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Design of a DLT-based Document Management System in Road Transport

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Purpose: *While the transportation sector enters a new phase of digital transformation, Distributed Ledger Technologies brought a new paradigm in the design of IS with numerous pilot-cases in logistics. Despite the various benefits (e.g., security, availability) little is empirically known about the development of such solutions. Where practitioners face numerous design decisions, we complement research by deriving six design principles for the construction of an applicable artifact in road transport.*

Methodology: *We follow design-science-research to generate design knowledge based on a literature review, a morphological analysis, and case studies on DLT-driven applications for document management. We refine the results and demonstrate practicability via an instantiation based on expert interviews to provide generalizability in terms of actionable guidelines.*

Findings: *We extend theory showing that DLT is an effective solution for cross-border information exchange. The design principles address the data architecture, access and storage across multiple stakeholders, and the way how data is exchanged. The results may further accelerate the adoption of DLT-based applications in logistics.*

Originality: *We bridge the gap between technology and practical utilization by evaluating existing cross-industry use cases combining elements from the business, legal, and information technology perspective. Additionally, the instantiation of an applicable solution is further the result of an inter-organizational development process involving feedback of various practitioners (e.g., carrier, authorities).*

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1 Introduction

The digitalization of business processes has been a main driver for new operational efficiencies in the transport industry (e.g., real-time tracking, digital freight marketplaces). While the awareness for the digital transformation has grown, relatively few companies have unlocked the full potential of successfully introducing new information systems (IS) to transform associated processes for even higher efficiency, safety, and sustainability standards (Min et al., 2019). Following the idea of a digital supply chain to improve the global movement of goods, the digitization of key documents in international trade has not received the required attention so far. Accordingly, document exchange between sender, forwarder, and recipient is still handled manually, printed on paper, and, thereby, a prevailing source for inefficiencies. Due to its susceptibility to errors and counterfeiting, associated processes show huge room for improvement (Naerland et al., 2017). It is estimated that 99% of cross-border transport operations in the European Union involves paper-based documents in at least one process stage (European Commission, 2018). One of these physical documents for the transport across national borders is the contract for the international carriage of goods by road, in short CMR (UNECE, 1956). The United Nations took note and agreed on a standardized protocol for a digitized consignment note, the so-called e-CMR, to be fully ratified in Europe soon (UNECE, 2021).

In comparison to established IS, we assume that the logistics industry may rely on a more secure, efficient, and trustworthy alternative for its implementation. Blockchain (BC) and Distributed Ledger Technology (DLT) enable decentralized IS that show potential to improve the information exchange across company boundaries and to increase transparency in supply chains (Wang et al., 2019). Electronic transport documents based on a shared ledger are verified in real-time and decrease administrative costs considerably (Belu, 2019). Transport information is stored in a tamper-proof database making it impossible to modify the documents without leaving traces. Hence, decentralized IS may eliminate intermediary intervention, reduce costs, provide integrity, and consistently streamline information across all participants (Juma et al., 2019). Despite the benefits and practicality of BC- and DLT-based document management systems, it is still unclear how to design such solutions against the backdrop of relevant requirements and features (Wieninger et al., 2019). Although DLT is often used synonymously with BC, a shared ledger approach is not always dependent on a chain of blocks. Recent research shows plenty of distributed database solutions that store an increasing amount of transaction records (Collomb and Sok, 2016). By focusing on DLT as the applicable level of abstraction, practitioners must identify relevant trade-offs to successfully introduce such applications (e.g., public or restricted view of transactions). While solutions for electronic document handling in logistics exist (e.g., bill of lading in sea freight), there has been no contribution for an applicable artifact in road transport so far (Naerland et al., 2017). To support organizations in the decision-making process, we address the following research question: *What are design principles for developing a DLT-based document management system in road transport?*

Based on design-science-research we define the problem area, specify objectives for development, identify relevant features of DLT and design decisions through both literature reviews as wells as empirical data from expert interviews. Accordingly, a morphological box is introduced to instantiate a specific solution design to derive knowledge in terms of six design principles.

The remainder of the paper is as follows: The next section highlights the motivation for digitalization in road transport and the challenges of applying DLT. Where section 3 introduces the methodology, section 4 describes the iterative development and artefact instantiation. Before the paper closes in section five, the design principles and their evaluation is presented and discussed.

2 Theoretical Background

2.1 Digitalization in Road Transport

Recent developments in real-time monitoring of vehicles and cargo slowly improved the electronic interaction in the road transport industry (Koroleva et al., 2019). A consistent flow of information in international trade across companies and authorities should therefore become a rule and not the exception (DTLF, 2018). According to Civelek et al.

(2017) one important factor for the digitalization of information flows across multimodal supply chains is the integration of electronic documents. As a prerequisite, it allows to access relevant information in one shared interorganizational system.

One of the key documents in international trade is the CMR. In general, a CMR serves the purpose of proving that goods have been securely transferred and accepted during their transport. It is applied when sender and recipient are located in two different countries. The CMR serves as a contract between sender, carrier, and consignee and must be issued prior to the transport operation. A legally valid CMR must be directly available to be signed by the sender as well as by the carrier (DTLF, 2018). In 2008, the e-CMR protocol was issued by the UNECE, which requests that the CMR should be managed electronically. However, new IS systems that should replace existing paper-based processes via e-CMR are still not widely adopted within the industry. Companies still have concerns to fully digitize the processes. Sensitive data may be shared, where third party provider cannot ensure standards of security and integrity (Chen, 2019). Hasratyan et al. (2020) indicate the lack of data security and the importance to improve the protection of company information. Technical interoperability between stakeholder also poses problems for cross-border information exchange. The reason is the lack of cooperation and the insufficient support for standardization (Burinskiene, 2019). Finally, various legal requirements at an international level are leading to low acceptance and unclear responsibilities in front of authorities and courts (Koroleva et al., 2019).

2.2 DLT-based Application Design

The implementation of more reliable data sharing technologies may improve the current situation. DLT provides a shared database for decentralized applications and ensures secure data provenance. The distributed solution represents an opportunity for data authenticity to enhance the low standards of security and integrity in cross border data exchange (ITU-UN, 2019). Every party in the process operates its own node to store and update information between all network participants. A decentralized management of the shared ledger lies at the core of any DLT system that improves the availability of transactional data and eliminates a single point of failure (Kannengiesser et al., 2020).

Ultimately, organizations can increase data sovereignty through the built-in mechanisms of DLT and its cryptographic functions (Juma et al., 2019).

Existing research on DLT-based document applications show that health records are very often applied in such cases (e.g., Lee et al., 2019, Xiao et al., 2018). Other research investigates the applicability of DLT for commercial, financial, or legal documents (e.g., Chang et al., 2019, Chen et al., 2019). Despite the advantages of a DLT-based document solution in road transport, the application of an e-CMR has not yet been considered to the best of the author's knowledge. However, all these use cases highlight critical dependencies when choosing a specific type of DTL. The characteristic of the various technologies lead to trade-offs (e.g., flexibility and security). On the one hand a low number of participating nodes within a DLT network may increase flexibility. But on the other hand, a limited degree of decentralization may decrease the security of the system (Kannengiesser et al., 2020). Due to these trade-offs, there is no DLT design that fulfills every requirement of a specific application area. For practitioners, it is still challenging to select a suitable DLT framework and to identify the relevant design options. Comprehensive knowledge is needed to understand these dependencies.

3 Methodology

To generate new knowledge in terms of design principles for a DLT-based document management system in road transport, we apply design-science-research (DSR) to create an artifact that solves the identified organizational problem (Hevner et al., 2004). The iterative approach uses rigor and relevance cycles and is based on the guidelines of Peffers et al. (2008) highlighting five phases associated with problem identification and definition, development, demonstration, evaluation, and the communication of results.

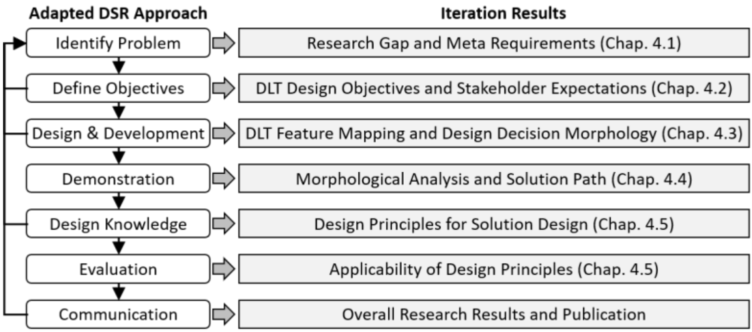

Figure 1: Design cycles and iterative results based on Peffers et al. (2008)

We adapted the approach in figure 1, where we identified problems in existing solutions at first. In the second cycle, we addressed opportunities of DLT-based systems through two interviews and a requirement workshop with seven practitioners. The goal of the third cycle was the identification of DLT-specific design features that map and fulfill the identified design objectives of our proposed system. Subsequently, we reviewed extant research to introduce a morphological box by addressing and refining relevant design decisions on the construction of an DLT-based application through existing cross-industry DLT use cases on document exchange. After we instantiated a solution path through secondary data and two expert reviews, the overall artifact in terms of the six design principles was finally evaluated by four experts according to the key criteria (e.g., applied effectiveness and efficiency) of Sonnenberg & Vom Brocke (2012). Beside secondary data gathered through extant literature following the guidelines of Webster &

Watson (2002) in common scientific databases (cf. EBSCOhost, AIS Library, Jstor), we collected primary data from 15 semi-structured interviews in total (Table 1). All participants were experts in their respective domain, where each interview lasted between 25 and 45 minutes according to the respective phase in the DSR cycle. We transcribed the interviews and analyzed them to identify the most important statements and outcomes (Ayres, 2008).

Table 1: Overview of interviewees

Interview Round	ID	Job Position	Company Information		Average Experience	
			Type	Size	DLT	Road Transport
1st Interview Round: Respective DSR Relevance Cylce	A1	Project Manager	Logistics Association	Medium	2 years	4 years
	A2	Economic Affairs	Logistics Association	Large	1 year	10 years
	U1	Researcher	University	Large	5 years	18 years
	A3	Head of Digital Policy	Technology Association	Small	4 years	8 years
	A4	Project Manager	Logistics Association	Medium	2 years	4 years
	P1	Consultant	IT Service Provider	Small	2 years	3 years
	P2	Managing Director	IT Service Provider	Small	1 year	13 years
	P3	Managing Director	IT Service Provider	Small	4 years	6 years
	P4	Business Development	IT Service Provider	Small	6 years	2 years
	C1	Software Developer	IT Consulting	Large	5 years	-
	U2	Researcher	University	Large	4 years	4 years
2nd Interview Round: Artifact Evaluation	C2	Senior Consultant	Technology Consulting	Large	3 years	-
	C3	Business Development	IT Consulting	Small	5 years	3 years
	P5	Business Development	IT Service Provider	Small	4 years	1 year
	C4	Senior Consultant	Technology Consulting	Large	4 years	3 years

4 Design and Development

4.1 Problem Statement

We address the research gap by identifying the relevance of data sharing solutions in the field of e-CMR documents through a systematic literature review, which indicated a lack of research for interorganizational information exchange in road transport. To further investigate the topic, we gained additional practical insights through expert interviews about the opportunities and challenges in applying a digital CMR (cf., e-CMR implementations). Where digitalization allows, for example, significant cost reductions, businesses may be concerned that electronic documents can easily be manipulated. There is a common understanding in practice to ensure a feasible design of the system. On that basis, we were able to define so-called meta-requirements of an e-CMR application in road transport. A DLT-based document management system must fulfill these criteria to increase the acceptance in the industry. The following three meta-requirements summarize this understanding and lay the basis for our research:

4. **Authenticity:** The risk of data manipulation must be very low so that no party involved can modify the e-CMR after its issuance without saving the modification in a neutral storage. There are many cases known where the CMR was modified after its issuance due to monetary benefits. Companies need a guarantee that the authenticity of the information is ensured and that they can fully trust the information (e.g., electronic signatures) (Interviewee: A1, A2, U1, A5, P1).
5. **Confidentiality:** The process of sharing information between businesses and authorities must be secure and confidential. The principles of data protection must be observed, and no personal data may be disclosed unintentionally (Interviewee: A1, A2; Engelenburg et al., 2019).
6. **Security:** A centralized data storage system for transport information entails a high threat for a cyber security issue and an incident could jeopardize the entire supply chain of a company (Interviewee: A2; Hasratyan et al., 2020).

4.2 Design Objectives

To fully address the meta requirements and to meet applicability in practice, we build upon the existing body of knowledge to specify design objectives (DO) based on the capabilities of DLT. The goal is to identify stakeholders and their needs for analysis, communication, and subsequent implementation. The traditional technique includes the usage of questionnaires, interviews, and review of existing literature (Nuseibeh and Easterbrook, 2000). To capture the key objectives, we rely on previous literature and align applicability with DLT applications. The most important document is called Business Requirements Specification from the United Nations for trade facilitation and electronic business (UN, 2018). It describes essential business processes, transactions, and information entities for implementing the e-CMR. Complemented by research on associated DLT-publications (Naerland et al., 2017) and evaluated by selected experts, table 2 shows the ten evaluated key design aspects from a user perspective for a DLT-based solution in practice.

Table 2: Overview of DLT Design Objectives for an e-CMR Implementation

No.	Objective	Description from a User Perspective
D01	Creation	I want to simply create a new e-CMR, so that I can use the document electronically.
D02	Modification	I want to modify an e-CMR in a neutral database to maintain its integrity so that I can adapt it to the circumstances.
DO3	Attachments	I want to attach additional documents and photos to the e-CMR, so that I can report issues in the exchange process.
DO4	Archive	I want to archive and restore the e-CMR, so that I can access it in the event of a legal issue.
DO5	Authentication	I want to access the e-CMR based on authorized and authenticated users to control the distribution of the e-CMR.
D06	Signature	I want to sign the e-CMR with a reliable, unique digital signature (Qualified Electronic Signature) to identify involved stakeholders (cf. signatory ID, sole control, visible changes).

No.	Objective	Description from a User Perspective
D07	Neutral Infrastructure	I want to store my signature in neutral server infrastructure, so that I can guarantee its authenticity and non-repudiation.
DO8	Accessibility	I want to electronically exchange and share the e-CMR with the authorities (e.g., customs declaration, border control).
DO9	Data Structure	I want to see the event, its timestamp, and its unique event ID in the distributed ledger to track the exchange process.
DO10	Data Protection	I want to store my data in a secure environment, so that my data is protected from corruption and threats.

4.3 Design Decisions and Features

According to the derived DOs, we conducted a literature review to identify design features (DF) of different DLT frameworks (e.g., public or private DLTs) and to highlight respective design decisions and trade-offs in the context of DLT taxonomies. We used the presented scientific databases in November 2020 and defined the following search string for a title and abstract search (“Blockchain*” OR “Distributed Ledger”) AND (“Classification” OR “Taxonomy”). The search resulted in a set of 54 documents. We excluded irrelevant (e.g., not available in English, non-research papers) and duplicate publications, resulting in five documents to answer our research question. After an additional full text screening, we selected the morphology of Wieninger et al. (2019) as the most suitable to meet our DOs. Considering the criteria of completeness and degree of detail, it represents a synthesis of sixteen existing DLT morphologies, classifications, and taxonomies focusing on various characteristics. The features are described below:

Participation section

DF1 Authorization to view transactions: The feature authorization to view transactions is divided into a public and a restricted characteristic. Public transactions are visible for everyone (e.g., Ethereum). A restricted read authorization is used in hybrid and private networks (e.g., Hyperledger).

DF2 Right of proposal: Similar to the first feature, the ability to propose a transaction is characterized by a public and a restricted distinction. Different authorization levels regulate the right of proposal.

DF3 Validation of transactions: The consensus mechanism defines who can validate transactions. The validation can be done by anyone (e.g., Bitcoin blockchain), a restricted group (e.g., Hyperledger) or a central, predetermined authority.

DF4 Awareness of identities: Underlying regulatory requirements and other privacy reasons define whether the identities of the participants in a DLT networks must be revealed or remain concealed.

Application section

DF5 Token type: The ownership of a digital unit is represented by a token. It can represent different values or is the value itself. Wieninger et al. (2019) has classified this feature along five characteristics. A cryptocurrency which is used in a digital payment system, a utility token for accessing an application, an asset token representing the asset itself, (e.g., shares or rights), other usages or that no token is to be utilized within the system.

DF6 Incentive for validation: The validation of a transaction requires an incentive for the user to ensure a sustainable maintenance of the network. A distinction is made between a monetary incentive and a non-monetary incentive.

DF7 Location of the assets: In the DLT, information is stored in form of a transaction, which represents a transfer of information (e.g., documents) from one node to another. This document can either exist in the DLT itself or just its link is stored within the distributed network pointing to an external data storage (e.g., IPFS).

DF8 Possibility of change: The possibility of change does not refer to the extension of the distributed network with additional transactions or blocks. Instead, it specifies who can change functionality such as the selection of the notary nodes. If a central power can change the functionality of the network, it is defined as one entity. In all other cases, the possibility of change is distributed over the entire network.

DF9 Source code: The rules of the network are programmed into the source code. In a network where participants do not trust each other, confidence could arise from the fact that the rules are transparent in the source code. When the source code is publicly available, the development of it can also happen through public users. In this context, the term open source is defined as the possibility to access the source code.

Technology section

DF10 Consensus mechanism: The consensus is a central element of the transaction process. The mechanism depends on its implementation and has a strong influence on the scalability and security of the system. If it requires a significant number of resources in terms of energy, storage, activity, or shares, it is described as resource-based consensus (e.g., proof-of-work algorithm). Non-resource-based mechanisms work without users having to provide a substantial contribution. Consensus can already be reached through a unique signature.

Feature 2 Turing completeness: The term Turing complete describes the possibility of a programming language to perform all the calculations a Turing machine is able to make. In a Turing-complete programming language like Solidity, complex conditions can be written, which is essential for smart contracts.

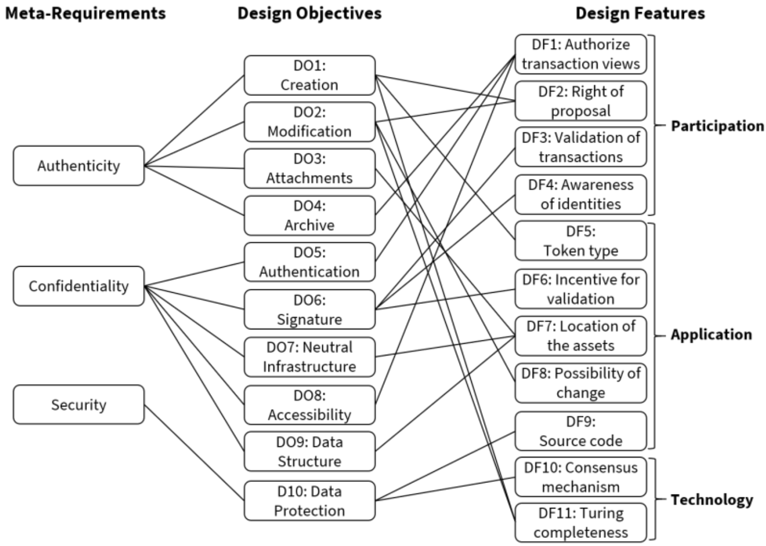

Figure 2: Mapping of Meta-Requirements, Design Objectives and Features

To visualize the coverage between challenges, objectives, and features for establishing a DLT-based document management solution in road transport, we mapped the presented DFs and DOs as well as the meta-requirements in Figure 2. The interdependencies are based on the premises that DLT is a feasible solution to cope with the identified challenges. For example, the meta-requirement *authenticity* (e.g., authenticity of the documents in the event of changes) is the basis for the design objective *modification*. The design objective *modification* can be fulfilled by the design features *right of proposal* (e.g., restricted), *possibility of change* (e.g., not one authority) and *Turing completeness* (e.g., yes, Turing-complete).

4.4 Solution Design

After selection and description of relevant features and their respective design decisions in terms of the morphological box by Wieninger et al. (2019), we extended the existing knowledgebase for a subsequent solution design on basis of existing cross-industry use cases. For the literature analysis on DLT/BC based document applications, the common databases were used. We identified a set of eight publications ranging from health records to legal document solutions and assessed their applicability for a DLT-based document management system in road transport shown in figure 3 (cf. scope, coverage design feature area). As a result, we identified three publications (c.f. Aswin et al. (2020), Chen et al. (2019), Truong et al. (2019)) that mostly cover the relevant DF areas to extend our understanding and specify our solution design.

Use Case / Reference	Scope		Coverage Design Feature Area		
	Focus Road Transport	Practical Contribution	Participation	Application	Technology
Health Record Documents (Lee et al., 2019)	○	◕	●	●	●
Health Record Documents (Xiao et al., 2018)	○	●	●	●	●
Health Record Documents (Aswin et al., 2020)	◔	●	●	●	●
Supply Chain Documents (Chang et al., 2019)	◕	○	●	◑	◑
Trade Documents (Chen et al., 2019)	◑	◕	●	●	●
Finance Documents (Singhal, 2020)	○	○	●	◔	○
Real Estate Documents (Kopylash, 2020)	○	●	●	●	●
Law Documents (Truong et al., 2019)	◔	◕	●	●	●

○ No Coverage ◔ Low Coverage ◑ Medium Coverage ◕ High Coverage ● Full Coverage

Figure 3: Comparison of selected Document sharing Use-cases

The three selected use-cases provide a very good foundation for the application in road transport, where we were able to instantiate a path for each use-case in the morphological box (Figure 4). The first case deals with health documents, where the patients have full control over their records and determine who can access their history, by surpassing the trust issue through tamperproof data via DLT. Existing asymmetric cryptography is used, requiring the users private key for sharing personal data. Accordingly, the architecture consists of four main components, an API module, the platform interface, the IPFS network using Hyperledger. The second case describes an end-to-end cross-border trade solution to share generic documents between multiple stakeholders across the entire supply chain, such as businesses and governments. An attribute-based encryption (ABE) for access connected to a private key for each user is proposed. The encrypted document is stored separately off-chain, where only a hash is kept for validation on the blockchain. The identity and data authenticity verification are done by smart contracts which are also implemented in Hyperledger's chaincode. The last case proposes a law document exchange platform, where a role-based authorization mechanism decides who can read, write, modify, and delete data. The data is distributed and stored over multiple places. A consensus mechanism protects the data from centralized modifications, including three main components (cf., Node JS web application, distributed file storage, and a private DLT system based on Hyperledger).

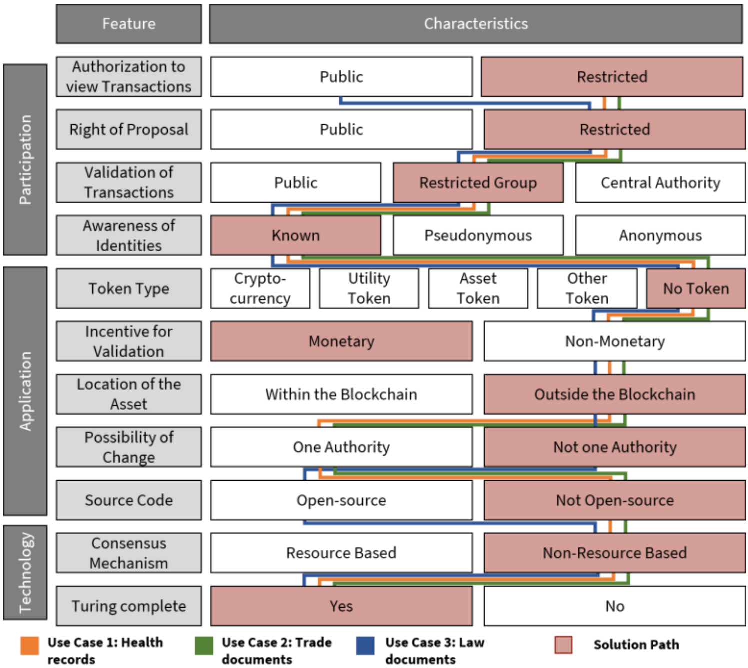

Figure 4: DLT design decision from literature use cases and solution path based on Wieninger et al. (2019)

Before a final solution design can be drawn, we evaluated these insights with two experts from the DLT and road transport domain. The final task was to select one specific design decision for each feature from our morphological box to identify the overall solution path and derive design principles. Beside a restricted authorization and validation of transport transactions by a selected group, a monetary incentive for operating the infrastructure was chosen, mostly driven by cost efficiencies and interoperability. According to "on-chain" data storage limitations, all relevant files (e.g., e-CMR, Pictures), except the identifier should be stored outside the shared ledger. The possibility to change the protocol should be initiated democratically by the group of stakeholders. Because of restricted properties within the network, the source code should not be publicly accessible. To ensure scalability of the network, the consensus mechanism needs to be non-resource based. Turing completeness is the last characteristic chosen by the experts. Overall, great potential for the application was identified. The main advantage lies in one global source of information to be accessed from various actors. Additional value may also come from supplementary functions (e.g., goods insurance or in-transit financing).

4.5 Instantiation and Evaluation of Design Principles

This work aims at an artifact represented by an instantiation that proposes six nascent design principles to be applied in developing a DLT-based document solution in road transport. Design principles are a way of communicating design knowledge within design theories, where the output can be further differentiated according to their maturity and generalizability (Gregor and Hevner, 2013). On the most applicable level, an implemented artifact can be represented by a software product applied in a specific situation. In comparison, design principles and design architectures represent operational knowledge and are more abstract and generic. Based on our solution path, the identified features, and the collected design objectives, we gather first evidence for nascent design principles shown in Table-3.

Table 3: Nascent Design Principles

Design Principles	Description
Data protection mechanism	A DLT document sharing application in supply chain management must be protected by a gatekeeper that restricts access to the private network. Businesses want to avoid liabilities and do not trust each other. They want to keep all information confidential and decide who can participate in their private network.

Design Principles	Description
Application of participation roles	Different participation roles are required to guarantee that predefined tasks are performed exclusively by the relevant owner. Sender, carrier, and consignee run full nodes and are able to read, write, and validate transactions. Their identity is known and are considered to be the main parties in the DLT network. Other parties (e.g., authorities, service provider) operate a lightweight node that allows them to perform basic tasks. Public authorities are only authorized to view documents. This read-only access is important, as it lays the basis for faster processing. The validation is done once the cargo is handed over. The Carrier of the package proposes a transaction while the receiver authorizes it. A monetary incentive is not required, as an agreement defines the handover process.
Tamper-proof data storage	All required documents and attachments are stored via the DLT-system to reduce tampering and ensure transparency in case of modifications. DLT does not efficiently handle big data files. An off-chain storage is applied, where only content-address hashes are stored as transactions and distributed across the network (e.g., IFPS). This combination creates a performant and resilient file storage system. However, it must comply with a restricted group access for sharing the meta-data in case of sensible information.
Neutrality Principle	The owner of a DLT document sharing solution must respect the principle of neutrality. The IT provider can either have the rights to modify the application or pass on some rights to the customers. What is important is that each participant must have confidence in the software provider. This trust can only be achieved if the software provider is not involved in the core business of its customers.

Design Principles	Description
Automated data exchange	Smart contracts are based on a Turing-complete language to be used as an enabler for efficient data exchange mechanisms and process automation. Once goods are handed over, the transfer of ownership and timestamp allows to initiate subsequent financial flows. Smart contract based automated workflows improve working capital management (e.g., days payables outstanding) and complete the transition to automated systems across the supply chain.
Cryptographic data protection	A DLT application in document sharing must provide a cryptographic layer to strengthen data protection. The application provides a single source of truth for several companies, making it vulnerable to cyberattacks. A cryptographic layer helps to protect the data in case of an incident. Privacy is key in data sharing.

The evaluation process in DSR is a crucial element, where the final artifact was reviewed by four experts with extent experience in the domain (Hevner et al., 2004). We applied the evaluation criteria by Sonnenberg and Vom Brocke (2012), namely effectiveness, efficiency, and impact from an environmental and user's perspective. A structured questionnaire was used by assessing the artifact on basis of a Likert scale of 1: fully disagree to 5: strongly agree. Each design principle has been analyzed on its own and is accepted if the experts at least partially agree on the effectiveness, efficiency, and impact. Table 4 summarizes the average of the four expert responses.

Table 4: Evaluation of the Artifact

Design Principles	Effectiveness	Efficiency	Impact
Data Protection Mechanism	4.50	4.50	4.50
Application of participation roles	5.00	4.25	4.25
Tamper-proof data storage	4.50	4.25	4.75

Design Principles	Effectiveness	Efficiency	Impact
Neutrality Principle	4.25	3.50	4.50
Automated data exchange	4.50	3.75	4.25
Cryptographic data protection	4.50	4.50	5.00

5 Conclusion, Limitations, and Outlook

5.1 Principal Findings

Our paper highlights the need for a DLT-based document management system in road transport mainly for three reasons: first, to prevent counterfeiting of e-CMR documents (due to financial tax benefits); second, to solve the trust problem between companies in the supply chain using enhanced data protection mechanisms (access rights) and participant roles (full nodes for sender, carrier, and consignee and lightweight node for authorities); third, to survive a single-point-of failure in case of a cybersecurity incident by using a cryptographic security layer.

The analyzed applications of DLT-based document management systems in different industries use similar design features. Thus, the choice of design features (e.g., validation of transactions) does not depend on the industry. However, DLT-based document management systems have not yet focused on further process automation through smart contracts. In the future, automated end-to-end workflows will add the greatest value through extended use-cases and additional services (e.g., goods insurance, in-transit financing).

5.2 Contributions

Our work has two contributions to practice. First, the evaluation of meta-requirements helps to understand the challenges that transport company face in digitizing their businesses (e.g., confidentiality of personal data). The design objectives may further specify the selection of DLT design features when applying document sharing processes.

Second, the identified design principles give practitioners a basis for decision making in choosing relevant design features for developing applications in other cross-industry use cases. This is very important due to the complexity and the number of DLT design decisions practitioners face when implementing a DLT system for document exchange.

Furthermore, this paper contributes to research by extending the existing literature on document sharing use-cases in logistics and by applying the morphological box of Wieninger et al. (2019) on basis of empirical data.

5.3 Limitations and Future Research

From a practical point of view, the paper is limited by the fact that the experts are mainly from the logistics industry and thus, the DLT design objectives are heavily influenced by their profound knowledge. Despite our efforts to provide a comprehensive literature review, we may not have found all use cases for document sharing. Nevertheless, the selected literature gives a good impression of the existing state of the art. Additionally, DLT is still an emerging technology, where the applied morphological box just represents the current state of research.

Future research should focus on a software implementation and the corresponding performance measurements. Afterwards, the document management system should be benchmarked against other implementations and integrated into a real-life environment. Only in this setting further transformational problems may (e.g., process reengineering) be identified and technical challenges may be improved.

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