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Design and Implementation of BlockAPI - a Blockchain-as-a-Service Platform

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Abstract: Organisations wishing to leverage blockchain technology's (BCTs) in their value chain processes are often deterred by the high costs to build and maintain blockchain-based solutions and infrastructure, and a lack of both organisational technical know-how and buy in from management. To remedy this, we develop BlockAPI, a lightweight Blockchain-as-a-Service (BaaS) platform, primarily for use in multi-stakeholder environments that required trusted data. BlockAPI BaaS exposes access-controlled application programming interface (API) endpoints for organisations to send data to and verify data on a blockchain network. The BlockAPI BaaS platform is used by applications in logistics, manufacturing, farming and financial services, and enables these use cases to easily and cost-effectively integrate blockchain technology as a trust registry in their SC processes and existing business systems, thereby lowering the cost and technical know-how barriers to BCT adoption in the process. Future work includes adding support for minting non-fungible tokens and conducting a robust performance evaluation.

Keywords: API, Blockchain-as-a-Service (BaaS), Supply Chain

1. Introduction

Blockchain technology (BCT) is an immutable ledger that allows transactions to occur amongst parties in a decentralized fashion, with an inbuilt ability to reach and prove consensus on the shared state of the ledger [1]. It can be used as a shared trust registry in multi-stakeholder environments such as supply chains (SCs). SCs are complex adaptive systems that encompass interconnected actors and organizations [2]. A blockchain-enabled SC comprises of a decentralized distributed system that uses blockchain to collect, store and manage key product information of each product throughout its life cycle, creating a secure, shared record of exchange for each product along with specific product information [3]. The use of BCT improves SC transparency, reduces fraud, enhances end-to-end tracking (traceability), and streamlines operations [3] [4].

However, building and deploying blockchain solutions, and by extension, organisational adoption of BCT is hampered by factors which include: the lack of availability of skilled technical resources to implement these solutions; complex infrastructure requirements; expensive infrastructure setup, maintenance and monitoring costs which can be prohibitively expensive for businesses; and the nascency of BCT which has resulted in a wide variety of blockchain networks (often with minimal differentiation) and difficulty in selecting an appropriate network for a specific use case for the long term [5].

Blockchain-as-a-Service (BaaS) has arisen as a potential solution, allowing enterprises to short-circuit the steep learning curve associated with BCT and cost-effectively utilise BCT without creating and managing their infrastructure [5]. BaaS is made possible by exposing blockchain-integrated application programming interfaces (APIs) that are hosted on cloud computing and distributed infrastructure [6]. BaaS can be applied to many domains including financial services, legal, SC, asset tracking, healthcare and digital identity.

1.1 Objectives

The research objectives for this study are as follows:

1. **RO1 -** Design and develop a lightweight BaaS implementation for SCs.
2. **RO2 -** The BaaS implementation should be pluggable into existing business systems i.e. seamless integration and a flexible schema.
3. **RO3 -** The BaaS platform should be energy friendly.
4. **RO4 -** The BaaS platform should be cost and time saving for businesses.

1.2 Contribution

To address the challenges of building and deploying blockchain solutions, and adoption of BCT by organisations, we develop a lightweight BaaS offering – BlockAPI BaaS - which combines BCT with cloud computing. Our BaaS offering is primarily used for integrating with existing business systems and anchoring value chain data atop a blockchain. It is accessible via an API and can be accessed by one or more organisations that each require a blockchain trust registry in the SCs. Crucially, organisations using the BaaS offering will not need to spin up and maintain their own blockchain infrastructure or require a high level of technical know-how, and their technical teams can focus more on business logic and application functionality and be more productive [6] [7].

1.3 Organisation

The rest of the paper is organised as follows: Section 2 introduces the background and motivation for the work; Section 3 and 4 details the design and implementation of the BlockAPI BaaS platform, respectively; Section 5 discusses how the BlockAPI BaaS platform works and compares it to alternative BaaS implementations; and Section 6 summarises our work and lists recommendations for future work.

2. Background

2.1 Challenges with Adoption of Blockchain Technology in Organisations

Various studies suggest that developing, deploying and maintaining blockchain solutions is hampered by infrastructure and running costs, organisational technical know-how and buy in from management, and regulatory uncertainty [5] [8] [6] [9]. [10] remark that the benefits of using blockchains and smart contracts to control business process executions might be diminished due to the high cost of implementation. [11] survey 212 small and medium enterprises (SMEs) in Johannesburg, South Africa, to identify the impact on adoption of blockchain that the following factors have: organizational readiness; trading partner pressure; government regulations and support; perceived benefits; competitive pressure; complexity; top management support; compatibility; and technological readiness. From this list, they narrow down the significant factors that enable adoption of BCT to compatibility; trading partner pressure; complexity; top management support; perceived benefits; and organizational readiness.

From a technical viewpoint, concerns regarding blockchain interoperability, performance (i.e. throughput) and energy consumption abound. Blockchain networks are not natively interoperable and organisation specific implementations and configurations of BCT solutions are typically proprietary, heterogeneous and isolated, making interoperability a moving target that is difficult to reach. In addition, the scalability/performance of non-blockchain solutions (e.g. standard database systems) is often superior to that of blockchain solutions. Lastly, environmental concerns on the energy consumption of BCT exist, even more so in emerging economies that are faced with energy shortages [9]. The BCT-related energy concerns are applicable in instances where a blockchain network makes use of a proof-of-work (PoW) consensus mechanism that requires continuous operation of energy intensive hardware for verifying transactions and creating new blocks, unlike the proof-of-stake (PoS) consensus mechanism that does not make use of energy intensive hardware and alleviates the concern. However, this distinction is unknown, particularly to non-technical management within organisations.

2.2 Cloud Computing and Blockchain-as-a-Service

The concept of cloud computing is a type of on-demand service that enables small, medium, and large businesses to access various IT resources such as databases, applications, and computing power through pay-as-you-go models [7]. According to [12], the top 5 cloud computing platforms are Amazon, Microsoft, Alibaba, Google and Huawei.

BaaS represents a novel approach that provides managed blockchain infrastructure, development APIs, scalability and flexibility, leveraging the benefits of BCT inside the framework of the cloud computing infrastructure [13]. Representational State Transfer (REST) APIs offer a simple way to integrate with a software system, allowing the access and use of data over the internet via the Hypertext Transfer Protocol (HTTP), and are used for building distributed software systems whose components are loosely coupled [14] [15] [16] [17]. BaaS platforms are therefore cloud-based platforms that enables customers to develop, host, and run BCT applications, leveraging APIs. BaaS platforms can be categorised as Platform-as-a-Service (PaaS) applications [7].

2.3 Existing Solutions and Related Work

There are existing BaaS platforms which can be categorised as commercial or experimental/research based. The commercial offerings, which are often referred to as managed services are typically enterprise grade and priced accordingly, tend to exhibit vendor lock-in characteristics, and often based on an enterprise grade permissioned blockchain such as Hyperledger Fabric [18]. These include: (i) IBM Blockchain Platform which enables a consortium of organizations to build and join a blockchain network based on Hyperledger Fabric [19]; (ii) Amazon Quantum Ledger Database [20] which is used to maintain an immutable, cryptographically verifiable log of data changes; (iii) Amazon Managed Blockchain which is a fully managed service designed to help organisations build resilient Web3 applications on both public and private blockchains (Amazon Managed Blockchain currently supports Ethereum, Polygon, Bitcoin and Hyperledger Fabric blockchains) [21]; (iv) Microsoft Azure Blockchain Service which is a managed service for building up and administering blockchain networks, and is compatible with several blockchain technologies, including Ethereum, Corda, and Hyperledger Fabric [22]; (v) Oracle Blockchain Platform Cloud Service which is a managed-permissioned blockchain designed for business based on Hyperledger Fabric and includes products for track and trace [23]. However, regarding adoption of specialized private blockchain cloud offerings, [8] notes that this remains surprisingly low, owing to the perception of blockchain needs to be decentralized.

Other BaaS platforms found in literature (i.e. experimental) include: (i) NutBaaS which offers functionality to deploy a network and smart contracts, and supports multiple blockchains including Hyperledger Fabric, Ethereum, EOS and Filecoin [24]; (ii) BlockPaaS which allows users to deploy and test blockchain protocols on IoT hardware and supports Ethereum [25]; and (iii) RBaaS which focuses on data redundancy and network resilience by extending blockchain deployment to the on-premises edge or private cloud with management capability from the public cloud, and is based on the FISCO BCOS consortium blockchain [26].

3. Design Strategy

3.1 BlockAPI BaaS Workflow

[13] note the structure of a BaaS platform as having cloud infrastructure, integration with a blockchain platform, a user interface, development APIs, and baked in security. Based on this, we design the BlockAPI BaaS platform workflow as follows: receive a JSON payload of data that needs to be stored on a blockchain from an exposed API endpoint; hash the payload; store the hashed payload on the blockchain; and return the transaction confirmation and metadata to the external sender application i.e. a tenant organisation's web application that sends data to the BlockAPI BaaS platform. This is shown in *Figure 1*.

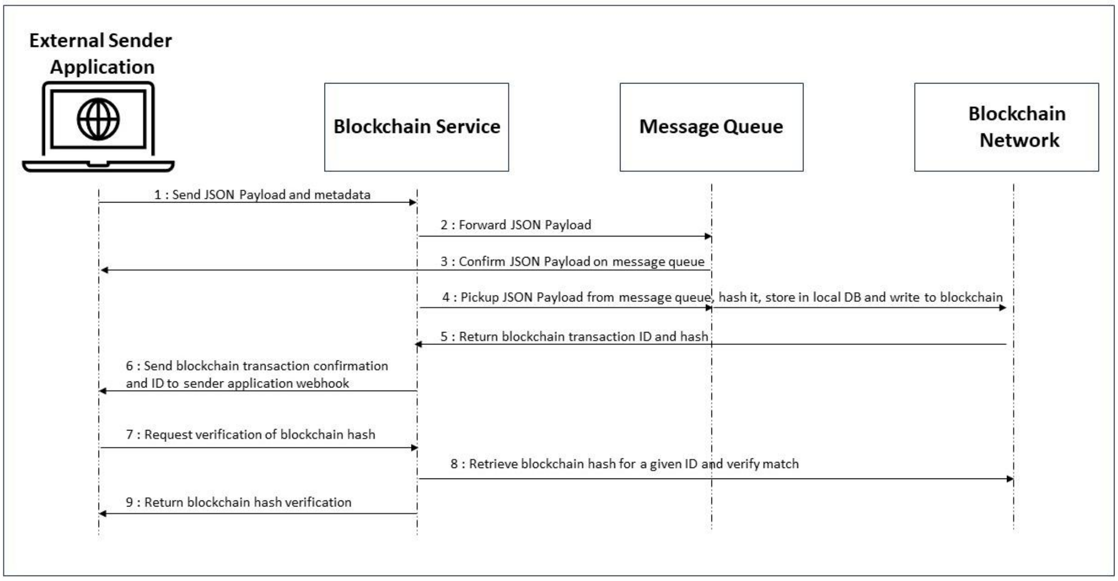

Figure 1: Illustration of the BlockAPI BaaS platform (i) receiving data that needs to be stored on the blockchain (i.e. a JSON payload) together with its metadata from an external sender; (ii) hashing the payload; (iii) storing the hashed payload on the blockchain; (iv) returning the hash, hash algorithm, transaction ID, and blockchain explorer URL to the external data sender; and (v) the external data sender (or another source) verifying the existence of the data on the blockchain.

3.2 Functional Requirements

Based on the BlockAPI BaaS workflow, we derive the following functional requirements (FR) for the BlockAPI BaaS platform:

1. **FR1** – Receive a data payload in JSON form, from an external sender application via an authenticated API endpoint.
2. **FR2** – Generate a hash of the received data payload.
3. **FR3** – Write the hash onto the blockchain.
4. **FR4** – Maintain context and blockchain status for all received data payloads.
5. **FR5** – Notify the external sender application of the outcome of the blockchain persistence for the data payload sent.
6. **FR6** – A user interface to allow an authorised admin to verify the existence of a data payload on the blockchain, using either the raw data payload or its hash, together with the reported transaction ID.

4. Implementation

4.1 BlockAPI BaaS Architecture

Conceptually, the BaaS platform is a REST API that allows one or more external sender applications to send cornerstone value chain event or product data to a blockchain. The high-level BlockAPI BaaS architecture is illustrated in *Figure 2*.

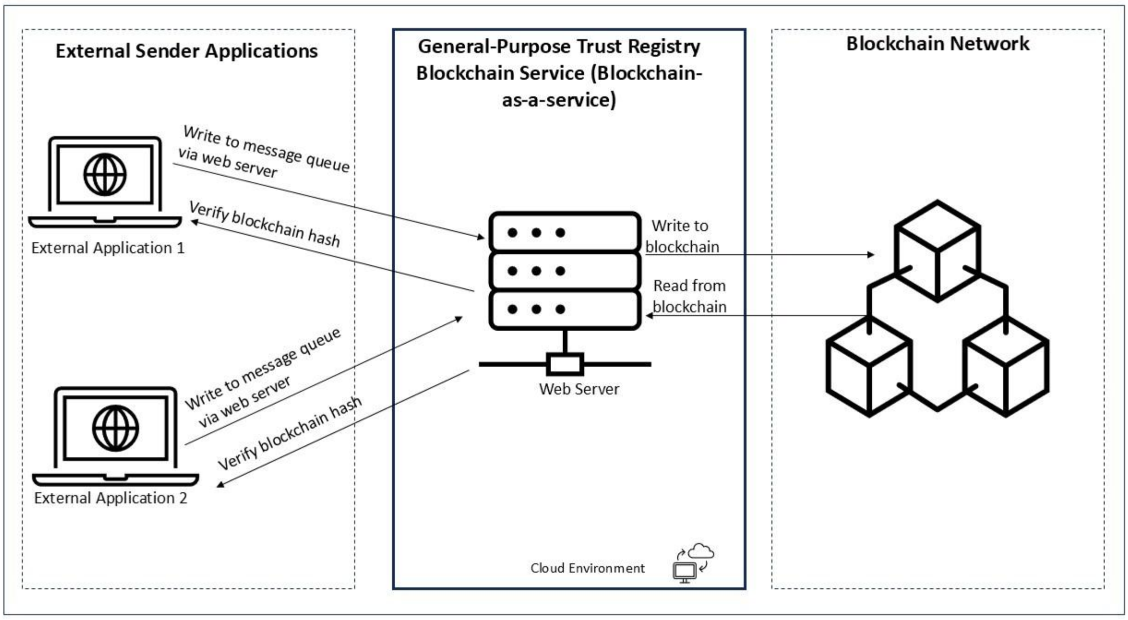

Figure 2: High-level architecture diagram for the BaaS, which securely writes cornerstone value chain event data from external sender applications to a blockchain network.

4.2 System Components

At a lower level, the BaaS architecture follows a microservices approach comprised of (i) a REST API service – the entry point and REST interface; (ii) a message queue for queuing of data payloads and asynchronous processing; (iii) a blockchain appender for consuming data payloads from the message queue, writing to the blockchain and returning a transaction confirmation to the external sender. See *Figure 3* below.

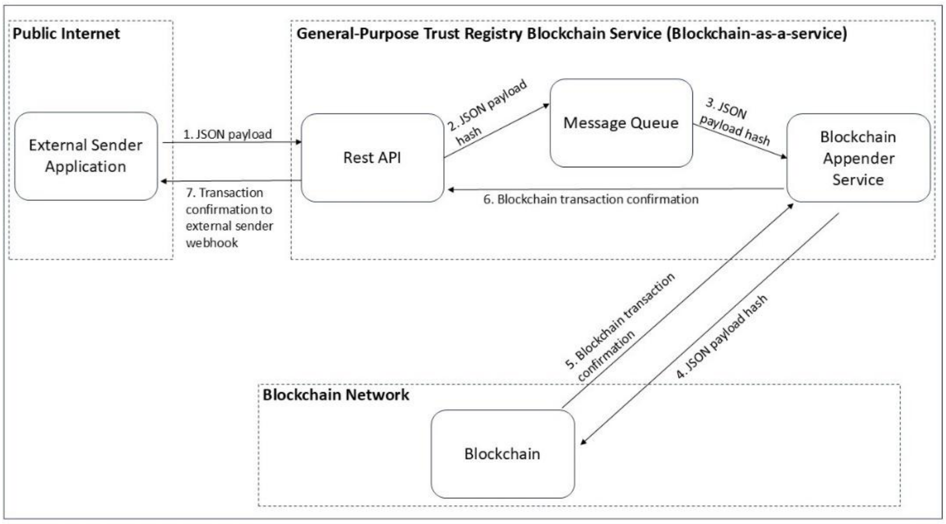

Figure 3: Component diagram for the BaaS platform, which consists of (i) a REST API service – the entry point and REST interface for external applications; (ii) a message queue for queuing of data payloads; (iii) a blockchain appender service for consuming data payload messages from the queue, writing to the blockchain and returning the transaction confirmation to the external sender. The flow of data of data through the different components is according to the numbered sequence.

These BlockAPI BaaS components are described below:

1. REST API service. This service is the BaaS entry point, providing the user interface for an admin to log into and configure external sender application API keys and blockchain networks, access API documentation and REST API functionality. Access to the BaaS

REST API endpoints by external sender applications (i.e. tenant organisations) requires a unique access token for each external sender application. This secures the API endpoints and is used to track API daily usage. Once the REST API receives a JSON payload, it hashes the payload to generate a fixed size fingerprint which will be placed onto the message queue for writing to the blockchain. The REST API service satisfies requirements FR1, FR2, FR4, FR5 and FR6.

2. Message queue. The message queue instance receives payloads to be written to a blockchain network. The use of message queues ensures scalability of the BaaS platform as external sender applications do not have to wait for a blockchain write to happen before receiving a response. Message queues store messages (data) and allow different terminals to connect to the queue to publish (producer) or subscribe to messages (consumer). They enable distributed computing and asynchronous communication and processing which is necessary for scalability and responsiveness [27]. This component satisfies requirement FR4.
3. Blockchain appender service. This service consumes messages from the message queue and then writes the data to the blockchain network. Currently, the blockchain network in use is the Algorand, a permissionless distributed ledger [28]. The Algorand blockchain network was selected for its secure, low cost and fast transactions (in contrast with the Ethereum blockchain where transactions are more expensive and do not achieve finality in seconds), and developer tooling support (in particular, the JavaScript SDK). In addition, it uses a Proof-of-Stake (PoS) consensus mechanism which alleviates energy consumptions associated with Proof-of-Work (PoW) blockchains – which earlier is noted as a hindrance to adoption. Once data is written to the blockchain, the appender receives the transaction ID, packages this with the identifying metadata for the external sender application, notifies the external sender application and updates its own local datastore. This service implements requirements FR3 and FR5.

5. Discussion

5.1 Applications of BlockAPI BaaS

The BlockAPI BaaS is application agnostic and has been integrated with four external sender applications:

1. Smart Cooler Box - a cold chain track and trace internet-of-things (IoT) solution for tracking temperature and GPS location of medical specimen [29]. This platform makes use of IoT sensors for measuring GPS and temperature data via a Raspberry PI which then sends this data to the blockchain and requires a lightweight mechanism to do so given the resource constraints on a Raspberry Pi. The Raspberry Pi sends data to the BlockAPI BaaS via a REST API call and the only requirement is that it should be connected to the internet.
2. A Greenhouse Gas Observatory platform in which emissions were being tracked and reported by an aluminium production facility in Midrand, South Africa (i.e. the foundry sector) [30]. This solution also makes use of a IoT sensors connected to a Raspberry Pi that is installed on the production floor of a manufacturing facility and sends data to the BlockAPI BaaS via a simple REST API call over the internet.
3. The ILIMA platform which is used by farmers to manage poultry production in Limpopo, South Africa (i.e. the agricultural sector) [31]. The ILIMA platform is an Android application that allows farmers to manage production processes, track movement of finished goods and access markets. These key value chain processes such as a change in stock type, custody and location are tracked via the blockchain, and the use of the BlockAPI BaaS provides a separation of concerns - it enables the developers of the ILIMA platform who do not have expertise in blockchain development to focus

on Android mobile development and integrate with BlockAPI using any programming language they are proficient in.

4. The EcoChain platform which is a University of Cape Town research project demonstrating the use of BCT in standardising environmental, social and governance (ESG) reporting by financial institutions [32]. By integrating with BlockAPI BaaS, the research team behind the EcoChain platform has been able to focus on developing a standardised ESG reporting template and undertake their research endeavours much quickly (i.e. save time and cost) without needing to undergo the steep learning curve of learning how to integrate natively with BCT.

The REST API exposed by BlockAPI BaaS accepts SC product/process specific data which is the key information that can be used to prove certain attributes of a product/process or provide other data as feedback to SC stakeholders [3]. This data is the form of key-value pairs which makes it flexible to use across different domains, as demonstrated by the examples in logistics, manufacturing, farming and financial services value chains, which highlight the simplicity and ease of integration with the BlockAPI BaaS.

5.2 Comparison of BlockAPI BaaS to Other BaaS Platforms

Table 1 compares the features provided by BlockAPI to other BaaS offerings. These features include: (i) network orchestration – the ability to deploy a blockchain network; (ii) network monitoring – ability to monitor health of a blockchain network; (iii) support for smart contract deployment – the ability to deploy and test smart contracts; (iv) API integration – offers an API interface for SaaS tenants to write to the blockchain; (v) support for multiple blockchains – the platform is blockchain-agnostic and can support different types of blockchain networks; (vi) can integrate with IoT hardware – the platform can be accessed from an IoT device such as a Raspberry Pi; and (vii) network reliance – the ability to recover in the event of network disruption i.e. offline support.

BlockAPI is a lightweight BaaS platform that primarily offers the ability to write and verify data on a blockchain network by means of a REST API. It does not offer advanced features such as network orchestration, monitoring and support for smart contracts. BlockAPI currently is integrated with energy-friendly and low cost Algorand blockchain. Algorand transaction fees are fixed at 0.001 ALGO (equivalent to 0.00021 USD as of 27 Feb 2025), regardless of the transaction type or complexity, making them very cost-efficient. Given the lightweight and generic nature of BlockAPI BaaS, there is potential for it be deployed at a national level, evidenced by India’s National Blockchain Framework which details rapid development of blockchain based applications along with OpenAPIs via a national blockchain API [33].

Table 1 – Comparison of BlockAPI to other BaaS offerings.

BaaS Platform	*NutBaaS*	*BlockPaaS*	*RBaaS*	*BlockAPI*
Network Orchestration	Yes	Yes	Yes	No
Network Monitoring	Yes	Unknown	Yes	No
Support for Smart Contract Deployment	Yes	Yes	Unknown	No
API Integration	Unknown	Unknown		Yes
Support for Multiple Blockchains	Yes - Hyperledger Fabric, Ethereum EOS, Filecoin.	No – Only supports Ethereum.	No – only support FISCO BCOS consortium blockchain.	Yes – currently supports Algorand blockchain and is being extended to support blockchains with SDK integrations.
Can Integrate with IoT Hardware?	Unknown	Yes	Unknown	Yes
Network Resilience	Unknown	No	Yes	No
Data Migration	Unknown	Unknown	Unknown	No

In this section, we have demonstrated how BlockAPI BaaS is lightweight and provides integration by means of a REST that accepts SC data in the form of key-value pairs which makes it flexible to use with an organisations existing data schema – allowing it to easily plug in to existing business systems. The BlockAPI BaaS platform is application agnostic - it can support different applications from different organisations and domains, and is blockchain agnostic - it can integrate with multiple blockchain networks, thereby avoiding vendor lock-in.

BlockAPI BaaS writes data to a blockchain network in a hashed form to prove its integrity and provide traceability and transparency. The use of REST APIs enables the application agnostic property, as an application can send data if it confirms to the expected structure of the exposed API endpoint. The hashing of data is achieved by using a hash function which is a one-way mathematical operation in which an input of arbitrary length is compressed to a result with a fixed length, thereby allowing for proof of integrity and efficient use of storage space [34], [35]. Hashing ensures data of a fixed size is written to the blockchain, which keeps the blockchain transaction cost minimal, and provides a level of quasi-data privacy.

Further, we have also noted how it leverages the low-cost transactions and energy friendliness of the Algorand blockchain, making it both cheap and sustainable. The BlockAPI BaaS, abstracts the complexities of BCT, allowing organizations to focus on developing blockchain applications and services, in line with remarks by [13], and satisfies the research objectives of this study.

5.3 Limitations

The limitations with BlockAPI BaaS include: it is blockchain agnostic and employs a modular design to allow it to integrate with multiple blockchains but it is currently integrated with only the Algorand blockchain; BlockAPI BaaS assumes the existence of a trusted centralised party (i.e. a trust anchor) to host the service which does not align with the decentralized ethos of BCT but may be necessary for digital inclusion [36]; the data passed through the service is currently stored on a public blockchain which may be a concern for private data (even though it is hashed); and a robust performance and cost evaluation has not yet been carried out.

6. Conclusion

This paper presents the POC BlockAPI BaaS platform which is intended to simplify blockchain integration for organisations wishing to provide data integrity and verification in multi-stakeholder environments. By abstracting the integration into a blockchain network and providing a simple to use REST API that is integrated with a low-cost blockchain (Algorand), the BaaS platform lowers the cost, reduces BCT implementation time, and lowers infrastructure and technical know-how barriers to entry for organisations to integrate and maintain blockchain as a trust registry into their SC processes. Behind the scenes, the BlockAPI BaaS platform receives a JSON payload via the REST API, hashes it and writes it to the Algorand blockchain. The transaction confirmation is sent back to the external sender application, thereby closing the transaction loop.

Future work includes integration with an Ethereum Virtual Machine (EVM)-compatible blockchain such as Ethereum or Polygon POS, given the widespread adoption of Solidity. In addition, integration with alternative scalable layer-1 blockchains such as Solana will provide support for higher transaction throughput than Algorand if required. Further, in its current form, BlockAPI BaaS does not support migration of data between blockchains and minting of non-fungible tokens (NFTs) which will be valuable features. Regarding data privacy, enhancement of on-chain data privacy can be enhanced by signing of data (even hashed data) using digital signatures. Lastly, a robust evaluation of performance and costs will be useful to evaluate the distributed BlockAPI BaaS architecture, and the extent to which it lowers the overall costs (both transaction and cloud hosting costs) associated with blockchain integration.

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