

# Integrating On-chain and Off-chain Governance for Supply Chain Transparency and Integrity

Shoufeng Cao  
Research Fellow

Queensland University of Technology

The 5<sup>th</sup> Symposium on Distributed Ledger Technology  
Brisbane, Australia

23 Nov 2021

# University-Industry Collaboration Team



Marcus Foth

Interaction Design,  
Blockchain and  
HCI – QUT



Shoufeng Cao

Blockchain for  
supply chain  
innovation  
– QUT



Thomas Miller

Blockchain,  
cryptography,  
and Computer  
Science – QUT



Xavier Boyen



Warwick Powell

Industry partners –  
BeefLedger and  
Smart Trade  
Networks



Charles  
Turner-Morris



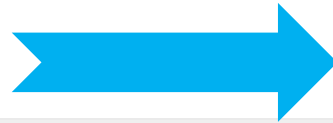
Felicity Deane

Regulation and  
Governance  
– QUT

**Smart Trade Hubs Project**  
Funded by **Future Food Systems CRC**

# Our Journey

BeefLedger Export  
Smart Contract Project  
(2018-2020)



Smart Trade Hubs  
Project  
(2020-2023)



Blockchain and IoT for  
beef supply chain  
traceability and the value  
of product provenance



Blockchain and distributed  
infrastructure for asset registration  
and tracking as well as credentialed  
trade and finance

# Supply Chain Transparency vs Integrity

Collection and sharing of relevant information  
pertaining to supply chain activities

Disclose information about an  
agent's operations at each link  
of the chain and how products  
are distributed to consumers

**Supply chain  
transparency**

**Supply chain  
integrity**

Adhere to good practice of  
being honest and show a  
consistent dedication to  
integrity in supply chains

Accountability resulted from transparent  
decision processes and behaviours to others  
could force companies to behave with integrity

# Is Distributed Ledger Technology a nature fit for supply chains?

**Supply chains** often involve geographical dispersed actors from production to consumption

- It is featured by **decentralised and distributed management** in a multi-actor environment



**Distributed ledger technology** is a digital system for recording transaction information across locations by multiple actors.

- It gives information control – access, validate and record – to the user and promotes **transparency and integrity**
- It is a solution for Know-Your-Supplier (KYS) and know-Your-Customer (KYC)

# Blockchain Technology for Supply Chains

Blockchain is one form of distributed ledger technology that uses **cryptography** to store data in each **block** and therefore provide more confidence in data integrity.

Supply chains are one of the promising areas of blockchain application with a focus on improving **traceability, visibility, transparency** and **integrity**.

Various proof-of-concept (PoC) work and experimental use cases have been reported to design and implement blockchain-based supply chains across industries



Research has shown the potential of blockchain for transforming various aspects of supply chain

# Challenges for Blockchain-enabled Supply Chains

Existing use cases largely build on the on-chain governance rules developed for cryptocurrency blockchains to **record and store some critical data points**.

Current on-chain governance rules **cannot** ensure the authenticity of information registered into a blockchain network, which could lead to the **garbage in and garbage out** issues



Blockchain applications to a multi-stakeholder supply chain can **generate a large amount of data** and increase the issue of **data storage cost and efficiency**.

The rise of **off-chain data storage**. However, a proper disclosure of **off-chain decision-making processes is often lacking**, which can jeopardise transparency, compliance and integrity expectations.

# Integrating On-chain and Off-chain Governance

**On-chain governance** has formal and rigid coding structures that restrict the system's flexibility to react to unforeseen circumstances.



**Off-chain governance** has less formal and unstructured formats that can complement the weakness of on-chain governance.

**Bitcoin and Ethereum** are two typical examples that use a combination of **offline coordination and online code modifications** to implement update changes.

However, they are **criticised for allowing miners and developers to play the role in coordinating and achieving consensus between stakeholders** in off-chain governance.

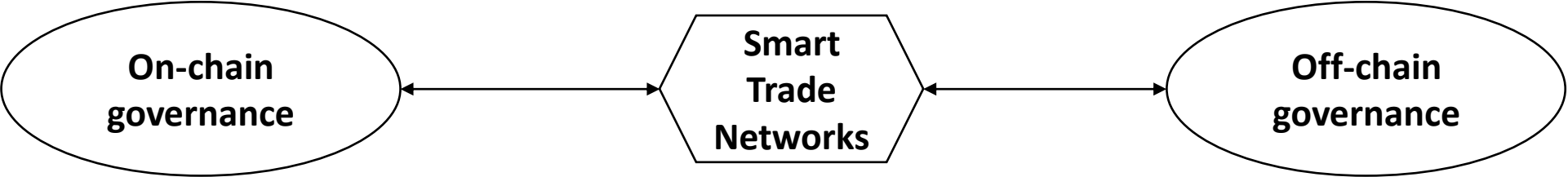


# An Integrated On-chain and Off-chain Governance

Our approach is **prototype, deployment and learning by doing**.  
Our PoC work is working in progress



Based on the problems identified previously, we co-develop an integrated on-chain and off-chain governance for supply chain transparency and integrity



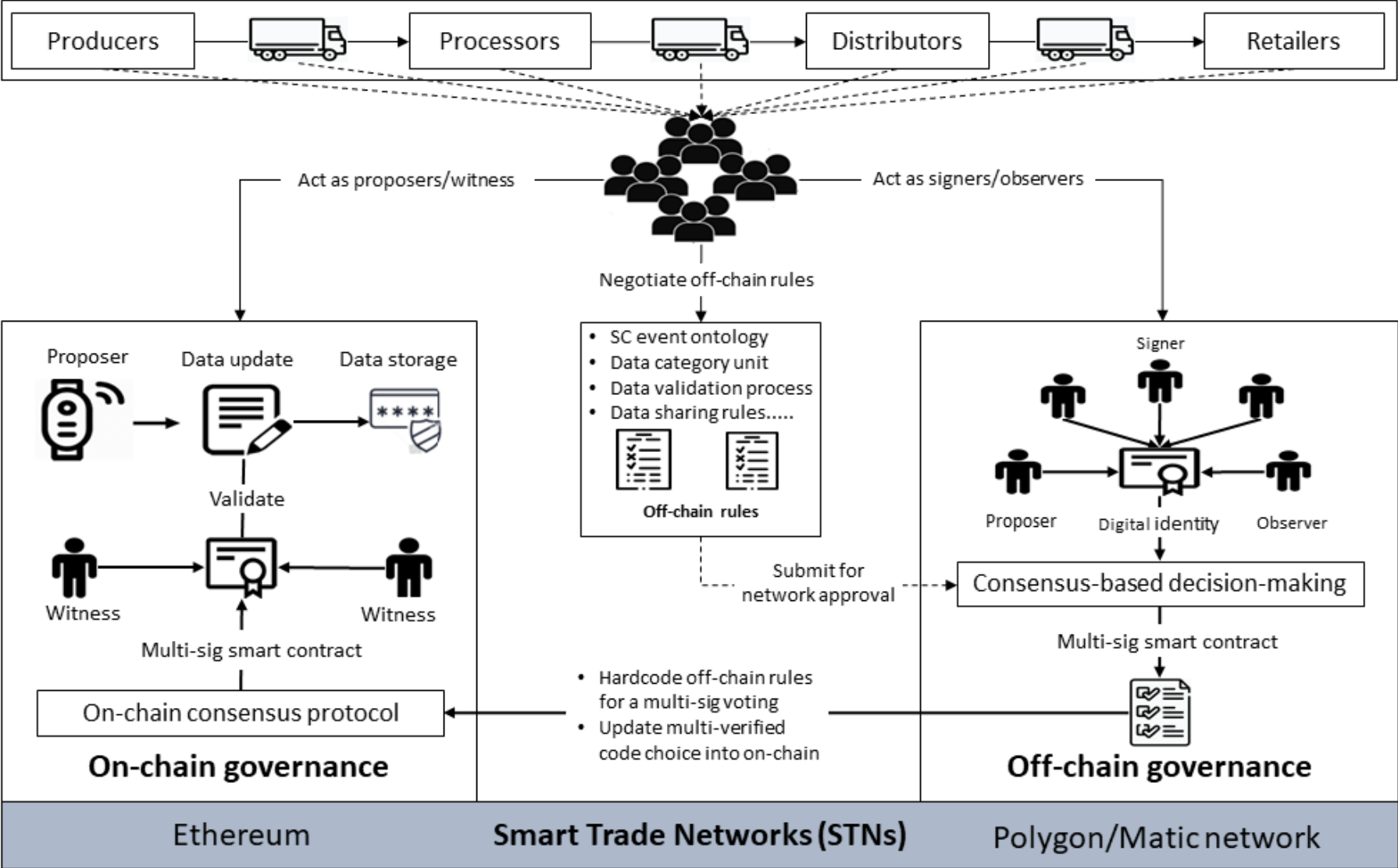
Deployed on Ethereum Mainnet  
Multi-sig for data proposal and validation

Multi-sig mechanism  
for track, trace and  
trade

Deployed on Polygon/Matic network  
Multi-sig for off-chain decision-making processes



# An Integrated On-chain and Off-chain Governance Architecture

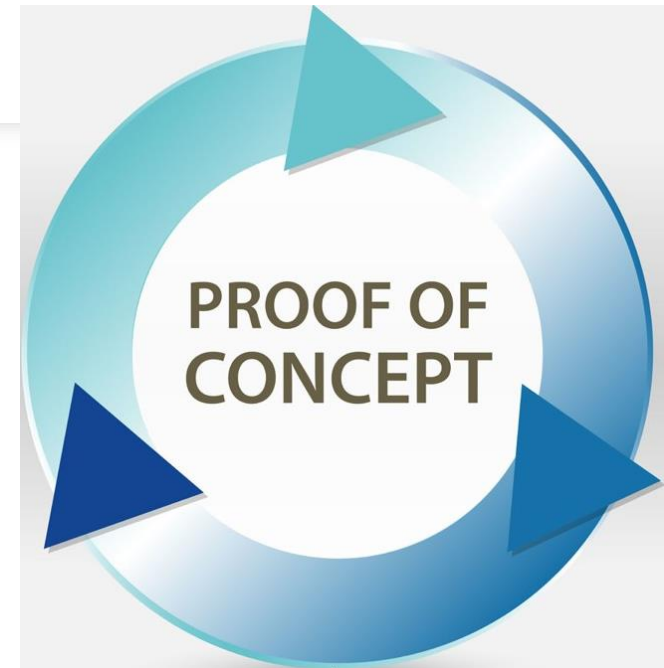


# Proof-of Concept (PoC) Design and Implementation

## Poc Design

The on-chain governance mechanism is designed with the multisig smart contract user interface on the Smart Trade Network (STN) blockchain that enables supply chain actors to set on-chain transaction rules.

The off-chain governance mechanism is built with the multisig smart contract user interface on the Polygon/Matic network that allows supply chain members to finalise off-chain rules.



**Poc Implementation:** Illustrated with an Australian beef supply chain.

# PoC and User Interface for Off-chain Governance

Forms Pending Tx Approved Tx

Set Multisig Name

Add Signer

Remove Signer

Change Requirement

Token Transfer

Token Minting

Profile

Name Data Integrity in Supply Chains Association Inc. STN Master Multisig

Why are you wanting to change name?

WARNING: This account is on the Polygon/MATIC Network do not use on Ethereum.

Contract address: 0x756B9136dA312443c6b2C5262d88Be592dd8A4A7

Contract creation salt: 26353485784

Description: Data Integrity in Supply Chains Association Inc. STN Master Multisig

Required: 2/5

Withdrawal Fee: 0.3%

Transactions: 13

Members

Tom

Santiago Del Valle

Warwick Powell #3 Matic / STN

0x62DA044e517223519445cBa247647dE7c4254d85

Ross James Honeyman

Token Balances

STN: 810.0

STN5: 0.0








USDT: 0.0









HDREC: 0.0


Id	Destination	Action	Submitted By	Confirmations	Description
0	0xFAAd3...F6762	setMultisigName	Tom	1	The account needs a name.
1	0xFdc4D...59a60	mint	Santiago Del Valle	1	Devs testing minting 1000 STN
2	0xFAAd3...F6762	setMultisigName	Tom	1	Following what Warwick put on here: <a href="https://docs.google.com/drawings/d/1J-Ma2YoHWzOjUfa2EbOtypUfizK-cEyzGSwpwRd1a2w/edit">https://docs.google.com/drawings/d/1J-Ma2YoHWzOjUfa2EbOtypUfizK-cEyzGSwpwRd1a2w/edit</a>
3	0x756B9...8A4A7	addOwner	Tom	1	Adding Warwick because he is the co-founder of STN.
4	0x756B9...8A4A7	changeRequirement	Tom	1	Changing to 2 signers to test with Warwick.
5	0x756B9...8A4A7	addOwner	Tom	2	Adding Charles Morris who is also a director and founder of STN and DISCA.
6	0x756B9...8A4A7	withdraw	Tom	2	Proof of Community Effort Resource Transfer to Proof of Community Effort Admin governance circle.
7	0x756B9...8A4A7	addOwner	Santiago Del Valle	2	Ross Honeyman is being added. Ross is a director of STN.


# PoC and Use Interface for On-chain Governance

## My Actions

 View Wallet Info	 Add new Member	 Remove Member	 Change Signing Requirements
 Set Contracts	 View Pending Transactions	 View Approved Transactions	

<b>Timestamp:</b>	March 25, 2021
<b>Active</b>	YES
<b>Block Number</b>	1784805
<b>Company</b>	0xe46F...CC42  
<b>Entry</b>	73
<b>Date Issued</b>	May 30, 2018
<b>LBRY video</b>	<a href="#">Link</a>
<b>LT</b>	Y
<b>PIC</b>	QKPD0130
<b>Date Issued</b>	July 10, 2020
<b>Species</b>	Cattle
<b>Timestamp</b>	2021-03-25T03:34:25.000Z
<b>Validated</b>	2361
<b>Visual ID</b>	2361
<b>Transaction</b>	0x791b...0c76  
<b>Timestamp:</b>	March 25, 2021
<b>Block Number</b>	1785328
<b>Company</b>	0xe46F...CC42  
<b>Entry</b>	81
<b>Required</b>	2
<b>Timestamp</b>	2021-03-25T05:45:10.000Z
<b>Validated</b>	
<b>Transaction</b>	0xc98d...fccd  

PRODUCE 

MEASURE 

# Contributions and a Way Forward

## Research Contribution

- **Technical contributions:** The development of multisig smart contracts and a compatible network to accommodate two different blockchain networks for an integrated on-chain and off-chain governance
- **Theoretical Contribution:** Blockchain governance for supply chain transparency and integrity management



## Limitations and Future Research

- The proof-of-work makes use of MetaMask to bridges two different blockchain networks for on-chain and off-chain integration.
- The Design and evaluation of cross-chain architecture that can enable more effective and cost-effective communications between two or more independent blockchain networks.
- Practical implementation with supply chain stakeholders.

| THANK YOU

Shoufeng Cao

Queensland University of Technology

[Shoufeng.cao@qut.edu.au](mailto:Shoufeng.cao@qut.edu.au)

