Design Principles for Establishing Trust in Decentralized Intercompany Capacity Exchange

Nick Große[1[0000-0001-8066-8796]]

[1] Chair of Enterprise Logistics, TU Dortmund University, Germany

Abstract: Blockchain-Technology (BCT) is a promising technology to establish trust in inter-organizational collaborative networks. Yet, there is a lack of prescriptive knowledge on applying them successfully. Based on established cooperation designs, the paper reports on an ongoing research project to develop a set of trust-building design principles for mitigating information asymmetries between participants in the intercompany capacity exchange. The design principles provide guidance for platform designers of decentralized markets and practitioners in capacity procurement. They serve as a decoupling point for discussions about how BCT can be considered during the implementation of the trust-building design principles.

Keywords: Intercompany Networks, Trust, Design Principles, Blockchain

Problem Awareness

Uncertainties in the capacity utilization require companies in production and maintenance to obtain additional resources via market-like networks [1, 2]. Networks as a mixture of the coordination structures market and hierarchy open the scope for cooperation [3]. A rationale for a network is establishing trust [3], which also is a significant parameter for reducing transaction costs [4]. Occurring information asymmetries leads to further tension between contractors [5]. Due to its fragility and vulnerability to collapsing effects, trust becomes challenging to maintain [6].

Against this backdrop, Blockchain-Technology (BCT) receives closer attention due to its properties in ensuring distributed trust, disintermediation, immutability, transparency and consensus [7], especially in decentralized markets [8, 9]. To circumvent exploitation, strict implementation rules for the platform designers and operators for establishing trust-building heuristics such as proposed by [10, 11] are becoming more relevant. To the best of our knowledge, there is a lack of prescriptive knowledge on how to apply them appropriately in the industrial scenario of outsourcing capacity, especially with BCT.

The study starts precisely at that point as it develops prescriptive design knowledge in the form of design principles on establishing trust in intercompany negotiation platforms. We do this to guide designers of these systems in implementing trust-establishing mechanisms more efficiently. The design principles lay the ground for a subsequent BCT-based implementation for practitioners to achieve confidence and efficiency in decentralized networks. Because of the above, the research question reads as follows: '*How to design a (blockchain-based) system that ensures trust in intercompany exchange of capacity resources?'* The term in brackets indicates that the design principles are initially without mentioning BCT and thus generic. In intention to derive reusable knowledge for both researcher and practitioner, we report on the current state of the ongoing research project, including the initial set of trust-building design principles. The design principles were instantiated by a BCT-based prototype, which is carried out in an scenario of production and maintenance as affected domains of capacity shift [2].

The paper is structured as follows: First, we substantiate the research question by pointing out the relevance of trust in intercompany networks. Afterward, we describe the research process by applying the Principal Constructor (PC), which provides a comprehensible report of the build and evaluate cycle of design principles [12]. Subsequently, an outlook of a BCT-based instantiation of the design principles is given.

Results: Preliminary Set of Design Principles

The paper uses the PC to report and publish design principles by filling 16 **building blocks** [12]. Following [13], the design principles were initially motivated by a *problem-centric* entry point (**design paradigm**), following the **design method** of [14]. The **specific problem** is motivated by the emergence of platform-based solutions and the short-term tension between participants in such environments. The **problem class** can be located to '*determining the most efficient contract governing the principal-agent relationship […]*' [5, p.58]. With a particular emphasis on capacity exchange of materials and services, the **solution objective** is to establish short-term trust between users within a negotiation platform. The research project is **theoretically grounded** in justificatory knowledge of transaction-cost theory [15, 16] and agency theory [5]. [4, 17] reveals the interplay of trust and transaction costs along the whole transaction lifecycle, which serves as a theoretical frame for elaborating the beneficiaries of blockchain in reducing information asymmetries in intercompany networks [18].

The **design team** consists of both practice and research partners as experts in the fields of platform design. The **empirical grounding** is done by conducting literature reviews and interviewing eleven field experts in production, maintenance and adjacent domains as a knowledge ground for deriving requirements for a virtual negotiation platform. Following [19] and referring to the entry points of abstraction proposed by [20], a mixed-approach of deductive (theory-driven) and inductive (practice-inspired) abstraction had been made for creating a category system consisting of 25 second-order themes and six aggregated dimensions, in which the **design requirements** were classified and proved in terms of intercoder-reliability by using Cohens-kappa [21]. Requirements embedded in the same category were aggregated to meta-requirements. An initial amount of 151 requirements were condensed to 19 meta-requirements, which has been further condensed to five key requirements [22, 23] using established cooperation designs as an explanatory approach. The cooperation designs were based on the fundamental methods for reducing information asymmetries and abusive behavior between trustor and trustee, such as signaling, screening, authority, reputation, or incentives [10, 11, 24, 25]. These designs consider central trust factors such as ability, benevolence, and integrity [26], different levels of trust [27], and also design heuristics for establishing trust [10]. These findings have been reused as design knowledge and form the basis for deriving theory-driven and practice-relevant **design principles**. The principles shown in **Table 1** were formulated using the **template** from [28] that proposes the following elements: **I**mplementer, **A**im, **U**ser, **C**ontext, **M**echanisms/**E**nactors, and **R**ationale. Each principle is linked to relevant literature about each cooperation design.

The design principles were **evaluated** in terms of reusability using the questionnaire and evaluation criteria proposed by [29]. We triangulated the set of design principles using a mixed-method [30] consisting of the questionnaire and the interview to assess *accessibility*, *importance*, *novelty*, *actability* and *guidance*, and *efficiency* [29]. The evaluation is conducted with three practitioners (i.e., potential implementers) and two theoretical experts in platform economy and trust. The findings indicate that the trust-building design principles' set achieves an approval in terms of reusability.

Table 1. Design Principles for Establishing Trust in Decentralized Capacity Exchange

Code	Theme	Formulation
DP1	Signaling of Information relevant to Tender [11, 24]	To allow demander and supplier (**U**) the storage of a precise tender (**A**) during the specification stage (**C**), the platform provider or developer (**I**) has to provide functions for a customized creation of tenders and its linkage to a verified identity and reveal them in a simultaneous and distributed manner (**M/E**). This allows the reduction of uncertainties due to a vague specification and lacks identity assignments, simultaneously providing the revealing of information to authorized participants (**R**).
DP2	Signaling of Information relevant to Identity [10, 11]	To establish trust in the identity (**A**) of each participant (**U**) during the information and initiation stage (**C**), the platform provider or developer (**I**) has to provide functions for the decentralized storage, configuration, and verification of identities (**M/E**). This allows transparency and correctness of the identity (**R**).
DP3	Authority and Fairness [11]	To maintain the authority (**A**) of the cooperation partner (**U**) before and after the negotiation and settlement stage (**C**), the platform provider or developer (**I**) has to provide functions and mechanisms for creating and decentralized storage of contracts as well as their order-relevant contents, functions for monitoring the compliance with the agreed terms and conditions for enforcing sanctions/rewards (**M/E**). This provides a transparent data basis for all participants, as well as traceability in the enforcement of countermeasures (**R**).
DP4	Incentive-Mechanisms [11]	To motivate the participants (**U**) in joining and maintaining cooperations before and after the negotiation and settlement stage (**A**), the platform provider or developer (**I**) has to provide the value-adding benefits of each cooperation and imminent losses in case of violations and demonstrate them using comprehensible and transparent data that can be observed by all participants (**M/E**). In this way, market participants are motivated to participated and deterred from acting opportunistically (**R**).
DP5	Screening-Functionality [24]	To ensure that the participants of the negotiation platform (**U**) can trust the deposited information (**A**) during the information and initiation phase (**C**), the platform provider or developer (**I**) has to provide functions for depositing information and for distributed and verified access, functions for checking its validity and services for searching information and contacting participants (**M/E**). This ensures that the information obtained during the information retrieval are valid and thus trustworthy (**R**).
DP6	Reputation Mechanism [11, 25]	To achieve a retraceable reputation (**A**) of each participant (**U**), the platform provider or developer (**I**) has to provide a reputation mechanism (**M**), which allows after the fulfillment stage (**C**) a serious rating of each identity, a decentralized collection of rating-relevant data, its transparent processing and distribution to all participants (**E**). In this way, participants have transparency over the data coining the reputation, and can trust them (**R**).

In an extended paper, we expect to operationalize the design principles into **design features**, including BCT functionalities, and **instantiate** them in the current research project. Design features '[…] *are specific ways to implement a design principle in an actual artefact* […] [and] *closes this last step of conceptualization*.' [31, p.807]. The design features consist of functionalities provided by smart contracts as inherent components of blockchain, which allow an automated execution based on predefined code and are an affordable feature for saving transaction costs through disintermediation [32, 33]. In terms of the **evaluation method**, an experimental design following the principles of control, randomization, and manipulation is used [34]. Platform providers are the **evaluation subjects** that can assess the instantiated artifact. **Testable propositions** shed light on cause-effect relationships in establishing trust through BCT. **Fig. 1** visualizes the above in a filled-in version of the PC. The operationalization, instantiation and ex-post evaluation is taking place in an extended version of this paper.

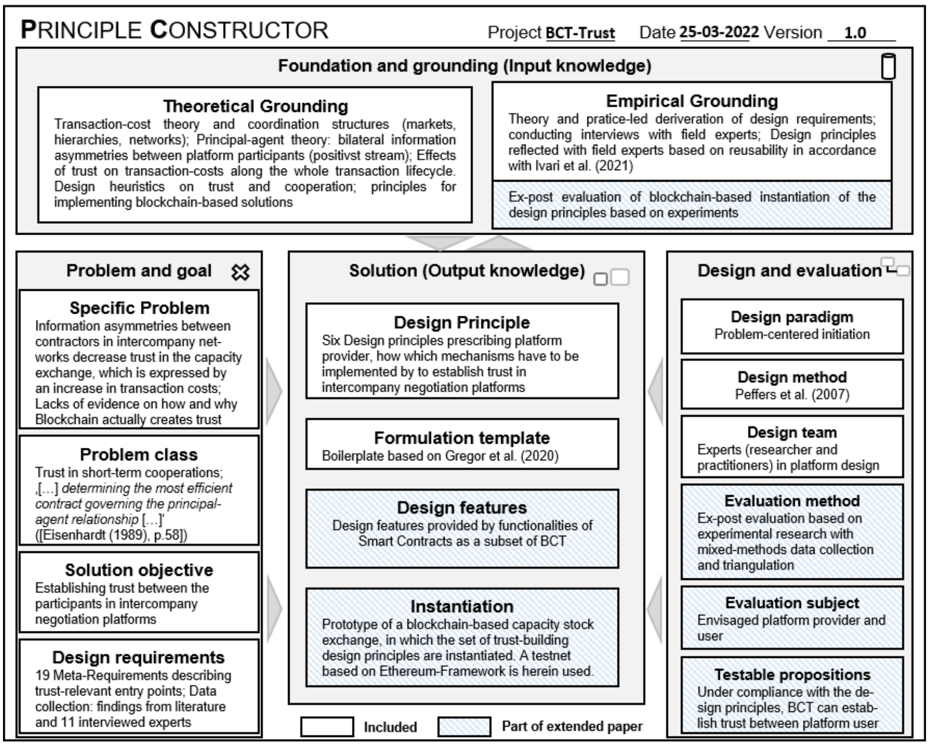

Fig. 1. DSR-Project located to the Principle Constructor based on [20]

Conclusion and Outlook

The paper presents the initial results of a DSR study of designing an artefact based on derived design principles addressing trust-relating issues in intercompany capacity exchange. The paper gives a comprehensible design report and insights into its theoretical and empirical grounding using the PC. However, it is limited in terms of depth and paves the way for deriving provable design theory for establishing trust with BCT. However, further empirical evidence through instantiation and ex-post evaluation is required, which is considered in an extended version of this research.

Acknowledgement

This research was funded by the ‘Deutsche Forschungsgemeinschaft (DFG) - 276879186/GRK2193’

References

1. Gassner, S.: Instandhaltungsdienstleistungen in Produktionsnetzwerken. Springer Fachmedien Wiesbaden, Wiesbaden (2013)
2. Schuh, G., Kurz, M., Jussen, P., Defèr, F.: Coordination Between Maintenance and Production by Means of Auction Mechanisms for Increased Efficiency of Production Systems. In: Mathew, J., Lim, C.W., Ma, L., Sands, D., Cholette, M.E., Borghesani, P. (eds.) Asset Intelligence through Integration and Interoperability and Contemporary Vibration Engineering Technologies. Lecture Notes in Mechanical Engineering, vol. 86, pp. 545–554. Springer International Publishing, Cham (2019). doi: 10.1007/978-3-319-95711-1_54
3. Powell, W.W.: Neither market nor hierarchy: Network forms of organization. In: Staw, B.M., Cummings, L.L. (eds.) Research in Organizational Behaviour, pp. 295–336. Jai Press Inc. (1990)
4. Cai, R.: Trust and transaction costs in industrial districts, vol. (2004)
5. Eisenhardt, K.M.: Agency theory: An assessment and review. Academy of management review, vol. 14, 57–74 (1989)
6. Suematsu, C.: Transaction Cost Management. Springer International Publishing, Cham (2014)
7. Treiblmaier, H.: Toward More Rigorous Blockchain Research: Recommendations for Writing Blockchain Case Studies. Front. Blockchain, vol. 2 (2019). doi: 10.3389/fbloc.2019.00003
8. Notheisen, B.: Engineering Decentralized Markets. A Blockchain Approach. Karlsruhe (2019)
9. Subramanian, H.: Decentralized blockchain-based electronic marketplaces. Commun. ACM, vol. 61, 78–84 (2018). doi: 10.1145/3158333
10. Riegelsberger, J., Sasse, M.A., McCarthy, J.D.: The mechanics of trust: A framework for research and design. International Journal of Human-Computer Studies, vol. 62, 381–422 (2005). doi: 10.1016/j.ijhcs.2005.01.001
11. Spremann, K.: Asymmetrische information. Zeitschrift für Betriebswirtschaft, vol. 60, 561–586 (1990)
12. Möller, F., Schoormann, T., Otto, B.: ‘Caution-Principle Under Construction’a Visual Inquiry Tool for Developing Design Principles. In: International Conference on Design Science Research in Information Systems and Technology, pp. 223–235 (2021)
13. Möller, F., Guggenberger, T.M., Otto, B.: Towards a Method for Design Principle Development in Information Systems. In: Hofmann, S., Müller, O., Rossi, M. (eds.) Designing for Digital Transformation. Co-Creating Services with Citizens and Industry. Lecture Notes in Computer Science, vol. 12388, pp. 208–220. Springer International Publishing, Cham (2020). doi: 10.1007/978-3-030-64823-7_20
14. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A design science research methodology for information systems research. Journal of management information systems, vol. 24, 45–77 (2007)
15. Williamson, O.E.: The economic institutions of capitalism. Firms, markets, relational contracting. Free Press, New York, NY (1985)

16. Williamson, O.E.: Markets and hierarchies: analysis and antitrust implications. A study in the economics of internal organization. The Free Press, New York, NY (1975)
17. Lee, J., Kim, J., Moon, J.Y.: What makes Internet users visit cyber stores again? Key design factors for customer loyalty. In: Proceedings of the SIGCHI conference on Human Factors in Computing Systems, pp. 305–312 (2000)
18. Grosse, N., Guerpinar, T., Henke, M.: Blockchain-Enabled Trust in Intercompany Networks Applying the Agency Theory. In: 2021 3rd Blockchain and Internet of Things Conference, pp. 8–14. ACM, New York, NY, USA (2021). doi: 10.1145/3475992.3475994
19. Gioia, D.A., Corley, K.G., Hamilton, A.L.: Seeking Qualitative Rigor in Inductive Research. Organizational Research Methods, vol. 16, 15–31 (2013). doi: 10.1177/1094428112452151
20. Möller, F., Schoormann, T., Otto, B.: 'Caution – Principle Under Construction' a Visual Inquiry Tool for Developing Design Principles. In: Chandra Kruse, L., Seidel, S., Hausvik, G.I. (eds.) The Next Wave of Sociotechnical Design. Lecture Notes in Computer Science, vol. 12807, pp. 223–235. Springer International Publishing, Cham (2021). doi: 10.1007/978-3-030-82405-1_23
21. Landis, J.R., Koch, G.G.: The measurement of observer agreement for categorical data. biometrics, vol. , 159–174 (1977)
22. Möller, F., Guggenberger, T., Otto, B.: Design Principles for Route Optimization Business Models: A Grounded Theory Study of User Feedback. Proceedings of the 15th WI, vol. , 1084–1099 (2020)
23. Koppenhagen, N., Gaß, O., Müller, B.: Design science research in action-anatomy of success critical activities for rigor and relevance, vol. (2012)
24. Spence, M., Rosen, S.: 10. Signaling, Screening, and Information. Studies in labor markets, pp. 319–358. University of Chicago Press (1981)
25. Voss, M.: Privacy preserving online reputation systems Information security management, education and privacy, pp. 249–264. Springer (2004)
26. Mayer, R.C., Davis, J.H., Schoorman, F.D.: An integrative model of organizational trust. Academy of management review, vol. 20, 709–734 (1995)
27. Nielsen, B.B.: Trust in strategic alliances: Toward a co-evolutionary research model. Journal of Trust Research, vol. 1, 159–176 (2011). doi: 10.1080/21515581.2011.603510
28. Gregor, S., Kruse, L., Seidel, S.: Research Perspectives: The Anatomy of a Design Principle. JAIS, vol. 21, 1622–1652 (2020). doi: 10.17705/1jais.00649
29. Iivari, J., Rotvit Perlt Hansen, M., Haj-Bolouri, A.: A proposal for minimum reusability evaluation of design principles. European Journal of Information Systems, vol. 30, 286–303 (2021)
30. Denzin, N.K.: The Research Act. A Theoretical Introduction to Sociological Methods. Routledge (2017)
31. Meth, H., Mueller, B., Maedche, A.: Designing a requirement mining system. Journal of the Association for Information Systems, vol. 16, 2 (2015)
32. Szabo, N.: Smart contracts: building blocks for digital markets. EXTROPY: The Journal of Transhumanist Thought,(16), vol. 18 (1996)
33. Glaser, F.: Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis. In: Proceedings of the 50th Hawaii international conference on system sciences, 1543-1552 (2017)
34. Mettler, T., Eurich, M., Winter, R.: On the Use of Experiments in Design Science Research: A Proposition of an Evaluation Framework. CAIS, vol. 34 (2014). doi: 10.17705/1CAIS.03410