Introduction to Blockchain
What is it?
Implications for Agriculture

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Issue

Digital content is easy to duplicate

What is it in general?

Rules for building a set of historical records that is difficult to alter

Implications for agriculture

In the food supply chain blockchain technologies are expected to

1. Reduce transaction costs
2. Improve transparency

Figure created using photos from NCSU Packpix

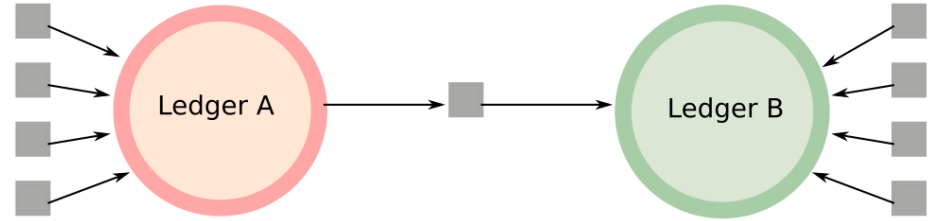# Old Concept, Modern Applications

Haber and Stornetta 1991

How can we create a time-stamping service for digital content such that

a)   A change in a single bit is obvious to everyone?

b)   The time-stamp is difficult to forge?

First large scale application was to cryptocurrency (proposed by Nakamoto 2008)
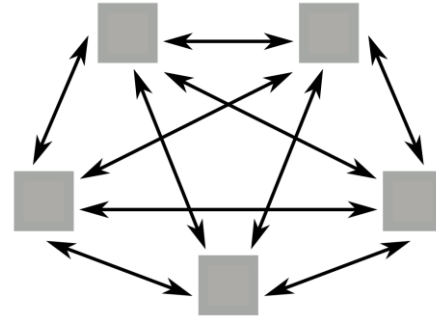
Centralized Ledgers

Ledgers A and B are trusted entities. They verify and record events/transactions.

Potential problems

- Single points of failure
- Costly to verify actions of other parties
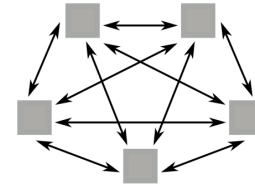
Distributed Ledgers

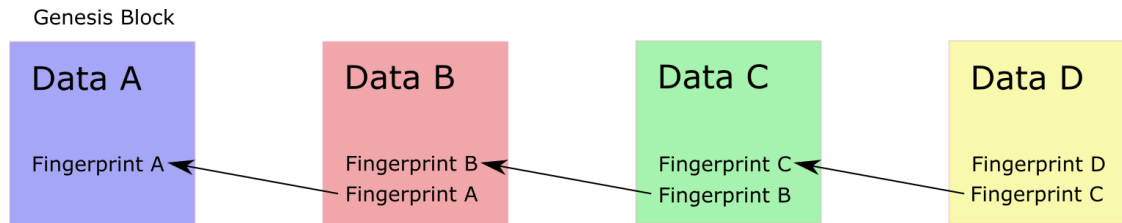All parties hold an identical copy of the ledger and participate in administration.

Typical security

- Data are encrypted
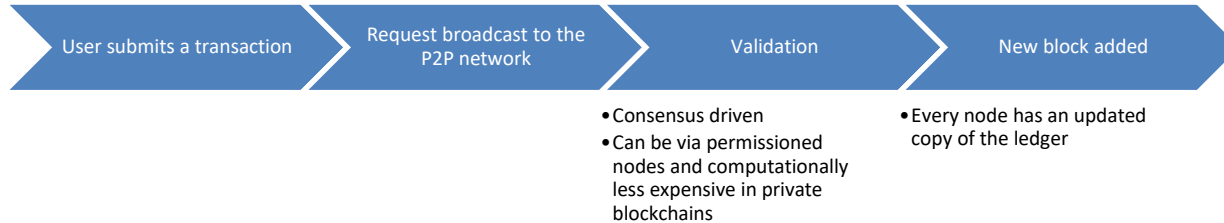- Majority of parties must agree to changes (consensus protocol)

Distributed Ledgers

More specific definition: currently, "blockchain" refers to a specific family of distributed ledger technologies

Genesis Block

Data A	Data B	Data C	Data D
Fingerprint A	Fingerprint B Fingerprint A	Fingerprint C Fingerprint B	Fingerprint D Fingerprint C

Each block is comprised of

(1) Timestamped data

(2) Digital fingerprint

(3) Fingerprint of previous block

Note: some communities may have differing definitions that evolve over time. This is common for emerging technologies, and is certainly the case in this space.

Updating the Blockchain

User submits a transaction	Request broadcast to the P2P network	Validation	New block added
		•Consensus driven •Can be via permissioned nodes and computationally less expensive in private blockchains	•Every node has an updated copy of the ledger

Hash functions: Data of any length → fixed length hash value

- Easy to compute
- Same input always gives same unique output
- Infeasible to figure out input data from the hash value alone

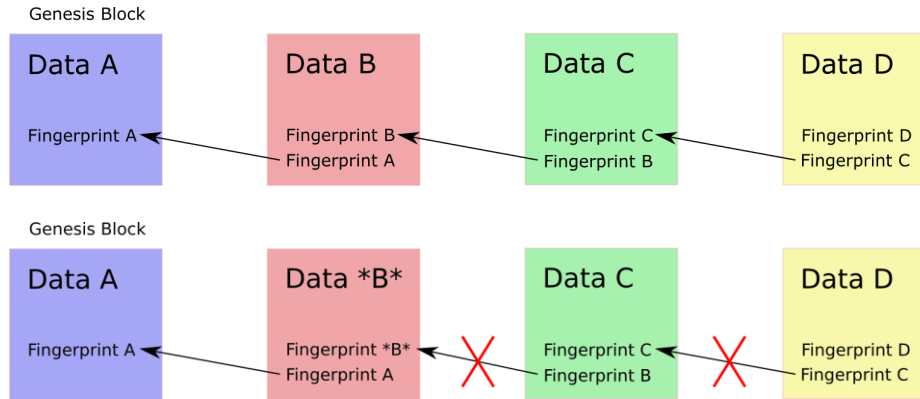Advantages: security, helps with bandwidth problems

Signature: proof of work or proof of stake in public blockchains, authorized nodes in private blockchains

- Food supply chains likely to implement permissioned/private blockchains

What if someone tries change or update a previous record?

Recall "fingerprints" are generated via hash functions. If B≠*B* then,

Hash Data B ≠ Hash Data *B*.

Genesis Block

Data A	Data B	Data C	Data D
Fingerprint A	Fingerprint B Fingerprint A	Fingerprint C Fingerprint B	Fingerprint D Fingerprint C

Genesis Block

Data A	Data *B*	Data C	Data D
Fingerprint A	Fingerprint *B* Fingerprint A	Fingerprint C Fingerprint B	Fingerprint D Fingerprint C

It's only possible to update records if there is agreement from other parties.

Potential Benefits in the Food Supply Chain

Imagine there are 20 entities involved in the farm to fork system. These include growers, transporters, processors, inspectors, distributors, and retailers.

Information sharing: downstream businesses learn and react to upstream events in (near) real time, improving supply chain efficiency and resilience

Reduced counterparty risk: difficult to falsify data, payment for goods and services may be automated via smart contracts

Regulatory compliance: compatible with the FSMA reporting requirements

Potential Benefits Cont.

In theory, blockchain technology allows rapid verification and sharing of data.

Agricultural/food products most likely to benefit may:

- Be perishable
- Have a high risk for foodborne disease
- Require substantial document processing (such as when crossing international borders)
- Have quality attributes consumers value, but are difficult to observe

Photo source: NCSU Packpix

Examples

THE
FINTECH
EFFECT

IBM partners with Nestle, Unilever and other food giants to trace food contamination with blockchain

- IBM has announced a blockchain collaboration with food giants including Nestle, Unilever and Walmart.
- The corporation said blockchain would enable food businesses to trace the source of contaminated produce in mere seconds.
- Blockchain maintains a digital ledger of transactions rather than a physical one.

Ryan Browne | @Ryan_Browne_

Published 8:00 AM ET Tue, 22 Aug 2017 | Updated 2:13 AM ET Wed, 4 Oct 2017

CNBC

Examples

Bloomberg

Technology

Dreyfus Teams With Banks for First Agriculture Blockchain Trade
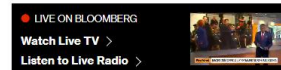
By Andy Hoffman and Ruben Munsterman
January 22, 2018, 1:00 AM EST

▶ ING, SocGen and ABN use blockchain for soybean trade to China
▶ LDC CEO says standardization will be key to costs savings

The blockchain is now part of the route from farm to table.

Louis Dreyfus Co., one of the world's biggest foodstuffs traders, teamed up with Dutch and French banks in December for what it says is the first agricultural commodity trade to use the ledger-based digital technology known as blockchain. The 166-year-old Rotterdam-based trading house used a blockchain platform to sell a cargo of U.S. soybeans to China's Shandong Bohi Industry Co.
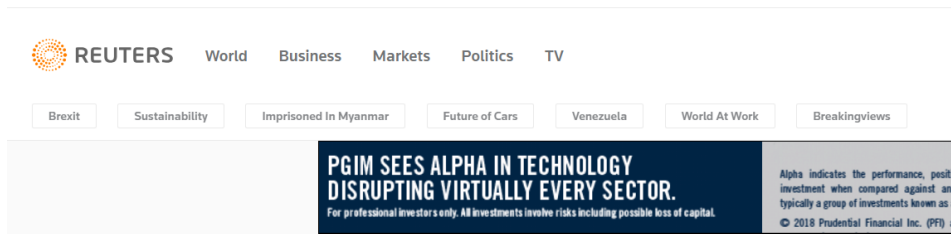
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Examples

FINTECH   MARCH 16, 2018 / 4:35 PM / A YEAR AGO

Coca-Cola, U.S. State Dept to use blockchain to combat forced labor

Gertrude Chavez-Dreyfuss   3 MIN READ

NEW YORK (Reuters) - Coca-Cola Co (KO.N) and the U.S. State Department along with two other companies said on Friday they are launching a project using blockchain's digital ledger technology to create a secure registry for workers that will help fight the use of forced labor worldwide.

Examples

Technology Mandates

Large food retailers have stated they will require suppliers of certain food products to use their blockchain.

We've seen retailer technology mandates before with RFID.

- Investors looked favorably on supplier compliance (Dietz, Hansen, and Richey 2009)
- Adoption did not necessarily lead to better financial performance in smaller businesses (Shin and Eksioglu 2014)
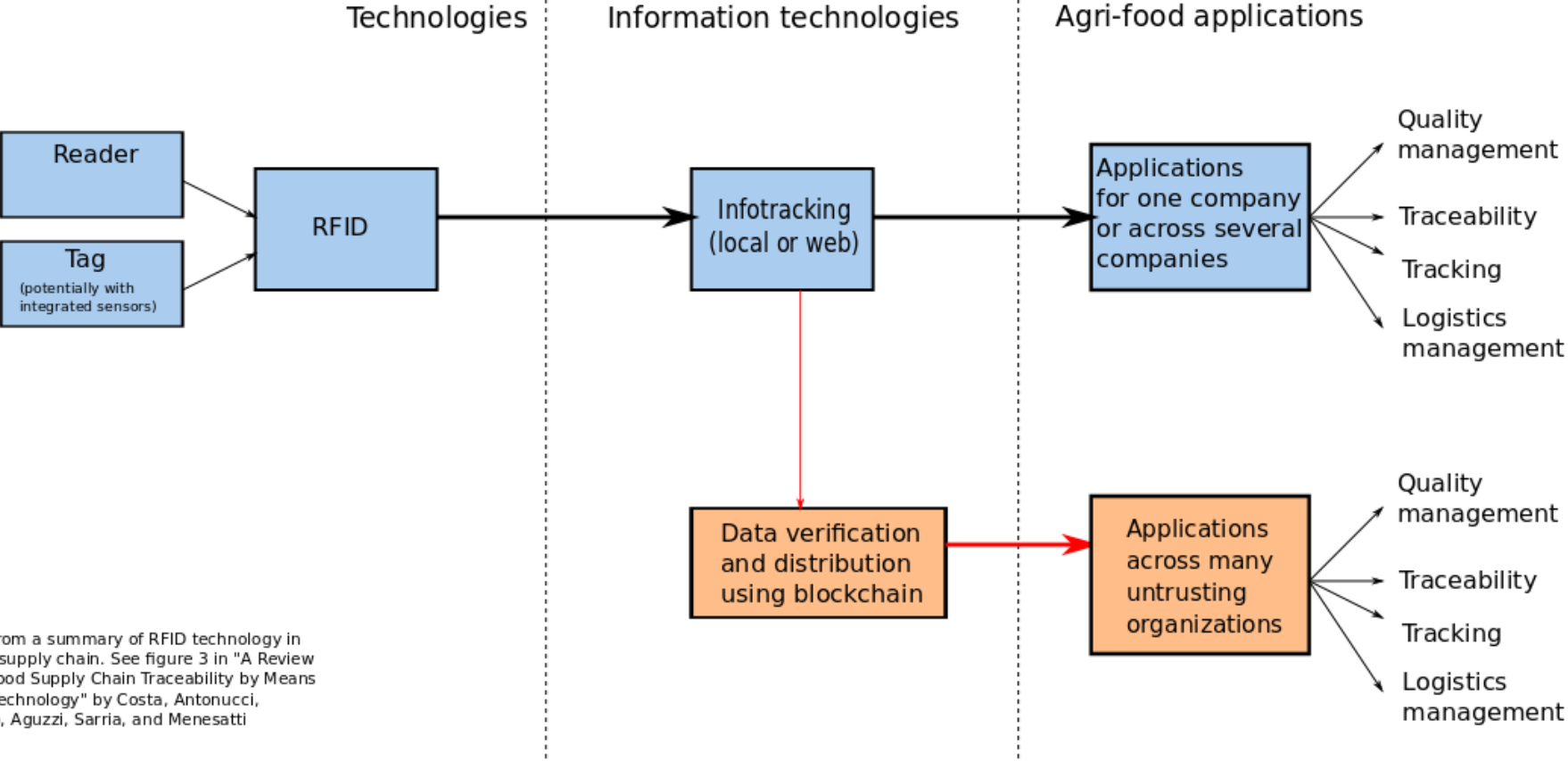
Photo source: NCSU Packpix

Challenges Implementing RFID

- Lack of industry standards
  - Frequency
  - Granularity (pallet, box, etc.)
- Uncertain reliability
- How to manage large volumes of data?
- Cost
  - Technology itself
  - Skilled personnel
- Information sharing not wanted by all parties

Retailers did not enforce technology mandates on schedule

Photos source: NCSU Packpix

Technologies | Information technologies | Agri-food applications

Reader

Tag
(potentially with
integrated sensors)

RFID

Infotracking
(local or web)

Applications
for one company
or across several
companies

Quality
management

Traceability

Tracking

Logistics
management

Data verification
and distribution
using blockchain

Applications
across many
untrusting
organizations

Quality
management

Traceability

Tracking

Logistics
management

Altered from a summary of RFID technology in
the food supply chain. See figure 3 in "A Review
on Agri-food Supply Chain Traceability by Means
of RFID Technology" by Costa, Antonucci,
Pallottino, Aguzzi, Sarria, and Menesatti

Challenges Implementing Blockchain

Blockchain applications in the food supply chain are still emerging, but we can anticipate some challenges:

- Lack of industry standards
    - Many blockchain vendors, platforms not well integrated with each other
    - Granularity of data
- Data management and ownership?
    - Capacity of the network to manage data
    - Who are the permissioned nodes?
    - Who benefits from farm-level data?
    - Privacy
    - Hackers

- Uncertain reliability of smart contracts
    - Legal status
    - Bugs
- Cost
    - Technology itself: typical fee schedules not yet established in the industry
      In the case of retailer mandates basic access to a platform might be provided at no cost to farmers, but fees could charged for add-ons (for example digitally certifying organic)
    - Knowledge and skilled personnel

Photos source: NCSU Packpix

Looking Forward

- Network externalities: benefits participants get from additional users
- Involvement of policymakers and regulators
- Reducing **data gathering costs** by connecting to sensors
  - Internet of Things (IoT)

Photo source: NCSU Packpix

Concluding Thoughts

- There is a push for integration and automation in food supply chains
  - Long term it may be via blockchain or other technologies
- Smaller upstream businesses, such as farmers and grower cooperatives, face difficult decisions about whether to invest in the technology
  - Early technology adoption vs. wait and see
- Importance to North Carolina:
  - Diverse agricultural economy with many perishables
  - Geographically situated for exports
    - Consumers in developing countries especially value food integrity

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