Blockchain: concept, critical success factors and possibilities in the food chain

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Abstract. *Blockchain is a relatively new concept that has initially been applied in 2009 with the launch of Bitcoin. It allows for disintermediation; processes that traditionally require dependencies of a central and/or intermediary entity can now – at least conceptually – be organized without this entity. The technology is enormously hyped and expectations are huge. This article clarifies when a blockchain approach can be useful, draws lessons from projects worldwide and gives additional recommendations, based own experience, to increase chances to go life with a blockchain project.*

What is blockchain?

Blockchain is a technology for disintermediation; processes that traditionally required dependencies is central and/or intermediary entity can now – at least conceptually – be organized without this entity, or at least the reliance on these entities can be reduced. The technology is enormously hyped and expectations are huge. The Harvard Business Review states [I17]:

"*Blockchain is not a "disruptive" technology, which can attack a traditional business model with a lower-cost solution and overtake incumbent firms quickly. Blockchain is a foundational technology: it has the potential to create new foundations for our economic and social systems. But while the impact will be enormous, it will take decades for blockchain to seep into our economic and social infrastructure. The process of adoption will be gradual and steady, not sudden, as waves of technological and institutional change gain momentum."*

But what is a blockchain? It is an append-only data structure that is collectively maintained by a group of participants. Many keep a local copy of the blockchain and the consensus mechanism guarantees that all agree on the same version. Hence, a malicious subset of participants cannot tamper the blockchain or negatively impact its correct functioning.

Three categories of applications of the technology can be distinguished:

- **Registration of facts.** Once data is registered in a blockchain, it can no longer be removed or changed. Tampering with the registration time is equally hard. This does not imply that the data itself is stored on the blockchain. Often, a unique fingerprint (cryptographic hash) suffices. E.g. the different steps in a supply chain could be registered in a blockchain. Additionally, meat processing companies could be issued a license on the same blockchain. Combined, this informs the consumer not only about the trajectory of the food, but also about the different companies involved.
- **Transfer of assets.** Everything of value can be represented on a blockchain: virtual currencies (e.g. Bitcoin) licenses, diplomas, domain names, securities, gold, cars, real estate, … The

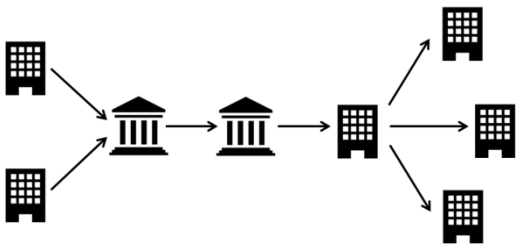
participants (the network) enforce that the creation, registration, transfer and destruction of assets happens according to the rules. Each of these steps is registered on the blockchain.

- **Enforcement of rules.** The transfer of assets requires the enforcement of relatively simple rules. With *smart contracts*, any kind of rule expressible in computer code can be enforced collectively by the blockchain network. Often it comes down to: " *If conditions A & B are met, transfer assets to X.* " For instance, real estate can be transferred only if the requested amount of (virtual) money is paid, if there is a valid soil certificate and if the notary has confirmed that buyer and seller are correctly informed. As a second example, a shop could order meat using a smart contract. He transfers the money to the contract. During the meat transport, smart sensors in the refrigerated vehicle register the conditions under which the meat is transported - such as temperature and humidity - and register it on the blockchain. If the meat was transported under the agreed conditions, the smart contract transfers the money to the meat supplier and indicates that the shop owns the meat. In the other case, it sends the money back to the shop.

Blockchain offers *transparency & real-time auditability*; participants can 1) verify when what information has been registered, 2) see the history of an asset and 3) verify whether the rules have been correctly enforced by the network. This could be convenient for supervisory authorities.

Bad case, good case

Blockchain is about *trust* and *robustness*. If none of the participants has an issue with the existence of a central, trusted entity on which they depend, a blockchain approach is most likely a bad idea. Other properties that blockchain can realize, can usually more also, and more easily, be realized with traditional and more mature technologies. Think of process automation, consistency of databases, streamlined processes, real-time updates and insight in the decision making process. This section presents negative and positive blockchain business cases.



A first negative example is a typical flow of personal data in government context, as shown in the figure. A blockchain approach Is not useful if the three central entities are maintained. The government interested in a blockchain approach was confronted not with a trust issue, but with a complexity issue. It was hoping that blockchain could reduce this complexity while maintaining the central entities. However, a blockchain approach requires a more complex infrastructure and extra cryptography to sufficiently protect the personal data. The blockchain approach has rightfully been abandoned.

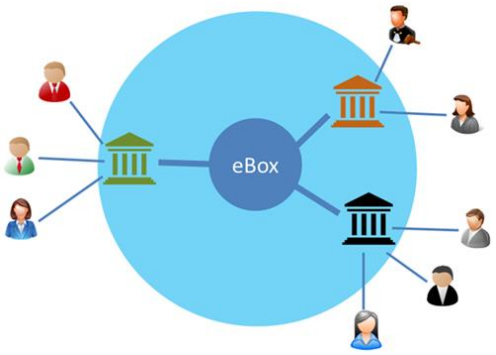
A second negative example is found in the Netherlands; application for a wheelchair [B17]. Currently, the citizen submits a request for a specific wheelchair to the municipality, which, in turn, contacts several care providers. In the proposal for a private blockchain, not only the care providers, but also the municipality would participate. The advantage is that the municipality cannot tamper and does not control the data. However, this approach requires a server for each participant, as well as a more complex implementation. It's unlikely that the reduction in dependency outweigh these extra costs.

A similar blockchain case is found in Flanders [R17]. Currently, a citizen applies at multiple social housing companies, which is cumbersome, and also transparency is lacking. The citizen does not know why she has not yet been assigned a social house. The social housing companies would have to participate in a blockchain network. It turned out that they prefer the cheaper and more convenient approach of a centralized system.

A first positive example are therapeutic relations in Belgium. They determine if a care provider has access to the patient's health data. Today, this information is dispersed over several entities that are to a certain extent competitors that are suspicious to hand over sensitive medical data to a central service. Also here, the citizens lacks overview. From a conceptual level, this is a good blockchain case.

A second positive example are cross-border processes, such as international container traffic, nuclear waste transport, food supply chains and the issuance and showing of diplomas in an international context. A centralized approach would raise the question about what country should be the *primus inter pares* and, hence, be responsible for the system.

A third positive example is the demonstrability service [V18]. Within the government an eBox is used for exchanging documents between end users belonging to a specific sector. Different organizations each represent a different, non-overlapping part of the end users (see figure). When Alice sends a message to Bob, Alice sends the message through her organization to the eBox and later Bob downloads it from the eBox through his organization. We need a proof that the document was sent by Alice at a certain moment, and that it was received by Bob at a certain moment. Unfortunately, the end users do not trust the eBox sufficiently, nor do they really trust each other. A blockchain approach is not only useful here, but also allows each participant to upgrade its role.



Experiences & lessons

Now that we can identify good business cases, let's draw some lessons from concrete projects.

The World Food Program of the United Nations offers a cash-for-food program for 100 000 Syrians in Jordan refugee camps. Thanks to blockchain technology no longer had to rely on local banks, which allowed a reduction of 98% of the transactions costs [J18]. Hence, a strong cost reduction is indeed possible by eliminating intermediary parties.

Several players in the financial sector are doing blockchain experiments. Swift has built with 34 banks a PoC for account settlement [F18]. Although the PoC was allegedly a resounding success, SWIFT acknowledges significant re-engineering costs and operational challenges. Ripple has built a PoC for international payments, but also had to acknowledge that blockchain technology faces significant scalability, confidentiality and flexibility challenges. Their new system, *xCurrent*, enables instant settlement, but is not based on a distributed ledger such as blockchain [I18]. The World bank is issuing bonds with blockchain technology. This reduced the settlement time from five days to a few seconds, which is an immense improvement. On the other hand, the promise of transparency and reduced transaction costs has not yet been realized [S18]. The financial industry was the first to start

experimenting with blockchain and are investing millions in it. The three example illustrate the challenges and that not all promises are realizable today.

The previous section mentioned the diploma case as a good one. However, this does not necessarily result in an optimal solution, as can be observed from the blockchain PoC by the Flemish government [D18]. The participants in the blockchain network would be schools and governments. All expected functionality was present. However, the PoC ignored security and privacy aspects. Every participant had full access to the diploma data of each citizen (personal data). Instead of distributing trust over the participants, it is multiplied by their number. Coming up with a blockchain solution that does take into account security and privacy would severely reduce the functionality. Blockchain not only enables transparency, but it also requires it. It can be hard – although not impossible – to reconcile this transparency with strong confidentiality and privacy requirements. Michèle Finck, research fellow at the Max Planck Institute for Innovation and lecturer at the University of Oxford, states: "*There are many tensions and uncertainties between GDPR and blockchain and many blockchain projects are likely not compatible with GDPR.*" [E18].

If a centralized approach is undesirable, blockchain *might* be a good approach, which does not imply that it necessarily *is* one. Often, we have more choices than either centralized or blockchain. In the diploma case, we can envisage a system where each country stores the diplomas issued by its own accredited educational institutions. When a citizen wants to manage or show her diplomas, she contacts the service provided by her country and maintains references to diplomas that the citizen obtained elsewhere. This results in a decentralized system without blockchain. We also see blockchain regularly in the context of self-sovereign identity, which enables the citizen to manage her identity and to selectively disclose personal data. She could just prove that she is an adult, without disclosing all information on her identity card. However, if we are only interested in this selective disclosure of personal attributes, another technology, called attribute-based credentials [R15], offers better privacy properties and does not require a full blockchain network. It's good to look at new technologies such as blockchain. Just don't forget that also alternative, less visible technologies exist.

The remainder of this section discusses blockchain experiments specifically in supply chain context.

Already in 2006, before blockchain existed, Walmart launched a project to trace the provenance of products by using RFID tags. The projects has been abandoned due to high investments and complexity at the side of the producers [G08]. Although meanwhile these costs might have lowered, we should realize that this will not be solved by using blockchain. Blockchain is not a full business solution, it is just one component in a bigger system.

Often over 30 parties involved in container transport from A to B. There is a low degree of digitization and a lot of paper works that constitutes over 50% of the total costs. During the transport, the same pin code is passed and reused, resulting in security risks. Therefore, Maersk, IBM and around hundred other companies form a joint venture. Their aim is more transparency and simplicity of cross-border transport of goods with an open blockchain platform for the sector. However, their blockchain-based solutions was rejected by its rivals [A18]. Why? Because within the sector, many similar projects are being developed, of which the one of Maersk is most the prominent one. Companies don't want to abandon theirs in favor of one ofa competitor. "*We are going to waste a lot of money*" says Hapag-Lloyd CEO Rolf Habben Jansen, who adds that common standards and a

joint solution are necessary. This emphasizes the need for a common project, in which all, or at least the most prominent, stakeholders are involved.

In conclusion, we see encouraging results, but not all blockchain projects result in a reduction of costs and blockchain is just one part of a complete solution. Additionally, today we are still facing several challenges. And we must not forget that there is more in the world than blockchain.

Beyond Proof of Concept

This section complements the guidance in the previous sections with concrete advice for your own blockchain project and stems from experiences of Belgian government agencies.

Clarify your ambitions before starting with a PoC. We distinguish four levels. 1) Maybe you just want to announce that you company is experimenting with the technology. As long as the hype lasts, this might have a positive effect on the company's prestige, media attention and share price. From a blockchain perspective, this is the least challenging. 2) It's more useful if you want to discover the new possibilities of the technology. The actual implementation of the PoC can be outsourced, and you focus on what the technology can do for you on a business level. 3) Maybe you want to acquire technical knowledge and competences in your own company. In that case, make sure to integrate a learning path in the process. 4) The most challenging, but also the most useful is building a PoC as a preparation towards a production-ready system. This requires a profound analysis to ensure that all possible issues, such as confidentiality and privacy, can be sufficiently covered.

The business model of many blockchain start-ups is selling PoCs. To avoid surprises, it is therefore paramount that you make clear agreements (on paper) beforehand if you are planning to go further. We heard start-ups saying: "*We make abstraction of the GDPR*", "*Given the limited budget, we do not do a prior analysis*" and even "*The blockchain PoC was not meant to run in a distributed way*".

If you want to go life, we also recommend to start small. This is what for instance Carrefour and Belfius did. Carrefour uses blockchain to control the supply chain of fresh products [B18a]. They started with eggs from the Auvergne region and are gradually expanding. Belfius uses blockchain to incentivize children to go by bike or on foot to school. For now, they rolled it out in three Belgian towns [B18b]. Carrefour and Belfius start small, but with the ambition to expand.

From our experience, we also recommend to initially avoid using blockchain technology that is too complex given the young and immature market, unless you have plenty of resources. And, finally, avoid technology lock-in by providing a migration path. Because today we cannot know what blockchain technology or technologies will become the de facto standards.

Conclusions

Blockchain is seen as a solution for many problems. This article clarified when it can have an added value, but also drew lessons from experiences in blockchain projects internationally and nationally, including in supply chain management. Additionally, recommendations are given for organizations, based on our own experiences.

References

[A18] O. ANDERSEN & L. VOGDRUP-SCHMIDT, *Rivals reject blockchain solution from Maersk and IBM*, ShippingWatch, 15 May 2018, https://shippingwatch.com/carriers/Container/article10602520.ece

[B17] *Gemeente Stichtse Vecht - Rolstoelgebruik in Blockchain*, Blockchain pilots Dutch Government, blockchainpilots.nl, Pilotronde 2, 2017. http://hostedby.frogjump.nl/blockchain-magazine#!/stichtse-vecht

[B18a] J. BIESEMANS, *De blockchain van de kip en het ei*, EOS Magazine, 30 april 2018, https://www.eoswetenschap.eu/voeding/de-blockchain-van-de-kip-en-het-ei

[B18b] *Belfius lanceert via zijn innovatielab The Studio, een mobiliteitsplatform voor scholen en gemeenten dat gebruik maakt van blockchaintechnologie*. Belfius, 10 September 2018. https://www.belfius.com/NL/publicaties/nieuwsberichten/2018/Pressrelease20180910.aspx

[D18] K. DANIELS, *Certified for Life — International exchange & authentication of diplomas via blockchain*, Medium, 31 july 2018, https://medium.com/wearetheledger/certified-for-life-international-exchange-authentication-of-diplomas-via-blockchain-4e947720edd9

[E18] EU Blockchain Observatory and Forum - *GDPR Workshop Report* - June 8, 2018 https://www.eublockchainforum.eu/sites/default/files/reports/workshop_2_report_-_gdpr.pdf

[F18] Adoption of DLT presents significant operational challenges for Swift member banks, Finextra, 8 March 2018, https://www.finextra.com/newsarticle/31787/adoption-of-dlt-presents-significant-operational-challenges-for-swift-member-banks

[G08] S. GAUDIN, *Some Suppliers Gain from Failed Wal-Mart RFID Edict*, CIO, 29 april 2008, https://www.cio.com/article/2436434/rfid/some-suppliers-gain-from-failed-wal-mart-rfid-edict.html

[I17] M. IANSITI & K. LAKHANI, *The Truth About Blockchain*. Harvard Business Review, January-February 2017, https://hbr.org/2017/01/the-truth-about-blockchain

[I18] A. IRRERA, *Banks unlikely to process payments with distributed ledgers for now, says Ripple*, Reuters, 13 June 2018, https://uk.reuters.com/article/us-blockchain-ripple/banks-unlikely-to-process-payments-with-distributed-ledgers-for-now-says-ripple-idUKKBN1J92JG

[J18] R. JUSKALIAN, *Inside the Jordan refugee camp that runs on blockchain*, MIT Technology Review, 12 april 2018. https://www.technologyreview.com/s/610806/inside-the-jordan-refugee-camp-that-runs-on-blockchain/ (laatste toegang: 19/09/2018).

[R15] K. RANNENBERG, J. CAMENISCH A. SABOURI. *Attribute-based Credentials for Trust: Identity in the Information Society*, Identity in the Information Society, Springer, 2015.

[R17] P. ROUSSEAU & P. BUYTAERT, *Sociale woningen toewijzen via blockchain*, Infosessie blockchain, Informatie Vlaanderen, 13 November 2017.

[S18] H. SENDER, *World Bank breaks ground with blockchain bond sale*, Financial Times, 9 August 2018, https://www.ft.com/content/f99186b2-9bb5-11e8-9702-5946bae86e6d

[V18] K. VERSLYPE, BeSure - A realistic blockchain case for the Belgian government, Medium, 11 September 2018, https://medium.com/@cryptovnet/besure-a-realistic-blockchain-case-for-the-belgian-government-c5b8c62dff38