Towards a better Understanding of the Dynamics of Platform as a Service Business Models

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Abstract

Platform as a Service (PaaS) solutions are changing the way software is produced, distributed, used, and priced. However, there has been little research into understanding the dynamics of PaaS business models and how these business models should be designed to establish a flourishing ecosystem around these platforms. Using design science research (DSR) we first identified the main design elements of PaaS business models as well as their relationships by investigating 24 PaaS providers. The resulting classification scheme as well as the qualitative systems dynamics model (in form of a causal loop diagram (CLD)) facilitates a better understanding of the adoption dynamics of PaaS business models. By focusing on the adoption dynamics of PaaS business models, our research goes beyond previous approaches for studying PaaS.

1 Introduction

1.1 Motivation and Problem Scope

Platform as a Service (PaaS) solutions are changing the way software is produced, distributed, used, and priced. Unlike Software as a Service (SaaS) or Infrastructure as a Service (IaaS), PaaS allows for value co-creation by offering complementary components and applications that are developed in emerging ecosystems of third-party developers [1]. “A burgeoning body of research has started to theorize about how such ecosystems are formed and their implications for platform owners, complementary providers, and users” [2]. However, despite increasing interest among practitioners and researchers, there has been little work on understanding the dynamics of PaaS business models and how these business models should be designed to establish a flourishing ecosystem around these platforms. This is a significant gap in understanding such platforms. This paper aims to develop a causal loop diagram (CLD) based on system dynamics according to [3] and [4] that facilitates the understanding of the adoption dynamics of PaaS business models. This project generates two research questions which finally lead to the two artifacts we introduce later. First, what are the essential design elements of PaaS business models? And second, how are the PaaS design elements thus identified interrelated and how do they cause the inherent dynamics in PaaS business models?

1.2 Research Approach

In order to facilitate a better understanding of PaaS business models, we followed the design science research (DSR) approach [5], [6] drawing on the previous literature in the domain of business models and the PaaS paradigm (see following sections) [7]. In chapter three, we have presented related work relevant to the research gap addressed in this paper. To arrive at rigorous and relevant research results, we draw upon [8] and follow their proposed DSR methodology: The first activity within the design science process is the problem identification and motivation, which we outlined in the first section. The second activity concerns the objective of the solution: Our objective is to address the above-mentioned research gap and facilitate a better understanding of the adoption dynamics of PaaS business models. Hence, as part of activity three, we identified the main design elements of PaaS business models through 24 case studies following guidelines of [9] and [10]. We propose a classification scheme illustrating the main design elements of PaaS business models by using a morphological box [11] (cf. Section 4). In order to understand the complex dynamics behind PaaS business models, we investigated the relationships between the identified elements developed a qualitative system dynamics model, following the guidelines of [3] and [4] (cf. Section 5). The use of the artifact to solve actual instances of the problem – representing the fourth activity - is demonstrated by applying the first artifact to the set of 24 PaaS providers we investigated (cf. Table 1). The evaluation of the artifacts, which represents the fifth activity, is comprised of proof of concept studies, where the artifacts have been demonstrated to work in the context of various PaaS business models. As a result,
iterations starting from the third activity had to be performed. One proof of concept study is presented in order to show how our artifacts have been applied (cf. Section 6). The results of our investigation are summarized and discussed at the end of this paper (cf. Section 7).

2 Background

2.1 Business Models

In recent years, several studies, such as [12], [13], [14], [15], [16], [17], [18], have noted the importance of actively analyzing and designing business models. As a basis for our research, we follow the definition by [17], according to whom a business model consists of four interlocking elements – customer value proposition (CVP), profit formula, key resources, and key processes – that, taken together, create and deliver value. Besides the definition of business models, [19] distinguish seven additional areas of business model research: components/ fundamental constructs, taxonomies used for categorizations of business models, conceptual models, design methods and tools, adoption factors, evaluation models, and change methodologies. We aim to develop a classification scheme as well as a CLD for a better understanding of the adoption of PaaS business models. Hence, we focus on the fourth research field – design methods and tools – equivalent to “building methods and developing tools for designing business models” [19].

2.2 Platform as a Service

Platforms in the software industry are defined as “…the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate” [1]. PaaS refers to software platforms that have primarily been discussed in the context of cloud computing. According to the most cited architectural concepts of cloud computing, PaaS represents the middle layer, connecting the IaaS and SaaS cloud layers [20], [21], [22]. Based on a systematic literature review, [23] describe PaaS as an execution environment in which external developers deploy and run their complementary components and applications. PaaS facilitates the development, testing, and management of software components, as well as knowledge exchange between developers.

3 Related Work

A considerable amount of literature has been published on multisided platforms (see [24], [25], [26], [27]). However, the following introduced approaches stand out by a very narrow focus on modeling and understanding the dynamics of business models. Kiani et al. [28] analyzed the business model ontology (BMO) [29] in order to capture the structure and achieve a better understanding of e-business models. Within this research the concepts of system dynamics [3], [4] were applied so as to qualitatively investigate as well as illustrate such e-business models by means of a qualitative model in form of a CLD. Through modeling the BMO as CLD, the dynamics of the system, its feedback structure, underlying assumptions, as well as the interrelations between the BMO elements were revealed and in total six feedback loops have been identified and discussed, viz: (1) prosperity, (2) offering, (3) resource supplement, (4) activity arrangement, (5) channel adjustment, and (6) customer relationship control. For instance the feedback loop offering describes the case of an increased offering regarding the value proposition at first leading to higher costs, and thereby decreasing the overall profit. However, as indicated by the feedback loop prosperity, the increased offering and value proposition will also lead to a higher customer base and will thus increase the revenue and finally the overall profit. Within these two feedback loops all four pillars of the BMO are included. The remaining four feedback loops describe further relationships between BMO elements. At the end of this paper, the authors argue that a better understanding of this kind of business model will finally lead to a higher quality level as well as higher utilization of such business models.

Another business model framework regarding ontology – the e-business model framework (eBMF) – was created by Ben Lagha et al. [30] in a more technical way by means of the corresponding e-business modeling language (eBML). eBML enables decision makers to design new business models by asking proper questions such as “what … exactly [is] my value proposition?” [30]. The eBML was developed in order to encode these business models. The eBML is based upon an extensible markup language (XML) and enables a structured approach to modeling and describing business models in a formal and re-usable way. In more detail, the eBML is actually a XML schema which by the structure and the available eBMF elements – namely product innovation, customer relationship, infrastructure management, and financial aspects – are defined in order to support the description of business models at a high level of abstraction. Moreover, as is inherent in XML documents, they can be easily transformed into
other formats or documents, such as business plans, graphical representations, reports for financing, or documents for knowledge sharing. Using this framework (eBMF) in combination with the proposed eBML provides the feature to simulate business models and to enable one to answer certain strategic questions such as “how can we act to alter that future for the better?” proposed by [31].

For the purpose of analyzing business models, Grasl [32] developed a multi-method approach and applied the resulting approach to a small case study in order to show its applicability. According to [32] three different kinds of complexity are inherent in business models: structural, behavioral, as well as dynamical complexity. These need to be investigated using appropriate methods. By applying on the one hand concepts of object-oriented analysis and design (OOAD) in combination with the notation of the unified modeling language (UML), and on the other hand concepts of system dynamics, the above mentioned complexities are analyzed in six successive activities: (1) initiation, (2) business model inception, (3) business model elaboration, (4) scenario analysis, (5) transfer, and (6) transformation. The structural and behavioral complexity is mainly investigated through OOAD concepts and the dynamical complexity by applying system dynamics techniques. These activities result finally in strategic questions, scenarios, recommendations, and most importantly the actual representation of the business model.

Existing approaches like [28], [30] and [32] are somewhat generic and do not consider the specifics of PaaS business models, which are at least two-sided or even multi-sided business models. However, we find that prior research on modeling and understanding the adoption dynamics of business models provides a suitable theoretical lens to study business models for PaaS.

4 Design Elements of PaaS Business Models

4.1 Study Design

Based on 24 explorative case studies according to [9] and [10], we elaborated a characteristic-based classification scheme for PaaS business models. This classification scheme is based on [33] and represents an advanced version of the classification scheme developed there.

Characteristic-based classification means that each classification object, in this case a PaaS business model, is characterized by several characteristics [34]. The classification scheme finally resulting for PaaS business models (cf. Figure 1) consists of five classification criteria (first column), the cardinality of each classification criterion (second column), and the corresponding characteristics. In particular, the introduction of cardinalities is a significant enhancement of the previous model of [33]. In order to classify PaaS business models we propose the following criteria: (1) customer segment, (2) core value proposition, (3) governance model, (4) technical scope, and (5) revenue stream. In doing so, we have retained three of criteria from [33], adapted the criteria technical value proposition and added governance model. In Figure 1 the classification scheme is illustrated by means of a morphological matrix according to [11].

We applied case study techniques according to [9] and [10] to identify these criteria and characteristics. The overall process is known as multi-case, multi-unit case study research [10] and the units of investigation were derived from [1], [17]. By using the approach of a cross-case pattern search according to [9] in combination with [17] we derived three criteria. First, the criterion customer segment was deduced from the business model element CVP [17], in particular from the part target customer. Also, the second criterion – core value proposition – was based on the CVP; here the offering was the main reason. And finally, the criterion revenue stream was derived from the business model element profit formula [17]. The remaining two criteria – governance model and technical scope – were deduced by comparing business models in pairs. Further, these criteria can partly be ascribed to the two business model elements key resources and key processes [17]. Possible differences in the governance model are classified according to [1] and diverse technical capabilities were identified during the process of analysis of the case studies.

4.2 Design Elements

In the following the five criteria and their characteristics are discussed in detail. PaaS business models are at least two-sided or even multi-sided business models [35] and hence, address several customer segments. In contrast to [33] we have identified five typical customer segments: (1) IT startups are dynamic in their early stages and thus will use new technologies and products compared to companies established before them. Thereby, these early adopters will help to place the platform within the market. (2) Systems integrators (SI) provide complementary services, for instance consulting services. (3) Platform modules [1] – applications, services, components, add-ons, extensions, and custom developments – are provided by independent software vendors (ISV). (4) Platform customers using the
platform internally to develop new applications for services upon it. The last customer segment, (5) application customers, are purchasing ready to use applications built upon the platform.

The criterion core value proposition is used to describe the main platform offer. In addition to the three characteristics already identified by [33], we added fourth characteristic: (1) Distribution channel describes the case of a company opening its ecosystem including the customer base to external stakeholders. These stakeholders in turn will provide additional features to the ecosystem’s existing customer base. (2) Application-based integration platforms provide features so as to extend SaaS solutions. (3) Platforms dedicated to supporting the entire application or service development process – including developing, testing, debugging, deploying, and versioning – are denoted simply as development platforms. (4) And finally, integration platforms integrate any combination of on-premise and on-demand applications as well as systems, and facilitate for instance the management of complex supply chains.

In alignment with [1] the investigated PaaS platforms differ noticeably in the governance model they support. Whereas [1] identified the three areas of decision right partitioning, control mechanisms, and proprietary vs. shared ownership within platform governance models, in our classification scheme a qualitative ordinal scale of three values was chosen: (1) strictly limited, (2) partly limited, and (3) open governance model. By focusing more on these qualitative values, it is possible to support the two classification guidelines of user-friendliness as well as economic efficiency [34].

The technical scope – for instance programming languages, development environments, frameworks, databases, APIs, and protocols – varies remarkably, as well as ranging from simple platforms with (1) limited technical capabilities, to powerful platforms providing (2) extensive technical capabilities.

The last classification criterion revenue stream “defines how the company creates value for itself while providing value to the customer” [17]. (1) In case of subscription, the customer pays a regular subscription fee – commonly a monthly charge – and in return gains the right to use the product for the paid period. (2) Transaction-based pricing models are usage-dependent, for instance time or processing units, but nonetheless paid on a regular basis. (3) Third-party applications and services are charged by the platform provider or the service provider. However, in both cases the revenue is shared between these two parties. (4) A considerable amount of PaaS providers offer additional services at a charge. These services include among other things trainings, certifications, advertisements, advisor services, and onboarding packages. (5) Another revenue stream which seems to be present within the PaaS ecosystem is open source software. Even though this revenue stream is mainly non-monetary, there are some open source platforms available on the market. In most cases, the promoting company behind such open source platforms also offers additional services, designed for
those platforms which carry a fee. Four of the five characteristics are in line with [33]. Variations are that we assigned advertisement to additional services and added open source.

The classification scheme just developed was used to assess the business models of the 24 PaaS providers we investigated. Table 1 illustrates how these platforms address the five classification criteria. In addition, this descriptive knowledge [36] provides the bases for the system dynamics model introduced in the following chapter.

5 Adoption of PaaS Business Models

5.1 Overview

In order to gain a better understanding of the essential interdependencies between the previously described design elements of PaaS business models, the elements are placed in context using the concept of system dynamics, more specifically by means of a CLD. System dynamics is an approach to studying complexity through capturing the structure as well as underlying assumptions of complex systems [3], [4].

Moreover, identifying critical feedback loops – self-reinforcing (R) as well as balancing (B) – makes it possible to capture the dynamics of the system under investigation, in this case the PaaS adoption process. Causal relationships between variables are modeled ceteris paribus and a causal variable will increase or decrease the influenced variable above or below what it would otherwise have been.

Figure 2 presents the main interactions between the previously identified design elements of PaaS business models in the form of a CLD. Two key areas are presented more precisely in separate CLDs for ease of understanding. First, the CVP represents a crucial element within business models and is therefore modeled in detail (cf. Subsection 5.3). And second, the inherent network effects between the five customer segments are significant concerning the CVP (cf. Subsection 5.4) and thus for the overall platform adoption process.

5.2 Adoption Cycles

For reasons of clarity, the actual adoption cycles are omitted in Figure 2. The five customer segment variables within Figure 2 signify the adoption cycle as illustrated in Figure 3, whereby the wildcard <customer segment> represents the five customer segments identified earlier. This adoption cycle is taken from [4] and our CLD is built around this central feedback structure.

![Figure 2. Dynamics of PaaS Business Models – Model Overview](image)

The value of the favorable word of mouth variable will increase in correlation with an increase in the
Similarly, an increase in the value of the word of mouth variable will lead to an increase in the value of the adoption rate. To close this first self-reinforcing cycle (R_1), an increase in the adoption rate will increase the population.

If the adoption rate increases, the potential variable will decrease and in turn will decrease the variable adoption rate. This cycle represents a balancing feedback loop (B_1) and prevents the variable adoption rate from growing exponentially.

### 5.3 Customer Value Proposition

The adoption rate described above is mainly influenced by the CVP, whereby each customer segment obtains its own, dedicated CVP [17]. In Figure 4 the interdependencies with regard to the CVP are illustrated. We identified six factors influencing the CVP positively: (1.) PaaS offers differ notably in their core value proposition which has a direct impact on the corresponding CVP. (2.) Which governance model a PaaS provider uses affects the CVP. For instance, presumably an open governance model is more attractive for potential customers. The next two features (3.) technical scope and (4.) additional services both influence the CVP positively and will gain strength over time through platform improvements. (5.) the platform improvements itself improve the CVP, through capabilities not considered in other influence factors. And finally (6.), the market penetration in the form of a company’s brand image and reputation supports the CVP. However this effect occurs with delay. Platform improvement and market penetration are not exactly design elements of PaaS business models, but they are essential to understand the adoption dynamics of platforms, and hence have been added to our model [2].

All the above mentioned factors increase the CVP and thereby the adoption rate, which in turn increases the customer base. Through the variable customer base, two general impacts are reinforced. First, the market penetration will increase if the customer base increases and thereby another self-reinforcing feedback loop is created (R_5). And second, if the customer base increases, the overall revenue and by association the reinvestments into the platform increase which later on will lead to enhanced platform improvements. Thereby three further self-reinforcing feedback loops are created (R_2, R_3, and R_4).

### 5.4 Customer Segments

Network effects – same- as well as cross-sided – are inherent within the PaaS domain and produce increased adoption rates [35], [37]. Especially the cross-sided network effects are of particular importance for PaaS business models. For reasons of clarity, these relationships are illustrated in Figure 5 in a simplified way.

![Figure 5. PaaS Customer Segment Dynamics](image)

Platform modules [1] – applications, services, components, and add-ons – are developed and provided by ISVs and IT startups, subsumed under complementors [38], [39]. These external platform modules are valuable for three customer segments. First, obviously the application customers purchase and use the platform modules and therefore an increase in the number of platform modules will increase the CVP for potential application customers. An increasing size of the application customer population in turn will increase the CVP for the complementors. These cross-sided network effects constitute two further self-reinforcing feedback loops (R_8, R_9). Second, even though platform customers are mainly upper small and medium-sized enterprises (SME) or large enterprises using the platform internally, the number of platform modules is also beneficial for these customers, for instance in form of ready-to-use modules to build applications upon. As with the application customers, the CVP for complementors is positively influenced by the size of the platform customer population and hence...
two more self-reinforcing feedback loops based on cross-sided network effects are revealed (R_10, \ R_11). And finally, flourishing platforms are often associated with numerous platform modules and are attractive for SIs, for the simple reason that they can support implementation projects for application as well as platform customers. Moreover, an increasing number of application and platform customers will subsequently increase the CVP for SIs. This demonstrates the last two self-reinforcing feedback loops in our model (R_6, \ R_7).

Figure 2 illustrates the overall CLD concerning the PaaS business model dynamics. This illustration is composed of the customer value proposition CLD (cf. Figure 4) as well as customer segments interdependencies CLD (cf. Figure 5). Each customer segment is served with their dedicated CVP as highlighted by [17].

6 Evaluation

In conformity with the design cycle of [7], our model has been evaluated against the real world by its reapplication in the context of PaaS business models. In this section, we present a proof of concept study using the 4CaaS platform\(^1\). The EU-funded research project 4CaaS aims to create an advanced PaaS cloud platform which supports the optimized and flexible hosting of Internet-scale multi-tier applications. Hence, the 4CaaS platform is a development-focused PaaS solution that mainly focuses on the customer segments IT startups, independent software vendors and platform customers. Although 4CaaS provides an electronic marketplace for cloud-based services, the potential customer segment of application customers is not in direct focus of 4CaaS, since most services offered on the marketplace consist in software components rather than ready to use applications. This is also indicated in Figure 6, where the main design elements of the 4CaaS business model are highlighted.

Large parts of the platform are available under open source licenses, hence 4CaaS pursue an open governance model. 4CaaS offers extensive technical capabilities by implementing concepts like real application container and bring-your-own-container. As already mentioned, currently large parts of the platform are open source. Nevertheless, a provider of the 4CaaS platform might charge its customers transaction-based fees.

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\(^1\) http://www.4caast.eu/ (Last visited: September 12, 2013)
the two self-reinforcing feedback loops $R_{10}$ and $R_{11}$ respectively the cross-sided network effects which are represented by these loops.

The application of our developed artifacts in the real world scenario of 4CaaSt clearly identifies two emphases, where 4CaaSt might improve their business model. First, 4CaaSt needs to ensure platform improvements. This could on the one hand be accomplished by the platform providers themselves, or 4CaaSt could also create incentives for open source developers. Second, 4CaaSt should definitely improve its value proposition to application customers to utilize critical cross-sided network effects.

![Figure 7. 4CaaSt Customer Segment Dynamics](image)

## 7 Discussion and Conclusion

The goal of this paper was to facilitate a better understanding of the dynamics of PaaS business models. In order to address this, a DSR approach was chosen and the resulting artifacts are of descriptive and prescriptive nature [36]: the classification schema presents the main design elements of PaaS business models and hence, adds descriptive knowledge to the knowledge base. Our qualitative system dynamics model, illustrating the complex dynamics of PaaS business models contributes prescriptive knowledge to the knowledge base. The system dynamics model is built upon Sterman’s concept of adoption cycle and highlights two main aspects crucial for the adoption of PaaS business models: First, each addressed customer segment needs a specific customer value proposition, based on its individual needs. Second, the interrelationships between customer segments are decisive for the platform adoption.

The results presented in the paper at hand provide a significant scientific and practical contribution. The two artefacts – the classification schema and casual loop diagrams contribute to the knowledge and understanding of PaaS business models. In particular, the casual loop diagram explaining the dynamics of PaaS adoption, enhances existing rather structural knowledge about PaaS business models. While other authors named in the related work section focused on explaining the inter-relationships of business model elements, the system dynamics analysis presented in the paper at hand focuses on and explains the impact of inter-relationships of business model components with respect to their adoption. Another contribution of the research presented here is also the analysis and explanation of the inter-relationships among the various target customer segments in n-sided business models. Besides providing a general casual loop model explaining the inter-relationships among adoption processes of involved target customer segments of PaaS, the applicability of system dynamics for the analysis of n-sided business models was illustrated on a concrete example and generalized for practical use.

The presented results provide also a contribution with practical relevance. The knowledge about typical balancing and reinforcing feedback loops presented in the generic casual loop diagrams can help PaaS providers to understand the adoption dynamics of their platform and which factors have influence on it. The evaluation example clearly demonstrates how based on the identified generic feedback loops, potential weak features of existing business models can be identified.

Despite of the promising results, the study has limitations that might affect the generalizability of the results and that need to be mentioned: even though the classification schema has been evaluated in 24 case studies, the developed qualitative system dynamics model has been evaluated only in two proof of concept studies. This number is sufficient to assure rigor and relevant results, but might limit the generalizability of the CLD.

Within this paper the dynamics of PaaS business models has been exhibited and illustrated in form of a CLD (qualitative model). Future research might include transforming this CLD into a quantitative model – a stock and flow diagram – where the insights gained so far could be further evaluated and manifested. Moreover, such stock and flow models enable the simulation of the PaaS business model dynamics and thereby the identification of detailed high-leverage interventions and policies. Thus, simulation of business models based on the gained knowledge would be interesting further research.

## 8 Acknowledgments

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9 References


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10. Appendix

Table 1. Investigated Platform as a Service Business Models

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