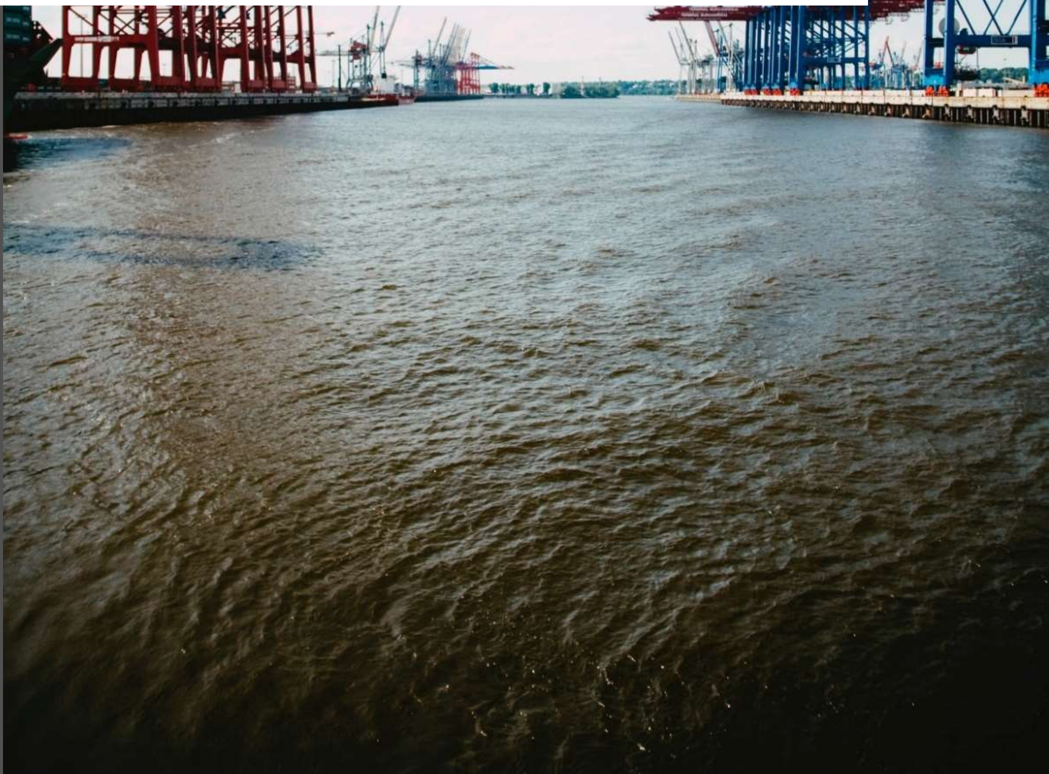
Proceedings of the Hamburg International Conference of Logistics (HICL) – 29

Tan Guerpinar, Sophie Harre, Michael Henke, and Farah Saleh

Blockchain Technology – Integration in Supply Chain Processes



Published in: Data science and innovation in supply chain management
Wolfgang Kersten, Thorsten Blecker and Christian M. Ringle (Eds.)
ISBN: 978-3-753123-46-2 , September 2020, epubli

Blockchain Technology – Integration in Supply Chain Processes

Tan Guerpinar [1], Sophie Harre [1], Michael Henke [1], and Farah Saleh [2]

1 – Chair of Enterprise Logistics, TU Dortmund University

2 – Digix

Purpose: Supply chain networks face an increasing demand to integrate globally distributed customers and suppliers. As supply chain processes are deemed to lack sufficient transparency and security, blockchain solutions are piloted to offer an IT infrastructure covering these needs. This paper aims to bring current projects one step further and evolves a model for integrating blockchain solutions into supply chain processes.

Methodology: In order to get an overview of existing models for technology integration, an exploratory research study is conducted. In addition, requirements for the specific integration of blockchain solutions are gathered and categorized in a systematic content analysis. Based on these requirements, the models are evaluated, compared and utilized for the development of a new model.

Findings: Since none of the presented models fully meet the specific blockchain-based requirements, the existing models must be further developed. Specifically, increases in the number of supply chain partners and external stakeholders involved in blockchain-based systems are not supported by current models, and need to be integrated systematically.

Originality: In this paper, an integration model is developed that is particularly suitable for blockchain integration into supply chain processes. In order to give starting points for a validation of the model, a case study is conducted in the field of blockchain-based payment gateway solutions.

First received: 6. Mar 2020 Revised: 20. Jun 2020 Accepted: 26. Jun 2020

1 Introduction

Today's complex supply chain networks demand for advanced technologies that establish information systems between growing numbers of supply chain partners. In 2019, Capgemini Consulting conducted a study on the topic of digital transformation, which reports that approximately 70% of global change management projects are focused on the integration of advanced technologies (Capgemini Consulting, 2019, pp. 14-16). In this globalized economy, cooperation and competition are increasing in the sense of co-opetition to achieve the next level of innovation (Henke, 2002). Advanced technologies, such as blockchain technology, are gaining in importance as they can establish trustful and traceable relations between multiple organizations. The German federal government has announced its own blockchain strategy in summer 2019. Even though the technology emerged from the finance sector, experts believe that the greatest opportunities lie in redesigning and optimizing business processes. Currently, 10% of all companies piloting blockchain solutions mention that "closer collaboration within their supply chain" can be seen as a main purpose and benefit. (Bitkom, 2019)

The goal of this paper is to develop a model for the integration of blockchain technology into supply chain processes of organizations. The following research questions are utilized to guide the research:

1. "Which requirements do blockchain technology and its use in supply chain processes place on integration models?"

2. "Which existing integration models can be utilized for our purposes?"

3. "What model do we need to specifically address the integration of blockchain technology in supply chain processes?"

To address the research questions above, the terms supply chain management and -processes, as well as blockchain technology are defined and explained briefly in the next section. In order to identify models that are suitable for the integration of IT technologies, a literature research is conducted and analyzed subsequently. For the purpose of analysis, requirements of blockchain technology and its application area are identified by means of the requirements engineering. To fully meet the identified requirements, a new concept will be developed based on selected existing models. Finally, the findings are summarized and recommendations for future research are presented.

2 Background

In literature, the concepts of supply chain management and blockchain technology have been defined in different ways. In this section, relevant definitions are presented to reach a common understanding.

2.1 Supply Chain Management and -Processes

Following Cooper et al. (1997), *supply chain managment* is defined as "the integration of business processes from the end user to the original supplier, who provides products, services and information that add value for the customer". Subsequently, *supply chain processes* are defined as key business processes that "run the length of the supply chain and cut across firms and functional silos within each firm" (Croxton et al., 2001). In this paper, supply chain processes are further understood to consider "material-, information- and value flows over the entire value-added process" (Arndt, 2008). In order to interlink the participants of todays' supply chains and enable a transparent but secured exchange within the mentioned material, information and value flows, new approaches, and technologies are needed. Yet there are several hurdles to overcome. First, during information construction, software and hardware costs are high, risks are difficult to mitigate, and the implementation cycle can be time consuming. Second, the participants of multi-party supply chains are often inhibited to provide relevant information. Therefore, they may suffer from issues such as poor supplier coordination, lack of accountability, or inability to monitor partner activities in real time. (Saberi et al. 2019, p. 2117 ff.). Blockchain solutions that are designed particularly for supply chain management promise to address these problems will be described in the next chapter.

2.2 Blockchain in Supply Chain Management

Blockchain technology by definition is a "technical concept that does not store data in a central database, but rather distributes data to the user's systems using cryptographic methods" (Burgwinkel, 2016, p. 1). The data is therefore stored in individual blocks that are sequentially connected to form a chain so that both the chronological order and the data integrity of the entire data stock are ensured. Manipulations of the data stock are detectable and data can only be appended in the form of a block at the end of the existing blockchain (Burgwinkel, 2016, pp. 5-6).

One advantage of using blockchain technology is having an increased transparency of processes and transactions throughout the whole supply chain. Every user of the blockchain, as soon as rights are granted, can observe specific transactions or processes, which makes it easier to create trust between individual partners. Moreover, data can be stored in a decentralized and immutable manner eliminating single points of failure, providing proof or issue certificates on the basis of untampered data (Bogart and Rice, 2015, pp. 9-12).

However, the technology also brings challenges. Considering the human factor, companies that want to integrate blockchain solutions have to train their employees with high time exposure (BMWi, 2016, p. 69). From a technical point of view, the interconnectivity of blockchain solutions and handling of different data formats still need to be investigated (Acatech, 2018, p. 59). Due to its novelty, the technology also has effects on security aspects and demands the consideration of new kinds of security mechanisms (Bitkom, 2019, p.39). Furthermore, from an organizational point of view, interdisciplinary problems can arise due to the required collaboration of different departments and disciplines (Gürpinar et al., 2019, p. 607). Also, governmental and legal regulations affect the development of blockchain solutions and have to be considered carefully (Reyna et al., 2018, pp. 182-183). Finally, another challenge for the technology integration is the difficulty in assessing its business value and concrete statement for potential cost savings (Fechtelpeter et al., 2019, p. 21).

As a result, a lot of blockchain projects remain in a proof of concept stage and need guidance to achieve the integration of their blockchain solution (Pai et al., 2018). There are some approaches that provide guidance on that topic. Fridgen et al. (2017) develop a process model guiding the reader from an understanding of the technology to the prototype stage. Also Wüst and Gervais (2018) focus on the part of understanding the technology and provide a flow chart to decide whether or not to use a blockchain solution. However, these approaches lack the consideration of an actual integration approach after the positive decision. Apart from that, Panarello et al. (2018), Reyna et al. (2018) and Gonczol et al. (2020) have presented work related to the integration of blockchain solutions, considering either an IoT environment or supply chain processes. However, their outcomes are comprised of integration benefits, challenges and considerations about technical characteristics without presenting integration models. Finally, Niehues and Guerpinar (2019) present a holistic integration model for disruptive technologies and highlight the need for a model that is aimed at blockchain solutions in particular.

3 Methodology

Because sufficient integration models for blockchain technology could not be found, a literature research on and an analysis of integration models for general IT technologies is conducted. Therefore, blockchain related requirements are developed and utilized to evaluate the identified models.

The procedure of the literature research is based on Van Wee and Banister (2016), as well as Durach et al. (2017). Scopus, Elsevier, IEEE, Google Scholar und Springer Link are used as a data sources to find concepts for the integration of IT technologies. Using the pyramid system, further relevant articles are identified and further specified with filter functions. Peer-reviewed articles are given priority in the selection of the articles, but in order to obtain a wider range of practice-relevant models, grey literature is also included.

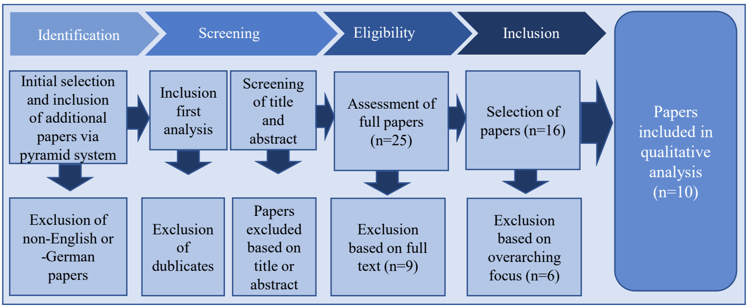


Figure 1: Literature Selection Procedure, based on Casino et al., 2019, p. 59

The selection of models (see Figure 1) is divided into four steps. First, articles that are not written in German or English language are excluded. Second, during the title check, articles that do not sufficiently refer to the integration of IT technologies are excluded. Third, the remaining papers are analyzed to ensure suitable integration models can be presented. Fourth, papers that are too generic or specific are excluded as well. Finally, ten models are selected for the analysis. The four most important ones are described in the next section.

3.1 Existing Integration Models

The **Accelerated SAP Model** (ASAP) represents a phase model with five main phases. In the first phase, the project preparation and organization take place. The second phase "Business Blueprint" defines the business requirements. In the third phase, the basis system is configured, system administrators are set up, interfaces are planned and data is converted. In the fourth phase, final system tests are carried out and the employees are trained. The final phase represents the system check and continuous support (Gulledge and Simon, 2005, pp. 715-719).

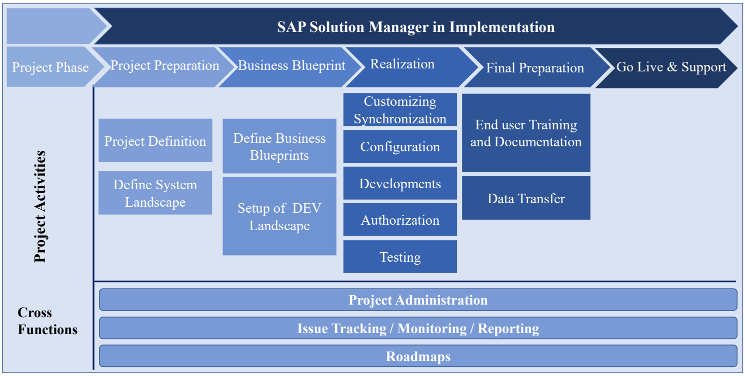


Figure 2: Accelerated SAP Model, based on (Gulledge & Simon, 2005, p. 720)

Scholl's cycle is based on the spiral model. First of all, the problem is concretized and the tasks are defined. Then, the stakeholders and their needs are considered. Next, Pre-studies are carried out, followed by a detailed analysis of business processes and data organization, which are then redesigned. The information system is then developed, integrated and tested. The first run concludes with the evaluation. The project team and management decide whether a further run is necessary. (Scholl, 2004, pp. 286-287) Stakeholders play an important role in the development of this cycle. By focusing on this stakeholder group, a better understanding between the project team and stakeholders is achieved. (Scholl, 2004, p. 298)

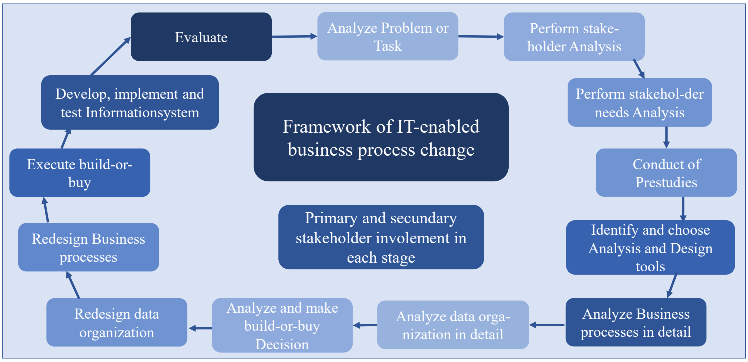


Figure 3: Scholl's cycle of IT-supported change of business processes, based on (Scholl, 2004, p. 286)

Nedbal's process model is based on a literature review. The phases of the model are not linear, but they overlap and are flexible in their order. In the first phase, the initial situation is analyzed and the primary objectives are defined. In the second phase, the current situation is determined by analyzing information systems, existing business processes and technical infrastructures. The third phase focuses on the selection of suitable concepts and tools. In the fourth phase, this is when the technical implementation takes place. The integration approach is introduced and the ready-to-use integration solution is created. In the final phase, the team evaluates the integration solution. Continuous monitoring ensures continuous and sustainable development. (Nedbal, 2013, pp. 162-168)

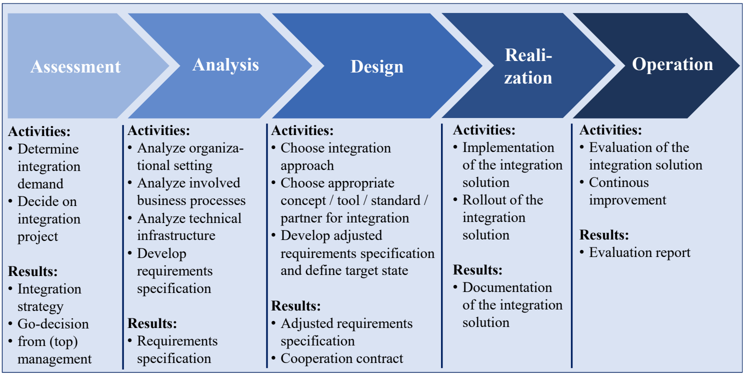


Figure 4: Nedbal's process model, based on (Nedbal, 2013, p. 163)

The **framework of Qu et al.** deals with value creation, business processes, functional structure, information flows, data flows and knowledge management. (Qu et al., 2018, p. 2) The model is divided into three phases: AS-IS model, TO-BE model and analysis of feasibility. In the AS-IS model, business processes, information systems and the management situation are analyzed. In the TO-BE model, information systems and business processes are redesigned. As far as possible, a flat, decentralized organizational structure is preferred and business processes are replaced by synchronized inter-organizational procedures. In the feasibility analysis, the information system is tested using quantitative methods to ensure the efficiency of the new system. (Qu et al., 2018, pp. 7-11)

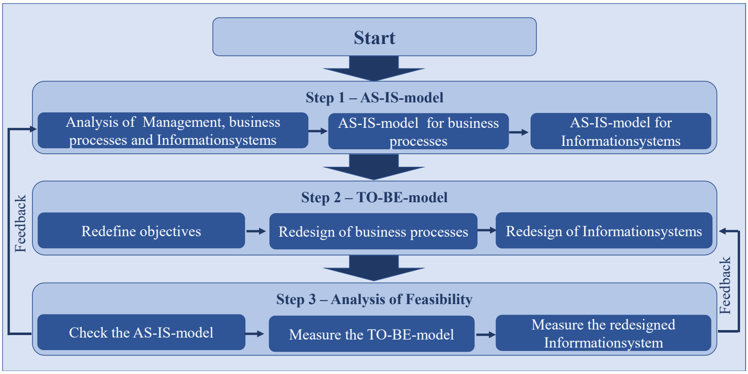


Figure 5: Qu et al.'s framework, based on (Qu et al., 2018, p. 7)

3.2 Requirements for Blockchain Integration

After models for the integration of IT technologies have been selected, requirements related to blockchain technology are developed. To do this, the requirements engineering developed by Pohl and Rupp (2015) is used. The requirements engineering has the task of "determining the requirements of the stakeholders, documenting them appropriately, checking and coordinating them and managing the documented requirements throughout the entire life cycle of the system". (Pohl and Rupp, 2015, p. 4) The following figure illustrates these steps.

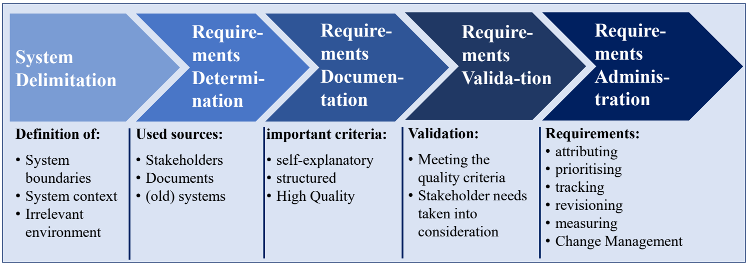


Figure 6: Rupp's requirements engineering, based on (Pohl and Rupp, 2015)

The first step in requirements engineering is the separation of the developed system from its environment. In this study, the focus is on blockchain technology and the requirements that this technology places on integration models. In addition, business processes and supply chain processes with their influencing factors and interfaces are relevant. The second step is the requirements determination for important requirement sources that are used including the consideration of stakeholders and documentation procedures of the existing IT systems. A further literature research is carried out to determine the requirements. The findings are then collected and documented. (Pohl and Rupp, 2015, pp. 21-23) The third step is the requirements documentation. The goal for this is to summarize and structure the requirements to make them easier and understandable. This step results in eight requirements that blockchain technology places on an integration model. These will be elaborated in the next steps. (Pohl and Rupp, 2015, p. 51) In the fourth step, the defined requirements are checked to ensure their quality, the needs of the stakeholders are considered and errors in content are resolved. The following types of errors are examined: completeness, traceability, correctness, consistency, verifiability and necessity. (Pohl and Rupp, 2015, pp. 97-98) In this step, two requirements can be combined. In the fifth step the requirements are managed. In this step the requirements are prioritized to determine the order of utilization. According to Rupp, the following criteria is used for prioritization: implementation costs, risk, damage in case of unsuccessful implementation, volatility, importance and duration of implementation. (Pohl and Rupp, 2015, pp. 123-129) In this step, one requirement is excluded as it does not contribute to the objectives of the integration project. The procedure results in the following six requirements a blockchain-centered integration model for supply chain processes needs to take into account:

(1) The stakeholders with their needs, requirements and wishes in order to enable a successful integration (Fechtelpeter et al., 2019, pp. 18-19);

(2) The consideration of the existing information systems and examination from different perspectives in order to create an intact system architecture (Kahloun and Ghannouchi, 2016, p. 1018);

(3) The company and the environment in order to avoid additional adaptation processes (Matthes, 2011, p. 25);

(4) Data management and the control mechanisms to be provided (Gupta Gourisetti et al., 2019, pp. 208-211);

(5) The monetary consideration of integration costs and benefits at the beginning of the integration process in order to ensure financial stability (Bosu et al., 2019, pp. 2653-2654);

(6) The quality and complexity of the integration model. The model must be easy to understand, versatile and of high quality (Nedbal, 2013, p. 162).

4 Evaluation

In order to evaluate the selected integration models for IT technologies along the developed requirements, the utility analysis is used as a method. The utility analysis is frequently used for multi-criteria decision problems on a qualitative and semi-quantitative level. It helps with reducing complexity and can easily be adapted to special cases. Also, individual aspects can be removed or reinserted easily. (Stuhr, 2013)

The first phase of utility analysis is dedicated to the definition of the evaluating requirements. This has already been done. In the second phase, a target tree is developed to weight the evaluating requirements. For this purpose, the requirements are assigned to two main categories: internal and external factors. In the third phase, possible characteristics are defined for the respective requirements. For this purpose, the verbal response options are assigned to numerical values of the utility value scale. (Example: requirement not considered in the model = 0; requirement strongly considered = 6) (Stuhr, 2013, p. 112) In the fourth phase, each integration model is evaluated regarding the individual requirements by forming partial utility values. In the fifth phase, the total utility of the respective model is calculated according to the weighting factors. The result is checked by plausibility and sensitivity analysis. In the last phase, the ranking is established. For this purpose, the total benefits are put in a sequence so that the best alternatives can be highlighted. (Stuhr, 2013, pp. 88-93) In Figure 7, the four best ranked models Scholl's cycle, the ASAP model, Nedbal's process model and the Qu et al. framework can be seen.

models	requirements						overall benefit	ran-king
	Quality & Com-plexity (20 %)	Control mechanism & data ma-nagement (15 %)	Mone-tary expense (10 %)	Busi-ness context (15 %)	structure of Informa-tionsys-tems (20 %)	Stake-holders & system users (20 %)		
Royce, Fairley: Waterfall model	6	4	2	4	6	0	3,8	7
Boehm: spiral model	6	4	2	4	6	0	3,8	7
Microsoft: MSF	6	4	2	4	6	0	3,8	7
TOGAF	6	2	2	6	6	4	4,6	5
ASAP & SAP Solution Manager	6	4	4	4	6	6	5,2	2
Ortiz et al: IE - GIP	4	6	2	6	2	4	4,0	6
Scholls cycle	4	6	6	6	6	6	5,6	1
Pilorget: MIIP	0	4	2	6	6	4	3,7	8
Nedbals process model	6	4	4	6	6	4	5,1	3
Qu et al.s framework	2	6	4	6	6	6	5,0	4

Figure 7: Total benefits of the integration models

Scholl's cycle is characterized by the special position of the stakeholders in this model. Stakeholders are analyzed intensively in order to fulfil their interests and wishes. Due to the small steps in the procedure, the model fulfils many of the defined requirements in the best possible way. A weakness is the complexity and usability of the model.

The ASAP model is characterized by a simpler structure. This ensures an easy understanding of the procedure and provides a good overview of the project progress. However, the control mechanisms could be a weakness for blockchain integration in this case.

Nedbal clearly divides his process model in activities and results, which simplifies goal-oriented project work and enables stakeholders to be proactively informed about the progress. However, for blockchain integration, more focus should be placed on data management.

The framework by Qu et al. is characterized by an intensive analysis of the initial situation and the existing information system's structure. Even though it is structured into three phases, it is more complex and harder to apply than the other models.

The TOGAF model analyzes intensively the structure of the information systems and the business context. (Lankhorst, 2017, pp. 139-140) Nevertheless, it has no sufficient control mechanisms in place. The IE-GIP model has a particularly high score in the category Stakeholder & System User. However, the monetary context and the existing information systems structure are hardly considered. The model has a simple structure and deals intensively with data management. (Ortiz et al. 1999, pp. 169-170) The waterfall model stands out for its simple structure and its intensive examination of the existing information systems structure but lacks flexibility. (Scharch, 2016, pp. 19-20) Boehm's spiral model is characterized by its low complexity. Data management and control mechanisms are also considered in each cycle. (Scharch, 2016, pp. 31-32) The MSF has a simple structure, a low complexity and deals intensively with the existing information systems structure. Like the waterfall and spiral model, stakeholders and system users are not taken into account. (Campbell et al., 2003, p. 7) Pilorget's model is very complex due to the 64 defined process dependencies and the 17 MIIP processes. (Pilorget, 2010, pp. 1-2) Although this model achieves good values in other categories, this model is ranked last as it is hard to handle.

5 Findings

In the previous section, four relevant models for technology integration were selected and further analyzed in terms of strengths and weaknesses by means of developed blockchain-specific requirements. In this chapter, a new model for the specific integration of blockchain technology in supply chain processes is introduced. During the development of the model, priority is placed on fulfilling all requirements and to find a balance between simple and complex visualization.

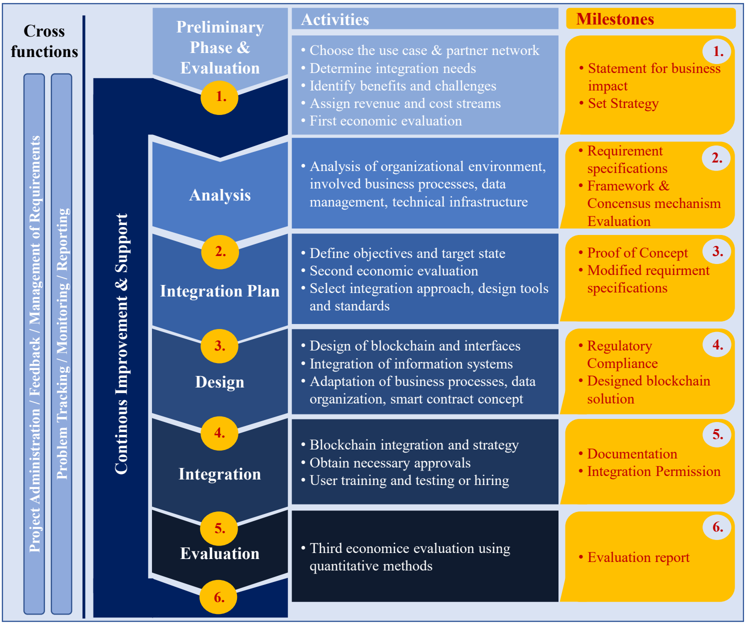


Figure 8: Model for integrating blockchain technology in supply chain

The new model is divided into six phases. It starts with the preliminary and evaluation phase, which initiates the integration project and is only run once. This first phase is followed by six subsequent processes, which can be run cyclically to ensure that user feedback and necessary changes are considered and regular quality checks conducted. Furthermore, the cyclical structure ensures that new requirements can be identified and integrates flexibly. This way, a long-term functioning system is guaranteed. In order to reach the next phase of the model, milestones have to be fulfilled. A milestone specifies certain criteria necessary to start the next phase and divides the project into manageable sections. (Scharch, 2016, p. 12)

The model also presents the following cross functions: project administration, consideration of feedback and management of requirements, problem tracking, monitoring, and reporting. By centrally anchoring these aspects, new requirements can be registered and documented immediately to be considered in the next development cycle. Also, requirements specified by stakeholders can be considered in this way. Furthermore, continuous project and problem tracking ensure that irregularities and errors are recorded and eliminated, before they can have serious consequences for the overall project. The documentation and reporting make the integration process traceable for management and also serve as an important basis of discussion with blockchain partners. The generated learnings can also be used for further blockchain projects or to report to other stakeholders on the project progress. (Gulledge and Simon, 2005, p. 729)

In the preliminary and evaluation phase, the blockchain use case, its application area, and potential partners are determined. Also benefits and challenges of a blockchain integration are raised and associated to potential revenue and cost streams. Through this and together with the methods for economic evaluation, a first statement about the business impact is produced. Finally, an integration strategy with primary goals and needs is issued and agreed upon already with relevant stakeholders.

After that, the cyclical main phase of the integration model begins. In the first phase, the analysis is based on components of the selected models. Namely, the analysis of the organizational environment and determination of project members, as well as of business processes, data management and the technical infrastructure. The findings of this analysis phase form the basis of a requirements specification and are consolidated in the end. In this phase, it is important to identify all organizational areas and respective business processes that are affected by a blockchain integration. Also, this phase has a strong technical focus, as the specifications of the blockchain framework and respective consensus mechanism have to be chosen with respect to data integrity and security.
In the integration planning phase, the requirement specifications are adapted. The goal of this phase is to find a suitable integration approach and to select appropriate tools for the integration. Therefore, the integration approach is determined, broken down in smaller elements that get prioritized and selected. The integration approach must include the consideration of affected business processes, middleware, information systems and data types. Also, supporting tools and standards as well as security mechanisms are selected at this point. Finally, the economic evaluation from step one can be enriched with more business process details and all findings from this phase can be incorporated into a documented requirement specification, which represents a milestone.

In the design phase, the technical system is designed. The value-added processes, data and information flows, functional structure, and knowledge management must be taken into account here. If necessary, the business processes, their data organization, and the handling of existent information systems have to be adapted or redesigned. The project team then sets up the system and plans the interfaces and necessary data conversions. Also, a concept for the use of smart contracts has to be installed here, which includes the decision of what data would be kept onchain or off-chain. Finally, the regulatory compliance hast to be ensured and the schedule for the start of operations determined. The milestone of this phase is the final documented design of the blockchain solution with the assigned responsibilities for all involved partners.

In the integration phase, the blockchain solution is integrated into the considered business processes. For this purpose, the system must be tested in advance and during the whole integration process. Besides organizational aspects, this phase focuses on the human factor. Trainings have to be conducted not only for end users but for all employees that have to deal with adapted business processes, especially for management that has to consider strategic consequences. In this phase, all necessary permissions are obtained for the system to go live. Once the permits have been granted, the blockchain solution can finally be tested. The milestone of this phase is the approval of the ready-to-use blockchain solution.

In the evaluation phase, the blockchain solution is further tested. At this point we also get more quantitative data for evaluation purposes and consider operational benefits and costs, project risks, the strategic importance and the internal resource requirements in our third economic evaluation. To do so, Qu et al. (2018) propose the use of quantitative methods to ensure the technology's effectiveness. The aim of the evaluation is to ensure that the business environment is fully considered and supported. This includes the validation of business processes, technical parameters, and the survey of end users. The milestone of this phase is the evaluation report, which documents the success of the blockchain integration project.

Once the system has been fully evaluated, the phase of support and continuous change follows. The concept of continuous change improves the integrated blockchain solution over time. In our model, this last phase represents the transition to the analysis phase because the cyclical arrangement allows newly arising requirements to be recorded and incorporated immediately. Thus, the blockchain integration is part of a recurring cycle of continuous improvement.

6 Case Study

In order to give starting points for a validation of the developed model, in this section a case study to consider practical aspects is introduced. With the COVID-19 pandemic we have seen a significant increase in demand for streamlined cashless payment systems, which is one reason why blockchain-based payment gateway solutions are piloted. Apart from public variants, there are also private solutions that are used with merchants and their partners to perform automatized purchases and verify the provenance of assets. These solutions are deemed to offer cheaper transaction costs, more transparency, and also disruptive opportunities like activity-based payments via smart contracts.

The Singaporean blockchain provider Digix develops such solutions with its Proof of Provenance (PoP) protocol. The PoP protocol utilizes the Ethereum platform and the Inter Planetary Files System (IPFS) to track assets through its chain of custody. Digix also offers an API allowing other applications to be built on top of their solution. In the following, we examine the methodical approach of the integration model and enrich it with aspects to be considered during the integration approach of a blockchain-based payment gateway solution at Digix as our case study.

1. Preliminary Phase

First, opportunities and challenges of the blockchain solution are gathered, possible revenue and cost streams on a monetary basis are not yet associated. Subsequently, all opportunities and challenges are compared to traditional payment solutions. The most important opportunity to be considered in our case is the enhanced transparency of the payment processes.

This includes the verification of identities and allows multiple parties to interconnect on a trustful basis. The most important challenge is to establish the consortium of partners.

2. Analysis Phase

In relation to the second phase, the project team considers specifications of the existing business processes and evaluates different blockchain platforms. Most of the public solutions for PoP are built on Ethereum platform, especially if there are multiple external parties involved. To keep transactions private in a B2B setting, private protocols are also considered. In this case, the Hyperledger Fabric protocol is commonly used. In the case of private blockchains, participants are known to one another and jointly decide to participate in the network. For this reason, they have to be provided with suitable credentials to be part of the network. Also, based on the preliminary profitability statement, they have to be provided with information about expected opportunities and challenges when participating. For this reason, in our case study, a lot of time is invested to specify organizational and technical opportunities and challenges for different partners.

3. Integration Planning

In the third phase, management has to decide if the software solution is to be developed in-house or development is outsourced to an external company. In the former, team members have to be selected or hired with respect to the right skillsets such as smart contract development. Also, the adaptability and scalability of a technology stack has to be evaluated to ensure core processes can be carried out with minimal distractions. The integration model also refers to design tools being considered. In our case this would be with regard to where the data is placed and stored in the architecture. This can be an on-chain data store of a private blockchain. Alternatively, data can also be stored off-chain using a third party tool such as IPFS. For the consideration of data security, in our case study, securing mechanisms like the chainpoint protocol can be selected to ensure that embedded data is secured.

4. Design

In the design face of a payment gateway, the use of complex smart contracts and micropayments have to be considered, which often come in an either/or relationship. As such, the project team has to evaluate how to design smart contracts and whether or not advanced rules are integrated into the templates. Throughout this phase, it is important to have all involved parties be able to respond and provide their input whenever they are triggered. Another aspect for consideration in the design phase is data governance. All parties must decide what parties share and own data and what data is enough for mutual agreement. In this phase, user interfaces of the blockchain solution must be developed to drive ease of adoption and usage with minimal distraction. Processes involved need to be assessed and streamlined and business functions have to be engaged in all phases. Lastly, the compliance with international, regional and country's respective regulations must be considered to reach the milestone. In this case, it is the Monetary Authority of Singapore Regulation (MAS). The regulations determine how the integration processes will be performed in detail and eventually lead to how interoperability such as exchanges between data need to be managed.

5. Integration

In the integration phase, the blockchain solution is to be tested. In our case study, because blockchain integrations tend to fail due to partner willingness, high importance is placed on understanding the partners' goals and showing that the product fulfills them. In this stage, the project team also needs to consider the interconnections between their chosen consensus mechanism and the system's modularity ensuring data integrity and scalability of the solution. Also, the integration model refers to trainings at this point, which are very important. Also, external parties involved such as partners and merchants need to be trained to get familiar with blockchain terms and terminologies to increase their confidence and competency to perform their tasks in the transparent network. Internal employees or newly hired development teams need to scale up their technical skillsets to ensure the product can be developed based on best practices. In this case study, the usability of go language for smart contract development plays an important role. At the same time, business functions such as marketing, procurement and compliance teams have to be trained to analyze blockchain data in order to perform their tasks.

6. Evaluation

The integration model suggests to conduct a final evaluation of the integration project. In this case study, the following positions would need to be evaluated.

(1) Partner acquisition costs: This can be related to marketing costs or expenses that occurred to drive partner's adoption such as training or compliance with regulations.

(2) Influence on IT infrastructure and maintenance: A good infrastructure regardless of a centralized or decentralized system has to be considered to ensure 99.99% uptime and its ability to scale up when the number of on-

boarded partners grows, or the size of data and network throughput increases.

(3) System interfaces: As the blockchain solution needs interfaces to existing systems, the ease of integrating the solutions also with partners' infrastructure needs to be evaluated.

(4) Data governance and analytics: Consensus relies on the parties making rational decisions. Controls such as transaction monitoring can be explored to ensure that no party is performing any illegal tasks and the wallet addresses used are whitelisted.

7 Conclusion

Since blockchain technology is increasingly crossing into various supply chain processes of organizations, but in some cases remains in proof of concept phases, an extensive literature research to identify suitable models for technology integration is conducted. In a second literature research, requirements that blockchain technology places on the integration models are collected. For this purpose, the requirements engineering following Pohl and Rupp is utilized. This way, six requirements are developed: The consideration of stakeholders & system users, as well as of existing information systems, the business context, control mechanisms & data management, monetary expenses as well as quality and complexity of the integration models. Together with these requirements, all models are evaluated by means of a utility analysis. As a result, four technology integration models emerged to be used as a basis. We then developed a new model that meets all the predefined requirements for blockchain integration and conducted a case study to ensure plausibility.

In summary, in this paper, an integration model was developed that is particularly suitable for blockchain integration into supply chain processes. Nevertheless, limitations have to be considered. First, all of the selected papers in the literature research have a focus on IT technologies. Other scientific approaches like innovation, or strategic management are not considered. Second, the integration model is not specified on a certain blockchain use case. Application areas in supply chain management might vary from one another, and therefore, additional case specific integration requirements need to be considered.

It should be noted that there are only few approaches dealing with the integration of blockchain technology into supply chain processes and a holistic model is needed to guide organizations in their attempts of fully utilizing the technology and overcome proof of concept phases. Hence, as further research need, the validation of our model along with a live case study can be suggested. Only this way, unconsidered aspects can be identified and practical applicability can be ensured. In addition, further models focusing on the economic evaluation of blockchain technology should be developed and integrated in order to reach the overall goal of scalable and profitable blockchain solutions in supply chain processes.

References

Acatech, 2018. Blockchain. Deutsche Akademie der Technikwissenschaften München/Berlin.

Allweyer, T., 2005. Geschäftsprozessmanagement: Strategie, Entwurf, Implementierung, Controlling. Herdecke: W3l-Verlag.

Bundesministerium für Wirtschaft und Energie (BMWi), 2016. Monitoring-Report Wirtschaft Digital 2016. Berlin.

Bitkom e. V., 2019. Blockchain in Deutschland – Einsatz, Potenziale, Herausforderungen. Studienbericht 2019. Berlin.

Bogart, S. and Rice, K., 2015. The Blockchain Report: Welcome to the Internet of Value. In: Needham & Company, 21.10.2015, S. 1-57.

Bosu, A., Iqbal, A., Shariyar, R., et al., 2019. Understanding the motivations, challenges and needs of Blockchain software developers: a survey. In: Empirical Software Engineering, 24 (2019) 4, S. 2636-2673.

Broad, J., 2013. System Development Life Cycle (SDLC). In: J. Broad (Hrsg.): Risk Management Framework. A Lab-Based Approach to Securing Information Systems. Rockland, USA: Syngress Publishing Elsevier, S. 39-45.

Burgwinkel, D., 2016. Blockchaintechnologie und deren Funktionsweise verstehen. In: D. Burgwinkel (Hrsg.): Blockchain Technology. Einführung für Business- und IT Manager, Berlin, Boston: De Gruyter Oldenbourg, S. 3-50.

Capgemini Consulting, 2019. Auf dem Sprung - Wege zur organizsational Dexterity. Change Management Studie 2019. Offenbach am Main.

Campbell, D., Lory, G. and Robin, A., 2003. Microsoft Solutions Framework v3 Overview. In: Microsoft (Hrsg.): Microsoft Solutions Framework – White Paper, 2003, S. 1-30.

Casino, F., Dasaklis, T. K. and Patsakis, C., 2019. A systematic literature review of blockchain-based applications: Current status, classification and open issues. In: Telematics and Informatics, 36 (2019), S. 55-81.

Croxton, K. & Garcia-Dastugue, S. & Lambert, D. & Rogers, D., 2001. The Supply Chain Management Processes. International Journal of Logistics Management, The. 12th, pp. 13-14.

Durach, C., Kembro, J. and Wieland, A., 2017. A New Paradigm for Systematic Literature Reviews in Supply Chain Management. In: Journal of Supply Chain Management, 53 (2017) 4, S. 67-85.

Fechtelpeter et al., 2019. Vorstudie zur Entwicklung einer bedarfs- und nutzergerechten Unterstützung von KMU bei der Einführung und Anwendung von Industrie 4.0. In: Acatech (Hrsg.): Forschungsbeirat Plattform Industrie 4.0. 2019, München.

Fridgen, G., Radszuwill, S., Schweizer, A., et al., 2017. Entwicklung disruptiver Innovationen mit Blockchain: Der Weg zum richtigen Anwendungsfall. In: Wirtschaftsinformatik & Management, 9 (2017) 5, S. 52–59.

Gonczol, P. & Katsikouli, P. & Herskind, L. & Dragoni, N., 2020. Blockchain Implementations and Use Cases for Supply Chains – A Survey. IEEE Access.

Guerpinar, T.; Straub, N.; Kaczmarek, S.; Henke, M., 2019. Blockchain-Technologie im interdisziplinären Umfeld. ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb.

Gulledge, T. and Simon, G., 2005. The evolution of SAP implementation environments: a Case study from a complex public sector project. In: Industrial Management & Data Systems, 105 (2005) 6, S. 714-736.

Gupta Gourisetti, N., Mylrea, M. and Patangia, H., 2019. Application of Rank-Weight Methods to Blockchain Cybersecurity Vulnerability Assessment Framework. In: 9th Annual Computing and Communication Workshop and Conference (CCWC), vom 07. bis 09.01.2019 in Las Vegas, USA, IEEE: S. 206-213.

Hanser, E., 2010. Agile Prozesse: Von XP über Scrum bis MAP. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg.

Kahloun, F. and Ghannouchi, S. A., 2016. Quality Criteria and Metrics for Business Process Models in Higher Education Domain: Case of a Tracking of Curriculum Offers Process. In: Procedia Computer Science, 100 (2016), S. 1016-1023.

Henke, M., 2003. Strategische Kooperationen im Mittelstand. Potentiale des Coopetition-Konzeptes für kleine und mittlere Unternehmen (KMU). Zugl.: München, Techn. Univ., Diss., 2002 u.d.T.: Henke, Michael: Strategische Kooperationen kleinerer und mittlerer Unternehmen (KMU) unter besonderer Berücksichtigung des Coopetitions-Ansatzes. Verl. Wiss. & Praxis, Sternenfels.

Lankhorst, M., 2017. Enterprise Architecture at Work. Modelling, Communication and Analysis. 4. Aufl., Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg.

Matthes, D., 2011. Enterprise Architecture Frameworks Kompendium. Berlin, Heidelberg: Springer Verlag Berlin Heidelberg.

Nedbal, D., 2013. A process model to guide the integration of business processes and services within and across organisations. In: International Journal of Services, Economics and Management, 5 (2013) 1, S. 154-177.

Niehues S., Guerpinar, T., 2019. Disruptive technologies : integration in existing supply chain processes. In: Hamburg International Conference of Logistics (HICL) 2019.

Ortiz, A., Lario, F. and Ros, L., 1999. Enterprise Integration - Business Processes Integrated Management: a proposal for a methodology to develop Enterprise Integration Programs. In: Computers in Industry, 40 (1999) 2-3, S. 155-171.

Pai et al., 2018. Does blockchain hold the key to a new age in supply chain transparency and trust? https://www.capgemini.com/wp-content/uploads/2018/10/Digital-Blockchain-in-Supply-Chain-Report.pdf., accessed at: 01.05.2020

Panarello, A. & Tapas, N. & Merlino, G. & Longo, F. & Puliafito, A., 2018. Blockchain and IoT Integration: A Systematic Survey. Sensors.

Pilorget, L., 2010. MIIP: Modell zur Implementierung der IT-Prozesse. Wiesbaden: Vieweg+Teubner Verlag.

Pohl, K. and Rupp, C., 2015. Basiswissen Requirements Engineering. Aus- und Weiterbildung nach IREB-Standard zum Certified Professional for Requirements Engineering Foundation Level. 4. Aufl., Heidelberg: dpunkt Verlag.

Qu, Y., Ming, X., Ni, Y. et al., 2018. An integrated framework of enterprise information systems in smart manufacturing system via business process reengineering. In: Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 233 (2018) 11, S. 2210-2224.

Reyna, A., Martin, C., Chen, J. et al., 2018. On blockchain and its integration with IoT. Challenges & opportunities. Future Generation Computer Systems, 88.

Saberi, S.; Kouhizadeh, M.; Sarkis, J., et al., 2019. Blockchain technology and its relationships to sustainable supply chain management. In: International Journal of Production Research, 57 (2019) 7, pp. 2117 ff.

Scharch, M., 2016. Vorgehensmodelle in der Software-Entwicklung. In: Professur BWL – Wirtschaftsinformatik, Justus-Liebig-Universität Gießen (Hrsg.): Arbeitspapiere WI, 4 (2016), S. 1-67.

Scholl, H. J., 2004. Involving Salient Stakeholders. Beyond the technocratic view on change. In: Action Research, 2 (2004) 3, S. 281-308.

Stuhr, H. J., 2013. Untersuchung von Einsatzszenarien einer automatischen Mittelpufferkupplung. Dissertation, Technische Universität Berlin.

Van Wee, B. and Banister, D., 2016. How to Write a Literature Review Paper? In: Transport Reviews, 36 (2016) 2, S. 278-288.

Vogel-Heuser, B., 2003. Systems Software Engineering. Angewandte Methoden des Systementwurfs für Ingenieure. München: Oldenbourg Wissenschaftsverlag.

Wüst, K. and Gervais, A., 2018. Do you Need a Blockchain? In: (Hrsg.): 2018 Crypto Valley Conference on Blockchain Technology. CVCBT 2018 : 20-22 June 2018, Zug, Switzerland : proceedings. Piscataway, NJ: IEEE, S. 45–54.

Zimmermann, O., Schlimm, N., Waller, G. et al., 2005. Analysis and design techniques for service-oriented development and integration. In: INFORMATIK 2005 - Informatik LIVE! Band 2.