Platform Configurations within Information Systems Research: A Literature Review on the Example of IoT Platforms

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Abstract. This contribution aims to shed light on the usage and application of different platform constructs within the context of IoT platforms. The motivation is that Information Systems (IS) scholars and practitioners use the term platform frequently as an unspecific or vague construct. Different research streams shape and influence the understanding of a platform. They range from economic practices like the Two-Sided Market (TSM), Multi-Sided Platform (MSP) or platform business models, to technical platform aspects including standardization and modularization, to the platform ecosystem and the construct of an IS platform fostering value co-creation. Within those constructs, the upcoming phenomenon of IoT platforms represents a specific case to analyze what constructs are used to which extent. Thus, the study helps future IS scholars to use the term platform more precisely and reveals the interrelatedness of the identified constructs. However, the literature review is only a first step towards demystifying the phenomenon of a platform, due to the limited context of IoT platforms.

Keywords: IoT, Platform, Platform Ecosystem, Two-Sided Market, Multi-Sided Platform

1 Introduction

The success in terms of company valuation of recently emerging platform companies indicates their rising importance. A prominent representative is Uber, a transportation service platform that ranks among the top of the Unicorn[1] list with a valuation of over $68 billion [1]. Fueled by this success, more and more companies try to jump on the bandwagon of platforms. To name but a few, Microsoft established the Azure Suite as a platform in the context of the Internet of Things (IoT), Apple created HealthKit as a healthcare platform, and Daimler founded the mobility platform moovel. Inevitably, this raises the question of what a platform is and how companies utilize this construct.

[1] A Unicorn defines a start-up company with an evaluation of over $1 billion.

Unfortunately, there is no clear answer to those questions, as the construct of a platform is context dependent. This becomes clear when considering that researchers use the term platform in various disciplines and meanings. They range from describing vehicles or carriers in the field of biology or medicine [2], to economic research streams on the example of Two-Sided Markets (TSMs) [3], to technical and architectural considerations [4], to production platforms [5]. Also, even within disciplines, scholars do not define the term platform accurately. They use the term platform depending on the context, where the level of analysis varies from a platform's technical architecture to economic and market effects [6, 7]. Thus, it is not clear if the construct platform only describes a technical architecture, or on the contrary a whole market. Using the constructs indifferently blurs the actual meaning of the construct platform in a specific context. To illustrate this point, this contribution draws on the emerging phenomenon of IoT platforms to shed light on what constructs are how used. IoT platforms act as intermediaries to connect different parties like companies, sensor manufacturers, and third-party developers within an ecosystem [8]. One reason for the selection of IoT platforms is that they provide a specific context to elaborate on what platform constructs Information Systems (IS) scholars use. Secondly, the IoT platform literature relates to the interdisciplinary IS research community and, thus, covers a broad range of platform constructs. Further, the community combines several constructs of the term platform, which helps to illustrate the need for a differentiation of platform constructs.

The first construct of a platform relates to TSMs or Multi-Sided Platforms (MSPs). The platform economics go back to the research stream influenced by Rochet and Tirole [3], Eisenmann, Parker and Alstyne [9], Armstrong [10], Evans [11], Hagiu [12], Rysman [13], and Bharadwaj [14]. Economic principles reflect constructs like TSMs or MSPs and deal with network externalities, the chicken & egg problem, pricing mechanisms, and platform envelopment. On the contrary, the idea of an IS platform originates from Gawer and Cusumano [15], Baldwin and Woodard [4], and Tiwana et al. [16]. Key aspects are technical considerations by taking advantage of standardization and modularization through Application Programming Interfaces (APIs) and Software Development Kits (SDKs), as well as the influence of the innovation capabilities within the platform. Besides the different constructs, there are also different levels of analysis. The (platform) ecosystem originates from Moore [17] and is subject to the fact that companies do not evolve in a vacuum but rely on their environment and resources. Here, the platform forms the core of the ecosystem by taking advantage of third-party innovations, also called value co-creation through turning competitors into complementors and suppliers into partners [15, 18]. Hence, the ecosystem takes the organizational level of analysis through value co-creation [19], as well as the market level through network externalities and pricing strategies into consideration [3]. Another level is the design of the technical platform architecture to foster standardization and modularization with the help of APIs and SDKs.

The presented constructs indicate that a platform can, dependent on the use of the construct, affect one or a combination of several levels of analysis. Platform constructs range from TSMs or MSPs including network effects or to more technical constructs in the form of an IS platform including standardization and modularization. Also, each of those constructs can be used to analyze different levels of analysis. Thus, this contribution aims to provide a first step in the direction of differentiating and delineating different platform constructs on the example of IoT platforms. For this purpose, the authors conduct a systematic literature review to reveal how IS scholars use the platform constructs of TSMs and MSPs, as well as IS platforms. The results show how the platform constructs differ, delineate, as well as the level of analysis ranging from technical, over to ecosystems.

2 Design of Literature Review

The literature research follows the proposed approach of Webster and Watson [20]. The structured process ensures reproducibility, transferability, transparency and to work towards a clearly defined goal.

The scope aims to identify how the platform constructs of TSMs [3, 9, 13, 21] or MSPs [11, 14, 22, 23] and IS platforms [4, 15, 16] are applied and differentiated within the IoT literature. The primary audience are IS scholars. The findings show a representative cross-section of the IoT platform literature [24, 25].

The central concept of the literature review is to identify how IS scholars use platform constructs in the context of IoT platforms to reveal differentiations, delineations, and the respective level of analysis. Accordingly, the authors spread the search terms across IoT platforms and the key IS scholars who influenced the constructs of TSMs/MSPs and IS platforms. For the literature search, the terms *"IoT Platform" and "[Alstyne | Armstrong | Baldwin | Bharadwaj | Eisenmann | Evans | Gawer | Hagiu | Rochet | Rysman | Tiwana]"* were used. To reduce the number of false negatives, the authors used the specification of the exact phrase to search the whole text (e.g., *"IoT Platform"* AND *"Gawer"*). By including the main contributors of both constructs in the search term, we focus the literature review on IoT platforms that utilize one or both constructs. This approach can be justified as the goal was not to identify new IoT platform constructs, but to show how TSMs/MSPs and IS platforms were used in the context of IoT platforms and on which levels of analysis. Only peer-reviewed papers were considered to meet the quality standards in research. However, we also included grey literature if the citing source was a peer-reviewed paper (e.g., during the backward search). The time period was not specifically set, as the key IS scholars determine the period for the two platform constructs.The selected database source was Google Scholar to incorporate a broad range of databases for the relatively new topic of IoT platforms. Further, we used Scopus to validate the results.

During the *first iteration,* we scanned the title and abstract and sorted out duplicates, no peer-reviewed, and non-English articles, to determine relevant documents. In the *second iteration,* we dismissed papers that were not subject to the phenomenon of platforms or did not fit the IoT context by reading through the whole text. Thirdly, we conducted a forward and backward search according to the remaining literature to identify additional articles [20]. In the *last step*, the final set of literature was used to conceptualize the findings according to the two constructs of TSMs / MSPs or IS platforms, as well as the units of analysis ranging from an ecosystem or technical perspective in a matrix.

3 Findings for IoT Platforms

In the initial search, we identified 210 articles. In the first iteration, we sorted out three duplicates, five non-English, one patent, ten not peer-reviewed articles, as well as 104 documents due to scanning the title and abstract. In the second iteration, we dismissed 73 articles due to a lack of context. In the third iteration, we completed the resulting 14 papers though adding three in regards to forward and 14 due to backward scanning. In total, the literature review revealed 31 relevant articles (see Table 1). Regarding the meta-data, over two-third (22) papers originate from the IS literature and are marked with parenthesis "[A | B | C | D | 0]". Further, the ranking from "A" (best) to "0" is shown, where "0" means that the conference or journal is not ranked at all[2]. Also, the table marks other research streams like books and book chapters. Additionally, the literature review revealed that other research areas like Marketing and Management work on the subject of IoT platforms.

Table 1 summarizes the results in a concept matrix. Here, the columns show the two major platform constructs of an *IS Platform* and a *TSM / MSP*. We divided them into sub-columns to show on which configuration they were applied (*Tech.* = technical, *Ecos.* = ecosystem).

Table 1. Results of the Literature Review to Identify Platform Constructs in the context of IoT Platforms

Literature	*IS Platform*		*TSM / MSP*	
	Tech.	*Ecos.*	*Tech.*	*Ecos.*
Berkers et al. 2013 [6] [0]				x
Fleisch et al. 2015 [26] [Whitepaper]				x
Giessmann et al. 2014 [27] [C]	x	x		x
Giessmann & Legner 2013 [28] [A]	x	x		x
Hahn et al. 2016 [29] [B]	x	x		x
Hahn et al. 2015 [30] [D]	x	x		
Huntgeburth et al. 2015 [31] [B]		x		
Iivari et al. 2016 [32] [Management]				x
Karapantelakis & Markendahl 2015[33] [0]				x
Keskin & Kennedy 2015 [34] [C]				x
Kortuem & Kawsar 2010 [35] [0]	x	x		
Kübel & Zarnekow 2014 [36] [C]	x	x		x
Kübel et al. 2014 [37] [D]	x	x		x
Leminen et al. 2012 [38] [Book]	x	x		x
Mack & Veil 2017 [39] [Book]	x	x		x
Mazhelis et al. 2012 [40] [Book]	x			
Mazhelis & Tyrvainen 2014 [41] [0]	x			
Menon et al. 2015 [42] [0]	x	x		x
Mineraud et al. 2015 [43] [0]	x			
Mohapatra & Bhuyan 2016 [44] [0]	x			
Ng & Wakenshaw 2017 [45] [Marketing]	x	x		x

[2] The rankings derive from the VHB expert assessment, which can be found at http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/hinweise/ (Accessed: 2017-3-14).

Literature	IS Platform		TSM / MSP	
	Tech.	*Ecos.*	*Tech.*	*Ecos.*
Rong et al. 2015 [46] [Marketing]		x		
Saariko et al. 2016 [47] [C]	x	x		
Tesch 2016 [48] [B]				x
Toivanen et al. 2015 [49] [0]	x	x		
Turber & Smiela 2014 [50] [B]	x	x		
Turber et al. 2014 [51] [C]	x	x		
Westerlund & Leminen 2014 [52] [Management]	x	x		
Yablonsky 2017 [45] [Management]				x
Yu et al. 2016 [53] [0]	x			
Zdravkovic & Trajanovic 2016 [7] [0]	x			

The IoT platform literature reveals three different configurations for the two constructs and their application on different levels (see Figure 1 and Table 2).

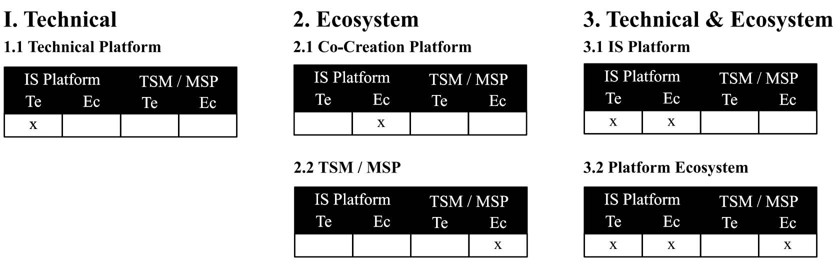

Figure 1. Different IoT Platform Configurations based on the Constructs: IS Platform and TSM or MSP, as well as the Level of Analysis

The *technical* configuration describes the case of a *technical platform* utilizing the construct of an IS platform. Going hand in hand with the definitions of Baldwin and Woodard [4], this configuration illustrates the technical nature of IoT platform regarding standardization and modularization aspects. In the defined context of IoT platforms, the technical usage of the term platform describes an isolated view on the *technical platform* as the core of a *technical* ecosystem, which specifies a corresponding set of modules. The modules serve as sub-systems that connect and add functionality to the core platform [40]. Another interpretation shows the IoT platform as the infrastructure that enables the end-user to interact with smart objects [43]. Lastly, IS scholars utilize the case of technical platforms to introduce technical encapsulated modules offering services like device management, connectivity, and testing on an IoT platform [44]. In total, the technical platform applies concepts like standardization or modularization to provide essential IoT specific services on a technical level.

Both, the case of a co-creation platform and TSM / MSP apply separately in the context of IoT platforms to the second ecosystem configuration. In the first case, the construct of an IS platform solely focus on the ecosystem perspective. A theoretical foundation can be found in the term value co-creation, where independent ecosystem participants influence the overall value captured of a platform [19]. In the context of IoT platforms, this configuration focuses on the organizational ecosystem and helps, for example, understanding the influence of platform openness on value co-creation or innovation [46]. The second case within this configuration is the utilization of the TSM or MSP construct on the ecosystem level. Regarding theory, this case is grounded in the principles of network effects, overcoming the chicken & egg problem, and platform envelopment [3]. Within IoT platforms, scholars apply this case on the organizational level to describe network externalities between products or services [32] and between devices and consumers [33]. Thus, depending on which case of configuration is applied, a co-creation platform describes the effect of value co-creation within the organization, while TSMs or MSPs help to describe network externalities on the organizational or market level.

Table 2: Summary of the Key Concepts of Platform Constructs in the Context of IoT Platforms.

#	Configuration	Level of Analysis	Key Concepts	IoT Example
1	Technical	Architecture	Standardization / Modularization	Technical architecture describing which standards (e.g. technical protocols) or modules (e.g. device management) are used [41].
2.1	Ecosystem	Organization	Value Co-Creation	Connection and co-evolution of stakeholders with the help of IoT devices [46].
2.2		Market	Network Externalities	The role of network externalities in machine-to-machine partnerships [33].
3.1	Technical & Ecosystem	Combination 1 + 2.1		Show the role of industry standards (e.g. technical protocols) for industry partners on the willingness to participate in an IoT platform [47].
3.2		Combination 3.1 + 2.2		Development of IoT business models based on modularized applications and the technical architecture, value creation through customer data, and the incorporation of network externalities [39].

Thirdly, the technical & ecosystem configuration covers the construct of an IS platform solely or in combination with a TSM / MSP and represents the cases of an IS platform or a platform ecosystem. Case one combines the technical and organizational level and, thus, follows the definition of an IS platform according to Gawer and Cusumano [15]. Within the IoT literature, IS scholars use this configuration to describe the technological platform including standardization and modularization as the technical core of an ecosystem [49, 52]. In this ecosystem, modular services or applications like

APIs, mobility or user management are combined with organizational considerations like fostering value co-creation through governance structures are of interest [30, 54]. In addition, IS scholars describe the roles of platform participants in the process of value co-creation [47, 50]. The second case combines the construct of an IS platform with a TSM or MSP, which leads to the case of a platform ecosystem. Besides value co-creation, the analyzed papers take network externalities, pricing, and competition into consideration. In the literature, IS scholars apply this concept, for example, by declaring technical platform modules or devices as a participant in the organizational ecosystem [28]. Those modules can then be extended (e.g., through complementaries) to foster network effects, which lead to a reinforcing effect [29, 37]. In total, the technical & ecosystem configuration applies on multiple layers and ranges from architectural and organizational aspects within the case of an IS platform, to the addition of market considerations in the case of a platform ecosystem.

4 Discussion

In total, the contribution reveals that IS scholars use the term platform with different meanings and on diverse levels. The literature review shows that the constructs of an IS platform, and a TSM / MSP appear in three different configurations in the context of IoT platforms. Each of the configurations results in one or two particular cases. Thus, the boundaries between the various configurations, as well as different manifestations within a configuration are an obvious choice to illustrate differences and commonalities (see Figure 2).

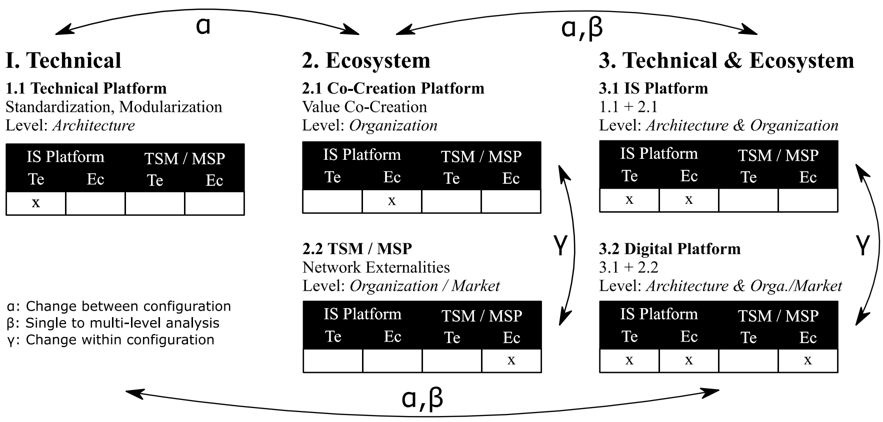

Figure 2. Illustration of changes between and within configurations and the underlying level of analysis.

Differences between configurations, as illustrated in Figure 2 α, lead to a shift in the level of analysis. The first scenario (α) explains a change from the technical to the ecosystem configuration. Here, IS scholars focus on an isolated configuration like the technical architecture or the ecosystem. A typical example is analyzing the influence of standardization and modularization on the development process of IoT applications [41] or taking organizational aspects like value co-creation through roles and complementaries into consideration [31]. The second scenario (α, β) illustrates a shift from a single to a multi-level analysis, where the level is dictated by the configuration. While the first and second configuration describes the phenomenon of platforms in isolation, the third configuration utilizes multiple constructs. In contrast to the example of the technical configuration, a multi-level analysis describes, for instance, the influence of technical modularized layers, like the integration of various IoT devices, on the capability of value co-creation with devices of partners [50]. Also, each of the different platform configurations incorporates distinct attributes like network externalities or value co-creation that help to describe the phenomenon on the respective level. Thus, it is of importance to apply the best-fitting platform construct to suit the underlying context and research design's needs.

For the second and third configuration, the results indicate differences within each of them (γ). The *ecosystem* perspective comprises two lenses. On the one hand, the case of a *co-creation platform* focuses on the organizational viewpoint, while the *TSM or MSP* help to explain organizational and market-based effects according to network externalities. So even in the ecosystem perspective, one must be aware of the different usage of the cases of a *co-creation platform* and a *TSM / MSP* and the underlying context varying from an organizational or market perspective. The *technical & ecosystem* point of view follows a multi-level analysis by combining technical and organizational or market-based aspects. In this case, the effect of technical aspects can influence either organizational roles on value co-creation activities or the whole market through economies of scale resulting from standardization, which leads to a more favorable pricing structure. Hence, even if the level of analysis is correct, IS scholars still need to determine if the particular case fits the research's needs regarding the constructs specific effects.

Lastly, the results share common threads to the Service-Dominant (S-D) logic of Lusch and Nambisan [18]. Their conceptualization differentiates between innovation as an actor-to-actor (A2A) network represented by a service ecosystem, a technical platform that incorporates resources for the facilitation of resources, as well as the value co-creation processes fostering resource integration. Our configuration of a technical platform maps to the concept of a service platform. The TSM/MSP platform illustrates an A2A network incorporating network externalities. Third, the value co-creation concept maps to the case of a co-creation platform. The third configuration with the cases of an IS platform and a digital platform is a combination of the service platform and value co-creation or all three constructs [18]. By combining our research with the results of Lusch and Nambisan [18], we contribute towards a better understanding in terms of the single- and multi-level characteristics of S-D logic in the light of different platform constructs.

Finally, all platform configurations share common features. Each of them aims to increase the value captured for the owner through, technology, organizational or market-based mechanisms ranging from modularization, value co-creation, and complementaries, to pricing and network effects.

This contribution provides theoretical and practical implications. On the theoretical side, the literature review increases the awareness and transparency of the two most common platform constructs in IS research. Here, the results indicate that the respective platform construct and configuration needs to suit the level of analysis. Further, the platform constructs differ also within the configurations by applying different mechanisms like value co-creation and network externalities. Thus, a clear definition of the underlying term platform is of importance and should always go along with the research design. Further, the results indicate that a majority of articles does not stick to one configuration, but utilizes also a second one to explain systemic effects between the technical and market/ecosystem level. Those findings highlight the interrelatedness to the S-D logic, where central S-D concepts can be mapped to concrete platform cases. For the practitioners, this contribution reveals the systemic character of the term platform. The technical introduction of APIs and SDKs, for example, also influences the capability of value co-creation of external partners or complementors through an increased ease of use and economies of scale. Also, the optimized value co-creation process might foster positive network effects that lead to positive reinforcement within an ecosystem. Those insights might help practitioners to take into account that technical changes on the infrastructure level might lead to consequences within the market or ecosystem level.

As a further result, the perspective on the different levels of analysis reveals fruitful avenues of future research. On the one hand, the results show the need of platform governance mechanisms in a new light. The different platform configurations could help to explain how different governance mechanisms [54, 55] mediate or moderate between the layers of analysis. Here, the introduction of boundary resources like APIs may influence the technical architecture, but also indirectly affect the organizational or market perspective. Thus, especially platform governance literature could benefit from future research from the angle of a multi-level characteristic and the systemic implications of the different platform constructs. Lastly, the literature review faces limitations. At first, this contribution can only be a first step towards demystifying the term platform, as the scope is limited to IoT platforms only. By expanding the view through a more established platform context, the study could benefit from an increased generalizability, which leads to a more accurate model of configurations. Also, the study focuses on the two most common platform constructs, ignoring similar constructs like electronic markets, which leads to a limitation regarding the completeness.

5 Conclusion

Overall, this contribution is a first step towards disentangling the buzzword of platforms into logical and understandable configurations. The literature review shows that IS scholars apply different platform constructs on different levels of analysis. On the example of IoT platforms, the results indicate that the technical and ecosystem layer are most frequently used. The usage varies depending on the underlying level of analysis. While the technical constructs focus on standardization and modularization, the ecosystem perspective differentiates between value co-creation and network externalities. Consequently, the exclusive sole bearing of either technical or ecosystem considerations follows a single-level analysis. In addition to that, the literature search revealed that those layers can be combined in a multi-level analysis elaborating on both, the technical and ecosystem perspective. Concluding, this contribution stresses the importance of defining the term platform according to the research subject and the underlying constructs.

6 Acknowledgements

This work is part of the TUM Living Lab Connected Mobility (TUM LLCM) project and has been funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology (StMWi) through the Center Digitisation.Bavaria (ZD.B), an initiative of the Bavarian State Government

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