INTEROPERABILITY AND BLOCKCHAINS IN AGRIFOOD

Data sharing and semantics | Dr. C.A.W. Brewster

Invited talk at DIGITAG/IRSTEA – 23 May 2018
OUTLINE

› The promise of blockchain technology
› Current actual applications
› The role of semantics here
› The challenge of food integrity
› The real utility of blockchain technology
BLOCKCHAIN AND DISTRIBUTED LEDGERS

- A distributed, decentralised, shared database (ledger)
  - Distributed across the network – every participant has a complete copy
  - Every copy is the same almost instantly
  - No transaction can be deleted
  - Usually open and public – everyone can add transactions
- Strong political dimension to blockchain technology
  - Smart contracts and distributed autonomous organisations
  - Desire to remain outside government control
  - Hugely optimistic about automation of all human activity and “tokenisation"
CORE DESIGN CHOICES IN BLOCKCHAINS

- **Permission design** – open, unpermissioned vs. closed, permissioned
- **Choice of consensus algorithm** – proof or work vs. proof of stake vs. other options
- **Smart contracts** – very sexy but cause a lot of problems
- **Use of a cryptocurrency** – depends on the choice of consensus algorithm mostly
Provenance.org (https://www.provenance.org) Ethereum based, focus on traceability and transparency, wants to “tell the story” of food, uses blockchains to guarantee trust.

Agriledger (http://www.agriledger.com/) “Blockchain for the greater good” → blockchain + network + “framework of trust” + cheap smartphones

Origen Trail (http://origin-trail.com/) “genuine transparency to stand out in the marketplace and increase trust in your brand” → “A global platform for building transparency in supply chains.”

Arc-Net (http://arc-net.io/) “a secure, immutable, trusted chain of custody for a product or asset” → “Enhancing Brand Protection and Consumer Loyalty”

…..and many more
THE PROMISE: WHY BLOCKCHAINS IN AGRIFOOD?

- Partly due to general hype that Blockchain is a solution to everything
- Partly due to the perception that Blockchain is a “universal database that all actors can transparently read and write to”.
- Partly due to ignorance - e.g. belief that it would be easy to put lots of data on the blockchain and control access (neither are true)
BENEFITS: TRANSPARENCY

- All transactions on a blockchain are visible (to everyone … or to selected parties)
- Immediate visibility (replication) of transactions means no third party is needed (… considered a virtue)
- Transparency of ledger eliminates fraud (it is claimed)
- Transparency = trust (or elimination of need for trust)

Claims in the agrifood context: transparency of the food supply chain, tracking and tracing, transparency of inputs and outputs
BENEFIT: IMMUTABILITY

- All transactions written to the blockchain are immutable/cannot be changed
- Immutability also guarantees avoidance of fraud or tampering
- **Claims in the agrifood context**: food fraud can be eliminated, environmental reporting can be made more effective (Dutch manure case)
BENEFITS: ROBUSTNESS & DECENTRALISATION

- Because the database is distributed, cannot fail
- No single point of failure
- No single point of control
- Helpful when competitive/enemy parties need to work together

Claims in the agrifood context: Supposed to lower costs, increase independence of the sector, increase efficiency
BENEFIT: SMART CONTRACTS

- A smart contract is a software implementation of legal contract. Originally developed by Nick Szabo in early ‘90s.
- Idea is to transfer contractual obligation onto an impersonal software system.
- Much excitement now that one can “run” smart contracts on the blockchain.
- Ethereum first to provide an infrastructure to run a VM for smart contracts. Many other frameworks have followed.
- Huge technical problems – errors and software failures.
HOW ARE BLOCKCHAINS ACTUALLY USED?
PROVENANCE.ORG

- Start-up and social enterprise focusing on “telling the story” of a product (especially food)
- They use “blockchain, mobile and open data to bring verified information from your supply chain to the point of sale”
- Blockchain (Ethereum) used to provide infrastructure for transparency, i.e. used to record certification (organic/Fairtrade).
- Several trials with Tesco/Co-Op/Soil Association/FairFood (NL)
Most information is stored on the digital platform.

Ethereum blockchain is used to store snapshots (a hash) of data (e.g. food certification, or data from smartphone app).

Blockchain provides immutable proof that the data was true at a certain point in time, using hash of data placed on public Ethereum blockchain.

Data on platform can be queried and compared with hash. Data on the blockchain can only be compared for integrity.

Because current blockchain technology is very limited
IBM AND AGRIFOOD

- Major attempt by IBM to enter blockchain agrifood sector
- 2016 Walmart starts project with IBM (Hyperledger) to track pork supply chain in China
- Intended to “ensure the accuracy of farm origination details; batch numbers; factory and processing data; expiration dates; storage temperatures; and shipping details”
- 2017 Walmart, Dole, Unilever and Nestle collaborate with IBM using blockchain technology
- 2017 New project tracking mangoes from Mexico
- All these are “track and trace” use cases to avoid food poisoning and food fraud.
IBM ARCHITECTURE

Product Recall (Traceability) Module
- Manage Actual Recalls
- Trace-back Products
- Post-Analysis
- Recall Simulator

Certificate Manager Module
- Version Control
- Automated Life cycle management
- Authenticity
- Real time Sharing

Future Modules

Food Safety Solution Core
- Permissioned Data Access & Entry
- IBM Blockchain Provenance engine
- Secure Document Storage
- API Integration

IBM Blockchain Platform

HYPERLEDGER
WUR/TNO TABLE GRAPE POC

- Small project in collaboration with WUR, funded by Dutch EZ Ministry (2017)
- Based on previous work on the table grape supply chain from South Africa to the Netherlands.
- Objective to demonstrate that grape certifications (organic, Fairtrade) can be managed on a blockchain.
TECHNICAL DESIGN

- Built with Hyperledger 0.6 on a permissioned blockchain.
- Using a smart contract ("chaincode") written in GO lang. Each SC in its own docker container.
- Business relationships encapsulated in the smart contract.
- Allows update and query of data (e.g. using identifier of box of grapes)
- Data is stored in a key-value store (RocksDB for v0.6)
- Code is open sourced (https://github.com/JaccoSpek/agrifood-blockchain)
LIMITATIONS

› Scalability
  › Technology in constant development, but we do not know how this will perform with very large numbers of transactions.
  › Similarly, we do not know, yet, how this will perform with many participants/nodes.
  › Millions of agrifood transactions per day, all recorded on a blockchain may cause cumulative disk space issues ....

› Visibility
  › We can control data access to this participants within a smart contract. This means a different set of partners needs a different smart contract.

› Digital to physical interface
  › Does not prevent GIGO (Garbage in, garbage out)

› .... This leads us to discuss semantics.
SEMANTICS
Early and constant argument for blockchain technology is that “a” blockchain would enable “a single view of truth” – because everyone would read and write to the same blockchain.

Similar echoes to arguments for one ontology to rule the world (cf. Cyc).

If a blockchain is a distributed decentralised database writing data on must have a data model/a vocabulary/a semantics

But this faces two problems:

- No agreement on ONE blockchain
- No agreement on ONE semantics in agrifood (or in any other domain)
There has been a surge of interest in “interoperability” with regard to blockchain protocols/stacks.

Basic challenge is “atomic swaps” i.e. exchange of a token from one blockchain to another.

People speak of “federated blockchains” – sound familiar?

Most of the semantics is hidden because people think only in terms of “tokens”.

Exchange of value has limited semantics!
SEMANTICS AND SMART CONTRACTS

- Smart contracts exist in multiple layers – from human intention through to CPU instruction.
- Each layer needs syntax and **semantics** – semantics to specify the meaning of concepts and the map to the real world.
- **Misunderstandings about this are an important cause of smart contract failure.**
- Real world impinges on the “blockchain world” – the meaning of concepts change, the real world changes.
- Proper semantics means formal vocabularies (ontologies) to systematise descriptions of the world.
SEMANTICS AND STANDARDS IN AGRIFOOD

- Many different standards and vocabularies
  - Messaging standards – GS1 EPCIS, EFSA’s FOODEX2, AgGateway, ISOBUS etc.
  - Ontologies and vocabularies – AGROVOC, GACS, PPEO, Foodie, etc.
- You are familiar with:
  - http://agroportal.lirmm.fr/
  - https://vest.agrisemantics.org/
- Three different communities with different approaches – huge challenge to achieve greater interoperability
- Not a lack of standards but a lack of uptake and adoption.
- What role here for the use of blockchains?
DEEPER ANALYSIS: FOOD INTEGRITY
THE FOOD INTEGRITY PROBLEM

Core challenge in value chain is **tracking and tracing**, due to food recall, food integrity issues and food crises

Lots of food crises

- E. Coli (repeated but especially 2011 in Germany)
- Horsemeat scandal (2013)
- Italian organic food scandal (2011)
- Lactalis scandal (2017)
- Fipronil scandal (2017)

Current practice is still mostly paper and very slow …

Much desire to find a technological solution ---- Blockchains have been promoted repeatedly for this issues
CURRENT ARCHITECTURE

From Scholten et al. 2016
MAIN STANDARD: GS1 EPCIS

- Core standard in supply/value chain - used with barcodes and RFID
- Event based, each time you scan an EPCIS event data occurs
- Beyond that allows “barcode (GTIN) → master data” look up
PROBLEMS WITH EPCIS

Possible architecture: centralised

Politically unacceptable … so far.

From Scholten et al. 2016
A BLOCKCHAIN SOLUTION?

› Privacy and business confidentiality
› If all data on a blockchain is transparent, then no privacy/confidentiality!
› Solutions:
  › Total anonymity (Zero Knowledge Proofs (ZKSnarks))
  › State channels (i.e. private data is handled off channel)
  › Encryption (public/private keys etc.)
› … or do not use a public blockchain …
A BLOCKCHAIN SOLUTION? - 2

IF an open unpermissioned blockchain (e.g. Ethereum):

- Transparency causes these political problems (business confidentiality)
- Difficulty for scalability (lack of throughput and quantity of data)
- Good to record an immutable record – but useless to search → therefore useless for track and trace

IF a closed, permissioned blockchain (e.g. Hyperledger Fabric):

- Agreement must be reached with participants in a chain
- Transparency vs. business confidentiality may remain a problem
- Scalability issues can be solved
- Good to record an immutable record – but useless for search again – has to be off blockchain.
A BLOCKCHAIN SOLUTION 3?

- BUT BUT BUT
- Assumptions are lying about here:
  - That everyone in the food system will read and write to the same blockchain
  - IF not, then we must achieve cross-blockchain interoperability - “a key design goal”
- Lots of work on cross-blockchain interoperability BUT largely concerns exchange of tokens (i.e. very simple semantics)
  - .... So again we need standards and vocabularies
A DIFFERENT APPROACH: LINKED PEDIGREES

LINKED PEDIGREES

- Each actor has their own database (triple store)
- All products generate a set of RDF statements from EPCIS events
- When a product moves a single link is created to enable a cross-triple store SPARQL query.
- Each actor retains access rights and control of their data

Enabled possible queries:
- What were the inputs used in processing batch id N shipped on date X?
- Which bottles were aggregated in in cases with identifier X or Y?
- How much water/fertiliser was used for cases with identifier X?
LINKED PEDIGREES (PARTLY) ON A BLOCKCHAIN

Agri-food supply chain

Integrated
Linked Pedigrees
store

Linked data

FARMER

Linked pedigree
manager agent

TRAIDER

DISTRIBUTION
CENTRE

TRAIDER

RETAILER

Agent - Agent
communication

shared vocabularies
relevant subset of the
LOD standards
Communication
protocols

Agri-food knowledge base

Agri-food Cloud for the
stakeholders in the Agri-food
supply chain

RESTful Agri-food knowledge services

VOID store
Access control
Interlinking components
Service registry
Ontology registry
Middleware services
OTHER WAYS TO USE SEMANTICS

- Ongoing project … (again with Wageningen, funded by Dutch Agriculture Ministry)
- Table grape project → **Banana certification project with semantics**
- Objectives:
  - Allow more complex data-structures
  - Prevent double-spend of certificates (a certificate is only good for x amount of produce)
  - Add functionality for controlled transparency
  - More generalized setup: Allow different produce and certificates
  - Upscale throughput of setup
- **Approach:** uses BigChainDB, a blockchain framework built over MongoDB (a NOSQL database with data recorded JSON structures).
  - Using an ontology to specify both validity and amount of produce a farmer can produce.
- Early days in the project still.
Fear of disruption is bringing many actors to the table.

Limitations of blockchain technology are forcing the use of permissioned, closed blockchains.

Permissioned blockchains need gatekeepers so trust has to be established first.

Permissioned blockchains need a data model/vocabulary/ontology.

Once the data model is agreed upon, the utility of the blockchain technology is quite narrow.
CONCLUSIONS

- Blockchain technology has limited **technical** utility (so far) in the agrifood arena.
- Problems with throughput, transparency/confidentiality, danger of smart contracts.
- Interoperability is now recognised as a challenge.
- Semantics has long offered solutions to interoperability problems.

- Blockchain technologies will play a bigger part in **enabling** semantics, than providing actual solutions!
THANK YOU

Special thanks to DigitAg and Clement Jonquet for the invitation.