Guidance for Cloud Service Selection: Evaluation of a Cloud Broker Platform

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GUIDANCE FOR CLOUD SERVICE SELECTION:
EVALUATION OF A CLOUD BROKER PLATFORM

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Abstract

Cloud brokers are intermediaries supporting the evaluation, selection, and implementation of cloud services. Especially small and medium-sized enterprises with limited technical competencies struggle with a complex and non-transparent market, selecting and combining services from different cloud service providers. They need guidance in the pre-adoption phase to successfully handle selection decisions. Using decisional guidance theory, we have designed a cloud broker platform that aims to provide such guidance. The results of its evaluation show how such a platform improves selection decisions by reducing complexity and structuring the selection process. They also show that the platform’s usefulness may be limited in the case of very complex cloud services depending, for example, on the degree of customization needs. Our study provides design knowledge for decisional guidance (in the context of cloud broker platforms) and shows how cloud service selection can be implemented in practice.

Keywords: Cloud Computing, Cloud Broker Platform, Guidance Support System, Decisional Guidance

1 Introduction

Cloud computing (CC) plays an important role in the current digitization debate, promising organizations of all sizes new benefits such as consuming computing resources (e.g., networks, servers, storage, applications, and services) with low/minimal entry costs, pay-per-use options, and greater flexibility and scalability. While larger enterprises began to benefit from the advantages of CC at an early stage (Wulf et al., 2019), a growing number of small and medium-sized enterprises (SME) are learning that using cloud services creates economic and operational advantages and thus bears great potential (Schneider and Sunyaev, 2016). However, unlike larger enterprises, SMEs often do not have access to the necessary know-how and resources to select, implement, and maintain complex information technology (IT) or the (financial) capabilities to set up and operate their own IT departments (Vithayathil, 2018). Thus, CC is likely to have great benefits for SMEs. However, especially the pre-adoption phase, which comprises the evaluation and selection of suitable cloud services, is a challenging and knowledge-intensive task for potential cloud service consumers (CSC) that requires experience (Wulf et al., 2021), widespread participation, and ownership among heterogeneous stakeholder groups (e.g., business managers, IT departments, etc.) (Winkler and Brown, 2013). These difficulties arise from the variety of available services along with a lack of informational transparency concerning product characteristics, technology, quality of service (QoS), pricing and their intercorrelations (e.g., price/quality trade-offs) (de Vaulx et al., 2017). Additional problems include a lack of universal definitions and standards for cloud services (Höfer and Karagiannis, 2011),
problems of comparing the characteristics and performance metrics of cloud services across various maturity levels and quality standards, and different naming conventions for the same services, an understanding of which requires domain-specific knowledge on the part of the CSCs (Slawik and Kümper, 2014). This leads to a state of ambivalence among SMEs. On the one hand, they are limited by a lack of know-how and resources while dealing with complex IT such as CC. On the other hand, they are forced by ongoing IT innovations to digitize their businesses to maintain efficient processes and remain competitive. As a result, SMEs increasingly need decision aid in the form of explanations (Silver, 1991) and guidance (Morana et al., 2017) to prepare and assist the decision-making process.

The research project behind this study contributes to closing this gap. The here-presented study itself summarizes the evaluation results of a prototypically implemented cloud broker platform (CBP) for supporting the cloud service selection process with a digital platform design (de Reuver et al., 2018). Following a design science research (DSR) approach (Hevner et al., 2004; Peffers et al., 2007), we first developed design principles (DP) for an IT artifact in this project, making use of knowledge from both existing research that has proved to be valuable and practical insights. We then evaluated the proposed design with practitioners in an almost real-world context. Our evaluation results indicate that the proposed design is a useful and effective instrument in the pre-adoption phase of cloud services. More precisely, the platform enables decision-makers in SMEs to profoundly improve service selection in comparison to common selection strategies such as using web searches, criteria catalogs, or comparison portals. However, our results indicate limitations in the case of complex cloud services. Our contributions to theory and practice are threefold. First, our results show that a cloud broker platform can improve the process of selecting cloud services by providing explanations (i.e., detailed information about cloud services) and decisional aid in the form of service recommendations. Second, such a platform can reduce complexity (e.g., aggregating, presentation of services, etc.) and force CSCs to comply with a predefined process. Third, our DPs provide prescriptive knowledge that may serve as a blueprint to facilitate the development of similar cloud broker platforms or extend existing platforms.

The remainder of this paper is structured as follows: we first present the theoretical background of decisional guidance, cloud computing, and cloud brokering. In Section 3, we describe the context of the research project. In Section 4, we detail the methodology of this study, including the evaluation strategy and data collection. We then present the evaluation results of the prototype in Section 5, which is the primary focus of this paper. In Section 6, we discuss the results and their contributions and limitations for research and practice and conclude with a summary and outlook (Section 7).

2 Theoretical Background

2.1 Decisional Guidance and Guidance Systems

Decisional guidance and related concepts have been widely discussed in the literature and are well-established in the information systems (IS) community. According to Morana et al. (2017), there are three streams of guidance in IS and decision support systems research: (1) decisional guidance, (2) explanations, and (3) decision aids. Decisional guidance (a form of guidance (1)) can either be informative, i.e., “providing pertinent information that enlightens the decision maker’s judgement without suggesting how to act,” or suggestive, i.e., “making judgmental recommendations”, i.e., recommending what to do (Silver, 1991, p. 108). Explanations (2) provide information such as why certain questions were asked or what certain terms mean and help to make something clear and understandable (Gregor and Benbasat, 1999). Additionally, explanations “will be used when the user lacks knowledge needed so he or she can contribute to problem-solving” (Gregor and Benbasat, 1999, p. 507). Decision aids (3) can either be a part of a decision strategy that assists in building a system to support a decision task (Todd and Benbasat, 1991), or they can be “intended to provide a specific recommendation to a given problem and/or provide expert advice that assists the user in making a better decision than when unaided” (Arnold et al., 2004, p. 13). Guidance systems such as decision
aids or decision support systems use the concepts of decisional guidance (e.g., helping users in decision-making) by referring to guidance design features (DFs) during the system’s implementation (Silver, 1991).

Morana et al. (2017) developed a ten-dimension taxonomy of guidance DFs, which we have adapted to the context of this research project. We then narrowed Morana et al.’s focus to four of these guidance dimensions: “form,” “mode,” “intention,” and “audience” as they appear to be most relevant in the context of SMEs. In addition to the form of guidance (informative/suggestive), the mode of guidance distinguishes predefined, dynamic, and participative guidance and describes how guidance is generated. Predefined guidance is defined as guidance that is prepared (e.g., a knowledge base implemented from experts a priori); dynamic guidance is generated by an adaptive mechanism that “learns” as the system is used (e.g., provides enhanced recommendations through intensive usage). Finally, participative guidance allows for increased user participation (e.g., service suggestions improved through user feedback) and therefore provides decisional guidance (Morana et al., 2017). The intention of guidance describes the context of why guidance is provided and can be clarified by providing additional information and/or making recommendations (i.e., giving advice intended to be used for recommending decisions) (Arnold et al., 2004). Finally, the dimension audience of guidance has two characteristics—novices and experts—and describes which types of users are being addressed. Novices are users with little to no knowledge or expertise within the domain, and experts have a high amount of knowledge and expertise. Since the required guidance for these two types of users may vary greatly (e.g., novices need more explanations than experts), the target audience should be considered in the design of a guidance system (Ye and Johnson, 1995).

### 2.2 Cloud Computing and Cloud Brokering

CC allows companies to gain access to a shared pool of managed and scalable IT resources on a rental basis (e.g., pay-per-use, pay-per-period, etc.). The resources (e.g., networks, servers, storage, applications, services, etc.) are offered in a scalable way via the internet without the need for any long-term capital expenditures or specific IT knowledge on the customer side (Venters and Whitley, 2012; Yang and Tate, 2012). CC represents a transformational shift in IT that is rapidly changing the way organizations manage and deliver IT services over the internet. Especially in large organizations' IT departments, CC has become an everyday phenomenon (Kappelman et al., 2017; Wulf et al., 2019). Through CC, SMEs can gain access to state-of-the-art technologies and standards without having to concern themselves with their development, maintenance, and/or operations (Mitra et al., 2018). For a long time, these technologies were only available to large companies. CC services are typically classified by type of service differentiated by the resources used, (e.g., according to application [SaaS], platform [PaaS] and infrastructure [IaaS] levels (Mell and Grance, 2011)). IaaS provides low-level infrastructure such as virtual machines, PaaS provides a platform for developing applications, and SaaS delivers entire applications.

Due to the proliferation of CC, a large number of different cloud offerings accompanied by a high degree of complexity have emerged (Sun et al., 2014; Elhabbash et al., 2019). For example, Amazon Web Services offer numerous services ranging from basic infrastructure services such as compute resources to ready-to-use software solutions. This makes comparisons difficult and overwhelming for consumers in the selection process. As a result, it is challenging for (novice) CSCs to predict the long-term effects of a decision in advance (e.g., vendor lock-in). These challenges affect smaller companies in particular as they often have limited technical expertise in handling complex technologies (El-Gazzar, 2014).

In order to bridge the gaps mentioned above, cloud brokers have emerged to act as an intermediary between CSCs and CSPs. In general, intermediaries are agents working to improve the match between suppliers and customers (Wigand, 2020) and reduce the number of possible contacts between trading partners (Bakos, 1991). Cloud brokers perform tasks such as the selection, integration, or delivery of cloud services and also fulfill functions such as aggregating information concerning goods and fostering trust between cloud providers and cloud consumers (Hogan et al., 2011). For both parties
reducing search costs (e.g., searching for products, sellers, or buyers), contracting costs (e.g., carrying out the contract), and adaptation costs (e.g., costs incurred in making changes during the life of a contract) are the main benefits of using a cloud broker (Wigand, 2020).

Today, there are many examples in which human intermediaries (e.g., brokers, wholesalers, agents, etc.) have been replaced with virtual forms such as digital marketplaces or platforms (e.g., Airbnb, Uber, etc.). The development of CBPs has also emerged within the context of electronic markets as a virtual organizational form through the automated mediation of market transactions (Rose, 1999).

Existing research on cloud broker systems or services (see Figure 1 for an overview) primarily focuses on evaluating and comparing different clouds in functional and non-functional aspects on a very generic level. For example, Slawik et al. (2018) focus on Open Service Compendium's business-relevant characteristics, wherein common cloud service criteria are presented through the lens of business vocabulary such as cloud service models, pricing, security, and quality of service (QoS). Evaluating and ranking quantitative QoS attributes based on the Service Measurement Index was surveyed in Garg et al. (2013). Jung et al. (2013) propose a cloud recommendation platform focusing on QoS configurations such as cost, performance expectations, etc. However, these generic approaches (No. 1, Figure 1) principally focus on comparing rudimentary cloud capabilities (e.g., evaluating various workloads on different clouds) rather than proposing guidance to select appropriate cloud services for CSCs. Consequently, users are challenged to either provide low-level specifications (e.g., resource requirements for applications) that are measurable and have comparable functional requirements or are limited to technical issues that can be solved using multiple-criteria decision-making methods (Rehman et al., 2011).

Besides these generic approaches, some approaches only deal with brokering on PaaS and IaaS levels (No. 3/4, Figure 1). Also, very little research has been done regarding cloud brokering in the SaaS field (No. 2, Figure 1).

![Figure 1: Overview of related work on cloud broker systems grouped by cloud service models](image)

In summary, the identified studies on cloud broker systems indicate that most approaches focus on generic brokering concepts. This means that they focus on evaluating and comparing different cloud capabilities (e.g., costs, performance, etc.), such as providing methods for workload assessment through different clouds or contributing some rudimentary recommendation features that help compare
twenty-nine different cloud providers. Moreover, there is some isolated research on each topic, but only a few insights into the combination of the underlying concepts exist. Neither organizational aspects such as adequately providing explanations for identifying CSCs’ requirements nor providing decisional guidance for selecting suitable cloud services are mentioned. Also, we were unable to find any approaches specific to the needs (e.g., limited technical expertise) of SMEs (Gupta et al., 2013; Hentschel et al., 2019).

3 Project Background

3.1 General Research Approach

CSCs, especially those in smaller companies, require (1) more explanations and decisional guidance to prepare the decision-making process in the best way possible and (2) more concrete assistance, i.e., in the form of decisional aids on how to execute the selection process. Therefore, we started a research project pursuing the following objectives:

- A conceptual design of a cloud broker platform to enhance the selection process of cloud services for SMEs in the pre-adoption phase
- An instantiation of the conceptual platform design and its systematic evaluation with experts in an almost real-world context

We followed a DSR approach (Hevner et al., 2004; Peffers et al., 2007), which is useful to address real-world problems (Venable et al., 2016) due to its iterative design and evaluation of the proposed artifact: a CBP supporting CSCs in evaluating and selecting cloud services during the pre-adoption phase, by taking the target group—that is the respective CSCs in SMEs—into account. Our instantiation focuses on a CBP for SaaS (e.g., collaboration tools or cloud storage) because first, these services have a high number of potential service configuration options, and second, the selection of SaaS is often made by business departments without the involvement of the IT department (Winkler et al., 2011) since the (technical) service responsibility for SaaS is already located within the CSP (Tang and Liu, 2015). This makes decision support for SaaS services highly useful (see Figure 1). For developing the platform, we adapted the DSR framework of Vaishnavi and Kuechler (2007) and extended the framework by distinguishing between the demonstration and evaluation phases, drawing on Peffers et al. (2007). The applied procedure model includes six steps (Figure 2), with step V being the major focus of this paper. Step VI, which includes implications and lessons learned, is partially covered in this paper.

Figure 2: Research design, activities, and outcomes adapted from (Vaishnavi and Kuechler, 2007)

We started the design cycle by investigating the underlying needs and problems perceived in real-world contexts from both the provider and user perspectives and supplemented these by an extensive review of the academic literature (Hentschel et al., 2018, 2019). We conducted exploratory interviews with sixteen CSPs as well as semi-structured interviews with eleven CSCs from SMEs. In these interviews, we gained in-depth insights into the CSC processes for selecting, evaluating, and implementing cloud services and knowledge about the provider perspective. This ensured relevance for business practice (Peffers et al., 2007) and therefore created awareness. Building on these
empirical findings and the existing body of knowledge found in the literature, we completed phase 1 by deriving a set of design requirements (DR) for cloud broker systems addressing the problem domain. These formulated and theorized DRs describe the goals, scope, and boundaries of a class of solution artifacts (Walls et al., 1992; Gregor and Jones, 2007; Gregor and Hevner, 2013). In phase 2, we used the knowledge incorporated in the DRs to make a suggestion, thus conceptualizing tentative DPs using the concepts of decisional guidance (Silver, 1991) as justificatory knowledge (Gregor and Jones, 2007). Therefore, we proposed six DPs for the development of CBPs as a meta-design in the vocabulary of Walls et al. (1992). We then instantiated the design in the development phase in the form of a prototype artifact by mapping the derived DPs onto DFs. These DFs represent specific capabilities related to each of the DPs (e.g., the concrete matchmaking method chosen), which we ultimately implemented in a prototypical CBP and thus demonstrated proof-of-concept (Nunamaker and Briggs, 2011). We have previously used formative evaluation within the development/demonstration phase. However, in order to receive further, summative feedback to ensure that the instantiated artifact, i.e., the platform is an effective instrument for solving the underlying research problem in an almost real-world scenario, we qualitatively evaluated the artifact with experts from CSCs following a “Human Risk & Effectiveness” strategy based on Venable et al. (2016). In this phase 5, which is the focus of this paper, we evaluated the effects of the instantiated DPs by conducting semi-structured interviews with real CSCs (e.g., real users) in the context of a realistic cloud sourcing case on the platform. Before detailing this phase, we recapture the prior phases’ main results in the following two sub-sections. In the conclusion phase—which will also be addressed in future work—we try to abstract the results by presenting the implications and lessons learned for practitioners and academics.

3.2 From Awareness of Problem to Suggestion

In our prior research, we conducted an extensive review of the academic literature and semi-structured interviews with experts from CSPs in addition to CSCs (Hentschel et al., 2018, 2019). In order to understand the cloud adoption challenges, we linked the users’ perspectives with the providers’ perceptions and thereby deepened our understanding of cloud sourcing decisions. We generalized the challenges SMEs face and derived a set of DRs, which were then put into the context of cloud broker systems as follows:

(1) Limitations in service comprehension, leading to considerable efforts for the pre-selection of suitable cloud service candidates.

(2) Limitations in technological competence and IT experience.

(3) Limitations in a vendor relationship, i.e., lacking cooperation within the parties

(4) Limitations in automation and software support.

Based on these CC challenges, we were able to derive six general DRs (Hentschel, 2020a) that describe the goals, scope, and boundaries of a class of systems called cloud broker systems. These DRs were mapped to the required types of decisional guidance. We posit that DRs are generic requirements that any cloud broker system needs to address to master the previously identified challenges (Baskerville and Pries-Heje, 2010). We suggest a conceptual CBP design derived from these requirements as a potential solution, i.e., a meta-artifact, utilizing justificatory knowledge (Gregor and Jones, 2007) from the body of knowledge on decisional guidance and on digital platforms to improve cloud-services selection for CSCs.

We followed Chandra et al.’s (2015) structure for DP formulation and accordingly formulated our principles as action-driven and materiality-oriented DPs that prescribe what an artifact should enable users to do and how it should be built in order to do so. Regarding the platform design, this means that the platform must utilize specific capabilities (e.g., intelligently aggregating, filtering, and displaying relevant information) and should consider the identified types of guidance in order to provide the required support (see Figure 3).
Enhance service discovery

Engage novice consumers

Embrace matchmaking mechanism

Engage participation of third parties

Minimize consumers’ time-effort

Learn from consumers’ actions

Tentative Design Principles

Provide CBP with an ontology-based mechanism that allows detection of commonalities and differences of cloud services to create a common understanding

Provide CBP with features that allow (novice) consumers to find relevant cloud services with no/low domain-specific knowledge from multiple sources in order to enhance knowledge for decision-making

Provide CBP with features which allow consumers to elaborate and validate the defined requirements in order to provide adequate discovery results

Provide CBP with matchmaking capabilities that allow consumers to get recommendations of cloud services in order to limit the effort required for selection and to improve decision-making

Provide CBP with a feedback capability that allows consumers to provide/generate knowledge from former selection projects in order to enhance matchmaking capabilities

Provide CBP with features that allow consumers to interact with other agents (e.g., consultants, integrators) to have access to expertise and obtain participative guidance

Figure 3: Deriving Design Principles from Design Requirements

3.3 Development and Demonstration of the Platform

In order to instantiate the DPs in the form of a software artifact (i.e., a CBP where CSCs can initiate new cloud service selection projects), we mapped the derived DPs to DFs which represent specific capabilities (e.g., the concrete matchmaking method). For the development process, we have grouped these DFs into broader components that serve as the basis of the platform architecture (Figure 4). We defined the Requirement Input Component as DF1, which satisfies DP2 and DP3. This component was realized using a multi-level input on the CBP’s front-end, where the CSC can specify requirements the cloud service should satisfy. Since complex technologies can be hidden within the services, this specification is provided in the form of questions about the planned use cases, which in turn reduces complexity and simplifies the handling for novice CSCs (DP2). As a correct identification of requirements is essential for the later matchmaking, the system asks the CSC a minimum number of questions. Each requirement can then be weighted to identify the CSC’s priorities using rating scales (DP3).

We then implemented an ontology-based mechanism using feature service models (Wittern and Zirpins, 2011) in the Decision Component (DF2) to discover and represent the commonalities of cloud services (DP1) and thus make automated matchmaking possible (Hentschel, 2020b). Each decision component can contain additional sub-components that can be addressed and enriched with the information provided by the CSPs who join the platform. Currently, the implementation is confined to one sub-component, more precisely, a SaaS catalog with features of cloud storage offerings (e.g., encryption, replication etc.). Additionally, the decision component contains a feedback mechanism designed to address DP5, which is implemented as an AI-based algorithm that learns from successful or non-successful use cases. This information is provided by the CSC who submits their degree of satisfaction with each criterion. Subsequently, the matchmaking can be improved by training the algorithm in accordance with these results.

The third component, the Cloud Matchmaker Component (DF3), performs the matchmaking through filtering, aggregating, and presenting the candidates that are most suitable for the CSC in the form of recommendations (displayed according to the degree of fulfillment) (DP4). We realized the matchmaking based on a comparison of normalized requirements vectors on the CSC and CSP sides.

Finally, we conceptualized an Evaluation Component (DF4), which enables CSCs to involve third parties (e.g., consultants, integrators, etc.) in order to satisfy DP6. Opening the platform to other parties allows them to offer value-added services and enables CSCs to receive expertise and build trust and confidence in potential partners and vendors.

The prototypical implementation serves as a demonstration that comprises a proof-of-concept of the DPs (Peffers et al., 2007). For this purpose, we instantiated the platform as a web application in Angular (https://angular.io/), providing a state-of-the-art user experience on the front-end. For demonstration, we limited the platform to one type of cloud service—cloud storage—as we wanted to
keep the effort manageable. The platform demonstration step already includes a formative evaluation (see Hentschel et al. (2020) for further details).

![Diagram](image)

**Figure 4. Mapping of DPs to concrete DFs. These features were implemented. Greyed out components are conceptualized but not yet implemented in the prototype.**

4 Evaluation Methodology

4.1 Evaluation Strategy

The goal of our ex-post evaluation is to provide evidence that the proposed conceptual design of the platform can be instantiated in the form of an artifact that addresses the outlined problems (DRs) and achieves the expected benefits (DPs) for CSCs (e.g., provide adequate discovery results, simplifies the handling for novice CSCs, etc.). Therefore, the Framework for Evaluation of Design Science Research (FEDS) was applied using the "Human Risk & Effectiveness" evaluation strategy. This strategy quickly progresses to more naturalistic settings for evaluations, including summative evaluations towards the end that focus on the rigorous evaluation of the effectiveness of the artifacts (e.g., utility) (Venable et al., 2016). We conducted such a summative ex-post evaluation of the instantiated platform prototype through a qualitative evaluation in an almost naturalistic setting with potential consumers. For this purpose, we used interviews as an opinion-based method (the “how” of evaluation) to evaluate the artifact (Kriglstein et al., 2016).

According to the design evaluation guidelines established by Hevner et al. (2004, p. 83), the “utility, and effectiveness of a design artifact must be rigorously demonstrated”. Other authors use “usefulness” as a synonym for “utility” (Peffers et al., 2007). However, several other evaluation properties/criteria for IT artifact evaluations are mentioned in the DSR literature (Cleven et al., 2009; Prat et al., 2015). Some are more generic (e.g., useable, reliable), while others are more specific (e.g., security awareness). Thus, the definition and choice of the evaluation properties are highly dependent on the DSR project’s goals (Venable et al., 2016). For our evaluation, we combined the DSR evaluation criteria (the “what” of evaluation) proposed by Sonnenberg and vom Brocke (2012) for instances of an artifact with the criteria from Gill and Hevner (2013).

These common criteria in IS literature include “ease of use (the degree to which the use of the artifact by individuals is free of effort) (Davis, 1989); “usefulness” (the degree to which the artifact positively impacts the task performance of individuals) (Davis, 1989); and “effectiveness” (the degree to which an artifact achieves its goal(s) in a real situation) (Venable et al., 2012).

The usefulness criterion plays an important role in motivating the use of an IT artifact. The perceived usefulness of an artifact strongly correlates with user acceptance and should not be ignored in
successful system design (Davis, 1989). Together with ease of use, it is well established in technology acceptance research (Gill and Hevner, 2013).

The evaluation property effectiveness is usually used to test if an artifact works in real-world settings (Venable et al., 2012). Instead of using a metric-based benchmarking of the artifact, which is hampered by our inability to measure and compare it to results from other approaches, we used a practice-based evaluation of effectiveness (Prat et al., 2015). To do so, we asked the participants (1) whether the selection process using the platform is a fundamental improvement over previously performed decision-making processes, and (2) to what extent (higher than/equal to/less than) the platform is an improvement in terms of time, personnel expenses and required expertise. The effectiveness is also intended to evaluate the extent to which the implemented DFs have an effect and thus yield the improvement the conceptual platform design initially targeted. Nevertheless, we can speak only of an almost real situation in our case because the instantiated platform was not used for a real problem, yet a realistic one. Therefore, the situation can be positioned in between artificial and naturalistic (Prat et al., 2015).

4.2 Data Collection

The study was structured in three parts: (1) context, (2) demonstration, and (3) feedback. In the context phase, a 12-minute video containing the research background, the (simplified) design goals, and the principles of the concept (meta-artifact) was presented. In the demonstration phase, the prototype was introduced to the participants by a click-through sample process within the CBP. This was done by selecting cloud storage as an exemplary cloud service. In the feedback phase, we engaged the participants in an open discussion following a set of guiding questions referring to proposed evaluation properties. In addition to the artifact-related questions, we asked the participants about the current selection process for cloud services in order to gain a better understanding of their actual situations. We also wanted to know if the interviewees have concerns or see barriers that could hamper widespread use of the platform.

Due to the ongoing COVID-19 pandemic, the evaluation was conducted by entirely digital means. We asked ten experts from different sectors and company sizes in Germany who had been substantially involved in the decision-making process of cloud service selections in the past. The majority of the participants were on the executive level of the company, and with one exception, all work for SMEs, thus reflecting the targeted user group. Table 1 illustrates the study participants. The interviews were conducted between October 2020 and the beginning of November 2020. The duration of the interviews ranged from 25 to 40 minutes. All interviews were recorded and then transcribed for analysis using MAXQDA (release 20.2.1). To ensure comparability, the interviews were conducted using semi-structured interview guidelines. To identify common themes, the statements of the interviewees were coded and analyzed by the first author and then reviewed by one of the other authors. The evaluation criteria were chosen as a basis for the interview guidelines and the subsequent coding process.

<table>
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Micro-enterprise: 1 to 9 employees, Small enterprise: 10 to 49 employees, Medium-sized enterprise: 50 to 249 employees, Large enterprises: more than 250 employees

Table 1. Overview of the interview partners
5 Evaluation Results

5.1 Current Cloud Service Selection

We started our interviews by asking participants about their current process of cloud service selection. Only one participant (P06) mentioned examples of using a system or a platform to facilitate selections. The majority of participants did not use tools in the pre-adoption phase but instead made use of web searches (P01, P02, P03, P04, P05, P07, P08) and comparison portals (P01, P06). Also, participants viewed demo or trial versions of potential cloud services as an appropriate way to get started. A structured requirements analysis was performed by three companies (P03, P07, P09). P04, for example, emphasized that the decision for or against a service “starts with a phone number that you can call. This is often no longer the reality with many providers. If you have a problem, you’re left out in the rain. This means that it is essential for me personally that there are people on the other side with whom you can talk”. We also asked how many and which stakeholders were involved in the cloud service selection decision. Nine of our interviewees mentioned at least three stakeholders, and P07 even named eight stakeholders. These stakeholders were mainly working in business or IT departments. In the case of P07, the complete in-house server infrastructure was replaced by an IaaS solution, resulting in higher numbers of consulting stakeholders because subsequent IT users were involved. External stakeholders were involved in the cloud sourcing process in five of the ten companies (P05, P06, P07, P09, P10) and in only three companies during the selection phase (P05, P07, P10). The other companies only consulted external stakeholders during the implementation and integration phase(s). Overall, the majority of participants used web searches, comparison portals, or demo versions to evaluate and select appropriate cloud services. Only a few companies proceeded in a more structured manner (e.g., requirement analysis, decision matrix, etc.) or used the support of a guidance system (e.g., platform).

5.2 Ease of Use and Usefulness

In general, the participants perceived the artifact very positively regarding ease of use and interaction within the platform (90%). Only one interviewee (P06) had problems understanding how to define the criteria across different cloud service categories: “The criteria would then be defined individually, for example, if it is a cloud storage or a cloud software system? That means that depending on the system and requirements, there would be different questions, right?” Since the CBP also targets novice users, two of the interviewees critiqued the terminology used in the selection process within the platform. For “users who are not dealing with IT systems every day, some technical terms might not be clear” (P01). P02 mentioned that specifying the detailed criteria after choosing the use cases for the cloud service could be a demanding task for non-technical users. The interview partners also made suggestions for improvements designed to meet these concerns. For example, the artifact could implement a help option to provide additional information if criteria are unclear (P02) or display a tooltip that explains, for example, what an ISO 27001 certification is (P01).

We asked which of the implemented features were deemed especially useful, less useful and which features were missing and should be implemented to enhance the platform's usefulness in practice. Seven of ten participants highlighted the way of specifying and categorizing requirements following a guided process (Requirement Input Component (DF1)) as very useful (P03, P05, P06, P07, P08, P09, P10). A participant mentioned (P05), for example, “there is no classic service description [on the platform]; instead the journey begins with the consumer’s problem”. Also, P03 described the guidance through the use-case assistant as: “[…] the assistant function with the different questions and the pre-staging […].” Additionally, three interviewees considered knowledge transfer/learning to be satisfactory by identifying the platform as useful (P01, P07, P09). P01 said: “I liked very much that you can see which certifications are available, for example. There were certificates that I didn’t even know about. This means that knowledge is actively conveyed to you”. Regarding missing features, it was noted that besides the already implemented weighting of individual criteria, users should also be able to define exclusionary criteria (P03, P07, P08).
5.3 Effectiveness

Concerning the selection time—i.e., the time required for a cloud service decision to be made—nine participants confirmed that less time will be required when using the platform than was required by their previous methods. Only P09 mentioned an equal or higher time-effort for service selection: “Of course, the time required is less if you just use the platform, but if you consider [the selection criteria] as an impulse to think, it is, of course, longer again, because then you start to think”. Three participants were more explicit about the artifact’s time-saving properties, which mainly result from the clearly defined selection process, esp. the matchmaking step, on the platform (P02, P05, P06). This means the Cloud Matchmaking Component (DF3) seems to be a useful instrument to address the targeted effort reduction as formulated in DP4. In terms of the personnel involved in such selection decisions, all participants confirmed that a smaller commitment of personnel is possible when using the CBP. Having limited expertise (i.e., know-how in the cloud domain) does not necessarily mean that the selection is more effectively supported through the broker. Five participants indicated that the required expertise would be lower when using the CBP (P01, P02, P04, P05, P06, P07). However, the other five interviewees confirmed that the required expertise would be unchanged (P02, P03, P08, P09, P10). In addition to the benefit of gaining access to expert knowledge in an aggregated form (P01), the automated recommendations of suitable cloud service candidates also represent a major enhancement, as can be seen in the following remark: “[. . .] I have never seen an automated suggestion system like this before. So that’s why I see potential and a significant improvement in any case” (P06).

5.4 Learnings from Using the Platform

We also gathered lessons learned from statements of interview partners while using the platform in practice. Using the platform can increase trust, as the platform owner ensures the correctness of the information provided by CSPs on the one hand (P01, P03), but also requires a high level of trust in the platform itself on the other hand (P07, P09). P01 mentioned, for example, “[. . .] because I have a higher trust in the results of such a platform than in an anonymous site on the Internet.” Therefore, it is important to guarantee the platform’s objectivity (e.g., recommendations, ranking, etc.) and to communicate the financial interests/business model of the CBP (e.g., agreements or commissions of CSPs that are guaranteed in case of a brokerage) (P01 - P05, P07 - P10). Additionally, concerns were stated about the selection support of more complex cloud services, such as CRM or ERP systems (P03, P04, P07, P10). P04 mentioned, for example, “[. . .] I just ask myself, how many questions have to be answered to get the perfect solution in terms of functions and costs”. In this context, the quality of the data, such as information quality, completeness, or timeliness, was also mentioned as challenging (P05, P09). Data privacy concerns—for example, that personal information might be shared with vendors for marketing purposes (P02) or that sensitive information about the IT services used in the company may become public (P05)—were occasionally stated. Additionally, one participant mentioned the risk that the platform might provide an incomplete overview of the market as a concern (P05).

6 Discussion

The evaluation of the instantiated artifact of a CBP, allows us to derive several implications for the platform design. At the level of DPs, no recommendations leading to an improvement of the conceptual platform design were derived. Concerning DP1, the ontology-based mechanism enabled, as expected to discover and represent the commonalities of cloud services and improved receiving adequate service recommendations in comparison to not using a tool (DP3), although it does not necessarily require less domain-specific knowledge (DP2). Consequently, we also measured effects of saving time for cloud service selections that means the matchmaking affected the effectiveness of
selection decisions (DP4). The effects regarding DP5 and DP6 cannot be assessed based on the evaluation results, as they have not been implemented in the prototype so far.

At the instantiation level, the study participants confirmed improvements for cloud service selections using a guided, intuitive selection process via the CBP. They appreciated the implemented guidance design features but also provided suggestions for improvements and expressed limitations. For using the platform in practice, further improvements regarding detailed descriptions of cloud service features or pricing models should be implemented. In addition, enhancements should be made to further reduce the required knowledge and expertise for selecting cloud services through the CBP. Finally, the platform could be improved by sharpening the CSC’s understanding of the selection decision by actively contributing to knowledge transfer and thus supporting the decision-making process.

In our evaluation, ten experienced practitioners indicated that the instantiated platform would be particularly valuable in the pre-adoption phase of cloud services and therefore indirectly confirmed that the proposed platform design is useful and effective. This means that providing guidance regarding requirement specification, complexity reduction (e.g., aggregating, presentation of services, etc.) enlightens the CSCs’ minds and enables decision-making without requiring extensive IT knowledge.

The evaluation results also show that the instantiated platform positively affects the effectiveness of cloud service selections (e.g., faster service discovery). As a result, the artifact provides an improvement in comparison to current selection approaches such as using web searches, criteria catalogs, or comparison portals.

Our findings contribute to both IS theory and practice. From a theoretical perspective, our paper contributes to the field of decisional guidance research (Silver, 1991; Morana et al., 2017). Although decisional guidance positively affects outcomes such as decision quality and decision confidence in other contexts (Limayem and DeSanctis, 2000), we evaluated the guidance concept within an instantiated prototype of a CBP. Consequently, we have implemented different types of decisional guidance as DFs in a prototype that provides explanations (i.e., detailed information about cloud services) and decisional aid (i.e., suitable service recommendations). Additionally, we contribute to the IS design knowledge base by providing DPs as abstract design knowledge evaluated through instantiating the suggested platform design (Sonnenberg and vom Brocke, 2012) and following the evaluation strategy proposed by Venable et al. (2016). Our research can be classified as an improvement because we have provided a new solution to a known problem (Gregor and Hevner, 2013). By formulating general DPs, we provide not only abstract but also prescriptive knowledge (Chandra et al., 2015), as these principles may serve as a blueprint for developing similar systems or may be adapted to fit multiple contexts.

From a practice perspective, our research contributes by proposing and instantiating a CBP that supports (novice) CSCs in their decision-making process regarding cloud service selections. The results of our evaluation show that such a CBP can have a positive impact on SMEs (e.g., by reducing complexity, required time-effort, etc.) and enhance selection decisions, even in cases of little expertise. Furthermore, our study shows that a guided selection process, as provided by the platform, enlightens the CSCs’ understanding by structuring the process and forcing CSCs to deal with requirement definitions and the evaluation of important selection criteria. Consequently, our CBP can provide a more efficient selection process, thereby saving costs due to time savings and partially reduced personnel requirements. Moreover, using the platform can also increase CSCs’ sense of trust because the platform acts as a mediator that ensures the correctness of the information provided by the CSPs.

Although we have demonstrated an improvement for CSCs using the platform for cloud service selections, some limitations remain. First, the platform provides limited decision support for more complex cloud services such as ERP or CRM. The effort required to define all relevant criteria coupled with the possible degree to which these criteria can be (formally) described can be challenging and overwhelming for (novice) CSCs. Also, extremely specific cloud service requirements or cloud services that require business process reengineering (i.e., important customization needs) could hamper the platform's usefulness. As a consequence, reducing complexity means making tasks
easier for CSCs on the one hand, but it could also lead to a loss of information that could be necessary for precise requirements specification on the other hand. Therefore, we argue that the platform is especially useful for cloud services with low-to-medium customization needs (e.g., cloud storage, accounting software, etc.). Typically, these are services with lower business specificity, either generic services encompassing the whole enterprise or services with a rather small functional scope.

Furthermore, the cloud service recommendations that are suggested by the platform through matchmaking are not useful in every case. The platform hides/reduces technological depth, such as performance metrics (e.g., maximum throughput per second) or compatibility with other services, in order to make decisions easier. However, in some cases, it may be necessary to know the exact specifications in order to make a meaningful selection decision. For example, a real-time application requires the lowest possible latency. In order to determine this information, further benchmarks and detailed analyses would have to be conducted. Consequently, these requirement specifications cannot be performed via the platform, which highlights the platform's focus on the pre-selection phase of cloud services.

Finally, as part of our evaluation, we also discussed the potential concerns of using a cloud broker platform. We observed that the participants have concerns about the economic interests of the platform owner. Therefore, it is important that service recommendations (i.e., the results of a selection process) are objectively and transparently derived through the matchmaking mechanism and not through financial commitments from CSPs or other platform participants. Moreover, participants expressed concerns about the relevance and timeliness of the data. Since the CC market changes very quickly and services are constantly being added or becoming obsolete, the platform owner will have to put forth a lot of effort to regularly update the platform’s databases and decision rules in the matchmaking system.

In summary, we measured the effects of the derived DPs on decisional guidance using a CBP compared to cloud service selections without guidance features. The positive results of our prototype evaluation have shown that our proposed design has validity in the pre-adoption phase of cloud services, which indicates the ease of use, usefulness, and effectiveness of the instantiated CBP artifact.

7 Conclusion

In this paper, we present the evaluation of an instantiated CBP as an artifact in a DSR project using decisional guidance theory to support SMEs by making cloud service selection decisions more effective. We instantiated a previously developed conceptual platform design with six DPs, derived from relevant literature and interview studies that described how CBPs can provide decisional aid for SMEs in finding and evaluating appropriate cloud services. Consequently, we developed a prototype of the platform in order to evaluate the proposed concept with ten well-experienced interview participants.

We contribute to research on cloud broker systems by proposing a CBP that combines guidance design features with an innovative matchmaking mechanism based on a digital platform, thereby demonstrating the feasibility of the derived DPs supporting CSCs’ decision-making. Our DPs provide prescriptive knowledge and may serve as a blueprint to facilitate the development of similar cloud broker platforms or to extend existing platforms. For practice, the evaluation results showed that the platform simplifies and enhances cloud service selections (e.g., reducing complexity, less time required) and forces CSCs to define and evaluate necessary requirements in advance. It, therefore, provides more structure to a usually less structured process in SMEs.

As this paper only examines the platform from the CSCs’ perspective, future research should investigate other parties such as CSPs or the platform owner. Additionally, future research should further investigate the platform’s applicability in light of the challenge of complex cloud services and further real-world selection problems. Regarding the DSR project, further steps such as the improvement of the instantiated platform design by considering the results of the prototype evaluation and addition of the missing DFs are still outstanding and should also be addressed in further research.
References


