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Blockchain-Based Crowd-Sourcing Applications and Related Business Intelligence Possibilities

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Research-in-Progress

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Abstract

Digitalization drives constantly changes in organizations, whereby disruptive technologies can act as a catalyzer for such adaptions. Specifically, blockchain as an emerging technology establishes data-driven businesses by offering an open and decentralized ecosystem for any kind of transactions. Among others, such blockchain ecosystems can be used by companies for crowd-sourcing to achieve competitive advantages through new access to external knowledge. In addition, new possibilities to integrate business intelligence into public distributed ledgers arise, allowing the investigation and analyses of information created by crowd communities. In our paper, we discuss the foundations of blockchain-based crowd-sourcing by applying the theories of absorptive capacity and knowledge of the firm. We used design science research and derived four general design requirements based on selected literature. The proposed findings serve as a starting point for designing blockchain-based crowd-sourcing applications and resulting business intelligence possibilities, which represent novel ways to transform information into winning business decisions.

Keywords

Business Intelligence, Blockchain, Crowd-Sourcing, Design Requirements, Design Science Research, Absorptive Capacity, Knowledge of the Firm

Introduction

Digitalization goes hand in hand with the adaption of disruptive technologies (Vial 2019), and blockchain (BC) has already demonstrated that it can transform traditional businesses due to its decentralized, persistent, pseudo-anonymous and audible character (Z. Zheng et al. 2017). New technologies like BC allow firms to adopt new business models (Brocas 2003), thus, the so-called digitalization of trust leads to new opportunities as emerging technologies are getting more and more attention for creating value and gaining competitive advantages (Avital et al. 2016).

BC has its origins in the financial sector as a technology behind crypto currencies, but is also establishing itself as a means of transforming market mechanisms (Gomber et al. 2018). However, BC outside the financial sector must be adapted to the specific characteristics of new application areas (Notheisen et al. 2017). The taxonomy study of Labazova et al. (2019) identified six BC application areas, but could not directly capture complex services, such as prediction markets or crowd-sourcing platforms. We consider this gap as a promising starting point for investigating BC usage in the field of knowledge management, in particular with regard to the utilization of external knowledge.

In the age of social media the integration of external knowledge into organizations is becoming increasingly important and the collaborative intelligence of social networks is frequently used for crowd-sourcing (CS) (Gill 2012). Such social networks are based on centralized platforms that must provide external interfaces in order to be successful on the market (Constantinides et al. 2018). However, this might affect transparency, security and traceability with regard to personal data (Plantin et al. 2018). In general, digitalization requires a paradigm shift from established centralized solutions towards innovative decentralized concepts (Nambisan and Majchrzak 2017).

There is a need to improve collaboration with external stakeholders through decentralized solutions, which in turn can be enabled by BC technology (Mendling et al. 2018). This means collaboration focused community platforms can be extended by BC with additional services, which include privacy and peer-to-peer structure by default (Nofer et al. 2017). On one hand privacy again can foster extended community-related incentives (Gächter et al. 2010). On the other hand if awards or even non-monetary bonuses like badges are not private, they encourage knowledge sharing inside the community (Bartol and Srivastava 2002). We see these two incentives as digitally customizable representation of the desired behavior on BC, which in turn builds a sense of cooperation. Still, BC as a public ledger for user communication and collaboration creates a controversy data privacy problem, due to the fact that BC preserves almost zero anonymity and privacy over time, if no additional protection models are applied (Wang et al. 2018).

The distributed peer-to-peer character of BC again allows openness in relation to platforms as well as features like interoperability and reliability (Underwood 2016). In practice platforms for open idea sourcing include highly interactive communication and collaboration (Blohm et al. 2016), which means for BC applications that they have to store such transaction data on a ledger. Observing this transaction traffic can help not only users in decisions, furthermore, business intelligence (BI) technologies make it possible for organizations to understand connections between the individual users, to analyze patterns and to build a sense of knowledge. A possible access control for stored knowledge on BC would be the private key of a user, which represents in the end a form of digital identity (Efanov and Roschin 2018).

In summary our focus is to address the value creation by external knowledge based on collaboration inside crowd communities, which leads us to the following research question:

How should BC-based CS applications be designed and which BI possibilities can be indicated?

We answer this two-part question as follows: First, we outline the fundamental aspects of crowd-sourcing, BC technology and our applied theories. Second, we introduce design science research (DSR) as the chosen research approach. DSR is proposed to be a suitable research method to leverage the benefits granted by BC (Mendling et al. 2018). Third, we present design requirements, which we have derived from selected literature, before we close with a conclusion and outlook.

Fundamentals

Absorptive Capacity and Knowledge of the Firm

A frequently used theoretical concept linked to the exploration and exploitation of knowledge is the absorptive capacity (AC) of an organization (Lichtenthaler and Lichtenthaler 2009). According to Cohen and Levinthal (1990, p. 128) AC is "the ability of a firm to (1) recognize the value of new external information, (2) assimilate it, and (3) apply it to commercial ends." Furthermore, AC contributes to the business success and secures a long-term existence of an organization (Lane et al. 2006; Lichtenthaler and Lichtenthaler 2009).

There are different approaches to specify AC more precisely. Zahra and George (2002) distinguish between potential AC, which represents the organization's ability to acquire external knowledge, and realized AC covering the usage of this knowledge. A further differentiation by Lane et al. (2006) distinguishes between recognizing and understanding, assimilating and applying external knowledge. Within information systems research the concept of AC is used and interpreted in various ways. Following the directions of Roberts et al. (2012) our research considers AC as a capability rather than an asset and pays particular attention to the use of knowledge management in organizations.

Besides AC the theory of knowledge of the firm (KF) provides another common perspective on knowledge. Following the KF theory the organization's ability to create knowledge became an entity (Nonaka 2000), which can be described by four basic components: driving objectives, dialogue, practice and vision (Nonaka and Toyama 2005). An important note is that these components are driving knowledge as an asset inside an environment similar to an ecosystem. Success inside the ecosystem can be determined by a firm´s ability to grow along knowledge or to carry it out more effectively than other firms (Kogut and Zander 1993). KF can be differentiated by four stages (Alavi and Leidner 2001): (1) know-how creation, (2) storage and retrieval, (3) transfer and (4) its application as value proposition. In this paper we use AC and KF to structure our proposed design requirements along the organization processes in regards to knowledge.

Crowd-Sourcing and Knowledge Management

CS can be described as a problem solving mechanism by external distributed humans whereby groups of people are formed depending on purpose, size of crowd and technology used to create collective activities (Dow et al. 2012). The high quality and quantity of Wikipedia articles serve as a good example for the power of the crowd (Arazy et al. 2006). It is important for this paper that BC-based crowd mechanisms are segmented in pure knowledge assimilation of AC in the actual storage or transfer of knowledge from KF theory. The reason is that BC by default has a conflict of objectives in the transaction costs for storage and the transfer of knowledge, since BC design determines the resulting suitability (Labazova 2019).

Furthermore, we consider knowledge as a dynamic flow of meaningful socialization in a community where social networks ultimately promote the influence on new content (Faraj et al. 2016). These social networks now create additional social processes that are closely linked to knowledge management processes (Ali et al. 2018). Knowledge management itself can be divided into five phases: creation, validation, presentation, distribution and application of knowledge (Bhatt 2001, p. 71). In this context, innovation and creativity are important to deliver the knowledge to the right places at the right time (Bhatt 2001).

External communities enable companies to outsource value creation activities at any time, in other words, to find a suitable CS mechanism for gaining competitive advantages is a continuous task. The application of CS involves strategy changes (Contractor et al. 2010), but should be done by seamless integration into extending business workflows and should essentially exhibit a high degree of automation and quality assurance (Satzger et al. 2013). The character of BC, specifically the digital incentive mechanism, is suitable for establishing privacy-driven CS applications (Gächter et al. 2010). This privacy-driven approach is controversial for organizations due to lack of control and monitoring of activities, but since BC is a 3rd party free trustless system CS and its applications can benefit. On top of that we see still possibilities for gaining control through BI possibilities.

Blockchain and Business Intelligence Possibilities

Bitcoin as the first use-case for BC technology is a layered and incentivized peer-to-peer system developed by an anonymous inventor and firstly published online in a whitepaper authored by Satoshi Nakamoto (2008). The core layer of BC consists of linked data blocks with a specific header and body whereby transactions are validated by digital signatures (P. Zheng et al. 2017). The hierarchy of transactions, similar to a historical ledger, needs to find in each block a network wide consensus, which is an autonomous agreement based on programmed protocols. Consensus mechanisms describe the technical BC transaction behavior (Avital et al. 2016; Z. Zheng et al. 2017).

Each transaction on BC allows third-party free exchange of data, which for us is a digital representation of user interactions. With BC development and real-world implementations research opportunities are emerging in various IT-related areas (Avital et al. 2016). As mentioned in the Introduction, literature describes BC as a solution for open decentralized applications. Furthermore, BC gives business processes another relevant perspective for evaluating company strengths and weaknesses (Mendling et al. 2018).

In case sensitive user data needs to be stored on-chain in the BC ecosystem, several privacy techniques are available. Those start for example from mixing up transaction inputs and outputs up to the construction of multi-signature addresses (Aitzhan and Svetinovic 2018). This includes new approaches in which BC transactions are supplemented by fine-grained attributes in order to enable selective encryption, which makes the stored data selectively transparent (Guan et al. 2018).

A different privacy technique is the class of zero-knowledge (zk) encryption. Whereby, zk proofs gain the underlying trust by initial setup procedures and have yet not reached complete acceptance within the cryptographic science. Nevertheless, therein contained homomorphic signatures can ensure that the data is guaranteed in correctness, whereby the transaction amount is always hidden (Lin et al. 2018). In BC transactions based on the zk-SNARK protocol extended encryption of the sender, receiver and the amount itself can be achieved by again having a correct peer-to-peer proofed ledger (Z. Zheng et al. 2017).

Privacy to facilitate hidden BC traffic makes fact-based decision making in organizations severely hard and inhibits the emerging research field of data analytics (Chen et al. 2012). BI applied to a public BC without privacy techniques allows everyone to gather the full ledger with all transactions ever made. Those include: (i) the transaction hash; (ii) the hash of the enclosing block; (iii) the date in which the block was appended to the chain; (iv) the list of transaction inputs and outputs (Bartoletti et al. 2017). Even in permissioned BC the accounts can be linked to a wallet in the system and then are uniquely identified by a public key (Nasrulin et al. 2018). The use of conflated wallets, which represent multi-signature addresses, only increases transaction complexity and makes BI just more complicated (Dinh et al. 2018). In conclusion, taking away completely the transparency of a BC would create a lack of trust, thus, this conflict requires a balancing solution.

An example to make BI useful in the BC context can be found in the health care industry, whereby the data is kept partly aside from the public ledger, e.g. in cloud pools, and allow by this way possibilities for queries, mining, analytics and machine learning (Karafiloski and Mishev 2017). Another use case in the smart grid area separates identity-critical information and protects it through on-chain authentication (Guan et al. 2018). Important for the design of BC-based business models is that the raw data in BC transactions can be referred as simple key-value store or document store type databases (Vo et al. 2018).

Research Approach

To investigate our research question we follow the DSR methodology by Peffers (2007). In this paper, we cover the first two steps – (1) identify problem & motivate and (2) define objectives of a solution – and lay the foundation for the (3) design & development of the DSR artefact by deriving design requirements (DR) from the literature. Starting from these DR, a BC-based CS application will be prototyped. We applied two theoretical lenses to get an actionable solution in emerging domains (Chanson et al. 2019) and to ensure a rigorous artefact design, which covers also possibilities of BI for analysis and data-driven decision support. BI is meant to be an analysis and control mechanism for knowledge management and initiates DSR step (4) demonstration and (5) evaluation – to complete the DSR methodology. This systematic approach contributes to the knowledge base in the emerging field of BC as well as in CS (Gregor and Hevner 2013).

Design Requirements

In this section, we present the DR, which are inspired by the benefits of BC technology for CS. The KF theory and AC as theoretical lenses built the deductive frame for inclusion of external stakeholders concerning value creation inside organizations. Important for CS applications based on BC are: (1) the unique way in sharing and processing personal data as cryptographic key-pairs, (2) the intangibility of knowledge as digital tokens and (3) the immanent open source self-driven optimization. Organizations have to face the tradeoff between decentralization and centralization with regards to a public network by BC to maximize community evolvement. For a comprehensive understanding each DR is described more in detail below.

DR1: BC has to offer selective privacy by design to give users the choice about data transparency.

BC allows trust without an intermediary for data sovereignty (Z. Zheng et al. 2017), providing the first step of privacy and data protection. The literature shows that in this case community contributions are encouraged (Gächter et al. 2010). In conclusion the community can choose with different privacy techniques about the transparency of data stored on the BC, so that beneficial ideas or recognizable success can afterwards be revealed about specific topics. In an abstract view this overlaps with the original idea of the Bitcoin white paper (2008), whereby pure positive behavior would be a long-term success. BI would be a tool for revealing a leak or hole of this user-oriented transparency.

DR2: BC has to dynamically adjust the throughput and size of transactions depending on the data traffic.

Transactions are immutable so that users decide about how many effort, e.g. amount of transaction fee or size of the content, is put on the BC (Avital et al. 2016). Thus, the usage and actual adoption will increase pressure for technological evolution (Nambisan and Majchrzak 2017). BI in this case can conduct time series analysis of this progress. The consequences for BC are for example to scale dynamically with data traffic by ensuring cost efficiency and linking knowledge about the interactions to the originators.

DR3: BC needs to be a tamper proof system whereby every single peer has semi-transparent data.

BC technology is based on a peer-to-peer network by cryptographic algorithms, whereby only updates can be done in reveling keypairs or in other words passphrases (Mendling et al. 2018), thus, every transaction data belongs not only to the originator and privacy techniques just lead to different levels of transparency. The BC infrastructure needs to be still tamper proof, which makes BI at this point a tool for controlling malicious network attacks, e.g. fraud detection (Z. Zheng et al. 2017).

DR4: BC needs to be economically feasible including standardization for interoperability.

BC technology offers trust by autonomous finding of a consensus over transactions based on wallet addresses in order to identify a specific exchange of data (Beck 2018). In case data is from the same address by timestamps accumulated over time a reputation can be built which verifies for the CS community a success (Dow et al. 2012), so that outstanding content creator grow inside and role models for awareness about specific knowledge are fortified. For organizations it is important at the end to have balanced cost and efforts in comparison to the utility of innovation (Nambisan and Majchrzak 2017). BI now allows both sides to request the unaltered BC data and makes information interpretation possible.

Table 1 is structured as follows: The theoretical perspective (1st row) is assigned to related characteristics of the BC technology (2nd row) and the corresponding relevance for the CS applications (3rd row). This triple jump results in the respective design requirement (4th row) and possibilities of BI (5th row). The columns represent the respective stages of the AC and KF theory.

Field	*Synthesis*				*Literature*
Absorptive Capacity	Recognize a/o Understand	Assimilation		Applying Ext. Knowledge	(Lane et al. 2006)
Knowledge of the Firm	Idea Creation	Storage a/o Retrieval	Transfer	Value Proposition	(Alavi and Leidner 2001)
Benefit of BC	No intermediary / no 3rd party control of stored data in transactions	Public and immutable ledger of hierarchy of transactions	Cryptographic Peer-to-peer access, changes need authentication	Each address with unique key-pair for identification of user/role with timestamps	(Avital et al. 2016; Beck 2018; Mendling et al. 2018; Wang et al. 2018; Z. Zheng et al. 2017)
Relevance for CS	Privacy increases contribution, rewards become user-centric	Trust helps in network effects for growth and adoption	Security increased if data owner is actually originator	Transparency helps to turn success into social commitment.	(Dow et al. 2012; Gächter et al. 2010; Gill and Hevner 2012; Nambisan and Majchrzak 2017)
Resulting DR	BC has to offer selective privacy by design to allow the choice of revealing data	BC has to scale dynamically in throughput and size of transactions	BC needs to be a tamper proof system whereby single peers optionally hide data	BC needs to be economically feasible including standardization	
BI possibility	Analytics of user behavior and external information	Access directly to the BC and time series analytics	Network analytics for transaction patterns	Query on raw data stored on BC or linked 2nd layer databases	

Table 1. Design requirements based on blockchain benefits and relevance for crowd-sourcing with derived possibilities for business intelligence.

Conclusion and Outlook

In this paper we derived DR for the BC integration based on selected literature in regards to AC and KF theory. Our proposed use-case for BC is to serve as an enabling technology for CS in organizations. BI provides important analytic and control mechanisms for the knowledge management in organizations. The research is in progress and constitutes basics of the DSR stages. Further research can be the prototyping with focus on technical rigor. We also consider the identified DR likely to be useful for other domains as they provide a guideline for BC integrations. Consideration of the DR could increase the likelihood of success and prior evaluation of improvement actions.

Limitations could mainly concern the literature selection itself and how relevant publications were identified. Since this paper is not a stand-alone literature review, we encourage future work in this direction. Furthermore, this paper combines heterogeneous fields of research and derives generally applicable DR as generally valid design rules.

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