Uses of Blockchain Technology in the agrifood system

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OUTLINE

- Brief Introduction to Blockchain technology
- Key technical characteristics
- Key social and business characteristics
- Why Agrifood and blockchains?
- Example Initiatives
- TNO/WUR Table grape demonstrator
- Current limitations

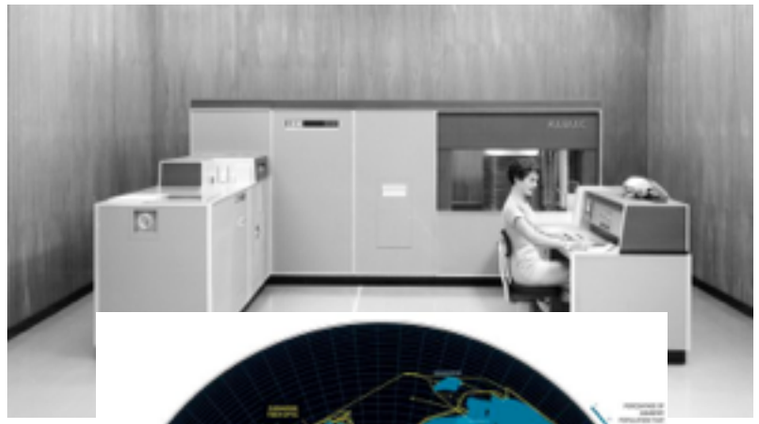
Technical Aspects

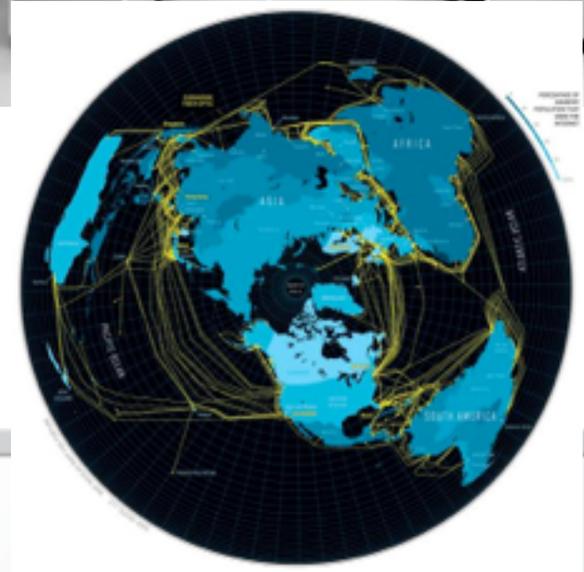
Blockchain and Bitcoin

- Origins lie in Bitcoin - Bitcoin was developed as *cryptocurrency - a* technological alternative to *fiat* currencies (dollar, euro, pound)
  - An attempt to be an anonymous “Bank of the Internet” or an anonymous Paypal
  - Finite number of Bitcoins supposedly provides *gold-standard* type guarantee against inflation
- Bitcoin depends on the *bitcoin Blockchain* to function
  - All Bitcoin transactions are recorded on the bitcoin blockchain
  - The blockchain is the infrastructure upon which bitcoin rests
  - Every 10 min a new block is add by “miners” (who consume huge amounts of energy)

In the beginning …

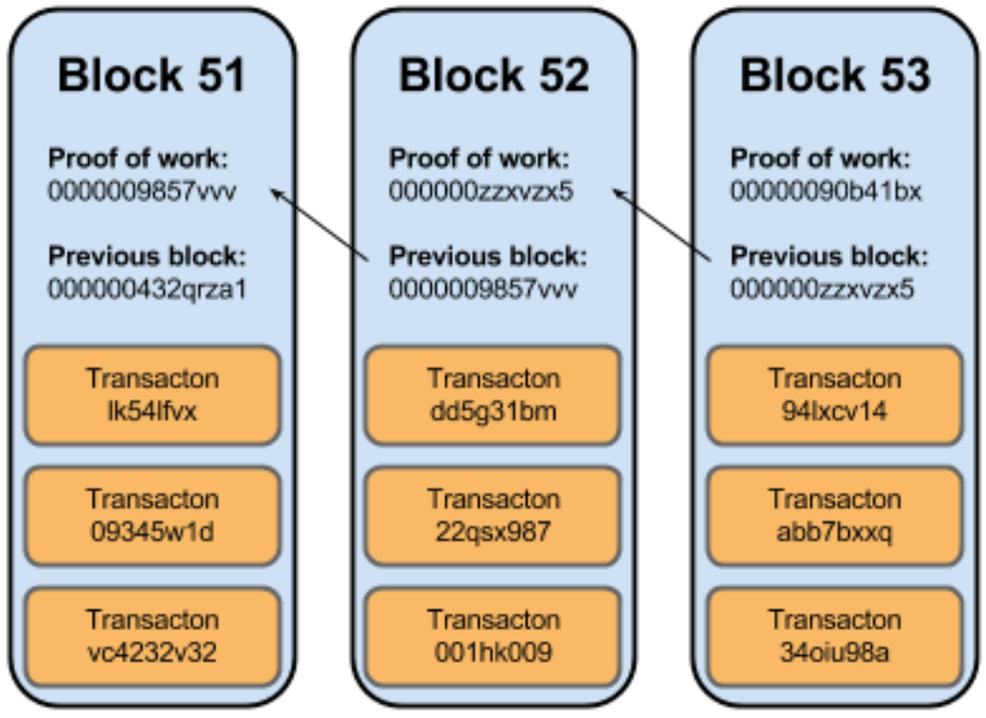
- There was the database ….
- … and then there was the network
- PUT THEM TOGETHER
- Gives us first “cloud computing”
- … and now “blockchain” technology





What is a blockchain?

- A blockchain is simply **database** but …:
  - Distributed across the network (Internet) - everyone has a copy
  - Auto-synced - every copy is the same *almost* instantly
  - **No transaction can be deleted**
  - Commonly open and public - everyone (authorised) can add.
- **AND** currently *very slow throughput, very low capacity*

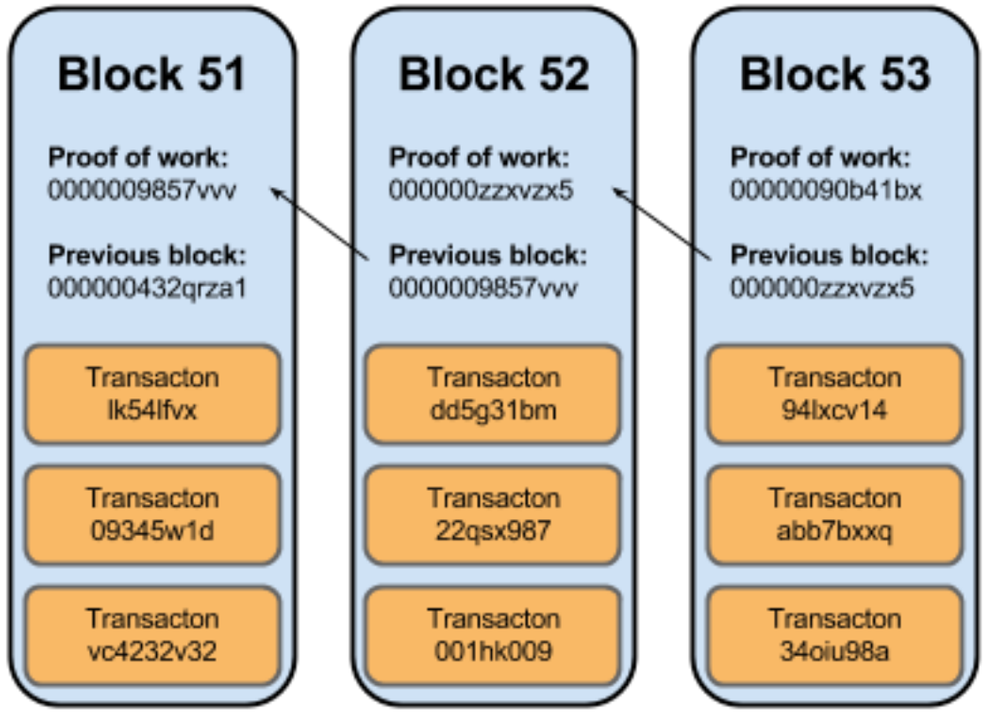


Blockchain technology is otherwise known as Distributed Ledge Technology (DLT)

http://dataconomy.com/wtf-is-the-blockchain-a-guide-for-total-beginners/

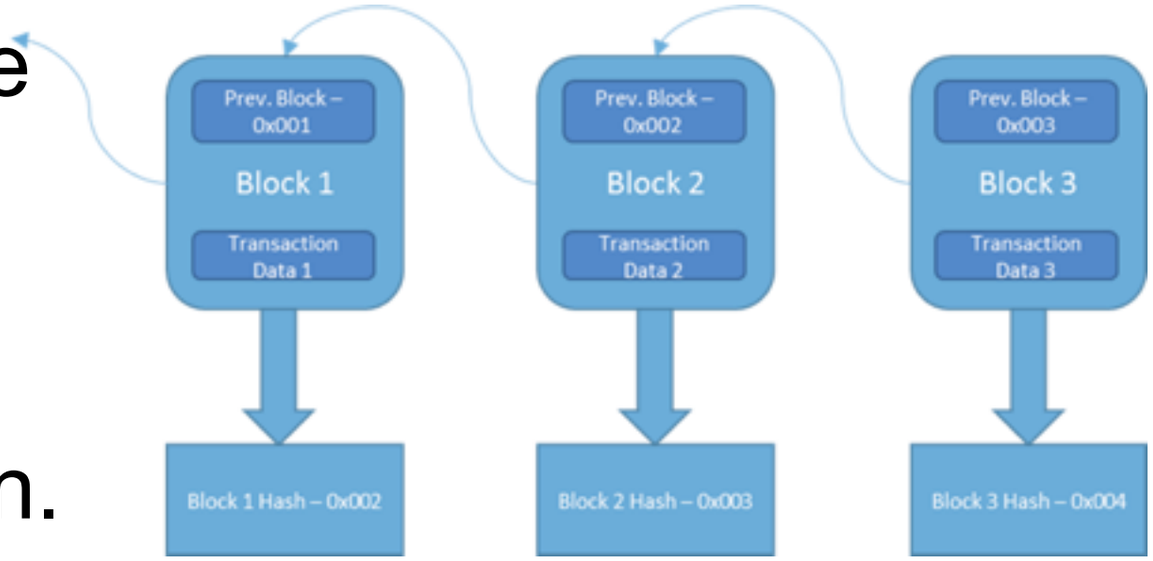
What is a “block”?

- A block consists of a set of database transactions placed in a “block”
- The blocks are shared in a distributed and decentralised manner i.e. each “node” has a complete set of blocks
- In theory, everyone can see all transactions (complete transparency)



What is a chain?

- Each block is linked to the previous block via a hash function. This means you cannot change a block without breaking the chain.



- Each block is cryptographically signed as well.

Consensus Algorithms

- Consensus algorithms determine who is allowed to “sign” the next block.
- Technically closely related to ensuring consistency across a distributed data base.
- Bitcoin and Ethereum use “Proof of Work” i.e. calculating the cryptographic hash of the current block (including all unconfirmed transactions + a hash of the previous block) with certain criteria (in Bitcoin this is finding a hash of the current block beginning with n zeros)
- There are other consensus algorithms (“Proof of Stake”, PBFT, simple voting)

Mining?

- “Mining” describes the act of validating a block on the blockchain.
- Using huge amount of energy and high powered computing to solve the hashing problem
- “Mining” is very energy intensive, takes place mostly in China.
- Currently 16.65 TWh per year (https://digiconomist.net/bitcoin-energy-consumption)

http://www.chinafile.com/multimedia/photo-gallery/inside-world-of-chinese-bitcoin-mining

Permissioned vs. Unpermissioned Blockchains

TNO innovation for life

- Bitcoin uses an **public unpermissioned** blockchain meaning anyone can. Trust is achieved through mining.
- Other options possible including permissioned/ public, permissioned/private, and a traditional ledger e.g. bank account.

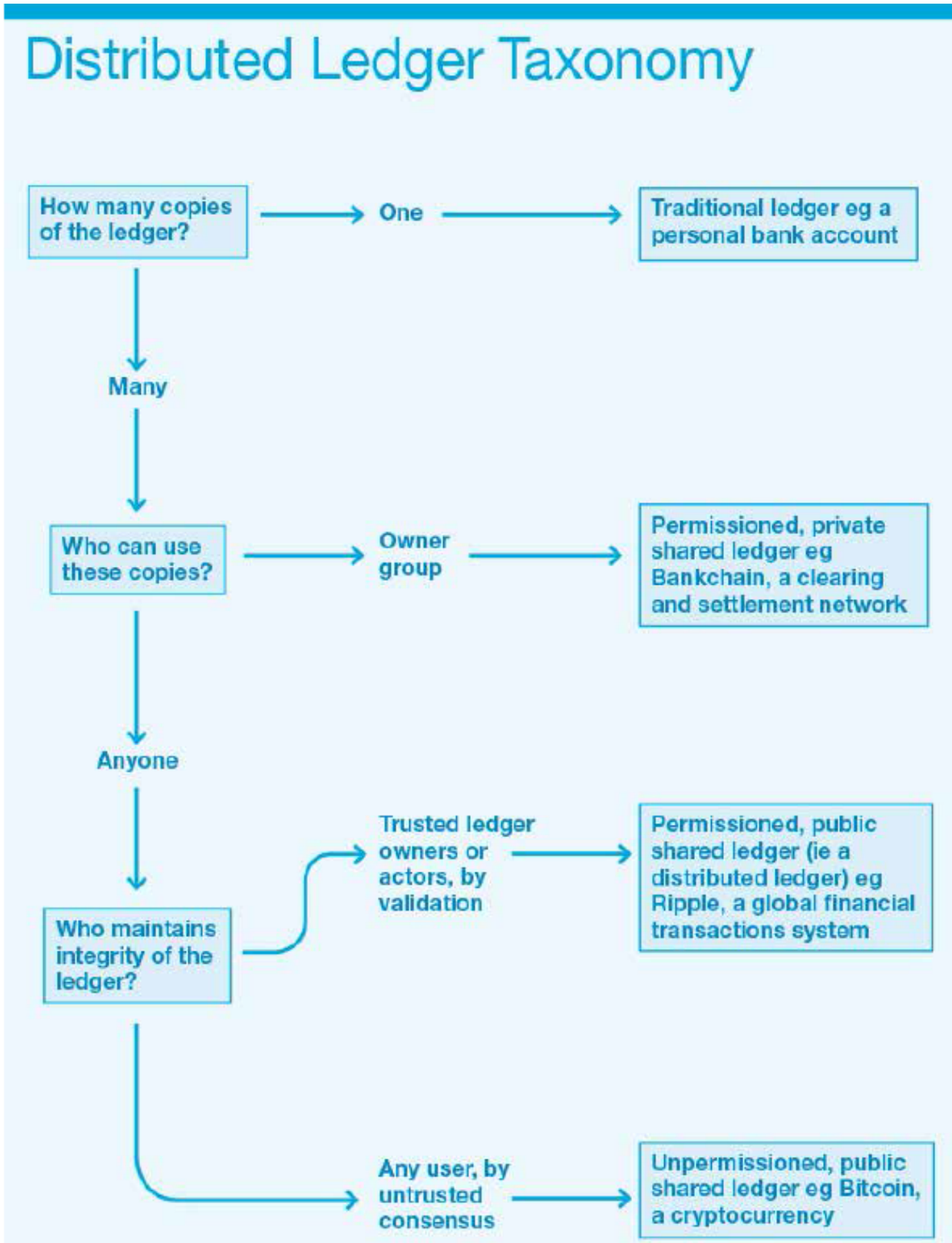
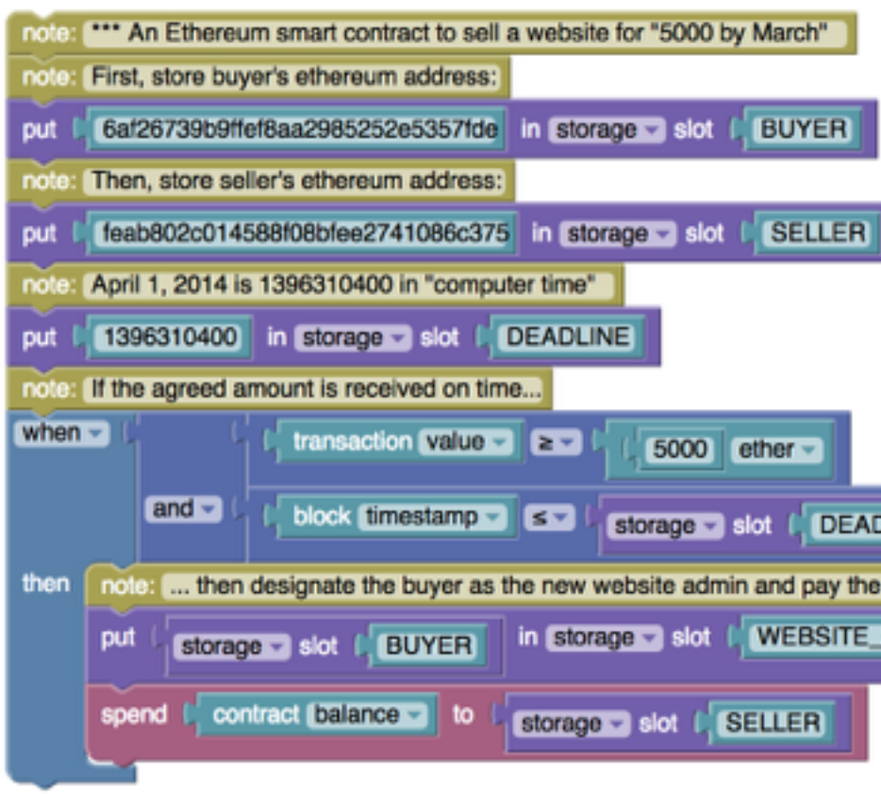


Figure courtesy of Dave Birch (Consult Hyperion)

Key feature: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
- Bitcoin includes a form of smart contacts - but very simple. **Etheruem** is an infrastructure to run a VM for smart contracts



http://etherscripter.com/what_is_ethereum.html

Example technology: Ethereum

- Etheruem (https://www.ethereum.org) is a programmable smart contract platform, using *ether* as its unit of currency.
  - Also **very slow**, guaranteed uptime computer!
- Started by Vitalik Buterin and Gavin Wood, presold $15M worth of *ether* which has funded its development.
- Major visibility and public backing, e.g. now available on Microsoft Azure.
- Consensus algorithm is based Proof of Work.

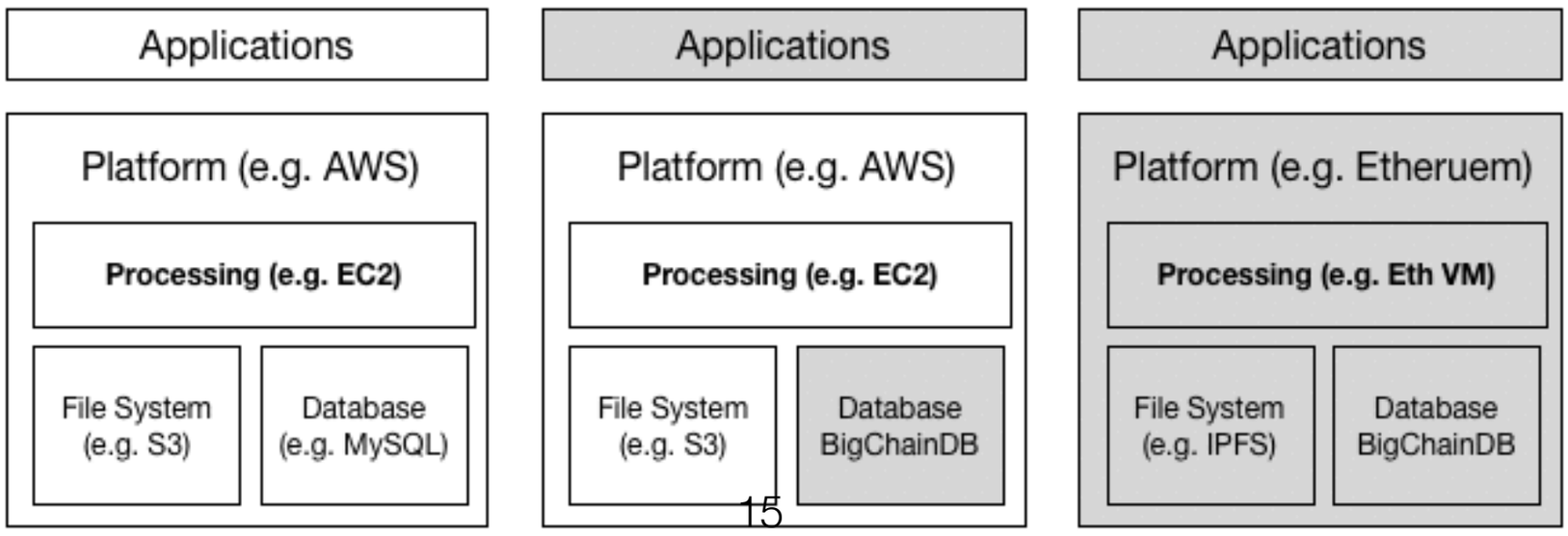
Hyperledger

- Hyperledger project founded by Linux Foundation with strong industry backing, especially IBM. Various sub projects including Hyperledger Fabric.
- Focus on *permissioned* blockchains, with a membership management service.
- Highly modular, plug and play for different modules including consensus algorithm.
- Includes smart contracts (“chaincode”) run inside Docker containers.

HYPERLEDGER

Example Technology: BigChainDB

- BigChainDB (https://www.bigchaindb.com/) is an attempt to solve the throughput challenge.
- BigChainDB provides a “blockchain” layer over a conventional DB (currently RethinkDB, soon MongoDB).
- Claims to handle 1m transactions per second
- Open source, under active development



Blockchain Design Choices

- Permissioned vs. non-permissioned blockchains
- Presence or absence of smart contracts
- Choice of consensus algorithm
- Use of a cryptocurrency (determined by consensus algorithm choice)

Important Blockchain Characteristics

- Very secure due to use of cryptography (public/private keys, cryptographic hashes)
- Capable of near real-time synchronisation or settlement
- Claims of very low transaction costs (only partially true)
- Typically based on open source software - changes are developed by the community
- Transparency and traceability of transactions is typically superior to current systems but user identification may be weaker or nonexistent

Social and Business Characteristics

Key Feature: Permanent Ledger

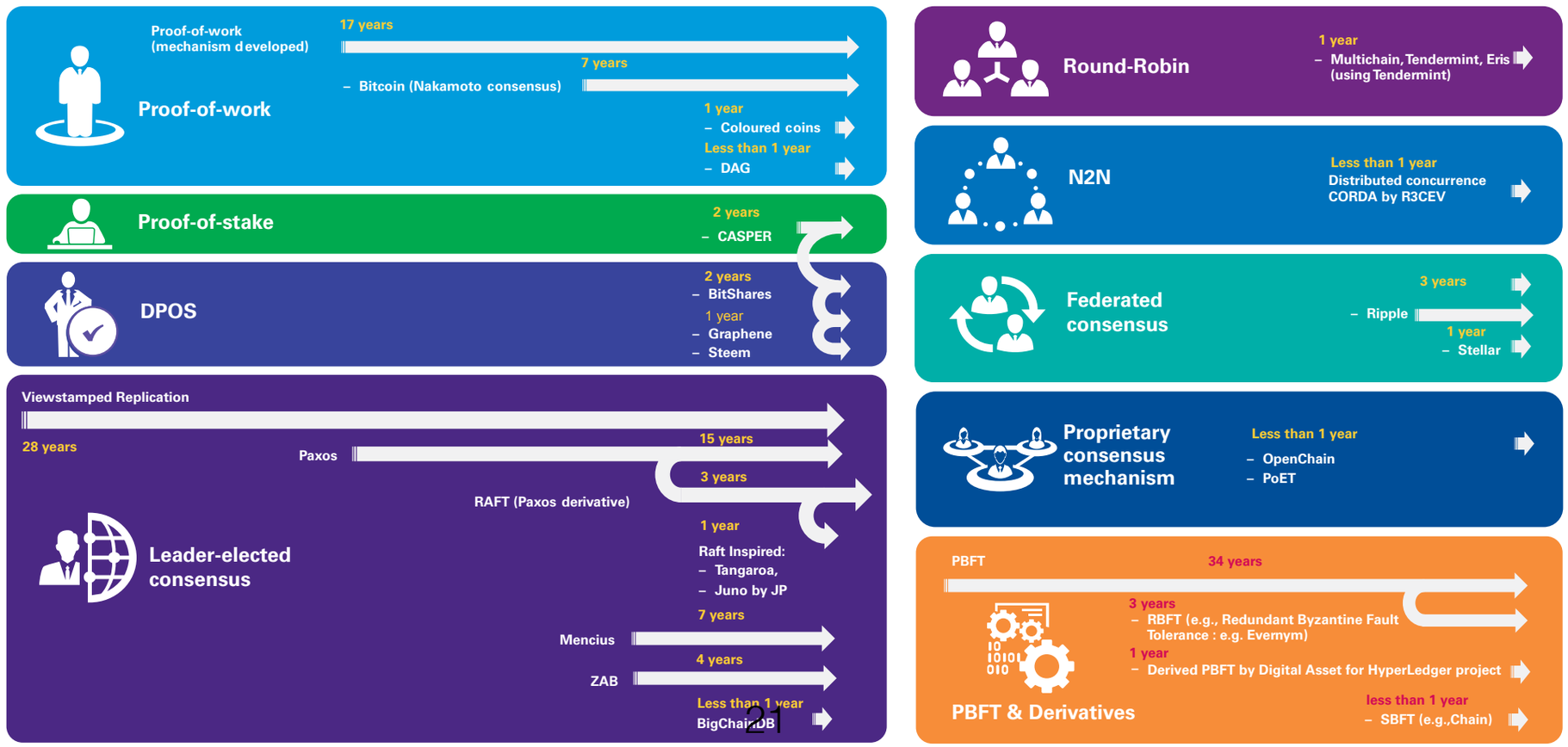
- “Nothing can be deleted ….”
- The blockchain as a distributed write only ledger is an ideal repository for certain types of data
- Ideal for some use cases:
  - Record auto accidents so only one claim can be made
  - Record valuables so that no fraudulent claims are possible
  - Tracking art works across chains of custody

Key Feature: Transparency and Trust

- All transactions on a blockchain can be visible (to everyone or to the selected parties)
- Immediate visibility (replication) of all transactions means no third party is needed (this is considered necessarily a virtue …)
- “The transparency of this distributed ledger virtually eliminates fraud, which further reduces the costs of doing business for all parties involved.” — Jason Leibowitz

Consensus and Governance

- Part of the intention with blockchain technology is to write the governance into the code
- The consensus algorithm is a key aspect of the governance of any blockchain - and there are several different kinds



http://www.disledger.com/kpmg-blockchain-consensus-mechanism.pdf

General Blockchain Benefits

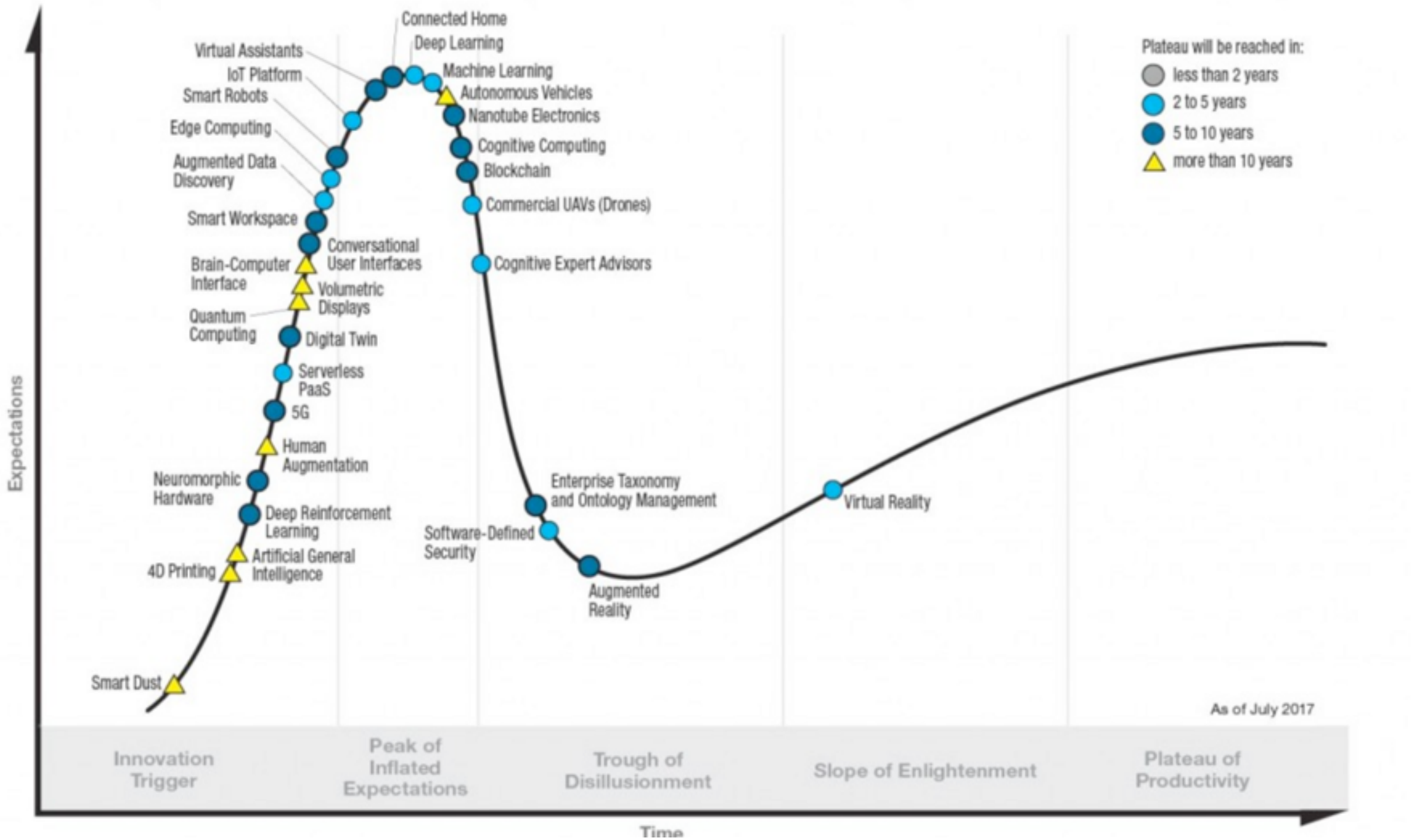
- **Decentralized / shared control** - situations where enemies need to work together for their mutual benefit, e.g. banks, perhaps in agrifood supply chains

- **Immutability / audit trail** - situations where it is of prime importance to have an immutable audit trail, where users cannot change data post hoc, e.g. Everledger for diamonds, perhaps for certification in agrifood

- **Assets / exchanges** - situations where the assets can live on the blockchain e.g. stock exchanges, currency or energy exchanges, perhaps for local agrifood marketplaces.

based on https://blog.bigchaindb.com/three-blockchain-benefits-ae3a2a5ab102#.2qi900pp9

Blockchain Hype



http://thearea.org/gartner-hype-cycle-emerging-technologies-2017/

Blockchains in Agrifood

Why agrifood?

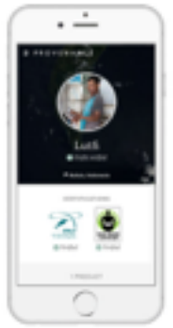
- Heterogenous, highly complex system, many actors, many different kinds of participants (from agrochemical firms, farmers, traders, processors, logistics providers, retails, consumers etc.)
- Many current challenges: climate change and environmental impacts; food crises, food integrity and food fraud; need for tracking and tracing; health impacts; etc.
- Low ICT penetration, and (sudden) interest in application of ICT to agrifood
- Major current focus: **food integrity and transparency**

Why blockchain 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)

An explosion of start-ups in agrifood

- 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.



- Filament (https://filament.com) wants to use blockchain for agricultural asset tracking.

- SkuChain (https://www.skuchain.com) want to track containers and transport shipments using blockchains

- FarmShare (http://farmshare.us) want to build decentralised community support agriculture

Startups (cont.)

- 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.”

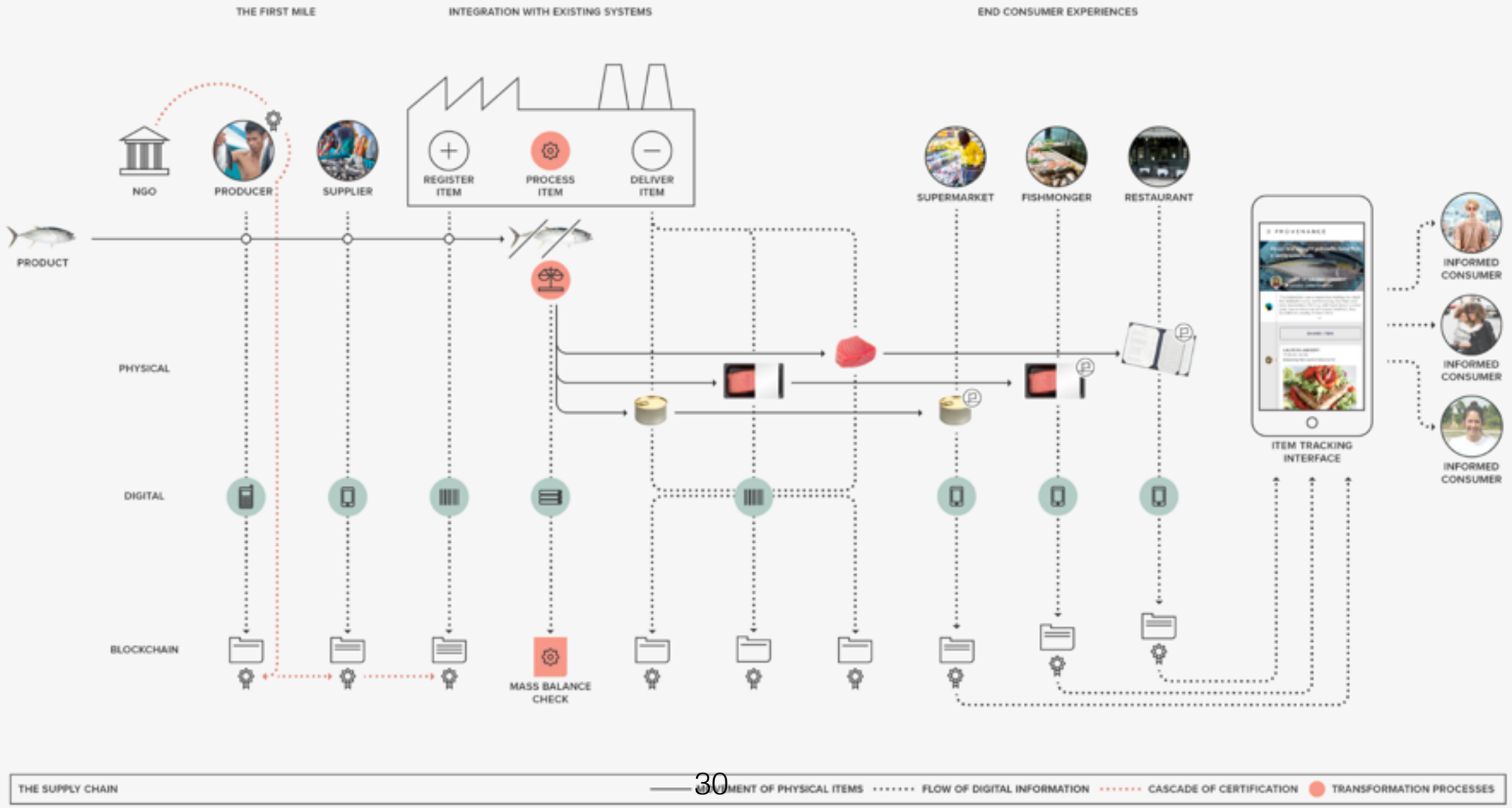
- Arc-Net (http://arc-net.io/) “a secure, immutable, trusted chain of custody for a product or asset” —> “Enhancing Brand Protection and Consumer Loyalty”

- Agridigital (http://www.agridigital.io/) “Trust & Transparency for Global Agricultural Supply Chains"

Provenance.Org — “Every product has a story”

- Start-up and social enterprise focussing 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, ie. used to record certification (organic/ Fairtrade).
- Several trials with Tesco/Co-Op/Soil Association

Tune Fish Example



Provenance.org technical approach

- Most information is stored on the digital platform.
- Ethereum is used to store snapshots of data (e.g. food certification, or data from smart phone 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.

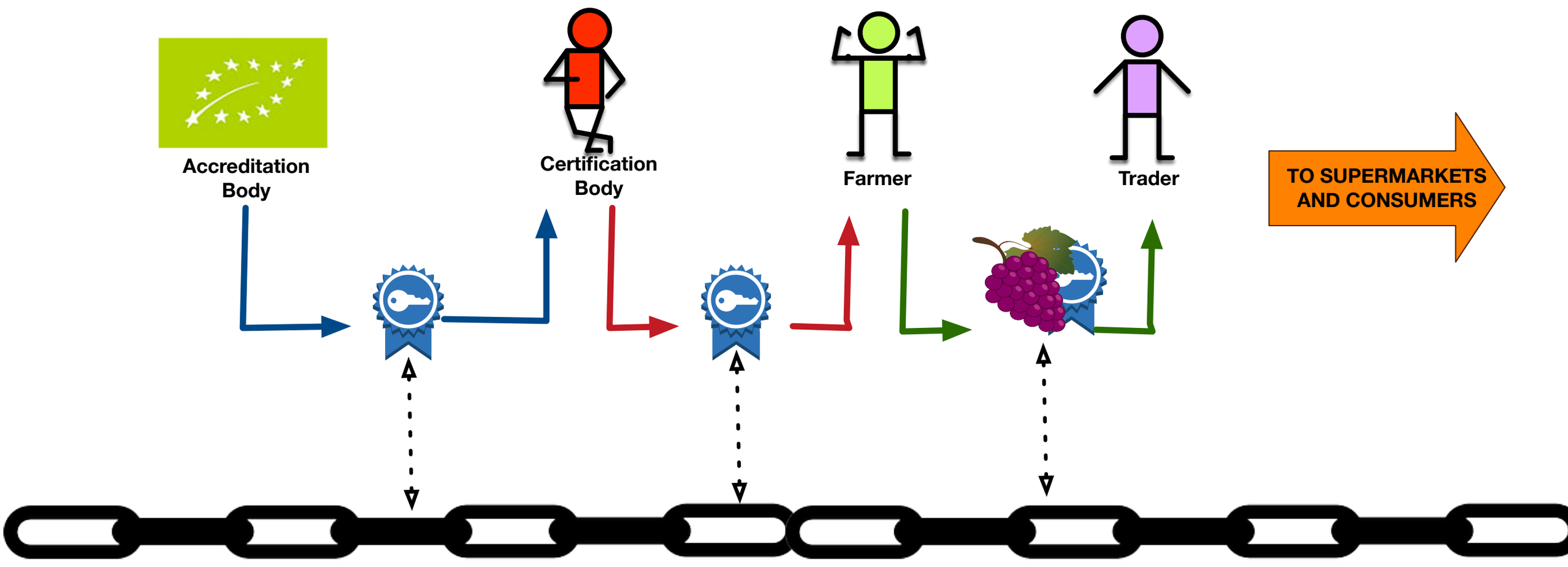
IBM and agrifood

- 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.

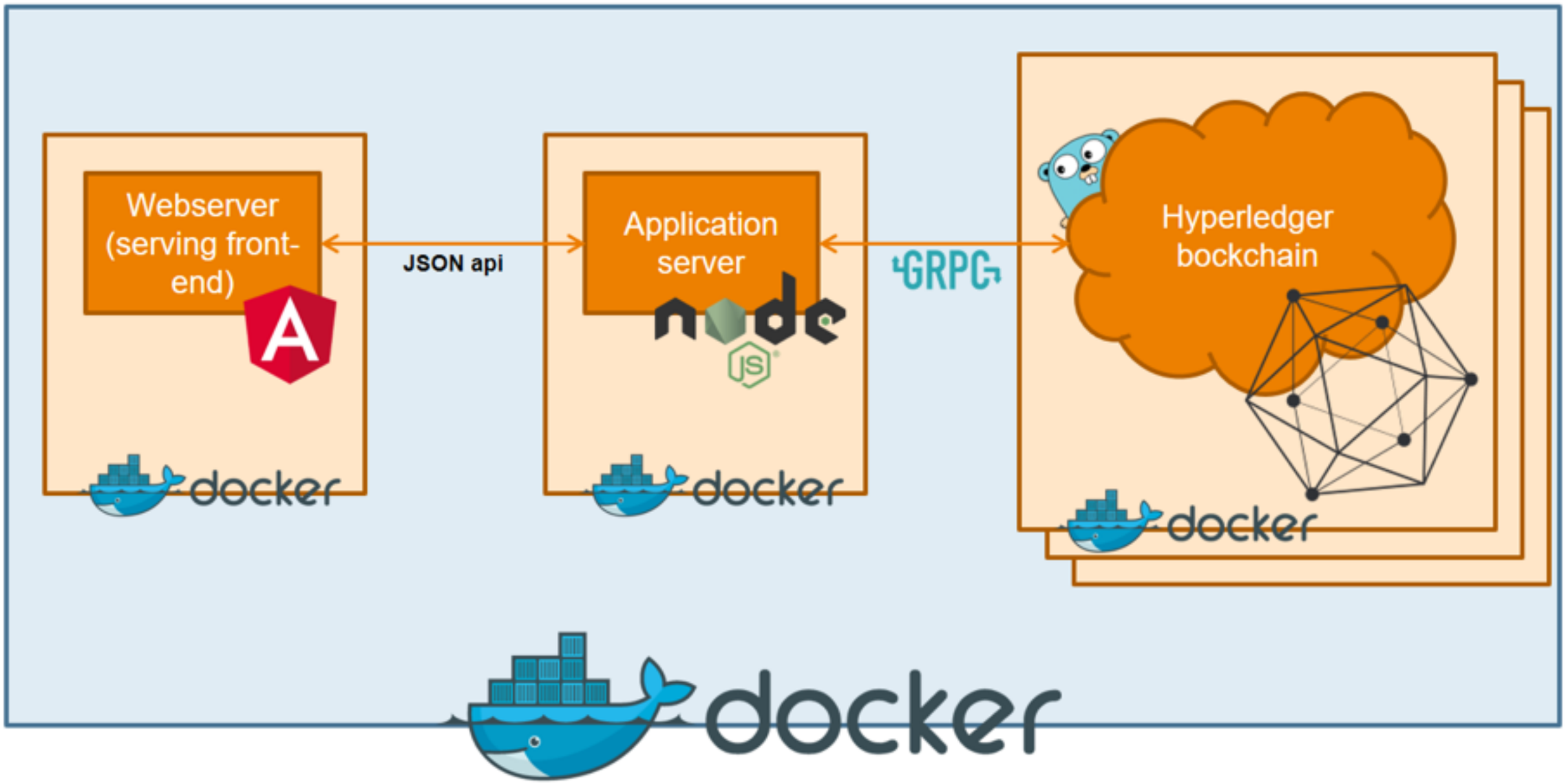
WUR/TNO Table Grape PoC

- Small project in collaboration with WUR, funded by Dutch EZ Ministry
- 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

Business Relationships



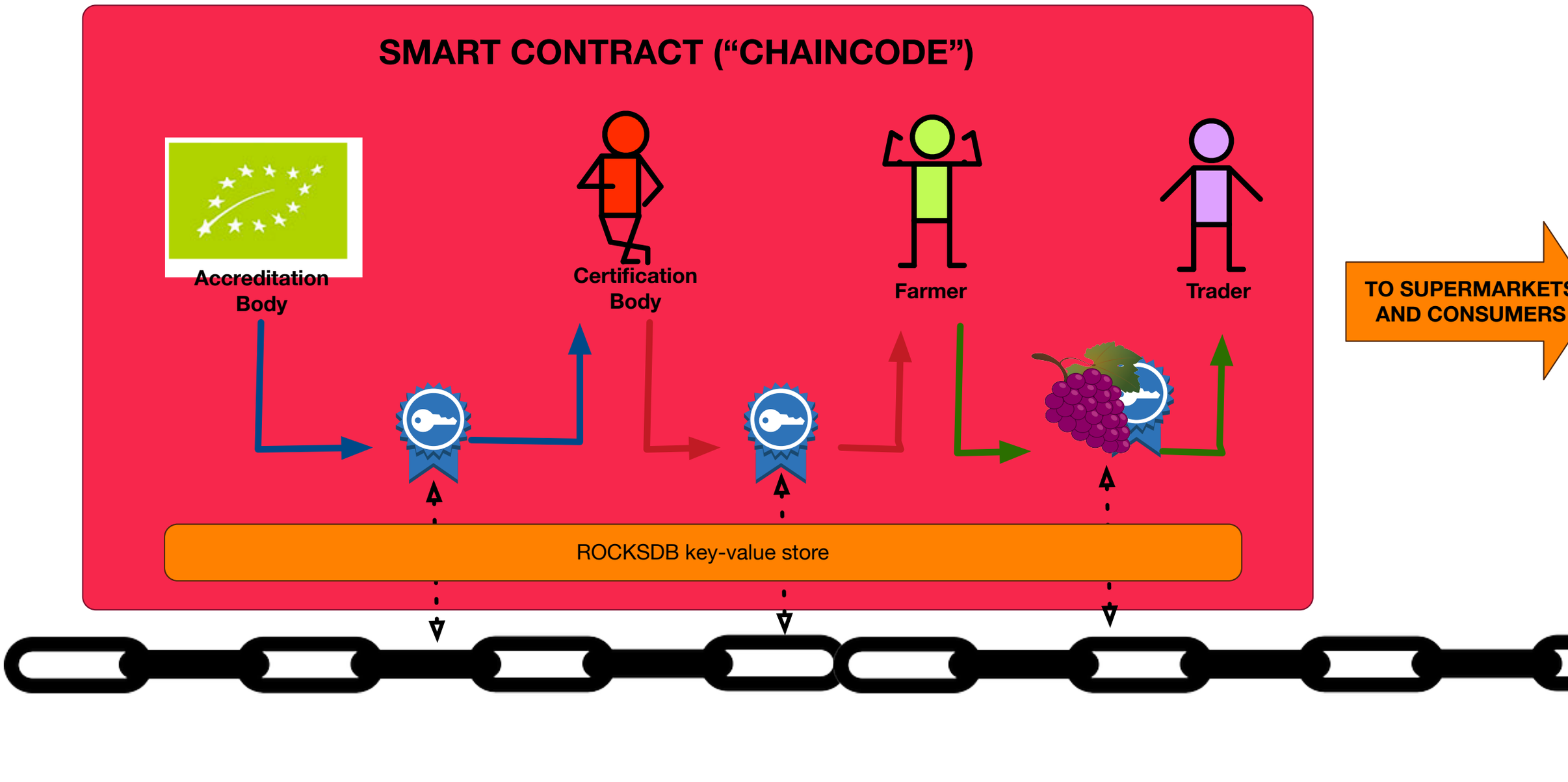
Basic Architecture



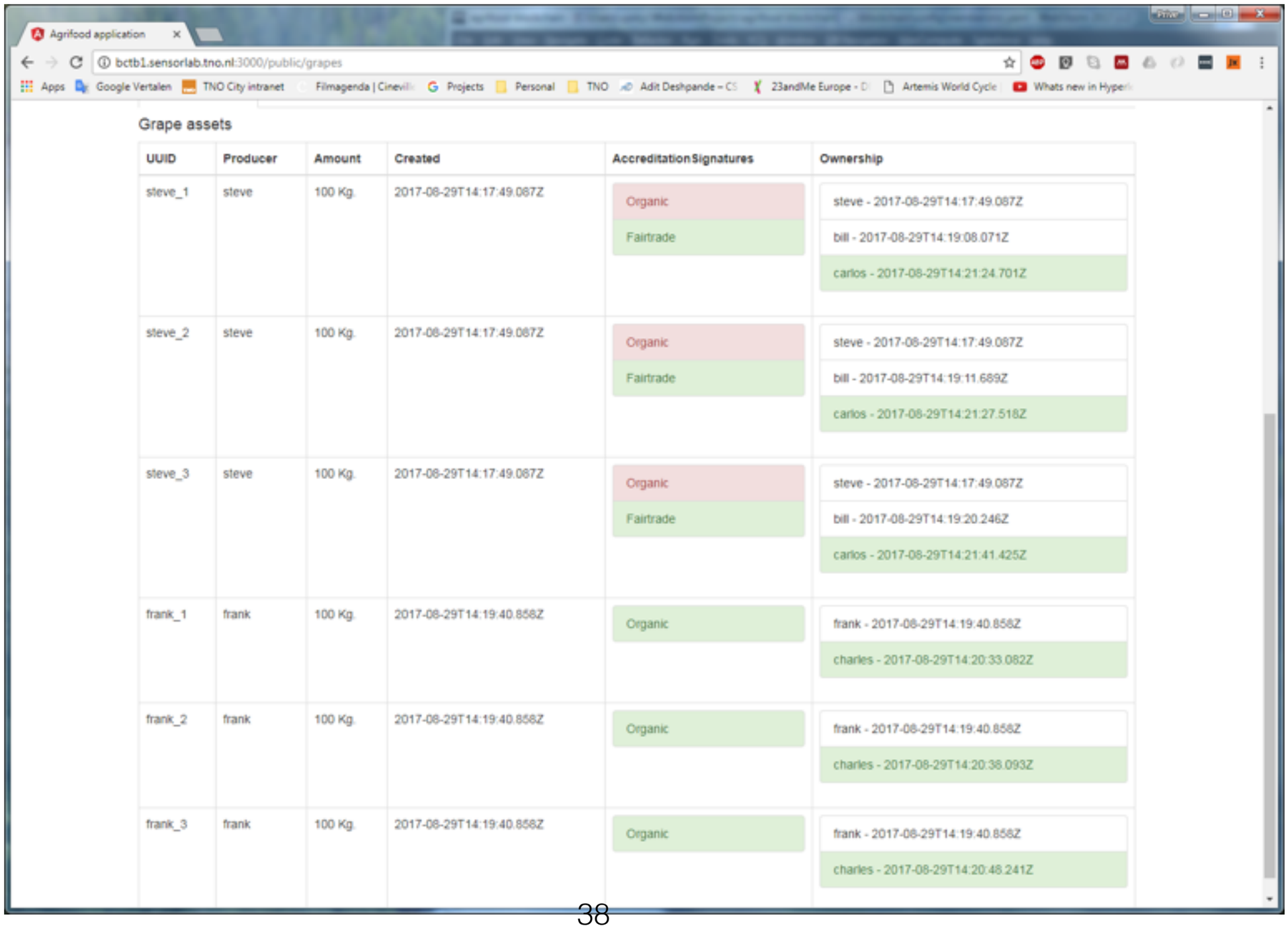
Technical design

- 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 (available shortly)

Smart Contract design



Simple frontend



Capabilities

- Real time update of data
- Capability to query smart contract for validity of certificate for a given consignment
- Cascading of certification and **revocations**
- All participants have transparent view on data = **greater trust (?)**
- Using a blockchain, all nodes have a complete set of the data.
- Impossible to alter transaction history i.e. permanent record/ data integrity.

Limitations 1

- 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.

Limitations 2

- Digital to physical interface
  - Does not prevent GIGO (Garbage in, garbage out)
- Data standards and semantics
  - Writing to blockchain does not avoid need for semantics and data standards
  - We need agreed vocabularies, ontologies, and messaging standards to make such a system work.

Future Work for Grape Demo

- Scale up
  - Number of transactions
  - Number of participants
    - Number of smart contracts
- Consider different use cases (meat/eggs/vegetable oils/fish/ horsemeat etc.)
- Economics and business
  - What are the economic/business drivers (if any)?
  - Is there a coherent business model around this?

Other Use Cases and Applications

- (Apart from tracking and tracing)
- Registration of holdings, animal, plant and transactions
- Sustainability and ethical certifications of other commodities
- Mass balance recording (e.g. of nitrogen usage)
- Import & Export certificates
- Insurance - index insurance
- New financing flows - supply chain finance
- Development in developing countries (inclusiveness)

partly from Lan Ge

Open Issues - 1

- Huge interest in this new technology
- Main (valid) motivation is **immutability** of transactions, and **visibility** of transactions.
- Expectation that this leads to increase in **trust**, reduction of **transaction costs**, and **disintermediation**. All this still to be proven.
- Transaction speed (throughput) still a major issue (especially for Ethereum's technology).

Open Issues-2

- **Transparency**: If data is transparent, business confidentiality is lost! If data not transparent (hashed or encrypted) what is the advantage?

- **Immutability**: If data can be updated then immutability is lost. If data cannot be updated then how to deal with changes in real world. (just recording changes can be done in version control/wiki type environment). **Also** GDPR makes immutability moot.

- **Trust**: Trust depends on transparency, business depends on opacity. How will this work?

Open Issues - 3

- “a single view of truth” - major selling point of blockchain technology
  - This ignores the need for semantics and data standards
  - (Remember the Mars orbiter …)

Conclusions

- Blockchain technology has considerable potential but many technical problems
- Because the technology transfers more business relationships into code (and ‘code is law’) great care is needed
- The technology will have a major role in the agrifood system, but the right use cases need to be found.

Thank You

QUESTIONS

Acknowledgements

- The WUR/TNO Table Grape project was led by Lan Ge and Christopher Brewster, demonstrator developed by Jacco Spek, with active input from Bob Klasse, Marieke de Ruyter de Wildt, and financial support of the Dutch Ministry of Economic Affairs (EZ) - http://blockchain.tno.nl/projects/agrifood/

- Other thanks are due to Vinay Gupta, Oskar van Deventer, Trent McConaghy, among others

Image credits:

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