A Proposed Conceptual Framework for Blockchain Systems

Chapter A proposed conceptual framework for Blockchain Systems

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ABSTRACT

Across organisations data exchange is a topic of increasing interest. Blockchain technology is a promising technology for this management problem. Understanding the technology requires an understanding of the vocabulary related to blockchain systems and blockchain technology. The aim of this paper is to develop vocabulary and definitions for blockchain system, blockchain system type, blockchain system functional characteristics, blockchain subtype, blockchain system non-functional characteristics, blockchain system application area and governance of blockchain systems. This research is done by a systematic literature review and a systematic mapping study to identify vocabulary for defining a proposed conceptual framework for blockchain systems. None of the definitions have yet been used. As such, more work has to be done before actual implementations of putting such technology in a real life setting.

Keywords: definitions, definition of blockchain technology, blockchain system, blockchain system type, blockchain functional characteristics, blockchain subtype, blockchain non-functional characteristics, blockchain system application area, governance of blockchain systems, elements of blockchain system, vocabulary, mapping

INTRODUCTION

Collaboration requires from organisations an exchange of data. Due to globalisation, reliable data exchange has become more important. Organising data for use in organisations is done in database systems. Databases managed by a third party have to be trusted. In traditional centralised database systems, transactions are inherently trusted or endorsed through central trusted intermediaries that guarantee validity (Walton, 1995). Organisations that provide a digital infrastructure (a platform) in a peer-to-peer network (P2P) to users for them to exchange or share access to goods or services, incorporate decentralized database systems into their digital platform (Barbe, 2019). Because organisations do not have control about the centralised database systems of the counterparty, they investigate methods for the data exchange. Blockchain technology is a prominent example as a promising technology to the distributed transaction management problem, being conducted among peers in a P2P network. The origin of blockchain technology can be traced to a "chain of blocks of transactions" (Halaburda, 2018). A blockchain system is a decentralised transaction and data management technology developed first for Bitcoin cryptocurrency (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). Data and transactions spread across multiple organisations or countries is a distributed ledger or shared ledger (Halaburda, 2018). That decentralised blockchain system is in essence accessible for anyone who like to share data. Sharing information means improving transparency of the data. Shared ledgers play a crucial role in facilitating the flow of information between organisations. Since the creation of this blockchain system in 2008 by Satoshi Nakamoto (2008), research has been done to applications. David Andolfatto mentioned: "not enough care is taken in defining terms before discussing the subject. And when terms are defined, they sometimes include desired outcomes as part of their definition." (Andolfatto, 2018). No clear insight in vocabulary and terms could as yet be found. It is clear what is understood by blockchain as a technique. However, it is not clear what is meant by a

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blockchain system. No coherent set of definitions allowing discussions could be found. Answering the research question about elements related to blockchain systems is beneficial when deciding where the research on blockchain systems should be directed to and what issues need to be solved. That is why in this paper such a vocabulary will be developed.

In the next paragraph a short summary of currently used definitions and their drawbacks will be given. After that the methodology of this research is explained. In paragraph 4 the results of this research are expressed. The paper ends with conclusions and a discussion.

Related work

A literature research is a first step to find vocabulary. Some research claims that the blockchain system is in the development stage (Halaburda, 2018; Hitoshi Okada, 2017; Lemieux, 2017; Meijer, 2018). Many authors make their own definitions. Below some definitions are cited and which shows that unambiguously is not present yet.

A blockchain is a new type of database that enables multiple parties to share the database and to be able to modify that in a safe and secure way even if they don't trust each other (Hileman, 2017). The definition argues that the blockchain is a new type of database.

Blockchain systems possess a number of attractive attributes for the banking and financial- services markets. Such systems are resilient and can operate as decentralised networks that do not require a central server and do not have a single point of failure. Because they operate using distributed open source protocols, they have integrity and do not need to trust a third party to execute transactions. Public blockchain systems are also inherently transparent, because all changes are visible by all parties. The blockchain functionality also allows applications and users to operate with a high degree of confidence because transactions are unchangeable – they cannot be reversed or resequenced. In general, blockchain systems are uniquely able to ensure that contracting parties all have accurate and identical records (Treleaven, September 2017). This definition shows a complex system in which many aspects are mentioned, what needs more explanation.

A public blockchain or ledger consists of a set of blocks that are linked together, where each block contains a set of transactions. A public blockchain is maintained by a group of users, who run a consensus protocol (e.g., proof of work with longest chain) to resolve disagreements regarding the blockchain. In a simple realisation of public blockchain, each user keeps a local copy of the entire blockchain, meaning that each user has access to all historic activities and can easily test whether a new transaction is consistent with the existing transactions. This explains why a public ledger does not have to rely on any centralised party. This technique is central to many popular applications, such as Bitcoin (Xu, 2017). In this definition the process of the transaction is mentioned, but a public blockchain is more complex.

Sinclair Davidson et al come up with "a new general purpose technology in the form of a highly transparent, resilient and efficient distributed public ledger (i.e. decentralised database)" (Davidson, 2018). The definition shows subjective elements like 'highly' and 'efficient'.

Wattana Viriyasitavat defines it as follow: "The core element of any Blockchain application is its consensus protocol for reaching consensus of information sharing, replicating state, and broadcasting transactions, among participants" (Viriyasitavat, 2019). The definition is only focussing on the protocol.

A blockchain system is an information system based on database technology. For the exchange of data over organisations a decentralised database is applied. To understand more of the blockchain system it is necessary to find vocabulary what is unambiguously. In the definitions mentioned it is not clear what a blockchain system is.

After analysing literature the current situation is that terms and definitions are not unambiguously used. The aim of this literature research will be to come to a coherent vocabulary for a blockchain system. In the next paragraph the methodology of this research is explained.

Research methodology

A systematic literature review involves several discrete activities. The stages in a systematic review are planning the review, conducting the review and reporting the review. The most important activity during

planning is to formulate the research question(s). The review protocol is a critical element of any systematic review (Kitchenham, 2007). Once the protocol has been agreed, the review can start. The aim of a systematic review is to find as many primary studies relating to the research question(s) as possible. It is necessary to determine and follow a search strategy. To provide an overview of this research area and to establish if research evidence exists, systematic mapping study was selected (Kitchenham, 2007). The results of the mapping study would help to identify and map elements related to blockchain systems into vocabulary needed for defining a proposed conceptual framework for blockchain systems (Yli-Huumo et al., 2016). The final phase involves writing up the results of the review. The systematic mapping process is the research methodology to gain insight into the vocabulary used to date about blockchain systems.

Definition of research question

The first stage of the systematic mapping process is the definition of the research question. The goal of this study is to find elements for definitions in current research on blockchain systems, and use them to develop a consistent vocabulary. Therefore, one research question is defined:

What are elements to create definitions for a vocabulary related to blockchain systems?

The second stage of a mapping study is to search for relevant scientific papers on the research topic.

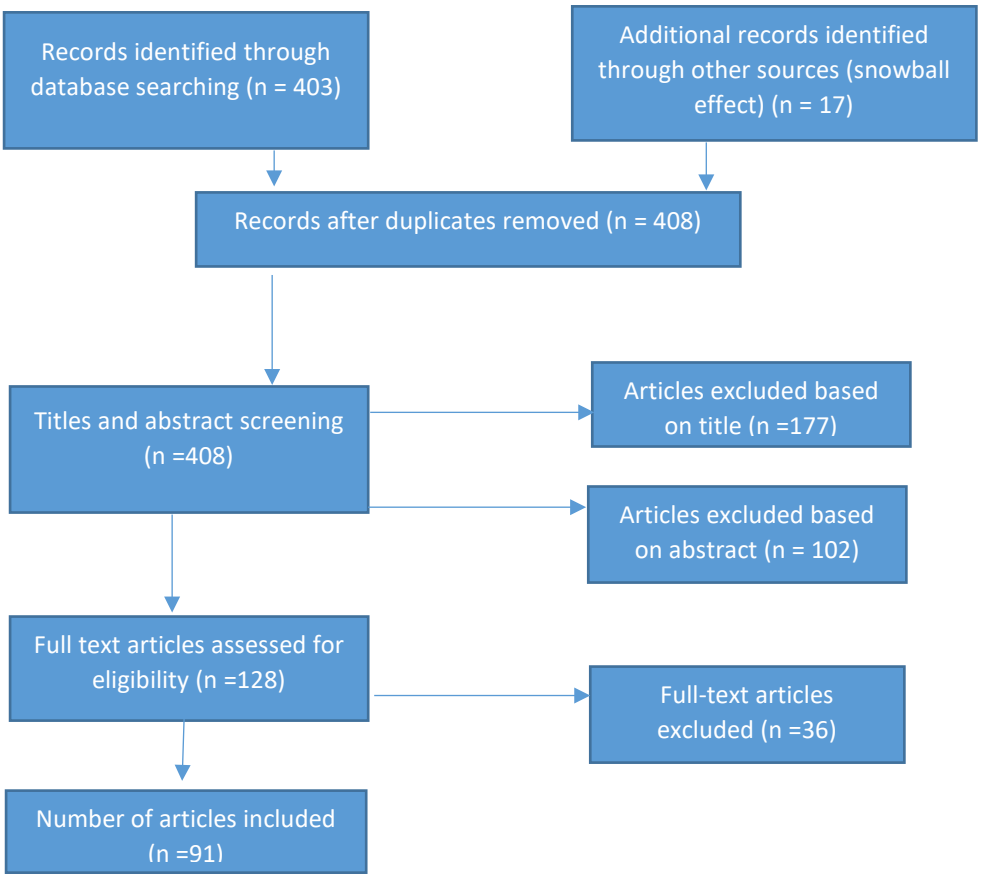


Figure 1 Flowchart of the search strategy

A search protocol is created that is used for scientific databases to gather the papers relevant for this research topic. The terms used in the search string were chosen after pilot searches, where possible keywords were tested. After the pilot search the queries “define blockchain systems”, “define blockchain system”, “definition of blockchain system”, “definitions of blockchain systems” were decided to use. Only 17 results appear. It was decided to concentrate on peer-reviewed, high quality papers published in conferences, books and journals related to the research topic. The 17 papers was too small to base the investigation on. Therefore other queries “definition of blockchain” and “define blockchain”, “blockchain typology” and “blockchain taxonomy” were also decided to use. However, in the pilot search also

'distributed digital ledger', 'applications of blockchain technology' and 'areas of blockchain technology' were used as a search term, but a huge number of papers that were related to Blockchain technology were identified, rather than system aspects of Blockchain. Therefore, since the goal in this mapping study process was to find and map the papers related to blockchain systems, it was decided to drop those terms.

After designing and testing the search protocol, the scientific databases for the searches were chosen. Seven scientific databases were used for paper retrieval. The databases chosen were (1) IEEE Xplore, (2) Emerald Insight, (3) Springer Link, (4) Science Direct, (5) Ebsco, (6) PLOS One, and Atlantis Press.

Screening of relevant papers

Because all papers in the searches were not necessarily related to the search questions, they needed to be assessed for their actual relevance (Kitchenham, 2007). After using the search protocol in the scientific databases, the next stage was the screening of the papers. At the first screening phase, the papers based on their titles including "blockchain" were screened and excluded studies that were not relevant to the research topic. The search protocol returned papers related to Blockchain in other scientific fields, which had different meaning than the blockchain systems. These papers were clearly out of the scope of this mapping study, which was a valid reason to exclude them. However, in some cases it was difficult to determine the relevancy of the paper on the basis of the title of the paper. In these situations, the paper passed through the next stage for further reading. In the second phase, the abstracts of every paper were read that past the previous phase. If the term "blockchain system" was mentioned in the abstract it was accepted. In addition, specific inclusion and exclusion criteria were used to screen each paper. It was decided to exclude the following types of papers: (1) papers where the main language was not English, (2) papers that had some other meaning than blockchain systems used in Information Systems, and (3) papers that were duplicates. When a paper passed all the three exclusion criteria, and after reading the abstract it was considered as focusing on blockchain systems, it was decided to include it in the next screening stage.

Table 1 Inclusion and exclusion criteria

Selection criteria	Scientific database	
Inclusion	Peer reviewed research articles, conference proceedings papers, book chapters and journals related to the research topic With a timeframe: January 1, 2008 up to now	
Exclusion	First criterion	Non English articles, articles with missing abstracts, notes, editorials
	During title screening	Generic articles related to blockchain technology and/or blockchain architecture
	During abstract screening	Not related to blockchain systems
	During full-text screening	Articles addressing aspects of blockchain technology

Elements on the basis of the abstract

The next stage in a mapping study process after finding the relevant papers through abstracts is finding definitions used by researchers so far. This definition is than starting point for further research.

Data extraction and mapping process

More elements related to the research topic will be looked for in literature. By using a hybrid meta plan methodology an open and closed card system is the start. An open card is used from the elements chosen out of the definitions and elements from the literature. A closed card is used when a new key concept can be added after the selecting of the elements over the key concept makes it relevant. When the key concepts are in view the selecting of the elements related to the definitions and literature are executed. An open card sorting methodology is a participatory, user-centered design activity to gain an understanding of how users

understand information. The open card method have very few restrictions, rename cards with better labels, add or remove cards from the list are possibilities (Paul, 2008). The participant sorts the cards into groups and labels each group. By open card sorting methodology key concepts about blockchain systems were created to develop a higher level of understanding based on these labels (Paul, 2008). Participants brainstorm and collaborate to reach consensus on elements related to labels. The moderated collaboration model aims to reduce bias. The phases conducted were: (1) discuss the labels (2) the cards of the elements were sorted to the labels, (3) some cards needed extra attention, (4) a new label can be added, (5) a list of elements related to the labels was created. That is the input for vocabulary related to blockchain system key concepts.

After the session of open card sorting definitions will be created per category. The elements select per category will be grouped. A group of terms will receive a general term what will be used for a definition. The definitions are the fundaments for vocabulary for further research.

Limitations of the systematic mapping research are the reading of the papers and the selecting of the definitions and the terms will be done by one person. It is possible that another person will select more, less or different elements of the literature. Time constraint is also a limitation.

Results

In this section, the search and selection results of the systematic mapping study are presented.

420 papers were initially retrieved when the designed search protocol was applied to the selected scientific databases. After that duplicates were removed. The first inclusion and exclusion round was based on the titles and the abstracts of the retrieved papers. All the paper titles and abstracts were examined which led to the selection of 128 papers. The reason for the high number of excluded papers (177 papers for titles) was that they were not related to the research topic. After that the abstracts were read and another 102 papers were excluded. For example, many excluded papers discussed the blockchain technology, and therefore they did not belong to our study. After that all papers were read and a list of elements belonging to blockchain systems were noted. The list contains words or terms related to the research question with a reference to the paper. Participants used the meta plan hybrid method to name the key concepts they created themselves. The key concepts are:

Key concepts

1 Blockchain technology
2 Blockchain system
3 Blockchain system type
4 Blockchain system functional characteristics
5 Blockchain system subtype
6 Blockchain system non-functional characteristics
7 Blockchain system application area
8 Governance of blockchain systems

After card sorting methodology the elements were added to the key concepts and one key concept was added, namely Governance of blockchain systems. Two elements were not used: infrastructure and open-source technology, because after discussing they have no relation with the classifications made.

After the session of open card sorting definitions are created per key concept. The elements selected per category are grouped. A group of terms received a general term what will be used for a definition. Below for ‘blockchain system non-functional characteristics’ it is worked out (available to the author). The definitions are the fundaments for vocabulary for further research.

6 **Blockchain system non-functional characteristics**

a. Trust across transaction value chains Anonymity Privacy No trusted intermediary Trust / control do not need to trust don’t trust
b. Consensus Validity Resilience Persistency resilient Confidence consensus protocol safe and secure do not have a single point of failure
c. Irreversible Tampering and revision Immutable / immutability Performance Write only (immutable)

d. Integrity of data Finality Provenance integrity changes are visible by all parties and can easily test whether a new transaction is consistent with the existing transactions.
e. Publicly accessible records A democratizing technology Disintermediary Transparency Openness transparent Blockchain application transparent, resilient and efficient distributed public

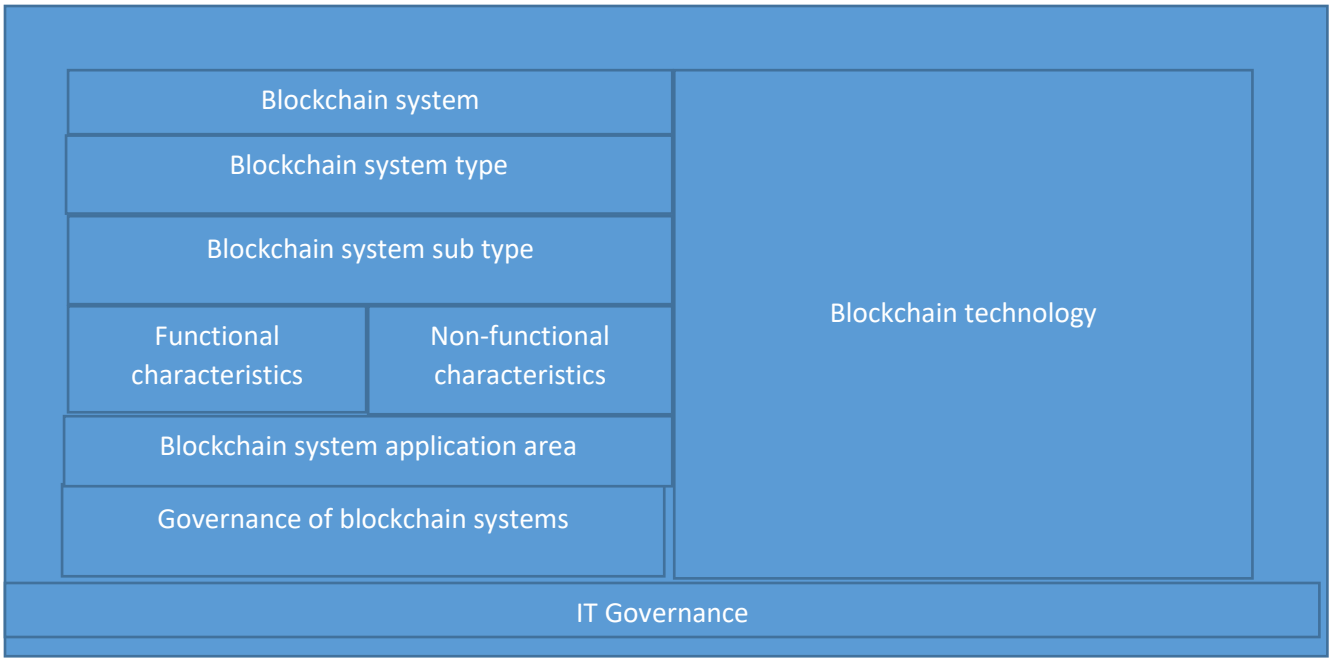
DEFINITION OF BLOCKCHAIN SYSTEM NON FUNCTIONAL CHARACTERISTICS

A democratising technology of a blockchain system needs integrity of data. The validity of the data is guaranteed by transparency of the process and the irreversibility and immutability of the transactions. Consensus is realised by protocol. This process is important for trust across the value chain.

The definitions of the key concepts are:

Number	Term	Definition
1	Blockchain technology	*A decentralised database using distributed open source consensus protocol in a peer-to-peer network what is cryptographically secured.*
2	Blockchain system	*A decentralised network where transactions can be executed.*
3	Blockchain system type	*A system in which digital data is included.*
4	Blockchain system functional characteristics	*A decentralised decision making system with no human or institutional intervention in transactions on the chain. In the system every identity can execute transactions by paying a transaction fee what is checked by a protocol. The system is organising historical information what makes it auditable.*
5	Blockchain system subtype	*The blockchain subtypes depends on authorities. If no intermediary is involved, and the transactions are approved by a protocol in the chain, it is called public. If an intermediary is involved, and the transactions are approved by a central party it is called private, or hybrid.*
6	Blockchain system non-functional characteristics	*A democratising technology of a blockchain system needs integrity of data. The validity of the data is guaranteed by transparency of the process and the irreversibility and immutability of the transactions. Consensus is realised by protocol. This process is important for trust across the value chain.*
7	Blockchain system application area	*An institutional or social technology for coordinating people. Each block contains a set of transactions. The transactions need economic coordination. Different types of markets can be involved.*
8	Governance of blockchain systems	*All blockchain systems will need/have a specific governance.*

An overview of the blockchain in blockchain system and blockchain technology is as follow:



In this chapter definitions are developed to create a proposed conceptual framework for blockchain systems. The aim was to find a coherent vocabulary for a blockchain system what was unambiguously up to know.

Conclusion and discussion

This paper provided an overview of the current blockchain system vocabulary discussion by using systematic literature review. The goal this study was to find elements for definitions in current research on Blockchain systems, to create a proposed conceptual framework for blockchain systems. Therefore, one research question was defined: *What are elements to create definitions for a vocabulary related to blockchain systems?*. Understanding which elements are critical to certain blockchain systems, a vocabulary can be developed for blockchain systems. Answering this research question is beneficial when deciding where the research on blockchain systems should be directed and what issues need to be solved. This paper takes an initial step to define certain elements of a blockchain system. If enough care is taken in defining terms before discussing the subject you make progress in further research.

Discussion

The principal limitations of a systematic mapping study are related to publication bias, selection bias, inaccuracy in data extraction, and misclassification (Fernandez, 2011). Publication bias refers to the problem that positive results are more likely to be published than negative ones, since negative results take longer to be published or are cited in other publications to a lesser extent (Fernandez, 2011; Kitchenham, 2007). To address this issue, well-known scientific databases were used in the search protocol to find papers. This increased the number of papers to find for this literature study. However, considering blockchain systems is rather a new topic in computer science and academia. Therefore, all research conducted on blockchain system aspects might not be included in this mapping study. However, by using only scientific databases as a source for finding relevant research, collecting papers that were probably of a higher quality.

Selection bias refers to the distortion of statistical analysis owing to the criteria used to select the publications (Fernandez, 2011). This issue is addressed by designing the research protocol carefully. It was also conducted with a pilot search with different keywords, to ensure that as many papers as possible were included in this mapping study. Rigorous inclusion and exclusion criteria were developed, to ensure that all selected papers were part of the research topic, and answered the research questions. However, there is a

one major limitation that needs to be addressed. The research protocol included only the term Blockchain system. There is a possibility that not all the research related to Blockchain systems was found due to the search protocol for paper retrieval. The aim was to study the system aspects of a blockchain, rather than trying to understand how the technology can work in real-world environment. Based on the pilot research, it is believed that a majority of the relevant papers was retrieved by using only (definition and define) blockchain as a search term.

Inaccuracy in data extraction and misclassification refer to the possibility that information is extracted differently by different reviewers (Fernandez, 2011). This issue was addressed by using four authors in the paper retrieval process of characteristics. In a situation where the opinions did not match, a discussion to address the characteristic was taken place to be included or excluded.

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