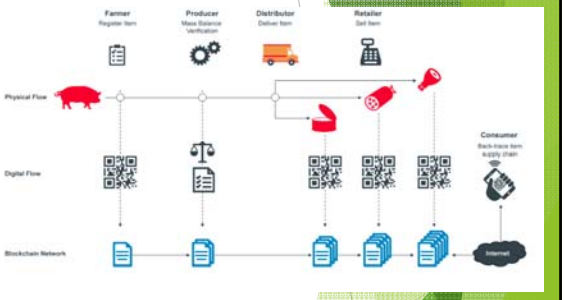
Walmart / IBM Food Tracing: Pork Example

Step 1: Information such as farm origination, batch numbers, factory and processing data, expiration dates, storage temperatures, and shipping details are digitally linked to the physical food items

Step 2: The information captured during each transaction is validated by businesses within the network forming a consensus.

- After each 'block' is validated it is added to a 'chain' of transactions, becoming a permanent record of the entire process.

Step 3: Each pork item received at store is verified as authentic, and its digital record could potentially reveal food safety issues picked up between farm and store.



Source: a chart from Resolve Solution Partners website where they describe blockchain technology in pork tracing

Food Tracing Projects

Source: an image from cointelegraph article where they describe an ethereum based food blockchain issues starting demo testing phase

- **Cointelegraph:** records Italian wine on the Blockchain to guarantee quality and geographical origin
- **Foodblockchain.xyz**: a new tool that aims at providing a realizable and comprehensive overview of food quality and origin
  - Example: Allow a company producing yogurt to create a risk free agreement with suppliers of milk
  - The agreement sources milk from multiple farmers and the company can decide to order the milk from one who passes quality requirements

2. Expand financial options for farmers

- Farmers, particularly in developing economies, have limited access to financial resources
  - Lending institutions perceive agricultural industry as risky and are hesitant to provide funding
  - Farmers cannot prove their ability to repay debt
- Blockchain technology provides farmers with the ability to show what they have harvested
  - Farmers can use the verification for funding or purchasing crop insurance
- Provides quicker access to funding resources and make farmers financially inclusive
  - Farmers can become financially inclusive in developing worlds

3. Immediate payment on delivery

- Farmers often must wait weeks or months to be paid after delivering harvest
- Blockchain technology enable real-time payment on delivery and improve settlement process for farmers
  - Farmers get paid immediately without delay
  - Adding transparency, trust, and inefficiency to settlement can decrease risk and unlock new financing mechanisms for banks

5. Enhance farmers purchasing power in agricultural transaction

- Farmers lack ability to conduct due diligence on their buyers and plan harvest sales considering market condition
- Blockchain provides farmers with access to information on current transactions, stock price of goods, and buyers information

Source: an image from businesslive.co.za website where they describe how blockchain technology may transform the lives of African farmers

Farmers have direct access to suppliers and market information

- Farmers are able to determine what their harvest is currently worth and sell at a price that reflects global market conditions
- Information sharing will increase industrial competition, and price will become higher

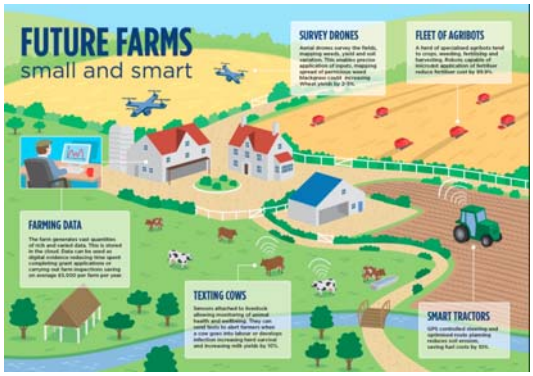
Source: an image from the-blockchain.com website where they describe blockchain helps African farmers where internet, phone, and computer are not available

V. Smart Farm

- Smart farm is a form of sustainable agriculture
  - Smart farm allows farmers to capture data in real-time: combined with IoT
  - Smart farm uses smart contracts
- Various data in smart farms
  - Weather data and alert
  - Crop growth, harvesting, expected yields
  - Data related to different farming method
  - Livestock data: animal health, reproduction forecast, GPS positioning

Smart Farm technologies

- Farming Data: generates rich and carried data stored in the cloud
- Texting Cows: sensors attached to livestock allowing monitoring of animal health and wellbeing
- Surveying drones: drones survey the fields, mapping weed, yield and sold variation
- Agribots: a herd of agribots tend to crops, weeding, fertilizing, and harvesting



Source: an image from wespeakiot.com website where they describe smart farm technologies including various application of blockchain

VI. Application: Companies in agricultural blockchain

- **Filament** – Smart Farm
- **SkuChain**, Provenance – Food tracking (Application: tracing tuna on blockchain)
- **Farmshare** – Community sponsored agriculture
- Blockchain agricultural in global
  - **Full Profile** – Australia
  - **Wakchain** – Africa

Filament: industrial application of IoT and blockchain

- IoT and blockchain application to agriculture: Connect physical objects and networks in smart farm technology
- Product: *Blocklet*, a penny-sized hardware dongle that will allow business to interface their existing equipment with blockchains

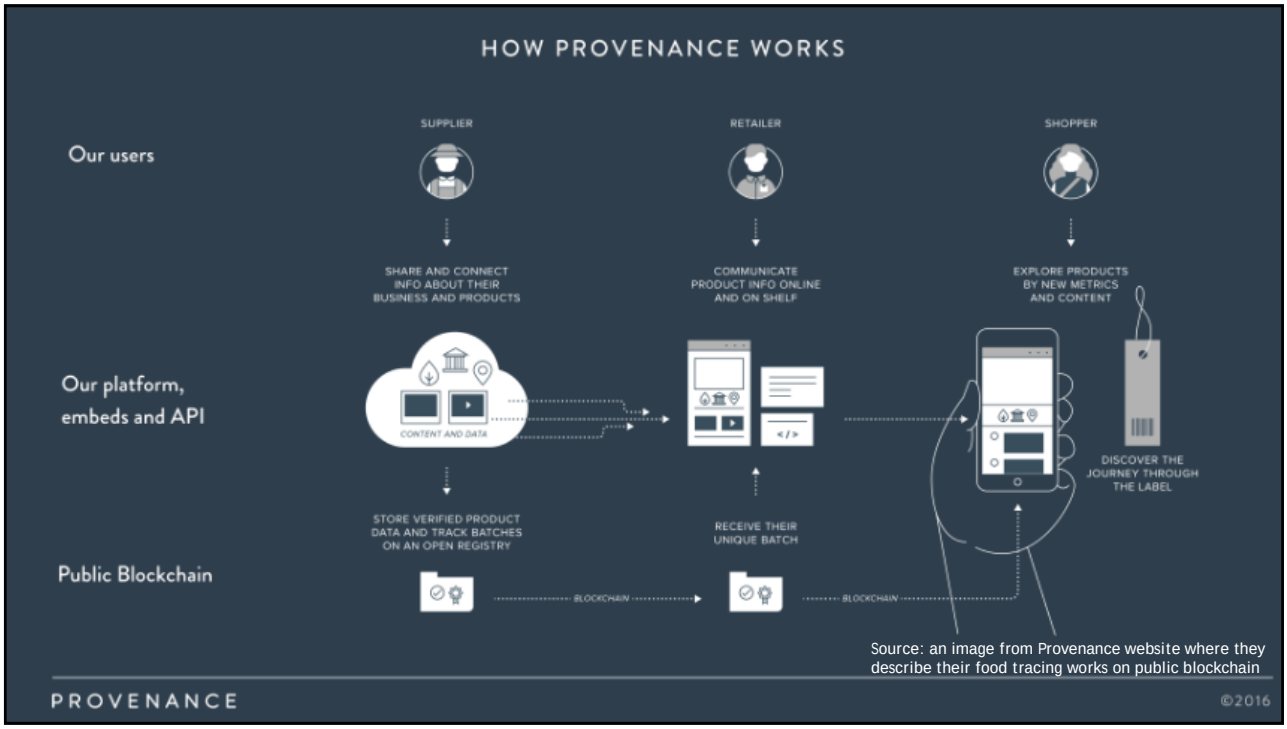
"The USB form factor of our Blocklet Chip allows companies to plug into existing machines or devices through any connected USB port, and immediately begin securely transacting against a blockchain," said Filament CEO Allison Clift-Jennings

Source: an image from Filament website where they describe their product allows business to interface their existing equipment with blockchins

Provenance: Food Tracing

- UK-based firm using blockchain technology to improve the traceability of food and provide proof of origin
- British pop star Peter Gabriel has invested in Provenance (July 2018)

Source: an image from Provenance website where they describe their product allows transparent food tracing



Source: an image from Provenance website where they describe their food tracing works on public blockchain

Application: Tracking tuna on the blockchain

- Blockchain presents a global solution for traceability
- Improving traceability in fish market: from hook to fork

Source: an image from Provenance website where they describe tracking tuna on the blockchain

Phase 1: Fishermen register data to blockchain

- The fishermen sends simple SMS messages to register their catch, thus issuing a new asset on the blockchain with each SMS.
- The blockchain assets are transferred from fisherman to supplier along with the catch, in both physical transactions and in the digital register on the blockchain.
- The identities of the fishermen are saved forever in the list of previous owners held on the blockchain.

Source: an image from Provenance website where they describe tracking tuna on the blockchain

Phase 2: Linking blockchain with existing systems for a single source of truth

- More than a simple identifier, fetching the data stored on the blockchain allows any entity to access details about that particular item
- To ensure trust in a system, there should be a single source of truth (SSOT) for each piece of information

1. Accepting raw materials: The record held on the blockchain are accessible to the item as a QR Code, RFID tag, or using any other hardware technology
2. Registering items: When raw materials and turned into new products, the corresponding assets need to be updated and transformed accordingly
3. Accepting items: Just as inputs were transferred on the blockchain when physically arriving at the factory, outputs are transferred to the next actor in the chain when leaving the facility.

Phase 3: Consumer Experience

- Records stored in the blockchain are made accessible to consumers where products are sold or served

Source: an image from Provenance website where they describe tracking tuna on the blockchain

1. NFC-enabled smart stickers carry the Provenance mark along with item or batch IDs.

2. Touching a smartphone over the stickers shows the product's journey from sea to supermarket.

3. The stickers attach to a wide variety of packaging, functioning on both dry and chilled sections

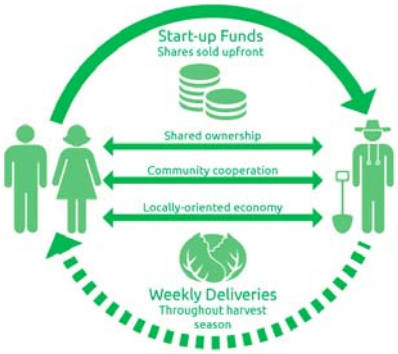
4. Item tracking extends to dining environments, indicating available information on ingredients

5. Bespoke items such as smart menus can be designed and developed by Provenance for

Source: an image from Provenance website where they describe tracking tuna on the blockchain

Farmshare: Blockchain Community-Supported Agriculture

- Community-supported agriculture: an alternative economic model for the production and distribution of locally grown food
- FarmShare is an evolution of the community-supported agriculture (CSA) model
- FarmShare Tokens: distributed consensus, token-based equity shares and automated governance



Source: an image from medium.com website where they describe Farmshare in white paper

Full Profile: Grain harvest in Australia

Source: an image from Full Profile website where they describe how blockchain technology removed settlement risk for wheat growers

- Blockchain technology removed settlement risk for wheat growers
- Real-time payments and settlements in blockchain allow growers to get paid for their grain instantly
- Distributed ledgers in blockchain can democratize access to finance by creating rich and secure data

Blockchain in African agriculture

- Wakchain: Africa's first permissioned blockchain for farmers – P2P transactions
- Cellulant: digital payment service provider serving nearly 7 million farmers (Payment Platform Infrastructure Service Provider)
- Blockchain can revolutionize land ownership: a blockchain-based digital land registry can replace unreliable cartels and community agreements

Source: an image from the-blockchain.com website where they describe blockchain helps African farmers where internet, phone, and computer are not available

VII. Conclusion: Future of Blockchain technology in agriculture

- No large-scale commercial adoption of blockchain yet: still many bottlenecks to remove
- The challenge now for blockchain, and agricultural technologies is connecting the technology to viable business models and compelling use cases
- Blockchain technology has the ability to fundamentally transform the agriculture industry.
  - All the start-ups mentioned above are working hard to do just this.
  - Farmers in the Western world have always been eager adopters of technologies that make sense and deliver real value.
- Agriculture as the last frontier of blockchain

Contact Us

ROYSE AGTECH INNOVATION NETWORK

RoyseAgtech.com

ROYSE LAW

Royse Law Firm, PC

rroyselaw.com

Silicon Valley
149 Commonwealth Drive
Suite 1001
Menlo Park, CA 94025

Los Angeles
12121 Wilshire Blvd
Suite 600
Los Angeles, CA 90025

San Francisco
135 Main Street
12th Floor
San Francisco, CA 94105

Orange County
135 S. State College Blvd
Suite 200
Brea, CA 92821

53