# Autonomous Agents Powered by Blockchain Technology

## Overview

Traditional Internet of Things (IoT) systems typically rely on Cloud or centralised systems for decision making and storage, resulting in an additional layer in the threat model when it comes to cyber-attacks [1]. This includes having a single point of failure, denial of service (DoS) attacks and trusting that data has not been manipulated.

Distribute Ledger Technology (DLT) was first introduced by Satoshi Nakamoto in 2008 with the original cryptocurrency Bitcoin [2] which offered a novel way for nodes to reach consensus in a decentralised manner via Proof of Work (PoW). Nodes of the blockchain network each store a copy of the ledger on their system removing the single point of failure [3]. Trust in a third-party intermediary is also no longer required as the system is sufficiently ‘decentralised’ and reaches ledger consensus (Nakamoto Consensus) [3].

Blockchain offers multiple improvements over traditional cloud or centralised systems by removing the single point of failure, trust in a third party intermediately such as a cloud provider and potential data manipulation by bad actors as data on the blockchain is considered immutable [4]. Blockchain technology comes with its own drawback, the main one being scalability (e.g., Bitcoin can process up to a maximum of 7 transactions per second currently) [5]. This is commonly referred to as the ‘Blockchain Trilemma’ [6] in improvements in decentralization, security, or scalability results in a compromise to the other properties.

Regarding current research relating to Blockchain and IoT, most of the research is currently focused on data immutability, data access permission and device authentication [7]. On the contrary, there is very little research into decentralised state changes within the IoT landscape. An example of a state change in this context could be a temperature sensor changing the temperature value of the room. Current implementations normally rely on a centralised entity to make state changes to IoT devices such as consuming a RESTful service to instruct IoT devices to perform another action [8] (add another example). This approach comes with the same drawbacks of centralised systems as mentioned previously.

Autonomous Agents are pieces of software that act and can function without any human intervention by reacting to states and events in their respective environment [9]. A change of state in the context of IoT devices could be a change in sensor data. An example of an autonomous agent present today is a computer virus [10], as it requires no human interaction at all and essentially operates in a machine-to-machine basis, using the host computer to ‘jump’ to another computer to infect.

As previously mentioned, in most IoT blockchain solutions, decision making is still carried out by a centralised entity, which comes with a host of security & maintenance threats [1]. This type of environment is hostile towards autonomous agents as downtime and cyber security threats disrupt autonomy of systems. A Blockchain network acting as a medium between IoT devices has the potential to promote total autonomy between devices and enable true peer-to-peer communication.

## Project Aims & Objectives

This research aims to complete the following objectives regarding autonomous agents and blockchain technology:

* Evaluate, systematise, and contextualize existing knowledge in regard to autonomous agents and blockchain technology
* Establish a framework that allows for efficient peer-to-peer communication via the blockchain between IoT devices

## Methodology

Testbed and system design will be carried out using NUFarms state of the art Agri-Tech test bed.

### Testbed

Data will be gathered from a wide variety of sensors within the context of Agri-Tech. Types of data includes location, optical, electro-chemical, mechanical, dielectric soil moisture, air flow, mobile apps, crop management systems (e.g., semios & arable) and a range of digital farm management programmes.

### System Design

We will design a lightweight blockchain system to decentralise data management and enforce the correct execution of standard programmes through the smart farming cycle: Pre-planting, Cultivation, Growing, Harvesting, Storage, Processing, Wholescale marketing, Retail marketing, and Consumption. We will study the requirements of such systems via evaluation of our testbed and beyond, leveraging our links with stakeholders across the entire food supply chain. This will inform our design choices e.g. platform type (e.g. Hyperledger, Ethereum, new blockchain) and access type (permissioned, permissionless, mixed). Our design will particularly include sensor data coming directly from the farm requiring a lightweight design. We will design our system in such a way that sensors will access and interact with the system securely without having to sync with the full blockchain (off‐chain vs on‐chain).

## Training & Abilities

Training will be required in Agri-Tech systems (e.g., crop management) and data analysis. Training in programming is not required as I worked as professional software engineer for many years and have experience in all programming paradigms as well as blockchain programming at the application layer (smart contract development).

The student will be trained in agri-tech systems (e.g. crop management), data analysis, sensor and blockchain programming, with support from both schools and NUFarms. Both Schools offer funding for student travel, e.g. to conferences, and to support knowledge transfer to varied stakeholder groups. The student will enhance their multidisciplinary skills by working with different groups, and will engage with industry and conduct impactful research.

## References

1. Fernandez-Carames, T. and Fraga-Lamas, P., 2018. A Review on the Use of Blockchain for the Internet of Things. *IEEE Access*, [online] 6, pp.32979-33001. Available at: <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8370027> [Accessed 29 September 2021].
2. Nakamoto, S., 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. [online] Available at: <http://www.bitcoin.org>.
3. Garay, J. and Kiayias, A., 2020. SoK: A Consensus Taxonomy in the Blockchain Era. Topics in Cryptology – CT-RSA 2020, [online] pp.284-318. Available at: <https://link.springer.com/chapter/10.1007/978-3-030-40186-3\_13> [Accessed 29 September 2021].
4. Kshetri, N., 2017. Can Blockchain Strengthen the Internet of Things?. IT Professional, [online] 19(4), pp.68-72. Available at: <https://ieeexplore.ieee.org/document/8012302> [Accessed 29 September 2021].
5. Croman K. et al. (2016) On Scaling Decentralized Blockchains. In: Clark J., Meiklejohn S., Ryan P., Wallach D., Brenner M., Rohloff K. (eds) Financial Cryptography and Data Security. FC 2016. Lecture Notes in Computer Science, vol 9604. Springer, Berlin, Heidelberg. <https://doi.org/10.1007/978-3-662-53357-4_8>
6. Zhou, Q., Huang, H., Zheng, Z. and Bian, J., 2020. Solutions to Scalability of Blockchain: A Survey. IEEE Access, [online] 8, pp.16440-16455. Available at: <https://ieeexplore.ieee.org/document/8962150> [Accessed 29 September 2021].
7. Conoscenti, M., Vetro, A. and De Martin, J., 2016. Blockchain for the Internet of Things: A systematic literature review. 2016 IEEE/ACS 13th International Conference of Computer Systems and Applications (AICCSA), [online] Available at: <https://ieeexplore.ieee.org/abstract/document/7945805> [Accessed 29 September 2021].
8. Hang, L. and Kim, D., 2019. Design and Implementation of an Integrated IoT Blockchain Platform for Sensing Data Integrity. Sensors, [online] 19(10), p.2228. Available at: <https://www.mdpi.com/1424-8220/19/10/2228> [Accessed 29 September 2021].
9. Lieberman, H., 1997, March. Autonomous interface agents. In Proceedings of the ACM SIGCHI Conference on Human factors in computing systems (pp. 67-74).
10. Buterin, V., 2014. DAOs, DACs, DAs and More: An Incomplete Terminology Guide. [online] Blog.ethereum.org. Available at: <https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/> [Accessed 29 September 2021].