

# Blockchain Driven Knowledge Acquisition Systems: A General Framework

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## Abstract

Knowledge acquisition is an activity of generating knowledge through presently accessible data or information. Knowledge-base of an expert system is created using collaborative effort of experts. However, the knowledge-base is vulnerable to physical and cyber threats, which hinder the proper functioning of an expert system for providing decision support or recommending services. In this paper, we propose a blockchain-assisted knowledge acquisition framework based on cryptographically encrypted transaction and access control mechanism. Theoretical framework results verify that it helps to strengthen security of the knowledge-base.

## 1. Introduction:

Knowledge acquisition is the procedure to discover, infer and extract knowledge from currently available resources such as domain experts, reports, documents, datasets - and afterward define, formulate and encode the knowledge in the form of rules such that captured knowledge can be authenticated, endorsed and employed [1].

An expert system is an Artificial Intelligence based computer program having knowledge acquisition facility, knowledge-base, user interface, inference engine, and interpretation sub-system. Expert systems rely on the process of knowledge acquisition to emulate the behavior of experts. Expert systems such as recommender systems and decision support systems are used in critical situations e.g. healthcare to assist users in the decision-making process. The perseverance of rules in the knowledge-base is of significant importance as decisions recommended by expert systems are dependent on them [2]. The perilous situation demand that the knowledge-base of the expert system must be prevented from malicious activities and intensive security measures should be taken to ensure users' trust in their expert system.

Moreover, Building a knowledge-base is a collaborative process. An expert system will be more reliable if it's knowledge-base has been built through

multiple resources to keep a hold on all aspects of a particular domain. Blockchain [3] provides an immutable, forge-proof distributed database that ensures the secure exchange and protected storage of information. Blockchain can be employed to build a collaborative, secure and tamper-proof knowledge-base for the expert system.

The rest of the document is formulated as follows: In section 2 we have investigated the recent research work directed towards employing blockchain for building knowledge-bases for effective expert systems, in section 3 we have proposed our novel framework for blockchain driven knowledge acquisition systems whereas we have summarized our research work in section 4.

## 2. Recent Advances:

An expert system is a well-established field with research history of over four decades. However, the concept of using blockchain for establishing knowledge-bases for expert systems is quite novel. In this section, we briefly investigate the latest efforts which utilize blockchain to enhance expert systems and enact knowledge-bases. We observed that the researchers were focused on collecting and storage of data, but there was little work on the perseverance of knowledge-base using blockchain.

D. Worner et. al. [4] proposed a recommendation

system which suggests e-commerce products to customers. The system uses highly sensitive user data to provide personalized suggestions. The expert system employs blockchain to secure the privacy of customer data. The customers store their relevant data on blockchain and give explicit permission to the recommender system for accessing their consumption data. The system can access only the information defined in the revocable smart contract signed by the customer. In this way, customers have ownership and complete control over their data. The data is later converted into knowledge using algorithms to propound e-commerce products later.

F.Harer et. al in [5] have used blockchain for secure storage of intellectual capital of enterprise organization in a readily accessible form such that its provenance and ownership remain trackable. The intellectual information valuable for the organization is stored at “Knowledge Blockchain” in the form of cryptographically validated transactions packaged in “knowledge blocks”. The

intellectual capital can be used for reliable & effective decision making.

### 3. Proposed Framework:

Knowledge acquisition is generally classified as expert-driven knowledge acquisition and data-driven knowledge acquisition. In Fig.1 shows the blockchain driven knowledge acquisition framework which accumulates both data & expert-driven approaches. A private blockchain network is established as a knowledge-base for an expert system. The transaction-generation process for expert  $i$  is illustrated in Fig.1. A similar process exists for every expert. Each Expert is assigned a pair of public & private keys e.g.  $epub_i$  &  $epri_i$  for expert  $i$ . The expert will enter the rules through user interface for expert-driven knowledge Acquisition. For data-driven knowledge acquisition, Machine learning, data mining or data science algorithm will generate the rules and afterwards are validated by the corresponding expert.

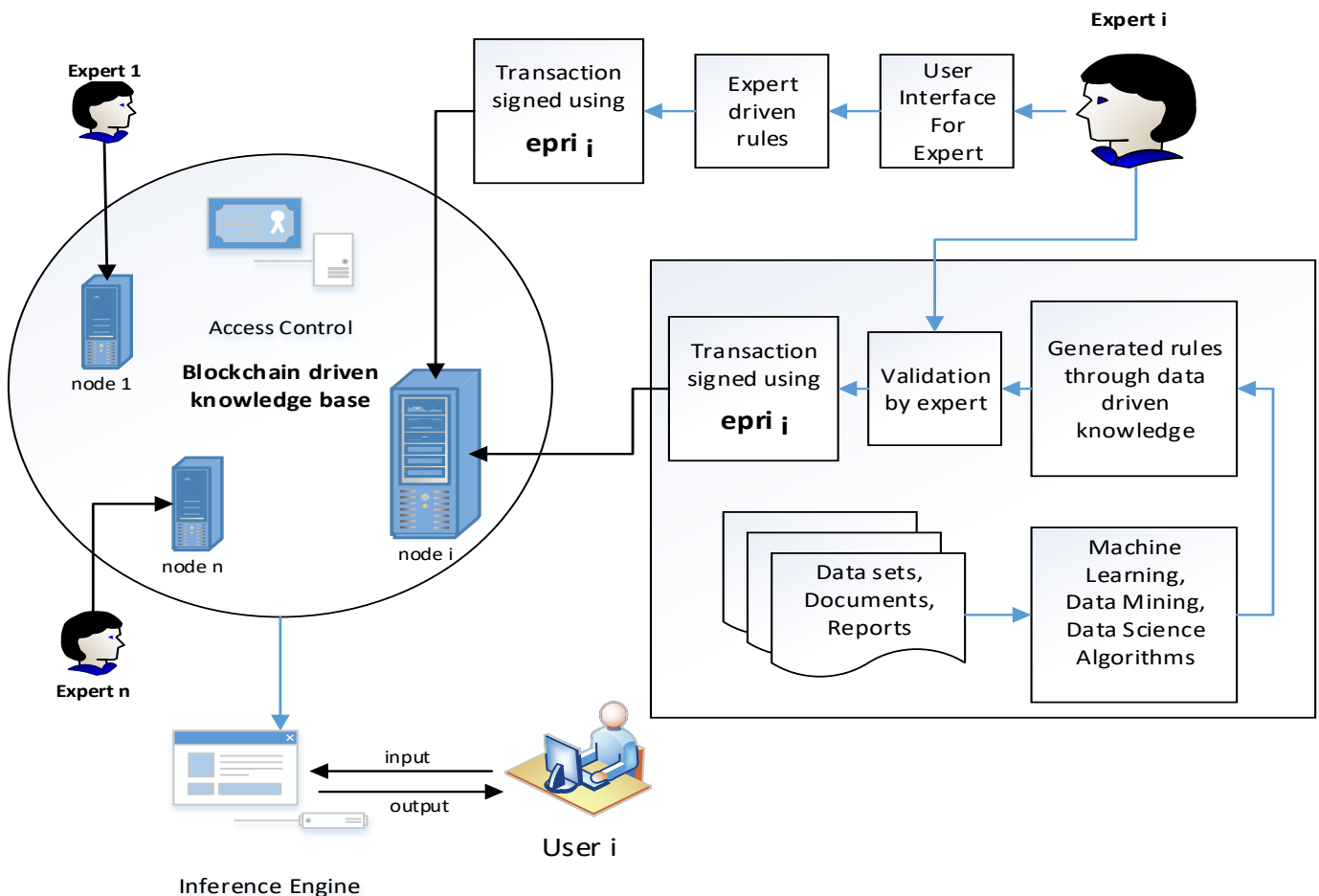


Figure 1: Blockchain driven knowledge acquisition framework

**Table 1: a qualitative comparison of traditional centralized knowledge-bases vs blockchain driven decentralized knowledge-bases**

<b>Traditional centralized knowledge-bases</b>	<b>Blockchain driven decentralized knowledge-bases</b>
They are prone to malicious attacks.	They are secure, immutable, irrevocable.
The provenance and ownership, data can be changed by a hacker.	The provenance, ownership, and data of the particular rule remain intact.
The rule submission process is not cryptographic encrypted thus can be subjected to malignant actions.	They provide a public & private key for submitting a rule securely to knowledge-base as a cryptographic encrypted transaction.

The rules will be encoded as a blockchain transaction, the transaction is signed by an expert using his private key and pushed into the blockchain network. Other nodes in the network will authenticate the transaction by verifying it through the public key of the expert as well as checking the permission status of a relevant expert from access control. The experts are permitted to insert a transaction on the knowledge-base by access control. Whereas, the users of the expert system are only authorized to access the rules in transactions through the inference engine. Later, the transactions are bundled in blocks to initiate consensus process e.g. Byzantine Fault tolerance similar to the typical private blockchain. After the consensus, each node in the network will have a complete copy of the knowledge-base stored in it.

The user of the expert system can provide the inputs to the inference engine. The inference engine utilizes the access control for getting access to the knowledge-base and eventually provide the services of the expert system to the user.

Table.1 shows the qualitative comparison between the traditional centralized knowledge-base and blockchain driven decentralized knowledge-base.

The knowledge engineer, expert system designer, and blockchain developer can collaborate for practical implementation of such an expert system for a specific domain. With blockchain based knowledge acquisition systems, the provenance, proprietorship, and data of peculiar rule in knowledge-base remain intact through cryptography.

**4. Summary:**

In this paper, we focused on strengthening the security of the knowledge-base of an expert system. We proposed a theoretical framework based on blockchain technology for traditional knowledge acquisition systems. The proposed framework generates a temper-proof knowledge-base for both data-driven and expert-driven knowledge procurement. Finally, we suggest researchers to propose a more comprehensive and revamped framework as future work of this study.

**Acknowledgment:**

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (NRF-2017R1A2A2A05000995). And also, This work was supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIT) (No.2015-0-00557, Resilient/Fault-Tolerant Autonomic Networking Based on Physicality, Relationship and Service Semantic of IoT Devices) \*Dr. CS Hong is the corresponding author

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