Thesis Project Portfolio

Blockchain Architectural Proposal for Radical Transparency of IoT Records in Supply Chains

(Technical Report)

Stakeholder Conflict in Shaping of Smart Supply Chains

(STS Research Paper)

An Undergraduate Thesis

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Robert Attiucs Owens

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Department of Computer Science

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Executive Summary

This thesis portfolio provides technical and socio-technical research to answer: how can technology increase transparency and efficiency in convoluted, global supply chains? In current supply chains, partners have difficulties verifying that their contractual agreements' terms were met. Regulators have difficulties tracing the origins of products or verifying the safety of products. Finally, consumers do not have full information about where products came from and what unethical practices may have been used to create them. Of all candidate technologies, this research focused on blockchain, a digital ledger, integrated with Internet of Things (IoT) technologies to provide data on the timing, location, and conditions of goods. The research focused on the food industry because of three constraints: timing, transportation conditions, and ethical & sustainable sourcing. These constraints are common among other supply chains so results can be adapted to other industries as well. All of these constraints can be monitored by IoT data increasing transparency. And an effectively designed blockchain can ensure that the transparency provided by IoT data is trustworthy between untrustworthy stakeholder partners that compose a supply chain. The three main stakeholder groups, businesses, regulators, and consumers, each have a bundle of preferences. Some of the preferences between stakeholders align, while others are in conflict with one another. This research identified misaligned incentives between stakeholders and designed a technological proposal in an attempt to create the most value for society as a whole and not any specific stakeholder.

The sociotechnical portion answers: how can blockchain and IoT technologies be developed to increase global supply chain transparency in the food sector? To answer, research was conducted as to how each group benefited from the existence of the technology. More importantly, the research analysis identified conflicts between stakeholders as to the ideal extent

of data transparency on the blockchain. For example, a business would not want the shipping rates it has negotiated to become public because other shipping companies could undercut them. In addition to researching the incentives of different stakeholder groups, two real business cases were considered. Walmart operates a limited private, centralized blockchain to track pork in China and leafy greens in the Americas for contamination and quality control. Whereas IBM attempted to facilitate *TradeLens,* a public, distributed blockchain for international shipping vessels but failed to implement the technology as a viable business. While either solution overall increases the efficiency of the food supply, the Walmart case only enables transparency for Walmart's internal use eliminating any utility for the consumers and regulators. Ideally, projects like *TradeLens* come to fruition as they provide more benefits to all stakeholders via increased transparency.

The technical portion of the thesis portfolio is a high-level blockchain proposal to achieve a maintainable public ledger that also allows for limited private information. The proposed blockchain attempted to solve the following issues. How to trust the accuracy of IoT data? How to limit blockchain storage size at scale? And how to achieve permissioned access to specific data on the public blockchain? The proposal is built on the research of others for the latter two questions and offers a unique solution to the first. What is unique is that data published to the blockchain, *data blocks*, are endorsed by other stakeholders in *feedback blocks* as appearing legitimate – presumably after receiving a shipment. Typically, blockchains proactively filter inaccurate data before incorporating it into the ledger. In this proposal, however, businesses risk their reputation when publishing inaccurate data because other businesses, regulators, and consumers can indicate inaccurate data in the *feedback blocks*. Two other features of this proposal are that data blocks can *archive* or be removed from the

blockchain and permissioned access to private information in *data blocks* is conducted by smart contracts using access control list principles. The limitations of this proposal are that no test blockchain network is implemented. And that the design is intentionally broad and vague for future research to implement granular details and adapt the general architecture for specific industry requirements.

The value of this research is in a realistic vision of how increased technological presence in global supply chains could be designed and to what effect. What needs to happen next is a dialogue between stakeholders to design a system collaboratively, similar to how the IEEE standardizes technologies. Otherwise, the technology is only likely to be implemented by and for the exclusive private benefit of large multinational companies like Walmart. With respect to the technical proposal, while there is creativity and value in the blockchain design it is unique in its purpose. Most decentralized blockchains rely on some currency of monetary value to create effective incentive structures. By contrast, this proposal was designed to be a semi-decentralized technological institution to increase information which requires a different design mindset. Others should treat it as a first iteration and redesign to improve the robustness and reliability of this proposal to achieve these institutional objectives. Overall, while this thesis portfolio is not exhaustive, it is a best-faith effort to proactively envision how to maximally increase transparency and efficiency in a globalized world.