Dynamic Strategic Modeling for Alliance-Driven Data Platforms: The Case of Smart Farming

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Abstract. The increasing availability of data offers opportunities for advancing business models, e.g., by combining hardware sales with value-added services. Besides platform companies aiming for a dominant market position, other configurations are relevant especially in contexts of highly qualified smaller enterprises in the industrial sector, where players in alliance-driven platforms cooperate to jointly create and capture value. The challenge is to identify and assess these opportunities early on. In this paper, we propose the combination of strategic modeling and setting control points to support organizations in adjusting and evaluating possible business models. Our approach was initiated in an extensive case study in the agriculture industry, yet we are confident that the results are transferable to other industrial areas with emerging alliance-driven data platforms.

Keywords: Data platform · Conceptual modeling · Industry 4.0

1 Introduction

The ongoing digitalization is changing entire value chains for industrial organizations. As one effect, networked devices produce more and more data. This data has the potential to increase productivity due to faster and more practical insights through features such as predictive maintenance, which enables the early detection of defective components, based on historical repair data. A challenge for many companies is not only to deal with these enormous amounts of data but also to create and capture value from them. Towards this goal, organizations increasingly rely on external data and service exchange within business networks. New data-driven business models provide potential for existing big

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players but also for startups, as there is a low entry barrier without investments in industrial hardware. Examples are service-oriented business models, enabling new interrelations such as multi-angular relationships between companies, as well as value co-creation [28]. However, policies and agreements between stakeholders are required to regulate collaboration between parties for data sharing [1].

Platform ecosystems evolved that connect various stakeholders from established business partners to emerging market entrants like complementors [32]. In industrial settings, physicality and complexity hamper value capture. Technological complexity results from connected physical components such as industrial assets and their association to information systems, business processes, and "smart" services on top [29,30]. Challenges are manifold; first, potential needs to be recognized in time, so that firms can take strategic decisions in advance. Second, data sovereignty of enterprises in terms of self-determination with regard to the use of their data needs to be taken care of. This is particularly valid for emerging alliance-driven platforms [24], where multiple players cooperate to jointly create value. The approach described in this paper combines i*-based strategic conceptual modeling, the setting of so-called control points, and the recognition of control points set by competitors.

Strongly extending an initial set of i* models [6], the paper is organized as follows. First, we discuss related work in the area of platform ecosystems and ecosystem modeling. Then, we discuss the specific needs for a dynamic strategic modeling approach for ecosystems, describe the basics of our approach, which differs by its multi-player approach from the existing alternative modeling approaches to adaptive resp. coopetition systems modeling. We validate these claims by modeling a large-scale evolution case study in the smart farming ecosystem. Finally, we discuss our findings and give a conclusion and point to ongoing and future work.

2 Related Work

An ecosystem is "an interdependent network of self-interested actors jointly creating value" [5]. Platform ecosystems consist of a central platform with multiple peripheral firms connected to it [17]. They are a sub-group of innovation ecosystems, where multiple actors mutually depend on each other to create value. Thereby, platform orchestrators hope to benefit from network effects [1,16], achieving a winner-takes-all (WTA) position [12,13]. Therefore, in common WTA ecosystems, a dominant industry platform has arisen, where the orchestrator is the de-facto leader. In integrated platform ecosystems relying on a modular architecture, openness is relevant [4] as value proposition and the underlying innovations are created jointly by platform owners and third-party contributors [1]. Openness is critical to building momentum at this stage [8].

Software vendors face the challenge of relying on third-party interfaces, libraries, and resellers, leading to numerous dependencies on technical and business levels. A clear view on technical dependencies on integrated libraries, their licenses, and update policies regarding, for instance, security aspects needs to be kept. To this end, visual modeling languages have been proposed. Software supply network (SSN) diagrams include material and monetary flows [18]. Product deployment context (PDC) models, in contrast, focus on the software in the running architecture [22]. Yu & Deng describe software ecosystems by modeling strategic goals of their stakeholders with the i* modeling language [36]. On top of the SSN and PDC approaches, i* modeling helps to highlight the intentional and strategic dimension of relationships. In the remainder of this paper, we profit from the findings of Yu & Deng by showing i*'s capabilities to a) make relationships explicit, b) facilitate exploring strategies and alternatives, as well as c) bring out structure for systematic reasoning.

From an *information systems perspective*, openness is enabled by standardized interfaces and autonomous data exchange, connecting formerly isolated companies [7]. The platform thereby embraces technology standards that support the integration of offerings and manage the interdependencies in the ecosystem [31]. The International Data Spaces (IDS) [25] Association has introduced an architecture, blueprint and standards for data-sharing among member organizations in a reliable, transparent, compliant and accountable manner. The IDS principles are also the basis for the ongoing GAIA-X initiative to enable the exchange of sensitive and valuable data [23]. The main idea behind the IDS is that actors can trustfully, and with full sovereignty over usage of their data, exchange data without knowing each other. Significant effort has been invested in creating a coherent standardized information meta model about all aspects of the IDS reference architecture [2,19]. IDS itself does not offer a conceptual abstraction for the actual valuable data objects to be exchanged. To address this issue, we have proposed the notion of *Digital Shadows* and are exploring it in the context of Aachen's large-scale research initiative Internet of Production [21] which is also the context for the approach and case study reported in this paper.

3 An Integrative Approach to Dynamic Ecosystems Modeling

Like ecosystems in nature, data-related ecosystems are not only highly complex but also need to be adaptive to outside developments and shifts in internal relationships. As illustrated by the IDS initiative and its multi-faceted metamodel [2], this applies to the operational and technical level of data management, service exchange, and IT security mechanisms, but equally to the business aspects of collaborative value creation, and to the strategic level of setting regulations for the ecosystem as well as developing strategies for the individual players. In this paper, we are mostly interested in concepts on the strategic level. While the i* concepts of goal orientation (Strategic Rationale) are the basis for managerial decision making of individual players in the network (considering or changing the dependency context), achieving a balanced network of dependencies is an important prerequisite especially for alliance-driven ecosystems setup [24] and stability. However, it is clear that actions from inside and outside the ecosystem will constantly challenge and not rarely change this structure.

This need for dynamic complements to the i* infrastructure has been recognized at least since the early 2000's. In cooperation between computer science and sociology [14], the dynamic nature of trust in networks was recognized and modeled by linking i* dependencies to workflow or AI planning models through which trust could be built up by kept commitments, and distrust monitored by suitable controls. In a complementary approach, Mylopoulos and colleagues conducted in-depth studies of adaptive IS engineering essentially by exploiting the structure of "alternative" links within Strategic Rationale models (e.g., [20]).

Closest to our approach is Vik Pant's recent study of an i* extension for modeling coopetition, i.e. how the combination of competition and cooperation can be modeled and analyzed [26,27]. In particular, his extension of reciprocality offers an interesting dynamic concept for our current research question. Pant and Yu combine Game Trees with i* dependencies as an operationalization of this dynamics [26]. Pant's case studies focus so far on binary coopetions, possibly facilitated by a third abstract platform actor like the IDS infrastructure and regulations. In alliance-driven settings, the more general case of multi-sided coopetition applies. For companies in such a platform it is of immense strategic importance to anticipate their future role at an early stage and plan appropriate steps along the way. Strategically, this is best done in a top-down way, as actively placed management decisions. In our approach, we therefore augment i* with *Control Points*. Control points, also referred to as bottlenecks [3,15], are technical and strategic decisions representing solutions to issues constraining value creation. In that sense, they can be set to grant access or impose certain behavior [11], analogous to the data usage control policies of IDS.

4 Case Study: Analysis and Dynamic Modeling of a Smart Farming Ecosystem

The farming sector is dominated by a few large manufacturers, with two strong market leaders in Europe and North America respectively. The European leader, under pressure from potential threats by market participants in other parts of the traditional supply pipeline (e.g. seed companies) as well as generic web-based marketing platforms, began in the 2010s with setting up its own platform-based ecosystem as a broad alliance-driven network including players in its supply chain as well as customers (farmers and their supporting contractors), service units, and the like. Recently, even competitors have been joining forces such that coopetition is becoming a strong element of the alliance. Our case study started as a qualitative analysis by the innovation researchers in the author team [33,34], accompanying the emerging ecosystem for a long time, but eventually the need for a conceptual modeling approach resulted from the observed complexity.

We adopted a qualitative case study approach, following the suggestions for rigorous case study research by Yin [35]. First, we conducted 55 interviews with key actors from the agricultural sector, e.g. manufacturers, input firms (seed, crop protection) and other relevant members (customers, suppliers, complementors, competitors, dealers, or new entrants). These platform actors are categorized and described in the next section. We then evaluated over 100 h of interview and workshop material in total. Extensive secondary data like information on connected machines, digital service usage, strategy documents, or annual reports were additionally analyzed. Based on this large-scale study of a competitive platform provider, cooperatives, as well as their internal strategies, we identified the interactions between ecosystem members.

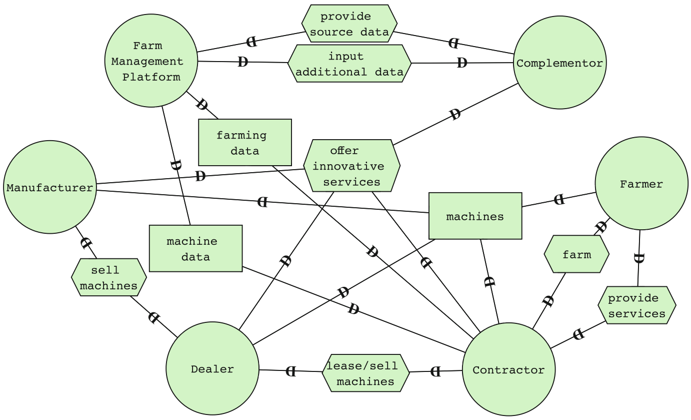

Fig. 1. Strategic dependency view of stakeholder relationships

For a detailed description of our models, created using the recent iStar 2.0 notation of i* [9], we refer the reader to our earlier publication [6]. Here, we shortly point out the actors. Market participants present in a pipeline ecosystem as well as a platform ecosystem are **Manufacturers**, **Dealers**, **Contractors**, and **Farmers**. When changing from a pipeline to a platform ecosystems, a **Farm Management Platform** and **Complementors** are joining. An i* strategic dependency model shows these actors and their goals, as well as the dependency relationships between them. Figure 1 depicts such a view of the stakeholder relationships in the smart farming ecosystem.

5 Control Points in Emerging Platform Strategies

Much of the relationships between the actors of the traditional agricultural value chain are changed with the appearance of the platform and emerging IT-related market participants. We hereby consider control points as active strategic decisions, that platform participants can exercise to achieve a certain ecosystem behavior. Organizations can set up control points, by adhering to specific technical standards. In this sense, this also signals a willingness to cooperate. Thus, in an emerging setting like industrial platforms, where roles and rules are yet unclear, control points are even more important [10]. The major strategic and technical control points concerning platform ecosystems and their relation concerning value capture and innovation paths are empirically identified and described in detail by [34]. For instance, the machinery firm could decide to technically modularize its offering, i.e. separate its hardware from its software-based services, to enable access for third-party complementors to create the basis for an innovation ecosystem. From a strategic perspective, a platform provider could try to impose multi-homing costs (costs for affiliating with multiple platforms) in order to increase the likelihood of a market to tip towards a dominant platform.

For the extensive discussion of identified control points, the reader is kindly referred to an earlier publication [34]. For instance, through passing the control point *Modularization*, value can be captured in a pipeline business model. By the control points *Opening* and *Prizing*, a platform model can be reached. In contrast, the traditional ultimate goal is a WTA approach, where one dominant market leader captures the entire value. Turning away from a WTA approach, additional value can be captured by a trust-enabled data sharing approach in an alliance-like platform ecosystem. Specifically, the actor concepts of the IDS model [25] can be mapped to the platform model. For example, The IDS concepts Data Owner and Data Provider are roles of our existing market participant. The interface represents the App Store and Broker for new complementor services. The IDS Clearing House is responsible for checking whether community rules are observed.

6 Discussion and Conclusion

Platform ecosystems in industrial settings are characterized by high complexity in terms of technology layers [29] and relationships [30]. In addition, interdependencies change as the ecosystem evolves. Questions are, for example, whether there will be one dominant platform, or two? How will future technical achievements change this interplay? We introduced two strategic tools to accompany this research: conceptual modeling using the i* language as well as control points.

The main contribution of our paper is the integration of strategic, technical and decisional perspectives, validated by a major real-world case study from industry. They result in decision making instruments that platform participants can use to plan their next step within an alliance-driven platform ecosystem. The strategic framework can also be used to identify, at an early stage or in face of major expected disruptions, which control points other companies are setting in relation to their competitors. This allows companies to react early and adapt their strategy or even enter negotiations for a new alliance or joining existing ones. Therefore, we claim that the right configuration of control points helps by indicating viable transition paths within and for platform ecosystems. In future work, the synthesis of these ideas by combining the comparison of platform variants with code generation may lead to a faster and more holistic analysis of data ecosystem variants. Ultimately, a repository of available graphical representations and code structures may facilitate automated, easier, and faster decision support for stakeholders in new data-driven ecosystems. Besides seeing their current status, this would allow organizations to see missing links, and potentially extend their current portfolio from a model repository.

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