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2nd Conference on Production Systems and Logistics

A Systematic Literature Review On The Suitability Of Cloud Migration Methods For Small And Medium-Sized Enterprises

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Abstract

The COVID-19 pandemic has shown companies that their on-premise infrastructures often reach their limits with a large number of remote accesses. The transition to cloud-based solutions could represent a more efficient alternative. However, many German companies, especially small and medium-sized enterprises (SME), are still hesitant to take this big step of transferring applications to the cloud. For this reason, this paper examines the question of whether existing migration approaches in the analysis phase fit the specific requirements of SMEs. Using a literature review methodology, we first identify and analyze determinant factors for cloud adoption in SMEs. On this basis, we analyze existing methods in the analysis phase for migrations from on-premise software to cloud solutions. We investigate whether these factors are considered in the analysis phase of the approaches and conclude their suitability for SMEs. Of the migration approaches we examined, none included all the factors we identified as relevant to SMEs. Fewer have considered all factors fully and in detail. We present the results of the literature search process in tabular form and conclude this paper with a discussion and synthesis of the literature as well as an outlook on further research fields.

Keywords

Systematic Literature Review; Cloud; Cloud-Computing, Infrastructure; Small And Medium-Sized Enterprises; SME; On-Premise; Manufacturing Companies; Business-Services

1. Introduction

Cloud computing (CC) offers great potential for small and medium-sized enterprises (SMEs), in terms of collaboration within the company and work efficiency [1], but also regarding the business domain, it can enable the realization of new products and business models [2] and unlike classical models of data processing, can meet the increasing demands on computing readiness and storage capacity [2]. It is assumed that SMEs benefit even more from cloud adoption than their larger counterparts [3], even though it must be mentioned that the decision in favor of CC requires a case-by-case consideration. The advantages for SMEs seem to contradict the fact that SMEs lack far behind larger companies in the adoption of CC [4,5].

This is a competitive disadvantage for SMEs without access to CC, which is exacerbated by the current pandemic situation. For example, insufficient bandwidth over the Internet connection for a large number of external accesses to the company's IT systems, as well as reduced data throughput rates due to VPN connections, reduced employee efficiency. Recent research has shown that adequate use of digital technologies enables better response to the COVID-19 outbreak [6,7]. Against the context of the pandemic situation, the question implied above becomes more pressing as to why the adoption of CC is not higher in SMEs. Rashmi et al. [4] mention various reasons for which SMEs actively decide against a cloud solution,

such as data protection and security concerns, and internet stability. Another possible reason is that migrations to the cloud cause major challenges for SMEs, for example, they find some practices that are fitting for large companies not applicable and have difficulty hiring employees with appropriate skills [8]. For this reason, this paper evaluates existing approaches of cloud migrations in terms of their suitability for SMEs. It is intended to show whether the special determinate factors of cloud adoption in SMEs are considered in the analysis phase of cloud migration methods and to identify possible gaps. When selecting an approach for cloud migration, procedures that prove unsuitable for SMEs can be excluded accordingly. By identifying suitable migration approaches, SMEs are enabled to take advantage of the benefits of CC. These potential advantages can, for example, include a reduction in capital lockup, location-independent access, lower barriers to market entry, and access to technologies that were previously only available to large companies [2].

Existing research has already highlighted the determining factors for and impacts of the adoption of CC by SMEs. Furthermore, methods for migration were classified and compared using a characterization framework [5]. Although there have been review papers produced, we could not retrieve a secondary study that consolidates and evaluates the research on migration approaches with respect to the specific needs of SMEs in the analysis phase.

The objective of this work is to present a systematic review of literature (SLR) of existing cloud migration approaches, specifically in the analysis phase, and compare their suitability for SMEs. We focus on the business domain (e.g., 'office IT', office applications) and are therefore able to limit the variety of use-cases linked to cloud migration in general. Furthermore, we are able to take edge computing out of our scope as edge-cloud-architectures are more common in a production domain. Topics concerning 'edge-computing' will be regarded as 'on-premise' in this paper.

2. Theoretical background

2.1 Cloud computing

According to Repschläger et al. [6], CC represents 'an accumulation of services, applications, and resources that are offered to the user flexible and scalable via the internet without requiring a long-term capital commitment and IT-specific expertise'. The National Institute of Standards and Technology (NIST) further distinguishes between five characteristics (on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service) and three service models (software as a service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS)) [7]. From an organizational and corporate perspective, a distinction can be made between the deployment models 'private cloud', 'public cloud', 'hybrid cloud' and a few mixed forms [8].

2.2 Cloud migration process

A cloud migration process (CMP) is an activity or a set of activities for transferring existing enterprises' digital assets, services, IT resources or applications to a cloud. Generally, according to the three mentioned service models, there are three types of CMP – SaaS, PaaS, and IaaS migration processes. During the SaaS migration process, on-premise applications are basically replaced through a cloud-based software or service. The PaaS migration covers the process of the exchange of on-premise software operating and deployment environments to the one in a cloud. PaaS enables the creation of own applications in the cloud. The IaaS migration describes transfers of an enterprise's complete infrastructure into a cloud, including storage and network capabilities. Enterprises then use applications, servers, storage, and network resources as a service via internet connections instead of on-premise network connections [9]. IaaS migration is the most suitable opportunity for moving applications to the cloud when there is no time to adjust or redevelop the applications

for a cloud. On a very general level, a cloud migration process can be divided into five phases (see Figure 1) [4].
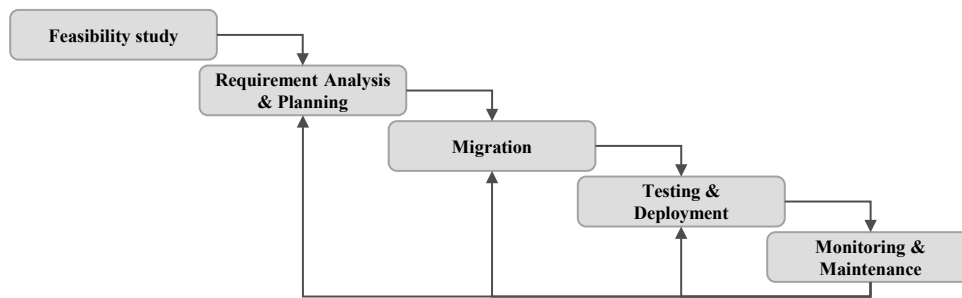

Figure 1: General five-phase model for a cloud migration process [4]

2.3 Challenges of migration to cloud-based business applications for SME

Especially small companies struggle with the selection of cloud-based solutions. Research suggests, the smaller the company, the more difficult it is for decision-makers to select the most suitable technology [10]. The risk of accidentally exposing sensitive data during the migration process is one important reason why business-critical systems are often operated on-premise [11]. SMEs also try to avoid vendor lock-in [12–19]. For this reason, it is not easy to find solutions with an appropriate balance between customization and standardization. On the other hand, cloud service providers see the necessity to provide their potential customers with a better understanding of technical and legal issues [2]. This lack of knowledge makes the assessment of service providers even more challenging from an SME's perspective. Further risks that can be identified are a high integration effort due to a lack of standards and possible misuse of data if the selection criteria are inadequate [2].

According to a survey of SMEs in Indonesia, effective cloud migration strategies and approaches can minimize the actual and perceived risks [20]. However, these may differ significantly from the actual deciding factors. To address the question of the suitability of existing migration approaches for SMEs, we examine the determining criteria for the adoption of CC in SMEs in chapter 4.2 [11]. However, these may differ significantly from the actual deciding factors. To address the question of the suitability of existing migration approaches for SMEs, we examine the determining criteria for the adoption of CC in SMEs in a later chapter.

3. Research methodology for a systematic literature review

In this paper, existing process models for cloud migrations are presented, and their suitability for small and medium-sized enterprises is investigated by applying the systematic literature review (SLR) method. An SLR is conducted to identify, evaluate and interpret available research relevant to a specific research question [21]. The selection of this method in question is based on its suitability to find gaps in existing research. We followed the procedure in [22,21], including the main phases of planning, conducting, and documenting in order to aggregate empirical evidence. The stages have been summarized and abbreviated to fit the scope of this work. Figure 2 displays our methodical approach. In the following chapters, we briefly describe our approaches during the planning, conducting, and documenting phase.
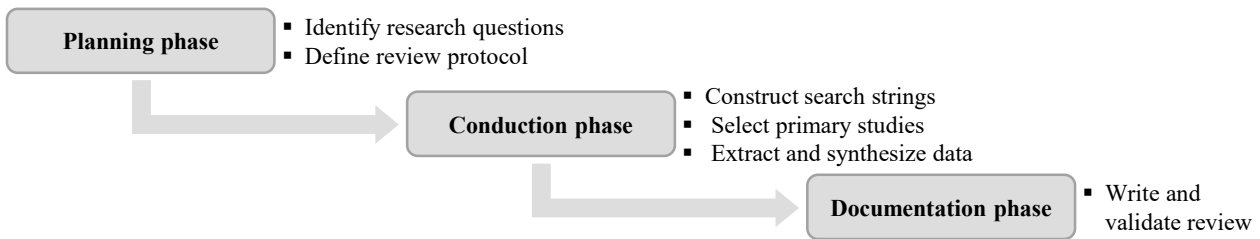
Figure 2: Our methodical approach for the SLR

3.1 Planning

In the planning phase, we identified our research questions, which are based on the objective of this work and not changed during the research process. Our identified research questions (RQ) are:

(1) *Which migration approaches do exist?*
(2) *What factors determine the decision for or against a cloud solution in SMEs?*
(3) *Are the determining factors for SMEs addressed in the migration approaches?*

Additionally, we define a review protocol in this phase. The protocol contains a precise plan for the conduction phase as well as detailed information on literature selection.

3.2 Conducting phase

The goal of the conduction phase is to find published papers (archival journals, conference proceedings, or technical reports) from the contents of predetermined electronic databases that can be used to answer the research questions. We used the following databases for our literature search: ACM Digital Library (dl.acm.org), Google scholar (scholar.google.com), IEEExplore (ieeexplore.ieee.org), Inspec (www.iee.org/Publish/INSPEC/), and ScienceDirect (www.sciencedirect.com).

We constructed strings for searching electronic databases to answer our structured research questions. Synonyms and alternative spellings were identified, and the question elements were linked with the boolean operators' OR' for synonyms and 'AND' for creating search strings. Table 1 displays the research question (RQ) and the applied search terms. For the search terms, we combined one term from each search category to form a search string. Categories were also skipped, which is represented by an epsilon (ε) within the listing of the search terms.

Table 1: Research questions and respective search terms

RQ	Research question	Search terms			
1	What migration approaches do exist?	Category 1.1: method, approach, plan, technique, way, scheme, ε	Category 1.2: transition, change, switch, migration	Category 1.3: cloud infrastructures, cloud, on-premises to cloud	
2	What factors determine the decision for or against a cloud solution in SMEs?	Category 2.1: small and medium-sized enterprises, SME, companies,	Category 2.2: determinants, challenges, benefits, ε	Category 2.3: transition, change, switch, migration	Category 2.4: cloud, cloud infrastructures, on-premises to cloud
3	Are the determining factors for SMEs addressed in the migration approaches?	*Mainly evaluation of search results, therefore no search terms applicable*			

The first selection of sources was based on a review of their title and abstract. To ensure relevance, we restricted the search to papers that were published in German and English after the year 2000. The second review of all selected studies was based on more detailed inclusion and exclusion criteria displayed in Table 2, to decide whether it can help to answer the predefined research questions.

Table 2: Inclusion and exclusion criteria for the first literature review

Inclusion criteria	Exclusion criteria
The topic of a research question is the central consideration area of the work.	The study does not cover on-premises to cloud migrations but other forms of migration such as migrations between different cloud solutions.
The work considers cloud migration in general or SaaS migrations.	The study is only published in languages other than English and German.
The study is available in full text.	Studies published before 2000.

After this step, 25 studies remained, and their citations and references were examined, as seen in Table 3.

Table 3: Results of our second literature view

Database	RQ 1 (13 studies)	RQ 2 (12 studies)
ACM Digital Library (dl.acm.org)	[23]	
Google scholar (scholar.google.com)	[9] [24] [25] [26] [27] [28]	[12] [14] [13] [29] [30] [19]
IEEExplore (ieeexplore.ieee.org)	[31] [32] [33] [34]	[35]
Springer Link (link.springer.com)	[36]	[18] [15] [17]
ScienceDirect (www.sciencedirect.com)	[40]	[37] [16]

4. Results

4.1 Migration approaches

As Zhao and Zhou [36] have already pointed out, there exist various academic research and industrial applications on legacy system migration to the cloud. Our research identified 13 relevant studies, which we further narrowed down to primary literature. Finally, eight novel frameworks, strategies, approaches, and methods for migrating to the cloud remained.

Table 4 displays existing novel migration approaches and answers our RQ1: What migration approaches do exist?

Table 4: Identified migration approaches in the primary literature

Index	Author(s)	Title	Year	Reference
1	Ahmed, Monjur; Singh, Navjot	A Framework for Strategic Cloud Migration	2019	[23]
2	Banerjee, Joydipto	Moving to the cloud: Workload migration techniques and approaches	2012	[25]
3	Khan, Nabeel; Al-Yasiri, Adil	Framework for Cloud Computing Adoption: A Roadmap for SMEs to Cloud Migration	2015	[24]
4	Nussbaumer, Nicolas; Liu, Xiaodong	Cloud Migration for SMEs in a Service Oriented Approach	2013	[27]
5	Pamami, Pooja; Jain, Aman; Sharma, Navneet	Cloud Migration Metamodel: A framework for legacy to cloud migration	2019	[33]
6	Peddigari, Bala Prasad	Unified Cloud Migration Framework — Using factory based approach	2011	[32]
7	Santikarama, Irma; Arman, Arry Akhmad	Designing enterprise architecture framework for non-cloud to cloud migration using TOGAF, CCRM, and CRMM	2016	[31]
8	Saripalli, Prasad; Pingali, Gopal	MADMAC: Multiple Attribute Decision Methodology for Adoption of Clouds	2011	[26]

4.2 Determinants of cloud computing adoption in SMEs

During the literature review, 12 papers were identified that present factors that determine the decision for or against a cloud solution in SMEs. However, factors and their influence differ from paper to paper. To identify the major influencing factors, we conducted a comparison of the named factors. We checked for each factor if it was mentioned, how detailed it was described, and what importance the authors of the paper attached to it. Importance (0 – not mentioned, 1 – low, 2 – medium, 3 – high) of respective factors was added up throughout the identified papers. As a result, we identified 15 major influencing factors. These factors do not necessarily conclude a direct advantage of CC over on-premises software. They represent what is important for SMEs when considering a migration to the cloud. The results are presented in Table 5.

Table 5: Influencing factors on the decision concerning the decision of implementing cloud solutions in SMEs
(in the order of descending importance)

Factor	Literature	Score	Description
Data security concerns	[13] [14] [17] [15] [18] [35] [37] [16] [12]	21	Many SMEs are afraid of losing the data or of handing it over to a third party. However, interviewees stated that sometimes cloud services have higher data security and, in those cases, are even better than on-premise services.
Cost reduction	[13] [14] [17] [15] [18] [30] [37] [16]	21	Companies look forward to cutting their IT-related expenses through the use of cloud services because the development and maintenance of on-premise infrastructure, networks, and software may be very costly.
Reduced set-up time	[13] [17] [15] [29] [18] [30] [16]	17	Fast set-up times of services in the cloud or the opportunity to start using a service instantly is a great advantage for companies.
Dependency on provider	[13] [14] [17] [15] [18] [19] [16] [12]	16	High dependency on the provider of cloud services discourages companies from using the cloud services.
Scalability	[13] [14] [17] [29] [18] [30] [12]	16	The possibility to increase cloud resources, storage, or functions is seen positively by enterprises.
Flexibility in regard to location and devices	[13] [14] [17] [15] [18] [16] [12]	15	Cloud services allow remote collaboration as well as the use of different devices and operating systems and, in such a manner, encourage companies to use cloud services.
Flexibility in regard to used services/apps	[13] [14] [17] [15] [29] [18] [16]	14	The majority of papers state that the possibility to add or remove functions depending on the enterprise's needs persuades SMEs to choose cloud services.
Focus on the main business	[13] [14] [17] [15] [29] [30]	13	Through outsourcing of IT operations, enterprises can focus on their main business and activities.
Easiness of use	[13] [14] [17] [29] [18] [30] [12]	13	Better user experience and user interface are reasons for enterprises to choose cloud services.
Dependency on the internet and its quality	[13] [17] [15] [18] [16] [12]	13	Enterprises hesitate to migrate fully to the cloud because of possible problems with access to the data or inability to work in case of a poor internet connection.
Transparency in regard to service	[13] [14] [17] [15] [19]	10	If it is not clear how a cloud service works, what are its privacy policies, who has access to the data, and where the servers are located, enterprises will hesitate to choose the service.
Organizational size and structure	[13] [14] [17] [37]	10	The smaller the company and the flatter its hierarchy structure, the easier and more likely it is to migrate to cloud services.
Technical knowledge / understanding of CC	[13] [14] [35] [37]	9	Deeper technical knowledge of CC has a positive impact on the decision to use cloud services.
Competitive pressure	[13] [14] [17] [35] [37]	9	Competing organizations adopting cloud and increasing adoption trends across industry sectors influence the decision to use cloud services.
Easy possibility to test services/apps before purchase	[13] [17] [29]	8	Cloud services allow to try new services before their actual purchase and thus encourage enterprises to use cloud services.

4.3 Synthesis of the literature of existing methods and approaches for migration

Although the literature examined explicitly addresses SMEs, in part because of the search terms chosen, none considers all of the factors identified. Depending on the objective of the literature analyzed, only very few of the factors were even considered in the critical analysis phase. Moreover, very few authors made a distinction with regard to IaaS, PaaS, and SaaS. Table 6 summarizes the results regarding research question 3: 'Are the determining factors for SMEs addressed in the migration approaches?'. In order to evaluate to what extend do the identified address the influencing factors, the following evaluation logic was used: 4 – if an approach provides a detailed guide on how to address a factor; 3 – if an approach proposes a concept to address a factor; 2 – if an approach describes general opportunities to address a factor; 1 – if a factor was mentioned in the approach.

Table 6: Analysis of the identified migration approaches regarding the identified influencing factors
(0: not at all, 1: partly, 2: mainly, 3: mostly, 4: fully)

Factor	[23]	[25]	[24]	[27]	[33]	[32]	[31]	[26]
Data security concerns	2	2	1	4	0	1	2	4
Cost reduction	1	1	4	4	2	2	2	4
Reduced set-up time	0	0	1	3	0	1	0	3
Dependency on provider	3	2	2	0	1	0	2	1
Scalability	1	1	1	4	0	2	0	2
Flexibility regarding location and devices	1	0	2	2	1	2	3	2
Flexibility regarding used services/apps	0	0	3	4	1	2	2	3
Focus on the main business	0	2	1	0	0	0	0	1
Easiness of use	4	0	1	4	0	0	0	4
Dependency on internet and its quality	1	0	1	4	1	0	2	4
Transparency in regard to service	0	0	1	0	0	0	0	0
Organizational size and structure	4	2	0	1	4	0	4	2
Technical knowledge/understanding of CC	3	2	1	2	2	0	2	0
Competitive pressure	0	0	0	0	0	0	1	0
Easy possibility to test services/apps before purchase	0	3	3	0	0	0	0	0

The table shows that no migration approach considers all factors. There are at least two factors not considered (0) in all approaches. The migration approach with the highest coverage, considers 6 out of 15 factors completely and in detail (4). Most of the analyzed literature did not consider a fair amount of the identified factors and were either too strategic or only addressing specific factors. In addition, the analysis phase can identify potential that could be realized through a change in processes or service utilization. The factors targeting this are insufficiently considered in the literature analyzed. In conclusion, the identified methods and approaches did not meet and fit the requirements of SMEs.

5. Discussion, conclusion, and outlook

This paper presented the results of SLR of research on CC and SMEs from 2000 to 2021. We reviewed a total of 25 scientific studies to identify cloud migration approaches in scientific papers, analyze what factors determine the decision for or against a cloud solution in SMEs, and subsequently investigate if the factors are addressed in the migration approaches. As presented in chapter 4.3, the identified migration approaches do not consider important factors and may therefore not be applied by SMEs.

In conclusion, this systematic literature review underlines the importance of continued research in this area to enable SMEs to utilize the potential of cloud-based services fully. In order to move away from existing

on-premise-based infrastructures, this paper shows that a variety of factors must be taken into consideration. A suitable and holistic approach that particularly considers the possibilities of SaaS for SMEs could not be identified. From the authors' point of view, there is a need to give greater consideration to the resulting advantages and develop suitable process models that take into account all the relevant influencing factors.

Acknowledgements

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Biography

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Nikita Fjodorovs (*1994) studied Business Administration and Engineering specializing in Industrial Engineering and Operations Management at RWTH Aachen University and Automotive Engineering at Tsinghua University as a part of a double degree program. He was also a graduate student research assistant at FIR at RWTH Aachen University. After his graduation in 2021 he started working as a project manager at FIR at RWTH Aachen in the division Production Management.

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