University of Passau
Departement of Informatics and Mathematics

Master's Thesis

„Innovative Blockchain-Driven Business Applications“

An Analysis Of Disruptive Product Offerings

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Abstract

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Acknowledgements

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1 Introduction

Starting to work in the context of industrial maintenance, I focused my research on current technologies in the field.
I did not have to look far to come to the conclusion, that the fourth industrial revolution is currently ongoing. In Germany the term 'Industry 4.0' emerged as a label for it and was widely accepted. There are certain technologies or more methodologies that play an important role: Machine Learning, Big Data, Data Analytics, Internet of Things (IoT), Blockchain and many more.
In the smart factory, mainly IoT technologies are implemented at this instant, to connect machines to other machines and make them work more autonomously. These IoT devices are usually connected by a centralized server in the cloud and focus on the server-client model. One of the main issues here is to find something that decentralizes the control of these IoT devices. Here the Blockchain (BC) is a technology that recently got a lot of attention. It was first used as the underlying technology to the cryptocurrency Bitcoin. Connecting these two technologies would therefore be an opportunity to provide a decentralized system.
Since there are not many defined standards describing Blockchain technology, it was quite hard to start the research. Digging deeper, I figured out, that there is a high need for use cases (empirical studies), so that for different areas, the advantages and drawbacks of the solutions can be tested. Reading the review papers on Blockchain use cases, I realized that neither of them were able to answer my question, neither to provide me with a good overview. I started to design my own schema to analyze the use cases and then tested it on some use cases.
The paper is structured as follows: in Chapter 2, a Background on the basics of the Blockchain technology and the state of the art in blockchain reviews are presented, in Chapter 3, my approach for information selection and the papers I selected to be analyzed, in Chapter 3, my approach on defining the criteria used to differentiate the selected paper, in chapter 4, the papers are discussed according to the criteria that were presented in chapter 3. In the 5th chapter, the results of chapter 4 are discussed, chapter 5 is the solution and presents further research opportunities.

2 Background

2.1 What is Blockchain?

Gartner[1], a research and advisory company, provides a yearly statistic called *"Hype Cycle for Emerging Technologies, 2017"*. The y-axis shows the expectations in the technology and the x-axis the time. This is categorized into five sections: **1)** Innovation Trigger **2)** Peak of Inflated Expectations **3)** Trough of Disillusionment **4)** Slope of Enlightenment **5)** Plateau of Productivity.

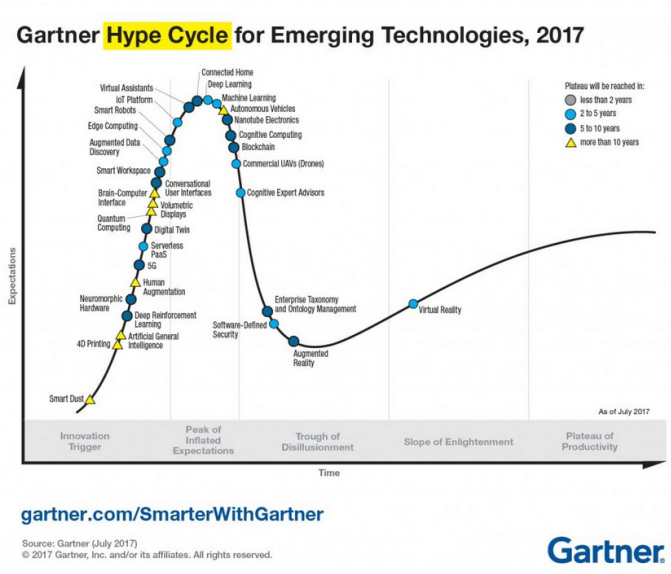


Figure 2.1: Gartner Hype Cycle for Emerging Technologies 2017

In 2016, the Blockchain technology was in the *"Peak of Inflated Expectations"*. That means it gained a lot of publicity and produced several successful use cases, but also that not many firms took part in using this new technology. By 2017, the Blockchain moved into the area of *"Trough of Disillusionment"*. This means that the interest in the technology is fading and that there is a certain number of use cases that did not succeed. The Blockchain is in between those two sections in 2017 and the final report of 2018 has not yet been published. [44]

The main thing to mention here, is that the Blockchain is not the same as Bitcoin.

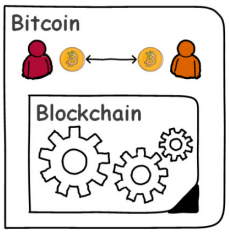


Figure 2.2: Bitcoin is not Blockchain

Nevertheless, Blockchain started with the invention of Bitcoin by Nakamoto [41] in

[1] https://www.gartner.com/

2009. Bitcoin is a system that used the Blockchain for digital payment processing. This makes Bitcoin the first application of the Blockchain technology. With the invention of Bitcoin, the following problems of cryptocurrencies were solved:

- Double spending problem (*"Byzantine Generals' Problem"*[2])
- No trusted third-party
- Cryptographic proof instead of trust

The Blockchain is nothing less than a successful combination of already existing technologies. The technologies it combined are: **1)** Peer-to-Peer (P2P) networks **2)** Cryptography **3)** Consensus decision-making.
A Peer-to-Peer (P2P) network is a form of a distributed architecture. Different peers participate in the system and all have equal rights. There is no central server, so the peers act as clients and servers at the same to share information between them. [47] Consensus decision-making is nothing less than a group decision-making process. Here, the group-members try to develop and then agree on a decision, which represents the best interest for the group. The consensus that they established can be seen the acceptable resolution. Overall, Cryptography is the research field that tries to establish secure communication between peers when there is an enemy, in this field also called adversary, that could steal the information. So basically, it describes the practice of converting someone's readable data, into unreadable data and vice-versa. [37]

2.1.1 Consensus algorithms

In a P2P Network, you have no trusted third party. Therefore, some rules need to be defined as for how to find a consensus between the different members of your system. There are multiple algorithms that already existed and are now used by various Blockchain technology implementations. Here, you can define between 'mining' and 'minting'. In a mining process you focus on how many resources you spend to build a new block in the blockchain and in minting, you focus more on how much existing resources you have. Consensus algorithms using mining are for example Proof-of-Work (PoW), Proof-of-Burn (PoB). Proof-of-Stake (PoS), Delegated Proof-of-Stake and Federated Byzantine Agreement (FBA) are on the other hand example for algorithms using minting.

2.1.2 Public-key cryptography

In the Blockchain context, Public-key cryptography is used. Every peer in the network has a private key and a public key. The public key can be seen by all other peers in the network, whereas the private key is kept secret by every user. The peers in the system have to fulfill two operations before sending a message: Encryption, Signature.
In the figure 2.1.2, you can see that the user 1 wants to transfer a message to user 2, he encrypts the message using the public key of the user 2. The encrypted message is then transferred via internet, so the user 2 can see it. Since only he is in possession of his private key, he is the only one that is able to encrypt it and read the message

[2] https://en.wikipedia.org/wiki/Byzantine_fault_tolerance

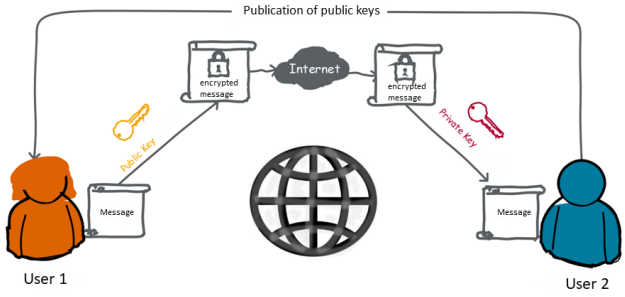


Figure 2.3: Public-key cryptography: Encryption process

that the user 1 wanted him to. All user that participate in the network have access to the public keys of the other peers, but only the peer with the right private key can encrypt the message that has been sent.
The signature process tries to copy a handwritten signature. This process provides proof, that a user is really the sender of a certain message. In Figure 4: Public-key cryptography: Signature Process, User 1 is sending a message to User 2. Since his message is very long, he is using a hash function to reduce the size of the message. Then he is using his private key to sign the message and the signed message will be send to another user. The user 2 then can verify with the public key of user 1, if it was really him that send the message.

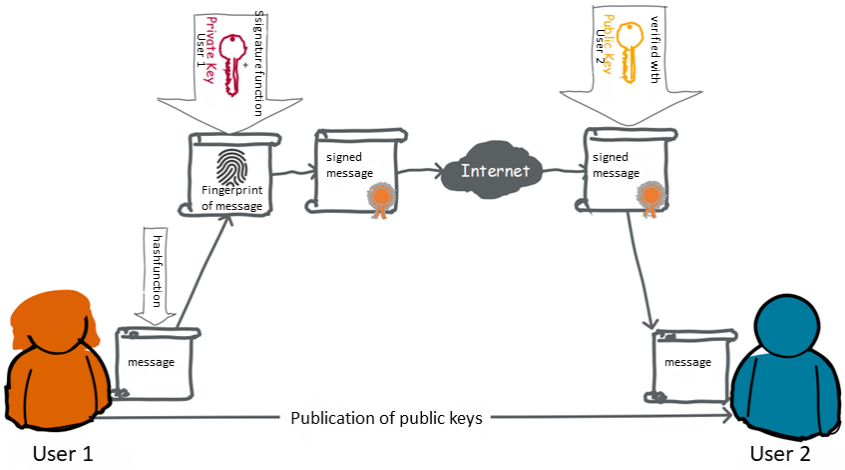


Figure 2.4: Public-key cryptography: Signature Process

These two processes are combined in the Public-key cryptography process.
Further, I would like to explain a bit, what a cryptographic hash function is. The process is quite simple, you get an input of any size, which is sometimes also called

a message, and you then use the hash function to map this input to an output of a fixed size. This function can not be reversed, meaning that you can not calculate the input by using the hash function on the output. In Blockchain systems, these hashes are organized into a hash tree or Merkle tree. This means that you have a certain number of transaction, that got hashed, then you hash them with each other and you build a tree until you arrive at the tree root, which is also called the Merkle Root.

2.1.3 Types of Blockchains

There is not a general specification of the different types of blockchains. Nevertheless, some researches are trying to establish a common standard. [17] mention that there are public and private Blockchains. Anyone can use a public blockchain without the approval of third parties, but a private blockchain is controlled by someone that can allow other peers to join the ecosystem. There are also permissionless and permissioned blockchains. The difference between those is that in a permissionless environment, any peer can act as a normal user or a miner and has access to all the functionalities offered by the blockchain. A permissioned blockchain is controlled by one instance and they can authorize peers to have access to certain functionalities and deny them the access to others. Another term is a consortium Blockchain. Here certain predefined peers have the control over the consensus process. [37] They also differ between logic-oriented and transaction oriented blockchains. Logic-oriented solutions focus on executing a certain logic implemented, like for example the smart contracts of Ethereum. The Bitcoin Blockchain is an example for a transaction oriented blockchain because it is clearly focused on transferring the cryptocurrency. Also, a blockchain system can be token-based or not.

2.1.4 Hyperledger

In the beginning, the 'Hyperledger' project was conducted by 11 different groups, including the Linux Foundation, IBM, JP Morgan and many more. Since this project is open source, the number of collaborators is constantly growing. Currently they have already developed various tools for their Hyperledger Fabric Blockchain. Their goal by implementing this blockchain technology was to provide an open source blockchain for enterprises so that they can construct industry-specific systems for secure transaction handling.

2.2 Blockchain Reviews

All the papers presented in chapter 2.2.4 have one thing in common, they analyzed the Blockchain and reviewed their results. Nevertheless, they all focus on different aspects of the newly popular technology. As can be seen in figure 2.5, the review publications were categorized in four major areas: finanical, technical, application and other reviews.

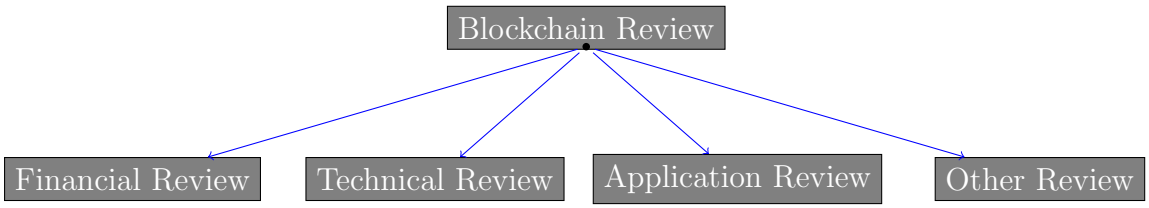


Figure 2.5: Blockchain Reviews

2.2.1 Financial Reviews

Since the Blockchain technology was born with the invention of a cryptocurrency, more precisely Bitcoin [41], there is a lot of research about it in the financial sector. There are multiple publications that focus on reviewing cryptocurrencies.

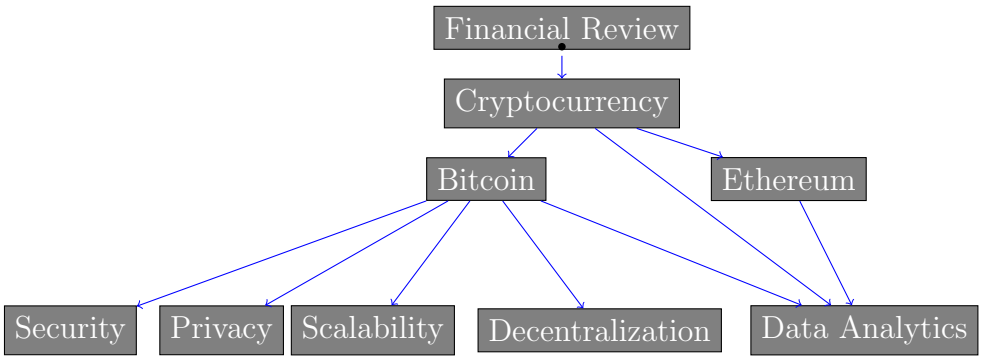


Figure 2.6: Financial Reviews

In their research, Tama et al. [51] review various areas in which the Blockchain technology has been implemented: **A)** Financial Service **B)** Healthcare **C)** Business and Industry **D)** Other Implementations. In their section "Finanical services" [51, chap. 3.A], they discuss the functionality of the Blockchain for financial transactions and different crytpcurrency systems, like Bitcoin[3], Litecoin[4], Peercoin[5], Ethereum[6], etc.
In [28] and [12] other issues related to only Bitcoin are adressed.
Karame [28] talks about the security measurements of Bitcoin's Blockchain regarding

[3] https://bitcoin.org/
[4] https://litecoin.org/
[5] https://peercoin.net/
[6] https://www.ethereum.org/

current attacks. They mention certain challenges of Bitcoin's Blockchain, above all in the areas security, scalability and decentralization.

- **Security**
  Studies [19, 22, 29] have been conducted to show certain attacks on Bitcoin. To improve the scalability issues, Bitcoin made some necessary changes to their system. Yet these changes effect the security of the environement. In their publication, Gervais et al. [19] tackle this problem. They show that an attacker can use these weak points for example for a *"Denial-of-service attack (DoS attack)*[7]*"*. As their contribution, they suggest certain countermeasures to be able to provide the same level of security while changing the scalability. In their research, Heilman et al. [22] implement an eclipse attack on the P2P-system of Bitcoin and present countermeasures to prevent their attack. Karame et al. [29] concluded that Bitcoin is not suitable to use for fast payments because the verification time for a transaction is 10 minutes. Their contribution was that they provided a survey about the security issues that result of using Bitcoin for fast payments.
- **Scalability**
  One of Bitcoin's problems is also the transaction rate. They are able to process 7 transactions per second, whilst Visa can process around 50.000 transactions.
- **Decentralization**
  In their study, Gervais et al. [18] analyze the limits of decentralization in the cryptocurrency Bitcoin. In their article, they proof that some of the processes that are implemented in Bitcoin are not fully decentralized and that a set of peers could be able to control the decision making process.

In their work, Conti et al. [12] discuss the security and privacy concerns of Bitcoin. In their first part, they review the current vulnerabilities which can end up being a security thread. Further on, they investigate the usefulness and stability of the current security solutions and they also discuss the privacy related challenges. In their conclusion, they summarize these open challenges and present countermeasures for them. Bartoletti et al. [5] on the other hand, put their attention more towards the data analytics that can be done on the information stored on the Blockchain. Their main contribution is a framework that can be used for general purpose analytics on the Blockchain of Bitcoin or Ethereum to be able to coordinate the Blockchain data with data from other sources and then to organize them in a database.

2.2.2 Technical Review

[TO DO] Papers to add: [14, 9, 39, 45, 56, 58, 7]

[7] https://en.wikipedia.org/wiki/Denial-of-service_attack

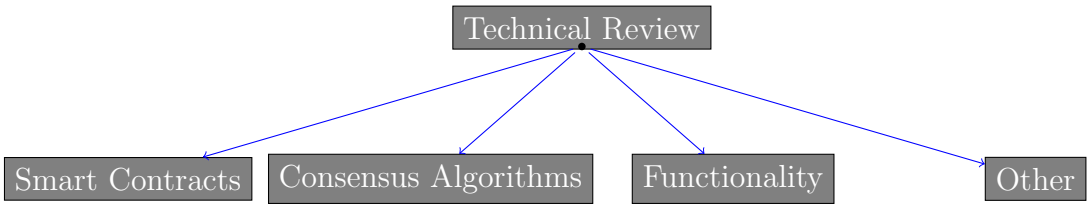


Figure 2.7: Technical Reviews

2.2.3 Application Reviews

There are also multiple review papers that focus on analyzing the application areas in which the Blockchain has been used or tested. Some papers focus only on one specific area, whilst others summarize all.

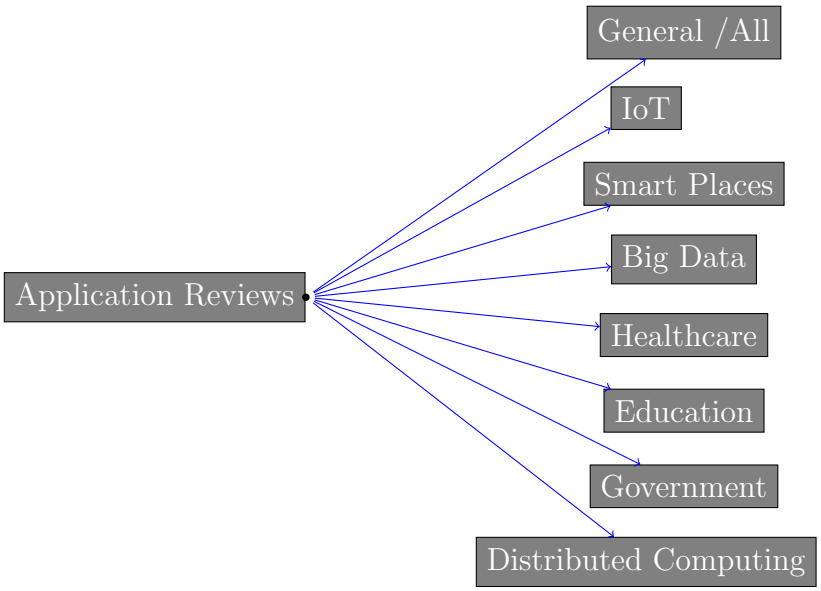


Figure 2.8: Application Reviews

Internet of things [11, 17, 55] Conoscenti et al. [11] conducted a *"Systematic Literature Review (SLR)"* on the blockchain use cases following the guide of Kitchenham and Charters [31]. They analyze 18 application examples from which 4 are designed for the IoT.
Fernández-Caramés and Fraga-Lamas [17] put their focus only on IoT use cases or as they call it in their publication, the *"Blockchain-based IoT (BIoT)"* applications. In the first part of their paper, they describe the Blockchain basics and then continue with explaining how it changes the current cloud-centered IoT applications. They finish by discussing challenges and optimization possibilities and provide ideas for further research.
Yeow et al. [55] on the other hand, focus their review on the consensus algorithms for decentralized edge-centric Internet of Things. *"Edge computing"*[8] shifts the control for computing away from the server or the central nodes.

Smart Places Brandão et al. [8] conduct a Systematic Literature Review on literature that was published about the Blockchain. Their five research questions focus on the evolution over the years in the numbers of publications on the topic, the main features analyzed, the application areas, the limitation in the present papers and potential future trends in the Blockchain research.

Big Data The Big Data areas that can be strengthened by using the Blockchain are analyzed by Karafiloski and Mishev [27]. In their research they review potential Blockchain applications, they focus on the following four areas: **A)** Personal Data **B)** Digital Property **C)** Internet of Things **D)** Healthcare.

[8] https://en.wikipedia.org/wiki/Edge_computing

Healthcare Ekİn and Ünay [16] review the use cases of the Blockchain in health care. They start by discussing advantages and disadvantages and then focus on the Estonian system, which is the first national health care system implemented on the Blockchain.

In their chapter *"Blockchain Applications - Healthcare"*, Tama et al. [51, chap. 3.B] discuss the usage of the BC in different examples regarding healt care systems. The health care the main issue if the interoperability. It is very difficult to share electronic health records because of a lot of privacy regulations involved. They present a few concrete example of how to solve these problems.

Kamel Boulos et al. [26] provide a review of the state-of-the-art today on the usage of Blockchain in health care. They analyze certain kind of challenges in that area: **1)** Securing Patient and Provider identities **2)** Health supply chain management **3)** Clinical research and data monetization **4)** Medical fraud detection **5)** Others. In their last chapter, they discuss geospacial Blockchain applications for smart cities or regions and their challenges. They state that in this area, the IoT with geo-tagged data builds the foundation for these smart ecosystems.

Education Chen et al. [10] present the current and future blockchain-based systems in education.They conclude with discussing potential issues the blockchain-based ecosystems in education.

Government Many governments wolrd wide explore the possibilities that can obtain by using new technologies to transform their services into smarter services. The work of Batubara et al. [6] on the other hand shows that the publications on blockchain application for e-Government are not very numerous yet. As they did in the publication [11], a *"Systematic Literature Review (SLR)"* is conducted on the blockchain use cases following the guide of Kitchenham and Charters [31]. Their research question focuses on the present challenges and future research regarding the blockchain-based systems for e-Government solutions.

Alketbi et al. [2] survey the most promising application areas of the Blockchain technology in the domain of government services. They investigate the literature and identify securtiy benefits but also challenges. In their conclusion, they mention that the technology has a high potential in this area.

Distributed Computing Herlihy [23] reviews the theory and practice of distributed systems that are based on the Blockchain technology and makes a clear distinction from current distributed systems.

All four papers [32, 33, 40, 51] review or analyze the current literature on Blockchain use cases or applications, yet each of them has put their focus on a different aspect. Whereas Miraz and Ali [40] and Li et al. [33] distance themselves from the first application of BC, Bitcoin and other crytocurrecies that followed, Kogon [32] and Tama et al. [51] include these financial applications in their publications.

Li et al. [33] provide a very global overview. They selected 39 relevant article from various databases and started to compare these. The comparison criteria were first the publication year and the geographic distribution and then the publication type and the nature of studies. In their section *"Main applications of blockchain in business organizations"* [33, chap. 3.3] they categorize the papers according to the form

of blockchain usage. They first divide their sample by saying that on the one hand they have various applciations of blockchain in business organizations and on the other hand they have research papers. Further on, they say that for the applications of Blockchain, you also have some that present a specific usage and others that make more of a general use of the technology. The other papers focus on topics like regulation issues, impact, advantages and disadvantages, user experience and opportunities, risks and challenges. Their last criteria is was the focus of inquiry and the level of analysis. For this they invented a schema and classified the papers accordingly. For the focus of the paper, they have the questions what (usage), why (incentive), whom (people) and how (process). Their levels of application were individuals, firms or governments.
Kogon [32]'s focus was more specific than [33]'s research. He did not only focus on the business literature but also on the original use cryptocurrencies. He divided the Blockchain applications, that he discussed in three areas: financial distributed ledgers, smart-contracts and non-financial distributed ledgers. He provided some examples for each of his categories.
[40]'s analysis was more specific than [32]'s again. He focused on three different areas of blockchain applications: **1)** Cloud **2)** IoT Ecosystem **3)** Digital Economy [53].

Also [42] says that there is a "need to investigate blockchain application for decentralized, inter-organizational environments that have already been implemented".

2.2.4 Review Publications

Publication Channel	Rating	Paper(s)
Hawaii International Conference on System Sciences	A	[33]
ACM Conference on Computer and Communications Security (CCS)	A*	[28]
ACM Symposium on Principles of Distributed Computing(PODC)	A*	[23]
IEEE Symposium on Security and Privacy S&P	A*	[7]
International Conference on Digital Government Research (DGO)	B	[6]
International Conference on Advanced Information Networking and Applications (AINA)	B	[9]
International Journal of Law and Information Technology	C	[14]
ACS/IEEE International Conference on Computer Systems and Applications (AICCSA)	C	[11]
World Conference on Information Systems and Technologies	C	[8]
Honors College, Pace University	N/A	[32]
MDPI Open Access Journals 'Cryptography'	N/A	[45]
Plos One	N/A	[56]
Workshop on Scalable and Resilient Infrastructures for Distributed Ledgers	N/A	[5]
International Conference on Smart Technologies	N/A	[27]
International Conference on Systems, Man, and Cybernetics (SMC)	N/A	[39]
International Conference on Electrical Engineering and Computer Science (ICECOS)	N/A	[51]
IEEE Access Volume 6	N/A	[55] [17] [38]
Learning and Technology Conference (L&T)	N/A	[2]
IEEE Communications Surveys & Tutorials	N/A	[12]
Signal Processing and Communications Applications Conference (SIU)	N/A	[16]
Annals of Emerging Technologies in Computing (AETiC)	N/A	[40]
Annals of Emerging Technologies in Computing (AETiC)	N/A	[40]
International Conference on Distributed and Event-based Systems	N/A	[58]
International Conference on Exploring Services Science (IESS)	N/A	[48]
Smart Learning Environments	N/A	[10]
International Journal of Health Geographics	N/A	[26]

3 Approach

3.1 Information Selection

3.1.1 Selection Process

The information selection was done in online libraries. Some of those online libraries are open-access, others require authentication. INSA Lyon offers access from the *Bibliothèque Marie Curie*[9]. The following online databases were used:

- Emerald Insight
- Ebooks on Ebsco
- Springer
- Thèses INSA

University of Passau offers access from the *Universitätsbibliothek Passau (DBIS)*[10]. The following online databases were used:

- ACM Digital Library
- IEEE Explore
- arXiv.org
- De Gruyter Online / E-Books
- Springer eBooks: Computer Science
- Springer eBooks: Technik und Informatik

Also, some free online libraries were used during the research:

- Google Scholar
- Google Books
- Google Search Engine

The main key words that were used during the search were: Blockchain, Bitcoin, Distributed Technology, Distributed Ledger Technology, Distributed Networks, Hyperledger, Use Case. The terms here were inspired by the keywords used in the scoping review conducted by [33].

[9] http://scd.docinsa.insa-lyon.fr/voir_tout2p.php
[10] http://dbis.uni-regensburg.de/fachliste.php?bib_id=ub_pa&lett=l&colors=&ocolors=

3.1.2 Selected Papers

Publication Channel	Rating	Paper(s)
ACM Conference on Digital Libraries (JCDL)	A*	Gipp et al. [20]
IEEE International Conference on Computer Communications (IEEE INFOCOM)	A*	Kianmajd et al. [30]
International Conference on Information Systems (ICIS)	A*	Nærland et al. [42]
IEEE Symposium on Security and Privacy (S&P)	A*	Zyskind et al. [59]
Americas Conference on Information Systems (AMCIS)	A	Madhwal and Panfilov [36]
European Symposium On Research In Computer Security (ESORICS)	A	Tackmann [50]
IFIP Information Security & Privacy Conference (IFIP SEC)	B	Schaub et al. [46]
International Computer Software and Applications Conference (COMPSAC)	B	Yasin and Liu [54]
Journal of Medical Systems	C	Yue et al. [57]
Journal of Software Engineering and Applications	Not ranked	Bahga and Madisetti [4]
International Journal on Advanced Science, Engineering and Information Technology	N\A	Alessandra et al. [1]
International Conference on Open and Big Data (OBD)	N\A	Azaria et al. [3]
Journal of Emerging Technologies in Accounting	N\A	Coyne and McMickle [13]
International Conference for Internet Technology and Secured Transactions (ICITST)	N\A	Dennis and Owen [15]
Book “The Changing Postal and Delivery Sector”	N\A	Jaag and Bach [24]
International Conference on Distributed Computing and Artificial Intelligence (DCAI)	N\A	Jacynycz et al. [25]
N\A	N\A	Liu et al. [34]
Symposium on Foundations and Applications of Blockchain (FAB)	N\A	Lucena et al. [35]
Europe and MENA Cooperation Advances in Information and Communication Technologies	N\A	Ouaddah et al. [43]
European Conference on Technology Enhanced Learning (EC-TEL)	N\A	Sharples and Domingue [49]
International Conference on Service Systems and Service Management (ICSSSM)	N\A	Tian [52]

3.2 My schema / Research questions

While doing research on for this 'Blockchain' review, everyone I talked to kept on asking me 'WHY?' would you use this technology. Since I was fairly new to the topic, I could not really respond. While reading, I understood the technical basics of the technology and how [41] solved the double-spending problem that occurred in the area of cryptocurrency. I afterwards looked for more cases that the technology was used for and found a lot of experiments. This got me curious and I wanted a review that told me the reasons, why the researches experimented with the Blockchain. Unfortunately, in all the review papers that I read, see chapter 2.2, there was no one that focused on this question and most important, gave a good overview about this. I then asked myself what I wanted to know about the use cases and about the technology Blockchain. I took a look at the basic questions used to gather information: [21]

- **Who** was involved?
- **What** happened?
- **Where** did it take place?
- **When** did it take place?
- **Why** did it that happen?
- **How** did it happen?

I then established that there were two different categories that I wanted to analyze: the general and the content-related information about the paper.

3.2.1 General Information

In their publication, Li et al. [33] used the following properties as general information: publication year, geographic distribution, publication type and nature of studies. Combining this with the 6 questions of the beginning, I established my own questions and formulated my research questions (RQ):

- **RQ1**) Publisher: **Who** published the paper?
- **RQ2**) Publication Type: **What** was the publication type of the paper?
- **RQ3**) Publication Channel: **Where** was the paper published?
- **RQ4**) Publication Date: **When** was the paper published?

For the general information, the questions *"Why"* and *"How"* were not relevant. Instead the keywords that were selected by the authors were put into consideration:

- **RQ5**) Keywords: **"Why" "How"**: What kind of keywords were used?

3.2.2 Content-based Information

For the second category, the content-related information, the publication of Li et al. [33] was considered again, since he defined to following schema:

- **What** is the nature of the used blockchain application?
- **Why** did they invest in the blockchain technology?
- **Whom** did they target with the blockchain technology?

- **How** does their implementation of the blockchain work and operate?

Combinig his ideas to my 6 questions again and rephrasing them, so they answer my primary questions. The questions *"Where"* and *"When"* were not treated in this section because they were not relevant. The question *"Conclusion"* was added in the end, to provide an overview of the outcome of the various use cases. My research questions in this category are:

- **RQ6**) Authors: **Who** conducted the research?
- **RQ7**) Contribution: **What** did they analyze? What is their contribution?
- **RQ8**) Reason/Problems: **Why** did they analyze this(these) problem(s)? And why do they think Blockchain could solve their problem(s)?
- **RQ9**) Implementation Process: **How?** What blockchain technology did they use and how did they implement it?
- **RQ10**) Conclusion: What was their conclusion? Does is make sense to use the Blockchain to solve the problem they selected? Any benefits or drawbacks?

4 Evaluation

4.1 General Information

4.1.1 RQ1: Publisher

As defined in the chapter 3.2.1, the first research question is:

RQ1) *"Who published the paper?"*

For the selected papers (see the section 3.1.2), 9 different publishers could be distinguished.

Publisher	Publication(s)
IEEE	[59, 20, 30, 54, 15, 3, 52]
Springer	[50, 46, 25, 49, 24, 43, 57]
AIS Electronic Library (AISeL)	[36, 42]
American Accounting Association (AAA)	[13]
arXiv.org	[35]
Indonesian Society for Knowledge and Human Development (INSIGHT)	[1]
Scientific Research Publishing (SCIRP)	[4]
University of Calgary (U of C)	[34]

Table 4.1: Publishers

IEEE "IEEE"[11] is globally the biggest organization committed to encourage the progress of technology. They have more than 423,000 members in over 160 countries. They provide publications in the domains of engineering, computing, and technology information.

Springer Springer [12] is a worldwide publishing firm that issues books, e-books and journals in areas like science, humanities, and many more. *"SpringerLink"*[13] is a online scientific database provided by Springer that holds a collection of journals, books and other publications.

American Accounting Association (AAA) Founded in 1916, the AAA[14] is the largest association for accountants in the academic field. Their focus lies on teaching, researching, publishing and keeping a constant network for accountants.

[11] https://www.ieee.org/
[12] https://www.springer.com/
[13] https://link.springer.com/
[14] http://aaahq.org

arXiv.org *"arXiv.org"*[15] is an online archive for research publications that was founded in 1991. It provides open access to articles in the areas of physics, mathematics, computer science, nonlinear sciences, quantitative biology, quantitative finance, statistics, electrical engineering and systems science, and economics, and also the opportunity to submit own research. The archive is managed by the Cornell University Library.

Indonesian Society for Knowledge and Human Development (INSIGHT) *"INSIGHT"*[16] is an association of experts from all technology, science and engineering practices. They produce the *"International Journal on Advanced Science, Engineering and Information Technology"*[17].

Scientific Research Publishing (SCIRP) *"SCIRP"*[18] is also an open-access online repository for research articles and journals. It includes a broad range of areas, like biomedical & life sciences, business & economis, chemistry & materials science, computer sciences & communications and many more.

AIS Electronic Library (AISeL) The *"AISeL"*[19] was founded by the Association for Information Systems (AIS) and is an online archive for research papers and journal articles that focus on information systems. It includes publications of the *"International Conference on Information Systems (ICIS)"* and the *"Americas Conference on Information Systems (AMCIS)"*, as well as all other publication channels related to the subject.

University of Calgary (U of C) The *"U of C"*[20] is a public univeristy in Canada. They provide open-access to certain research papers on their website.

[15] https://arxiv.org
[16] http://www.insightsociety.org/
[17] http://ijaseit.insightsociety.org/
[18] https://www.scirp.org
[19] http://aisel.aisnet.org/
[20] https://www.ucalgary.ca/

As can be seen in the figure 4.1, the dominating publishers in this area are Springer and IEEE. These two publishers are very renommated and big. But on the other hand, there is also a growing interest from smaller publishers to start writing about this topic.

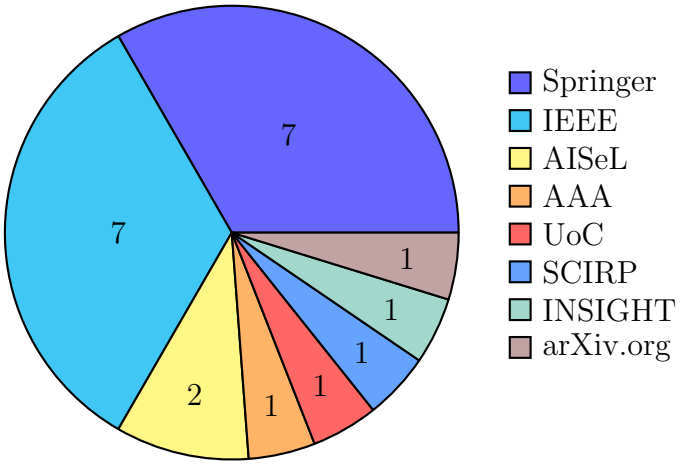


Figure 4.1: Number of publications per publisher

4.1.2 RQ2: Publication Type

As defined in the chapter 3.2.1, the second research question is:

RQ2) *"What was the publication type of the paper?"*

For the selected papers (see the section 3.1.2), three (see figure 4.2) different publication types could be identified.

Table 4.2: Publication Types

Publication Type	Publication(s)
Inproceedings	[3, 15, 20, 25, 30, 42, 43, 46, 50, 49, 52, 54, 59]
Article	[1, 4, 13, 34, 35, 36, 57]
InBook	[24]

There are various types of scientific papers. In this synthesis, the ones that are provided by BibTeX[21] are used. BibTeXis a reference management software. It is mostly used to create lists of references for the document preparation system LaTeX. The types are[22]

- *Article:* An article that was published in a journal or magazine
- *Book:* A book (with a publisher)
- *Booklet:* A published work without a reference to the publisher
- *InBook:* A part of a book
- *InCollection:* A part of a book with an explicit title
- *Inproceedings:* An article that was presented in the context of a conference proceeding
- *Manual:* A technical documentation
- *Mastersthesis:* A master's thesis
- *Misc:* If no other type fits your resource, use this one
- *Phdthesis:* A Ph.D. thesis
- *Proceedings:* Collection of scientific papers that were published during a conference
- *Techreport:* A report (usually published by a school/university)
- *Unpublished:* A document that has not been officially published

[21] http://www.bibtex.org/
[22] https://en.wikipedia.org/wiki/BibTeX

In the pie chart 4.2, the number of publications per publication type is plotted. Since the technology is in an early phase, most research papers were presented during conference procceedings. The interest in the technolgy is very high at the moment and journals or books are being published.

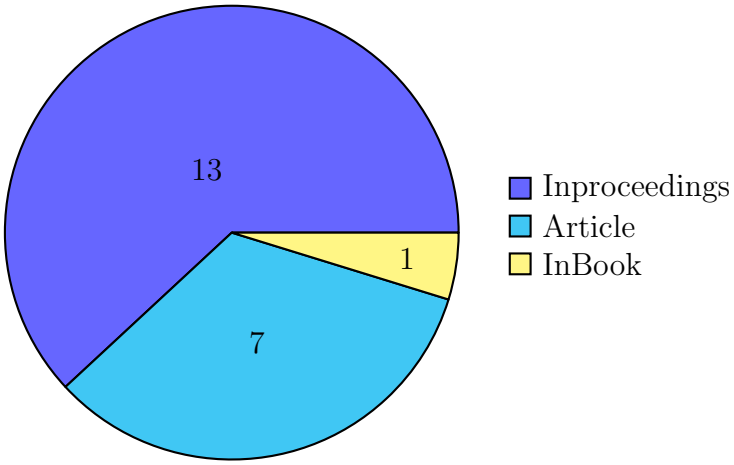


Figure 4.2: Number of publications per publication type

4.1.3 RQ3: Publication Channel

As defined in the chapter 3.2.1, the third research question is:

RQ3) *"Where was the paper published?"*

For the selected papers (see the section 3.1.2), 19 different publication channels could be identified. For one article, no information was provided.

Table 4.3: Publication Channels

Publication Channel	Rating	Publication(s)
Joint Conference on Digital Libraries (JCDL)	A*	Gipp et al. [20]
IEEE International Conference on Computer Communications (IEEE INFOCOM)	A*	Kianmajd et al. [30]
International Conference on Information Systems (ICIS)	A*	Nærland et al. [42]
IEEE Symposium on Security and Privacy (S&P)	A*	Zyskind et al. [59]
Americas Conference on Information Systems (AMCIS)	A	Madhwal and Panfilov [36]
European Symposium On Research In Computer Security (ESORICS)	A	Tackmann [50]
IFIP Information Security & Privacy Conference (IFIP SEC)	B	Schaub et al. [46]
International Computer Software and Applications Conference (COMPSAC)	B	Yasin and Liu [54]
Journal of Medical Systems	C	Yue et al. [57]
Journal of Software Engineering and Applications (JSEA)	Not ranked	Bahga and Madisetti [4]
International Journal on Advanced Science, Engineering and Information Technology (IJASEIT)	N\A	Alessandra et al. [1]
International Conference on Open and Big Data (OBD)	N\A	Azaria et al. [3]
Journal of Emerging Technologies in Accounting (JETA)	N\A	Coyne and McMickle [13]

International Conference for Internet Technology and Secured Transactions (ICITST)	N\A	Dennis and Owen [15]
Book "The Changing Postal and Delivery Sector"	N\A	Jaag and Bach [24]
International Conference on Distributed Computing and Artificial Intelligence (DCAI)	N\A	Jacynycz et al. [25]
N\A	N\A	Liu et al. [34]
Symposium on Foundations and Applications of Blockchain (FAB)	N\A	Lucena et al. [35]
Book "Europe and MENA Cooperation Advances in Information and Communication Technologies"	N\A	Ouaddah et al. [43]
European Conference on Technology Enhanced Learning (EC-TEL)	N\A	Sharples and Domingue [49]
International Conference on Service Systems and Service Management (ICSSSM)	N\A	Tian [52]

Joint Conference on Digital Libraries (JCDL) The JCDL[23] is a combination of the ACM Digital Libraries Conference and the IEEE-CS Advances in Digiitales libraries Conference. The core research suject are the technical, practical and social problems of digital libraries. The conference was ranked with an A*[24].

IEEE International Conference on Computer Communications (IEEE INFOCOM) The *"IEEE INFOCOM"*[25] is focused on the theoretical and systems research in the domain of networking. It is an annual forum that started in 1982. The conference was ranked with an A* [26].

International Conference on Information Systems (ICIS) The *"ICIS"*[27] is all about information systems. Starting in 1980, this conference is a annual flagship event that brings together academics and researchers in this area. The conference was ranked with an A*[28].

[23] http://www.jcdl.org/
[24] http://portal.core.edu.au/conf-ranks/2085/
[25] https://ieeexplore.ieee.org/xpl/conhome.jsp?punumber=1000359
[26] http://portal.core.edu.au/conf-ranks/2074/
[27] https://aisnet.org/page/ICISPage
[28] http://portal.core.edu.au/conf-ranks/1078/

IEEE Symposium on Security and Privacy (S&P) The *"IEEE (S&P)"*[29] is a yearly symposium that has been held since 1980. Its research focus is on computer security and electronic privacy. The conference was ranked with an A*[30].

Americas Conference on Information Systems (AMCIS) The *"AMCIS"*[31] is a yearly conference since 1995. The papers presented at this conference talk about the areas information systems and information technology. The conference was ranked with an A[32].

European Symposium On Research In Computer Security (ESORICS) Being held for the first time in 1990, *"ESORICS"*[33] is a conference on computer, information and cyber security and privacy. Their goal was also to create a european forum that brings together different researches in the area. The conference was ranked with an A[34].

IFIP Information Security & Privacy Conference (IFIP SEC) The *"IFIP SEC"*[35] is an event that focuses on information processing systems, especially on the information security and privacy protection. It is the most important event of the International Federation for Information Processing Technical Committee. The first conference was in 1986. The conference was ranked with a B[36].

International Computer Software and Applications Conference (COMPSAC) The research focus in the *"COMPSAC"*[37] is on computer and software technologies and applications. It is a forum for researchers to talk about research, progress, open questions and future trends in the area. The conference was ranked with a B[38].

Journal of Medical Systems The Journal of Medical Systems[39] is published by Springer. It publishes various articles that talk about information systems in health care. The journal includes six different sections:

- Mobile & Wireless Health
- Quality Improvement
- Transaction Processing Systems
- Image & Signal Processing
- Patient Facing Systems
- Education & Training

[29] https://ieeexplore.ieee.org/xpl/conhome.jsp?punumber=1000646
[30] http://portal.core.edu.au/conf-ranks/750/
[31] http://aisel.aisnet.org/amcis/
[32] http://portal.core.edu.au/conf-ranks/115/
[33] http://conf.laas.fr/esorics/
[34] http://portal.core.edu.au/conf-ranks/515/
[35] https://www.ifipsec.org/
[36] http://portal.core.edu.au/conf-ranks/804/
[37] https://ieeexplore.ieee.org/xpl/conhome.jsp?punumber=1000143
[38] http://portal.core.edu.au/conf-ranks/871/
[39] https://link.springer.com/journal/10916

The journal was ranked with a C[40].

Journal of Software Engineering and Applications (JSEA) The *"JSEA"*[41] is a journal on software engineering and application. The aim of the journal is to provide a forum for academicians world-wide to improve, share and argues about new concerns and developments in the field. The journal was ranked with *"Not ranked"*[42].

International Journal on Advanced Science, Engineering and Information Technology (IJASEIT) The *"IJASEIT"*[43] is an international journal. They publish articles related to all research in science, engineering and information technology. The journal was not ranked.

International Conference on Open and Big Data (OBD) The goal of the *"OBD"*[44] conference is to analyze the combination of open data and big data. It is sponsored by the Technical Committee on the Internet of the IEEE Computer Socicety. The conference was not ranked.

Journal of Emerging Technologies in Accounting (JETA) The *"JETA"*[45] is an academic journal that cover three domains **A)** information technology **B)** accounting **C)** management advisory systems. Their goal is to promote and simplify the research, education and practice of information systems, new technologies and artificial intelligence (AI). The journal was not ranked.

International Conference for Internet Technology and Secured Transactions (ICITST) The *"ICITST"*[46] is an international refereed conference dedicated to the advancement of theory and practical implementation of secured internet transactions and to fostering discussions on the evolution of information technology. The conference was not ranked.

The Changing Postal and Delivery Sector The book *"The Changing Postal and Delivery Sector"*[47] is about the important problems in postal and delivery services world-wide, in particular the dangers and chances of the digital competition. The book was not ranked.

International Conference on Distributed Computing and Artificial Intelligence (DCAI) The *"DCAI"*[48] concentrates on distributed computing and

[40] http://portal.core.edu.au/jnl-ranks/615/
[41] http://www.scirp.org/journal/JournalArticles.aspx?JournalID=45
[42] http://portal.core.edu.au/jnl-ranks/413/
[43] http://ijaseit.insightsociety.org/
[44] http://easyconferences.eu/portfolio/obd-2016/
[45] http://aaajournals.org/loi/jeta?code=aaan-site
[46] http://icitst.org/
[47] https://www.springer.com/gp/book/9783319460451
[48] https://www.dcai-conference.net/

artificial intelligence and their various application areas. The conference was not ranked.

Symposium on Foundations and Applications of Blockchain (FAB) The one day symposium *"FAB"*[49] is about various aspects of the blockchain technology. Subjects that are being discussed are for example secure smart contracts and social aspects of blockchain. The symposium was not ranked.

Europe and MENA Cooperation Advances in Information and Communication Technologies The book[50] contains the procceedings of the *"Europe, Middle East and North Africa Conference on Technology and Security to Support Learning 2016 (EMENA-TSSL'16)"*. The field of interest is security to support learning and information & communication technologies.

European Conference on Technology Enhanced Learning (EC-TEL) The *"EC-TEL"*[51] takes the imapct into account that technolgy has on learning methods and adresses ongoing challenges and advances in the field. The conference was not ranked.

International Conference on Service Systems and Service Management (ICSSSM) All fields related to information management are covered by th *"ICSSSM"*[52] conference. The conference was not ranked.

Definitions According to the *"Merriam-Webster Dictionary"*[53], the following terms are defined as follows:

> **Conference:** *"a meeting of two or more persons for discussing matters of common concern"*
>
> **Symposium:** *"a formal meeting at which several specialists deliver short addresses on a topic or on related topics"*
>
> **Journal:** *"a periodical dealing especially with matters of current interest"*
>
> **Book:** *"something that yields knowledge or understanding"*

[49] https://scfab.github.io/2018/
[50] https://link.springer.com/book/10.1007/978-3-319-46568-5
[51] https://link.springer.com/conference/ectel
[52] https://ieeexplore.ieee.org/xpl/conhome.jsp?punumber=1002157
[53] https://www.merriam-webster.com/

The figure 4.3 presents the number of publications per publication channel. More than half the papers were published during a conference. There is a huge interest in research on the topic and even new conferences, symposiums, journals are only dedicated to solve the current issues. The development is in its peak which confirms further more that the blockchain is a very promising.

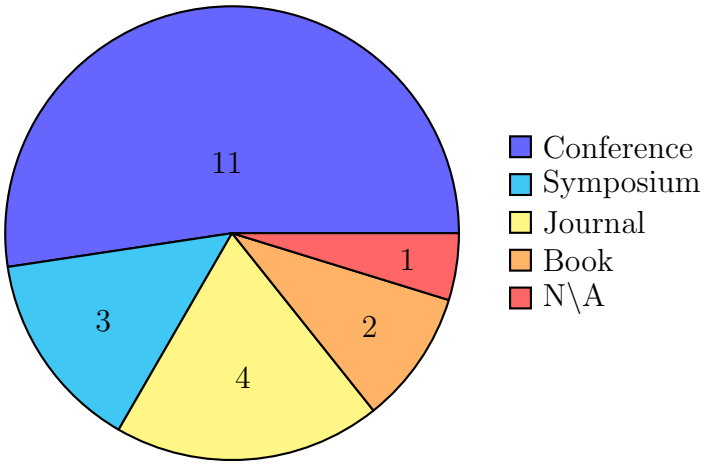


Figure 4.3: Number of publications per publication channel

CORE Rankings Portal The *"Computing Research and Education Association of Australasia (CORE)"* is a community of various computer science departements of different universities all over Australia and New Zealand. Their objectives are over all to **A)** create a professional community for computer scientists and information technologists **B)** aid and progress research and teaching in these areas **C)** present a forum open for discussion **D)** encourage partnerships with other organizations. They provide the *"CORE Rankings Portal"* on their website. The *"CORE Conference Ranking"*[54] evaluates significant conferences in various computing disciplines and the *"CORE Journal Ranking"*[55] ranks different journals. The different ranks are:

- **A*** *"flagship conference"*: an outstanding conference in its field
- **A** *"excellent conference"*: a highly valued conference in its field
- **B** *"good conference"*: a well valued conference in its field
- **C** *"other conference"*: a confernce that satisfies minimal demands
- **Australasian** *"australasian conference"*: a conference that is mainly in Australia and New Zealand
- **Unranked** *"unranked conference"*: an unranked conference
- **National** *"national conference"*: a conference that is mainly in one specific country
- **Regional** *"regional conference"*: a conference that is mainly in one specific region

The number of publications per rank is plotted in figure 4.4. Since the blockchain is a relatively new technology, there is many publication channels that are not considered in the ranking yet. Nevertheless, some publications were presented at very renomated conferences and given good feedback.

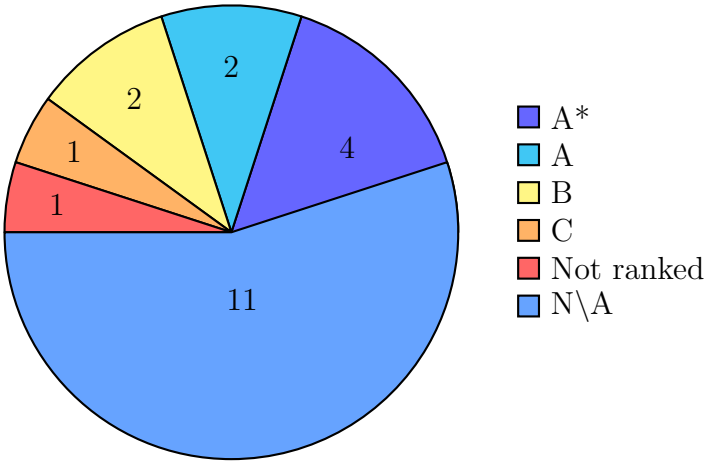


Figure 4.4: Number of publication per rank

[54] http://portal.core.edu.au/conf-ranks/
[55] http://portal.core.edu.au/jnl-ranks/

4.1.4 RQ4: Publication Date

As defined in the chapter 3.2.1, the fourth research question is:

RQ4) *"When was the paper published?"*

As can be seen in figure 4.4, the selected papers (see the section 3.1.2) were all published between 2015 and 2018.

Table 4.4: RQ4: Publication Date

Publication Year	Publication(s)
2015	[15, 59]
2016	[3, 4, 25, 30, 46, 49, 52, 54, 57]
2017	[13, 20, 24, 34, 36, 42, 43, 50]
2018	[1, 35]

The figure 4.5 shows the number of publication per year. All research papers were published from 2015 to this day. There is very few publications on application use cases before 2015. As from 2016, the interest in this research area increased tremendously and is still increasing this ongoing year.

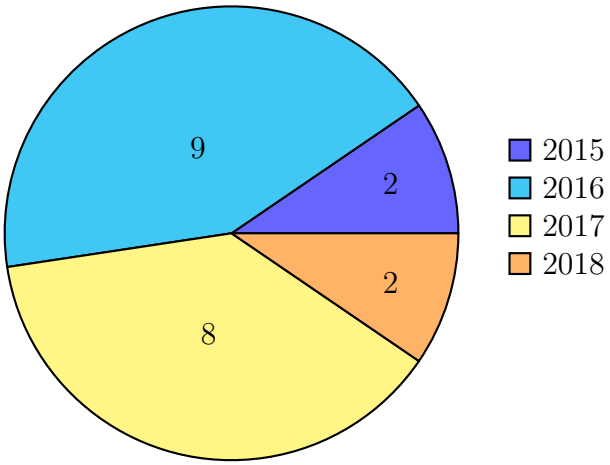


Figure 4.5: Number of publications per year

4.1.5 RQ5: Keywords

As defined in the chapter 3.2.1, the fifth research question is:

RQ5) *"What kind of keywords were used?"*

From the twenty publications selected (see the section 3.1.2) three [34, 35, 50] did not provide keywords, they were therefore excluded from this evalutation. This leaves a total of seventeen publications that stated keywords.

Table 4.5: Keywords

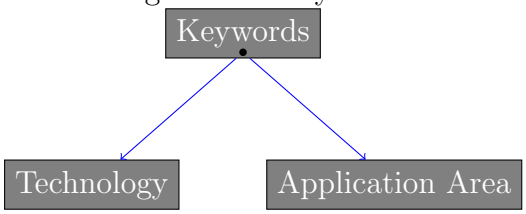
Publication	Keywords
Alessandra et al. [1]	*Information Technology, Smart City, Digital Revolution, Digital Innovation, Blockchain, Smart Energy Grid, Machine Learning*
Azaria et al. [3]	*electronic medical records, cryptographic protocols, access control, distributed information systems*
Bahga and Madisetti [4]	*Internet of things, Blockchain, Smart Contracts, Cloud-based manufacturing*
Coyne and McMickle [13]	*financial accounting, blockchain, ledger, database*
Dennis and Owen [15]	*Blockchain, reputation systems, cryptographic protocols, distrubted networks, peer-to-peer, Bittorent*
Gipp et al. [20]	*Electronic publishing, peer review, manuscript submission, blockchain, conference management, scientific data managemet*
Jaag and Bach [24]	*Credit Card, Financial Service, Payment System, Financial Intermediary, Financial Inclusion*
Jacynycz et al. [25]	*Bitcoin, Blockchain, Bounty, Crowdfunding, Cryptocurrencies, Distributed Software, Ethereum, P2P, Smart contract*
Kianmajd et al. [30]	*Protocols, Power demand, Cryptography, Microgrids, Home appliances, Internet of Things, Schedules*
Madhwal and Panfilov [36]	*Supply Chain Management, Blockchain, Aircraft, Segments*
Nærland et al. [42]	*Blockchain, Bill of Lading, International Trade, Decentralized Environments*
Ouaddah et al. [43]	*Internet of things, Security, Privacy, Access control, Blockchain, Bitcoin, Cryptocurrency*
Schaub et al. [46]	*Service Provider, Blind Signature, Certification Authority, Trusted Third Party, Reputation System*
Sharples and Domingue [49]	*Blockchain, Reputation management, Self-determined learning, e-portfolios, Records of achievement*
Tian [52]	*Agri-food supply chain, traceability system, RFID, blockchain, food safety*

Table 4.5: Keywords

Publication	**Keywords**
Yasin and Liu [54]	*Digital Identity, Online Reputation, Blockchain, Smart Contract Utility*
Yue et al. [57]	*Healthcare data system, Indicator-centric schema, BlockChain, Healthcare data sharing, Privacy Riks*
Zyskind et al. [59]	*Blockchain, Privacy, Bitcoin, Personal data*

There are two kind of categories of keywords. The first are words that describe the technical content of the paper and the second are thos that explain the application area.

Figure 4.6: Keywords

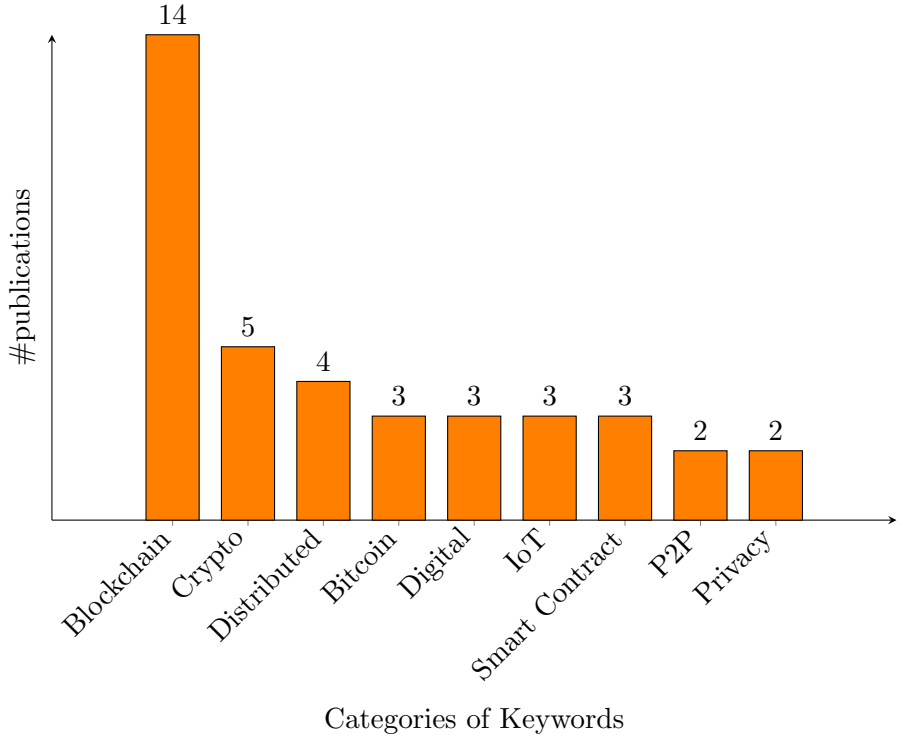


All technical keywords that were found are listed in this table:

Table 4.6: Keywords

Category	Term	Publication(s)
Bitcoin	Bitcoin	[25, 43, 59]
Blockchain	Blockchain	[1, 4, 13, 15, 20, 25, 36, 42, 43, 49, 52, 54, 57, 59]
Crypto	cryptographic protocols	[3, 15]
	Cryptocurrency(ies)	[25, 43]
	Cryptography	[30]
Digital	Digital Identity	[54]
	Digital Revolution	[1]
	Digital Innovation	
Distributed	distributed networks	[15]
	distributed information systems	[3]
	distributed software	[25]
	Decentralized environments	[42]
Internet of Things	Internet of things	[4, 24, 30]
P2P	peer-to-peer	[15]
	P2P	[25]
Privacy	Privacy	[43, 59]
	Privacy Risk	[57]
Smart Contract	Smart Contract(s)	[4, 25]
	Smart Contract Utility	[54]
Others	Bittorent	[15]
	Bounty	[25]
	Ethereum	
	Protocols	[30]
	Blind Signature	[46]
	Certification Authority	
	Trusted Third Party	
	Traceability system	[52]
	RFID	
	Indicator-centric schema	[57]
	Ledger	[13]
	Security	[43]
	Information Technology	[1]
	Machine Learning	

Figure 4.7: Number of publications per category



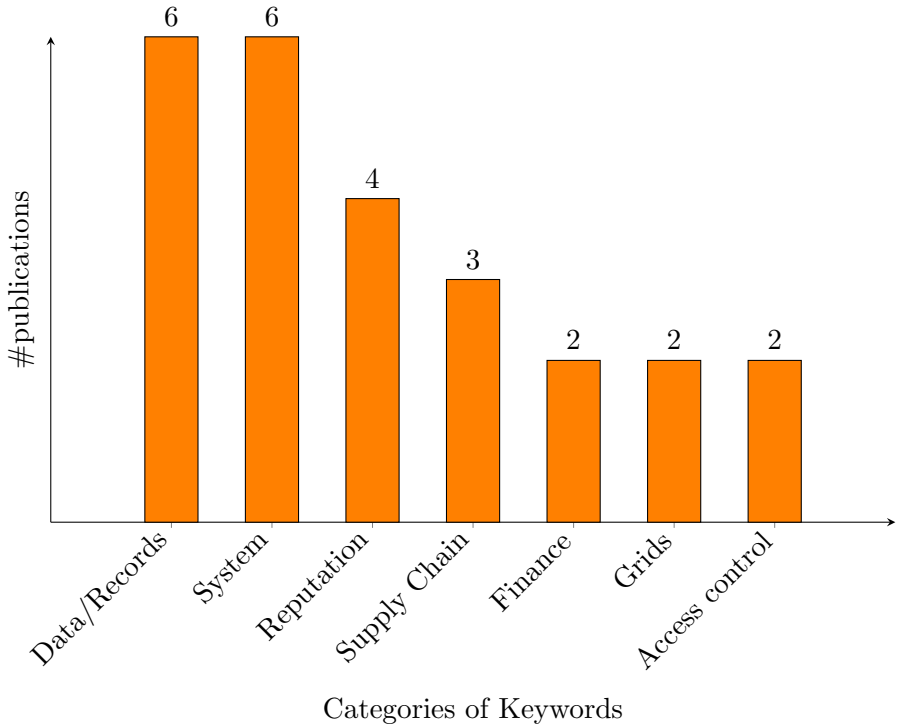
All keywords related to the application area can be found in this table:

Table 4.7: Keywords Application Area

Category	Term	Publication(s)
Access control	Access control	[3, 43]
Data/records	Personal data	[59]
	Electronic medical records	[3]
	Records of achievement	[49]
	Healthcare data system	[57]
	Healthcare data sharing	
	Database	[13]
	Scientific data managemet	[20]
Finance	Financial accounting	[13]
	Financial Service	[24]
	Financial Intermediary	
	Financial Inclusion	
Grids	Microgrids	[30]
	Smart Energy Grid	[1]
Reputation	Reputation system(s)	[15, 46]
	Reputation management	[49]
	Online Reputation	[54]
Supply Chain	Supply Chain Management	[36]
	Agri-food supply chain	[52]
	Bill of Lading	[42]
	International trade	
System	Reputation system(s)	[15, 46]
	Distributed information systems	[3]
	Traceability system	[52]
	Healthcare data system	[57]
	Payment System	[24]
Others	Cloud-based manufacturing	[4]
	Crowdfunding	[25]
	Power demand	[30]
	Home appliances	
	Schedules	
	Service Provider	[46]
	Self-determined learning	[49]
	E-portfolios	
	Food safety	[52]
	Electronic publishing	[20]
	Peer review	
	Manuscript submission	
	Conference management	
	Credit Card	[24]
	Payment System	
	Aircraft	[36]

Table 4.7: Keywords Application Area

Category	Term	Publication(s)
	Segments	
	Smart City	[1]



4.2 Content-based Information

4.2.1 RQ6: Authors

The table 4.8 presents all the authors involved in each research paper. It also includes from which city and country the researcher are and what institution, university or company, they belong to.

Table 4.8: Authors

Paper	Who?		
[20]	Name	Location	Institution
	Bela Gipp	Konstanz, Germany	University Of Konstanz
	Corinna Breitinger		
	Norman Meuschke		
	Joeran Beel	Dublin, Ireland	Trinity College Dublin
[30]	Name	Location	Institution
	Parisa Kianmajd	Davis, United States	University of California, Davis
	Jeff Rowe		
	Karl Levitt		
[42]	Name	Location	Institution
	Kristoffer Nærland	Mainz, Germany	Brainbot technologies
	Christoph Müller-Bloch	Copenhagen, Denmark	IT University of Copenhagen
	Roman Beck		
	Søren Palmund		
[59]	Name	Location	Institution
	Guy Zyskind	Cambridge, United States	Massachusetts Institute of Technology (MIT)
	Alex “Sandy” Pentland		
	Oz Nathan	Tel-Aviv, Israel	Tel-Aviv University
[36]	Name	Location	Institution
	Yash Madhwal	Moscow, Russia	Higher School of Economics
	Dr. Peter B. Panfilov		
[50]	Name	Location	Institution
	Björn Tackmann	Zurich, Switzerland	IBM Research
[46]	Name	Location	Institution
	Alexander Schaub	Lyon, France	École Polytechnique
	Rémi Bazin		
	Omar Hasan		LIRIS
	Lionel Brunie		
[54]	Name	Location	Institution

Table 4.8: Authors

Paper	Who?		
	Affan Yasin	Beijing, China	Tsinghua University
	Lin Liu		
[57]	Name	Location	Institution
	Xiao Yue	Fujian, China	Huaqiao University
	Huiju Wang	Wuhan, China	Zhongnan University of Economics and Law
	Dawei Jin		
	Wei Jiang		
	Mingqiang Li		
[4]	Name	Location	Institution
	Arshdeep Bahga	Atlanta, United States	Georgia Institute of Technology
	Vijay K. Madisetti		
[1]	Name	Location	Institution
	Pieroni Alessandra	Rome, Italy	Guglielmo Marconi University
	Luca Di Nunzio		University of Rome Tor Vergata Institute
	Noemi Scarpato		Università Telematica San Raffaele
	Francesca Fallucchi		Università Telematica Guglielmo Marconi
[3]	Name	Location	Institution
	Asaph Azaria	Cambridge, United States	Massachusetts Institute of Technology
	Ariel Ekblaw		
	Thiago Vieira		
	Andrew Lippman		
[13]	Name	Location	Institution
	Joshua G. Coyne	Memphis, United States	University of Memphis
	Peter L. McMickle		
[15]	Name	Location	Institution
	Richard Dennis	Portsmouth, United Kingdom	University of Portsmouth
	Gareth Owen		
[24]	Name	Location	Institution
	Christian Jaag	Zurich, Switzerland	Swiss Economics
	Christian Bach		University of Liverpool and Swiss Economics
[25]	Name	Location	Institution
	Viktor Jacynycz	Madrid, Spain	Universidad Complutense de Madrid
	Adrian Calvo		
	Antonio A. Sánchez-Ruiz		

Table 4.8: Authors

Paper	Who?		
	Samer Hassan	Madrid, Spain and Cambridge, United States	Universidad Complutense de Madrid and Harvard University
[34]	Name	Location	Institution
	Yuan Liu	Shenyang, China	Northeastern University
	Zheng Zhao		
	Guibing Guo		
	Xingwei Wang		
	Zhenhua Tan		
	Shuang Wang		
[35]	Name	Location	Institution
	Percival Lucena	Brazil	IBM Research
	Alecio P. D. Binotto		
	Fernanda da Silva Momo	Porto Alegre, Brazil	Federal University of Rio Grande do Sul (UFRGS)
	Henry Kim	Toronto, Canada	York University
[43]	Name	Location	Institution
	Aafaf Ouaddah	Marrakesh, Morocco	Cadi Ayyad University
	Anas Abou Elkalam		
	Abdellah Ait Ouahman		
[49]	Name	Location	Institution
	Mike Sharples	Milton Keynes, United Kingdom	The Open University
	John Domingue		
[49]	Name	Location	Institution
	Feng Tian	Vienna Austria	Vienna University of Economics and Business

Overall there were 64 authors involved in the writing the papers. One author works for two institues that are not located in the same country, neither the same continent, therefore he was counted twice, which leaves us with a total of 65 authors. The author was Samer Hassan [25], who works in Madrid, Spain and Cambridge, United States. The figure 4.8 shows that 29 authors came from Europe which makes it with 44.6% the biggest part. Also not negligible are America with 26.2 % and Asia with 24.6%.

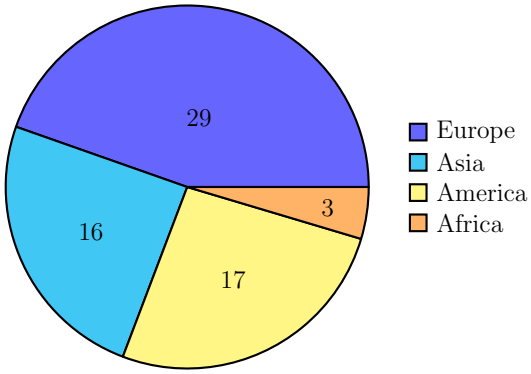


Figure 4.8: Number of authors per continent

As in figure 4.9, there are some countries that do more research in this area. The United States and China are the leading countries with each 20%. But also other european countries like Spain, Germany, France, Italy and the United Kingdom research in this area. Nevertheless, 27.7% of the authors were from other countries. This shows that various researches in different locations are working on this topic, which proves once more its importance. (high diversity)
Overall there were 64 different authors, but two of them work for two different institutions, so they were counted twice.

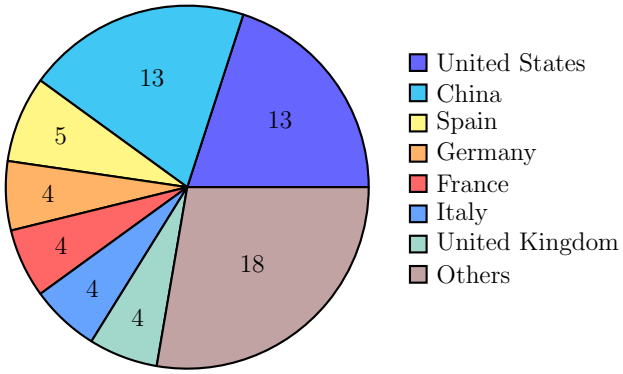


Figure 4.9: Number of authors per country

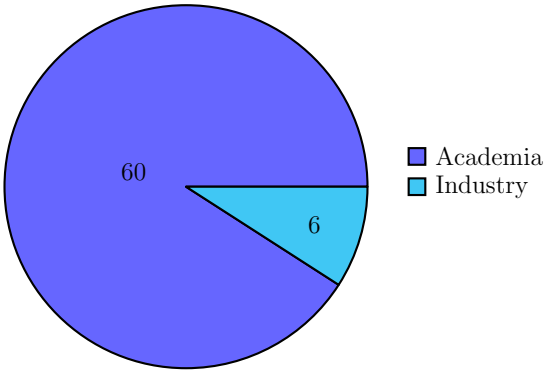


Figure 4.10: Academia vs Industry

These authors were Christian Bach [24] who works for the *"University of Liverpool"* and the company *"Swiss Economics"* and Samer Hassan [25] who works for the *"Universidad Complutense de Madrid"* and the *"Harvard University"*. Another interesting question is, if the author was from industry or academia. The results show that only 9.1% of the au-

thors came from the industry and 90.9% do their research at universities. All publications done in industry were done in partnership with a university, except for one publication ([50]), which was conducted only by *"IBM Research"*.

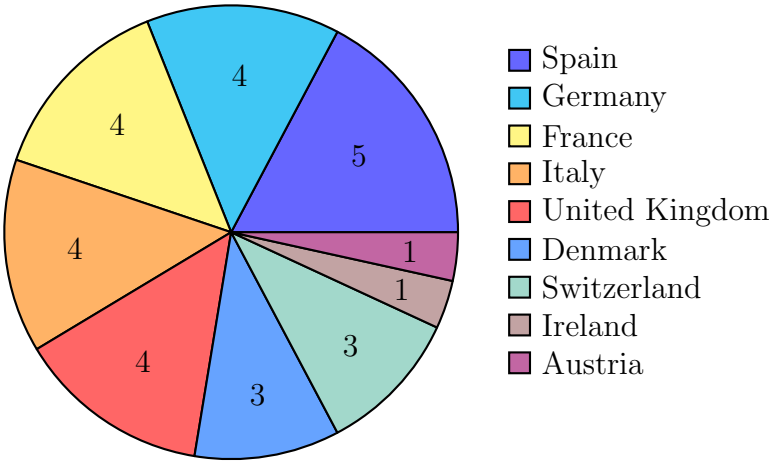


Figure 4.11: Number of authors per European Country

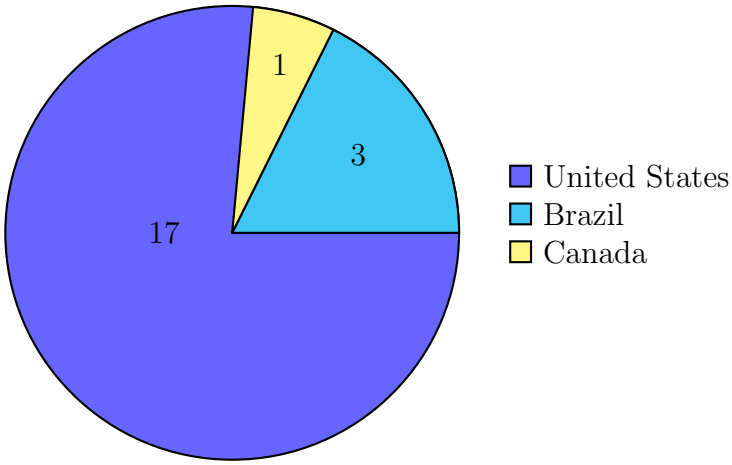


Figure 4.12: Number of authors per American Country

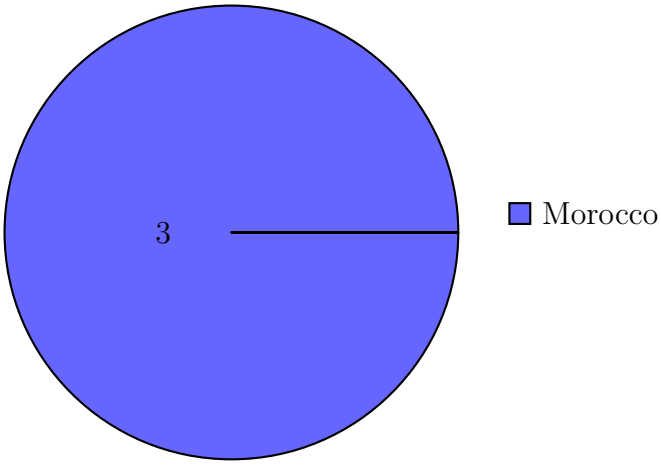


Figure 4.13: Number of authors per African Country

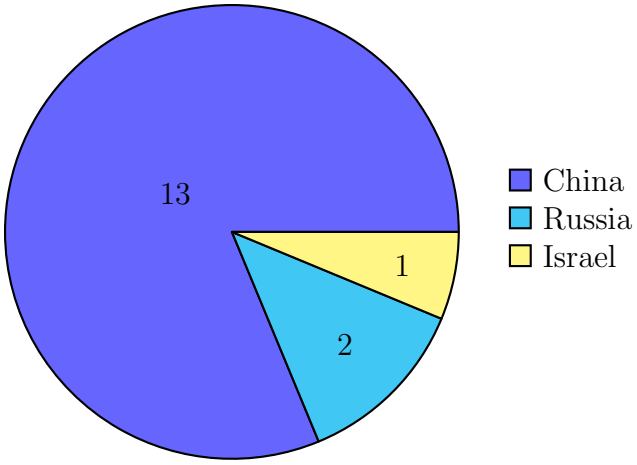


Figure 4.14: Number of authors per Asian Country

4.2.2 RQ7: Contribution

Table 4.9: Contribution

Paper	Contribution
[20]	Manuscript submission system
[50]	Event ticket management system

4.2.3 RQ8: Reason/Problems

Table 4.10: Reasons/Problems

Paper	Reasons/Problems
[20]	Disadvantage of current manuscript submission systems: no existence of proof, seperate of the system to confirm the time of the author's work was uploaded.
[50]	

4.2.4 RQ9: Implementation Process

Ideen fur diesen Abschnitt sind auch noch: Smart Contracts!!! was it actually implemented ? testing phase open source real world problem

Table 4.11: Implementation

Paper	Blockchain Technology/Platform	**Open Source?**
[20]	Bitcoin	✓
[50]	Hyperledger Fabric V1	✗
next	✗	

4.2.5 RQ10: Conclusion

Table 4.12: Conclusion

Paper	Advantages	Disadvantages	Future Work
[20]	Tamperproof timestamp: proof for ownership of intellectual property	✗	
	Timestamp is independent of manuscript management system		
	Proof of ownership of the peer-review feedback		
[50]	Consistency		
	Unforgeability		

5 Discussion

[TO DO]

6 Conclusion

[TO DO]

A lot of use cases are very well explained and their data is avaliable open-source, which shows that the researches are willing to share their work and to improve the blockchain use cases to establish a design.

Technological research on the blockchain is evolving very fast, therefore there is more and better tools available that can be used for application examples

This could also help researchs to establish standard for the blockchain that have nothing to do with the application area.

6.1 Summary

6.2 Future Work

Appendix A List of abbreviations

Nomenclature

Others

AI Artificial intelligence

IT Information Technology

MENA Middle East and North Africa

P2P Peer-to-Peer Network

QR code Quick Response Code

RQ(s) Research Question(s)

Publication Channels

AMCIS Americas Conference on Information Systems

COMPSAC International Computer Software and Applications Conference

DCAI International Conference on Distributed Computing and Artificial Intelligence

EC-TEL European Conference on Technology Enhanced Learning

EMENA-TSSL Europe, Middle East and North Africa Conference on Technology and Security to Support Learning

ESORICS European Symposium On Research In Computer Security

FAB Symposium on Foundations and Applications of Blockchain

ICITST International Conference for Internet Technology and Secured Transactions

ICSSSM International Conference on Service Systems and Service Management

IEEE INFOCOM IEEE International Conference on Computer Communications

IFIP SEC IFIP Information Security & Privacy Conference

IJASEIT International Journal on Advanced Science, Engineering and Information Technology

JCDL Joint Conference on Digital Libraries

JETA Journal of Emerging Technologies in Accounting

JSEA Journal of Software Engineering and Applications

OBD International Conference on Open and Big Data

S&P IEEE Symposium on Security and Privacy

Universities

LIRIS Laboratoire d'Informatique en Images et Systèmes d'Information

MIT Massachusetts Institute of Technology

UFRGS Federal University of Rio Grande do Sul

Appendix B Second Appendix

Summary Review articles

Li et al. [33]

The review article was published by Li et al. [33] in 2018. Its main goal is to determine the size and scope of the business literature on the blockchain technology. During their scan, they found 39 papers that fit all their criteria.
In the second chapter (pp. 4475 - 4477), the authors describe their technique for reviewing the existing literature. As described earlier, I oriented my search also based on their keywords, but I used different online libraries. They created a 3x4 matrix to classify their information. It refers on the one hand to the focus of the paper. Here they established 4 different sections:

- What? What kind of blockchain application was used in the publication?
- Why? Why did the authors decide to use blockchain technology?
- Whom? Who did they implement the blockchain for?
- How? How did they implement the blockchain?

And on the other hand, it shows the level of application and is divided into individuals, firms and governments. The third chapter (pp. 4477 - 4480) covers the results that were found. Here, they divided into four sections:

Publication year and geographic distribution In this section, they name the publication year of every paper. Also, they took a look at where, geographically, the paper was published (the research was conducted).

Publication type and nature of studies This part gives an overview of the different types of papers that were used and the method of scientific research that was conducted. Most papers were conference proceedings and the main method used was conceptual research.

Main applications of blockchain in business organizations 76.9 % of the selected 39 papers discuss the different usages of the blockchain technology in business organizations. The rest 23.1% concentrate on other subjects, for example opportunities, risks or challenges.

Focus of inquiry and level of analysis Classification of the papers according to their framework that they developed for their research. X axis and y axis. Most of the papers focused on the how for firms.

Their analysis was described in the fourth chapter (pp. 4480 - 4481). The authors found a few gaps in the current literature on the subject:

- Not a lot of empirical studies have been conducted and there is a big absence of these studies that examine why companies would invest and adopt the blockchain.

- In their classification, they had the whom question, which analyzed the impact of blockchain on different actors. They think that in the literature this is not documented yet.

Nevertheless, they also say that they had some limitations during their search. The first one was the language restriction to English and also their search strategy. Secondly, the risk of selection bias was there. They concluded by saying that in the end there was no panel of experts that validated their findings, like it would normally be done.
The scoping review that was done in this paper was well conducted and scientifically very well described. Also, as mentioned on (p. 4479), the full list of blockchain usages, that they used, is available upon request (Types of Blockchain Usage, 2018). Therefore, I mailed the leading author and he send me a list of all used articles within a few days.
Reading this review, I expected to find more technical aspects, but they were missing completely. I got a very good selection of papers, but I could not say which one is good or which blockchain implementation I would use, because they never presented an overview in the end. Also, the list the author mailed includes 22 articles that are types of blockchain usage. Yet it was a little hard to find the articles because he did not put the original title of the respective publication. In the end, I was quite disappointed to not get an overview of all article and criteria to be able to see the difference between the articles they selected.
Overall a very good scientific publication which provides a good selection of literature of blockchain use cases in the business area.

Karame [28]

[28]
Objective:
In their work, they present a tutorial that overviews, details and analyzes the security measurements done by Bitcoin and the underlying Blockchain.
Contribution:
captured recent reported attacks or threats in the systems He mentions three challenges that Bitcoin has to overcome at the time: Security - [19], [22] [29] Scalability Limits of (De-)centralization [18]

Appendix C Content-Based Information per paper

CryptSubmit: Introducing Securely Timestamped Manuscript Submission and Peer Review Feedback using the Blockchain

Authors

The authors of the paper [20] can be viewed in table C.1.

Table C.1: Authors

Name	Location	Institution
Bela Gipp	Konstanz, Germany	University Of Konstanz
Corinna Breitinger		
Norman Meuschke		
Joeran Beel	Dublin, Ireland	Trinity College Dublin

Contribution

The contribution of Gipp et al. [20] was a manuscript submission system called *"CryptSubmit"*. It provides the functionality for academics to submit their manuscript(s), to get peer review feedback and most importantly to securely confirm the existence of research concepts, data or outcomes when a manuscript is submitted to be reviewed. Their research question is:

> *"How can researches verify that their contribution already existed at the time of submission to a conference or journal?"*

Another contribution that they made was integrated in *"CryptSubmit"* and was a service called *"OriginStamp"*[56]. This service can be used to create decentralized trusted timestamps on Bitcoin's Blockchain. Their work is available open source:

1) *"CryptSubmit"* https://www.gipp.com/cryptsubmit/

2) *"OriginStamp"* http://originstamp.org/home

.

Reason/Problems

The disadvantages of current manuscript submission systems are in particular the **1)** lack of standards that cause for example data leaks **2)** chance of bias and fraud

[56] http://originstamp.org/

during the peer-review **3)** no existance of proof, seperate of the system, to confirm the time the author's work was uploaded. They stated that currently there are various trusted-timestamping systems based on Bitcoin's Blockchain, but non that adresses the issue of priority management for academic manuscripts.

Implementation Process

For their manuscript submission system *"CryptSubmit"*, they used the *"Open Journal System (OJS)"*[57], which is an open-source management submission software for academic journals. The figure C presents the architecure of *"CryptSubmit"*. In their provided frontend, there are several functionalities to exploit: **1)** User Registration **2)** File (e.g. manuscript) upload **3)** Management of peer review procedure. If a person then uploads some data, a hash is automatically created by the backend of the system. This hash then gets sent to the *"OriginStamp Service"*, which adds the hash onto Bitcoin's Blockchain. The service then gets the trusted timestamp back from the Blockchain and sends it to the submission system. Here the manuscript verficiation link and the trusted timestamp are presented. The person to review the paper is notified by the system, that there was an upload and also has access to verify the timestamp. The third actor in the system is the research community or simply the public. Everyone has access to the manuscript and the associated hash, so that they are able to check the time and the content of the idea that was published on the system.

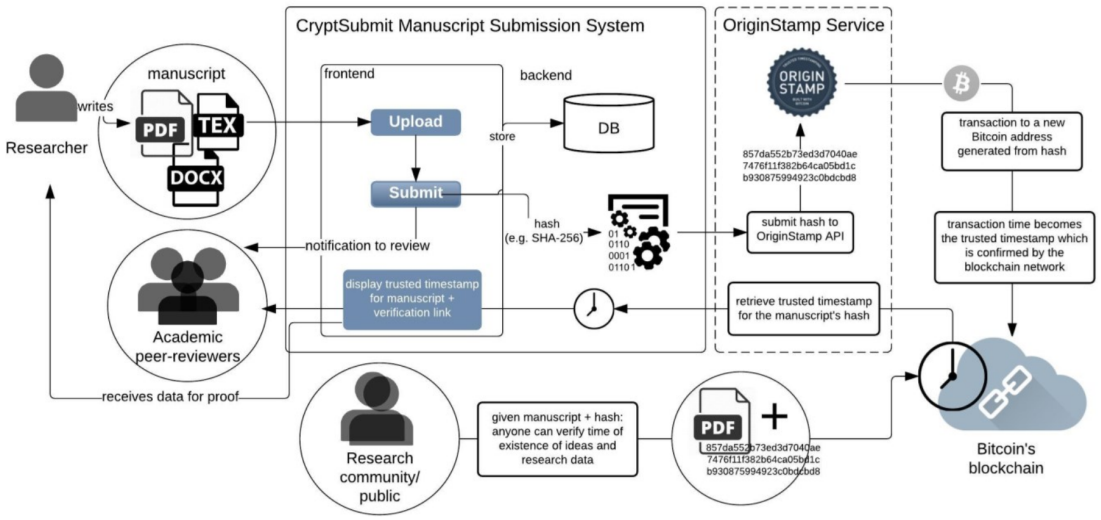


Figure C.1: Overview of the manuscript submission system implemented by Gipp et al. [20]

[57] https://openjournalsystems.com/

Conclusion

The decentralized trusted timestamp system *"OriginStamp"* that they presented in the paper has a crucial advantage compared to traditional timestamp systems, there is no central timestamping authority (TSA). In the Bitcoin system this is called the Third-Trusted-Party, which represents the bank.
Combing the manuscript submission system which *"OriginStamp"*, results in certain improvements:

- Each author receives a tamperproof timestamp of when they submitted their work. This timestamp is independent of *"CrtpySubmit"* system. This means, that even if someone steals the idea, the author is able to proof that he published the work first.
- The proposed solution will not help to fully prevent plagiarism in academia, nevertheless it will aid the researchers to justify their claim of ownership of a certain intellectual property.
- There are not only benefits for the authors but also for the reviewers. They are also given a proof of their feedback and can also demand to be cited for their contribution in the publication after.

For future work, they say that the approach could also be used for other submission systems and that more features of the Blockchain e.g. store the complete publication on the Blockchain, could be integrated.

Privacy-Preserving Coordination for Smart Communities

Authors

The authors of the paper [30] can be viewed in table C.2.

Table C.2: Authors

Name	Location	Institution
Parisa Kianmajd	Davis, United States	University of California, Davis
Jeff Rowe		
Karl Levitt		

Contribution

Reason/Problems

Implementation Process

Conclusion

Blockchain to Rule the Waves – Nascent Design Principles for Reducing Risk and Uncertainty in Decentralized Environments

Authors

The authors of the paper [42] can be viewed in table C.3.

Table C.3: Authors

Name	Location	Institution
Kristoffer Nærland	Mainz, Germany	*"Brainbot technologies"*[58]
Christoph Müller-Bloch	Copenhagen, Denmark	IT University of Copenhagen
Roman Beck		
Søren Palmund		

Contribution

Reason/Problems

Implementation Process

Conclusion

[58] http://www.brainbot.com/

Decentralizing Privacy: Using Blockchain to Protect Personal Data

Authors

The authors of the paper [59] can be viewed in table C.4.

Table C.4: Authors

Name	Location	Institution
Guy Zyskind	Cambridge, United States	Massachusetts Institute of Technology
Alex "Sandy" Pentland		
Oz Nathan	Tel-Aviv, Israel	Tel-Aviv University

Contribution

Reason/Problems

Implementation Process

Conclusion

Industrial Case: Blockchain on Aircraft's Parts Supply Chain Management

Authors

The authors of the paper [36] can be viewed in table C.5.

Table C.5: Authors

Name	Location	Institution
Yash Madhwal	Moscow, Russia	Higher School of Economics
Dr. Peter B. Panfilov		

Contribution

Reason/Problems

Implementation Process

Conclusion

Secure Event Tickets on a Blockchain

Authors

The authors of the paper [50] can be viewed in table C.6.

Table C.6: Authors

Name	Location	Institution
Björn Tackmann	Zurich, Switzerland	IBM Research

Contribution

The contribution of Tackmann [50] is an event ticket management system. His system provides more security for the ticket owner to prevent ticket theft and to be able to re-sell the tickets in a secure way. His research question is:

> *"Can we use blockchain technology to achieve the convenience of standard tickets, but with the improved security of ID-based ones?"*

His work is not available open-source.

Reason/Problems

Today, the event providers sell tickets in form of a piece of paper with an unique Quick Response code (QR code) to their customers.. This poses no problem for the organizing entity because he usually scans a QR code at the gate and lets everyone with a valid QR code enter. For the ticket buyer on the other hand, there are various issues. The main problems that are trying to be solved with this research are:

1) **Ticket theft** by reprinting the same ticket multiple times

2) Proofing the validity of tickets when **re-selling spare ones**

. The questions that the author asked himself in his research is if by using the Blockchain technology, one could improve the issues of the ticket owner by keeping the current level of comfort for both parties involved. In the research, they link the unique identifier of a concert ticket with the cryptographic identity of the ticket owner on the Blockchain.

Implementation Process

To implement his ticket manangement system, he used *"Hyperledger Fabric V1"*[59] as his Blockchain Platform. There are three different actors involved, each of which has a pair of keys (private key and public key):

1) **Ticket Seller**

[59] https://www.hyperledger.org/projects/fabric

2) **Ticket owner**

3) **Event organizer**

. Each of these actors has a functionality. The customers can re-sell their tickets, the organizers can invalidate the ticktes and the tickets seller can enroll new tickets onto the Blockchain. For each of these tasks an application was developed to provide the function that is needed. All application were developed with Swift for *"iOS"*. These application communicate with the Hyperledger Blockcain via a REST proxy.

Table C.7: Implementation

Actor	Task	Realisation
Ticket seller	Enrolling a ticket on the Blockchain	Seller Application
Ticket owner	Re-selling a ticket	Client Application
Event organizer	Invalidation a ticket	Organizer Application

The ticket is implemented as a tuple of parameters:

1) Ticket Identifier (ticket id)

2) Signature Public Key of the ticket owner

3) Signature Public Key of the event organizer

4) Ticket State (valide or invalid)

5) Ticket age

The procedure to execute each task is precisely specified.

Enroll a ticket Only the ticket seller can enroll a ticket onto the Blockchain. He takes an unique identifier, the public key of the event organizer and the public key of the ticket owner to do so. He signs this process with his private key to provide a signature. This ensures that only he can add tickets to the system.

Re-sell a ticket To re-sell a ticket, the ticket owner takes to ticket id, the public key of the buyer and signs this with his private key to create a signature. The system then checks if the id exists and if the state is valide. If all is good, the age of the ticket is augmented to prevent from replay attacks.

Invalidate a ticket The event organizer takes the ticket id, the owners public key and his signature to invalidete the ticket. If the ticket id with the right public key is correct, the status of the ticket changes to invalid.

Conclusion

The developed prototype solves the research question successfully. Yet there is non theoretical necessity to use a Blockchain. The event organizer could also host the system on his servers. On the other hand, by using this system, an organizer has the opportunity to outsource the application to multiple providers. By doing so, he can prevent his severs from being attacked. Since the Blockchain is used, he does not have to trust the other parties. To increase resilience, multiple event organizers could run the system together. The benefits of Blockchain system are:

1) **Consistency** For each task, the ticket can only make valid changes of its current state.

2) **Unforgeability** Change requests can only be made by relevant parties.

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A trustless privacy-preserving reputation system

Authors

The authors of the paper [46] can be viewed in table C.8.

Table C.8: Authors

Name	Location	Institution
Alexander Schaub	Lyon, France	École Polytechnique
Rémi Bazin		
Omar Hasan		Laboratoire d'Informatique en Images et Systèmes d'Information (LIRIS)
Lionel Brunie		

Contribution

Reason/Problems

Implementation Process

Conclusion

An Online Identity & Smart Contract Management System

Authors

The authors of the paper [54] can be viewed in table C.9.

Table C.9: Authors

Name	Location	Institution
Affan Yasin	Beijing, China	Tsinghua University
Lin Liu		

Contribution

Reason/Problems

Implementation Process

Conclusion

Healthcare Data Gateways: Found Healthcare Intelligence on Blockchain with Novel Privacy Risk Control

Authors

The authors of the paper [57] can be viewed in table C.10.

Table C.10: Authors

Name	Location	Institution
Xiao Yue	Fujian, China	Huaqiao University
Huiju Wang	Wuhan, China	Zhongnan University of Economics and Law
Dawei Jin		
Wei Jiang		
Mingqiang Li		

Contribution

Reason/Problems

Implementation Process

Conclusion

Blockchain Platform for Industrial Internet of Things

Authors

The authors of the paper [4] can be viewed in table C.11.

Table C.11: Authors

Name	Location	Institution
Arshdeep Bahga	Atlanta, United States	Georgia Institute of Technology
Vijay K. Madisetti		

Contribution

Reason/Problems

Implementation Process

Conclusion

Smarter City: Smart Energy Grid based on Blockchain Technology

Authors

The authors of the paper [1] can be viewed in table C.12.

Table C.12: Authors

Name	Location	Institution
Pieroni Alessandra	Rome, Italy	Guglielmo Marconi University
Luca Di Nunzio		University of Rome Tor Vergata Institute
Noemi Scarpato		Università Telematica San Raffaele
Francesca Fallucchi		Università Telematica Guglielmo Marconi

Contribution

Reason/Problems

Implementation Process

Conclusion

MedRec: Using Blockchain for Medical Data Access and Permission Management

Authors

The authors of the paper [3] can be viewed in table C.13.

Table C.13: Authors

Name	Location	Institution
Asaph Azaria	Cambridge, United States	Massachusetts Institute of Technology
Ariel Ekblaw		
Thiago Vieira		
Andrew Lippman		

Contribution

Reason/Problems

Implementation Process

Conclusion

Can Blockchains Serve an Accounting Purpose?

Authors

The authors of the paper [13] can be viewed in table C.14.

Table C.14: Authors

Name	Location	Institution
Joshua G. Coyne	Memphis, United States	University of Memphis
Peter L. McMickle		

Contribution

Reason/Problems

Implementation Process

Conclusion

Rep on the block : A next generation reputation system based on the blockchain

Authors

The authors of the paper can be viewed in table C.15.

Table C.15: Authors

Name	Location	Institution
Richard Dennis	Portsmouth, United Kingdom	University of Portsmouth
Gareth Owen		

Contribution

The titel of their publication is:

"Rep on the block : A next generation reputation system based on the blockchain"

Reason/Problems

Implementation Process

Conclusion

Blockchain Technology and Cryptocurrencies: Opportunities for Postal Financial Services

Authors

The authors of the paper [24] can be viewed in table C.16.

Table C.16: Authors

Name	Location	Institution
Christian Jaag	Zurich, Switzerland	Swiss Economics[60]
Christian Bach		University of Liverpool and Swiss Economics

Contribution

Reason/Problems

Implementation Process

Conclusion

[60] https://www.swiss-economics.ch

Betfunding: A Distributed Bounty-based Crowdfunding Platform over Ethereum

Authors

The authors of the paper [25] can be viewed in table C.17.

Table C.17: Authors

Name	Location	Institution
Viktor Jacynycz	Madrid, Spain	Universidad Complutense de Madrid
Adrian Calvo		
Antonio A. Sánchez-Ruiz		
Samer Hassan	Madrid, Spain and Cambridge, United States	Universidad Complutense de Madrid and Berkman Center for Internet and Society, Harvard University

Contribution

Reason/Problems

Implementation Process

Conclusion

An Identity Management System Based on Blockchain

Authors

The authors of the paper [34] can be viewed in table C.18.

Table C.18: Authors

Name	Location	Institution
Yuan Liu	Shenyang, China	Northeastern University
Zheng Zhao		
Guibing Guo		
Xingwei Wang		
Zhenhua Tan		
Shuang Wang		

Contribution

Reason/Problems

Implementation Process

Conclusion

A Case Study for Grain Quality Assurance Tracking based on a Blockchain Business Network

Authors

The authors of the paper [35] can be viewed in table C.19.

Table C.19: Authors

Name	Location	Institution
Percival Lucena	Brazil	IBM Research[61]
Alecio P. D. Binotto		
Fernanda da Silva Momo	Porto Alegre, Brazil	Federal University of Rio Grande do Sul (UFRGS)
Henry Kim	Toronto, Canada	York University

Contribution

The contribution of Lucena et al. [35] is a grain quality assurance tracking system. Their work is not available open source. Say here that the system was a real world use case and actually installed and tested in brazil.

Reason/Problems

The brazilian *"Grain Exports Business Network (GEBN)"* is composed of the following actors:

1) **Grain Producer**
2) **Rural Credit Bank agent**
3) **Private warehouse agent**
4) **Trading company agent**
5) **Food processing company**

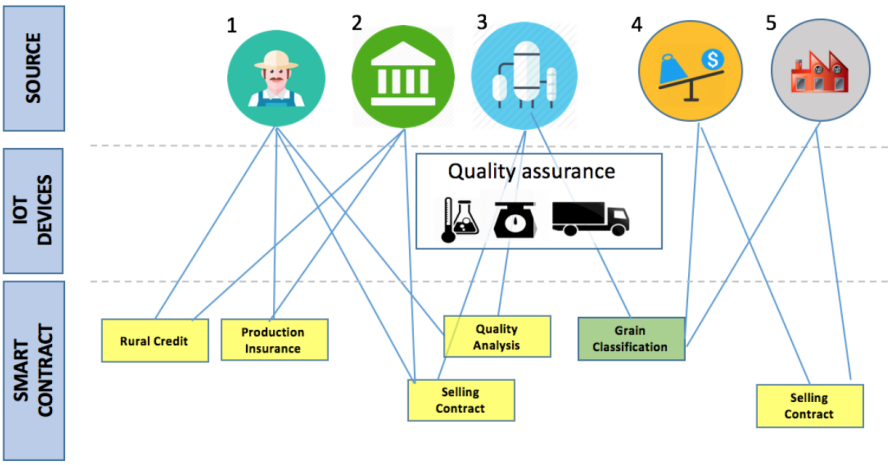
The actors in the GEBN network are not able to trust in each other, because they all have different business goals. This leads to various problems in logisitics and information manangement.
In lgoistics, the main problem is:

1) There a tremendous logistics and warehouse issues in the moving process of the production from the fields to the other actors on the supply chain. The transportation network and warehouse storage method today has a huge influence on the grain quality.

Since there is no trust, the actors are not willing to share their information with the others. This resolves in multiple problems:

[61] https://researcher.watson.ibm.com/researcher/view_group_pubs.php?grp=5113

Figure C.2: Business Network



1) The grain quality control information is saved in various software programs and then distributed to diverse databases. This leads to inaccurate information flow which causes financial losses in the agreement process between producers and traders.

2) Also the real time information about the grain quality is only available to the local actor and not shared with all other players on the supply chain.

Each of these actors has his own issues with the way the current system works. In the table C.20, an overview of all actors are listed with their concern and the reason why they have it.

Table C.20: Issues with current network

Actor	Concern	Reason
Grain Producer	Correct management of grain ingest and classification	Receive a fair payment
	Proper ingest receipt	Acquire a credit on Rural Credit Banks
		Agree on a production insurance
Rural Credit Bank agent	Accurate data from producers	Lower credit giving risks
		Offer reduced interest credit rates for credit operations
Private Warehouse agent	Precise grain classification data	Sell the grains to various actors

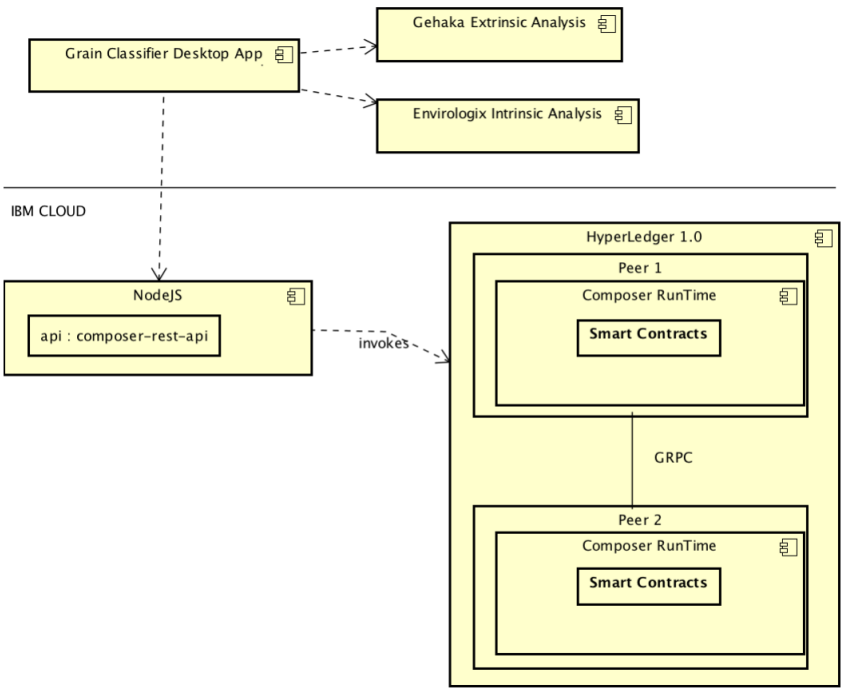
Table C.20: Issues with current network

Actor	Concern	Reason
Trading Company agent	Purchase of large amounts of grains with the right quality from several warehouses	Achieve an export request
Food processing company	Acquisition of special selected grains that have specific characteristics (e.g. high protein)	✗

Implementation Process

To implement their prototype, they used the permissioned Blockchain *"Hyperledger Farbic Blockchain V1"*. There are multiple distributions of this product and they used a cloud instance. Another IBM product they used is the Hyperledger Composer Framework for the creation of smart contracts. The hyperledger framework is hosted on the IBM cloud. Via a Node.js, the system then communicates with the *"Grain Controller Desktop Application (GDPA)"*.
The protoype was actually tested in a warehouse in Brazil. The grain quality was tested and then the information about it was documented onto the Blockchain.

Figure C.3: Architecture



Conclusion

The main benefits of using a Blockchain in this scenario are:

1) All members of the supply chain can now use the same business rules and also share the same transaction data. This lowers the discussions between business partners.
2) Since the Blockchain is very transparent, the participating actors are forced to collaborate with each other to define common rules for the smart contracts. This provides them with the opportunity to define or even vote on their own common rules and consensus principles.

They also mention that in this area, there is future work to do.
Especially, they discuss the legal value that is offered with the Blockchain. In this case, Brazil excepts these digital signatures as a valid legal contract. Unfortunately, this is more difficult for a more international solution and yet to prove.
Also they state that Blockchain could be a huge advantage for Global Trade. All partner that trade can share their information on a Blockchain and therefore avoid large paper trails and information loss.
Overall their project was succesfull and they encourage others to future explore Blockchain Business Networks in other industries.

Towards a Novel Privacy-Preserving Access Control Model Based on Blockchain Technology in IoT

Authors

The authors of the paper [43] can be viewed in table C.21.

Table C.21: Authors

Name	Location	Institution
Aafaf Ouaddah	Marrakesh, Morocco	Cadi Ayyad University
Anas Abou Elkalam		
Abdellah Ait Ouahman		

Contribution

Reason/Problems

Implementation Process

Conclusion

The Blockchain and Kudos: A Distributed System for Educational Record, Reputation and Reward

Authors

The authors of the paper [49] can be viewed in table C.22.

Table C.22: Authors

Name	Location	Institution
Mike Sharples	Milton Keynes, United Kingdom	The Open University
John Domingue		

Contribution

Reason/Problems

Implementation Process

Conclusion

An Agri-food Supply Chain Traceability System for China Based on RID & Blockchain Technology

Authors

The authors of the paper [52] can be viewed in table C.23.

Table C.23: Authors

Name	Location	Institution
Feng Tian	Vienna Austria	Vienna University of Economics and Business

Contribution

Reason/Problems

Implementation Process

Conclusion

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Eidesstattliche Erklärung

Hiermit versichere ich an Eides statt, dass ich diese Masterarbeit selbständig und ohne Benutzung anderer als der angegebenen Quellen und Hilfsmittel angefertigt habe und dass alle Ausführungen, die wörtlich oder sinngemäß übernommen wurden, als solche gekennzeichent sind, sowie dass ich die Masterarbeit in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegt habe.
Christina Krutzenbichler
Passau, den Thursday 9th August, 2018