

# **Application Landscape of Blockchain Technologies.**

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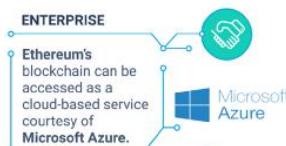
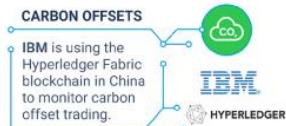
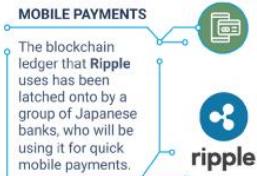
# Growing Interest on Blockchain Technology

- The number publications indexed by Web of Science:
  - 2 in 2013
  - 4 in 2014
  - 21 in 2015
  - 118 in 2016
  - 521 in 2017
  - 1,080 in 2018

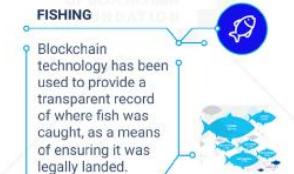
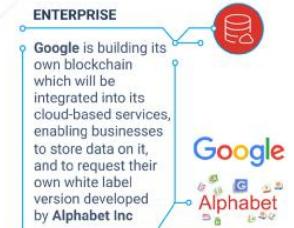
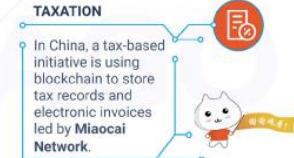
# Blockchain Technology

## Behind the success of Bitcoin

IoT	Supply Chain	EHR	Copyright Protection	KYC	Land Registry
Data Sharing	Cryptocurrency	Smart Grid	Insurance	Smart Agriculture	Smart Homes
E-Commerce	E-Governance	Social Networking	Education Certificate	File Sharing	Crowd Funding
Postal System	E-Voting	Data Provenance	E-Governance	Asset Transfer	Criminal Record Sharing
		Finance	Many More....		



# 50+ BLOCKCHAIN REAL WORLD USES CASES



Source  
Destination  
Number of  
seats  
Car Type  
Time of  
Departure

Image Credit:  
[www.leewayhertz.com](http://www.leewayhertz.com)



# Blockchain to Disrupt Uber

## Problems with Existing Platform

- High fees due to intermediaries
- Lack of Transparency
- Lack of Safety Standards

## Actors

- User
- Rider
- Legal Authorities

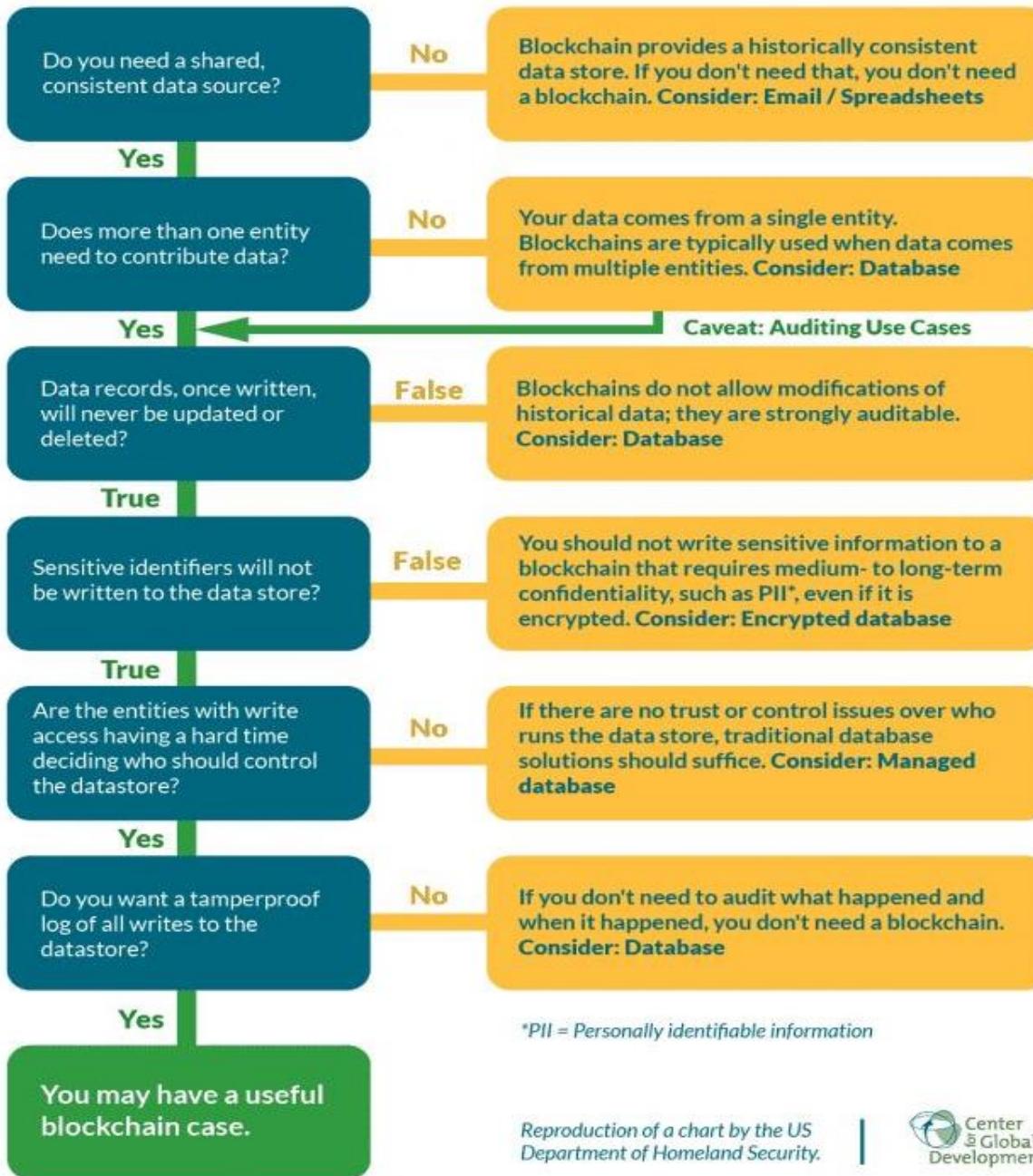
*"Instead of putting the taxi driver out of a job, blockchain puts Uber out of a job and lets the taxi drivers work with the customer directly"* - Vitalik Buterin

# Framework for Blockchain use case Evaluation

*Image Credit: NITI Aayog, India*

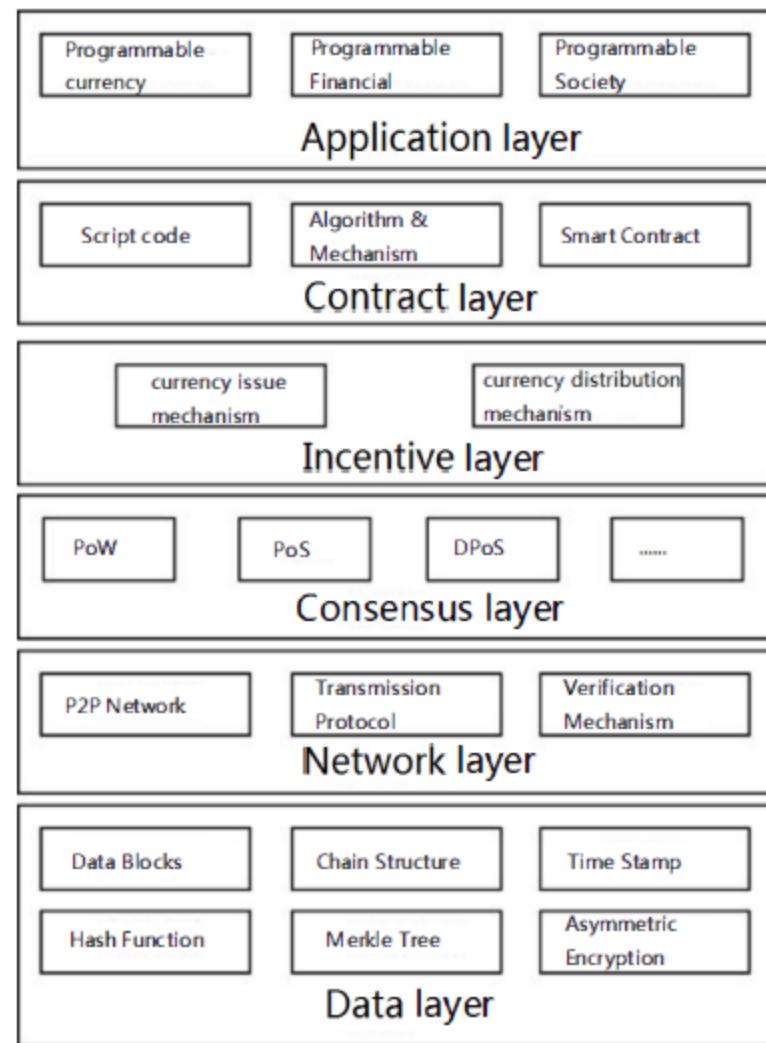


# Do You Need a Blockchain?



\*PII = Personally identifiable information

# Layered Architecture



# Blockchain-based Supply Chain Traceability: Token Recipes model Manufacturing Processes

Martin Westerkamp, Friedhelm Victor and Axel Küpper

Service-centric Networking

Telekom Innovation Laboratories, Technische Universität Berlin  
Berlin, Germany

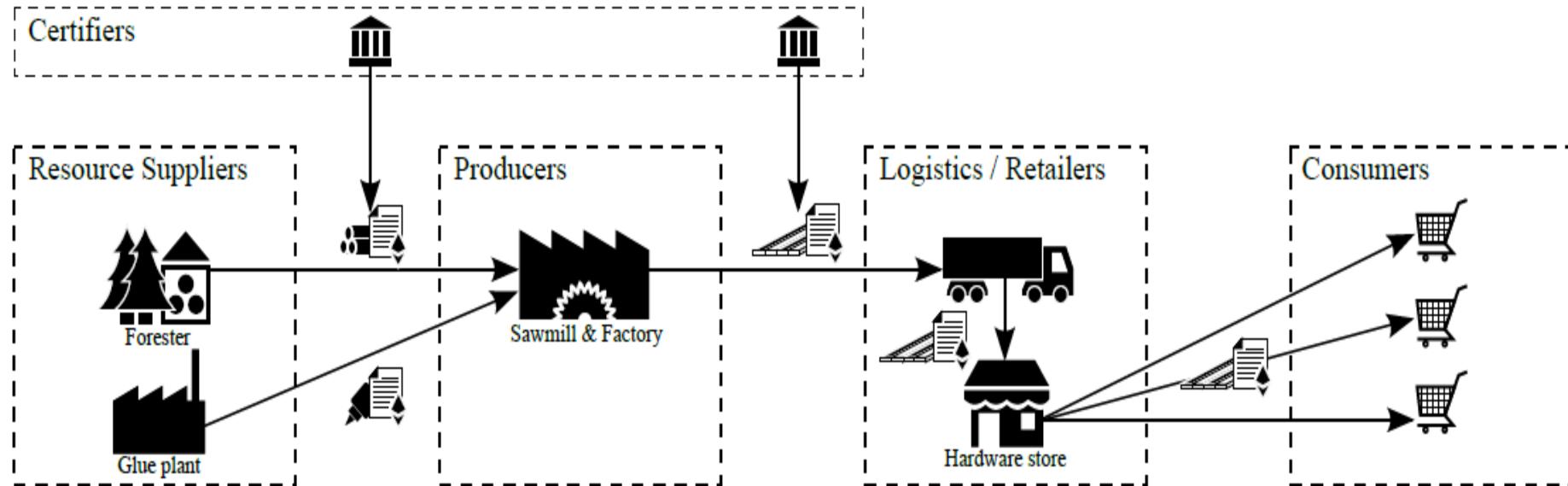
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*Abstract*—Growing consumer awareness as well as manufacturers' internal quality requirements lead to novel demands on supply chain traceability. Existing centralized solutions suffer from isolated data storage and lacking trust when multiple

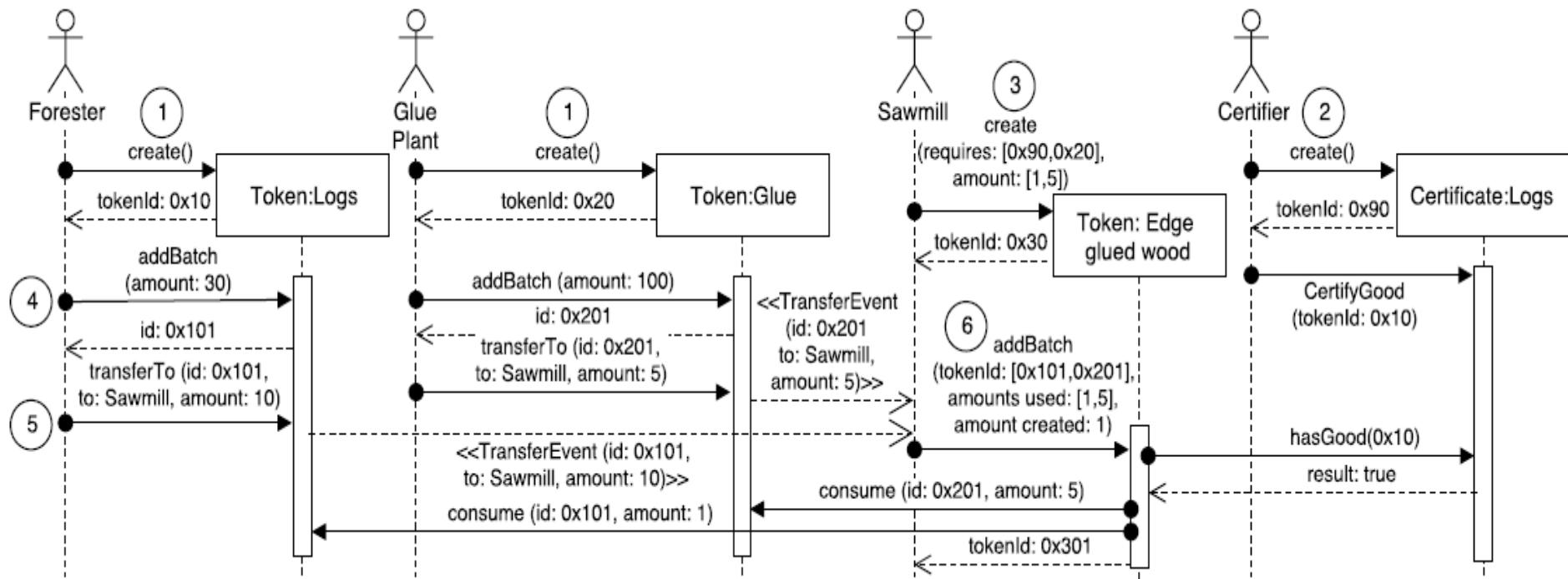
isolated data storage and unsatisfactory standardization in communication and data formats [5], [6].

Recently, blockchain technology has been proposed for

# Supply Chain



# Use Case of Supply Chain



## Blockchain-based Trusted Computing in Social Network

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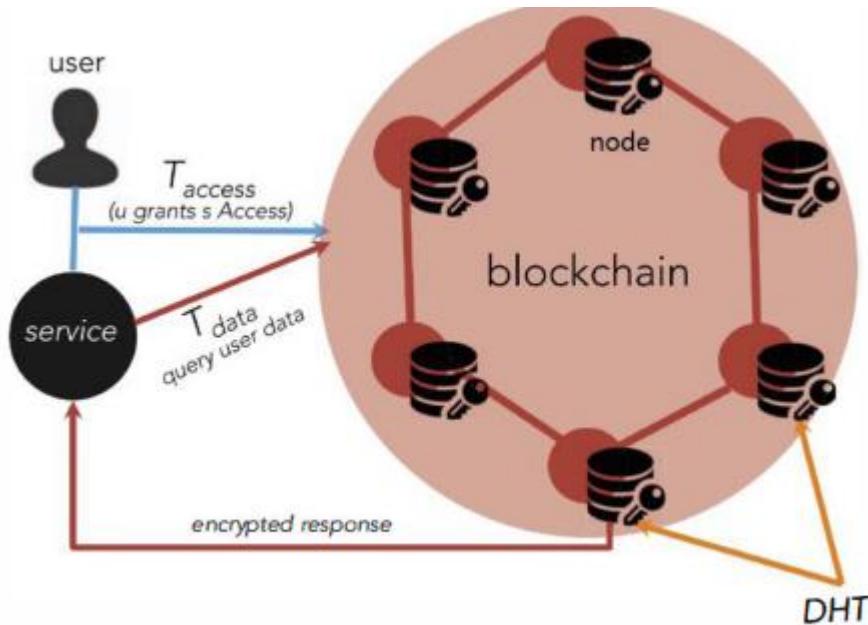
**Abstract**—MIT Media Lab employed blockchain to describe a decentralized personal data management system (i.e. Decentralizing Privacy) that ensures users own and control their data without authentication from a third party. In this paper, we employ a better encryption algorithm from NTT Service Evolution Laboratory to enforce the “Decentralizing

Today, data is a valuable asset in our economy [7]. Facebook, the largest online social-network, collected 300 petabytes of personal data since its inception – a hundred times the amount the Library of Congress has collected in over 200 years [8].

In recent years, a new class of accountable systems

# Data Privacy Management (at MIT)

- Discrete Hash Table (Inter Planetary File System, IPFS)
- Two Transactions:  $T_{access}$  and  $T_{data}$



As illustrated in Fig. 2, the three entities consisting the system are mobile phone users, interested in downloading and using applications; services, the providers of such applications who require processing personal data for operational and business related reasons; and nodes, entities entrusted with maintaining the blockchain and a distributed private key-value data store in return for incentives. The blockchain accepts two new types of transactions:  $T_{access}$ , used for access control management; and  $T_{data}$ , for data storage and retrieval.

For example, a mobile phone user installs an application that uses the platform for preserving her privacy. As the user signs up for the first time, a new shared identity (user, service) is generated and sent, along with the associated permissions, to the blockchain in a  $T_{access}$  transaction. Data collected on the phone is encrypted using a shared encryption key and sent to the blockchain in a  $T_{data}$  transaction, which subsequently routes it to an off-blockchain key-value store, while retaining only a pointer to the data on the public ledger (the pointer is the SHA-256 hash of the data).

# Blockchain for IoT Security and Privacy: The Case Study of a Smart Home

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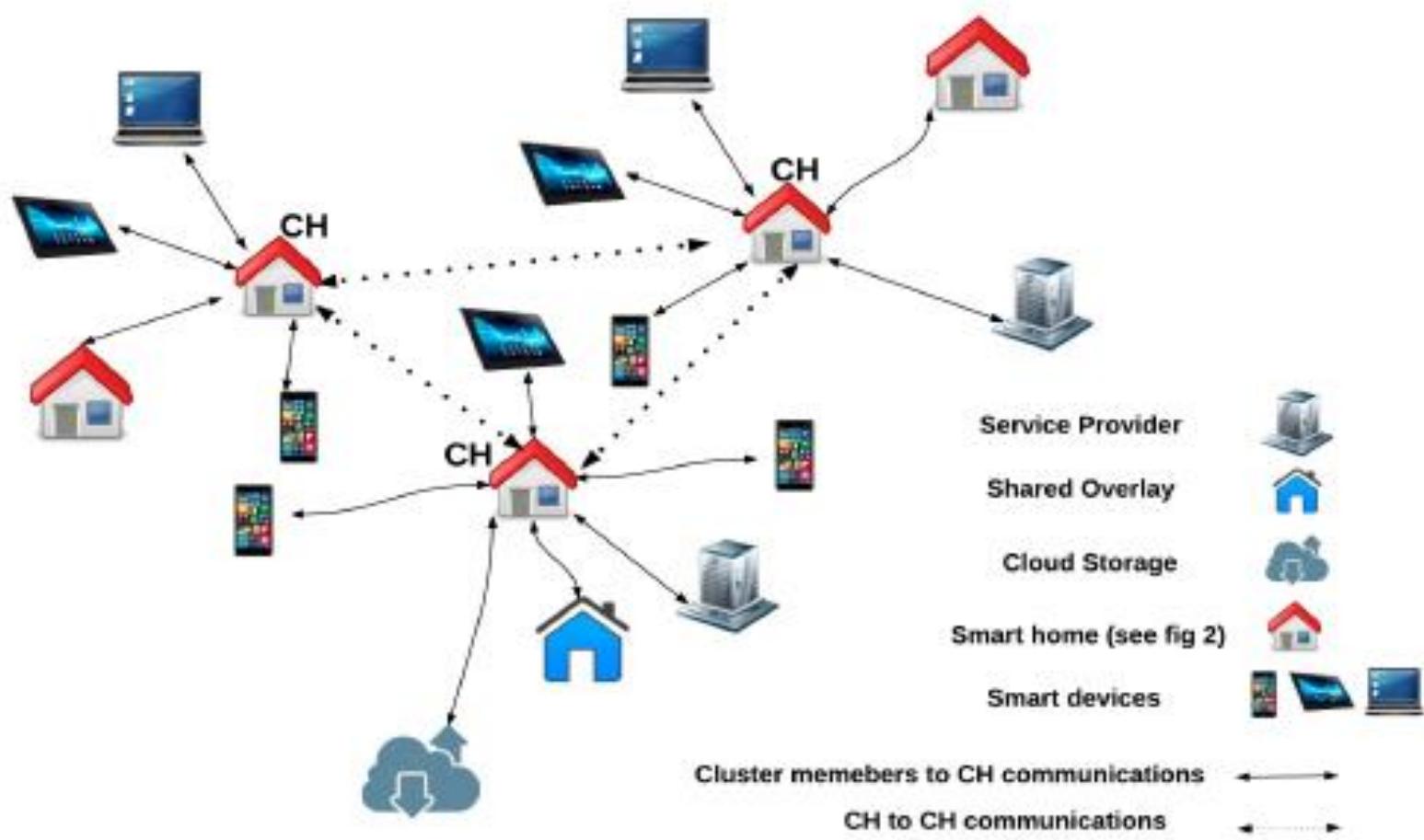
‡ Tata Consultancy Services, Australia.

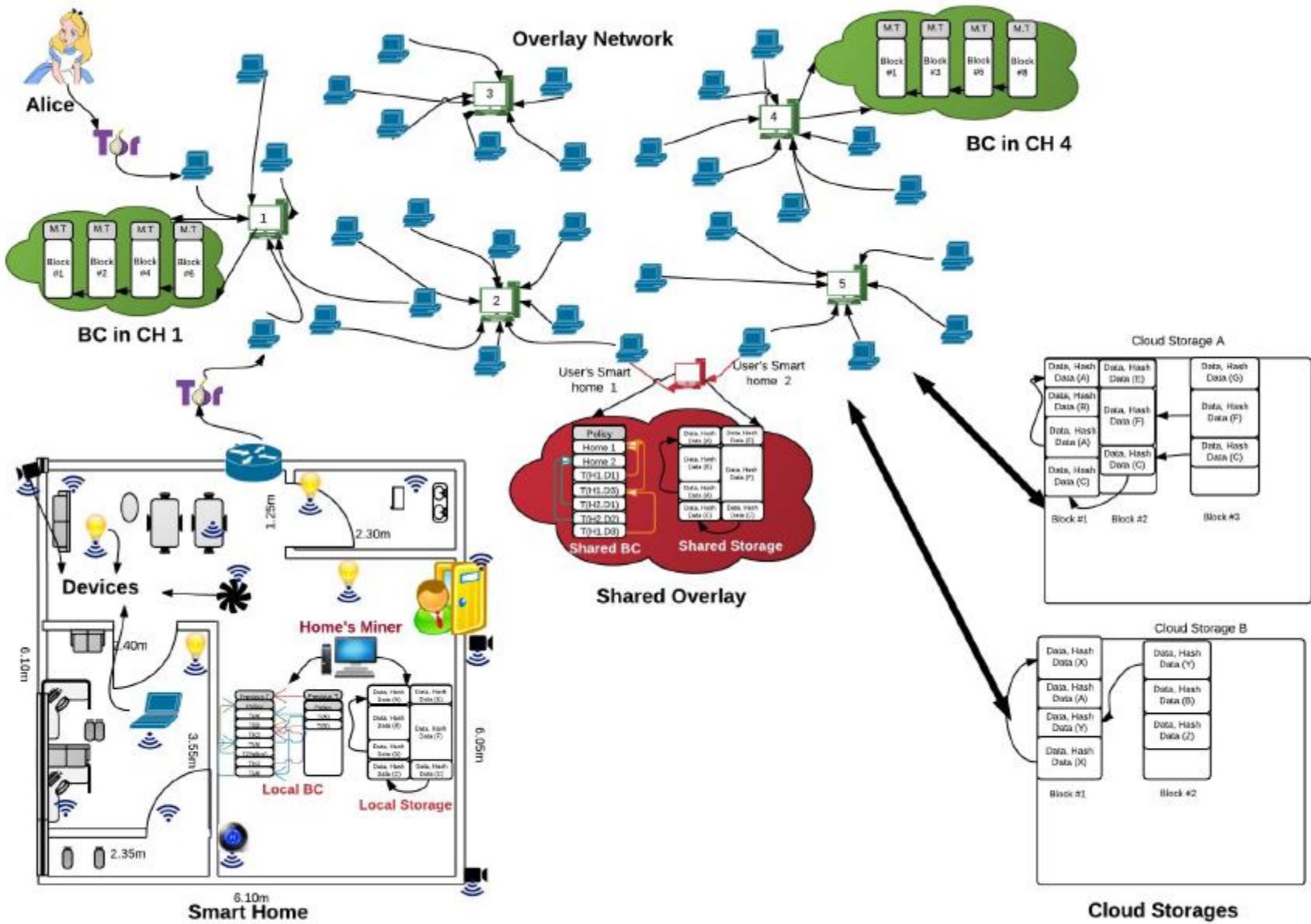
Email: p.gauravaram@tcs.com

**Abstract**—Internet of Things (IoT) security and privacy remain a major challenge, mainly due to the massive scale and distributed nature of IoT networks. Blockchain-based approaches provide decentralized security and privacy, yet they involve significant energy, delay, and computational overhead that is not suitable for most resource-constrained IoT devices. In our previous work, we presented a lightweight instantiation of a BC particularly geared for use in IoT by eliminating the Proof

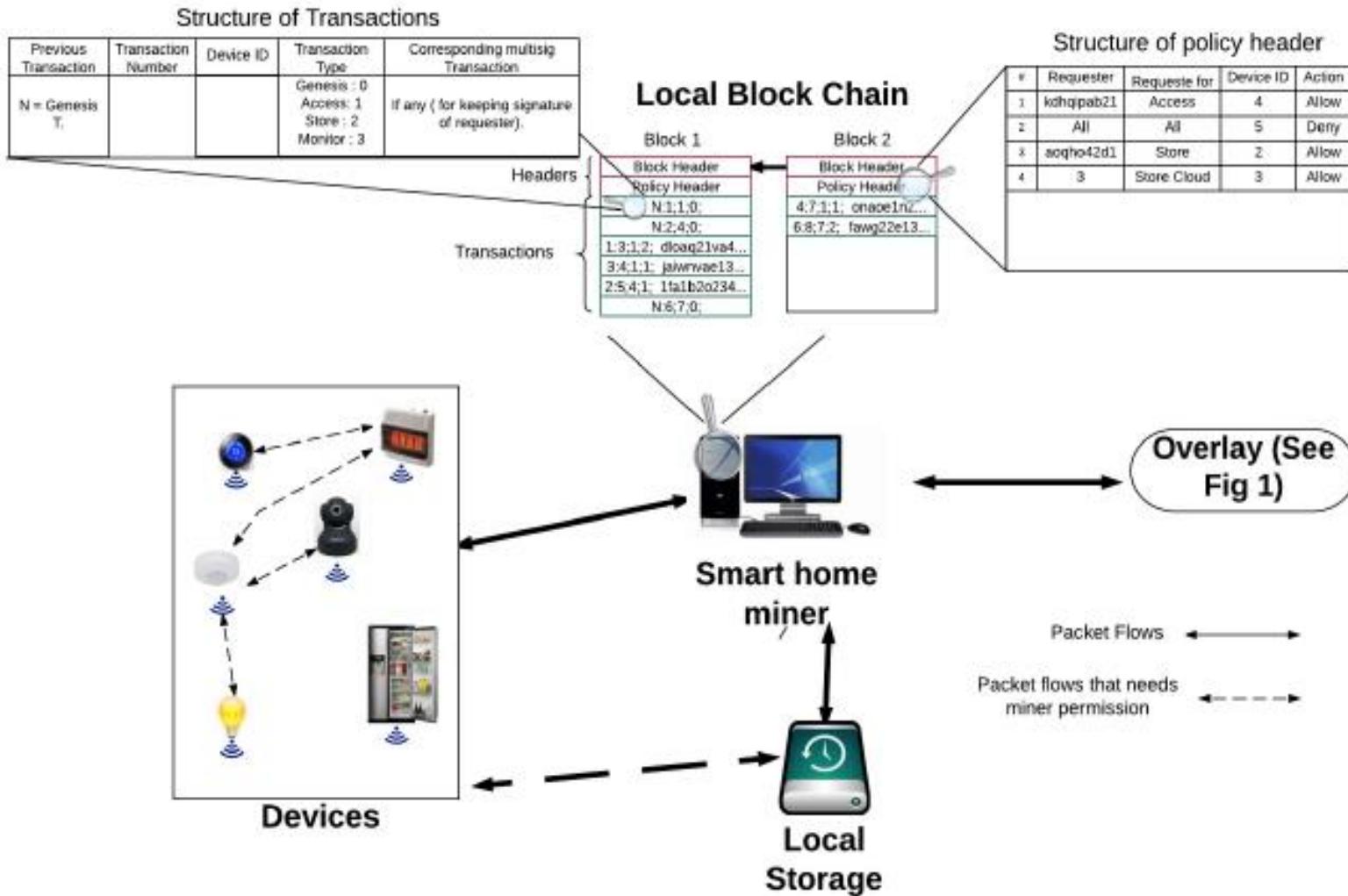
hinder some IoT applications from offering personalised services [3]. Consequently, IoT demands a lightweight, scalable, and distributed security and privacy safeguard. The Blockchain (BC) technology that underpins Bitcoin the first cryptocurrency system [4], has the potential to overcome aforementioned challenges as a result of its distributed, secure, and private nature.

# Smart Homes



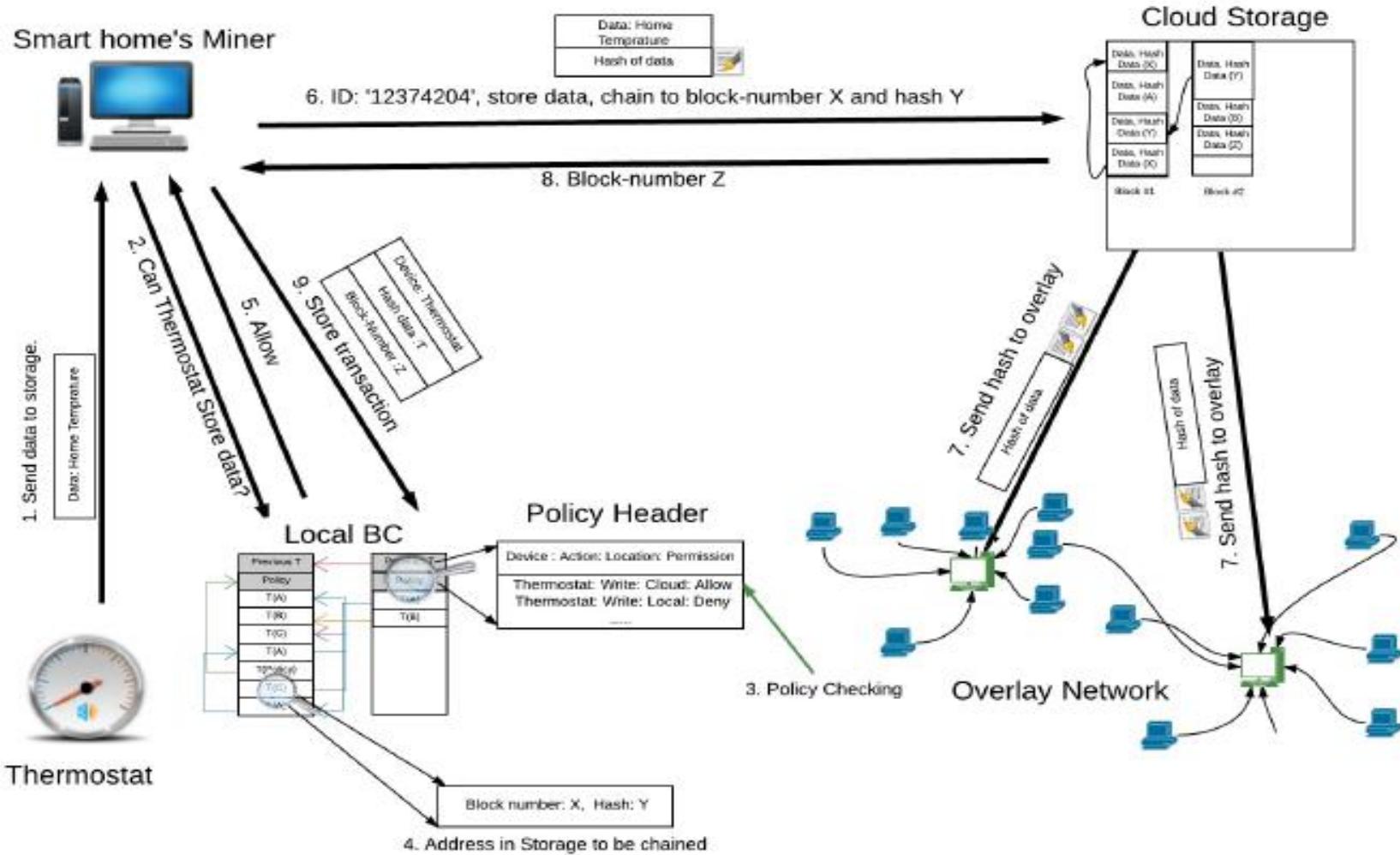


# Smart Homes



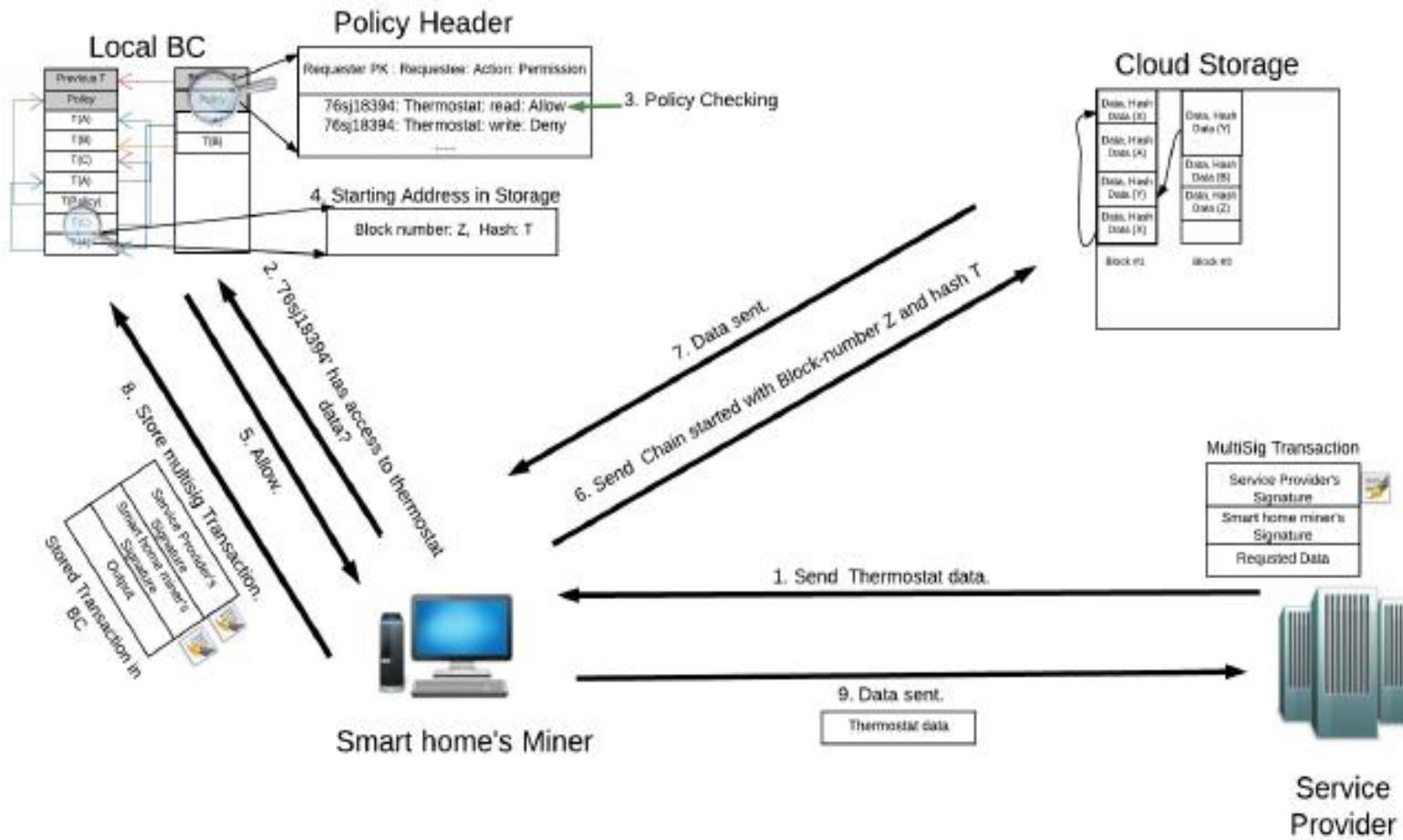
# Smart Homes

## Store Transaction

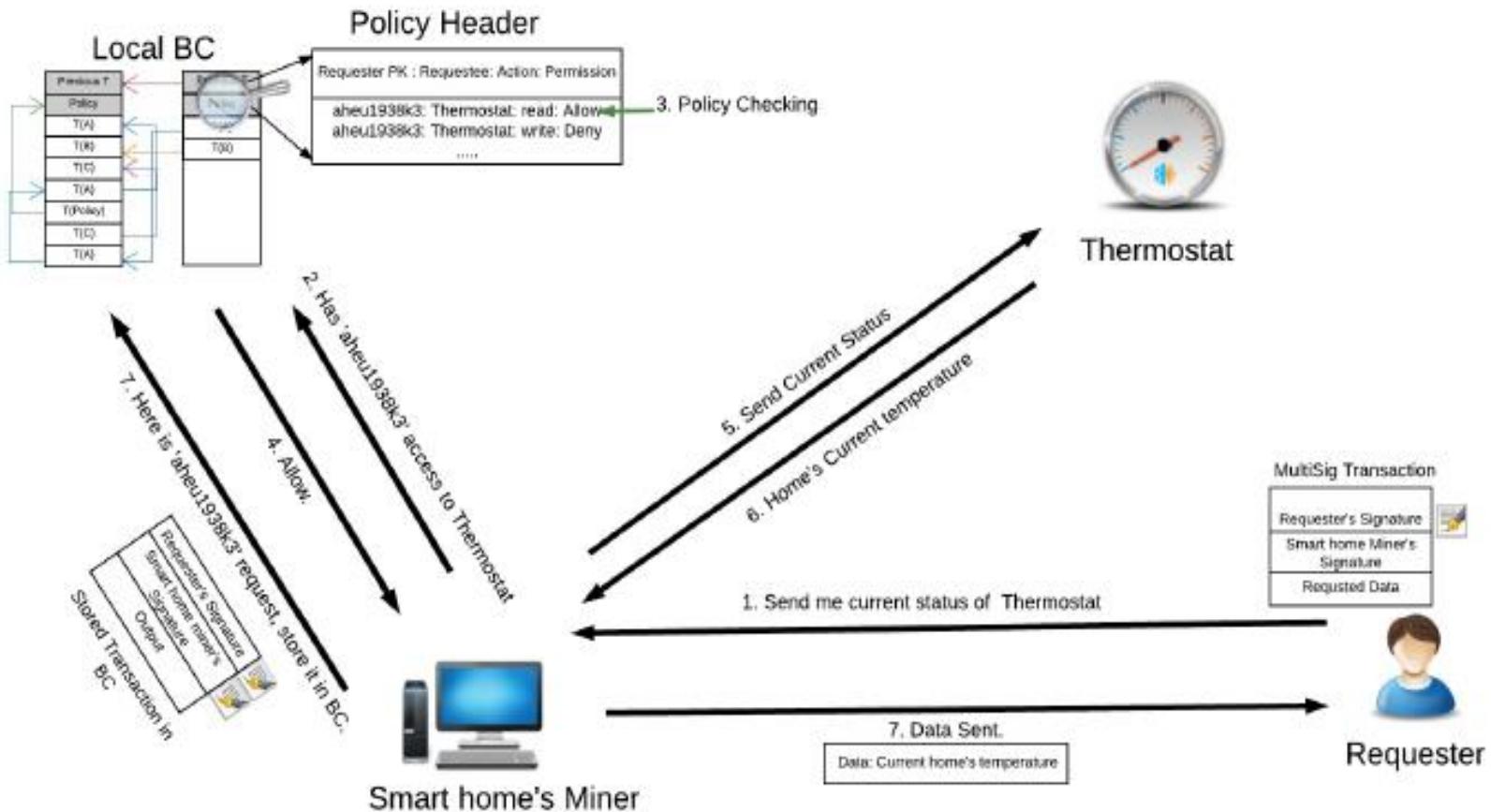


# Smart Homes

## Access Transaction



# Smart Homes Monitor Transaction



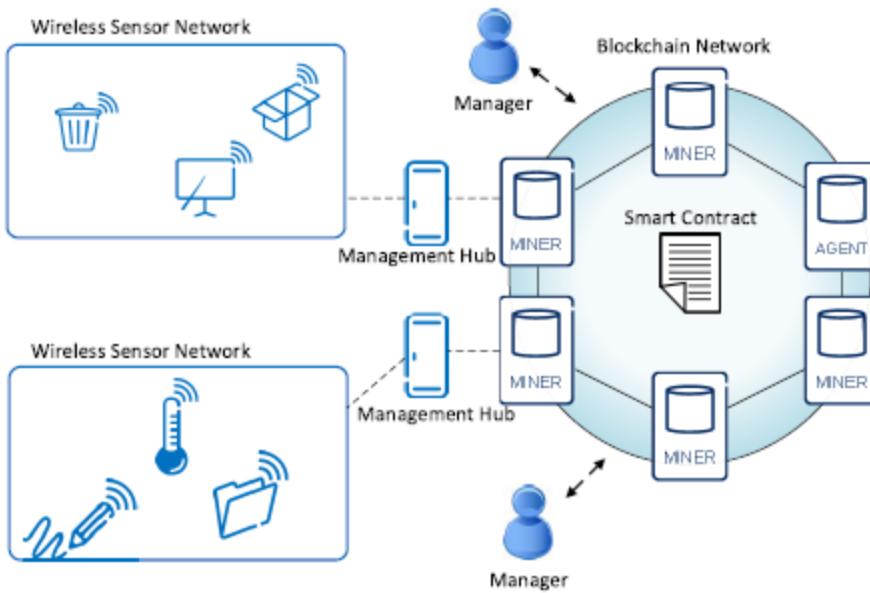
# Blockchain Meets IoT: An Architecture for Scalable Access Management in IoT

Oscar Novo<sup>lb</sup>

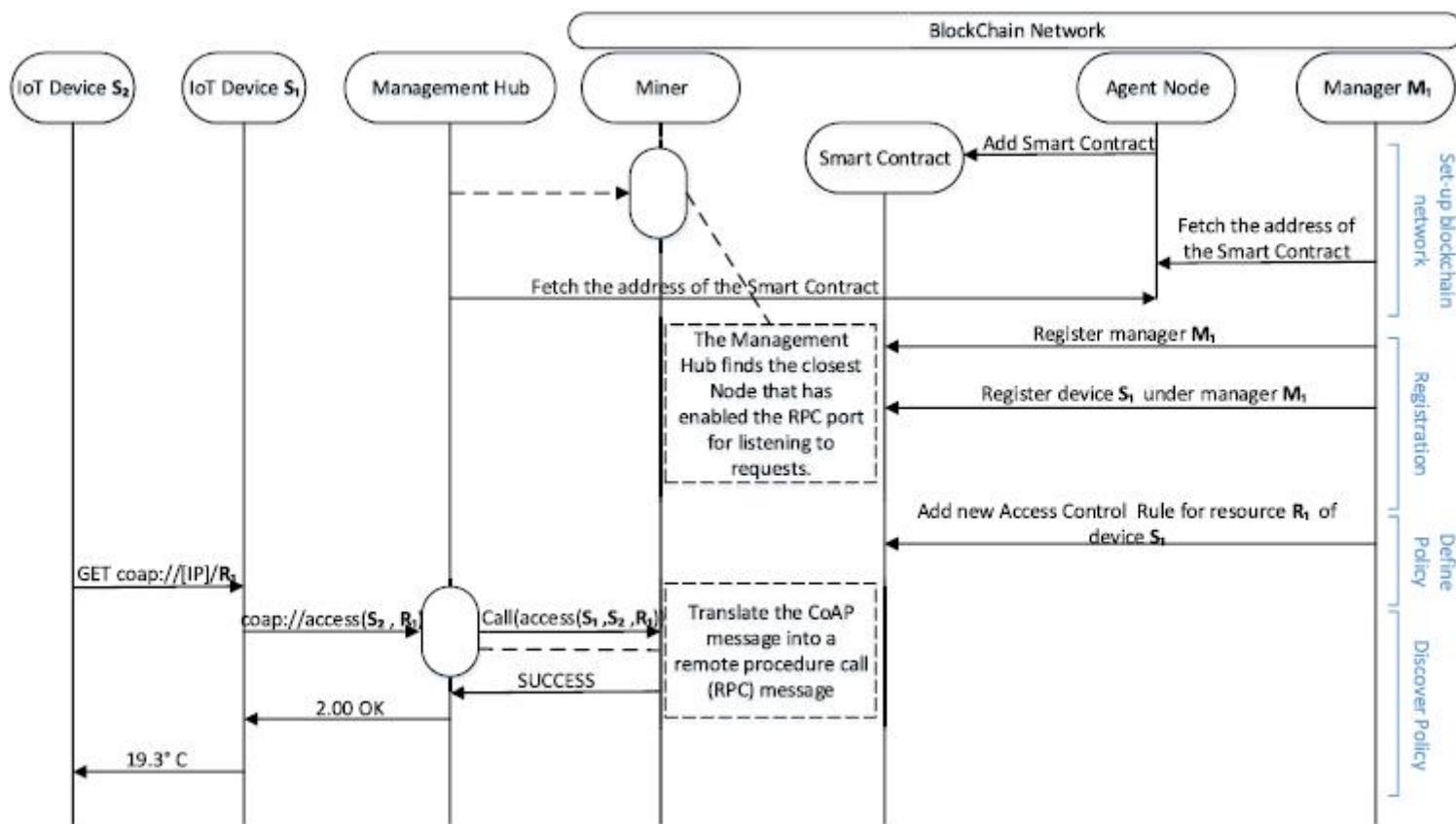
*Abstract*—The Internet of Things (IoT) is stepping out of its infancy into full maturity and establishing itself as a part of the future Internet. One of the technical challenges of having billions of devices deployed worldwide is the ability to manage them. Although access management technologies exist in IoT, they are

access control system connected to geographically distributed sensor networks. The solution is based on blockchain technology whereas the access control policies are enforced by it. By adopting blockchain, this solution eliminates centralized access management. On the contrary, a single centralized

# Access Management in IoT



# Access Management in IoT



# Blockchain-Based E-Voting System

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**Abstract**—Building an electronic voting system that satisfies the legal requirements of legislators has been a challenge for a long time. Distributed ledger technologies is an exciting technological advancement in the information technology world. Blockchain technologies offer an infinite range of applications benefiting from sharing economies. This paper aims to evaluate the application of blockchain as service to implement distributed electronic

- (iv) A majority of the network nodes must reach a consensus before a proposed new block of entries becomes a permanent part of the ledger.

These technological features operate through advanced cryptography, providing a security level equal and/or greater than that of traditional systems.

# Election as Smart Contract

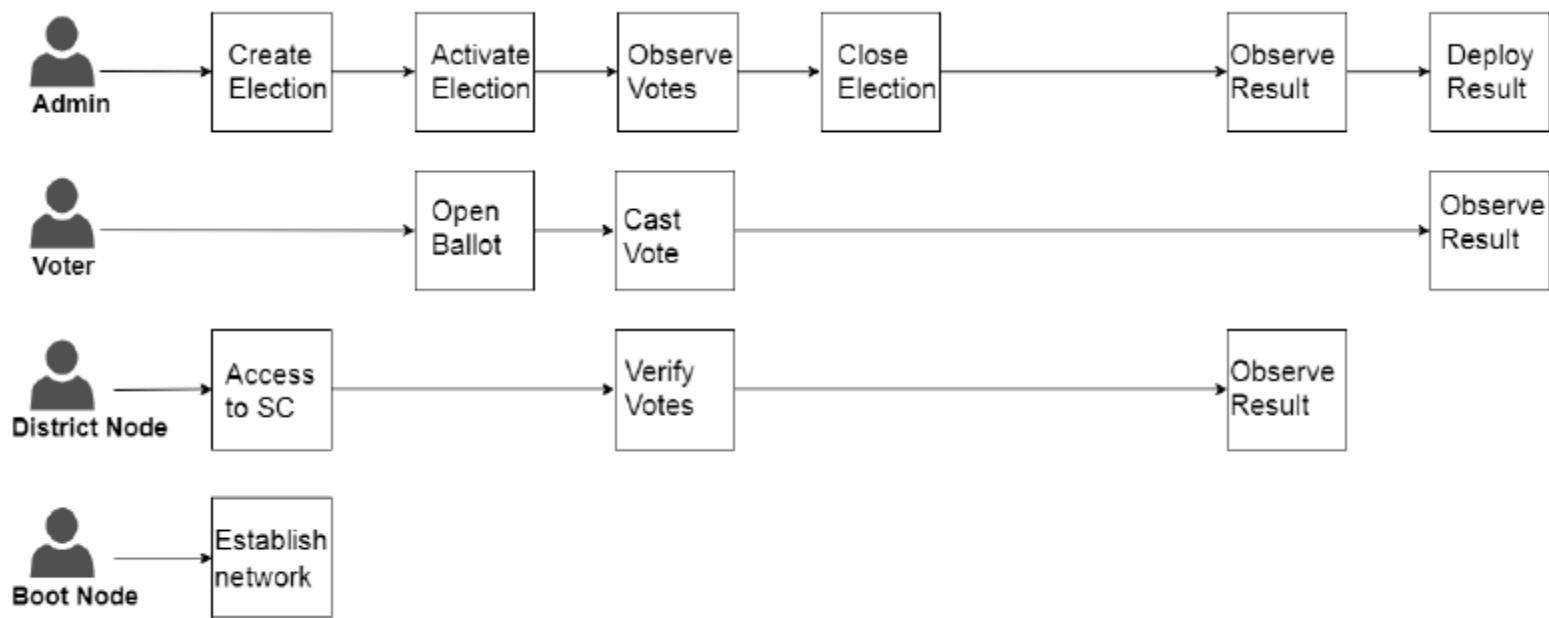
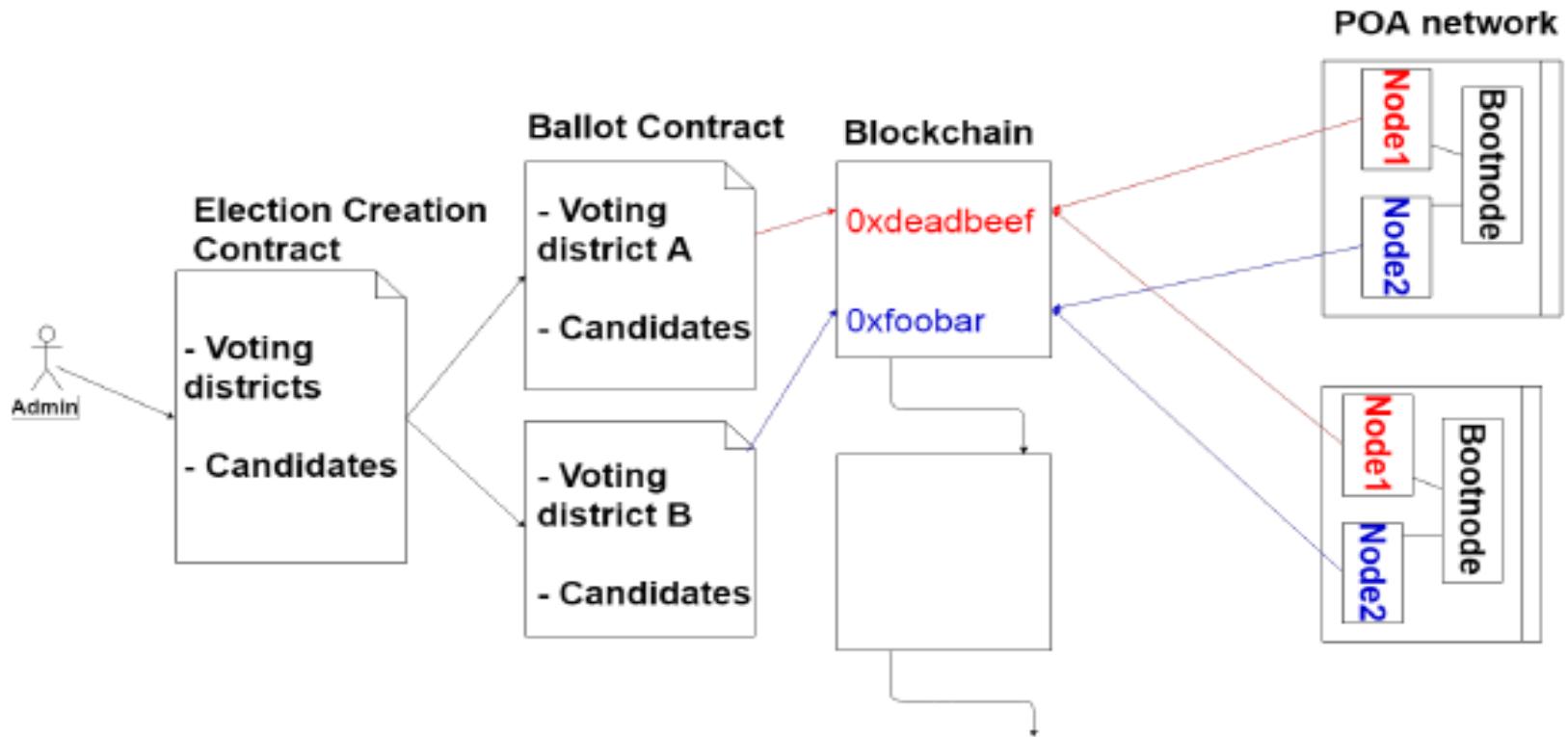


Fig. 1: Election roles and process

# Election as Smart Contract



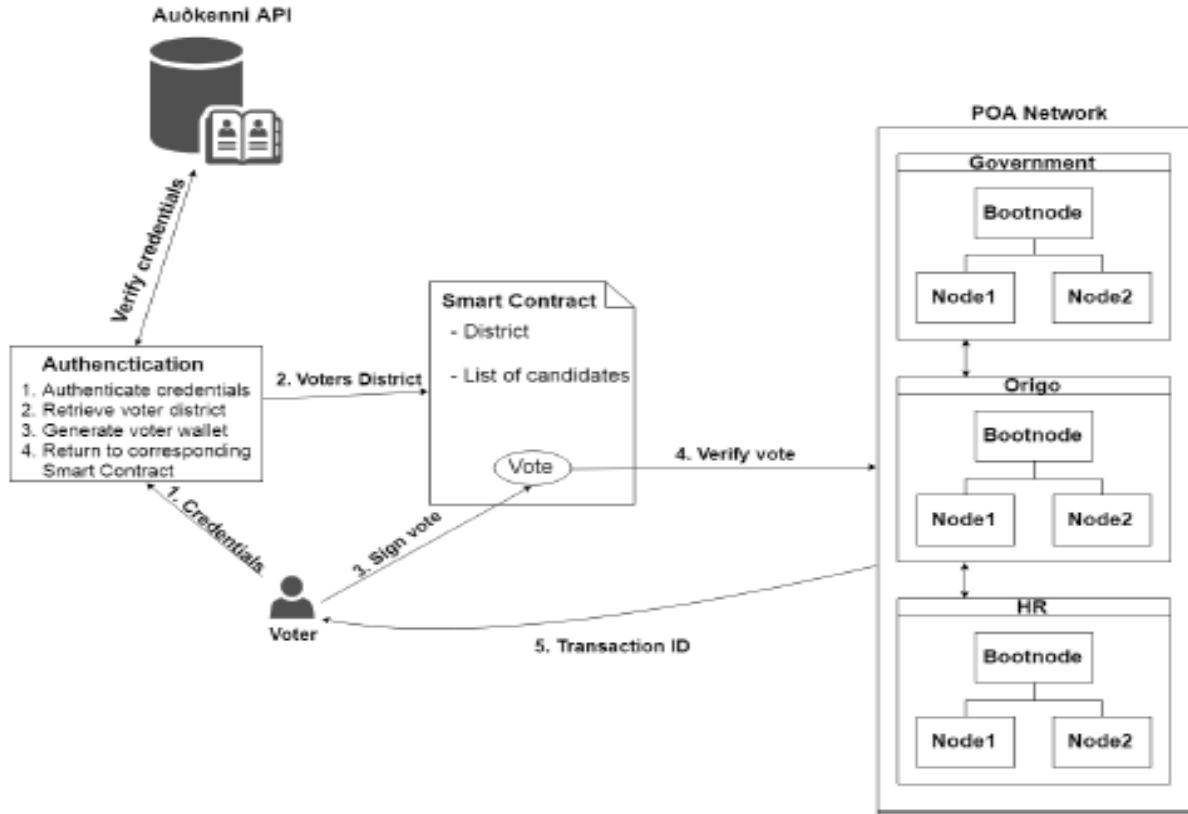


Fig. 3: Voter authenticates himself and casts vote

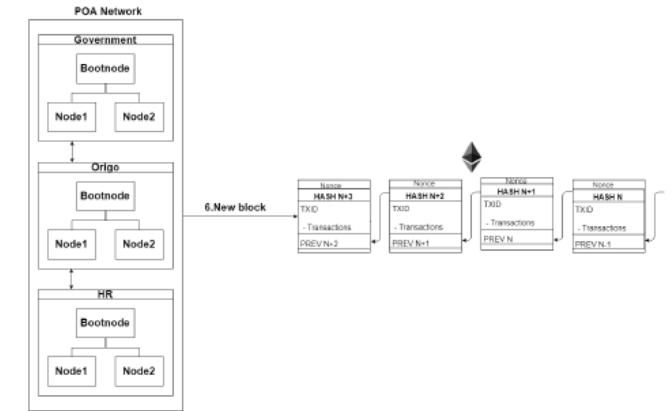


Fig. 4: Block added to the blockchain

# Blockchain for Secure EHRs Sharing of Mobile Cloud Based E-Health Systems

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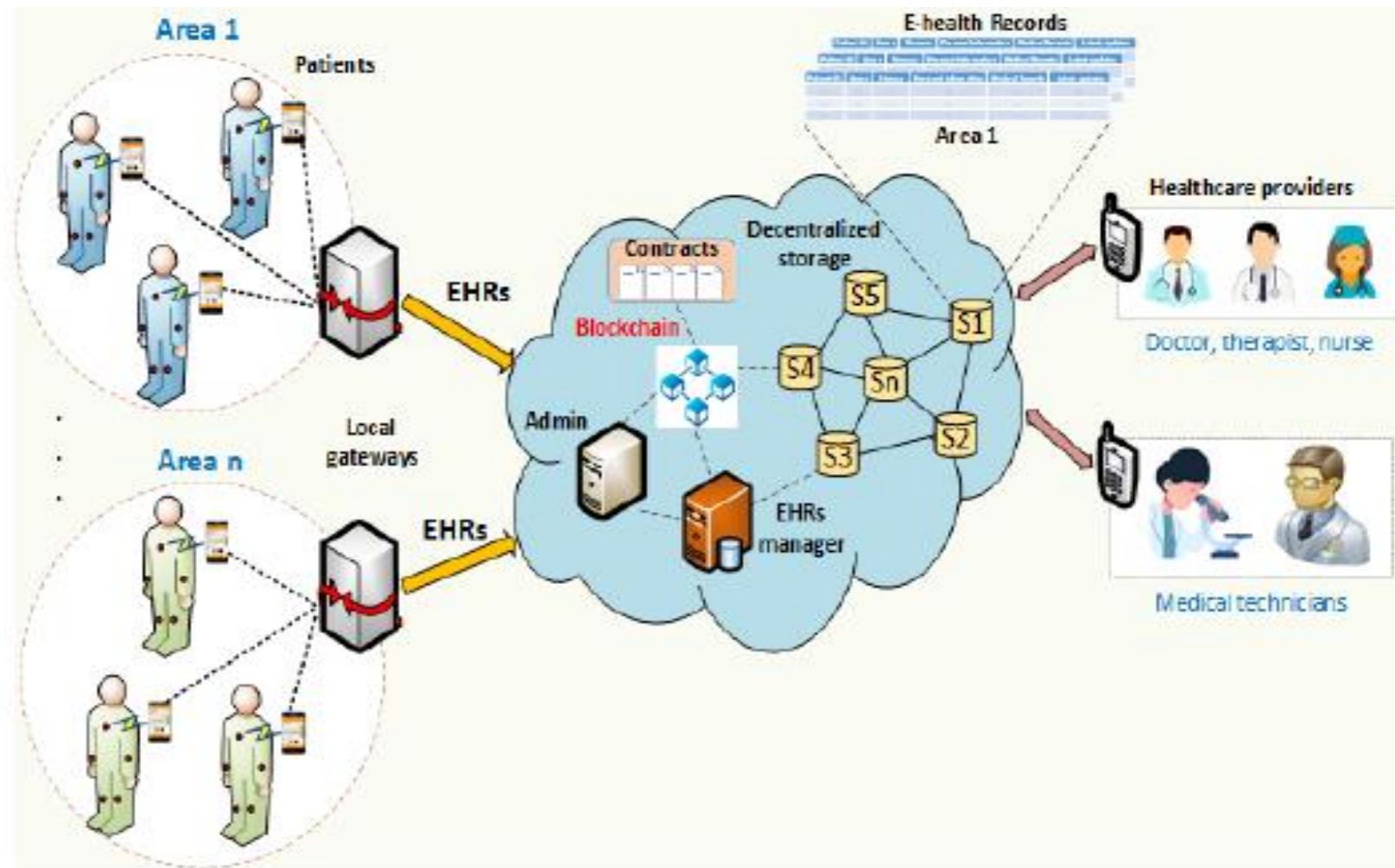
<sup>3</sup>School of Electrical Engineering and Telecommunications, University of New South Wales (UNSW), Sydney, NSW 2052, Australia

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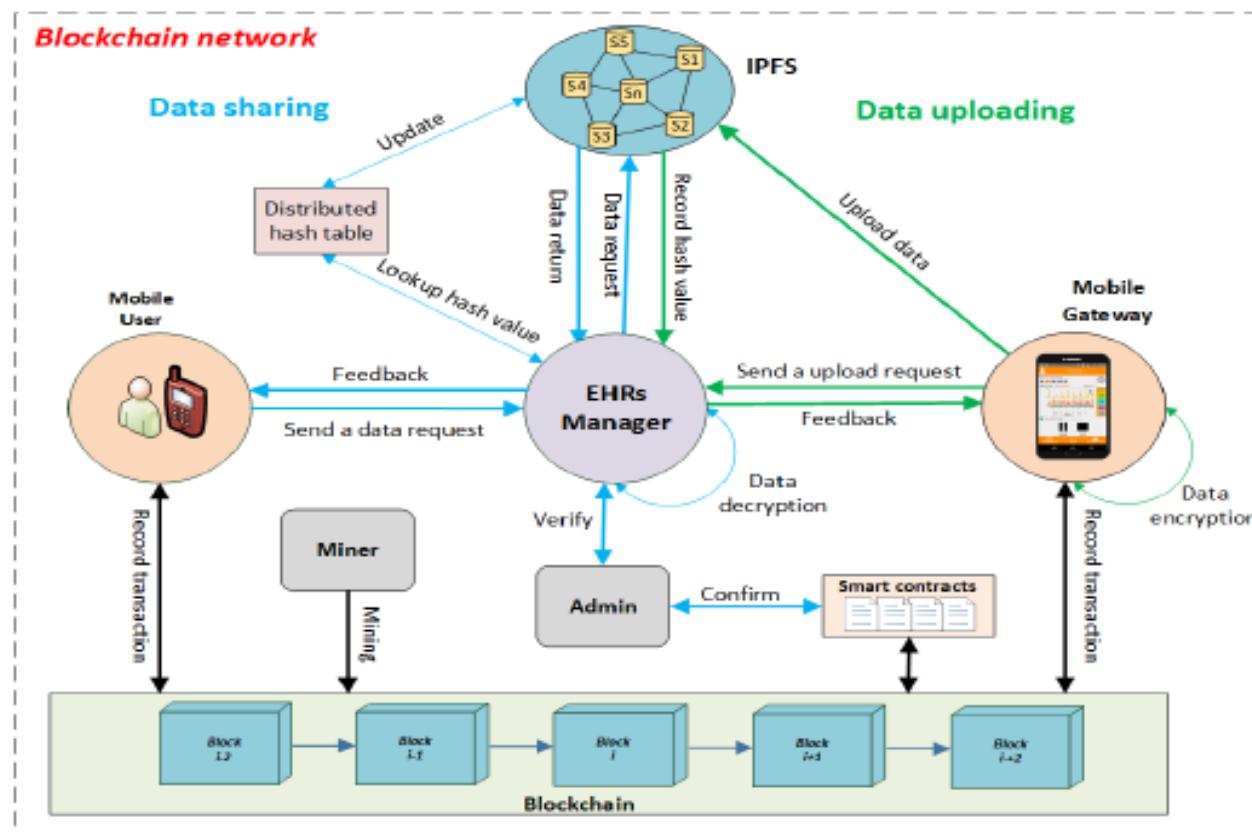
This work was supported in part by the CSIRO Data61, Australia.

**ABSTRACT** Recent years have witnessed a paradigm shift in the storage of Electronic Health Records (EHRs) on mobile cloud environments, where mobile devices are integrated with cloud computing to facilitate medical data exchanges among patients and healthcare providers. This advanced model enables healthcare services with low operational cost, high flexibility, and EHRs availability. However, this new paradigm also raises concerns about data privacy and network security for e-health systems. How to reliably share EHRs among mobile users while guaranteeing high-security levels in the mobile cloud is a challenging issue. In this paper, we propose a novel EHRs sharing framework that combines blockchain and the decentralized interplanetary file system (IPFS) on a mobile cloud platform. Particularly, we design a trustworthy access control mechanism using smart contracts to achieve secure EHRs sharing among different

# HealthCare



# HealthCare



# MedRec: HealthCare

**A Case Study for Blockchain in Healthcare:  
“MedRec” prototype for electronic health records and medical research data**

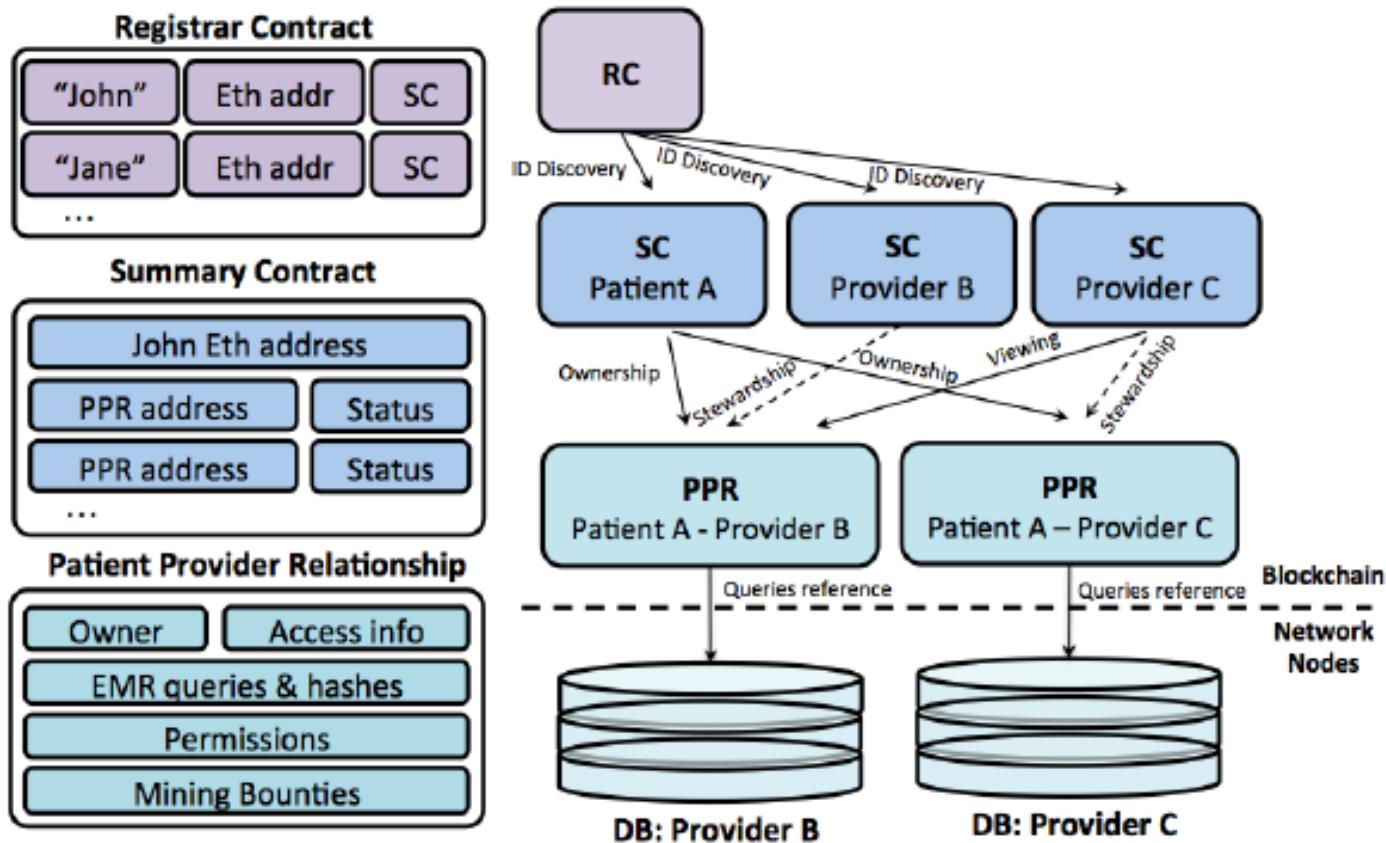
**White Paper**

Ariel Ekblaw\*, Asaph Azaria\*, John D. Halamka, MD†, Andrew Lippman\*

\*MIT Media Lab, †Beth Israel Deaconess Medical Center

August 2016

# MedRec: HealthCare

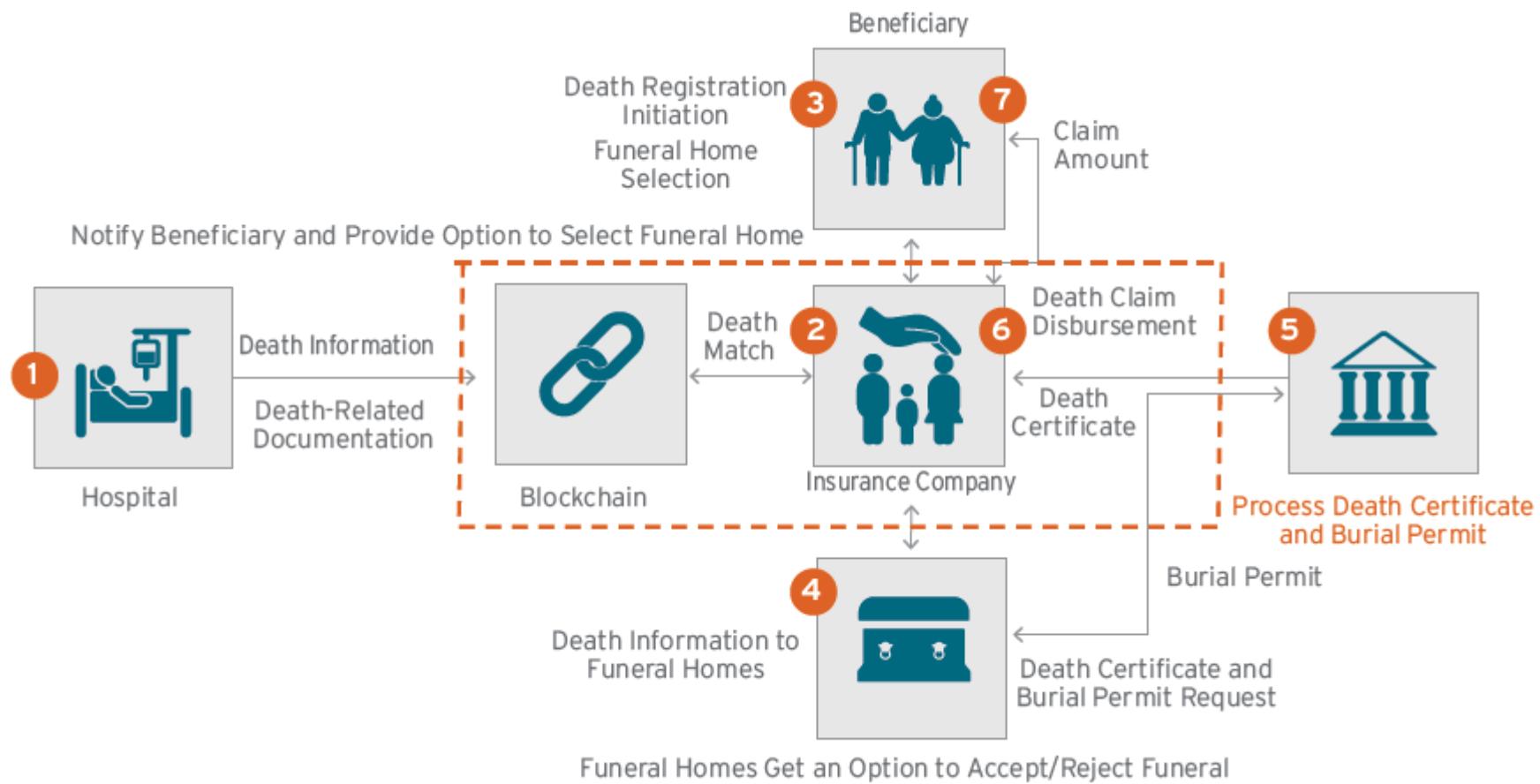




# Blockchain: A Potential Game-Changer for Life Insurance

In a world in search of more open, trusted and secure IT systems, all eyes are on blockchain, which through its distributed ledger, smart contracts and non-repudiation capabilities acts as a shared infrastructure that can transform multiple processes across the insurance value chain. Here's how.

# Claim after death!



# Decentralised Social Network

1] Diaspora ([diasporafoundation.org](http://diasporafoundation.org))

2] SocialX ([socialx.network](http://socialx.network))

3] Minds ([wefunder.com/minds](http://wefunder.com/minds))

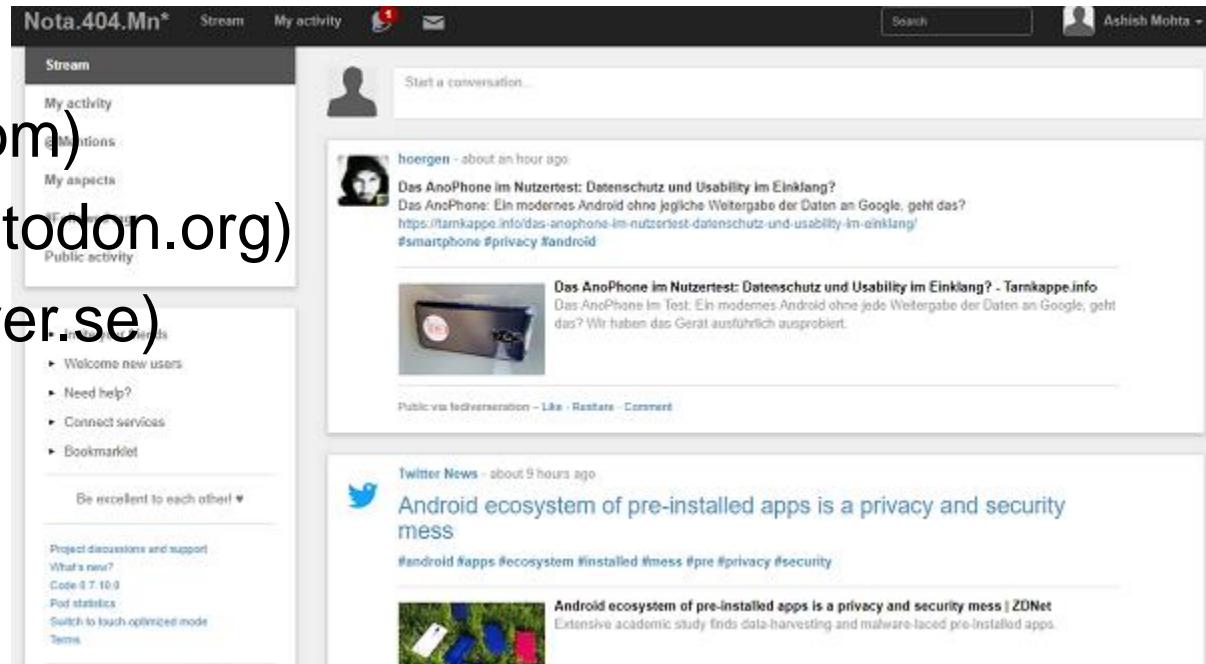
4] Memo ([memo.cash](http://memo.cash))

5] Sola ([sola.ai](http://sola.ai))

6] Steemit ([steemit.com](http://steemit.com))

7] Mastodon ([joinmastodon.org](http://joinmastodon.org))

8] Manyverse ([manyver.se](http://manyver.se))



## ProvChain: A Blockchain-based Data Provenance Architecture in Cloud Environment with Enhanced Privacy and Availability

Xueping Liang<sup>1</sup>, Sachin Shetty<sup>2</sup>, Deepak Tosh<sup>3</sup>, Charles Kamhoua<sup>4</sup>, Kevin Kwiat<sup>4</sup>, and Laurent Njilla<sup>4</sup>

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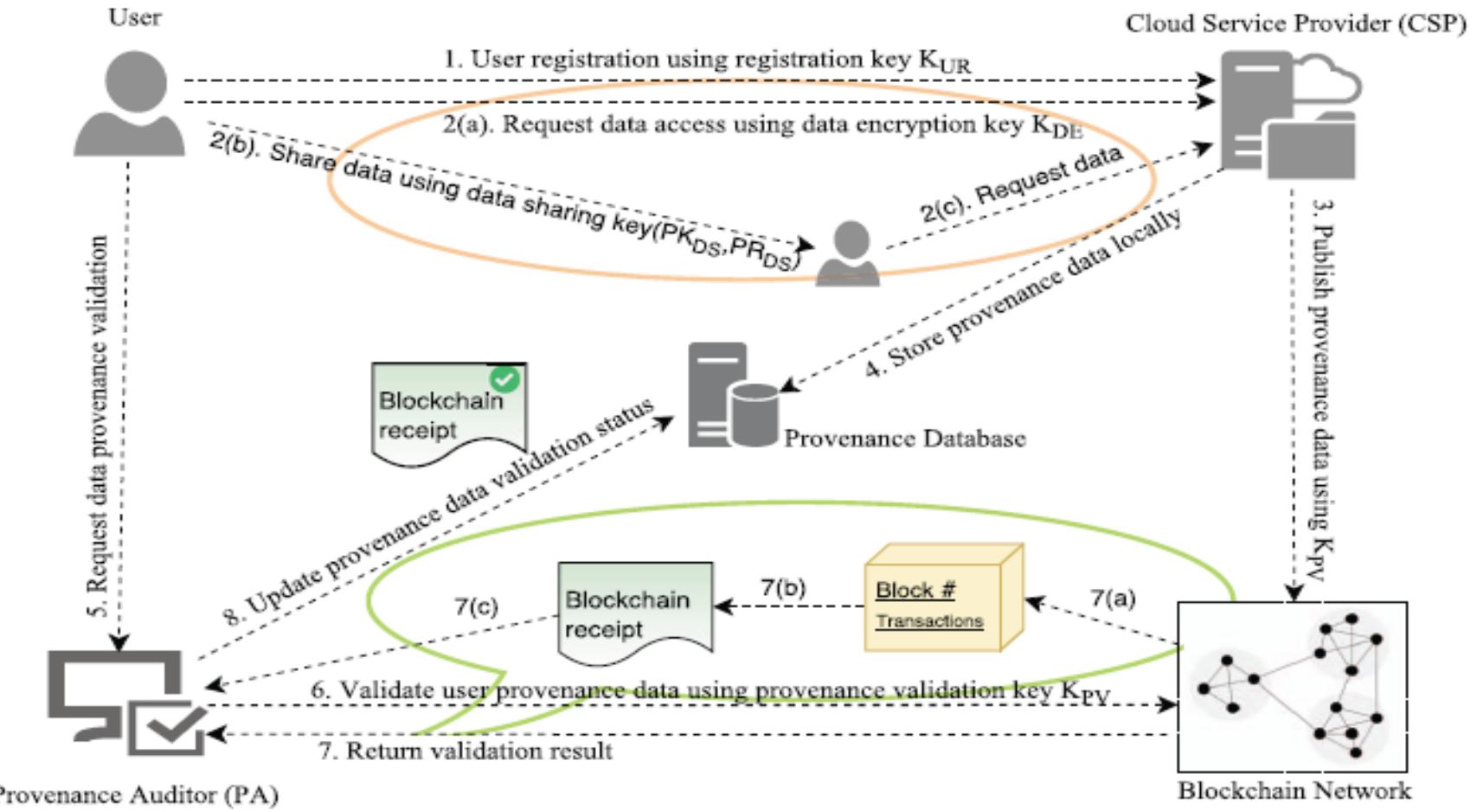
<sup>4</sup>Cyber Assurance Branch, Air Force Research Laboratory, Rome, NY 13441

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**Abstract**—Cloud data provenance is metadata that records the history of the creation and operations performed on cloud data object. Secure data provenance is crucial for data accountability, forensics and privacy. In this paper, we propose a decentralized and trusted cloud data provenance

provenance remains a critical issue for cloud storage applications. Besides, provenance data may contain sensitive information about the original data and the data owners. Hence, there is a need to secure not only the cloud dat

# Blockchain-based Data Provenance in Cloud



Article

# A Hierarchical and Abstraction-Based Blockchain Model

Swagatika Sahoo<sup>1</sup>, Akshay M. Fajge<sup>1</sup>, Raju Halder<sup>1</sup> and Agostino Cortesi<sup>2,\*</sup> 

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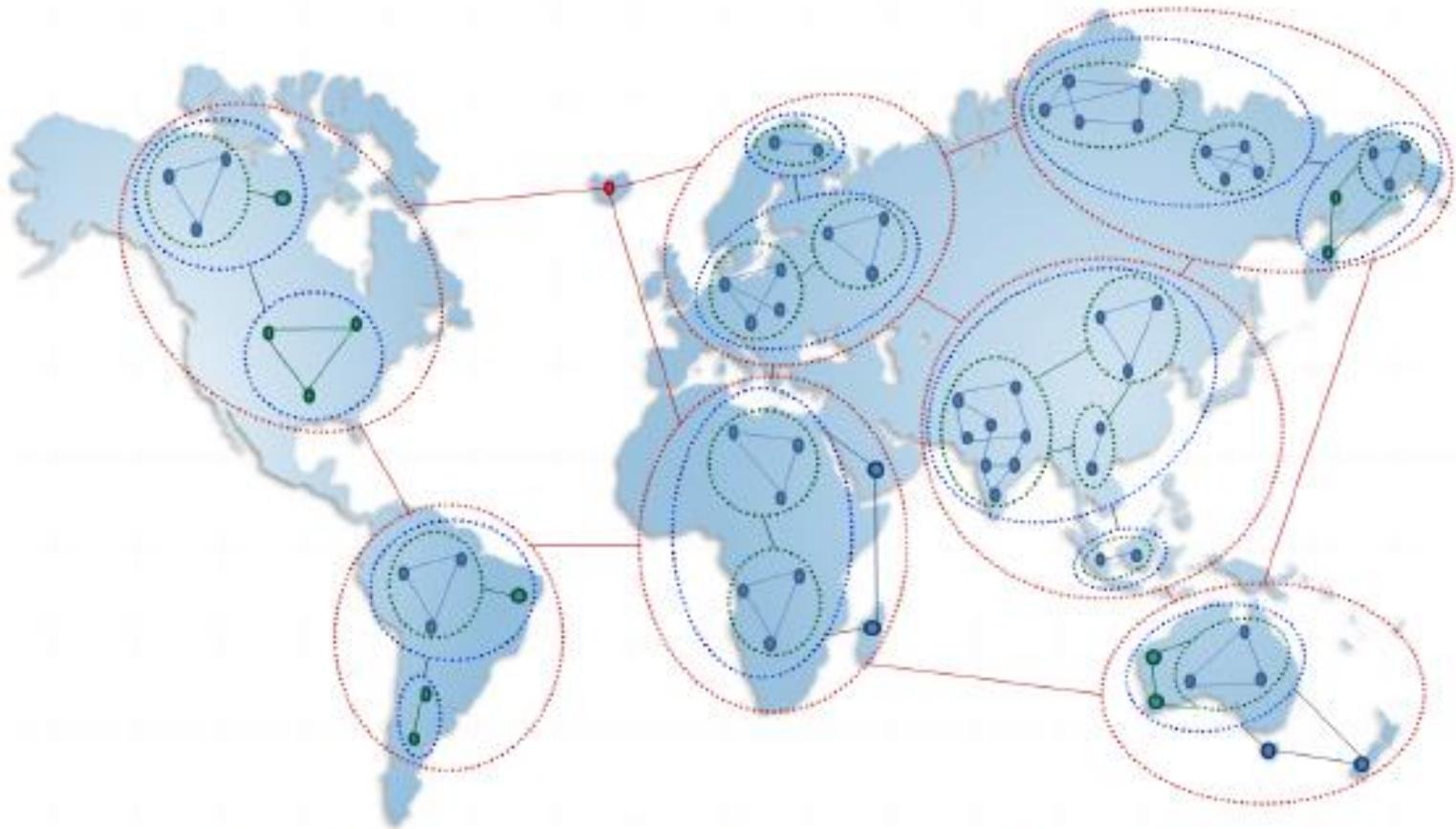
<sup>2</sup> Dipartimento di Scienze Ambientali, Informatica e Statistica, Università Ca' Foscari, via Torino 155, 30170 Venice, Italy

\* Correspondence: cortesi@unive.it

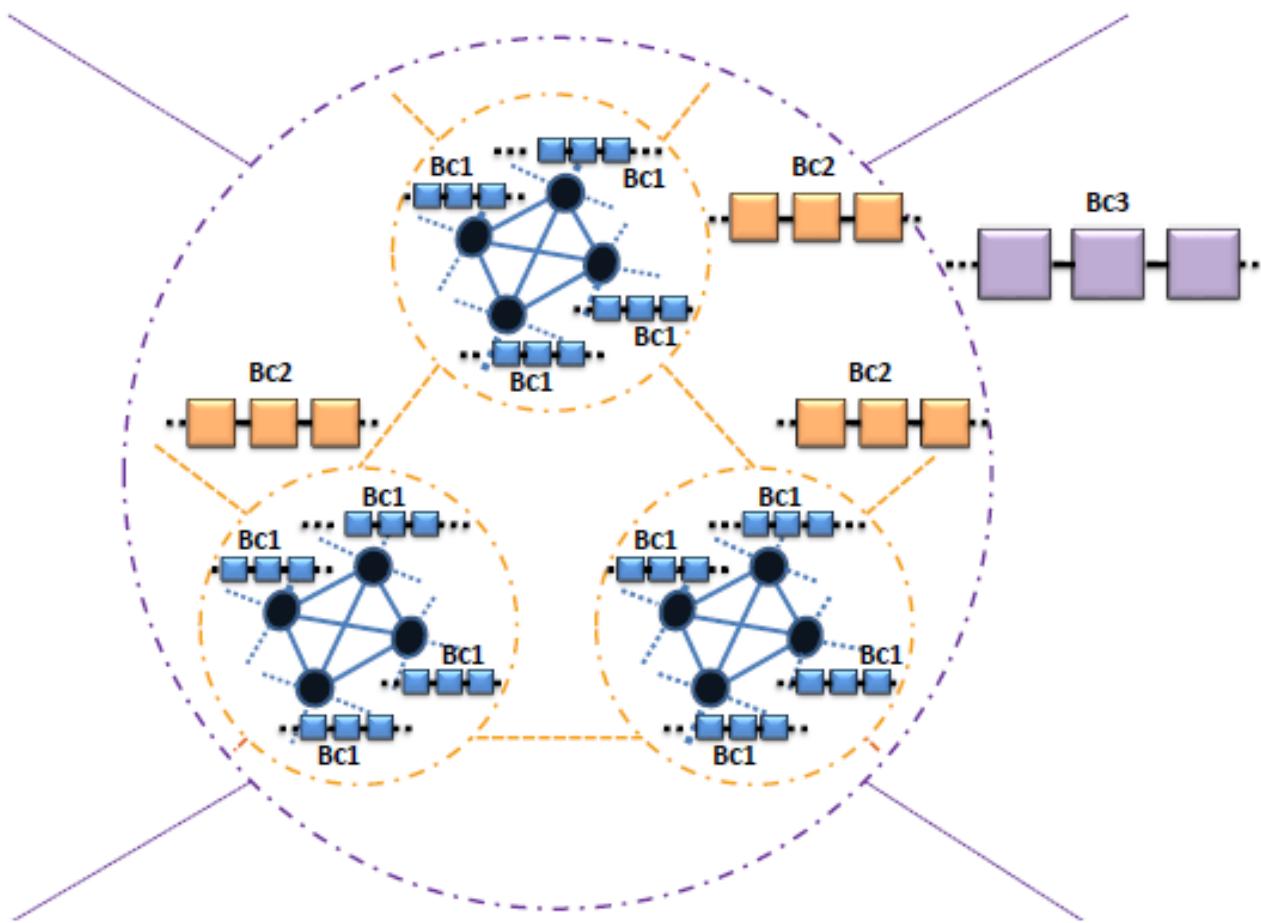
Received: 24 April 2019; Accepted: 5 June 2019; Published: 7 June 2019



**Abstract:** In the nine years since its launch, amid intense research, scalability is always a serious concern in blockchain, especially in case of large-scale network generating huge number of transaction-records. In this paper, we propose a hierarchical blockchain model characterized by:



**Figure 1.** Decentralized network views at various levels of hierarchy.



**Figure 2.** Schematic diagram of hierarchical blockchains model.

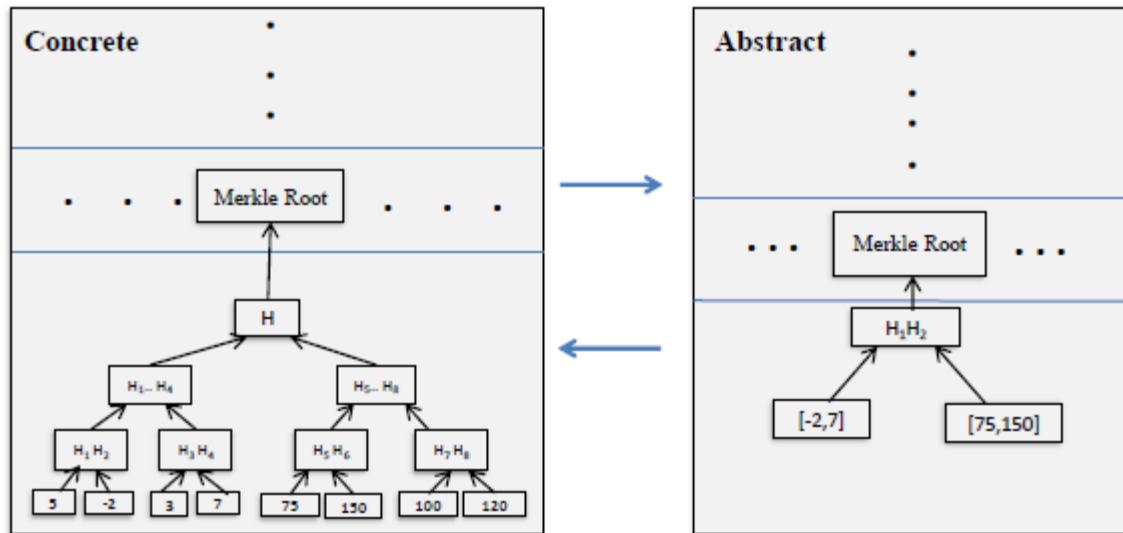


Figure 8. Abstract Block in Interval Domain.

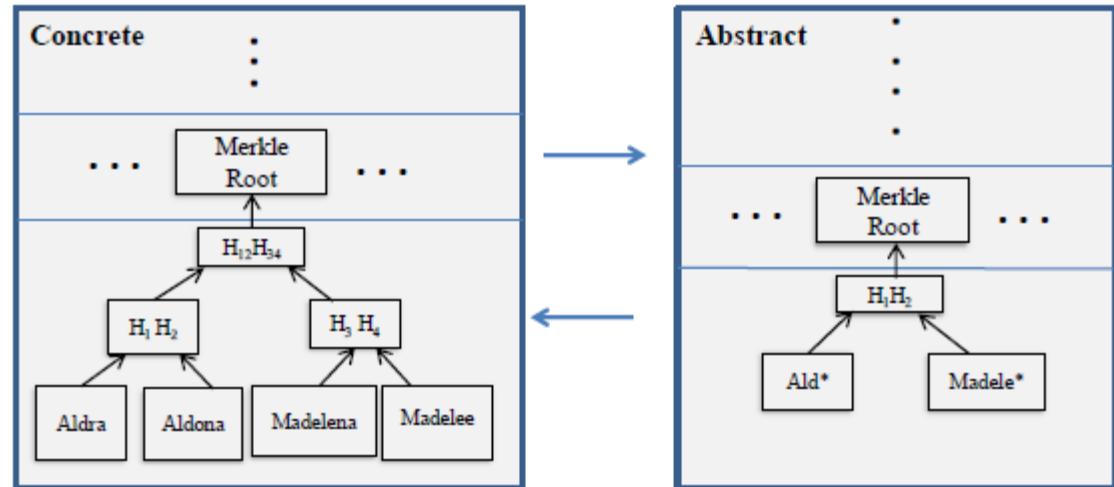


Figure 9. Abstract Block in Prefix Domain.

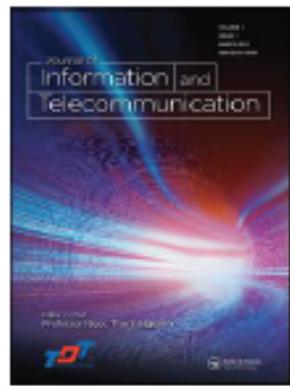
# **BDmark: A Blockchain-driven Approach to Big Data Watermarking**

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**Abstract.** Over the last decade, most enterprises are harnessing the power of big data as a driving force to their business growth. This creates a new paradigm which encourages large number of start-ups and less-known data brokers to adopt data monetization as their key role in the data marketplace. As a pitfall, such data-driven scenarios make big data prone to various threats, such as ownership claiming, illegal reselling, tampering, etc. Unfortunately existing watermarking solutions are ill-suited to big



## Journal of Information and Telecommunication



ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/tjit20>

# Traceability and ownership claim of data on big data marketplace using blockchain technology

Swagatika Sahoo & Raju Halder

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To link to this article: <https://doi.org/10.1080/24751839.2020.1819634>

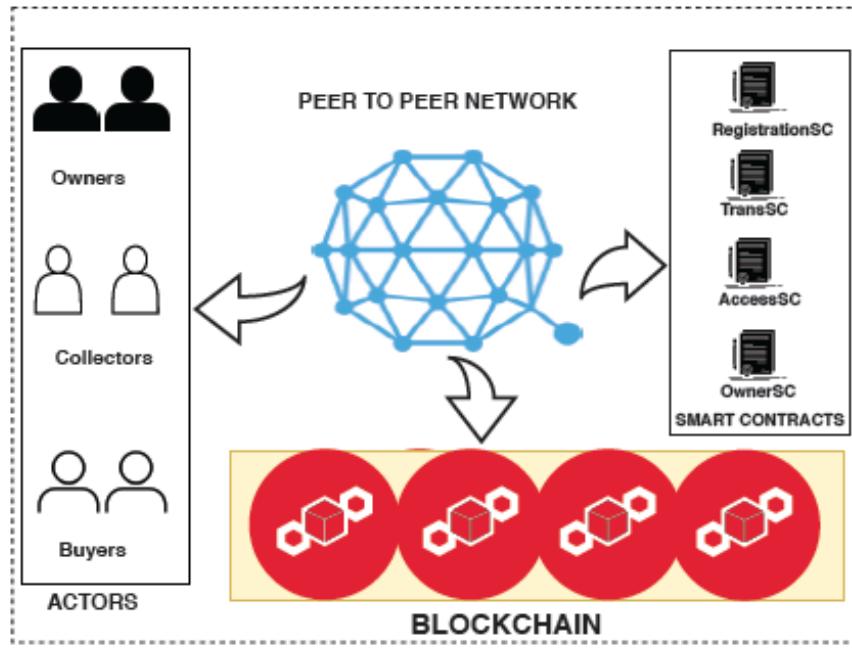
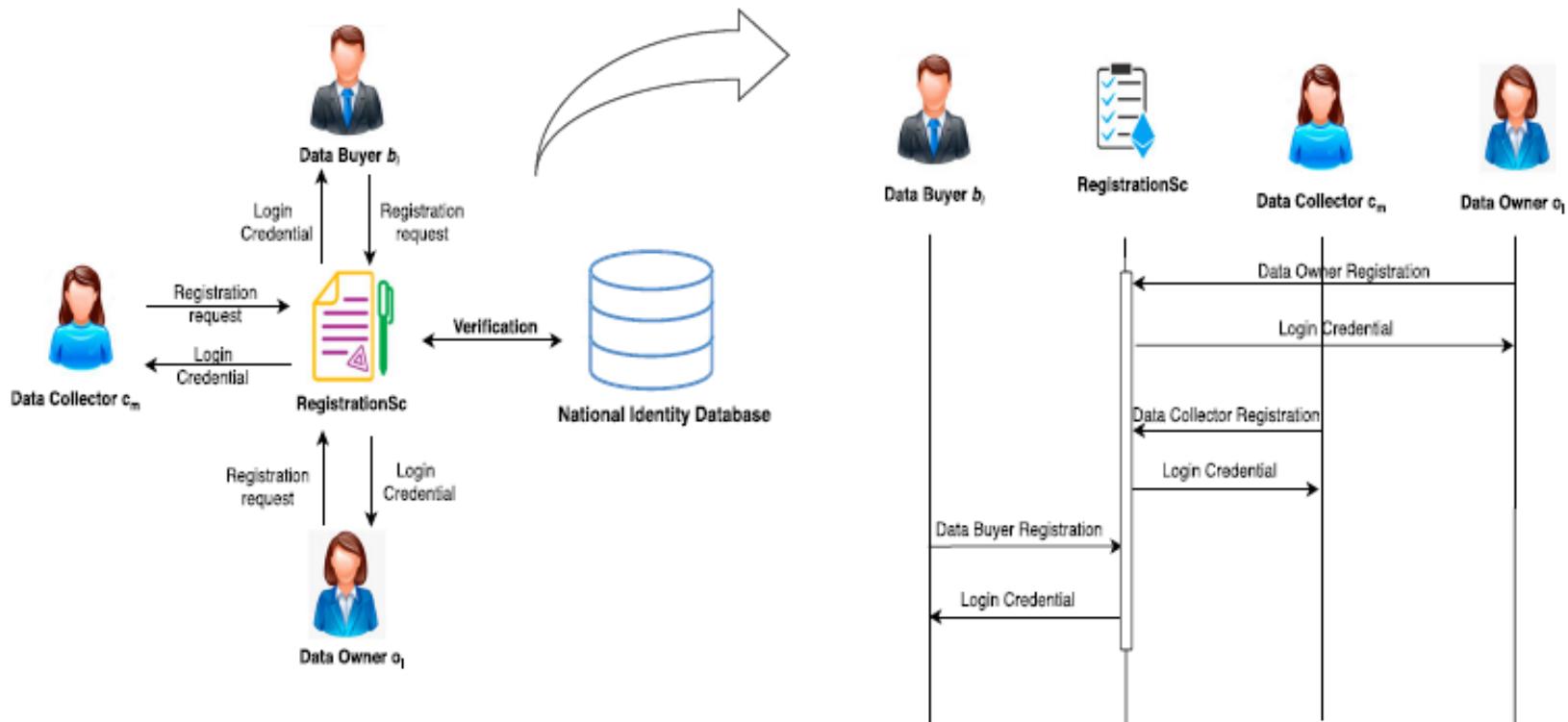
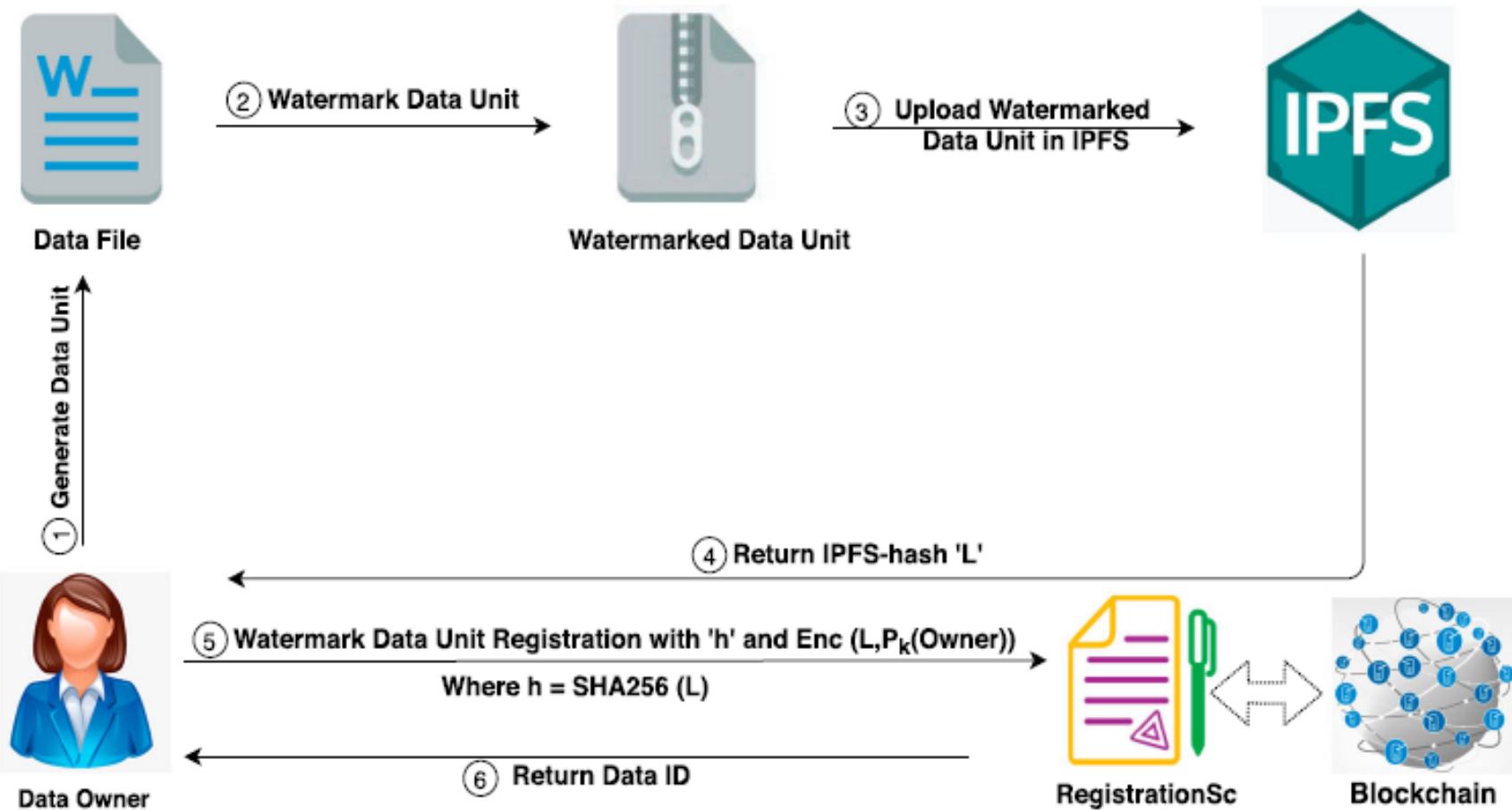


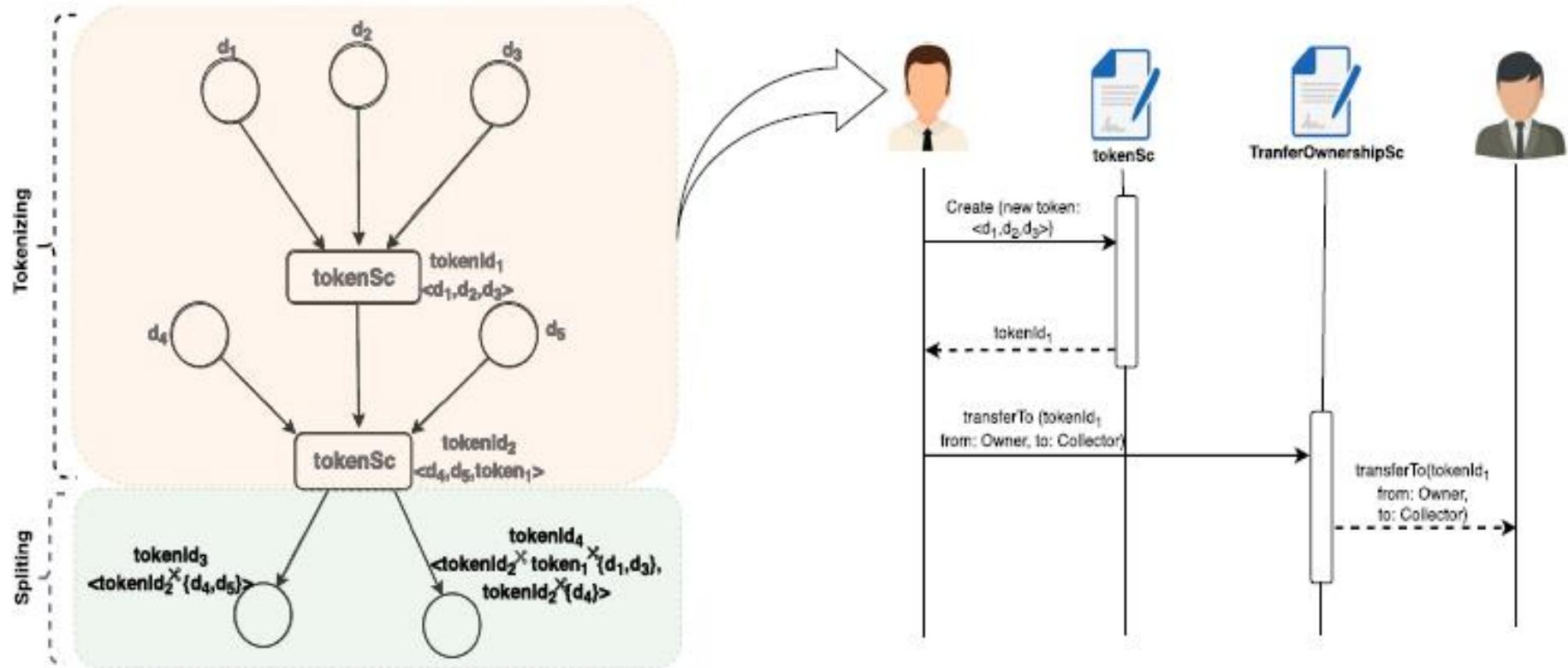
Fig. 1: A pictorial representation of the overall system components



**Figure 3.** Actors' registration process.



**Figure 4.** Data watermarking, storage, and registration.



**Figure 5.** Tokenization, splitting and transfer.

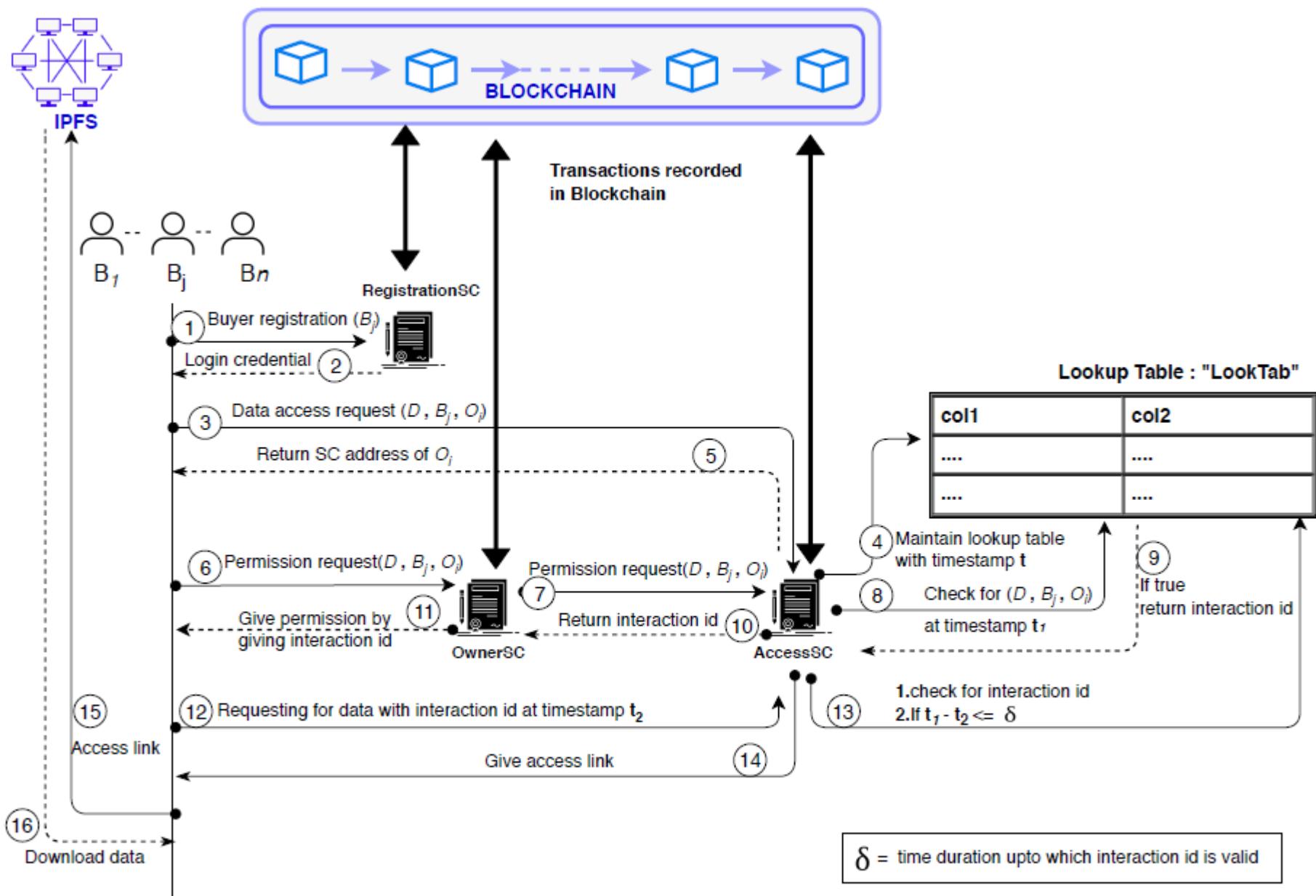


Fig. 3: Interaction-diagram between data-buyers and smart contracts.

# Blockchain-based Interoperable Healthcare Using Zero-knowledge Proofs and Proxy Re-Encryption

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**Abstract**—The development of a robust, transparent and interoperable E-healthcare infrastructure has been a difficult task due to many regulations and legislatures like HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General Data Protection Regulation). Healthcare service providers prefer to store data about their patients in locked up silos, behind often inadequate layers of security and firewalls. Such an approach results in data breaches and limits the ability to get a holistic view of the medical history of a patient. The obscure cost of treatment is another issue brought to attention recently in media. In this paper, we have proposed a national blockchain framework for managing patients' Electronic Health Records (EHRs) access control and funds in the context of India's National healthcare scheme. We introduce a transparent insurance claim process for healthcare providers and an auditable trail of EHR access using smart contracts. We use a smart card approach allowing beneficiaries to authenticate their identity using zero-knowledge proofs and delegate access to service the providers via proxy re-encryption.

**Index Terms**—Blockchain, Healthcare, Proxy Re-Encryption, ZK-Snarks, Zero Knowledge Proofs

empanelled hospitals it is necessary to enforce a national pricing mechanism for the 1350 medical treatments covered under this scheme.

Blockchain-based solutions are emerging to be a viable option for overcoming the flaws in current healthcare systems by allowing secure data sharing and controlled access between healthcare providers and insurance companies [5], [6]. Research has also been done to allow privacy assured health insurance claims using blockchain technology [7]. A blockchain acts as a distributed and immutable ledger between the stakeholders like Hospitals, Patients, Pharmacies and Government agencies. Its immutability allows for an auditable trail of transactions that are cryptographically linked and transparent. A recent study by IBM [8] showed that 56% of healthcare institutes plan to adopt blockchain technology for EHR sharing. Privacy is a major feature that needs to be built by design into a blockchain architecture for it to be adopted, especially in the case of

# **PoliceChain: Blockchain-Based Smart Policing System for Smart Cities**

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**Raju Halder**

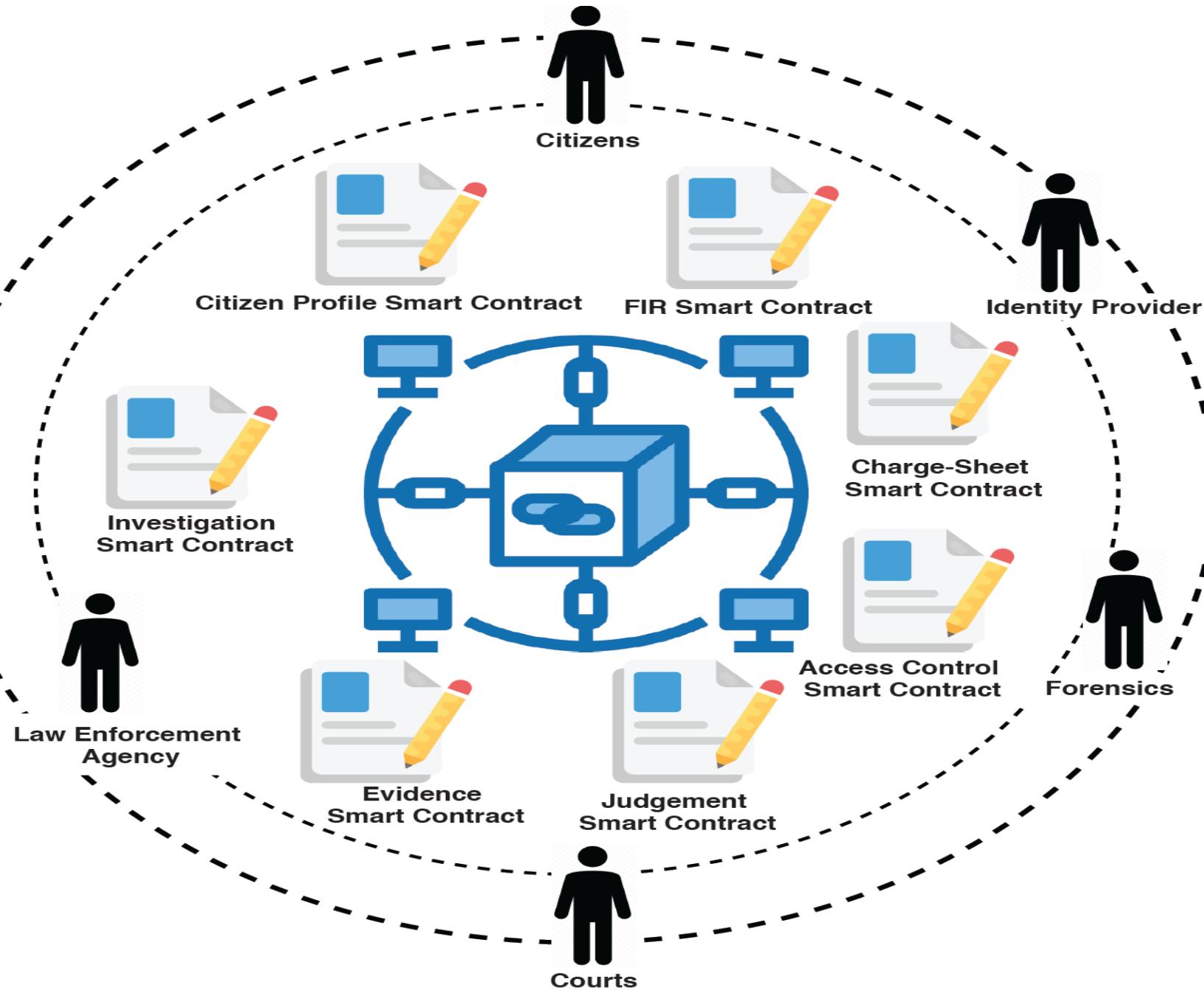
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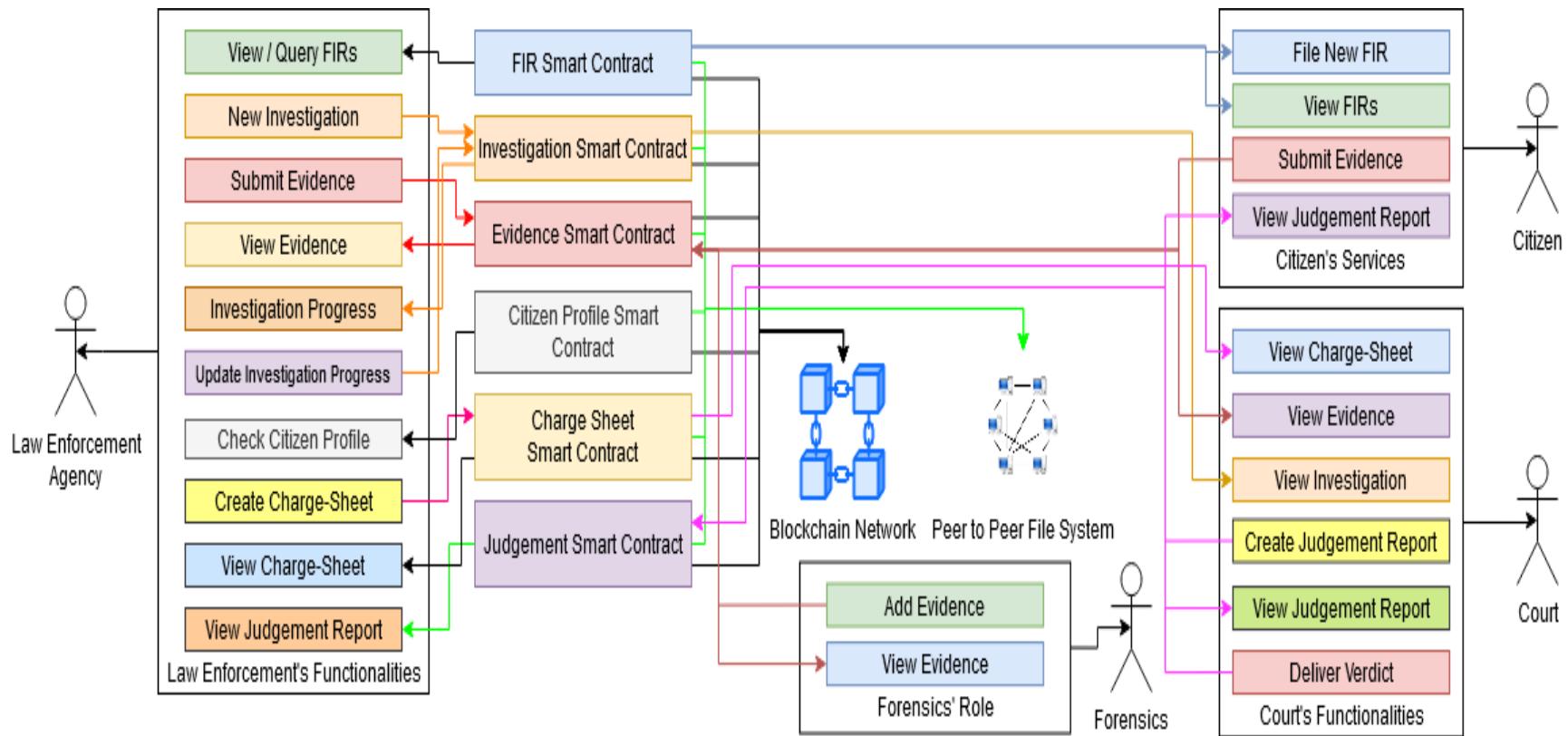
## **ABSTRACT**

This paper proposes a novel blockchain-based smart policing system which increases accountability, transparency, and trust concerning the storage, safeguarding, and sharing of evidence and intelligence related to ongoing investigations, criminal cases, and justice information among the stakeholders. The system allows various stakeholders, such as citizens of the country, law enforcement agencies, intelligence agencies, forensic departments, government bodies, and judges, to participate and to provide crucial services, such as filing FIR, initiating investigations, adding forensic reports, delivering justice, etc., related to smart policing. We present a proof of concept of our proposal using Hyperledger Fabric, adopting the Attribute-Based Access Control (ABAC) policy, and we perform an experimental evaluation to demonstrate the performance of the system. To the best of our knowledge, this is the first proposal on a blockchain-based smart policing system in the literature.

smart service, among many others, which smart cities must adopt is a smart and robust policing system that allows the citizens to interact with law enforcement agencies securely (even without visiting them physically) and to avail all related services respecting S.M.A.R.T. principles – strict and sensitive, modern and mobile, alert and accountable, reliable and responsive, techno-savvy and trained [8].

Observably, in most of the developing and under-developed countries where a significant gap in the police-population ratio exists, a major part of the population is often denied, directly or indirectly, to avail policing services. In most of the cases, it is observed that citizens need to visit a nearby police station to file a First Information Report (FIR) in the form of written documents. This has few downsides, firstly it is not always possible for the citizen to visit the nearest police station from the place of occurrence of the offense, secondly, the police may not always let citizens file an FIR. Even if an FIR is filed, the law enforcement agency might not actively take action on the FIR. Moreover, the current system of policing suffers from





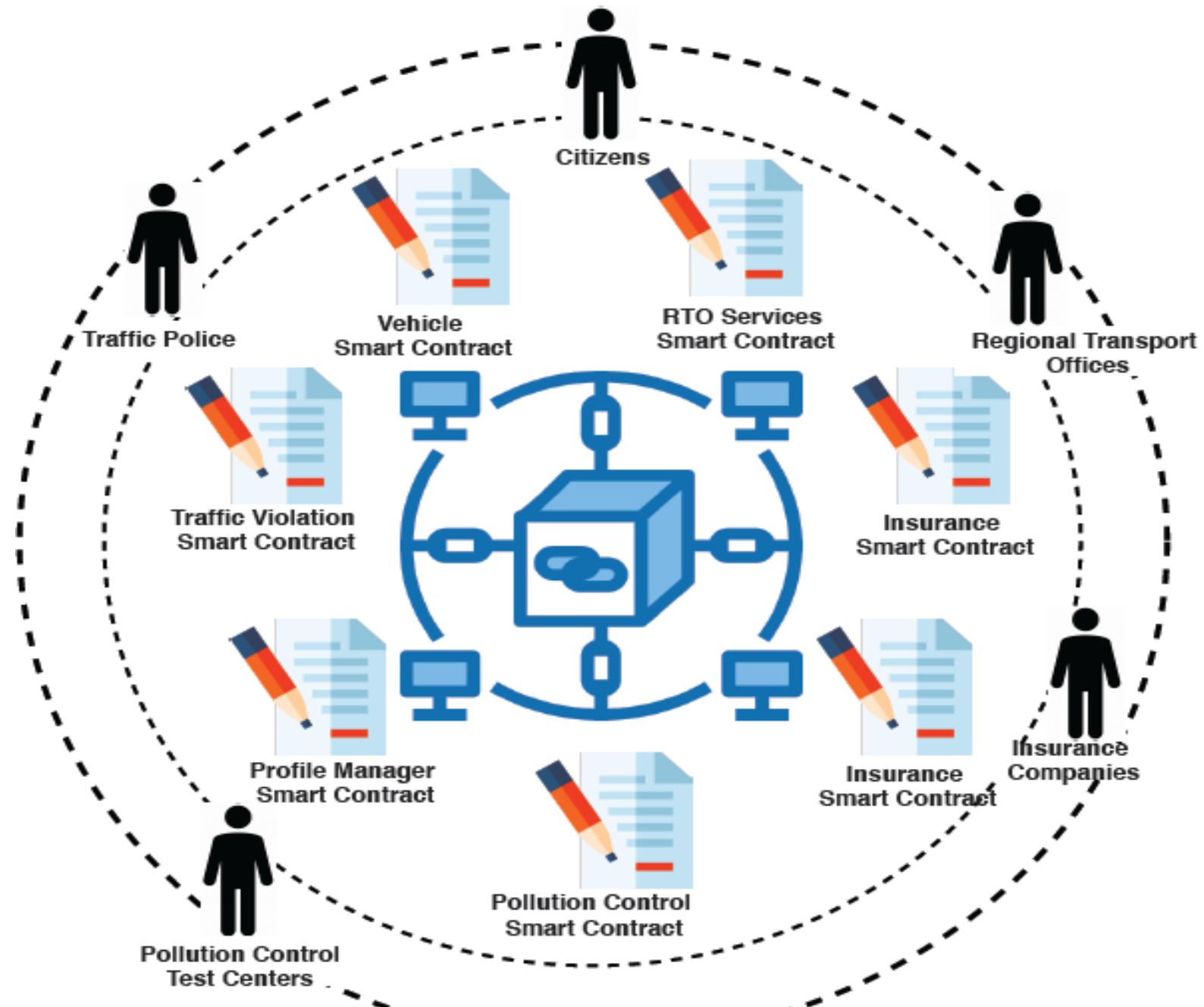
# An Integrated Platform for Vehicle-Related Services and Records Management using Blockchain Technology

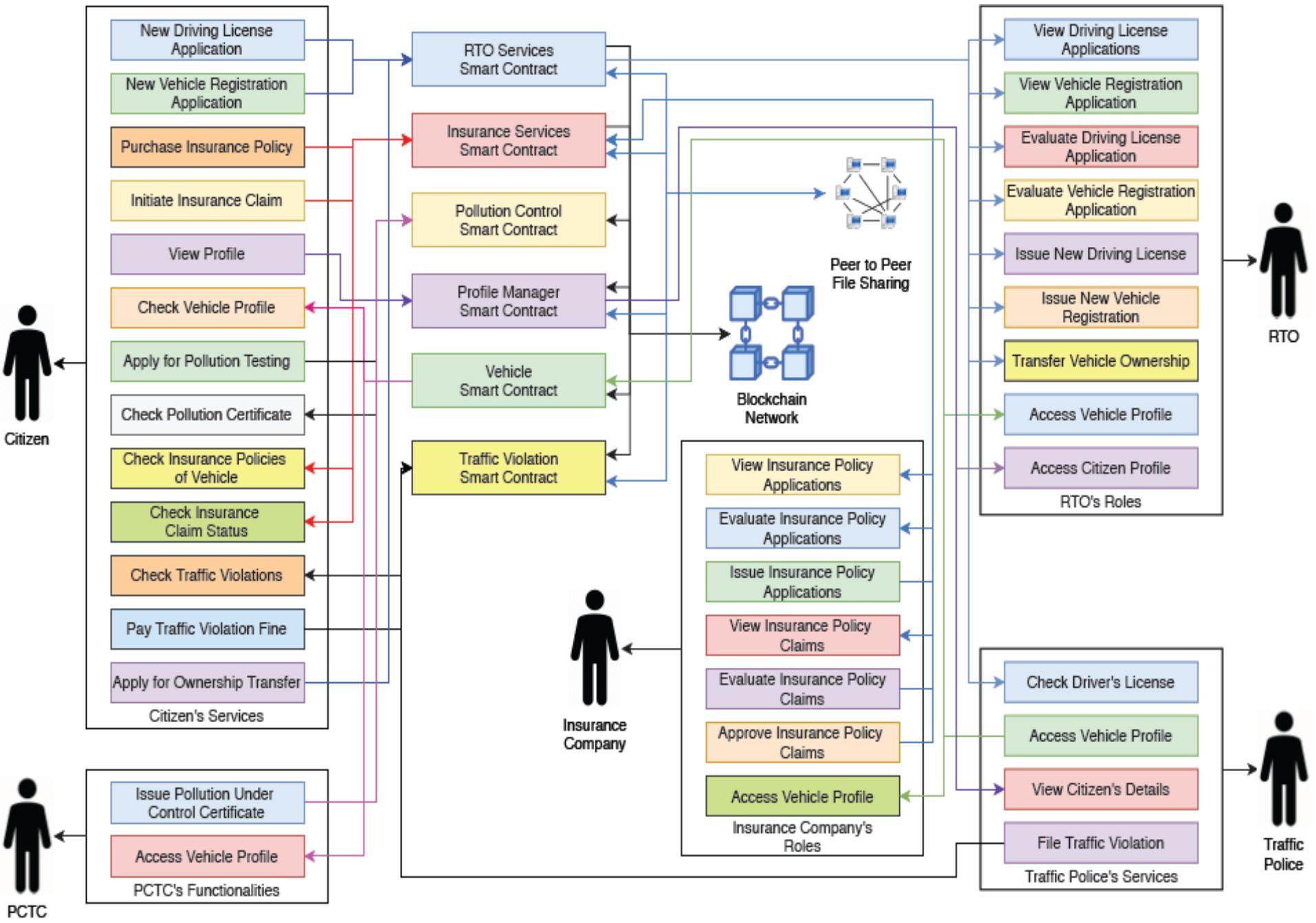
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**Abstract.** This paper proposes an integrated system for vehicle-related services and records management using blockchain technology, where various stakeholders (vehicles owners, regional transport offices, insurance issuers, pollution control test centers, traffic polices) can avail or provide various services (vehicle's registration, driving license issuance, insurance and pollution under control certificates issuance, automated insurance claim, auditable trail of vehicle's documents access and verification) in a hassle-free manner without any untrusted intermediaries. While the use of blockchain technology increases accountability, transparency and trust in the system, this allows a cohesive integration of the proposed system with other smart city digital infrastructure easily. We develop a prototype of our proposal as a proof of concept using Hyperledger Fabric, adopting Attribute Based Access Control (ABAC) policy, and we present experimental evaluation to demonstrate the performance of the system. To the best of our knowledge, this proposal is the first of its kind to provide a common blockchain-driven platform for all vehicle-related services and record-management.

**Keywords:** Vehicle Records · Vehicle Services · Blockchain Technology · Smart Contract.





# Few Survey papers

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1

## A Survey of Blockchain Technology Applied to Smart Cities: Research Issues and Challenges

Junfeng Xie, Helen Tang, Tao Huang, F. Richard Yu, *Fellow, IEEE*, Renchao Xie, Jiang Liu, and Yunjie Liu

**Abstract**—In recent years, the rapid urbanization of world's population causes many economic, social and environmental problems, which affect people's living conditions and quality of life significantly. The concept of "Smart City" brings opportunities to solve these urban problems. The objectives of smart cities are to make the best use of public resources, provide high quality services to the citizens, and improve the people's quality of life. Information and Communication Technology (ICT) plays an important role in the implementation of smart cities. Blockchain as an emerging technology has many good features, such as trust-

has been affected by environmental resource constraints, traffic congestion, air pollution, greenhouse gas emission and waste disposal [4]. All these challenges and problems force participants in cities (e.g., governments and citizens) to pay attention to smarter approaches for the sustainable development of cities and the improvement of citizens' quality of life. In this case, the concept of "Smart City" is proposed [4]–[7].

What is a smart city? Although there are many definitions of "Smart City", a commonly accepted definition is that

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Review

### Blockchain for smart communities: Applications, challenges and opportunities



Shubhani Aggarwal<sup>a</sup>, Rajat Chaudhary<sup>a</sup>, Gagangeet Singh Aujla<sup>b</sup>, Neeraj Kumar<sup>a</sup>, Kim-Kwang Raymond Choo<sup>c,d,\*</sup>, Albert Y. Zomaya<sup>e</sup>

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## Review

### Blockchain-based decentralized storage networks: A survey



Nazanin Zahed Benisi <sup>a</sup>, Mehdi Aminian <sup>a,\*</sup>, Bahman Javadi <sup>b</sup>

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#### ARTICLE INFO

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#### ABSTRACT

*Blockchain* is a new approach to create a distributed network which was first introduced in 2008. By the help of this disruptive technology a peer-to-peer network can be formed where nodes have to reach a consensus and form a chain from accepted blocks, while no central party or trusted controller is required. Among all the existing uses of this technology, decentralized storage systems are one of its prominent applications. Decentralized storage networks, are consisted of a group of people willing to rent out their unused hardware storage space. By

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Multidisciplinary | Rapid Review | Open Access Journal

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## Blockchain in Industries: A Survey

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Corresponding author: Jameela Al-Jaroodi (aljaroodi@rmu.edu)

**ABSTRACT** Blockchain technologies have recently come to the forefront of the research and industrial communities as they bring potential benefits for many industries. This is due to their practical capabilities in solving many issues currently inhibiting further advances in various industrial domains. Securely recording and sharing transactional data, establishing automated and efficient supply chain processes, and enhancing

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## Smart Contract Security: A Software Lifecycle Perspective

**YONGFENG HUANG<sup>ID 1,3</sup>, YIYANG BIAN<sup>2,3</sup>, RENPU LI<sup>1</sup>, J. LEON ZHAO<sup>3</sup>, AND PEIZHONG SHI<sup>ID 1,3</sup>**

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# Few Survey papers

## **Blockchain Technology for Cloud Storage: A Systematic Literature Review**

PRATIMA SHARMA and RAJNI JINDAL, Delhi Technological University, Delhi, India

MALAYA DUTTA BORAH, National Institute of Technology Silchar, Assam, India

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The demand for Blockchain innovation and the significance of its application has inspired ever-progressing exploration in various scientific and practical areas. Even though it is still in the initial testing stage, the blockchain is being viewed as a progressive solution to address present-day technology concerns, such as decentralization, identity, trust, character, ownership of data, and information-driven choices. Simultaneously, the world is facing an increase in the diversity and quantity of digital information produced by machines and

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**RESEARCH ARTICLE**

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## A survey on blockchain cybersecurity vulnerabilities and possible countermeasures

Huru Hasanova  | Ui-jun Baek | Mu-gon Shin | Kyunghee Cho | Myung-Sup Kim 

Department of Computer and Information  
Science, Korea University, Sejong,  
Republic of Korea

**Correspondence**

### Summary

Blockchain technology has attracted considerable attention owing to its wide range of potential applications. It first appeared as a cryptocurrency, called Bitcoin, but has since been used in many other business and nonbusiness

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## **Blockchain challenges and opportunities: a survey**

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Hong-Ning Dai

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# A Systematic Literature Review of Blockchain and Smart Contract Development: Techniques, Tools, and Open Challenges

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<sup>a</sup>*Department of Engineering, University of Sannio, Italy*

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## Abstract

Blockchain platforms and languages for writing smart contracts are becoming increasingly popular. However, smart contracts and blockchain applications are developed through non-standard software life-cycles, in which, for instance, delivered applications can hardly be updated or bugs resolved by releasing a new version of the software. Therefore, this systematic literature review oriented to software engineering aims at highlighting current problems and possible solutions concerning smart contracts and blockchain applications development. In this paper, we analyze 96 articles (written from 2016 to 2020) presenting solutions to tackle software engineering-specific challenges related to the development, test, and security assessment of blockchain-oriented software. In particular, we review papers (that appeared in international journals and conferences) relating to six specific topics: smart contract testing, smart contract code analysis, smart contract metrics, smart contract security, Dapp performance, and blockchain applications. Beyond the systematic review of the techniques, tools, and approaches that have been proposed in the literature to address the issues posed by the development of blockchain-based software, for each of the six aforementioned topics, we identify open challenges that require further research.

**Key words:** Software Engineering for Blockchain Technologies, Software Quality, Software Metrics, Empirical Study, Ethereum,

# Survey on Blockchain based Smart Contracts: Applications, Opportunities and Challenges

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Madhusanka Liyanage

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*Centre for Wireless Communications, University of Oulu, Finland*

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## Abstract

Blockchain is one of the disruptive technical innovation in the recent computing paradigm. Many applications already notoriously hard and complex are fortunate to ameliorate the service with the blessings of blockchain and smart contracts. The decentralized and autonomous execution with in-built transparency of blockchain based smart contracts revolutionize most of the applications with optimum and effective functionality. The paper explores the significant applications which already benefited from the smart contracts. We also highlight the future potential of the blockchain based smart contracts in these applications perspective.

**Keywords:** Blockchain, Smart Contracts, Applications, DLT, Hyperledger Fabric, Ethereum, Corda, Stellar

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## 1. Introduction

The blockchain is a decentralized, distributed and immutable ledger comprised of a cryptographically linked chain of record collection. The collection of records referred as blocks and the

The records are computationally tamper resistant with the existence of the cryptographic links.

**Cryptographic Link:** The cryptographic link between each record sorted in the chronological order and the block builds the chain of integrity in the entire blockchain. The digital signature

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Blockchain-based Charitable Donations Tracking System
Meeting Room Booking System (Blockchain + Android App)
Mess Complaint Management System (Blockchain + Android App)
A common blockchain-based Platform for Criminal Records
Bringing Transparency in Govt. Mid-day Meal Scheme
Inter-departmental Library Management System using Blockchain
Educational/Job Certificate Sharing and Verification using Blockchain
Adhaar-based KYC using Blockchain
College Election/Voting System Using Blockchain (Privacy+Verifiability)
Remote HealthCare System using Blockchain
Blockchain-based Platform for Judicial System to reduce delay in Justice Delivery
Visualization of Blockchain Creation: Block Creation and Mining
Multigroup Data Sharing using Blockchain and IPFS
Blockchain-based Automatic Attendance Management System (Android App)
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