Research Center
Finance & Information Management

Fraunhofer FIT
Project Group
Business & Information
Systems Engineering

Challenges and Opportunities of Blockchain-based Platformization of Digital Identities in the Public Sector

by

Gilbert Fridgen, Florian Guggenmos, Jannik Lockl, Alexander Rieger

to be presented at: Workshop on Platformization in the Public Sector,
26th European Conference on Information Systems (ECIS),
Portsmouth, UK, June 2018

University of Augsburg, D-86135 Augsburg
Visitors: Universitätsstr. 12, 86159 Augsburg
Phone: +49 821 598-4801 (Fax: -4899)

University of Bayreuth, D-95440 Bayreuth
Visitors: Wittelsbacherring 10, 95444 Bayreuth
Phone: +49 921 55-4710 (Fax: -844710)

www.fim-rc.de

WI-758

CHALLENGES AND OPPORTUNITIES OF BLOCKCHAIN-BASED PLATFORMIZATION OF DIGITAL IDENTITIES IN THE PUBLIC SECTOR

Research in Progress

Abstract

Digitalization promises unprecedented opportunities for public sector institutions to increase efficiency of current and to introduce new services. One of these opportunities are unique digital identities which could improve migration and refugee management, simplify distribution of social services, and improve healthcare systems. A major challenge, however, to the adoption of such digital identities is finding a suitable technological basis. Blockchain might be such a technology. The challenges of introducing blockchain-based digital identities, however, are both significant and fuzzy. To provide guidance on how to overcome these challenges, we provide a detailed exploration of blockchain-based platformization of digital identities and discuss interview insights from refugee and migration management in Germany. We find that blockchain offers promising solutions for unique digital identity management. Likewise, we find that implementation in the public sector would entail a range of organizational and technological challenges. Successful adoption, on the other hand, might ultimately pave the way for decentral and efficient e-government services.

Keywords: Blockchain, Digital Identity, Platformization, Public Sector.

1 Introduction

As digitalization rapidly advances (Denner et al., 2017), public organizations and governments increasingly face emerging digital technologies with the potential to disrupt their processes and services. Governments and public sector institutions thus increasingly evaluate how to digitalize public authorities and citizen services. Estonia, for instance, provides its citizens with a new kind of identity card that grants access to e-government services such as online voting (Government of Estonia, 2018a). In contrast, federalist countries often lack sufficient information to trace, for instance, medical records or the asylum status of migrants (Beaumont, 2018).

Simultaneously, a novel technology arises that could support transnational digital identity management without a central party – blockchain technology (Beck et al., 2018; Schweizer et al., 2017). Blockchain first appeared as the backbone of bitcoin. Newer 2nd generation blockchains also offer smart contract functionalities that enable a broad range of applications (Buterin, 2014). These 2nd generation blockchains allow to better manage processes and mechanisms along the supply chain (Korpela et al., 2017; Nærland et al., 2017), to increase security and privacy (Aitzhan and Svetinovic, 2016; Dorri et al., 2017), and even to automate and decentralize whole organizations (Beck et al., 2018). Based on this increasing number of options, both academia and practitioners believe that blockchain could have groundbreaking societal impact (Beck et al., 2018; Niederman et al., 2017; Schweizer et al., 2017).

For digital identity management, especially blockchain's characteristics of being tamper-proof, transparent, and trustless are intriguing (Fanning and Centers, 2016; Glaser and Bezzenberger, 2015). Moreover, blockchain could allow to platformize digital identities (Bakre et al., 2017; Deloitte, 2016). Yet, little research has examined blockchain-based platformization in the public sector and to the best of our knowledge, none the case of digital identities. Capitalization on blockchain proves difficult, however, as little practical experience is available (Fridgen et al., 2018a; Fridgen et al., 2018b; Schweizer et al., 2017). Thus, initiators of candidate platformization projects need to examine thoroughly the potential of blockchain. Moreover, they require advice on the challenges and opportunities that blockchain brings to platformization of digital identities. We thus addressed the following research question:

What are the challenges and opportunities a blockchain-based platformization of digital identities in the public sector?

To answer this question, we conducted expert interviews with the Federal Office for Migration and Refugees in Germany. These interviews were part of an on-going project to evaluate the applicability of blockchain as supporting technology for the German asylum process and as a prospective platform for digital identities.

Our insights provide four major contributions. First, we augment knowledge about blockchain applications in the public sector. Second, we enhance knowledge about blockchain-based platformization. Third, we derive challenges and opportunities of introducing blockchain technology as a basis for digital identity management. Fourth, we provide managerial implications. Specifically, we illustrate how to capitalize on blockchain in the public sector and provide guidance on how to conduct blockchain-based platformization projects successfully. Finally, we highlight the opportunities of a joint digital identity platform in Europe.

The remainder of this paper structures as follows: In section two, we introduce blockchain, digital identities, and platformization of digital identities. In section three, we explain our methodological approach: a literature review of current challenges in the public sector, a test of the suitability of blockchain technology to overcome these challenges, and semi-structured interviews to explore concrete challenges of transnational platformization of digital identities. In section four, we describe the challenges of such a blockchain implementation in detail. In section five, we review the opportunities of blockchain-based platformization of digital identities, discuss our theoretical as well as managerial implications, highlight limitations of our work, and close with directions for future research.

2 Theoretical Background

2.1 Blockchain

Nakamoto conceived blockchain in 2008 as a distributed digital ledger for Bitcoin transactions (Avital et al., 2016; Beck et al., 2018; Nakamoto, 2008). Since 2008, global interest in blockchain has increased substantially and various practitioners and researchers believe that blockchain has the potential to radically change several spheres (Beck et al., 2018). Today, blockchain technology has evolved into a multipurpose technology. Modern blockchain solutions exemplary support supply chain records (Korpela et al., 2017), security and privacy in the context of the internet of things (Dorri et al., 2017), energy trading (Munsing et al., 2017), and prediction markets (Clark et al., 2014).

Conceptually, a blockchain is a transparent, transactional, distributed database and every node of a peer-to-peer (P2P) network stores this database redundantly (Glaser, 2017). Condos et al. (2016) alternatively describe a blockchain as an electronic registry for digital records, events, or transactions managed by the participants of a distributed computer network. A blockchain groups this information into blocks and cryptographically "chains" blocks to one another in chronological, structured order, i.e., each block contains a reference to the previous block (Schweizer et al., 2017). A so called consensus mechanism determines the correct order of transactions (i.e., in the blocks) as well as the correct order of the blocks (i.e., in the "chain"); this mechanism is performed by all or special authorized nodes to provide "consensus" on the order and content of all stored blocks (Glaser, 2017). Blockchain developers can choose from various of these consensus algorithms, each providing slightly different levels of security, latency, and energy consumption (Christidis and Devetsikiotis, 2016; Zheng et al., 2016). Moreover, blockchains can have different designs with varying levels of read/write permissions, centralization, and efficiency (Christidis and Devetsikiotis, 2016; Peters and Panayi, 2016; Zheng et al., 2016). Generally, all blockchain systems are characterized by data redundancy (Porru et al., 2017), the use of cryptography (Porru et al., 2017) and consensus mechanisms (Christidis and Devetsikiotis, 2016; Porru et al., 2017), decentralization (Zheng et al., 2016), and auditability (Zheng et al., 2016). Exemplary, Schweizer et al. (2017) provide a more a detailed description of the characteristics of blockchain.

2.2 Digital Identity

Identity "is a set of permanent or long-lived attributes" (Camp, 2004, p. 36) that are clearly associated with a thing or person (Camp, 2004). It may describe a person's unique properties (date of birth, fingerprint, iris) or those of a thing (hashed computer password). In principle, one can distinguish between identification in the analogous and the digital world. In the analogous world, identification mostly depends on identification (ID) cards that provide sufficient information to authenticate a person (e.g., passport photo, name, and date of birth) and written signatures (Camp, 2004). In the digital world, authentication mostly depends on digital signatures that consist of a public and private key pair. To sign, the signer calculates a value using the private key only the signer knowns. Other users can derive the integrity of the signature from the calculated value using the publicly accessible public key. Moreover, governments increasingly store in a digital form biometric characteristics to identity travelers, migrants and refugees. For example, European airports have begun to use face recognition software (so called Easy-PASS) to match passenger faces with the image stored on the passport's chip (Markus Nuppeney, 2014). In a Jordanian refugee camp near the Syrian border, the World Food Program in cooperation with the UN also uses blockchain and iris scans to identify refugees and distribute food fairly. In addition, refugees can shop in the camp's supermarket and pay by Iris Scan (World Food Programm, 2016; Aloudat et al., 2016).

Estonia, meanwhile, has taken a pioneering role in the field of e-government and digital identity (Government of Estonia, 2018b) and provides 99% of its state services online (Government of Estonia, 2018d). The Estonian ID cards and digital signatures provide access to government information and services as well as private sector services in health care, banking and education, and law (Anthes, 2015),

and even voting can be done digitally (Government of Estonia, 2018d). In addition, many of these services can also be accessed securely via smartphones using a so called Mobile ID app (Government of Estonia, 2018c). Since 2001, the Estonian system uses "X-Road", a blockchain-like middleware that connects different data sources to a "single database". The actual data, however, is stored in a decentral way (Anthes, 2015; Eixelsberger, 2010) and can be accessed selectively by other administrative organizations and companies (e.g., banks). Estonia also focuses on singular collection and storage of citizen data following the so-called once-only principle (Government of Estonia, 2018a).

2.3 Identities on Digital Platforms

The digital infrastructure that enables services such as the Estonian ID card is a platform. Platforms provide a set of functionalities that are accessible to its participants through one unified point. The service providers share the platform's costs and standardized rule sets support the creation of network effects (Economides and Katsamakas, 2006; Iansiti and Levien, 2004; Mazhelis and Tyrvainen, 2014).

Literature differentiates between product platforms, industry platforms, and multi-sided platforms. Product platforms offer product components that facilitate efficient development and production of derivative products on a joint foundation (Baldwin and Clark, 2000; Gawer and Cusumano, 2014). Industry platforms provide the technological foundation for complementary product development. They epitomize software or popular devices such as the App Store (Gawer and Cusumano, 2014; Cusumano and Yoffie, 1999). Multi-sided platforms mediate service or product transactions between the engaging parties. Currently, however, these MSPs often lack in interoperability (Seppälä and Mattila, 2016) as, for instance, Uber and Lyft illustrate: consumers enrolled with one of the two cannot hail producers (i.e., drivers) from the other platform unless the producer is registered with both mobility providers.

Blockchain is a candidate infrastructure to solve this lack of interoperability, and store and provide unique digital identities. Research is consequently interested in understanding blockchain-based platforms (Lindman et al., 2017). For such platforms, blockchain not only provides unique digital ID capabilities but empowers participants by ensuring data sovereignty and direct transactions without the need for an additional intermediary (Avital et al., 2016; Subramanian, 2017).

3 Methodological Approach

Studies from the AIS basket of eight, affiliated journals (e.g., BISE, JITTA), and affiliated conferences (e.g., AMCIS, ECIS, HICSS, ICIS, PACIS) provided us with an initial theoretical basis to derive challenges of the public sector that relate to or could be solved through information systems. Another source were the search results using the search string *challenge* AND "public sector" AND e-government AND Europe* to identify papers in the AiSEL, EBSCOhost, and ScienceDirect databases. As the public sector differs from country to country, we restricted the search results to Europe. To warrant recentness of our data, we required the papers to be published in 2017 or 2018. The search resulted in 80 papers. After elimination of duplicates, we covered a set of 61 results. We rated the papers collected within our review database with a three-point Likert Scale (Likert, 1932) ranging from zero (i.e., not relevant) to two (i.e., highly relevant). Two authors independently read the titles and abstracts of the papers and rated them. A third author screened the papers rated with a one to decide about refusal or admission of the paper for in-depth screening. In a first step, we rated 13 papers as highly relevant (Likert Scale: 2), 13 as relevant (1), and 35 as not relevant (0). The third author's screening finally yields 20 relevant and 41 non-relevant papers. To improve the quality of our literature review, we used forward searches (Webster and Watson, 2002). From the paper screening process, we extracted codes of unsorted and overlapping challenges that we coded into general challenges.

To evaluate the potential of blockchain to address the challenges of the public sector, we used the method of Wüst and Gervais (2017). Based on positive results from the evaluation test, we conducted interviews with experts from the public sector, blockchain development, blockchain advisory, and academia. Expert interviews are among the sources of choice to collect data on new phenomena (Myers and Newman, 2007) and allow for the exploration of cutting-edge knowledge from practice (Schultze and Avital,

2011). To further enrich our practical insights, we semi-structured the interviews and asked our questions in an open manner (Creswell and Creswell, 2017; Yin, 2017). Our interviewees could thus deliver more knowledge than predefined questions would ask for (Urquhart et al., 2010). To achieve rigor, we designed the interview guide by focusing on reduction of ambiguity and improvement of the comparability of the answers given (Creswell and Creswell, 2017; Yin, 2017). This interview guide allowed us to identify the actual challenges and allowed the interviewees to take a retrospective, reflective point of view on personal experiences. Our interview guide structured the questions along a logical sequence and supported a fluent dialogue. The major topics addressed in each interview were: the public sector, platformization of digital identities, blockchain, and challenges of taking advantage of blockchain in the public sector as well as in the platformization of digital identities.

To derive appropriate challenges, we coded the interviews (Saldaña, 2015). First, we consolidated each interview, clarified statements, and augmented the interview with descriptive notes. To initially subsume the codes, we adopted the use case evaluation framework of Fridgen et al. (2018a). The framework suggests that technical, functional, and legal criteria are relevant for the evaluation of blockchain use cases. After subsuming the codes to the three categories, we adapted the codes to iteratively develop mutually exclusive and collectively exhaustive challenges. We accepted constructs that at least two of our interviewees mentioned (Klein and Myers, 1999).

4 Transnational Platform for Digital Identities

4.1 Challenges in the Public Sector

The introduction of a cross-European digital identity is a complex task that leads back to the different requirements and intentions of the EU's member states. Whereas many challenges arise from the mixed confederate-federal organization of the European Union, certain challenges are already evident at the individual member state level. Germany, for instance, offers a wide variety of services at various federal levels. Its heterogeneous service catalogue of public administration currently comprises approximately 5.900 entries (Leika, 2018). For the most part, the federal government, however, does not provide these services itself. This role rather falls to approximately 11.000 cities, municipalities, and administrative districts in Germany. They are the first point of contact for citizens in administrative matters. Due to the large number of different administrative bodies and services, citizens often lose track (Fromm et al., 2015).

Structured e-government processes may reduce this complexity and allow for faster processing times and lower fees (fortiss, 2017). A core aspect of e-government is the singular collection of data, which means that only a single authority collects each data. Each third German citizen expects this so-called once-only principle (fortiss, 2017). For security, governmental e-services should be decentralized to a similar degree (Anthes, 2015). Likewise, decentralization should not limit compatibility among applications or negatively affect user experience (fortiss, 2017). Further, satisfaction with the range and use of digital services declined sharply in comparison with the previous year. Moreover, at the European level additional challenges arise from different requirements and political agendas of member states (Brusca et al., 2016). These challenges include, for instance, the establishment of joint data sources and the integration of processes (Cavanillas et al., 2016).

4.2 Blockchain-based Platformization of Digital Identities

From literature and our interviews, we identified a set of challenges for a blockchain-based system that platformizes digital identities in the public sector. We divide these challenges into three categories: technological, functional, and legal challenges.

Challenge 1, technological: Ensuring security, performance, and scalability

Security is a very important paradigm in the public sector. In addition to the encryption of stored identity data, security also requires encryption of communication channels and preservation of integrity (i.e., correctness and authenticity of data, traceability of changes). Moreover, the acceptance of a system that

platformizes digital identities depends on the benefits that the system can offer. These benefits clearly trace back to performance, 24/7 availability, and time savings (fortiss, 2017). Scalability, finally, allows for integration of new services and user base expansion at any time.

Challenge 2, technological: Ensuring maintainability, operability, and usability

Maintainability (i.e., software updates and hardware replacements) is a decisive factor. Consequently, non-experts must be able to supervise the system. On the user's side, graphical user interfaces must be user-friendly and barrier-free.

Challenge 3, functional: Ensuring flexibility, process integrity, and analytical capability

First, the system must ensure that it is suitable for complex processes such as the asylum process in Germany. In addition, the systems must guarantee process integrity (e.g., correct sequence of process steps). The system must be able to handle unexpected processes (e.g., skipped process steps). Ultimately, the system must offer analytical capabilities to identify problems at an early stage and take required countermeasures.

Challenge 4, functional: Creation of an accepted neutral instance

According to fortiss (2017), many citizens in Germany do not want their personal data to be stored centrally. Citizen acceptance, on the other hand, is an important aspect of a successful system. In Estonia, X-Road ensures citizen acceptance by providing a neutral technology. All data is stored in a decentralized manner by different organizations. X-Road only serves as a middleware and challenges data flows between organizations. Since states will be reluctant to grant other states and countries unchecked access to data on their citizens, creation of such a neutral system is also relevant in the German and European context.

Challenge 5, legal: Ensuring compliance with all applicable regulations and laws

The introduction of a system that could platformize digital identities throughout Germany or the EU requires compliance with applicable law. The system must not violate laws or regulations of any country, in particular data protection laws.

Challenge 6, legal: Ensuring deletion in accordance with data protection regulations

The General Data Protection Regulation stipulates that organizations must store personal data only as long as required for the originally purpose of the data storage. Otherwise, the system must delete the data after a defined period. Since data deletion is particularly relevant in the case of blockchain, we list this characteristic separately. However, in its current implementation, a typical blockchain does not or permits only with disproportionate effort to delete data.

4.3 Opportunities for European Governments

Platformization of digital identities provides multiple advantages. To begin, public sector organizations can realize large savings of time and costs. Estonia shows that digital identities can save about 500 million dollars per year, which is equivalent to about 2% of Estonia's GDP (Anthes, 2015). In addition, the use of X-Road and the associated acceleration of processes saves approximately 800 years of working time per year (Government of Estonia, 2018d). Faster processes also save time for citizens. Moreover, a unified digital identity enables transparency on each individual and her processual history. Traceability is relevant for each of the aforementioned opportunities (e.g., medical records, legal integrity) but must comply with data protection regulations. Platformization of digital identities can also improve legal security. Courts can decide faster due to the increased transparency and traceability of processual history. Moreover, ruled-based processing could reduce process errors.

5 Discussion

Our research delivers three theoretical contributions. First, we enhance the knowledge about the applicability of blockchain in the public sector. Second, we enhance knowledge about blockchain-based platformization. Specifically, we address, how blockchain could help to platformize digital identities, which are essential elements of a digitalized society (Otjacques et al., 2007). Third, we derive challenges and

opportunities of such an approach. Additionally, our study offers three managerial implications. First, we highlight how to capitalize on blockchain in the public sector. Second, we state the challenges to blockchain-based platformization projects. Third, we illustrate the opportunities of digital identities, which would reduce administrative costs, increase transparency and warrant traceability.

While we provide theoretical and managerial contributions, our research is limited in scope, generalizability, and rigor. First, we reviewed 61 studies and five white papers. We acknowledge, however, that we lack a structured or systematic holistic literature review, which we will conduct as we evolve our present research. Second, we only interviewed experts in refugee management. Thus, we cannot fully ensure generalizability of our results. Future research must address this limitation and more broadly examine the potential of blockchain technology to platformize digital identities. Third, we interviewed twelve employees with similar personal backgrounds. To broaden the study's background, future research should encompass additional interviews or survey research.

Consolidating our findings, the public sector holds potential to digitalize and capitalize on disruptive technologies like blockchain. Furthermore, blockchain-based platformization of digital identities represents an intriguing potential to introduce unique digital identities across Europe. Future research must examine this potential as the use of information systems captures a central role in this progress.

6 References

Aitzhan, N. Z. and D. Svetinovic (2016). "Security and privacy in decentralized energy trading through multi-signatures, blockchain and anonymous messaging streams" *IEEE Transactions on Dependable and Secure Computing*, 1–14.

Aloudat, A., K. Michael and R. Abbas (2016). "The Implications of Iris-Recognition Technologies. Will our eyes be our keys?" *IEEE Consumer Electronics Magazine* 5 (3), 95–102.

Anthes, G. (2015). "Estonia. A model for e-government" *Communications of the ACM* 58 (6), 18–20.

Avital, M., R. Beck, J. L. King, M. Rossi and R. Teigland (eds.) (2016). *Jumping on the Blockchain Bandwagon. Lessons of the Past and Outlook to the Future:* ICIS Proceedings.

Bakre, A., N. Patil and S. Gupta (2017). "Implementing Decentralized Digital Identity using Blockchain".

Baldwin, C. Y. and K. B. Clark (2000). *Design rules. The power of modularity:* MIT press.

Beaumont, P. (2018). *Unicef recruits gamers to mine Ethereum in aid of Syrian children*. URL: https://www.theguardian.com/global-development/2018/feb/06/unicef-recruits-gamers-mine-ethereum-aid-syrian-children (visited on 04/04/2018).

Beck, R., C. Müller-Bloch and J. Leslie King (2018). "Governance in the Blockchain Economy. A Framework and Research Agenda" *Journal of the Association for Information Systems* (forthcoming).

Brusca, I., E. Caperchione, S. Cohen and F. M. Rossi (2016). *Public sector accounting and auditing in Europe. The challenge of harmonization:* Springer.

Buterin, V. (2014). "A next-generation smart contract and decentralized application platform" *Whitepaper*.

Camp, J. L. (2004). "Digital identity" *IEEE Technology and society Magazine* 23 (3), 34–41.

Cavanillas, J. M., E. Curry and W. Wahlster (2016). *New horizons for a data-driven economy. A roadmap for usage and exploitation of big data in Europe:* Springer.

Christidis, K. and M. Devetsikiotis (2016). "Blockchains and Smart Contracts for the Internet of Things" *IEEE Access* 4, 2292–2303.

Clark, J., J. Bonneau, E. W. Felten, J. A. Kroll, A. Miller and A. Narayanan (eds.) (2014). *On decentralizing prediction markets and order books:* Workshop on the Economics of Information Security.

Condos, J., W. H. Sorrell and S. L. Donegan (2016). *Blockchain technology: Opportunities and risks*. URL: https://legislature.vermont.gov/assets/Legislative-Reports/blockchain-technology-report-final.pdf (visited on 03/15/2018).

Creswell, J. W. and J. D. Creswell (2017). *Research design. Qualitative, quantitative, and mixed methods approaches:* Sage publications.

Cusumano, M. A. and D. B. Yoffie (1999). "What Netscape learned from cross-platform software development" *Communications of the ACM* 42 (10), 72–78.
Deloitte (2016). "Blockchain: Opportunities for Health Care".
Denner, M.-S., L. C. Püschel and M. Röglinger (2017). "How to Exploit the Digitalization Potential of Business Processes" *Business & Information Systems Engineering* 11 (1), 177.
Dorri, A., S. Kanhere, R. Jurdak and P. Gauravaram (2017). "Blockchain for IoT Security and Privacy: The Case Study of a Smart Home" *2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*, 618–623.
Economides, N. and E. Katsamakas (2006). "Two-sided competition of proprietary vs. open source technology platforms and the implications for the software industry" *Management Science* 52 (7), 1057–1071.
Eixelsberger, W. (2010). "E-Government in Estland" *E-Government Review* 6, 8–9.
Fanning, K. and D. P. Centers (2016). "Blockchain and Its Coming Impact on Financial Services" *Journal of Corporate Accounting & Finance* 27 (5), 53–57.
fortiss (2017). *eGovernment MONITOR 2017. Nutzung und Akzeptanz digitaler Verwaltungsangebote - Deutschland, Österreich und Schweiz im Vergleich.* Berlin: Initiative D21.
Fridgen, G., F. Guggenmos, J. Lockl, A. Schweizer and N. Urbach (2018a). "An Evaluation Framework for Blockchain in the Public Sector. The Example of the German Asylum Process" *Working Paper* (forthcoming), 1–8.
Fridgen, G., J. Lockl, S. Radszuwill, A. Rieger, A. Schweizer and N. Urbach (2018b). "A Solution in Search of a Problem. A Method for the Development of Blockchain Use Cases" *Working Paper* (forthcoming), 1–10.
Fromm, J., C. Welzel, L. Nentwig and M. Weber (2015). "E-Government in Deutschland: vom Abstieg zum Aufstieg".
Gawer, A. and M. A. Cusumano (2014). "Industry platforms and ecosystem innovation" *Journal of Product innovation management* 31 (3), 417–433.
Glaser, F. (2017). "Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis" *Proceedings of the 50th Hawaii International Conference on System Sciences*, 1543–1552.
Glaser, F. and L. Bezzenberger (2015). "Beyond Cryptocurrencies - A Taxonomy of Decentralized Consensus Systems". In: *Proceedings of the 23rd European Conference on Information Systems*. Ed. by J. Becker, J. Vom Brocke, M. de Marco. Münster, Germany, pp. 1–18.
Government of Estonia (2018a). *A digital leadership for the European Union - e-Estonia*. URL: https://e-estonia.com/press-review-a-digital-leadership-for-the-european-union/ (visited on 04/07/2018).
Government of Estonia (2018b). *ID card - e-Estonia*. URL: https://e-estonia.com/solutions/e-identity/id-card (visited on 04/04/2018).
Government of Estonia (2018c). *Mobile iD - e-Estonia*. URL: https://e-estonia.com/solutions/e-identity/mobile-id (visited on 04/04/2018).
Government of Estonia (2018d). *X-Road - e-Estonia*. URL: https://e-estonia.com/solutions/interoperability-services/x-road/ (visited on 04/04/2018).
Iansiti, M. and R. Levien (2004). "Strategy as ecology" *Harvard business review* 82 (3), 68–81.
Klein, H. K. and M. D. Myers (1999). "A set of principles for conducting and evaluating interpretive field studies in information systems" *MIS Quarterly*, 67–93.
Korpela, K., J. Hallikas and T. Dahlberg (2017). "Digital Supply Chain Transformation toward Blockchain Integration". In: *Proceedings of the 50th Hawaii International Conference on System Sciences*, pp. 4182–4191.
Leika (2018). *Geschäfts- und Koordinierungsstellen Leistungskatalog (LeiKa)*. URL: http://www.gk-leika.de/startseite/ (visited on 04/07/2018).
Likert, R. (1932). "A technique for the measurement of attitudes" *Archives of psychology* 22, 1–55.
Lindman, J., V. K. Tuunainen and M. Rossi (2017). "Opportunities and Risks of Blockchain Technologies. A Research Agenda". In: Hawaii International Conference on System Sciences.

Markus Nuppeney (2014). *Automated Border Control – state of play and latest developments* (visited on 04/07/2018).

Mazhelis, O. and P. Tyrvainen (eds.) (2014). *A framework for evaluating Internet-of-Things platforms. Application provider viewpoint:* IEEE.

Munsing, E., J. Mather and S. Moura (2017). *Blockchains for Decentralized Optimization of Energy Resources in Microgrid Networks*. URL: http://escholarship.org/uc/item/80g5s6df (visited on 09/01/2017).

Myers, M. D. and M. Newman (2007). "The Qualitative Interview in IS Research. Examining the Craft" *Information and Organization* 17 (1), 2–26.

Nærland, K., C. Müller-Bloch, R. Beck and S. Palmund (2017). "Blockchain to Rule the Waves - Nascent Design Principles for Reducing Risk and Uncertainty in Decentralized Environments". In: *Proceedings of the 38th International Conference on Information Systems*. Ed. by Y. J. Kim, R. Agrawal, J. K. Lee.

Nakamoto, S. (2008). "Bitcoin. A peer-to-peer electronic cash system".

Niederman, F., R. Clarke, L. M. Applegate, J. L. King, R. Beck and A. Majchrzak (2017). "IS Research and Policy. Notes from the 2015 ICIS Senior Scholar's Forum" *CAIS* 40, 5.

Otjacques, B., P. Hitzelberger and F. Feltz (2007). "Interoperability of e-government information systems. Issues of identification and data sharing" *Journal of Management Information Systems* 23 (4), 29–51.

Peters, G. W. and E. Panayi (2016). "Understanding modern banking ledgers through blockchain technologies. Future of transaction processing and smart contracts on the internet of money". In *Banking Beyond Banks and Money*, pp. 239–278: Springer.

Porru, S., A. Pinna, M. Marchesi and R. Tonelli (2017). "Blockchain-Oriented Software Engineering. Challenges and New Directions". In: *2017 IEEE/ACM 39th International Conference on Software Engineering companion. ICSE-C 2017 : 20-28 May 2017, Buenos Aires, Argentina : proceedings*. Piscataway, NJ: IEEE, pp. 169–171.

Saldaña, J. (2015). *The coding manual for qualitative researchers:* SAGE.

Schultze, U. and M. Avital (2011). "Designing interviews to generate rich data for information systems research" *Information and Organization* 21 (1), 1–16.

Schweizer, A., V. Schlatt, N. Urbach and G. Fridgen (2017). "Unchaining Social Businesses - Blockchain as the Basic Technology of a Crowdlending Platform". In: *Proceedings of the 38th International Conference on Information Systems*. Ed. by Y. J. Kim, R. Agrawal, J. K. Lee.

Seppälä, T. and J. Mattila (2016). "Ubiquitous network of systems" *Berkeley Roundtable of International Economy (BRIE)*, 1–3.

Subramanian, H. (2017). "Decentralized blockchain-based electronic marketplaces" *Communications of the ACM* 61 (1), 78–84.

Urquhart, C., H. Lehmann and M. D. Myers (2010). "Putting the 'theory' back into grounded theory. Guidelines for grounded theory studies in information systems" *Information Systems Journal* 20 (4), 357–381.

Webster, J. and R. Watson (2002). "Analyzing the Past to Prepare for the Future: Writing a Literature Review" *MIS Quarterly* 26, xiii–xxiii.

World Food Programm (2016). *WFP Introduces Iris Scan Technology To Provide Food Assistance To Syrian Refugees In Zaatari*. URL: https://www.wfp.org/news/news-release/wfp-introduces-innovative-iris-scan-technology-provide-food-assistance-syrian-refu (visited on 04/07/2018).

Wüst, K. and A. Gervais (2017). "Do you need a Blockchain?" *IACR Cryptology* 2017, 375–382.

Yin, R. K. (2017). *Case study research and applications. Design and methods:* Sage publications.

Zheng, Z., S. Xie, H.-N. Dai and H. Wang (2016). "Blockchain Challenges and Opportunities: A Survey" *Int. J. Web and Grid Services*, 1–25.