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The influence of dynamic business models on IPS² network planning – an agent-based simulation approach

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Abstract

Industrial Product-Service Systems (IPS²) are delivered in networks consisting of IPS² provider, customer and various suppliers of service and product shares. For successful IPS² delivery, these networks must be managed effectively. In particular, having the right resources available when and where needed is crucial to delivering superior customer value. At the same time, innovative IPS² business models increasingly gain importance and need to be considered during the organization of IPS² delivery. Depending on the contracted revenue model, the objectives of IPS² delivery planning can vary from one IPS² to the other, with influences on required lead times and the capacity level, which needs to be maintained. Furthermore, several other business model characteristics, such as the risk distribution, property rights and process responsibility, will have an influence on IPS² delivery, which need to be considered in IPS² network planning.

In this paper, an agent-based simulation approach for strategic IPS² network planning is presented, which is able to cover and represent various business model-specific objectives, constraints and parameters. Different business models influence not only IPS² functions and physical modules, but also the types, times and frequency of services, which need to be delivered. The described agent-based model is prototypically implemented. It can be applied as a decision-support system in the design and restructuring of IPS² networks and for strategic capacity planning decisions. A scenario study is presented to evaluate the simulation approach and to show how the influence of dynamic business models can be represented in IPS² network planning.

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1. Introduction

Industrial product-service systems (IPS²) are integrated solutions, which provide superior customer value. IPS² represent a new way of value creation that does not focus on the mere provision of products and services, but on satisfying the customer's needs with the help of individual, customized solutions [1]. Due to the paradigm shift associated with IPS² as opposed to solitary products and services, specific IPS² business models have evolved to define different types of value creation, revenue, cost and risk sharing as well as collaboration between network partners within the IPS² network [2–4].

Since IPS² are provided in networks with intensely collaborating partners, these networks need to be planned and managed thoroughly [5]. The strategic task of IPS² network planning involves decisions regarding the quantity,

quality/qualification, flexibility and location of resources and is critical to ensuring an effective IPS² delivery [6].

Because IPS² business models determine the way in which value and revenue are created within the IPS² network, business model characteristics have to be taken into account during IPS² network planning. In line with this, the aim of this paper is to describe the influence of business models on the IPS² network and delivery organization. An agent-based simulation approach is introduced as a tool for scenario-based network planning. Subsequently, a fictional evaluation scenario of a machine tool manufacturer is presented. In this scenario, 25 percent of the customers change to an availability-oriented business model. With the help of the agent-based simulation approach, the effects on machine availability, revenue and costs as well as on network partners and resources are examined quantitatively.

2. IPS² delivery in networks

Due to customer integration, high levels of uncertainty and technology-intensive hardware, the planning and delivery of IPS² is a complex task [1]. Therefore, many different network partners are involved, which can cooperate both vertically (on different levels of the supply chain) and horizontally (on the same levels of the supply chain) [7]. In each IPS² network, there is one IPS² provider, who manages the network, is responsible for IPS² delivery and represents the *one-face-to-the-customer* [8]. The other basic roles within the IPS² network are the customer, IPS² module suppliers, component suppliers and service suppliers. IPS² module suppliers provide integrated products and services, which cannot be marketed independently due to their integral character. Opposed to this, component suppliers provide physical components, either to the IPS² provider or to the customer directly, and service suppliers deliver or assist in delivering services to the customer. [9,7]

The provider network is the consortium of all partners from all IPS² networks – it comprises all organizations with whom the IPS² provider is currently cooperating to deliver customer value by means of IPS². It needs to be managed carefully in order to make sure that the required resources for IPS² delivery can be provided in the right quantity and quality, where and when needed. One important task of strategically planning the provider network therefore is to manage resource capacity with regard to resource quantity, quality or qualification, location and availability [6].

IPS² network planning is a strategic planning task. Network planning approaches therefore have to take into account several types of uncertainty [10]. Most importantly, there is uncertainty regarding the specific demand for IPS² delivery processes. Since the planning horizon is usually longer than one year, only a small proportion of all delivery processes is known with certainty and can be planned in advance. The largest proportion can only be estimated by means of statistical evaluation and distribution functions based on historical data [12]. Uncertainty is further increased by the unpredictability of the market development and of the availability of resources within the provider network.

Additionally, possible shifts in business models and technological innovations will have an impact on the quantity and type of required IPS² delivery processes. Especially if the provider has previously focused on selling high-technology products with complementary services and is now gradually undergoing a migration towards an IPS² provider, the entire provider network including partners and resources has to be adapted constantly.

Consequently, service managers in charge of planning the provider network for IPS² delivery need to consider a large quantity of influencing factors [10]. More than that, the scope for action in strategic network planning is very large, i.e. a great variety of measures must be taken into account. These represent strategic capacity management options and include for example hiring or lay-off of field service engineers (FSE), qualification of FSE, relocation of FSE, product modifications, changing preventive maintenance periods, amongst others [6].

Because of this complexity in strategic network planning, sophisticated decision support is required to help estimating the effect of different management options [13,6]. For this purpose, a simulation-based approach for IPS² network planning is presented within this paper (section 5). Prior to this, an overview of IPS² business models is given (section 3) and relevant interdependencies between IPS² business models and the IPS² delivery organization are explained (section 4). These foundations have to be taken into account during strategic IPS² network planning and are thus integrated in the simulation model.

3. IPS² business models

IPS² are always tailored and continuously adapted to individual and dynamically changing customer requirements as well as supplier capabilities. Thus, in the majority of cases, an IPS² is unique. Consequently, in order to allow for individual customer solutions, the underlying IPS² business models have to be discussed on a very concrete product-service level, which unfortunately has been widely omitted in existing literature [3].

Business models for IPS² characterize a specific relationship between a provider and a customer, and possibly other value-adding partners of the provider network [2–4]. They are highly complex systems that are composed of various components, often described as partial models. Amongst these partial models, the value proposition is the central characteristic of an IPS² business model [4]. It determines how and by which IPS² components value is created and how processes are distributed between customer and provider.

Another important partial model is the revenue model, which describes if the provider's revenue is based on single transactions (such as product sale or service delivery), the provision of a promised availability ratio or the output of the product use, for example. Furthermore, a business model is characterized by the way in which costs as well as risks are distributed within the provider network and which of the partners is responsible for which tasks and processes. Of course, also the ownership structure, property rights and value distribution are part of the IPS² business model. [3]

IPS² business models can be differentiated by the degree of collaboration between customer and provider. In traditional transaction-based business models, single products or services are sold. Thus, the intensity of collaboration is low as the customer conducts nearly all processes. Opposed to this, in provider-driven models, the provider takes over most of the processes from the customer in his responsibility. This means that the collaboration intensity is also relatively low and the provider bears most of the risks. The business models between these two extremes can be characterized by a high degree of collaboration. In these collaboration-intense models, customer and provider jointly conduct sub-processes, e.g. to ensure the availability within the superordinate IPS² delivery process. Hence, the partners have to collaborate and coordinate, which requires an intense and trustful business relationship. [3,4]

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